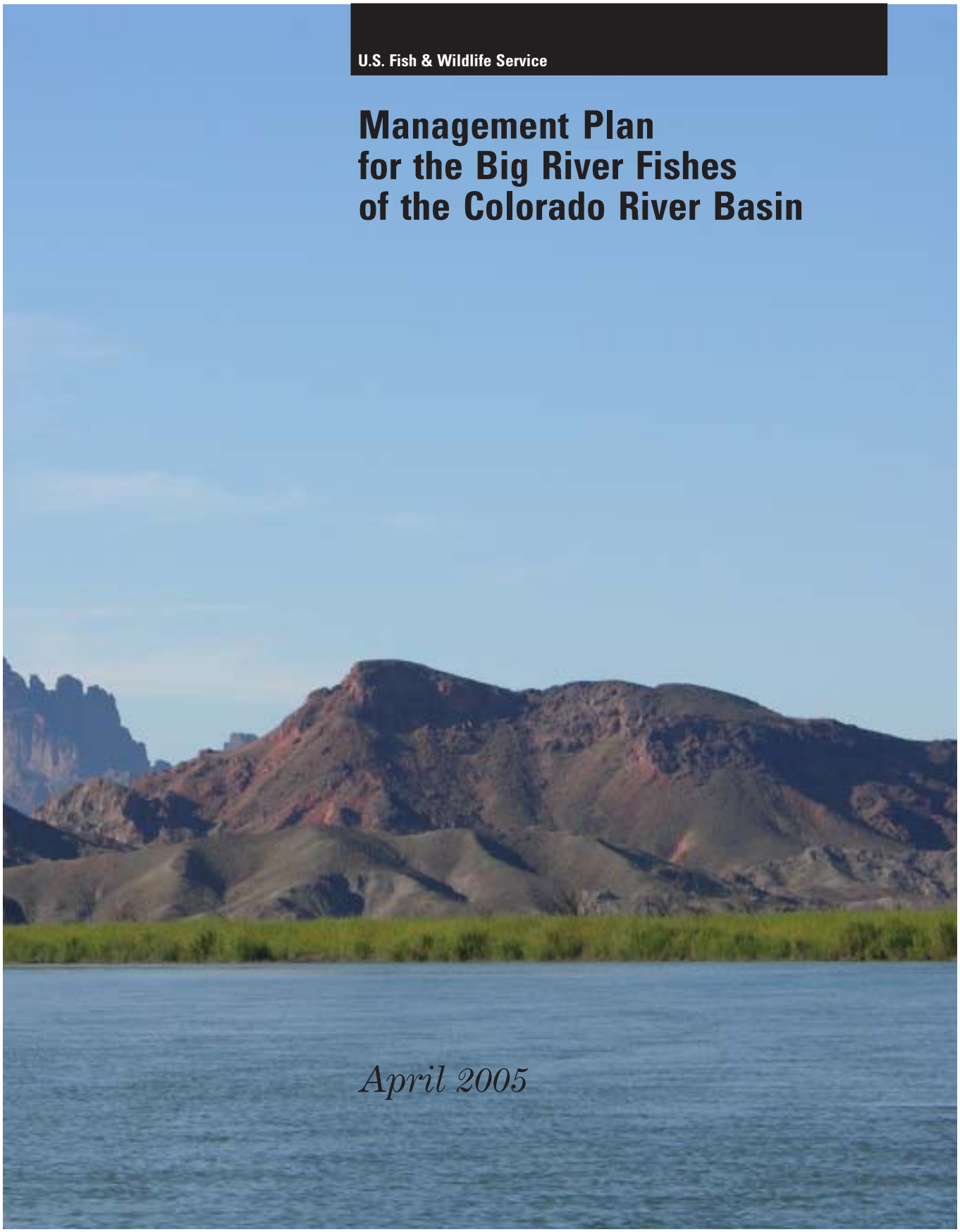
U.S. Fish & Wildlife Service

# Management Plan for the Big River Fishes of the Colorado River Basin



*April 2005*

# MANAGEMENT PLAN FOR THE BIG-RIVER FISHES OF THE LOWER COLORADO RIVER BASIN

U. S. Fish and Wildlife Service
Southwest Region (2)
Albuquerque, New Mexico

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# APPROVAL/SIGNATURE PAGE

## APPROVAL/SIGNATURE PAGE

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This document is designed to supplement to the existing recovery plans for the federally endangered bonytail (*Gila elegans),* Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), and razorback sucker (*Xyrauchen texanus*) and their recovery goals. The U.S. Fish and Wildlife Service publishes these recovery plans, which may be prepared with the assistance of recovery teams, contractors, State agencies, and others. Attainment of the objectives and provision of any necessary funds are subject to priorities, budgetary, and other constraints affecting the parties involved. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service ***only*** after they have been signed by the Regional Director or Director as ***approved***. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

## CITATION FOR THIS MANAGEMENT PLAN

**This Management Plan should be cited as follows:**

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# EXECUTIVE SUMMARY

This document is the Lower Colorado River Management Plan (LCRMP) for big-river fishes and presents the strategies needed to recover and manage these species in the lower basin. These management strategies are intended to contribute to and assist with basin wide recovery of these fishes, and to their eventual down- and de-listing. This document was prepared by a team appointed in 1999 by the Regional Director of the U.S. Fish and Wildlife Service, Region 2. It supplements the existing recovery plans for the federally endangered bonytail (*Gila elegans*), Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), and razorback sucker (*Xyrauchen texanus*) and their recovery goals. The LCRMP includes the mainstem Colorado River and its tributaries from Lees Ferry to the Southerly International Boundary with Mexico and is divided into six subunits: Grand Canyon, Lake Mead, Lake Mohave, Lake Havasu, Parker-Imperial, and the Gila River basin.

The LCRMP will maintain genetic refugia for razorback sucker and bonytail and establish self-sustaining populations of these species in the lower basin. In addition, the plan calls for maintenance of the current humpback chub population size with no decline in numbers and maintenance of an experimental nonessential population of Colorado pikeminnow in the lower basin. These ideas build on ongoing efforts in the lower basin that have prevented the extirpation of existing populations and developed habitat and life history information on these species. The management actions presented are believed to be the most likely to enable the survival, reestablishment, and stabilization of big-river fish populations in the lower basin. The plan will achieve this through maintaining several inter-related large populations in a spectrum of habitat types. These objectives will be accomplished using three strategies: 1) the use of hatcheries to produce larger fish for reintroduction, 2) the use of natural or constructed habitats to develop self-sustaining populations and to produce larger fish for the mainstem habitat; and 3) the exploitation of habitats made available by reservoir drawdown or drying to establish populations of large adults. These strategies will necessarily include genetic, habitat, and population management components.

# INTRODUCTION

The Lower Colorado River Basin Management Plan (LCRMP) identifies strategies necessary to achieve the Recovery Goals (USFWS 2002a, b, d) for the federally endangered bonytail (*Gila elegans)*, humpback chub (*G. cypha*), and razorback sucker (*Xyrauchen texanus*) in the lower basin. There are currently no Recovery Goals outlined for Colorado pikeminnow (*Ptychocheilus lucius*) in the lower basin; however, we do address the provisional recovery goals for this species for the lower basin (2002c). These species are collectively known as the "big-river fishes." The pertinent Recovery Goals are listed in Appendix I.

The LCRMP identifies management strategies at the programmatic level. It is not intended to provide the level of detail needed to implement specific actions under the management strategies. Implementation of the LCRMP will be guided through the voluntary efforts of Federal and State agencies and interested Tribes, local groups and private cooperators. When a specific action is proposed for implementation, a comprehensive planning process will involve cooperating agencies, interested stakeholders and resource groups to design the proposed action to meet the needs of the LCRMP and avoid effects to significant environmental resources.

This document was prepared by the Recovery Implementation Planning/Scientific Work Group, a team appointed in 1999 by the Regional Director of the U.S. Fish and Wildlife Service (Service), Region 2. It is currently comprised of personnel from Arizona Game and Fish Department (AGFD), California Department of Fish and Game (CDFG), Nevada Department of Wildlife (NDOW), U.S. Bureau of Reclamation (USBR), Arizona State University (ASU), U.S. Geological Survey (USGS), the Service, and the University of Nevada, Las Vegas (UNLV).

## COLORADO RIVER BASIN

The entire Colorado River basin drains ~650,000 $km^2$ of western North America (Carlson and Carlson 1982; Carlson and Muth 1989). The basin is divided for administrative purposes into the upper and lower basins at Lees Ferry, Arizona. The lower basin consists of portions of Arizona, California, and Nevada and includes the mainstem Colorado River and its tributaries, from Lees Ferry to the Southerly International Boundary. Major lower basin tributaries include the Virgin, Moapa, Paria, Little Colorado, Bill Williams, and Gila rivers. Inflows from

the Rio Hardy and Rio Sonoita in the states of Baja California Norte and Sonora, respectively, are also part of the drainage. The waters in this basin are more heavily used than any other river drainage in the USA and perhaps the world (Fradkin 1989). For purposes of this document, the lower basin has been divided into six subunits: Grand Canyon, Lake Mead, Lake Mohave, Lake Havasu, Parker-Imperial, and Gila River basin.

Historically, the Colorado River in the lower basin had both canyon-bound and alluvial valley reaches. Canyon reaches were narrow with rapids, fast flowing runs, and shoreline eddies. Where the river meandered through the alluvial valleys it formed braided channels, backwaters, oxbow lakes, and marshes. Riparian forests of cottonwood (*Populus fremonti*) and willow (*Salix* spp.) formed on the lower terraces with stands of mesquite (*Prosopis* spp.) on upper terraces. River flows were highly variable. Before impoundments, the hydrologic conditions to which these fishes were adapted included relatively short periods of torrential flooding or severe drought alternating with far longer periods of variable but less extreme flow conditions. Its annual flow reflected snowmelt from the Rocky Mountains, high and cold in the spring and early summer, then dropped abruptly and remained relatively low in summer through winter. The River drained to the Sea of Cortez forming a large estuarine delta at its mouth. Extensive alluvial deposits resulted from an annual sediment load in excess of 100 million metric tons (USBR data), and water temperatures changed with ambient temperatures throughout much of the year.

Beginning in the mid-1800s, settlers along the Colorado River began constructing temporary diversions for agriculture and by 1905 had constructed Laguna Dam, the first permanent dam in the lower basin. By the 1960s, Hoover, Davis, and Parker dams were completed and controlled river flow. Smaller diversion dams such as Headgate Rock, Palo Verde, and Imperial, controlled and removed water released from the large dams, decreasing the volume of water in the river as it flowed south. After water deliveries were made to Mexico at Morelos Dam at the Southerly International Boundary, the river channel was dry in all but exceptional runoff years. Floodplains were developed for agriculture or flooded by reservoirs. Remaining river sections were channelized and controlled by bank stabilization or levees. Backwaters and marshes cut off by channelization were lost and those remaining were maintained by human efforts.

## BIG-RIVER FISHES

The “big-river” fishes are characterized by endemism and unique adaptations to this harsh environment and display remarkable physiological, morphological, and behavioral traits. Today the remaining populations of these species are small and isolated. The disappearance of native fishes in the lower basin has attracted attention since early days of river modification (Dill 1944; Miller 1946, 1961). Two inter-related actions are primarily responsible for the elimination of the “big-river” fish. One is the alteration of habitat due to dam construction and diversions and the other is the introduction of nonnative fish. Dams and permanent diversion structures interrupted the seasonal flow patterns, replacing them with managed flows, and also altered thermal regimes in reservoir impoundments and the remaining river channel. Sediment transport was interrupted, causing changes to channel morphology and dynamics. Dams also blocked migration routes and isolated groups of fish. The meandering of the river within its historic floodplain, which had created backwaters and marshes, was halted, and the floodplain was isolated behind levees or stabilized banks. Some habitats suitable for adult fish persistence still remain throughout the system but the low variance in flows and thus seasonal conditions critical for key life stages of native fish in the presence of nonnative predators and competitors, are greatly reduced.

Concurrently, the introduction and spread of nonnative fishes may have been even more detrimental than loss of habitat. The new physical conditions in the lower basin provided suitable habitat for these introduced species and they spread rapidly. Most nonnatives are ecological generalists and are very competitive with other fish species. Many are predators, or if omnivorous, are still a threat to native fish eggs and young. Decades of monitoring and research in the lower basin have shown that nonnative predators or competitors prevent native fish populations from completing their life cycle in the few suitable habitat patches remaining (Blinn et al. 1993, Minckley and Deacon 1968, 1991; Minckley 1973, 1985, 1991; Pacey and Marsh 2000). These nonnative species now dominate the aquatic habitats available in the lower basin.

## Bonytail

Currently, small populations of bonytail occur in Lake Mojave and Lake Havasu. Both reservoirs are designated critical habitat (USFWS 1994a). Stocking efforts in Lake Havasu and Lake Mohave are ongoing under projects directed by biological opinions (BO). Bonytail have successfully recruited in the High Levee

Pond a small isolated site on Cibola National Wildlife Refuge (CNWR) (Mueller et al. 2002).

Colorado pikeminnow

Wild populations of Colorado pikeminnow are extirpated from the lower basin (Minckley 1991). There are ongoing activities to reintroduce this species into the Gila subbasin as an experimental nonessential population (Jahrke and Clark 1999).

Humpback chub

The humpback chub occurs in the Colorado River in Grand Canyon. Although it occurs sporadically throughout the entire subunit the largest concentration of fish is associated with the lower 14.2 km of the Little Colorado River and its confluence.

Razorback sucker

Small populations of razorback sucker persist in the Grand Canyon and Lake Mead subunits (Minckley and Carothers 1975; Abate et al. 2002). The largest population of razorback sucker occurs in Lake Mohave where fewer than 3,000 individuals remain from the relic adult population (P. Marsh pers. comm.). The number of wild razorback sucker in the Lake Havasu and Parker-Imperial subunits is unknown.

Current research on humpback chub in Grand Canyon is based on the Grand Canyon Protection Act of 1992, directed by the Adaptive Management Work Group (AMWG), and implemented by the Grand Canyon Monitoring and Research Center (GCMRC). The Southern Nevada Water Authority (SNWA), USBR and NDOW are funding investigations on the razorback sucker population in Lake Mead. The Lake Mohave Native Fish Group (LMNFG) and the Service are fulfilling a BO to stock Lake Mohave with subadult razorback sucker and bonytail. The Bureau of Land Management (BLM) is completing a BO to stock subadult razorback suckers and bonytail into Lake Havasu. The AGFD and USBR are collaborating in stocking razorback sucker downstream of Parker Dam. The USBR is funding monitoring by ASU for razorback sucker stocked downstream of Parker Dam. Additionally, Willow Beach National Fish Hatchery capabilities have been enhanced by construction of new facilities at the main

hatchery and at the Achii Hanyo facility to increase production. Funds for these efforts were provided by the Service and USBR. Funds have also been provided to the AGFD Bubbling Ponds Hatchery by USBR for site renovation to increase their capabilities to raise native fish. Isolated habitats on private golf courses, CNWR, and Havasu National Wildlife Refuge (HNWR) are being used for rearing and for identifying suitable habitat conditions that can be used toward developing sustainable populations. This latter project has been funded by the Service. Activities are also ongoing in the Gila River drainage where razorback sucker and Colorado pikeminnow are being introduced by AGFD under an experimental nonessential designation for Colorado pikeminnow and a fully protected status for razorback suckers.

The 2002 Recovery Goals address the recovery of the four “big-river” fishes in both the upper and lower basins. The two basins differ significantly in the degree to which the river has been modified or controlled for water development, remaining natural habitats, extant populations of the “big-river” fishes, and the significance of the existing sport fish populations. The LCRMP is designed to take advantage of the lower basin’s physical and biological conditions, and addresses lower basin habitats, extant populations, and previous actions taken that have contributed to their survival and recovery.

These strategies reflect ideas thought most likely to promote the survival, reestablishment, and stabilization of “big-river” fish populations, leading to recovery in the lower basin by developing inter-related populations of these species in a variety of habitats. This document has as a primary goal the coordination among stakeholders and the continued focus on the Recovery Goals for each species. Down-listing and de-listing criteria and Recovery Goals for these species in the lower Colorado River basin are presented in Appendix I.

# MANAGEMENT STRATEGIES

## KEY FACTORS USED IN DEVELOPING MANAGEMENT STRATEGIES

In developing this plan, the team realized that several factors inherent to the lower basin would be important in developing appropriate “big-river” fish management strategies.

1. Water resource development of the lower Colorado River is essentially complete. However, there are available habitats that can be used to manage these fishes and opportunities exist for the development of additional habitats.

2. Lower basin populations of bonytail, humpback chub, and razorback sucker are the largest remaining within the range of these species and therefore can provide an essential resource for future management actions. Beyond providing genetic refugia as a hedge against extinction, existing and augmented lower basin populations will be a valuable resource for use in rangewide recovery activities.

3. Ongoing stocking programs exist to increase the number of bonytail and razorback sucker in Lake Mohave, Lake Havasu, and Parker-Imperial subunits.

4. The long-lived nature of these species allows for time to implement management actions and assess their affects under an adaptive management program.

5. Many of the ideas presented herein have been throughly researched and documented in the literature (Deacon and Minckley 1974, Minckley 1973, 1985, 1991; Minckley and Deacon 1991; Minckley et al. 2003).

## MANAGEMENT STRATEGIES OVERVIEW

The strategies presented in this document are designed to meet two key recovery actions for the “big-river” fishes: the maintenance of adult genetic refugia in lower basin Colorado River mainstem reservoirs and the establishment of self-sustaining populations that exceed Minimum Viable Population (MVP) levels identified in the Recovery Goals. The suggested actions, though directed at successful management of the “big-river” fish through management of current ecosystem components, are also intended to be flexible and adaptable to conditions dictated by the species, available habitat, and obligations for flood control, water storage and delivery, and other human consumptive needs. Research and adaptive management are necessary components of this plan as is provision for future management activities to ensure success of the restored fishes within their respective habitats.

In general, the strategies for razorback sucker and bonytail will be accomplished through stocking sub-adult fish from production facilities or collected from wild populations. As adult populations are established in suitable mainstem and off-channel habitats, research and monitoring will be implemented for development of management strategies to promote self-persistence of the populations. Concurrently, isolated habitats may also provide fish for repatriation to the river or reservoirs. Fish from the mainstem may also be moved to the isolated habitats as needed for genetic and management purposes. Similar strategies are presented for reestablishing the Colorado pikeminnow in the lower basin. These strategies will not be implemented until specific Recovery Goals are established for Colorado pikeminnow for the lower basin. The AMWG is currently developing a Comprehensive Action and Management Plan for humpback chub in Grand Canyon. Once completed, that plan will be reviewed in the context of the LCRMP to determine if additional actions are necessary to meet the Recovery Goals.

Due to uncertainties about funding and implementation, no initial timeline is given to complete these actions for any species; however, the timelines given in the Recovery Goals will be incorporated in any future management actions. Future versions of this document will be based on results of implementation of the included strategies.

The lower basin contains a variety of habitats that will be used to establish self-sustaining populations and genetic refugia. These include free flowing and managed rivers, reservoirs, connected and isolated backwaters, and ponds on private lands such as golf courses. The project area is divided into subunits based on physical attributes and each subunit has its own specific management strategies. The initial development of persistent adult populations will require stocking large numbers of fish. Smaller numbers would be difficult to detect in these large subunits and would therefore be outside our ability to monitor, meaning that survivorship, habitat use, and other key data parameters would go unobserved. Stocking programs will be conducted in as many subunits as feasible to maximize opportunities for detecting adult fish persistence. This may also aid in identification of habitats and river reaches where potentially beneficial management actions can be implemented. Once the best habitats are identified, activities will be focused on those areas to achieve the number of genetic refugia and self-sustaining populations required under the Recovery Goals.

## STRATEGY DESCRIPTION

The LCRMP identifies three strategies to successfully achieve the maintenance of genetic refugia and self-sustaining populations in the lower basin.

Strategy 1: Augmentation

The first strategy involves the use of production facilities to raise either hatchery-produced fish, or fish from wild-collected early life stages, to a size suitable for stocking to augment existing populations and establish new ones. This strategy will initially contribute to the establishment of genetic refugia and the expansion and persistence of existing mainstem adult populations. Over time, as opportunities are identified through monitoring and research, this strategy may contribute to the eventual establishment of self-sustaining populations through future management actions such as enhancement of cover attributes and habitat complexity, use of connected backwaters, and selective nonnative fish control.

This strategy will involve the stocking of large numbers of fish into backwaters, reservoirs, and/or riverine reaches for several years to achieve the Recovery Goals of genetic refugia and self-sustaining populations for razorback sucker and bonytail. Continued smaller maintenance stockings will be required to maintain and stabilize populations until recruitment occurs. The total number of fish that will need to be stocked over the entire life of the recovery program to meet these Recovery Goals is unknown; however, they will be considerably higher than the final population sizes contained in the Recovery Goals. There are several reasons for this.

1. Mortality of stocked fish in the wild is unknown; but information from past stockings in the lower basin indicate a <10% survival and recruitment into adult stocks under most circumstances (Marsh 1999).

2. The proposed riverine and reservoir areas are expansive, making it necessary to stock large numbers of fish. Stocking success will be gaged by monitoring subunit populations to evaluate rearing techniques, stocking protocols, fish size, etc. Large numbers of fish are necessary to monitor and assess stocking efforts with statistical accuracy. The paucity of returns for bonytail from recent stockings into Lake Mohave may provide insight into the inefficacy of stocking small numbers of fish into large systems (Minckley and Thorson 2002).

3. Related to the previous issue, success of the program also relies on the ability to define what habitats within the subunits are used by the fish. In Lake Mohave

we have the advantage of 20 years of data on the known spawning areas, and are able to observe them in these locations each year. For most of the other subunits, we do not have information on historically used habitats, or those that would most likely be used. In order to identify these habitats in an effective manner, we must be able to contact a large number of individuals. Our ability to assess the preferred habitats, and to devise management for those areas to foster recruitment opportunities, will rely on these data.

4. Historic population sizes were large (Minckley et al. 2003); however, in today's river the actual population size that would be sufficient to take advantage of management actions that foster recruitment is unknown. The population size that each subunit could support is unknown. Stocking large numbers of fish into the subunits over time will increase population sizes and enable us to evaluate, through monitoring, when these levels have been reached and how those levels relate to the Recovery Goals.

Strategy 2: Isolated Habitats

The second strategy involves the use of natural, semi-natural, or newly created backwaters or lakes dedicated for use of one or more species. These isolated waters must be able to support a healthy fish population and be isolated from other waters to prevent invasion by nonnative fishes. Specific management activities will be determined by the habitat and species. At a minimum, management will consist of tracking the development of the native fish population and allowing selection to act. In other cases, a more aggressive management plan will be used to better ensure the success of these habitats while affecting natural processes as little as possible. Two habitat types are proposed for the second strategy:

1. *Long-term habitats.* These wild habitats are designed to develop the genetic resource, establish self-sustaining populations, and mimic the historic backwater habitat conditions of the lower river. The original stocks would be wild fish, or the best genetic stock from hatchery production. Management of these habitats would be minimal but would be done if necessary to lessen human or naturally caused perturbations. There would be periodic mixing of fish between long-term habitats in accordance with a genetic management plan, but no other movement of fish would occur. The fish from these habitats would contribute to genetic diversity during periodic mixing with mainstem populations.

2. *Production habitats* are designed to raise wild-born or hatchery-produced fish to stocking size for release into the mainstem populations or to establish long-term habitats. When a large number of fish suitable for stocking are present they would be harvested and released. The facility would then be re-stocked to initiate another production cycle.

Requisite to the success of this plan is the continued maintenance of these isolated habitats. This includes periodic evaluation and renovation of habitats and their fish populations as follows:

1. It is anticipated that, over time, nonnative fish species will invade the isolated habitats. The interactions of the native and nonnative fishes in the habitats will be studied, particularly with regard to the larger nonnative predators, to assess interactions between species. Renovations to remove the nonnative fish from native fish habitats will occur as needed.

2. Repeated translocations of native fish from the habitats will be necessary with attendant needs for genetic, population, and production planning. The types and frequencies of fish movement will vary depending on planning needs and the type of habitat involved.

3. Physical maintenance of the habitats will be necessary over the life of the plan. Construction of new habitats and rehabilitation of existing habitats will require dry-land excavation or dredging to provide proper water depths and bottom contours, eliminate excess marsh vegetation encroachment, and maintain inlet and outlet works. Habitats will be physically managed in concert with wetland and riparian restoration programs to enhance ecosystem values.

<u>Strategy 3: Unique Opportunities</u>

The third strategy exploits unusual circumstances. Original persistent adult reservoir populations of “big-river” fish in the lower Colorado River reservoirs formed as the reservoirs were filling. Initial recruitment of native fish was high since the relative abundance of nonnative fishes was low. Low reservoir levels may occur again as a result of maintenance draw-downs, drought, or other reasons. Adult or larval native fish should be stocked into these reservoirs coincident with reservoir re-filling to take advantage of:

1. an absence or reduction of predators, allowing adults to successfully and naturally recruit young into the system or allow hatchery-produced larvae to survive, grow quickly, and establish a population.

2. Rapid growth potential for longevity of the “big-river” fishes, resulting in the establishment of a long-lived population even if later recruitment is suppressed by nonnative predation.

3. a dramatically expanded population size, allowing for selection to operate for a time on an abundant gene pool which is then available for translocation elsewhere within the management area.

## GENETIC CONCERNS

Because populations of the “big-river” fishes have undergone rapid contraction in terms of size and extent of populations, conservation of the remaining genetic variability within each species is crucial. If a species lacks sufficient genetic capabilities to adjust and adapt to shifts in conditions in available habitats, it cannot re-establish a self-sustaining state despite human intervention. This plan focuses on the perpetuation of the existing level of genetic variability through maximization and conservation of variability in founder populations and on the maximization of the variability in the progeny of those founders destined to be returned to the wild. In order to maximize the number of individuals contributing to the next generation, the LCRMP has identified four management options:

1. Maximize the number of individuals contributing to the next generation. Where possible collect early life history stages from natural reproduction of wild adults for rearing in protected areas. Collections over the entire spawning season and from all spawning areas are needed to maximize the number of breeding adults contributing to the collected wild progeny.

2. Stock suitable numbers of wild adults (tagged for identification) into isolated bays from which nonnative fish have been eliminated and allow them to spawn naturally. Once progeny have reached suitable size for release, they will be marked and released to the adjacent mainstem adult population. The amount of genetic variability conserved by this technique is limited by the number of breeding adults, which in turn is limited by the acreage of available habitat. The same adults should not be used repeatedly for this purpose.

3. Utilize hatchery propagation based on a broodstock. Broodstock used in hatchery propagation should include the maximum number of wild fish possible. Strict breeding pedigrees should be followed to minimize inbreeding and at the same time pass on a maximum diversity of alleles to F2 progeny. Genetic variability passed on from a given-sized broodstock is governed by:

a. measured contributions of gametes from individuals with known genetic attributes; or

b. a statistical breeding regime based on the probabilities that each allele present in the broodstock is present in their progeny.

4. Use wild adults from Lake Mohave as broodstock. Once spawned, each wild adult would be PIT tagged and returned to Lake Mohave, using each adult only once.

Of these strategies, the first one is preferred as it maintains the highest genetic variability in these fish by potentially using the maximum number of wild fish. Regardless of the mating strategy applied, the only genetic variation that can be passed on to the progeny in a hatchery setting is that of the original broodstock (Minckley et al. 2003). If the complete component of genetic variance is not captured in the broodstock, genetic variation will be diminished and less new variation generated. The potential for reduced fitness due to fixation of detrimental alleles may be increased. Such reductions in fitness when the number of contributing individuals declines appear to be a particularly severe problem in species with large ancestral populations and consequently high historical genetic loads (Hedrick and Kalinowski 2000). Management to maintain genetic variance should be under the most natural conditions possible, emphasizing achievement and maintenance of the species' carrying capacities in diverse habitats. The end result should be increasing opportunities for emergence of novel variation, thus maximizing adaptive potentials.

## CONDITIONING METHODS

Enhancement of fish populations through stocking has taken place for decades and in recent years has included listed species, the most obvious being members of the Family Salmonidae. However, these actions have not always been in the best interest of the species and fish culture experts have recognized for over a century that hatchery raised fish have certain behavioral deficits that result in poor survival rates in the wild (Brown and Day 2002). Recently, three principal

management techniques have been proposed to increase survival rates of stocked fish thus leading to persistence and their possible recovery. These management techniques include: environmental enrichment, life-skills training, and hard vs soft release (Brown and Day 2002).

Environmental enrichment includes increasing the structural diversity of the rearing site. Fish should be raised in a more natural area (pond) or structures should be added in the hatchery. Life-skills training involves exposure to prey and potential predators. Hard release is the practice of immediately releasing fish into a habitat without prior conditioning to that habitat. Soft release enables the fish to become accustomed to the prevailing environmental conditions, familiarize themselves with the habitat, recover from the stress of transport (both physiological and from transport chemicals), and evade potential avian and aquatic predators. Researchers have shown that fish raised in a lentic habitat and exposed to current prior to release, are better conditioned to flowing water and are better able to survive (Mueller and Marsh 1998; Mueller et al. 1999). Factors such as site of release, time of day/year, size at stocking, and stocking procedure (en masse or in small groups) all have impacts, which need to be determined for “big-river” fishes. Preliminary studies have illustrated less erratic behavior in razorback suckers that were held for several days prior to release vs razorback suckers that were “hard released” (Mueller 2000, Mueller et al. 2003). It is also known that razorback sucker <30 cm exhibit little or no return to the creel; hence fish >30 cm are stocked (Marsh 1999). Surprisingly, the time needed to change the behavior of a species is short, taking less than a week, and in some cases only a few hours of conditioning have a significant effect on survivability (Brown and Day 2002).

# MANAGEMENT PLAN SUBUNITS

## GRAND CANYON SUBUNIT

Background Information

*Location:* Coconino and Mohave Counties AZ

*Geographic Boundary:* Glen Canyon Dam to Separation Rapid.

*Description of Habitats Available:* This is a riverine reach with flows controlled by Glen Canyon Dam. Habitats include rapids, runs, deep

channel pools, and shoreline eddies, pools and small backwaters. It includes the spring-fed lower 21 km of the Little Colorado River to the confluence with the Colorado River. Other small tributaries, such as the Paria River, Bright Angel Creek, Kanab Creek, and Havasu Creek, join with the main river through the canyon. These tributary streams provide pools, riffles and quiet water habitats.

*Land Ownership/Management Agencies:* The National Park Service (Grand Canyon National Park, Lake Mead and Glen Canyon National Recreation Areas) is the primary landowner along the river corridor. Adjacent landowners or managers include the Havasupai Tribe, Hopi Tribe, Hualapai Tribe, and the Navajo Nation. Colorado River flows are controlled by USBR, Salt Lake City, Utah. Arizona Game and Fish Department is the lead for fish and wildlife management, in coordination with other agencies.

*Species/Critical Habitat Present:* Humpback chub and razorback sucker are present. Critical habitat for both species is designated in the reach (USFWS 1994a).

Humpback Chub

*Current Status and Recovery Efforts:* Historically, this species occurred from Glen Canyon Dam to Separation Rapid. Currently, distribution of the humpback chub in Grand Canyon is centered near the confluence of the Little Colorado River some 102.5 RKM downstream from Lees Ferry. A large portion of the population occurs from the confluence of the Little Colorado River upstream 14.2 km. Other small populations occur in the mainstem near South Canyon (RKM 50), Bright Angel Creek (RKM 240), Shinumo Creek (RKM 180), Blacktail Rapid (RKM 205), Kanab Creek (RKM 240) and Havasu Creek (RKM 260) (Carothers and Minckley 1981, Minckley 1990). Several population estimates ranging from 2,700 to 15,000 individuals have been made for the Little Colorado River population (Douglas and Marsh 1996; Minckley 1988, 1989, 1990a, 1990b; Valdez and Ryel 1995). The most recent estimates made in the spring and fall of 2002 were 2,666 humpback chubs (spring) in the Little Colorado River > 15 cm; 2,002 of these fish were > 20 cm. The fall estimate for 2002 was 2,774 humpback chubs >15 cm in the system; 839 of these fish were >20 cm (VanHaverbeke 2002, 2003). This is a marked

decline from estimates made in 1992 that estimated the population size between 4,500 - 5,500 individuals >15cm (Douglas and Marsh 1996). Most of the reproduction occurs in the Little Colorado River, although limited reproduction does occur in the mainstem Colorado River (Minckley 1990, Valdez and Ryel 1995). This species exhibits migratory behavior in and out of the Little Colorado River during spawning activities (April - May). More larger fish are present in the system in the spring than in the fall due to these movements (VanHaverbeke and Coggins 2003). Factors impacting this population include the release of cold hypolimnectic water releases from Glen Canyon Dam, competition/predation by nonnative fish, and parasitism.

Research activities on humpback chub fall under the purvue of the Adaptive Management Work Group (AMWG) associated with the Grand Canyon Protection Act of 1992. The AMWG has the responsibility of defining management objectives associated with the resources downstream of Glen Canyon Dam, and developing a long-term monitoring program to assess those resources. The Grand Canyon Monitoring and Research Center (GCMRC) is responsible for implementing the long-term monitoring program and assuring that it meets the needs of AMWG. In this role, GCMRC has initiated a program that focuses on stock assessment of humpback chub for future long-term monitoring of Grand Canyon fishes (VanHaverbeke and Coggins 2003). Another component of the long-term monitoring includes monitoring the humpback chub population in the Colorado River.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain one self-sustaining population while moving toward recovery.

*Downlisting Criteria:*

1. The Grand Canyon population is maintained as a core over a 5-year period, starting with the first point estimate acceptable to the Service, such that:

a. The trend in adult (age 4+; >200 mm TL) point estimates does not decline significantly, and

b. mean estimated recruitment age of age-3 (150-199 mm TL) naturally produced fish equals or exceeds adult mortality, and
c. each core population estimate exceeds 2,100 adults (MVP).

*Delisting Criteria:*

1. The Grand Canyon population is maintained as a core over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that:
   a. The trend in adult (age 4+; >200 mm TL) point estimates does not decline significantly, and
   b. Mean estimated recruitment of age-3 (150-199 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
   c. Each core population estimates exceeds 2,100 adults (MVP)

*Management Strategies:* The AMWG is currently developing a Comprehensive Action and Management Plan for humpback chub in Grand Canyon. Once completed, that plan will be reviewed in the context of the LCRMP to determine if additional actions are necessary to meet the Recovery Goals.

Razorback Sucker

*Current Status and Recovery Efforts:* Based on collection records, the razorback sucker is very rare in this reach with fewer than 20 individuals reported since 1944 (Maddux et al. 1987, Minckley and Carothers 1978, Valdez and Ryel 1995). Individuals that were collected were generally taken from side tributaries (Paria and Little Colorado rivers and Bright Angel Creek. Hybrids (razorback sucker X flannelmouth sucker) have also been taken from the Little Colorado River. There are no research activities in this subunit for razorback sucker. Razorback sucker are recorded when encountered in standard collecting activities, PIT tagged, and then released. In 1996, the Hualapai Tribe released several radio-tagged sub-adults into the Colorado River downstream of Diamond Creek. The fish dispersed in the river and were not found during monitoring efforts.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* There are no Recovery Goals for this species specific to this subunit.

*Management Strategies:* The LCRMP is emphasizing maintaining and enhancing populations of this species in other subunits.

## LAKE MEAD SUBUNIT

Background Information

*Location:* Mohave County AZ and Clark County NV

*Geographic Boundary:* Separation Canyon to Hoover Dam.

*Description of Habitats Available:* Lake Mead is a large, deep reservoir with several basins, numerous shallow coves and bays and a riverine segment in the lower portion of the Grand Canyon (above Pierce Ferry). The extent of the riverine section is dependent on the water surface elevation of the reservoir (lake levels). At lower lake levels, the reach is riverine, but at higher lake levels the water is ponded and lake-like in the lower Grand Canyon. Yearly fluctuations in lake level can exceed 50 feet. There are three tributaries of note, the Muddy and Virgin rivers (both in the Overton Arm) and Las Vegas Wash (Las Vegas Bay) that provide inflows, shallow water habitats, and small marshes.

*Land Ownership/Management Agencies:* The National Park Service (Lake Mead National Recreation Area and Grand Canyon National Park) has broad resource management responsibilities within the boundaries of the National Recreational Area. The Hualapai Tribe also has management interests in this reach. Water levels of Lake Mead are controlled by USBR, Boulder City, Nevada. Nevada Department of Wildlife and AGFD are the leads for fish and wildlife management, in coordination other management agencies.

*Species/Critical Habitat Present:* Razorback sucker is present with critical habitat designated in the reach (USFWS 1994a). A humpback chub has recently been taken in the upper reservoir. Colorado pikeminnow and bonytail are extirpated from this subunit.

Razorback Sucker

*Current Status and Recovery Efforts:* A large population of razorback sucker was present in Lake Mead until the 1960s, but was not found during sampling efforts in the 1970s (Minckley 1973, Minckley 1991). Subsequent to that, NDOW and others contacted this species infrequently during fishery investigations on Lake Mead. In the 1990s, two small concentrations of razorback sucker were located in Las Vegas Bay and Echo Bay, respectively (Abate et al. 2002, Golden and Holden 2001, Holden 1994, Holden et al. 1997, Sjoberg 1995). Adult population estimates for these areas ranged from 68 to 124 for Las Vegas Bay and from 45 to 66 fish for Echo Bay (Abate et al. 2002). Wild larvae have also been collected at the inflow of the Colorado River. Unlike other areas of the lower basin, recruitment in these populations has been documented by aging several fish using the pectoral rays. Three fish were aged at 10 years or less, three ranged from 10 to 15 years of age, nine ranged from 16-20 years and four were > than 20 years old, including one fish that was near 35 years of age. One 40.7 cm subadult was aged at 6 years (Abate et al. 2002). Radio-telemetry studies have also been conducted by BIO/WEST with funding provided by SNWA and USBR. Small numbers of wild larvae from this subunit have been grown to a larger size and repatriated into Lake Mead since 2000 (Abate et al. 2002).

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain self-sustaining population while moving towards recovery.

*Management Strategies:* The LCRMP will assist as appropriate and utilize the findings from ongoing research as applicable in Lake Mead. However, the LCBMP will not initiate any large-scale activities in this subunit at this time. As more information on the Lake Mead razorback suckers is obtained, additional recovery actions will be considered.

## LAKE MOHAVE SUBUNIT

Background Information

*Location:* Mohave County AZ and Clark County NV

*Geographic Boundary:* Hoover Dam to Davis Dam

*Description of Habitats Available:* This is a 61 km long reservoir with a 35 km riverine section in the Black Canyon below Hoover Dam. Flows are controlled by releases from Hoover Dam. Hourly and daily fluctuations in releases dominate the riverine reach, and the reservoir fluctuates up to 5 meters during a normal year. Riverine habitats include riffles, runs, pools, and shoreline eddies and bars. Reservoir habitats include deep water, and numerous bays and coves that provide sheltered, shallow water habitats. In the riverine reach there are several small spring inflows to the system. There are no tributaries that provide water inflows except during runoff events.

*Land Ownership/Management Agencies:* The National Park Service (Lake Mead National Recreation Area) has broad resource management responsibilities within the boundaries of the National Recreation area. Water levels of Lake Mohave are controlled by USBR, Boulder City, Nevada. Nevada Department of Wildlife and AGFD are the leads for fish and wildlife management, in coordination with other agencies.

*Species/Habitat Present:* Bonytail and razorback sucker are present. Critical habitat for both species is designated within the reach (USFWS 1994a).

Bonytail

*Current Status and Recovery Efforts:* Wild populations of bonytail are virtually extinct in the Colorado River basin (Minckley 1973) with 113 collected between 1980 and 2003 from Lake Mohave (Minckley and Thorson 2002). Fourteen of those fish were considered wild. Since 1981, 200,205 bonytail have been stocked in Lake Mohave. Eighty-five percent of these fish were <25 cm; 15% were larger. The Service is also currently working toward fulfilling the terms of a biological opinion to stock 125,000

bonytail > 30 cm into Lake Mohave (USFWS 1994b). Based on our current knowledge, most of the fish <25 cm were eaten by predators or otherwise perished because of their small size. Larger fish have either been eaten, failed in some other way, or have yet to enter the catch (Minckley and Thorson 2003). Annual week-long trips have been made to Lake Mohave during the spring since 1980 to collect additional bonytail broodstock. These trips generally resulted in few or no bonytail collected, although occasionally ten or more fish were taken (Minckley and Thorson 2002). In addition to these trips, in 2001 and 2002, collecting efforts for larger fish were expanded to five weeks. One large 52 cm bonytail was collected in 2002 and transferred to Willow Beach National Fish Hatchery. It was later transported to Dexter National Fish Hatchery but died enroute (Minckley and Thorson 2003). Another five week effort will be made in 2003 to collect bonytail for broodstock.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain a genetic refugia and/or self-sustaining population while moving towards recovery.

*Downlisting Criteria*:

1. Genetic variability of bonytail identified and a genetic refuge (e.g. in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 5-year period.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over 5-year period, starting with the first point estimate acceptable to the Service, such that for each population:

   a. The trend in adult (age 4+; >250 mm TL) point estimates does not decline significantly, and
   b. Mean estimated recruitment of age-3 (150-249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
   c. each point estimate exceeds 4,400 adults (MVP).

*Delisting Criteria:*

1. A genetic refuge (e.g., in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 3-year period beyond downlisting.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries are maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that for each population:
   a. The trend in adult (age 4+; >250 mm TL) point estimates does not decline significantly, and
   b. Mean estimated recruitment of age-3 (150-249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
   c. Each point estimate exceeds 4,400 adults (MVP).
   Four self-sustaining populations (minimum viable population of 4,400 adults); two in the upper basin and two in the lower basin.

*Management Strategies:* These Recovery Goals will be met through the use of Strategy 1: Augmentation.

Colorado Pikeminnow

*Current Status and Recovery Efforts:* Wild Colorado pikeminnow are extirpated from the lower basin. This species occurred in large numbers in the lower river prior to its development for power generation and the introduction of nonnative fishes (Mueller and Marsh 2003). Colorado pikeminnow have been reintroduced to the Salt and Verde rivers as experimental non-essential populations, or 10(j) populations. In amending the Endangered Species Act in 1982, Congress added section 10(j) to provide administrative flexibility for selectively applying the prohibitions of the Act to experimental populations of listed species. This section authorizes the treatment of an experimental population as “threatened” even though the donor population from which the experimental population came is listed as endangered. Treatment of the experimental population as threatened enables the use of less restrictive taking prohibitions under the authority of section 4(d) of the Act. Experimental populations that have been determined to be non-essential to the continued existence of a species in the wild and are not located within a unit of the National Park

System or National Wildlife Refuge System are excluded from the requirements of section 7(a)(2) of the Act. For such species, Federal agencies would only be required to informally confer with the Service, as delineated in section 7(a)(4). The 10(j) status for Colorado pikeminnow extends from Roosevelt Dam upstream in the Salt River and from Horseshoe Dam upstream to Perkinsville in the Verde River. Restoration of the Colorado pikeminnow to the Lake Mohave subunit in the future can be accomplished, but will require addressing specific concerns of Arizona and Nevada. These concerns and issues are identified below.

In Arizona, AGFD proposed 10(j) populations of Colorado pikeminnow for the lower basin in the past Future proposals would require AGFD to complete an Arizona Game and Fish Commission-approved 12-step process for developing and approving reestablishment proposals for nongame and endangered wildlife. In addition to biological, feasibility, and financial issues, principal concerns with proposals to repatriate this species to the lower river would likely focus on effects to cities, communities, and affected interests along or served by the River. The Department has not given a position on repatriation of the Colorado pikeminnow in the Colorado River mainstem, but it already manages 10(j) repatriation efforts for the species in Central Arizona. In addition to the 12-step process, any repatriation proposal or implementation effort in Arizona would be guided by recovery objectives and objective scientific evaluation of opportunities to achieve recovery objectives. Collaborative state-federal development of a 4(d) rule would allow states to address incidental take or eventual management of repatriated populations as a sports fishery.

In Nevada, Colorado pikeminnow is classified as “Protected Endangered” under NAC 503.065 (2)(a). Because Colorado pikeminnow may be at substantially higher risk of incidental take by sport anglers than other “big-river” fishes, a 10(j) designation for pikeminnow released into areas of the lower Colorado River mainstem is necessary. As an alternative strategy, range wide downlisting to threatened status based on positive progress and recovery in the upper basin, could be combined with a 4(d) rule that would allow states to address possible incidental take by anglers. Reclassification under NAC to allow sport harvest or catch-and release angling for Colorado pikeminnow, if the species were to be downlisted to threatened with appropriate 4(d) rule implementation, would require the

approval of the Nevada Board of Wildlife Commissioners. Any repatriation action would need to be included as part of an agreed upon cooperative management planning document, and (2) as part of an approved Service/Recovery Team strategy inclusive of the lower basin.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal (provisional):* Establish and maintain one self-sustaining population while moving towards recovery.

*Downlisting Criteria*:

1. Two self-sustaining populations (e.g. mainstem and/or tributaries are maintained over a 5-year period starting with the first point estimates acceptable to the Service, such that for each population:
    a. the trend in adult (age 7+ ;> 45 cm TL) point estimates does not decline significantly, and
    b. Mean estimated recruitment of age-6 (40-45 cm TL) naturally produced fish equals or exceeds mean annual adult mortality8, and
    c. Each point estimate exceeds 2,600 adults.

*Delisting Criteria*:

1. Two self-sustaining populations (e.g. mainstem and/or tributaries are maintained over a 7-year period beyond downlisting, starting with the first point estimates acceptable to the Service, such that for each population:
    a. the trend in adult (age 7+,>45 cm TL) point estimates does not decline significantly, and
    b. Mean estimated recruitment of age-6 (40-45 cm TL) naturally produced fish equals or exceeds mean annual adult mortality, and each point estimate exceeds 26,000 adults (MVP).

*Management Strategies:* This Recovery Goal will be met through the use of Strategy 1: Augmentation.

Razorback Sucker

*Current Status and Recovery Efforts:* The Lake Mohave population of razorback sucker has been studied extensively (Burke et al. 1992, Buth et al. 1987, Marsh 1994, Marsh and Minckley 1989, Minckley 1983, Minckley et al. 1989, 1991, Pacey and Marsh 2000). It represents the largest population of razorback sucker in the lower basin with 4,000 wild individuals still occurring there in 2003. These wild adults are expected to disappear from the lake through natural mortality in the next decade (Marsh pers comm.). However, 70,000 subadult razorback sucker have been stocked into Lake Mohave by USBR and the Service since 1992 in part as a result of section 7 consultations. These fish are beginning to enter the population and replace the aging wild fish. The Lake Mohave Native Fish Work Group, a group made up of State and Federal agencies and university personnel, developed this stocking program. The goal of the group is to establish an adult population of 50,000 fish using wild larvae produced in Lake Mohave, to provide a genetic refugium for this species in the lower basin.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain genetic refugia in the lower basin and/or self-sustaining population while moving towards recovery.

*Downlisting Criteria*:

1. Genetic variability of razorback sucker in Lake Mohave is identified, and a genetic refuge is maintained over a 5-year period.

2. Two self-sustaining populations (e.g. mainstem and/or tributaries) are maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that for each population:

a. the trend in adult (age 4+ ;> 400 mm TL) point estimates does not decline significantly, and

b mean estimated recruitment of age-3 (300-399 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

c. Each point estimate exceeds 5,800 adults (MVP).

*Delisting Criteria*:

1. A genetic refuge is maintained in Lake Mohave over a 3-year period beyond delisting.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that for each population:

a. the trend in adult (age 4+; >400 mm TL) point estimates does not decline significantly, and

b. Mean estimated recruitment of age-3 (300-399 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

c. Each point estimate exceeds 5,800 adults (MVP).

*Management Strategies:* These Recovery Goals will be met through the use of Strategy 1: Augmentation and Strategy 2: Isolated Habitats.

## LAKE HAVASU SUBUNIT

Background Information

*Location:* Mohave and La Paz Counties AZ, San Bernardino County CA, Clark County, NV

*Geographic Boundary:* Davis Dam to Parker Dam

*Description of Habitats Available:* This reach contains an 85 km riverine reach between Davis Dam and the upper end of the 55-km long Lake Havasu. Flows in the reach are controlled by releases from Davis Dam and have significant hourly and daily fluctuations that attenuate with distance downstream. Riverine habitats are mostly runs, with few backwaters or coves. Much of the riverine shoreline has been modified by bank stabilization and channelization. Large backwater marsh areas, including Topock Marsh, are present at the lower end of the riverine

section and the upper end of the reservoir, and provide shallow water habitats. The reservoir provides areas of deep water, shallow bays, and coves. Yearly lake level fluctuations are less than 2 m. The Bill Williams River is the only tributary, and contains riparian and marsh areas. The Bill Williams River is controlled by Alamo Dam and exhibits much reduced flows into the lake.

*Land Ownership/Management Agencies:* The Arizona State Land Department and the BLM own portions of the shoreline, as does the Service (Havasu and Bill Williams River NWRs). The Fort Mohave and Chemehuevi Tribes also own shoreline areas on the river and reservoir. Much of the remainder is privately owned. River flows and reservoir levels are controlled by USBR in Boulder City, Nevada. Flows in Bill Williams River are controlled by the U.S. Army Corps of Engineers and seldom reach the reservoir. California Department of Fish and Game, NDOW, Nevada Division of State Lands (NDSL), Colorado River Commission of Nevada (CRCN) and AGFD share fish and wildlife management responsibilities, in coordination with other agencies.

*Species/Critical Habitat Present:* Bonytail and razorback sucker are present. Critical habitat for bonytail is designated in this reach (USFWS 1994a).

Bonytail

*Current Status and Recovery Efforts:* In the 1930s, bonytail was one of the most common fish in the Colorado River in the reach now inundated by Lake Havasu. The populations declined significantly in the lake by the late 1960s (Mueller and Marsh 2003). Currently, the BLM and its partners are responsible for stocking 30,000 sub-adult bonytail under a 1993 biological opinion (USFWS 1993, Doelker 1996). At this time, approximately 15,000 bonytail >25cm have been stocked. To date, 9 individuals from this effort have been recovered. One was taken from the Colorado River near Laughlin (Mueller 2002), one was taken by angling from deep water near Parker Dam, six were collected from the Bill Williams River National Wildlife Refuge, and, most recently, (12/02) an individual was taken at the Havasu Springs fishing dock. An annual native fish survey was started on Lake Havasu in 2000 to assist in monitoring these reintroductions. In

addition to these activities a Beal Lake was established on Havasu NWR in 2002 and may provide a long-term habitat for this species in the future.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goals:* Maintain genetic refugia and/or maintain a self-sustaining population while moving toward recovery. (See Lake Mohave Subunit and Appendix I for downlisting and delisting criteria).

*Management Strategies:* These Recovery Goals will be met through the use of Strategy 1: Augmentation and Strategy 2: Isolated Habitats.

Razorback Sucker

*Current Status and Recovery Efforts:* Beginning in 1993, subadult razorback sucker were first reintroduced into Lake Havasu following a program designed after the Lake Mohave program. The goal of this program was to repatriate 30,000 subadult razorback sucker and bonytail by 2003; this goal was met for razorback suckers in 2001. As in Lake Mohave, the repatriated razorback suckers are beginning to return to the catch, particularly in 2002 when many larger adult fish were observed on spawning sites. In addition to these activities, a long-term habitat (Beal Lake) was established in 2002 on Havasu National Wildlife Refuge for razorback suckers. A management plan is currently in preparation to address this facility.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain one self-sustaining population while moving toward recovery. (See Lake Mojave Subunit and Appendix I for downlisting and delisting criteria.)

*Management Strategies:* This Recovery Goal will be met through the use of Strategy 1: Augmentation and Strategy 2: Isolated Habitats.

## PARKER-IMPERIAL SUBUNIT

Background Information

*Location:* La Paz and Yuma Counties AZ, San Bernardino, Riverside, and Imperial Counties, CA

*Geographic Boundary:* Parker Dam to Imperial Dam

*Description of Habitats Available:* This is a 250 km riverine reach with backwaters and fringe marshes scattered along its length. Flows are controlled by releases from Parker Dam and include significant hourly and daily fluctuations that attenuate downstream. Main channel habitats include runs, shoreline bars and eddies, and occasional areas of braided channel where sediment loads have been deposited. Many shorelines have been stabilized and some reaches have been channelized. Behind the diversion dams in the reach (Headgate Rock, Palo Verde, Imperial), water is ponded to form small flow-through lakes. There are significant areas of marshes and backwaters, but no perennial tributary streams.

*Land Ownership/Management Agencies:* The BLM owns some shoreline lands, and there are several recreational areas including State Parks in the reach. The Service has two refuges (Cibola NWR and Imperial NWR). The Colorado River Indian Tribes are a major landowner. Much of the remainder is privately owned. Water flows in the river are controlled by USBR, Boulder City, Nevada who is also responsible for channel maintenance activities. California Department of Fish and Game and AGFD are the leads for fish and wildlife management, in coordination other agencies.

*Species/Habitat Present:* Razorback sucker is present with critical habitat for this species designated within the reach (USFWS 1994a). Reintroduction of bonytail to this subunit is under consideration. This reach was considered for establishment of an experimental non-essential population of Colorado pikeminnow.

Bonytail

*Current Status and Research Efforts:* The bonytail was one of the most abundant fish present in the lower Colorado in the 1930s and is now extirpated from this river reach. A long-term habitat is present in this subunit at the High Levee pond on Cibola National Wildlife Refuge. This facility is currently the focus of a five year investigation (Mueller et al. 2002). The data collected will be used to manage this site and other long-term habitats as they are developed in the LCRMP management area.

*Applicable Recovery Goals and Management Strategies:*

Recovery *Goal:* Create and maintain a genetic refugia and/or self-sustaining population while moving toward recovery. (See Lake Mohave Subunit and Appendix I for downlisting and delisting criteria).

*Management Strategies:* These Recovery Goals will be met through the use of Strategy 1: Augmentation and Strategy 2: Isolated Habitats.

Colorado Pikeminnow

*Current Status and Recovery Efforts:* Wild Colorado pikeminnow are extirpated from the lower basin. This species occurred in large numbers in the lower river prior to its development for power generation and the introduction of nonnative fishes (Mueller and Marsh 2003). Restoration of the Colorado pikeminnow to this reach and in the future can be accomplished; however, success depends upon addressing the concerns of LCRMP team members from Arizona and California. The following comments reflect those concerns and issues by these states on the proposed restoration in this subunit (CDFG 2001).

In Arizona, AGFD proposed 10(j) populations of Colorado pikeminnow for this subunit in the past. Approval of a repatriation effort would require the Department to complete an Arizona Game and Fish Commission approved 12-step process for developing and approving reestablishment proposals for nongame and endangered wildlife. In addition to biological, feasibility, and financial issues, principal concerns with proposals to repatriate this species to the lower river would likely focus on effects to cities, communities, and affected interests along or served by the

Colorado River. The Department has not given a position on repatriation of the Colorado pikeminnow in the Colorado River mainstem, but it already manages 10(j) repatriation efforts for the species in Central Arizona. In addition to the 12-step process, any repatriation proposal or implementation effort in Arizona would be guided by recovery objectives and objective scientific evaluation of opportunities to achieve recovery objectives. Collaborative state-federal development of a 4(d) rule would allow states to address incidental take or eventual management of repatriated populations as a sport fishery.

In California, the Colorado pikeminnow is a "fully protected" species under California Fish and Game Code and 5515. This designation thus limits potential management options, and CDFG is unable to authorize take of this species. Without the current "fully protected" issues associated with Colorado pikeminnow, a 10(j) designation and/or a 4d rule, and creation of a 10(j) type tool under the California Endangered Species Act might be feasible. In addition, a nonessential designation may allow sportfishing opportunities and access to Sport Fish Restoration Act funding opportunities and resources, as well as broad public support for the repatriation efforts.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal (provisional):* Establish and maintain one self-sustaining population while moving toward recovery. (See Lake Mohave Subunit and Appendix I for provisional downlisting and delisting criteria).

*Management Strategies:* This Recovery Goal will be met through the use of Strategy 1: Augmentation.

Razorback Sucker

*Current Status and Recovery Efforts:* Razorback sucker occurred in this subunit in large numbers until the 1950s when the population began to fail (Mueller and Marsh 2003). Small numbers of wild individuals persist in the reach today but the population size is unknown. Currently, 7,500 individuals have been released by AGFD/USBR into this subunit. These releases are being monitored; however, this monitoring program is in its

initial stages and no information is available at this time. Habitat use by hatchery-reared adult fish (Bradford and Garden 2000) and predation on this species by ictalurids (Marsh and Brooks 1989, Slaughter et al. 2002, Young and Marsh 1990) has been investigated in this subunit.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain self-sustaining populations while moving toward recovery. (See Lake Mohave Subunit and Appendix I for downlisting and delisting criteria).

*Management Strategies:* This Recovery Goal will be met through the use of Strategy 1: Augmentation and Strategy 2: Isolated Habitat.

## GILA RIVER SUBUNIT

Background Information

*Location:* Gila, Graham, Greenlee, Pinal, and Yavapai Counties AZ

*Geographic Boundary:* The Gila River from the Arizona-New Mexico border to Coolidge Dam, including San Carlos Reservoir. The Salt River from the US60/SR77 bridge crossing to Roosevelt Diversion Dam. The Verde River from Sycamore Canyon to Horseshoe Dam including Horseshoe Lake.

*Description of Habitats Available:* These three rivers have upper reaches without controlled flows but with some degree of diversion for municipal and agricultural purposes. They include riffle, run, and pool habitats with shoreline eddies and bars and some braided channel features. Small tributaries to the Salt and Verde are included in the reach, with more significant flows coming into the Gila River through the San Francisco River drainage in addition to that from smaller tributaries. These tributaries provide riffle, run, and pool habitats, and shallow, sheltered areas. The Gila River subunit includes a medium-sized reservoir at the terminus of the sub-reach. Horseshoe Lake and San Carlos Reservoir are water storage reservoirs that fluctuate in response to water releases for downstream users. Both reservoirs have a history of nearly drying up and

then re-filling from seasonal runoff. The reservoirs provide deep and shallow water habitats, as well as shorelines with coves and bays.

*Land Ownership/Management Agencies:* Private individuals, the San Carlos Apache Tribe, and BLM own lands adjoining the Gila River. Various private water rights holders control diversions from the Gila River subunit. The San Carlos Irrigation Project operates Coolidge Dam for the benefit of the Gila River Indian Community and the San Carlos Irrigation and Drainage District.

The Forest Service (Tonto National Forest) and the San Carlos Apache Tribe manage lands adjoining the Salt River. Private water rights holders and the Salt River Project control upstream diversions.

Lands adjoining the Verde River are managed by the Forest Service (Prescott National Forest) or are privately owned. The Salt River Project also has significant water rights on the Verde.

*Species/Critical Habitat Present:* Colorado pikeminnow are present in the Verde River as an experimental, non-essential population. The species has not recently been found in the Salt River though attempts at reestablishment have been made (Dave Weedman, pers comm.). Razorback sucker is also present in the Verde River though not in the Salt or Gila rivers despite attempts at reestablishment (Weedman, pers comm.). These rivers are also critical habitat for the razorback sucker (USFWS 1994a).

Colorado Pikeminnow

*Current Status and Recovery Efforts:* Colorado pikeminnow have been reintroduced to the Salt and Verde rivers as experimental non-essential populations, or 10(j) populations. The 10(j) status for Colorado pikeminnow extends from Roosevelt Dam upstream in the Salt River and from Horseshoe Dam upstream to Perkinsville in the Verde River. Colorado pikeminnow have not been reintroduced to the Gila River (Hendrickson 1993, Jahrke and Clark 1999).

Since 1995, 11,216 Colorado pikeminnow >30 cm in length have been stocked into the Verde River (Weedman, email comm.). To date, 84 of

these fish have been recaptured (though this does not include Region 3 AGFD data) and were taken both upstream and downstream of their original release sites (Weedman, email comm.). There are currently several sites in the middle Verde River where Colorado pikeminnow can be found throughout the year. These fish have shown the ability to successfully transition from the hatchery environment to the river system, and also have exhibited reproductive condition during the appropriate time of year. Anglers have also reported catching Colorado pikeminnow sporadically from the Verde River, which has necessitated a public outreach program to train anglers in what the fish looks like and what to do with them (Jahrke and Clark 1999, Clark pers comm 2002).

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Establish and maintain self-sustaining populations while moving towards recovery. (See Lake Mohave subunit and Appendix I for downlisting and delisting criteria).

*Management Strategies:* These Recovery Goals will be met through the use of Strategy 1: Augmentation.

Razorback Sucker

*Current Status and Recovery Efforts:* Since 1994, 21,414 razorback sucker have been released into the Verde River (Weedman, email comm.). The majority of the fish were > 30 cm in total length. There has been one stocking of razorback sucker in the Salt River in 1996 of 2,046 individuals. No other razorback sucker have been stocked in the Salt River due to concerns expressed by the White Mountain Apache Tribe (Jahrke and Clark 1999). A total of 137 individuals have been recaptured from the Verde River (Weedman, email comm.). Many of these individuals have grown well while in the system and have exhibited reproductive conditions when taken.

*Applicable Recovery Goals and Management Strategies:*

*Recovery Goal:* Maintain self-sustaining populations while moving towards recovery. (See Lake Mohave Subunit for downlisting and delisting criteria).

*Management Strategies:* This Recovery Goal will be met through the use of Strategy 1: Augmentation and Strategy 3: Unique Opportunities.

## FUTURE NEEDS

This document contains strategies and ideas for consideration in moving toward recovery of the “big-river” fishes in the lower basin that are proffered as a template or springboard for future work on these species. Although the document addresses lower basin issues, it also represents the opportunity to integrate efforts between basins while moving towards recovery. The following list represents future actions necessary for a successful management program in the lower basin. They are not inclusive and will be expanded upon as more information becomes available.

1. Secure long term funding for implementation. Possible funding sources include Congressional appropriations, other federal and state agencies, and private sources.

2. Plan for additional rearing space in hatcheries or in other areas to allow for production of a large number of subadult fish. The production of fish >30 cm seems paramount in view of recent information provided on repatriated razorback suckers in Lake Mohave (P. Marsh, pers. comm.). The Service (Division of Fisheries, Region 2) estimates that any commitment to initiate or expand captive propagation of listed species would require significant additional infrastructure (isolation systems and production programs) and staff (1.5 million to construct the requisite facilities at an existing hatchery, and $200,000 annual operations support).

3. Develop an outreach program to inform stakeholders and the general public of project actions. We do not foresee significant impacts from the project on recreation or water use and need to inform concerned citizens that this is the case.

4. Create a Lower Colorado Basin Management Group (LCBMC), including a full-time coordinator. This team would be comprised of species experts and would act as a forum for the discussion of past, ongoing, and new ideas. It would also review, revise, and integrate management plans as well as individual projects and study plans for activities in the lower basin. The team would compile, assimilate, and provide the best biological information on each species and habitat to participating agencies. It would also present recommendations to the Service regarding implementation of management actions. The coordinator would consult with upper-basin representatives on management actions and advise the Service Region 2 Regional Director (or an appointed representative) on program implementation and progress. Without such a forum to discuss ideas, problems, and possible solutions, these efforts may fall into redundancy of efforts, repetition of research and unneeded misunderstandings between researchers, all of which will impede efforts to recover these species.

5. Develop strong ties with other, regional and local endangered species managers and researchers.

6. Initiate annual working sessions to explore the state of knowledge of the biology of the subject taxa. The principal goals of such sessions will be to:

a) ascertain the best possible information and produce documented decisions until replaced by new and more effective scenarios developed through data accumulation;

b) settle upon a means of acquisition and production of broodstock and progeny for augmentation and translocation. Determine means for long-term husbandry to maximize long-term quality of existing and future stocks; and

c) consolidate the best information available on ways to stabilize and perpetuate populations of each with the ultimate goal of having self-sustaining populations.

7. Continue to synthesize information from throughout the Colorado River basin and use this synthesis as the foundation for future management and recovery actions. In addition, there remain many unanswered questions about life history needs of the four species that must be resolved if recovery is going to be

successful (e.g. the role of wetlands as nursery habitat, possibility of natal imprinting, need for spatial separation of life history stages etc). As recovery progresses, there will be a need to identify factors that either pose a threat to recovery or offer potential for enhancement of recovery efforts. Such research needs should be identified and research projects encouraged with support and funding.

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# LIST OF APPENDICES

## APPENDIX I - SUMMARY OF RECOVERY GOALS FOR BONYTAIL, HUMPBACK CHUB, RAZORBACK SUCKER, AND COLORADO PIKEMINNOW IN THE LOWER BASIN

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Bonytail

*Overview:*

1) Genetic variability is identified and a genetic refuge is maintained over a 5-year period.
2) Two self-sustaining populations are maintained over a 5-year period.

*Downlisting Criteria:*

1. Genetic variability of bonytail identified and a genetic refuge (e.g. in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 5-year period.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over 5-year period, starting with the first point estimate acceptable to the Service, such that for each population:

> a. The trend in adult (age 4+; >250 mm TL) point estimates does not decline significantly, and
> b. Mean estimated recruitment of age-3 (150-249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
> c. each point estimate exceeds 4,400 adults (MVP).

*Delisting Criteria*

1. A genetic refuge (e.g., in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 3-year period beyond downlisting.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries are maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that for each population:

a. The trend in adult (age 4+; >250 mm TL) point estimates does not decline significantly, and
b. Mean estimated recruitment of age-3 (150-249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
c. Each point estimate exceeds 4,400 adults (MVP).
Four self-sustaining populations (minimum viable population of 4,400 adults); two in the upper basin and two in the lower basin.

<u>Humpback chub</u>

*Overview:*

1. Genetic variability is identified and a genetic refuge is maintained over a 5-year period.

2. Two self-sustaining populations are maintained over a 5-year period.

*Downlisting Criteria:*

1. The Grand Canyon population is maintained as a core over a 5-year period, starting with the first point estimate acceptable to the Service, such that:

a. The trend in adult (age 4+; >200 mm TL) point estimates does not decline significantly, and
b. mean estimated recruitment age of age-3 (150-199 mm TL) naturally produced fish equals or exceeds adult mortality, and
c. each core population estimate exceeds 2,100 adults (MVP).

*Delisting Criteria:*

1. The Grand Canyon population is maintained as a core over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that:

a. The trend in adult (age 4+; >200 mm TL) point estimates does not decline significantly, and
b. Mean estimated recruitment of age-3 (150-199 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

c. Each core population estimates exceeds 2,100 adults (MVP)

Razorback sucker

*Overview:*

1. Genetic variability of razorback sucker in Lake Mohave is identified, and a genetic refuge is maintained over a 5-year period.
.
2. Two self-sustaining populations are maintained over a 5-year period.

*Downlisting Criteria:*

1. Genetic variability of razorback sucker in Lake Mohave is identified, and a genetic refuge is maintained over a 5-year period.

2. Two self-sustaining populations (e.g. mainstem and/or tributaries) are maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that for each population:

a. the trend in adult (age 4+;>400 mm TL) point estimates does not decline significantly, and
b mean estimated recruitment of age-3 (300-399 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
c. Each point estimate exceeds 5,800 adults (MVP).

*Delisting Criteria:*

1. A genetic refuge is maintained in Lake Mohave over a 3-year period beyond delisting.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that for each population:

a. the trend in adult (age 4+; >400 mm TL) point estimates does not decline significantly, and
b. Mean estimated recruitment of age-3 (300-399 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

c. Each point estimate exceeds 5,800 adults (MVP).

Colorado Pikeminnow: Provisional Recovery Goals Lower Colorado River Basin[1]

*Overview:*

1. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 7-year period beyond downlisting, starting with the first point estimates acceptable to the Service.

*Downlisting Criteria:*

1. Two self-sustaining populations (e.g. mainstem and/or tributaries are maintained over a 5-year period starting with the first point estimates acceptable to the Service, such that for each population:

    a. the trend in adult (age 7+;>45 cm TL) point estimates does not decline significantly, and
    b. Mean estimated recruitment of age-6 (40-45 cm TL) naturally produced fish equals or exceeds mean annual adult mortality8, and
    c. Each point estimate exceeds 2,600 adults.

*Delisting Criteria:*

1. Two self-sustaining populations (e.g. mainstem and/or tributaries are maintained over a 7-year period beyond downlisting, starting with the first point estimates acceptable to the Service, such that for each population:

    a. the trend in adult (age 7+, >45 cm TL ) point estimates does not decline significantly, and
    b. Mean estimated recruitment of age-6 (40-45 cm TL) naturally produced fish equals or exceeds mean annual adult mortality, and
    c. Each point estimate exceeds 26,000 adults (MVP).

[1] Strategies presented in this document for this species will be considered for implementation if the Recovery Goals are revised to include this species in this document.

## APPENDIX II – ACRONYMS USED IN LCRMP DOCUMENT

| Agency | Acronym |
|---|---|
| Adaptive Management Work Group | AMWG |
| Arizona Ecological Services Office | AESO |
| Arizona Game and Fish Department | AGFD |
| Arizona State University | ASU |
| Biological Opinion | BO |
| California Department of Fish and Game | CDFG |
| Colorado River Commission of Nevada | CRCN |
| Cibola National Wildlife Refuge | CNWR |
| Grand Canyon Monitoring and Research Center | GCMRC |
| Havasu National Wildlife Refuge | HNWR |
| Lower Colorado River Management Plan | LCRMP |
| Lake Havasu Fisheries Project | LHFP |
| Lake Mohave Native Fish Group | LMNFG |
| National Park Service | NPS |
| Nevada Division of State Lands | NDSL |
| Nevada Department of Wildlife | NDOW |
| Nevada Ecological Services Office | NESO |
| Recovery Implementation Planning/Scientific Workgroup | RIP/SWG |
| Southern Nevada Water Authority | SNWA |
| University of Nevada, Las Vegas | UNLV |
| U.S. Bureau of Land Management | BLM |
| U.S. Fish and Wildlife Service | USFWS |
| U.S. Geological Survey | USGS |
| U.S. Bureau of Reclamation | USBR |

## APPENDIX III – GLOSSARY OF TERMS USED IN THE LCRMP DOCUMENT

Breeding pedigree – refers to characterizing the relationships of individuals used for propagation by known pedigree or inferred from genetic data to insure fish previously used are not used again and that siblings are not used to produce fish. Insures the production of the best individuals for a given program.

Broodstock – the use of wild or hatchery stock in a propagation program to produce fish for stocking.

Critical habitat – specific areas within a species range with physical or biological features essential to conservation of the species or which may require special management considerations or protection (USFWS 1988).

Endemic - endemism - refers to a species that occurs in a specific area and nowhere else (Meffe et al. 1997).

Fixation – a situation in which one allele at a gene is fixed (all others are lost) that may result in a reduction in fitness.

Genetic management plan – a plan detailing the genetics of a given species(s) to be used to produce fish for a specific management plan.

Genetic refugia – sites where populations of known genetic stocks are maintained in perpetuity.

Genetic variability – the variability expressed in the genetic makeup of a given population of fish.

Habitat renovation – the redevelopment or modification of a habitat to benefit a given species or population of fish or other organisms.

Inter-related populations – populations that occur in disjunct habitats but are related genetically.

Isolated bays – habitats that are not connected to the mainstem Colorado River or any other tributary – landlocked habitats.

Population success – populations that reproduce and recruit on a continuing basis maintaining that population.

Reproductive condition – condition describing the sexual development of a given species during its lifetime. Includes non-reproductive, ripe, and scenescent

individuals.

Self-sustaining – refers to a population that reproduces and recruits through time maintaining a population with numerous age classes in perpetuity.

Translocation – the movement of fish from one habitat to another with the numbers and timing based on a genetic management plan for that habitat.

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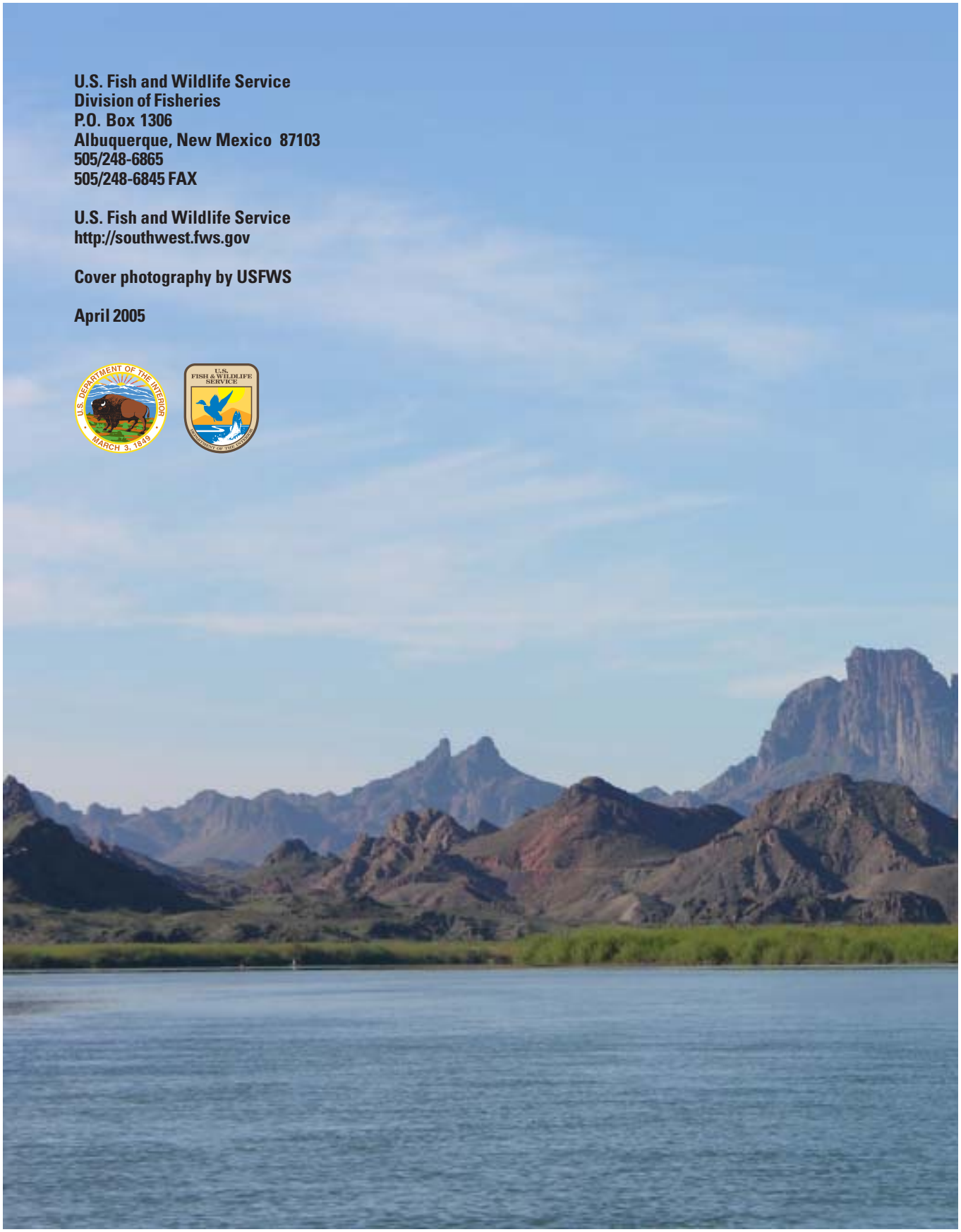
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