2008

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

29th ANNUAL RECOVERY PROGRAM RESEARCHERS MEETING

Photo provided by Larval Fish Laboratory, Fort Collins, Colorado

January 15—16, 2008
Moab Valley Inn
Moab, Utah

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SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

29th ANNUAL RECOVERY PROGRAM RESEARCHERS MEETING

January 15—16, 2008

Tueday, January 15, 2008

8:30 Patrick Goddard (Utah Division of Natural Resources) – Welcome and Housekeeping

SESSION I: INSTREAM FLOW - EVALUATING FLOW RECOMMENDATIONS

8:40 Tom Chart (Instream Flow Coordinator), and Jana Mohrman (Regional Hydrologist, U.S. Fish and Wildlife Service) –Introduction

8:50 **Cooperative Water Management to Improve Endangered Fish Habitat in the Colorado and Yampa Rivers.** *Jana Mohrman.*

9:10 **Implementation of Flow and Temperature Recommendations for the Green River below Flaming Gorge Dam.** *Rick Clayton and Dave Speas.*

9:30 **An evaluation of suspended-sediment transport equations using daily-sediment records for the Gunnison River near Grand Junction, Colorado; and the Green River near Jensen, Utah; Water Year 2005.** *Cory A. Williams.*

9:50 **Entrainment of beads and marked razorback sucker *Xyrauchen texanus* larvae into depression floodplain wetlands of the middle Green River, Utah, 2004-2006.** *Trina Hedrick*, Kevin Bestgen and Kevin Christopherson.

10:10 Break

10:30 **Effects of Flaming Gorge Dam on the Green River Fish Community in Lodore and Whirlpool Canyons, 1962 to present.** *K. R. Bestgen*, K. A. Zelasko, C. T. Wilcox, R. I. Compton, and T. C. Chart

10:50 **Monitoring Topography of In-Channel Sediment Features as It Relates to Green River Flows.** *John Hayse*, Kirk LaGory, Lee Walston, Brian Cantwell, and Jim Kuiper.

11:10 **Evaluating Flow Recommendations on the San Juan River.** *Paul B. Holden* and Ronald D. Bliesner.

11:20 Questions and Open Discussion with Session Speakers

12:00 LUNCH

SESSION II: PROPAGATION

1:30 Tom Czapla (Propagation Coordinator) – Introduction

1:40 **Razorback Sucker Production at Ouray National Fish Hatchery.** *Sam Pollock.*

2:00 **An overview of the 24 Road Hatchery and culture practices for the propagation of razorback sucker.** *Brian Scheer* and Thad Bingham.

2:20 **An overview of the Grand Valley pond culture and harvest operations.** *Rick Smaniotto.*

2:40 **Update on Flood Damage Repairs at Wahweap Hatchery and Culture Activities.** *Quent Bradwisch.*

3:00 BREAK

3:20 **Ouray National Fish Hatchery Broodstock: History, Current Status, and Concerns.** *Mike Montagne.*

3:40 **An Overview of the Augmentation Programs for the Endangered Fishes of the San Juan River.** *Dale Ryden.*

4:00 **Genetic Assessment of Humpback Chub from the Little Colorado River**. *Connie Keeler-Foster*.

4:20 Questions and Open Discussion with Session Speakers

Wednesday, January 16, 2008

SESSION III: STOCKED FISH EVALUATION / CONTRIBUTED PAPERS

8:30 Tom Czapla (Propagation Coordinator) – Introduction (anecdotal information from Trina Hedrick, Bruce Haines & Travis Francis)

8:40 **Survival of hatchery-reared razorback sucker *Xyrauchen texanus* in the Upper Colorado River Basin, Utah and Colorado: progress to date.** *Koreen A. Zelasko* and Kevin R. Bestgen.

9:00 **A general overview and preliminary assessment of the Upper Colorado River Recovery Program's Bonytail (*Gila elegans*) Propagation program utilizing the Upper Colorado River Basin Database with data collected thru 2006.** *Travis Francis.*

9:20 **LCR-MSCP Update: Native fish stocking, monitoring and research activities in the lower Colorado River downstream of Grand Canyon.** *Tom Burke.*

9:40 **A brief summary of USGS native fish research activities on the Colorado River.** *Gordon Mueller.*

10:00 BREAK

10:20 **Movements and habitat associations of native and introduced catostomids in a tributary system of the Colorado River: Implications for restoration of the natives.** *Diana Sweet* and Wayne Hubert.

10:40 **Population estimates of native and introduced catostomid species and their hybrids in an isolated headwater tributary to the Green River in Wyoming.** *David Banks* and Wayne Hubert.

11:10 **A summary of 2002—2007 research on bluehead suckers, flannelmouth suckers, and roundtail chubs in upper Muddy Creek, Carbon County, Wyoming.** *Wayne A. Hubert*, Robert I. Compton, Michael R. Bower, Michael C. Quist, Frank J. Rahel, David B. McDonald, and Thomas L. Parchman.

11:30 **Monitoring the Performance of Boat-mounted 5.0-GPP Electrofishers.** *Patrick J. Martinez* and Lawrence Kolz.

11:50 LUNCH

1:00 **Closed Population Estimates of Humpback Chub (*Gila cypha*) in the Little Colorado River, Grand Canyon, Arizona.** *David R. Van Haverbeke*.

1:20 **Capital Projects Review and Update.** *Brent Uilenberg.*

1:40 Questions and Open Discussion with Session Speakers

SESSION IV: NONNATIVE FISH

2:00 Tom Chart (Nonnative Fish Coordinator) and Rich Valdez (Contractor) – Introduction

2:20 **Restoring a Native Fish Community: Mechanical Removal Efforts in Bright Angel Creek, Grand Canyon National Park.** *Pam Sponholtz.*

2:40 BREAK

2:50 **Yampa River Nonnative Fish Control Strategy.** *Richard A. Valdez*, Tom Chart, Tom Nesler, Dave Speas and Melissa Trammell (*Ad Hoc* Committee).

3:10 **2007 Nonnative Fish Management Workshop.** *Richard A. Valdez* and Tom Chart.

3:20 Questions and Open Discussion with Session Speakers

SESSION I: INSTREAM FLOW - EVALUATING FLOW RECOMMENDATIONS

Cooperative Water Management to Improve Endangered Fish Habitat in the Colorado and Yampa Rivers. *Jana Mohrman,* U.S. Fish and Wildlife Service, Lakewood, Colorado.

Providing flows to improve endangered fish habitat was understood as vital to recovery from the inception of the Upper Colorado River Endangered Fish Recovery Program. Cooperatively managing water with other water users has become a critical tool to improve spring peaks and augment late summer flows. Late summer flows in the "15-Mile Reach" of the Colorado River are augmented through releases from Ruedi, Wolford, Williams Fork, and Green Mountain reservoirs. A significant portion of this is water saved through the Grand Valley Water Management irrigation efficiency improvement project. In 2007, a total of 53,884 af of augmentation water was provided, plus 8,500 af to make up for the Shoshone power plant outage, for an overall total of 62,384 af. On the Yampa River, Elkhead Reservoir has been enlarged and the Recovery Program used 4,300 af of its 5,000 af pool of water in Elkhead to augment late summer flows in 2007. Peak flows on the Colorado River are augmented through Coordinated Reservoir Operations when certain target flows are met. In 2006, a total of 28,460 af was released from Green Mountain, Ruedi, Wolford, Williams Fork, and Dillon reservoirs, adding an average 2,049 cfs to the peak at the Cameo gage over 7 days.

Implementation of Flow and Temperature Recommendations for the Green River below Flaming Gorge Dam. *Rick Clayton and Dave Speas*, U.S. Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah.

Since February of 2006, Flaming Gorge Dam has operated under the authority of the Flaming Gorge Record of Decision (ROD). The ROD calls for the operation of Flaming Gorge Dam to achieve to the extent possible specific flow and temperature regimes described in the 2000 Flow and Temperature Recommendations[1]. A process for determining how best to achieve these flow and temperature regimes has been established and followed through the past two runoff seasons. The purpose of this discussion is to describe this process and the role of the Recovery Program, Flaming Gorge Technical Working Group and the Flaming Gorge Working Group in this process. The effectiveness of the process implemented over the past two seasons will also be discussed.

[1]Muth, R. T., L. W. Crist, K. E. LaGory, J. W. Hayse, K. R. Bestgen, T. P. Ryan, J. K. Lyons, and R. A. Valdez. 2000. Flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

An evaluation of suspended-sediment transport equations using daily-sediment records for the Gunnison River near Grand Junction, Colorado; and the Green River near Jensen, Utah; Water Year 2005. *Cory A. Williams*, U.S. Geological Survey Hydrologist, Colorado Water Science Center, Grand Junction, Colorado.

Suspended-sediment transport equations were developed from long-term records at U.S. Geological Survey streamflow-gaging stations on the Gunnison and Green Rivers as part of a sediment retrospective assessment completed in 2005. The transport equations relate suspended-sediment load to streamflow and coarse-scale seasonality, such as snow-melt runoff and base-flow conditions. Intensive sediment monitoring was done at these sites in Water Years 2005-07 to quantify the daily suspended-sediment records and evaluate suspended-sediment loads calculated from the equations. Preliminary findings from the comparisons of transport equations and daily-sediment samples may show that streamflow source area (tributary locations) and timing (relative to snowmelt peak) contribute significantly to the concentration and size distribution of sediment transported in these rivers. Factors controlling suspended-sediment concentration and load are related to hydraulic force (stream power) as well as sediment source availability. Transport equations represent the average response to changes in streamflow and seasonality but only indirectly represent the sediment-source component of sediment loads. Conventional estimates of suspended-sediment load from transport equations may not adequately account for all sediment transport as it relates to endangered fish habitat; specifically, when the sediment transport includes highly-variable seasonal inputs such as monsoon rain events and the timing of tributary peak-streamflows. Further analysis will be done and results will be released in the USGS Scientific Investigations Report scheduled for completion in 2009.

Entrainment of beads and marked razorback sucker *Xyrauchen texanus* larvae into depression floodplain wetlands of the middle Green River, Utah, 2004—2006. *Trina Hedrick* (Utah Division of Wildlife Resources, Vernal, Utah), Kevin Bestgen (Larval Fish Laboratory, Department of Fish, Wildlife, & Conservation Biology, Colorado State University, Fort Collins, Colorado), and Kevin Christopherson (Utah Division of Wildlife Resources, Vernal, Utah).

Floodplain wetlands are presumed important rearing habitat for razorback sucker, *Xyrauchen texanus* in the middle Green River, Utah. Reproduction by razorback suckers occurs during high spring flows and larvae are entrained into flood plain wetlands, areas which are food rich and relatively warm. These areas may promote faster growth and higher survival of razorback sucker larvae, but reduction of peak flows by storage of Green River spring runoff in Flaming Gorge Reservoir reduced the historical connection frequency of river-floodplain habitats, and is thought a main reason for lack of recruitment of this endangered species. For example, pre-dam peak instantaneous flows averaged 641 m^3/sec (22,619 cubic feet per second [cfs], 1947-1962), but after dam construction, peak flows averaged only 478 m^3/sec (16,885 cfs; 1965-2005). In response to the need for enhanced razorback sucker recruitment, the Upper Colorado River Endangered Fishes Recovery Program breached levees surrounding key floodplains,

implemented flow recommendations for Flaming Gorge Dam, and initiated this study to better understand entrainment dynamics of razorback sucker larvae in the Green River.

From 2004-2006, we undertook field studies to estimate drift and entrainment rates of near-neutrally buoyant, gelatinous beads and newly hatched and marked razorback sucker larvae. In 2004, we released beads and marked larvae in the middle Green River at Razorback Bar (River kilometer, [RK], 501). The river did not connect with any flood plain during 2004; therefore, crews set drift nets within the main river channel at near shore and far shore locations (relative to the release) one mile and five miles downstream of the release location. Main findings were that beads and larvae tended to remain near the shore closest to where they were released and that large numbers of wild razorback larvae, presumably from razorback suckers that were stocked and grew to adult size, were present during sampling. In 2005, we again released and recaptured beads and razorback sucker larvae at Razorback Bar and also on the Escalante spawning bar (RK 493) during river and flood plain connections and drift-netted within levee breaches, along the far shore, the near shore, and in the river mid-channel at four floodplain locations. We recaptured beads and larvae in drift nets at all wetlands, including up to 87 RK downstream near the Ouray National Wildlife area at Leota-10. Beads were well mixed in the cross-channel profile only after substantial downstream dispersal.

In 2006, crews released beads 1.6 RK upstream of Thunder Ranch, Stewart Lake, and Bonanza Bridge flow-through flood plain wetlands, located between RK 493 and 465 in the middle Green River. Razorback sucker larvae were only released above Thunder Ranch wetland. Bead and flow entrainment at Thunder Ranch and Stewart Lake sites was highly and positively correlated, bead entrainment increased with river flow, and was highest at the highest flows tested at both sites. Larvae were entrained at all wetland sites, but inadequate preservation techniques did not allow for substantial interpretation of fish sampling data. At Thunder Ranch, bead entrainment rates were relatively low at Green River flow < 430 m^3/sec (15,200 cfs) but increased in a non-linear fashion and was 16X higher at 526 m^3/sec (18,600 cfs). At Stewart Lake, bead entrainment rates were relatively low at river flow < 345 m^3/sec (12,200 cfs) but was nearly 6X higher at 515 m^3/sec (18,200 cfs). At Bonanza Bridge, bead entrainment rates were highest at river flows of 487 and 535 m^3/sec (17,200 and 18,900 cfs, respectively) and up to 5X as high as during flows of 453 m^3/sec (16,000 cfs). Inferences from the relatively low bead and flow entrainment observed at Bonanza Bridge wetland, likely a result of limited breach connection, geomorphic factors, and small wetland size, are limited. Observations at Thunder Ranch and Stewart Lake wetlands suggested that entrainment rates were highest at Green River flows above about 510 m^3/sec (18,000 cfs), and that entrainment rates would continue to increase, perhaps in a non-linear fashion, at higher flows. Recommendations for Flaming Gorge Dam flows during spring appear to be suitable to maximize entrainment of razorback sucker larvae and may enhance recovery of this endangered species.

Effects of Flaming Gorge Dam on the Green River Fish Community in Lodore and Whirlpool Canyons, 1962 to present. *K. R. Bestgen*, K. A. Zelasko, C. T. Wilcox, R. I. Compton, and T. C. Chart, Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado.

Installation of Flaming Gorge Dam in 1962, and subsequent operations, have had profound effects on downstream habitat and the fish community of the Green River. We review the sequence of changes and subsequent flow, water temperature, and fish community response, with a particular focus on comparisons between the periods 1994 to 1996 and 2002 to 2007. The goal of the study is to understand effects of newly implemented flow and temperature regimes on the fish community of the upper Green River in Lodore and Whirlpool canyons, Utah and Colorado. Recent flow and temperature conditions which are similar to those in recommendations include high spring flows in 1997 and 1999, and drought-induced high water temperatures in 2002 to 2007, and created conditions that more closely resembled pre-dam regimes that may benefit native fishes. Our sampling showed that native fishes comprised only about 10% of total catch and nonnatives were 89%; the remainder were hybrids. Nearly every native fish in the Green River, with the exception of Colorado pikeminnow, declined in abundance compared to those collected in 1994 to 1996, but strong populations of most species remain. We also detected reproduction by endangered Colorado pikeminnow and razorback sucker in Lodore Canyon in summer 2006. Distribution and abundance of nonnative fishes, particularly small-bodied cyprinids, and non-native predaceous fishes such as smallmouth bass and channel catfish, increased compared to the period 1994 to 1996. Smallmouth bass reproduction, which was not observed in Lodore Canyon prior to this study, increased through the 2002 to 2007 period, and the species was widespread in the study area. Salmonids were temporarily reduced in abundance in the very warm year 2002, but rebounded by 2003 to levels similar to the period 1994 to 1996. Abundance of white suckers and their hybrids increased steadily through the 2002 to 2007 period. Thus, the net effect of recent flow and temperature regimes on the native fish community was mixed. We were able to obtain reliable information on the response of the fish community to flow and temperature effects, but only at the lower end of the flow spectrum and the high end of the temperature spectrum. Additional information is needed for other flow and temperature conditions to fully assess the effects of flow and temperature recommendations for Flaming Gorge Dam on the fish community of the Green River. Such information also may enhance understanding of factors that limit invasive predaceous fishes, which have the potential to offset hypothesized benefits of newly implemented flow and temperature recommendations.

Monitoring Topography of In-Channel Sediment Features as It Relates to Green River Flows. *John Hayse*, Kirk LaGory, Lee Walston, Brian Cantwell, and Jim Kuiper Environmental Science Division, Argonne National Laboratory, Argonne, Illinois

To protect backwater habitats used by Colorado pikeminnow (*Ptychocheilus lucius*) juveniles, flow recommendations for the Green River call for limiting within-day stage changes to 0.1 m or less at the USGS gage on the Green River near Jensen, Utah during the baseflow period. We determined the topography of in-channel sediment features

(sandbars) in the Ouray reach of the Green River to evaluate the effects of stage changes on the physical characteristics of associated backwater habitats. Detailed topographic information for 4 to 6 backwaters was obtained annually during the autumns of 2003-2006. Stage data in the study area was collected using a temporary stage recorder in 2003 and was used to develop a water stage relationship between the Ouray reach and data recorded at the USGS Jensen gage. Using topographic data, we developed contour maps and GIS models for each backwater area to predict the area, volume, and depths for each backwater as a function of changes in flow. The data suggest that sandbar and associated backwater topography is quite variable from year-to-year and that the relationship between flows and backwater habitat availability characteristics is complex. Backwater habitat was not always available in the same location each year. However, within the overall Ouray reach, habitat was available each year over a wide range of base flows encompassing the range of base flows (900 to 3,000 cfs) included in the Green River flow recommendations. (Work supported by the U.S. Department of Energy, Western Area Power Administration under contract W-31-109-Eng-38.)

Evaluating Flow Recommendations on the San Juan River. *Paul B. Holden*, BIO-WEST, Inc., Logan, Utah, and Ronald D. Bliesner, Keller-Bliesner Engineering, Logan, Utah.

Flow recommendations for the endangered Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) were developed on the San Juan River by the San Juan River Basin Recovery Implementation Program (SJRIP) in 1999. Data collected during a 7-year research period (1991-1997) were used to develop the linkages between biology, habitat, geomorphology, and hydrology. The flow recommendations require mimicry of statistical parameters of flow, based on the linkages developed and the statistical variability of the pre-dam hydrology rather than mimicry of each annual hydrograph. A 65-year-long period of record (1929-1993) was used to assess the relationship between water development scenarios and the ability to meet the flow recommendations. Due to low population size, stocked fish were used to assess habitat selection and availability as was information from other parts of the Colorado Basin. Hydrological and geomorphological studies assessed the quantity and quality of important endangered fish habitats under different flow regimes. The flow recommendations were implemented on the San Juan River in 2000 and monitoring projects have continued to follow habitat availability and rare fish habitat use. Since 2000 the San Juan Basin has been in a drought but all aspects of the flow recommendations were met except during one year. Habitat studies since 2000 have shown that some important habitats (backwaters) have declined since the flow recommendations were implemented. This decline is coincident with the extended drought, and has occurred in the past. However, some of the flow recommendations thought to be effective in backwater maintenance during such conditions were found to be ineffectual. Additional studies of habitat use and availability are being conducted as more endangered fish are stocked into the San Juan River. The SJRIP Biology Committee has recommended modifying the flow recommendations based on recent studies.

SESSION II: PROPAGATION

Razorback Sucker Production at Ouray National Fish Hatchery. *Sam Pollock*, U.S. Fish and Wildlife Service, Ouray National Fish Hatchery.

Ouray National Fish Hatchery produces approximately 15,000 300mm razorback suckers, *Xyrauchen texanus,* annually for release in the Green river. Broodstock are spawned in April and fish are reared using a combination of intensive and extensive fish culture for up to 18 months. The hatchery is made up of a 30,000 gallon reuse system, 24 production ponds, and 12 broodstock holding ponds.

An overview of the 24 Road Hatchery and culture practices for the propagation of razorback sucker. *Brian Scheer* and Thad Bingham, U.S. Fish and Wildlife Service, Grand Junction, Colorado.

In 1995, the Bureau of Reclamation donated an existing warehouse (1149 24 Road) to the U.S. Fish and Wildlife Service for the purpose of constructing an intensive water re-use facility for the culture of the endangered fishes in the Upper Colorado River Basin. In spring of 1996 the facility was complete and ready for operation. The hatchery uses domestic water purchased from Ute Water Conservancy District and has a capacity of 14, 000 gallons. In 2000, an additional water re-use facility was constructed and added to the existing building. The new facility also uses domestic water and has a capacity of 24,000 gallons.

The 24 Road Hatchery consists of 78 4-ft-diameter circular tanks (200 gallon capacity each) and 14 8-ft diameter circular tanks (900 gallon capacity each). As a water re-use facility, the same water is re-used over and over, therefore several different pumps and filtration systems are needed to maintain water quality and fish health. Water re-use systems are fairly complex and can be extremely sensitive to inconsistencies in management techniques and water quality. Along with water quality, density and flow indexes are the limiting factors contributing to daily growth and overall fish health. In addition to the hatchery, approximately 400 adult razorback brood are maintained in 6 refugia ponds located at Horsethief Canyon State Wildlife area.

Annually, 28,000 razorback sucker are reared at the 24 Road Hatchery. In early to mid April, captive reared razorback sucker brood are spawned using paired matings. Twenty to twenty five family lots of eggs are taken. Eggs are transferred to the 24 Road Hatchery where they are incubated, hatched and reared to a total length of 200mm in 12 months. Of the 28,000, 7,000 are reared for an additional 4 months to reach 300mm. Starting in March of the following year, the 200mm razorback sucker are stocked into 14 different grow-out ponds located throughout the Grand Valley. Of the 7,000 that are 300mm, 3,500 are stocked into the Green River and the rest into the Colorado and Gunnison Rivers in early August.

An overview of the Grand Valley pond culture and harvest operations. *Rick Smaniotto*, U.S. Fish and Wildlife Service, Grand Junction, Colorado.

After 1 year in the 24-Road intensive-culture hatchery, razorback suckers are transferred to 14 grow-out ponds scattered throughout the Grand Valley. These ponds are intended to be a "stepping-stone" to life in the river, allowing the fish an opportunity to adapt to wild conditions; feeding, growing and maturing in a relatively predator free environment. After 6 months (or more in some ponds) the fish are harvested, tagged and released into the Colorado, Gunnison, or Green rivers. Grow-out ponds vary from leased gravel-pit ponds to some constructed specifically for pond culture. Physical and chemical characteristics vary greatly among ponds. Pond size, depth, productivity and water source interact to determine the success of the culture operation. Growth and survival of razorback suckers vary among ponds depending on interaction of these variables.

Update on Flood Damage Repairs at Wahweap Hatchery and Culture Activities. *Quent Bradwisch*, Wahweap Hatchery Manager, Utah Division of Natural Resources, Bigwater, Utah.

Wahweap Hatchery experienced a major flood event in 2006 that caused extreme instability along the bank of Wahweap Creek. In 2007 the Utah Division of Wildlife applied and received NRCS flood damage funding to repair the creek bank damage. This has involved placing a rock wall 12 ft high for the entire reach of the hatchery boundary using 55,000 ton of lava rock.. This will provide protection from flood events cutting directly into the pond complexes and also prevent compromising of our pond drain system.

Wahweap has been rearing bonytail for the past 12 years and stocking Utah river reaches. Summary of 2007 stockings and plans for the next 3 years stocking events.

Ouray National Fish Hatchery Broodstock: History, Current Status, and Concerns. *Mike Montagne*, U.S. Fish and Wildlife Service, Ouray National Fish hatchery, Vernal, Utah.

In the late 1980's, the Recovery Program and the U.S. Fish and Wildlife Service (USFWS) recognized the need to hold some of the endangered fish in a protected refugia to prevent extinction and allow for study of the fishes life history. The Colorado River Fisheries Project (CRFP) in Vernal, Utah, established a small experimental culture facility in 1987 at Ouray National Wildlife Refuge (ONWR). The facility eventually evolved from a small experimental facility (used to determine the logistics of rearing razorbacks at a small facility using ponds, to determine the survival of different age classes of razorbacks released into the Green River, and to determine if streamside spawning and rearing of razorbacks could be successful), into a National Fish Hatchery to be used as a endangered fish refugia and technology development facility to assist in the recovery of razorback sucker, Colorado pikeminnow, bonytail, and humpback chub.

From the initial effort at the facility, razorback sucker broodstock were developed consisting of 25 individual lots that were created from wild captured fish. These first generation fish are backed up by a genetically identical set of fish that are held at Wahweep State Fish Hatchery. If managed properly these fish should continue to contribute to the recovery of the species, but there are some concerns that should be addressed.

An Overview of the Augmentation Programs for the Endangered Fishes of the San Juan River. *Dale Ryden*, U.S. Fish & Wildlife Service, Grand Junction, Colorado.

Augmentation programs for razorback sucker and Colorado pikeminnow in the San Juan River began in the mid-1990's. Between 1994 and 2007, over 54,000 razorback sucker were stocked into the San Juan River, with most of these (76.4%) being stocked in 2006 and 2007. The razorback sucker augmentation program is currently shifting from using pond-rearing to producing fish at hatcheries in order to more reliably meet annual stocking targets. Between 1996 and 2007, over 2½ million Colorado pikeminnow were stocked into the San Juan River. All of these fish were reared at hatcheries. The large majority of stocked Colorado pikeminnow (99.1%) were age-0 fish that were stocked each fall from 2002-2007. Both of these augmentation programs are just now beginning to reach their full production potential.

With the large numbers of fish that have been stocked, collections of razorback sucker and Colorado pikeminnow have become relatively common during sampling efforts in the San Juan River. The presence of these stocked fish in the San Juan River has led to many discoveries that would have been impossible in their absence.

Genetic Assessment of Humpback Chub from the Little Colorado River. *Connie Keeler-Foster*, U.S. Fish and Wildlife Service, Dexter, New Mexico.

Humpback chub are of concern in the Colorado River as overall, the species continues to decline. Genetic analysis of humpback chub from the Little Colorado River currently held at Willow Beach NFH indicate those fish have potential for the development of a captive refuge stock. Willow Beach fish were compared to fish from the Little Colorado River including Salt Camp, Coyote Camp, Boulders, Chute Falls, the Lower 1200 and fish provided by SWCA from the mainstem Colorado River. A total of 333 humpback chub were assessed at 8 microsatellite loci, and the results used to develop a draft genetic management plan for humpback chub in the lower basin. Results indicate that while fish at Willow Beach had fewer alleles, and slightly lower levels of genetic diversity, the captive fish should provide a sound foundation to develop a genetic reserve population to represent the Little Colorado River humpback chub population. Using this information, a strategy to manage the stock to better reflect the Little Colorado River population has been developed.

SESSION III: STOCKED FISH EVALUATION / CONTRIBUTED PAPERS

Survival of hatchery-reared razorback sucker *Xyrauchen texanus* in the Upper Colorado River Basin, Utah and Colorado: progress to date. *Koreen A. Zelasko* and Kevin R. Bestgen, Larval Fish Laboratory, Department of Fish, Wildlife, & Conservation Biology, Colorado State University, Fort Collins, Colorado

Status and trajectory of an animal population depends on its demographic rates, and endangered species management, in particular, relies on such quantifiable population descriptors to guide the recovery process. Recovery goals for federally endangered razorback sucker *Xyrauchen texanus* require that the Upper Colorado River Basin maintain two "genetically and demographically viable, self-sustaining" adult populations, each exceeding 5,800 individuals. Current wild populations are so imperiled that the first management action to achieve recovery is to reestablish populations with hatchery-produced fish. Stocking goals call for 9,930 age-2 (≥ 300 mm TL) individuals to be stocked in each of the middle Green River and upper Colorado River subbasins for each of six consecutive years, thus creating the presumptive recovery populations. The plan assumes annual survival rates of 50% for age-2 fish, 60% for age-3 fish, and 70% for adult fish. Assumed adult survival rate for stocked fish is consistent with that for wild individuals measured for historical populations. Analysis of recapture records will fulfill a fundamental requirement of any recovery action, evaluation of success, via a robust analysis of survival rate using the Cormack-Jolly-Seber open population class of models. Parameters of interest for this study are apparent survival, Φ, and capture probability, p. Recapture data, collected under multiple projects in the basin and stored in the USFWS central database, Grand Junction, CO, was proofed and summarized. A total of 150,148 individually PIT-tagged razorback suckers were stocked into the Colorado, Gunnison, Green, and Yampa rivers from 1995 through 2006. Recapture frequencies among years (subsequent to stocking years) ranged from 0 to 5. Covariates in the database that may affect Φ or p include: river, river reach, year, season, and individual fish total length. A set of a priori candidate models was created based on available data and biology of the razorback sucker. Program MARK will be used to design candidate models and analyze data. Model selection procedures, such as Akaike's Information Criterion and likelihood ratio tests, will be used to choose best model structure(s) for the data, from which maximum likelihood estimates of apparent survival and measures of precision will be obtained. Results will be useful to managers attempting to restore razorback sucker in the Upper Colorado River Basin and will guide production strategies for hatcheries.

A general overview and preliminary assessment of the Upper Colorado River Recovery Program's Bonytail (*Gila elegans*) Propagation program utilizing the Upper Colorado River Basin Database with data collected thru 2006. *Travis Francis*, U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Various propagation plans have been developed since the Recovery Programs inception in the middle 1980's with the most recent summary plan developed in 2003. This plan sets goals and targets for the rearing and stocking of three endangered large bodied Colorado fishes in the rivers of the Upper Colorado River Basin. Razorback sucker

(*Xyrauchen texanus*) and bonytail (*Gila elegans*) are the two primary species produced because of their fragile status in the wild, and the Colorado pikeminnow (*Ptychocheilus lucius*) are also stocked in limited numbers throughout the upper basin.

Bonytail that are stocked in the Upper Colorado River Basin are produced at Mumma Native Aquatic Species Restoration Facility, and Wahweap State Fish Hatchery. The 2003 integrated stocking plan calls for a total of 15,990 bonytail to be stocked annually in the upper basin rivers. Passive integrated transponder (PIT) tagged fish are individually marked fish that are uniquely identified by an alphanumeric code. These data are managed in a centralized stocking database. Batch marked fish (coded wire tag, or fin clipped) are not uniquely identified; thus, not included in the upper basin database. 13,168 PIT tagged bonytail were stocked between 1996 and 1999, no PIT tagged bonytail were stocked in 2000 and 2001, and 86,246 were stocked between 2002 and 2006 in upper basin rivers.

The Recovery Program has not funded a specific study to evaluate the bonytail propagation plan for the Upper Colorado River Basin since an initial review of the stocking program in the lower Green and Colorado rivers from 1996 - 2001. Various funded field studies throughout the Upper Colorado River Basin have the potential to capture stocked bonytail. These studies utilize a variety of sampling protocols on different stretches of river during various times of the year. However, these studies have handled a few hatchery produced bonytail and report that data to the Upper Colorado River Basin Database. Between the years 1996 – 2006, 105 individual PIT tagged hatchery reared bonytail were captured in the Colorado River (18 were captured twice), with only one that was at large (in the river) for greater than one year (15 months). 181 individual PIT tagged hatchery reared bonytail were captured in the Green River basin (11 were captured twice), with only four that were at large for at least one year (three for 12 months and one for 25 months). 619 additional bonytail were captured in the upper basin (21 were captured twice), during the same time period, but were not found in the stocking PIT tag database. These fish are most likely batch marked hatchery reared fish.

This presentation will summarize stocking data, reported to the Upper Colorado River Basin Database, and compare this information with the goals set forth in the bonytail stocking plan. It will describe hatchery produced bonytail distribution, movement, and growth in the rivers of the Upper Colorado River Basin. These quantifiable descriptors should assist in the decision for the continued use of ongoing field studies, or to fund specific studies, to assess the success of the bonytail stocking program.

CONTRIBUTED PAPERS

LCR-MSCP Update: Native fish stocking, monitoring and research activities in the lower Colorado River downstream of Grand Canyon. *Tom Burke*, Bureau of Reclamation, Lower Colorado Region, Boulder City, NV 89006-1470

The LCR-MSCP is a coordinated, comprehensive, long-term multi-agency effort to conserve endangered species and their habitats on the lower Colorado River downstream of Grand Canyon. Fishery conservation actions involve three native fishes: razorback sucker, flannelmouth sucker, and bonytail. Principal program goals are to augment populations, conduct species research, and to monitor both the extant and stocked populations. This report provides an overview of the native fish activities accomplished in 2007, and updates the status of these fishes in each reach of the main stem Colorado River below Grand Canyon.

A brief summary of USGS native fish research activities on the Colorado River. *Gordon Mueller*, U.S. Geological Survey, Denver, Colorado.

Work was conducted on three research projects in 2007. One involved the native fish sanctuary work, the second finished investigations on the role of physical acclimation and predator avoidance of razorback sucker and bonytail and the last dealt with testing monitoring techniques for razorback sucker in the lower river. The first bonytail sanctuary was established in 2007. One hundred bonytail were stocked following renovation of a small pond and within two weeks they spawned, filling the pond with their off-spring. Behavioral and physical acclimation tests showed hatchery reared bonytail and razorback suckers were predator naïve. Survivorship of exercised razorback suckers was significantly greater ($p = 0.046$) than unexercised razorback suckers and fish that were both exercised and experienced predator exposure, exhibited even greater ($p = 0.017$) predator avoidance than control fish. Bonytail that had prior predator exposure experienced a 38% greater survival rate compared to their counterparts when exposed to largemouth bass. Development of techniques to monitor razorback suckers using aerial photography, surface counts and electrofishing were compared to standard trammel netting. Costs to capture razorback suckers in the river exceeded $1,100/fish using trammel nets and $65/fish for electrofishing. Detection costs for aerial imagery was $78/fish and only $18/fish for boat surveys. Approaches provided different types of information that must be evaluated in terms of what information is required for future monitoring needs. Reports are, or will soon be available for the above studies on the USGS-FORT website (www.fort.usgs.gov).

Movements and habitat associations of native and introduced catostomids in a tributary system of the Colorado River: Implications for restoration of the natives. *Diana Sweet* and Wayne Hubert, U. S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department 3166, 1000 East University Avenue, Laramie, Wyoming.

Bluehead sucker *Catostomus discobolus* and flannelmouth sucker *Catostomus latipinnis* populations are declining throughout their native ranges in the Colorado River Basin. The Big Sandy River in the Green River Basin of Wyoming contains populations of both native sucker species, as well as introduced white suckers *Catostomus commersonii* and longnose suckers *Catostomus catostomus*, and introgressed forms of the native and introduced species. The Big Sandy River may become a focus of efforts to restore genetically pure populations of bluehead suckers and flannelmouth suckers in the future. Information on movement patterns and habitat associations of native and introduced suckers in the Big Sandy River was needed to guide such efforts. Twenty to twenty-two adults of each species were captured over 70 km of the Big Sandy River and implanted with radio transmitters in September or October 2006 and tracked until July 2007. Spatial distributions of the native and introduced catostomids overlapped widely in the Big Sandy River. During fall and winter all four species were relatively sedentary and generally found within 2 km of previous locations, and all four species selected pools with rock substrates. Spring movements and habitat use varied among species with bluehead suckers and flannelmouth suckers moving downstream, white suckers remaining sedentary, and longnose suckers moving upstream. Bluehead suckers selected pools with rock substrates, flannelmouth suckers selected braided channels with sand substrates, white suckers selected pools, and longnose suckers selected deep runs during spring. Bluehead suckers and flannelmouth suckers in the Big Sandy River displayed spring movements that appeared to differ from other populations. This research provides insights into management options for restoration of genetically pure bluehead suckers and flannelmouth suckers in the river.

Population estimates of native and introduced catostomid species and their hybrids in an isolated headwater tributary to the Green River in Wyoming. *David Banks* and Wayne A. Hubert, University of Wyoming, Department of Zoology and Physiology 1000 East University Avenue, Department 3166, Laramie, Wyoming.

The bluehead sucker *Catostomus discobolus* and flannelmouth sucker *C. latipinnis* are two native catostomid species that are in decline within the Colorado River Basin. It is likely that future conservation efforts by state and federal management agencies will focus on isolated populations in small tributaries, but little is known about the abundance or population structures of these species in small tributaries. Information is also needed on the abundance and population structures of introduced white suckers *C. commersoni* and hybrids between white suckers and the two native species. We addressed these information needs in a study of Little Sandy Creek, a small isolated stream in the east-central Green River basin of Wyoming. During the summer 2007 we estimated the abundances and length structures of bluehead suckers, flannelmouth suckers, white suckers, and hybrids greater than 100-mm total length over a 43-km segment of the creek

near the upstream extent of the distributions of these catostomids. Three-pass depletion estimates of abundance were used in two different sampling designs (1) 50 randomly-selected 75-m reaches and (2) 12 randomly-selected 200-m reaches. White suckers were common throughout the study area. More variation in abundance estimates was observed among 75-m reaches compared to 200-m reaches. Abundances of the two native catostomids were low in most of the sampled reaches, but they were high in some reaches apparently related to habitat features in these reaches. Over the entire study segment, the most abundant catostomids were white suckers and hybrids.

A summary of 2002-2007 research on bluehead suckers, flannelmouth suckers, and roundtail chubs in upper Muddy Creek, Carbon County, Wyoming. *Wayne A. Hubert*, Robert I. Compton, Michael R. Bower, Michael C. Quist, U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department 3166, 1000 E. University Ave., Laramie, WY 82071 and Frank J. Rahel, David B. McDonald, Thomas L. Parchman, Department of Zoology and Physiology, University of Wyoming, Dept. 3166, 1000 E. University Ave., Laramie, WY 82071.

Upper Muddy Creek is one of only two locations in Wyoming where sympatric populations of bluehead suckers, flannelmouth suckers, and roundtail chubs are known to persist. Several research projects addressing these species have been conducted by graduates students and faculty at the University of Wyoming beginning in 2002. Upper Muddy Creek is a headwater stream that originates in the Sierra Madre and flows into the Little Snake River in northern Colorado. An isolated 80-km segment at the upper elevation limits of all three species has been the focus of study. Species-specific information has been obtained regarding the distributions, habitat associations, growth, population structure, and abundance. Information has also been obtained on the extent of hybridization between introduced white suckers and the two native catostomids. Issues involving population fragmentation and population viability have been identified for the three species, as well as the extent of genetic integration among the introduced and native catostomids. The insights from these research projects provide information as to magnitude of the challenges that managers face in preserving these isolated populations of native fishes into the future.

Monitoring the Performance of Boat-mounted 5.0-GPP Electrofishers. *Patrick J. Martinez*, Aquatic Researcher, Colorado Division of Wildlife, Grand Junction and A. Lawrence Kolz, Electrical Engineer (PE), retired (USFWS-NCTC), Grand Junction, Colorado.

Electrofishing is widely used and effective for collecting fish. The broad acceptance of this sampling technique is, in part, based on the performance and reliability of the equipment available for controlling the electrical power applied to the water to create an electrical field sufficient to stun target fishes. In recent years, there has been a major shift in the electrofishing equipment used by many agencies. Smith-Root (S-R) is now the dominant supplier of electrofishing equipment in the USA. Many fishery professionals have switched to using S-R Gas Powered Pulsators (GPPs) for their boat-mounted

electrofishing systems. In the Upper Colorado River Basin (UCRB), the Recovery Implementation Program (RIP) for endangered fishes relies almost exclusively on S-R 5.0-GPP electrofishers for their fleet of aluminum-hulled electrofishing boats operating within critical habitat. Recently, there has been concern that operators might not fully understand how adjustment of the GPP's controls affects their electrical output. As part of an overall effort to standardize the electrofishing operations of the RIP fleet, it was determined that the ambient water conductivity encountered by operators of aluminum-hulled electrofishing boats in rivers of the UCRB ranged from 100 to 1,000 µS/cm. This range of water conductivity was used to calculate the theoretical resistance of stainless steel spherical anodes ranging in diameter from 5 to 11 inches (125 to 5.7 ohms), which might be used by RIP and other personnel. The output characteristics of three 5.0-GPPs were measured while connected to static electrical loads having resistance values of 5.9, 9.6, 19.5, and 114 ohms. The performance of the 5.0-GPPs in these tests is presented with regard to effective fish capture, avoidance of fish injury, and the need for operators to monitor the output of their electrofishing systems.

Closed Population Estimates of Humpback Chub (*Gila cypha*) in the Little Colorado River, Grand Canyon, Arizona. *David R. Van Haverbeke*, U.S. Fish and Wildlife Service, Flagstaff, Arizona.

From 2000 to 2007, a series of two-pass, closed mark-recapture efforts have been conducted in the spring and in the fall in the Little Colorado River (LCR) to track the abundance of humpback chub (HBC). During spring 2007 the estimated abundance of HBC ≥ 150 mm in the lower 13.57 km of the LCR was 5,124 (SE = 423). Of these fish, it was estimated that 2,544 (SE = 275) were ≥ 200 mm. These numbers are significantly higher than estimates obtained for the spring seasons between 2001 and 2006, indicating an increase in the spring spawning population. During fall 2007, the estimated abundance of HBC ≥ 150 mm in the lower 13.57 km of the LCR was 4,079 (SE = 345). Of these fish, it was estimated that 2,247 (237) were ≥ 200 mm. These numbers also suggest an increasing trend in the LCR population.

Between 2003 and 2005, 1,150 HBC (50-100 mm TL) were translocated from the lower reaches of the LCR to above a travertine structure known as Chute Falls. During 2006 and 2007, mark-recapture efforts were conducted in the reaches of the LCR above 13.57 km, largely in order to track the fate of the translocated HBC. During June and July 2007, it was estimated that there were 573 (SE = 15) HBC ≥ 150 mm residing above 13.57 km in the LCR. Of these fish, it was estimated that 476 (SE = 23) were ≥ 200 mm. Study results suggest that most of the translocated fish are dispersing downriver in the LCR, but that limited natural spawning occurred above Chute Falls.

Finally, in spring 2007 an effort was conducted to obtain a concurrent estimate of the abundance of HBC residing in the LCR and of HBC residing in the mainstem Colorado River in the vicinity of the LCR. Data have been summed and pooled, and efforts are being made to analyze the results with a multi-state model.

Capital Projects Review and Update. *Brent Uilenberg*, U.S. Bureau of Reclamation, Grand Junction, Colorado.

The Upper Colorado River Endangered Fish Recovery Program embarked on a major capital projects initiative in 1999, including construction of irrigation system improvements and enlargement of Elkhead reservoir to enhance flows, restoration of flooded bottomlands, construction of several major fish passages and screens, and construction of fish propagation facilities. The status of these capital projects and lessons learned will be discussed.

SESSION IV: NONNATIVE FISH

Restoring a Native Fish Community: Mechanical Removal Efforts in Bright Angel Creek, Grand Canyon National Park. *Pam Sponholtz*, U.S. Fish and Wildlife Service, Flagstaff, Arizona.

The U.S. Fish and Wildlife Service is working with Grand Canyon National Park on a project to restore native fish populations in Bright Angel Creek, a small tributary to the Colorado River using mechanical removal of nonnative trout. The purpose of this project is to enhance native fish populations and restore natural ecosystem values within the Park. Currently, Bright Angel Creek is home to nonnative brown and rainbow trout and native species such as speckled dace, bluehead and flannelmouth sucker. There is some evidence that endangered humpback chub use the inflow areas during some parts of the year. Nonnative brown trout are removed using two methods. The first method uses a weir placed at the mouth of Bright Angel Creek to intercept fish migrating upstream to spawn. During 2006, only 54 brown trout were captured in the weir, 87% lower than similar efforts in 2003 suggesting river-wide changes in the mainstem Colorado such as temperature has impacted migrating brown trout. The second method to augment brown trout removal in Bright Angel Creek, uses multi-pass electrofishing in a 3 kilometer reach to deplete numbers of brown trout. In fall 2006, 158 brown trout were removed from the sampling reach in Bright Angel Creek located from the weir to river kilometer 3. This represents an average of 55% of the estimated number of brown trout present in this reach. Abundance estimates for brown and rainbow trout varied greatly between the two species suggesting much higher rainbow trout densities than originally anticipated. Rainbow trout densities were between 3 and 1.6 times higher than brown trout, respectively. Length frequencies of rainbow and brown trout indicate a strong year class for both species from spawning events in spring 2006. There is also evidence of a second year class of rainbow trout (spawned in spring 2005) residing in Bright Angel Creek. The absence of larger fish may indicate that summer temperatures exceed the thermal tolerances of trout causing them to move into the colder mainstem Colorado during the summer. The lack of larger fish also indicates that the weir was effective in intercepting migrating adults and that the dual approach of operating the weir and incorporating electrofishing sampling as a removal method is effective in targeting different life history stages in Bright Angel Creek.

Yampa River Nonnative Fish Control Strategy. *Richard A. Valdez*[1], Tom Chart[2], Tom Nesler[3], Dave Speas[4] and Melissa Trammell[5] (*Ad Hoc* Committee). [1]SWCA, Logan, Utah; [2]Upper Colorado River Recovery Program, Denver, Colorado; [3]Colorado Division of Wildlife, Denver, Colorado; [4]Bureau of Reclamation, Salt Lake City, Utah; and [5]National Parks Service, Salt Lake City, Utah.

The Yampa River Nonnative Fish Control Strategy (Strategy) was developed in response to a directive from the Recovery Implementation Committee, dated October 13, 2006. The purpose, goals, and objectives of the Strategy were adopted from the Implementation Committee's directive and are consistent with the Recovery Program's Nonnative Fish Management Policy. The purpose of the Strategy is to identify and describe an

aggressive approach based on defensible data and consensus interpretation for controlling problematic nonnative fish in the Yampa River. The goals of the Strategy are to (1) Provide an assessment of current efforts to control problematic nonnative fish species in the Yampa River; and (2) Develop a stronger adaptive management framework to identify nonnative fish management actions of sufficient scale and intensity to achieve measurable success criteria based on fish population responses over the shortest plausible timeframe. The objectives of this Strategy are to (1) Develop a set of nonnative fish control actions for the Yampa River of sufficient scale and intensity that can achieve specific quantitative goals over the shortest plausible timeframe; (2) Assess these actions against the current tactics for nonnative fish control in the Yampa River and the likelihood of achieving the quantitative goals; (3) Based on the assessment, recommend adjustments to the current tactics, even if the effectiveness of those adjustments may be unproven; (4) Establish a timeframe for implementing the adjustments and a progress reporting schedule through the Recovery Program's committee process; and (5) Evaluate the effectiveness of control actions, and refine and update the nonnative fish control strategy and control actions. The Strategy identifies 14 actions within seven components including: information and education; prevention; early detection and reporting; data repository and information management; information sharing and collaboration; mechanical removal; and research and development.

2007 Nonnative Fish Management Workshop. *Richard A. Valdez* (SWCA, Loagan, Utah) and Tom Chart (Upper Colorado River Recovery Program , Denver, Colorado).

Nonnative Fish Management is an important element of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) for achieving recovery of the four endangered Colorado River fish species. A nonnative fish management workshop was convened by the Recovery Program on December 18-19, 2007 in Grand Junction, Colorado. This was the fourth workshop held since 2002 to bring researchers and managers together to develop and implement better strategies for managing the nonnative fish in the Upper Colorado River Basin. Forty-one researchers and managers attended the 2-day workshop. Presentations from the workshop are available at the Recovery Program's web site at: http://www.fws.gov/coloradoriverrecovery/documents.htm. The purpose of the 2007 workshop was to (1) examine the results from 2007; (2) compare those results with previous years' data; (3) recommend changes to 2008 nonnative fish management efforts; and (4) recommend a process to evaluate the Program's ability to reduce the threat of nonnative species on a river-wide or population scale. Researchers reported that control of northern pike populations in the Yampa and Middle Green rivers was possible with continued mechanical removal, minimized escapement from source populations, and possibly increased removal effort upstream of Craig, Colorado. Northern pike were reported in small numbers in the Upper Colorado River and absent through most of the remainder of the upper basin. Smallmouth bass have been mechanically removed for about 4 years (2004-2007) from various parts of the upper basin. Shifts in size distribution to smaller fish indicates an effect of removal, but researchers concur that it is too soon to determine if smallmouth bass can be effectively controlled with ongoing mechanical removal. Exploitation models indicate that 60-85% exploitation is necessary to effectively deplete ("crash") the population. Exploitation

rates are currently below 60% and numbers of removal passes in 2008 will increase accordingly, or efforts will focus on times and locations where the species is most vulnerable ("Achilles heel").