

# Native Aquatic Vertebrates: Conservation and Management in the Río Sonoyta Basin, Sonora, Mexico

**C. Minckley**

Cuenca los Ojos, Flagstaff, Arizona

**Izar Izaguirre Pompa**

Reserva de la Biosfera del Pinacate y Gran Desierto de Altar, Puerto Peñasco, Sonora, Mexico

**Doug Duncan**

U.S. Fish and Wildlife Service, Tucson, Arizona

**Ross Timmons**

Arizona Game and Fish Department, Phoenix, Arizona

**Dennis Caldwell**

Caldwell Design, Tucson, Arizona

**Jaime López Méndez**

Colegio de Bachilleres del Estado de Sonora, Sonoyta, Sonora, Mexico

**Phil Rosen**

University of Arizona, Tucson, Arizona

***Abstract**—The Río Sonoyta in northern Sonora is an important aquatic ecosystem that is disappearing because of drought and groundwater withdrawal. Its native species are also threatened by introduced species. The only watered reach is an intermittent segment (<1 km, Agua Dulce), found just across the International Border from Organ Pipe Cactus National Monument. The native fish present in the river include the endangered Sonoyta pupfish and the indigenous longfin dace. In the wild, the pupfish occurs only at Quitobaquito Springs and at Agua Dulce. The longfin dace may be extirpated. A partnership formed and led by the La Reserva de la Biosfera El Pinacate y Gran Desierto de Altar included partners from the United States and Mexico to create fish refuges in Mexico. We summarize conservation efforts to maintain native fishes in refuge ponds, report on their status, and offer suggestions for future management. We also present information on the future establishment of refuges for longfin dace and augmentation of pupfish refuges in the United States and Mexico. We briefly discuss the impact of a new wastewater treatment plant on the Sonoyta River.*

## Introduction

The native aquatic vertebrates of the southwestern United States and northwestern Mexico are in trouble. This is particularly true for native fishes that have been recognized as endangered, threatened, or rapidly declining for decades, a trend also increasingly observed in many aquatic invertebrates, amphibians and reptiles (Hershler and Landye 1988; Miller 1961; Miller and others 2005; Minckley 1973; Minckley and Deacon 1991; Minckley and Marsh 2009; Rosen and Melendez 2010). These declines result from effects of introduced fishes, drought, and groundwater pumping, all of which dramatically affect native aquatic habitats. This paper presents information

on the recent conservation activities implemented for native aquatic vertebrates of the Río Sonoyta.

## Description of the Río Sonoyta

The Río Sonoyta basin of Arizona-Sonora covers roughly 3,160 km<sup>2</sup> and was formerly a tributary of the Colorado River system. This former connection was diverted to the Sea of Cortez during the Pleistocene by the Pinacate lava flows (Donnelly 1974; Miller and Fuiman 1987). The drainage originates near the Sierra del Pozo Verde in Mexico, running northwest in Sonora and crossing into the United States where it turns west as Vamori Wash on the Tohono O'odham Nation. Vamori Wash then joins San Simon Wash, draining the western Tohono O'odham Nation and joining Sonoran parts of the basin as it crosses back into Mexico. It forms the Río Sonoyta near La Nariz. From there the river continues west through Sonoyta paralleling the border. The river then turns south along the east side of the Pinacate volcanic shield, passing through the eastern fringe of the Gran Desierto before reaching the Sea of Cortez east of Puerto Peñasco.

---

In: Gottfried, Gerald J.; Ffolliott, Peter F.; Gebow, Brooke S.; Eskew, Lane G.; Collins, Loa C., comps. 2013. Merging science and management in a rapidly changing world: Biodiversity and management of the Madrean Archipelago III; 2012 May 1-5; Tucson, AZ. Proceedings. RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Before the 19th and 20th centuries, perennial surface flow and cienegas occurred along portions of the river. Channel down-cutting in the mid 1800s degraded much of the upper drainage due primarily to groundwater pumping and livestock grazing (Hendrickson and Varela Romero 1989; Miller and Fuiman 1987; Rosen and others 2010; Shoenherr, 1988).

Today, the river continues this trend of degradation and desiccation, still driven by the burgeoning demands for water by an increasing human population (Hendrickson and Minckley 1985; Miller and others 2005; Minckley and Marsh 2009). Reduced perennial surface flow during summer (<1 km) is usually present in the privately owned Agua Dulce or “Papalote” reach 17 km downstream from Sonoyta, where flow is maintained by shallow groundwater discharge. The federal government considers the river channel federal land but has an agreement with the landowner to provide access to the property.

## Río Sonoyta Fishes

Fish surveys of the Río Sonoyta have been well documented starting in the 1800s and continuing into the present (McMahon and Miller 1985; Miller and Fuiman 1987; Minckley and Marsh 2009; Rosen and others 2010; Snyder 1915). The only native fishes collected from this desert river have been the Sonoyta pupfish (*Cyprinodon eremus*) and longfin dace (*Agosia chrysogaster*) (Miller and others 2005; Minckley and Marsh 2009). The pupfish also occurs at Quitobaquito Spring, just across the International Border on Organ Pipe Cactus National Monument (QSWG 2011). The two pupfish populations have been isolated long enough to differ genetically and are managed separately (Loftis and others 2009). The Sonoyta pupfish is listed as endangered by the United States (USFWS 1986).

The longfin dace is a widespread and genetically diverse species, occurring in the Bill Williams, Gila, and Santa Cruz rivers of the United States, and in the Ríos Santa Cruz, de la Concepción, and Sonoyta in Sonora, Mexico (Minckley and Marsh 2009). The Ríos Sonoyta and de la Concepción populations display some overlap or gradation of morphological characters with populations of the more southern and easterly “*Agosia* sp.” in drainages to the east and southeast (Hendrickson 1987; Minckley and Marsh 2009; Tibbets 1993). The longfin dace is listed as threatened by Mexico (SEDESOL 2010).

Records of introduced fishes from the river include mosquitofish (*Gambusia affinis*), black bullhead (*Ameiurus melas*), and Gila topminnow (*Poeciliopsis occidentalis*) (Bagley 1997; McMahon and Miller 1985; Rosen and others 2010; Snyder 1915). An unidentified tilapia was reported in 2003 but not collected (Knowles 2010). The blue tilapia (*Oreochromis aureus*) has been introduced into the springs and pond at Ejido Quitovac, an isolated spring southeast of Sonoyta (this species may have been misidentified as *Tilapia zilli* in Rosen and others 2010). There are also commercial fish farms in the drainage near the town of Sonoyta, which reportedly raise some species of tilapia that have not yet been sampled or identified by any of the authors.

Recently, riverine populations of the Sonoyta pupfish have plummeted. Longfin dace, abundant in the system as recently as 2005, now appear extirpated from the river and have not been collected there since 2008 (Minckley and Izaguirre Pompa 2010; Rosen and others 2010).

## Río Sonoyta Amphibians and Reptiles

There are six species of anuran amphibians (toads) in the Río Sonoyta valley and a population of endemic Sonoyta mud turtle

*Kinosternon sonoriense longifemorale*, a candidate species for listing under the U.S. Endangered Species Act (Knowles and others 2004; Rosen 2007; Rosen and others USFWS 2011). Little is known about the amphibians of this river or their use of it.

The Sonoyta mud turtle was once widespread in the Río Sonoyta watershed and is still common today at Quitovac and Quitobaquito Springs (Rosen and others 2010; Rosen and Melendez 2010). However, since downcutting of the cienega at Sonoyta and the advent of increased water pumping in the 1970s, populations of this endemic turtle have declined markedly. Currently, a population can be found in the sewage lagoon and associated wastewater effluent discharge from the town of Sonoyta (Rosen and others 2010). Populations of this turtle also occur at the Presa Xochimilco dam site in Sonoyta and in the wetted portion of Río Sonoyta at Agua Dulce (Rosen and others 2010). Small numbers of individuals have been found in the river at Santo Domingo and within 4 km upstream of Sonoyta.

## Conservation Actions

The future plight of native fishes in the arid southwest was recognized by ichthyologists working on native fishes in the region by the 1940s (Minckley and Deacon 1991). The first recovery actions were also carried out by these individuals who moved fish they thought were in danger of extirpation to sites where they were protected from immediately obvious threats and believed likely to survive. Beginning in the 1960s and continuing to the present, government agencies have developed recovery programs that include natural sites and artificial refuges for listed fish species (Section V, Minckley and Deacon eds. 1991). By 1993, the Desert Pupfish Recovery Plan (USFWS 1993) listed over 100 attempts at establishing refuges, including the Sonoyta (Quitobaquito) pupfish (USFWS 1993). The U.S. Fish and Wildlife Service received internal funding to build pupfish refuges in northern Sonora in 2006. The USFWS Preventing Extinction grant was deemed necessary due to the on-going drought and groundwater pumping from the Río Sonoyta, which threatened to extirpate the Río Sonoyta population of the pupfish.

The design of the refuge ponds constructed in Sonora is based on the ideas and plans developed by individuals and agencies working on native aquatic vertebrate’s recovery in Arizona. The ponds are lined with a Geo-Pad™ polypropylene felt underliner covered by a 45 mil EPDM Pondguard™ liner, and are 3 by 4 M in area, hold ~ 5600 L of water and are ~1 M deep. Each pond has an inflow that passes through a short stream habitat before entering the main pond. Water is recirculated and leaves the pond through a filtered outflow, which is maintained using an electric pump. Pond substrate is fine sand and gravel. The refuge ponds were designed to accommodate both native fish species although the stream habitat was designed specifically to provide spawning habitat for the longfin dace.

Fish used to stock the ponds were obtained in 2007 from the Agua Dulce reach of the Río Sonoyta by seining and netting. Particular emphasis was placed on sorting the fish during capture and before stocking to prevent introduction of mosquitofish into refuges. Both species were collected and placed into coolers containing clean aerated water. Marine salts and a commercial conditioner were added to the water in all of the transport coolers to reduce the stress caused by handling and transport. The fishes were transported directly to the ponds, gradually acclimated to the pond water temperature, and stocked.

By 2011, five refuges were established and stocked with pupfish and longfin dace. In 2007, two refuge ponds were constructed at the Pinacate Biosphere Reserve headquarters and at the Centro Intercultural de Estudios de Desiertos y Océanos (CEDO) in Puerto Peñasco.

Fish were also stocked into the springs at Ejido Quitovac. The fourth refuge was completed and stocked in 2008, at the Colegio de Bachilleres del Estado de Sonora high school (COBACH) in the town of Sonoyta (López Méndez 2011); this pond also contains a Río Sonoyta mud turtle (introduced by students at the school). A fifth refuge was constructed in 2011 at the new Pinacate Biosphere Visitors Center by staff.

Conservation activities for the Sonoyta mud turtle are centered on salvage of turtles at Sonoyta from effluent waters that are, or will be desiccated as the antiquated sewage system of the town is updated. A cooperative agreement involving the Municipio of Sonoyta, local ejidos, the U.S. EPA (which is providing partial funding), and SEMARNAT, the Mexican national conservation authority, includes conservation considerations in the development of a new sewage treatment plant for the town of Sonoyta (Rosen 2009). This facility will have one or more ponds that will provide turtle habitat, which when combined with habitat created in the river channel by effluent discharge from the plant should allow this species to persist in Sonoyta. Once the sewage plant is operational the turtles present at the current sewage lagoon and near Presa Xochimilco will be salvaged and moved to the new facility. Water in the new effluent reach of Río Sonoyta may be suitable for establishment of native fishes as well (USEPA 2008).

## Summary

Construction of refuge ponds for Río Sonoyta native fishes has been successful to date, and appears to have successfully secured small populations of the Río Sonoyta forms of Sonoyta pupfish and longfin dace. Today, pupfish are present in all of the ponds and a small population of longfin dace persists at the refuge at COBACH. As the water levels in Río Sonoyta continue to be unreliable—it is generally dry through most of its length and the remaining wetted portion has gone nearly or completely dry during recent droughts—these refuges are necessary to continue to provide a place to maintain these species for the foreseeable future. These habitats lack careful management and remain precarious due to silting in by blowing sand, maintenance issues, water supply issues, and funding for replacement of parts. If flows are returned to the river these refuge populations can be used to re-establish populations in their historical habitat.

In addition to construction of the refuge pond at COBACH, development of a curriculum using the pond as a research and study tool is in progress. Plans are to have the students explore different aspects of conservation, ecology, and aquatic biology using a hands-on approach, while managing their pond for the security and continued existence of endangered and threatened species. During the past year students have given presentations at the annual meeting of the Desert Fishes Council in Hermosillo, Sonora and at the 2012 Sonoran Desert Symposium. Future plans include community outreach to further raise awareness about the plight of native aquatic vertebrates and the Río Sonoyta.

There are also tentative plans to move between 200 and 500 individuals of both native fish species to refuges in the United States. The Sonoyta pupfish from Mexico would be used to provide immigrants into genetically bottlenecked populations of this species that were established in the United States in 1976 (AGFD 2001). Today, current refuges such as the one at Organ Pipe Cactus National Monument introduce wild individuals into their artificial refuge ponds to maintain genetic diversity. Longfin dace from the refuges would be used to establish a refuge population at the Arizona-Sonora Desert Museum as a hedge against extinction in Mexico.

## References

- Arizona Game and Fish Department. 2001. Quitobaquito pupfish, *Cyprinodon eremus*. Unpublished abstract compiled and edited by the Heritage Data Management System, Arizona Game and Fish Department, Phoenix, AZ. 4 p.
- Bagley, B. 1997. Desert pupfish collections in Baja California and Sonora, Mexico. January 10-17, 1997. Trip Report, Arizona State University, Tempe, AZ. 13 p.
- Donnelly, M. F. 1974. Geology of the Sierra del Pinacate volcanic field, northern Sonora, Mexico and southern Arizona, U.S.A. Unpubl. Ph.D. dissertation, Stanford University, Stanford, CA.
- Hendrickson, D. A. 1987. Geographic variation in morphology of *Agosia chrysogaster*, a Sonoran Desert cyprinid fish. PhD dissertation, Arizona State University, Tempe, AZ.
- Hendrickson, D. A., and W. L. Minckley. 1985. Cienegas: Vanishing climax communities of the American Southwest. *Desert Plants* (Boyce Thompson Arboretum, Superior, AZ) 6 no 3 (1984): 131-175.
- Hendrickson, D. A., and A. Varela-Romero. 1989. Conservation status of desert pupfish, *Cyprinodon macularius*, in Mexico and Arizona. *Copeia* 1989:478-483.
- Hershler, R., and J. J. Landye. 1988. Arizona Hydrobiidae (Prosobranchia: Rissoacea). *Smithsonian Contributions to Zoology*, Number 459:1-63.
- Knowles, G. 2010. E-mail to C. O. Minckley documenting the observation of a tilapia in the Río Sonoyta in the Agua Dulce reach on 15 October 2003.
- Knowles, G. W., J. Rorabaugh, R. Paredes Aguilar, P.C. Rosen, D.H. Hall, and D. Riedle. 2004. Distribution, status and conservation of the Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*). Hendrickson, D. A., and L. T. Findley, eds., *Proc. of the Desert Fishes Council Vol XXXVII* (2002):28-29.
- Loftis, D. G., A. A. Echelle, H. Koike, R. A. Van Den Bussche, and C. O. Minckley. 2009. Genetic structure of wild populations of the endangered Desert Pupfish complex (Cyprinodontidae: Cyprinodon). *Conservation Genetics*. 10:453-463.
- López Méndez, J. 2011. Refuge populations of Río Sonoyta pupfish (*Cyprinodon eremus*) and longfin dace (*Agosia chrysogaster*) in COBACH Campus Sonoyta. Presentation to 43 Annual Meeting of the Desert Fishes Council, Hermosillo, MX.
- McMahon, T. E., and R. R. Miller. 1985. Status of the fishes of the Río Sonoyta Basin, Arizona and Mexico. Pister, E. P. ed., *Proceedings of the Desert Fishes Council XIV* (1982): 237-245.
- Miller, R. R. 1961. Man and the changing fish fauna of the American Southwest. *Pap. Michigan Acad. Sci., Arts, Lett.* 46: 365-404.
- Miller, R.R., and L. A. Fuiman. 1987. Description and conservation status of *Cyprinodon macularius eremus*, a new subspecies of pupfish from Organ Pipe Cactus National Monument, Arizona. *Copeia* 1987: 593-609.
- Miller, R.R., W.L. Minckley, and S.M. Norris. 2005. *Freshwater fishes of Mexico*. University of Chicago Press, Chicago, Illinois. 490 p.
- Minckley, C. O. and I. S. Izaguirre Pompa. 2010. Fishes of the Río Sonoyta—Past, Present, Future? Presentation at Sonoran Desert Symposium, Ajo, AZ. March 2010.
- Minckley, W. L. 1973. *Fishes of Arizona*. Arizona Game and Fish Department, Phoenix, Arizona.
- Minckley, W. L., and J. E. Deacon, eds. 1991. *Battle against extinction: native fish management in the American West*. University of Arizona Press, Tucson, AZ.
- Minckley, W. L., and P. C. Marsh. 2009. *Inland fishes of the greater southwest: chronicle of a vanishing biota*. University of Arizona Press, Tucson, AZ.
- Quitobaquito Springs Working Group. 2011. *DRAFT Conservation agreement and rangewide conservation assessment and strategy for the Sonoyta mud turtle, Sonoyta pupfish, Quitobaquito spring snail, and longfin dace in Quitobaquito and Río Sonoyta*.
- Rosen, P. C. 2007. The amphibian and reptiles of the dry borderlands of northwestern Mexico and southwestern Arizona. Pages 310-337 in Felger, R. S., and B. Broylesm, eds., *Dry Borderlands*, University of Utah Press, Salt Lake City, UT.
- Rosen, P. C. 2009. Summary of water quality, quantity, and habitat location needs for native fish and turtles associated with new wastewater treatment

- infrastructure at Sonoyta, Sonora, Mexico. School of Natural Resources, University of Arizona, Tucson, AZ.
- Rosen, P. C., and C. Melendez. 2010. Observations on the status of aquatic turtles and the occurrence of ranid frogs and other aquatic vertebrates in northeastern Mexico. Pages 205-224 in Halvorson, W., C. Schwalbe, and C. Van Riper III, eds., *Southwestern Desert Resources*, University of Arizona Press, Tucson, AZ. 360 p.
- Rosen, P.C., C. Melendez, J.D. Riedle, A. C. Pate, and E. Fernandez. 2010. Ecology and Conservation in the Sonoyta Valley, Arizona and Sonora. Pages 143-160 in Halvorson, W., C. Schwalbe, and C. Van Riper III, eds., *Southwestern Desert Resources*, University of Arizona Press, Tucson, AZ. 360 pp.
- Schoenherr, A. A. 1988. A review of the life history and status of the desert pupfish, *Cyprinodon macularius*. *Bull. So. Calif. Acad. Sci.* 87:104-134.
- SEDESOL. 2010. NORMA Oficial Mexicana NOM-059-SEMARNAT-2010. Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Listado de especies en riesgo.
- Snyder, J. O. 1915. Notes on a collection of fishes made by Dr. Edgar A. Mearns from rivers tributary to the Gulf of California. *Proceedings, U.S. National Museum* 49 No 2125.
- Tibbets, C. A. 1998. Evolutionary genetics of *Agosia chrysogaster*. PhD dissertation. Arizona State University, Tempe, AZ.
- U.S. Environmental Protection Agency. 2008. Environmental assessment: improvements to the wastewater collection and treatment systems for the City of Sonoyta, Sonora, Mexico. Region IX San Francisco, CA. 50 p
- U.S. Fish and Wildlife Service. 1986. Endangered and threatened wildlife and plants: Determination of endangered status and critical habitat for the desert pupfish. *Federal Register* 51 (61):10842:108501.
- U.S. Fish and Wildlife Service. 1993. Desert pupfish recovery plan. U.S. Fish and Wildlife Service, Phoenix, AZ. 67 p.
- U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; review of native species that are candidates for listing as endangered or threatened; annual notice of findings on resubmitted petitions; annual description of progress on listing actions. *Federal Register* 76(207):66370- 66439.

---

The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented herein.