

**San Juan River Basin  
Recovery Implementation Program**

**2010 Nonnative Fish Workshop**

**Final Report**

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## 1.0 INTRODUCTION

The San Juan River Recovery Implementation Program (Recovery Program) hosted a San Juan River nonnative fish management workshop on May 26 and 27, 2010, to evaluate and modify, if needed, the Recovery Program's nonnative fish management program. The two-day workshop provided a forum for the Recovery Program's principle investigators, Biology Committee, Program Office, peer reviewers, and invited outside experts to: a) review the threats nonnative fish pose to the native fish community in the Basin, with focus on the Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*); b) review the findings and progress related to the Recovery Program's efforts to reduce the threat of nonnative fishes; c) identify the responses of native and nonnative fish to nonnative fish removal; d) review current methods employed for nonnative fish management on the San Juan River; e) develop targets and milestones to evaluate the effectiveness of the nonnative fish management program; and, f) explore new methods and techniques that may have application for the San Juan River nonnative fish management program.

The objectives of the workshop were:

1. Review and define the threat of nonnative species to the native fish ecology of the San Juan River.
2. Review current nonnative fish removal activities, including effort, removal numbers, age and size class of fish removed, temporal and spatial distribution of fish removed, catch per unit effort (CPUE) statistics, and population estimates.
3. Review the analyses and synthesized field data collected during previous years as they relate to a) channel catfish (*Ictalurus punctatus*) management, b) common carp (*Cyprinus carpio*) management, and c) the San Juan River native fish community response to the nonnative fish removal targets.
4. Review or develop metrics for nonnative fish removal targets.
5. Review removal methods and techniques that may have application on the San Juan River.
6. Develop a removal strategy with targets for species of concern.
7. Provide recommendations to the Recovery Program Office on modifications to the current nonnative fish removal program.

The goal of the workshop was to develop a unified strategy to guide the nonnative fish management program for the San Juan River and to make recommendations to the Recovery Program on how the nonnative fish control program could more effectively reduce the threat of nonnative fish in 2011 and out-years. Thirty people attended including principle investigators, Biology Committee members, biologists from the Upper Colorado River Endangered Fish Recovery Program, peer reviewers, Program staff, and invited outside experts ([Appendix A](#)). This report summarizes the presentations that were given, the discussions that occurred, and recommendations that were developed during the workshop.

## **2.0 BACKGROUND**

The Recovery Program was initiated in 1992 to conserve and recover populations of the Colorado pikeminnow and razorback sucker in the San Juan River Basin (Basin) while allowing water development to proceed in compliance with all applicable federal and state laws. The Recovery Program is intended to provide the measures for compliance with the Endangered Species Act of 1973 (ESA) for water development and water management activities in the Basin. Activities and actions within the Recovery Program serve as the “reasonable and prudent alternative” for projects in the Basin and help to ensure that those projects will not jeopardize the continued existence of the two endangered fish. It is anticipated that actions taken under the Recovery Program to recover the endangered fish will benefit other native fishes in the Basin and prevent them from becoming endangered.

### **LONG RANGE PLAN**

The Recovery Program’s Biology Committee (BC) developed a Long Range Plan (LRP) in 1995 primarily to guide the Recovery Program through the completion of a 7-year research program (1991-1997) to identify and characterize factors limiting the two endangered species. The research program was completed in 1997 and the LRP was revised and updated to provide guidance on the implementation and management phase of the Recovery Program. The LRP identifies specific actions and tasks to be implemented in the Basin that will contribute to recovery of the Colorado pikeminnow and razorback sucker in accordance with species recovery goals (U.S. Fish and Wildlife Service [Service] 2002a, 2002b). The LRP also specifies that the recovery of both protected species will be accomplished within the context of conservation and management of the entire native fish assemblage and in a manner that does not compromise, impair, or diminish persistence of unprotected native fishes. The LRP uses research information from past San Juan River studies as well as that from other regions, and from Recovery Program evaluation reports to identify multi-year research, monitoring, and recovery actions necessary to achieve the Recovery Program goals. Accomplishing the actions and tasks described in the LRP constitute the milestones toward achieving recovery of the endangered fish species. By satisfactorily meeting the actions and tasks in the LRP and demonstrably contributing to recovery of the listed fishes, the Recovery Program is able to serve as the foundation for a reasonable and prudent alternative for ESA section 7 consultations.

Recovery goals, actions, and tasks deemed necessary to achieve the overall Recovery Program purpose are identified and described in the LRP by the following six Recovery Elements:

1. Management and Augmentation of Populations and Protection of Genetic Integrity.
2. Protection, Management, and Augmentation of Habitat.
3. Management of Nonnative Species.
4. Monitoring and Evaluation of Fish and Habitat in Support of Recovery Actions.
5. Program Coordination and Assessment of Progress toward Recovery.
6. Information and Education

**MANAGEMENT OF NONNATIVE SPECIES – RECOVERY ELEMENT #3**

The impact of nonnative species on native fish populations is an ongoing concern for the Program. Nonnative fishes can numerically dominate riverine habitats and communities, negatively interacting with native and endangered fish species, and contributing to their decline. Over 30 species of nonnative fish have been documented from the San Juan River Basin, compared to nine native species. The 2002 recovery goals for Colorado pikeminnow and razorback sucker (Service 2002a, 2002b) identify predation and competition by nonnative fish species as a primary threat to the endangered species. The recovery goals require that management actions be implemented to address threats posed by nonnative fishes by: (1) developing management programs to identify the levels of management needed to minimize or remove the threat for selected species in selected river reaches (requirement for downlisting), and (2) implementing the identified levels of nonnative fish management (requirement for delisting).

Element 3 of the LRP, *Management of Nonnative Species*, identifies actions and tasks the Recovery Program will implement to reduce negative interactions between the endangered fish species and problematic nonnative fish species in the San Juan River. These include controlling problematic nonnative fishes (Goal 3.1) and preventing the introduction and establishment of other nonnative invasive species (Goal 3.2). The actions and tasks under Goal 3.1 focus on full implementation of the nonnative fish control strategy initiated in 2008, evaluation of methods, assessment of effects on the fish community, and development of targets for nonnative fish removal. Goal 3.2 focuses on establishing policies and agreements with states and tribes to manage sport fish and bait species in the San Juan River in a manner compatible with endangered fish recovery and to identify potential invasive nonnative species and control their introduction and escapement into the river, floodplain, and tributaries. Included are tasks to assess the effects of non-native fish from Lake Powell and from other sources on the fish community in the San Juan River and to track all nonnative species in the basin to the extent possible.

Mechanical removal by electrofishing was implemented by the Recovery Program as a full-scale, stand-alone effort in 2001 in the upper river from PNM Weir (RM 166.6) to Shiprock Bridge (RM 147.9) and in 2002 in the lower river from Mexican Hat (RM 52.9) to Clay Hills (RM 2.9). Channel catfish and common carp are considered the primary nonnative threat to the recovery of Colorado pikeminnow and razorback sucker in the San Juan River. Following the initiation of intensive nonnative removal, capture rates of common carp were decreasing but river-wide capture rates of channel catfish remained relatively constant. Catfish appeared to be responding to removal efforts by shifting their distribution into sections of the river that had not experienced the long-term removal effort. In 2008, the nonnative fish removal effort was expanded to provide river-wide coverage (163.7 river miles) by including the river reach from Shiprock Bridge to Mexican Hat (RM 147.9-52.9).

Other measures are being implemented by the Recovery Program to control nonnative species. All nonnative species river-wide that are collected during research and fish monitoring activities are opportunistically removed. The Recovery Program operates a selective fish passage at the PNM

Weir where all nonnative fish that pass through the structure are removed. In 2003, a waterfall formed at Piute Farms on the lower San Juan River creating a barrier to fish movement from Lake Powell to the San Juan River. Prior to waterfall formation, an objective of the lower river nonnative fish removal program was to identify factors involved in movement of striped bass (*Morone saxatilis*) and other reservoir fish species out of Lake Powell and into the lower San Juan River to inform and refine the removal effort timing. With movement of nonnative fish from the reservoir halted, river-wide nonnative removal focus is currently on channel catfish and other nonnative fishes that occur in the San Juan River. The LRP includes actions and tasks to identify and track potential sources of nonnative species, to identify measures to prevent their introduction into the river, and to implement those measures as necessary. The Recovery Program is also evaluating nonnative fish stocking and baitfish policies of affected states to ensure nonnative fish are not stocked into endangered species critical habitat in the San Juan River.

### **NONNATIVE SPECIES MANAGEMENT REVIEW, EVALUATION, AND MODIFICATION**

An important part of the Recovery Program's nonnative fish management program is regular review of methods and results, assessment of effects on the fish community to ensure the effectiveness of the nonnative fish control program, and making modifications when appropriate. During the two-day workshop, participants reviewed and evaluated available data, results, and other information generated from within the Recovery Program and from outside the Basin. Based on this review, workshop participants developed recommendations and measures to guide nonnative fish management activities. The agenda was organized into sections including: threats from nonnative species, nonnative fish response to nonnative fish removal, native fish response to nonnative fish removal, and nonnative fish removal methods. Each session included presentations to address each topic with discussion periods after each presentation and section. The workshop wrapped up with overall discussion and development of recommendations and measures for improving the effectiveness of the Recovery Program's nonnative fish management program.

## **3.0 THREATS FROM NONNATIVE SPECIES**

### **3.1 Presentation - Nonnative Species Interactions: Summary of Past and Present Work on the San Juan River, 1991-2010 (Jason Davis, U.S. Fish and Wildlife Service [USFWS], Albuquerque, NM)**

Davis reported that over 30 species of nonnative fish have been found in San Juan River and four of those, common carp, channel catfish, fathead minnow, and red shiner, were found to be comparatively common and widely distributed during the Recovery Program's research period, 1991-1997. Channel catfish were first reported in 1957 and were stocked throughout the 1980's. They were the second most abundant fish (80% of all collections) during the 1991-1997 sampling period. Common carp, introduced in New Mexico waters in 1883, was the fourth most abundant fish (76% of all collections). Schnabel pop estimates, 1992-1995, estimated 274,484 catfish and 107,268 carp in 1995. Combined with river-wide abundance estimates it was determined that the presence of these nonnative fish may result in significant impact to the native fish community. Predation on

native fish by nonnative fish was documented. Channel catfish >450 mm total length (TL) were found to be piscivorous with 13.7% of stomachs containing fish or fish remains. Channel catfish are a broad-niched species and carp inhabit low velocity, shoreline habitats with silt/sand substrate. This results in a potential resource overlap between nonnative and native fish species. Negative impacts from catfish include aggression, predation, choking hazard when ingested, and competition for resources. Electrofishing was found to be the most effective method for catching channel catfish. Beginning in 2001, the Recovery Program committed to a river-wide, long-term, institutionalized nonnative fish removal policy.

### 3.1.1 Discussion Points Raised

1. What are river conditions during nonnative fish removal?
  - a. Response: removal trips occur between 500 cubic feet per second (cfs) to 5,000 cfs. Any flow below 4,000 to 5,000 cfs does not affect the effectiveness of removal efforts. Turbidity associated with summer storms does affect the removal efforts because identifying channel catfish can be difficult. The common carp catch rate does not seem to be affected by increased turbidity levels.
2. The Public Service Company of New Mexico (PNM) weir is the only range constriction on the population within the San Juan River. The catfish population above the weir is limited. This low number above the PNM weir could be due to cold water releases that limit reproduction and there being too few fish to effectively spawn.
3. Larval nonnative fish are not collected during the removal efforts, but all other age classes are collected. Minimum 300-mm size fish are affected by the electrofishing gear used by the Recovery Program. High frequencies are typically used for removal efforts.
4. Current electrofishing techniques on the San Juan River include 16-foot rafts with one anode and series of rat tails hanging from the back. Smith-Root, Inc. equipment is typically used. The Program uses a 5,000-watt generator with 4 to 5 amps (depending on conductivity of the river and the cycling of the unit). Conductivity can range from 400 to 700 microsiemens/meter in the river. Electrofishing is done only during the daylight for safety purposes.

### 3.2 Presentation – Diet of Channel Catfish in the San Juan River: Preliminary Results (Tim Patton, Southeastern Oklahoma State University)

Patton presented on preliminary results of a San Juan River channel catfish diet analysis. Channel catfish in the San Juan River, as in other places, are highly omnivorous. Most reports from lotic systems note piscivory is relatively low but even low levels of piscivory may impact native species [e.g., caused the failure of efforts to re-establish razorback sucker in the Gila River Basin of Arizona (Marsh and Brooks 1989)]. Patton's preliminary results are based on examination of stomachs from 229 channel catfish. Among these, 70% had Russian olive (*Elaeagnus angustifolia*) seeds in their stomachs, and 21% had fish or fish remains. Of the fish remains, 80% appear to be native cyprinids, 15% native catostomids, and 5% other; however, additional time is needed to further examine

partially digested fish parts for more conclusive identification. It is difficult to analyze fish in stomachs because they digest rapidly. He is looking at the feasibility of using pharyngeal teeth remains to identify fish in stomachs because they last longest and may be unique identifiers. Information on volume of fish consumed from this study could be used in a bioenergetics analysis. Patton emphasized that although piscivory by channel catfish in the San Juan River appears to be relatively low, impacts on Colorado pikeminnow and/or other native fishes may be significant due to the large number of catfish in the system.

### **3.2.1 Discussion Points Raised**

1. How many arches counted had broken pharyngeal teeth?
  - a. Response: Even if pharyngeal teeth are broken, the arch has a socket and it is counted as a tooth.
2. Have you looked at other boney parts?
  - a. Response: Not at this time because pharyngeal teeth last the longest in the stomach and are unique identifiers.
3. How is the Recovery Program going to use this information? What is the purpose of this study in terms of recovery?
  - a. Response: The Recovery Program is not funding this particular study. It is hypothesized that channel catfish are predators of Colorado pikeminnow but the Recovery Program is not sure what the predation rates are. This study could help with understanding what the predation rates actually are. These types of projects are important to gain knowledge the Recovery Program currently does not have. Channel catfish may be more of a predator of the Colorado pikeminnow's prey than the endangered species itself.
  - b. This project may be important to calculate the volume of fish consumption, which may lead to bioenergetics analysis.
4. Smaller-sized channel catfish may contribute to piscivory similar to the larger-sized fish.
5. Are channel catfish eating Russian olive fruit or seeds?
  - a. Response: The fish seem to be eating the fruit and possibly not digesting the seeds.
6. Catfish may be regurgitating stomach contents when they are shocked. This could underestimate the predation factor based on analysis of incomplete stomach contents.

### **3.3 Presentation - Invasive and Illicitly Introduced Aquatic Species: Perspectives from the Upper Colorado River Basin (Patrick Martinez, Colorado Division of Wildlife/USFWS, Grand Junction)**

Martinez, CDOW Aquatic Researcher/USFWS Nonnative Fish Coordinator, reported on invasive species and illicit introductions from his perspective working with the Upper Colorado River Endangered Fish Recovery Program (CRRP). The Colorado River native fish community has been affected by many things. Numerous species are in decline and are being protected and/or recovered by various state/federal/tribal programs. Federally-listed species have recovery goals that include

eliminating threats from nonnative species. Legally or illegally stocked nonnative species have been identified as a major threat to native fish in the Colorado River Basin. The number of nonnative fishes has increased over time as well as the number of illegal aquatic species introductions. Illicitly stocked nonnative fish may affect reservoir sport fisheries or riverine native aquatic food webs and perform differently in the two different environments. Some of the legally or illegally stocked nonnative fish that are currently a threat, or could potentially become a greater threat to native fish in Colorado River, include: northern pike (*Esox lucius*), channel catfish, black crappie (*Pomoxis nigromaculatus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), green sunfish (*Lepomis cyanellus*), walleye (*Sander vitreus*), gizzard shad (*Dorosoma cepedianum*), and burbot (*Lota lota*).

The San Juan and Upper Colorado River endangered fish recovery programs have active nonnative fish control programs. State agencies are also committed to working cooperatively to conserve native species in their states and have formed conservation agreements and strategies for conserving species that cross state lines. For example, Utah, Wyoming, and Colorado have a Conservation Agreement in place to work cooperatively to conserve roundtail chub (*Gila robusta*), bluehead sucker (*Catostomus discobolus*), and flannelmouth sucker (*C. latipinnis*) throughout their respective ranges. The plan states they will identify and significantly reduce and/or eliminate threats to the persistence of these native species. Stocking Procedures are in place between the partners of the Upper Colorado River Recovery Program, the States, and the U.S. Fish and Wildlife Service, to ensure that all future stocking of nonnative fish are consistent with the recovery of the endangered fishes and activities of the recovery program. The Stocking Procedures are intended to minimize access by stocked nonnative, non-salmonid fishes to critical habitat where they may adversely affect endangered fishes. The Stocking Procedures allow salmonids to be routinely stocked, except into riverine critical habitat. Nonnative, non-salmonid fish stocking and their management in public waters requires evaluation by the States and the Service on a case-by-case basis. Private stocking is also addressed.

All introduced nonnative aquatic species may prove to be invasive species (i.e., nonnative aquatic species that spread, persist or proliferate in aquatic habitats, and pose ecological and/or economic liability). Introduced or stocked aquatic species may originate from authorized or illegal introduction and either dispersal mechanism undermines policies, procedures, and recovery actions including nonnative fish control, selective fish passages, native fish preservation and reintroduction, native fish conservation areas, and sport fisheries.

Nonnative introductions are not limited to fish. No crayfish species are native to the Colorado River basin yet crayfish are widespread in the upper Colorado River Basin. Proliferation of virile crayfish and smallmouth bass in the Yampa River in the early 2000's coincided with prolonged drought. Warmer water temperatures likely favored these two nonnative species which likely contributed to the reduction and suppression of native, small-bodied fish species through hyperpredation. This reconfiguration of the native food web is likely to persist. Emphasis clearly needs to be placed on prevention of nonnative introductions versus control of nonnatives. The Upper Colorado River

Basin States have various regulations regarding crayfish and most of them specifically prohibit rusty crayfish; however, crayfish species cannot be readily identified based on color of the carapace because it differs with stage of molt, water quality, and other variables.

Prevention is key but challenging. For the San Juan River, the waterfall at Lake Powell currently keeps nonnatives from entering the river, for now, but there are still risks from other reservoirs such as Lake Nighthorse. The Recovery Programs needs to be vigilant because any number of events could potentially trigger a problem, such as the rapid proliferation of smallmouth bass that occurred in the Yampa River and elsewhere in the Upper Colorado. The trigger could be an introduction of a nonnative species, an event in a reservoir, something that changes the environment in the river, stocking practices, or release events at Navajo Dam or other reservoirs.

### 3.3.1 Discussion Points Raised

1. Are gizzard shad maintaining populations in the Green and Colorado rivers?
  - a. Response: The Colorado River populations seem to be more persistent. Young-of-year fish are caught at the mouth of the Green River, and large fish are caught near Grand Junction.
2. It is interesting that the three species agreement is conserving roundtail chub, bluehead sucker, and flannelmouth sucker but these species are excluded from the two well-funded Upper Colorado River recovery programs. Why isn't there better integration between the programs? Prevention will need cooperation across the river basins.
  - a. Response: These issues need to be considered as food web issues instead of river by river.
3. What are some of the illicit introductions in the San Juan Basin that may be not well known?
  - a. Response: McPhee Reservoir has northern pike and walleye.
  - b. Response: Navajo Dam acts as a large barrier for introduced nonnative species.
  - c. Response: Escapement of smallmouth bass from reservoirs along the San Juan River, similar to historic escapement from the Elkhead Reservoir into the Yampa River, should be taken seriously by the Recovery Program.
4. Not many smallmouth bass have been caught in the San Juan River.
  - a. Smallmouth bass are also in Lake Powell, but the waterfall currently restricts their migration.
  - b. The aggressive nonnative control program should continue in order to prevent the invasion of other nonnative fish.
  - c. Lake Nighthorse could become a threat for nonnative fish introductions.
5. What would be the benefit of constructing one or two selective fish passages to assist with nonnative fish removal efforts? It would also help if the waterfall becomes inundated.
  - a. Response: This may be worth considering because there are areas of the river that would be conducive to selective fish barriers.
  - b. The Hogback reach could be a good location for a fish barrier.

- c. The Recovery Program needs more research before determining if and where the selective fish barriers could be located.
6. There are questions about fish movement in the river. The Recovery Program could set up an experimental design with hydrophone grids and acoustic tags to track movement.
  - a. This could also be accomplished cheaper with mark-recapture studies like Elverud is doing but relying on capture and movement can be sporadic.
  - b. Catfish movement data, if projected for the entire population, could show where fish are moving in the river system. Movement may occur more with juveniles.

### **3.4 Section Discussion – Current nonnative fish removal efforts and nonnative species threats in the San Juan River**

#### **3.4.1 Discussion Points Raised**

1. There are so many other factors in the San Juan River that predatory fish species may not be the problem.
2. Can the Recovery Program separate the threats to the native fish populations from nonnative fish and other environmental threats?
3. Competition with other fish could be more of a threat than predation. Other variables compound the issue, such as the construction of Navajo Reservoir.
4. Predation issues can be a symptom instead of the real problem. The hydrograph may be the real problem.
5. The Recovery Program needs to understand all sources of nonnative fish within the San Juan Basin.
6. Nonnative fish may not be as large a threat as previously thought; other abiotic factors may be bigger problems.
7. Russian olive may be providing substantial energy to the system. Information on volume of fish and Russian olive consumed by channel catfish could be used in bioenergetics analyses.

## **4.0 NONNATIVE FISH RESPONSE TO NONNATIVE FISH REMOVAL**

### **4.1 Presentation - Mechanical Removal of Large Bodied Nonnative Fishes in the Upper/Middle San Juan River 2001–2009 (Jason Davis, USFWS, Albuquerque, NM)**

[This text has not been edited by Davis]

Davis presented on temporal and spatial shifts in distribution and abundance, biomass, and condition factor of channel catfish and carp. Data collected from 2001-2009 during nonnative fish removal efforts in the upper and middle reaches of the San Juan River show: 1) a decrease in abundance in the upper two removal sections; 2) seasonal differences in channel catfish CPUE; 3) increased juvenile fish abundance 1-2 years after the initiation of intensive removal; 4) shifts in size class

structure and dependence on single year classes; 5) apparent movement by juvenile channel catfish from areas of higher abundance; 6) total biomass removed and mean kilograms/hour of electrofishing declined (increased juvenile abundance did not correspond to increase biomass overall); 7) Mean condition factor (Kf) for both species increased overtime; and, 8) fewer fish possibly limiting intra/interspecific competition.

#### **4.1.1 Discussion Points Raised**

1. Have you analyzed the condition factor based on a certain size class and across years?
  - a. Response: Not for this presentation. Condition factor was calculated for juvenile and adult age groups only; however, the calculation could be easily completed with available data. The condition factor presented is calculated for the entire year. Condition factor could also change within the year.

#### **4.2 Presentation - Nonnative fish response to nonnative fish removal (Dale Ryden, USFWS, Grand Junction, CO)**

Ryden reported on nonnative fish data collected during routine sub-adult/adult fish community monitoring. The entire length of riverine critical habitat for both endangered fish species (Geomorphic Reaches 6-1) was sampled from 1996-2009. All nonnative species encountered were removed from the river during this time period. River-wide, overall numbers of channel catfish have not been reduced since the initiation of nonnative fish removal; however, channel catfish distribution has changed since 2001 and channel catfish are now concentrated in the middle section of the San Juan River (RM 109-35). Intensive, repetitive nonnative fish removal efforts have been effective in keeping numbers of channel catfish low in the upper removal section (RM 166.6-147.9) and in the lower section (RM 52.9 – 2.2), until 2009. Changes to channel catfish age-class/size-class and length-weight relationships have been observed. The majority of channel catfish collected in 2009 were age-1 and age-2 fish. Long-term trend lines indicate that the mean TL and mean biomass have decreased. Mean condition factor has increased significantly since 1991. There are many outstanding questions about the extent of ecological impact from channel catfish on the native fish community. It has been documented that channel catfish prey upon stocked endangered fish and other native fishes and Colorado pikeminnow choke on small ictalurids. Is the latter interaction more or less important than predation or is it important at all? Managing channel catfish in the San Juan River is a challenge. Are the current exploitation rates for channel catfish high enough to make a difference?

In contrast, the nonnative removal effort has been a success in decreasing the number of common carp in the system. Numbers of common carp collected and CPUE river-wide significantly declined since the initiation of intensive nonnative fish removal. Juvenile common carp, which were never common in adult monitoring collections are now as common or outnumber adults. Common carp are now less common than Colorado pikeminnow in electrofishing surveys.

#### **4.2.1 Discussion Points Raised**

1. Total catfish caught would indicate that electrofishing efforts had greater impact before the intensive electrofishing trips were initiated.

2. Has the Recovery Program compared size classes for channel catfish and compared Ryden's data with the data presented by Davis earlier?
  - a. Response: This analysis has not been done.
3. The decrease in common carp population numbers could be the result of the waterfall formation at Lake Powell in 2003. Catfish and carp numbers have spiked in the past when the waterfall is inundated by Lake Powell.

#### **4.3 Presentation – Nonnative Removal Efforts the Lower San Juan River (Derek Elverud, Utah Division of Wildlife Resources, Moab)**

Since 2002, common carp CPUE significantly decreased and the majority of the population is now made up of young-of-year and juvenile fish. Channel catfish CPUE and TL varied between years. No discernable channel catfish trends in condition factor or biomass were observed. Biomass and condition factor varied similarly to CPUE and TL between years. In March 2009, 701 catfish were tagged to look at movement and exploitation rates. Emigration out of the study reach is occurring as 18 marked fish were caught upstream of Mexican Hat and three catfish moved >100 river miles; however, no trends have been detected. The tagging data shows exploitation rate increases substantially as the size of the catfish increases.

##### **4.3.1 Discussion Points Raised**

1. The Fulton index does not account for allometric growth. It might be useful to consider calculating relative condition or relative weight because these metrics consider allometric growth.

#### **4.4 Presentation – Effects of Nonnative Fish Removal on Nonnative Fish – Modeling of Population Response of Channel Catfish to Nonnative Fish Removal Efforts (James Morel, Navajo Nation)**

Morel presented on results from his Master's project to model population response of channel catfish to nonnative fish removal efforts. The project was done to assist the recovery effort by exploring useful survival models conducive to channel catfish catch-effort data and constructing models to examine the impact of large-scale removal efforts on the channel catfish population. To determine the age structure of channel catfish, he developed an Age-Length Key that can be applied to length frequencies of a larger sample and converted to age frequencies. He used spine cross sections for aging. To determine age-specific fecundity, he applied length specific fecundity to the Age-Length Key. He used the Robson and Chapman maximum likelihood method with age-length variation survival estimates for three study reaches to determine population-wide channel catfish survival over a temporal scale. Average population-wide survival of Ages 0-7 was used. Matrix models/projections using vital rate estimates were constructed. The matrices show significantly higher population growth rates (~ 3.5) even with current removal efforts. He questioned if vital rates are conducive to a population crash. Matrix modeling suggests current survival and reproductive output results in population growth. Sensitivity analysis suggests that age 0-7 survival has the largest affect on population growth. A major increase in effort for all individuals would likely induce

a precipitous population crash. Substituting some level of current effort toward younger fish would likely induce a population crash.

Morel concluded that more information is needed to refine/improve the key and matrices and that mark-recapture information could help in more accurate understanding of the parameters. This study illustrates the limitations of the current data set and that CPUE may not be the best parameter to use for this type of analysis. Morel's work was funded outside the Recovery Program but the analysis could be continued and improved with Recovery Program support.

#### **4.4.1 Discussion Points Raised**

1. How sensitive is the model to the age structure?
  - a. A length-based model would be a more effective approach to this analysis, but mark-recapture data would be needed.
2. Mark-recapture data could be collected by the Recovery Program to improve the datasets available for this analysis.
3. What can the Recovery Program use to determine overall level of effort?
  - a. Mark-recapture data are needed to determine level of effort.
4. Lambda for average/average model was around 1.5; is this close to reality?
  - a. Response: Morel thinks this Lambda is close to reality because nine years of CPUE data were used for this analysis. If there was not exploitation, Lambda could be expected to be larger than 3.57.
5. How many fish were used for the model?
  - a. Response: 121 fish were used at age 8 and above for the model. The project needs to analyze otoliths to better estimate age.
6. This study reinforces the need for new technology to impact the life history of the fish.
7. There seems to be a lack of information for age 0 to 7 fish because it is driving the entire analysis. These assumptions for age 0 to 7 fish affect the overall Lambda. The system shows a steady population or decrease in the population or a Lambda of 1 or less.
  - a. Calculations for age 0 to 7 fish need to be calibrated to a Lambda of 1 and then undertake the analysis for changes in manipulation.
  - b. Once a fish reaches reproductive age, the age/length relationship can fall apart. The ages that are most critical at driving the projections are the ones that the Recovery Program does not have the data for. The age/length relationship is for those fish where the relationship is less reliable.
8. This study shows us the limitations of the current available data. CPUE data are not the appropriate data to use for this type of analysis.

## 4.5 Section Discussion – Effects of nonnative fish removal on the nonnative fish

### 4.5.1 Discussion Points Raised

1. Based on population estimates, it appears there are larger densities of channel catfish in the San Juan River than in the Yampa River, approximately twice the number. Bioenergetics analysis could help determine the impact. It might be helpful to compare relative abundance of channel catfish in other systems to the San Juan River. One solution is to provide population estimates for channel catfish. The population estimate could be used to demonstrate progress towards nonnative removal goals.
2. The Recovery Program is trying to evaluate the success without population estimates and only relying on CPUE. Population estimates are needed for this analysis. CPUE data are not enough.
3. Elverud's mark-recapture data are very important. The Recovery Program needs more information on the percentage of exploitation on the population. Age structure data and bioenergetics are also very important. Too much variability occurs in the CPUE data.
  - a. It would be worth the money to collect mark-recapture data.
4. Quantifying the effects of nonnative fish can be tricky. The group may need to consider other variables such as flow, sediment, etc. For example, channel catfish are probably more of a problem during low flows than during high flows.
5. The current population may be somewhere around 250,000 catfish or 1,000 catfish per river mile.
6. There are areas that may demonstrate the effects of nonnative fish removal. No catfish are present above PNM weir whereas the area below the weir has catfish. There are also areas of the river that have been hit hard by capture efforts. The Hogback reach or PNM weir to Shiprock reach may be good places to start.
7. Why are channel catfish the only nonnative fish species that have become well established in the San Juan River when other nonnatives have not?
  - a. In total, 35,000 channel catfish were removed in 2009. The Recovery Program needs to age some of these fish for the age key.
8. The issue was raised that Russian olive may be supporting the nonnative fish population. What is the trend in Russian olive becoming more dominant in the river system?
  - b. It is expected that benthic species, such as channel catfish, would respond to the increase in Russian olive trees first via the buildup of detritus from the trees.
  - c. Russian olive to channel catfish in the San Juan River could be analogous to crayfish introduction and smallmouth bass proliferation in the Upper Colorado River.
  - d. Channel catfish were present in the system before Russian olive became established.
9. There are a few data gaps that need to be filled before a response can be detected.
  - a. An exploitation rate for the entire river system needs to be established.

- b. The Recovery Program needs to calibrate catch curves. Juvenile fish (that are not being removed from the system; the gear does not effectively remove these fish) should be removed from the analysis in order to not dilute the biomass figures.
  - c. Does the number of 300- to 400-mm fish caught change over time?
  - d. The Recovery Program needs to develop solid catch curves for each monitoring program and apply them to the first year of recruitment.
10. It may be necessary to consider other equipment/methods for nonnative fish removal.
- e. Size selectivity with equipment – is there any other gear that could catch fish under 300 mm at representative abundance levels?
  - f. Could the Recovery Program use electric seines? This would require extra people to hold nets at the end of each reach. Flow conditions would need to be appropriate.
  - g. Equipment selection could help with catching smaller fish.
  - h. Electrofishing could affect the reproductive productivity of other fish species.
  - i. Is it possible to introduce spike flows to disrupt the catfish's spawning activities?
11. The Recovery Program has not been able to demonstrate that exploitation has changed the catfish population.
- a. The exploitation rate may not be large enough and the methods for detecting change may not be sensitive enough. Without population numbers it may be difficult to tell.
  - b. The 95-mile stretch of the San Juan River where nonnative fish removal does not occur frequently may be masking the effects of the exploitation efforts in other sections of the river.
12. Another issue to consider is carp populations. What would happen to carp population numbers if the Recovery Program was to stop the removal activities?
- a. Before the waterfall between the San Juan River and Lake Powell, carp moved into the river from the lake. The waterfall shut off reproduction of carp and removal efforts sped up the reduction of the species. The waterfall is not a permanent barrier.
13. Should the Recovery Program continue its current efforts with the increased removal effort in the middle reach or should the Recovery Program shift emphasis from nonnative fish removal efforts?
- b. Response: Sometimes the Recovery Program is too critical of its accomplishments. The work really just started in 2006, except for Elverud's efforts for the last six years. It may take more time to see a response.
  - c. Response: This is probably the wrong time to stop the removal effort.
  - d. Response: Mark-recapture data are important. The Recovery Program should consider substituting a mark-recapture river trip in place of a scheduled trip for catfish removal.

- e. Response: Size selectivity issues of electrofishing gear could hinder the exploitation levels. It was suggested that adjustments made in the field to electrofishing equipment be recorded; this would be helpful in comparing results to the Upper Basin.
- f. Response: The Recovery Program needs to develop a hypothesis for new data collection.

#### **4.5.2 General Discussion**

Most of the group members agreed the Recovery Program needs to continue to be vigilant in order to control problem nonnative fish and prevent any other nonnative species from becoming established in the San Juan River. The group emphasized that the Recovery Program should understand that the nonnative fish population will never be eliminated, but can be controlled at a reasonable level. The group discussed other techniques that could be implemented such as using electric seines, targeting spawning grounds to disrupt reproductive behavior, creating desirable spawning grounds for focused treatment (i.e., baiting), and focusing on vulnerable life history stages in order to better control the nonnative fish populations.

The group discussed budgetary limitations for the Recovery Program. Some group members expressed the concern that time is running out for new experiments to be proposed that could lead to a change in nonnative removal techniques. The Recovery Program may need to demonstrate the impact to channel catfish for future budget justifications and evaluations. It may be wise to piggyback the mark-recapture study with the current annual removal efforts; the mark-recapture study does not have to be approved as a separate project. The group also suggested that a request for proposals (RFP) could be a beneficial tool to engage universities or private entities to create nonnative species life tables.

There was general agreement on the following potential modifications to the current nonnative fish removal program and data needs:

- Need to look for response in nonnative fish before looking for response in native fish.
- Need to collect additional data and conduct analyses needed to detect response to nonnative fish control (e.g., collect otoliths to age channel catfish).
- Need to do additional mark-recapture monitoring to develop population estimates of nonnative fish populations and exploitation rates. Could do a mark-recapture effort in conjunction with current nonnative fish removal trips.
- Need to establish river-wide metrics such as constructing life tables for channel catfish, relative abundance estimates, and exploitation rates (this rate may not be that helpful if a population estimate is unavailable).
- Should consider looking for methods for capturing 300 mm and smaller fish.
- Should consider conducting bioenergetics analyses to help determine the impact of nonnative removal on nonnative fish.
- Should consider additional capture gears (e.g., electric seines).

- Should consider targeting spawning areas for removal activities, even if this means creating suitable spawning habitat.

## **5.0 NATIVE FISH RESPONSE TO NONNATIVE FISH REMOVAL**

### **5.1 Presentation - Summary of the San Juan River Larval Ichthyofaunal Surveys in Relation to Nonnative Removal Efforts (Michael Farrington, American Southwest Ichthyological Researcher, Albuquerque)**

Farrington presented on the Recovery Program's larval fish survey data. Larval Colorado pikeminnow surveys began in 1995 using drift-nets and larval razorback sucker surveys began in 1997 using light traps. Sampling methodologies shifted from passive to active (i.e. seining) sampling in 1998 for razorback sucker and in 2002 for Colorado pikeminnow. Beginning in 2003, the two projects were combined into a single ichthyofaunal survey with a uniform sampling protocol. Current sampling protocol consists of monthly sampling trips conducted between April and September from River Mile 141.5 (Cudei, NM) to 2.9 (Clay Hills Crossing, UT). Some level of nonnative fish removal has been occurring since the beginning of the larval surveys in 1995. Examining pre/post nonnative removal response of the larval community to nonnative removal is problematic. It was not until 2006 that intensive nonnative removal began in the majority of the larval fish survey study area. From 2006 to present, the entire larval survey study area and sections of river upstream have been the focus of intensive nonnative removal efforts. With the exception of fathead minnow, there was no significant change between 2003 and 2009 in the overall trend data for the most common species encountered in the San Juan River larval fish surveys. Given the number of biotic and abiotic factors that influence yearly catch rates of larvae, attributing any change to a single factor such as nonnative removal is difficult.

#### **5.1.1 Discussion Points Raised**

1. The San Juan River is in a dry period. The 10-year antecedent flows are low.
2. If the in-river source of carp has maintained stability, the main source of carp could be from Lake Powell. Carp production should drop off soon if there are not inputs of additional carp; however, carp is also present upstream and in the Animas River.

### **5.2 Presentation - San Juan River Small-Bodied Fishes 2009 (Dave Propst, New Mexico Department of Game and Fish, Santa Fe, NM)**

Propst presented on the Recovery Program's small-bodied fish survey data. Primary, secondary, and backwater species have been sampled since 1998. The most noteworthy finding is an increase in abundance of native fishes in the primary and secondary channels. Red shiner, a nonnative species, numerically dominated backwater collections in all years although their density is considerably less common now than it was during late 1990s and early 2000s. Generally, the density of nonnative small-bodied fishes has declined since 2003 and uncommon nonnative fishes increasingly rare. Native small-bodied fishes have been numerically dominant since 2004. Elevated summer flows are detrimental to nonnative fishes and the red shiner bounce in 2009 is a consequence of low summer

flows. His investigations show that the Recovery Program needs to look at flows and other physical conditions leading up to the time and during small-bodied fish sampling periods and look for common explanations for “bumps” in the data. Abiotic conditions can mask the population responses to nonnative fish removal. Additional investigations of the relationships among Colorado pikeminnow distribution, prey availability, habitat, and nonnative predators are needed and backwaters should be renovated.

### **5.2.1 Discussion Points Raised**

1. Where are catfish spawning? This presentation shows that young catfish are not monitored in the PNM–Hogback or Hogback–Shiprock reaches.
2. The Shiprock–Four Corners reach may be an area to focus on since many age-0 catfish are consistently sampled.
3. Does clear water such as in 2009 help with sampling efforts? It may contribute to the higher number of fish sampled.
  - a. Response: The Recovery Program can look for common explanations for “bumps” in the data.
4. Abiotic conditions can mask the population response to nonnative removal. The Recovery Program needs to look for a suitable response from nonnative removal that is less affected by “noise,” such as condition factor. Catfish have been in the San Juan River for more than 100 years, so the response to removal activities may be more subtle. Not seeing a response by the native fish to the removal of catfish does not mean catfish are not a problem. The native fish, the focus of this work, did not evolve with the catfish and the river has changed a lot since the native fish numbers were reduced.

### **5.3 Presentation - Overall Trends in the Adult Native Fish Community and how it relates to Nonnative Fish Removal (Dale Ryden, USFWS, Grand Junction, CO)**

Ryden reported on the Recovery Program’s sub-adult/adult large bodied fish monitoring data. Large-bodied fish have been sampled river-wide since 1991. The native fish population has not shown any tangible positive population response which can specifically be attributed to nonnative fish removal efforts. This could be explained by the timing of when adult monitoring began in 1991. Colorado pikeminnow and razorback sucker had over a hundred year’s exposure to common carp and 30-40 years exposure to channel catfish in the San Juan River. There is no comparison of how these fish were doing before and after the introduction of nonnative species. They may have reached some kind of equilibrium with channel catfish and common carp. Any large-scale responses from these two species may not be seen until levels of nonnatives are much lower than their current levels. The large numbers of Colorado pikeminnow (predators) and razorback sucker (competitors) stocked by the Recovery Program are likely filling some of the voids and utilizing some of the resources that have been freed up by removing nonnatives. When looking for responses among native fishes in connection to nonnative fish removal, Colorado pikeminnow and razorback sucker may not be the correct species to use. Both species in the San Juan River were extremely stressed when monitoring began in 1991. Colorado pikeminnow were nearly extirpated and razorback sucker were extirpated.

Currently, these two species are not necessarily reflective of how a wild population would react in the presence of an incursion by channel catfish and common carp. Additionally, no data is available to assess rare fish augmentation prior to nonnative fish removal since both have been occurring concurrently.

The Recovery Program should determine if the current monitoring effort is correctly designed to detect the effects of nonnative fish removal on the native and nonnative fish populations. For example, could age structure data, bioenergetics analysis, or channel catfish population estimates help determine impact? If the current methodologies are not able to detect response, the Recovery Program should determine what methods are needed and incorporate them into the comprehensive monitoring plan.

#### **5.3.1 Discussion Points Raised**

1. Colorado pikeminnow may be replacing the predator role for bluehead and flannelmouth sucker. The Recovery Program may need to look to the Colorado pikeminnow and razorback sucker for evidence of response to the nonnative fish removal.

### **5.4 Section Discussion - Effects of nonnative fish removal efforts on the native fish community**

#### **5.4.1 Discussion Points Raised**

1. Channel catfish are known to eat native fish, but are they eating enough to be a problem?
2. Is the Recovery Program looking at the wrong indicator species when considering the impacts on native species?
3. The roundtail chub in the Yampa River kept a steady population even though channel catfish were present. Smallmouth bass is the problem on that river system.
4. Just because a change in the native fish population has not been detected, it does not mean that nonnative fish removal is not successful. There might be less native fish if it were not for these efforts.
5. What are the prevailing theories for why the roundtail chubs are not in the system? Habitat features suggest they should not disappear. Prior to Navajo Reservoir, roundtail chub was a common fish but by the mid-1970s, the fish was gone.

#### **4.4.2 General Discussion**

The group discussed the material that had been presented, as well as what information is needed to understand the threat that channel catfish poses to the native fish community.

The group seemed to be in disagreement about whether channel catfish pose a risk to native fish populations. Some group members argued that nonnative fish are not a problem in the San Juan River, unlike other river systems. One member of the group said an Upper Colorado River Basin

paper rated channel catfish as a low threat to the native fish community. Another member said that in most cases when you have a problem with a predator, populations of native fish are stressed and native fishes in the San Juan River do not seem to be stressed. Another group member responded that the Recovery Program may not be able to detect that stress in the Colorado pikeminnow and razorback sucker populations because there are very few native fish in the river system. The dialogue continued regarding the risk to the native fish community from channel catfish.

The group agreed more information is needed to determine the threat to natives in the system. The expectation is to first see a response in the nonnative fish population as a result of nonnative fish removal before a response in the native fish populations would be evident. Traditional response metrics, such as size structure, length frequency, and early maturation of reproductive fish, could be used to detect a change in an exploited fish population. It was suggested that it may be too soon to see a response to the nonnative fish removal because the 95-mile middle reach of the San Juan River has not undergone nonnative fish removal efforts for as long as the upper and lower reaches.

Two statements could summarize the issue: 1) the effect of nonnative fish on native fish in the San Juan River system is unknown, and 2) a response by native fish may not be seen because a response in nonnative fish has not been seen yet.

## **6.0 NONNATIVE FISH REMOVAL METHODS**

### **6.1 Presentation - Impacts of Electrofishing Exploitation on the Introduced Flathead Catfish Population in the Satilla River, Georgia (Tim Bonvechio, Georgia Department of Natural Resources)**

Bonvechio reported on the impacts of electrofishing exploitation on the introduced flathead catfish (*Pylodictis olivaris*) population in the Satilla River in Georgia. From 1996-2006 with a limited effort, 12,020 flathead catfish were removed from the river but the number and size of flathead catfish per hour of electrofishing continued to increase. Starting in 2007, a three-year intensive removal effort was initiated and between 2007 and 2009, 13,472 flathead catfish were removed or more than 42,570 pounds of fish. The size and length of catfish removed were significantly affected with the average size/length of fish removed dropping from 5.8 pounds/512 mm TL in 2007, to 2.9 pounds/352 mm TL in 2008, to 1.4 pounds/281 mm TL in 2009. Biomass per effort also declined from 57.1 kg/hr in 2007, to 23.6 kg/hr in 2008, to 19.9 kg/hr in 2009. The age structure was also truncated by removal efforts. In 2007, 15% of population was made up of Age-1 and Age-2 fish, and it was dominated by a strong 2003 year-class of Age-4 fish (50%), and 5% of the population consisted of fish Age-6 or older. In 2008, the strong 2003 year-class of now Age-5 fish was still present and made up 13% of the population and the same amount of older fish (>age-6) still comprised 5% of the population, but the population began to show signs of being heavily exploited because 50% of the catch was now Age-1 or Age-2 fish. In 2009, the age structure data revealed a typical population that has received high exploitation characterized by a large numbers of small fish (<356mm TL), with over 80% of the fish being Age-1 or Age-2 and only 3% of the population was

Age-6 or older, including that once strong 2003 year class. Despite the dramatic changes demonstrated in the biomass and age and size structure, there was evidence of higher recruitment and earlier maturation. The electrofishing catch rate increased dramatically in 2009 to 32.5 fish per hour in comparison to 22 fish per hour in 2007 and 18 fish per hour in 2008. Gravid females turning Age-2 were found ranging in size from 200 to 251 mm TL. There appeared to be a shift in sexual maturity due to over a decade of increased exploitation. This could be a textbook example of how the Satilla River flathead catfish are adjusting to high levels of exploitation, otherwise known as a compensatory mechanism in fish population dynamics.

Maintenance control of flathead catfish in the Satilla River is possible given the reported changes in biomass and size and age-structure but higher recruitment and earlier maturation was demonstrated. Continued intensive harvest will be required to prevent the flathead population from rebuilding within 2 to 5 years. Bonvechio said it has been difficult to detect the effects of catfish removal in the Satilla River on the native redbreast sunfish (*Lepomis auritus*).

### 6.1.1 Discussion Points Raised

1. Do you think your results are related to the timing of removal efforts after introduction?
  - a. Response: The Georgia DNR initiated removal efforts immediately after the species was introduced (1996). The numbers removed in the early years (1996–2006) were low, so the DNR only kept the population in check.
  - b. Response: On other river systems in Georgia (e.g., Altamaha River), the nonnative fish were left alone because they were favored by the anglers.
2. What has been the response by the redbreast sunfish?
  - a. Response: The data are still noisy regarding the response of the sunfish. The first year with a favorable water year in recent history is 2010.
  - b. Response: It has been difficult to detect the native response to the removal effort.
3. Was the fisherman prosecuted for the illegal introduction?
  - a. Response: The DNR has pursued the fisherman, but enforcement funds are limited. The DNR is required to catch a person in the act of physically introducing a nonnative fish to the river.
4. How bad did the redbreast fishery get during the years of the catfish introduction?
  - a. Response: The fishery did not collapse because there is not suitable catfish habitat upstream in the Satilla River. The redbreast population source is currently upstream to repopulate the downstream populations.
5. Is anyone looking at the response by other native fish in the Satilla?
  - a. Response: The DNR looks at the native sport fish.
  - b. Response: Bonvechio is looking at changes in all catfish populations. Channel catfish and white catfish (*Ictalurus catus*) are also present.
6. Are the younger catfish eating the redbreast sunfish? The DNR could be creating more mouths to feed by shifting the age structure of the populations.

- a. Response: There could be large ecosystem-level impacts from the project.
  - b. Response: The biology of the redbreast sunfish is not protective of the species. They tend to feed in open, moving waters that catfish prefers.
7. What is the sustainability of this removal program? Can you maintain a budget of \$100,000 per year into perpetuity? What is the long-term view of this removal program?
- a. Response: The difference between Satilla River and San Juan River is recreational fish versus Endangered Species Act compliance issues.
  - b. Response: Other state agencies are watching this project because they also have nonnative fish populations that need to be controlled.

## **6.2 Presentation - Triploid Flathead Catfish Production & Where Do We Go From Here? (Tim Bonvechio, Georgia Department of Natural Resources)**

Bonvechio presented on triploid flathead catfish investigations by Professor Rex Dunham, Auburn University. Physical removal of nuisance species is one option that has had success, but is not a cure all for complete eradication. New innovative approaches are available for evaluation, as physical removal continues. The literature demonstrates that introduction of sterile triploid males into an effected ecosystem could result in reduced numbers of the diploid conspecifics. Theoretically, triploid males would be capable of courtship and mating behaviors, stimulating females to mate and release eggs, but they would be unable to successfully fertilize the female's gametes. This "screwfly" approach may be a mechanism to control reproduction of nuisance species. To produce triploids, 53 flathead catfish were captured in May 2007 from the Satilla River and delivered to Auburn's E.W. Shell Fisheries Research Center. Treatments were conducted during ovulation and hatching to produce triploids. Thirty triploids were produced and released into 2-acre ponds but only two survived into adulthood and growth rates were extremely poor. Dunham has expressed interest in conducting further research but funding will be needed. More broodstock adult flathead catfish will require spawning to produce more triploids. Triploid techniques are much more advanced for channel catfish artificial reproduction than for flathead catfish. Piggy-backing triploid work with Auburn University on both flatheads and channel catfish may have possible application for the San Juan River. Bonvechio emphasized the need for more lab research on the concept of triploidy before Georgia DNR would be in any position to introduce triploid catfish into the Satilla River.

### **6.2.1 Discussion Points Raised**

1. What is the basis for the assumption that a triploid flathead catfish male would be capable of courtship and mating behaviors if they are lacking the hormones to drive the process?
  - a. Response: This is a good point; however, the literature demonstrates that the fish will mate.
2. How does this solve the redbreast sunfish issue if you are stocking the system with large, but sterile fish?
  - a. Response: This concept still needs more research; the Georgia DNR is not ready to introduce the fish into the Satilla River.

3. How many triploid fish would you need to introduce into the population to have an impact?
  - a. Response: This concept still needs more research; the Georgia DNR is not ready to introduce the fish into the Satilla River.

### **6.3 Presentation - Nonnative Fish Removal in the Columbia Basin Thomas Poe (U.S. Geological Survey [USGS], retired)**

Poe gave a presentation on effectiveness and strategies of nonnative fish removal efforts in the Columbia River Basin. In the 1980s, studies showed native northern pikeminnow (*Ptychocheilus oregonensis*), an endemic species of the Columbia and Snake rivers, consumed more juvenile salmonids than the nonnative predators. Northern pikeminnow are opportunistic feeders that typically select the most abundant prey item which fluctuates seasonally in the Columbia and Snake rivers but most noticeably involves juvenile salmon and steelhead as they undergo mass emigration to the ocean. Northern pikeminnow are an effective predator in low flow conditions provided by lakes, dams, or water diversions. The construction of hydroelectric dam facilities on both the Columbia and Snake rivers altered the natural stream flow and aided in increasing optimum habitats used by northern pikeminnow. In the 1990s, a predator removal effort was launched in the lower Columbia and Snake rivers to reduce system-wide juvenile salmonid mortality by northern pikeminnow. To reach desired exploitation levels, the program operates as a targeted northern pikeminnow sport-reward fishery with a tiered reward system. The first 100 fish are worth \$4 each, the next 300 are worth \$5 each, and anything over the 400th fish is worth \$8 each. The “lottery effect” is used to stimulate angling effort and ensure high tag return rates by annually making some tagged northern pikeminnow worth \$500.

In addition to northern pikeminnow, two non-native species, smallmouth bass and walleye, are monitored to determine if any of these piscivores are exhibiting compensatory responses to prolonged exploitation from the removal program. The goal is to maintain a 10-20% exploitation rate which was modeled to have a disproportional effect of 50% reduction in predation. Northern pikeminnow have been successfully targeted with over 25,000 angler days put in by program anglers in 2007. Over three million northern pikeminnow have been removed system-wide between 1991 and 2007 with minimal bycatch. The exploitation rate is generally maintained in the 10-20% range (>10% exploitation achieved in 13 of 15 years) but the 50% reduction in predation has not been achieved. Maximum, median, and minimum estimates of potential predation is calculated based on the potential differences in exploitation and consumption rate. The modeled median reduction in predation does not reach the 50% prediction. It appears to have leveled off at about 38%, with a range of 21-55%, and no dramatic future reductions in predation are expected. Overall the program is a success. They have reduced salmonid predation by an estimated 22% in a cost-effective manner and over 30 journal articles have been published documenting some of these results. A lack of a compensatory response by the piscivore community in previous reviews of the removal program and in other reservoirs and reaches could be the result of a limited time scope and may yet appear in the future as northern pikeminnow can live longer than 20 years and do not reach sexual maturity until ages 4 to 6.

Poe's recommendations for the Recovery Program were: explore potential for a sport reward fishery for channel catfish (although this seems unlikely as there is not much angling pressure on the San Juan River), increase tag studies (active and passive tags including PIT tags), install PIT tag detector arrays to monitor seasonal movements of target PIT-tagged catfish, obtain more information on early life history to adult and age and size structure of channel catfish population, continue food habits studies (e.g., gastric evacuation studies in lab; importance of Russian olive in catfish diets), determine exploitation rates of channel catfish, and study electrofishing effects on native fishes. He also emphasized prevention over control measures because once a population of non-native species is established, removal is extremely difficult if not impossible.

### 6.3.1 Discussion Points Raised

1. In the Columbia River Basin example, not enough catfish were captured to calculate population estimates.
2. Establishing a commercial or sport reward fishery in the San Juan River has not been considered because there is not much angling pressure on the San Juan River.
3. Has the 22% decrease in salmonid predation, resulted in an increase in juvenile salmonids?
  - a. Response: Modeling indicates there is an increase.
4. This may be the third major study that does not demonstrate response by native fish species after nonnative removal.
5. Do you have a sense of the state and federal commitment to prevention? Nonnative species of crayfish (Astacoidea) are becoming an issue.
  - a. Response: The state is looking for macro-invertebrates and zebra mussels (*Dreissena polymorpha*); however, it is hard to enforce introduction by outside sources.
6. Has there been an increase in the northern pikeminnow populations after the dams were built?
  - a. Response: Studies show the population has increased in recent history, possibly corresponding with dam construction. Northern pikeminnow have responded by feeding at the dams. Other predators have not had a similar responses to the dam system in the river basin.
7. What do pikeminnow eat when the salmon spawning run is over?
  - a. Response: Their diet strategy changes to crayfish, sculpin (Cottoidea), and juvenile suckers when the spawning run is over.
8. The time period is narrow for salmonids moving in the river. Can the salmonid population be increased to overwhelm the pikeminnow when they are moving downstream?
  - a. Response: This was attempted with hatcheries but there are other sources of mortality such as birds and turbines. Northern pikeminnow switch food sources around spawning season.

## **6.4 Presentation - Innovative Conservation Technologies for the Protection and the Re-establishment of Endangered and Native Fishes (Jackson Gross, USGS Northern Rocky Mountain Science Center, Bozeman, MT)**

[This text has not been edited by Gross]

Invasive species negatively affect native species and have ecosystem-wide impacts. Since introduction of lake trout into the Yellowstone ecosystem, Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) populations have declined dramatically. Loss of pure strains of Yellowstone cutthroat trout can alter the genetic integrity of the species within the Basin. There are many invasive fish, but few management methods proven to be successful. Limitations and challenges include costs, time, and logistics (size of waterbodies, consequences of killing other species). Methods used for integrated suppression management could be physical (electricity, suction/blowing, seismic, barrier netting, egg/fry traps), covers (polymers, tarping), light (visual/uv), biological (genetics, triploids, trojans), pheromones, nutrition (deficiencies, supplementation), predators, or chemical (gases/oxidizers such as carbon dioxide, hydrogen peroxide, chlorite, peracetic acid). Most current methods primarily target adult fish. Gross is interested in looking at lethal or nonlethal methods that might affect specific life stages at critical periods of susceptibility. He recently did a study on the effects of seismic air gun use on pallid sturgeon in Lake Sakakawea in North Dakota. The company uses seismic air gun technologies for oil and gas exploration in the reservoir. They had concluded there was no possibility that using this instrument would result in fish kills of any significance because of the relatively low peak pressure and moderate rise-time of the air gun pulse. Gross found significant mortality in exposed juvenile pallid sturgeon after 14 days. On the other hand, the same technology could hypothetically be used as a diversion barrier for control, herding, and eradication of nuisance species such as Asian carps.

Gross said he would be interested in looking at the effects of electrofishing on razorback sucker reproduction. He said the Recovery Program should not presume that current electrofishing is not having a long-term effect on the existing fish community. Studies indicate potential impacts on egg and sperm development. Effects may not be detectable at this time and could vary with species. It would be useful to know the effects on both razorback sucker and channel catfish. He said the study would be low cost but would require hatchery space and time. He also questioned if Russian olive seeds/fruit could be bioengineered and used as nutritional technology to control channel catfish.

### **6.4.1 Discussion Points Raised**

1. Have you looked at the effects of electrofishing on eggs in females?
  - a. Response: No, but Gross is interested in conducting experiments on razorback suckers to consider this question.
2. Knowing the effects of electricity, what would you predict the impacts to be on gravid razorback sucker females?
  - a. Response: Studies indicate potential impacts on egg and sperm development. It would depend on the stages of susceptibility and when the electroshock occurs.

- b. Response: It would be a low cost study to determine the effects; space and time are needed to conduct the study. This could possibly take place at Dexter National Fish Hatchery.
    - c. A study was conducted on catfish in the Southeast but it is unknown whether you would see the same effect on a fecund females of different species. It would be beneficial to know the potential impacts on both catfish and razorback sucker.
  3. Have any of the technologies been successfully implemented to impact nonnative species?
    - a. Response: Gross and his team have been together for one year and are implementing some of these technologies in the field for testing.
    - b. Response: These technologies seem like they would have profound effects on the entire fish communities. Although current electrofishing techniques on the San Juan River do not appear to be having long-term effects on the existing fish community, it would be presumptuous to think the Recovery Program is not affecting the fish community. Effects may not be detectable at this time.
  4. Could backpack electroshock technology be targeted at catfish spawning areas?
  5. Could bioengineered Russian olives seeds or fruits be used as a nutritional technology to control catfish?

### **6.5 Section Discussion - Applicability of alternative non-native fish removal methods in the San Juan River**

The group discussed the use of biological control, such as a virus, to inoculate the nonnative channel catfish population. This idea was not carried forward in discussion due to concerns about public pushback, and the State of Utah would be unlikely to agree to such treatment options.

## **7.0 RECOMMENDATIONS AND MEASURES**

After all presentations were given and discussed, the group focused on making recommendations that could be incorporated into the Recovery Program's nonnative species management program. Seven main recommendations were identified as a result of discussions throughout the workshop. The discussion is captured below. [Appendix B](#) includes a compiled list of the recommendations and measures identified.

1. The Recovery Program should continue intensive removal efforts while considering possible modifications. The removal effort in the middle reach of the San Juan River needs more time before any significant modifications are made in the removal program. Mark-recapture data needs to be collected in order to develop population estimates of nonnative fish populations and to inform exploitation rates. One nonnative removal trip in the upper section of the San Juan River could be replaced with a mark-recapture trip. Three 3-day removal trips could be replaced with one 9-day mark-recapture trip in the spring of 2011. The goal would be to tag 3,000 fish with both pit tags and external tags for mark-recapture data to inform an exploitation rate. This rate would be used to determine how much the removal effort could be reduced or increased to see a response in nonnative fish populations.

2. The Recovery Program needs to place emphasis on detecting a nonnative response to the removal effort. Less emphasis needs to be placed on detecting a native response to removal efforts at this time. Once a response is detected in nonnative populations, the Recovery Program can begin to look for native fish responses. By focusing on a nonnative response, qualifying and quantifying the degree of threat to native fish species can begin.

The group discussed expanding removal techniques to better capture juveniles (less than 300 mm) to reflect a proportional sample of all life stages. To accomplish this, other methods and gear types (e.g., electric seines, different electrofishing units, and types of nets) that more effectively capture smaller fish will need to be evaluated. The group recognized that by changing methods and gear types, the continuity of the data may be affected. The focus on removing nonnative fish using current methods and gear can continue but fish crews could be trained to better remove smaller fish from the river. All nonnative fish removal techniques, staff training, equipment/gear use, equipment calibration, waveforms, and procedural aspects should be standardized.

3. The Recovery Program needs to establish metrics and develop milestones/targets to detect response of nonnative fish to removal efforts and measure success of the nonnative fish removal program.

Recovery Program-specific catch curves and retrospective analysis needs to be established. Separate curves for Ryden's monitoring program and Davis' fish removal program could be computed and compared. The first fully recruited size class could be used to calculate the change in the first fully recruited age group to the gear. Bonvechio suggested using Catfish Otolith Aging Workshop information under the Catfish link on the Southern Division of the American Fisheries Society website. When calculating condition factor for the fully recruited age groups, the analysis should be stratified. Finally, the Recovery Program should develop milestones for evaluating success of the nonnative fish removal program or moving to another plan.

4. The Recovery Program needs to pursue other activities and information including establishing stocking policies, collecting additional data, and conducting analyses in support of the nonnative species management program. Using data that currently exists, a basic bioenergetics analysis could be conducted. Consumption by catfish relative to the standing stock of productivity should be estimated. The model has been developed; however, the data are not strong enough to parameterize the model. Stomach content analysis should be continued. Further analysis to detect native and nonnative response could be coordinated with the New Mexico Department of Game and Fish.

Additional data analysis efforts should include determining the age of first reproduction on a small subsample of nonnative fish. Life tables for channel catfish need to be improved and completed. This effort would build upon Morel's initial study. McKinstry and Gross indicated they would pursue a study for determining the effects of electrofishing on nonnative and native fish reproduction. Other potential actions recommended included: upgrading equipment, investigating target areas for increased nonnative fish removal (e.g., spawning grounds, baited areas), and experimenting with electric seines for small-bodied fish monitoring.

Related San Juan River research conducted outside of the Recovery Program (e.g., Morel's population modeling, Patton's catfish diet analyses, Gido and Propst data syntheses) provides invaluable information to inform management actions and can typically be done for less money. The Recovery Program should utilize RFPs as a beneficial tool to engage universities, agencies, or private entities to answer important questions by analyzing existing data or doing original research.

5. The Recovery Program needs to develop alternative nonnative fish removal strategies and methods. This includes developing recommendations for specific flow events for nonnative control. An "Achilles Heel" of the nonnative fish community needs to be identified, such as temperature sensitivity for the channel catfish, targeting of spawning grounds, or potential hormone attractants to improve fish removal. Removal strategies based on available data could then be modified.

The Recovery Program should consider new technologies such as floating weirs and/or permanent selective fish passages and permanent fish barriers above the waterfall at the inlet to Lake Powell. Larvae and young-of-year data could be tracked to identify preferred reaches of the San Juan River.

6. The Recovery Program needs to consider the threat from other nonnative species. There are institutional solutions, such as a zero tolerance policy for introductions and stocking policies. A San Juan River risk assessment is another beneficial tool. The risk assessment should be expanded to include topics such as:
  - a. Other nonnative species, e.g., crayfish, smallmouth bass, walleye, striped bass, and small-bodied nonnative fish
  - b. New sources of nonnative species in the system that could sustain and increase in population size
  - c. Significant events that could occur at the reservoirs
  - d. Changes in the ecosystem downstream, such as thermal regime change and increase in crayfish populations
  - e. Hybridization (white sucker [*Catostomus commersonii*] hybrids)
  - f. Aquatic invasive species (e.g., quagga mussels [*Dreissena rostriformis bugensis*])
  - g. New and existing reservoirs including Lake Powell, Lake Nighthorse, and Morgan Lake (gizzard shad)
  - h. The relationship of nonnative populations to climate change

The group recommended the Coordination Committee on behalf of the Recovery Program write a letter to the State of Colorado and Bureau of Reclamation supporting the "no release policy" at Lake Nighthorse. The group also emphasized preventing the introduction of nonnative species needs to be part of the Recovery Program's nonnative species management program and adequately covered in the LRP. Regular monitoring by the Recovery Program and coordination with other agencies, and States and Tribes are important in preventing nonnative species introductions.

7. The Recovery Program needs to develop a document that establishes a comprehensive nonnative species management plan. To date, nonnative species management, monitoring, and analyses has been fragmented. The plan needs to be integrated with the other Recovery Program activities and describe fish removal and monitoring protocols being implemented. The plan should also discuss strategies, thresholds, priorities, data integration, and adaptive management.

## **8.0 WORKSHOP SUMMARY**

Participants of the workshop concluded that current intensive removal of nonnative fishes needs to continue at some level. Nonnative fish pose a serious threat to the viability of the native fish community and the recovery of razorback sucker and Colorado pikeminnow. Electrofishing removal programs are a reasonable management option where a top-level predator like channel catfish has been introduced, recognizing that continual, long-term removal may be required to maintain levels of lowered biomass. Nonnative removal on the San Juan River has effectively reduced the potential negative impacts common carp may pose on the native fish community. Although overall numbers of channel catfish have not been reduced, changes in distribution, mean TL, mean biomass, condition factor, and age and size class structure are being detected. Young-of-year monitoring data has shown that the density of smaller nonnative fish have declined since 2003, native fish have been numerically dominant since 2004, and uncommon nonnative fish are increasingly rare.

Positive population responses of native fishes have not been observed since the initiation of intensive nonnative fish removal. This lack of response may be the result of a limited time scope. Given the number of biotic and abiotic factors that influence yearly catch rates of fish, attributing any change to a single factor such as nonnative removal is difficult and intensive river-wide removal only began in 2008. Any large-scale response from razorback sucker and Colorado pikeminnow may not be seen until levels of nonnatives are much lower than their current levels. Additionally, no data is available to assess rare fish augmentation prior to nonnative fish removal because both have been occurring concurrently.

To detect response, the Recovery Program may need to focus on species other than the two endangered fish. Workshop participants agreed that the focus for evaluating the success of the nonnative fish removal program should be on detecting a response of nonnatives, at least initially. Participants of the workshop recognized the need to determine if the current monitoring and data collection methods are correctly designed to detect the effects of nonnative fish removal on the native and nonnative fish populations. For example, could age structure data, bioenergetics analyses, or channel catfish population estimates help determine impact. If the current methodologies are not able to detect response, the Recovery Program should determine what methods are needed and incorporate them into the comprehensive monitoring plan.

Another strong message that came out of the workshop was the importance of prevention in managing nonnative species. Nonnative introductions are not limited to fish and all introduced nonnative aquatic species have the potential to become an invasive species. Intentionally or illicitly

introduced or stocked aquatic species undermine recovery actions. Nonnative species that are already in the system but not currently a problem need to be tracked because any number of events could potentially trigger a problem. For the San Juan River, a waterfall at Lake Powell currently keeps nonnative fish from entering the river from that source but the waterfall is not permanent and other reservoirs in the basin could be sources. The Recovery Program needs to be vigilant in preventing the introduction of all nonnative species by approving a comprehensive nonnative fish stocking policy for the Basin and tracking nonnative species that are already present in the system.

Possible modifications to the Recovery Program's current nonnative fish removal program were identified during the workshop. Some can be implemented in 2011 such as adding a channel catfish mark/recapture study in the upper/middle reach to inform exploitation rates. Other measures will require further investigation before implementation. A task identified during the workshop was to develop a comprehensive nonnative species management plan to insure the Recovery Program has an effective and cost-efficient program to reduce the threat of all nonnative species to the recovery of the listed species. The plan will include monitoring protocols, removal protocols, strategies, data integration, milestones/targets, and an adaptive management component. The Recovery Program will consider all actions, methods, data needs, and research questions identified during the workshop for inclusion in the nonnative species management plan.

No known strategy will eliminate unwanted nonnative fishes from the San Juan River and the Recovery Program will need to continue reducing their populations to a level that minimizes or removes threats to the recovery of razorback sucker and Colorado pikeminnow. Mechanical removal of nonnative fish will continue to be supported by the Recovery Program as one management tool for accomplishing this recovery activity. The Recovery Program will also utilize other measures to effectively accomplish this recovery action such as establishing stocking procedures to prevent invasive species introduction, conducting regular reviews to evaluate results, modifying methods when indicated, initiating studies to answer important questions, and coordinating with other programs in the Upper Colorado River Basin to share information.

## Appendix A – List of Attendees at the SJRRIP Nonnative Fish Workshop (May 26–27, 2010)

Attendees	
Organization	Attendee(s)
American Southwest Ichthyological Research Foundation (ASIR)	W. Howard Brandenburg Michael Farrington Steve Platania
Bureau of Indian Affairs	Michael Howe Keith Lawrence
Colorado Department of Wildlife/USFWS	Pat Martinez
Georgia Department of Natural Resources	Tim Bonvechio
Jicarilla Apache Nation	Paul Holden Warren Vigil
National Park Service	Melissa Trammell
Navajo Nation	James Morel
New Mexico Department of Game and Fish	David Propst
Southeast Oklahoma State University	Tim Patton
Southern Ute Tribe	Bill Miller
SWCA Environmental Consultants	Coleman Burnett
U.S. Bureau of Reclamation	Mark McKinstry Dave Speas
USFWS	Jim Brooks David Campbell Jason Davis Bobby Duran Scott Durst D. Weston Furr Dale Ryden Ernie Teller Sharon Whitmore
U.S. Forest Service	Mel Warren*
U.S. Geological Society	Jackson Gross Tom Poe (retired)
University of New Mexico	Steve Ross*
Utah Division of Wildlife Resources	Darek Elverud
Utah State University	Ron RyeI*
Water Development Interests	Tom Wesche

\*Indicates a peer reviewer for the SJRRIP

## **Appendix B – Recommendations and Measures for Improving the Effectiveness of the SJRRIP’s Nonnative Species Program** (developed at the May 26-27, 2010 SJRRIP Nonnative Fish Workshop)

1. Continue current intensive removal methods with possible modifications
  - a. Conduct mark/recapture studies to develop population estimates of nonnative fish populations and to inform exploitation rates (e.g., switch three 3-day control trip in April in upper section with one 9-day marking trip)
  - b. Emphasize removal techniques to capture all life stages (proportional catch)
  - c. Standardize methods (e.g., equipment/gear, wave form, procedural aspects)
2. Emphasize detection of nonnative fish response to the nonnative fish removal program
  - a. Place less emphasis on detection of native response at this time.
  - b. Focus on detection of response in nonnatives (the degree of threat to natives can then be qualified/quantified)
  - c. Develop monitoring metric(s) to quantify nonnative response.
  - d. Establish criteria for measuring success and to trigger modifications to existing techniques.
3. Establish metrics and develop milestones/targets to detect response of nonnative fish to removal efforts and measure success of the nonnative fish removal program.
  - a. Establish metrics, recalibrate catch curves with emphasis on narrower size/age range
  - b. Develop project-specific catch curves; retrospective analysis
  - c. Continue weight/length analyses
  - d. Develop river-wide exploitation rates
  - e. Develop milestones/targets for evaluating response
4. Pursue other activities and information identified during the workshop in support of the nonnative species management program.
  - a. Institute Nonnative Fish Stocking Policy
  - b. Upgrade equipment based on new information
  - c. Monitor age at first reproduction
  - d. Continue developing life tables for channel catfish (Morel’s work)
  - e. Develop SOW to investigate effects of electrofishing on nonnative and native fish reproduction (McKinstry/Gross)
  - f. Use existing data to answer questions (data integration)
    - i. Further analyses of nonnative and native fish response in coordination with Gido
    - ii. Estimate consumption by channel catfish relative to standing stock of productivity
    - iii. Stomach content analysis (two more samples will be taken by Morel)
    - iv. Low Priority: Bioenergetics (e.g., Russian olive)
  - g. Utilize RFPs as a tool to engage universities, agencies, or private entities to answer important questions by analyzing existing data or doing original research
5. Investigate alternative strategies and methods for managing nonnative species and modify current nonnative species management strategies/methods when appropriate
  - a. Investigate techniques for targeting areas to increase nonnative fish removal (e.g., at spawning grounds, baiting, attractants)

- b. Evaluate other capture gear (e.g., electric seines)
    - i. Gear types for size selectivity to capture fish under 300 mm and smaller
  - c. Investigate floating fish weirs and/or selective fish passages to block movement of nonnative fish including from Lake Powell
  - d. Find the “Achilles Heel” of channel catfish and common carp (e.g., channel catfish temperature sensitivity and spawning grounds)
  - e. Manage flows for nonnative fish control (data integration and flow recommendations revision)
  - f. Use RFPs for engaging universities or private entities to obtain needed information (nonnative fish life tables, otoliths for aging)
6. Assess and plan for threats from other nonnative species
- a. Institutional (prevention, stocking, policies)
    - i. Zero tolerance policy
    - ii. Recommend the Coordination Committee write a letter to Reclamation about Lake Nighthorse fish stocking supporting a “no release policy” at the reservoir
    - iii. Insure actions and tasks for nonnative species prevention is included in the LRP
  - b. San Juan River risk assessment/contingency plan – include as part of threats assessment
    - i. New/existing reservoirs; Lake Powell
    - ii. Crayfish
    - iii. White sucker
    - iv. Aquatic invasive species (e.g., Quagga mussels)
    - v. Other nonnative fish species (e.g., red shiner, mosquito fish)
    - vi. Establish thresholds for dealing with other nonnative species (current threats seem to be seasonal, i.e. striped bass, walleye); risk assessment targets
    - vii. Climate change relationships
7. Develop a comprehensive, long-term nonnative species management plan that includes:
- a. Monitoring protocols
  - b. Removal protocols
  - c. Hypotheses/strategies and measures of success
  - d. Data integration
  - e. Adaptive management framework (i.e., develop measures/strategies, implement actions, analyze actions/results, adjust/modify measures/strategies/actions based on results)

## **Appendix C – PowerPoint Presentations at Nonnative Fish Workshop (May 26–27, 2010)**

1. Nonnative Species Interactions: Summary of Past and Present Work on the San Juan River, 1991–2010 (Jason Davis, U.S. Fish and Wildlife Service [USFWS], Albuquerque, NM)
2. Diet of Channel Catfish in the San Juan River: Preliminary Results (Tim Patton, Southeastern Oklahoma State University)
3. Invasive and Illicitly Introduced Aquatic Species: Perspectives from the Upper Colorado River Basin (Patrick Martinez, Colorado Division of Wildlife/USFWS, Grand Junction)
4. Mechanical Removal of Large Bodied Nonnative Fishes in the Upper/Middle San Juan River 2001–2009 (Jason Davis, USFWS, Albuquerque, NM)
5. Nonnative Removal Efforts the Lower San Juan River (Derek Elverud, Utah Division of Wildlife Resources, Moab)
6. Nonnative fish response to nonnative fish removal (Dale Ryden, USFWS, Grand Junction, CO)
7. Effects of Nonnative Fish Removal on Nonnative Fish – Modeling of Population Response of Channel Catfish to Nonnative Fish Removal Efforts (James Morel, Navajo Nation)
8. Effects of Nonnative Fish Removal on Nonnative Fish Community
9. Summary of the San Juan River Larval Ichthyofaunal Surveys in Relation to Nonnative Removal Efforts (Michael Farrington, American Southwest Ichthyological Researcher, Albuquerque)
10. San Juan River Small-Bodied Fishes 2009 (Dave Propst, New Mexico Department of Game and Fish, Santa Fe, NM)
11. Overall Trends in the Adult Native Fish Community and How it Relates to Nonnative Fish Removal (Dale Ryden, USFWS, Grand Junction, CO)
12. Impacts of Electrofishing Exploitation on the Introduced Flathead Catfish Population in the Satilla River, Georgia (Tim Bonvechio, Georgia Department of Natural Resources)
13. Triploid Flathead Catfish Production & Where Do We Go From Here? (Tim Bonvechio, Georgia Department of Natural Resources)

14. Nonnative Fish Removal in the Columbia Basin Thomas Poe (U.S. Geological Survey [USGS], retired)
15. Innovative Conservation Technologies for the Protection and the Re-establishment of Endangered and Native Fishes (Jackson Gross, USGS Northern Rocky Mountain Science Center, Bozeman, MT)