32^{ND} ANNUAL RESEARCHERS MEETING

OF THE

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

JANUARY 12–13, 2011

MOAB VALLEY INN

MOAB, UTAH

REGULAR SESSIONS

Wednesday, January 12, 2011

7:30 **Registration:** Fee is $25.00 (Cash or check) to offset costs of meeting room and refreshments.

08:30 WELCOME/LOGISTICS. *Krissy Wilson*, Utah Division of Natural Resources.
08:35 INTRODUCTION TO THE RESEARCHERS MEETING. *Tom Chart*, Upper Colorado River Endangered Fish Recovery Program.

<u>Session 1</u>: Program Updates
(Moderator: Tom Chart)

8:40 HYDROLOGY UPDATE. *Jana Mohrman,* Hydrologist, U.S. Fish and Wildlife Service.
8:55 NONNATIVE FISH MANAGEMENT UPDATE. *Patrick Martinez,* Nonnative Fish Management Coordinator.
9:10 PROPAGATION AND RESEARCH UPDATE. *Tom Czapla,* Propagation and Research Coordinator.
9:25 **Break** (20 minutes)

<u>Session 2</u>: Propagation and PIT Tag Technology
(Moderator: Tom Czapla)

9:45 MEETING PRODUCTION GOALS FOR THE COLORADO RIVER RECOVERY PROGRAM AT OURAY NATIONAL FISH HATCHERY. *Matthew Fry*, Ouray National Fish Hatchery, U.S. Fish and Wildlife Service.
10:05 WAHWEAP, THE UTAH WARM WATER STATE FISH HATCHERY. *Zane C. Olsen*, Wahweap State Fish Hatchery, Utah Division of Wildlife Resources
10:25 USE OF STATIONARY PIT DETECTION SYSTEMS TO MONITOR ENDANGERED AND NON-LISTED NATIVE FISH IN THE COLORADO RIVER BASIN. *Dave Speas,* Upper Colorado Regional Office, U.S. Bureau of Reclamation.
10:45 **Break** (15 minutes)
11:00 DEVELOPMENT OF A FLOATING PIT TAG ANTENNA DETECTION SYSTEM. *Mark McKinstry*, U.S. Bureau of Reclamation.

<u>Session 3</u>: Three Species
(Moderator: Tom Czapla)

11:20 FLANNELMOUTH SUCKER MOVEMENTS IN BIG RIVER HABITATS: POTENTIAL INFLUENCE OF LIFE-HISTORY ADAPTATIONS. *Matthew J. Breen*, Utah Division of Wildlife Resources
11:40 **Lunch**

<u>Session 4</u>: Ecology and Status of Razorback sucker and Humpback chub
(Moderator: Krissy Wilson)

1:00 REPRODUCTIVE ECOLOGY OF RAZORBACK SUCKER XYRAUCHEN TEXANUS IN THE GREEN RIVER BASIN, 1993−2009. *Kevin R. Bestgen*, Larval Fish Laboratory, Colorado State University.
1:20 FLOW RELEASES TO OPTIMIZE CONNECTIONS OF THE GREEN RIVER WITH FLOOD PLAIN WETLANDS TO BENEFIT RECRUITMENT OF RAZORBACK SUCKER LARVAE. *Kevin R. Bestgen*, Larval Fish Laboratory, Colorado State University.
1:40 RAZORBACK SUCKER EMIGRATION FROM THE STIRRUP FLOODPLAIN, MIDDLE GREEN RIVER, UTAH, 2007–2010. *Trina N. Hedrick*, Utah Division of Wildlife Resources.
2:00 **Break** (15 minutes)
2:15 REPRODUCTIVE SUCCESS OF RAZORBACK SUCKER IN THE LOWER GREEN RIVER, UTAH. *Kenneth Breidinger*, Utah Division of Wildlife Resources.
2:35 POPULATION ESTIMATE FOR HUMPBACK CHUB, GILA CYPHA, AND ROUNDTAIL CHUB, GILA ROBUSTA, IN WESTWATER CANYON, COLORADO RIVER, UTAH, 2007-2008. *Darek Elverud*, Utah Division of Wildlife Resources.
2:55 MONITORING THE REPRODUCTIVE SUCCESS OF RAZORBACK SUCKER IN THE SAN JUAN RIVER. *W. Howard Brandenburg*, American Southwest Ichthyological Researchers.
3:15 **Break** (15 minutes)
3:30 RAZORBACK SUCKER IN LOWER GRAND CANYON AND THE LAKE MEAD INFLOW AREA. *Mark McKinstry*, Bureau of Reclamation.
3:50 LAKE MEAD RAZORBACK SUCKER POPULATION AND RECRUITMENT TRENDS, 1935−2010. *Paul Holden*, BIO-WEST, Inc.

<u>Session 5</u>: Nonnative Fish Genetic Control
(Moderator: Krissy Wilson)

4:10 GENETIC BIOCONTROL: REVIEW, RESEARCH NEEDS, AND MANAGEMENT APPLICATIONS IN THE UPPER COLORADO RIVER BASIN. *Patrick J. Martinez*, Upper Colorado River Endangered Fish Recovery Program.
4:30 **Adjourn**

6:00-9:00 pm **POSTER SESSION,**

EVENING SOCIAL
(Food and Drinks)

&

SPECIAL AWARDS

Thursday, January 13, 2011

Session 6: General Nonnative Fish Management
(Moderator: Pat Martinez)

8:30 RESPONSE OF THE NATIVE FISH COMMUNITY OF THE YAMPA RIVER TO REMOVAL OF NON-NATIVE PISCIVORES, 2003−2010. *Kevin R. Bestgen*, Larval Fish Laboratory, Colorado State University.

8:50 NATIVE FISH RESPONSE TO NONNATIVE REMOVAL IN THE MIDDLE GREEN RIVER: YOUNG-OF-YEAR MONITORING AND COLORADO PIKEMINNOW SURVIVAL IN BACKWATER HABITATS. *Matthew J. Breen*, Utah Division of Wildlife Resources.

9:10 EMIGRATION OF NONNATIVE PISCIVORES FROM UPPER COLORADO RIVER BASIN RESERVOIRS: PREDICTIONS AND OBSERVATIONS. *Brett Johnson*, Department of Fish, Wildlife, and Conservation Biology, Colorado State University.

9:30 **Break** (20 minutes)

Session 7: Nonnative Fish Management below Glen Canyon Dam
(Moderator: Shane Capron)

9:50 ECOSYSTEM ECOLOGY MEETS ADAPTIVE MANAGEMENT: FOOD WEB RESPONSE TO A CONTROLLED FLOOD ON THE COLORADO RIVER, GLEN CANYON. *Colden V. Baxter*, Department of Biology, Idaho State University.

10:10 THE USE OF INVERTEBRATE DRIFT IN COMBINATION WITH FLOW FOOD WEBS TO EVALUATE THE EFFECTS OF A CONTROLLED FLOOD ON A TAILWATER TROUT POPULATION. *Theodore A. Kennedy*, Southwest Biological Science Center, US Geological Survey.

10:30 EFFECTS OF FLUCTUATING FLOWS AND A CONTROLLED FLOOD ON INCUBATION SUCCESS AND EARLY SURVIVAL RATES AND GROWTH OF AGE-0 RAINBOW TROUT IN A LARGE REGULATED RIVER. *Josh Korman*, Ecometric Research.

10:50 **Break** (15 minutes)

11:05 FIGHTING FOR STEAK AT THE SALAD BAR: LOW AVAILABILITY OF HIGH QUALITY PREY MAY AMPLIFY POTENTIAL FOR COMPETITION BETWEEN NATIVE AND NON-NATIVE FISHES IN THE COLORADO RIVER, GRAND CANYON, AZ. *Kevin Donner*, Stream Ecology Center, Idaho State University.

11:25 TROUT REMOVAL IN THE COLORADO RIVER, GRAND CANYON: EFFICACY, DIET, PREDATION, AND FUTURE INFLUENCE ON NATIVE FISHES. *Michael D. Yard*, Grand Canyon Monitoring and Research Center, U.S. Geological Survey.

11:45 **Lunch**

Session 8: Northern Pike and Smallmouth Bass Management
(Moderator: Sharon Whitmore)

1:00 NORTHERN PIKE CONTROL AND EVALUATION IN THE MIDDLE YAMPA RIVER AND GREEN RIVER: 2004−2010. *F. Boyd Wright*, Colorado Division of Wildlife

1:20 COMPARISON OF CAPTURE RATES OF SMALLMOUTH BASS *MICROPTERUS DOLOMIEU* USING SMITH ROOT GPP5.0 AND VVP15B ELECTROFISHERS IN THE YAMPA RIVER, COLORADO, 2010. *Cameron D. Walford*, Larval Fish Laboratory, Colorado State University.

1:40 SMALLMOUTH BASS REMOVAL IN THE UPPER COLORADO RIVER BASIN, 2003-2010. *John Hawkins*, Larval Fish Laboratory, Colorado State University.

2:00 SMALLMOUTH BASS OTOLITH MICROSTRUCTURE ANALYSES AND IMPLICATIONS FOR GREEN RIVER BASIN FISH AND FLOW MANAGEMENT. *Kevin R. Bestgen*, Larval Fish Laboratory, Colorado State University.

2:20 A RETROSPECTIVE ASSESSMENT OF THE UPPER COLORADO RIVER RECOVERY PROGRAM'S EFFORTS TO CONTROL NONNATIVE SMALLMOUTH BASS. *André R. Breton*, Larval Fish Laboratory, Colorado State University.

2:40 **Adjourn**

ABSTRACTS

MEETING PRODUCTION GOALS FOR THE COLORADO RIVER RECOVERY PROGRAM AT OURAY NATIONAL FISH HATCHERY.

Matthew Fry, Ouray National Fish Hatchery, 1380 South 2350 West, Vernal, Utah 84078, 435-828-7134

The Recovery Program and the U.S. Fish and Wildlife Service recognized the need to hold some of the endangered fish in protected refugia to prevent extinction and allow for study of the fish's life. In 1992, construction began on Ouray National Fish Hatchery (ONFH). The hatchery would be used to help recover the endangered Colorado River fishes and restore other imperiled fish populations in the Upper Colorado River Basin. The hatchery was built on Ouray National Wildlife Refuge to replace a small experimental facility practicing extensive culture of Colorado River endangered species. In 1998, the hatchery was completed with 36 lined ponds, and a recirculating facility. Poor water quality, design flaws, and poor research have led to nearly a complete replacing of all water filtration components. These problems resulted in chronic under performance and inability to fulfill stocking quotas. Funding for the hatchery was in jeopardy due to the continued failure to produce quota numbers or a quality product.

In 2002 through 2010, new personnel were brought in, the recirculating hatchery was rebuilt, and a new multi-media filtration system was installed. The new management developed new production plans and stratagem to produce enough of the endangered fish to begin meeting production goals. ONFH currently produces in excess of 15,000 > 300mm genetically diverse razorback suckers (*Xyrauchen texanus)* to meet the Recovery Program stocking goals for the Green River, and produces excess fish for flood-plain stocking, and other research purposes. One other species of Colorado River native fish are currently being held in refugia at ONFH, the endangered humpback chub (*Gila cypha).* In 2010 Ouray was complexed into the western Colorado/Utah fisheries complex and acquired the 24 road experimental hatchery in Grand

Junction Colorado. The Grand valley unit has had its share of challenges in the past including water quality and grow out facilities

WAHWEAP, THE UTAH WARM WATER STATE FISH HATCHERY

Zane C. Olsen, Wahweap State Fish Hatchery, Utah Division of Wildlife Resources, Big Water, Utah 435-675-3714

The Wahweap State Fish Hatchery is located in Big Water, Utah and was constructed in 1972. It began production in 1974 with the production of striped bass. Striped Bass were produced and stocked into Lake Powell for the sole purpose of starting a sportfish population for anglers everywhere.

Some 36 years later we are part of the Upper Colorado Recovery Program, Virgin River Program, Least Chub Program, and Utah Sportfish Program. We have 8 species on station including Bonytail Chub, Razorback Sucker, Least Chub, Virgin River Chub, Virgin River Woundfin, Channel Catfish, Wiper, and Tiger Muskie.

As part of the Upper Colorado River Recovery Program we raise and stock 10,660 bonytail chub annually at 200mm. We also hold a backup brood stock of razorback suckers. Over the past couple of years WW has been looking at new ways to reach the 200mm mark in a shorter time period. This was proposed when we were hit with heavy predation during the winter of 2008 and 2009. During this time we lost a whole year class for stocking in 2010. In the spring of 2009 we brought in an additional 30,000 fry from the Dexter National Fish Hatchery for stocking in 2010. With some adjustment in feed, feeding procedures, and stocking densities we were able to reach an average of 195mm in 17 months. This growth usually took 29 months with the same end results. With Dexter going down and the threat of LMBv in our hatchery, Utah decided to retest and confirm that LMBv was not present in our bonytail ponds. Unfortunately, we did not receive the results back until river temperatures were too low for stocking in 2010.

Also, during May of 2010 pond temperatures were much lower than usual and the likelihood of bonytail fry surviving these temperatures was questionable. We decided to hold them inside until water temperatures we suitable. For a 17 day period the fry were held in the only inside tank available on station. Fry were fed a Platinum Grade Argentemia Brine Shrimp that were harvested from the San Francisco Bay National Wildlife Refuge. The results from holding them inside were phenomenal and survival was outstanding.

Currently we have plans to stock 23,000 bonytail in 2011 and are planning on continuing production for the upcoming years.

USE OF STATIONARY PIT DETECTION SYSTEMS TO MONITOR ENDANGERED AND NON-LISTED NATIVE FISH IN THE COLORADO RIVER BASIN.

Dave Speas[1] and Peter MacKinnon[2]

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Use of stationary PIT detection systems to monitor endangered and non-listed native fish in the Colorado River Basin has increased markedly in recent years. Such systems have been deployed to address a wide range of research and monitoring questions including use of fish passage structures, escapement of translocated fish from tributaries (Shinumo Creek, Grand Canyon National Park, Arizona) and off-channel habitats, and seasonal use and movement within tributaries (San Rafael River, Utah). Development of a PIT detection system is also currently underway to investigate entrainment of endangered fish in an irrigation canal adjacent to the Yampa River in northwest Colorado. In this presentation we discuss objectives, design and implementation of such systems, technical challenges, and highlights from the results of selected studies.

DEVELOPMENT OF A FLOATING PIT TAG ANTENNA DETECTION SYSTEM

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Detection systems for PIT-tagged fish (Passive Integrated Transponder) in the Pacific Northwest are well established and work effectively with anadromous species, providing information on fish passage rates, movement patterns, survival, and return rates. In the Colorado River Basin most species do not have predictable movement patterns and must be detected by electrofishing, netting, or physical handling of fish captured in passage facilities. Some notable exceptions include stationary passive detection systems at the Price-Stubb fish passage facility on the Colorado River in Colorado and the San Rafael River and Stirrup Wetland in Utah. In the San Juan River (SJR) up to 12 electrofishing passes are made each year for nonnative fish removal; PIT-tagged Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) are also captured during these trips to provide information on movements, growth, survival and population size. Nonnative removal provides the best and largest amount of information on the status of the two endangered fish in the SJR, but is expensive, time consuming, and has an uncertain future. To begin investigating alternative strategies for detecting these fish we developed a mobile floating PIT tag detection system that detects PIT tags as it floats over them. The system consists of three 10-foot antennas connected to a

multiplexer, integrated GPS, and data logger. As the antennas float over a tag the system records date, time, location, and unique PIT tag number. During two days of testing on the San Juan River in October we detected 75 tags in 21 miles of river, including almost 25 tags in ~ 500m of Chaco Wash. A concurrent electrofishing trip sampling the same stretch of river captured about the same number of fish/boat. The system is limited to detection distances that are less than two feet, but the system could be useful in shallow streams, weirs, or in broad shallow areas of larger rivers, such as the lower San Juan River. Another application would be to use the system in a stationary configuration that allows the antennas to fluctuate with water levels and debris (e.g., logs). Some important drawbacks of this system are that it detects tags and not fish, and biological information such as length, weight, and health are not measurable.

FLANNELMOUTH SUCKER MOVEMENTS IN BIG RIVER HABITATS: POTENTIAL INFLUENCE OF LIFE-HISTORY ADAPTATIONS

Matthew J. Breen and Trina N. Hedrick, Utah Division of Wildlife Resources, 152 East 100 North, Vernal, Utah 84078, 435-781-5317, mattbreen@utah.gov

Flannelmouth sucker (*Catostomus latipinnis*) is currently listed as a Tier I Sensitive Species in Utah due to reductions in their historical range. Although recent investigations indicate that viable, self-sustaining flannelmouth sucker populations persist in the Green and White rivers of Utah, relatively little is known about their movement patterns in this large un-impounded section of the upper Colorado River basin (UCRB). From 2007-2009, we PIT-tagged a total of 3,058 flannelmouth suckers in the Green (314 continuous river km [RK]) and White (107 continuous RK) rivers. Spring (April-June) and summer (July-August) electrofishing surveys from 2008-2010 yielded 71 recaptures. Mean movement distance was 61.0 ± 9.0 km (range = 0–360), where movements were positively associated ($r_S = 0.355$; P = 0.003; $N = 71$) with total length (433.1 ± 7.7 mm; range = 196–507) and movements by reproductively mature flannelmouth (76.0 ± 11.4 km; $N = 52$), individuals of intermediate maturity (28.7 ± 9.0 km; $N = 12$), and immature fish (5.2 ± 3.0 km; $N = 7$) differed significantly ($H = 12.332$; P = 0.002; df = 2). Preliminary home range analyses (seasonal separation of recaptures; $N = 41$) may indicate that spawning and post-spawn habitats are widely separated (63.2 ± 11.4 km). Additionally, we observed inter-drainage movements by 10% of the recaptures and substantial within-season movement (124.9 ± 35.6 km; movement rate = 10.5 ± 3.2 km/day), but there was not a significant difference in movement distance based on direction ($U = 562$; P = 0.703; $N = 70$). Our results indicate that flannelmouth are highly migratory, with a maximum recorded movement distance of 360.0 km; the longest movement documented for this species to our knowledge. Given the timing and extent of observed movements, as well as size-related movements, we hypothesize that flannelmouth in big river habitats maintain summer home ranges that are widely separated from distinct spring spawning locations. However, spawning migrations likely differ greatly by metapopulation based on differences in timing and direction. Overall, reproductively mature flannelmouth utilized larger portions of the UCRB, including multiple drainages, which is likely an important factor for recruitment by this species.

REPRODUCTIVE ECOLOGY OF RAZORBACK SUCKER XYRAUCHEN TEXANUS IN THE GREEN RIVER BASIN, 1993−2009

Kevin R. Bestgen[1] and G. Bruce Haines[2], and Angela A. Hall[1]

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[2] U. S. Fish and Wildlife Service, Vernal, Utah.

Decline of endangered razorback sucker *Xyrauchen texanus* has been attributed to alterations of physical habitat and negative effects of introduced fishes, which has ultimately led to recruitment failure. A better understanding of reproductive ecology of razorback sucker may assist managers tasked with restoration of the species throughout its range. Based on light trap sampling results, razorback suckers reproduced every year in the middle Green River from 1992-2010 and in the lower Green River from 1993-1999, and 2008-2010, the only years sampling occurred there. Abundance of razorback sucker larvae declined in the middle Green River from 1993-1994, until 1999, concurrent with declining abundance of wild adult razorback suckers. Abundance of razorback sucker larvae increased in the middle Green River perhaps beginning around 2000 and certainly after 2004, coincident with establishment of larger populations of stocked razorback suckers, indicating successful acclimation and reestablishment of some adults. Timing of spawning, hatching, and emergence of razorback suckers in the lower and middle Green River had close associations with water temperature; timing of first occurrence of razorback sucker larvae captured in light traps in the lower Green River was typically before peak flows because warmer water temperatures there promoted earlier reproduction. Timing of first occurrence of razorback sucker larvae captured in light traps in the middle Green River was typically coincident with peak flows because water temperatures were cooler and promoted later reproduction. Recapture rates of marked razorback sucker larvae released from 2004-2006 were similar across most release occasions and indicated rapid downstream dispersal of larvae. Larvae were able to rapidly colonize quiet, nearshore areas adjacent to flood plain wetlands, many were recaptured well downstream from release locations, and their broad spatial distribution suggested that provision of mosaic of wetland habitat downstream of spawning areas was important. Understanding timing of reproduction and dispersal and abundance of larvae will be useful to optimize timing and duration of releases from Flaming Gorge Dam to enhance flood plain wetland connections with the Green River, and perhaps, recruitment of razorback suckers in the middle Green River.

FLOW RELEASES TO OPTIMIZE CONNECTION S OF THE GREEN RIVER WITH FLOOD PLAIN WETLANDS TO BENEFIT RECRUITMENT OF RAZORBACK SUCKER LARVAE

Kevin R. Bestgen[1] and G. Bruce Haines[2]

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[2] U. S. Fish and Wildlife Service, Vernal, Utah.

Decline of endangered razorback sucker *Xyrauchen texanus* has been attributed to alterations of physical habitat including loss of flood plain wetlands, and negative effects of introduced fishes, which has ultimately led to recruitment failure. Flood plain wetlands, particularly those in the Green River Basin, are thought to have great value as rearing areas for razorback sucker larvae because they are low-velocity, relatively warm, and food-rich. Understanding timing of reproduction and dispersal and abundance of larvae was useful to better understand how to optimize timing and duration of releases from Flaming Gorge Dam to enhance flood plain wetland connections with the Green River. Surface area of flood plain wetlands increased as flow levels in the middle Green River increased when thresholds of inundation for breaches were reached. Entrainment rates of water (assumed proportional to entrainment rates of razorback sucker larvae for flow-through and single breach wetlands) for four flow-through wetlands increased exponentially at higher Green River flows and entrainment rates of flow-through wetlands were approximately 7x that of single-breach wetlands. Entrainment rates of water for single-breach wetlands increased at higher Green River flows; the nature of the entrainment rate-flow relationship was uncertain but short-term (e.g., daily snowmelt fluctuations) fluctuations were substantial and responsible for a large proportion of total flow entrainment. Entrainment rates of single-breach wetlands were approximately 12% of that for flow-through wetlands, in spite of much greater wetland numbers and total surface area. Unfortunately, flow releases from Flaming Gorge Dam and timing of occurrence of razorback sucker larvae were usually mis-matched. This was because Flaming Gorge Dam releases in spring designed to enhance flood plain-river connections usually occurred too early and well before first appearance of the razorback sucker larvae. Releases were also often well in advance of peak flows from the Yampa River; occurrence of razorback sucker larvae may be a better trigger to signal release of Flaming Gorge flows. Simulations of flow and entrainment rates showed that even at average flow levels, the volume of water entrained into flood plain wetlands when razorback sucker larvae were present was low and constituted only a few hours of Green River flow per year in all backwater types. Simulations also showed that flow regimes since 1992 resulted, on average, in only about 50% of the number of days of flood plain inundation at the two lowest flow levels tested and only 25% of the number of days at the higher flow level tested compared to the unregulated condition; the higher flow was only the equivalent of the Average hydrologic condition called for in Green River flow recommendations. Longer duration and especially, higher magnitude flows, timed to occur when razorback sucker larvae were present, may be minimally sufficient conditions to enhance recruitment of razorback suckers in the middle Green River, Utah.

RAZORBACK SUCKER EMIGRATION FROM THE STIRRUP FLOODPLAIN, MIDDLE GREEN RIVER, UTAH, 2007–2010

Trina N. Hedrick and Steven P. Keddy, Utah Division of Wildlife Resources, 152 East 100 North, Vernal, Utah 84078

The use of floodplain habitats is thought to be an integral component of the life history of the razorback sucker (*Xyrauchen texanus*) a long-lived Catostomid native to the Colorado River Basin. Upon swim-up, larvae enter the riverine drift, are carried downstream and become entrained in slack-water habitats, including off-channel floodplains. Floodplains that are connected to the main channel require occasional reset to eradicate nonnative fish, thus the question of timing is a concern. How many years must a floodplain hold adequate water levels for razorback sucker management? We ascertained the answer to this question through the stocking of 7,991 PIT-tagged razorback suckers into the Stirrup floodplain, located at river mile 275.5 in the middle Green River near Vernal, UT. The Stirrup has a single, narrow connection to the river, in which a series of antennas was installed to detect PIT-tagged fish moving from the floodplain to the river. These antennas, connected to a multi-plexing reader (MUX), detected and recorded PIT-tagged fish that moved between the river and the floodplain in both directions. The MUX was in place for spring runoff flows in 2008, 2009, and 2010. All fish tags recorded during this time were downloaded, compiled, their histories researched, and evaluated for age upon movement out and overall length of time spent in the floodplain. In all, 11 bonytail (*Gila elegans*), nine Colorado pikeminnow (*Ptychocheilus lucius*), one roundtail chub (*Gila robusta*), and 64 razorback sucker were detected entering or leaving the floodplain during the three years of the study. Of the 64 razorback sucker, 48 were stocked into the Stirrup for this study. The remaining fish were either raised in Baeser floodplain (N = 7) or stocked into the middle Green River (N = 10). Of the 48 razorback sucker that moved out of the Stirrup, 16 were age-1 fish and 31 were age-2 fish at the time they left the floodplain (one was unknown). All but two of the razorback suckers spent only one year in the floodplain (one was in the floodplain for two years; the other was unknown). While this study was somewhat artificial due to the use of hatchery-spawned and tagged fish, we conclude that active management of floodplains for razorback sucker need only occur in one year segments. While not all razorback suckers left the floodplain after one year, the majority did. This conclusion may depend upon the size of the floodplain, as fish in the Stirrup, estimated at 28 acres when Green River flow is 18,600 cubic feet per second, are susceptible to bird predation due to its shallow overall depth (four to five ft deep at its maximum). In addition, overwinter survival can be low in small, shallow floodplains, as they are productive in the summer, but can experience extended, low dissolved oxygen conditions overwinter (< 1.0 mg/L) due to their productivity.

REPRODUCTIVE SUCCESS OF RAZORBACK SUCKER IN THE LOWER GREEN RIVER, UTAH.

Kenneth Breidinger, Utah Division of Wildlife Resources, Moab, Utah 435-259-3781

An increasing number of Razorback suckers have been encountered during sampling for Colorado pikeminnow in the lower Green River (RM 120–0) between 2006 and 2008. The capture of three juvenile Razorback suckers and aggregates of ripe adults prompted a study to determine the presence/absence, distribution and probable spawn timing of early life stages of Razorback sucker. Light traps and seines were used to sample nursery habitats between May 21 and August 20, 2009 resulting in the capture of 178 larval razorbacks. Catch per unit effort since previous samplings in the mid and late 1990's has increased. Catch rates were highest in the Millard Canyon area (RM 34–27). Estimated spawning dates ranged from April 21 to June 8 with the majority of spawning occurring during the ascending limb of the hydrograph. One early juvenile razorback was captured during seining efforts in mid August near the San Rafael River confluence. This fish's spawn date was estimated to be May 10 near an apparent spike in spawning activity.

POPULATION ESTIMATE FOR HUMPBACK CHUB, GILA CYPHA, AND ROUNDTAIL CHUB, GILA ROBUSTA, IN WESTWATER CANYON, COLORADO RIVER, UTAH, 2007-2008

Darek Elverud, Utah Division of Wildlife Resources, Moab Field Station, 1165 S. Hwy 191, Suite 4, Moab, Utah 84532, 435-259-3782

Westwater Canyon on the Colorado River in eastern Utah contains the largest of the five remaining populations of endangered humpback chub, *Gila cypha*, in the upper Colorado River Basin. Westwater Canyon also contains a large population of roundtail chub, *Gila robusta*, which are listed as a species of concern throughout their range. Multiple pass closed capture population estimates of sympatric adult humpback chub and adult roundtail chub were calculated in 2007 and 2008 and have been calculated periodically in Westwater Canyon since 1998. Fishes were captured via trammel net and cataraft mounted electrofishing and were implanted with PIT tags upon initial capture. Three sampling trips were completed in both 2007 and 2008. Four sites are sampled per trip and the duration of a sampling trip is eight days. Closed-capture population estimates for adult humpback chub indicate a significant decrease in the population from 1998, but no significant differences were found between the 2007-2008 sampling period and years after 1998. Trammel net catch per unit effort (CPUE) likewise show a significant decrease in catch rate of adult humpback chub from 1998 and years prior to 1998, but exhibit no significant decrease from years after 1999. Population estimates and CPUE metrics alternately did not show significant change over time in the population of adult roundtail chub. No change has been observed in the relative condition or total length of either humpback chub or roundtail chub through time.

MONITORING THE REPRODUCTIVE SUCCESS OF RAZORBACK SUCKER IN THE SAN JUAN RIVER

W. Howard Brandenburg, Michael A. Farrington, Mary A. Brandenburg, and Steven P. Platania, American Southwest Ichthyological Researchers, L.L.C., 800 Encino Place, N.E., Albuquerque, New Mexico 87102-2606

The apparent extirpation of razorback sucker in the San Juan River drainage necessitated stocking of adults of this species by the San Juan River Basin Recovery Implementation Program (beginning in 1994) between Hogback, New Mexico, and Bluff, Utah. Studies of the reproductive success of stocked razorback sucker in the San Juan River began in 1998. Reproduction by razorback sucker in the San Juan River has been documented annually since 1998 through the collection of larval specimens. Over 3,500 larval razorback sucker have been collected during this period with the number of individuals taken annually ranging from two (1998) to 1,251 (2010). Proto and mesolarval specimens comprise the majority of the San Juan River razorback sucker catch with older developmental stages (metalarval and juvenile) specimens being rare in monthly (six) samples. In addition to documentation of the annual reproductive success of razorback sucker, this study has attempted to determine timing, duration, and magnitude of annual spawning events and to correlate those results with discharge and water temperature. In 2010, we expanded the scope of the research and began studying larval

razorback sucker otoliths (daily incremental analysis) to more accurately determine hatching dates, spawning duration, and growth rates. Preliminary results of these 2010 studies will be reported at this meeting.

RAZORBACK SUCKER IN LOWER GRAND CANYON AND THE LAKE MEAD INFLOW AREA

Mark McKinstry[1] and Richard Valdez[2]

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In December 2007 the US Fish and Wildlife Service (FWS) issued a Biological Opinion to the Bureau of Reclamation (Reclamation) on proposed coordinated operations of Lake Powell and Lake Mead. One of the Conservation Measures in the Biological Opinion was for Reclamation to "…examine the potential habitat in the lower Grand Canyon for the species [razorback sucker, *Xyrauchen texanus*], and institute an augmentation program in collaboration with FWS, if appropriate." A companion project to survey for razorback sucker at the Colorado River inflow (CRI) area of Lake Mead was also recommended in the comprehensive review report on 10 years of razorback sucker monitoring in Lake Mead. In 2010 Reclamation initiated two projects to evaluate razorback sucker use of the CRI and lower Grand Canyon. The first project was a comprehensive survey for the fish at the CRI area using captive, pond-reared, sonic-tagged razorback suckers to locate wild fish. The second project consisted of two components: (1) a thorough literature review of the species, with special emphasis on information about this species in Grand Canyon, and (2) a river trip with several experts on the species' ecology and biology, as well as representatives of various management agencies, to evaluate the habitat in the lower Grand Canyon and make recommendations regarding fulfilling the Biological Opinion's conservation measure. In early spring of 2010 three wild adult razorback sucker were discovered using the CRI area and several larvae were captured, indicating that fish are using this area and are reproducing. The literature review found 10 records of razorback suckers being captured in Grand Canyon between 1944 and 1990, primarily near the mouths of tributaries, including the Paria River, Little Colorado River, and Bright Angel Creek. All were adult fish and none have been captured since 1990. Habitat conditions in the lower Grand Canyon appear to be suitable for razorback sucker, with large stretches of riffles, slow moving water, and backwaters, and suitable water temperatures, although these conditions fluctuate with changes in dam releases. Additionally, large numbers of native fish, especially flannelmouth suckers (*Catostomus latipinnis*) and bluehead suckers (*C. discobolus*), were found during non-random surveys of the backwaters and nearshore areas in the lower river. Recommendations from the expert panel are likely to focus on more fully determining the status of fish in the CRI area, establishing a better monitoring program for fish in the lower Grand Canyon, and using translocated wild fish to better understand razorback sucker use of the CRI. Plans are currently underway to increase the survey efforts in the CRI area and complete the report on findings and recommendations from the expert panel and management agencies. This action is being conducted under collaboration with the Glen Canyon Dam Adaptive Management Program, Lower Colorado River Multi-Species Conservation Program, Upper and Lower Colorado Regions of Reclamation, National

Park Service, FWS, Grand Canyon Monitoring and Research Center, Nevada Division of Wildlife, Arizona Game and Fish Department, Hualapai Indian Tribe, Bio-West Inc. and other stakeholders and is one of the few projects where both the upper and lower basins are working together.

LAKE MEAD RAZORBACK SUCKER POPULATION AND RECRUITMENT TRENDS, 1935−2010

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Razorback sucker have been found in Lake Mead, Arizona and Nevada, since it was formed in the 1930s. An ongoing research project on Lake Mead, has been funded by the Southern Nevada Water Authority and the U.S. Bureau of Reclamation for the past14 years. This study has documented the presence of 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. Non-lethal fin ray aging data and back-calculation techniques have indicated that recruitment of razorback sucker in Lake Mead has occurred nearly every year since the 1970s. Cover features and lake management appear to be responsible for this continued recruitment within Lake Mead. Intensive efforts to look for new populations in Lake Mead commenced in 2010 with efforts to locate razorback sucker in the Colorado River Inflow of Lake Mead. Methods included sonic telemetry, larval sampling, and trammel netting. Three adult and seven larval razorback sucker were collected documenting the presence of razorback sucker in the Colorado Inflow area of Lake Mead. Lessons learned from previous efforts allowed for early success in this endeavor; however, there is still much to be studied and many questions to answer regarding this population. The methods employed during this study and the knowledge gained from previous studies on razorback sucker in Lake Mead may have implications basin-wide for this endangered sucker

Genetic Biocontrol: Review, Research Needs, and Management Applications in the Upper Colorado River Basin

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The Upper Colorado River Endangered Fish Recovery Program was a co-sponsor of the International Symposium on Genetic Biocontrol of Invasive Fish held in Minneapolis, MN in June 2010. The Symposium reviewed the status of genetic biocontrol technologies with a focus on nonnative fishes. Potential genetic methods for the control of nonnative fishes include three primary categories intended to reduce the abundance of problematic fishes: 1) the release of sterile individuals to induce reproductive interference; 2) chromosome-set manipulations to cause populations reduction; and 3) genetic constructs to promote population eradication. The most information and examples of application exist for the first category. The release of chemically sterilized male sea lamprey is a key strategy in the control of sea lamprey impacts to fishes in the Great Lakes. Much is known about inducing triploidy to impart sterility and its potential benefits for sport fishery management. While stocking triploid nonnative or hybridized sport fish is increasingly being used to preserve stocks of native fishes, its utility with some sport fish species is less widespread. Additional research on triploidy and its role in chromosome-set manipulations would facilitate the understanding and potential application of these techniques for nonnative fish control in the upper Colorado River basin (UCRB). Monitoring research progress and developments regarding genetic constructs is advised to determine if this technology will prove feasible for controlling nonnative fishes of concern in the UCRB. The required use of triploid/hybrid fishes in stocking proposals in the UCRB is recommended to promote sterility and to reduce the invasive capacity of nonnative piscivores.

RESPONSE OF THE NATIVE FISH COMMUNITY OF THE YAMPA RIVER TO REMOVAL OF NON-NATIVE PISCIVORES, 2003−2010

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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 2003-2010, 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, 2009, and 2010 when flows were relatively high and cool later in summer. Positive native fish response was likely due to synergistic effects of smallmouth bass removal and return to a higher, more normal hydrologic regime, which delayed bass spawning, and growth and perhaps abundance of smallmouth bass in the Yampa River, Colorado.

NATIVE FISH RESPONSE TO NONNATIVE REMOVAL IN THE MIDDLE GREEN RIVER: YOUNG-OF-YEAR MONITORING AND COLORADO PIKEMINNOW SURVIVAL IN BACKWATER HABITATS

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Beginning in 1986, young-of-year (YOY) Colorado pikeminnow (*Ptychocheilus lucius*; CPM) have been monitored in the upper Colorado River basin to determine potential relationships between cohort strength and abiotic (i.e., habitat variables) and biotic parameters (i.e., small-bodied nonnative fishes). In the middle Green River from Split Mountain (river mile [RM] 319) to Sand Wash (RM 215), we conduct fall seining in two low-velocity backwater habitats/five-mile subreach. However, in 2005 a third backwater/subreach was added to measure the response of YOY native fishes to removal of smallmouth bass (*Micropterus dolomieu*) and northern pike (*Esox lucius*). Limited fall recruitment of CPM from 1994-2008 warranted an additional study beginning in 2009 to assess their arrival and survival in backwater habitats. Components of the third study include verifying larval CPM arrival in nursery habitat, documenting CPM abundance in backwaters as the season progresses, reducing densities of small-bodied nonnative fishes in backwaters before and after arrival of CPM, and determining the success of excluding nonnatives from backwaters using various blocking treatments. Catch-per-unit-effort (CPUE) of CPM in 2010 was 10.7 fish/100m^2 (first two backwaters), which is the highest observed since 1991. Furthermore, 2010 sampling marks the second consecutive year with high CPM abundance in the middle Green River. Including all three backwaters, 2009 marks the highest observed CPUE for YOY bluehead sucker (*Catostomus discobolus*; 0.53 fish/100m^2), flannelmouth sucker (*Catostomus latipinnis*; 0.96 fish/100m^2), and roundtail chub (*Gila robusta*; 0.35 fish/100m^2) since the initiation of the native fish response study. Although small-bodied nonnative cyprinids continue to dominate backwater habitats, total abundance over the past four years is considerably lower than 2006 and our blocking treatments appear to alleviate competitive and predatory threats, thus aiding CPM survival. Specially, over five sample periods we observed higher CPM abundance in backwaters blocked with ¼ inch mesh nets (27 fish) compared to ½ inch mesh nets (7 fish) and controls (no block nets; 4 fish). However, an improved experimental design in 2011 will allow a statistically robust assessment of possible treatment effects. Overall, 2009-2010 results, namely an increase in YOY bluehead sucker, flannelmouth sucker, and roundtail chub, as well as recruitment success of CPM, indicate the possibility of successful control actions of nonnative predators (i.e., positive response by early life-stages of the native fish community). Additionally, CPUE of YOY CPM resembles that of the early 1990's, which is an encouraging trend towards the potential recovery of this species.

EMIGRATION OF NONNATIVE PISCIVORES FROM UPPER COLORADO RIVER BASIN RESERVOIRS: PREDICTIONS AND OBSERVATIONS

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Nonnative fishes in critical habitat of the Upper Colorado River Basin continue to be an impediment to recovery of endangered fishes but determining the degree of emigration from reservoirs has been problematic. We are examining how fish and reservoir characteristics, hydro-climate, and dam operations affect emigration risk. Spillway type, penstock elevation and reservoir surface elevation affect the opportunity for nonnative fish to escape from reservoirs. Surface elevation is affected by hydro-climate driving water demand and dam operations. Because of variation in local conditions and reservoir design, synchrony of emigration risk among reservoirs across the basin should not be expected, with some reservoirs experiencing a higher frequency of high emigration risk than others. The advent of precise methods for determining ^{87}Sr:^{86}Sr in otoliths is providing the means to trace origins of fish captured in critical habitat, thereby estimating emigration directly. We have found that ^{87}Sr:^{86}Sr is consistent among species in a given reservoir, temporally stable and nearly unique across reservoirs examined. Apparent differences in river and reservoir signatures suggest that we can identify reservoir escapees in rivers and estimate the actual degree of emigration from Basin reservoirs. Our results suggest a surprising number of nonnative fish are escaping into critical habitat from several reservoirs across the Basin.

ECOSYSTEM ECOLOGY MEETS ADAPTIVE MANAGEMENT: FOOD WEB RESPONSE TO A CONTROLLED FLOOD ON THE COLORADO RIVER, GLEN CANYON

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Large dams have been constructed on rivers to meet human demands for water, electricity, navigation and recreation. As a consequence, flow and temperature regimes have been altered, strongly affecting river food webs and ecosystem processes. Experimental high flow dam releases, i.e., controlled floods, have been implemented on the Colorado River, USA, in an effort to re-establish pulsed flood events, redistribute sediments, improve conditions for native fishes, and increase understanding of how dam operations affect physical and biological processes. We quantified secondary production and organic matter flows in the food web below Glen Canyon dam for two years prior and one year after an experimental controlled flood in March 2008. Invertebrate biomass and secondary production declined significantly following the flood (total biomass: 55% decline, total production: 56% decline), with most of the decline driven by reductions in two non-native invertebrate taxa, *Potamopyrgus antipodarum* and *Gammarus lacustris*. Diatoms dominated the trophic basis of invertebrate production before and after the controlled flood, and the largest organic matter flows were from diatoms to the three most productive invertebrate taxa (*P. antipodarum*, *G. lacustris*, and Tubificida). In contrast to invertebrates, production of rainbow trout (*Oncorhynchus mykiss*) increased substantially (194%) following the flood despite the large decline in total secondary production of the invertebrate community. This counterintuitive result is reconciled by a significant post-flood increase in production and drift concentrations of select invertebrate prey (i.e., Chironomidae and Simuliidae) that supported a large proportion of trout production, but exhibited relatively low secondary production. In addition, interaction strengths, measured as species impact values, were strongest between rainbow trout and these two taxa before and after the flood, demonstrating that the dominant consumer-resource interactions were not necessarily congruent with the dominant organic matter flows. Our study illustrates the value of detailed food web analysis for elucidating pathways by which dam management may alter production and strengths of species interactions in river food webs. We suggest that controlled floods may benefit production of non-native rainbow trout, and this information will help guide future dam management decisions.

THE USE OF INVERTEBRATE DRIFT IN COMBINATION WITH FLOW FOOD WEBS TO EVALUATE THE EFFECTS OF A CONTROLLED FLOOD ON A TAILWATER TROUT POPULATION

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Flow food webs and production-budget analyses can be used to assess the potential for food limitation in salmonid populations, but invertebrate production may overestimate available food if prey are invulnerable to predation because they rarely drift. We evaluated the effects of a March 2008 controlled flood on food availability for the rainbow trout population below Glen Canyon Dam (Colorado River, Arizona) by evaluating invertebrate production, drift and diets of trout two years before and one year after the flood. We found the flood strongly reduced total invertebrate production (from 29 to 13 g AFDM m^2 yr^{-1}) but production of two less-common taxa increased (chironomidae—0.6 to 0.9 g AFDM m^2 yr^{-1}; simuliidae—0.2 to 1.2 g AFDM m^2 yr^{-1}). In contrast, invertebrate drift concentrations increased by more than 2X after the flood (from around 0.9 mg/m^3 to around 0.22 mg/m^3). This increase in drift was driven by substantial increases in concentrations of chironomidae and simuliidae in the drift (4-8X increase, depending on taxa and which post-flood data are used for comparison). Proportionately more chironomidae and simuliidae production was present in drift relative to other taxa (10-15% vs. <1-3%), and consumption of these taxa also increased in trout diets after the flood. Our comparisons highlight the strength of using measurements of both invertebrate production and drift to assess the response of invertebrate assemblages to controlled floods and other management actions.

EFFECTS OF FLUCTUATING FLOWS AND A CONTROLLED FLOOD ON INCUBATION SUCCESS AND EARLY SURVIVAL RATES AND GROWTH OF AGE-0 RAINBOW TROUT IN A LARGE REGULATED RIVER

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Hourly fluctuations in flow from Glen Canyon Dam were increased in an attempt to limit the population of rainbow trout in the Colorado River, AZ, due to concerns about negative effects of nonnative trout on endangered native fish. Controlled floods have also been conducted to enhance native fish habitat. We estimated that incubation mortality rates for rainbow trout resulting from greater fluctuations in flow were 23-49% (2003, 2004) compared to 5-11% under normal flow fluctuations (2006-2010). Effects of this mortality were apparent in redd excavations, but were not seen in hatch date distributions or in the abundance of the age-0 population. Multiple lines of evidence indicated that a controlled flood in March 2008, intended to enhance native fish habitat, resulted in a large increase in early survival rates of age-0 trout. Age-0 abundance in July 2008 was over four-fold higher than expected given the number of viable eggs that produced these fish. A hatch date analysis indicated that early survival rates were much higher for cohorts that hatched about one month after the controlled flood (~ April 15th) relative to those that hatched before this date. These cohorts, which were fertilized after the flood, were not exposed to high flows and emerged into better quality habitat with elevated food availability.

Controlling nonnative fish populations via flow manipulations will be most effective when such flows target older life stages after the majority of density dependent mortality has occurred. It is likely that strong compensation in survival rates shortly after emergence mitigated the impact of incubation losses caused by increases in flow fluctuations during the spawning and incubation period. Monthly habitat-stratified estimates of age-0 population size showed that the proportion of the trout population in low-angle shorelines in the Lees Ferry reach, which are potentially more sensitive to flow variability, declined linearly from 70% in June to 20% in November. Relatively extreme hourly fluctuations in flow during the early operation of the dam (i.e., before 1991) were unintentionally very effective at limiting trout abundance but a return to such operations would have negative effects on a number of critical resources in Grand Canyon. However, a more limited fluctuating flow regime, targeting juvenile trout after the majority of density dependence has occurred, but before they leave habitats that are potentially more sensitive to flow fluctuations, may be effective. Information from this study suggests that it would be worth testing a regime where flow variation is increased during late spring and summer months when small age-0 trout are utilizing potentially flow-sensitive low-angle habitat.

FIGHTING FOR STEAK AT THE SALAD BAR: LOW AVAILABILITY OF HIGH QUALITY PREY MAY AMPLIFY POTENTIAL FOR COMPETITION BETWEEN NATIVE AND NON-NATIVE FISHES IN THE COLORADO RIVER, GRAND CANYON, AZ.

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Interactions with non-native fishes have contributed to the decline of native Colorado River fishes. The impacts of predation by non-natives are well documented, but competition with non-natives for food may also be contributing to native fish declines. To evaluate the potential for such exploitative competition, we quantified the trophic basis of production (TBP), potential for food limitation, and coefficient of competition for all native and non-native fishes found in 6 segments of the Colorado River in the Grand Canyon. We sampled the diets of fishes seasonally during 2007 and 2008, incorporated assimilation efficiencies (AE), net production efficiencies, and secondary production data to estimate TBP, consumption (demand) rates, and Schoener's coefficient of competition (1974). In order to assess potential food limitation, we compare demand of invertebrate prey by fish to estimates of invertebrate secondary production derived from a separate study. Two invertebrate taxa (simuliidae and chironomidae) fueled 54±6% and 47±5% of fish assemblage production across sites during 2007 and 2008, respectively. Approximately one third of fish production was fueled by materials assigned low AE (<0.2) during both years. Our estimates of fish demand for simuliidae and chironomidae were similar to, or exceeded, estimates of their secondary production at all sites. Coefficient analyses suggest the potential for strong interspecific competition between native and non-native fishes in several cases. Such competition appears likely, particularly for high quality invertebrate prey, and may contribute to the decline of native fishes. Given the dynamic nature of invertebrate availability, trophic generalism among extant native fishes is not surprising and may buffer competitive interactions if food resources are limiting.

Trout Removal in the Colorado River, Grand Canyon: Efficacy, Diet, Predation, and Future Influence on Native Fishes

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Predation by nonnative rainbow trout (RBT, *Oncorhynchus mykiss*) and brown trout (BNT, *Salmo trutta*), has been hypothesized as a mechanism contributing to the decline of native fishes of the Colorado River in Grand Canyon, including endangered humpback chub (*Gila cypha*). During 2003–2006, 23,266 nonnative fish were removed from a 15-km segment of the Colorado River near the Little Colorado River confluence. Fish community composition rapidly shifted

from one dominated by salmonids to one composed primarily of native fishes. On average, trout ingested 85% more native than nonnative fishes. Incidence of piscivory for BNT was higher (8 to 46%) than for RBT (0.5 to 3%). Although RBT were less piscivorous than BNT, they were also 50 times more abundant; this resulted in a greater cumulative effect in piscivory (65% of the total estimated fish consumed). Piscivory by BNT was positively correlated to fish prey density and temperature; whereas RBT piscivory was positively correlated to fish prey density and sediment concentration. Although turbidity may mediate piscivory directly by reducing prey detection, this expected response was not apparent in our data for visual sight feeders like RBT. Currently native fish appear to have responded positively to nonnative fish suppression; however, because of other confounding physical and biological factors (temperature, movement and survival) changes in native fish abundance, especially HBC, cannot be attributed solely too mechanical removal efforts. Additionally, RBT reproduction, survival, recruitment, and downstream emigration from the Lees Ferry sport fishery appear to be strongly linked to flow management activities at Glen Canyon Dam. More recent monitoring data suggest that RBT have increased system-wide to high abundance levels. Therefore, it remains uncertain whether or not implementing prescriptive measures (high flow experiments) designed to conserve sediment resources at a system-wide scale will also have a corresponding affect on RBT abundance levels in Grand Canyon.

NORTHERN PIKE CONTROL AND EVALUATION IN THE MIDDLE YAMPA RIVER AND GREEN RIVER: 2004−2010

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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 the Middle Yampa River. In 2010, following six years of removal and evaluation, northern pike abundance in the middle Yampa River remains stable, since the initial depletion documented in 2005 and 2006. Further, northern pike densities in critical habitat of the Yampa River remain well above the interim goal of 3 northern pike per mile, despite exploitation rates as high as 72% of the population point estimate removed per year. In 2010, the population was predominantly comprised of young fish and recruitment of these juvenile northern pike appears to be sustaining abundance in Critical Habitat of the Yampa River. Researchers have long suggested that off-channel ponds and mainstem impoundments in the upper Yampa Basin serve as source populations, contributing significantly to the observed recruitment of northern pike in the middle Yampa River. Beginning in 2008, the CDOW has been engaged in using habitat manipulation and mechanical pike removal as prevention and control strategies in some known northern pike sources in the upper Yampa Basin. The CDOW is also in the process of identifying and evaluating other potential off-channel sources, with the aim to prioritize and implement future control and prevention of northern pike sources. Major recommendations generated during the 2010 Nonnative Fish Workshop were: (1) better coordinate marking passes between studies, (2) reallocate effort away from the peak in the hydrograph to capitalize on higher removal efficiency observed at lower flows, (3) Discontinue translocation of northern pike to Loudy Simpson Pond in Craig, since escapement has been documented, and (4) discontinue abundance estimates in the buffer reach, upstream of Critical Habitat in the middle Yampa River, to increase removal numbers.

COMPARISON OF CAPTURE RATES OF SMALLMOUTH BASS *MICROPTERUS DOLOMIEU* USING SMITH ROOT GPP5.0 AND VVP15B ELECTROFISHERS IN THE YAMPA RIVER, COLORADO, 2010

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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 capture 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 2010 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 for both electrofisher types. General patterns such as increases or decreases, and overall high or low capture rates were usually shared by both electofishers. Differences in capture rates among electrofishers 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, 0.08 more adult bass per hour were captured with the VVP15B than the GPP5.0 at Little Yampa Canyon, and 0.8 more adult bass per hour were captured with the GPP5.0 than the VVP15B at Lily Park. Efficiencies of both electrofishing units for adult smallmouth bass were more similar in 2010 than 2009. Differences in operator technique were less in 2010 (12% and 10% more electrofishing hours for the VVP15B in Little Yampa Canyon and Lily Park respectively) than in 2009 (18% and 17% more electrofishing hours in Little Yampa Canyon and Lily Park). These differences resulted in the removal of 14% more adult bass (n=60, 4% of the pre-removal adult abundance estimate) over the entire season in Little Yampa Canyon with the VVP15B. The GPP5.0 removed 6% more adult bass (n=8, 1% of the pre-removal adult abundance estimate) over the entire season in Lily Park than the VVP15B. The GPP5.0 had much higher capture rates for sub-adult and juvenile bass (39% and 215% more) in Little Yampa Canyon. In Lily Park, the GPP5.0 had higher capture rates for sub-adult bass (67% more) and juvenile bass capture rates were higher for the VVP15B (8% more). Observations by boat operators and netters under a wide variety of conditions suggested that the VVP15B consistently produced better taxis than the GPP5.0.

Evidence of the GPP5.0 having higher capture rates would suggest that taxis maybe inconsequential for capture rates. These findings have implications for design of optimal electrofishing removal strategies for smallmouth bass in the Yampa River.

SMALLMOUTH BASS REMOVAL IN THE UPPER COLORADO RIVER BASIN, 2003-2010

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In the recent past, nonnative smallmouth bass *Micropterus dolomieu* dramatically increased in number and expanded their range in the rivers of the Upper Colorado River Basin. Prior to 1990, low numbers of smallmouth bass occurred in the Duchesne River and near its confluence in the Green River and in the Colorado River around Grand Junction. In 1992, a draw-down of Elkhead Reservoir located on a Yampa River tributary released a large portion of the reservoir fishery including smallmouth bass into the Yampa River. Low, early-peaking water years enhanced production and growth of these invading smallmouth bass, allowing them to establish reproducing populations not only in the newly invaded Yampa River, but also in the Green and Colorado rivers where they had once been rare.

Smallmouth bass now occupy a large portion of the Yampa, Green, and Colorado rivers and several but not all of their tributaries. In the Yampa River, adults (≥200-mm total length, TL) are found mostly upstream near their source in the reaches of South Beach, Little Yampa Canyon, and Upper Maybell. Spawning habitat occurs sporadically throughout the river; but, spawning concentrations are known to occur in the upper reaches where larger adults reside. Sub-adults (100-199-mm TL) also occur in these concentration areas but their densities are highest downstream in Lily Park and Yampa Canyon suggesting that downstream reaches are colonized by downstream movement of young fish. Green River and Colorado River smallmouth bass populations may have similar dynamics.

Removal of smallmouth bass started in 2003 in a 6-mile section of the Yampa River. Effort has expanded into several other reaches and the number of removal occasions has increased over time in each of those reaches to the point where we now remove smallmouth bass from over 315 miles of the Yampa, Green, and Colorado rivers. Results are mixed with some reaches showing declines in the number of smallmouth bass and other reaches showing a stable population after an initial decline. Starting in 2010, we initiated an intensive sampling program in the Yampa River that targeted reaches known to have spawning concentrations of smallmouth bass. Several electrofishing crews converged on the target reaches with goal of increasing the catch and removal of spawning adults and reducing spawning success. We will discuss those results and plans for 2011 that should enhance the effectiveness of this approach.

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 2003-2009. 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, 2008, and 2009 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. Shifts in flow and water temperature management to disadvantage smallmouth bass will need to consider effects on other taxa as well as water availability tradeoffs to achieve goals for baseflow and spring flow peaks.

A RETROSPECTIVE ASSESSMENT OF THE UPPER COLORADO RIVER RECOVERY PROGRAM'S EFFORTS TO CONTROL NONNATIVE SMALLMOUTH BASS

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The Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin initiated extensive non-native fish removal in several rivers to reduce their abundance and assist with recovery of endangered fishes. Invasive smallmouth bass (*Micropterus dolomieu*) have been particularly problematic because of their widespread distribution and abundance, particularly in the Colorado, Yampa, and middle Green Rivers. Between 2001 and 2008, the program removed 107,284 smallmouth bass from basin rivers: 23,348 of unknown age, 25,142 juveniles, 36,043 sub-adults (100-199 mm), and 22,751 adults (≥200 mm). The majority were removed between 2004 and 2008 using from six reaches, three on the Yampa, three on the Green and one on the Colorado including the lower Gunnison River. The removal effort in these reaches encompassed 445 river kilometers and 5,868 hours of electrofishing. Analyses indicate that after five years of intensive removal population responses have been mixed. Reduced abundance of smallmouth bass was detected in the Colorado-Gunnison and Yampa Canyon, but was likely due to environmental factors. In other reaches, annual removal rates exceeded 70% in some years but abundance levels recovered by the next year. Persistence of bass in the Upper Colorado River Basin may be due to a number of factors including dispersal, recruitment, reservoir escapement, and inadequate levels of exploitation.

POSTER SESSION

ILLUSTRATIONS OF THE FLEXION MESOLARVAE OF CYPRINIDS IN THE UPPER COLORADO RIVER BASIN.

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Only five of the fifteen cyprinids in the Upper Colorado River Basin are native species and three of those are designated as federally endangered. Of the ten non-native species, four are relatively common throughout much of the basin; the remainder are only locally abundant or rare and very limited in distribution. A guide and key for identification of their larvae and early juveniles is in preparation. Here, we present drawings of the recently transformed flexion mesolarvae for each species, one of eight developmental-stages drawings prepared for the guide, to illustrate similarities and differences in their typical size, form, and pigmentation. (Two additional species of cyprinids have been more recently reported in specific tributary drainages of the basin and are not included in the guide or this poster—the lake chub *Couesius plumbeus* and the newly recognized southern leatherside chub *Lepidomeda aliciae*.)