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Razorback Sucker (Xyrauchen texanus) Recovery Plan

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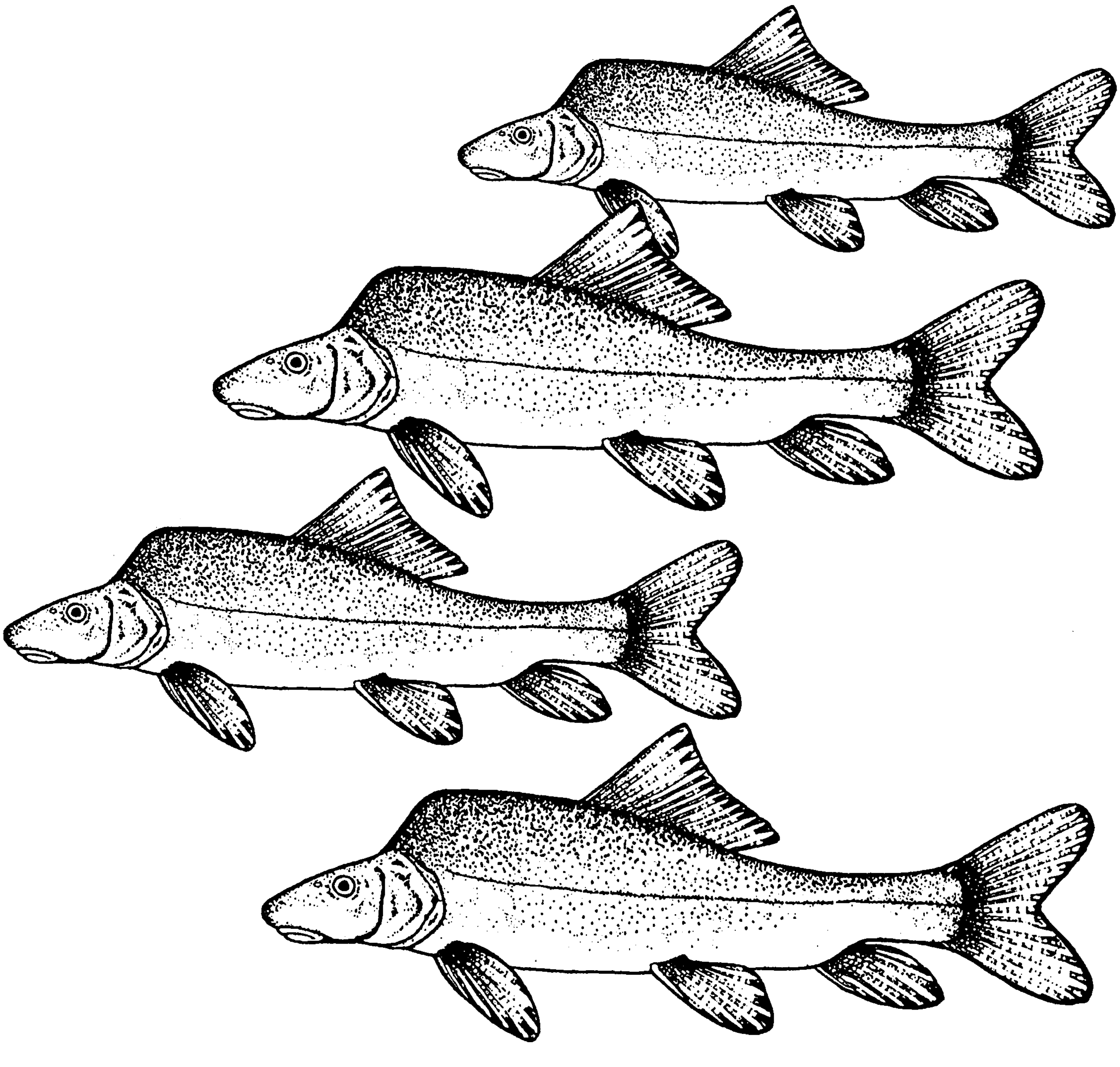

RAZORBACK SUCKER
(Xyrauchen texanus)

Recovery Plan

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for
Region 6
U.S. Fish and Wildlife Service
Denver, Colorado

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Regional Director, Region 6, U. S. Fish and Wildlife Service

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PREFACE

The Colorado River of the American West supports a mainstream fish community that is classified as the “Big River” fishes. Four of these fishes are listed as endangered under provisions of the Endangered Species Act of 1973, as amended. Three fishes (i.e., Colorado pike minnow *Ptychocheilus lucius*, humpback chub *Gila cypha,* and bonytail G. *elegans*) have been listed for over 10 years, and they have recovery plans that were prepared prior to designation of critical habitats. Recently the Colorado squawfish was renamed by the American Fisheries Society and hereafter will be refered to in this document as the Colorado pike minnow. A fourth fish, the razorback sucker *Xyrauchen texanus* was listed in 1991. Critical habitats for all four fishes were designated by the U.S. Fish and Wildlife Service in 1994.

The listing of these four fishes, and the potential endangerment of others suggest that this large river ecosystem is at risk. When such major environmental problems exist, present policy and philosophies have resulted in the decision to consider the recovery of more than one species, and thus to prepare multispecies or ecosystem recovery plans. The razorback sucker recovery plan has been prepared in the spirit of this philosophy. In addition, the recovery plan has been drafted more as a strategic plan to allow flexibility in its implementation. Presently, recovery of the fish is being accomplished by formal recovery implementation programs conducted in important geographic areas. It is anticipated that these recovery implementation programs will develop very site-specific work plans under the broad guidance provided in the razorback sucker recovery plan.

ACKNOWLEDGMENTS

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The Colorado River Fishes Recovery Team approved a draft of this plan on 11 December 1996. The team is composed of the following individuals: J. Petersburg, Team Leader, National Park Service; T.A. Burke, U.S. Bureau of Reclamation; L.W. Crist, U.S. Bureau of Reclamation; T.J. Foreman, California Department of Fish and Game; L.D. Lentsch, Utah Division of Wildlife Resources; C.W. McAda, U.S. Fish and Wildlife Service; C.O. Minckley, U.S. Fish and Wildlife Service; T.P. Nesler, Colorado Division of Wildlife; D.L. Propst, New Mexico Division of Fish and Game; J.C. Sjoberg, Nevada Division of Wildlife; and K.L. Young, Arizona Department of Fish and Game.

EXECUTIVE SUMMARY

Current Status: The razorback sucker, *Xyrauchen texanus* (Abbott), was listed as endangered on October 23, 1991 (56 FR 54957). A final rule designating critical habitat was published on March 21, 1994 (59 FR 13374). An endemic fish of mainstream rivers in the Colorado River basin, the razorback sucker was once abundant and widely distributed. It now occurs only in remnant populations in a few lakes and river reaches. The largest extant population occurs in Lake Mohave, Arizona, and the largest riverine population occurs in the Green and Yampa rivers, near Vernal, Utah.

Habitats and Limiting Factors: Razorback sucker populations have been declining for much of this century. This decline is a result of major alterations to the historical physical and biological environment. Extensive water development projects have depleted flow, altered flow regimes, changed water quality, and fragmented habitat. At the same time, the nature and composition of the fish community has been altered dramatically by the introduction of many nonnative fish species. Predation by nonnative fishes and loss of habitat are primary reasons for the virtual failure of recruitment in razorback sucker populations.

Recovery Objectives: Protection and expansion of three existing populations, and establishment of five new ones from remnant stocks or reintroductions.

Recover-v Criteria: The three steps for recovery of the razorback sucker to a less endangered status are: prevent immediate extinction, downlist to threatened, and delist. The short-term goal, which is to prevent extinction of the razorback sucker, will be considered accomplished when decline of extant stocks in Lake Mohave, the middle Green River and the lower Yampa river has been reversed, those populations are stabilized, and target population sizes are maintained or exceeded for at least 5 years. The long-term goal is to sufficiently recover the fish to allow down listing and then delisting. Down listing to a threatened status would signify that immediate extinction in the wild has been averted, and will be possible when a remnant population has been reestablished in the lower Green River, one additional population has been established in the upper basin, and one additional population has been established either in the upper or lower basin. Delisting will be possible after the fish has been down listed to threatened, and two additional populations have been established and protected. One of these additional populations shall be in the upper and one shall be in the lower basin.

Actions Needed: (1) Maintain existing genetic diversity in hatchery refugia and increase diversity if possible. (2) Reverse the decline, increase, and stabilize three existing populations by management actions: Lake Mohave, middle Green River, and lower Yampa River. (3) Protect habitats of these populations from further degradation. (4) Restore habitats to make them compatible with recovery goals. ((5) Augment or reestablish five additional populations of the fish in its critical habitat.

<u>Date of Recovery</u>: The three major populations should be stabilized and the immediate threat of extinction avoided by the year 2000. Down listing may be possible by 2010. Delisting could occur as soon as 2020, if recovery criteria have been met.

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PART I. INTRODUCTION

History

The razorback sucker, *Xyrauchen texanus* (Abbott), an endemic fish of the Colorado River basin of the American West (Figure I), is a member of the sucker family (Catostomidae: Catostominae). Catostomids, a diverse and successful group of freshwater fishes, are abundant in North America (Moyle and Cech 1996). Catostomids occur in northeastern Siberia, Alaska, and from northern Canada to Mexico (Nelson 1994). The origins of North American suckers remains somewhat obscure due to an incomplete fossil record. Oldest known North American catostomid specimens come from Paleocene formations (ca. 53-65 mya; Cavender 1986). However, the Catostomidae may have occurred earlier in northern latitudes where fossil records may have been destroyed or covered by glaciers. The razorback sucker arose from an ancient form that diverged very early from the main line of catostomid evolution (Miller *1958). Xyrauchen* presumably originated by Pliocene and one “well-preserved” Pleistocene specimen from Salton Sea, California has been identified as *Xyrauchen texanus* (Miller 1958, Minckley et al. 1986).

The razorback sucker is placed in the monotypic genus *Xyrauchen,* one of four genera in the tribe Catostomini (Nelson 1994). The species was originally described in 1860 as *Catostomus texanus* by Abbott (1861), who mistakenly believed that the stuffed specimen came from the Colorado River of Texas. The fish also was described as C. *cypho* by Lockington (1881). Eigenmann and Kirsch (in Kirsch 1889) recognized the unusual features of this species and assigned it to a new genus *Xyrauchen* (literally, “razornape”; Jordan and Evermann 1896). LaRivers (1962) redescribed the species and provided a complete synonymy. He also corrected the identity of the type locality, which was the “Colorado and New Rivers” in Arizona. The New River is tributary to the Gila River in Central Arizona.

The razorback sucker was known to humans in prehistoric times and used by them as food. Common names, including “tsa’xnap” and “suxyex” were given to the fish by American Indians (reviewed by Minckley et al. 1991). Other common names include “humpback sucker”, "buffalo” and “buffalofish” (Jordan and Evermann 1896; Sigler and Miller 1963; Minckley 1973). Presently, the American Fisheries Society recognizes the common name of razorback sucker (Robins et al. 1991).

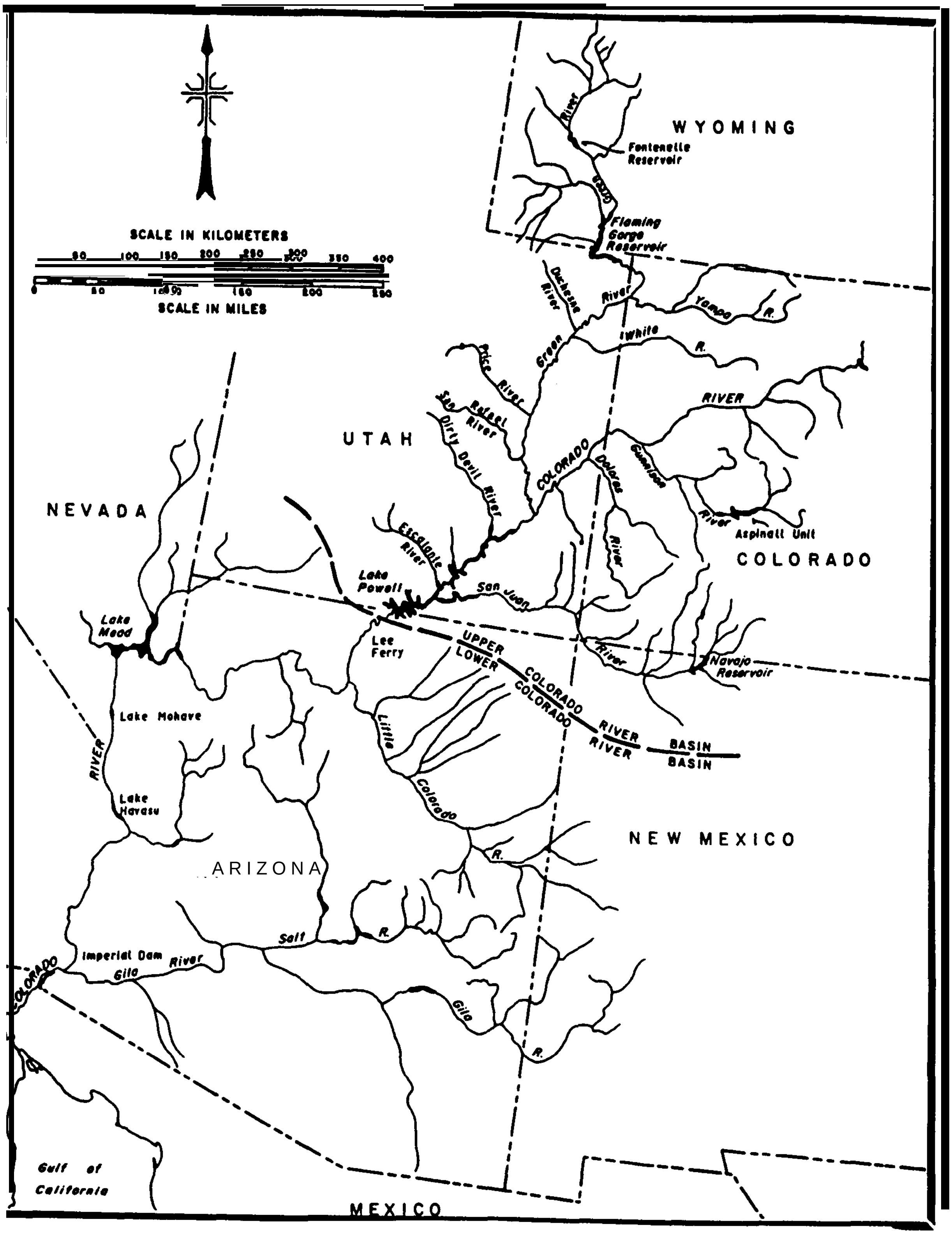

Figure 1. Colorado River basin in the United States.

Razorback sucker populations have declined markedly in the last 50 years. At one time it was thought that the razorback sucker was "holding its own" and perhaps even expanding in large impoundments (Wallis 1951; Miller 1961), but most of these populations have almost entirely disappeared. Extant populations consist primarily of old fish believed to be nearing their maximum life expectancy (Minckley et al. 1991). There are no historic population estimates for this fish, but it is presumed that extant populations represent a 90% decline in historic range and abundance.

General Description

Adult razorback suckers may grow to a total length of about 1 m and a weight of 5-6 kg. However, most specimens of the fish are smaller. The largest fish presently occur in the warmer climate of the lower Colorado River, and sizes of 470-740 mm are reported in Lake Mojave, Arizona (Minckley 1983). In the upper Colorado River basin, sizes of 405 to 597 mm were reported (Tyus and Karp 1990). Females are generally larger than males of the same age. Females ranged in size from 470 to 740 mm and males ranged in size from 370 to 640mm in the lower basin (Minckley 1983). In the upper basin, females captured on spawning grounds averaged 547mm and males averaged 507 mm (Tyus and Karp 1990).

The razorback sucker shares many characters with other catostomid, but is distinguished from all other catostomid by a pronounced bony keel that grows from the dorsal surface of its back (i.e., behind the occiput). Formed mostly from enlarged neural and interneural bones, this relatively thin, sharp-edged keel is the basis for its common name. The species also is distinguished by well-developed, elongated filaments on its gill rakers, an adaptation for feeding on zooplankton. Characteristics shared with other members of its family include an intermediate number of moderately compressed pharyngeal teeth arranged in comb-like fashion, which is presumably an adaption to benthic feeding (Eastman 1977; Sublette et al. 1990). Its bony dorsal keel, heavily ossified caudal skeleton, and thickened and foreshortened caudal rays are thought to be adaptations to the strong river'currents in which the fish lives (La Rivers 1962, Eastman 1980, Moyle and Cech 1996).

The razorback sucker has an elongated head with a flattened dorsal surface and a well-developed fontanelle. The moderate-sized ventral mouth has a cleft lower lip, with lateral margins continuous and rounded. Meristics include: dorsal fin rays usually 14-15 (13-16), anal fin rays 7, total vertebrae 45-50, lateral line scales 68-87, and gill rakers 44-50 on the first arch. Pharyngeal teeth are 64-74 per arch and occur in a single row (Minckley 1973, Sublette et al. 1990).

Razorback sucker coloration ranges from dark brown to olivaceous dorsally and yellow to white ventrally, but color and morphology differ due to a sexual dimorphism that is especially obvious during reproductive seasons. Breeding males are dark colored dorsally and bright yellow to orange on lateral and ventral surfaces. Pelvic and anal fins are generally longer in males than in females, whereas the reverse is true for the urogenital papillae. Females are generally longer and heavier than males and usually have a broader, or lower dorsal keel (reviewed by Minckley et al 1991). Tubercles are produced as secondary sex characteristics during the breeding season, and are more abundant and pronounced in males. Tubercles occur on the anal and caudal fins and on the ventral surface of the caudal peduncle.

Suckers are mainly detritivores or herbivores, and thus occupy a crucial position at the base of the consumer food chain. Although sometimes regarded as “trash fish,” suckers are important food for other fishes and have been widely used for food by humans. Numerous razorback sucker bones have been excavated from prehistoric camps of Native Americans, and numerous records authenticate its use as human and animal food. Early settlers used many tons of razorback suckers as food (Minckley et al. 1991, Quartarone 1993).

Distribution and Abundance

<u>Historic</u>

The razorback sucker was once widely distributed and abundant in mainstream and the major tributary rivers of the Colorado River basin (Ellis 1914; Jordan and Evermann 1896; Minckley 1973, 1983; Figure 2). In the lower Colorado River basin, razorback suckers occurred from the Colorado River delta upstream to Lees Ferry, Arizona (Gilbert and Scofield 1898). Archeological evidence indicates that razorback suckers were common periodically in the Salton Sea area (Minckley 1983; Minckley et al. 1991). They invaded the Salton Sea when it last filled in 1904-I 907, but increasing salinity made this habitat marginal to uninhabitable for freshwater fishes after 1929 (Evermann 1916, Coleman 1929). Razorback suckers occurred in most of the Gila River drainage (reviewed by Bestgen 1990) and may have been common in the Gila River mainstream upstream nearly to the New Mexico border (Kirsch 1889), however Huntington (1955) did not document presence of the fish in New Mexico. The fish was abundant in the lower Salt River, and occurred in lower Tonto Creek and in the Verde River to Perkinsville, Arizona (Hubbs and Miller 1953, Minckley 1973). Upstream distribution in the Salt River may have been limited by extensive canyon habitat (Bestgen 1990), but no surveys were made before the 1960s.

In the upper Colorado River basin, razorback suckers occurred in the Colorado, Green, and San Juan river basins. Razorback suckers occurred in the Colorado River from Lee’s Ferry, Arizona to Rifle, Colorado, and in the Gunnison River to Delta, Colorado (Hubbs and Miller 1953, Wiltzius 1978, Minckley 1983). Razorback suckers once occurred in the Green River from its confluence with the Colorado River upstream to Green River, Wyoming (Jordan 1891, Evermann and Rutter 1895, Simon 1946, Sigler

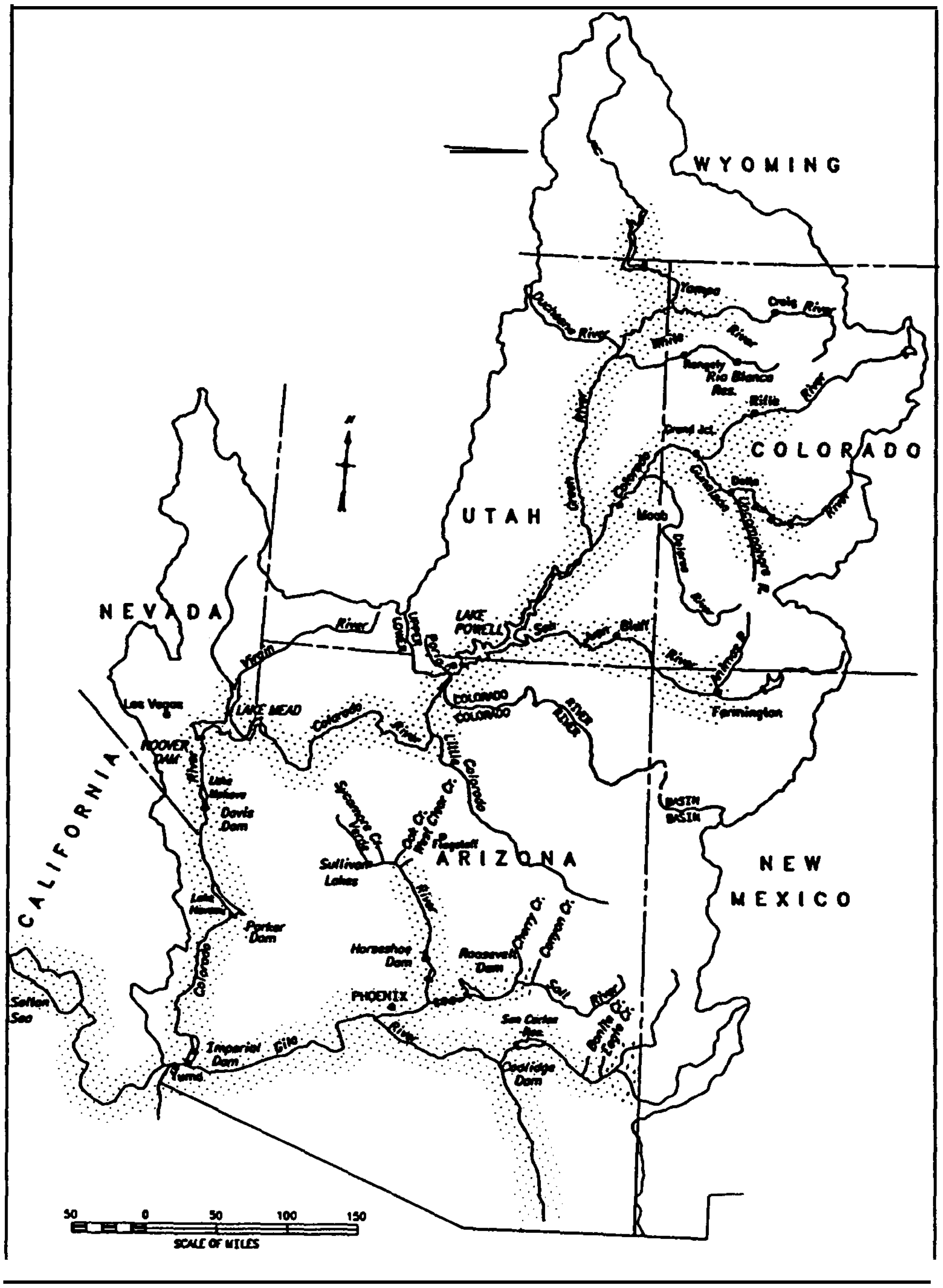

Figure 2. Historic distribution of razorback sucker (after Maddux et al. 1993)

and Miller 1963, Baxter and Simon 1970, Vanicek et al. 1970). Razorback suckers also have been captured in the lower few miles of the Duchesne River (Tyus 1987) and in the lower White River near Ouray, Utah (Sigler and Miller 1963). Razorback suckers occurred in the lower Yampa and Little Snake rivers of Colorado (McAda and Wydoski 1980, Lanigan and Tyus 1989, John Hawkins, Colorado State University, pers. comm., 1995). Historic status of the razorback sucker in the San Juan drainage is not well documented (Bestgen 1990), but there is ample evidence that the fish historically occurred there. Early accounts that razorback suckers "ran" up the tributary Animas River in spring (Jordan 1891) presumably represent spawning migrations. Koster (1960) reported anecdotal evidence of razorback suckers captured by anglers in the Animas River, and in 1992, anglers identified razorback sucker pictures as the fish they had captured in the Animas River during the 1940s. Anecdotal accounts indicate that razorback suckers were observed in irrigation ponds and perhaps in the mainstream river near Bluff, Utah, in 1977 (Minckley et al. 1991). The first verified record of razorback suckers from the San Juan River consisted of a 571 mm adult in spawning condition captured in 1988 from the mainstream river near Bluff (Platania et al. 1991).

Present

In the lower basin, razorback sucker apparently began to decline shortly after impoundment of Lake Mead in 1935 (Dill 1944, Miller 1946, Wallis 1951, Jonez and Sumner 1954, Allen and Roden 1978). Larval and juvenile razorback suckers have been reported widely from the lower basin, and larvae are regularly captured in Lake Mojave (reviewed by Minckley et al. 1991). The largest extant population occurs in Lake Mojave, where the population consisted of approximately 60,000 adults in 1988 (Minckley et al. 1991). By 1995, that population had declined to about 25,000 fish (Marsh 1995). Small numbers of razorback suckers occur in Lake Mead and in the Grand Canyon, where individuals are found sporadically downstream on the mainstream river, and associated impoundments and canals (Marsh and Minckley 1989).

In the upper basin, the present range of the razorback sucker is much less than its historical distribution (Holden and Stalnaker 1975, McAda and Wydoski 1980, Tyus et al. 1982). Adults and larvae are widely distributed in the Green River basin; the largest concentration is in the upper Green River, in a reach that extends from the mouth of the Duchesne River upstream to the lower 4 miles of the Yampa River. Lanigan and Tyus (1989) estimated that about 1,000 adult razorback suckers (x=948, 95% confidence interval: 758-l ,138) inhabited the upper Green River basin. A more recent analysis suggests that this population is "precariously low," consisting of only about 500 fish (x=524, 95% confidence interval: 351-696)(Modde et al. 1996). A small, reproducing population of razorback suckers exists in the lower Green River; 18 adult fish and numerous larvae have been captured there from 1980-1996 (Tyus et al. 1987; McAda et al. 1994; 1996; Muth et al. 1998). Although the fish regularly occurs in the lower Yampa, it is rarely found upstream as far as the Little Snake River (McAda and

Wydoski 1980, Lanigan and Tyus 1989, John Hawkins, Colorado State University, pers. comm., 1995).

In the upper Colorado River, most razorback suckers occurred in the Grand Valley (Valdez et al. 1982), but captures of wild fish have declined (Osmundson and Kaeding 1990). Razorback suckers also have been captured in the mainstream Colorado River downstream of the Green River confluence, including Cataract Canyon, and in Lake Powell (Minckley et al. 1991). Individuals of the fish have been captured in the flooded San Juan River arm of Lake Powell, but few specimens have been confirmed in the riverine portion of the San Juan River upstream of Lake Powell (Platania et al. 1991, Minckley et al. 1991). Fifteen adults have been captured and removed from Lake Powell (11 from the San Juan arm of the lake and 4 from the Colorado River arm; unpublished U.S. Fish and Wildlife Service [USFWS] permitting records, Denver, CO), and a few individuals presumably remain there.

Larval and juvenile razorback suckers have been captured in different locations of the upper Colorado River basin, and especially in the Green River in the last 20 years (Tyus 1987, Gutermuth et al. 1994, Muth et al. 1998), but identification of razorback sucker larvae has been difficult or impossible when other catostomid larvae were present. Recent advances in taxonomic techniques have made it possible to identify razorback sucker larvae, even in the presence of other catostomid (Muth et al. 1998). Using these new techniques the Larval Fish Laboratory at Colorado State University conducted an intensive survey of the Green River from 1992 to 1996. During this period, 1,735 larval razorback suckers (99% of captures) were taken from the "middle" portion of the Green River, including the Escalante, Jensen, and Ouray reaches, and 440 larvae were identified from samples taken from the Labyrinth and Stillwater canyons, near the confluence of the San Rafael River, Echo Park, and Green River valley (Muth et al. 1998). The exact origin of these larval fishes is unknown due to larval drift, but is presumed to be nearby in upstream areas. Despite the presence of these larvae, no significant recruitment to any population has been documented (Tyus and Karp 1990, Minckley et al. 1991, Modde et al. 1996).

Razorback suckers have been reintroduced at several locations in the upper and lower Colorado River basin. More than 12 million young and juvenile razorback suckers were reintroduced into riverine habitats in Arizona and California from 1981 to 1990, but indications are that most of these stocked fish were consumed by nonnative predatory fishes (Marsh and Brooks 1989; Minckley et al. 1991; Mueller 1995). More recent stockings completed or planned in the Salt and Verde rivers, Lake Mojave, Lake Havasu, and the Imperial Division (unpublished USFWS stocking records) have utilized larger fish to reduce predation risks. Some small-scale augmentation stockings also have occurred in the Green, Colorado, Gunnison, and San Juan rivers upper basin (unpublished records). Recapture results indicate that some fish survive, and thus these stockings have been successful in the short term (e.g., Ryden and Pfeifer 1995).

Life History

General

The razorback sucker and other endemic Colorado River fishes are adapted to the fluctuating hydrologic environment of the historic Colorado River (Minckley 1973, 1983; Carlson and Muth 1989), with its periodically extreme flow conditions and high turbidities. Historic riverine systems provided a wide variety of habitats including backwaters, sloughs, oxbow lakes, and seasonally inundated flood plains, which were used to satisfy various life history requirements (Holden and Stalnaker 1975; Minckley 1983; Lanigan and Tyus 1989). The fish also occurs in reservoirs, where it is capable of surviving for many years. Although the fish has been successfully propagated in hatcheries, some of the life history needs of the fish in nature, including certain habitat requirements of the various life stages, and other attributes of this fish remain unknown.

Reproduction

Razorback suckers have been captured in breeding condition in many different habitats and environmental conditions. Spawning has been documented in mainstream rivers, riverine-influenced areas of large impoundments, and wave-washed shorelines of reservoirs. The ability to use a variety of habitats and flow conditions may reflect adaptations to conditions in the historic Colorado River system, which may now be changed. Absence of any substantial level of recruitment makes it difficult to determine if the present habitat and flows are the most suitable for recovery efforts. It is not known whether all life history requirements can be met in either the mainstream river or an impoundment. For clarity, the following discussion of what is known about reproductive requirements and habitat use is separated into lacustrine and riverine habitats.

Lacustrine habitats. The largest surviving stock of razorback suckers exists in Lake Mojave in the lower Colorado River basin. Successful spawning has been documented in Lake Mojave and numerous larvae have been collected (Bozek et al. 1990, Marsh and Langhorst 1988). However, juveniles have been extremely rare in collections (Minckley et al. 1991). Spawning in Lake Mojave occurs early in the year, from January through April/May (Langhorst and Marsh 1986, Mueller 1989). Water temperatures during spawning ranged from 11.5-18°C (52.7-64.4°F) (Douglas 1952, Langhorst and Marsh 1986). Spawning fish congregate and spawn in flat or gently sloping shoreline areas over gravel, cobble, or mixed substrate types (Douglas 1952, Bozek et al. 1990, Minckley et al. 1991). Medel-Ulmer (1983) observed similar spawning activity in Senator Wash Reservoir in water depths of 10 to 18 m. In Lake Mojave, razorback suckers were observed spawning in several locations water up to 5 m deep, with most fish in less than 2 m of water. Minckley et al. (1991, p. 320) summarized spawning in Lake Mojave as follows:

> "In Lake Mojave, males stage over coarse, wave washed cobble in water 0.5-5 m deep. Groups of up to several hundred fish . . . move slowly a meter or less from the bottom or lie immobile near or on the substrate for hours. Based on trammel netting, females remain in deeper water until ripe, then appear singly on the spawning grounds . . . When she is ready to spawn, a female, flanked by two or more males, separates from a group and moves to the bottom The males press closely against the female's posterior abdomen and caudal peduncle, and all contact and agitate the substrate for three to five seconds in apparent spawning convulsions after which they typically return to a larger group... The entire sequence lasts from a few seconds to three minutes, usually the former. Females recognizable because of an injury or some other distinctive feature have been observed to spawn repeatedly in a given hour and day, and on successive days within a week."

Riverine habitats. The reproductive ecology of riverine razorback suckers has been most intensively studied in the Green and Yampa rivers (McAda and Wydoski 1980, Tyus 1987, Tyus and Karp 1990, Modde and Irving 1998). Staging occurs in flooded lowlands and eddies formed in the mouths of tributary streams, and then the fish move to main-channel sand, gravel and cobble bars for egg deposition (Tyus 1987, Tyus and Karp 1990). Radiotracking and recaptures of tagged fish indicated that fish were homing to two spawning sites in Dinosaur National Monument: one in the Green River near Jensen, Utah, and one at the mouth of the Yampa River (Tyus and Karp 1990). Larval razorback suckers recently have been captured below these two areas, and in others (Muth et al 1998). Although some radiotagged fish have been monitored on more than one known or suspected spawning areas (Tyus and Karp 1990, Modde and Irving 1998), it is not known if individual fish actually spawn at more than one site, or whether fish residing in locations distant from their preferred spawning area are only moving through one spawning area in route to another (noted by Tyus and Karp 1990).

Ripe razorback suckers were captured in suspected spawning areas in the Green River from mid to late April through May (Tyus 1987, Tyus and Karp 1990). In the Grand Valley, near Grand Junction, Colorado, 40 of 42 running ripe adults were captured between May 24 and June 17 (Osmundson and Kaeding 1990). Spawning movements and the appearance of ripe fish were associated with increasing spring flows and average water temperatures of 14°C. (range 9-17°C or 48-63°F; Tyus and Karp 1990). Thus, the time of spawning is later than that observed for the lower basin populations, but the temperature range is very similar. Tyus (1987) and Tyus and Karp (1990) collected ripe adults over coarse sand substrates and in the vicinity of gravel or cobble bars submersed by an average depth of water of 0.63 m. Average velocity of water over the bars was 0.74 m/s. Direct observation of spawning behavior and gametic release was precluded by high turbidity prevalent during spring flows.

Razorback sucker spawning also has been observed in riverine sections of the Colorado River below Hoover Dam (Minckley 1983). Mueller (1989) gave the following account of reproductive behavior in that riverine habitat:

> "Spawning behavior was similar to that reported for populations in reservoirs. However, spawning appeared to be less mobile in the river. The majority of fish, which appeared to be "small" (approximately 40 cm total length) males, maintained stationary positions on the downstream end of the site. This behavior was different from the roving nature previously observed and reported for reservoir-spawning groups (Minckley, 1983). Larger fish, presumably females, periodically moved into the area from the adjacent river, attracting some of the otherwise stationary males to form spawning groups of three to eight fish. These groups, composed of one female and several males, would spawn over depressions or swim around the area before dispersing. The spawning act only took a few seconds and, other than orienting with the current was similar to that reported elsewhere. However, on several occasions spawning groups appeared to seek shelter downstream of large boulders and, while maintaining their position, would roll in mass for several seconds."

Habitat Preferences

Adults. Habitat selection by adult razorback suckers changes seasonally. Tyus and Karp (1990) detected movements of adult fish into flooded areas in early spring, and suggested that flooding of bottomland during spring runoff was important to adults for feeding and for temperature regulation. The flooding of bottomland also supplies allochthonous input to the river, which may subsequently provide food for one or more life stages.

Radiotelemetry showed that adult fish in the Green and Duchesne rivers, Utah, selected deeper near-shore runs during the spring, but shifted to relatively shallow waters of submerged mid-channel sandbars during the summer months. The fish occupied locations with water depths ranging from 0.6 to 3.4 m (2.0 to 11 .O ft), water velocities of 0.3 to 0.4 m/s (1.3 to 2.0 ft/s), substrates of sand or silt (Tyus 1987). During summer, the fish occupied midchannel sand bars where the water was less than 2 m deep and velocity averaged 0.5 m/s (Tyus 1987). These bars consisted of small, underwater dunes and depressions in which the fish may have been feeding on trapped allochthonous material (Tyus 1987). In winter, radio-tagged razorback suckers used slow runs, "slack waters" and eddies, in depths of 0.6 to 1.4 m (2.0 to 4.6 ft) and velocities of 0.03 to 0.33 m/s (0.1 to 1 .1 ft/s; Valdez and Masslich 1989).

In the upper Colorado River, near Grand Junction, Osmundson and Kaeding (1989) reported similar habitat use: pools and slow eddies from November through April, runs and pools from July through October, runs and backwaters during May, and backwaters, eddies, and flooded gravel pits during June. Selection of depths changed seasonally; use of relatively shallow water occurred during spring and use of deeper water during winter. Mean depths were 0.9 to 0.99 m (3.0-3.3 ft) during May and June, 1.62 to 1.65 m (5.3-5.4 ft) from August through September, and 1.83 to 2.16 m (6.6-7.1 ft) from November through April (Osmundson and Kaeding 1989).

Adult razorback suckers use a great variety of habitats, including lower gradient, low-velocity riverine sections of canyon-bound areas. The fish also have been tracked moving through whitewater habitats (Tyus and Karp 1990), but spent little time there. There are few historic records of razorback suckers in Grand and Marble canyons of the lower Colorado River, possibly due to lack of historic sampling in these inaccessible whitewater canyons (Minckley et al. 1991). Lanigan and Tyus (1989) suggested that razorback sucker distribution in the Green River may be constrained by whitewater canyons that either impede migration or do not have suitable habitat. Although the fish has been extirpated from its historic riverine habitats in the lower Colorado River basin, the species never may have been common in whitewater canyons there (Bestgen 1990). As an example, historic locations occupied by the fish in the Gila and Verde rivers lacked extensive whitewater areas.

Razorback suckers also utilize reservoir habitat, where the adults may survive for many years and habitat use of adults and larvae have been thoroughly studied (Minckley et al. 1991). The fish move throughout Lake Mojave and other reservoirs, where they use a variety of habitats (e.g., Medel-Ulmer 1983, Minckley 1983, Marsh and Minckley 1989, Minckley et al. 1991). Habitat preferences of adult razorback suckers reared in hatcheries and implanted with ultrasonic transmitters also have been studied in the complex environment of the lower Imperial Division of the Colorado River in Arizona and California. The fish used all habitat types, but preferred backwaters and the main impoundment (Bradford et al. 1998).

Larvae and juveniles. Habitat use of small life stages of the razorback sucker have not been studied in riverine environments. Marsh and Langhorst (1988) observed that larval razorback suckers in Lake Mojave remained near shore after hatching, but disappeared within a few weeks. Young hatchery-produced fish remain along shorelines, in embayments along sandbars, or in tributary mouths, and later disperse into the main channel or larger backwaters (Minckley et al. 1991). One laboratory study indicated that 2-week old larval razorback suckers actively, rather than passively, entered the drift and moved primarily at night (Paulin et al. 1989). The tendency to enter the drift suggests that the species takes advantage of downstream transport for moving from spawning to nursery habitats, which are presumed to be ephemeral shoreline habitats. Tyus (1987) reported captures of young razorback sucker larvae from a backwater immediately downstream of a known spawning area, and during a four year period (1992-1996), 1,735 drifting larvae were captured from the mid and lower Green River using a variety of sampling gear (Muth et al. 1998).

Habitat needs of juvenile razorback suckers are not well known because juveniles are not commonly encountered, especially in riverine habitats (Tyus 1987). Most encounters involve just a few individuals, although R.R. Miller seined 6,600 larvae and small juveniles along warm, shallow margins of the Colorado River at Cottonwood Landing, Nevada in 1950 (Sigler and Miller 1963). Taba et al. (1965) collected a few juveniles from backwaters in the Colorado River near Moab. Smith (1959) caught two young fish on the Colorado River in Glen Canyon, one from a backwater and one from a creek mouth. Gutermuth et al. (1994) captured two small juvenile razorback suckers in a silty backwater in the lower Green River in 1991. Juveniles also have been collected in the middle Green River. Two juveniles (59 and 29 mm) were collected in a main channel backwater in 1993 and 28 juveniles (74-l 24 mm) were collected from Old Charley Wash, a wetland adjacent to the Green River, in October 1995 (Modde 1996). Another 45 juvenile razorback suckers were collected from Old Charley Wash in August 1996 (T. Modde, USFWS, pers. comm., 1996).

Additional information about the movement of juvenile razorback suckers has been obtained from 55 hatchery-reared fish that were tagged with sonic transmitters and released into lakes Mojave and Powell. These fish utilized backwaters and coves, and more than half of the tracked fish utilized flooded and emergent vegetation, and rock cavities as cover (Mueller and Marsh 1998). In another study, 33 juvenile razorback suckers were tagged with sonic transmitters and released in Neskahi Wash and Zahn Bay of the San Juan arm of Lake Powell (23 and 42 miles, respectively, above the historic river mouth). Twenty three of these fish were located in the upper 32 miles of the Lake Powell-San Juan River inflow area and were found in association with flooded vegetation. Eight individuals of the fish were tracked for 21 months, and exhibited an overall upstream movement to reach and occupy the lake-reservoir mixing zone (near Paiute Farms, river mile 42 to 62) (C. Karp, U.S. Bureau of Reclamation, pers. comm., 1998).

Young razorback suckers presumably require quiet, warm, shallow water (e.g., eddies and backwaters) for nursery habitats in riverine environments. Backwaters provide quiet, warm water where there is a potential for increased food availability. During higher flows, flooded bottomland and tributary mouths may provide still water. Tyus and Karp (1989, 1990) identified the importance of flooded bottomland for the growth of young fish. Many of these off-channel habitats have been eliminated in the Colorado River basin by construction of mainstream dams, diking of floodlands, and channelization (Beland 1953, Tyus and Karp 1989, Osmundson and Kaeding 1990). Gravel-pit ponds connected to the river may provide a substitute for inundated riparian cottonwood bottomland, other wetlands, and oxbow channels. However, these habitats also support nonnative predatory fish, such as largemouth bass, catfish, and green sunfish, which feed on young razorback suckers, or other smaller nonnative fishes such as red shiner and fathead minnow that are known to consume the larvae or display agonistic behaviors (Minckley et al. 1991, Mueller 1995, Tyus and Saunders 1996). In reservoirs, coves can provide warm, shallow shorelines suitable for nursery habitat (Minckley et al. 1991).

Movement and Migrations

Historical accounts document spring spawning movements of razorback suckers in various locations in the basin (Jordan 1891, Hubbs and Miller 1953, Sigler and Miller 1963). Spawning migrations and other movements presumably evolved in the context of flow regimes, pluvial events, and the diversity of available habitats (Smith 1981; Tyus 1986, 1987; Tyus and Karp 1989, 1990). Similar spawning migrations have been studied for other riverine catostomid and appear to be a major part of their reproductive ecology (Dence 1948, Breder and Rosen 1966, Werner 1979). The factors controlling migratory behavior and homing in the razorback sucker have not been studied, but there is some evidence that learned behaviors (e.g., imprinting) may have an influence (Scholz et al. 1992, Modde et al. 1995).

Razorback suckers may travel long distances in both lacustrine and riverine environments during the spawning season, and exhibit some fidelity to specific spawning areas. In Lake Mojave, razorback suckers move throughout the lake, which is about 100 km long (Marsh and Minckley 1989). Spawning migrations of 30 to 106 km (one way) have been recorded in the Green River near Jensen, Utah, and in the lower Yampa River in Dinosaur National Monument (Tyus 1987, Tyus and Karp 1990). Extensive movements also have been observed in juvenile razorback suckers stocked in Lakes Mojave and Powell, and rapid dispersal was observed in sonic-tagged fish (Mueller and Marsh1998). Fish stocked in the San Juan River arm of Lake Powell displayed a preference for the river inflow area, which they moved into and remained for an extended period (C. Karp, pers. comm., 1998).

Razorback suckers travel mainly during the spring spawning season and are more sedentary during the remainder of the year. In summer, razorback suckers in the Green River were relatively sedentary, traveling only a few kilometers upstream or downstream (Tyus 1987, Tyus and Karp 1990). Little is known about movements of razorback suckers in winter, but Valdez and Masslich (1989) reported a net movement of less than 5 km (3 mi) between 1 December and 31 March. Valdez and Masslich (1989) also documented that changing flows stimulated fish movements in winter.

Diet

Razorback sucker diet varies depending on life stage, habitat, and food availability. When larvae hatch, the mouth is terminal, which appears to facilitate great diversity in feeding behavior. In the laboratory, larvae may feed at the surface, in the water column, and on the surface of the substrate (unpublished USFWS records, Vernal, Utah). In Lake Mojave, larvae begin exogenous feeding at about 9-10 mm total length, and feed mostly on phytoplankton and small zooplankton (Minckley and Gustafeson 1982, Marsh and Langhorst 1988, Papoulias and Minckley 1990). However, larvae stocked in a backwater in the Salt River, Arizona, consumed mainly chironomid larvae (J.E. Brooks, USFWS, pers. comm., 1994). No information is available regarding food habits of larval razorback suckers in riverine habitats. However, larvae of other southwestern catostomid (flannelmouth sucker, Sonora sucker, desert sucker, bluehead sucker) in riverine conditions feed almost exclusively on benthic larval Chironomidae and early instar Ephemeroptera (Maddux et al. 1987; R.T. Muth, Colorado State University, pers. comm., 1992).

As razorback sucker larvae grow, the mouth changes and becomes inferior, and the fish feed on more benthic foods. Unfortunately, few details are known about the diet of juvenile razorback suckers because fish of this age are rarely encountered. The only study known reports "algae and bottom ooze" from the digestive tract contents of eight juvenile (90-I 15 mm) razorback suckers taken from a Colorado River backwater (Taba et al. 1965).

The diet of adult razorback suckers taken from riverine habitat consisted chiefly of immature Ephemeroptera, Trichoptera, and Chironomidae, along with algae, detritus, and inorganic material (Jonez and Sumner 1954, Banks 1964, Vanicek 1967). The diet was of benthic origin, but may have been taken from drift. Diets of reservoir-dwelling adults were dominated by planktonic crustaceans, but also contained some algae and detritus (Minckley 1973; Marsh 1987).

Larval and juvenile razorbacks in hatchery ponds at Dexter, New Mexico (Hamman 1987) and Vernal, Utah (Lanigan and Tyus 1988) have been reared successfully on natural foods (i.e., phytoplankton and small zooplankton). They also have been reared in aquaria using brine shrimp (*Artemia* sp.; Papoulias and Minckley 1990). In addition, razorback sucker larvae have been successfully reared on selected, dry commercial diets (Tyus and Severson 1990, Severson et. al. 1991).

<u>Aae and Growth</u>

Estimates of growth rates for individuals captured in the wild have been hampered by difficulties in determining age. McCarthy and Minckley (1987) evaluated seven different morphological structures, and determined that otoliths gave the most reliable ages. Their results indicated that razorback suckers are long-lived fish: individuals from Lake Mojave were 24 to 44 years of age in the 1980s (McCarthy and Minckley 1987).

Razorback suckers grow rapidly during the first six years, but growth is very slow for older individuals in extant populations (McCarthy and Minckley 1987, Minckley et al. 1991). Adults in the Lake Mojave population have shown little or no growth for a period of at least 20 years (Minckley et al. 1991). Tyus (1988) found slow growth (average of 2.2 mm/year) for 39 adult razorback suckers recaptured l-8 years after tagging, and Modde et al. (1996) reported similar results. Adults from the San Juan River recaptured one year after tagging had grown an average 3.1 mm (Roberts and Moretti 1989).

Most of the information on the growth of early life stages is from hatchery-produced fish, or fish spawned in human-influenced environments. Growth under these controlled conditions may reflect growth potential rather than the rates that might occur in more natural habitats. Very little information exists concerning growth rates of young razorback suckers in natural environments because survival rates are negligible (Minckley et al. 1991, Marsh 1995, Mueller 1995).

Growth rates of razorback suckers that have been spawned and reared under hatchery conditions can be rapid. Newly-hatched larvae are generally 7-9 mm TL (e.g., Hamman 1985, Papoulias and Minckley 1990, Tyus and Severson 1990). Larvae fed brine shrimp reached an average length of 23.2 mm after 50 days (Papoulias and Minckley 1990). Larvae (i.e., swim-up fry) produced from ripe females in the Green River and reared on natural foods in ponds at Ouray, Utah, grew to an average total length of 127 mm (range: 49-205 mm) during the 1987 growing season (i.e. April to October) and 156 mm (range: 40-271 mm) in 1988 (unpublished data on file with the USFWS, Vernal, Utah).

In Lake Mojave, growth of razorback sucker larvae has been studied in isolated backwaters from which other fishes have been removed. In one study, fish grew as much as 35 cm between January and November, 1992 (N=296; Mueller 1995). In other studies, larvae hatched in late March attained average length of 18.9 cm by December (N=12; Minckley et al 1991). Marsh and Langhorst (1988) evaluated the feeding and fate of wild razorback sucker larvae in Lake Mojave and also found that fish placed in a backwater free of predaceous fishes survived and grew rapidly.

Rapid growth also has been documented for juveniles that have been stocked in ponds and streams. Osmundson and Kaeding (1989) reported growth from 55 mm to 307 mm TL in 6 months for fish stocked in a small pond near Clifton, Colorado. Two years and seven months after this stocking, the survivors had a mean length of 422 mm. Juveniles of 40 mm TL that were stocked in two stream locations, where they grew an average of 43.4 and 47.5 mm in two months (Brooks 1986). Growth of fish stocked in two isolated backwaters on Bonita Creek Arizona, averaged 6 and 36 mm respectively, in three months (Brooks 1986).

Genetic Diversity

With any rare or endangered species, there is concern about loss of genetic diversity in small or isolated populations. A reduction of genetic diversity is a concern for the razorback sucker not only for extant populations, but also for hatchery stocks as well. Reduced genetic diversity and adaptation to captivity could impair prospects for successful reintroduction of the species.

In a recent study of genetic diversity in hatchery and Lake Mojave stocks, Dowling et al. (1996) found the large stock in Lake Mojave had a high degree of mitochondrial (m_tDNA) diversity (0.97) with all known genotypes of the fish are represented there. This suggests that the Lake Mojave stocks are descended from a large panmictic population. An earlier, preliminary study (Dowling and Minckley 1993) also examined haplotypes, finding evidence of some genetic isolation between Lake Mojave stocks and stocks in the upper basin. Hatchery stocks had lower, but adequate m_tDNA diversity (0.71-0.91; Dowling et al. 1996). Recent monitoring studies of razorback suckers taken as larva from Lake Mojave and repatriated there as older fish indicate that the repatriates represent the same high genetic diversity as the wild stocks (P. Marsh, pers. comm. 1998).

Concern also has been raised about possible genetic introgression in brood stocks proposed for use in reintroduction efforts (Minckley et al. 1991). Allozyme studies of Lake Mojave brood fish and their progeny from Dexter National Fish Hatchery indicated that the degree of hybrid introgression between the razorback sucker and other suckers was no higher than that reported for other catostomid species, i.e., introgression was rare (Buth et al. 1987).

Reasons for Decline

Decline of the razorback sucker has been associated with major changes in its riverine ecosystem. The native fish fauna of the Colorado River basin evolved in a river system characterized by a diverse mix of riverine, floodplain, and lacustrine habitats (Maddux et al. 1993), and an extreme seasonal variation in flow and turbidity (Carlson and Muth 1989). The geographical isolation of the basin led to a high degree of endemism in the fish fauna, especially within the big river fish community (Miller 1961, Minckley et al. 1986). Several of the big river fishes, including the razorback sucker, are now threatened with extinction (Minckley et al. 1991). Decline of the razorback sucker has been so extensive that it now occupies only a small fraction of its historic range. Continuing decline is expected for the near future because there is virtually no recruitment to wild populations, despite successful spawning and dispersal of larval razorback suckers in some locations.

The decline in abundance of the big river fishes has occurred at the same time that major changes occurred in their physical, chemical, and biological environment. Physical changes were primarily a consequence of the construction and operation of the many dams and diversions in the Colorado River basin since 1905. These structures deplete water, alter flow regimes, change water quality, and fragment habitat. Chemical changes are primarily contaminants, which mainly have increased in reservoirs, and increases in the concentration of selenium in impounded areas and in irrigation return flows. At the same time the physical and chemical attribute of the riverine environment was being altered by human actions, the nature and composition of the fish community was altered dramatically by the introduction of nonnative species, many of which did well in the changed environments. As a result, native fish species were confronted with competitors and predators with which they had no evolutionary "experience" (Molles 1980, Johnson et al. 1993). The complexity of the new system, both physically and biologically suggests that recovery of the razorback sucker may necessitate a new viewpoint that considers management of the riverine ecosystem as a whole.

Chanaes in Physical Environment

Construction of water development projects beginning after 1900 has had a major impact on the physical habitat of the native fishes of the Colorado River basin (Fradkin 1984, Carlson and Muth 1989). More than 20 major dams have been constructed on mainstream rivers beginning with Roosevelt Dam on the Salt River in 1911 and ending with closure of Glen Canyon Dam in 1963. By 1963, much of the mainstream river had been converted into a system of dams and diversions. Extensive flow regulations altered the timing, duration, and magnitude of annual flood flows. Modification by impoundment resulted in increasing water clarity and lower water temperatures in downstream sections. In addition, peak discharges in many areas of the Colorado River system have been reduced by about 50% since 1942, and base flows have been increased by 21% (Fradkin 1984).

Diversions from the river systems begin at or above tree line in most sub-basins. In the upper Colorado basin, transmountain diversions take water out of the basin. This water is diverted for agricultural, municipal, and industrial uses, and is also lost from the system by evaporation from reservoirs. Consumptive use data for the river system suggest that, if water usage equates to habitat, fish have to survive on 60% less basinwide, and much less than 60% at specific locations within the system (Brookshire 1993; Maddux et al. 1993).. Flow depletions constitute a major threat to endangered fishes in some areas. For example, historic aquatic habitats once maintained in important tributaries, such as the Salt and Gila, may now be dry.

Construction of large impoundments has changed the distribution of riverine and lacustrine habitats in the basin over a very short time period. The effect is more pronounced in the lower basin. Historically, portions of the Colorado River system have had extensive flood plains that were inundated seasonally. The seasonally flooded bottomland, marshes, and oxbow lakes once were a normal feature of the river system, and presumably were important habitats in the life cycle of the razorback sucker.

By reducing the magnitude and duration of peak flows, impoundments have greatly reduced the extent and duration of seasonal flooding. Channelization and construction of dikes, especially in valleys near human population centers and agricultural areas, also have reduced seasonal inundation of the floodplain (Bestgen 1990). For example, many of the flooded pastures or oxbow lakes in the Grand Valley near Grand Junction have been filled or access has been blocked with dikes (Osmondson and Kaeding 1989). Access has also been blocked on the Green River, where several waterfowl management units have been created by constructing levees along the river and filling the wetlands with water from the river or from irrigation ditches. Through channelization, dams, and diversions, the Gila River drainage has lost much of the habitat that once supported razorback suckers.

Changes in the hydrologic regime also have had more subtle influences on physical habitats. Closure of mainstream impoundments has altered sediment transport and resulted in channel degradation (Lyons 1989). As the river cuts down into the bed of the channel, wetlands and riparian areas can lose their hydrologic connection to the river. Loss of this connection can dry up the riparian areas or reduce water levels so that floodplain habitats are unavailable to the fish.

Changes in the hydrograph also can lead to changes in channel geometry. Reduction in channel width has increased the average velocity in the main channel and decreased the number of low-velocity backwaters (Wick et al. 1982). Important backwater and low-velocity shoreline habitats have been eliminated through siltation and subsequent vegetative growth (Wick et al. 1982). In particular, river shorelines have been altered by establishment of the exotic plant tamarisk (*Tamarix chinensis*). In Canyonlands National Park, the establishment of tamarisk on islands, sandbars, and river shorelines has decreased channel width by an average of 25% (Graf 1978).

Physical structures that have altered flow regime also may be barriers to fish movement. In the Colorado and Green rivers above Glen Canyon Dam, there are five structures which completely block fish movement and two others that block fish movement either partially or seasonally (Burdick and Kaeding 1990). On the San Juan River in New Mexico, there are five diversion structures with the potential to impede fish movement (Platania et al. 1991). The lower basin has at least 15 mainstream dams that block fish movement on the Colorado, Gila, Verde, and Salt Rivers. This accounting is by no means complete, but demonstrates that water development projects have greatly fragmented fish habitat, thus interrupting life cycles.

Flow regulation has had indirect, but significant, effects on water quality in the Colorado River system. The native fish fauna evolved in a warmwater system in which there was extreme seasonal variation in suspended sediment concentration. Reservoirs in the system now trap large quantities of sediment and release clear water. The reduction of sediment load may have effects on the fish fauna that go beyond the alteration of channel geometry. Increased water clarity may have increased vulnerability of younger life history stages of the razorback sucker through predation by introduced, visual predators.

The large impoundments also have had a significant effect on river temperatures. The impounded lakes stratify seasonally and typically release cold hypolimnetic water. The cooler water temperatures resulting from dam operations may exclude endangered fishes from portions of their original range (Vanicek 1967). For example, adult razorback suckers prefer water temperatures between 22-25°C (71.6-77°F) and may avoid water temperatures below 14.7°C (58.5°F) and above 27.4°C (81.3°F) (Bulkley and Pimental 1983). Winter water temperatures drop well below this reported preference range throughout most habitat occupied by razorback sucker in the upper basin, but summer temperatures are generally within the preferred range. However, there are two reaches of the Green and Colorado rivers where spring and summer temperatures are clearly below the preferred range of razorback sucker. The fish is virtually absent below Flaming Gorge Reservoir for 105 km (65 mi) where summer temperatures average less than 15°C (59°F)(Ugland et al. 1987), and below Lake Powell for 384 km (238 mi) where summer water temperatures rarely exceed 15°C (59°F)(Carothers and Minckley 1981).

In some portions of the historic razorback sucker range, temperatures may now be too cold for survival of fertilized eggs (Marsh, pers. comm. 1996). Marsh (1985) reported an optimal temperature of 20°C for incubation of razorback sucker eggs in the laboratory; hatching success was lower at 15°C and hatching failed completely at 5" and 10°C. Bozek et al. (1990) reported similar results.

Chemical Chanaes

Changes in water quality also are associated with an increasing human presence. Environmental contaminants may be introduced from municipal or industrial point source discharges, or from non-point sources associated with agricultural activity or resource extraction. The threat posed by environmental contaminants has not been studied adequately. Preliminary results from one study show that exposing young razorback suckers to agricultural drainage from areas near the Green River can produce mortality in the range of 30 to 50% (Bruce Waddell, US Fish and Wildlife Service, pers. comm. 1993). The specific agent responsible for the mortality has not yet been identified, but trace elements or metals are possibilities. For example, at the Stewart Lake Waterfowl Management Area near Jensen, Utah, concentrations of boron, selenium, and zinc in water, bottom sediments and biological tissues (Stephens et al 1992) were sufficiently high to be harmful to fish and wildlife (e.g, Ostler 1985).

Selenium has probably received more attention than other environmental contaminants that may be harmful to razorback suckers. Hamilton and Waddell (1992) reported values of 3.7, 4.7, and 10.6 μg/g dry weight for selenium in eggs of razorback suckers collected from fish spawning in the Green River. Waddell and May (1995) reported selenium concentrations of 24-54 μg/g dry weight in muscle plugs collected from Green River razorbacks. Concentrations that high have caused poor growth and reproductive failure in other fishes (Gillespie and Badman 1986). High selenium levels also occur in backwater habitats along the Colorado and Gunnison rivers, and preliminary data suggest that the selenium concentrations in some areas are high enough to cause reproductive failure in razorback suckers (S.J. Hamilton, USGS Biological Service, pers. comm. 1996).

Because razorback sucker recovery will require the use of some of the large reservoirs in the Colorado River system, it is pertinent to understand threats of environmental contaminants that also may occur. As an example, one area that has been intensely studied is the effect of drainage from Las Vegas Valley on the limnology of Lake Mead, Arizona and Nevada. Contaminants there include organochlorines, polycyclic aromatic hydrocarbons (PAHs), and phenols (Bevans et al. 1996). Using common carp as a surrogate fish for razorback sucker, Bevans et al (1996) found necrotic changes in kidney and hepatopancreas tissues, evidence of long-term exposure to environmental contaminants. In addition, there were significant differences in the endocrine systems of both female and male fish attributed to exposure to compounds that alter the function of the endocrine system associated with reproduction and recruitment. Due to a lack of mixing in Las Vegas Wash within Lake Mead (LaBounty and Horn 1997), there is concern that these contaminants are also being transported downstream into the mainstream Lower Colorado River. The discovery of perchlorates, likely originating from Lake Mead, as far downstream as Lake Havasu (R.D. Williams, personal communication, 1998), suggests that contaminant problems in Lake Mead may pose a threat to razorback sucker recovery downstream.

Changes in the Biological Environment

In many areas, nonnative fishes are the most significant threat to survival of the razorback sucker. Nearly 70 nonnative fish species have been introduced actively or passively into the Colorado River system during the last 100 years (Minckley 1982, Tyus et al. 1982, Carlson and Muth 1989, Minckley and Deacon 1991, Maddux et al. 1993). As demonstrated by Moyle and Light (1996) biotic resistance to invasions by native fishes appears to play only a small part in limiting the success of invading species. More important appears to be the suitability of the hydrologic regime and perhaps other physicochemical factors. In natural systems, rapid extinctions of native fishes seldom occur. However, some invading species may be "preadapted" to changed conditions, and native fish populations can be extirpated from waters that have been greatly modified by humans. Such extirpations can be anticipated where native populations have been "depleted, disrupted or stressed" (Moyle and Light 1996).

Creation of the US Fish Commission in 1872 is thought to be the beginning of organized stocking initiatives for the Colorado River basin (Miller 1961). The original motivation for fish stocking included, among other justifications, an attempt to "benefit" the relatively "depauperate" Colorado River fauna (e.g., Jordan 1891). Several species including common carp, channel catfish, and largemouth bass were introduced prior to 1900 (e.g., Wiltzius 1985). In the two decades prior to 1950, at least 36 fish species, mostly game fishes from the eastern US, were introduced in the basin (Miller 1961). By 1980, more than 50 nonnative species had been actively introduced into rivers and reservoirs of the Colorado River basin (Minckley 1982, Tyus et al. 1982, Carlson and Muth 1989).

The primary reason for most intentional introductions was the desire to expand or enhance sport fishing opportunities. Other reasons for fish introductions include providing forage fish for game species, biological control of unwanted pests, and aesthetic or ornamental purposes (reviewed by Taylor et al. 1984). Even though most stocking in the river channels has been curtailed, nonnative fishes continue to enter the river channel through escapement from adjacent water bodies or by recruitment from the mainstream populations (Tyus and Saunders 1996).

For more than 50 years, researchers have expressed concerns about the role that nonnative fishes have played in causing the decline of native fishes in the Colorado River basin. Dill (1944) was one of the first to suggest that nonnatives were responsible for the observed declines in native fish populations in the lower basin. He traced the decline to about 1930 and observed that it was coincident with a large increase in the abundance of nonnative fishes, especially channel catfish and largemouth bass. By 1960, Miller (1961) noted that the "most impressive documentation for changing fish fauna" occurred in the lower Colorado River where it was associated with a replacement by introduced fishes. Schoenherr (1981) believes the evidence was "overwhelming" that native fishes were being replaced by aggressive, introduced fishes. A decline in the abundance of native fishes as nonnative species have increased in abundance has been documented by many workers (e.g., Joseph et al. 1977, Behnke 1980, Osmondson and Kaeding 1989, Quaterone 1993).

A substantial body of indirect evidence exists for predation by nonnatives on the razorback sucker. Marsh and Langhorst (1988) reported that larval razorback suckers in Lake Mojave survived longer and grew larger in the absence of predators. Loudermilk (1985) observed that young larvae exhibited little defensive behavior in the presence of potential predators. Johnson et al. (1993) compared predator avoidance of razorback sucker larvae with that of northern hog sucker (*Hypentelium nigricans*) and concluded that "larval razorbacks are not likely to survive in habitats that support high numbers of nonnative fishes." Smaller nonnative species such as red shiner and fathead minnow may attack or display agonistic behavior toward razorback sucker larvae (Karp and Tyus 1990), and young of some of the more aggressive game fish also are problematic because they are highly agonistic (Sabo et al. 1996).

Several nonnative fishes, including green sunfish, common carp, and flathead and channel catfish, have been observed feeding on eggs and/or larval razorback suckers (Medel-Ulmer 1983, Minckley 1983, Brooks 1986, Langhorst 1989, Marsh and Langhorst 1988, Marsh and Brooks 1989). Karp and Tyus (1990) reported results of predation experiments in which several nonnative species were offered razorback sucker larvae in 4-minute trials: green sunfish consumed 90% of the larvae offered; red shiner, 50%, and redside shiner, 10%. A field experiment in Lake Mojave provided indirect evidence of predation by monitoring larvae in habitats with and without predators. Razorback sucker larvae up to 30 mm long occurred in the predator-free environment, but larvae exposed to predation did not exceed 1 O-l 2 mm, implying that predators removed the larger larvae (Brooks 1986, Langhorst 1989, Marsh and Brooks 1989). In addition, laboratory studies have also shown that razorback sucker larvae may face predation by native invertebrate species, such as odonate nymphs, which are common in backwater areas of Lake Mojave (Horn et al. 1994).

Direct observations, including stomach content analyses, of predation by nonnatives on razorback suckers have been reported by many investigators (Table 1). The list is extensive and should leave no doubt that predation by nonnatives is significant. Part of the difficulty in documenting predation on larvae in early studies is that the rapid digestion of some of the centrarchid fishes was not appreciated. Langhorst and Marsh (1986) found that razorback sucker larvae were only distinguishable in stomachs of green sunfish (*Lepomis cyanellus*) for about 30 minutes. After that time the larvae were dissolved.

It is now thought that introduced nonnative fishes are the most important biological threat to the razorback sucker. At one time, there was concern about hybridization between the razorback sucker and other riverine suckers (e.g. Wick et al. 1982). Although recent work has largely dismissed that concern that hybridization poses a threat to the existence of the razorback sucker in the present system (reviewed by Minckley et al. 1991), the potential remains. The exotic parasitic copepod *Lernaea cyprinacea* (anchor worm) has been implicated as a factor in lack of successful razorback sucker reintroduction efforts in the Verde River (Clarkson et al. 1993), but there is no evidence that diseases or parasites have played a major role in its endangerment (Flagg 1982). However, the possibility of further introduction of foreign parasites and diseases remain. Finally, competition for food also may be a mechanism by which nonnatives limit the success of razorback sucker populations (Papoulias and Minckley 1990).

Relative Importance of Physical, Chemical , and Biological Factors

Native big river fishes have disappeared from about three-fourths of their original range during a time when there have been major alterations to physicochemical and biological conditions in the Colorado River system. Thus, the relative importance of physical, chemical, and biological changes in producing a decline in the fish is uncertain. However, even in the present system there are locations where physical habitat has been altered relatively little, such as in the Yampa River, but the abundance of native fishes has declined while nonnative fishes have become abundant. This suggests that natural physical habitat conditions are a necessary, but not a sufficient condition for recovery of the razorback sucker in its present environment. Although it is obvious that suitable physical habitat is a requirement for the native fishes, the suitability of the physical habitat is not the only issue. Most suitable physical habitat now is occupied by introduced species, including many that are predaceous and highly competitive, and therefore harmful to the native fish fauna (Minckley 1982, Tyus et al. 1982, Carlson and Muth 1989, Tyus and Saunders 1996). An increasing number of chemicals have entered the Colorado River system, but the effect of chemicals on the decline of razorback suckers is not very n the system is not understood.

Introduced Predator	Reference
channel catfish	Medel-Ulmer 1983, Minckley 1983, Bozek et al. 1984, Brooks 1985, Langhorst 1987, Marsh and Langhorst 1988, Marsh and Brooks 1989, Marsh and Minckley 1989
common carp	Jonez and Sumner 1954, Medel-Ulmer 1983, Minckley 1983, Bozek et al. 1984, Brooks 1985, Langhorst 1987, Marsh and Langhorst 1988, Marsh and Brooks 1989, Marsh and Minckley 1989
green sunfish	Langhorst and Marsh 1986, Medel-Ulmer 1983, Minckley 1983, Bozek et al. 1984, Brooks 1985, Langhorst 1987, Marsh and Langhorst 1988, Marsh and Brooks 1989, Marsh and Minckley 1989, Muth and Beyers, in press
sunfishes	Mueller 1995
largemouth bass	Mueller 1995
flathead catfish	Medel-Ulmer 1983, Minckley 1983, Bozek et al. 1984, Brooks 1985, Langhorst 1987, Marsh and Langhorst 1988, Marsh and Brooks 1989, Marsh and Minckley 1989

Table 1. Summary of citations for direct evidence of predation by nonnatives on razorback suckers in the Colorado River basin.

In the proximate sense, populations of razorback suckers have declined because recruitment has been insufficient to maintain population numbers. Some reduction in recruitment is attributable to alterations to the physical habitat, or reduced access to suitable habitat. But even with major modifications to physical conditions, razorback suckers continue to spawn in riverine and lacustrine habitats. A number of investigators have collected viable embryos and/or larvae in areas where razorback suckers have been observed spawning (Bozek et al. 1984, Medel-Ulmer 1983, Marsh and Langhorst 1988, Tyus 1987, Mueller 1989), but few have collected larvae larger than 14 mm. Many small larvae are collected in certain areas (e.g. Lake Mojave), but the small number of larger larvae and juveniles suggests that recruitment is curtailed at this point. The failure of adequate recruitment is largely attributable to predation by nonnative fishes (Minckley et al. 1991, Johnson et al. 1993, Tyus and Saunders 1996).

Razorback suckers now exist in areas where the populations are geographically isolated. With the possible exception of the population in Lake Mojave, all razorback sucker populations are small. Small, isolated populations (isolates) are very susceptible to "faunal collapse," a phenomenon that has been observed when such isolates are invaded by nonnative species (Wilcox 1980, Frankel and Soulé 1981). Increasing fragmentation of the Colorado River system presents problems that are presumably very similar to those observed in isolates elsewhere, where declining habitat diversity and introduction of new predators are main reasons for declines of native species (e.g., see Frankel and Soulé 1981). Thus, the impact of nonnative fishes is considered a significant detriment to isolates of a once larger Colorado River native fish community (reviewed by Tyus and Saunders, 1996).

Conservation and Recovery

Recovery Planning

Recovery plans, written under the authority of Section 4 of the Endangered Species Act, guide recovery activities. A recovery plan promotes conservation and provides the steps required for delisting species. In addition, a recovery plan provides guidance for implementing recovery actions and establishes priorities for those actions.

The Act incorporates several measures to promote conservation of listed species, making the conservation of endangered species a high priority of Federal agencies (Section 2). The act also aids recovery by identifying the status of a species by listing and identification of critical habitat (Section 4), providing Federal grants to States (Section 6), requiring Federal agencies to engage in conservation activities (Section 7), prohibiting the unauthorized take of listed species (Section 9), requiring permits to enhance survival of listed species (Section IO), and other means (e.g., research, land acquisition, etc.). All of these measures are brought into action by recovery planning, and the completion of recovery plans.

Recovery actions outlined in this plan will be implemented by various agencies guided by the USFWS and its cooperators, including the Colorado River Fishes Recovery Team, and recovery implementation programs. Recent policy (i.e., USFWS and National Marine Fisheries Servicel994) dictates that recovery of the four listed fishes in mainstream rivers of the Colorado River system should be accomplished using a multispecies, or aquatic ecosystem approach. The rationale for this approach is that all four species are declining for similar reasons, and that a functioning native ecosystem would provide a desirable degree of stability for recovery of the fishes . An ecosystem perspective is not typically used in recovery plans for individual species, but is crucial for integrating recovery efforts for all four species. A multispecies recovery plan has been drafted by the USFWS, but has not yet been accepted by the Colorado River Fishes Recovery Team. A multispecies plan would potentially have a different set of recovery priorities based on the need for recovery of the fish community rather than only one species. In addition, such a plan could integrate ongoing recovery implementation efforts for the four fishes within the Colorado River basin and facilitate a speedier recovery for the fish community than would have been possible with single species plans alone.

Review of Recovery Actions

The razorback sucker has long been considered a species at risk (Miller 1964, 1972; Minckley and Deacon 1968; Ono et al. 1983). It was placed on a list of threatened fishes by the American Fisheries Society in 1972 (Miller 1972). The razorback sucker was proposed for listing on April 24, 1978 (43 FR 17375), but this proposal was withdrawn on May 27, 1980 (45 FR 35410). The Sierra Club, National Audubon Society, The Wilderness Society, Colorado Environmental Coalition, Southern Utah Wilderness Alliance, and the Northwest Rivers Alliance petitioned the USFWS to list the fish as an endangered species on March 14, 1989. A proposed rule to list the fish as endangered was published in the Federal Register on May 22, 1990 (55 FR 21154), and a final rule listing the fish was published on October 23, 1991 (56 FR 54957). Critical habitat for the razorback sucker, and three other listed Colorado River fishes, was designated by publication of a final rule on March 21, 1994 (59 FR 13374); the most recent list of previous Federal actions and a listing chronology are provided in the final rule. The states of Arizona, California, Colorado, Nevada, and Utah had provided legal protection for the razorback sucker by 1987 (Minckley et al. 1991).

In 1987, after several years of study, a Recovery Implementation Program was initiated by several cooperating agencies and interests with the goal of recovering the endangered fishes in the upper Colorado River basin while allowing water resources development to continue. The razorback sucker, although not Federally listed at that time, was included in the program (USFWS 1987). More recent recovery activities in the upper basin have been conducted by the San Juan River Basin Recovery Implementation Program (USFWS 1995) and by programs of various state and other agencies (reviewed by Minckley and Deacon 1991).

Efforts to reintroduce razorback suckers in the lower Colorado River basin began in 1981 with a memorandum of understanding between the Arizona Game and Fish Department and the US Fish and Wildlife Service (1981-I 987 stockings reviewed by Minckley et al. 1991). Similar, but less extensive, reintroduction programs have been conducted by the states of California and New Mexico. In addition, some partnership programs have emerged such as the Lake Havasu Fisheries Improvement Program, which has agreed to release 30,000 sub-adult razorback sucker into Lake Havasu by the year 2003 (J. Provencio, U.S. Bureau of Land Management, pers. comm. 1998).

Reintroduction efforts began during the 1980s when over 12 million small razorback suckers were stocked in the rivers of the lower basin (Mueller 1998). Very few of these stocked fish were recaptured in subsequent years, despite considerable monitoring effort. Because survival of young fish was very low (Minckley et al. 1991), recent stocking efforts have used larger razorback suckers. The most extensive razorback sucker augmentation effort now in progress is in Lake Mojave (summarized by Mueller 1995, 1997). Biologists are rearing the larval fish captured from lakeside backwaters of Lake Mojave and returning the larger juveniles back into the lake. About 15,000 of these “repatriated” juvenile razorbacks have been stocked in Lake Mojave since 1992. Annual monitoring has indicated that recaptures of repatriates ranges from a “few” to nearly half of all the razorback suckers captured, and ripe fish of both sexes have been recaptured on spawning grounds in the lake (P. Marsh, personal communication 1998). Although razorback suckers also have been reintroduced in Lake Havasu, reintroduction efforts there have been hampered by poor survival of the fish (i.e., 0.005%) in grow out facilities (Doelker and Conner 1998). A total of 2,360 razorback suckers were released into Lake Havasu from 1994 to 1997 (Doelker and Connor 1998).

The behavior and habitat use of hatchery-reared razorback suckers reintroduced into various locations have been monitored by biotelemetry. This includes studies in lakes Mojave and Powell where many of the fish have survived for over one year (e.g., Mueller 1998). Hatchery-reared razorbacks also have been radiotracked in the Gila and Verde rivers, but none of those fish survived over a year (P.B. Marsh, pers. comm. 1996; Creef and Clarkson 1993). Survival of reintroduced fish in the San Juan River has been more successful and razorback suckers there have survived for at least two years (Ryden and Pfeifer 1995). Augmentation plans have been developed recently for various locations in the upper Colorado River Basin (e.g., Modde et al. 1995, Nesler 1997).

<u>Critical Habitat</u>

A central feature of the recovery program for the razorback sucker is the designation and protection of critical habitat. Critical habitat (defined in section 3[5][A] of the Act) includes locations within the geographical area occupied by the species that contain physical or biological features essential to the conservation of the species, and that may require special management considerations or protection. Critical habitat may also include locations outside the area currently occupied by the species, when such locations contain physical or biological qualities essential for its conservation. These physical or biological qualities are “primary constituent elements”.

There are five features of critical habitat that require special management or protection for recovery of the razorback sucker: space for growth and normal behavior; food, water, or other nutritional or physiological requirements; cover or shelter; breeding and rearing sites; habitats protected from disturbance or representative of geographical and ecological distributions. These features generally fall into three areas that are considered primary constituent elements: water, physical habitat, and the biological environment (Maddux et al. 1993).

The “water” element includes consideration of water quality and quantity. Water quality is defined by parameters such as temperature, dissolved oxygen, environmental contaminants, nutrients, turbidity, and others. Water quantity refers to the amount of water that must reach specific locations at a given time of year to maintain biological processes and to support the various life stages of the species.

The “physical habitat” element includes areas of the Colorado River system that are or could be suitable habitat for spawning, nursery, rearing, and feeding, as well as corridors between such areas. Habitat types include bottomland, main and side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated may provide habitat or corridors to habitat necessary for the feeding and nursery needs of the razorback sucker.

The “biological environment” element includes living components of the food supply and interspecific interactions. Food supply is a function of nutrient supply, productivity, and availability to each life stage. Negative interactions include predation and competition with introduced nonnative fishes.

The Service determined critical habitat for the razorback sucker in a final rule published on March 21, 1994 (59 FR 13374). Fifteen river reaches covering about 49% of the historic habitat of the razorback sucker (1,724 mi.) were designated within the Colorado River basin (Figure 3). Included are portions of the Green, Yampa, Duchesne, Colorado, White, Gunnison, and San Juan rivers in the upper Colorado River Basin, and portions of the Colorado, Gila, Salt, and Verde rivers in the lower Colorado River Basin. The designated areas contain habitats within the 100 year flood plain that will meet the needs of the razorback sucker as defined by primary constituent elements. As an integral park of making the critical habitat determination, the USFWS also has produced a Biological Support Document (Maddux et al. 1993) and an economic analysis (Brookshire et al. 1994).

The 15 reaches of critical habitat for the razorback sucker are described below with a brief summary of features important to the various life history stages. Legal descriptions of those areas are given elsewhere (USFWS 1994). Nonnative fishes, may cause mortality of razorback sucker larvae (Bruce Waddell, USFWS, pers. comm. 1993). Although predaceous game fish occur in this reach the States of Colorado and Utah have removed bag and possession limits to encourage their removal.

RZ3: Green River section from Sand Wash to the Colorado River.

The lower portion of the Green River, which now contains a small population of razorback suckers, may provide important nursery habitat when water levels are high enough to flood bottomland. However, flow regulation by upstream reservoirs has prevented inundation of nursery habitat and may restrict movements of razorback sucker from main river channels to flooded areas. This reach may facilitate genetic exchange between razorback sucker populations in the Colorado River and the Green River. This reach is under close evaluation as a recovery area due to the presence of newly hatched razorback sucker larvae.

RZ4: Lower 18 miles of the White River.

This reach contains seasonally flooded habitat and may be used by razorback suckers from the adjoining Green River. Historic flow patterns of White River below Rangely, Colorado, were altered by construction of the Taylor Draw Dam, which poses a complete barrier to fish migration. Water quantity is acceptable for razorback suckers, but the potential for degradation of water quality by various industries along the river should be investigated. Although predaceous game fish occur in this reach the State of Utah has removed bag and possession limits to encourage their removal.

RZ5: Lower 2.5 miles of the Duchesne River.

This reach is presently used by razorback suckers and is presumably an important staging area for fish spawning in the mainstream Green River (Tyus and Karp 1990). Water diversions, which have eliminated habitat upstream, continue to threaten the remaining habitat in this reach. Several proposed diversion projects would further threaten flows.

RZ6: Gunnison River from Redlands Diversion to Uncompahgre River.

Upstream reservoirs (Taylor Park Dam and the Aspinall Unit) have changed the timing of runoff flows, but water use is mainly nonconsumptive and most of the water still flows down the Gunnison River. The Fish and Wildlife Service and the Bureau of Reclamation have been working to manage reservoir releases to mimic the shape of the natural hydrograph. A formal agreement is expected in 1998 with completion of a Biological Opinion. Adequate flows are maintained in most of the reach because the Redlands Diversion Dam has a senior water right. However, the 2.3 miles of river below the dam have been completely dewatered in the past. A recent MOU between the Fish and Wildlife Service, Bureau of Reclamation, and Gunnison River water users will guarantee a minimum flow of at least 300 cfs below the Redland diversion at all times. Completion of fish passage around the Redlands diversion dam in 1996 allows fish movement between this reach and the Colorado River..

RZ7: Colorado River from Rifle, Colorado to Westwater Canyon.

The Colorado River near Grand Junction contains adult razorback suckers and there is some evidence of spawning. Physical habitat is suitable for razorback suckers, but the Government Highline Dam at the lower end of DeBeque Canyon and the Price-Stubb Dam downstream completely block upstream movements. Fish passage structures have been completed for the downstream Grand Valley Diversion, and are being discussed for these other sites. Flows below these structures are greatly altered from the natural hydrograph and the river channel is constrained by dikes and riprap. Management actions have been taken to provide water to the reach and to restore parts of the floodplain. Selenium levels are high in some areas. Although predaceous game fish occur in this reach the State of Colorado has removed bag and possession limits.

RZ8: Colorado River from Westwater to the Dirty Devil River.

Razorback suckers are present in this reach and were historically abundant in this portion of the Colorado River. Although the reach contains bottomland and other habitats, inadequate water quantity and nonnative fish species threaten to the small population of razorback sucker in this reach.

RZ9: San Juan River from Hogback Diversion to Neskahai Canyon.

Anecdotal information from long-time area residents indicated that razorback sucker once occurred as far upstream as the Animas River (L. Ahlm, NM Dept. of Game and Fish, pers. comm.). Habitat has been fragmented by construction of diversion structures and degraded by associated water depletions. The flow regime is now regulated by Navajo Dam, and channel geometry has been altered by establishment of nonnative tamarisk and Russian olive. Water quality has been degraded by discharges from domestic, agricultural, and industrial sources. Nonnative fish species have become established throughout the reach, and they compete with and prey on the native fish fauna. Despite the alterations, some suitable habitat remains for the razorback suckers (Bliesner and Lamarra 1995, 1996; Ryden and Pfeifer 1995).

RZ10: Colorado River from Paria River to Hoover Dam.

This segment of the Colorado River contains riverine and lacustrine habitat. The riverine portion below Glen Canyon Dam consists of cold, high-velocity water, with some pools and long runs through the Marble and Grand canyons. The dam controls the quality and quantity of water in the reach, and habitat conditions can change drastically due to reservoir operation. In contrast, Lake Mead provides deep water, shallow bays, and cove habitats. These low velocity areas have suitable temperatures for all life stages and physical habitat for adults. However, the reach, and especially Lake Mead, also contains many nonnative predators. The USFWS is presently consulting with the Bureau of Reclamation to potentially change management of Glen Canyon to improve downstream conditions for razorback sucker.

RZ1 1: Colorado River from Hoover Dam to Davis Dam.

The largest known population of razorback suckers (about 25,000) occurs in Lake Mojave. Flows into Lake Mojave are controlled by the releases from Hoover Dam. This population of razorback suckers provides almost all hatchery stocks and has been the focus of extensive research on population genetics, parasites, disease, and many other aspects of razorback life history. A reintroduction program is presently underway.

RZ12: Colorado River from Parker Dam to Imperial Dam.

Extensive construction for water development projects and other physical habitat alteration has occurred along this reach. Several diversion dams impose partial and seasonal barriers to fish migration. Water quality has been altered by increased salinity due to water re-usage and lower temperatures from hypolimnetic release. However, water temperatures below Parker Dam are higher than tailrace temperatures below Glen Canyon or Hoover Dam. Portions of the channel have been stabilized or channelized, but suitable habitat (i.e., unmodified channel, backwaters, and gravel bars) is still available for all life stages of the razorback sucker and the presence of 1 I- to 12-inch juveniles in canals and drainage ditches provides evidence of successful spawning within this reach. Recruitment to the population is probably suppressed due to predation by nonnative fishes.

RZ13: Gila River from Arizona/New Mexico state line to Coolidge Dam.

Razorback suckers were extirpated from this reach by the 1950s. Water quantity and quality appears acceptable for razorback suckers from Safford, Arizona, to the confluence with the San Francisco River. However, hatchery-reared juveniles have been stocked into the Gila River and tributaries since 1981, but apparently with little success. Water depletion in this reach is extreme, and reservoirs may nearly dry up during periods of drought but pools in the main channel and tributaries can provide some habitat during low flow periods.

RZ14: Salt River from the US 60/SR 77 bridge to Roosevelt Lake.

Razorback suckers were extirpated from the Salt River by the 1960s. A cooperative effort was started in 1981 to reintroduce the species, apparently with little success. Hydrologic conditions, water quality, and physical habitat have remained similar to the historic, natural conditions of this reach. However, as in other areas, the threats to recovery are mainly the many introduced fishes (including the highly predaceous flathead and channel catfishes)..

RZ15: Verde River from Prescott National Forest Boundary to Horseshoe Lake.

Wild razorback suckers have not been reported from the Verde River since 1954. Hatchery-raised individuals have been stocked since 1981, but the reintroduction apparently was not successful until recently, when larger individuals were stocked (K. Young, personal communication, Arizona Game and Fish Department). Flows within this reach have been altered by several diversion projects, but water levels remain adequate. Water quality parameters such as salinity, nutrients, and temperature have been changed, but remain within tolerance of aquatic species. The presence of nonnative fishes and heavy infestation of parasitic copepods have hampered reintroductions of razorback suckers in the Verde River (Creef and Clarkson 1993, Clarkson et al. 1993).

Critical habitat areas RZ1, RZ2, RZ3, and RZ9 overlap with critical habitat designated for the other big river Colorado River endangered fishes. RZ4, RZ6, RZ7, and RZ8 overlap with designated Colorado pike minnow area. RZ10 and RZ11 overlap with humpback chub and the bonytail chub areas respectively. Critical habitat designations RZ14 and RZ15 are areas where experimental, non-essential populations for the Colorado pike minnow have been authorized. RZ15 also overlaps with proposed critical habitat for the threatened spikedace, *Meda fulgida*.

Taraet Population Numbers

Recovery plans strive to present recovery objectives in quantified terms. However, it is difficult to determine needed population sizes of an endangered species because the species is almost always a rare one, which makes data difficult to obtain. Thus, the means for determining what population sizes are needed to facilitate down listing or delisting are often lacking.

The development of quantitative recovery goals will require determining population sizes of the fish in various locations that can be expected to persist over time, i.e., wild populations that would be "viable" in nature. In order for down listing or delisting to occur, a species would have to maintain populations for some time period, during which it would be expected to survive natural and anthropogenic threats. Although minimum population sizes needed to maintain populations of domestic animals or captive populations for a number of generations have been determined, minimum population sizes needed to maintain wild species are less well understood. Target population sizes for populations of the endangered big-river fishes used in this document were provided by the Colorado River Fishes Recovery Team and accepted by USFWS. These population numbers represent the best professional judgement and fall within the range of ". . . several thousand to 10,000 . . ." thought to provide minimum viable population sizes to sustain wild populations (reviewed by Thomas 1990). However, more specific population targets are being developed for portions of the upper Colorado River basin (e.g., Crowl and Bouwes 1997). At present these target sizes are preliminary and have not been accepted by USFWS. Recovery plans can be updated as necessary when final population targets are developed and accepted. It is anticipated that it will take several years before such numbers are finalized. Although population targets must be based on genetic requirements, they also must consider how the population viability of wild populations are affected by existing conditions and how they might be threatened by new changes.

Ecosystem Recovery

The USFWS and NMFS (1994) has identified ecosystem recovery as an integral part of endangered species recovery program and the USFWS funded preparation of a draft multi-species recovery plan for the Colorado River fishes in 1996. This multi-species plan is preliminary and has not been approved by the Colorado River Fishes Recovery Team. However, it is assumed that a multispecies or ecosystem recovery plan will eventually be forthcoming.

Critical habitat designation will play an important role in maintaining the natural ecosystem. However, as important as critical habitat determination and management has been as a recovery tool, there is still a need for management of the riverine ecosystem due to widespread, continuing anthropogenic changes. Single species recovery remains important, but continuing habitat change and the complexity of riverine ecosystems suggest that recovery of the endangered Colorado River fishes should also include a more holistic approach.

Part II. RECOVERY

Organization and Priorities

The Colorado River Compact divided the Colorado River system into upper and lower basins at Lees Ferry, AZ in 1922. This legacy is so strong and pervasive that it makes a logical point of departure for organizing recovery efforts. In addition, institutional recovery frameworks are roughly aligned along an upper-lower basin axis, such as the Upper Colorado River Basin Recovery Implementation Program (operational), and the Lower Colorado River Multispecies Conservation Program (still in an early stage of planning). The San Juan River basin is the exception because it has its own Recovery Implementation Program.

Recovery objectives and criteria for the razorback sucker can best be accomplished using a two-basin concept: the upper and lower Colorado River basins. This concept recognizes fundamentally different approaches to recovery that may be needed in these two locations, and also that different entities assume primary responsibilities for different parts of the basin. Priorities for recovery within each basin will be established on the basis of important extant populations and recovery areas for which critical habitat evaluations suggest high potential. The designation of priorities does not exclude other populations or critical habitat from the protection afforded by the Act, but does provide a mechanism for focusing attention and resources on recovery actions needed in the most promising locations.

Recovery Goals

The short-term goal for recovery of the razorback sucker is to prevent extinction. The goal shall be attained when the continuing decline of the three extant stocks of the razorback sucker in Lake Mojave (Arizona and Nevada), and in the lower Yampa River (Colorado) and middle Green River (Utah) has been reversed, as indicated by increasing population sizes produced by natural recruitment.

The long-term goal is to recover the fish to the point that it may be down listed and then delisted. Fragmentation of the habitat of this species by construction of dams and diversion has resulted in isolated populations and recovery areas. Because of continuing environmental change, prudence dictates that the safety of this species will require recovery of a number of these isolates. After the short-term goal is attained, down listing will be possible when populations have been established and protected in the lower Green and San Juan rivers, and one additional population has been established and protected in the upper or lower basin. After the fish has been down listed to threatened, delisting will be possible when a total of two additional populations, one in the upper and one in the lower basin (i.e., a total of five new or recovered populations in addition to the three extant populations) have been established by natural recruitment and protected.

Recovery Criteria

When the following criteria have been met, the short-term goal will have been met:

1. Decline of the extant stock of the razorback sucker in Lake Mojave, Arizona and Nevada, has been reversed by management action, and the population reaches a sufficient size that genetic diversity is protected. The target size is 50,000 or more adult fish, and this abundance must be maintained or exceeded by natural recruitment for at least 5 years.

2. Management actions result in a razorback sucker population size of 5,000 adult fish in the lower Yampa-middle Green river stocks, with adequate numbers of naturally-recruited immature fishes to sustain this target adult population size for 5 years.

3. Management practices must be developed and instituted to improve biological (adverse nonnative fish interactions) and physical habitat conditions (e.g., flow regime, temperature, turbidity) to prevent further degradation habitats used by the populations listed under criteria 1-3.

Because of ongoing studies of the razorback sucker, population objectives stated for the short-term goal will be reviewed periodically and modified as needed for recovery of this species.

After the short-term goal has been achieved, down listing of the species may be considered when the following conditions are met:

1. Management actions result in a razorback sucker population size of 2,000 wild-produced adult fish in the lower Green River, with adequate numbers of naturally-recruited immature fishes to sustain the target adult population size for 5 years.

2. One additional population is recovered or established in the upper basin and one additional population is recovered or established in either the upper or lower basin.

3. All three of these additional populations shall reach a sufficient size to maintain genetic diversity and to be relatively secure from potential threats (to be determined by USFWS with advice of the Colorado River Fishes Recovery Team) and they shall receive legal protection necessary to insure their long-term survival. These populations must equal or exceed and identified threshold size for at least 5 years by means of natural recruitment. On the basis of critical habitat information, promising areas in the lower basin may include the Salt River (RZ14) and the Verde River (RZ15). Promising areas in the upper basin may include the Colorado (RZ7), Gunnison (RZ6), and San Juan (RZ9) rivers.

After the species has been down listed to threatened, delisting of the species may be considered when the following conditions have been met:

1. A total of two additional populations of the fish have been recovered or established under the criteria for down listing. One of these additional populations shall be in the upper basin and one in the lower basin, and also shall have the necessary management programs established to protect and, if necessary, manage habitats to ensure the long-term survival of the razorback sucker populations.

2. By the time all conditions have been met for delisting, there will be eight razorback sucker populations in the Colorado River basin that are secure from known threats and legally protected from anticipated future threats to their persistence as viable populations.

In addition to the recovery criteria specified above, recovery efforts might benefit from the establishment of natural (i.e., wild) refugia for razorback suckers. At times, there is excess hatchery production of the fish with no place to keep these fish. It has been suggested that such fish be marked to record genetic identity and placed in isolated areas where there is little chance of mixing with other stocks (R.S. Wydoski, USFWS, pers. comm., 1996). This concept has merit from several standpoints: a supply of fish for future efforts of recovery programs, a reduction of expense for holding the fish, and an opportunity to learn about survival and behavior of hatchery fish. One such area that has already been stocked with excess hatchery fish is Lake Powell (USFWS unpublished permitting records, Denver, CO). This area appears to be well suited because of its semi-isolation from other upstream and downstream populations. Stocking of fish in Lake Powell presently is occurring under terms of a MOU signed by cooperating agencies (J. Hamill, pers. comm. 1996).

Recovery Priorities

The stepdown outline and narrative of this plan are based on five priorities as described below. These priorities are necessary for directing the allocation of recovery efforts, but should not be regarded as immutable indefinitely. Experience has shown that planning should be strategic (rather than tactical) and should have a relatively short time horizon, because of the very precarious status of endangered species (Clark et al. 1994). As actions are taken and new information is obtained, this plan must be sufficiently flexible to allow changes of direction in the inherently unpredictable business of managing an endangered species.

This razorback sucker recovery plan has been drafted in an attempt to avoid some of the problems caused by an inflexible, tactical approach. It has been written as a brief strategic plan to provide incentives and a vehicle for development of conservation activities involving many interested parties. Conservation of endangered species requires state-of-the-art efforts that may be urgent, risky, complex, and costly. Thus, it is intended that implementation of the priority items in the plan be guided, rather than constrained by the stepdown provided. Existing recovery implementation programs can provide flexibility in recovery of endangered species and work planning efforts of those programs, where they exist, will constitute some of the geographic implementation of this plan.

The following priorities are ranked in order of importance. The most urgent task (Priority 1) lists the actions considered necessary for preventing extinction of the razorback sucker. The next most urgent task (Priority 2) lists the actions considered necessary for recovery, down listing, and delisting. The remaining, and less urgent, tasks detail the long term actions necessary to meet other recovery objectives relating chiefly to population maintenance: management plans (Priority 3), habitat protection (Priority 4), and improved communication (Priority 5).

Priority 1. An action that must be taken to prevent extinction in the immediate future, and to prevent the species from declining irreversibly in the foreseeable future.

Priority 2. An action that must be taken to prevent a significant decline in the number of extant populations and needed habitats of this species, and to allow recovery to a less endangered status.

Priority 3-5. All other actions necessary to meet the recovery objectives.

Stepdown Outline

1. Prevent extinction of major extant razorback sucker populations and Permanent loss of aenetic diversitv of existina populations.

    1.1. Protect fish in refuaia and maintain aenetic diversity .

    1 .1.1. Maintain adequate refugia.
    1 .1.2. Collect razorback suckers for refugia.
    1 .1.3. Manage genetic composition of razorback sucker refugia populations.
    1 .1.3.1. Maintain diversity found in wild populations.
    1 .1.3.2. Identify and maintain separate stocks if necessary and determine significance to recovery.
    1 .1.3.3. Determine degree of hybrid introgression and potential for affecting recovery effort.

    1.2. Restore physical habitats and provide fish access.

    1.2.1. Restore water flows.
    1.2.2. Restore fish passage.
    1.2.3. Reduce contaminants.

    1.3. Reduce adverse biological impacts.

    1.3.1. Control nonnative fishes.
    1.3.1 .1. Control nonnative fish in razorback habitat.
    1.3.1.2. Stop movement of nonnative fish into razorback habitat.
    1.3.1.3. Prevent new introduction of nonnative aquatic species.

    1.4. Auament wild populations.

    1.4.1. Introduce and protect wild larvae life stages.
    1.4.2. Introduce and protect juvenile or adults.

    1.5. Monitor populations and habitat status.

    1.51. Develop standardized population monitoring procedures.
    1.5.2. Implement population monitoring programs.
    1.5.3. Compile and analyze population data.
    1.5.4. Monitor habitat.
    1.5.5. Compile and analyze habitat data.

2. Establish and protect additional wild populations.

    2.1. Develop criteria for selectinq additional recoverv areas.

    2.2. Assess restoration and access needs.

    2.2.1. Determine flow, water level requirements.
    2.2.2. Determine effects of contaminants.

2.2.3. Determine nonnative impacts that may limit recovery.
2.2.4. Quantify food abundance.
2.2.5. Determine annual temperature regimes.
2.2.6. Identify required fish passage.

2.3. Select additional recovery areas in critical habitat reaches.

2.4. Determine habitat restoration needs.
2.4.1. Determine habitat to be restored.
2.4.2. Identify habitat parameters that may be limiting.

2.5. Restore Needed Habitats and provide fish access.
2.5.1. Restore physical habitat components.
2.5.1.1. Restore water conditions.
2.5.1.2. Restore fish passage.
2.5.1.3. Reduce contaminants.
2.5.1.4. Reduce effects from diseases and parasites
2.5.2. Restore biological habitat components.
2.5.2.1. Restore food resources.
2.5.2.2. Control/manage nonnative fishes.

2.6. Augment or reintroduce razorback suckers in recovery areas.
2.6.1. Propagate razorback suckers.
2.6.1 .1. Refine propagation, holding, and rearing techniques.
2.6.1.2. Maintain a diversified broodstock.
2.6.2. Develop and implement introduction and monitoring activities.
2.6.2.1. Develop procedures for introduction and monitoring.
2.6.2.2. Reestablish or augment razorback suckers.
2.6.2.3. Monitor reestablishment and augmentation efforts.

3. Protect and maintain razorback sucker populations and their habitats.

3.1. Determine threats to razorback sucker populations

3.2. Monitor and assess the impact of development projects.

3.3. R e f i n e
sucker.
3.3.1. Review conservation and enforcement responsibilities of appropriate agencies
3.3.2. Ensure compliance with Section 7 of the Endangered Species Act by all Federal Agencies.
3.3.3. Foster better relationships with non-federal agencies and promote more effective state and local government protection.

3.3.4. Assess effectiveness of current regulations/management and draft additional regulations or increase protection and enforcement as needed.

3.3.5. Discontinue or prevent introductions of nonnative fish species that may have a negative impact on the razorback sucker.

3.3.6. Protect high priority recovery areas.

3.4. Develop and implement cooperative interaaencv proarams to protect and recover the razorback sucker.

4. Develoo quantitative recoverv aoals and a lona-term habitat protection strateav.

4.1. Develop quantitative recovery aoals for each recovery area.

4.1 .1. Develop goals for population size for each recovery area.

4.1.2. Develop habitat restoration or development goals compatible with recovery area needs.

4.2. Develop quantitative recovery aoals for each recovery area.

4.2.1. Develop goals for population sizes needed for various recovery objectives.

4.2.2. Develop ecosystem restoration or development goals.

5. Promote and encouraae improved communication and information dissemination.

5.1. Develop and conduct workshops to coordinate recovery efforts.

5.2. Conduct nationwide information and education proarams.

5.3. Conduct local information and education proarams.

5.4. Promote information and education programs within management aaencies.

5.5. Encouraae and support publication of research and other recovery results in the technical literature.

Narrative

1. Prevent extinction of major extant razorback sucker Populations and permanent loss of genetic diversity of existing populations.

The razorback sucker is one of the most endangered fish species in the Colorado River basin. Several stocks are known, but there is no evidence that any of these populations is self-sustaining. Immediate action is required to prevent extinction, and to maintain the present wild populations and their gene pool. Habitat changes have no doubt affected populations of the razorback sucker, but there is compelling evidence that competition and especially predation by nonnative fishes is the greatest present problem contributing to their decline. Highest priority actions for recovery of the razorback sucker include maintaining wild populations, protecting genetic diversity, restoring habitat, and reducing the impact of nonnative fishes. It does not appear possible that the present razorback sucker populations can maintain themselves in nature without effective implementation of all of these recovery needs.

Management plans are required to address and implement site-specific recovery needs within the following framework:

1.1. Protect fish in refugia and maintain genetic diversity.

Most of the razorback suckers in the wild are older fish. As these fish die, they are not being replaced in sufficient numbers to maintain the present stocks. Loss of stocks may reduce the survivability of this species and lessens chances for recovery by depleting the gene pool. To prevent complete and permanent loss of this genetic material, portions of the gene pool are being protected. Further genetic evaluations should be made to ensure that the proper brood stock is in protective captivity in case remnant populations are extirpated.

1.1.1. Maintain adequate refugia.

Refugia for razorback suckers currently exist (or are being developed), at Dexter National Fish Hatchery, New Mexico; Ouray National Fish Hatchery, Utah; Horsethief Ponds, Grand Junction, Colorado; Wahweep Warm Water Facility, Big Water, Utah; Lake Powell; and the four National Wildlife Refuges along the lower Colorado River. Potential sites include Arizona Game and Fish Department's Bubbling Pond Hatchery. In addition, Tribes may furnish additional ponds, such as land in northwest New Mexico (Navaho Nation).

1.1.2. Collect razorback suckers for refugia.

Razorback suckers held in refugia should be maintained by captive breeding programs to lessen the number of the fish that have to be removed from the wild. However, it is necessary to obtain additional genetic material in order to lessen the chance of inbreeding due to inadvertent selection and limited parental stock. Workers should be prepared to properly capture, handle, and transport razorback suckers to refugia according to established protocol. In order to limit stress to older individuals, high priority shall be placed on obtaining younger life stages of the fish, as is being accomplished in Lake Mojave.

1.1.3. Manage genetic composition of razorback sucker refugia populations.

1.1.3.1. Maintain diversity found in wild populations.

Manage refugia populations so that their genetics are representative of all wild populations.

1.1.3.2. Identify and maintain separate stocks if necessary and determine their significance to recovery.

Monitor razorback matings to ensure that the genetics of the original wild populations are maintained.

1.1.3.3. Determine the degree of hybrid introgression and the potential for affecting recovery efforts.

Hybridization with other catostomid is not regarded as a serious problem at present. However, it is possible that the incidence of introgression may increase in the future. All fish brought into captivity should be evaluated for potential introgression. Fish with a higher degree of introgression than is now present may not be suitable as broodstock.

1.2. Restore physical habitats and provide fish access.

Using the best available information, restore razorback sucker habitats and maintain required habitat parameters.

1.2.1. Restore water flow regimes.

Maintain the historic variability of flows by water management and /or by acquiring and managing spring flows to more adequately mimic the natural hydrograph. These flows should: create and maintain habitats (i.e., move sediments to form spawning, nursery, and adult habitats); inundate selected floodplain bottomland; maintain seasonally flooded backwaters; flood tributary mouths. Use of flows to reduce nonnative fish abundance should be further evaluated where potentially feasible. Because of geomorphic changes, there are areas where flows alone cannot provide desired outcomes, and other management options need to be evaluated, such as stream channel reconstruction or other mitigating features.

Acquire and manage non-spring flows to: maintain appropriate seasonal water levels in backwaters; provide a diversity of habitats for adult razorbacks; and allow passage at diversion structures.

1.2.2. Restore fish passage.

The use of existing passage structures by razorback suckers needs to be evaluated, and the feasibility of restoring passage at other barriers and impediments that block access to habitat required for recovery also needs to be addressed. There is a need to investigate behavioral attributes of razorback sucker that may facilitate the design of passage structures. The design of new passage structures should include any measure to restrict passage of problematic nonnative fishes.

1.2.3. Determine the role of environmental contaminants in recovery.

Investigate point and non-point source discharges that may harm razorback suckers. Reduce levels of harmful contaminants in problem areas (e.g., those areas where razorback adults seem to congregate, such as flood plains, tributary mouths, irrigation drains, etc.). Review existing spill contingency plans for adequacy in protecting areas important to the razorback sucker. Work with involved agencies to identify specific measures to protect important areas and include this information in updated spill contingency plans.

1.3. Reduce adverse biological impacts.

Razorback suckers can live for a long time, but young stages are extremely vulnerable to mortality in the present environment. For recovery to be successful, measures must be found to increase recruitment.

1.3.1. Control nonnative fishes.

Predation and perhaps competition by nonnative fishes has been shown to limit recruitment in razorback sucker populations (reviewed by Minckley et al. 1991, Tyus and Saunders 1996). The spread of nonnative fishes throughout razorback sucker habitat must be controlled if the razorback sucker is to be recovered. Especially vulnerable to predation are the younger life stages, but even larger juveniles are exposed to predation in some locations. An extensive review and plan for nonnative fish control has been developed for the upper Colorado River basin (Tyus and Saunders 1996). This plan provides guidance for evaluating and implementing fish control methodologies.

1.3.1 .1. Control nonnative fishes in razorback sucker habitats.

Several nonnative fishes occupy razorback sucker habitats. Control actions are needed to reduce their numbers in specific areas. New technologies should be developed to assist with fish control.

1.3.1.2. Stop movement of nonnative fishes into razorback sucker habitats.

Predaceous game species continue to escape from reservoirs and other areas and move into occupied habitat. Areas must be identified and effective escapement controls should be put into place to reduce escapement or the stocks of these nonnative fishes must be eradicated where practical or warranted.

1.3.1.3. Prevent new introductions of nonnative aquatic species.

Nonnative fish that are not currently in the Colorado River basin should be kept out. In addition, the introduction of nonnative fishes that are already in one part of the basin should not be placed in another. There are interagency agreements for a stocking policy to effectively preclude introduction of all species that do not currently occur within the Colorado River Basin.

1.4. Auament wild populations.

1.4.1. Collect and rear wild larvae.

Wild razorback sucker larvae are presently being captured on location in Lake Mojave, reared to a larger size, and repatriated into the lake to augment the wild population. Because of the success of this program relative to the survival and genetic diversity of these larvae, such procedures may have merit in other locations where wild larvae require protection to escape predators, and also may need to be reared in the absence of predators to survive.

1.4.2. Introduce juvenile or adult fish.

Larger size razorback suckers are less vulnerable to predation and population augmentation with larger fish has a greater chance of success. However, razorback suckers may imprint to natal areas in the late egg or early larval stages. Using the best available technology, it may be necessary to imprint introduced fish with natural or synthetic chemicals to maximize use of high quality spawning areas and to ensure long-term reproductive success. This may be particularly important for riverine areas. Imprinting may be less important in lacustrine areas.

1.5. Monitor populations and habitat status.

Razorback sucker populations and their habitats should be monitored to track the status of the populations, determine habitat conditions, and to detect potential problems. Effective and safe monitoring techniques should be developed. Evaluations relative to problems should be done as needed on a case by case basis.

1.5.1. Develop standardized population monitoring procedures.

Standardized procedures are needed for implementing efficient and compatible monitoring procedures throughout the Colorado River basin. Monitoring shall be accomplished with minimal harm to individual fish and with minimal stresses to fish populations. Monitoring procedures, including netting, electrofishing, angling, handling, tagging, and larval fish sampling should be developed and evaluated to reduce impacts to razorback sucker populations. New techniques should be evaluated for potential use.

1.5.2. Implement population monitoring programs.

The status of all wild and reestablished populations of razorback suckers will be monitored. Because of the extreme longevity of the fish (up to 50 years), and the relative inability to detect differences in population levels to date, monitoring programs should be long-term efforts (i.e., a minimum of 20 years) designed to detect population changes. This information is critical for evaluating the success of management and recovery efforts. Results of monitoring programs will be needed to determine progress of recovery, and to determine when the objectives for down listing and delisting have been met.

1.5.3. Compile and analyze population data.

Compile and analyze information on population abundance, distribution, migration, and other general biological information to determine population status and trends (Le., identify age classes, hatching and rearing success, relative abundance, etc.).

1.5.4. Monitor habitat.

Monitor the quantity and quality of habitats that have been identified in site-specific management plans for recovery areas.

1.5.5. Compile and analyze habitat data.

At present, mechanisms for compiling, analyzing, and interpreting habitat data for the fish are not in place basin-wide. Using habitat monitoring procedures, compile and analyze information on the quality of habitat, as related to the habitat use and success of populations of razorback sucker in various locations, must be compiled, analyzed, interpreted, and shared throughout the range of the species.

2. Establish and protect additional wild populations.

Historically, razorback suckers were common or abundant in many areas of the Colorado River basin, but most populations have been extirpated. Some habitat areas that have recovery potential do not contain razorback sucker populations. These areas and others should be considered as candidates for recovery of razorback sucker populations. Specific recovery areas should be selected from these candidates based on likelihood of success. This selection process can benefit from the intensive efforts undertaken in various parts of the basin where biotelemetry and other habitat assessment methods have demonstrated persistence of introduced hatchery or repatriated individuals.

Candidate sites for reestablishment of razorback sucker populations are lotic and lentic habitats. Such areas in the upper Colorado River Basin include the Grand Valley area of the Colorado River; the Gunnison River near Delta, Colorado; and the San Juan River. In the lower basin, such sites in the Gila, Verde, Salt, and lower Colorado rivers are being considered. However, each site will require some restoration prior to introduction of razorback suckers. Habitats in the recovery sites should be identified and classified as “suitable” with regard to spawning sites, nursery areas, floodplain, nonnatives, contaminants, flows, temperatures, and access. Care must be taken to ensure that all of the primary constituent elements of critical habitat are present (or can be restored) and specifically defined for these recovery areas. Each selected recovery area must have a specific management plan developed using the following guidance:

2.1, Develop criteria for selecting additional recovery areas.

A recovery area will have defined geographic boundaries (i.e., upstream, downstream, and floodplain boundary limits) which encompass the home range of the population, and will contain components believed necessary to sustain a population of razorback suckers. For example, studies of riverine areas suggest that a recovery area should include a spawning bar near the upstream end of the Unit, nursery habitats for larvae and young downstream from the spawning bar (e.g., floodplain bottomland and backwaters), and a variety of habitats managed seasonally for adults (e.g., pools, runs, riffles, backwaters, side channels, flooded tributary mouths, inundated bottomland). In locations were a self-sustaining population will be maintained it must accommodate all life history phases of the razorback population. Thus, the length of the recovery area should be at least 30-50 river miles in length, depending upon conditions. Unrestricted passage for upstream, downstream, and lateral movements also may be needed within the area. Riverine areas such as the upper Colorado, Gunnison, San Juan, Verde, Salt, and Gila rivers should be re-evaluated for recovery potential using these criteria.

Some impounded reaches also may provide suitable razorback sucker habitat, especially those that retain certain riverine attributes. Criteria for such recovery units should be determined by study of Lake Mojave, Lake Powell, Senator Wash Reservoir, or other impoundments. Studies should identify all habitat areas within the recovery units that presently, or with proper modification may meet the habitat requirements of specific life stages of razorback suckers (e.g., spawning bars, nursery areas, adult habitats, and etc).

2.2. <u>Assess restoration and access needs.</u>

Evaluate the habitat conditions of each candidate recovery area and identify suboptimal conditions and other problems that need to be resolved within the recovery area. All recovery areas will differ with respect to various flow and water level and other habitat conditions. The evaluation process can be supported by biotelemetry and other studies that indicate habitats are acceptable or identify preferred habitats.

2.2.1. Determine flow and water level requirements.

Using data and information obtained through activities outlined in Section 155, determine spring flows (magnitude and duration) that are necessary to create and maintain razorback habitats (i.e., flows which may scour, move, and deposit sediments to form spawning and nursery habitats). Determine spring flows necessary to inundate floodplain bottomland and tributary mouths. Determine non-spring flows needed to provide a diversity of habitats for adult razorbacks. Make recommendations regarding methods or actions needed to obtain required habitats, including land form alteration if needed due to flow limitations.

2.2.2. Determine effects of contaminants.

Candidate recovery areas should be screened to determine if serious contaminant problems exist. For contaminants that are likely to be a problem, potential effects on razorback life cycle events (e.g., growth, survival, reproduction, etc.) should be evaluated to determine if they might reduce the potential of an area for recovery.

2.2.3. Determine nonnative impacts that may limit recovery.

Within each selected recovery area, characterize composition, distribution, and abundance of the fish community. Determine partitioning by life stage and habitat type. Conduct field experiments on management of nonnative predators/competitors (e.g., net enclosures, controlled access to ponds and flooded bottomland habitats, etc.). Monitor differences in predation on young razorbacks and relative depletion of food resources. Make recommendations on methods to control negative interactions with nonnative fishes.

2.2.4. Quantify food abundance.

An important component of the life history needs of the razorback sucker is adequate food. Recovery sites need to have the ability to sustain populations of the fish, and this cannot occur if proper foods are not available. If foods are not available, additional management measures may be required to manipulate habitats and produce food at the proper time of year.

Within selected recovery areas, the availability and abundance of foods for larvae and adults should be evaluated for various habitats considered important for recovery. Efforts should also be made to determine food preferences of juvenile razorback suckers, and to assess food abundance for them as well.

2.2.5. Determine annual temperature regimes.

Within selected recovery areas, monitor water temperatures; compare measured, modeled, and historical temperatures to those considered necessary for razorback growth, reproduction, and gonadal maturation.

2.2.6. Identify and evaluate required fish passage.

Evaluate the net ecological benefit of providing razorback sucker passage versus the appropriateness of maintaining barriers to nonnative fishes. Identify potential barriers and impediments to razorback sucker movement, and determine if flow management can relieve obstructions. Determine physical changes to barriers that facilitate passage, using care to ensure that barriers which restrict problematic nonnative fishes are not removed.

2.3. Select additional recovery areas in critical habitat reaches.

Once criteria have been determined for selecting new areas, all areas that may provide recovery for the fish must be reviewed for suitability.

2.4. Determine habitat restoration needs.

Habitat restoration needs should be developed for each site, and according to site-specific planning efforts. Feasibility studies will be conducted to determine if there are ecological, sociopolitical, economic, or other constraints that might limit habitat restoration.

2.4.1. Identify habitat parameters that may be limiting.

Identify the habitat parameters (depths, flows, substrates) and any environmental contaminants that may be limiting razorback sucker populations, habitat establishment, or utilization. Make recommendations for restoring, maintaining, and protecting these habitats.

2.4.2. Determine habitat to be restored.

Identify those habitats which are absent or are limited within the recovery units and which need to be restored or protected in order to recover the species. As suggested above, this will require a careful consideration of physical and biological components of razorback sucker habitat.

2.5. Restore needed habitats and provide fish access.

Utilizing the recommendations developed under Task 2.4, and in accordance with a site-specific management plan, restore razorback sucker habitats and required habitat parameters. The development of a management plan for each area will require some form of feasibility study to determine if there are constraints in developing and maintaining habitats.

2.5.1. Restore physical habitat components.

According to the needs of various recovery areas, physical habitat components shall be restored where possible and required for recovery of the fish.

2.5.1.1. Restore water conditions.

Water flows or levels should be provided as needed for recovery, create/maintain habitats (i.e., move sediments to form spawning, nursery, and adult habitats). Inundate selected floodplain bottomland. Fill backwaters with water; flood tributary mouths. Evaluate the use of flows to reduce nonnative fishes if appropriate.

Acquire and manage non-spring flows to: Fill backwaters with water; provide a diversity of habitats for adult razorbacks; and allow movements into various habitats.

2.5.1.2. Restore fish passage.

Identify and remove barriers and impediments to fish passage within each recovery area where prudent. In locations where barriers cannot be removed for economic or other reasons, important sites should be evaluated for providing needed passage by the potential use of fish ladders or other structures.

2.5.1.3. Reduce contaminants.

Identify contaminants of concern to razorback suckers and determine potential problem areas (e.g., those areas where razorback adults seem to congregate, such as flood plains, tributary mouths, irrigation drains, etc.). Utilize all federal and state resources to develop and implement plans to prevent contamination from point and non-point sources.

2.5.1.4. Reduce effects from diseases and parasites

At present, diseases and parasites are not considered a major factor in the recovery effort. However, managers should be alert to guard against disease or parasite problems that may occur in the future

2.5.2. Restore biological habitat components.

Biological components of razorback sucker habitat are essential. Nonnative fishes have limited razorback sucker recruitment and they are an important impediment to recovery. Availability of adequate food and control of nonnative fishes are considered major biological components to be addressed in the recovery effort.

2.5.2.1. Restore food resources.

Adequate food resources must be provided in each recovery area. This will require obtaining additional information about foods utilized by the fish in different habitats.

2.5.2.2. Control/manage nonnative fishes.

Reduce the adverse impacts caused by nonnative fishes within recovery area, especially in sensitive areas such as nursery/rearing habitats. The use of fish barriers, chemical and physical eradication, mechanical removal, and other options must be evaluated and implemented as needed.

2.6. Auament or reintroduce razorback suckers in recover-v areas..

Propagation and reintroduction are essential to preventing the species extinction and will require consideration of proper techniques for propagation, genetics management, environmental conditioning, imprinting, and stocking of appropriate size fish.

2.6.1. Propagate razorback suckers.

Propagation has included capture and rearing of wild larvae and hatchery production. It is important to produce razorback suckers that are genetically diverse, but it also is imperative that stocked fish be compatible with needs of candidate reintroduction or augmentation sites. These needs have not been adequately characterized to date, and may include rearing fish under various conditions, and site-specific imprinting or imprinting the fish to chemicals.

2.6.1 .1. Refine propagation, holding, and rearing techniques.

Additional development of propagation, rearing, and holding techniques may be needed to improve production and survival. There is a need to determine optimum capacities of holding/rearing facilities for different sizes of fish. Additional production and rearing capability should be developed to meet future needs, but emphasis should be placed on maximizing the use of existing facilities.

2.6.1.2. Maintain a diversified broodstock.

Studies should continue to determine the brood fish and matings needed to maintain genetic diversity of fish needed for specific reintroduction areas.

2.6.2. Develop and implement introduction and monitoring activities.

When a reintroduction or augmentation program is defined, fish will be reintroduced according to an implementation plan that will detail how fish are to be conditioned, stocked, and evaluated for success of the effort.

2.6.2.1. Develop procedures for introduction and monitoring.

The importance of imprinting to razorback sucker is under evaluation. If imprinting is determined to be an important component in the life history strategy of this species, the use of imprinting technology should be included with recovery efforts. This could be accomplished within selected candidate recovery areas by introducing razorback sucker embryos on the selected spawning bar (for natural imprinting), or hatchery-reared razorback suckers (which have been exposed to natural waters or imprinting chemicals) could be stocked and, upon sexual maturity, enticed to migrate to the selected spawning bar by release of chemical attractants.

2.6.2.2. Reestablish or augment razorback suckers.

Restocked areas will be sampled by standard fishery techniques to assess survival, growth, etc. Monitoring results will determine if stocking is contributing to the reestablishment of a self-sustaining population.

2.6.2.3. Monitor reestablishment and augmentation efforts.

Monitor the reestablished or augmented populations to determine relative success of stocking efforts, and to determine if additional efforts are needed.

3. Protect and maintain razorback sucker populations and their habitats.

Provision of adequate habitats needed for down listing or delisting will require appropriate legal guarantees for adequate streamflow and temperature regimes, water quality, and physical characteristics. Populations and habitats must be monitored until the species is delisted, and for at least 20 years after delisting to ensure habitat and population stability. Monitoring procedures shall be specified in a long-term management plan, not stipulated as part of a post-delisting recovery requirement.

All of the above recovery needs should be evaluated and presented in management planning efforts. In addition, site-specific plans must be developed for each recovery unit.

3.1. Determine threats to razorback sucker populations.

An assessment of threats facing razorback sucker and potential impacts on the species and its habitat should be made and periodically reevaluated. Management and protective regulations can be instituted or revised as needed.

3.2. Monitor and assess the impact of development projects.

Ongoing or proposed water development or related projects should be monitored/evaluated to determine their effects on razorback sucker populations and habitat. Considerations should include, but are not limited to flow, temperature, channel morphology, nonnatives, and water quality changes (e.g., turbidity, salinity, environmental contaminants). Care must be taken to ensure that primary constituent elements of critical habitat are not destroyed, or adversely modified.

3.3. Refine and enforce existina laws and regulations protecting the razorback sucker.

The purpose of this task is to maintain razorback sucker populations by preventing any further degradation of essential habitat.

3.3.1. Review the conservation and enforcement responsibilities appropriate federal agencies and provide input.

All affected agencies should actively preform their responsibilities to conserve endangered species as required by Section 7(a)(l) of the Endangered Species Act and should be pro-active in protecting listed species and their habitats (e.g., Endangered Species Act, Fish and Wildlife Coordination Act, and Lacey Act). Agencies should keep current on all laws and regulations or revisions that would change agency responsibility.

3.3.2. Ensure compliance with Section 7 of the Endangered Species Act by all Federal Agencies.

Section 7 consultation should help in ensuring that the ecological requirements of the razorback sucker are maintained and further impacts minimized, especially with regards to any actions that might limit the success of the recovery effort.

3.3.3. Foster better relationships with non-federal agencies and promote more effective state and local government protection.

Although "take" provisions of the Act apply to private individuals, and state and local agencies, these entities are not under constraints that prohibit modification of critical habitat. Enforcement capabilities and other needed recovery actions that local, state, and tribal agencies can provide to protect and recover the fish should be evaluated and encouraged. The development of new non-federal statutes, regulations, or policy may be needed, and, if so, should be encouraged.

3.3.4. Assess effectiveness of current regulations/management and draft additional regulations or increase protection and enforcement as needed.

All management practices and protection or enforcement activities should be evaluated to determine effectiveness in conserving the species.

3.3.5. Discontinue or prevent introductions of nonnative fish species that may have a negative impact on the razorback sucker.

Stocking of nonnative species should be discontinued until it is demonstrated that such introductions do not have a negative impact on the razorback sucker. Some interagency agreements have been made to limit stocking of problematic species, but a broader cooperative agreement should be initiated by the Service, Tribes, and the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming to prohibit introduction or spread of nonnative fishes that might further endanger the razorback sucker or jeopardize its recovery.

3.3.6. Protect high priority recovery areas.

If studies determine that certain reaches of river provide habitat necessary for the continued existence or recovery of razorback sucker, such areas must be protected and maintained. Costs identified for this action cover only initial efforts of determining habitat protection needs. Significant funds for habitat protection and maintenance will, most likely, be needed and will be identified in the future.

3.4. Develop and implement cooperative interagency proarams to protect and recover the razorback sucker.

A major cooperative effort to recover endangered fish species in the upper basin (excluding the San Juan River drainage) was initiated in August 1984. This Recovery Program (USFWS 1987) is intended to provide a coordinated implementation of the Service's recovery plans for the endangered razorback sucker, Colorado pike minnow, bonytail, and humpback chub in the Upper Basin.

A recovery implementation program for the Colorado pike minnow and the razorback sucker also has been developed for the San Juan River by the Service in coordination with appropriate Federal and State agencies, Indian tribes, and water development interests.

An additional cooperative interagency plan for recovery actions for these endangered fish in the lower basin is being planned. The Service shall ensure that the upper basin Recovery Program, the San Juan Recovery Program, and the Lower Colorado River Basin Multispecies Conservation Program currently being developed are fully coordinated.

4. Develop quantitative recovery aoals and a lona-term habitat protection strategy.

The razorback sucker is nearly extirpated from most of its historic range. This recovery plan focuses on those immediate actions that are believed necessary to prevent extinction, to gather essential life history and habitat information, and to restore habitats and populations. Interim goals are being developed in some locations, but these have not been finalized.

4 1. Develop quantitative recovery aoals for each recovery area.

4.1 .1. Develop goals for population sizes needed for each recovery area compatible with carrying capacity.

Interim goals for population sizes of razorback sucker have been developed in portions of the upper Colorado River basin. At present, these are very general goals and have not been finalized nor accepted by the USFWS.

4.1.2. Develop habitat restoration or development goals compatible with recovery area needs.

Habitat restoration or development goals have not been developed for specific recovery sites. Each identified recovery area should have goals developed for recovery of each of the listed fish and the community upon which they depend.

4.2. Develop quantitative recovery aoals for the species.

4.2.1. The number of populations needed for various recovery objectives has been determined. However, the number of fish required for these populations and the amount of habitat to be protected has not. Each recovery site must be of suitable size to support the defined population. Different recovery sites may have different goals in this regard. However, environmental variability and inadequate knowledge of potential future threats will make it necessary to produce and sustain larger populations of razorback suckers than may theoretically be required only to maintain gene frequencies.

4.2.2. Develop ecosystem restoration or development goals.

The Service has developed a draft multi-species recovery plan for the endangered Colorado River fishes in 1996. Completion of this multispecies plan and development of goals to support the multispecies concept need to be given higher priority.

5. Promote and encourage improved communication and information dissemination.

Information and education programs should be implemented at local, regional, and national levels to focus on the value of the razorback sucker as an endemic natural resource. An active effort will be made by the Service and State agencies to inform the public of recovery activities. Inter- and intra-agency communications, the sharing of information, and the education of the public about the goals, objectives, methods, and benefits of the recovery program are essential for success.

5.1. Develop and conduct workshoos to coordinate recoverv efforts.

Agencies should encourage communication among their professional and managerial staffs to accelerate recovery efforts. Such communication should include coordinating responsibilities for implementation of the razorback sucker recovery program and conducting workshops for the exchange of information on recovery progress to keep staffs aware of state-of-the-art methods, progress, and new initiatives.

5.2. Conduct nationwide information and education programs.

Conduct a national campaign to inform the public of the need to recover the razorback sucker. News of restoration efforts should be published in the Service's Endangered Species Technical Bulletin. Also, national environmental groups, newspapers, and the media should be contacted and encouraged to promote the value of recovering the razorback sucker.

5.3. Conduct local information and education proarams.

All State wildlife agencies should continue to develop and provide leaflets for use by the local chapters of sportsmen and environmental groups, river runners, newspapers, and the media. Efforts should focus on recent investigations, problems facing the razorback sucker, and recovery efforts. The ecological value of the razorback sucker as an endemic species should be emphasized.

5.4. Promote information and education proarams within management agencies.

Increase awareness among agency personnel regarding razorback sucker identification, importance, role in the ecosystem, etc., and the agency responsibility to aid in the recovery effort.

5.5. Encourage and support publication of research and other recovery results in the technical literature.

All participating agencies and their contractors should encourage publication of research findings in technical literature. These agencies should provide support by funding printing or other necessary logistical support.

PART III. IMPLEMENTATION SCHEDULE

The following table is a summary of scheduled actions and costs for this recovery program. It is a guide to meet the objectives of the recovery plan for the endangered razorback sucker. The table indicates the priority in scheduling tasks to meet the objectives, which agencies are responsible to perform these tasks, a time-frame for accomplishing these tasks, and the estimated costs to perform them. Implementation of the recovery actions, when accomplished, will satisfy the recovery objectives. Initiation of these actions is subject to the availability of funds.

Abbreviations Used in Implementation Schedule

AZ	Arizona Game and Fish Department
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management, U.S. Department of Interior
BR	Bureau of Reclamation, U.S. Department of Interior
CA	State of California, Fish and Game Department
CO	Colorado Division of Wildlife
FWS	Fish and Wildlife Service, U.S. Department of Interior
NM	New Mexico Department of Game and Fish
NPS	National Park Service, U.S. Department of Interior
NV	Nevada Department of Wildlife
UT	Utah Division of Wildlife Resources
WY	Wyoming Game and Fish Department

Other Definitions

Continuous	Task which will be required over a very long or undetermined amount of time.
Ongoing	Task which is now being implemented, and should be continued on an annual basis.
Unknown	The cost and/or duration of this task is yet to be determined and may require completion of other tasks to determine amount of effort required.

Razorback sucker (*Xyrauchen texanus*) Recovery Implementation Schedule

Priority	Task	Task Description	Task Duration	Responsibility Party: FWS Region	Responsibility Party: Other	Cost Estimates: FY-01	Cost Estimates: FY-02	Cost Estimates: FY-03	C
1	111	Maintain adequate refugia	Ongoing	2,6	AZ, CO, NM, NV, UT, WY	300,000	300,000	300,000	I fi
1	112	Collect razorback suckers for refugia	Ongoing	2,6	AZ, CO, NM, NV, UT, WY	---	---	---	I
1	113	Maintain genetic composition of razorback sucker refugia populations	Continuous	2,6	AZ, CO, NM, NV, UT, WY, CA	---	---	---	I
1	1131	Maintain diversity found in wild population	Continuous	2,6		---	---	---	C f
1	1132	Identify and maintain separate stocks if necessary and determine significance to recovery	Ongoing	2,6		---	---	---	C f
1	1133	Determine degree of hybrid introgression and potential for affecting recovery effort	3 years	2,6		---	---		C
1	121	Restore water flows	Ongoing	2,6	all agencies	---			I fi L
	122	Restore fish passage	Ongoing	2,6	BR, BLM, NPS	$1.5 million	unknown	unknown	I fi
1	123	Reduce contaminants	Ongoing	2,6	BR, BLM, NPS	unknown	unknown	unknown	I fi
	1311	Control nonnative fish in razorback habitat	Ongoing	2,6	all agencies	172,000	unknown	unknown	I fi ir
	1312	Stop movement of nonnative fish into razorback habitat	Ongoing	2,6	all agencies	---	---	---	C
1	1313	Prevent new introduction of nonnative aquatic species	Ongoing	2,6	all agencies	---	---	---	D
1	141	Introduce and protect wild larvae life stages	Ongoing	2,6	AZ, CO, NM, NV, UT, WY, CA	$3 million	477,000	477,000	C r n

Priority	Task	Task Description	Task Duration	Responsibility Party		Cost Estimates			Comments
				FWS Region	Other	FY-01	FY-02	FY-03	
1	142	Introduce and protect juveniles or adults	Ongoing	2,6	AZ, CO, NM, NV, UT, WY,CA	---	---	---	Costs included in introduction and protection of wild larvae life stages.
1	151	Develop standardized population monitoring procedures	1 year	2,6	AZ, CO, NM, NV, UT, WY,CA	131,200	---	---	
1	152	Implement population monitoring programs	Continuous	2,6	AZ, CO, NM, NV, UT, WY	---	193,200	200,000	Included in costs identified for developing standardized population monitoring procedures
1	153	Compile and analyze population data	Continuous	2,6		28,000	28,000	28,000	Include as part of program for all rare Colorado River fishes
1	154	Monitor habitat	Continuous	2,6	all agencies	unknown	unknown	unknown	
1	155	Compile and analyze habitat data	Continuous	2,6		unknown	unknown	unknown	
2	21	Develop criteria for selecting additional recovery areas	2 years	2,6		unknown	unknown	unknown	
2	22	Select additionrecoveryıs in critical habitat reaches	3 years	2,6		unknown	unknown	unknown	
2	231	Determine flow, water level requirements	3 years	2,6		22,000	22,000	22,000	Includes basin wide channel monitoring
2	232	Determine effects of contaminants	Ongoing	1,2,6	BR, BLM, NPS	unknown	unknown	unknown	Include as part of program for all rare Colorado River fishes
2	233	Determine nonnative impacts that may limit recovery	Ongoing	1,2,6	BR, BLM, NPS	unknown	unknown	unknown	Include as part of program for all rare Colorado River fishes
2	234	Quantify food abundance	3 years	2,6	all agencies	97,000	unknown	unknown	Include as part of program for all rare Colorado River fishes
2	235	Determine annual temperature regimes	3 years	2,6	all agencies	---	---	---	To be conducted as part of monitoring protocol
2	236	Identify required fish passage	2 years	1,2,6	BR	---	---	---	Include as part of program for all rare Colorado River fishes
2	241	Determine habitat to be restored	Ongoing	1,2,6		unknown	unknown	unknown	
2	242	Identify habitat parameters that may be limiting	Ongoing	1,2,6		---	---	---	Costs are included in ongoing studies such as food web dynamics
2	2511	Restore water conditions	Unknown	1,2,6	all agencies	unknown	unknown	unknown	

Priority	Task	Task Description	Task Duration	Responsibility Party		Cost Estimates			Comments
				FWS Region	Other	FY-01	FY-02	FY-03	
2	2512	Restore fish passage	Unknown	1,2,6		$1.5 million	unknown	unknown	Include as part of program for all rare Colorado River fishes
2	2513	Reduce contaminants	Ongoing	1,2,6	all agencies	unknown	unknown	unknown	Include as part of program for all rare Colorado River fishes
2	2521	Restore food resources	Unknown	1,2,6	all agencies	unknown	unknown	unknown	
2	2522	Reduce nonnative fish interactions	Continuous	1,2,6	all agencies	unknown	unknown	unknown	
2	2611	Refine propagation, holding, and rearing techniques	Ongoing	1,2,6	AZ, CO, NM, NV, UT, WY	---	---	---	Costs are included as part of propagation, facility operation and maintenance costs
2	2612	Maintain a diversified broodstock	Continuous	2,6		---	---	---	Costs are included as part of propagation costs
2	2621	Develop procedures for introductions and monitoring	Ongoing	2.6	AZ, CO, NM, NV, UT, WY,CA	22,000	22,000	22,000	Costs include evaluating experimental stocking plan
2	2622	Reestablish or augment razorback suckers	Ongoing	1,2,6	AZ, CO, NM, NV, UT, WY.CA	---	---	---	Costs are included as part of propagation, facility operation and maintenance costs
2	2623	Monitor reestablishment and augmentation efforts	Ongoing	2,6	AZ, CO, NM, NV, UT, WY,CA	---	---	---	Costs are included in standardized monitoring program
3	31	Determine threats to razorback sucker populations and protect them	10 years	1,2,6		unknown	unknown	unknown	Costs in part covered by section 7 funds
3	32	Monitor and assess the impact of development projects	Ongoing	q,2,6		---	---	---	Costs in part covered by section 7 funds
3	331	Inform appropriate agencies of their conservation and enforcement responsibilities	Ongoing	1,2,6		---	---	---	Done with existing personnel and funds
3	332	Ensure compliance with Section 7 of the Endangered Species Act by all Federal agencies	Ongoing	1,2,6		---	---	---	Done with existing personnel and funds
3	333	Foster better relationships with non-federal agencies and promote more effective state and local protection	Ongoing	1,2,6	all agencies	---	---	---	Done with existing personnel and funds

Priority	Task	Task Description	Task Duration	Responsibility Party		Cost Estimates			Comments
				FWS Region	Other	FY-01	FY-02	FY-03	
3	334	Assess effectiveness of current regulations/management and draft additional regulations or increase protection and enforcement as needed	Ongoing	1,2,6	all agencies	unknown	unknown	unknown	
3	335	Discontinue or prevent introductions of nonnative fish species that may have a negative impact on the razorback sucker	Ongoing	1,2,6	AZ, CO, NM, NV, UT, WY	---	---	---	Done with existing personnel and funds
3	336	Protect high priority recovery areas	Ongoing	1,2,6	all agencies	unknown	unknown	unknown	Costs in part covered by section 7 funds
4	411	Develop goals for population size for recovery areas	1 year	2.6		---	---	---	Part of ongoing agency efforts
4	412	Develop habitat restoration or development goals compatible with recovery area needs	1 year	2,6		unknown	unknown	unknown	
4	421	Develop goals for population sizes needed for various recovery objectives	1 year	2,6		unknown	unknown	unknown	
4	422	Develop ecosystem restoration or development goals	3 years	1,2,6		unknown	unknown	unknown	
5	51	Develop and conduct workshops to coordinate recovery efforts	Ongoing	1,2,6	all agencies	---	---	---	Include as part of program for all rare Colorado River fishes
5	52	Conduct nationwide information and education programs	Ongoing	1,2,6	all agencies	27,000	27,000	27,000	Include as part of program for all rare Colorado River fishes
5	53	Conduct local information and education programs	Ongoing	1,2,6	all agencies	---	---	---	Include as part of program for all rare Colorado River fishes
5	54	Promote information and education programs within management agencies	Ongoing	1,2,6	all agencies	---	---	---	Done with existing personnel and funds
5	55	Encourage and support publication of research and other recovery results in the technical literature	Ongoing	1,2,6	all agencies	10.000	10,000	40,000	Include as part of program for all rare Colorado River fishes

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