Research and Monitoring Plan in Support of the Environmental Assessment Non-Native Fish Control Downstream from Glen Canyon Dam

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Preface

This research and monitoring plan describes a general framework for evaluating key science questions arising from the **Environmental Assessment for Non-Native Fish Control Downstream from Glen Canyon Dam** (U.S. Department of Interior, Bureau of Reclamation, 2011a). This research and monitoring plan is conceptual and will become more specific as proposed management actions also become more specific. The science activities proposed in this document, and revised in subsequent plans, will also be guided by the information needs of the stakeholders as they identify key management uncertainties surrounding the efficacy of nonnative fish removal to benefit the endangered humpback chub (*Gila cypha*).

Introduction

This science plan has been developed in support of the **Environmental Assessment for Non-Native Fish Control Downstream from Glen Canyon Dam** (hereafter referred to as the NNFC EA). The goal of the proposed action is to minimize the negative effects of nonnative fish on endangered humpback chub (*Gila cypha*) in Grand Canyon. The primary threats imposed by nonnative fish are through competition and predation. The NNFC EA proposes to accomplish this goal by reducing numbers of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) near the Little Colorado River (LCR) confluence (river mile 61; Figure 1), where humpback chub are most abundant. This goal will be achieved by removal of rainbow trout from the Paria River to Badger Rapid (PBR) reach (river miles 1 to 8; Figure 1), removal of brown trout from Upper Granite Gorge (river miles 83 to 93.5; Figure 1) and Bright Angel Creek (Figure 1), and removal of all nonnative fishes from the LCR reach (river miles 56 to 66; Figure 1). Additionally, management of the trout population in the Lees Ferry reach (river mile -15 to 0; Figure 1) and decreased emigration of these fish further downstream will be accomplished through manipulations of Glen Canyon Dam releases.

Although the proposed action is predicated on documented adverse effects of trout on humpback chub, the significance of those effects at a population level are poorly understood. Thus, key research questions identified in the NNFC EA to be addressed by this science plan focus on quantifying the degree to which humpback chub recruitment and population trends are controlled

by nonnative fish, improving understanding of the factors influencing the abundance and distribution of trout in the Colorado River, and identifying the most effective methods of controlling trout populations. This science plan will be implemented through a combination of existing research and monitoring projects and proposed new projects. Given that the proposed action of the NNFC SA will occur over a 10-year period, this research and monitoring plan represents the initial step of an ongoing and evolving science effort.

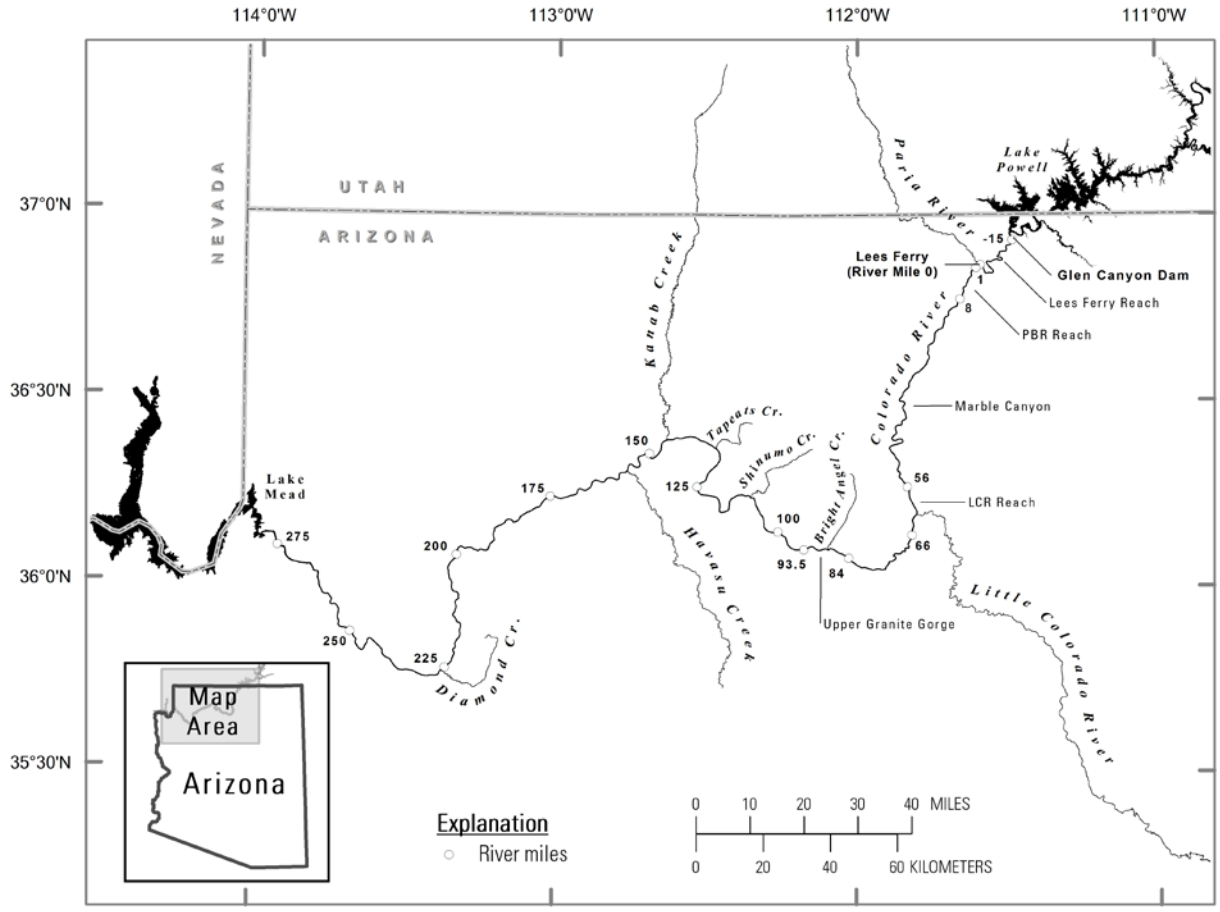

Figure 1. Map of the extent of the study area with river miles identified in 25-mile segments starting at Lees Ferry. The Little Colorado River (LCR) is identified and its confluence is at river mile 61. Key river reaches and associated river miles (RM) are also identified including the Lees Ferry reach (-15 – 0 RM), the Paria River to Badger Rapid (PBR) reach (1 – 8 RM), Marble Canyon (8 – 56 RM), the LCR reach (56 – 66 RM), and Upper Granite Gorge (84 – 93.5 RM).

The nonnative fish control actions described in the NNFC EA are predicated on four fundamental premises. In order of importance, these premises are:

1. Survival and recruitment of juvenile humpback chub rearing in the Colorado River mainstem are significant factors limiting the adult humpback chub population in the Colorado and Little Colorado Rivers;
2. Competition with and/or predation by nonnative fishes, especially rainbow trout and brown trout, significantly limit survival and recruitment of juvenile humpback chub into adult populations in the Colorado River mainstem;
3. Rainbow trout in the LCR reach primarily come from the Lees Ferry reach; brown trout in the LCR reach primarily come from Upper Granite Gorge, mainly from Bright Angel Creek; and
4. Trout abundance in the LCR reach and elsewhere in Grand Canyon, such as near Bright Angel Creek, can be controlled by fish population management activities like removal and flow manipulation.

If all of these premises are correct, then the nonnative fish control actions proposed in the NNFC EA will likely benefit humpback chub populations. However, if the first premise is found to be incorrect, then it negates the relevance of the other premises and the utility of the proposed management actions will be of limited value. For example, if the Colorado River mainstem rearing environment is not contributing significantly to juvenile humpback chub growth, survival, and recruitment, then it is unlikely that any management activity directed at trout removal will have significant positive benefits to humpback chub. On the other hand, if a relatively high proportion of juvenile humpback chub that move or disperse into the mainstem ultimately recruit into the adult population, then trout predation and competition may be limiting humpback chub recruitment in the Colorado River mainstem. Current research and monitoring results (Coggins and others, 2011;Yard and others, 2011; Korman and others, 2011) have identified uncertainty in all of the premises listed above.

Many physical and biological variables vary annually and can have direct effects on humpback chub survival within the LCR. High annual variation in timing and magnitude of flood events within the LCR can impact spawning success and survival of larval humpback chub (Gorman and Stone, 1999). Density dependent effects, such as a strong cohort of juvenile humpback chub within the LCR, may also impact the survival of subsequent humpback chub cohorts. In addition, changes in physical attributes of the mainstem Colorado River can also impact survival rates of humpback chub. Changes in mainstem water temperatures impact humpback chub growth rates (Coggins and Pine, 2010) and subsequent swimming ability of native fishes (Ward and others, 2002), which in turn can alter predation rates (Ward and Bonar, 2003). High turbidity in the mainstem Colorado River is also known to alter predation rates (Yard and others, 2011), and altered mainstem flow regimes may also impact juvenile humpback chub survival. All of these factors can directly affect survival of young humpback chub as well as confound the assessment of the effects that rainbow in the mainstem Colorado River may have on the humpback chub population.

Studies that seek to determine the effect of experimental management actions on humpback chub populations must be of a sufficient duration to allow the effect of experimental manipulation to be separated from natural variability and potential confounding factors. For humpback chub, management actions need to be applied for a duration that approaches or exceeds the generation time of this species—four to six years. Alternatively, inferences regarding the impact of management actions on humpback chub populations can be made using data on how the actions affect juvenile humpback chub growth or survival. Approaches that use these vital rates to make inferences about specific actions will still likely take three to four years to assess due to annual variation in physical and biological factors.

Objectives

The proposed action in the NNFC EA is to control nonnative fish as a means of conserving the endangered humpback chub and other native fishes. This action is predicated on fundamental observations concerning the nature of interactions between humpback chub and trout. As described above, several aspects of these interactions have large scientific uncertainty. Consequently, the proposed action will be pursued in an adaptive management framework such that management actions undertaken in later years will be informed by monitoring and research conducted during the first years of implementation. Thus, the context of this science plan is the effort to reduce uncertainty of management actions and to revise these actions as knowledge is gained throughout the 10-year duration of this EA. The Grand Canyon Monitoring and Research Center (GCMRC) and its science cooperators have identified five key objectives to be addressed to support management decisions associated with the NNFC EA:

1. Understand the relative roles of the LCR and the mainstem Colorado River in juvenile humpback chub survival rates and recruitment into the adult humpback chub population;
2. Determine the linkage between nonnative fish abundance and juvenile humpback chub abundance and survival rates in the LCR reach and elsewhere in Grand Canyon;
3. Determine the natal origins of rainbow trout found in Marble Canyon (river miles 8 to 56) and the LCR reach;
4. Assess the efficacy of nonnative fish removal in the PBR reach for rainbow trout and Upper Granite Gorge for brown trout; and
5. Assess the efficacy of flow manipulations to manage trout populations in the mainstem Colorado River from Lees Ferry to the LCR reach.

Background: Structured Decision Making and Science Planning

Structured decision making (SDM) is an approach that can be used to facilitate management decisions involving multiple competing objectives. A SDM approach (Runge and others, 2011) was used by Reclamation to identify and evaluate alternative non-native fish control actions for application in the NNFC EA (U.S. Department of Interior, Bureau of Reclamation, 2011a). The project consisted of two workshops with representatives of NNFC EA cooperating agencies and

tribes. The workshop focused on developing and evaluating a wide range of non-native fish control alternatives considering effectiveness, stakeholder values, costs, and other factors. Trout removal at the PBR, with supplemental removal at the LCR if necessary, ranked highest among the "value weighted" control alternatives considered. Ranking was based on a variety of factors, including five fundamental objectives:

1. Manage resources to protect tribal sacred sites and spiritual values;
2. Manage resources to promote ecological and native species integrity;
3. Preserve and enhance recreational values and uses;
4. Maintain and promote local economies and public services; and
5. Operate within the authority, capabilities, and legal responsibility of the Bureau of Reclamation.

Two key uncertainties emerged from the SDM project: 1) the degree to which rainbow trout limit humpback chub populations, and 2) the effectiveness of PBR removal to reduce trout out-emigration from the Lees Ferry reach downstream to Marble and Grand Canyons. The SDM analysis identified two approaches that might be pursued by resource managers: 1) a direct action strategy for nonnative fish control that assumes that native and nonnative fish interactions in mainstem and near the LCR confluence limits humpback chub recovery, and 2) an adaptive strategy that delays removal to verify the premise in approach 1.

The outcome of the SDM project suggested that the Glen Canyon Adaptive Management Program (GCDAMP) was not driven by learning as a fundamental objective. The authors of the SDM project concluded that approach 1 was a logical step accepted by managers. The conclusion by managers to move toward approach 1 may have been based on several studies (Coggins and Yard, 2010; Yard and others, 2011) that indicate trout prey upon and compete with humpback chub. In light of ESA mandates to management agencies to take reasonable actions to avoid jeopardy to and promote recovery of humpback chub, approach 1 emerged as the preferred approach by workshop participants. The NNFC EA emphasizes taking appropriate management action to conserve humpback chub by controlling trout while addressing some of the key uncertainties related to the impacts that trout have upon humpback chub recovery.

Several objectives and activities proposed in this science plan were not recommended as outcomes of the SDM project. Since the completion of the SDM workshops, additional information has become available and scientific thinking has evolved. This science plan strives to be inclusive of not only relevant recommendations from the SDM project, but also of the most current thinking of scientists. As the authors of the SDM report note, their conclusions are not meant to be definitive and can best be used as a starting point for the decision making process.

Monitoring and Research Activities

Monitoring and research activities will be organized to meet the five science support objectives identified by GCMRC.

Objective 1 – Understand the role of the Little Colorado River and the mainstem Colorado River in juvenile humpback chub survival rates and recruitment to the adult humpback chub population.

Justification

Although juvenile humpback chub are found in the LCR reach and elsewhere in Grand Canyon, it is not known to what degree those fish contribute to the reproducing population in the LCR. If juvenile humpback chub rearing in the mainstem recruit to the adult population in low numbers relative to juvenile humpback chub rearing in the LCR, then determining the best approach for managing nonnative fish abundance in the mainstem is potentially irrelevant. Thus, understanding the relative contribution of the LCR rearing environment versus the mainstem rearing environment in sustaining humpback chub populations would help managers to determine whether nonnative fish removal from the LCR reach provides a measurable benefit to humpback chub.

Science Activities

To resolve this key uncertainty concerning the role of the mainstem in humpback chub recruitment, GCMRC recommends a hybrid research project be implemented that incorporates elements of the recently completed Nearshore Ecology (NSE) project, a proposed LCR aquatic food base monitoring program, and ongoing humpback chub monitoring in the LCR and mainstem Colorado River. The overall goals of this hybrid project are to assess the carrying capacity of the LCR to support humpback chub, and to determine the relative importance of mainstem versus LCR rearing to sustaining humpback chub populations. This information would also inform decisions regarding how many humpback chub can be taken from the LCR for translocations to other tributaries, and how translocations upstream from Chute Falls affect humpback chub carrying capacity within the LCR.

Objective 2 – Determine the linkage between nonnative fish abundance and juvenile humpback chub abundance and survival rates in the LCR reach and elsewhere in Grand Canyon.

Justification

Predation of juvenile humpback chub by rainbow trout and brown trout (Yard and others, 2011) clearly demonstrates a negative effect of nonnative fishes on native species at the level of the individual. What remains uncertain is if trout have population level effects on humpback chub. Quantifying population level effects of trout on humpback chub will require continuation and/or expansion of existing monitoring efforts as well as initiation of new research projects.

Science Activities

Continued annual assessments of juvenile humpback chub survival rates and abundance in the mainstem using methods developed in the NSE study is essential since these are the key metrics by which other actions will be measured. This work will continue in 2012 as part of the new Natal Origins study described in Objective 3. The mainstem fish monitoring program will continue because it provides critical information on the relative abundance of rainbow trout and other nonnative fishes in Marble Canyon and Grand Canyon and how they change over time. A proposed expansion of this study to include additional sampling and mark-recapture methods would provide more quantitative information on the status and trends of nonnative fish populations and therefore help reduce uncertainty regarding their effects on humpback chub. Monitoring of humpback chub in the LCR and mainstem must be maintained at a level that allows adult abundance estimates to be generated using the Age-Structured Mark Recapture (ASMR) Model. An effort to revise the ASMR model is currently underway with the goal of developing a more flexible length-based model that will minimize potential bias associated with age-assignment errors that exists in the current model (S. Martell, written communication, 2011). Required sampling levels will be re-evaluated following the revision of the ASMR. Expansion of effort in the mainstem may also be warranted in order to provide a more quantitative assessment of status and trends in these population segments or aggregations as they are commonly called.

Actions proposed in the NNFC EA could also be used in an experimental framework to clarify how trout abundance relates to juvenile humpback chub abundance and survival rates. Trout management actions could be implemented or postponed either as part of a set study design or adaptively as certain biological or environmental conditions occur in an effort to facilitate learning about humpback chub-trout interactions. Specific actions to apply experimentally included in this science plan are the removal activities described in Objective 4 and the flow manipulations proposed in Objective 5.

Objective 3 – Determine the natal origins of rainbow trout found in Marble Canyon and the LCR reach

Justification

Rainbow trout abundance is greatest in the Lees Ferry reach and generally decline downstream, reaching their lowest abundance in western Grand Canyon (Makinster and others, 2010). Sources of rainbow trout in the mainstem downstream from Lees Ferry could include downstream migration of trout from the Lees Ferry reach, trout that spawn in tributaries such as Nankoweap, Bright Angel or Tapeats Creek, or local reproduction in the mainstem. The relative contribution of each of these potential sources to the mainstem population is sufficiently uncertain as to warrant further study. Of particular interest to managers is whether changes in the Lees Ferry reach trout population affect downstream rainbow trout abundance. Though there

is not conclusive evidence linking high rainbow trout abundance in the Lees Ferry reach with high mainstem trout abundance, the patterns of increase between these areas are similar, with generally a one-year lag between pronounced spikes in rainbow trout abundance in the Lees Ferry reach and a comparable increase in rainbow trout abundance downstream (Makinster and others, 2010; Makinster and others, 2011). Analysis of size-frequency data for rainbow trout captured in Marble Canyon indicate an absence of small-sized fish, which suggests these populations are supported by individuals that migrated from the Lees Ferry reach. Alternatively, it is possible that scattered local reproduction in Marble Canyon, combined with relatively high growth and survival of juvenile rainbow trout in Marble Canyon, may also contribute sufficient numbers of trout to support observed adult densities (J. Korman, personal communication, 2011). Resolving these competing hypotheses is important to determining the viability of removing rainbow trout from the PBR reach as a way to manage the trout population in the LCR reach.

Science Activities

The newly initiated Natal Origins project will quantify the abundance and size classes of rainbow trout in the Lees Ferry reach and estimate what fraction of rainbow trout in Marble Canyon and the LCR reach were spawned and reared in the Lees Ferry reach. Additionally this project will determine if emigration is due to trout production in the Lees Ferry reach, then determine what factors (density dependent versus flows) or interaction of factors are responsible for emigration. This project includes a program of tagging, mark-recapture, and depletion sampling that focuses efforts between Lees Ferry and Badger Rapid. Ongoing downstream monitoring for nonnative fish in the mainstem will sample Marble Canyon and the LCR reach and contribute catch data to inform objectives laid out in this plan. Additionally, any nonnative fish monitoring or removal efforts that may occur will also be used to recapture marked fish.

Objective 4 – Assess the efficacy of nonnative fish removal in the PBR reach for rainbow trout and Upper Granite Gorge for brown trout.

This objective will be addressed through two projects described below.

1. The Paria River to Badger Rapid Sampling and Removal Project

Justification

Understanding rainbow trout population dynamics and movement characteristics in the Lees Ferry reach and the PBR reach is an important first step in being able to assess the potential for successful system-wide control of rainbow trout through actions taken in these reaches. If fish from the Lees Ferry reach are found to be a primary source for rainbow trout downstream, then removing fish in the PBR reach may be less intrusive and more culturally acceptable than control efforts conducted at or near the LCR confluence. Uncertainty remains, however, as to the feasibility of conducting removal in the PBR reach to the degree that it can effectively control rainbow trout abundance in the PBR reach, Marble Canyon, and subsequently in the LCR reach.

Science Activities

This project is proposed as a pilot level effort with two trips to be conducted in FY 2012. The project is intended to estimate age stratified capture probability and abundance of rainbow trout in the Lees Ferry reach and the PBR reach as well as age stratified downstream movement of rainbow trout between these reaches. Additionally, estimates of proportions of marked juveniles will be generated for comparison to proportions established upstream through the Natal Origins marking program. Finally this project will help assess the feasibility of removal in the PBR reach as a means to control trout abundance in the removal and LCR reaches. If rainbow trout move downstream and out of the Lees Ferry reach, then this project will provide information about the age- and size-class structure of fish that move downstream, and whether there is any "dilution" in the upstream mark rate indicative of local recruitment in the PBR reach. Information from ongoing monitoring of rainbow trout in the Lees Ferry reach will also be incorporated to assess any potential correlation between rainbow trout density in the Lees Ferry reach and potential emigration out of the reach.

2. The Brown Trout Sampling and Removal Project

Justification

Experimental reductions of brown trout populations in Bright Angel Creek and the mainstem Colorado River near its confluence could reduce predation pressure on humpback chub not only in areas where removal occurred, but also in the LCR reach. Bright Angel Creek appears to be the primary spawning area supporting brown trout populations in the mainstem Colorado River including the LCR reach. While brown trout are concentrated in Upper Granite Gorge nearest the confluence of Bright Angel Creek, high catch rates of this species in the LCR reach has corresponded with periods of high abundance in Upper Granite Gorge (Makinster and others, 2011). Any increase in abundance of this predatory fish in the LCR reach would be of concern given the high incidence of piscivory reported for this species (Yard and others, 2011). The concentration of brown trout in Upper Granite Gorge may also be a threat to humpback chub because high levels of predation in this reach may limit dispersion of humpback chub, particularly younger fish, into downstream aggregations, effectively limiting their range within Grand Canyon.

Science Activities

The proposed Brown Trout Sampling and Removal Project is intended to determine efficacy of brown trout removal in the Colorado River mainstem in Granite Gorge and in Bright Angel Creek. Capture probabilities for specific gear used in the study reaches will also be estimated and used in the development of an open population model for estimating size-structured abundance of brown trout. Additionally, densities of native fishes in Bright Angel Creek and areas near its confluence would be monitored. A multi-year, brown trout removal treatment would be applied to both the mainstem Colorado River and Bright Angel Creek with the objective of significantly

reducing brown trout abundance. Proposed removal in the Colorado River mainstem would occur in Upper Granite Gorge using primarily electrofishing depletion methods (See Coggins and others, 2011). This effort is to be conducted in collaboration with the National Park Service's ongoing removal efforts (fish weir and electrofishing) in Bright Angel Creek and potential future efforts (for example, expanded electrofishing, chemical treatments, or rotary screw traps designed for capturing migrating juvenile fish). This project is proposed as an experimental research project to be conducted in FY 2012 with possible extension through FY 2015 to assess the effectiveness of removal in this reach and increase knowledge of humpback chub movement into downstream reaches through recaptures of previously tagged fish.

Any fish removed as part of either of these projects would be put to beneficial use in a manner consistent with the NNFC EA.

Objective 5 – Assess the efficacy of experimental flow manipulations (through dam operations) to manage trout populations in the mainstem Colorado River from Lees Ferry to the LCR reach.

Justification

Past efforts to control trout populations in the LCR reach by lethal removal appear to have resulted in temporary reductions that were likely only successful due to a concurrent system-wide decline in trout abundance (Coggins and others, 2011). Given that trout populations appear to be increasing (Korman and others, 2011; Makinster and others, 2011; GCMRC unpublished data) and the possible limitations of removal as a population control tool, future efforts at trout management should include experimentation to develop other approaches. One approach that warrants investigation is identifying flows or flow regimes that limit trout reproduction and/or survival of fertilized eggs, larvae, or juveniles in the Lees Ferry reach. Flow manipulation as a trout population control measure is attractive as it would target the most vulnerable life stages of rainbow trout at their likely source using a method that has the potential of affecting high proportions of the population. Some experimentation with flows to manage trout populations was conducted from 2003 through 2005 (Korman and others, 2011; also see USGS Fact Sheet 2011-3002 available at http://www.usgs.gov). The range of daily releases from Glen Canyon Dam was increased from January through March to promote rainbow trout spawning in high elevation areas that would subsequently be dewatered, thus increasing mortality rates of eggs and young fish. While survival rates of these early life stages were lowered, age 0 abundance did not decrease likely due to compensatory increases in survival rates among survivors (Korman and others, 2011). These results demonstrate flows can affect survival of some trout early life stages, but also make it clear that the factors controlling trout recruitment need to be understood and accounted for when designing future experiments.

Science Activities

An experimental approach would be used to determine which flows (volumes, duration) or flow regimes (fluctuating, rapid ramp rates) would be best suited to managing mainstem trout populations by limiting available spawning or rearing habitat, de-watering redds, stranding young fish, or displacing young fish to sub-optimal habitats.

Linkages to Existing Monitoring and Research Projects

As part of the GCDAMP there are five existing long-term monitoring projects that will also provide additional data to evaluate the efficacy of nonnative fish removal efforts and natal origin objectives. These long-term monitoring projects include:

1. Monitoring Lees Ferry Fishes (BIO 4.M2.11, 12) – Ongoing status of the Lees Ferry trout fishery (adult and juvenile fish);
2. Monitoring Mainstem Fishes (BIO 2.M4.11, 12) – Ongoing monitoring of the documented humpback chub aggregations in the mainstem and downstream monitoring of native and nonnative fish distribution and relative abundance in the mainstem (includes sampling downstream of Diamond Creek);
3. Stock Assessment of Native Fish in Grand Canyon (BIO 2.R7.11, 12) – Age-structured mark recapture recruitment modeling update for adult humpback chub (Age- 4+);
4. Little Colorado River Humpback Chub Monitoring (BIO 2.R1.11, 12) – Annual point estimates for humpback chub population in the lower 13.57 km; and
5. Natal Origins (BIO 2.E18. 11, 12) – Determine the natal origins of rainbow trout found in Marble Canyon and the LCR reach and assess humpback chub survival and abundance and trout abundance downstream of the LCR confluence.

These projects are described in more detail in the Glen Canyon Dam Adaptive Management Program Biennial Budget and Work Plan—Fiscal Years 2011-12 (FY 2011-12 BWP). Other research and reporting efforts that are part of FY 2011-12 BWP projects associated with the mainstem and its tributaries will also help inform the adaptive decision-making process. These include:

1. Annual Nonnative Fish Workshop (see BIO 2.R17.11, 12) – conduct a workshop with scientists and managers to review current data and findings and adapt the program as needed; and
2. Continued ecosystem modeling (see PLAN 12.P1.11, 12) – collaborate with GCMRC's Senior Ecologist and other cooperators to employ novel approaches to link study results into conceptual and quantitative models of responses of the Colorado River aquatic ecosystem to management actions.

Linkages to High Flow Experimental Protocol EA and Monitoring and Research Plan

The NNFC EA and this science plan were developed concurrently with another Environmental Assessment, **Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam, Arizona, 2011 through 2020** (HFE EA; U.S. Department of

Interior, Bureau of Reclamation, 2011b), and its associated science plan. Although the HFE EA and the NNFC EA are separate documents, they are interrelated. The actions described in each not only overlap geographically and temporally, but also contain elements that interact and affect one another. Of particular relevance to this science plan are the effects High Flow Experiments (HFEs) may have on native and nonnative fishes. Past HFEs may have positively affected nonnative trout populations. The spring 2008 HFE was followed by a dramatic increase in rainbow trout abundance, a result thought to be related to high flow releases (Korman and others, 2010; also see USGS Fact Sheet 2011-3002 available at http://www.usgs.gov). For native fishes, including humpback chub, effects of HFEs may be negative through mechanisms such as increases in predation and competition associated with more abundant nonnative fish (Wright and Kennedy, 2011).

Understanding the effects of HFEs on both physical and biological resources in the Colorado River will be essential for managers to make fully informed decisions regarding operations of Glen Canyon Dam. Several ongoing or proposed monitoring and research projects described above will help determine the biological effects of any HFEs that occur during the period this science plan is in place. The effects of HFE timing and frequency on rainbow trout population dynamics and outmigration will be evaluated by activities proposed in Objectives 2, 3, and 4. The influence of HFEs on humpback chub habitat use, predation risk, and competitive interactions will be evaluated through activities proposed in Objective 2. Other aspects of HFEs and their effects on biological resources that have not been addressed in this science plan are those that relate to the Lees Ferry recreational trout fishery. As noted above, HFEs can result in high trout abundance in the Lees Ferry reach. Under these conditions, high levels of competition for limited food resources can limit the numbers of larger and, presumably, more desirable trout available to anglers. HFE induced changes in the trout population structure like these may in turn affect recreational experience quality. This is of concern as maintaining this important trout fishery has been identified as a priority for the GCDAMP. As part of the FY 2011-12 BWP, the GCMRC has proposed to conduct a recreation experience valuation study for the Lees Ferry reach of the Colorado River (REC 9.R4.11, 12). The objective of this study is to provide a foundation for evaluating how different dam operations, including future HFEs, affect the biological and physical attributes of the Lees Ferry reach that visitors value and consider to be important for maintaining high quality recreation experiences there.

Annual Reporting

Annual reporting is proposed to occur in December or January either as part of the GCMRC's Annual Fish Cooperators Meeting or another planning meeting. A written summary will also be provided that includes the annual resource assessment and criteria for supporting the decision making process to be used the coming year. The primary information provided will include: 1) humpback chub abundance, 2) humpback chub survival rates, 3) LCR reach trout abundance estimates and total fish catch and removal numbers (if removal occurs), 4) PBR reach trout

abundance estimates and total fish catch and removal numbers (if removal occurs), and 5) Lees Ferry reach age-0 trout marking numbers and recaptures in the Lees Ferry reach, the PBR reach, Marble Canyon, and the LCR reach.

Budget

The GCMRC anticipates that the monitoring and research activities described above will be funded as part of ongoing monitoring and research projects included in the approved FY 2011-12 BWP, including use of experimental funds as described in that work plan. Continuation of the tasks described here, or the addition of any other tasks that may be needed to provide information about actions implemented beyond 2012, will be developed through ongoing planning efforts between the GCMRC and the GCDAMP, starting with development of the draft FY 2013-14 Biennial Work Plan during 2012.

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