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A Program for Maintaining the Razorback Sucker in Lake Mohave

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Abstract.—Lake Mohave, Arizona–Nevada, supports the last large population of the Endangered razorback sucker *Xyrauchen texanus*. Razorback suckers successfully spawn in Lake Mohave; however, predation by nonnative fish appears to restrict recruitment. Most razorback suckers are believed to be more than 40 years old and nearing the end of their life span. The population is expected to perish within the next few years unless steps are taken to ensure survival and recruitment of young.

Concerned biologists from seven state and federal agencies formed the Native Fish Work Group (NFWG) to maintain the razorback sucker in Lake Mohave. The NFWG has developed a program to replace the aging population with young adults that reflect the genetic divergence of the reservoir population. Larval fish spawned naturally in the reservoir are collected and stocked by themselves into small, isolated nursery areas. Fish are grown in these predator-free environments to 25 cm, a length believed large enough to evade most predators. The NFWG plans to release a minimum of 10,000 young adult razorback suckers back into Lake Mohave and monitor their survival. This represents the first step in a long-term management commitment.

Populations of razorback suckers *Xyrauchen texanus* are now restricted to less than 25% of their former range (Minckley et al. 1991). Nearly all razorback suckers collected during the past 2 decades have been adults. These fish are nearing extinction in the upper Colorado River basin (Tyus 1987; Osmundson and Kaeding 1991; USFWS 1991). The largest remaining population of razorback suckers is found in Lake Mohave, Arizona–Nevada, a regulatory reservoir formed by Davis Dam. These fish are old, and, as in the more pristine upper Colorado River basin, reproduction occurs but few young survive to reach adulthood. The Lake Mohave population has declined 60% (59,500 to 23,300) in the past 5 years (Marsh 1994). Populations elsewhere are also declining and extinction will occur this decade unless steps are taken immediately to augment populations (Minckley et al. 1991; Burdick 1992).

The species decline is attributed to habitat degradation and competition and predation by nonnative species. Razorback suckers do successfully spawn at several locations throughout the basin. Eggs incubate and hatch and larval razorback suckers are produced, but young longer than 25 mm total length (TL) rarely are found. Today young razorback suckers are vulnerable to a large host of predators not present a century ago. Over 40 nonnative fish species have been successfully introduced into the Colorado River basin. Implications of these introductions are difficult to quantify; however, Marsh and Brooks (1989) showed that small razorback suckers stocked in Arizona streams were eaten by channel catfish *Ictalurus punctatus* and other nonnative species. Predation on larval razorback suckers, although not quantified, is considered the single most important factor limiting recruitment in Lake Mohave (Minckley 1983; Marsh and Langhorst 1988; Minckley et al. 1991).

Efforts to recover the razorback sucker and other native fishes began in 1976 with the creation of the Colorado River Fishes Recovery Team (K. D. Miller 1982). The Colorado River Fishery Project was initiated by the U.S. Fish and Wildlife Service (USFWS) in 1979. Its purpose, along with a substantially larger recovery program for the upper Colorado River basin that followed in 1987, was to recover the razorback sucker, bonytail *Gila elegans*, humpback chub *G. cypha*, and Colorado squawfish *Ptychocheilus lucius* in a manner that allows further water development. The cost for the remaining 10 years of the 15-year recovery program is estimated to be US$84–134 million (USFWS 1993). A cooperative agreement between USFWS and Arizona Game and Fish Department delayed listing of the razorback sucker in order to reintroduce nearly 12 million small razorback suckers into Arizona streams between 1980 and 1989 (Johnson 1985; Minckley et al. 1991). This massive stocking attempt was unsuccessful in reestablishing self-sustaining populations, and the razorback sucker was listed as Endangered in 1990.

Unfortunately, 18 years of recovery effort have failed to slow, let alone reverse, the decline of this native fish (Tyus 1987; Marsh and Brooks 1989; Langhorst 1989; Osmundson and Kaeding 1991;

Minckley et al. 1991). Much effort has gone into research, habitat restoration, and legislative protection. Furthermore, recovery efforts have generally focused on the upper Colorado River basin where the razorback sucker is rare; little has been done to actively manage surviving populations or repress nonnative fish communities.

The continual decline of the razorback sucker prompted Lake Mohave field biologists to adopt an active management effort to maintain razorback suckers in Lake Mohave. The group adopted a quick response management approach, rather than developing a more conventional recovery program. The goal was simple: to replace Lake Mohave's old razorback sucker population before the relict population was lost. The purpose of this paper is to describe the development, operation, and results of a cooperative program to maintain the razorback sucker in Lake Mohave.

Approach

Cooperative Partnership

The Native Fish Work Group (NFWG) is a cooperative effort of the Arizona Game and Fish Department, Arizona State University, Bureau of Reclamation, USFWS, National Biological Service, National Park Service, and Nevada Division of Wildlife. The NFWG and the program to save the Lake Mohave razorback sucker were conceived, created, and implemented at the field level. Participants are local biologists, many directly responsible for managing the Lake Mohave resource. The NFWG has no specific budget; work is accomplished through the collective resources of participating agencies. The NFWG meets every 4 months, or as needed, to review past work and to plan and assign future activities. Decisions are made at the lowest possible management level. Tasks are assigned according to available expertise, resources, and function. For instance, environmental compliance and permits are usually handled by the National Park Service, Endangered Species Act (16 U.S.C.A. §§1531 to 1544) compliance is completed by the USFWS, construction activities are managed by the Bureau of Reclamation, and Arizona State University and the National Biological Service assist with research needs. Monitoring activities, fish collection, and site maintenance are generally accomplished by personnel from all the agencies.

The NFWG first drafted a research and management plan in 1990 that outlined the goals and potential methods for sustaining the Lake Mohave razorback sucker population. The plan is a working document that identifies and prioritizes goals while allowing for implementation flexibility. The plan is periodically updated as needed. Annual and specific task reports provide information regarding activities. The program has focused resources on actual implementation rather than administrative processes.

Factors influencing the program are limited resources, the rapid decline in razorback sucker numbers, and time. The existing population is dying of old age and could perish by the end of this decade. The program is being expedited by using the reproductive potential of thousands of reservoir spawners rather than the conventional culturing practice of mass-producing fish from a small captive broodstock.

Management Concept

Habitat degradation in the lower Colorado River basin has been extensive, but research suggests predation is the single most important factor for recruitment failure in Lake Mohave (Minckley 1983; Marsh and Langhorst 1988; Minckley et al. 1991). Razorback suckers do successfully spawn in reservoirs and other lentic bodies of water. Eggs incubate and hatch, but young razorback suckers apparently survive only in environments where nonnative predators are absent or rare (Minckley et al. 1991). Razorback suckers once flourished in several newly impounded reservoirs in the lower Colorado River basin (Minckley et al. 1991). Apparently, populations of razorback suckers were able to expand while reservoirs filled and before nonnative predators became established.

The ecology of these fish is not clearly understood. However, razorback suckers do spawn with the rising water from spring runoff. Prior to the channelization of the Colorado River and the creation of large reservoirs, larval razorback suckers were dispersed into large, newly flooded, and highly productive nursery areas (Minckley et al. 1991). Survival may have depended on a combination of high spawner fecundity, rapid larval growth, and the dispersal of a naturally small predator community contained by seasonal low river conditions. Today, conditions are much different. Reservoirs have inundated seasonally flooded nursery areas and have modified, but also expanded and stabilized, aquatic habitats. The early colonization of many of the lower Colorado River reservoirs by razorback suckers suggests the fish could tolerate some physical habitat changes. However, it appears the introduction and management of sport fishes may have been the decisive factor in the razorback sucker's decline.

Options available to the NFWG were few. Meaningful habitat restoration or the removal of nonnative fish from Lake Mohave and other upstream portions of the river basin are unlikely. We thought the only feasible approach was to stock fish large enough to ensure some survival. Razorback suckers are reared successfully and grow rapidly. Unfortunately, the costs of raising and transporting thousands of large razorback suckers from Dexter National Fish Hatchery (1,100 km) or other existing fish culture facilities would be high. Experiments conducted in the mid-1980s showed that razorback suckers spawned and produced young if provided habitats free of nonnative fishes (Minckley et al. 1991). We believed a razorback sucker of 25–30 cm TL was large enough to escape most predators, and we chose that size as the target for stocking. Fish would be grown to this length, implanted with passive integrated transponder (PIT) tags, and released into the reservoir. A minimum of 10,000 young razorback suckers would be released over 5 years. Arizona State University has conducted an ongoing reservoir monitoring program for nearly 20 years, and this continuing monitoring program will provide the information necessary to determine stocked fish survival. Stocking will be refined as data become available.

Development of Rearing Areas

Aerial photographs and surveys identified several potential rearing sites along Lake Mohave's shoreline. The reservoir has several naturally occurring backwaters that seasonally become isolated from the main reservoir. These ephemeral backwaters and coves that easily could be closed were visited, prioritized, and surveyed. Few coves were suitable for rearing because of their size or the expense to make them suitable for rearing razorback suckers. Alternative rearing sites away from the reservoir were also examined. Five specific types of potential rearing areas have been identified or are being used. They include ephemeral backwaters, backwaters closed by net, permanent backwaters, hatchery facilities, and outlying ponds.

Since 1990, nine small ephemeral backwaters (0.1–0.8 ha) have been developed as seasonal rearing areas. These shallow backwaters are seasonally closed to the main reservoir by gravel berms formed by wave-induced beach erosion and deposition. Berms prevent fish passage, but backwaters remain hydraulically connected to the reservoir. Backwaters are seasonally flooded and drained as the reservoir is operated within its 5-m-vertical-fluctuation zone. Backwaters are normally flooded from spring through late summer and drained in autumn as the reservoir is lowered to develop storage for spring runoff. Drainage prevents the establishment of resident fish populations and assists in the recovery of reared fish.

Growth-rate information provided by Dexter National Fish Hatchery suggested 25-cm razorback suckers could be raised in 18 to 24 months; therefore, permanent (year-round) rearing areas were desirable. Ephemeral backwaters would be used for rapid seasonal growth, but fish less than 25 cm would have to be moved to a deeper, permanent-water cove in autumn when the reservoir elevation dropped. Davis Cove provided a potentially excellent rearing site because of its size, shape, and depth. The cove has a maximum depth of 4 m at minimum reservoir pool, a narrow entrance, and a surface area of 1.2 ha. The cove's entrance was closed in 1991 using a 10-mm-bar-mesh net and a flotation boom. The net conformed to the entrance and accommodated the reservoir's 5-m fluctuation zone. This temporary barrier was used for 3 years and was replaced with an earthen berm in fall 1994.

Willow Beach National Fish Hatchery is a cold-water trout hatchery located on Lake Mohave, 16 km downstream from Hoover Dam. The facility is currently adding water heaters that will allow the hatchery to hatch and rear razorback sucker. Raceway operations are being modified to rear 5–15-cm (TL) razorback suckers. We plan to test the concept of stocking backwaters with larger juveniles in order to reduce the number of fish smaller than 25 cm at the end of the growing season. This approach could help optimize survival, production, and fish growth while reducing the need to transfer, hold, and handle fish smaller than 25 cm.

Razorback suckers have been reared successfully elsewhere (Minckley et al. 1991). The option of rearing fish away from Lake Mohave in city park ponds, golf course ponds, and housing development lakes is being explored. A Memorandum of Agreement was recently signed between the Bureau of Reclamation and City Manager of Boulder City, Nevada. Under the agreement, razorback suckers have been stocked in a municipal golf course pond.

Propagation and Rearing

The Lake Mohave project is unique among endangered fish stocking programs because of the range of methods available to produce young fish.

Some methods optimize production, whereas other techniques produce fewer fish but focus on genetic diversity. The following propagation methods have been or currently are being tested.

(1) Backwaters were stocked with mature adults from the reservoir prior to the spawning season. Adults were stocked at a ratio of one female to two males. Males were stocked in larger numbers because females normally spawn with multiple males at one time (Minckley 1973). Adults were recaptured and returned to Lake Mohave following spawning. A different spawning group was used each year.

(2) Another approach was examined to reduce spawner handling and stress associated with allowing fish to spawn in the backwaters and eventually recapturing and returning them to the reservoir. Spawning fish were collected from Lake Mohave in 1993, gametes were stripped, eggs were fertilized, and fish were returned to the reservoir. The egg contribution from each female was fertilized by at least two males. About 250,000 eggs from 24 females and about 60 males were collected; 200,000 were dispersed in Yuma Cove, and the remainder were hatched in the laboratory for larval research. Unfortunately, the reservoir dropped about 1 m shortly after the eggs were distributed in Yuma Cove.

(3) Larvae are phototactic and can be captured easily at night by using lights. Naturally spawned reservoir larvae have been collected for a number of years using handheld spotlights and small dip nets or light traps (Minckley et al. 1991; Mueller et al. 1993). These techniques are being refined to collect large numbers of larval razorback suckers for stocking into the backwaters.

(4) Dexter National Fish Hatchery is the USFWS warmwater, endangered-fish culturing facility. The hatchery maintains a broodstock of Lake Mohave razorback sucker and produces fish for scientific research and stocking. The hatchery supplied 10,000, 6-cm (TL) fish for Davis Cove on 28 June 1992.

All backwaters except Davis Cove were poisoned to remove nonnative fish. Davis Cove was not poisoned due to its close proximity to a large public marina and in order to test if razorback suckers could survive in a cove where nonnative fish were reduced but not eliminated. Here the nonnative fish community was reduced using gill and trammel nets and by electrofishing.

Stocking Criteria

Lake Mohave contains several piscivores, including striped bass *Morone saxatilis*, largemouth bass *Micropterus salmoides*, bluegill *Lepomis macrochirus*, and channel catfish. The stocking-size criterion was based on the assumption that most piscivores would have difficulty consuming a 25-cm razorback sucker. This criterion will be refined as survival rates of recaptured fish are developed. Currently, razorback suckers longer than 25 cm that are taken from the rearing areas are tagged with PIT tags and stocked directly into the reservoir. Smaller fish are moved to a permanent backwater and allowed to continue their growth.

Monitoring

Larval and juvenile fish are collected using lights and small dip nets, light traps, small-mesh seines, fish traps, small-mesh trammel nets, and electrofishing. Ephemeral backwaters and Davis Cove are sampled bimonthly to monitor fish survival, growth, and condition. Piscivorous fish collected in Davis Cove during sampling events are removed.

Arizona State University has been monitoring the reservoir's razorback sucker population for nearly 20 years. The reservoir is sampled specifically for razorback suckers during spring and Thanksgiving class breaks. This effort has been intensified during the past 8 years to estimate the population size. Sampling is conducted in March when spawners are concentrated in shallow water and are vulnerable to trammel nets, large beach seines, and electrofishing. Usually 1,000 to 2,000 adults are collected and tagged with PIT tags annually. The spring and fall monitoring efforts are providing the information required to determine the survival of backwater-reared fish.

Results

Propagation and Rearing

In January 1991, 100 (33 females, 67 males) adult razorback suckers were stocked into Yuma Cove just prior to spawning season. Larvae were collected during the spawn; however, for reasons unknown, no young fish survived. A similar effort was attempted in January 1992 with 88 adults (28 females and 60 males), and 296 young fish were recovered (Table 1). Juveniles collected in November 1992 averaged 35.4 cm TL (maximum 39.1 cm). One hundred fifty-three fish larger than 25 cm were tagged with PIT tags and released in Lake Mohave; the remainder (<25 cm) were placed in Davis Cove to continue their growth. Fifteen juveniles were sacrificed for genetic (mitochondrial DNA and allozyme) analyses to determine the number of females that actually contributed to the 1992 year-class. Results showed that although 28 females were introduced, the 15 juveniles were produced by 5 females, and 8 were produced by a single female (T. Dowling, Arizona State University, personal communication).

The 1993 fertilized egg experiment produced 17

TABLE 1.—Razorback sucker production and survival in ephemeral backwaters in Lake Mohave, Arizona–Nevada, during 1991–1994. The number stocked represents larvae unless otherwise noted.

Year and location	Surface area[a] (ha)	Number stocked (size, cm)	Number juveniles harvested (% survival)	Yield (number/ha)	Average size (cm) at harvest[b]
1991					
Yuma Cove	0.82	100 spawners	0	0	
1992					
Yuma Cove	0.82	88 spawners	296	361	35.4
1993					
Yuma Cove	0.82	200,000 eggs	17 (<0)	21	32
		420 (2.6)	386 (92)	470	23.2
Willow Cove	0.17	500 (1.5)	26 (5)	153	21.9
Nevada Larvae	0.10	2,000 (1.1)	250 (13)	2,500	13.8
Arizona Juvenile	0.17	2,010 (1.5)	198 (10)	1,165	17.4
		69 (13.5)	55 (80)	324	30.7
1994					
Yuma Cove	0.82	3,000 (2)	358 (12)	407	32.0
Willow Cove	0.17	1,000 (2)	160 (16)	941	20.8
Dandy Cove		1,000 (2)	562 (56)		19.8
Nevada Larvae	0.10	500 (2)	217 (44)	2,190	22.4
North Chemheuvie	0.16	1,000 (2)	812 (81)	4,476	19.4
South Sidewinder	0.05	500 (2)	201 (40)	3,960	20.1

[a]Surface area at reservoir elevation 195 m.
[b]Harvest dates ranged from August to November.

juvenile razorback suckers. After the water level fell, 420, 2.6-cm-laboratory-reared fry were stocked into Yuma Cove. This stocking produced 386 juveniles; survival was 91.5% (Table 1). Three other coves were stocked with laboratory-reared fish of various size groups. Fish stocked at lengths of 1.1–1.5 cm showed a 5.2–12.5% survival rate; the survival of stocked fish larger than 2.5 cm was 80% (Table 1). Four hundred eighty-seven juvenile fish were tagged with PIT tags and released into the reservoir; the remaining smaller fish were stocked into Davis Cove.

Intensive larval collections from the reservoir began in January 1994. Larval razorback suckers were collected each week at multiple locations until the last week in March. The 3-month effort yielded over 11,000 larvae. Larvae were held in laboratory tanks and fed until they reached 2 cm TL and then distributed to all nine ephemeral backwaters. Stocking rates ranged from 4,000 to 10,000 larvae/ha. The USFWS received 2,000 larvae to rear for future broodstock at Dexter National Fish Hatchery.

Six of the nine backwaters produced young razorback suckers. The absence of razorback suckers in three backwaters was attributed to berm failure (reconnection to the reservoir) or poor water quality. Approximately 2,200 young suckers were harvested, tagged with PIT tags, and released into Lake Mohave in the fall of 1994. Survival rates for fish in backwaters ranged from 12 to 76% (Table 1).

Davis Cove was intensively sampled prior to stocking to remove resident fish. Electrofishing and gill netting harvested over 600 kg of nonnative fish (largemouth bass, striped bass, green sunfish *Lepomis cyanellus*, bluegill, channel catfish, yellow bullhead *Ameiurus natalis*, and common carp *Cyprinus carpio*) from the 1.2-ha cove. Scuba divers removed additional fish with spear guns and concluded that few large (>30-cm-long) predators remained. The cove was stocked on 24 June 1992, with 10,000 juvenile razorback suckers from Dexter National Fish Hatchery and 143 fish reared in an ephemeral backwater. Although the hatchery- and cove-reared fish were young-of-the-year, hatchery fish were about half the size (average 6.8 cm) of cove-reared fish (>12 cm). Predation of smaller hatchery fish by *Lepomis* sp. and juvenile largemouth bass was witnessed by divers. Subsequent sampling during the following 18 months yielded only 2% of the hatchery fish and over 50% of the larger cove-reared fish.

Recovery of Cove-Reared Fish

The spring monitoring effort recovered 5 of the 153 cove-reared fish released into Lake Mohave during autumn 1992 (Table 2). These fish were collected as far as 34 km from their release points. All five fish were males. Release of 487 fish in 1993 brought the total number of fish stocked into Lake Mohave to 640. Ten 28–52.9 cm (TL) cove-reared

TABLE 2.—Growth of and distance traveled by razorback suckers released into and recaptured from Lake Mohave during 1992 through 1994.

Year class and sex	Release		Recapture		Distance traveled (km)
	Date	Length (cm)	Date	Length (cm)	
1992					
Male	Jan 15, 1993	28.3	Mar 17, 1993	28.4	3
Male	Oct 15, 1992	35	Mar 17, 1994	52.9	8
Male	Oct 23, 1992	36	Mar 14, 1993	36.3	8
Male	Nov 23, 1992	36.5	Mar 15, 1993	38	24
Male	Nov 23, 1992	34.2	Mar 15, 1993	36.1	29
Male	Nov 23, 1992	37.5	Mar 19, 1993	38	34
Male	Nov 23, 1992	34.5	Mar 15, 1994	46.9	2
Male	Nov 23, 1992	35.2	Mar 15, 1994	46.9	2
Male	Nov 23, 1992	35.2	Mar 14, 1994	43.7	13
Male	Nov 24, 1992	34.6	Mar 15, 1994	48	2
Male	Nov 24, 1992	35.3	Mar 15, 1994	44.5	2
Male	Nov 25, 1992	37.1	Mar 14, 1994	49	13
1993					
Immature	Jul 8, 1993	28.5	Mar 14, 1994	36	4
Immature	Aug 18, 1993	36	Mar 17, 1994	36.8	4
Immature	Sep 21, 1993	24.3	Mar 15, 1994	28	2

fish were recaptured during the 1994 spawning period. The majority of fish collected in both 1992 and 1993 were spawning males (Gustafson 1975). One male taken in 1993 had reached adult size (50–55 cm) in just 2 years.

Discussion

The NFWG recognized, as others before us, that any attempt to manage an Endangered species should also adhere to social, political, and economic constraints (Johnson 1977; Wydoski 1977, 1982). Four basic issues and their relationship to the Lake Mohave razorback sucker population provided guidance for our activities: recovery, management considerations, genetics, and economics.

One of the first questions asked was, "Is recovery of the razorback sucker (i.e., attainment of a self-sustaining population) in Lake Mohave a realistic goal?" The team agreed recovery would be nice but not realistic. Recovery of the razorback sucker would require habitat restoration or at least changes in resource management. The water resource of the lower Colorado River and its associated politics would prevent any rapid modifications to existing river operations. Reservoirs would not be drained nor would dams be removed before the existing population disappeared. Evidence showed that dam removal would not be necessary if nonnative fish could be eliminated (Minckley 1983; Minckley et al. 1991). The current fishery of Lake Mohave, Lake Mead, other upstream reservoirs and the Colorado River is dominated by nonnative fishes that constitute a valuable recreational fishery. The removal of this biological component would be undesirable to the general public and logistically impossible to accomplish.

State and federal agencies have legislative commitments under the Endangered Species Act; however, often political and environmental issues concerning recovery are complex and controversial. Administrative processes, inaction justified by uncertainty, inadequate resources, and conflicting management goals often lead to slow or ineffective recovery programs (Rohlf 1991; Tear et al. 1993). The rapid decline of the Lake Mohave razorback sucker population was warning us that we no longer had the luxury of time for further debate or research. Our choices were simple: either continue the debate and monitor their decline, or, for the present, accept something less than total recovery by actively managing the species.

Minckley and Deacon (1991) recently pointed out that technology and resources are normally available to sustain or replace endangered populations. The critical question is whether the affected agencies have the political conviction to do so. We found the agencies would support an active Endangered Species management program as long as the effort did not unreasonably conflict with other resource management objectives. Any major conflict would demand formal coordination, consultation, and, most importantly, time necessary for resolution. Recognizing that time was our greatest enemy, we concluded our best chance to implement a maintenance effort was through an active stocking and management program. We were confident stocking 25-cm razorback suckers was feasible, but we had to identify where, by whom, and how these fish were going to be raised.

No one agency volunteered the funds or facilities to accomplish this task; it became a cooperative effort. We were unable to identify any existing culturing facilities that would raise tens of thousands of large razorback suckers, nor did we have the resources to build new facilities. As an alternative to conventional culturing, we proposed to develop a low-cost, on-site rearing program as a method of producing 10,000, 25-cm razorback suckers. We thought if this concept worked, it could be used to reintroduce and maintain other Threatened or Endangered, long-lived fish species in different reservoir and riverine habitats.

The debate over the method of producing genetically acceptable razorback suckers has been an evolutionary process. Mitochondrial DNA diversity in the Lake Mohave population is high compared with other relict populations located farther upstream (Dowling and Minckley 1993). The reservoir population is composed of direct descendants of a very large, diverse population that inhabited the river prior to impoundment. Methods being used to produce 25-cm razorback suckers were reviewed in autumn 1993 (Dowling and Minckley 1993). Natural spawning (stocking reservoir adults in backwaters) was successful only 1 of 2 years. The progeny produced by these fish exhibited the greatest growth but resulted in only 296 juveniles for the 2-year effort. Genetic analysis suggested the majority of these fish came from very few females. We also suspected the use of early spawners may not have adequately represented the total spawning effort. Fertilized egg experiments were unsuccessful, partially because of unpredictability of reservoir operations. Light-trapping experiments showed that large numbers of razorback sucker larvae could be harvested (Mueller et al. 1993). Dowling and Minckley (1993) recommended, in order of priority, the following methods for producing razorback suckers for stocking into Lake Mohave: (1) collect naturally produced larvae, (2) artificially collect gametes (protocol would be developed), (3) stock backwaters with spawning adults, and (4) use hatchery-produced fish. The method of choice, collecting larvae naturally spawned in the reservoir, allows us to produce young adult razorback suckers that represent greater genetic diversity than those produced using other recommended matrix spawning techniques or hatchery facilities (Williamson and Wydoski 1994; Dowling and Minckley, in press). Rather than manipulate spawning, we are now taking advantage of the product of natural spawning as a means of conserving the population's genetic diversity.

Fish have survived nearly 18 months since their release into Lake Mohave. Return of 15 of 640 stocked fish from an 11,400-ha reservoir was higher than expected and represents the largest number of subadults collected from Lake Mohave, and possibly the entire Colorado River, in the last 20 years. We anticipate returns will increase in 1995; a total of 2,880 fish have been released and earlier-stocked females should become sexually active and more susceptible to capture.

Active management of relict populations is a critical component of recovery that many feel is being neglected or overlooked. The razorback sucker is following the same path toward extinction as other fish species. For instance, the bonytail, which co-inhabits the Colorado River, was federally listed as Endangered in 1980. A recovery plan was formalized in 1984 (revised in 1990) calling for the augmentation of wild populations through stocking (Colorado River Fishes Recovery Team 1984). Even though culturing facilities, broodstock, and a recovery plan have been in place for over a decade, managers remain reluctant to stock fish. Bonytail are now considered extirpated from the upper Colorado River basin, where less than 5 have been captured during the last 10 years (USFWS 1990; R. S. Wydowski, personal communication). Concerns have now shifted from recovery to preventing extinction.

The "hands off" recovery philosophy for the bonytail and the razorback sucker is failing while unique, irreplaceable biological components are being lost. The necessity for an active and long-term management commitment to maintain these populations was recognized 14 years ago (W. H. Miller 1982), but researchers have not identified any solutions. Management should be considered a practical safeguard to conserve remaining populations while recovery programs are further developed, implemented, and tested. Reversing environmental degradation will take a concerted and long-term commitment not obtainable in a 10- or 15-year recovery program. The Lake Mohave program falls short of recovery; however, it does represent a modest step toward conserving an existing population. Similar, proactive management approaches are needed to prevent further population declines and potential extinctions.

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