GCDAMP Protocol Evaluation Panel Prospectus: Fisheries Program Review

July 15, 2016

The U.S. Secretary of the Interior (Secretary) established the Glen Canyon Dam Adaptive Management Program (GCDAMP) in early 1997 to implement the Grand Canyon Protection Act of 1992, the 1995 Operation of Glen Canyon Dam Final Environmental Impact Statement, and the 1996 Record of Decision. The GCDAMP advises the Secretary on the effects of Glen Canyon Dam operations and related management actions on key resources in and alongside the Colorado River and its tributaries in Glen, Marble, and Grand Canyons, Arizona, between the Glen Canyon Dam (Lake Powell) forebay and Lake Mead. The lands alongside these waters lie within the jurisdictions of Glen Canyon National Recreation Area, Grand Canyon National Park, and Navajo, Hualapai and Havasupai Tribes. The Bureau of Reclamation manages dam operations. Stakeholders on the GCDAMP include the U.S. Fish and Wildlife Service, Arizona Game and Fish Department, National Park Service, six Tribes (Hualapai, Hopi, Navajo, Kaibab and Shivwits Bands of Southern Paiute, Zuni), the U.S. Department of Energy-Western Area Power Administration and the energy distributors it serves, and all seven states in the Colorado River basin, for which the river is a critical source of water, recreational fishing and rafting interests, and environmental conservation organizations.

The GCDAMP fisheries monitoring and research program is a collaborative effort of the U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) and several cooperators including the U.S. National Park Service, the U.S. Fish and Wildlife Service, the Arizona Game and Fish Department, and contractors (Bureau of Reclamation, 2014). Key fishery resources include native humpback chub *Gila cypha*, an endangered species, and nonnative rainbow trout *Oncorhynchus mykiss*, a popular sport fish. Among its many goals, the GCDAMP seeks to maintain or attain stable populations of humpback chub in this portion of the Colorado River while also maintaining an economically-viable rainbow trout sport fishery in the tailwater of Glen Canyon Dam (National Park Service, 2013; Rogers, 2015). The GCDAMP also seeks to maintain and improve the state of other native fish species, including endangered razorback sucker *Xyrauchen texanus*, and to manage non-native fish species that pose risks to native fish and/or rainbow trout (National Park Service, 2013). The fisheries investigations carried out by the GCRMC and cooperators are intended to address specific information needs identified by stakeholders, and to inform ongoing adaptive management of dam operations and related management actions.

As lead science provider for the GCDAMP, the GCMRC periodically convenes independent review panels to assess the quality, comprehensiveness, and need for various research and monitoring programs. This document presents the background, goals, and steps for a review of the GCDAMP fisheries monitoring and research program.

Fisheries Program – Background and Key Questions

The Colorado River is the most highly regulated river in North America, with numerous dams and diversions that are operated primarily to ensure mandated deliveries of water to the basin

states and to Mexico. Glen Canyon Dam is operated to balance the volumes of water supplies stored in Lake Powell upstream of the dam and Lake Mead behind Hoover Dam, downstream; and as a load-following hydroelectric facility. Hourly water releases from Glen Canyon Dam can vary up to 50% during seasons of peaking electrical demand. The resulting hydrograph bears little resemblance to the pre-regulation flow regime. Dam management policies also seek to provide for recreation and the conservation of natural and cultural resources of the Colorado River. Regulatory constraints and infrastructure design limit the range of options available to the GCDAMP for experimenting with Glen Canyon Dam operations to effect changes in fish populations and habitat in this 400 kilometer-long segment. Lake Powell traps all the massive quantity of sand and mud that was formerly delivered into Glen Canyon from upstream segments. Only sand and mud delivered by tributaries downstream of Glen Canyon Dam continues to contribute to turbidity and fluvial geomorphic dynamics downstream of the dam. The pre-regulation temperature regime of the Colorado River through Glen Canyon exhibited a wide intra-annual range of variation. Glen Canyon Dam has fixed intake structures that withdraw water from deep within Lake Powell, and water temperatures near the dam are often cold throughout the year with little intra- or inter-annual variation (i.e., 8-11 ºC). However, ongoing drought in the region has lowered the elevation of Lake Powell reservoir, and intake structures now withdraw from nearer the surface of Lake Powell. Outflow water temperatures consequently have increased (i.e., outflow temperatures 13-16 ºC have occurred recently). Water temperatures warm with distance downstream from the dam, but the large discharge (mean of 330 $m^3 \cdot s^{-1}$) and short residence time through Grand Canyon (~3 days) constrain downstream warming to around 1 ºC every 50 kilometers.

The GCDAMP fisheries monitoring and research program aids GCDAMP decision making by: (1) estimating the current state of key resources, and (2) quantifying the relative impacts of various factors including management actions on the condition, distributions, survival, growth, recruitment, and movement of focal fish species, to improve predictions of the effects of future management actions on these key resources. Given the complexity and scale of the regulated system, long-term monitoring is crucial for detecting and evaluating the magnitude of changes in resource conditions in response to environmental variability and management actions, including experimental dam operations (Rogowski and others, 2016; Winters and others, 2016; VanHaverbeke and others, 2013; Stone and Gorman, 2006). Research activities in turn typically focus on shorter-term specialized sampling (Yard and others, 2011; Korman and others, 2016; Kennedy and others, 2016), interpretation and integration of data using models (Yackulic and others, 2014; Dodrill and others, 2016), and laboratory-based experiments to reduce uncertainties (Ward and others, 2015). Monitoring projects typically collect catch-per-unit-effort (CPUE; Rogowski and others, 2016; Winters and others, 2016) and/or mark-recapture data using established protocols (VanHaverbeke and others, 2013). However, some monitoring protocols have evolved through time. For example, mark-recapture studies in the Little Colorado River (LCR), a tributary of the Colorado River in which many humpback chub spawn, began in 2000 and eventually replaced CPUE monitoring (VanHaverbeke and others, 2013). In another example, mark-recapture in a fixed section of the Colorado River near the LCR confluence began in 2009 as a research activity, and the success and insights from this project led to its continuation as a monitoring program (Yackulic and others, 2014).

The fisheries program is currently grappling with how to plan future monitoring and research activities in light of recent advances in our scientific understanding, proposed future management actions, and financial constraints. Important questions for the review panel include:

1. **How could the program better balance priorities and trade-offs among its various monitoring and research activities focused on the rainbow trout in Glen and Marble Canyons?**
   Many of the current fishery monitoring and research projects focus on rainbow trout in the upper 120 river kilometers of Colorado River between Glen Canyon Dam and the LCR confluence (Rogowski and others, 2016; Winters and others, 2016; Korman and others, 2016). The GCDAMP seeks to maintain a highly productive rainbow trout fishery particularly between the dam and Lees Ferry, located 25 river kilometers downstream (Rogowski and others, 2016; Winters and others, 2016). However, the rainbow trout also disperse a varying distance farther downstream (Korman and others, 2016) and prey on juvenile humpback chub near the LCR confluence (Yard and others, 2011; Ward and others, 2015), where juvenile humpback chub survival is negatively correlated with rainbow trout abundances (Yackulic and others, 2014). Modeling of long-term CPUE data (Winters and others, 2016), combined with detailed study of rainbow trout early life history in the tailwater (Avery and others, 2015), has established that rainbow trout survival, growth, and recruitment in the tailwater are linked to dam operations (Korman and others, 2012). In turn, but more recently, a costly, large-scale mark-recapture study has established that the majority of rainbow trout found near the LCR confluence come from upstream sources (Marble and Glen Canyons; Korman and others, 2016). To help control the abundance and downstream dispersal of rainbow trout, and potentially increase the maximum size of rainbow trout in the tailwater, managers are proposing dam operations designed to produce flows that limit rainbow trout recruitment in years when flow conditions otherwise would be expected to produce large recruitment events. Managed flows also potentially could be used to enhance trout recruitment following episodes of significant population loss. Additionally, recent studies have provided compelling evidence that dam operations affect the availability of food for all insectivorous fish species below the dam, by limiting aquatic insect recruitment (Kennedy and others, 2016). Determining the effectiveness of "trout management" flows, and continuing to provide the best estimates of the current state of the rainbow trout fishery, key invertebrate prey resources, and the drivers of changes in fishery condition (e.g., prey availability), are key long-term concerns of stakeholders.

2. **How could the program better balance priorities and trade-offs among its various monitoring and research activities focused on humpback chub, both around the LCR confluence, where most individuals are found, and at other locations that could potentially harbor secondary populations?**
   Mark-recapture studies in the LCR (VanHaverbeke and others, 2013) and at a fixed site in the Colorado River near the LCR confluence have provided important insights into vital rates and abundances of different size classes of humpback chub (Yackulic and others, 2014). However, opportunities and needs still exist for refining monitoring and research focused on this species below the dam. Our understanding of humpback chub vital rates and size-class abundances is much more limited along reaches downstream of the LCR (Yackulic and others, 2014), but humpback chub CPUE (per spatially extensive monitoring; see Question #3) along these downstream reaches in Grand Canyon are increasing (Persons and others, in

review). Based on the success of monitoring at the fixed site in the Colorado River near the LCR confluence, scientists and stakeholders alike are interested in establishing one or more additional fixed sites downstream to determine how drivers of vital rates may vary along the river system as well as to develop more accurate abundance estimates for these downstream populations. Extending mark-recapture sampling at one or more sites would likely require a reallocation of the effort currently placed in Glen and Marble Canyons to study rainbow trout. Further, the merits of fixed-site monitoring (e.g., Korman and others, 2016) must be weighed against those of randomized or habitat weighted sampling designs (e.g., Rogowski and others, 2016). The increase in humpback chub CPUE in the western Grand Canyon, and uncertainties about the natal origins of this western expansion (i.e., dispersal from the LCR populations versus local or tributary origins in the western canyon, including translocation sites – see Question #4), add to the complexity of decisions about reallocations of effort. As noted above, too, recent studies have highlighted the potential impacts of dam operations on the base of the aquatic food web for insectivorous fishes including both rainbow trout and humpback chub (Kennedy and others, 2016). Continuing to provide the best estimates of the current state of the humpback chub, key invertebrate prey resources, and the drivers of changes in fishery condition are key long-term concerns of stakeholders.

3. **How could the program better balance priorities and trade-offs among its various monitoring and research activities focused on statuses and trends of native and nonnative fish species outside of fixed study locations?**
System-wide monitoring of native and nonnative fish populations is currently accomplished through two trips annually primarily using electrofishing at randomly selected sites (Rogowski and others, 2016), and a third trip using hoopnets that primarily focuses on humpback chub aggregations in the Colorado River (Bureau of Reclamation, 2014). Hoopnet sampling has recently (2016) been incorporated in the system-wide monitoring effort, primarily to improve system-wide sampling for humpback chub. System-wide monitoring is crucial for the detection, mapping, and age classification not only of humpback chub but also of potentially harmful/invasive nonnative species and other rare native species such as the endangered razorback sucker (Bureau of Reclamation, 2014). These efforts have been successful, for example detecting a green sunfish outbreak in a Glen Canyon backwater in late 2015 leading to an effective eradication effort. Nevertheless, it is important to consider whether, and how, these efforts can be improved through use of additional gear types and sampling methods (e.g., angling, e-DNA, etc.), remote sensing using PIT tag arrays in the LCR and other places in the canyon, targeted research (e.g., use of otoliths to determine natal origins of different species), or implementation of approaches to improve accuracy and efficiency (e.g., field-based data entry into computers, use of tender boats, etc.), to provide the best possible information concerning the status and trends of fish species throughout the river. At the same time, budgetary constraints dictate that any increase in the costs of monitoring and research activities focused on statuses and trends of native and nonnative fish will require a reallocation of effort from other monitoring and research activities.

4. **How could the program improve research or monitoring to evaluate the effectiveness of ongoing experimental management actions involving translocation of humpback chub within the Little Colorado River and to other tributaries?**
Fish managers along the Colorado River have been translocating humpback to additional tributaries along the canyon both downstream from the LCR confluence (i.e., Havasu Creek,

Shinumo Creek) and in upstream reaches within the LCR above Chute Falls. Are present monitoring methods and data streams sufficient to guide the selection of translocation sites and evaluate the effectiveness of these experimental management actions, and what data or analyses should be prioritized to inform managers about the effectiveness of these programs?

5. **How could the program modify its handling of both native and non-native fishes to maintain the quality of the science while also better accommodating Native American concerns for the value of all life-forms in the river?**
   The research and monitoring program has a responsibility to handle all subject life forms in a manner consistent with the values of all stakeholders to the GCDAMP. However, these values may be incompatible with each other across the diverse community of stakeholders or incompatible with some investigative methods. For example, the Zuni people regard all fish species in the river as related beings (Zuni Tribal Council, 2010) and they object to activities such as otolith studies, used to trace natal origins of humpback chub and other species, because such studies require euthanizing the fish, an activity they consider incompatible with efforts to maintain the viability of the humpback chub. The Zuni are not alone in this regard, several Tribes share the concern of taking any form of life without putting it to direct "beneficial use" (Dongoske and others, 2010). One example of addressing these concerns has been incorporated into an effort to control nonnative fishes in Bright Angel Creek. Trout removed from the creek have been processed and preserved and then made available to the Tribes and others for human consumption as well as for the eagle aviary at the Pueblo of Zuni. In contrast, other stakeholders may value introduced sport fishes over native species that are typically less interesting from a recreational fishing perspective (Jordan and Hamill, 2015; Rogers, 2015), while others may value all native species over all introduced species (National Park Service, 2013). These incompatibilities pose important challenges to the GCMRC and its cooperators in the research and monitoring program, for pursuing investigations that are both sensitive to the values of all GCDAMP stakeholders and scientifically effective.

The Protocol Evaluation Panel (PEP)

The PEP has been developed and is managed by the GCMRC with support from the GCDAMP Science Advisors Program (SAP) Executive Coordinator. The review panel consists of individuals with widely recognized expertise in current best practices for designing, implementing, and analyzing the data from high-quality fisheries monitoring and research programs. The GCMRC will reimburse the panel members for their travel expenses, and provide an honorarium to panelists who are not U.S. federal government employees. While the above questions provide some guidance to the review panel, the panel will consider all aspects of the GCDAMP fisheries monitoring and research program described in the current three-year (FY 2015-2017) GCDAMP Triennial Work Plan (Projects 6-9). Ultimately, the panel will consider how the work being done by GCMRC and its cooperators can continue to provide the necessary data to address the information needs identified by stakeholders in the GCDAMP for guiding adaptive management of dam operations and related management actions. **In sum, the panel will review the program and make recommendations regarding its scope and direction, including levels of effort, study designs, and the relevance of individual research activities to existing and emerging monitoring and research questions.**

Specifically, the review panel will:

(1) To the extent feasible, review background documents on the GCDAMP fisheries monitoring and research program that are cited in this document prior to participating in a review workshop at the GCMRC in Flagstaff, AZ, August 1-5, 2016. A more comprehensive list of relevant references and associated pdfs is available on a public ftp site (ftp://ftpext.usgs.gov/pub/nonvisible/wr/PEP%202016%20documents/) and a flash drive that will be shipped to you.
(2) Spend time on the river to experience the physical setting of the investigations and its constraints, and hear and discuss presentations on the fisheries investigations by the GCMRC and cooperators as well as from GCDAMP stakeholders with particular interests in the fisheries research and monitoring program.
(3) Return to Flagstaff and meet in open sessions to hear presentations from GCMRC and cooperating scientists, as well as from GCDAMP stakeholders with particular interests in the fisheries research and monitoring program.
(4) Meet in a closed workshop session following the open sessions to discuss potential questions, comments, and recommendations to the GCDAMP, and discuss assignments and the timeline for completing a draft report on its findings and recommendations.
(5) Prepare a draft report for review and feedback from the GCMRC and the SAP Executive Coordinator.
(6) Prepare a final report incorporating the feedback from the GCMRC and the SAP Executive Coordinator. The GCMRC in turn will deliver the final report to the GCDAMP Secretary of the Interior's Designee, Adaptive Management Work Group, and Technical Work Group for their consideration in developing the next triennial work plan for the GCDAMP.

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