31ST ANNUAL RESEARCHERS MEETING

OF THE

UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM
AND
SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

JANUARY 26–27, 2010

CLARION HOTEL
HORIZON DRIVE
GRAND JUNCTION, COLORADO

REGULAR SESSIONS

Tuesday January 26, 20102

7:30 **Registration:** Fee is $20.00 (Cash or check) to offset costs of meeting room and refreshments.

Session 1: Program Management
(Moderator: Tom Czapla)

8:30 THE UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM: FUTURE CHALLENGES. *Tom Chart*, Upper Colorado River Endangered Fish Recovery Program.

8:50 THE DEVELOPMENT OF RESEARCH AND INFORMATION NEEDS FOR THE SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM. *Mark McKinstry,* U.S. Bureau of Reclamation.

9:10 THE VIRGIN RIVER RESOURCE MANAGEMENT AND RECOVERY PROGRAM. *Steve Meismer,* Virgin River Program.

9:30 **Break**

9:40 NEW PERSPECTIVES ON HYDROCLIMATIC VARIABILITY IN THE UPPER COLORADO RIVER BASIN**.** *Jeff Lukas*, Colorado University.

Session 2: Razorback sucker/Bonytail in Lower Basin and Acclimation
(Moderator: Tom Czapla)

10:10 LOWER COLORADO RIVER MULTI-SPECIES CONSERVATION PROGRAM: OVERVIEW AND STATUS OF RAZORBACK SUCKER AND BONYTAIL IN LOWER COLORADO RIVER. *Tom Burke,* U.S. Bureau of Reclamation.

10:30 INDICATIONS OF CONTINUED LAKE MEAD RAZORBACK SUCKER RECRUITMENT AND MANAGEMENT PROGRESSION. *Brandon Albrecht*, BIO-WEST, Inc.

10:50 **Break**

11:00 STATUS OF RAZORBACK SUCKERS STOCKED INTO THE LOWER COLORADO RIVER BETWEEN DAVIS AND PARKER DAMS. *Jeff Lantow,* U.S. Bureau of Reclamation.

11:20 ACCLIMATION OF RAZORBACK SUCKERS, *XYRAUCHEN TEXANUS*, IN A MANIPULATED FLOOD PLAIN WETLAND ON THE MIDDLE GREEN RIVER, UTAH. *Aaron Webber*, U.S. Fish and Wildlife Service.

Session 3: Three Species of Concern and Backwater Habitat
(Moderator: Dave Irving)

11:40 HABITAT OVERLAP AMONG ROUNDTAIL CHUB AND TWO POTENTIAL PREDATORS IN GLACIAL LAKES OF THE UPPER GREEN RIVER BASIN. *Sarah Laske*, University of Wyoming.

11:50 **Lunch**

1:00 THE WHITE RIVER, UTAH: A REFUGE FOR NATIVE FISHES? *Matthew J. Breen*, Utah Division of Wildlife Resources.

1:20 VARIATION IN BACKWATER PHYSICAL HABITAT CHARACTERISTICS IN THE MIDDLE GREEN RIVER FROM 2003 THROUGH 2009. *John Hayse*, Argonne National Laboratory.

1:40 STATUS OF THE REINTRODUCED FLANNELMOUTH SUCKER IN THE LOWER COLORADO RIVER BETWEEN DAVIS AND PARKER DAMS. *Eric Best*, U.S. Bureau of Reclamation.

2:00 **Break**

Session 4: Propagation and Fish Health

(Moderator: Dave Irving)

2:10 EVALUATING THE RELATIVE COST-BENEFIT OF STOCKING AGE-0 VERSUS AGE-1+ COLORADO PIKEMINNOW IN THE SAN JUAN RIVER. *Scott L. Durst*, U.S. Fish and Wildlife Service.

2:30 GENETIC EVALUATION OF RAZORBACK SUCKER BROODSTOCKS AT DEXTER NATIONAL FISH HATCHERY AND TECHNOLOGY CENTER. *Wade D. Wilson*, U.S. Fish and Wildlife Service.

2:50 THE ROLE OF NUTRITION IN FISH CONSERVATION. *Wendy Sealey*, U.S. Fish and Wildlife Service.

3:10 **Break**

3:20 DEVELOPMENT AND OPTIMIZATION OF SPAWNING AND INTENSIVE CULTURE TECHNIQUES FOR WOUNDFIN. *Cal Fraser,* U.S. Fish and Wildlife Service.

3:40 FIELD ASSESSMENT OF MERCURY EXPOSURE TO ENDANGERED COLORADO PIKEMINNOW WITHIN CRITICAL HABITAT. *Barb Osmundson*, U.S. Fish and Wildlife Service.

Session 5: Population Dynamics

(Moderator: Tom Czapla)

4:00 CLOSED POPULATION ESTIMATES OF HUMPBACK CHUB (*GILA CYPHA*) IN THE LITTLE COLORADO RIVER, GRAND CANYON, ARIZONA. *David R. Van Haverbeke*, U.S. Fish and Wildlife Service.

4:30 **Adjourn**

4:20–5:00 **SPECIAL EVENT: HANDS ON DEMONSTRATION OF NEW PIT TAG METHOD.** *Brian Beckley*, BioMark, brian.beckley@biomark.com.

6:00 **EVENING SOCIAL**

(Food and Drinks)

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SPECIAL AWARDS

Wednesday January 27, 2010

8:30 POPULATION STATUS OF COLORADO PIKEMINNOW IN THE GREEN RIVER BASIN, UTAH AND COLORADO, 2000–2003 AND 2006–2008. *Kevin R. Bestgen*, Larval Fish Laboratory.

8:50 SURVIVAL RATE ESTIMATION OF HATCHERY-REARED RAZORBACK SUCKERS *XYRAUCHEN TEXANUS* IN THE UPPER COLORADO RIVER BASIN, UTAH AND COLORADO, SINCE IMPLEMENTATION OF THE INTEGRATED STOCKING PLAN IN 2003. *Koreen A. Zelasko,* Larval Fish Laboratory.

Session 6: Nonnative Fish Management and Evaluation
(Moderator: Michelle Shaughnessy)

9:10 INNOVATIVE TECHNOLOGIES FOR THE ERADICATION OF INVASIVE FISH FROM THE WESTERN UNITED STATES**.** *Jackson Gross*, U.S. Geological Survey.

9:30 **Break**

9:40 COMPARISON OF CAPTURE RATES OF SMALLMOUTH BASS *MICROPTERUS DOLOMIEU* IN THE YAMPA RIVER, COLORADO, IN 2009 USING SMITH ROOT GPP5.0 AND VVP15B ELECTROFISHERS. *Cameron D. Walford*, Larval Fish Laboratory.

10:00 SMALLMOUTH BASS POPULATION DYNAMICS AND CONTROL IN THE UPPER COLORADO RIVER BASIN. *M. Tildon Jones,* U.S. Fish and Wildlife Service.

10:30 RESPONSE OF THE NATIVE FISH COMMUNITY OF THE YAMPA AND GREEN RIVERS TO REMOVAL OF NON-NATIVE PISCIVORES, 2003–2009. *Kevin R. Bestgen*, Larval Fish Laboratory.

10:40 **Break**

10:50 NORTHERN PIKE CONTROL AND EVALUATION IN THE MIDDLE YAMPA RIVER AND GREEN RIVER: 2004–2009. *F. Boyd Wright*, Colorado Division of Wildlife.

11:10 STRONTIUM ISOTOPE RATIOS (^{87}SR:^{86}SR) AS TRACERS OF ORIGINS AND MOVEMENTS OF NONNATIVE PISCIVORES IN THE UPPER COLORADO RIVER BASIN. *Brian Wolff*, Colorado State University.

11:30 NATIVE FISH RESPONSE TO NONNATIVE FISH, 1986–2009. *Trina Hedrick*, Utah Division of Wildlife Resources.

11:50 **Lunch**

Session 7: New Approaches to Nonnative Fish Management
(Moderator: Michelle Shaughnessy)

1:00 MATRIX PROJECTIONS OF CHANNEL CATFISH (*ICTALURUS PUNCTATUS*) POPULATION DYNAMICS IN THE SAN JUAN RIVER, UTAH – NEW MEXICO. *James Morel*, New Mexico State University.

1:20 WORKING TOWARDS A UNIFIED DATABASE AND META-ANALYSIS OF THE UCREFRP'S SMALLMOUTH BASS (MICROPTERUS DOLOMIEU) DATASET: PROGRESS IN DATA MANAGEMENT, SOFTWARE AND PRELIMINARY ANALYSES. *André Breton*, Colorado State University

1:40 SMALLMOUTH BASS OTOLITH MICROSTRUCTURE ANALYSES AND IMPLICATIONS FOR GREEN RIVER BASIN FISH AND FLOW MANAGEMENT. *Kevin R. Bestgen*, Larval Fish

Laboratory.

2:00 **Break**

2:10 CHRONOLOGY AND POPULATION CHARACTERISTICS OF AN INVASIVE VIRILE CRAYFISH *ORCONECTES VIRILIS* POPULATION IN MIDDLE YAMPA RIVER, COLORADO. *Patrick J. Martinez*, Colorado Division of Wildlife.

2:30 INVASIVE CRAYFISH AND SMALLMOUTH BASS IN THE MIDDLE YAMPA RIVER: IMPLICATIONS OF DROUGHT, CLIMATE CHANGE & FOOD WEB RECONFIGURATION. *Patrick J. Martinez*, Colorado Division of Wildlife.

2:50 NONNATIVE SPECIES IN THE UPPER COLORADO RIVER BASIN: INCORPORATING COMMUNITY ECOLOGY CONCEPTS & INVASIVE SPECIES DETERRENTS INTO NATIVE FISH RESTORATION & CONSERVATION. *Patrick J. Martinez*, Colorado Division of Wildlife.

3:10 **Adjourn**

POSTER SESSION

LARVAE AND EARLY JUVENILES OF ENDANGERED CYPRINIDS IN THE UPPER COLORADO RIVER BASIN: *PTYCHOCHEILUS LUCIUS, GILA CYPHA,* AND *GILA ELEGANS*. Darrel E. Snyder, Larval Fish Laboratory.

PATTERNS OF GROWTH RATES AND LENGTHS OF AGE-0 SMALLMOUTH BASS IN THE YAMPA RIVER, 2003–2009. Angela A. Hill, Larval Fish Laboratory.

A QUICK COMPARISON OF THREE DIFFERENT TAGGING METHODS. Larry Zeigenfuss, U.S. Fish and Wildlife Service.

FIELD ASSESSMENT OF MERCURY EXPOSURE TO ENDANGERED COLORADO PIKEMINNOW WITHIN CRITICAL HABITAT. Barb Osmundson, U.S. Fish and Wildlife Service.

THERMAL REGIME SUITABILITY: UPSTREAM RANGE RESTORATION POTENTIAL FOR COLORADO PIKEMINNOW. Doug Osmundson, U.S. Fish and Wildlife Service.

ABSTRACTS

Session 1: Program Management

THE UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM: FUTURE CHALLENGES.

Tom Chart, Angela Kantola, Tom Czapla, Jana Mohrman, and Debbie Felker.

Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado, tom_chart@fws.gov, angela_kantola@fws.gov, tom_czapla@fws.gov, jana_mohrman@fws.gov, debbie_felker@fws.gov

The Program Director's Office briefly evaluates progress under each program element (Instream Flow Protection, Habitat Development, Nonnative Fish Management, Population Monitoring, Propagation, and Information and Education) to set the stage for their assessment of Near Term and Long Term challenges. Near Term challenges generally focus on information gaps and management actions Program partners will need to consider in the next five to ten years. Long Term challenges are much more forward looking and refer to commitments Program partners will need to consider beyond the Recovery Program, i.e. after the fish have been de-listed.

THE DEVELOPMENT OF RESEARCH AND INFORMATION NEEDS FOR THE SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM.

Mark McKinstry[1], Howard Brandenburg[2], Scott Durst[3] and Dale Ryden[4].

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[2] American Southwest Ichthyological Researchers L.L.C., Albuquerque, New Mexico, howard_brandenburg@asirllc.com.
[3] U.S. Fish and Wildlife Service, Albuquerque, New Mexico, scott_durst@fws.gov.
[4] U.S. Fish and Wildlife Service, Grand Junction, Colorado, Dale_Ryden@fws.gov.

The San Juan River Basin Recovery Implementation Program (SJRIP) recently held three workshops to define and review the current knowledge and information available regarding razorback sucker (*Xyrauchen texanus*) and Colorado pikeminnow (*Ptychocheilus lucius*), the two species the SJRIP is charged with recovering in the San Juan Basin. The goal of the workshops was to evaluate ongoing monitoring activities and develop a comprehensive monitoring plan for evaluating progress towards recovery of the two fish species. One of the major outcomes of the workshops was the identification of information gaps and the development of new research needs that could assist the SJRIP in recovering these two species. The workshops benefited from a diverse knowledge base including members of the SJRIP Biology Committee (BC), SJRIP standing Peer-Reviewers, invited peer-reviewers external from the SJRIP, and other interested parties (primarily researchers working on projects within the Basin). Through an iterative process, we created a document which organized the information and research needs developed from the workshops. This document was presented at a BC meeting and the BC members

revised and prioritized the information and research needs for the SJRIP. While there are many needs for information, and a long list of things that would be "nice to know," the group quickly realized that much of the information is available from past monitoring and research conducted within the San Juan River or from outside of the Basin. Additionally, many of the questions proved to be intractable (e.g., Can the San Juan River provide enough habitat to recover the two endangered fish?), or are currently being answered by ongoing management and monitoring activities (e.g., How can we increase the survival of stocked fish?). Two questions were identified that may be worthy of future work: Is water quality (i.e., selenium and mercury) a limiting factor for the endangered fish? And, what role does Lake Powell play in providing habitat for fish that move into the lake by passing over the waterfall that is now present in the lower river? However, not all BC members agreed that these two questions should be pursued. Discussion of these questions and other issues will occur in future meetings and the important questions will be integrated with the Long-Range Plan.

THE VIRGIN RIVER RESOURCE MANAGEMENT AND RECOVERY PROGRAM.

Steve Meismer, Virgin River Program, St. George, Utah, smmeismer@utah.gov.

The Virgin River Resource Management and Recovery Program (Virgin River Program) was established in 2002 to serve as a reasonable and prudent alternative for water withdrawals from the Virgin River. The Program has two goals 1) to implement actions to enhance, protect, conserve, and recover native species in the Virgin River basin and 2), to enhance the ability to provide adequate water supplies for sustaining human needs. The Program works with six native fish species (two federally listed) and one endangered bird species. Issues facing these species include negative interactions with nonnative species, water quality, and habitat alteration. Initial efforts of the Program have revolved around eradication of red shiner from the Virgin River, establishing and maintaining broodstock of the listed species at various hatcheries for production purposes, and addressing factors that limit populations. The Program has moved to develop more effective public outreach, not only to the local citizenry, but also to local cooperators in the municipalities. Recent capital projects include the establishment of a third mainstem fish barrier on the Virgin River, a pump project designed to trade water with local irrigators during the summer to maintain critical summer flows, and participation in a project to construct a new building for state biologists working with the Program. The Virgin River Program has been successful in eradicating red shiner from the Virgin River within Utah (previously occupied about 30 miles of river as well as extensive off-channel marshes, irrigation systems, and ponds). Presently we are working to further our red shiner eradication activities to extend an additional 12 miles into Arizona to our most downstream fish barrier.

Program partners include U.S. Fish and Wildlife Service, Utah Department of Natural Resources, Washington County Water Conservancy District, Bureau of Land Management, National Park Service, The Nature Conservancy, Washington County Farm Bureau, Dixie Conservation District, and U.S. Forest Service.

NEW PERSPECTIVES ON HYDROCLIMATIC VARIABILITY IN THE UPPER COLORADO RIVER BASIN.

Jeff Lukas, Western Water Assessment, University of Colorado, Lukas@colorado.edu.

Historically, the US Bureau of Reclamation and others have depended on gaged flow records for the as the hydrologic baseline for planning and management of the Upper Colorado River Basin. With over 100 years of data, Reclamation's natural flow records for Lees Ferry and other Upper Basin gages provide an apparently robust depiction of the long-term mean and the variability about that mean. But two types of data—one back-looking, the other forward-looking—call into question the adequacy of the gaged record as a baseline for planning for the 21st century. First, reconstructions of annual streamflow from tree rings now extend our perspective on Colorado River hydrology back over 1000 years. These paleohydrologic data depict a broader range of natural variability in the Upper Basin than that seen in the gaged records, including severe, sustained droughts and large fluctuations in the "long-term" (100-year) mean. Second, global climate models (GCMs) consistently project that significant warming will occur in the Colorado River Basin over the next several decades, with much less consensus about change in precipitation. Hydrologic modeling of these projected climate changes indicates overall declines in Colorado River flow of 5-20% by mid-century. New datasets of both types have become available in the last few years, and Reclamation and other entities are now incorporating them into planning scenarios and analyses of risk.

Session 2: Razorback sucker/Bonytail in Lower Basin and Acclimation

LOWER COLORADO RIVER MULTI-SPECIES CONSERVATION PROGRAM: OVERVIEW AND STATUS OF RAZORBACK SUCKER AND BONYTAIL IN LOWER COLORADO RIVER.

Tom Burke, U.S. Bureau of Reclamation, Lower Colorado Region, Boulder City, Nevada, TBurke@usbr.gov.

The LCR-MSCP is a coordinated, comprehensive, long-term multi-agency effort to conserve and recover 26 native species, and protect and maintain habitat on the lower Colorado River. The program extends from Lake Mead downstream to the southerly boundary with Mexico. The program is implementing conservation measures for four native fishes: razorback sucker, bonytail, flannelmouth sucker and humpback chub. Actions underway include fish rearing/stocking, species research, system-wide monitoring, and habitat development. This report provides an overview of the fishery work accomplished through the first five years, along with the current status of razorback sucker and bonytail in the lower Colorado River.

INDICATIONS OF CONTINUED LAKE MEAD RAZORBACK SUCKER RECRUITMENT AND MANAGEMENT PROGRESSION.

Brandon Albrecht, Paul Holden, and Ron Kegerries, BIO-WEST, Inc., Logan, Utah, balbrecht@bio-west.com, pholden@bio-west.com.

An ongoing razorback sucker (*Xyrauchen texanus*) research project on Lake Mead, Arizona and Nevada, has been funded by the Southern Nevada Water Authority and the U.S. Bureau of Reclamation for 13 years. This study continues to document the presence of actual, wild razorback sucker recruitment in the form of young, sexually immature individuals. Continued recruitment denotes that the Lake Mead razorback sucker population is an anomaly in terms of razorback sucker persistence throughout the Colorado River drainage, despite similar non-native fish composition and densities as other locations. Fin ray aging data and back-calculation techniques have indicated that recruitment of razorback sucker on Lake Mead has occurred nearly every year. Furthermore, data collected indicate that high lake elevations - those typically associated with maximum amounts of inundated terrestrial vegetation- appear to be responsible for pulses in recruitment. However, beginning with the 2007 spawning period, we captured large numbers of juvenile/subadult and adult razorback suckers that, based on back-calculation techniques, were spawned under low and declining lake elevations. In fact, the largest number of recruits observed to date coincides with 2005, a low-water year, which alone produced 29 recruits thus far. We believe that cover - both vegetative and in the form of turbidity - provides protection and food resources for larval and juvenile razorback sucker, thereby enabling them to avoid predation by nonnative sportfish present in the system. As monitoring efforts continue, we expect to capture individuals spawned during 2007, 2008, 2009, and beyond. Continued monitoring efforts on Lake Mead should help ascertain if recruitment events continue, and to help understand more fully how to enable this unique trend in other locations.

This year a Lake Mead Razorback Sucker Work Group consisting of various state and federal agencies was formalized. In addition, a management plan was developed to present goals, tools, and infrastructure currently available for the conservation of Lake Mead razorback sucker. It is our hope that this management plan will facilitate adaptive management, help in further understanding this unique population, and benefit other researchers focused on razorback sucker recovery efforts.

STATUS OF RAZORBACK SUCKERS STOCKED INTO THE LOWER COLORADO RIVER BETWEEN DAVIS AND PARKER DAMS

Jeff Lantow[1], Rick Wydowski[2], Don Portz[2], and Eric Best[2]

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Since 1995, over 50,000 large razorback suckers have been stocked into Lake Havasu as part of two separate programs. The Lake Havasu Fishery Improvement Project stocked over 30,000 fish from 1997–2001, and the Lower Colorado River Multi-Species Conservation Program has

stocked more than 20,000 fish since 2006. The initial stockings resulted in the reestablishment of a riverine population of suckers which have consolidated their spawning efforts upstream of Needles, CA. Over the past decade there have been numerous studies and surveys designed to monitor this population. Telemetry surveys have shown that individuals are highly mobile (>30 miles), but also exhibit seasonal site fidelity. Current population estimates are in excess of 1,200 individuals with ages ranging from 3–22 years.

ACCLIMATION OF RAZORBACK SUCKERS, *XYRAUCHEN TEXANUS*, IN A MANIPULATED FLOOD PLAIN WETLAND ON THE MIDDLE GREEN RIVER, UTAH.

Aaron Webber, U.S. Fish and Wildlife Service, Vernal, Utah, aaron_webber@fws.gov.

The razorback sucker, *Xyrauchen texanus*, is an endangered fish endemic to the Colorado River Basin. As part of recovery efforts, razorbacks were placed in hatcheries to be produced and stocked into the rivers. These hatchery fish may lack the behavioral skills necessary to survive well in the wild. We thought that if we stocked larval razorbacks into the natural environment where they would grow up in the wild, these fish would acquire the skills necessary to survive in the wild and survive better than the razorbacks produced in hatcheries. We chose Baeser Bend (a 38 acre wetland on the middle Green River, UT) as a wetland we could manipulate to use as an acclimation site for razorback suckers. Baeser was reset during the winter of 2007-2008 to eliminate any other fish species and then was refilled using a pump. In May 2008, 43,400 larval razorbacks from the Ouray National Fish Hatchery were stocked into the wetland. In April 2009, an estimated 3,784 survived (9%). In October 2008, 24,000 more razorbacks that were raised in an earthen pond at the hatchery and averaged 93 mm were stocked in Baeser. In April 2009, we estimated that cohort at 9,395. In June 2009, an additional 110,000 larval razorbacks were stocked. From April-October 2009, 1,026 razorbacks were tagged from Baeser and released into the Green River at an average length of 302mm. We report 92% mortality from April-October and suspect that the majority is due to avian predation. We plan on continuing to use Baeser Bend as an acclimation site, and ultimately we plan to deploy pit tag readers on a known razorback spawning bar near Baeser Bend to determine if the razorbacks from Baeser Bend will contribute to the spawning razorback population.

Session 3: Three Species of Concern and Backwater Habitat

HABITAT OVERLAP AMONG ROUNDTAIL CHUB AND TWO POTENTIAL PREDATORS IN GLACIAL LAKES OF THE UPPER GREEN RIVER BASIN.

Sarah Laske, Frank Rahel, and Wayne Hubert, University of Wyoming, Laramie, slaske@uwyo.edu.

The roundtail chub *Gila robusta*, an endemic species of conservation concern in the Colorado River system, co-occurs with introduced piscivores, brown trout *Salmo trutta* and lake trout *Salvelinus namaycush*, in several glacial lakes in the Upper Green River basin. We examined habitat overlap among these species and determined if predation on roundtail chub was taking

place. Similarities in habitat use varied with water temperature. There was overlap in habitat use among all three species before summer thermal stratification, when lake temperatures were cool (< 10°C). Brown trout and roundtail chub used warm (18°C) shallow habitats after stratification, whereas lake trout retreated to deep, cold-water habitat. Analysis of over 300 trout stomachs indicated that the rate of piscivory is higher in brown trout than lake trout. Further work with isotope analysis will shed light on the diets of both trout species, including diet shifts to piscivory and potential common food items.

THE WHITE RIVER, UTAH: A REFUGE FOR NATIVE FISHES?

Matthew J. Breen[1], and Justin Jimenez[2]

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[2] Bureau of Land Management, Salt Lake City, Utah, Justin_Jimenez@blm.gov.

Bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and roundtail chub (*Gila robusta*), collectively referred to as the "three species", are listed as Tier I Sensitive Species in Utah due to drastic reductions in their historical range. Recent investigations indicate that the White River, Utah is an important system for all three species. However, potential mechanisms contributing to their success are unclear. In spring, summer, and fall of 2009, we sampled the White River (river miles 66.5–24) by cataraft electrofishing and seining to evaluate three species seasonal population dynamics and movements, fish community composition, and natural reproduction by native fishes. Electrofishing resulted in a total of 356 blueheads (8.98 fish/hr), 701 flannelmouth (16.71 fish/hr), and 69 roundtails (1.68 fish/hr). Native fishes comprised 54.7% of the total catch from eight randomly selected miles, with channel catfish (*Ictalurus punctatus*) as the most abundant nonnative species (37.9%). Fall seining produced a total of 13,761 fish consisting of 73 blueheads (2.65 fish/100 m^2), 99 flannelmouth (3.60 fish/100 m^2), 101 roundtails (3.67 fish/100 m^2) and one Colorado pikeminnow (*Ptychocheilus lucius*), which documents natural reproduction for this species in the White River. The small-bodied fish community was dominated by nonnatives (95.3%), but higher catch rates existed for native young-of-year than other systems (e.g., middle Green River). During spring sampling, 59% of three species were reproductively mature (41% with reproductive signatures), representing a large spawning population. There was not a significant difference in the size of blueheads (U=5264; P=0.065), flannelmouth (U=54765; P=0.933), or roundtails (U=142; P=0.139) between seasons and movement was not related to size for blueheads (r_P=-0.586; P=0.414; N=4) or flannelmouth (r_P=0.586; P=0.058; N=11), possibly suggesting that year-round residency rather than large-scale spawning migrations maintain these populations. Additionally, flannelmouth moved 18.36 ± 5.91 km between recaptures with no significant difference (t_9=-1.969; P=0.0580) in movement distance between (24.64 ± 6.92 km; N=8) and within years (1.61 ± 0.81 km; N=3), thus providing further evidence that this species maintains relatively sedentary home ranges in the White River. Potential explanations for successful recruitment by three species include a relatively natural hydrograph and low densities of nonnative piscivores such as smallmouth bass (*Micropterus salmoides*), which present only a minor threat (CPUE=1.11 fish/hr). Both factors have presented difficulties for natives in other drainages of the upper Colorado River Basin. Although the White River appears to be valuable

in providing essential three species spawning and nursery habitat, development-induced habitat modification (i.e., natural resource extraction) threatens the system. Continued monitoring of this population is essential to ensure protection of these species and their associated habitat.

VARIATION IN BACKWATER PHYSICAL HABITAT CHARACTERISTICS IN THE MIDDLE GREEN RIVER FROM 2003 THROUGH 2009.

John Hayse, Kirk LaGory, Lee Walston, and Cory Weber, Argonne National Laboratory, Argonne, Illinois, hayse@anl.gov, lagory@anl.gov, lwalston@900.dis.anl.gov, cweber@anl.gov.

To protect backwater habitats used by Colorado pikeminnow (*Ptychocheilus lucius*) juveniles, flow recommendations for the Green River call for limiting within-day stage changes to 0.1 m or less at the USGS gage on the Green River near Jensen, Utah during the baseflow period. We have been collecting detailed topographic information for sandbars and associated backwaters in the Ouray reach of the Green River annually since 2003 and have modeled changes in the area, depth, and volume of backwaters during the annual base flow seasons. The data suggest that sandbar and backwater topography is quite variable from year-to-year and that the relationship between flows and backwater habitat characteristics is complex. Within the overall Ouray reach, backwater habitat was available each year over a wide range of base flows encompassing the range of base flows (900 to 3,000 cfs) included in the Green River flow recommendations. Comparison of results across the study period indicates that mean backwater volume and area in 2009 were greater than during most previously sampled years. Although the overall mean backwater area for sampled backwaters was comparable in 2006 to the values for 2009, the day-to-day average area was much more variable in 2006, even though day to day variability in flows was similar between the 2 years. The differences in habitat variability result from differences in backwater topography, and the resulting relationships between flow and habitat characteristics. Annual differences in backwater topography have potentially significant implications for the availability of nursery habitat and survival for age-0 Colorado pikeminnow.

STATUS OF THE REINTRODUCED FLANNELMOUTH SUCKER IN THE LOWER COLORADO RIVER BETWEEN DAVIS AND PARKER DAMS.

Eric Best, Bureau of Reclamation, Denver, Colorado, EBest@usbr.gov.

Flannelmouth suckers were not historically common in the lower Colorado River below Davis Dam (Minckley 1973). This native fish was believed extirpated from the lower river by 1975. In 1976, Arizona Game and Fish Department captured 611 flannelmouth suckers at the confluence of the Colorado and Paria Rivers at Lee's Ferry, Arizona. These fish were transferred to the Colorado River below Davis Dam which led to their successful reintroduction. This population has persisted and grown over the last thirty years, and is now holding at over 2000 individuals. Flannelmouth suckers ranging in age from young of the year to 27 years of age have been contacted regularly in a reach of river which has been dramatically altered by water development.

Session 4: Propagation and Fish Health

EVALUATING THE RELATIVE COST-BENEFIT OF STOCKING AGE-0 VERSUS AGE-1+ COLORADO PIKEMINNOW IN THE SAN JUAN RIVER.

Scott L. Durst, U.S. Fish and Wildlife Service, Albuquerque, New Mexico, scott_durst@fws.gov.

In an effort to recover populations of the endangered Colorado pikeminnow (*Ptychocheilus lucius*) in the San Juan River, the San Juan River Basin Recovery Implementation Program (Program) has been stocking two different age classes under a formal augmentation plan since 2006. The Program's goal is to annually stock 300,000 and 3,000 age-0 and age-1+ Colorado pikeminnow, respectively. During monitoring and management activities, Colorado pikeminnow stocked in the two age classes are recaptured in the San Juan River allowing for the calculation of return rates. I used these return rates to conduct a cost-benefit analysis of stocking Colorado pikeminnow in these two size classes. Age-1+ Colorado pikeminnow are over 30-times more expensive to propagate, rear, transport, and stock compared to age-0 pikeminnow. However, although age-1+ Colorado pikeminnow have higher relative return rates, 15-times more age-0 pikeminnow are recaptured in the San Juan River at least one-year post-stocking. This analysis appears to suggest that stocking age-0 Colorado pikeminnow is a more cost effective way to reestablish populations of this endangered species in the San Juan River.

GENETIC EVALUATION OF RAZORBACK SUCKER BROODSTOCKS AT DEXTER NATIONAL FISH HATCHERY AND TECHNOLOGY CENTER.

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The razorback sucker, *Xyrauchen texanus*, is an endangered endemic fish from the Colorado River system. Wild populations are in rapid decline, with an estimated 420 wild adults remaining in Lake Mohave. Dexter maintains three stocks of razorback sucker that originated from Lake Mohave. Dexters' captive stocks provide an essential link to the original wild fish from the Lake Mohave area, and may be needed for future recovery efforts to provide fish for augmentation in Lake Mohave. Our goal was to document the genetic diversity of Dexter's broodstocks so future management of broodfish and production fish can provide a genetically appropriate product for restoration activities. The captive stocks held at Dexter were assessed for genetic diversity at 17 microsatellite loci and compared to wild individuals taken from Lake Mohave. Overall observed heterozygosity (HO) was high and ranged from 0.85 to 0.90. Likewise, allelic richness was high for most of the loci and ranged from 5.5 to 22.5 alleles per locus. In addition, pairwise FST was low and ranged from 0.0008 to 0.0190.

The Role of Nutrition in Fish Conservation.

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The importance of nutrition in fish conservation has most often been evaluated in captive propagation programs by determining if management requests are fulfilled and by considering the cost of fish produced. Assessing the potential for successful recruitment of hatchery-raised fish into wild populations requires an evaluation of quality, not just quantity, of fish released. An undernourished animal cannot maintain its health and be productive, regardless of the quality of its environment. Gross nutritional inadequacy obviously impairs fish productivity and results in deterioration of health to the extent that recognisable disease ensues. However, the lines between reduced growth or diminished health and overt disease are often difficult to distinguish, and released fish of lower quality may be predisposed to the effects of various stocking-associated stressors thus reducing their adaptation potential. Historically, fish nutrition research for conservation species has been reactive and focused on preventing gross nutritional inadequacies that occurred when commercially available diets designed for food-fish species were fed. Nutritional problem-solving studies such as these were necessitated by the lack of knowledge regarding the nutritional needs of lesser studied threatened or endangered fishes. These studies have provided the scientific basis for additional research that focuses on refinement of formulations to meet specific recovery goals. Diet formulations developed at the Bozeman Fish Technology Center serve as examples of where nutrition research has already, or has the potential to, benefit recovery efforts for several species. Results from previous studies with threatened or endangered fish species that have benefited from nutrition research, as well as potential future collaborations, will be presented. The range of responses observed for the various fish species of concern in these studies when coupled with their highly divergent life histories, indicate the need for species-optimized diet formulations. Further, these data demonstrate the importance of species-specific formulations to provide a sound nutritional foundation that enhances conservation programs by optimizing animal health and thus quality.

DEVELOPMENT AND OPTIMIZATION OF SPAWNING AND INTENSIVE CULTURE TECHNIQUES FOR WOUNDFIN.

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The endangered woundfin *Plagopterus argentissimus* has been reared in captivity since the mid–late 1980s, initially as a means to retain natural genetic diversity and maintain a refuge population. Since the early 2000s, production numbers of woundfin have been requested for restocking into the Virgin River, Utah, and those numbers are likely to increase substantially in the future. That anticipated increase in production demand may be met through expanded extensive culture, intensive culture, or a combination of these techniques. This project was

started in fall 2008 at the Bozeman Fish Technology Center for the purpose of establishing intensive culture techniques for woundfin that can be applied at production facilities (e.g., Dexter National Fish Hatchery and Technology Center). To date, intensive culture of woundfin has been accomplished on a research scale, the species' reproductive cycle (from onset of oogenesis and spermatogenesis through spawning) has been described, development of tools to determine sexual dimorphism and assess spawning readiness continues, and trials are underway to determine optimal diets for larvae and juveniles. Objectives for future planned studies include: (1) refine intensive culture conditions to maximize spawning success and condense the spawning season, (2) determine optimal rearing densities and tank design, (3) determine thermal optima for embryos and larvae, and (4) develop brood stock diet formulations to increase fecundity and larval survival and performance. The overall goal of this project is to establish intensive culture techniques that will enable or facilitate the hatchery production of up to 100–200 thousand woundfin annually to meet the restocking requirements determined by the Virgin River Resource Management and Recovery Program.

FIELD ASSESSMENT OF MERCURY EXPOSURE TO ENDANGERED COLORADO PIKEMINNOW WITHIN CRITICAL HABITAT.

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Fish sampling surveys in the last 20 years have demonstrated widespread mercury contamination; especially in the freshwater systems of the northern hemisphere. Human activity, particularly coal-fired power plants and gold-mining, release large amounts of mercury into the atmosphere. In 1994, critical habitat was designated in the states including Colorado, Utah, and New Mexico for four endangered Colorado River fish. Of concern is the proximity of 12 coal-fired power-plants to critical habitat. Also contributing to mercury emissions are Nevada goldmines. Mercury residing in the gold ore is released into the air when the ore is heated to extract the gold, and transported to downwind sites including Utah and southern Idaho. Of the four Colorado endangered fish species, the Colorado pikeminnow (*Ptychocheilus lucius*) is of most concern when considering potential mercury exposure. Colorado pikeminnow (CPM) are long-lived piscivorous species, and voracious predators at the top of the food chain. Though extirpated from the Lower Basin, native populations of Colorado pikeminnow are now restricted to the Upper Basin in Colorado, Utah, and New Mexico. Critical habitat is designated in portions of the Colorado, Green, Yampa, White, and San Juan rivers. Long-term dietary exposure to methyl mercury can cause incoordination, inability to feed, and diminished responsiveness in fish, affecting growth, behavior, reproduction, and survival. Mercury has also been associated with endocrine disruption in fish, causing suppressed hormone levels and inhibited gonadal development.

Muscle biopsies provide a non-lethal method to accurately determine mercury residues in endangered fish. Mercury concentrations in Colorado pikeminnow were determined for all listed segments of critical habitat in the Yampa, White, Green, Colorado, Gunnison, and San Juan

rivers. Mercury concentrations in Colorado pikeminnow are compared to toxicity thresholds, compared between river reaches, and compared to locations of coal-fired power plants. Muscle plugs will also be taken from archived Colorado pikeminnow collected before the advent of coal-fired power generation for comparison to current mercury muscle residues. Mercury tissue residues in Colorado pikeminnow will be compared to their population survey data to determine if there is a correlation.

Session 5: Population Dynamics

CLOSED POPULATION ESTIMATES OF HUMPBACK CHUB (*GILA CYPHA*) IN THE LITTLE COLORADO RIVER, GRAND CANYON, ARIZONA.

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Since 2000, a series of two-pass, closed mark-recapture efforts have been conducted in the spring and in the fall in the Little Colorado River (LCR) to track the abundance of humpback chub (HBC). Preliminary results indicate that during spring 2009 the estimated abundance of HBC ≥ 100 mm in the lower 13.57 km of the LCR was 12,007 (SE = 947). Of these fish, it was estimated that 7,679 (SE = 636) were ≥ 150 mm, and that 5,480 (SE = 537) were ≥ 200 mm. These numbers provide continued supporting evidence of an increasing trend in the abundance of the spring LCR adult spawning population. During fall 2009, the estimated abundance of HBC ≥ 100 mm in the lower 13.57 km of the LCR was 5,470 (SE = 581). Of these fish, it was estimated that 3,982 (SE = 480) were ≥ 150 mm, and that 1,572 (182) were ≥ 200 mm. These numbers may suggest a stabilizing trend in the fall population of HBC in the LCR, perhaps related to over-winter carrying capacities. In addition, preliminary results at estimating abundances and over-winter survival of age-0 HBC in the LCR are shown.

Between 2003 and 2008, 1,449 HBC (50-136 mm TL) were translocated from the lower reaches of the LCR to above a travertine structure known as Chute Falls. Since 2006, mark-recapture efforts have been conducted in the reaches of the LCR above 13.57 km, largely in order to track the fate of the translocated HBC. During June 2009, it was estimated that there were 500 (SE = 28) HBC ≥ 200 mm residing above 13.57 km in the LCR. Results suggest that 1 year survivorship of fish from the 2008 translocation was high (>70%), but that most of the translocated fish eventually disperse downriver in the LCR with very limited natural recruitment coming from above Chute Falls.

Population status of Colorado pikeminnow in the Green River Basin, Utah and Colorado, 2000–2003 and 2006–2008.

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Multiple-pass, capture-recapture sampling was conducted in most (819 river km, about 88% of basin) warm water reaches of the Green River Basin, Utah and Colorado, to estimate demographic parameters for juvenile (< 400 mm TL), recruit (400 to 449 mm TL), and adult (≥ 450 mm TL) Colorado pikeminnow *Ptychocheilus lucius*. Parameter estimates derived from a Huggins robust-design multi-state model suggested about a 50% increase in abundance of adult Colorado pikeminnow throughout the Green River Basin, Colorado and Utah, over the study period, and about a 70% increase over 2003 estimates. Based on the trend in annual point estimates from 2006 to 2008, abundance increases were highest in Desolation-Gray Canyon, the middle Green River, and the White River, reaches which supported the most adult Colorado pikeminnow in the 2000 to 2003 period. Abundance of adult Colorado pikeminnow was stable and low in the Yampa River during the 2006 to 2008 period, but populations showed continued decline since 2003. Abundance of adult Colorado pikeminnow in the lower Green River declined over the study period, but abundance levels were higher than in the 2000 to 2003 period. Basinwide, adult Colorado pikeminnow abundance increased each year of the study, from 2,454 fish (95% CI = 2,190 to 3,185) in 2006, 2,718 (95% CI = 2,055 to 3,656) in 2007, and 3,672 (95% CI = 2,397 to 5,715) in 2008. Higher survival rates, and increased recruitment in 2006 to 2008, compared to the 2000 to 2003 period, were the main factors responsible for increased abundance of adult Colorado pikeminnow in the Green River sub-basin. Most of the recruits were apparently produced in 2000 in the lower Green River when a large year-class of age-0 Colorado pikeminnow was produced by abundant adults, a recruitment scenario which matches with growth expectations over time. Increased survival of Colorado pikeminnow may be related to increased flows in the 2006 to 2008 period relative to the 2000 to 2003 period. Increased survival may also be due to ongoing non-native fish removal programs, although Colorado pikeminnow abundance did not increase in the Yampa River where intensive non-native fish removal was occurring. Increased sampling effort is needed during the next abundance estimation sampling period in some areas to increase precision of estimates. Procedures to increase capture probabilities of Colorado pikeminnow in reaches where abundance estimates were relatively imprecise, such as increasing effort or adding alternative gears, should also be investigated.

SURVIVAL RATE ESTIMATION OF HATCHERY-REARED RAZORBACK SUCKERS *XYRAUCHEN TEXANUS* IN THE UPPER COLORADO RIVER BASIN, UTAH AND COLORADO, SINCE IMPLEMENTATION OF THE INTEGRATED STOCKING PLAN IN 2003.

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An integrated stocking plan for endangered razorback sucker *Xyrauchen texanus* was implemented in 2003 to assist development of two "genetically and demographically viable, self-sustaining" adult populations in the Upper Colorado River Basin, as required by Recovery Goals for the species. To evaluate success of the 2003 stocking plan, we 1), refined a previous survival analysis (1995-2005 data) using recapture records of razorback suckers stocked from 2004–2007 and 2), evaluated different hatchery rearing methods. A total of 96,448 individually PIT-tagged razorback suckers (mean total length [TL] = 302 mm) were stocked into the Colorado, Gunnison, and Green rivers from 2004–2007 and 1,511 recapture events (of 1,470 unique individuals) occurred from 2005–2008. Recapture frequencies ranged from 0–3. Effects analyzed included rearing method, year, first year in the river, river reach and season of stocking, and individual fish TL at time of stocking. Razorback suckers were grouped based on three rearing methods: raised in hatchery tank only (20.2%), moved from tanks to ponds prior to stocking (33.4%), or an intensive practice of alternating tanks and ponds (46.4%). Number of fish stocked per year was similar, but most fish were stocked during autumn (57.1%) and summer (37.1%). More fish were stocked in the Green River (61.4%) than the Colorado (32.9%) and Gunnison (5.7%) rivers. A set of a priori models was created based on razorback sucker biology, available data, and previous analyses. Program MARK was used to design models and analyze data. Akaike's Information Criterion was used to choose best model structure(s) for the data, from which maximum likelihood estimates of apparent survival and measures of precision were obtained. Imbalance or absence of data for many combinations of the above variables, as well as confounding among several, was evident. For example, nearly all (94%) tank-reared fish were stocked during summer, which potentially confounded interpretation of results because a previous analysis showed poor survival of razorback suckers stocked in that season. The majority of fish raised by other culture methods were stocked during autumn when survival was typically higher. Further, rearing methods were mostly river-specific with overlap only in one reach, which limited inferences regarding best culture techniques. Results will enhance current propagation and stocking protocols to increase efficiency of recovery efforts for razorback sucker.

Session 6: Nonnative Fish Management and Evaluation

INNOVATIVE TECHNOLOGIES FOR THE ERADICATION OF INVASIVE FISH FROM THE WESTERN UNITED STATES.

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Many native fisheries in the western United States are impacted by introduced or invasive fish. Millions of dollars have been spent on suppression programs, as in many locations throughout the United States Mountain West; these fish have significantly altered both the aquatic and terrestrial ecosystem. To date no current fisheries management strategy such as gill netting, poison application or physical barriers have yielded successful outcomes at eliminating these invasive predators from these or other large lakes. Current methodologies are costly and have significant environmental implications. Unintended consequences include mortality in non-target organisms from by-catch or piscicides, further alterations in food web dynamics, and the impediment of genetic material and nutrient movement in a watershed. Additionally while eradication strategies tend to target adult organisms few methods address other life history stages such as recruitment from the embryo and larval stages of fish. Since studies have shown the introduction of just a few founder fish can establish or rebound a population, new conservation technologies must be employed to address recruitment of new individuals into a population. This presentation will discuss new innovative technologies that offer promise to inhibit recruitment of invasive fish.

COMPARISON OF CAPTURE RATES OF SMALLMOUTH BASS *MICROPTERUS DOLOMIEU* IN THE YAMPA RIVER, COLORADO, IN 2009 USING SMITH ROOT GPP5.0 AND VVP15B ELECTROFISHERS.

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Variation in fish capture efficiencies with electrofishing units that produce different wave forms and power outputs are poorly understood. To evaluate this issue, we compared catch rates of adult (> 200 mm total length [TL]), sub-adult (100 to 199 mm TL), and juvenile (<100 mm TL) smallmouth bass *Micropterus dolomieu* captured in spring 2009 from the Yampa River, Colorado, using two Smith-Root electrofishers, the GPP5.0 and the VVP15B. Capture rates of smallmouth bass varied substantially over the season and overall patterns were similar among electrofisher types. Differences in capture rates over the season may have been affected by several correlated factors including water temperature, conductivity, turbidity, and discharge magnitude. Over the course of the season, 0.6 and 1.6 more adult bass per hour were captured with the VVP15B at Little Yampa Canyon and Lily Park, respectively, than with the GPP5.0. Greater efficiency of the VVP15B and difference in operator technique resulted in removal of 37% more adult bass (n=167, 16% of the pre-removal adult abundance estimate) over the entire season in Little Yampa Canyon. Similarly, 43% more adult bass (n=112, 14% of the pre-

removal adult abundance estimate) were removed with the VVP15B over the entire season in Lily Park. The GPP5.0 had higher catch rates for sub-adult and juvenile bass (12% and 4% more) in Little Yampa Canyon and the VVP15B had higher catch rates (11% and 21% more) in Lily Park. Observations by boat operators and netters suggested that the VVP15B consistently produced better taxis than the GPP5.0 which likely contributed to higher catch rates. These findings have implications for design of optimal electrofishing removal strategies for smallmouth bass in the Yampa River.

SMALLMOUTH BASS POPULATION DYNAMICS AND CONTROL IN THE UPPER COLORADO RIVER BASIN.

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Since 2003, researchers from the Upper Colorado River Basin Recovery Program have monitored the density and distribution of smallmouth bass populations in the Green, Colorado, and Yampa River drainages in an attempt to control this invasive, nonnative species. Removal programs have since expanded throughout multiple river reaches as the extent of this bass expansion was determined. To date, crews are estimating bass abundance and removing smallmouth bass from approximately 315 miles of river in the Green, Yampa, and Colorado Rivers. The various studies have shown a general decrease in smallmouth bass between 2004 and 2009. With the completion of the 2009 field season, researchers at the Nonnative Fish Workshop noted the prevalence and growth of a large cohort of fish produced during the dry, warm summer of 2007. Data through 2009 will be presented showing the relationship between environmental conditions and bass reproduction, bass densities throughout the upper basin, the level of exploitation achieved during removal, and how this information is guiding ongoing removal efforts in 2010.

RESPONSE OF THE NATIVE FISH COMMUNITY OF THE YAMPA AND GREEN RIVERS TO REMOVAL OF NON-NATIVE PISCIVORES, 2003–2009.

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Mechanical removal of several non-native fish predators has been implemented in several rivers of the Upper Colorado River Basin in an effort to restore once-abundant native fishes. From 2003-2009, we sampled small-bodied fishes in low-velocity habitat in treatment (piscivorous fish removal) and control (no removal) reaches with a variety of gears to assess whether predator removal benefited the native fish community in the Yampa River, Colorado. Through 2007, main channel fish communities were dominated by non-natives, 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 uncommon, higher frequencies of native fishes in main stem samples since 2005, were coincident with increased removal of YOY smallmouth bass, particularly in the treatment reach.

Native fish abundance in main channel samples in the control and treatment reach was particularly high in 2008 and 2009, when flows were relatively high and cool later in summer. Positive native fish response was likely due to synergistic effects of bass removal and return to a higher, more normal hydrologic regime, which delayed spawning, and reduced growth and perhaps abundance, of smallmouth bass in the Yampa River, Colorado.

NORTHERN PIKE CONTROL AND EVALUATION IN THE MIDDLE YAMPA RIVER AND GREEN RIVER: 2004–2009.

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Non-native northern pike in the Yampa and Green Rivers pose a threat to the recovery of the endangered fishes of the Upper Colorado River basin by directly preying on native fishes. In 2003, the Recovery Program initiated several projects with the objectives of reducing northern pike numbers via electrofishing and fyke netting in the Middle Yampa and Green Rivers, and evaluating these efforts with annual mark-recapture abundance estimation. In 2009, following six years of removal and evaluation, northern pike abundance in the middle Yampa River has decreased little, despite exploitation rates as high as 70% of the population point estimate removed per year. However, CPUE (# of fish/hour of electrofishing) for northern pike in a small section of the lower portion of the middle Yampa River, below Cross Mountain, has shown a continued marked decline and is one quarter of what it was in 2004. The size structure of the overall population has been altered and is comprised of smaller fish. In 2009, relative abundance of young of year and age 1 pike increased from the previous year. The CDOW is currently engaged in using habitat manipulation and mechanical pike removal to control northern pike in source populations of the upper Yampa Basin. A total of 2,422 northern pike were removed from upper basin source populations in 2009. Major recommendations generated during the 2009 Nonnative Fish Workshop were: (1) better coordinate marking passes between studies, (2) increase sampling in the upper reaches in late June and early July to detect presence of YOY, and (3) thoroughly evaluate escapement of translocated northern pike from Loudy Simpson and consider cessation of such practice.

STRONTIUM ISOTOPE RATIOS (^{87}Sr:^{86}Sr) AS TRACERS OF ORIGINS AND MOVEMENTS OF NONNATIVE PISCIVORES IN THE UPPER COLORADO RIVER BASIN.

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Nonnative fishes entering critical habitat in the Upper Colorado River Basin continues to be a major impediment to recovery of endangered fishes but determining their origins has been problematic. Strontium isotope ratios ($^{87}Sr/^{86}Sr$) are showing great promise as a natural tracer for studying fish origins and movements. We are continuing to refine our methods for analyzing ^{87}Sr:^{86}Sr using laser ablation mass spectrometry. We are now ablating material from within multiple annuli instead of the transect method we used initially. The new method provides more precise isotopic signatures for a given portion of a fish's life than laser transects, which provided less certain information about when changes in environmental chemistry occurred. Our work continues to corroborate early findings that suggested ^{87}Sr:^{86}Sr is very consistent among species in a given reservoir, temporally stable throughout many years, and is nearly unique across all reservoirs examined. Additionally, differences in river and reservoir signatures appear to allow us to track origins of fish that have escaped from reservoirs into critical habitat. We have validated our ability to detect fish movements between reservoirs and rivers by comparing isotope data with known fish movement provided by tagging data. The implications from this research suggest that ^{87}Sr:^{86}Sr can be used to determine source locations of escapement into critical habitat with the precision of within a year's time. Thus, we are confident that more intensive sampling regimes could provide important insights into processes that increase escapement risk into critical habitat such as dam operations, weather conditions, fish behavior, and fish physiology.

NATIVE FISH RESPONSE TO NONNATIVE FISH, 1986–2009.

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Smallmouth bass (*Micropterus dolomieu*) catch rates have increased in the middle Green River (RM 319.4-215.0) from 0.098 fish/hr in 1986 to 4.918 fish/hr in 2009. However, catch rates have even been higher for certain years or certain projects within that time period. In addition, catch rates of young-of-year (YOY) native fish have fluctuated drastically, but overall declined from 18.17 fish/100 m^2 in 1986 to 0.788 fish/100 m^2 in 2008 before coming back up in 2009 to 7.95 fish/100 m^2. Exact reasons for this decline are unknown; however, large-bodied, nonnative piscivorous fish, such as smallmouth bass, are suspected. Given the concern over the rising number of nonnatives and their potential effect on the YOY fall community, the Utah Division of Wildlife Resources moved from adult community sampling in the 1990's to intensive nonnative fish removal in the 2000's. This intensive removal began in 2001 with northern pike removal, increased during the 2004-2006 period with smallmouth bass removal, and increased again in the

2007-2009 period to significantly increase exploitation rates for the species. One measure of success in this effort would be stabilizing and decreasing catch rates for smallmouth bass. Another measure of success would be a positive response in the native fish, which is expected to occur more quickly in the YOY community. To this end, we continued fall YOY sampling, but added the collection of more information in a study called Native Fish Response (which added one additional backwater to each five-mile subreach sampled during YOY fall seining), to better be able to detect a response. This study began in 2005 and since then, catch rates for YOY native fish have remained low (0.306-1.12 fish/100 m^2), with the exception of 2009 (7.95 fish/100 m^2). Graphic associations between smallmouth bass catch rates and native fish YOY catch rates reveal there may be a correlation between the two variables; however, it also appears that YOY catch rates are correlated with total electrofishing effort, which has increased dramatically from 21 hours in 1986 to over 500 hours in 2009. Crews discontinued electrofishing backwaters in August 2009 due to the confirmation of YOY pikeminnow; however, in most years, backwaters have been electrofished during all boat electrofishing projects due to the potential for nonnatives to "hide" in these types of habitats. Based on these potential correlations, backwaters within the middle Green River will no longer be electrofished once larval native fish are observed in the drift.

Session 7: New Approaches to Nonnative Fish Management

MATRIX PROJECTIONS OF CHANNEL CATFISH (*ICTALURUS PUNCTATUS*) POPULATION DYNAMICS IN THE SAN JUAN RIVER, UTAH – NEW MEXICO.

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Non-native fish removals have been implemented in the San Juan River for over a decade in effort to reduce competition and predation of native fish populations. Efforts have proven to reduce the overall number of non-native fish significantly, though an appreciable, positive native fish response has yet to be seen. Our goal is to examine population dynamics of the channel catfish (*Ictalurus punctatus*), thought to be the most detrimental of non-native species toward native fish, addressing three primary questions: (1) What impact does the current level of harvest have on catfish abundance? (2) What is the long term relationship of catfish size and production to harvest rate? and (3) How do vital rates vary over a temporal scale? Using various statistical methods on previous catch data and empirical data collected in the field, we estimated age specific *I. punctatus* vital rates (survival and fecundity) and developed a matrix population model to address these questions. This model accommodates environmental stochasticity, as well as the ability to manipulate exploitation rates of the population, a useful tool in understanding control measures and population fluctuations as a result in harvest of the species. Because of the robust temporal nature of the catch data (> 7 years), we believe these matrix projections will be an accurate and effective means for evaluating temporal changes in the channel catfish population and serve as a management tool for future consideration.

WORKING TOWARDS A UNIFIED DATABASE AND META-ANALYSIS OF THE UCREFRP'S SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU*) DATASET: PROGRESS IN DATA MANAGEMENT, SOFTWARE AND PRELIMINARY ANALYSES.

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Integration of the UCREFRP's smallmouth bass (*Micropterus dolomieu*) dataset into a relational Microsoft Access database has been underway for two months with the initial goals of data normalization, assessment and error checking. A graphical interface is in the development phase including features that allow users to efficiently view the data and their relational structure (river>reach>gear>sample>fish). Users can also extract encounter histories for analysis in program MARK and derive summary statistics including numbers of target species captured, marked, recaptured and removed (CMRR). Size classes can be modified at any time and the CMRR counts recalculated. Although CMRR counts and other derived data were developed principally for data assessment and error checking, these and other software features could significantly reduce how much time is required to prepare Recovery Program Annual Reports. In this presentation, the initial versions of these and other features of the database software will be reviewed. To demonstrate the utility of these features, I will also extract an encounter history dataset from the database using a tool incorporated into the graphical interface and use it to produce an abundance estimate within program MARK.

SMALLMOUTH BASS OTOLITH MICROSTRUCTURE ANALYSES AND IMPLICATIONS FOR GREEN RIVER BASIN FISH AND FLOW MANAGEMENT.

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Otolith microstructure analysis, particularly daily age estimation, has been a useful tool in fish ecology and management. Here we present results of otolith microstructure analyses and daily age estimation conducted on smallmouth bass *Micropterus dolomieu* collected in the Green and Yampa rivers, Colorado, from 2003-2008. Analyses showed that smallmouth bass spawning was usually initiated in June, but timing and peak spawning were strongly dependent on water temperature and streamflow, with bass spawning later in cooler and higher flows years such as 2005 and 2008 and earlier in warmer and lower flow years such as 2007. In most years, smallmouth bass spawning occurred over about a 4-week period. Small temperature differences substantially influenced the relatively fast growth rates of smallmouth bass. Simulations showed that relatively slow-growing native fish that hatched in early-July were only 60% of the length of fast-growing smallmouth bass that hatched on the same day after just two weeks, and thus, were susceptible to predation for the duration of the growing season. Otolith analyses may also enhance our understanding of smallmouth bass ecology in the Green River Basin and guide efforts to disrupt spawning and reduce recruitment of this invasive predaceous species.

CHRONOLOGY AND POPULATION CHARACTERISTICS OF AN INVASIVE VIRILE CRAYFISH *ORCONECTES VIRILIS* POPULATION IN MIDDLE YAMPA RIVER, COLORADO.

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No crayfish species are native to the Colorado River basin. One species, virile crayfish *Orconectes virilis*, is widespread in the upper Colorado River basin. Virile crayfish were established in Crosho Lake near the Yampa River headwaters by the mid-1950s and they were subsequently spread to other lakes and reservoirs. Periodic investigations of macroinvertebrate populations in the Yampa River indicate that virile crayfish incrementally invaded downstream over five decades. Virile crayfish displayed an abrupt increase in abundance in the middle Yampa River in the early 2000s. A quadrat sampling technique was used to estimate virile crayfish abundance in 2005 and 2006. Sampling was conducted at three stations, each representing the major habitat categories in the middle Yampa River, run, pool and riffle-rapid. The proportion of each habitat type was used to weight the density estimate and mean mass of crayfish from each station. Weighted mean densities and masses of virile crayfish in 2005 (6.4-m^{-2}/6.4 g-m^{-2}) and 2006 (9.3^{-2}/11.4 g-m^{-2}) represented a standing crayfish biomass of 86.9 kg/ha during the mid-2000s, which exceeded the estimate for other macroinvertebrates (25.6 kg/ha) and rivaled that of fish (89.2 kg/ha). Invasive crayfish become a keystone species at high densities approaching or exceeding 8-m^{-2}, altering or dominating the flow of energy in food webs. The overall mean density of virile crayfish for both years in the middle Yampa River was 7.9-m^{-2}. A high abundance of invasive crayfish, such as that documented in the middle Yampa River during the mid-2000s, would be expected to have adverse consequences for aquatic communities native to the upper Colorado River basin.

INVASIVE CRAYFISH AND SMALLMOUTH BASS IN THE MIDDLE YAMPA RIVER: IMPLICATIONS OF DROUGHT, CLIMATE CHANGE & FOOD WEB RECONFIGURATION.

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The abrupt increase in the abundance of invasive virile crayfish *Orconectes virilis* in the middle Yampa River in the early- to mid-2000s coincided with a drought, an increase in the abundance of nonnative smallmouth bass *Micropterus dolomieu*, and a decline in the abundance of native small-bodied fishes. Peak flows in the Yampa River during the drought were similar to normal conditions, but base flows were reduced from an average of 10 m^3/s to 5 m^3/s. Mean water temperatures during this period increased from 19.0^o to 20.6^{o}C. Maximum daily consumption rates for both virile crayfish and smallmouth bass have been shown to increase most steeply from 18^o C to 22^o C. It is likely that both smallmouth bass and verile crayfish were able to exploit the drought conditions in the Yampa River, increasing their distribution and abundance in explosive fashion. Similarly, climate change which reduces streamflow, increases water temperatures and lengthens growing seasons may further facilitate reproduction, survival, growth, and range expansion of virile crayfish and smallmouth bass. Invasive crayfish may adversely affect native fishes through exploitation competition for food, interference competition for shelters or

predation on fish larvae or eggs. In addition, native fish in the middle Yampa River appeared to be subjected to apparent competition, or hyperpredation. Hyperpredation, occurs when an introduced prey animal (virile crayfish) that is heavily preyed upon by an introduced predator (smallmouth bass) gains a competitive advantage over native species (small-bodied fishes) by increasing and sustaining predator numbers that severely reduce the abundance of the native prey. As a result, the introduced prey enjoys a competitive advantage over the native prey and flourishes due to behaviors better adapted to withstand intense predation by the introduced predator. Other data support hyperpredation as a negatively synergistic outcome of the concurrent expansion of both virile crayfish and smallmouth bass in the middle Yampa River. It was suspected that smallmouth bass may show a drop in body condition or decline in abundance once the availability of native small-bodied fish as prey declined. However, crayfish became the dominant prey of smallmouth bass, providing them a trophic refuge and making their growth independent of small-bodied fish as prey. Smallmouth bass relative weights remained high in 2003 and 2004 (Wr = 102) and 2007 (Wr = 104) and the abundance of smallmouth bass declined only modestly by the late-2000s (20%), despite intensive removal efforts. The invasion of the middle Yampa River by virile crayfish has reconfigured the food web, entrenching smallmouth bass in the fish community to the detriment of native fishes. Normal flows and water temperatures may periodically reduce favorable conditions for virile crayfish and smallmouth bass, but reconfiguration of the food web is likely to persist, particularly if droughts become more frequent, intense or prolonged due to climate change.

NONNATIVE SPECIES IN THE UPPER COLORADO RIVER BASIN: INCORPORATING COMMUNITY ECOLOGY CONCEPTS & INVASIVE SPECIES DETERRENTS INTO NATIVE FISH RESTORATION & CONSERVATION.

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Native fishes of the Colorado River basin are especially vulnerable to invasive species as they lack the competitive or predator defense capabilities of fishes that evolved in more species-rich regions. A nonnative species becomes invasive when it adversely contributes to the reconfiguration of the native food web or community through competition, predation or infection, causing ecological damage, increasing management costs or raising the extinction risk for imperiled species. Invasion ecology suggests that relentless introductions of new species or reintroductions of existing nonnative species into the habitats of native fishes raise the likelihood that invasions may occur. These additions further transform native aquatic assemblages into communities dominated by nonnative species, potentially resulting in unexpected ecological outcomes due to efforts to control invasive species. Over a dozen new or recurring nonnative species were documented in the Yampa River in the past decade alone, including potentially invasive invertebrates and piscivorous fishes. Increasingly, prevention and eradication are viewed as the best methods to combat invasive species, but current strategies in the upper Colorado River basin are focused primarily on the mechanical control of problematic nonnative fishes. Additional techniques to control or eradicate invasive species would help, but stricter policies or more diligent application of existing policies are needed to prevent increases in nonnative species and the costs associated with their management. Invasive species prevention

is a “weakest-link” public good whose effectiveness is ultimately dictated by the state with the most permissive policies, lenient regulations or lax enforcement. While states with stricter regulations and enforcement may enjoy greater protection from invasive species, the best programs can be defeated by the weak policies of surrounding states. Viewing invasive species as biological pollutants which degrade water quality for native species is an emerging analogy in efforts to preserve native aquatic communities. State and federal fishery agencies presently self-regulate the introduction and spread of nonnative species, but elements of a more preemptive model such as that used to protect water quality may be one option to strengthen invasive species prevention. The identification of three new crayfish species in the Yampa River illustrates the need for preventive policies. Definitive identification of crayfish species is difficult, making the prohibition of individual species ineffective. Given the nonnative status of crayfishes in the Colorado River basin, their invasive capacity and potential to negatively reconfigure native lotic food webs, the importation, movement, sale, possession and stocking of any live crayfish should be prohibited in western Colorado and within those portions of the upper Colorado River Basin in adjoining states.

POSTER SESSION

LARVAE AND EARLY JUVENILES OF ENDANGERED CYPRINIDS IN THE UPPER COLORADO RIVER BASIN: *PTYCHOCHEILUS LUCIUS, GILA CYPHA,* AND *GILA ELEGANS.*

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The Upper Colorado River Basin is inhabited by five native and ten non-native cyprinid fishes. Of the native cyprinids, three are federally endangered species here, as well as in the Lower Colorado River Basin: Colorado pikeminnow *Ptychocheilus lucius,* humpback chub *Gila cypha,* and bonytail *Gila elegans*. The adults of these, and the native roundtail chub *Gila robusta,* are large cyprinids, with Colorado pikeminnow historically exceeding a meter in length and serving as the native top predator of the system. To better facilitate morphological identification of captured larvae and early juveniles, prior descriptions (Seethaler 1978, Snyder 1981, Muth 1990, and Snyder et al. 2005) are being supplemented with new illustrations and data and incorporated in a comprehensive guide and computer-interactive key to cyprinid larvae and early juveniles of the basin. This poster comparatively highlights some of the endangered cyprinid drawings and descriptive information being prepared for the guide.

PATTERNS OF GROWTH RATES AND LENGTHS OF AGE-0 SMALLMOUTH BASS IN THE YAMPA RIVER, 2003–2009

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Smallmouth bass is an invasive, non-native centrarchid fish that is widespread and abundant in the Yampa River, Colorado. Following introduction and establishment of smallmouth bass, small-bodied native fishes in the Yampa River declined, presumably due to predation by bass. We used otolith microstructure analyses to examine patterns of growth of age-0 smallmouth bass. Specifically, we compared intra-annual and inter-annual patterns of bass growth rates and lengths and related those patterns to thermal and hydrologic characteristics in the period 2003-2009. We also examined differences in growth rates of smallmouth bass in the mainstem Yampa River and isolated pools. Bass growth was faster earlier in the year when water temperatures were relatively warm and slower later in the year when water temperatures cooled; bass growth ceased when water temperatures declined to about 10°C. Age-0 bass growth rates were highest, and bass were longer in September, in years when flows declined early and the growing season was longer and when water temperatures were highest. Conversely, age-0 bass growth rates were lower, and bass were shorter in September, in years when spring runoff was prolonged or when water temperatures were cool. Bass from some isolated pools grew more slowly than those from the mainstem Yampa River. Quantifying factors that affect growth and ecology of age-0

smallmouth bass in the Yampa River will assist with population dynamics investigations of bass relative to optimizing strategies for their removal, and aid recovery efforts for native fishes in the Upper Colorado River Basin.

A QUICK COMPARISON OF THREE DIFFERENT TAGGING METHODS.

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A comparison was made of three different tagging methods used by three different stations; The 24 Road Hatchery in Grand Junction, Colorado, the Vernal Colorado River Fish Project in Vernal Utah, and the Ouray National Fish Hatchery in Ouray, Utah. All three stations tag their fish with Passive Integrated Transponder (PIT) tags but use different needle sizes and different injection sites. A staff member from each station tagged a group of approximately 60 razorback suckers (mean length = 280 mm). The fish were held in 4 foot diameter tanks and monitored for 45 days. There were no mortalities in any of the tagged fish after 45 days. Tag retention was 100 % for the fish tagged by the 24 Road Hatchery Staff. Tag retention for Ouray NFH was 89 % and 85 % for the Vernal CRFP.

FIELD ASSESSMENT OF MERCURY EXPOSURE TO ENDANGERED COLORADO PIKEMINNOW WITHIN CRITICAL HABITAT.

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Fish sampling surveys in the last 20 years have demonstrated widespread mercury contamination; especially in the freshwater systems of the northern hemisphere. Human activity, particularly coal-fired power plants and gold-mining, release large amounts of mercury into the atmosphere. In 1994, critical habitat was designated in the states including Colorado, Utah, and New Mexico for four endangered Colorado River fish. Of concern is the proximity of 12 coal-fired power-plants to critical habitat. Also contributing to mercury emissions are Nevada goldmines. Mercury residing in the gold ore is released into the air when the ore is heated to extract the gold, and transported to downwind sites including Utah and southern Idaho. Of the four Colorado endangered fish species, the Colorado pikeminnow (*Ptychocheilus lucius*) is of most concern when considering potential mercury exposure. Colorado pikeminnow (CPM) are long-lived piscivorous species, and voracious predators at the top of the food chain. Though extirpated from the Lower Basin, native populations of Colorado pikeminnow are now restricted to the Upper Basin in Colorado, Utah, and New Mexico. Critical habitat is designated in portions of the Colorado, Green, Yampa, White, and San Juan rivers. Long-term dietary exposure to methyl mercury can cause incoordination, inability to feed, and diminished responsiveness in fish, affecting growth, behavior, reproduction, and survival. Mercury has also been associated with endocrine disruption in fish, causing suppressed hormone levels and inhibited gonadal development.

Muscle biopsies provide a non-lethal method to accurately determine mercury residues in endangered fish. Mercury concentrations in Colorado pikeminnow were determined for all listed segments of critical habitat in the Yampa, White, Green, Colorado, Gunnison, and San Juan rivers. Mercury concentrations in Colorado pikeminnow are compared to toxicity thresholds, compared between river reaches, and compared to locations of coal-fired power plants. Muscle plugs will also be taken from archived Colorado pikeminnow collected before the advent of coal-fired power generation for comparison to current mercury muscle residues. Mercury tissue residues in Colorado pikeminnow will be compared to their population survey data to determine if there is a correlation.

THERMAL REGIME SUITABILITY: UPSTREAM RANGE RESTORATION POTENTIAL FOR COLORADO PIKEMINNOW.

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Dams have reduced distribution of the endangered Colorado pikeminnow *Ptychocheilus lucius* in the upper Colorado River basin by 38%: low-head diversion dams blocked upstream passage and large dams inundated free-flowing segments and cooled downstream reaches with deep-water releases. To date, range restoration efforts in the Colorado and Gunnison rivers have focused on building fish ladders around diversion dams to allow recolonization of upstream reaches. Upstream thermal suitability for this warmwater cyprinid was assessed using temperature data and existing distributional information from river reaches where Colorado pikeminnow movements were unrestricted. Among-site thermal regime comparisons were made using mean annual thermal units (ATU), a metric derived from mean daily temperatures during 1986—2005 and the relation between temperature and Colorado pikeminnow growth. Upstream distributional limits in the Yampa and Gunnison rivers were found to be where in-channel thermal regimes fell below a long-term mean of 47—50 ATU, suggesting that two fish ladders on the Colorado River will make available an estimated 17 km (10 miles) of thermally suitable habitat. A Gunnison River fish ladder successfully re-established access to 54 km (33 miles) of suitable habitat, but 32 km (20 mles) of critical habitat upstream remains unsuitable. Thermal suitability there could be achieved by raising temperatures only 1—2°C from late May to mid-October with installation of a temperature control device on an upstream dam.