GCMRC Annual Reporting Meeting and
Glen Canyon Dam Technical Work Group Meeting
January 20-21, 2015

Conducting: Vineetha Kartha, TWG Chair
Convened: 9:30 a.m.
TWG Vice-Chair: Shane Capron

Committee Members/Alternates Present:

Jan Balsom, NPS/GRCA
Cliff Barrett, UAMPS (phone)
Charley Bulletts, So. Paiute Consortium
Shane Capron, WAPA/TWG Co-Chair
Kerry Christensen, Hualapai Tribe
Jerry Lee Cox, Grand Canyon River Guides
Kevin Dahl, National Parks Conservation Assn.
Bill Davis, CREDA
Kurt Dongoske, Pueblo of Zuni
Evelyn Erlandsen, State of Arizona
Paul Harms, State of New Mexico
Chris Harris, State of California
Robert King, State of Utah (phone)
Glen Knowles, Bureau of Reclamation
Ted Kowalski, Colo. Water Conservation Board
Jerry Myers, Federation of Fly Fishers
Don Ostler, representing Wyoming & New Mexico
Larry Stevens, Grand Canyon Wildlands Council
Bill Stewart, Arizona Game and Fish Dept.
Jason Thiriot, State of Nevada
Michael Yeatts, Hopi Tribe
Kirk Young, FWS

Committee Members Absent:

Tony Joe, Jr., Navajo Nation
Chip Lewis, Bureau of Indian Affairs
Robert King, State of Utah
VACANT, State of Wyoming

Grand Canyon Monitoring and Research Center:

Lucas Bair, Economist
Joshua Caster
Helen Fairley, Social Scientist
Kyrie Fry, Communications Coordinator
Paul Grams, Supervisory Hydrologist
Ted Kennedy, Aquatic Biologist
Dave Lytle, USGS-SBSC Director
Jeff Muehlbauer, Research Biologist
Erich Mueller, Research Hydrologist
Emily Palmquist,
Bill Persons, Fishery Biologist
Joel Sankey, Research Geologist
Daniel Sarr,
Scott VanderKooi, Acting Center Director
David Ward, Fishery Biologist
Charles Yackulic, Research Statistician
Mike Yard, Fishery Biologist

Interested Persons

Mary Barger, Bureau of Reclamation
Rob Billerback, NPS
Peter Bungart, Hualapai Tribe
Brian Collins, USGS (Menlo Park)
Marianne Crawford, Bureau of Reclamation
Jen Dierker, NPS
Craig Ellsworth, WAPA (phone)
Ed Gerak, CREDA
Gerald Hooee, Sr., Pueblo of Z
Leslie James, UAMPS/CREDA
Sam Jansen, GCRG
Lynn Jeka, WAPA
John Jordan, Federation of Fly Fishers
Matt Kaplinski, Northern Arizona University
Joe Miller, Trout Unlimited
Fred Nials, Desert Archaeology, Inc.
Dr. Sarah Rinkevich, Joint Tribal Liaison
Dave Rogwoski, AGFD
Brian Sadler, WAPA
Seth Shanahan, SNWA
Rosemary Sucec, NPS/GCNRA
Jerry Wilhite, WAPA
Lisa Winters, AGFD

Meeting Recorder: Linda Whetton

Welcome and Administrative: Ms. Kartha welcomed the members and the public. Introductions were made and a quorum determined.

GCDAMP T-shirts – Mr. Jason Thiriot. Members wanting to purchase a t-shirt with the GCDAMP logo need to submit their orders and money to Jason. The order will be placed on January 23, 2015.

Geomorphology of the Active Channel and Valley Margins

Streamflow, Water Quality, and Sediment Transport in the Colorado River Ecosystem

David J. Topping[1], Ronald E. Griffiths[1], Nicholas Voichick[1], Thomas A Sabol[1], Nancy J. Hornewer[2], Bradley D. Garner[2], and David J. Dean[1]
[1]U.S. Geological Survey, Grand Canyon Monitoring and Research Center
[2]U.S. Geological Survey, Arizona Water Science Center

The Streamflow, Water Quality, and Sediment Transport Core Monitoring Project is focused on high-resolution monitoring of stage, discharge, water temperature, specific conductance, dissolved oxygen, turbidity, and suspended-sediment concentration and particle size at a number of mainstem and tributary sites located throughout the Colorado River Ecosystem (CRE). These data are collected to address GCDAMP GOAL 7 and are used to inform managers on the physical status of the Colorado River in the CRE and how this physical status is affected by dam operations in near realtime. The high-resolution suspended-sediment data collected under this project are used to construct the mass-balance sediment budgets used by managers to trigger controlled floods under the 2012-2020 HFE protocol.

During 2013-14, this project completed work on and delivered all data and publication products promised under the 2013-14 Biennial Work Plan. The single most significant accomplishment during the period of the 2013-14 work plan was the completion of the new database and website. This website provides access to all of the current and legacy data collected by the Streamflow, Water Quality, and Sediment Transport Project and to all of the historical unit-value gage height and discharge data collected by the USGS at USGS gaging stations with QW and sediment data relevant to the CRE. The user-interactive tools available at this website to visualize and operate on the data are unique in the world. The two urls to use to access this new website are: http://www.gcmrc.gov/discharge_qw_sediment/ or http://cida.usgs.gov/gcmrc/discharge_qw_sediment/.

Additional results will be made available on demand during the website demonstration at the poster session.

Sandbars and Sediment Storage in Marble and Grand Canyons: Response to Recent High-flow Experiments and Long-term Trends

Paul E. Grams, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

In October 2013, approximately 11 months after the 2012 high-flow experiment (HFE), the median size of sandbar monitoring sites in Marble Canyon had increased from the low point measured one year earlier. Topographic surveys and images from remote cameras indicate that the fall 2012 and 2013 HFEs resulted in increases in sandbar size in both Marble Canyon and Grand Canyon. These results indicate that the implementation of the HFE Protocol is causing increases in sandbar size. However, it is still too early in the Protocol implementation to determine whether the repeated HFEs are resulting in a cumulative increase in sandbar size. Analysis of remote sensing images for select reaches do not indicate a significant trend (increase or decrease) in sandbar area above the 8,000 ft^3/s elevation between May 2002 and May 2009. Analysis of these images together with images taken following the 1996 HFE indicate that sandbar area visible on these images is a function of the elapsed time between a HFE and image acquisition, supporting the hypothesis that sandbar area will increase, on average, with more frequent HFEs.

Repeat mapping of the river channel has demonstrated that changes in sand storage are highly variable from one storage location (eddy) to the next. Repeat mapping of sandbars and the river channel in lower Marble Canyon (river mile (RM) 30 to 61) shows scour of the river bed and decreases in sandbar volume between May 2009 and May 2012. Most of this erosion occurred during the 2011 equalization flows and most of the sediment loss was from the river bed in the channel rather than from eddies or sandbars above the 8,000 ft^3/s stage. The magnitude of this sediment loss was less than the average annual input of sand from the Paria River. This suggests that, despite the large amount of sediment evacuation caused by equalization flows, most of the evacuated sediment likely consisted of recently accumulated Paria River sand inputs rather than older deposits of pre-dam sediment. Analysis of this repeat map that includes more than 80 large sandbars in this segment has also been used to evaluate the representativeness of the long-term monitoring sandbars. This analysis shows that the mean change in sandbar elevation at the long-term monitoring sandbars (the Northern Arizona University monitoring sites) in lower Marble Canyon was consistent with the mean response at all sandbars mapped in the 2009 and 2012 channel mapping efforts.

Final Results of BWP Project J: Conditions and Processes Affecting Sand Resources at Archaeological Sites in the Colorado River Corridor Below Glen Canyon Dam

Joel B. Sankey, presenting for the Project J Staff [David Bedford, Josh Caster, Brian Collins, Skye Corbett, Amy East, Helen Fairley]

Project J studied processes affecting archaeological sites in order to assess the likely effectiveness of HFEs to replenish sand supply to river-corridor sites, and to detect processes and rates of landscape change at selected sites. We determined that of the 358 river-corridor archaeological sites we evaluated, 266 (74%) have river-derived sand as a substrate, and that 232 (65%) have the potential to be affected by windblown sand from 45,000-cfs sandbars. We identified 31 sites that currently have the greatest potential to receive aeolian sand supply from HFE sandbars, because they have a direct upwind sand source and no vegetation or topographic barriers that could limit sand supply by wind. We determined that the proportion of sites affected by windblown sand from sandbars has varied over time. 40 years ago, there were 238 sites that had the potential to be affected by windblown sand, and 98 sites were in the category with greatest potential to receive aeolian sand supply.

We determined that gullies are less prevalent in sand areas that have active aeolian transport, whereas gullies occupy more of the sand area in places where the sand is inactive with respect to aeolian transport. Gully prevalence, and the proportion of active aeolian sand, vary substantially by reach, which is a function of canyon morphology, sand supply, and dominant wind direction. The reaches of the canyon that now have the greatest archaeological-site density (Glen Canyon, Furnace Flats, and Granite Park) are also those with the greatest gully prevalence, which are also the areas with the lowest proportions of active aeolian sand. Sand deposits in Glen Canyon are particularly gully-prone owing to canyon morphology, substantial bed incision, and very low modern sand supply.

Archaeological sites that receive HFE sand supply can, even in a "best-case scenario", still be affected by gully erosion on daily to seasonal time scales. Nonetheless, management actions that increase deposition of active aeolian sand area can reduce gully erosion, and HFEs can reduce gully extent in areas with upwind sandbars.

Stakeholder Discussion: Management Implications of Geomorphology Monitoring and Research – Mr. Paul Grams.

- *If we can't build bigger sand bars, can we build more sandbars?*
- *Need for more cameras? Current preliminary reporting is from same set of sites.*
- *Is there a larger model of wind direction and intensity possible in this system?*
- *How do we balance preservation and excavation with other forms of destruction to archaeological sites?*

Cultural Resources

Cultural Site Monitoring in Glen and Grand Canyons
Brian Collins, U.S. Geological Survey, Menlo Park, California

Cultural sites within the Colorado River corridor of Glen Canyon National Recreation Area and Grand Canyon National Park are subject to a suite of geomorphic processes that, in some cases, can threaten site integrity and stability. Using high-resolution lidar-derived topographic surveys and geomorphologic analyses of these survey data, we identify the magnitude and causes of changes at eight archaeological sites. We present change detection results for two recent time periods (2010-2013 and 2013-2014) in Grand Canyon and one time period (2012-2013) in Glen Canyon that bracket two recent high flow experiments (HFEs) from Glen Canyon Dam (November 2012 and November 2013). These results indicate that precipitation-induced gullying erosion is prevalent in most cases, but that aeolian deposition can also occur and limit the magnitude of gullying. The source of aeolian sands at some sites appears to be from river-derived sand, indicating that gullying annealing processes can be directly related to fluvial processes of the Colorado River.

Tourism's Impact on Zuni Cultural Resources in Grand Canyon
Gerald Hooee, Zuni AMWG Representative

The Grand Canyon is a sacred place for the Zuni people. It is the location of the Zuni emergence into this present world, the place where sacred medicine bundles were created, and where the migrations of the Zuni medicine societies began. As part of the Glen Canyon Dam Adaptive Management Program, the Zuni religious leaders have been participating in annual river trips for the purpose of renewing their cultural and religious connections to the Grand Canyon and to monitor the health and condition of important Zuni places. In discussions with Zuni religious leaders, the greatest impacts to places of Zuni importance in the Grand Canyon result from tourism. The various types of adverse impacts to Zuni traditional cultural properties that result from tourist activities in the Grand Canyon are presented. Mitigative activities that constructively control and/or modify tourist behavior are offered.

Stakeholder Discussion: Management Implications of Cultural Monitoring and Research – Ms. Mary Barger. There is a lot of overlap in the program which is good in that encroachment limits people going into some archaeological sites. She continue to work with the tribes to see if there is a way to blend their work with what GCMRC is doing.

- *The federal agencies have a responsibility to ensure that the identity of the tribes carries into the future and every facet of work being done should enable that.*
- *The biggest cultural disconnection is the "white" world sees the canyon as objective in trying to solve problems whereas the tribes talk about a living landscape and paying homage and respect by doing the right things. Having tribal presentations facilitates greater understanding.*
- *Tribes need better understanding of what types of monitoring and reports are expected from them.*
- *Need to know purpose for river trips.*

Riparian Resources

Developing Riparian Vegetation-Flow Response Guilds for the Colorado River Ecosystem in Grand Canyon, Arizona

Daniel Sarr[1], David Merritt[2], Emily Palmquist[1], Julian Scott[2], Patrick Shafroth[3], and Barbara Ralston[1]
US Geological Survey, Grand Canyon Monitoring and Research Center-SBSC, Flagstaff, AZ 86001
U.S. Forest Service National Stream and Aquatic Ecology Center, USFS Watershed, Fish, Wildlife, Air and Rare Plants Staff, NRRC, 2150 Centre Ave., Bldg A, Suite 368, Fort Collins, CO 80526
USGS Fort Collins Science Center, U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526

River regulation in the semi-arid West has resulted in major changes to riparian communities and geomorphic patterns. To restore riparian vegetation communities and associated values, managers desire a better understanding of the linkages between flow variables and vegetation response. Riparian vegetation-flow response guilds provide a potential tool to mechanistically link flow attributes to the distribution and abundance of specific riparian vegetation groups.

In this study, we compiled physiological and morphological trait information for 114 vascular plant species collected in 2012 and 2013 sampling along the Colorado River in Grand Canyon. For these species, we conducted two guild classifications using hierarchical cluster and analysis and Principal Coordinates Analysis ordination using eight trait variables. The first guild classification was an unsupervised classification that used a Gowers distance metric to classify the pool of 114 species into 7 groups. The second guild classification was supervised, and intentionally upweighted three traits (Anaerobic Tolerance, Drought Tolerance, and Height at Maturity) to ensure guilds were strongly linked to flow and were visually distinct. The supervised guild classification yielded 10 groups, from which we recognized 7 guilds with at least three species.

For each guild classification, we constructed logistic regression models linking species probability of presence with flow exceedance (the proportion of time that a site was inundated during the period of detailed flow records from 1985-2013). Logistic regression models were used to map the probability of occurrence on a large, heterogeneous sandbar, which showed a range of patterns from xeroriparian guilds on the highest microsites to hydroriparian guilds which occurred near the water's edge or in lower side channels. We conclude that riparian vegetation flow response guilds present a new and valuable way of classifying vegetation into functional groups that may have direct application to riparian management and restoration.

Southern Paiute Vegetation and Cultural Resource Monitoring Programs – Mr. Charley Bulletts.

Stakeholder Discussion: Management Implications of Vegetation Monitoring and Research – Mr. Larry Stevens

- *It appears we may be discounting changes that would've occurred naturally if there was no dam.*
- *There are historical photos showing where some plants haven't changed.*

- *Silt is probably a strong driver for vegetation and may need some attention.*

Update on GCMRC Chief Position – Mr. Dave Lytle. The GCMRC Chief candidates' public presentations will be held on January 28th (James "Dar" Crammond) and 29th (Joseph "Joe" Schubauer-Berigan) in Flagstaff, Arizona. WebEx details will be provided at a later date.

Public Comment: None

Adjourned: 4:50 p.m.

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Charley Bulletts, So. Paiute Consortium
Shane Capron, WAPA/TWG Co-Chair
Kerry Christensen, Hualapai Tribe
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Bill Davis, CREDA
Kurt Dongoske, Pueblo of Zuni
Evelyn Erlandsen, State of Arizona
Paul Harms, State of New Mexico
Chris Harris, State of California
Robert King, State of Utah (phone)
Glen Knowles, Bureau of Reclamation
Ted Kowalski, Colo. Water Conservation Board
Jerry Myers, Federation of Fly Fishers
Don Ostler, representing Wyoming & New Mexico
Larry Stevens, Grand Canyon Wildlands Council
Bill Stewart, Arizona Game and Fish Dept.
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Committee Members Absent:

Tony Joe, Jr., Navajo Nation
Chip Lewis, Bureau of Indian Affairs
Robert King, State of Utah
VACANT, State of Wyoming

<u>Grand Canyon Monitoring and Research Center</u>:

Lucas Bair, Economist
Joshua Caster
Helen Fairley, Social Scientist
Kyrie Fry, Communications Coordinator
Paul Grams, Supervisory Hydrologist
Ted Kennedy, Aquatic Biologist
Dave Lytle, USGS
Ted Melis, Physical Scientist
Jeff Muehlbauer, Research Biologist
Erich Mueller, Research Hydrologist
Emily Palmquist,
Bill Persons, Fishery Biologist
Joel Sankey, Research Geologist
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Jerry Wilhite, WAPA
Lisa Winters, AGFD

Meeting Recorder: Linda Whetton

<u>Welcome and Administrative</u>: Ms. Kartha welcomed the members and the public. Introductions were made.

Management Actions, Experiments, and Related Research

Endangered Humpback Chub Translocations to Colorado River Tributaries in Grand Canyon National Park

Omana Smith, Emily C.[1], Brian D. Healy[1], Clay Nelson[1], Melissa Trammell[2], Shannon Blackburn[1]
[1]National Park Service, Grand Canyon National Park, 1824 South Thompson Street, Suite 200, Flagstaff, Arizona 86001
[2]National Park Service, Intermountain Region, 324 S. State St. Suite 200, Salt Lake City, UT 84111

Historic fish communities in Grand Canyon National Park consisted of eight species, six of which are endemic to the Colorado River Basin. Today, reproducing and recruiting populations of only four native species are known to occur in the Park, including Humpback Chub, *Gila cypha*, which is listed under the Endangered Species Act. The Colorado River in Grand Canyon contains the largest remaining population of Humpback Chub, one that faces significant threats, including the presence of nonnative fish and parasites, and altered temperature and flow regimes. Additionally, the Grand Canyon population primarily spawns in one location, the Little Colorado River, which is threatened by watershed-wide impacts. In accordance with the Comprehensive Fisheries Management Plan for Grand and Glen canyons (NPS 2013), Grand Canyon National Park, with the assistance of the Bureau of Reclamation and others, initiated a series of Humpback Chub translocations in Havasu and Shinumo creeks to contribute towards the long-term goals of establishing additional spawning aggregations and/or increasing mainstem aggregations of the Humpback Chub within the park. Apparent annual survival rates are presented for translocated fish in Shinumo and Havasu creeks, along with contribution to mainstem Humpback Chub, growth, and evidence for spawning. Additionally, flood and fire impacts to the Shinumo Creek fish community following the 2014 managed Galahad Fire are presented.

Bright Angel Creek Trout Reduction Project

Clay Nelson, Brian Healy, Emily Omana Smith, Shannon Blackburn
NPS - Grand Canyon National Park
David Ward, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

The Bright Angel Creek Trout Reduction Project is an NPS-led interagency cooperative effort with the USGS, and funded by the Bureau of Reclamation to enhance native fish populations and contribute towards the fulfillment of Humpback Chub (*Gila cypha*) conservation measures for the operation of Glen Canyon Dam. The results of this adaptive management project will be measured against objectives included in the NPS Comprehensive Fisheries Management Plan, following implementation of 5 consecutive years (2012-2017) of nonnative trout control in and around Bright Angel Creek. Trout reduction efforts consist of the installation and operation of a weir to trap and remove spawning trout in the mouth of Bright Angel Creek, backpack electrofishing depletion sampling in Bright Angel Creek (approx. 10 miles), and boat mounted electrofishing depletion sampling in the Bright Angel Creek Inflow. The third year of reduction efforts is currently underway, and will conclude in March 2015. Preliminary results indicate that weir captures have varied from year to year, and reduction efforts in the creek have yielded 12,456 and 10,545 Brown Trout (*Salmo trutta*) and 1,735 and 1,400 Rainbow Trout (*Oncorhynchus mykiss*) in 2012-2013 and 2013-2014, respectively. A Bright Angel Creek Inflow depletion sampling feasibility study occurred in November-December of 2013-2014. While catches were limited due to turbid water, a depletion was still achieved with a total of 332 Brown Trout and 1,375 Rainbow trout removed. Population estimates, length frequency data, and native fish survival analyses will be used to evaluate the effectiveness of the project. All nonnative fish removed during the project have been put to beneficial use, consistent with a Memorandum of Agreement with the State Historic Preservation Office, following NHPA Section 106 consultation with Traditionally Associated tribes.

Native-Nonnative Interactions; Factors Influencing Predation Vulnerability

David Ward, Rylan Morton-Starner, and Ben Vaage, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

Predation on juvenile native fish by introduced rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) is considered a significant threat to the persistence of endangered humpback chub (*Gila cypha)* in the Colorado River. Diet studies of rainbow trout and brown trout in Grand Canyon indicate that these species do eat native fish, but population level impacts are difficult to assess because predation vulnerability is highly variable depending on the sizes of the prey and predators and the water temperature and turbidity under which the predation interactions take place. We conducted laboratory experiments to evaluate how short-term predation vulnerability of juvenile native fish changes in response to fish size, water temperature and turbidity using captive reared humpback chub, bonytail (*Gila elegans*), and roundtail chub (*Gila robusta*). Juvenile chub 45 to 90 mm total length (TL) were exposed to adult rainbow and brown trout at 10, 15, and 20 °C and at turbidities ranging from 0 to 150 formazin nephlometric units (FNU). A 1°C increase in water temperature decreased short term predation vulnerability of humpback chub to rainbow trout by about 5% although the relationship was is not linear. Our results indicate that turbidity as low as 50 FNU can reduced predation vulnerability of bonytail to rainbow trout by 63% (95% confidence interval = 43% - 82%). Of the factors we tested, chub size and turbidity had the largest effect on predation vulnerability to rainbow trout. Brown trout were highly piscivorous at any size >220 mm TL and at all of the water temperatures and turbidities tested. Understanding the effects of predation by trout on endangered humpback chub is critical in evaluating management options aimed at preservation of native fishes in Grand Canyon. We present a modeling tool, based on laboratory data, which can assist managers in evaluating these management options.

Aquatic Ecology and Fishes in Marble and Grand Canyons

Aquatic foodbase in Glen, Marble, and Grand Canyon

Ted Kennedy, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

Foodweb studies conducted from 2006-2009 demonstrated that algae is the base of the foodweb in Glen, Marble, and Grand Canyon, and native and desired non-native fish are limited by the availability of high quality insect prey (i.e., midges and blackflies). Based on these insights, long-term monitoring of key foodbase components was implemented in 2007 (invertebrate drift in Glen Canyon), 2009 (algae production in Glen, Marble, and Grand Canyon), and 2012 (insect emergence in Marble and Grand Canyon). In this presentation I will show recent analyses from long-term drift and algae production monitoring programs. Analysis of algae production data from Marble and Grand Canyon (2009-2011) demonstrates that turbidity, light, temperature and hydropeaking control rates of algae production, with turbidity and light being most important. Long-term drift monitoring in Glen Canyon (2007-2013) indicates drift abundance of key prey items (midges and blackflies) was low in 2007 and increased dramatically in 2008 due to the March HFE. However, drift abundance of these species has declined from 2008-2013. In contrast, drift of New Zealand mudsnails, tubificid worms, and Gammarus was high in 2007 and declined precipitously in 2008 because of the HFE, but drift of these three species has increased from 2008 through 2013. Thus, the November 2012 HFE did not restructure Glen Canyon invertebrate assemblages in the same way that the March 2008 HFE did. Specifically, midge and blackfly drift in 2013 was low and similar to prior years, while drift of mudsnails, worms, and Gammarus remained high in 2013 and was similar to prior years.

Rainbow trout movement, recruitment, population dynamics and modeling in Marble Canyon

Josh Korman, Ecometric Research Inc., 3560 W 22nd Ave, Vancouver, BC, Canada
Michael D. Yard, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

We conducted an intensive mark-recapture study of rainbow trout (*Oncorhynchus mykiss*) downstream of Glen Canyon Dam to better understand what controls their abundance in areas used by endangered native fish. In this study, we describe seasonal and spatial variation in abundance, movement and condition of rainbow trout in the Colorado River downstream of Glen Canyon Dam, and use this information to better understand factors that could be influencing their population dynamics. Over a 3-year period, we PIT-tagged more than 80,000 trout in the130 km-long study area, and recovered over 9,213 tagged fish. There was a rapid decline in trout abundance with increasing distance from Glen Canyon Dam, with densities ranging from 10,000-25,000 fish/km near the dam to 200-800 fish/km 125 km downstream, near the Little Colorado River (LCR) where native fish rear. Trout populations in upstream reaches declined over the study period, while the population grew in reaches near the LCR. The extent of rainbow trout movement was limited, with less than 1% of over 8,000 recaptures making movements greater than 20 km. Although, there is local reproduction in middle and lower Marble Canyon that is variable across years the small the proportion of fish emigrating from upstream reaches that move downstream are sufficient to explain the increasing trend in abundance at the LCR.

Movement of trout from Lees Ferry to Marble Canyon can be episodic, and recaptures show that both small (age-0) and large (older) trout can move from Lees Ferry to Marble Canyon. These movements may be driven by density dependent factors and poor condition. Reducing the magnitude and frequency of large annual cohorts in Lees Ferry (e.g., 2011super-cohort) may be best way to reduce trout emigration to Marble Canyon. This may also help maintain the quality of fishery in Lees Ferry and avoid the cyclical patterns in abundance and condition previously observed.

Colorado River fish monitoring in Grand Canyon, Arizona: 1990-2014 humpback chub, *Gila cypha*, aggregations

William R. Persons, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona
David R. VanHaverbeke, U.S. Fish and Wildlife Service
Michael Dodrill, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona
Brian Healey, Grand Canyon National Park

Humpback chub, *Gila cypha*, is an endangered cyprinid species endemic to the Colorado River basin of the western United States. The species was described in 1946 by R. Miller from a specimen taken near the mouth of Bright Angel Creek, Grand Canyon National Park, Arizona; and was listed as endangered in 1967. Long term fish monitoring in the Colorado River downstream of Glen Canyon Dam is a component of the Glen Canyon Dam Adaptive Management Program. Monitoring for humpback chub in the mainstem Colorado River in Grand Canyon has been conducted sporadically since the 1970's, and has improved since the introduction of small motorized watercraft and the use of hoopnets and trammel nets. Mainstem netting has occurred in three time periods: period 1 (1991–1993), period 2 (2002–2006), and period 3 (2010-2013). Nine humpback chub aggregations were originally identified based on fish collected during 1990-1993, and closed population model abundance estimates were generated for six of those aggregations. An aggregation was defined as "a consistent and disjunct group of fish with no significant exchange of individuals with other aggregations, as indicated by recapture of PIT-tagged juveniles and adults and movement of radio-tagged adults". We redefined aggregations and their boundaries based on current catch and PIT tag recapture information. Efforts to estimate abundance of mainstem humpback chub using pooled capture probabilities and catch rates were unsuccessful due to model assumption violations and relatively low recapture rates. Instead, we fit generalized linear models with a negative binomial error distribution to model adult (> 200 mm total length) humpback chub catch (counts) and included the log of effort (hours) as an offset to account for varying levels of effort. We found support for the hypothesis that adult humpback chub catch varies by time period, river location, and that the catch of fish within the LCR inflow aggregation varies between time periods compared to other mainstem locations. Models that included a term specifying whether a location is an aggregation or non-aggregation were not as highly supported. Fish that have been translocated to Shinumo and Havasu Creeks were generally recaptured in river sections close to the tributaries, and hoop net catch was higher when including translocated fish.

Humpback Chub (*Gila Cypha*) Population Dynamics and Modeling: Juveniles, Sub-adults, and Adults in the Colorado and Little Colorado Rivers

Charles Yackulic and Maria Dzul, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

Since 2009, GCMRC biologists and their collaborators have regularly sampled a fixed reference reach in the Colorado River just below its confluence with the Little Colorado River as a part of monitoring the status of humpback chub (*Gila cypha*). Mark-recapture data from this reach have dramatically improved our understanding of humpback chub survival and growth in the mainstem Colorado River, particularly with respect to juvenile fish. When these data are analyzed together with longterm system wide sampling in the Little Colorado River led by USFWS, a holistic understanding of humpback chub population dynamics emerges. Recent data suggests a stable adult population, however, because of long time lags this stability could be misleading. Understanding juvenile recruitment, outmigration, and survival provides a leading indicator of future change. Many factors likely contribute to variation in juvenile survival including the size of juveniles and the abundance of rainbow trout. Growth allows chub to quickly move through vulnerable life stages and appears to be strongly driven by water temperature. The size structure of juveniles in the mainstem is affected by preceding conditions in the LCR as the amount of outmigrants and their size structure can vary annually. Turbidity also likes play a role in both juvenile survival and growth.

Biological Opinion Trigger Update

Scott VanderKooi, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

The Bureau of Reclamation received a biological opinion on the operation of Glen Canyon Dam from the U.S. Fish and Wildlife Service in December of 2011. This presentation will review the biological and physical triggers for nonnative fish control implementation. A review of current population estimates for humpback chub (*Gila cypha*) and rainbow trout (*Oncorhynchus mykiss*), survival estimates for juvenile humpback chub, and Colorado River mainstem temperatures recorded in 2014 will also be provided. Results from 2014 indicate that the suite of triggers required to implement nonnative fish control have not been met. To date only one criterion, rainbow trout abundance just downstream of the Little Colorado River confluence, has exceeded trigger levels identified in the 2011 biological opinion.

Stakeholder Discussion: Management Implications of Aquatic Ecology and Native and Nonnative Fish Monitoring and Research – Mr. Kirk Young.

- *Translocation is a tool that can be used to jumpstart fish, increase growth.*
- *Different effects and what's driving survival – looking at size of prey.*
- *Looking at what a spring flow might do in terms of food is another management tool.*
- *Josh Korman's work on trout and what's driving food and movement is another opportunity to integrate information.*
- *It would be interesting to clarify that HBC are reproducing in springs-related areas.*
- *Per Wendell Minckley's report on abundant HBC at the Paria River. That is a "ghost" aggregation and it needs to be recognized.*
- *What happens if LCR is wiped out? How does the population respond? That's missing from recovery goals.*
- *A critical gap in knowledge is the issue of imprinting.*
- *The Pueblo of Zuni may not have known about mechanical removal occurring at Ribbon Falls.*

Aquatic Ecology of Glen Canyon and the Lees Ferry Fishery

Physical Environment of the Glen Canyon Dam Rainbow Trout Fishery

T.S. Melis, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

Rainbow trout responses to Glen Canyon Dam operations are complex and generally known to vary relative to physical and biological processes. Flows and quality-of-water monitoring, such as water temperature, dissolved oxygen and turbidity, typically supports fishery studies. Increased trout recruitment in Glen Canyon has occurred in at least 5 of 18 years (28%) since Glen Canyon Dam was re-operated to Modified Low Fluctuating Flows (MLFF) in fall 1996 (1997, 2000, 2008-9 and 2011). Recent modelling research identified dam releases in 1997, 2000 and 2008, as key to explaining the two-fold increases in trout recruitment between 1990 and 2010, and monitoring also showed elevated recruitment in 2009 and 2011. In 4 of the years, high-flow dam releases occurred in spring, and annual dam release volumes were above the minimum required to meet downstream water deliveries. All 5 years had steadier flows in either spring/summer, and (or) fall, and included experimental flows in addition to MLFF. River bed characteristics, consisting of highly varied sediments that are substrates for invertebrates, vegetation, are also commonly considered in trout studies. Sediment inputs from tributaries to the Colorado River can alter channel geometry and bed texture in ways that might influence aquatic resources, but bed evolution has not been part of past fishery studies. In Glen Canyon, there are 32 ephemeral tributaries that drain 291 square kilometers (km^2). During summer 2013, at least two floods from Waterholes Canyon delivered new sediment to the Colorado River, altering its bed in lower Glen Canyon. MLFF dam releases and 3 fall-timed high flow experiments have since winnowed and transported the finer fraction of the deposits downstream, revealing new gravel bars. Analyses of bed-texture imagery, aquatic vegetation, foodbase, and water quality data collected in coordination with Natal Origins of Rainbow Trout project monitoring in Glen Canyon are being integrated to determine how tributary and main channel sediment-transport processes may influence the recreational tailwater fishery.

Quagga Mussel Risk Assessment

Ted Kennedy, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

Quagga mussels (*Dreissena bugensis)* became established in Lake Powell and the Glen Canyon segment of the Colorado River in spring/summer of 2014. In this presentation, I describe 1) potential risks of quagga mussels establishing at high densities in the Colorado River ecosystem (CRE) and 2) the risk of ecological impacts should quagga establish at high densities in the CRE.

The risk of quagga establishing within the CRE appears low, except for the Glen Canyon tailwater reach where the risk appears high. Quagga are unlikely to establish at high densities within the CRE because of high suspended sediment, high ratios of suspended inorganic: organic material, and high water velocities, all of which interfere with the ability of quagga to effectively filter feed. Additionally, high turbulence in the rapids of Grand Canyon may represent a large source of mortality to larval quagga mussels, which would limit their ability to disperse and colonize downstream reaches of the CRE. In contrast, conditions within the Lees Ferry tailwater appear suitable for quagga establishment, and recent surveys indicate this has already occurred.

If quagga mussels establish within the CRE, the risks of negative ecological impacts appear low. If quagga mussels are able to attain moderate densities in Lees Ferry, estimates of filtration capacity indicate they are unlikely to substantially alter the composition (e.g., nutrient concentrations, suspended organic matter concentrations) of water exported from Lees Ferry. Further, a moderate density of *Dreissena* within Lees Ferry may actually increase food available to fishes by increasing habitat complexity and stimulating benthic production. If quagga attain moderate densities in the CRE mainstem, which seems unlikely, ecological impacts will probably be comparable to Lees Ferry—an increase in benthic production. Quagga mussels may also have ecological impacts on the CRE, if they substantially alter the composition of water released from Glen Canyon Dam; however, it is unclear whether changes in the composition of water released from Glen Canyon Dam (i.e., lower phytoplankton abundance and higher dissolved nutrients) will have a net positive or negative impact on food availability in the CRE mainstem.

Rainbow Trout Growth, Condition, Population Dynamics and Modeling in Glen Canyon
Michael D. Yard, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, AZ
Josh Korman, Ecometric Research Inc., 3560 W 22nd Ave, Vancouver, BC, Canada

The Lees Ferry model uses a standard Cormack-Jolly-Seber approach to estimate survival rate and capture probability of marked rainbow trout (*Oncorhynchus mykiss*), based on the known number of marks released and recaptures on latter trips. Estimates of across-trip capture probability are enhanced by within-trip recaptures and the assumed relationship between across-trip and within-trip capture probabilities (i.e., robust design approach). The unmarked catch on any trip can be expanded by the across-trip capture probability to estimate a size-stratified abundance of the unmarked population. Preliminary analyses indicate that trout abundance has declined over a 2.5 year period by 83% from 1,200,000 to 200,000 fish. There is considerable heterogeneity in capture probabilities influenced by fish size, density, and season, which affects the interpretation of monitoring indices for relative abundance and size-structured catch proportions. Decreased growth and survival of large fish, particularly in 2014, indicate that smaller fish are disproportionately acquiring or not expending energy relative to larger fish. Following the 2011 super-cohort, reduced recruitment of age-0 fish and their subsequent low survival has been insufficient to sustain population levels. Size-stratified condition factors for trout are highly variable across size classes, among and within years, and throughout sampling sites. There is a longitudinal downstream trend of decreasing fish condition in Glen Canyon. Although there are numerous factors (prey availability, diversity, and size; high flow experiments and water quality) that are potential mechanisms, the most likely proximal factor in the decline of trout is excessive trout recruitment in 2011, and perhaps earlier in 2008 that has been linked to higher and steadier dam operations, and has negatively influenced the carrying capacity of Glen Canyon, through a top down effect. Implementing novel measures that prescriptively control for excess recruitment through trout management flows and managed harvesting are two options that can be explored as management strategies.

Annual Reporting 2015 – Bioenergetics Modeling
Mike Dodrill, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona
Charles B. Yackulic, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona
Ted Kennedy, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona

The Lees Ferry tailwater supports a recreational fishery in which the maximum size of adult rainbow trout (*Oncorhynchus mykiss*) has declined through time. Field, laboratory, and modeling studies have demonstrated that water temperature, prey availability (concentration of drifting invertebrates), and the size distribution of prey often interact to influence growth of drift-feeding fish. We developed a drift foraging and bioenergetics model to identify which of these factors limit rainbow trout growth in the Colorado River downstream of Glen Canyon Dam. Model predictions were first validated by comparing predicted growth with empirical growth estimates from the natal origins project. We then explored the importance of temperature, prey quantity, and prey size by comparing predicted growth under the current biological (drift) and physical (temperature) conditions with scenarios representing altered conditions. Our results demonstrate that rainbow trout growth in Lees Ferry is limited by the scarcity of large prey items and overall prey availability. Additionally, warmer temperatures (2005) always resulted in lower growth compared to cooler temperatures (2002), even when prey availability was simultaneously increased. These results provide additional evidence that rainbow trout growth is food limited, and the effect of food limitation is exacerbated when water temperatures are warm.

Lees Ferry Fishery Monitoring: Electrofishing Surveys, Angler Surveys, and Spawning and Rearing Surveys
David L. Rogowski and Lisa K. Winters, Arizona Game and Fish Department, Flagstaff, Arizona
Glen Canyon Dam on the Colorado River, Arizona was completed in 1963. The resulting cold water releases created a popular rainbow trout tailwater fishery known for trophy size rainbow trout. Arizona Game and Fish Department has been monitoring the Lees Ferry fishery since the early 1980s using angler (creel) surveys and boat electrofishing. Dam operations have had a significant effect on the rainbow trout population. Flow from the dam was regulated in response to power demands with water levels fluctuating up to 15 feet daily, until 1996 when modified low fluctuating flows (MLFF) were implemented, significantly reducing variance in flows. Prior to the MLFF the rainbow trout fishery was maintained via stocking. However, stocking ceased in 1998 when the majority of rainbow trout were maintained via natural production. Since 1981 the median size of reproductively mature rainbow trout has declined as well as the percent of large fish (>456 mm; 18 inches) in the population. Consistent flow levels have allowed rainbow trout to naturally reproduce every year, thereby increasing density and competition for a limited food base. Rainbow trout populations have been somewhat cyclical with a recent record peak in catch per unit effort in 2011-2012, after record young of the year production from 2008-2011; catch per unit effort (electrofishing) has since declined. Currently (Fall 2014) rainbow trout condition is at the lowest level since standardized monitoring began 24 years ago. Current conditions favor fish that mature and reproduce early, resulting in smaller fish, a concern for the status of this important blue ribbon fishery. While managers have trigger points for action when there are too few rainbow trout (minimum catch rates, percent young of the year), these metrics are lacking for when there are too many fish. Future management goals are to reduce these extremes in recruitment and fish condition.

Stakeholder Discussion: Management Implications of Applied Research and Recent Findings in Lees Ferry and Glen Canyon – Mr. Bill Stewart.

Public Comment: Mr. Joe Miller (Trout Unlimited) – The Sixth Annual Native and Wild Trout Conference is scheduled for April 23, 2015, at Arizona Game and Fish Headquarters. For more information: http://az-tu.org/2015/sixth-annual-native-and-wild-trout-conference-scheduled-april-23-2015.

Adjourned: 5 p.m.

Upcoming Meetings:

• May 28, 2015	AMWG Meeting via webinar
• (W-Th) June 10-11, 2015	TWG Meeting at ADWR or June 10 via webinar
• (late) August 19-20, 2015	AMWG Meeting in Flagstaff (location TBD)

Respectfully submitted,
Linda Whetton
Bureau of Reclamation
Upper Colorado Region

Key to Glen Canyon Dam Adaptive Management Program Acronyms

ADWR – Arizona Dept. of Water Resources
AF – Acre Feet
AGFD – Arizona Game and Fish Department
AIF – Agenda Information Form
AMP – Adaptive Management Program
AMWG – Adaptive Management Work Group
AOP – Annual Operating Plan
ASMR – Age-Structure Mark Recapture
BA – Biological Assessment
BAHG – Budget Ad Hoc Group
BCOM – Biological Conservation Measure
BE – Biological Evaluation
BHBF – Beach/Habitat-Building Flow
BHMF – Beach/Habitat Maintenance Flow
BHTF – Beach/Habitat Test Flow
BIA – Bureau of Indian Affairs
BO – Biological Opinion
BOR – Bureau of Reclamation
BWP – Budget and Work Plan
CAHG – Charter Ad Hoc Group
CAP – Central Arizona Project
GCT – Grand Canyon Trust
CESU – Cooperative Ecosystems Studies Unit
cfs – cubic feet per second
CFMP – Comprehensive Fisheries Management Plan
CMINS – Core Monitoring Information Needs
CMP – Core Monitoring Plan
CPI – Consumer Price Index
CRBC – Colorado River Board of California
CRAHG – Cultural Resources Ad Hoc Group
CRCN – Colorado River Commission of Nevada
CRE – Colorado River Ecosystem
CREDA – Colorado River Energy Distributors Assn.
CRSP – Colorado River Storage Project
CWCB – Colorado Water Conservation Board
DAHG – Desired Future Conditions Ad Hoc Group
DASA – Data Acquisition, Storage, and Analysis
DBMS – Data Base Management System
DOE – Department of Energy
DOI – Department of the Interior
DOIFF – Department of the Interior Federal Family
EA – Environmental Assessment
EIS – Environmental Impact Statement
ESA – Endangered Species Act
FACA – Federal Advisory Committee Act
FEIS – Final Environmental Impact Statement
FRN – Federal Register Notice
FWS – United States Fish & Wildlife Service
FY – Fiscal Year (October 1 – September 30)
GCD – Glen Canyon Dam
GCES – Glen Canyon Environmental Studies
GCT – Grand Canyon Trust
GCMRC – Grand Canyon Monitoring & Research Center
GCNP – Grand Canyon National Park
GCNRA – Glen Canyon Nat'l Recreation Area
GCPA – Grand Canyon Protection Act
GLCA – Glen Canyon Nat'l Recreation Area
GRCA – Grand Canyon National Park
GCRG – Grand Canyon River Guides
GCWC – Grand Canyon Wildlands Council
HBC – Humpback Chub (endangered native fish)
HFE – High Flow Experiment
HMF – Habitat Maintenance Flow
HPP – Historic Preservation Plan
IG – Interim Guidelines
INs – Information Needs
KA – Knowledge Assessment (workshop)
KAS – Kanab Ambersnail (endangered native snail)
LCR – Little Colorado River
LCRMCP – Lower Colorado River Multi-Species Conservation
Program
LTEMP – Long-Term Experimental and Management Plan
LTEP – Long Term Experimental Plan
MAF – Million Acre Feet
MA – Management Action
MATA – Multi-Attribute Trade-Off Analysis
MLFF – Modified Low Fluctuating Flow
MO – Management Objective
MRP – Monitoring and Research Plan
NAU – Northern Arizona University (Flagstaff, AZ)
NEPA – National Environmental Policy Act
NHPA – National Historic Preservation Act
NNFC – Non-native Fish Control
NOI – Notice of Intent
NPCA – National Parks Conservation Association
NPS – National Park Service
NRC – National Research Council
O&M – Operations & Maintenance (USBR Funding)
PA – Programmatic Agreement
PBR – Paria to Badger Creek Reach
PEP – Protocol Evaluation Panel
POAHG – Public Outreach Ad Hoc Group
Powerplant Capacity = 31,000 cfs
R&D – Research and Development
RBT – Rainbow Trout
RFP – Request for Proposal
RINs – Research Information Needs
ROD Flows – Record of Decision Flows
RPA – Reasonable and Prudent Alternative
SA – Science Advisors
Secretary – Secretary of the Interior
SCORE – State of the Colorado River Ecosystem
SHPO – State Historic Preservation Office
SOW – Statement of Work
SPAHG – Strategic Plan Ad Hoc Group
SPG – Science Planning Group
SSQs – Strategic Science Questions
SWCA – Steven W. Carothers Associates
TCD – Temperature Control Device
TCP – Traditional Cultural Property
TEK – Traditional Ecological Knowledge
TES – Threatened and Endangered Species
TMC – Taxa of Management Concern
TWG – Technical Work Group
UCRC – Upper Colorado River Commission
UDWR – Utah Division of Water Resources
USBR – United States Bureau of Reclamation
USFWS – United States Fish & Wildlife Service
USGS – United States Geological Survey
WAPA – Western Area Power Administration
WY – Water Year

(Updated: 2/20/2014)