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[Article]

Stocking of Endangered Razorback Suckers in the Lower Colorado River Basin over Three Decades: 1974–2004

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Abstract.—The razorback sucker *Xyrauchen texanus* was historically widespread and abundant throughout the larger streams of the Colorado River basin, ranging from Sonora, Mexico, to Wyoming. The species was federally listed as endangered in 1991 because it has been extirpated from most of its range. Its decline is attributed to habitat loss and predation by nonnative fishes. Thirty years of federal and state effort have resulted in stocking millions of razorback suckers to the lower Colorado River basin, but only a few individuals have been recaptured because the young are rapidly consumed by introduced predators, resulting in insufficient recruitment to adulthood. Elderly, wild adults of this long-lived species are vanishing, and lower Colorado River basin recovery efforts now focus on replacement of these fish with repatriated (or reintroduced) adults. Stocking success and subsequent survival increases with size at release. When estimates of size-based, first-year survival rates were applied to individual batches of repatriated fish, we observed less than 1% overall first-year survival, and most fish stocked to date are thought to have been consumed soon after release. Overall, stocking has been unsuccessful, long-term survival is unknown, and no new populations have been established.

The razorback sucker *Xyrauchen texanus*, a large catostomid, was historically widespread and abundant throughout the larger streams of the Colorado River basin, ranging from Sonora, Mexico, to Wyoming (Minckley 1973; Minckley et al. 1991). Historical densities of the species are not well quantified, but before the introduction of nonnative fishes and the construction of dams on the Colorado River, razorback suckers were commonly utilized as human or animal food and fertilizer, and they even supported a commercial fishery (Minckley et al. 1991). The species was listed as endangered in 1991, following 10 years of failed reintroduction attempts (USFWS 1978, 1980, 1990, 1991). The few remaining wild populations are found in Lakes Mead and Mohave of the lower Colorado River basin and in portions of the Colorado, Duschene, Green, White, and lower Yampa rivers of the upper Colorado River basin (Modde et al. 1996; USFWS 1998, 2002; Marsh et al. 2003). Elsewhere the species is extirpated, except for scattered individuals, small aggregations, and reintroductions (Figure 1).

The razorback sucker's rarity accords with that of other big river fishes. Bonytail *Gila elegans*, humpback chub *G. cypha*, woundfin *Plagopterus argentissimus*, Colorado pikeminnow *Ptychocheilus lucius*, and desert pupfish *Cyprinodon macularius* are also federally listed as endangered. Flannelmouth sucker *Catostomus latipinnis*, bluehead sucker *C. discobolus*, roundtail chub *G. robusta*, and speckled dace *Rhinichthys osculus* have no federal protected status at this time, but they are extirpated from most of their historical ranges (Minckley et al. 2003). Additional native marine fishes (machete *Elops affinis*, spotted sleeper *Eleotris picta*, and striped mullet *Mugil cephalus*) entered the historical Colorado River from the Sea of Cortez, but dams and reduced river flows have since precluded their presence in all but the southernmost reaches.

The razorback sucker's decline is attributed to habitat loss and modification in concert with predation by introduced, nonnative fishes (Tyus and Saunders 2000; Clarkson et al. 2005; Marsh and Pacey 2005). Although adults spawn annually and produce offspring in the anthropogenically modified habitats (Marsh and Langhorst 1988; Holden et al. 2001a; Marsh et al. 2005), early life stages are rapidly consumed by introduced predators, curtailing recruitment to adulthood (Minckley and Deacon 1968; Miller 1972; Johnson and Rinne 1982; Medel-Ulmer 1983; Minckley 1983). Population declines continue in both the upper and lower basins (Holden et al. 2001a; Abate et al. 2002; Bestgen et al. 2002; Albrecht and Holden 2005; Arizona Game and Fish Department [AGFD], unpublished data). The decline of the abundant Lake Mohave population (Minckley et al. 1991; Dowling et al. 1996a; Turner et al., in press) was predicted by Minckley (1983) to occur soon after the year 2000; this decline has since been well documented (Minckley 1983; Minckley et al. 1991; Marsh et al. 2003; Marsh et al. 2005; Pacey and Marsh 2005), population estimates being fewer than 3,000 wild fish in 2001

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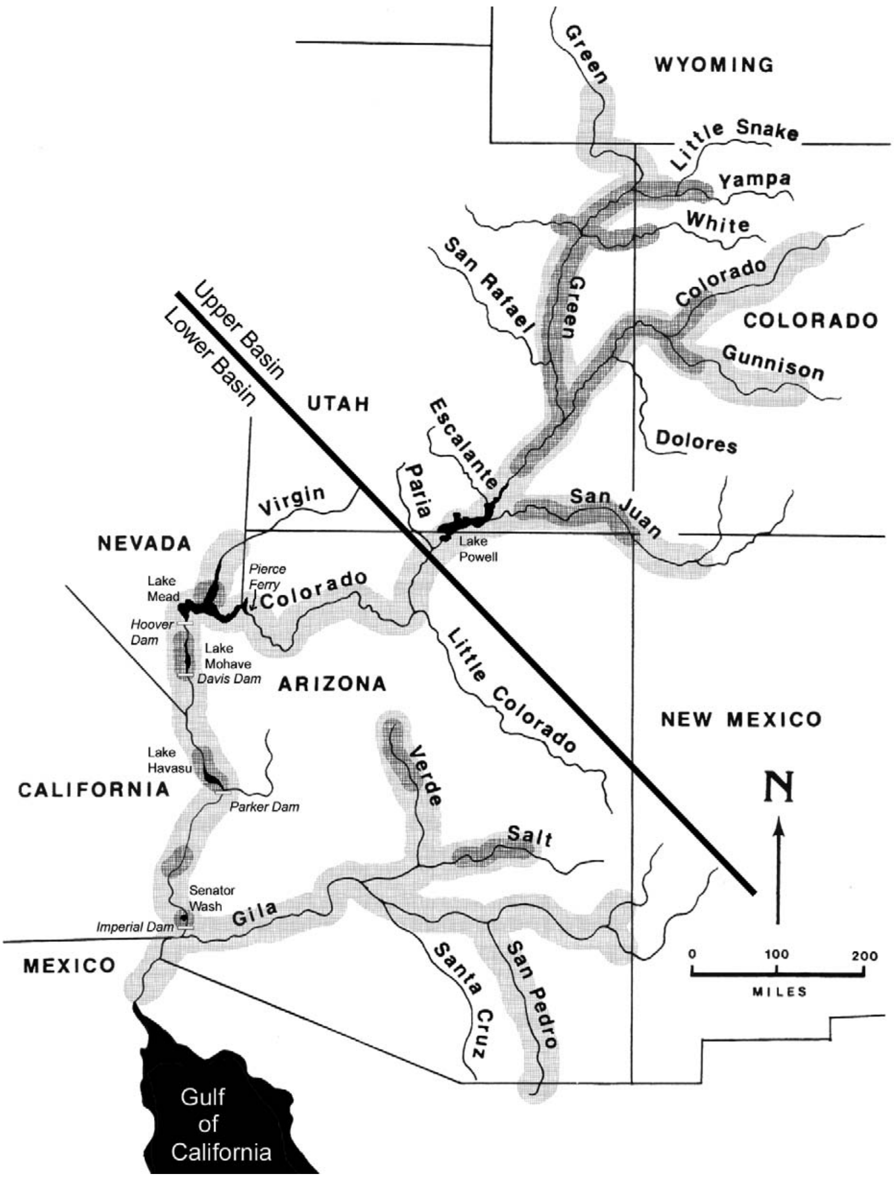

FIGURE 1.—Razorback sucker distribution, both historical (light shading) and present (dark shading); current reservoirs are shown in black. The historical distribution was adapted from Minckley et al. (1991), excluding the Salton Sea area. The present distribution was adapted from USFWS (2002) and Bestgen et al. (2002) and includes primary stocking locations in addition to areas of natural occupation.

(Marsh et al. 2003) and fewer than 1,500 repatriate fish in 2002 (Marsh et al. 2005). Elderly, wild adults of this long-lived species (>40 years; McCarthy and Minckley 1987) are vanishing (Marsh et al. 2003; Marsh et al. 2005), and lower basin recovery efforts continue to focus on replacement of these fish with repatriated (or reintroduced) adults (USFWS 1998, 2002).

Early stockings were solely supported by artificial propagation, and initial technological development of these techniques began in 1974 when 40 wild adults were collected from Lake Mohave and became the first broodstock at Willow Beach National Fish Hatchery (Toney 1974). Similar transfers were made to Dexter National Fish Hatchery (now Dexter National Fish Hatchery and Technology Center) soon afterwards, and the progeny of paired matings were distributed to a suite of central Arizona rivers and streams. Since those pioneering efforts, accumulated knowledge has been used to modify razorback sucker repatriation protocols, resulting in two stocking approaches that differ both philosophically and practically.

The first stocking approach utilizes artificial propagation of hatchery broodstocks for repatriation to the main-stem Colorado River (including Lake Havasu) and other waters in Arizona, Utah, Colorado, and New Mexico. The second approach is embodied by the Lake Mohave repatriation program (Mueller 1995), in which only wild-born progeny are stocked, alleviating a possible bottleneck effect from utilizing a limited number of parents as broodstock in hatchery production (USFWS 2002). The high genetic diversity of this wild population (Dowling et al. 1996b) has been well preserved (Dowling et al. 2005), even though the wild population has been all but replaced by a repatriated one.

Under the terms of a biological opinion for lower Colorado River operations and maintenance (USFWS 1997), and working towards the goal of reestablishing self-sustaining populations, U.S. Bureau of Reclamation (USBR) was to stock 50,000 adults in Lake Mohave and 25,000 in Lake Havasu by 2000. These goals were quantitatively reached, but long-term survival of stocked fish has yet to be observed. The Colorado, Gila, Salt, and Verde rivers of the lower basin were designated as critical habitat for razorback suckers (USFWS 1991). Colorado River reaches deemed critical included (1) Pierce Ferry to Davis Dam, including Lakes Mead and Mohave to full pool elevation, and (2) Parker Dam to Imperial Dam, including the 100-year floodplain. The Razorback Sucker Recovery Plan (USFWS 1998) was amended and supplemented with recovery goals (USFWS 2002) and additionally by the Big-River Fishes Management Plan (also called the Lower Colorado River Management Plan; USFWS 2004). All three documents culminate in three management strategies: (1) augmentation (i.e., stocking of hatchery-reared fish), (2) the utilization of isolated habitats, and (3) taking advantage of unique opportunities (dam closures, establishing new habitats). Monitoring programs are ongoing throughout the basin, stocking success and survival being the primary gauge for the recovery efforts for the species.

We review here the razorback sucker stocking efforts for the lower Colorado River and connected bodies of water. Although the sources of information were diverse, errors and conflicting information were rare. This synthesis presents the most complete and accurate information currently available on this intensively managed species.

Study Area

The stocking and survival data we examined encompassed the lower Colorado River downstream from Lee's Ferry, Arizona (hereafter, lower river), plus the Gila, Salt, and Verde rivers and their tributaries in central Arizona (Figure 1). Stocking locations include floodplain lakes, reservoirs, backwaters, canals, isolated or closed habitats, streams, creeks, and main-stem rivers. There are eight dams on the lower main stem plus 11 more on its tributaries (USWPRS 1980); these have dramatically altered and in some cases eliminated the vast floodplains of the historical system (Mueller and Marsh 2002).

Methods

Stocking records for razorback sucker were compiled from agency stocking receipts, annual hatchery reports, and electronic hatchery records obtained from federal and state agencies, including USFWS, AGFD, California Department of Fish and Game (CDFG), USBR, and U.S. Bureau of Land Management (BLM). Additional information, such as site descriptions, was gathered from third-party sources (e.g., university personnel), stocking summaries, investigative reports (published literature and technical reports), interoffice memoranda, and personal communications.

Stocking records and other pertinent information (date, quantity, total length and weight statistics, tagging variables, stocking location, batch origin, and source of information) were entered into a Microsoft Access database. Original data were presented in various formats and often only partial information was available. Incomplete records were further investigated, completed if possible, and inconsistencies noted. Many stocking events were reflected by multiple sources, occasionally with differing totals or details. Stocking receipts generally were favored as more reliable compared with summary compilations or third-party literature.

Records were grouped by general destination: hatchery or grow-out facility, lower Colorado River below Parker Dam, central Arizona rivers (including the Gila, Salt, and Verde river watersheds), Lake Mead, Lake Mohave, Lake Havasu, or other locations (i.e., transfers to museums, refugia, aquaria, conservancies, universities, etc.). Fish transferred between hatcheries (e.g., federal to state) were not treated as repatriates until stocked into open waters. The category "other locations" generally involved transfers for novelty, investigative (sacrifice), or collection purposes and, therefore, with few exceptions, did not represent repatriates.

Individual stocking batches were analyzed by mean total length ($\overline{\mathrm{TL}}$). When no mean value was provided for a given stocking batch, one was derived ($\mathrm{d}\overline{\mathrm{TL}}$) by one of the following three methods:

(1) The stocking record text was examined for clues and translated to $\mathrm{d}\overline{\mathrm{TL}}$. For this method, the text had to include size data that could be easily translated to mean total length (e.g., "3–6-in fingerlings" would translate to 114 mm).

(2) If no length data were available but weight data were, mean weight ($\overline{\mathrm{W}}$) was calculated and converted to $\mathrm{d}\overline{\mathrm{TL}}$ by inverse linear regressions of total length on weight (developed from log-transformed field measurements of paired weights and lengths; Kutner et al. 2005), namely, as

$$\ln(\mathrm{d}\overline{\mathrm{TL}}) = \text{intercept} + \text{slope} \times \ln(\overline{\mathrm{W}}).$$

Fish were classified as small juvenile ($\overline{\mathrm{W}} < 10$ g), juvenile ($10 \leq \overline{\mathrm{W}} \leq 1{,}000$ g), and adult ($\overline{\mathrm{W}} > 1{,}000$ g), and the appropriate regression model was applied. (Conversions from weight to length were not used for larval fish.) Parameter estimates and 95% confidence intervals (CIs) are shown in Table 1. For the adults, growth was first determined by gender. Using a weight–length correlation to estimate $\overline{\mathrm{TL}}$ for an adult-stage stocking batch requires the assumption of a 1:1 male : female ratio. Therefore, $\mathrm{d}\overline{\mathrm{TL}}$ was calculated for males and females individually and a mean derived from these two values.

(3) Minimum TL was used in the place of $\overline{\mathrm{TL}}$. The decision to use the minimum TL rather than the maximum or an average based on the minimum and maximum was based on several factors. First, the minimum TL was often provided instead of the mean. Second, according to hatchery personnel, an average derived from the minimum and maximum values would not be an adequate substitute for the actual mean because of TL frequency distributions and varying growth rates within batches (i.e., a few large fish in a batch of smaller fish).

TABLE 1.—Parameter estimates and confidence intervals (CIs) for inverse regressions of log-transformed mean total length on log-transformed mean weight for razorback sucker stocking batches, lower Colorado River basin.

	Intercept		Slope	
Category	Estimate	95% CI	Estimate	95% CI
Small juveniles	3.817	3.804–3.831	0.289	0.266–0.312
Juveniles	3.862	3.843–3.882	0.328	0.324–0.331
Males	3.998	3.937–4.059	0.308	0.300–0.317
Females	3.978	3.906–4.050	0.312	0.302–0.322

The analysis applied size-based survival estimates to each individual batch of stocked fish. First-year survival was calculated from estimates of first-year survival based on TL at release (as in Marsh et al. 2005). The following formula was applied:

$$S = \frac{\exp\left(\frac{\mathrm{TL}}{1{,}000} \times \beta\right) + \mathrm{INT}}{1 + \exp\left(\frac{\mathrm{TL}}{1{,}000} \times \beta\right) + \mathrm{INT}},$$

where S = survival rate, β = 22.782459, INT = –9.0170896, and TL (here, $\mathrm{d}\overline{\mathrm{TL}}$) is in millimeters. The formula is derived from mark–recapture data for razorback suckers repatriated to Lake Mohave, Arizona and Nevada, 1992–2002. Figure 2 graphically depicts this size-based first year survival relationship.

We attempted to estimate the portion of these 14.6 million first-year fish that are alive today. We applied the Lake Mohave survival model to stocking locations elsewhere because limited capture data precluded similar formulations for each location. Lower river surveys during 2003–2004 resulted in few razorback sucker captures and only one recapture (Schooley et al. 2004), and similar results were reported for the Verde and Salt rivers during 1991–2004 (Hyatt 2004). Both examples indicate low poststocking survival, which is consistent with the Lake Mohave model. There are no other survival models for razorback suckers, and although survival may be site-specific, we believe the Lake Mohave model provided suitable estimates for survival in other lower basin populations.

Results

Records indicate that a total 14.6 million razorback suckers were repatriated in 544 separate batches distributed to nearly 200 individual sites within the

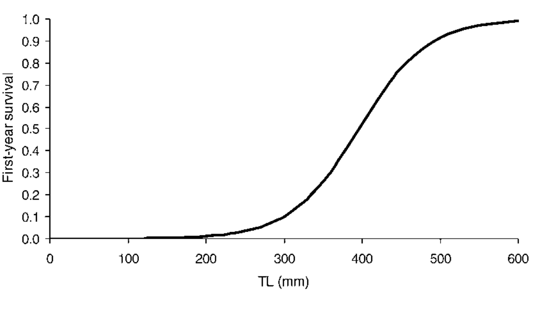

FIGURE 2.—First-year survival curve as a function of total length (TL) at release for repatriated razorback suckers that were later recaptured as adults during annual March censuses in Lake Mohave, Arizona–Nevada, 1992–2002 (reproduced from Marsh et al. 2005).

lower Colorado River and tributaries (Table 2); the number of stocking sites is approximate because of equivocal site descriptions and the use of ambiguous synonyms. Although the initial broodstock was collected in 1974, available records indicate that the first repatriation consisted of 354 juveniles returned to Lake Mohave in 1978 (Toney 1974). Razorback suckers have been distributed in the following quantities: 146 to Lake Mead, 124,942 to Lake Mohave, 514,098 to Lake Havasu, 2.5 million to the lower river below Parker Dam, and 11.4 million to central Arizona rivers and streams (including the Verde River [837,347], Salt River [9.4 million], and Gila River [1 million]).

Records corresponding to 1.5% of all repatriated fish lacked sufficient size details and were therefore excluded from analysis. These records, generally from summaries or third-party sources, were not reflected in stocking receipts or hatchery reports.

Inverse linear regressions for razorback sucker total length and weight resulted in high coefficients of determination and similar relationships across size and gender categories, including small juveniles ($N = 47$; $R^2 = 0.94$), juveniles ($N = 2{,}138$; $R^2 = 0.93$), adult males ($N = 515$; $R^2 = 0.90$), and adult females ($N = 278$; $R^2 = 0.93$).

Among stocking records for which size data were provided or inferred, 85% were larvae (<27 mm TL; Snyder 1981). Most fish (96%) were repatriated at an average annual rate of 2 million fish during the period 1982–1988, before listing as an endangered species. For the 13 years (1992–2004) since listing, an average of 26,227 fish were stocked annually (range, 5,775–79,313).

Discussion

First-year survival estimates (Table 2) suggest that 39,149 fish survived the first year after release, a 0.27% survival rate. Because the spatial and temporal variations in first-year survival rates (Table 2) are based solely on the mean size at release for individual batches, they may be misleading, however. For example, it might seem that the Lake Mead stockings were the most successful based on the estimated 65%

TABLE 2.—Razorback suckers stocked annually into the lower Colorado River basin and, in parentheses, the estimated number of first-year survivors as formulated from derived mean total length ($d\overline{TL}$).This table excludes stocking batches for which size data were insufficient for survival rate estimation; those batches (3,274 fish in Lake Mohave, 6,975 fish in Lake Havasu, 24,020 fish in the lower river, and 196,275 fish in central Arizona waters) total 14,564,677 fish stocked into the lower Colorado River basin.

Year, $d\overline{TL}$, and survival	Stocking site						$d\overline{TL}$ (mm)	Survival (%)
	Lake Mead	Lake Mohave	Lake Havasu	Lower River	Central Arizona waters	All sites		
1980				79 (16)		79 (16)	334	20.25
1981					7,000 (6)	7,000 (6)	81	0.09
1982					612,627 (143)	612,627 (143)	18	0.02
1983				457 (0)	2,664,296 (590)	2,664,753 (590)	16	0.02
1984					3,183,235 (705)	3,183,235 (705)	16	0.02
1985				57 (4)	3,026,687 (677)	3,026,744 (681)	18	0.02
1986			466,923 (71)	1,045,271 (412)	718,531 (362)	2,230,725 (845)	30	0.04
1987				1,276,367 (278)	334,018 (308)	1,610,385 (586)	28	0.04
1988				1,700 (13)	558,532 (465)	560,232 (478)	30	0.09
1989				1,375 (145)	79,680 (679)	81,055 (824)	103	1.02
1990				3,039 (560)	7,228 (103)	10,267 (663)	242	6.46
1991					3,968 (72)	3,968 (72)	197	1.81
1992		10,899 (42)			207 (40)	11,106 (82)	84	0.74
1993		1,358 (16)	1,949 (810)	14,006 (16)	1,120 (181)	18,433 (1,023)	141	5.55
1994		2,195 (63)	6 (2)	81 (6)	3,493 (1,448)	5,775 (1,519)	320	26.3
1995	40 (37)	1,501 (181)	9,888 (12)	13,514 (92)	3,156 (288)	28,099 (610)	129	2.17
1996		3,094 (297)	91 (12)	70,165 (84)	5,963 (741)	79,313 (1,134)	81	1.43
1997	6 (6)	7,317 (471)	986 (249)	2,000 (53)	1,641 (484)	11,950 (1,263)	283	10.57
1998	11 (11)	7,667 (788)	9,332 (2,149)	62 (50)	2,391 (293)	19,463 (3,291)	321	16.91
1999	39 (0)	20,166 (1,358)	6,358 (1,320)	2,421 (268)	2,000 (454)	30,984 (3,400)	294	10.97
2000		7,215 (993)	4,634 (1,000)	4,380 (337)	2,131 (326)	18,360 (2,656)	310	14.47
2001	9 (9)	15,392 (2,221)	6,784 (1,349)	4,425 (558)	1,574 (206)	28,184 (4,343)	318	15.41
2002	23 (14)	11,747 (1,704)	30 (21)	15,548 (1,144)	2,022 (412)	29,370 (3,295)	299	11.22
2003	12 (12)	19,638 (3,630)	142 (23)	14,070 (1,135)	378 (69)	34,240 (4,869)	313	14.22
2004	6 (6)	13,479 (3,484)		9,869 (1,692)	2,325 (873)	25,679 (6,055)	342	23.58
All years	146 (95)	121,668 (15,248)	507,123 (7,018)	2,478,886 (6,863)	11,224,203 (9,925)	14,332,026 (39,149)		
$d\overline{TL}$	444	286	32	27	23	26		
Survival (%)	65.07	12.53	1.38	0.28	0.09	0.27		

survival rate at that location, but this rate is attributable to the large size of the razorback suckers stocked into Lake Mead ($d\overline{TL}$ = 444 mm). On the other hand, the stockings into central Arizona waters might seem to be the least successful based on the estimated survival rate of 0.09%. This, however, is simply the result of the small size of the fish stocked into those waters ($d\overline{TL}$ = 23 mm). We are therefore not implying that any stocking locations are more suitable than others.

Though most fish were stocked during 1982–1988, the estimated survival of pre-1997 stockings was negligible (0.07%). Conversely, three-fourths of the overall survivors were stocked during 1997–2004 (Figure 3); the estimated post-1996 survival rate was 14.72% (range, 10.57–23.58%). The Arizona State University (ASU) native fish mark–recapture database indicates that less than 0.02% of the razorback suckers stocked into the lower basin have been recaptured to date (C. Pacey, ASU, personal communication), and nearly one-fourth of these recaptures occurred a short time after stocking.

Considering the long stocking history and number of fish stocked, the razorback sucker is arguably further from recovery now than when stocking began in 1974. Minckley et al. (2003) indicate that the wild population of razorback suckers in Lake Mohave alone was near 73,000 during 1980–1993. This estimate probably eclipses the total population of razorback suckers persisting in the wild today. The flagship population in Lake Mohave has since dwindled to fewer than 3,000 wild fish in 2001 (Marsh et al. 2003) and fewer than 500 fish in 2006 (unpublished data). Quantitative recovery goals require establishment of multiple populations, each of at least 5,800 adult fish, before down-listing can occur (USFWS 2002), a result that seems unlikely anytime soon in view of currently available information.

In retrospect, it makes little sense to produce and stock millions of larvae (85% of all repatriates to date) and expect them to have a better chance of surviving than the wild-produced variety. Nonetheless, it has taken more than 30 years for the lower basin stocking program to evolve in a way that notably increases survival to adulthood (i.e., repatriates now spend all of their early life stages in protected environments). Strict adherence to this protocol is likely to produce a measurable increase in repatriate captures near recent stocking locations, after which time survival rates for point locations may be estimated.

Although reintroduction of the razorback sucker to historical habitat is presently the prevailing species conservation strategy, the ultimate goal still is the reestablishment of self-sustaining populations (USFWS 2002). Nonnative predator and native prey interaction indicates that this goal is not attainable with simple replacement. Interactions between native and nonnative fishes in the Southwest have been thoroughly studied (Minckley and Deacon 1968; Minckley 1973; Meffe 1985; Minckley and Jensen 1985; Minckley and Deacon 1991; Blinn et al. 1993; Douglas et al. 1994; Pacey and Marsh 1998; Bryan et al. 2000; Tyus and Saunders III 2000; Mueller and Marsh 2002; Marsh and Pacey 2005; Mueller 2005). Successful natural recruitment has been demonstrated repeatedly in habitats absent of nonnative predators (Marsh and Pacey 2005), and also in the presence of native omnivores such as bonytails (Mueller et al. 2004). Minimal natural recruitment has been observed in Lake Mead, but it is the exception to the norm (Abate et al. 2002; Albrecht and Holden 2005). Considering that

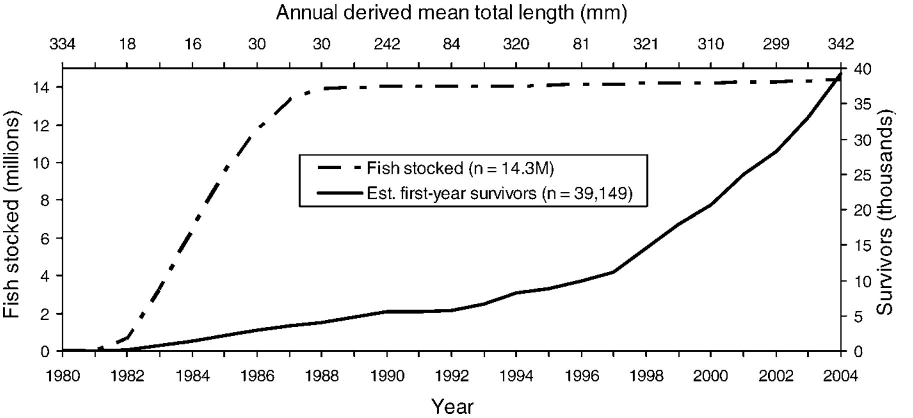

FIGURE 3.—Cumulative numbers of razorback suckers stocked into the lower Colorado River basin from 1980 to 2004 and estimated numbers of first-year survivors formulated from size at release. Estimates of annual derived mean total lengths appear at the top of the figure.

poor survival of repatriated fish probably is indicative of the losing battle between imperiled native fishes and introduced predators, the future management of natives undoubtedly lies in the creation of segregated habitats (Clarkson et al. 2005). Such habitats are both presently available (but underutilized) and easily created and managed. A plan for the design, creation, and management of predator-free habitats for native fish is presented by Minckley et al. (2003) and reiterated in the Big-River Fishes Management Plan (USFWS 2004), but the mechanisms have not been achievable due to inter- and intra-agency conflicts regarding the management and disposition of nonnative sport fishes and native species (see also Clarkson et al. 2005). However, implementation of the Multi-Species Conservation Plan, a 50-year, $626-million conservation initiative enacted in April 2005, will presumably alleviate many of these roadblocks.

The razorback sucker stocking program as a whole has shown limited success. Early stocking efforts mostly were mass releases of young fish to replenish disappearing populations, but they were in vain because fish disappeared soon after stocking and long-term survival was negligible. Statistical analyses show a logistic relationship between size at release and subsequent-year survival, where bigger is better in respect to release size (Marsh et al. 2005). Therefore, lower basin repatriates presently are held in nonnative-free environments until they reach at least 300 mm TL. This takes at least a year to attain, and only about 10% survive their first year in the wild. Had the earlier incantations of the razorback sucker repatriation program been based on today's knowledge of size-based survival, this review would tell a completely different story. If all repatriates had been released at 350 mm TL, we would estimate more than a 100-fold increase in survivors today.

Stocking programs have become the cornerstone for recovery of western native fishes (USFWS 2004), but the implementation and outcomes have been variable. Notable success was realized for cui-ui *Chasmistes cujus* in Pyramid Lake (Scoppettone et al. 1986). The same could be said for Colorado pikeminnow in the San Juan River (Brooks et al. 2000), but this program was accompanied by aggressive nonnative fish control. Stocked bonytails have yet to establish new populations anywhere in the Colorado River, and repatriation programs for Colorado pikeminnow and razorback suckers in central Arizona have similarly failed (Hyatt 2004). Further, stocking programs for smaller fishes, such as woundfin (Holden et al. 2001b), Gila topminnow *Poeciliopsis occidentalis* (Voeltz and Bettaso 2004), have not met expectations (Minckley and Brooks 1985; DFT 2003, 2004). In stark contrast, three-fourths of more than 100 nonnative fish species released into the lower Colorado River basin have established populations, or still are actively stocked in the region.

Short of the eradication of or strict segregation from nonnative predators and the decommissioning of dams to restore historical floodplain habitats and floods, continued human management of razorback suckers is the only means of perpetuating this species. A proactive, continued increase in minimum release size is cost-effective for this species (C. Figiel, personal communication) and would have a dramatic effect on poststocking survival to adulthood.

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