ARIZONA GAME AND FISH DEPARTMENT
HERITAGE DATA MANAGEMENT SYSTEM

Animal Abstract **Element Code:** ARAAE01041
Data Sensitivity: YES

CLASSIFICATION, NOMENCLATURE, DESCRIPTION, RANGE

NAME: *Kinosternon sonoriense longifemorale*
COMMON NAME: Sonoyta Mud Turtle
SYNONYMS:
FAMILY: Testudines: Kinosternidae

AUTHOR, PUBLICATION: J.B. Iverson, Tulane Stud. Zool. And Bot. 23(1): 43-44. 1981.

TYPE LOCALITY: Mexico: Sonora: Sonoyta, from "artificial pond fed by springs."

TYPE SPECIMEN: USNM (Smithsonian) 21710 (holotype). United States – Mexican Boundary Survey. Jan. 15, 1894. Apparently collected by E.A. Mearns (Iverson 1981).

TAXONOMIC UNIQUENESS: The most wide-ranging and ecologically diverse genus of turtles, ranging from southern Canada to South America (Ernst and Barbour 1989). There are six species of *Kinosternon* in the United States. Three of the species, *K. arizonense, K. flavescens* and *K. sonoriense* are found in Arizona. There are two subspecies of *K. sonoriense*: the typic *K. s. sonoriense*, which is widespread in southeast, sub-Mogollon central Arizona and along the Salt and Gila drainages to the Colorado River, and the Sonoyta Mud Turtle, *K.s. longifemorale*, which is highly restricted in the Rio Sonoyta basin. *K. sonoriense* was originally split into subspecies based upon shell morphology by Iverson (1981), and mitochondrial DNA analyses have supported this classification (Rosen 2003, Rosen et al. 2006).

DESCRIPTION: Dark, small (shell up to 135 mm (5.3 in)) freshwater turtle with a dome-shaped shell (USDI, FWS 2017a). The upper shell (carapace) is olive brown to dark brown with dark seams. The underside of the shell (plastron) is usually yellow-brown and has two hinges so that the front and back can close when the turtle retreats inside. Long barbels are usually present on the chin. The head, neck, and limbs are marked with yellow or cream-colored mottled patterns on a dark olive background. All feet are webbed. The markings on the head and neck distinguish this turtle from our other mud turtles (Brennan and Holycross 2016).

AIDS TO IDENTIFICATION: Subspecies may be distinguished from nominate subspecies by the long femoral scute, short anal schute, wide first vertebral scute, and narrow gular scuts (Iverson 1981). Given the highly restricted distribution, location can also be a determining factor in the identification of this subspecies.

ILLUSTRATIONS:
Color photo (Behler 1979).

Color drawing (Stebbins 2003).
Photo of Holotype Specimen: http://collections.nmnh.si.edu/media/index.php?irn=6000521.
Color photo (USDI, FWS 2017).

TOTAL RANGE: Historic range of the Sonoyta Mud Turtle is not known with certainty, but is assumed to include areas of the Rio Sonoyta basin which maintained perennial surface water, including sections of the Sonoyta, Santo Domingo, and Papalote reaches (Rosen et al 2010). These reaches likely provided 19 to 27 km (12 to 17 mi) of stream habitat in southern Arizona and northern Sonora, Mexico. This turtle was historically known from at least five sites; one site in the U.S. and at least four, possibly five, sites in Mexico (USDI, FWS 2017a).

The Sonoyta Mud Turtle currently occurs in five known locations. One is in Arizona at the Quitobaquito Springs in Organ Pipe Cactus National Monument, and four are in Sonora Mexico; the Papalote reach (also known as Agua Dulce), the Xochimilco reach, the Quitovac spring complex, and the Sonoyta sewage lagoon (USDI, FWS 2017a). The historical Santo Domingo reach population is believed extirpated.

Quitobaquito Springs and the Rio Sonoyta may have been joined by perennial flows in the past, but now are separated by about 1.5 km of desert and a national highway. (NatureServe 2016).

RANGE WITHIN ARIZONA: Known from a pond and limited watercourse habitat from the springs to the pond at Quitobaquito Springs in Organ Pipe Cactus National Monument, Pima County.

SPECIES BIOLOGY AND POPULATION TRENDS

BIOLOGY: Survivorship of Sonoyta Mud Turtles is known only from the Quitobaquito Springs population, where male survivorship ranged from 0.83-0.95 and female survivorship ranged from 0.85-09.5, with juvenile survivorship being lower and gradually increasing as turtles moved towards adulthood (Riedle et al. 2012, Rosen and Lowe 1996). In this population, a male-biased sex ratio has been observed by multiple researchers since the 1980's, ranging from 2:1 to 1.02:1 (Rosen and Lowe 1996, Riedle et al. 2012, USDI NPS 2012, USDI NPS 2013, USDI NPS 2014, USDI NPS 2015). Variation in body size among populations appears to be positively correlated to water permanence and aquatic invertebrate abundance (Stanila 2009, Rosen and Lowe 1996). Mean cohort generation time is approximately 10 to 12 years (Rosen 1986, Rosen and Lowe 1996). Average expected longevity for female Sonoyta Mud Turtles is about 19 years, though the oldest known wild individual was 39 years old (USDI, FWS 2017a).

REPRODUCTION: Limited information available. Minimum age of sexual maturity is just under 6 years for female turtles, and 4 years for males (Rosen and Lowe 1996). Observed clutch size (based upon three gravid females) was 4 eggs per clutch (Rosen 1986). Clutch frequency was estimated at 1.4 to 1.6 clutches per year per female (Rosen and Lowe 1996). Eggs are buried on land. Egg survivorship is rather high at 85-90%. Sex determination depends on

incubation temperatures at a critical period (it is likely that females are produced by warm temperatures) (Rosen and Lowe 1998).

FOOD HABITS: Opportunistic carnivores, feeding primarily on aquatic invertebrates. Like the Sonora Mud Turtle, hatchlings and juvenile turtles likely feed on littoral invertebrates, while subadults and adults likely feed on benthic and plant-crawling invertebrates (Hulse 1974, Rosen 1986, Rosen and Lowe 1996, Lovich et al. 2010, Stanila et al. 2008). If aquatic invertebrates are scarce, Sonoyta Mud Turtles will shift to omnivorous feeding, including plants and vertebrates in their diet (Rosen and Lowe 1996).

HABITAT: Historically found in cienegas and streams supported by springs. Current habitat consists of streams and natural or man-made ponds. Sonoyta mud turtles need aquatic habitats free of nonnative predators or competitors with perennial or near-perennial surface water, terrestrial riparian habitats that maintain moist soils necessary for nesting and estivation, and shoreline that is free of insurmountable barriers to movement between aquatic and terrestrial sites (USDI, FWS 2017a).

Aquatic habitat usually consists of water up to 2 m (7 ft) deep, with rocky, sandy, or muddy substrate and emergent and/or submergent vegetation (USDI NPS 2015, Paredes-Aguilar and Rosen 2003, Rosen 2003, Rosen et al. 2010). In general, subadult, juvenile, and hatchling turtles prefer areas of shallower water with dense emergent and overhead vegetation, while adult turtles require similar shallow water with complex structure for protective shelter, but also utilize areas of deeper (up to 2 m (7 ft)) water with submerged vegetation where they likely forage for invertebrates (Rosen 1986, Rosen and Lowe 1996).

ELEVATION: For the species, elevation ranges from sea level to about 6,700 feet (2044 m). Quitobaquito Pond is situated at about 1080 feet (330m).

PLANT COMMUNITY: Aquatic and riparian. Emergent aquatic vegetation includes American bulrush (*Schoenoplectus americanus*), cattail (*Typha domingensis*), spikerush (*Eleocharis geniculate*), and traveling spikerush (*Eleocharis rostellata*) (Felger et al. 1992). Submerged aquatic vegetation includes holly-leaved water nymph (*Najas marina*), slender pondweed (*Potamogeton pectinatus*), ditch-grass (*Ruppia maratima*), and horned pondweed (*Zannichellia palustris*) (Felger et al. 1992). Riparian vegetation includes Fremont cottonwood (*Populus fremontii*), Gooding willow (*Salix goodingii*), honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*P. glandulosa*), seepwillow (*Baccharis salicifolia*), greythorn (*Ziziphus obtusifolia*), wolfberry (*Lycium* spp.), salt grass (*Distichlis spicata*), and arrowweed (*Pluchea sericea*) (Felger er al. 1992).

At Quitobaquito Pond, American bulrush is a dominant plant.

POPULATION TRENDS: Decreasing. At Quitobaquito Pond, this subspecies declined from probably several hundred in the 1950's to fewer than 100 (68 in 1989, Rosen and Lowe 1998) in the late 1980's. Definitive reasons for this decline are not known, but it has been surmised

that several drainings and renovations of the pond (which included the loss of the shallow water juvenile habitat) were factors. After some habitat improvements, the juvenile survivorship increased, and the 1995 population was estimated at 130 individuals. Surveys in 2002 yielded an estimate of 134 individuals. (NatureServe 2004). Estimates from 2001 – 2006 ranged from 39 – 153, but the high estimate may have been inflated due to only a single recapture during the second sampling period (Riedle et al 2012). The average estimated population (excluding young of the year at < 40mm or 1.6in) is 105.1 for the 18 year period since 1984. The largest estimate since the mark-recapture surveys began was 189 (+/- 78) in 2013. This site requires continued maintenance by the National Park Service to maintain water levels and control encroachment of vegetation (USDI FWS 2017a).

There is no reliable census from any of the known locations in Mexico. Rosen estimates the combined population from all sites for this subspecies to be 1200 (estimate ranges from 600 to 2700) (USDI FWS 2017). Paredes-Aguilar and Rosen (2003) estimated the Papalote population at over 100 animals, the Quitovac population at 200 animals and stable, and the Xochimiclo population at 400 animals based on professional judgement and available habitat. Because water quality is poor enough to present a hazard to human health, trapping efforts of Sonoyta mud turtles have never been implemented at the Sonoyta sewage lagoon, but numerous turtles have been observed there. The population at the sewage lagoon is believed to be stable and recruiting (USDI FWS 2017a)

SPECIES PROTECTION AND CONSERVATION

ENDANGERED SPECIES ACT STATUS: LE (USDI, FWS 2017) with CH (USDI FWS 2020)
[C (USDI, FWS 2007)]
[C USDI, FWS 1997]
[C USDI, FWS 1999]
[C USDI, FWS 2002, 2004-2011]

STATE STATUS: 1 (AZGFD, AWCS 2022)
[1A (AGFD SWAP 2012)]

OTHER STATUS: P, Determined Endangered in Mexico (NORMA Oficial Mexicana NOM-059-SEMARNAT-2010)
Not Forest Service Sensitive (USDA, FS Region 3 2013, 2007)
[Forest Service Sensitive (USDA, FS Region 3 1999)]

MANAGEMENT FACTORS: The most significant threat to the Sonoyta Mud Turtle is loss of aquatic and riparian habitat. The main cause of habitat loss within the range of the turtle is drought and anthropogenic groundwater pumping, which have reduced surface water available to the species. Groundwater withdrawal will continue to affect baseflow in the Rio Sonoyta

basin, and will be exacerbated by climate change. This could result in reduced or eliminated surface water for four of five remaining populations.

Perennial water supporting four of five turtle populations has been reduced, and all populations are isolated from each other (USDI FWS 2017a). Discharge from Quitobaquito Springs has diminished by 42 percent over the past 35 years (USDI FWS 2017a). The perennial reaches of the Xochimilco, Papalote, and Santa Domingo in the Rio Sonoyta have decreased by 80 to 92 percent due to groundwater pumping and drought. The Santa Domingo reach population is believed extirpated due to lack of perennial water (USDI FWS 2017a). The population at the Sonoyta sewage lagoon has the most reliable source of water, but plans for a new wastewater treatment plant will have 75 percent less habitat available for Sonoyta Mud Turtles.
The Quitobaquito Pond also serves as the primary refugia for the endangered Pupfish (*C. eremus*). Although pupfish are found in the nearby Rio Sonoyta, they are a different species, *C. macularius*). Since the 1950's (the pond was officially purchased by the U.S. National Park Service in 1957) there have been several efforts to improve, modify and/or repair this manmade water. Not all have been well advised, or executed. During one draining, turtles encountered were actually given away as pets! During these decades while the turtle population was declining, it was eventually realized that the shallow water habitats (both in the pond and along the 100+ meter water course from the main spring to the pond) were critical for juvenile turtles. Trapping efforts during the 14 years of study also demonstrated that juveniles were only caught near the vegetated margin of open water, or in dense emergent vegetation. This vegetation is primarily tule (or American bulrush), *Schoenoplectus* (formerly *Scirpus*) *americanus*. This lack of optimal juvenile habitat might explain part of the population decline during this period (Rosen and Lowe 1996). Maintenance of this preferred habitat for juveniles will remain important. Over 15 years later, Riedle et al (2012) re-emphasize this importance by stating that for the Quitobaquito population to persist, it is essential that reproduction and juvenile survivorship be maintained by constant maintenance of shallow water habitat and continual monitoring for introduced predators.

In the late summer of 2007, a rapid decline in the water level at Quitobaquito Pond began. Between late 2007 and 2009, a total of 81 turtles were evacuated from the pond and taken to both the Arizona-Sonora Desert Museum and the Phoenix Zoo in order to maintain assurance populations. The last census prior to this removal, and completed in 2007, estimated the total population at 119 turtles. During the evacuation, when hand capture of turtles was used, many marked turtles that had not been recaptured in years were found. They had apparently become trap-shy. This is significant because it suggests that the census methods had probably been underestimating the population size. The 2011 census estimated a population of 156 turtles. The turtles evacuated during the pond leak crisis from 2007 were eventually repatriated to the pond, starting in 2011, except for the assurance population that continues to be maintained at the Arizona-Sonora Desert Museum.

Beyond potential issues with the pond and urban/agricultural encroachment problems in Mexico, there are additional threats to the Sonoyta Mud Turtle. Further loss or fragmentation of aquatic habitat in Mexico could be exacerbated by surface water diversion, ground water

pumping, overgrazing and wildfires. In 2007, a report was made to the Arizona-Mexico Commission Water Committee that preliminary data from a study suggested that groundwater usage from the Rio Sonoyta aquifer was exceeding the recharge rate (USDI FWS 2014). According to unpublished data at Organ Pipe Cactus National Monument, discharge from Quitobaquito Springs has decreased by almost 50% during the past 30 years.

The introduction of exotic species is another threat. Exotic fish and turtles have already been removed from the pond, and non-native fish are currently found with known turtle populations in Mexico. Other exotic aquatic species that could devastate the turtle population would include the American Bullfrog (*Rana catesbeiana*) and the crayfish (e.g., *Orconectes virilis*). Exotic plants, including salt cedar (*Tamarix ramosissima*), bufflegrass (*Pennisetum ciliare*) and Sahara mustard (*Brassica tournefortii*) have established along the Rio Sonoyta and have increased the risk for more frequent and more intense wildfires (USDI FWS 2014).

Rosen (2008) summarized the main threats as ground water pumping and other water diversions. Urbanization (in the Sonoyta locality) and possibly climate change were also noted for moderate impacts, but human take was considered to be only a low threat. Road kills, hybridization, and the effects of introduced species (competitors, predators and disease transmission) were thought to be none.

Border activities are also a concern. Mexico Highway 2 is about 100 meters (328 feet) south of the pond. Vehicle tire tracks have been observed on the pond's berm some 10-15 times during 2008-2009. This activity could cause deterioration or even the collapse of the berm with severe consequences to the pond, the turtles and the pupfish. It was also documented in 2009 that vehicles have driven over the artificial cement channel designed by the Arizona Sonora Desert Museum to carry water from the springs to the pond and to create habitat for the turtles, especially juvenile habitat. Although no damage has yet occurred, if the concrete is broken water might be diverted from reaching the pond. In this context, it is important to note that OPCNM staff are not free to visit the pond at any and all times because they must be accompanied by law enforcement due to the dangerous illegal border traffic. Thus, any kind of significant damage to the channel or pond may not be immediately noticed (USDI FWS 2014).

Climate change also appears to pose a risk. Rosen and Lowe (1996) did directly correlate precipitation with recruitment during 2002-2005. While droughts over the range of the Sonoyta Mud Turtle are not uncommon, the consensus of 19 climate models predicts that the southwest will become drier during the 21st century and that this trend has already begun. Given this setting, conditions for a highly restricted aquatic species in this very arid area could well become more difficult, but the magnitude and extent of this change cannot be specified at this time (USDI FWS 2014).

PROTECTIVE MEASURES TAKEN: In 2001, The Quitobaquito Rio Sonoyta Work Group was formed, consisting of biologists and managers from the National Park Service, Arizona Game and Fish Department, the US Fish and Wildlife Service, the University of Arizona,

Arizona-Sonora Desert Museum, Commission on Ecology and Sustainable Development of the State of Sonora, Pinacate Biosphere Reserve, and private citizens interested in conservation of aquatic native species in the Rio Sonoyta basin of Arizona and Sonora. In the United States, management actions have included monitoring of the single wild population, creation of a refuge population, habitat management, and manipulation of habitat to maintain water levels at Quitobaquito Springs. Management actions in Mexico have included defining the status and distribution of the Sonoyta Mud Turtle in Mexico, planning to create habitat to offset the loss of habitat at the Sonoyta sewage lagoon, removal of nonnative aquatic species, advocating for integration of conservation into urban infrastructure design, and outreach.

The only habitat for the Sonoyta Mud Turtle in the United States, Quitobaquito Springs, is protected by the U.S. National Park Service. This habitat is also shared with the Quitobaquito Desert Pupfish, a species listed as endangered and the pond (spring) is designated as critical habitat for both species. This site is actively managed to maintain water levels which support turtles and increase habitat features important to the species (USDI FWS 2017a).

In 2008, Mexico registered Agua Dulce (the Papalote reach) as site #1813 with the Annotated Ramsar (Convention) List of Wetlands of International Importance. Agua Dulce is a 3 km stretch of the Sonoyta River, within the Biosphere Reserve "Del Picante y Desierto de Altar," where water comes to the surface and creates an oasis, and is of binational interest to both Mexico and the United States. This site is occupied both by the rare Pupfish (*Cyprinodon macularius*) and the Sonoyta Mud Turtle (*Kinosternon sonoriense longifemorale*), Ramsar 2013.

Plans to upgrade the wastewater facilities for the growing town of Sonoyta will lead to the eventual decommission of the lagoon where one of the significant Mud Turtle populations resides in Mexico. In order the protect this rare turtle, plans have been negotiated that include that (1) all processed waste water will be returned to the Rio Sonoyta; 2) a new pond will be constructed for eventual relocation of the local population of the Sonoyta Mud Turtles; and 3) a biologist be hired to oversee the implementation of these mitigations (USDI FWS 2014).

Based on a population viability analysis, it was determined that an offsite minimum assurance population of 8 small juveniles (0-1 years), 8 large juveniles (2-6 years), and 8 adult (7-12 years) females, along with a smaller number of males, would be sufficient to maintain a zero extinction probability population. (Riedle et al 2012). This population is housed at the Arizona Sonora Desert Museum near Tucson. In addition to this assurance population, a number of other refugia population sites have been identified in the U.S. and in Mexico that one day might serve to create additional populations for this subspecies (USDI FWS 2014).

SUGGESTED PROJECTS: Despite the rather intensive studies that have been made on this small and restricted population during the past 30+ years, various researchers have identified a number of additional studies or projects that would assist the conservation of this unique subspecies:

- Regular censuses should continue to monitor population trends at Quitobaquito;

- The populations in Mexico should be surveyed and also monitored via capture and release census methods on a routine basis;
- Obtain additional information on nesting, either by studying the more common *K. sonoriense sonoriense* subspecies in similar habitat settings, or by using minimally instrusive methods on the Quitobaquito population, or both;
- Monitor for any mortalities (turtles or pupfish) and use established protocols and laboratory analyses to ascertain causes (current or potentially future contaminants or other water quality issues are still of concern);
- Limit public access to the exposed watercourse and banks that runs from the springs to the pond (to minimize disturbance to turtles, especially juveniles, and to control potential illegal collecting);
- In Mexico, increase local awareness of the unique resources of the Rio Sonoyta, and increase community involvement in the conservation of these resources.

LAND MANAGEMENT/OWNERSHIP: USDI, National Park Service - Organ Pipe Cactus National Monument. Assurance population that evolved from turtles salvaged at Quitobaquito Pond during emergency repairs in 2008 is maintained at the Arizona-Sonora Desert Museum.

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ADDITIONAL INFORMATION: At one time, the Rio Sonoyta flowed westward to the Colorado River. About 100,000 years ago, eruptions within the Sierra Pinacate Volcanic Field diverted the river more southwards towards the Gulf of California. The Sonoran Mud Turtles found along the Rio Sonoyta became isolated and eventually evolved into a taxon different from

the typic *Kinosternon sonoriense*, and has since been recognized as the subspecies *K. s. longifemorale* (Riedle et al 2012). The population at Quitobaquito Pond is even further isolated from the Rio Sonoyta populations by the borderline Mexican Highway 2. There has been no aquatic connection in recent times, and the distance (not to mention the highway crossing hazard) is beyond the known terrestrial migrations of mud turtles.

When handled, mud turtles gives off a musky odor, hence they are sometimes called stinkpots or stinking jims. The odor glands are located on each side of the body where the skin meets the underside of the shell.

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