RECLAMATION

Managing Water in the West

Biological Assessment for Non-native Fish Control Downstream from Glen Canyon Dam

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

January 28, 2011

CONTENTS

Page

Figures

Page

Tables

Page

1.0 Introduction

1.1 Background

This document serves as the biological assessment for the Bureau of Reclamation's (Reclamation) request for consultation on the operation of Glen Canyon Dam regarding implementation of the conservation measure on non-native fish control (U.S. Fish and Wildlife Service 2008, 2009, 2010). This biological assessment analyzes the effects of the proposed action to implement up to 6 non-native fish removal trips in the Little Colorado River (LCR) reach, river mile (RM) 56 to 66 as measured downstream from Lees Ferry, and up to 10 removal trips in the Paria River to Badger Creek (PBR) reach, RM 1-8, in any one year for the ten-year period of 2011-2020 in the Colorado River downstream of Glen Canyon Dam within Glen Canyon National Recreation Area (GCNRA) and Grand Canyon National Park (GCNP), Coconino County, Arizona (Figure 1). This biological assessment analyzes the effects of the action on the endangered humpback chub (*Gila cypha*), razorback sucker (*Xyrauchen texanus*), Kanab ambersnail (*Oxyloma haydeni kanabensis*), and southwestern willow flycatcher (*Empidonax traillii extimus*).

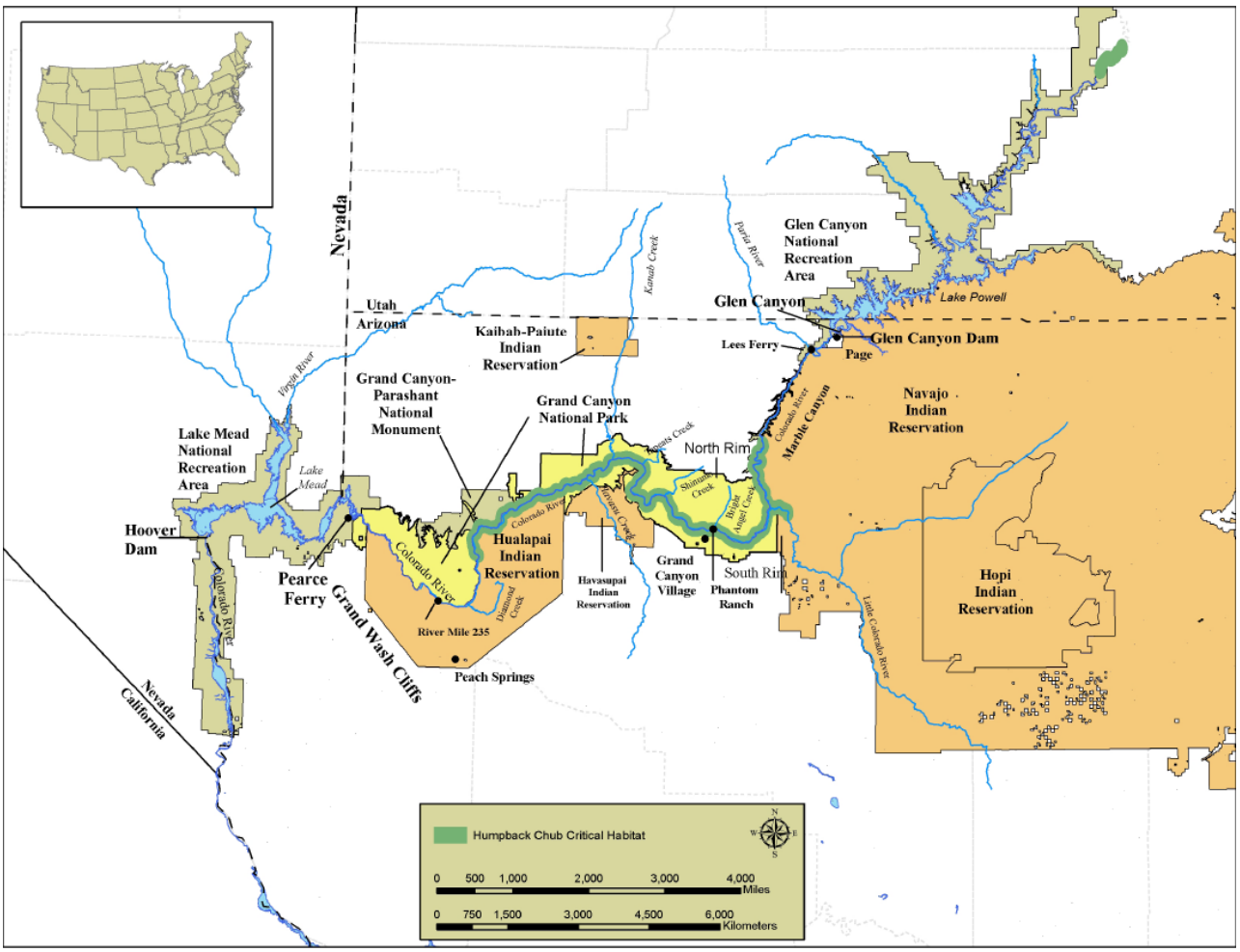

Figure 1. Map of Action Area and humpback chub (*Gila cypha*) critical habitat in the Colorado and Little Colorado Rivers (courtesy of the U.S. Fish and Wildlife Service).

This document was prepared by Reclamation as part of its compliance with the Endangered Species Act of 1973, as amended (ESA; 87 Stat. 884; 16 U.S.C. §1531 *et seq.*). Reclamation has determined that the proposed action may affect, but is not likely to adversely affect the humpback chub and its critical habitat and the razorback sucker and its critical habitat. The Proposed Action will not affect the Kanab ambersnail, or the southwestern willow flycatcher (see Table 1). Take of humpback chub may occur during removal of trout but an ESA Section 10(a)(1)(A) Permit for scientific research to enhance the propagation and survival of the species will be obtained to cover this potential loss.

Reclamation proposes to control non-native fish in the Colorado River downstream from Glen Canyon Dam to ensure that its operation of Glen Canyon Dam does not jeopardize the continued existence of endangered native fish. Non-native fish have long been identified as a threat to native aquatic biota (Cambray 2003, Clarkson et al. 2005), and a specific threat to native fish in the Colorado River and its tributaries in Grand Canyon (Marsh and Douglas 1997; Valdez and Ryel 1995; Minckley 1991). Since passage of ESA and its implementing regulations at 50 CFR 402, Reclamation has consulted with the U.S. Fish and Wildlife Service (USFWS) to ensure that

its operations of Glen Canyon Dam do not jeopardize the continued existence of the endangered endemic Colorado River fishes, the humpback chub, razorback sucker, Colorado pikeminnow, and bonytail or destroy or adversely modify their designated critical habitat. This analysis concentrates on the humpback chub because it is the only one of these species that currently occurs in the project area. The Colorado pikeminnow and bonytail are no longer found in this part of the Colorado River and are not included in this assessment. Although the action area or geographic scope of this biological assessment is a 294-mile reach of the Colorado River corridor from Glen Canyon Dam downstream to the Lake Mead inflow near Pearce Ferry, the action will be implemented in two reaches of the Colorado River: the reach from the Paria River to Badger Creek (the PBR reach), River Mile (RM) 1 to 8 (as measured in river miles from Lees Ferry downstream), and in the reach surrounding the Little Colorado River from RM 56-66 (the LCR reach). The proposed action is not anticipated to affect the razorback sucker because it is absent from the action area and unlikely to occupy the area in the reasonably foreseeable future; the reaches where non-native removal will be conducted also are expected to have no effect on the abundance of non-native fishes in Lake Mead, where the species still occurs (Albrecht et al. 2010).

Critical habitat for the humpback chub and the other "big river" fishes was designated by the USFWS in 1994 (50 CFR 17) and includes areas within Marble and Grand Canyons. Humpback chub critical habitat includes 175 miles of the Colorado River from Nautiloid Canyon (river mile, RM 34; with Lees Ferry river mile 0) to Granite Park (RM 209) and the lower 8 miles of the LCR. Critical habitat for razorback sucker extends for 234 miles of the Colorado River from the Paria River confluence (RM 1) to Lake Mead. These reaches of designated critical habitat lie within the boundaries of GCNRA and GCNP and are managed by the National Park Service. The reach of the Colorado River from RM 30 to RM 75 is a principal nursery area for humpback chub (Figure 2), and it is the reach of river downstream from Lees Ferry that has the highest densities of young humpback chub, and thus impacts of predation and competition to humpback chub by non-native fishes are greatest in this reach.

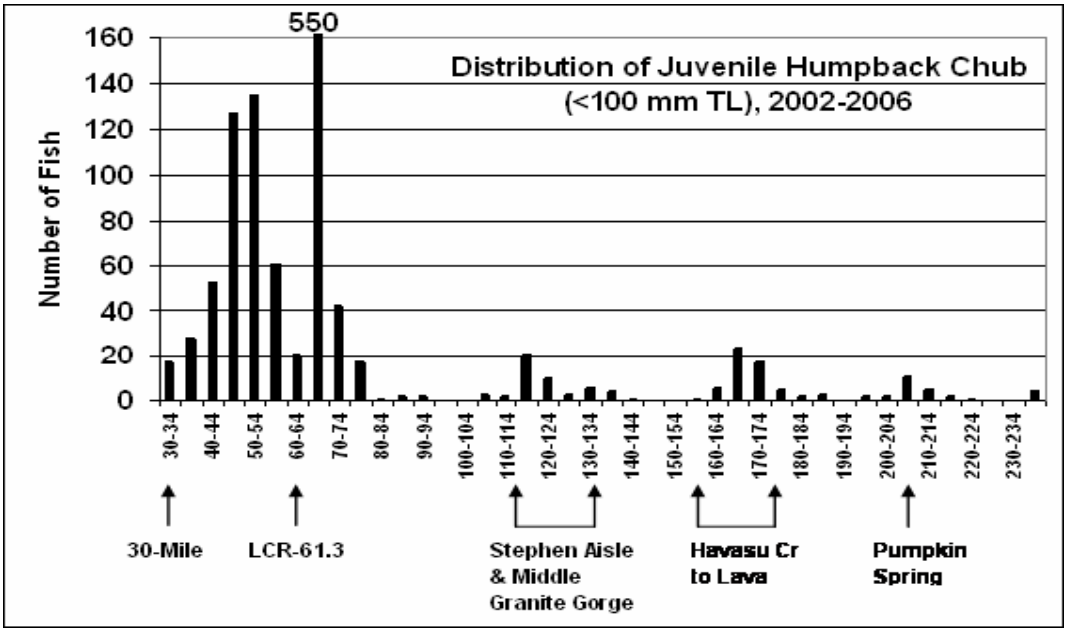

Figure 2. Distribution of juvenile humpback chub<100 mm TL caught during 2002-2006 by 5-mile increments from RM 30 to RM 240. Principal humpback chub aggregations are indicated (data from Ackerman 2008).

The USFWS also identified the need for controlling non-native fish species in the recovery goals for the humpback chub (U.S. Fish and Wildlife Service 2002a)[1]. The focus of non-native fish control in the recovery goals is on controlling the proliferation and spread of non-native fish species that prey on and compete with humpback chub in the mainstem Colorado River. The Recovery Goals identify the need to develop, implement, evaluate, and revise (as necessary through adaptive management) procedures for stocking and other sport fish management actions to minimize out-migration of non-native fish species into the Colorado River and its tributaries through Grand Canyon, and to develop and implement levels of control for rainbow trout, brown trout, and warm water non-native fish species, to minimize negative interactions between non-native fishes and humpback chub (U.S. Fish and Wildlife Service 2002a).

In prior ESA section 7 consultations on the operation of Glen Canyon Dam, Reclamation, and the USFWS have agreed that controlling the numbers of non-native fish that compete with and prey on the endangered fish through the Glen Canyon Dam Adaptive Management Program (GCDAMP) would serve as conservation measures for Reclamation's dam operations planned through the year 2012. Non-native fish control was identified as a conservation measure in the February 27, 2008, Final Biological Opinion on the Operation of Glen Canyon Dam (U.S. Fish and Wildlife Service 2008, consultation number 22410-1993-F-167R1), in the October 29, 2009, Supplement to the 2008 Final Biological Opinion for the Operation of Glen Canyon Dam (U.S. Fish and Wildlife Service 2009, consultation number 22410-1993-F-167R1), and the Reissuance

[1] In 2006, a U.S. District Court ruling set aside the recovery goals, essentially because they lacked time and cost estimates for recovery. The court did not fault the recovery goals as deficient in any other respect. USFWS is in the process of updating the recovery plan and goals for the humpback chub.

of the Incidental Take Statement on the 2009 Supplemental Biological Opinion on the Operation of Glen Canyon Dam 2008-2012 (U.S. Fish and Wildlife Service 2010a, consultation number 22410-1993-F-167R1). Control of non-native fish species in Marble and Grand Canyons through the GCDAMP is also part of the conservation measures identified in the 2007 Biological Opinion for the Proposed Adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (U.S. Fish and Wildlife Service 2007, consultation number 22410-2006-F-0224). Once Reclamation accepted these conservation measures, implementation of non-native fish control became a part of ongoing operations, with discretion in exactly where, when, and how non-native fish control is conducted. A fourth biological opinion on the cancellation of non-native mechanical removal trips in 2010 was issued on November 9, 2010, and required as a term and condition that Reclamation

> "Resume nonnative control at the mouth of the LCR in 2011. Attempt to implement the program in a manner compatible with the interests of Tribes and other interested stakeholders" and/or "Work with interested Tribes and other parties, expeditiously, to develop options that would move nonnative removal outside of the LCR confluence tribal sacred areas in 2011, with the goal that nonnative removal of trout in sacred areas will be reserved for use only to ensure the upper incidental take level is not exceeded" (U.S. Fish and Wildlife Service 2010b, consultation number 22410-1993-F-167R1).

A panel of independent scientists convened by U.S. Geological Survey (USGS) also concluded that non-fish control should continue to be implemented for conservation of humpback chub in Grand Canyon (U.S. Geological Survey 2008). Rainbow trout and brown trout are not native to the Colorado River Basin and were introduced into the region by federal and state agencies as sport fish before and after the 1963 completion of Glen Canyon Dam (e.g., the Arizona Game and Fish Department (AZGFD) stocked rainbow at Lees Ferry as recently as 1998). These trout species are important competitors and predators of humpback chub, as well as the other native Colorado River fishes (Valdez and Ryel 1995, Yard et al. *in press*). Other species of fish, including the channel catfish (*Ictalurus punctatus*), black bullhead (*Ameiurus melas*), and green sunfish (*Lepomis cyanellus*) also prey upon and compete with the native fishes.

Recent and ongoing investigations show negative impacts from trout on native fish are occurring near the confluence of the Colorado and Little Colorado rivers (RM 56-66), where rainbow trout and brown trout co-inhabit the area with the native humpback chub, flannelmouth suckers (*Catostomus latipinnis*), bluehead suckers (*C. discobolus*), and speckled dace (*Rhinichthys osculus*). The trout species eat juvenile humpback chub and other native fishes and also compete with them for food and space (Yard et al. *in press*). This area of the Colorado River supports the largest aggregation of humpback chub in Grand Canyon, and the nearshore habitat (talus and vegetated shorelines and backwaters) is used as a nursery area by young humpback chub originating from the LCR. Recent and ongoing investigations (Makinster et al. 2010) indicate that rainbow trout in this area likely originate from the Lees Ferry reach (first 15 miles below the dam) and most of the brown trout originate from Bright Angel Creek (RM 88; Liebfried et al. 2003, 2006). Korman et al. (2010) noted that rainbow trout mortality in Lees Ferry and their emigration from Lees Ferry appear to be density dependent. An important aspect of this action is the need test methods to reduce numbers of rainbow trout and brown trout near the confluence of

the Colorado and Little Colorado rivers by reducing the numbers of trout emigrating from these population sources in the Lees Ferry reach and Bright Angel Creek.

Reclamation is serving as the lead federal agency in this action because it has operational authority over Glen Canyon Dam and it has agreed to address non-native control through the AMP pursuant to the terms of the biological opinions issued by the USFWS (U.S. Fish and Wildlife Service 2007, 2008, 2009, 2010a, 2010b). However, Reclamation's legal authority does not include direct management of Colorado River fishes. That authority rests with the AZGFD, the state resource agency responsible for managing sport fish, and the National Park Service (NPS), the federal land management agency responsible for the management of resources within GCNRA and GCNP.

Native American Concerns

The United States has a unique legal and political relationship with American Indian Tribes, established through and confirmed by the Constitution of the United States, treaties, statutes, executive orders, and judicial decisions. In recognition of that special relationship, pursuant to Executive Order 13175 of November 6, 2000, executive departments, and agencies are charged with engaging in regular and meaningful consultation and collaboration with tribal officials in the development of federal policies that have tribal implications, and are responsible for strengthening the government-to-government relationship between the United States and Native American tribes. Furthermore, the federal government has a general trust responsibility towards the tribes, meaning that it should protect tribal assets and interests. This derives first and foremost from the many treaties entered into by the tribes and the U.S. Government.

Reclamation has a responsibility to recognize Indian Trust rights and maintain compliance with section 106 of the National Historic Preservation Act (NHPA). The Federal government holds Trust responsibilities that recognize the sovereign status and management authority of Tribes, and assures the Tribes that Federal agencies will not knowingly compromise traditional practice and livelihoods in execution of their duties. Executive Order 13007 adds specificity to this principal in stating that Federal agencies "shall avoid adversely affecting the physical integrity of sacred sites," while Secretarial Order 3206 stipulates that within the context of the ESA the "Departments will carry out their responsibilities under the Act in a manner that harmonizes the Federal trust responsibility to tribes." Further, the NHPA requires Federal agencies to take into account the effects of their actions on historic properties, which, through the National Register of Historic Places, includes special provisions for places of cultural and religious importance.

Reclamation consulted with American Indian tribes over the removal of non-native fish in the Grand Canyon in 2002. The Hopi Tribe, the Kaibab Band of Paiute Indians, Hualapai Tribe, and Zuni Tribe objected to the experimental action of removal unless there was a beneficial human use for fish removed. Consultation between these tribes, Reclamation, and the USGS resulted in the identification of a beneficial human use that served to mitigate the tribes' concerns for the experimental action. From 2003 through 2006 and in 2009, a removal and related mitigation program was implemented in the vicinity of the Colorado and Little Colorado rivers confluence (LCR reach). Fish that were removed where euthanized, emulsified, and used as fertilizer on the Hualapai Tribal Gardens. The program was effective at reducing numbers of trout, although the

program was conducted at a time that the trout population was undergoing a system-wide decline.

As part of the Annual Work Plan of the Glen Canyon Dam Adaptive Management Program for Fiscal Year 2010-2011, one or two river trips to remove non-native fish were included and tentatively scheduled for May-June 2010 and 2011. Some tribal representatives to the program expressed concern and asked for government-to-government consultation regarding the killing of non-native fish in the vicinity of the confluence of the Little Colorado and Colorado rivers, a location of cultural, religious, and historical importance. The Pueblo of Zuni, in a letter dated June 30, 2009, from expressed the Zuni Tribe's concerns with the "taking of life" associated with non-native fish removal, and their perception that the Bureau of Reclamation and the United States Fish and Wildlife Service had failed to adequately consult with the Zuni Tribe concerning the action, and the Zuni Tribe requested consultation with the Bureau of Reclamation on the issue. In response, DOI representatives attended a meeting with Zuni tribal leaders to hear their concerns on September 15, 2009. DOI's approval of the work plan acknowledged tribal concerns for removal of non-native fish and expressly noted that as a result of tribal concerns, DOI would work to examine and evaluate "different locations for carrying out the mechanical removal" and noted that "tribal consultation regarding non-native fish control is underway."

A meeting of DOI and tribal representatives was held on January 12-13, 2010, where all of the GCDAMP tribes requested government-to-government consultation on the proposed removal. Tribal concerns were also expressed in February 2010, as part of a 2-day series of GCDAMP-related public meetings in Phoenix, Arizona. The Pueblo of Zuni sent a letter to Assistant Secretary of the Interior for Water and Science Anne Castle on February 19, 2010, in which the Governor of Zuni expressed his dissatisfaction with the nature and content of consultation that had occurred thus far regarding non-native fish control. Assistant Secretary Castle met with Pueblo of Zuni Governor Norman J. Cooeyate and the Tribal Council on August 5, 2010 during which time the Pueblo presented Zuni Tribal Council Resolution No. M70-2010-C086 to Assistant Secretary Castle. This document and formal position statement generated by the Executive and Legislative Branches of the Zuni Government stated the position of the Zuni Tribe and religious leaders concerning the adverse affects to the Pueblo from the removal of non-native fish in Grand Canyon and also explained that the Zuni Tribe believes the Grand Canyon and Colorado River are Zuni Traditional Cultural Properties eligible to the National Register of Historic Places.

Government-to-government consultation was initiated with the Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Paiute Indian Tribe of Utah, San Juan Southern Paiute Tribe, Las Vegas Paiute Tribe, Moapa Band of Paiutes, Navajo Nation, the Yavapai Apache Nation, the Pueblo of Jemez, and Pueblo of Zuni regarding the proposed action, and consultation is continuing. The following government-to-government tribal consultation, informal tribal consultation, and cooperating agency (CA) meetings were held:

- Government-to-government tribal consultation meetings were held with the Zuni Tribe at the Pueblo of Zuni at Zuni, New Mexico, on September 15, 2009, and on March 24 and June 4, 2010;

- Government-to-government tribal consultation meetings were held with the Hopi Tribe (March 4 and April 22 2010, January 27, 2011), Navajo Nation (June 9, 2010, and January 26, 2011), Hualapai (March 6, 2010, and January 8, 2011), Havasupai (March 15, 2010), Kaibab Pauite Tribe (March 18, 2010, and January 20, 2011), and the Paiute Indian Tribe of Utah (December 13, 2010);

- Reclamation served on a discussion panel about this issue at the 2010 Native American Fish and Wildlife Society Southwest Conference;

- Assistant Secretary Anne Castle and other representatives from DOI and Reclamation met with the Governor and Tribal Council, Zuni Cultural Resource Advisory Team, and the Zuni public at Zuni, New Mexico, to discuss removal and the objection of the Zuni people to the killing of rainbow trout on August 5, 2010.

- The Pueblo of Zuni sent Reclamation the Zuni Tribal Council Resolution No. M70-2010-C086 regarding their concerns with removal and the request that Grand Canyon be included as a TCP eligible for listing on the National Register. This resolution was given to Assistant Secretary Castle at the August 5, 2010 meeting.
- A CA and tribal meeting was held in Flagstaff on August 20, 2010; and,

- CA conference calls were conducted on September 2, 9, 16, 23, 30, and November 4 and 21, 2010, and on January 5, 2011. These often included the tribes that participated as cooperating agencies, the Pueblo of Zuni and Hualapai Tribe.

- SDM Workshops were conducted on October 18-20, November 8-10, 2010, and representatives from three of the five tribes (the Navajo, Hopi, and Zuni tribes) participated in these.

- A tribal consultation meeting with the Pueblo of Zuni was held on January 25, 2011, during which the tribe indicated that they would prefer, if fish are to be killed, to be used for human consumption as a beneficial use.

Reclamation is committed to ongoing consultation with concerned Native American tribes with assistance from the USFWS, NPS, BIA, and U.S. Geological Survey, on non-native fish removal, including the option of continued non-native control near and within the LCR confluence.

Assistant Secretary Castle determined it was not appropriate to precede with the planned removal trips in spring 2010 until additional meaningful tribal consultation was completed and any necessary environmental compliance responsibilities under applicable law were undertaken, including, but not limited to, the National Historic Preservation Act. In March 2010 Reclamation requested reinitiation with the USFWS to stay in compliance with ESA. Reclamation produced a Biological Assessment; *Proposed Action to Cancel Non-native Fish Mechanical Removal in the Colorado River, Grand Canyon, Scheduled for May-June 2010* that documents the details of this decision. A Biological Opinion from the USFWS followed on November 9, 2010 that required Reclamation to resume non-native control at the mouth of the

LCR in 2011 and attempt to conduct it in a manner compatible to the tribes and other stakeholders (Section 1.2.6).

1.2 Related Consultation History

Reclamation has consulted with the USFWS under section 7 of the ESA for various projects that could have had effects on ESA listed species and designated critical habitat within the action area, leading to the definition of the current environmental baseline. Since 1995, Reclamation has consulted with the USFWS on a total of five important experimental actions, and undertaken a sixth experimental action that did not require separate ESA consultation. The current baseline is a result of these consultations and their effects on ESA-listed species and designated critical habitat within the action area. This history is provided in the 2008 Biological Opinion and the two relevant consultations are described below:

1.2.1 2002 Biological Opinion on experimental flows and non-native fish control

In 2002, Reclamation, the NPS, and the USGS consulted with the USFWS on: (1) experimental releases from Glen Canyon Dam, (2) mechanical removal of non-native fish from the Colorado River in an approximately 9-mile reach in the vicinity of the mouth of the Little Colorado River to potentially benefit native fish, and (3) release of non-native fish suppression flows having daily fluctuations of 5,000-20,000 cfs from Glen Canyon Dam during the period January 1-March 31. Implicit in experimental flows and mechanical removal was the recognition that modification of dam operations alone likely would be insufficient to achieve objectives of the GCDAMP, which include removal of jeopardy from humpback chub and razorback sucker.

In their biological opinion, the USFWS concluded the proposed action was not likely to jeopardize the continued existence of the humpback chub, Kanab ambersnail, bald eagle, razorback sucker, California condor, and southwestern willow flycatcher. The December 2002 biological opinion included incidental take of up to 20 humpback chub during the non-native fish removal efforts and the loss of up to 117m² of Kanab ambersnail habitat.

Two conservation measures were included in the USFWS biological opinion. The first measure included relocation of 300 humpback chub above Chute Falls in the LCR to increase the likelihood of humpback chub surviving in the lower LCR, reduce predation, and other inclement environmental conditions. The second conservation measure consisted of temporary removal and safeguard of approximately $29m^2 – 47m^2$ (25 to 40 percent) of Kanab ambersnail habitat that would be flooded by the experimental release. The relocated habitat and ambersnails would be replaced once the high flow was complete to facilitate re-establishment of vegetation.

1.2.2 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, Final EIS

The December 2007 biological opinion on the Shortage Record of Decision (ROD) included the geographic scope of this biological assessment, Glen Canyon Dam to Lake Mead (U.S. Bureau of Reclamation 2007a). The Shortage ROD specified reduction of consumptive uses below Lake Powell during times of low reservoir conditions and modification of the annual release volumes

from Lake Powell through 2026. The Shortage ROD, as adopted on December 13, 2007, established annual release volumes from Glen Canyon Dam, but did not, in any manner, alter the constraints imposed by the 1996 ROD or as adopted in the 1997 Glen Canyon Dam Operating Criteria (discussed in Section 1.4.2). Since many of the potential resource impacts identified in that final EIS were being investigated in the GCDAMP, the biological opinion made use of this institutional arrangement as a key mechanism for addressing these impacts. With respect to the listed species in Grand Canyon the USFWS determined that implementation of the Guidelines is not likely to jeopardize the continued existence of the humpback chub, the southwestern willow flycatcher, or the Kanab ambersnail, and is not likely to destroy or adversely modify designated critical habitat for the humpback chub or the southwestern willow flycatcher. Conservation measures under this consultation included non-native fish control, humpback chub refuge establishment, examining habitat for the potential reintroduction of razorback sucker in the lower Grand Canyon, support for a genetic biocontrol symposium, sediment research, parasite monitoring, and other monitoring and research. Regarding non-native fish control, Reclamation is to work with other GCDAMP members and through the GCDAMP to continue efforts to control both cold- and warm-water non-native fish species in the mainstem of Marble and Grand canyons, including determining and implementing levels of non-native fish control as necessary. Control of these species using mechanical removal and other methods would help to reduce this threat.

1.2.3 2008 Biological Opinion

On February 27, 2008, the USFWS issued a biological opinion on the operation of Glen Canyon Dam for the period 2008-2012 (2008 Opinion) that implementation of the March 2008 high flow test and the five-year implementation of Modified Low Fluctuating Flow (MLFF) with steady releases in September and October, as proposed, was not likely to jeopardize the continued existence of the humpback chub or the Kanab ambersnail, and is not likely to destroy or adversely modify designated critical habitat for the humpback chub. The Incidental Take Statement in the 2008 Opinion states that incidental take would be exceeded if the proposed action results in detection of more than 20 humpback chub mortalities during the high flow test of March 2008 and is attributable to the high flow test. The 2008 biological opinion identified eight conservation measures for the humpback chub, including a Humpback Chub Consultation Trigger, a Comprehensive Plan for the Management and Conservation of Humpback Chub in Grand Canyon, Humpback Chub Translocation, Non-native Fish Control, Humpback Chub Nearshore Ecology Study, Monthly Flow Transition Study, Humpback Chub Refuge, and Little Colorado River Watershed Planning.

On May 26, 2009, the District Court of Arizona, in response to a lawsuit brought by the Grand Canyon Trust, ordered the USFWS to reevaluate the conclusion in the 2008 Opinion that the MLFF does not violate the Endangered Species Act of 1973 (16 U.S.C. 1531-1544), as amended (Act) (Case number CV-07-8164-PHX-DGC). The Court ordered the USFWS to provide an analysis and a reasoned basis for its conclusions in the 2008 Opinion, and to include an analysis of how MLFF affects critical habitat and the functionality of critical habitat for recovery purposes by October 30, 2009.

1.2.4 2009 Supplement to the 2008 Biological Opinion

On October 29, 2009, the USFWS issued a Supplement to the 2008 Final Biological Opinion for the Operation of Glen Canyon Dam, as a result of the Court Order of May 26, 2009, and concluded that the action was not likely to jeopardize the continued existence of the humpback chub or the Kanab ambersnail, and was not likely to destroy or adversely modify designated critical habitat for the humpback chub. The Incidental Take Statement in the 2009 Supplement states that incidental take would be exceeded if the proposed action causes the conditions of the consultation trigger to be met. The consultation trigger was identified in the 2008 Opinion as a conservation measure, and states in the 2009 Supplement that "Reclamation and USFWS agree to specifically define this reinitiation trigger relative to humpback chub, in part, as being exceeded if the population of adult humpback chub (≥200 mm [7.87 in] TL) in Grand Canyon declines significantly, or, if in any single year, based on the age-structured mark recapture model (ASMR; Coggins 2007), the population drops below 3,500 adult fish within the 95 percent confidence interval." Based on the recommendation of the Protocol Evaluation Panel (PEP), the decision was made to employ the ASMR model once every three years. Hence, the ASMR would not be utilized annually, but only employed to test the humpback chub consultation trigger if other data, such as annual mark-recapture based closed population estimates of humpback chub abundance in the Little Colorado River (Van Haverbeke and Stone 2008, 2009), indicate that the population is declining to the abundance level defined in the trigger.

1.2.5 Reissuance of the Incidental Take Statement on the 2009 Supplemental Biological Opinion on the Operation of Glen Canyon Dam 2008-2012

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" is defined as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering (50 C.F.R. § 17.3). Under the terms of section 7(b)(4) and section 7(o)(2), "take" that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of the Incidental Take Statement. Section 10(a)(1) of the ESA authorizes the Secretary to permit any taking of listed species otherwise prohibited by section 9(a)(1)(B) if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

Incidental Take Statements were issued in the 2008 Opinion and the 2009 Supplement relative to experimental operations of Glen Canyon Dam and were designed to mitigate estimated "take" resulting from experimental dam operations. In response to the court order, the USFWS issued a revised ITS on September 1, 2010, for the 2009 Opinion, which changed the amount of incidental take authorized to "if monitoring detects a decrease in the adult chub population below an estimate of 6,000 adult chub using the Age-Structured Mark Recapture model (ASMR, Coggins and Walters 2009) that is not attributable to other factors (such as parasites or diseases), that decrease is reasonably indicative of higher than expected levels of juvenile mortality caused

by the proposed action." The USFWS cited as its reasoning for this, numbers of chub estimated by the ASMR at the time the 2008 biological opinion on Glen Canyon Dam operations was issued is an appropriate surrogate for take "because it represents the species' ability to reproduce, survive, and recruit during the life of the project which provides information on the health of the overall population."

1.2.6 Reinitiation of the 2009 Biological Opinion on the Continued Operations of Glen Canyon Dam without Mechanical Removal of Non-native Fish in 2010 from the Colorado River, Grand Canyon, Arizona

On March 5, 2010, Reclamation requested reinitiation of formal consultation (2009 Supplemental Opinion) to accommodate a modification of the 5-year experimental non-native fish removal efforts planned for May and June 2010. Concerns were expressed by Native American Tribes over the killing of fish as loss of life in sacred areas. A draft biological opinion was submitted by USFWS to Reclamation on October 14, 2010, evaluating the cancellation of non-native mechanical removal in 2010.

The focus of this consultation was the cancellation of two non-native removal trips scheduled for May and June 2010. All other aspects of the proposed action remained the same as described in the 2009 Supplemental Opinion described above.

On November 9, 2010, the USFWS issued a biological opinion on the Reclamation's cancellation of non-native mechanical removal trips in 2010. They determined that the proposed action of not removing trout would adversely affect the humpback chub and its critical habitat and critical habitat for the razorback sucker. All other effects determinations remained the same as for the 2008 and 2009 Opinions for the razorback sucker, Kanab ambersnail, and southwestern willow flycatcher. The Service required as a term and condition that Reclamation "[r]esume non-native control at the mouth of the LCR in 2011" and "[a]ttempt to implement the program in a manner compatible with the interests of Tribes and other interested stakeholders" (U.S. Fish and Wildlife ServiceService 2010b, consultation number 22410-1993-F-167R1). The incidental take statement for the biological opinion acknowledged that the September 1, 2010, revised ITS, but added that "we anticipate that between 1,000 and 24,000 young of year or juvenile humpback chub will be lost to predation by trout as a result of the modified proposed action during this 13-month period. We adopt the incidental take estimate provided in the April 2010 BA, of 10,817 humpback chub for this 13-month period."

2.0 Description of the Proposed Action

2.1 Purpose and Need for Action

The federal action analyzed in this Biological Assessment is the control of non-native fish in the Colorado River downstream from Glen Canyon Dam within Glen Canyon National Recreation Area and Grand Canyon National Park, Coconino County, Arizona. The purpose of the action is to reduce the negative impacts of competition and predation by rainbow trout and brown trout on the endangered humpback chub and its critical habitat in Grand Canyon while supporting public recreation in GCRA and GCNP. The need for this action is to fulfill the conservation measures and terms and conditions of several U.S. Fish and Wildlife biological opinions, to contribute to the recovery of humpback chub by helping to maintain high juvenile survival and recruitment rates resulting in an increasing adult population, to continue to provide quality recreational opportunities in GCRA and GCNP, and to address concerns expressed by Native American Indian Tribes over the killing of trout in the Grand Canyon, a location of cultural, religious, and historical importance to several tribes.

Reclamation, in response to the USFWS biological opinion, proposes that this action start in 2011 and extend to 2020. The necessity to implement non-native fish control in 2011 is a consequence of cancelled efforts in 2010 that allowed and likely increased the ongoing threat to the humpback chub from predation and competition.

2.2 Proposed Action

As part of the National Environmental Policy Act Environmental Assessment for the proposed action, Reclamation, in partnership with the U.S. Geological Survey, conducted a Structured Decision Making Project (SDM) to develop and provide substantive input to Reclamation and provide a forum for the diverse cooperating agencies and Tribes to discuss, expand, and articulate their respective values, to develop and evaluate a broad set of potential control alternatives using the best available science and to indicate how they would individually prefer to manage the inherent trade-offs in this non-native fish control problem (Runge et al. 2011). The proposed action is the top ranking alternative that resulted from the SDM Project. The proposed action combines a strategy of removing rainbow trout in the LCR reach to reduce the extant threat of rainbow trout in the LCR reach (RM 56 to 66) with a strategy of testing removal of RBT in the PBR reach (RM 1 to RM 8) to reduce or eliminate emigration of rainbow trout from Lees Ferry downstream to the LCR reach Up to 6 LCR reach removal trips and up to 10 PBR reach removal trips will be conducted in any one year for the ten-year period of 2011-2020 depending on trout abundance (see below). In the short term (one to several years), the focus will be to reduce trout at the LCR reach because they are currently abundant there. If abundance of trout can be reduced at the LCR using removal there, and removal in the PBR reach proves effective at limiting emigration of trout from the Lees Ferry area, effort would be concentrated at the PBR.

Removal of rainbow and brown trout from Bright Angel Creek with a fish weir in fall of 2002 effectively removed large numbers of trout (Leibfried et al. 2003, 2006). The NPS Bright Angel Creek removal project is ongoing and expected to reduce what is considered to be the primary source of brown trout to the LCR reach, but is not part of the proposed action. NPS already has a biological opinion from NPS on this action.

Removal of trout will be conducted as it was done in 2004-2006 and 2009 (Coggins 2008a; Coggins and Yard 2010), in which trout were removed near the LCR confluence during multiple trips each year. One to six removal passes would be conducted in each trip, as described in Coggins (2008a). Removal will be conducted with boat-mounted electrofishing and will remove all non-native fish captured. The number of removal trips conducted depends on numbers of trout in each reach. Effort is focused on the LCR reach when trout numbers are high, but shifts to the PBR reach when trout numbers are low in the LCR reach. If trout numbers are low in both reaches, removal may not be necessary.

Removal in the PBR reach is anticipated to be most efficient during the fall or early spring (suspected emigration periods) but multiple trips throughout the year may be necessary in order to be effective. Seasonal movement by young trout from the Lees Ferry reach and the time that emigrating fish reside in the PBR reach is unknown. If residence time in this reach is short, only a small fraction of downstream migrants would be removed using removal. Fish removal downstream as far as Badger Creek Rapid (RM 8) will enable boats to return upstream to Lees Ferry in the same day and avoid expensive trips through the entire Grand Canyon.

The number of trips in any given year would not exceed 6 LCR reach trips and 10 PBR reach trips. Methods would be similar to Coggins (2008a) and would include up to 6 passes with a boat-mounted electrofisher in a single trip. The number of trips implemented in a given year would depend on the abundance of non-native fish in these reaches and other considerations through adaptive management and in coordination with the USFWS and other agencies. The abundance and other population parameters of humpback chub will also be considered, and a recovery plan that is currently in development by the U.S. Fish and Wildlife Service should provide guidance in this regard when it becomes available. As more information about removal is gathered as the proposed action is implemented, effort may be shifted between reaches to maximize reductions and minimize cost. Also, Reclamation will continue to work with the GCDAMP to design and test additional flow and non-flow non-native fish control actions over the life of the proposed action. Additional environmental compliance may be necessary for these actions.

The taking of life in a sacred location without beneficial use is a spiritual concern to Native American tribes. The proposed action will include euthanizing and freezing fish removed for later beneficial use to address these concerns. Acceptable uses of the frozen fish are being explored in government-to-government tribal consultation. Potential uses include use for human consumption or as feed for wildlife in zoos or other captive wildlife facilities.

Based on past and ongoing consultation and communication with interested tribes, relevant regulatory authorities, and other stakeholders, Reclamation has reluctantly concluded that live removal is not a viable option at this time for removal of non-native fish. The potential for

spreading whirling disease, which was detected in rainbow trout in Lees Ferry in 2007, to unaffected areas by transfer of live fish, and the unknown effects to endangered and threatened species by this action, have been raised as substantive objections and require additional study.

2.3 Action Area

The action area or geographic scope of this environmental assessment is a 294-mile reach of the Colorado River corridor from Glen Canyon Dam downstream to the Lake Mead inflow near Pearce Ferry (Figure 1). Glen Canyon Dam impounds the Colorado River about 16 miles upstream from Lees Ferry, Coconino County, Arizona. This action area includes GCNRA in a 16-mile reach from Glen Canyon Dam to the Paria River; and GCNP, a 277-mile reach from the Paria River downstream from Lees Ferry to the Grand Wash Cliffs near Pearce Ferry. In terms of geomorphic features, Glen Canyon encompasses a 16-mile reach from the dam to the Paria River; Marble Canyon is a 61-mile reach from the Paria River to the LCR; and Grand Canyon is a 217-mile reach from the LCR to near Pearce Ferry. The Glen Canyon segment of the action area is also commonly referred to as the Lees Ferry reach. Additional description of the action area and its associated resources can be found in Gloss et al. (2005).

2.4 Relevant Statutory Authority

The Secretary of the Interior (Secretary) is vested with the responsibility to manage the mainstream waters of the Lower Colorado River Basin pursuant to applicable federal law. The responsibility is carried out consistent with a body of documents commonly referred to as the Law of the River. While there is no universally accepted definition of this term, the Law of the River comprises numerous operating criteria, regulations, and administrative decisions included in federal and state statutes, interstate compacts, court decisions and decrees, an international treaty, and contracts with the Secretary. Notable among these documents include the Colorado River Compact of 1922; the 1944 Treaty (and subsequent minutes of the International Boundary and Water Commission); the Upper Colorado River Basin Compact of 1948; the Colorado River Storage Project Act of 1956 (CRSPA); the 1963 United States Supreme Court Decision in Arizona v. California; the 1964 US Supreme Court Decree in Arizona v. California ; the Colorado River Basin Project Act of 1968 (CRBPA); the Colorado River Basin Salinity Control Act of 1974; and the Grand Canyon Protection Act of 1992. In compliance with ESA section 7(a)(2) and its implementing regulations, Reclamation is responsible for defining the extent of its discretionary authority with respect to this action.

Reclamation's authority does not extend to direct management of native and non-native fish. Those authorities rest with the federal land management agency, the National Park Service, the state fish and wildlife agency, the Arizona Game and Fish Department, and, on tribal lands, the designated fish and wildlife agency for the given tribe. These agencies, either directly or through commissions or councils, make decisions on stocking procedures, set bag limits, and determine other actions to increase or limit the distribution and abundance of species under their authority. Where species listed under the ESA are potentially affected by a proposed action, the primary regulatory authority for those species is held by the USFWS.

2.5 Glen Canyon Dam Adaptive Management Program

The 1996 ROD directed the formation and implementation of an adaptive management program to assist in monitoring and future recommendations regarding the impacts of Glen Canyon Dam operations. The GCDAMP was formally established in 1997 to implement the Grand Canyon Protection Act (GCPA), the 1995 Operation of Glen Canyon Dam Final Environmental Impact Statement, and the 1996 ROD. The GCDAMP provides a process for assessing the effects of current operations of Glen Canyon Dam on downstream resources and using the results to develop recommendations for modifying dam operations and other resource management actions. This is accomplished through the Adaptive Management Work Group (AMWG), a federal advisory committee to the Secretary. The Secretary's Designee serves as the chair of the AMWG and provides a direct link between the AMWG and the Secretary.

The AMWG consists of stakeholders from federal and state resource management agencies, the seven Basin States, Native American Indian tribes, hydroelectric power marketers, environmental and conservation organizations and recreational and other interest groups. The duties of the AMWG are an advisory capacity only. Coupled with this advisory role is long-term monitoring and research that provides a continual record of resource conditions and new information to evaluate the effectiveness of the operational modifications to Glen Canyon Dam and other management actions.

The Technical Work Group (TWG) translates AMWG policy into information needs, provides questions that serve as the basis for long-term monitoring and research activities, and conveys research results to AMWG members. The USGS Grand Canyon Monitoring and Research Center (GCMRC) provides scientific information on the effects of the operation of Glen Canyon Dam and related factors on natural, cultural, and recreational resources along the Colorado River between Glen Canyon Dam and Lake Mead. The independent review panels provide independent assessments of the GCDAMP to assure scientific validity. Academic experts in pertinent areas make up a group of Science Advisors.

2.6 Regulatory Context

Past consultations have evaluated the impact of proposed actions on the threatened and endangered species that live in the Colorado River and its floodplain between Glen Canyon Dam and Separation Canyon, near the inflow area of Lake Mead, Coconino and Mohave counties, northern Arizona. This biological assessment focuses on the LCR and PBR reaches, although the impacts of trout removal could extend downstream and upstream of these areas in the action area, depending on movement potential and limiting temperature requirements of non-native fish, primarily rainbow trout and brown trout. The anticipated area of effect lies within the State of Arizona and in Grand Canyon National Park. The area is bordered by, or is in proximity to the Navajo Nation, Hopi, Pueblo of Zuni, Paiute and Hualapai tribal lands.

2.7 Effects of Climate Change

The Fourth Assessment Report (Summary for Policymakers) of the Intergovernmental Panel on

Climate Change (IPCC 2007), presented a selection of key findings regarding projected changes in precipitation and other climate variables as a result of a range of unmitigated climate changes projected over the next century. Although annual average river runoff and water availability are projected to decrease by 10-30 percent over some dry regions at mid-latitudes, information with regard to potential impacts on specific river basins is not included. Recently published projections of potential reductions in natural flow on the Colorado River Basin by the mid 21st century range from approximately 45 percent by Hoerling and Eischeid (2006), to approximately 6 percent by Christensen and Lettenmaier (2006), but, as documented in the Shortage EIS (U.S. Bureau of Reclamation 2007b), these projections are not at the spatial scale needed for CRSS, the model used to project future flows.

The hydrologic model, CRSS, used as the primary basis of the effects analysis does not project future flows or take into consideration projections such as those cited above, but rather relies on the historic record of the Colorado River Basin to analyze a range of possible future flows. Using CRSS, projections of future Lake Powell reservoir elevations are probabilistic, based on the 100- year historic record. This record includes periods of drought and periods with above average flow. However, studies of proxy records, in particular analyses of tree-rings throughout the upper Colorado River Basin indicate that droughts lasting 15-20 years are not uncommon in the late Holocene. Such findings, when coupled with today's understanding of decadal cycles brought on by El Niño Southern Oscillation and Pacific Decadal Oscillation (and upstream consumptive use), suggest that the current drought could continue for several more years, or the current dry conditions could shift to wetter conditions at any time (Webb et al. 2005). Thus, the action period may include wetter or drier conditions than today. An analysis of hydrologic variability and potential alternative climate scenarios is more thoroughly discussed in the Shortage EIS (Reclamation 2007b) and is incorporated by reference here.

Although precise estimates of the future impacts of climate change throughout the Colorado River Basin at appropriate spatial scales are not currently available, these impacts may include decreased mean annual inflow to Lake Powell, including more frequent and more severe droughts. Such droughts may decrease the average storage level of Lake Powell, which could correspondingly increase the temperature of dam releases. Increased release temperatures have been cited as one potential factor in the recent increase of juvenile humpback chub (Andersen 2009) but concerns also exist that warmer aquatic habitat will also increase the risk of warm water non-native fish predation. To allay this risk if such warming occurs, in the 2007 Opinion Reclamation committed to the monitoring and control of non-native fish as necessary, in coordination with other Department of the Interior agencies and working through the GCAMP (U.S. Fish and Wildlife Service 2007).

3.0 Listed Species and Critical Habitat in the Action Area

3.1 Species Identified for analysis

Four species are identified as endangered within or near the area affected by the proposed action, including the humpback chub, razorback sucker, Kanab ambersnail, and the southwestern willow flycatcher. Only the humpback chub and razorback sucker may be affected by the proposed action and are addressed in detail in this biological assessment.

3.1.1 Humpback Chub

The humpback chub is currently listed as "endangered" under the ESA. The humpback chub recovery plan was approved on September 19, 1990 (U.S. Fish and Wildlife Service 1990) and Recovery Goals were developed in 2002 (U.S. Fish and Wildlife Service1 2002). Designated critical habitat exists in two reaches near the action area (U.S. Fish and Wildlife Service 1994); the lower 8 miles of the LCR and 173 miles of the Colorado River and its 100-year floodplain in Marble and Grand Canyons from Nautiloid Canyon (RM 34) to Granite Park (RM 208). Primary threats to the species include streamflow regulation and habitat modification (including cold-water dam releases and habitat loss), competition with and predation by non-native fish species, parasitism, hybridization with other native *Gila*, and pesticides and pollutants (U.S. Fish and Wildlife Service 2002).

The humpback chub is a moderately large cyprinid fish endemic to the Colorado River system (Miller 1946). It is surmised from various reports and collections that the species presently occupies about 68 percent of its historic habitat of about 470 miles of river (U.S. Fish and Wildlife Service 2002). Range reduction is thought to have been caused primarily by habitat inundation from reservoirs, cold-water dam releases, and non-native fish predation. Six humpback chub populations are currently known—all from canyon-bound reaches (U.S. Fish and Wildlife Service 2002). Five are in the upper Colorado River Basin and the sixth is located in Marble and Grand Canyon's of the lower basin. Upper basin populations range in size from a few hundred individuals to about 5,000 adults. The lower basin population is found in the Little Colorado River and the Colorado River in Marble and Grand canyons and is currently at between 6,000 and 10,000 (most likely estimate at 7,650 adults; Coggins and Walters 2009) and is the largest of the extant populations.

Young and juvenile humpback chub are found primarily in the LCR and the Colorado River near the LCR inflow, although many are found upstream of the LCR (Figure 2), presumably from spawning near warm springs (Valdez and Masslich 1999). Reproduction by humpback chub occurs annually in spring in the LCR, and the young fish either remain in the LCR or disperse into the Colorado River. Dispersal of these young fish has been documented as nighttime larval drift during May through July (Robinson et al. 1998), as density dependent movement during strong year classes (Gorman 1994), and as movement with summer floods caused by monsoonal

rain storms during July through September (Valdez and Ryel 1995). Survival of these young fish in the mainstem is thought to be low because of cold mainstem temperatures (Clarkson and Childs 2000; Robinson and Childs 2001), but fish that survive and return to the LCR contribute to recruitment in this population. Predation by rainbow trout and brown trout in the LCR confluence area has been identified as an additional source of mortality affecting survival and recruitment of humpback chub (Coggins 2008a; Marsh and Douglas 1997; Valdez and Ryel 1995; Yard et al. 2008).

3.1.2 Razorback Sucker

The razorback sucker was listed as endangered under the Endangered Species Act of 1973, as amended, on October 23, 1991 (56 FR 54957). Designated critical habitat includes the Colorado River and its 100-year floodplain from the confluence with the Paria River (RM 1) downstream to Hoover Dam, a distance of nearly 500 miles, including Lake Mead to the full pool elevation. A recovery plan was approved on December 23, 1998 (U.S. Fish and Wildlife Service 1998) and Recovery Goals were approved on August 1, 2002 (U.S. Fish and Wildlife Service 2002b). Primary threats to razorback sucker populations are streamflow regulation and habitat modification and fragmentation (including cold-water dam releases, habitat loss, and blockage of migration corridors); competition with and predation by non-native fish species; and pesticides and pollutants (Bestgen 1990; Minckley 1991; U.S. Fish and Wildlife Service 2002b).

The razorback sucker is endemic to the Colorado River system. Historically, it occupied the mainstem Colorado River and many of its tributaries from northern Mexico through Arizona and Utah into Wyoming, Colorado, and New Mexico. Distribution and abundance of razorback sucker declined throughout the 20th century over all of its historic range, and the species now exists naturally only in a few small, disconnected populations or as dispersed individuals. The razorback sucker has exhibited little natural recruitment in the last 40–50 years and wild populations are comprised primarily of aging adults, with steep declines in numbers.

Razorback sucker in the lower Colorado River basin persist primarily in reservoirs, including Lakes Mohave and Mead (Minckley 1983). Currently, the group of razorback sucker in Lake Mohave is the largest remaining in the entire Colorado River system. Estimates of the wild stock in Lake Mohave, now old and senescent, have dropped precipitously in recent years from 60,000 in 1989 (Marsh and Minckley 1989) to 25,000 in 1993 (Holden 1994; Marsh 1993) and to about 9,000 in 2000 (personal communication, T. Burke, U.S. Bureau of Reclamation). A second razorback sucker population of approximately 500 individuals occurs in Lake Mead. The Lake Mead population is the only known recruiting population of razorback sucker in the Lower Colorado River Basin (Holden et al. 2000; Abate et al. 2002; Albrecht and Holden 2006). The majority of the fish are found in Las Vegas Bay and Echo Bay, where spawning has been documented over alluvial deposits and rock outcrops.

In the spring of 2010, larval sampling in the Colorado River inflow area (presently in the Gregg Basin region of Lake Mead) resulted in the capture of seven larval razorback sucker, one larval flannelmouth sucker (*Catostomus latipinnis*), and four larval fish thought to be either flannelmouth sucker or hybrid flannelmouth x razorback sucker (Albrecht et al. 2010). Although catch per unit effort was low, the identification of larval razorback sucker in the Colorado River

inflow area helped confirm the presence of spawning adult razorback sucker and documented successful spawning in 2010. Moreover, Albrecht et al. (2010) reported that trammel netting in the inflow area yielded three wild razorback sucker, four razorback x flannelmouth sucker hybrids, and 52 flannelmouth sucker. Of these fish one hybrid and five flannelmouth sucker were recaptured. All three razorback sucker were males expressing milt, which helped confirm spawning activities. Two of these individuals were 6-years old and one was 11-years old.

The razorback sucker has not been reported from Grand Canyon since 1990, and only 10 adults were reported between 1944 and 1995 (Valdez 1996; Gloss and Coggins 2005). Carothers and Minckley (1981) reported four adults from the Paria River in 1978-1979. Maddux et al. (1987) reported one blind female razorback sucker at Upper Bass Camp (RM 107.5) in 1984, and Minckley (1991) reported five adults in the lower Little Colorado River from 1989-1990.

4.0 Effects Analysis

An analysis of the effects of the proposed action on the endangered humpback chub is confounded by various management actions or studies coincident with changing environmental conditions. Abundance of the principal predator considered in this action—the rainbow trout—increased in the Lees Ferry reach below Glen Canyon Dam during 1992-2001, but abundance in this reach steadily fell during 2002-2006 (Makinster 2007). Simultaneously, reservoir elevations of Lake Powell dropped steadily from 2000 to 2005 and the temperature of water released at the dam increased from a daily maximum of about 10 °C to about 15.5 °C. During this same time period, releases from Glen Canyon Dam included the low steady summer flow experiment of 2000, and the high flow experiments of November 2004 and March 2008. To an unknown extent, these independent events likely interacted to affect the various fish populations, including rainbow trout, brown trout, and humpback chub. When non-native fish removal was implemented from 2003 through 2006, environmental factors had already begun to influence the target fish populations. In 2010 non-native fish removal was cancelled and the rainbow trout population was allowed to increase. Wright and Kennedy (*in press*) now report that rainbow trout numbers have increased 3,800 percent since 2006 in the LCR reach. Any effects analysis of the proposed action cannot be singly attributable to the action described in this biological assessment.

4.1 Scientific Basis for Non-native Fish Removal

The scientific basis for non-native fish removal of non-native fishes in Grand Canyon is well documented. Predation by non-native fish species is considered a primary threat to numerous native fish species worldwide and particularly in the southwestern United States (Cambray 2003, Clarkson et al. 2005). Non-native fish in Grand Canyon prey on and compete with humpback chub, and predation may result in the loss of large numbers of young-of-year humpback chub in some years (Valdez and Rye1 1995, Marsh and Douglas 1997, Yard et al. *in press*). Because low survivorship of young humpback chub and concomitant reductions in recruitment are the primary factors limiting recovery (Coggins 2008b; Coggins and Walters 2009), ameliorating this threat is a primary strategy in recovery of humpback chub (U.S. Fish and Wildlife Service 2002a). Mechanical removal, which for fisheries means using electrofishing, nets, and other gear types to physically remove fish from an ecosystem, is recognized as a potentially viable option for addressing this threat (Clarkson et al. 2005, Simberloff et al. 2005), although in practice, mechanical removal of non-native fishes in the mainstem Colorado River has not been well evaluated and has achieved varying degrees of success (Mueller 2005).

Mueller (2005) recommended a success criteria of 80 percent reduction for non-native fish removal programs. He implied that lesser levels of removal are likely ineffective, but there are limited results from controlled studies to confirm or reject this criterion. Mechanical removal of non-native fish species in Grand Canyon was tested at the LCR inflow reach (LCR, RM 56.3-65.7) from 2003 to 2006 (Coggins 2008a). The LCR inflow reach is the area of the mainstem with the highest densities of young humpback chub in the Grand Canyon population, and thus

the clear choice of location for targeting removal of non-native fishes. Relying primarily on electrofishing, mechanical removal proved especially effective at removing both rainbow and brown trout, with rates up to 90 percent in removal reaches (Coggins 2008a, Yard et al. *in press*).

Stomach analysis of removed trout revealed that while the predation rate by rainbow trout was low, numbers of humpback chub lost to rainbow trout were very high due to the high densities of the predator in the removal reach (Yard et al. 2008, *in press*). In a hypothetical modeling scenario developed using trout diet information obtained from these removal efforts, Yard et al. (2008, *in press*) assessed the impact removed trout might have had on humpback chub had they not been removed. Assuming that trout captured during removal were not removed, and fish abundance and catchability conditions remained the same during the period of the trout diet study from January 2003 through September 2004, the number of humpback chub that could have been consumed by these trout had they not been removed during the 12 removal trips was 12,169 young-of-year fry and subadults (Hilwig et al. 2010).

4.2 Justification for Non-native Fish Control

An external scientific review panel conducted in 2007 by the USGS to recommend experimental actions to the GCDAMP reviewed the data resulting from the 2003¬2006 removal efforts. They recommended continued removal in Grand Canyon to maintain low levels of rainbow trout in the LCR confluence reach (U.S. Geological Survey 2008). Hilwig et al. (2010) also reviewed the existing information and scientific literature and recommended removal targets of 10-20 percent of 2003 abundance levels of rainbow trout in the removal reach, which would achieve the 80 percent reduction recommended by Mueller (2005).

Despite the conventional wisdom on the need to continue removal, the GCMRC acknowledges that the link between non-native fish predation and humpback chub adult abundance has not been firmly established, and other variables in the ecosystem apart from reductions in non-native predators, such as the warmer mainstem water temperatures caused by the recent drought, may have contributed to the recent improvement in humpback chub recruitment observed over the last decade (Andersen 2009; Coggins and Walters 2009; Hilwig et al. 2010).

4.3 Results of Mechanical Removal Study

The mechanical removal study of 2003-2006 demonstrated that rainbow trout can be effectively reduced in numbers within a 9.4-mile removal area around the confluence of the Colorado and Little Colorado rivers (Coggins 2008a). It also illustrated the rate of immigration of trout, presumably from upstream sources, and the offsetting effect on removal. During the period of removal, the humpback chub population stabilized and increased, suggesting that removal had enabled higher survival, and hence recruitment, by humpback chub (Andersen 2009; Coggins 2008a; Coggins and Walters 2009). The coincidental effect of warmer temperature releases from Glen Canyon Dam, the result of lowered reservoir elevations in Lake Powell, confounded the results of removal as a beneficial action for humpback chub.

The decline of rainbow trout abundance observed in the control reach was likely precipitated by at least two factors. First, rainbow trout abundance in the Lees Ferry reach of the Colorado River increased during approximately 1992-2001 and abundance in this reach steadily fell during 2002-2006 (Makinster 2007). The 2002-2006 decrease took place during the period of mechanical removal, and suggests there was a system-wide decrease in rainbow trout not attributable to removal. With the exception of limited spawning activity in select tributaries of the Colorado River in Grand Canyon, rainbow trout reproductive activity appears to be limited mainly to the Lees Ferry reach (Korman et al. 2005). The second major factor likely influencing these distributional patterns is sediment delivery from tributaries and the subsequent effects of elevated turbidity in the Colorado River on food availability and feeding behavior of sight feeders, such as trout.

One non-native removal trip was also conducted in 2009, which provided important information for consideration of non-native control efforts (Makinster et al. 2009a). Results from the 2009 trip indicated that rainbow trout populations rebounded since declines in 2006-2007, a trend first documented in 2008 (Coggins 2008a). AGFD estimates that the population in the LCR inflow reach was about 2,300 - 3,300 prior to the 2009 removal, which removed about 1,873 rainbow trout. The numbers of rainbow trout in 2009 in the LCR inflow reach were approaching those seen in 2002 and 2003 when numbers were among the highest recorded for that reach. Roughly 500 -1,500 rainbow trout were thought to remain in the LCR inflow reach at the end of the trip, which is approximately the 10-20 percent of 2003 levels recommended by Hilwig et al. (2010), or 600-1,200 adult rainbow trout.

The number of trout in the inflow reach following removal appears dependent on numbers of trout immigrating into the reach, plus trout reproduction in the reach which is thought to be very low (Coggins 2008a). Hilwig et al. (2010) used immigration rates observed by Coggins (2008a) to estimate potential numbers of trout in the inflow reach, relative to hypothetical scenarios of 1, 2, or 3 removal trips conducted per year. At the lowest immigration rate of 50 fish per month, two removal trips per year appears sufficient to keep trout numbers below 1,200 rainbow trout in the reach. However, at higher immigration rates of 300 fish per month, even 3 trips per year appears insufficient to achieve the 600-1,200 fish target for much of the year (Hilwig et al. 2010).

4.4 Effects of HFEs on Trout and other Fishes

In separate NEPA process, Reclamation is developing an Environmental Assessment concerning high-flow experimental releases from Glen Canyon Dam for the purpose of promoting more natural sediment dispersal throughout the Canyon. A high flow protocol is being developed with the intention to allow for multiple high flow tests over a period of 10 years. The SDM Project analysis results suggested that there is a close relationship between the decision to conduct high flow experiments and to implement non-native fish control because of the apparent effect that HFE flows have on trout recruitment in Lees Ferry. The coupled trout-chub models developed as part of the SDM Project assessment provided some valuable predictions about the effects of HFEs (see Appendix A, Table 7). Wright and Kennedy (*in press*) also concluded available evidence indicates that HFEs can substantially impact humpback chub population levels due to the positive effect of HFEs on trout abundance and the negative effect of trout completion and

predation on humpback chub and other native fishes. Wright and Kennedy reported that rainbow trout abundance in the LCR reach increased approximately 3,800 percent since 2006. They attribute this increase to downriver migration of the large 2008 rainbow trout cohort spawned in the Lees Ferry tailwater reach immediately after the 2008 HFE, together with local recruitment along downriver sections.

Results from the 1996 and 2008 HFEs indicate that high flow experiments have the potential to increase numbers of rainbow trout in Lees Ferry and likely influence the abundance of rainbow trout throughout Grand Canyon due to several factors. Korman et al. (2010) found multiple lines of evidence indicating that the March 2008 HFE resulted in large increases in abundance of rainbow trout in Lees Ferry due to improved habitat conditions for young-of-year rainbow trout. Numbers of young-of-year rainbow trout in July of 2008 were four-fold greater than would be expected based on numbers of eggs produced during the 2008 spawn based on stock-recruitment analysis. Survivorship was also greater for fish that hatched after the HFE based on hatch-date analysis, also indicating that habitat conditions were improved after the HFE. Growth rates of young-of-year rainbow trout were also as high as has been recorded in Lees Ferry, despite the fact that abundance was also much greater than previous years, suggesting a greater carrying capacity for young trout in Lees Ferry following the HFE (Korman et al. 2010). Korman et al. (2010) speculate that the 2008 HFE (41,500 cfs for 60 hours) resulted in these effects because the high flow increased interstitial spaces in the gravel bed substrate and food availability or quality, resulting in higher early survival of young-of-year rainbow trout, as well as improved growth of young trout. This improved habitat effect of the 2008 HFE also apparently carried over into 2009; trout abundance in 2009 was more than twofold higher than expected from egg counts (Korman et al. 2010).

Although there is less data from the 1996 and 2004 HFEs, those events appeared to have effects to rainbow trout as well. Trout abundance in Lees Ferry appeared to increase following the 1996 event which was conducted in April (Makinster et al. 2009b). During a three-week period that spanned the November 2004 HFE, abundance of age-0 trout, estimated to be approximately 7 months old at that time, underwent a three-fold decline; a two-fold decline was also observed in November-December 2008 (Korman et al. 2010). The decline observed during the 2004 HFE may have been due to either increased mortality or displacement/disbursal as a result of the higher flow (Korman et al. 2010). However, long-term trout monitoring data indicated that trout started to decline system-wide in 2001/2002 and declined through the period of the 2004 HFE and only began to recover in about 2007 (Makinster 2009b). Also, key monitoring programs to detect ecosystem pathways that affect rainbow trout in Lees Ferry were not in place at the time of the 2004 HFE (Wright and Kennedy *in press*). Higher water temperatures and lower dissolved oxygen in fall 2005 also may have increased mortality and reduced 2006 spawning activity (Korman et al. 2010). Thus the overall effect of fall HFEs on rainbow trout abundance is unclear.

The high flow experiment protocol currently under development by Reclamation would provide for the opportunity to conduct multiple high flows over a 10-year period of from 31,500 cfs to 45,000 cfs. Proposed time frames are March/April and October/November, periods following the primary sediment-input season are of late Summer/early fall and winter. High flows conducted in the March/April period likely will result in improved conditions for rainbow trout

based upon observations from the 1996 and 2008 HFEs. Given that a 3,800 percent increase in rainbow trout from what appears to be downstream density-driven emigration to the LCR Reach resulting from the 2008 Spring HFE (Korman et al. 2010; Wright and Kennedy *in press*), multiple HFEs over a 10-year period would reasonably be predicted to increase rainbow trout abundance system-wide including in the LCR Reach. Under the no action alternative, losses of young humpback chub to predation by rainbow trout would also be expected to increase, even exceeding previously observed levels (Yard et al. *in press*).

Under the proposed action, removal will take place, including up to 10 removal trips in the PBR Reach and up to 6 removal trips in the LCR reach. PBR removal may serve to limit emigration of young trout from Lees Ferry. LCR reach removal is predicted to be effective at removing trout in that reach to address this threat if conditions warrant this action. In this way, the proposed action should serve to offset the adverse impacts of multiple HFEs on rainbow trout abundance and the concomitant increased predation and competition to humpback chub.

4.5 Humpback Chub Effects Analysis

4.5.1 LCR Reach Removal Effects to the Population

We evaluated impacts of the proposed action by first comparing the predicted amount of predation by rainbow and brown trout (henceforth referred to as "trout") on humpback chub across a range of mechanical removal effort by electrofishing, including: (1) No removal effort; (2) Removal effort assuming a low level of capture efficiency; (3) Removal effort assuming a high level of capture efficiency; and (4) Removal effort assuming an average level of capture efficiency. Second, we considered population level impacts of these four alternatives on the adult humpback chub population by estimating number of juvenile and age-4 (first year adults) humpback chub that would be absent to the population as a whole because of predation by rainbow trout.

We had to make several simplifying assumptions in conducting this analysis but made every attempt to assure that these assumptions remained conservative. The overriding assumptions of this analysis are that the actual levels of predation under any alternative will vary with:

1) The actual number of trout remaining in the LCR reaches since March 2009 (the last time an effort was taken to mechanically remove rainbow trout and estimate their numbers).

2) The immigration rate of trout into the LCR inflow reach since March 2009 (the last time an effort was taken to mechanically remove rainbow trout and estimate their numbers).

3) The total number of trout in the inflow reach would be removed at a rate which varies among those observed in the recent literature (no action alternative; Coggins 2008a; Coggins and Yard 2010; Yard et al. *in press*).

4) Predation rates in this analysis are assumed to vary directly and positively with prey density; in other words, high predation rates are commensurate with high prey density and vice-versa (Yard et al. *in press*).

5) Electrofishing total effort was assumed to be two LCR reach trips with methods as described by Makinster et al. 2009. Note that the proposed action allows for up to 6 river trips in the LCR reach and 10 river trips in the PBR reach, but we have no data to quantitatively evaluate the effects of PBR reach removal.

6) Mortality of humpback chub due to electrofishing is negligible compared to decreased mortality due to reduced predation and competition.

We estimated predation rates of trout on humpback chub for a period of one year and evaluated effects on the adult population several years later. We calculated our predictions using minimum and maximum parameter estimates if they were available. By most statistical distributions, the probability of minimum and maximum values actually occurring is relatively small, but these distributions serve to provide a limit on the range of possible outcomes. Estimated rainbow trout remaining in the LCR reach after the last removal effort in March 2009 was 427 to 1,427 fish (Makinster et al. 2009). Estimates of brown trout abundance in the LCR inflow reach in 2009 were not available, so brown trout predation was based on values ranging from zero to 245 fish, which was the maximum observed by Yard et al. (*in press*).

Immigration rates of rainbow trout into the LCR inflow reach were assumed to vary between 50 and 300 fish/month (Hilwig et al. 2010). Brown trout immigration rates were not available but were estimated by regressing brown trout against rainbow trout captures (effort was constant for both species; Coggins 2008a) and applying that relationship to rainbow trout immigration rates. Mean immigration rate was used to model immigration rates during 2010-2011 for the sake of simplicity; however we feel this did not influence the range of predicted outcomes significantly. Minimum and maximum predation rates calculated by Yard et al. (*in press*) were applied to the predicted number of predators during 2010-2011 (1.7 and 7.1 prey/rainbow trout/year, and 18.2 to 106 prey/brown trout/year). Of prey fish consumed, we assumed that 27.3% were humpback chub as reported in Yard et al. (*in press*). Reduction in predator numbers by mechanical removal (serial pass electrofishing; Coggins 2008a) was calculated according to high, average and low rates of removal efficiency, or 35, 18 and 2 percent of fish in the LCR inflow reach removed per electrofishing pass; we assumed four electrofishing passes/trip would be conducted as was the protocol in previous years (Coggins 2008a; Hilwig et al. 2010). Capture probabilities were assumed to be the same for both trout species.

As the number of humpback chub available to predation in the mainchannel is unknown at this time, we assumed it to be unlimited for the sake of computing and comparing estimates among alternatives across the range of variables described above. We also assumed that the overwhelming majority of humpback chub are comprised of young-of-year fry and subadults (Yard et al. 2008). Calculation of age-0 and age-1 humpback chub abundance in the LCR is currently in its infancy, and it is unknown how many of these fish would actually inhabit the main channel at any given time.

Evaluation of population level effects was conducted by converting losses of age-1 humpback chub to losses of adult humpback chub, which is the metric identified in the Recovery Goals (U.S. Fish and Wildlife 2002a) and the incidental take statement from the 2009 Supplemental Biological Opinion and the 2010 Reissued Incidental Take Statement (U.S. Fish and Wildlife Service 2009, 2010). We applied published survival rates for humpback chub (Valdez and Ryel

1995; Coggins et al. 2006) to estimate numbers of preyed-upon humpback chub as described above. We then compared these losses to the minimum population size contained in the incidental take statement (6,000 adult humpback chub; U.S. Fish and Wildlife Service 2010b).

The proposed action would have only beneficial effects to humpback chub. Depending on electrofishing efficiency, two electrofishing removal trips could reduce predation pressure by rainbow trout substantially (Figure 3). Under worst case conditions (i.e., low efficiency), total humpback chub predation would be reduced by 10-14% depending on immigration rates and individual trout predation rates. Assuming average electrofishing efficiency, total humpback chub predation would be reduced by 41-70%, and 49-85% under high efficiency conditions depending on immigration rates and individual trout predation rates. Similarly, 129-3,292 humpback chub would be theoretically saved from predation under the low efficiency scenario, 532-16,851 humpback chub in the average efficiency scenario and 637 to 20,384 humpback chub in the high efficiency scenario.

The aforementioned savings of age-0 and age-1 humpback chub due to reduced predation from 2 electrofishing trips would theoretically translate into a substantial savings of adult fish (Figure 4). Four to 96 fish would survive due to reduced predation in the low efficiency scenario, 15 to 491 fish in the average efficiency scenario, and 19 to 594 humpback chub in the high efficiency scenario. The grand mean of estimated fish saved from predation across all variables (predation and immigration rates as well as electrofishing efficiency) is 169 fish. Note that this estimate is for two LCR reach removal trips. Additional removal trips would likely not result in a linear increase in adult humpback chub saved, but would result in substantial additional increases in fish saved.

Another potential effect to humpback chub is increased competition between adult humpback chub and nonnative fishes, in particular adult rainbow and brown trout. Valdez and Ryel (1995) found that simulids, chironomids, and *Gammarus* were the three most prevalent diet items in 158 adult humpback chub stomachs sampled by gastric lavage in the mainstem Colorado River in Grand Canyon. Yard et al. (*in press*) also found that these same three types of aquatic invertebrates were important components of both rainbow and brown trout diets, often accounting for 40 to 90 percent of the proportion of diet by weight over a 1.75 year study from 2003-2004. The degree to which competition occurs between humpback chub and rainbow trout is a function of food availability, which is not currently well understood (Hilwig et al. 2010). The ongoing GCDAMP food base research project should provide insight into the effect of competition from nonnative fishes on humpback chub in light of food availability within the Colorado River ecosystem, and the Nearshore Ecology Study may also provide information about feeding ecology of fishes in nearshore environments (U.S. Bureau of Reclamation and U.S. Geological Survey 2009). Because of these uncertainties, no additional losses of humpback chub were attributed to competition from nonnative fish.

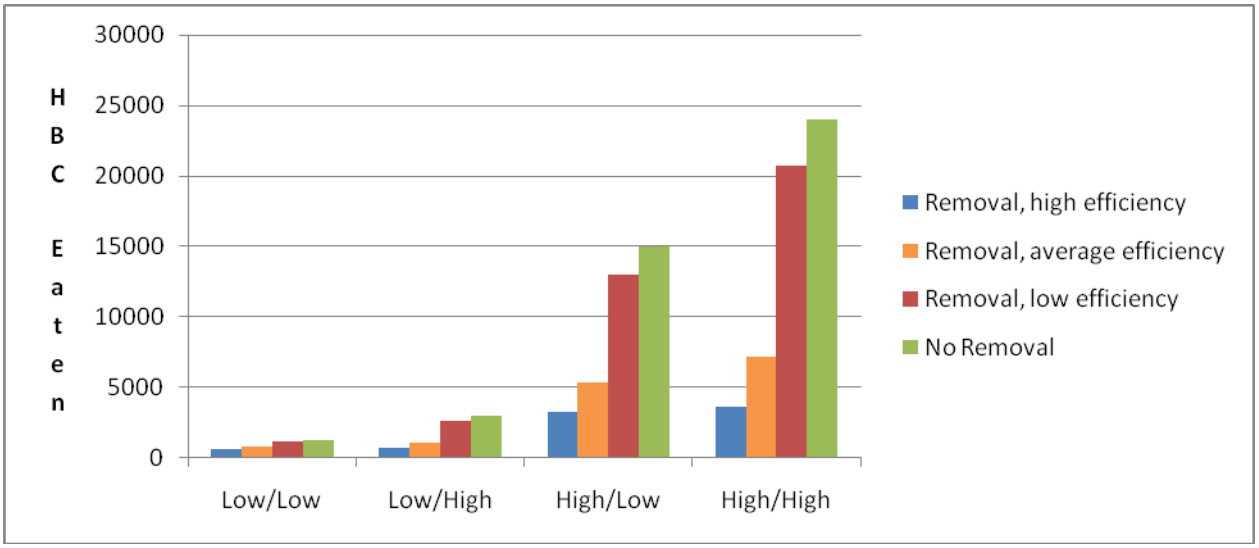

Figure 3. Expected predation of young-of-year fry and subadult humpback chub by trout in the absence of non-native fish removal (green bars) and over a range of mechanical removal efficiencies (blue, orange and red bars). X-axis labels refer to assumptions on predator density and piscivory rates. For example, "Low/Low" refers to low levels of predatory density (as a function of trout immigration rates) and low piscivory rates (Yard et al. 2008).

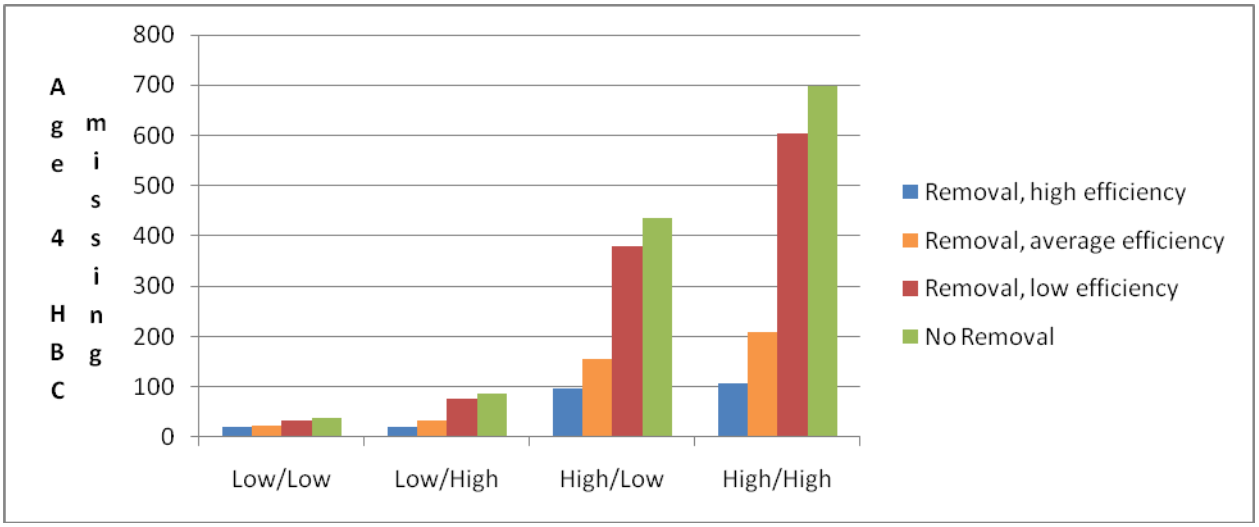

Figure 4. Expected losses of adult humpback chub (age 4) due to predation by trout in the absence of non-native fish removal (green bars) and over a range of mechanical removal efficiencies (blue, orange and red bars).

4.5.2 PBR Reach Removal Effects to Population

Effects of removal in the PBR reach to humpback chub are uncertain due to lack of information on the timing, magnitude and other controls on migration rates of rainbow trout from Lees Ferry. A study plan for the proposed action provided by GCMRC will help guide monitoring and research associated with implementing removal actions in this reach.

4.5.3 Effects to Critical Habitat

Critical habitat for humpback chub occurs in two reaches in the action area (U.S. Fish and Wildlife Service 1994): the lower 8 miles of the LCR and 173 miles of the Colorado River in Marble and Grand Canyons from Nautiloid Canyon (RM 34) to Granite Park (RM 208). A more detailed description of critical habitat and its primary constituent elements (PCEs) is provided in the original rule designating critical habitat and in the 2009 Supplemental Biological Opinion (U.S. Fish and Wildlife ServiceService 1994, 2009a).

The effect to humpback chub critical habitat from changes to the proposed action would be from implementing 1-6 removal trips at the LCR in 2011-2020 and implementing up to 10 removal trips per year in the PBR reach to reduce downstream emigration. This would result in removing several thousands of rainbow trout and other non-native fish species in the LCR confluence reach and in the PBR reach, and result in reduced predation on and competition to humpback chub from non-native fish species.

From a critical habitat perspective, this change would affect the biological primary constituent element of critical habitat, which includes three specific elements--food supply (B1), predation from non-native fish species (B2), and competition from non-native fish species (B3).

Food supply is a function of nutrient supply, productivity, and availability of food to each life stage of the species. One potential effect to humpback chub is decreased competition between adult humpback chub and non-native fishes, in particular adult rainbow and brown trout. Valdez and Ryel (1995) found that simulids, chironomids, and *Gammarus* were the three most prevalent diet items in 158 adult humpback chub stomachs sampled by gastric lavage in the mainstem Colorado River in Grand Canyon. Yard et al. (*in review*) also found that these same three types of aquatic invertebrates were important components of both rainbow and brown trout diets, often accounting for 40 to 90 percent of the proportion of diet by weight over a 1.75 year study from 2003-2004. The degree to which competition occurs between humpback chub and rainbow trout is a function of food availability, which is not currently well understood (Hilwig et al. 2010). The ongoing GCDAMP food base research project should provide insight into the effect of competition from non-native fishes on humpback chub in light of food availability within the Colorado River ecosystem, and the Nearshore Ecology Study may also provide information about feeding ecology of fishes in nearshore environments (Reclamation and U.S Geological Survey 2009).

Predation and competition are normal components of the ecosystem, but are out of balance due to introduced fish species within these critical habitat units, particularly in Reach 7. As described above, the effect of the proposed action would be to decrease predation and competition from non-native fishes, potentially increasing the food supply available to humpback chub, thus all three aspects of the biological environment constituent element would be positively affected by the proposed action for 2011-2020.

The Recovery Goals (U.S. Fish and Wildlife Service 2009b) identify the need to develop and implement levels of control of non-native fish species. The GCDAMP has demonstrated that successful removal of non-native trout is possible, and may benefit humpback chub (Yard et al. *in review*; Coggins and Walters 2009). The degree to which these removal efforts have improved the PCEs B1, B2, and B3 is still a research question. However, as described above, Yard et al. (*in review*) presented some preliminary results indicating that the 2003-2006 removal of rainbow and brown trout contributed significantly in reducing predation losses of juvenile humpback chub. This evidence, along with information from the most recent 2009 removal effort (Makinster et al. 2009), provides a good indication of what affect the proposed action is likely to have on humpback chub critical habitat, although the overall effect on recovery is less clear.

Non-native fish removal has been identified by several authors as a likely cause of improved status of humpback chub (Andersen 2009, Coggins and Walters 2009, Van Haverbeke and Stone 2009), but a definitive link between removal and improvement in humpback chub status is still lacking (Coggins and Yard 2010). However, Reclamation's proposed action should continue to refine methods of controlling non-native fish species, and may ultimately improve the effectiveness of the conservation measure in the long-term, which would directly address this recovery need for the B2 and B3 PCEs of Reach 7 and, to a lesser extent, Reach 6. Overall, the proposed action should provide a substantial beneficial effect to humpback chub and its critical habitat.

4.6 Razorback Sucker Effects Analysis

The only effect to razorback sucker from the proposed action would be from conducting non-native fish removal trips in 2011 to 2020. This would result in removing thousands of rainbow trout and other non-native fish species in the LCR confluence reach. However removal in both the LCR and PBR reaches is anticipated to have no effect to razorback sucker because of its absence in the areas where removal actions will be occurring and the distance from the removal areas, over 300 miles, to where razorback sucker occur in Lake Mead.

The nearest population of razorback sucker to the proposed action area is in Lake Mead at Echo Bay and near the Virgin River and Muddy River inflows into the lake. These groups of fish are reproducing and evidently self-sustaining. These razorback suckers are located about 300 miles downstream of removal reaches of the action area and it is highly unlikely that individuals would move upstream into the action area.

Critical habitat for razorback sucker occurs throughout the Colorado River in Grand Canyon from the Paria River to Hoover Dam, including Lake Mead (U.S. Fish and Wildlife Service 1994). Best available scientific information indicates that the habitat of the Colorado River and its tributaries within Grand Canyon is currently unoccupied by razorback sucker. Although the proposed action will likely have little if any effect on razorback sucker, the unoccupied reaches of its critical habitat that overlap with the removal reaches, the LCR and PBR reach, will benefit in the same way that humpback chub critical habitat will benefit.

4.7 Limitation on Commitment of Resources

Section 7(d) of the ESA provides that after initiation of consultation required under subsection 7(a)(2), the Federal agency and the permit or license applicant shall not make any irreversible or irretrievable commitment of resources with respect to the agency action which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures which would not violate subsection 7(a)(2). Reclamation is in compliance with Section 7(d) and no irretrievable investment of resources has been made on this action.

4.8 Effects Determinations

A summary of effects determinations for the four listed species is presented in Table 1. Analysis of effects determination are based 50 CFR 402.02, in which "Effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process."

Effects on critical habitat in this biological assessment relied on 50 CFR 402.02, in which "Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical." In its determination on destruction or adverse modification of critical habitat, Reclamation has relied on the 9th Circuit Court ruling of August 6, 2004 (Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service, 378 F.3d 1059), to consider whether the action appreciably diminishes the value of critical habitat for either the survival or recovery of a listed species.

Based on the analysis of effects of predation by trout on humpback chub (See Section 3.2), Reclamation has determined that the proposed action may affect, but is not likely to adversely affect the humpback chub and its critical habitat in the Colorado River within Grand Canyon. This determination is due to the overall beneficial effect to humpback chub from the proposed action. Conducting removal of non-native fishes, predominately rainbow trout, from 2011-2020 will reduce losses of humpback chub to predation and likely increase recruitment into the adult population. We have also determined that the removal action is likely to appreciably increase the value of critical habitat for survival and recovery of the humpback chub by positively affecting the biological principal constituent elements of critical habitat by not allowing known predators of humpback chub to remain in an area used by part of the population for rearing.

However, we acknowledge that here is incomplete knowledge of the complexity of survival rates associated with a large number of variables that would translate to adult recruitment. These include: the uncertainty of numbers and sizes of chubs eaten by trout, various annual densities of juvenile chubs depending on year class strength, relationship of predator and prey densities, and the levels of mainstem chub survival. To place the effect of the new action in context of the

Grand Canyon population of humpback chub, investigators have surmised that most of the young humpback chub that recruit to the adult population are reared in the LCR where trout predation is not a problem because of unsuitable water quality conditions for the trout (e.g., Coggins et al. 2006; Valdez and Ryel 1995;Van Haverbeke and Stone 2008, 2009). Furthermore, the mechanical removal in 2003-2006 was implemented in only a 9.4-mile reach of the Colorado River, but removal of predators has not been conducted elsewhere in Grand Canyon. In some years, there can be substantial numbers of juvenile humpback chub in reaches upstream of the LCR (see Figure 1), where trout are present, but predation rates there are unknown. The effects determination in this biological assessment is for the action of removing predators from a 9.4-mile reach of the Colorado River near the LCR confluence and an 8 mile reach in the PBR, where predation is one of five possible sources of mortality for humpback chub (i.e., cold-water shock, starvation, cannibalism, diseases and parasites, and downstream transport to less suitable habitat).

Reclamation has determined that the action may affect, but is not likely to adversely affect the razorback sucker or its critical habitat in the Colorado River within Grand Canyon. This determination is based on current scientific information that indicates an absence of the endangered razorback sucker from the action area or its proximity (the nearest capture of razorback sucker in the last decade is over 200 miles downstream). Reclamation also determined that the action is not likely to directly or indirectly alter critical habitat in a manner that appreciably diminishes the value of critical habitat for either the survival or recovery of the razorback sucker. The action does not adversely affect the survival of the species because of its absence from the action area, and it does not adversely affect the recovery of the species because Grand Canyon is not specifically identified as a recovery unit in the Razorback Sucker Recovery Goals (U.S. Fish and Wildlife Service 2002b) and the prospect for the species to return to this area is currently thought to be low. This determination is also based on the dynamic nature of the predator trout population in the action area and the unpredictable duration of the effect of predation. There is also uncertainty of effects on razorback sucker if the species was to somehow gain access to the action area or to be intentionally reintroduced into the area. In the case of reintroduction, any augmentation action would need to comply with the ESA and a reevaluation of critical habitat would be done at that time.

We have determined that the proposed action will not affect the Kanab ambersnail. This determination is based on the absence of the ambersnail from the project area and the lack of a relationship to trout; i.e., trout are not known to prey on Kanab ambersnail. We have also determined that the new action will not affect the southwestern willow flycatcher. This determination is based on the lack of any relationship between trout and their removal on the flycatcher or of indirect effects on the flycatcher from the action. NPS and GCRMC conduct monitoring of flycatchers in Grand Canyon. If their status should change in Grand Canyon or monitoring detect that there are effects to the species from the proposed action, reinitiation of consultation may be necessary.

Table 1. Summary of effects determinations for the four listed species.

Species	Determination	Basis for Determination
Humpback chub	May affect, not likely to adversely affect	Predation and competition by trout would be reduced as a result of conducting removal trips for 2011 to 2020; biological primary constituent element of critical habitat would be beneficially affected by removing predators to humpback chub.
Razorback sucker	May affect, not likely to adversely affect	Species not present in action area or likely to be affected by action; biological primary constituent element of critical habitat would be beneficially affected.
Kanab ambersnail	No affect	Species not present in action area or likely to be affected by action; no critical habitat is designated.
Southwestern willow flycatcher	No affect	Species not likely to be affected by action; no critical habitat is affected by action.

5.0 Literature Cited

Abate, P. D., T. Welker, and P.B. Holden. 2002. Razorback sucker studies on Lake Mead, Nevada and Arizona 2001 - 2002 annual report PR 578-6. Department of Resources; Southern Nevada Water Authority, Las Vegas, NV.

Ackerman, M.W. and R.A. Valdez. 2008. 2006 Native fish monitoring activities in the Colorado River, Grand Canyon. Cooperative Agreement (04WRAG0030) Annual Report to U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona. SWCA Environmental Consultants, Flagstaff, Arizona.

Albrecht, B., and P. B. Holden. 2006. Razorback Sucker studies on Lake Mead, Nevada and Arizona. 2005-2006 Annual Report. Prepared for the Department of Resources, Southern Nevada Water Authority. Prepared by Bio-West, Inc. Logan, Utah. PR-977-1.

Albrecht, B, R. Keggeries, P. Holden and R. Rogers. 2010. Razorback sucker investigations at the Colorado River inflow area, Lake Mead, Nevada and Arizona 2010 annual report. U.S. Bureau of Reclamation, Boulder City.

Andersen, M.E. 2009. Status and trends of the Grand Canyon population of humpback chub. U.S. Geological Survey Fact Sheet 2009-3035, April 2009.

Bestgen, K. R. 1990. Status review of the razorback sucker, *Xyrauchen texanus*. Final Report of Colorado State University Larval Fish Laboratory to U.S. Bureau of Reclamation, Salt Lake City, Utah.

Cambray, J.A. 2003. Impacts on indigenous biodiversity by the globalization of alien recreational freshwater fisheries. Hydrobiologia 500:217-230.

Carothers, S. W., and C. O. Minckley. 1981. A survey of the fishes, aquatic invertebrates and aquatic plants of the Colorado River and selected tributaries from Lees Ferry to Separation Rapids. Final Report to U.S. Bureau of Reclamation, Museum of Northern Arizona, Flagstaff.

Christensen, N. and D. P. Lettenmaier. 2006. A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River basin, Hydrology and Earth System Sciences Discussion 3:1-44.

Clarkson, R. W. and M. R. Childs. 2000. Temperature effects of hypolimnial-release dams on early life stages of Colorado River basin big-river fishes. Copeia 2000(2):402-412.

Clarkson, R.W., Marsh, P.C., Stefferud, S.E. and J.A. Stefferud. 2005. Conflicts between native fish and non-native sport fish management in the southwestern United States. Fisheries 30: 20-27.

Coggins, L. G. 2007. Abundance trends and status of the Little Colorado River population of humpback chub: an update considering 1989-2006 data. United States Geological Survey open file report 2007-1402.

Coggins, L. G. 2008a. Active management for native fish conservation in the Grand Canyon: implementation and evaluation. Gainesville, University of Florida, Ph.D. dissertation.

Coggins, L.G. 2008b. Abundance trends and status of the Little Colorado River population of humpback chub: an update considering 1989-2006 data. United States Geological Survey open file report 2007-1402.

Coggins, L. G., W. E. Pine III, C. J. Walters, and S. J. D. Martell. 2006. Age-Structured Mark-Recapture Analysis: A Virtual-Population-Analysis-Based Model for Analyzing Age-Structured Capture-Recapture Data. North American Journal of Fisheries Management 26:201-205.Coggins, L. G. Jr., and Walters, C., 2009, Abundance trends and status of the Little Colorado River population of humpback chub-an update considering data from 1989-2008: U.S. Geological Survey Open-File Report 2009-1075, 18p.

Coggins, L.G., Jr., and Walters, C.J. 2009. Abundance trends and status of the Little Colorado River population of humpback chub; an update considering data from 1989-2008: U.S. Geological Survey Open-File Report 2009-1075.

Coggins L.G., and M.D. Yard. 2010. Mechanical removal of non-native fish in the Colorado River within Grand Canyon. Pages 227-234 *in* Melis TS, Hamill JF, Coggins LG, Bennett GE, Grams PE, Kennedy TA, Kubly DM, Ralston BE, eds. Proceedings of the Colorado River Basin Science and Resource Management Symposium, November 18-20, 2008, Scottsdale, Arizona. U.S. Geological Survey Scientific Investigations Report 2010-5135.

Coggins, L., M. Yard, and C. Paukert. 2002. Piscivory by non-native salmonids in the Colorado River and an evaluation of the efficacy of mechanical removal of non-native salmonids. Grand Canyon Monitoring and Research Center, Flagstaff, AZ. [online] http://www.gov/uc/envprog/amp/amwg/mtgs/03mar28/lc_mod_fishremprop_attach10.pdf

Gloss, S. P., and L. G. Coggins. 2005. Fishes of Grand Canyon. Pages 33-56 in Gloss, S.P., J.E. Lovich, and T.S. Melis (editors). The state of the Colorado River ecosystem in Grand Canyon. A report of the Grand Canyon Monitoring and Research Center 1991-2004. USGS Circular 1282. U.S. Geological Survey, Flagstaff, Arizona.

Gloss, S.P., J.E. Lovich, T.S. Melis, eds. 2005. The state of the Colorado River ecosystem in Grand Canyon: U.S. Geological Survey Circular 1282. 220 p.

Gorman, O. T. 1994. Habitat use by humpback chub, *Gila cypha*, in the Little Colorado River and other tributaries of the Colorado River. Glen Canyon Environmental Studies Phase II Final Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Flagstaff, Arizona.Hilwig, K.D., Andersen, M.E., Coggins, L.E., Jr. 2009. Non-native fish management plan for Grand Canyon—a comprehensive approach to management and research of non-native fish species. U.S. Geological Survey Planning Document.

Hilwig, K.D., Andersen, M.E., Coggins, L.E., Jr. 2010. Non-native fish in Grand Canyon-summary of non-native fish control options and recommended monitoring and research activities. U.S. Geological Survey Planning Document.

Hoerling, M. and J. Eischeid. 2006. Past Peak Water in the Southwest. Southwest Hydrology 6(1).

Holden, P. B. 1994. Razorback sucker investigations in Lake Mead, 1994. Report of Bio/West, Inc., Logan, Utah, to Southern Nevada Water Authority.

Holden, P. B., P. D. Abate, and J. B. Ruppert. 2000. Razorback sucker studies on Lake Mead, Nevada. 1998-1999 Annual Report PR-578-3 to Southern Nevada Water Authority, Las Vegas.

Intergovernmental Panel on Climate Change (IPCC). 2007. IPCC Fourth Assessment Report: Climate Change 2007, Climate Change Impacts, Adaptation and Vulnerability - Summary for Policymakers.

Korman, J., M. Kaplinski, J. E. Hazel III, and T. S. Melis. 2005. Effects of the Experimental Fluctuating Flows from Glen Canyon Dam in 2003 and 2004 on the Early Life History Stages of Rainbow Trout in the Colorado River. Final Report to Grand Canyon Monitoring and Research Center, Flagstaff, AZ.

Korman, J., M. Kaplinski, and T.S. Melis. 2010. Effects of high-flow experiments from Glen Canyon Dam on abundance, growth, and survival rates of early life stages of rainbow trout in the Lees Ferry reach of the Colorado River: U.S. Geological Survey Open-File Report 2010–1034. 31 p.

Liebfried, B., K. Hilwig, K. Serrato, and M. Lauretta. 2006. Restoring Native Fish Habitat in Selected Tributaries of Grand Canyon National Park. Draft Report to the National Park Service from SWCA, Inc., Flagstaff, Arizona.

Leibfried, W. C., H. Johnstone, S. Rhodes, and M. Lauretta. 2003. A study to determine the efficacy of removing brown trout in Bright Angel Creek, Grand Canyon, Arizona. Report submitted to Grand Canyon National Park Science Center. SWCA Environmental Consultants, Inc., Flagstaff, AZ.

Maddux, H. R, D. M. Kubly, J. C. deVos, W. R. Persons, R. Staedicke, and R. L. Wright. 1987. Evaluation of varied flow regimes on aquatic resources of Glen and Grand Canyon. Final

Report of Arizona Game and Fish Department to U.S. Bureau of Reclamation, Glen Canyon Environmental Studies, Salt Lake City, Utah.

Makinster. 2007. Recent trends in the Lee's Ferry tailwater fishery, with additional input on findings of whirling disease, crayfish and exotic species. Presentation to the Glen Canyon Dam Adaptive Management Program Adaptive Management Workgroup; available at http://www.usbr.gov/uc/rm/amp/amwg/mtgs/07aug29/Attach_03e.pdf.

Makinster, A.S., C. Nelson, W.R. Persons, and L. Coggins. 2009a. Summary of 2009 mechanical removal project. Arizona Game and Fish Department, Research Branch and U.S. Geological Survey Grand Canyon Monitoring and Research Center. Presentation to the Adaptive Management Work Group, August 13, 2009. Available at http://www.usbr.gov/uc/rm/amp/amwg/mtgs/09aug12/Attach_05c.pdf

Makinster, A.S., M.A. Hangsleben, R.S. Rogers, W.R. Persons. 2009b. Status of the Lees Ferry rainbow trout fishery with additional input regarding potential impacts of the 2008 High Flow Experiment. Report from the Arizona Game and Fish Department to the Grand Canyon Monitoring and Research Center, Cooperative Agreement No. 05WRAG0050 – Mod 5.

Makinster, A.S., W.R. Persons, L.A. Avery, and A.J. Bunch. 2010. Colorado River fish monitoring in Grand Canyon, Arizona—2000 to 2009 summary: U.S. Geological Survey Open-File Report 2010–1246. 26 p.

Marsh, P. C. 1993. Draft biological assessment on the impact of the Basin and Range Geoscientific Experiment (BARGE) on federally listed fish species in Lake Mead, Arizona and Nevada. Arizona State University, Center for Environmental Studies, Tempe, Arizona

Marsh, P. C., and M.E. Douglas. 1997. Predation by introduced fishes on endangered humpback chub and other native species in the Little Colorado River, Arizona. Transactions of the American Fisheries Society 126:343–346.

Marsh, P. C., and W. L. Minckley. 1989. Observations on recruitment and ecology of razorback sucker: Lower Colorado River, Arizona-California-Nevada. Great Basin Naturalist 49:71–78.

Miller, R. R. 1946. *Gila cypha*, a remarkable new species of cyprinid fish from the Colorado River in Grand Canyon, Arizona. Journal of the Washington Academy of Sciences 36(12):409-415.

Minckley, W. L. 1983. Status of the razorback sucker, *Xyrauchen texanus* (Abbott), in the Lower Colorado River Basin. Southwestern Naturalist 28:165–187.

Minckley, W. L. 1991. Native fishes of the Grand Canyon region: an obituary? Pages 124–177 *in* National Research Council Committee (eds.). Colorado River ecology and dam

management. Proceedings of a symposium, May 24–25, 1990, Santa Fe, New Mexico, National Academy Press, Washington, D.C.

Mueller, G. A. 2005. Predatory fish removal and native fish recovery in the Colorado River mainstem: what have we learned? Fisheries 30(9):10-19.

National Park Service. 2005. Draft Environmental Assessment/Assessment of Effect September 2005 Bright Angel Creek Trout Reduction Project. Department of the Interior, National Park Service, Grand Canyon National Park.

Robinson, A. T. and M. R. Childs. 2001. Juvenile growth of native fishes in the Little Colorado River and in a thermally modified portion of the Colorado River. North American Journal of Fisheries Management 21:809-815.

Robinson, A.T., R.W. Clarkson, and R.E. Forrest. 1998. Dispersal of larval fishes in a regulated river tributary. Transactions of the American Fisheries Society 127:722–786.

Runge, M.C., Bean, Ellen, Smith, D.R., and Kokos, Sonja, 2011, Non-native fish control below Glen Canyon Dam—Report from a structured decision-making project: U.S. Geological Survey Open-File Report 2011–1012, 74 p., at http://pubs.usgs.gov/of/2011/1012/http://pubs.usgs.gov/of/2011/1012/.

Simberloff, D., Parker, I.M., and P. N. Windle. (2005) Introduced species policy, management, and future research needs. Frontiers in Ecology and the Environment 3:1, 12-20.

U.S. Bureau of Reclamation. 2007a. Colorado River interim guidelines for lower basin shortages and coordinated operations for Lake Powell and Lake Mead, Record of Decision. U.S. Bureau of Reclamation, Upper and Lower Colorado River Regions.

U.S. Bureau of Reclamation. 2007b. Colorado River interim guidelines for lower basin shortages and coordinated operations for Lake Powell and Lake Mead, Final Environmental Impact Statement. U.S. Bureau of Reclamation, Upper and Lower Colorado River Regions. Four volumes.

U.S. Bureau of Reclamation. 2008. Annual operating plan for the Colorado River 2009. U.S. Department of the Interior, U.S. Bureau of Reclamation.U.S.

U.S. Bureau of Reclamation and U.S. Geological Survey. 2009. Biennial Budget and Work Plan—Fiscal Years 2010–11. Prepared in cooperation with the Glen Canyon Dam Adaptive Management Program.

U.S. Fish and Wildlife Service. 1990. Humpback Chub Recovery Plan. Mountain-Prairie Region, Denver, CO. 43 pp.

U.S. Fish and Wildlife Service. 1994. Final rule, determination of critical habitat for the Colorado River endangered fishes: razorback sucker, Colorado squawfish, humpback

chub, and bonytail chub. Federal Register 59:13374-13400.

U.S. Fish and Wildlife Service. 1998. Razorback sucker recovery plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2002a. Humpback chub recovery goals: amendment and supplement to the humpback chub recovery plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

U.S. Fish and Wildlife Service. 2002b. Razorback sucker recovery goals: amendment and supplement to the razorback sucker recovery plan. USFWS, Mountain-Prairie Region (6) Denver, Colorado.

U.S. Fish and Wildlife Service. 2007. Final biological opinion for the proposed adoption of Colorado River interim guidelines for lower basin shortages and coordinated operations for Lake Powell and Lake Mead. Consultation number 22410-2006-F-0224. U.S. Fish and Wildlife Service, Phoenix, Arizona.

U.S. Fish and Wildlife Service. 2008. Final Biological Opinion for the Operation of Glen Canyon Dam. U.S. Fish and Wildlife Service, Phoenix, Arizona.

U.S. Fish and Wildlife Service 2009. Supplement to the 2008 Final Biological Opinion for the Operation of Glen Canyon Dam. U.S. Fish and Wildlife Service, Phoenix, Arizona.

U.S. Fish and Wildlife Service. 2010a. Reinitiation of the 2009 Biological Opinion on the Continued Operations of Glen Canyon Dam without Mechanical Removal of Nonnative Fish in 2010 from the Colorado River, Grand Canyon, Arizona. U.S. Fish and Wildlife Service, Phoenix, Arizona.

U.S. Fish and Wildlife Service. 2010b. Reissuance of the Incidental Take Statement on the 2009 Supplemental Biological Opinion on the Operation of Glen Canyon Dam 2008-2012. U.S. Fish and Wildlife Service, Phoenix, Arizona.

U.S. Geological Survey. 2008. U.S. Geological Survey, Grand Canyon Monitoring and Research Center, workshop on scientific aspects of a long-term experimental plan for Glen Canyon Dam, April 10–11, 2007, Flagstaff, Arizona. U.S. Geological Survey Open-File Report 2008–1153. 79 p.

Valdez, R. A. 1996. Synopsis of the razorback sucker in Grand Canyon. Paper presented at the Razorback Sucker Workshop, January 11–12, 1996, Laughlin, Nevada. Sponsored by U.S. Bureau of Reclamation, Glen Canyon Environmental Studies, Flagstaff, Arizona.

Valdez, R. A., and W. J. Masslich. 1999. Evidence of reproduction by humpback chub in a warm spring of the Colorado River in Grand Canyon, Arizona. Southwestern Naturalist 44(3):384-387.

Valdez, R. A., and R. J. Ryel. 1995. Life history and ecology of the humpback chub (*gila cypha*), in the Colorado River, Grand Canyon, Arizona: final report. [online] http://www.gcmrc.gov/library/reports/biological/Fish_studies/gces/valdez1995f.pdf.

Van Haverbeke, D.R. and D.M. Stone. 2008. Stock Assessment and Fisheries Monitoring Activities in the Little Colorado River within Grand Canyon during 2007. Annual Report to U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona. Interagency Acquisition No. 01-3022-R1009. U.S. Fish and Wildlife Service Document No. USFWS-AZNFWCO-FL-08-002.

Van Haverbeke, D.R. and D.M. Stone. 2009. Stock Assessment and Fisheries Monitoring Activities in the Little Colorado River within Grand Canyon during 2008. Annual Report To U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, AZ. Interagency Acquisition No. 01-3022-R1009. U.S. Fish and Wildlife Service Document No. USFWS-AZFWCO-FL-09-004.

Webb, R. H., P. G. Griffiths, C. S. Magirl, and T. C. Hanks. 2005. Debris flows in Grand Canyon and the rapids of the Colorado River. Pages 139-152 in Gloss, S.P., J.E. Lovich, and T.S. Melis (editors). The state of the Colorado River ecosystem in Grand Canyon. A report of the Grand Canyon Monitoring and Research Center 1991-2004. USGS Circular 1282.U.S. Geological Survey, Flagstaff, Arizona.

Wright, S.A., and T.A. Kennedy. in press. Science-based strategies for future high flow experiments at Glen 3 Canyon Dam, in Melis, T.S., ed., Effects of three high-flow experiments on the Colorado River ecosystem downstream from Glen Canyon Dam, Arizona: U.S. Geological Survey Circular 1366.

Yard, M.D., L.G. Coggins, and C.V. Baxter. 2008. Foraging ecology of non-native trout in the Colorado River, Grand Canyon: predation on native fishes and the effects of turbidity. U.S Geological Survey, Powerpoint presentation to the Glen Canyon Dam Adaptive Management Program, Technical Work Group, June 16-17, 2008.

Yard M.D., Coggins L.G., Baxter C.V., Bennett G.E. *In review*. Trout piscivory in the Colorado River, Grand Canyon: effects of turbidity, temperature, and fish prey availability. Transactions of the American Fisheries Society.