Conservation Status of the Razorback Sucker in the Colorado River Basin

Reid Brennan
March 8, 2017

The Colorado River was once the home to robust populations of native, endemic, fishes. This river is unique as it harbors high levels of endemism but low levels of diversity. However, of the 10 native fish species in the main stem of the Colorado River, six are currently listed as endangered (Dowling et al., 2012). The species receiving particular attention are the biggest species in the river, the razorback sucker (*Xyrauchen texanus*), Colorado squawfish (*Ptychocheilus lucius*), bonytail (*Gila elegans*), and humpback chub (*Gila cypha*). These large species (> 1 foot in length) historically dominated the river system but due to multiple factors have since seen catastrophic declines in abundance and are all listed as endangered (Minckley et al., 2003). Efforts have been made to restore populations of these river species, with the razorback sucker receiving considerable attention. In this review, I focus on the razorback sucker to explain the causes of its decline, evaluate the success of conservation efforts, and identify contributors to its persistence in the wild.

General biology of the razorback sucker

The razorback sucker is endemic to the Colorado River Basin and historically inhabited waters throughout the basin. Its name comes from the sharp bulge on its back, just behind its head, which resembles a hump or a “razor” keel, presumably an adaptation to the relatively strong currently present in the Colorado River (U.S. Fish and Wildlife Service, 1998). Adults of this species grow up to one meter in length and can weigh 5-6 kg (U.S. Fish and Wildlife Service, 2002). They are long lived and survive more than 50 years in the wild. Razorback sucker reach sexual maturity somewhat slowly; males mature at 2-3 years and females at 3-5 years (Dowling et al., 2012).

Razorback sucker have historically inhabited diverse environments in the warm water regions of the Colorado River Basin and habitat requirements vary according to time of year and reproductive activity. Adults typically require rather deep pools, runs, and eddies year round (U.S. Fish and Wildlife Service, 2002). They are detritivores or herbivores and occupy the base of the consumer food chain (U.S. Fish and Wildlife Service, 1998). Typical food items include algae, microcrustaceans and detritus (Marsh and Langhorst, 1988). Spawning time is in winter to late spring (Minckley, 1983) and occurs on gravel and sand substrate. Access to spawning grounds can require long distance migration (U.S. Fish and Wildlife Service, 1998) and requires warm water (> 14°C) for success (Bozek et al., 1990; U.S. Fish and Wildlife Service, 2002). Females are quite fecund, producing more than 100,000 ova/year (Dowling et al., 2012). Young individuals require shallow, productive, non-flowing nursery grounds, typically coves or flood plains (U.S. Fish and Wildlife Service, 1998).

Threats and Decline

Aquatic habitats within the Colorado River has experienced dramatic alterations due to the building of dams, introduction of invasive species, and overfishing. Razorback sucker have historically been distributed throughout the entire river basin, but more recently have been restricted to only a fraction of this historical range (Fig. 1) (Marsh et al., 2015).

Prior to damming, the Colorado River was a highly variable environment to which the razorback sucker was adapted (Minckley, 1983). The undammed environment experienced fluctuating flow regimes and high turbidity. This uncontrolled flow resulted in diverse habitats including seasonal flood plains, backwaters, sloughs, and oxbow lakes, all of which provide essential habitat for various life stages (Holden and Stalnaker, 1975; Minckley, 1983). However, more than 20 dams have been constructed on the man river have controlled the fluctuating flows present on the Colorado (U.S. Fish and Wildlife Service, 1998). These changes have resulted in increased base flows and highly reduced peak flows (Melis et al., 2011).

The alterations in these flow regimes caused two main changes: 1. Water temperature is decreased due to water release from the bottom of dams; 2. Flooding events are relatively rare. In combination with physical changes to the river, introductions of non-native species have been frequent. About 70 non-native fish species have been introduced to the Colorado River Basin in the last 100 years (U.S. Fish and Wildlife Service, 1998). Some of the most problematic include channel catfish, flathead catfish, rainbow trout, and brown trout (Coggins, 2003; Marsh and Brooks, 1989). Each of these factors has an important impact on the survival of razorback suckers and will be discussed in depth below.

The aforementioned alterations to habitat have resulted in drastic reductions in population size and distributions. Pre-European population sizes have not been quantified, but archaeological data indicates that razorback sucker were abundant and fished commonly throughout the Colorado River Basin (Miller, 1961). Personal testimony from the early to mid 1900's suggests that razorback sucker were easy to catch and plentiful. In many cases, this species was viewed as a trash fish and something to exterminate to make room for more desirable species such as trout (Quartarone, 1995). The species was routinely used as food and fertilizer or simply left to perish on the bank. Unfortunately, it seems that these efforts were successful and populations have plummeted in recent years.

While it is clear that population size and distribution has been significantly reduced in razorback sucker, a few case studies provide the most clear examples of its current status. As previously stated, the distribution has dramatically shrunk from historical times (Fig. 1). Much work has focused on Lake Mohave, which sits between the Hoover and Davis Dams. Davis Dam was completed in 1951 and Lake Mohave was created. Most adults in Lake Mohave in 1987 were estimated to be >50 years old and were likely carryovers from the original individuals trapped upon the creation of the lake (McCarthy and Minckley, 1987), indicating that recruitment is extremely low. It should be noted that recent efforts have likely shifted this age distribution as conservation efforts have begun to see success (discussed more below). Extensive monitoring from 1991 until 2001 shows that population size dropped from around 44,000 individuals to 2,600 (Fig. 2, Marsh et al., 2003). This small population represents the most genetically diverse and abundant population of razorback sucker. However, it would almost certainly be extinct if not for current conservation efforts. Lake fish persist only due to extensive management efforts including "repatriation" of young that have been reared in captivity (Marsh et al., 2015).

The precipitous decline in numbers is not unique to Lake Mohave; lakes, rivers, and tributaries throughout the entire Colorado River Basin have experienced similar declines, though most other populations have not received the management attention allowing for persistence despite the declines. In non-managed populations, recruitment of new young to the population is zero (U.S. Fish and Wildlife Service, 2002)

Effects of alterations in temperature

Temperature is of utmost importance in controlling reproductive success of razorback suckers. First and foremost, hatching success is directly affected by temperature. Bozek et al. (1990) manually spawned fish and incubated eggs at 8, 12, 16, and 20 °C. Eggs experienced total mortality at 8°C, reduced survival at 12°C, and relatively normal hatching at 16 and 20°C. Similarly, Marsh (1985) saw total mortality of embryos at 8, 10, and 30°C, but successful development at 15, 20, and 25°C.

Water temperature can also influence larval development. Bestgen (2008) investigated growth of razorback sucker from hatch to 37 days post-hatch. This study found a dramatic positive relationship between growth and temperature. Those individuals reared at 25.5°C grew twice as fast and gained weight 4 times as fast as individuals reared at 16.5°C. Growth rate is important as it serves as a refuge from predation; large individuals are less likely to be consumed by predators than smaller individuals. Therefore, individuals that grow faster are more likely to escape predation and survive.

These results suggest that reduced temperatures can have a severe impact on the ability of razorback sucker embryos to successfully develop and hatch. While high temperatures can result in mortality, it is unlikely that eggs would experience 30°C during winter and spring spawns. However, cold temperatures are much more likely given the reduction in water temperature caused by dams. Moreover, restrictions in flow rates make flood plain habitats rare (see discussion below). These shallow environments are easily heated to a higher temperature than the main river and can help to promote growth of young individuals (Bestgen, 2008). That is, these shallows serve as a nursery to facilitate rapid growth to help individuals escape predation upon reaching a larger size.

Low temperatures can also influence adult behavior and habitat availability. Bulkley and Pimentel (2011) conducted an experiment to determine the thermal preferences of adult razorback suckers. In these experiments, adult fish could choose their ideal water temperature in a chamber. Preferred temperature was found to be between 22.9 and 24.8°C. Fish especially avoided temperature below 14.7°C and above 27.4°C. While winter temperatures regularly drop below this preferred range, summer temperatures in dam free waters are typically above these lower limits. However, there are regions of the river below dams where water temperature virtually never exceeds 15°C. These abnormally cold areas of the river can be limiting to razorback sucker survival and most of these stretches of river contain no razorback sucker (U.S. Fish and Wildlife Service, 1998).

Effects of alterations in flow regime and non-native species

While changes in temperature have had a negative impact on razorback sucker, changes in flow regime and the addition of non-native species have also been extremely influential. These two seemingly disparate factors are, in fact, intimately tied together. The changes in flow have, in many cases, favored non-native species at the expense of razorback sucker.

Over the past 100 years, almost 70 species of non-native fishes have been introduced into the Colorado River Basin (U.S. Fish and Wildlife Service, 1998). It is commonly thought that these non-native fishes are directly responsible for the lack of recruitment to wild populations. Those species exerting the most negative impacts include flathead catfish, largemouth bass, common carp, channel catfish, smallmouth bass, bluegill, and sunfish (U.S. Fish and Wildlife Service, 2002).

There have been numerous studies documenting the impact of these non-native species on razorback sucker. Marsh and Brooks (1989) investigated the impact of catfishes on mortality of reintroduced juvenile razorback suckers. The authors sampled gut contents of the channel catfish and flathead catfish in a 2.5 km stretch of river. The authors estimate that the catfish in this area of the river consumed 450 individuals/day/km, a shockingly high rate of predation. Similarly, following the release of 900,000 larvae and 200,000 juvenile razorback sucker in 1987 stomach contents of predators in the introduction area were analyzed (Langhorst, 1988). Non-native bluegill were the primary predator of larvae following introduction while largemouth bass were the main consumer of juveniles.

Marsh and Langhorst (1988) studied growth and survival of larval razorback sucker in predator-free versus predator-present habitats. They compared food availability and dietary makeup for larvae in each habitat. No differences in habitat quality were identified, food was abundant in each, zooplankton communities were similar, and the size of available food items was the same. However, individuals in the predator free environment survived to older ages and grew to larger sizes. These results suggest that habitat quality in and of itself is not resulting in mortality, but rather predation by non-natives is directly playing role.

How then do flow regimes fit into this picture? Put simply, flooded backwaters, flood plains, and tributaries provide a refuge from predation for juvenile razorback suckers. Natural high flow events tend to correspond to spawning time. These floods provided warm, shallow, quiet, water that is ideal for juvenile razorback suckers. These habitats are also extremely productive environments, food is abundant and easily accessible (U.S. Fish and Wildlife Service, 2002). The effects of the loss of this habitat are two-fold. First, juveniles experience high predation due to direct interaction with non-native predators. Razorback sucker larvae are not adapted to survive in open water, swift moving environments and easily fall victim to predation. Secondly, loss of floodplain habitats forces juveniles to grow in a colder, less productive environment. Smaller juveniles are more susceptible to predation in that larger juveniles can only be consumed by larger predators (Marsh and Brooks, 1989). The high temperature and abundant food items facilitate fast growth in flooded environments. Fast growth early in life also serves as a refuge from predation, larger individuals can only be consumed by large predators. Slowing growth rate essentially extends the time juvenile razorback suckers are susceptible to predation and may increase overall mortality.

Recovery efforts

There have been substantial efforts to conserve and restore populations of razorback sucker throughout the Colorado River Basin. Initially, these efforts achieved very poor results; recovery was low and population numbers did not increase. However, more recent efforts have proven more successful.

Initial hatchery efforts

The initial push to restore razorback sucker populations began in the early 1980's. This effort concentrated mainly on stocking rivers with hatchery fish from an original broodstock of 281 wild caught individuals (Marsh et al., 2015). Razorback sucker are excellent candidates for hatchery production and quickly produced large amounts of larvae and juvenile fish for release. Records of exact numbers of released individuals from this period are scarce, but it is estimated that close to 14 million fish were stocked in the first decade (Schooley and Marsh, 2007). The lack of success of these efforts is dramatic. Through the first 10 years, survival is estimated to be less than 0.1% (Schooley and Marsh, 2007). Functionally, the stocking efforts resulted in absolutely no increase in razorback sucker population numbers.

In hindsight, the expectation that stocking larvae and juveniles would increase population numbers was unrealistic. Populations in the wild were struggling to recruit and there was no reason to think that this lack of recruitment was due exclusively to a lack of actual reproduction and production of young. Instead, it is now thought that predation by non-native species was the main factor suppressing population sizes, especially survival of small individuals (Marsh et al., 2015). Clearly, a different approach was necessary.

Repatriation program

This new approach came in the form of a repatriation program orchestrated by the Lake Mohave Native Fishes Work Group starting in 1991. The idea behind this program is to collect naturally produced larvae from Lake Mohave. These young could be reared in an environment safe from predation until they were large enough to avoid predation on their own. Once they reached adequate size, they could be "repatriated" back into Lake Mohave (Marsh et al., 2015). Because most predation occurs at small stages, this should allow for high survival and the preservation of genetic diversity within the lake because the approach does not rely on a small broodstock population. The goal of this program was to increase the population of Lake Mohave to 50,000 individuals.

These efforts have been working fairly well. Between 1992 and 1998, about 23,000 repatriated individuals were released in the lake. In this same time period, 212 repatriated individuals were recaptured, a 1% recapture rate (U.S. Fish and Wildlife Service, 2002). While this may seem low, it is estimated that the repatriated population survival was around 13% and represented 25% of all individuals (Pacey and MARSH, 1998). Since this time, the proportion of adults in Lake Mohave that are repatriates has increased; essentially all current adults were once repatriates (Marsh et al., 2015). However, current population sizes have not rebounded and currently hover around 2,000-5,000 individuals. At the same time, genetic diversity has remained high, indicating that there is still much potential for recovery (Dowling et al., 2012).

While the massive conservation efforts have been successful to the extent that they have prevented extinction of the razorback sucker, much work is left to be done. Until habitat is restored, non-native species are removed, and flow regimes are returned to pre-dam patterns, the razorback sucker will likely continue to be threatened. This large river fish is unique to the southwest and its future is precarious. It is important to preserve this species for future generations and to minimize the negative impacts our development has had on the environment and its ecosystems.

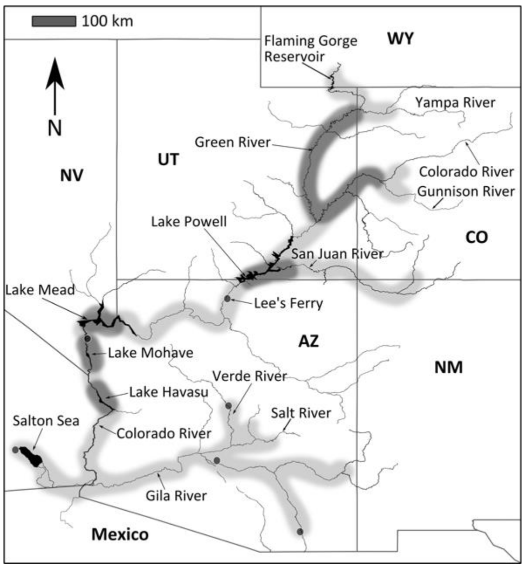

Figure 1: Map of the current range for razorback sucker. Light grey indicates historical range, dark grey is current range. Figure from Marsh 2015.

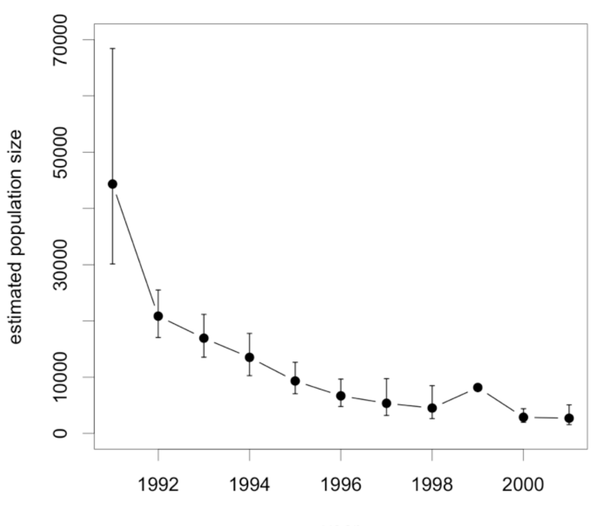

Figure 2: Annual single-census population sizes in Lake Mohave based on mark and recapture. Estimated values from Marsh 2003.

References

Bestgen, K. R. (2008). Effects of water temperature on growth of razorback sucker larvae. *Western North American Naturalist* **68**, 15–20.

Bozek, M. A., Paulson, L. J. and Wilde, G. R. (1990). Effects of ambient Lake Mohave temperatures on development, oxygen consumption, and hatching success of the razorback sucker. *Environ Biol Fish* **27**, 255–263.

Bulkley, R. V. and Pimentel, R. (2011). Temperature Preference and Avoidance by Adult Razorback Suckers. *Transactions of the American Fisheries Society* **112**, 601–607.

Dowling, T. E., Saltzgiver, M. J., Adams, D. and Marsh, P. C. (2012). Genetic Variability in a Recruiting Population of Endangered Razorback Suckers from Lake Mead, Arizona–Nevada. *Transactions of the American Fisheries Society* **141**, 990–999.

Holden, P. B. and Stalnaker, C. B. (1975). Distribution of Fishes in the Dolores and Yampa River Systems of the Upper Colorado Basin. *The Southwestern Naturalist* **19**, 403.

L Coggins, M. Y. U. (2003). Non-native Fish Removal Efforts in Grand Canyon. 1–62.

Langhorst, D. R. (1988). A monitoring study of razorback sucker (*Xyrauchen texanus*).

Marsh, P. C. (1985). Effect of Incubation Temperature on Survival of Embryos of Native Colorado River Fishes. *The Southwestern Naturalist* **30**, 129.

Marsh, P. C. and Brooks, J. E. (1989). Predation by ictalurid catfishes as a deterrent to re-establishment of hatchery-reared razorback suckers. *The Southwestern Naturalist* **122**, 188–195.

Marsh, P. C. and Langhorst, D. R. (1988). Feeding and fate of wild larval razorback sucker. *Environ Biol Fish* **21**, 59–67.

Marsh, P. C., Dowling, T. E., Kesner, B. R., Turner, T. F. and Minckley, W. L. (2015). Conservation to Stem Imminent Extinction: The Fight To Save Razorback Sucker Xyrauchen texanusin Lake Mohave and Its Implications for Species Recovery. *Copeia* **103**, 141–156.

Marsh, P. C., Pacey, C. A. and Kesner, B. R. (2003). Decline of the Razorback Sucker in Lake Mohave, Colorado River, Arizona and Nevada. *Transactions of the American Fisheries Society* **132**, 1251–1256.

McCarthy, M. S. and Minckley, W. L. (1987). Age estimation for razorback sucker (Pisces: Catostomidae) from Lake Mohave, Arizona and Nevada. *Journal of the Arizona-Nevada Academy of Science* (1987): 87-97

Melis, T. S., Grams, P. E., Kennedy, T. A., Ralston, B. E., Robinson, C. T., Schmidt, J. C., Schmit, L. M., Valdez, R. A. and Wright, S. A. (2011). Three Experimental High-Flow Releases from Glen Canyon Dam, Arizona-Effects on the Downstream Colorado River Ecosystem. No. 2011-3012. US Geological Survey, 2011.

.

Miller, R. R. (1961). *Man and the changing fish fauna of the American Southwest*. Michigan Academy of Science, Arts, and Letters, 1961.

Minckley, W. L. (1983). Status of the Razorback Sucker, Xyrauchen texanus (Abbott), in the Lower Colorado River Basin. *The Southwestern Naturalist* **28**, 165.

Minckley, W. L., Marsh, P. C., Deacon, J. E., Dowling, T. E., Hedrick, P. W., Matthews, W. J. and Mueller, G. (2003). A conservation plan for native fishes of the lower Colorado River. *BioScience* **53**, 219–234.

Pacey, C. A. and MARSH, P. C. (1998). Resource use by native and non-native fishes of the Lower Colorado River: literature review, summary, and assessment of relative roles of biotic and abiotic …. *Final Report submitted to Bureau of …*.

Quartarone, F. (1995). *Historical accounts of upper Colorado River Basin endangered fish*.

Schooley, J. D. and Marsh, P. C. (2007). Stocking of Endangered Razorback Suckers in the Lower Colorado River Basin over Three Decades: 1974–2004. *North American Journal of Fisheries Management* **27**, 43–51.

U.S. Fish and Wildlife Service (1998). *Razorback sucker (Xyrauchen texanus) recovery plan*. 1998

U.S. Fish and Wildlife Service (2002). Razorback sucker (Xyrauchen texanus) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan. *Razorback sucker (Xyrauchen texanus) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan.* (2002).