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Reintroduction of the Flannelmouth Sucker in the Lower Colorado River

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Abstract.—A single stocking of 611 wild flannelmouth suckers *Catostomus latipinnis* in 1976 represented the first successful reintroduction of a native fish in the lower Colorado River. Flannelmouth suckers ranging in age from young of the year to 24 years were captured during 1999–2001; their population was estimated as at least 2,286 (95% confidence interval, 1,847–2,998). Recruitment appeared sporadic, consisting of consecutive years of low recruitment (<10%) supplemented by a stronger (31%) year-class. Historically, this native fish was rare and was believed extirpated from the lower river by 1975, but it now reproduces naturally in a reach dramatically altered by water development. This successful reintroduction indicates that one native fish can successfully tolerate environmental alterations whereas another, the razorback sucker *Xyrauchen texanus*, apparently cannot. Other opportunities may exist in altered rivers to benefit native fishes where they were absent or historically rare.

Historically, the Colorado River downstream of the Grand Canyon supported nine endemic fish species, but habitat degradation and the proliferation of nonnative predators resulted in seven being listed as endangered under the Endangered Species Act. One of the remaining two, the flannelmouth sucker *Catostomus latipinnis*, was listed as a species of special concern (USFWS 1994). Historically the flannelmouth sucker was rare in the lower main-stem river, having been reported only five times before 1976 (Dill 1944; Minckley 1973; Moyle 1976). One flannelmouth sucker was captured from Lake Mohave shortly after the reservoir was formed in 1954 (Jonez and Sumner 1954). Flannelmouth suckers were believed extirpated by 1970 because of their absence in surveys conducted in the late 1960s and early 1970s (Ponder 1975; Marshall 1976; Kennedy 1979; Minckley 1979). Miller (1952) suggested that fish represented in earlier records were either transients that had drifted downstream from tributaries or baitfish released by anglers. Construction of Hoover Dam (1935), Davis Dam (1954), and Parker Dam (1938) effectively blocked immigration of flannelmouth suckers from other portions of the watershed (Mueller and Marsh 2002).

In 1976, the Arizona Game and Fish Department (AGFD) translocated 611 adult flannelmouth suckers from the confluence of the Paria River to the lower Colorado River near Bullhead City, Arizona (Figure 1), where they were stocked for black fly abatement (T. Liles, AGFD unpublished report). The reintroduction was not specifically monitored, but by the mid-1990s, young suckers were found by the AGFD and the Nevada Department of Wildlife (NDOW) during annual recreational fish surveys (AGFD and NDOW, unpublished data). The present study was initiated in 1998 to document the status of native species in the 80-km reach downstream from Davis Dam, with emphasis on flannelmouth suckers.

Methods

The study area extended from Davis Dam to Lake Havasu, a distance of approximately 80 km. Fish were sampled between December and May, coincident with the native sucker spawning season and low recreational boating traffic. Fish were collected with small (1.4 m × 17 m × 1.2 cm) and large (2 m × 50 m × 3.7 cm) trammel nets, hoop nets (6-mm mesh), minnow traps, and larval light traps (Mueller et al. 1993). Sampling was also attempted with an electrofishing boat equipped with a Coffelt RF-10 voltage regulator and a 5,000 W generator, but that method was ineffective.

Sucker larvae were sampled in 2000 and 2001with quatrefoil, larval-light traps. Traps were set in backwaters just before dark and retrieved

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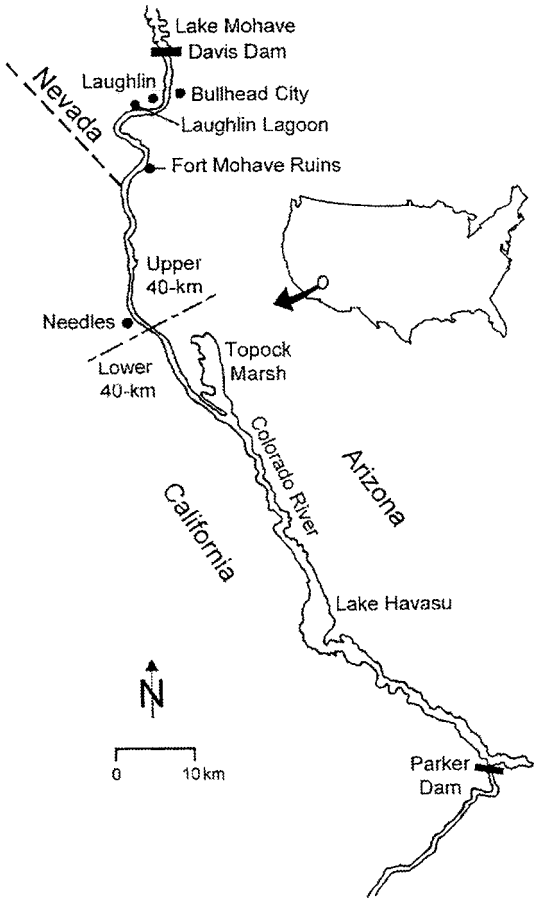

FIGURE 1.—General map of the study area located between Davis and Parker Dams, Arizona–California–Nevada.

shortly after dawn. The floating traps were powered by size D batteries that provided illumination for 10–12 h. Trap contents were preserved in 5% formalin, from which larval fish were later removed and identified (Snyder 1981). All sampling was conducted after dusk; nets and traps were retrieved shortly after dawn.

The flannelmouth sucker population was estimated by using Schuymarher and Eschmeyer's mark–recapture approaches (Ricker 1975) derived from 2002 trammel net data and from daytime visual surveys conducted in 2001. Water visibility exceeded 4 m, which allowed fish to be spotted, identified, and counted. An observer stood in the bow of a boat and counted fish while the boat was driven downstream at speeds of 4–6 km/h. Individual surveys were limited to 15 min. Fish densities (fish/m^2) were quantified by limiting fish counts to a 5-m radius of the boat and using global positioning equipment to measure the distance traveled.

Two sampling trips were scheduled for 1999 and eight surveys were conducted annually in 2000, 2001, and 2002. Sampling started near Bullhead City, Arizona, in 1999 and was expanded to include the 80-km river reach downstream of Davis Dam in 2000. Nets were initially set every 3–4 km along the river corridor, adjacent to the channel, off jetties, and in backwaters. Sampling in 2001 and 2002 was focused on those areas where suckers proved to be most plentiful.

All captured fish were measured to the nearest millimeter in total length (TL). Suckers longer than 20 cm were marked with passive integrated transponders (PIT) tags and released. All fish were scanned for PIT tags and any unmarked fish were PIT-tagged. Mature fish were sexed and checked for ripeness. For determining fish ages, scales and segments of pectoral rays were taken from live fish, whereas vertebrae, entire dorsal and pectoral fin rays (including their base), and otoliths were taken from netting mortalities. Structures were sectioned and ages checked by two readers.

Results

More than 8,000 fish larvae and 8,095 larger fish were captured. Common carp *Cyprinus carpio* was the predominant species among nonlarval life stages (19.4%), followed by largemouth bass *Micropterus salmoides* (18.6%), flannelmouth sucker (16.7%), bluegill *Lepomis macrochirus* (11.2%), threadfin shad *Dorosoma petenense* (9.8%), redear sunfish *L. microlophus* (8.1%), and 12 other species (16.2%). A total of 1,349 flannelmouth suckers were captured (11 larvae and 1,338 juveniles and adults).

Larval-light traps collected more than 8,000 fish larvae during the 2000 and 2001 efforts. Clupeids were the most abundant (61%), followed by cyprinids (38%) and centrarchids (1%). Flannelmouth sucker larvae represented less than 0.1% ($n = 11$) of our sample, small numbers being taken both years.

Adult flannelmouth suckers were commonly observed in the main channel, where depths exceed 2 m and velocities were swift (0.5–1 m/s). Electrofishing and trammel netting proved ineffective in the main channel, where less than 1% of the flannelmouth suckers were taken. The majority were captured in trammel nets set off-channel adjacent to spawning concentrations. Nearly all (99.2%) flannelmouth suckers were captured within 40 km of Davis Dam. Trammel net catch per

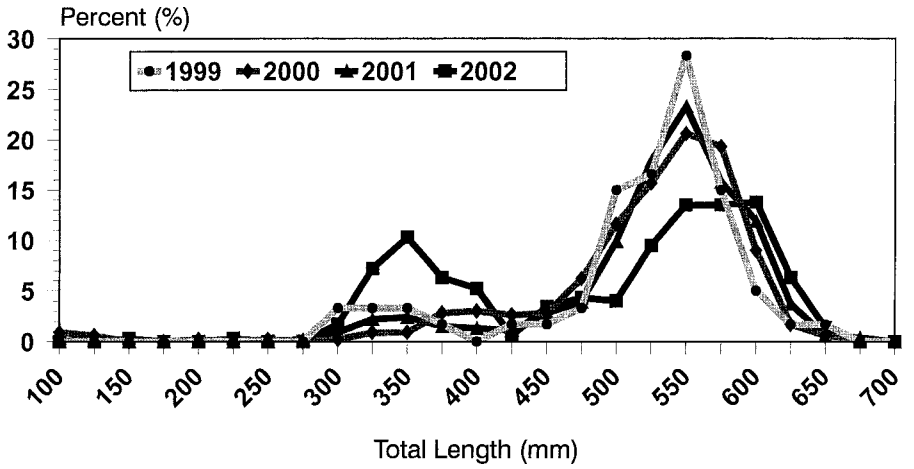

FIGURE 2.—Size distribution of flannelmouth suckers captured from the Colorado River downstream of Davis Dam, Arizona–-Nevada, during 1999, 2000, 2001, and 2002.

unit effort (CPUE) indicated that flannelmouth suckers were nearly 50 times (3.81 versus 0.08 fish/100 m^2) more abundant in the upper 40-km reach below the dam than the reach 40–80 km downstream of the dam.

Two large spawning congregations (>200 fish) of flannelmouth suckers were observed at the same locations during the course of the study. One was located adjacent to Laughlin Lagoon (15 km downstream of the dam), the second near the Fort Mohave ruins (25 km downstream of the dam). Sixty-nine percent of all captured suckers were taken within 100 m of the lagoon's entrance, and the majority of these (73%) were females. Sampling was biased as to location and to spawning females but, unfortunately, this was the only location and season when flannelmouth suckers, which normally were found only in the main channel, were vulnerable to our collection gear.

Annual size distributions were similar for 1999, 2000, and 2001 (Figure 2). Although some immature fish were taken (<5%), the majority of captured fish were spawning adults. Attempts to age fish were hindered by the study area's mild climate and the cool tailwater releases from Lake Mohave, which prevented development of sharp annuli, especially after the 10th annuli. Preliminary testing suggested that annuli patterns of larger aging structures such as entire fin rays (including their base) and vertebrae were more discernable than those found in otoliths or fin segments. Based on this information, additional vertebrae and fin rays were collected (n = 119) and used for determining age (Figure 3). The majority of fish (73%) were

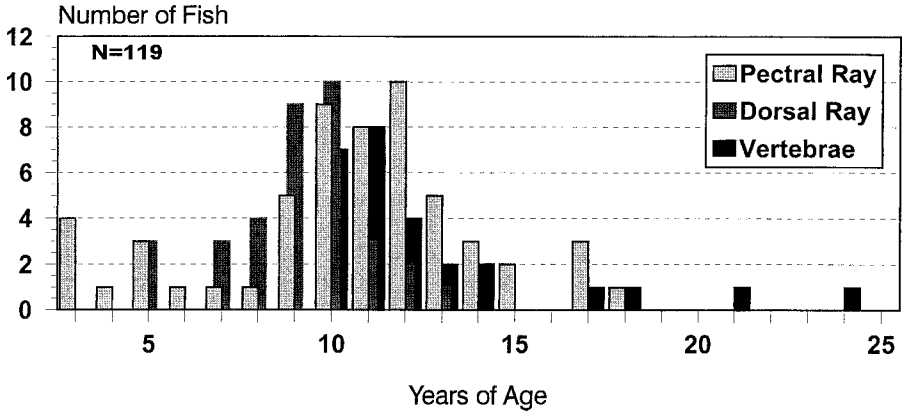

FIGURE 3.—Age distribution of flannelmouth suckers based on vertebrae and fin rays taken from netting mortalities captured in the Lower Colorado River, Arizona–Nevada, from 1999 to 2002.

8–13 years old with most of the growth occurring by age 6. The oldest sucker encountered was 24 years, substantially younger than the 39-year-old fish reported by Minckley (Scoppettone and Vinyard 1991). Annuli typically became weak or fuzzy, especially after the 10th annuli.

Both techniques used to develop population estimates found that the community had expanded well beyond the numbers initially stocked. Between 1999 and 2001, 715 flannelmouth suckers were PIT-tagged and released for the mark–recapture estimates. Eight field surveys in 2002 captured 329 flannelmouth suckers, of which 115 were recaptures. The flannelmouth sucker population was estimated to be 2,286 (95% confidence interval, 1,847–2,998) based on multiple census estimates ($n = 8$). Further analysis suggested that marked fish were predominately mature females (73%). We also discovered that the ratio of unmarked to marked suckers increased proportionately with distance from Laughlin Lagoon, suggesting that the marked fish were not evenly dispersed through population but were localized in distribution. Although visual surveys are not a common technique for estimating population size, it is further evidence that the recapture estimate was probably biased low.

These sampling biases were not prevalent in the visual survey attempt. Twenty-five 15-m surveys were conducted along the 80-km study area during 2001. In the 40-km reach downstream from Davis Dam 301 flannelmouth suckers were observed; none was observed in the 40–80-km reach downstream of the dam. Flannelmouth sucker density averaged 8.6 fish/ha in the upper 40-km reach, based on numbers of fish observed and estimated surface area of the river surveyed. The population size was estimated at 6,794 fish (8.6 fish/ha $\times$ 790 ha), a more realistic estimate than that derived by the mark–recapture method. Unfortunately, no replicates were taken for statistical analysis.

Discussion

Water development is typically viewed as detrimental to native fish communities, but conditions downstream of Davis Dam were readily used by spawning flannelmouth suckers. Other populations have adapted to construction and operation of dams and have occupied river reaches downstream of the dams (Chart and Bergersen 1992; Weiss et al. 1998; McKinney et al. 1999; Bestgen and Crist 2000). We found a similar colonization of the tailwater of Davis Dam by flannelmouth suckers, which were historically rare. We speculate that Davis Dam and other upstream water development projects have altered historical habitat conditions (e.g., shallow, turbid, warm) to mimic tributary habitats (e.g., cooler, channelized, and rockier substrates) preferred by flannelmouth suckers.

Nearly all (94.8%) of the flannelmouth suckers we collected were adults (>35 cm), in contrast to the abundance of young reported in smaller streams (McAda and Wydoski 1985; Douglas and Marsh 1998). Weiss et al. (1998) suggested that the absence of young and the increasing size of the spawning cohort at the confluence of the Paria and Colorado rivers indicated that flannelmouth suckers were experiencing recruitment failure. They attributed poor recruitment to the cold, fluctuating hydropower releases that often dewatered that particular spawning area. McKinney et al. (1999) examined the same population for a longer period and concluded the population had remained relatively stable, even though young suckers were uncommon. Our data suggest that although young may be scarce, numbers are sufficient to maintain the Davis Dam population.

Female flannelmouth suckers have a remarkable reproductive capability in terms of fecundity and longevity. Each mature female can produce 15,000 eggs a year and may spawn for more than two decades (McAda and Wydoski 1985; Minckley et al. 1991; Douglas and Marsh 1998). The ability to annually produce large numbers of young reflects a reproductive strategy that allows low recruitment or even periodic recruitment failure. Our length distribution data suggest that recruitment into the spawning cohort (ages 3 and 4) averaged slightly more than 15% (range 9.4–31.3%) per year during the 4-year study. This recruitment rate is low compared to that of short-lived species (>50%) but apparently is adequate to replace the spawning cohort. Seventy-three percent of the suckers aged ($N = 109$) were 8–13 years old, indicating that an annual recruitment of 15% could replace the spawning cohort (15%/year $\times$ 8 years = 120%) if adult mortality was low.

The year-class strength of some fish species is often determined by environmental conditions such as suitable water temperature or the quality and quantity of food organisms available to larval fish within the first few weeks after hatching (i.e., critical period; Houde 1987). During years of optimum environmental conditions, high survival of larval and juvenile fish produces strong year-classes. Several of the large Colorado River fishes are long-lived and are believed to have periodically produced strong year-classes that helped maintain

the populations over periods when environmental conditions were unfavorable for the survival of young (Kaeding and Zimmerman 1983; Minckley et al. 1991; Osmundson and Burnham 1996).

The response of the flannelmouth sucker population to altered habitat conditions is contrasted by ongoing efforts to recover the endangered razorback sucker *Xyrauchen texanus*. Razorback suckers were historically abundant in the lower main stem but are now rare. More than 12 million small razorback suckers have been stocked since 1980 with little measurable survival (Minckley et al. 1991; Marsh in press). Initial stocking attempts failed because of predation; today, larger fish are being stocked to improve survival chances and to reestablish spawning cohorts (Mueller 1995; Marsh in press). Although this approach has improved survival and fish are spawning, natural recruitment has yet to be documented.

Physical changes, compounded by nonnative predators, have devastated seven of the nine native species that evolved in the lower Colorado River. Those same altered conditions, however, support natural flannelmouth sucker reproduction, which historically was restricted to the upper tributaries and headwaters of the Colorado River Basin. The successful reintroduction of flannelmouth suckers exemplifies that one native fish can successfully tolerate environmental alteration other natives cannot. Other opportunities may exist to benefit native fishes in altered rivers in which those species were either absent or historically uncommon.

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