

**Sonora chub/Charalito Sonorense
(*Gila ditaenia*)**

**5-Year Review:
Summary and Evaluation**



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**U.S. Fish and Wildlife Service
Arizona Ecological Services Office
Phoenix, Arizona**

August 2013

5-YEAR REVIEW

Sonora chub/Gila ditaenia

1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional or Headquarters Office: Region 2 (Southwest Region)
Susan Jacobsen, Chief Threatened and Endangered Species, 505-248-6641
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1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service or USFWS) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the Act. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.3 Methodology used to complete the review:

This five year review was conducted by Nichole Engelmann and Jason Douglas, USFWS, Arizona Ecological Services Office, with review by supervisors in that field office, as well as within the Division of Endangered Species in the USFWS Southwest Region, Albuquerque, New Mexico. Coordination occurred between the Arizona Fish and Wildlife Conservation Office in Pinetop, Arizona, and the Arizona Game and Fish Department; both declined to provide review comments. Survey data were provided by Coronado National Forest (CNF) staff, and information on the captive population provided by the Arizona Sonoran Desert Museum (ASDM). A recovery plan was published in 1992 (USFWS 1992). That document, together with limited new information in the form of peer-reviewed literature and unpublished survey data, form the basis for the review. No peer review of this document was sought for the

following reasons: (1) the 5-year review resulted in a recommendation to leave the status unchanged; (2) most new information has undergone prior peer review; (3) survey data have not been peer-reviewed, but no population trends can be discerned from the data due to insufficient sample sizes; and (4) the level of public interest and/or scientific uncertainty or controversy is low. In the United States, the species occurs only within Arizona hence, there are no other cooperating Regional Offices. The Sonora chub is distributed more widely in Sonora, Mexico, but no review comments were submitted by the team member from the Centro Ecologico de Sonora.

1.4 Background:

In November 1982, the USFWS contracted with Mr. C.O. Minckley to prepare a report on the status of Sonora chub. Minckley's report (Minckley 1983) was received subsequent to the publication of the 1982 Vertebrate Notice of Review. Minckley (1983) contained the additional information required to evaluate the status of the Sonora chub and the author recommended listing the species as threatened with critical habitat.

Sonora chub was included on the USFWS's December 30, 1982, Vertebrate Notice of Review (47 FR 58454; December 30, 1982) in category 2, a designation for those taxa thought to possibly warrant listing as threatened or endangered, but for which more information was needed to determine the status of the species and to support listing.

Sonora chub is listed by the State of Arizona as a "species of greatest conservation need" (AZGFD 2012), and as a threatened species by the Republic of Mexico (Secretaria de Desarrollo Social 1994). Sonora chub is listed as "vulnerable" on the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (IUCN 2009).

1.4.1 FR Notice citation announcing initiation of this review

FR notice: 73 FR 14995

Date: March 20, 2008

1.4.2 Listing history

Original Listing

FR notice: 51 FR 16042

Date listed: April 30, 1986

Entity listed: *Gila ditaenia*

Classification: Threatened with Critical Habitat

1.4.3 Associated rulemakings: A 4(d) rule was published concurrent with the Final Rule listing the species as threatened with critical habitat (51 FR 16042, April 30, 1986). The 4(d) rule allowed for collection of the species for educational, scientific, enhancement of propagation, and zoological exhibition purposes under a state permit. A

Federal permit would not be required if a state permit is held. The rule also stated that incidental take from state licensed recreational fishermen is not a significant threat.

1.4.4 Review history: The relevant documents reviewing the status of the species are the final rule (51 FR 16042, April 30, 1986) and the final Recovery Plan (September 30, 1992). No additional reviews have been accomplished.

1.4.5 Species' Recovery Priority Number at start of 5-year review: 2C, indicating that the Sonora chub is a full species in a polytypic genus, exists under a high degree of threat, is in conflict with construction or other development projects, but with a high degree of recovery potential.

1.4.6 Recovery Plan or Outline

Name of plan: Sonora Chub Recovery Plan

Date issued: September 30, 1992 (final)

Dates of previous revisions, if applicable: Not applicable

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? Yes.

2.1.2 Is the species under review listed as a DPS? No.

2.1.3 Is there relevant new information for this species regarding the application of the DPS policy? No.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan¹? Yes.

2.2.1.1 Does the recovery plan contain objective, measurable criteria? No.

The Recovery Plan lacks measurable, objective criteria, instead stating that “Delisting is unlikely to occur due to presence of non-native species, degradation of habitat, and continued demand for water for human consumption.” Rather than recovery criteria, the plan includes recovery objectives to maintain populations of Sonora chub in all extant locations, to monitor for presence of non-native fishes and remove these fish as necessary, to protect existing habitat from degradation, and to implement public education in the United States and México.

¹ Although the guidance generally directs the reviewer to consider criteria from final approved recovery plans, criteria in published draft recovery plans may be considered at the reviewer's discretion.

2.2.2 Adequacy of recovery criteria

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? No.

This 5-year review recommends updating the Recovery Plan, creating down-listing and delisting recovery criteria, and developing a more specific recovery objective.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No.

There is new information regarding climate change, fire retardant use, and impacts associated with cross-border Department of Homeland Security (DHS) activities along the U.S. and Mexico border including deposition of trash, new trails from human traffic, soil compaction and erosion, and increased fire risk from human traffic.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

As stated in Section 2.2.1.1, above, the Recovery Plan contains only recovery objectives which involve maintaining populations of Sonora chub in all extant locations, monitoring for presence of non-native fishes and removing these fish as necessary, protecting existing habitat from degradation, and implementing public education in the United States and México. The objectives are followed by recovery actions or tasks, as given below. Objective and measurable recovery criteria have yet to be developed. Delisting was determined to be unlikely.

The aforementioned objectives are largely qualitative, and the anticipated results of their implementation are similarly unquantifiable.

The Plan's recovery outline contains tasks that, when completed, would achieve the stated ends. The tasks are as follows:

- I. Protect Remaining Populations of Sonora Chub
 - A. Recognize Critical Habitat.

Critical habitat has been recognized, and designated along Sycamore Creek in Santa Cruz County, Arizona. Critical habitat is not designated along California Gulch in Santa Cruz County, Arizona. Critical habitat was designated in 1986 and includes portions of Sycamore Canyon and its tributaries, which is occupied by the main population of Sonora chub in the U.S. At that time, Sonora chub were not known to occur in California Gulch, and critical habitat was not designated in that stream. Since that time, we determined that California Gulch is occupied by Sonora chub. While it is not included in the original

critical habitat designation, the presence of Sonora chub there ensures that consultations for actions within the area are completed. As of this time, designation of critical habitat is not needed, but should it become necessary, the Service may modify the existing critical habitat to include California Gulch.

B. Remove Non-native Fishes

In Arizona, non-native, predatory bluegill (*Lepomis macrochirus*) was found in California Gulch and nearby lakes. The potential sources of these fish are private tanks and ponds in upstream areas. Complete extirpation of these fish has not been successful, but some gains may be realized with ongoing management. We encourage the continuation of management actions to remove non-native fish and bullfrogs, and the maintenance of tanks that separate the Sonora chub from the non-native fish. In Mexico, Hendrickson and Juarez-Romero (1990) observed bluegill, green sunfish (*Lepomis cyanellus*), and black bullhead (*Ameiurus melas*) with the Sonora chub on the Rio Magdalena, however it is unknown if any non-native species management actions are being implemented there.

The USFWS has consulted on impacts of monitoring for non-native fishes, and according to the Biological and Conference Opinion for Federal Funding of Aquatic Inventory, Survey and Monitoring Activities, the Sonora chub are not generally found in areas where sport-fish monitoring activities are likely to occur (USFWS 2011a). In the incidental take statement of the biological opinion, the USFWS anticipated the take of up to 10 Sonora chub individuals total in the form of mortality from routine capture and handling activities and 10 percent of the affected individuals from non-routine activities (such as emergency salvage) (USFWS 2011a).

C. Determine Water Use Patterns and Protect Water Rights

Both Sycamore Canyon and California Gulch are within the Tucson Active Management Area (AMA) and the Arizona Department of Water Resources (ADWR) manages this area (ADWR 2012b). This management area is well established, and the Arizona Supreme Court of Arizona upheld the ruling that ADWR may issue 'in-stream' permits (ADWR 2012b). Presence of endangered or threatened species "may be a critical consideration in water resource management and supply development" according to ADWR (2012b). No further action is necessary for this objective at this time.

D. Incorporate Sonora chub Management Needs into Management Plans for Goodding Research Natural Area and Pajarita Wilderness

The CNF is guided by their Land and Resource Management Plan (LRMP), and updated section 7 consultation for its continued implementation (USFWS 2012a).

The CNF in Santa Cruz County manages the Pajarita Wilderness and the Goodding Research Natural Area. The wilderness area does not allow motorized or mechanized vehicles or equipment, including mountain bikes which are known to be significant

contributors to erosion. This restriction addresses the concern of erosion and impacts of recreation on wildlife, including the Sonora chub. As stated in the 1992 Recovery Plan, a statement of the management position that incorporates the rules, regulations, and policy for species of concern is needed to reduce conflicts between the CNF, AZGFD, and USFWS.

E. Ensure Habitat Integrity

Safety concerns have limited on the ground habitat assessments. However consultations, in accordance with the Endangered Species Act, will continue to assess proposed actions in an effort to maintain habitat integrity by minimizing adverse effects from Federal actions, and ensure that no activities jeopardize the existence of the species or adversely modify critical habitat. As described in the CNF LRMP, livestock grazing has been eliminated from the riparian corridor of Sycamore Canyon, and in portions of the riparian corridor of California Gulch (USFWS 2012a). A bridge was constructed to replace a road that was causing erosion and runoff (USFWS 2012a). Roadways in Sycamore Canyon south of Ruby Road have been closed to traffic and off-highway vehicles (OHV) (USFWS 2012a). In addition, CNF and the USFWS agreed to establish a buffer area around waterways to prevent fire toxicity (USFWS 2011b).

F. Survey All Existing and Potential Habitats

The CNF completes annual monitoring in Sycamore Canyon and California Gulch as a part of their LRMP. Those surveys are presence or absence based, and do not count the individual fish, but provides general information on population dynamics. In Sonora, the Rio de La Concepcion was last surveyed in 1990, and the Rio Cocospera at Rancho el Aribabi was last surveyed in 2006 (Duncan 2006). Both of these surveys verified the presence of Sonora chub; however, the number of individuals is not known. Additional surveys are needed to develop an estimate of population size and trends in habitat suitability. There are no available surveys regarding population estimates from the AZGFD, which supplies the ASDM with wild caught fish every three to four years (described below), the number caught fluctuates.

II. Monitor and Assess Population and Habitat Dynamics

A. Establish Standardized Monitoring Techniques for Fish and Habitat

Recent survey and monitoring data describes presences or absences, and does not give population dynamic or population size information. It is recommended that monitoring measurements be standardized to potentially include population dynamic information, but there is little value to surveying population size for a desert adapted fish that lives for 2-3 years. Currently the survey data that are available have been collected by the CNF. Because the species occurs in Mexico and the U.S., consideration should be given to development of a protocol that will lend consistency to how data are collected. The Recovery Plan recommends that surveys be done twice a year, before and after summer rains, and that capture and holding techniques be developed to reduce stress on the fish.

This objective may be reasonable if coordination continues and safety concerns can be addressed.

B. Assess Population Dynamics

1. Determine Reproductive Variables
2. Determine Effects of Predation and Competition
3. Determine Survivorship by Age Group
4. Determine Disease and Parasites
5. Determine Diet, Seasonal, and Annual Distribution of Life Stages
6. Determine Other Factors Pertinent to Perpetuation of Sonora chub

The above determinations were listed in the Recovery Plan's narrative outline. This information is still important to determine since we do not know of any new information regarding the Sonora chub's population dynamics. These determinations are reachable if coordination between agencies in both the U.S. and Mexico is achieved, and current data collection efforts are expanded to include the number of individuals, and size class of those individuals.

C. Assess Habitat Dynamics

1. Determine Fish-Habitat Relationships
2. Determine Precipitation-Runoff Relationships
3. Evaluate Relationships of Runoff-Instream Flow Needs

The above information is still important to determine since we do not know of any new information regarding the Sonora chub's habitat dynamics. A narration of the description of actions, events, water flow, and estimates on water loss within the Tucson AMA that would impact the habitat quality would be useful. These determinations are also reachable if information regarding land use and water use continues to be shared between the U.S and Mexico given the Sonora chub's habitat can be impacted by actions on both sides of the border.

III. Maintain Captive Reserves of Sonora chub

A. Establish Captive Reserve Populations

A captive assurance population has been maintained at the ASDM since 1988. These fish are kept separate from other fish so hybridization does not occur. Under AZGFD authority, wild fish are brought in every 3 to 4 years, and the population is between 400-500 fish. While this program has not been used to restock areas, the ASDM has shown initiative in organizing the program, and proficiency in managing it so that the population can grow in a sustainable way. This program is discussed further in Section 2.3.1.2. The population at Hank and Yank's Tank, while not captive, can also be considered a reserve population since the threats discussed below have a low potential effect on the tank, and

the population in the tank is self-sustaining with consistent presence. Population size at the tank is not known.

B. Determine the Genetic Variability of the Species

The genetic variability of the species is not known at this time.

IV. Produce Information for Public Education in the United States and México

- A. Produce an Information Pamphlet
- B. Issue News Releases
- C. Develop and Conduct Interpretive Programs
- D. Provide Status Information to Interested Parties

The ASDM maintains a healthy captive population of Sonora chub. The facility has exhibits that offer information to the public, as well as a Conservation Education and Science Department. As of now there are no Sonora chub on display, but there is the potential, especially given the success the ASDM has had in maintaining the population.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

The Sonora chub is a medium sized fish of approximately 125 mm (about 5 inches). A part of the minnow family Cyprinidae, the Sonora chub is native to southeastern Arizona and northern Mexico (USFWS 1992). Miller (1945) described it as being a moderately chubby fish and dark colored, with two distinct black, lateral bands above the lateral line. The Sonora chub inhabits pools created by cliffs, boulders or other cover in intermittent stream channels. The Sonora chub's current distribution appears to be relatively similar to its historical range of Sycamore Canyon and California Gulch in the U.S. and the Rio de Concepción drainage in Mexico (USFWS 1992).

Sonora chub spawn at multiple times during spring through summer, most likely in response to floods or freshets during the spring and summer rains (Hendrickson and Juárez-Romero 1990). During spawning, Sonora chub broadcast their eggs onto fine gravel substrates in slowly flowing water, where the eggs develop and hatch. There are no nests built, nor parental care given. Larvae likely use shallow habitats at pool margins where they feed on microscopic organisms and algae. As adults they can exploit shallow to deep pools, and runs and riffles as available (USFWS 2005).

Although Sonora chub is regularly confined to pools during arid periods, it prefers riverine habitats. In lotic waters in México, Hendrickson and Juárez-Romero (1990) found it commonly in pools less than 0.60 m (2 ft.) deep, adjacent to or near areas with a fairly swift current, over sand and gravel substrates. It was less common in reaches that were predominately pools with low velocities and organic sediments. Sonora chub are adept in exploiting small, marginal habitats, and can survive under the severe

environmental and hydrologic conditions present in Sycamore Canyon and California Gulch. It is also apparent that they can maneuver upstream past small waterfalls and other obstructions to colonize newly-wetted habitats (Carpenter and Maughan 1993).

Historical and current information was compiled to illustrate the overall range of the Sonora chub; Figure 1 provides a range map for the chub, and Figure 2 provides an illustration of historical records for the species. Critical habitat has been designated along Sycamore Canyon, Penasco Creek, and an unnamed tributary, and is illustrated in Figure 3.

Publications known to the USFWS since the 1986 Final Rule listing the species as threatened with critical habitat range from field notes and records of anecdotal observations to peer-reviewed articles in scientific journals. Information from these sources is included below.

2.3.1.1 New information on the species' biology and life history:

Some informal and scholarly publications addressed the Sonora chub prior to its 1986 listing. Prior to that time, life history information was limited to food habit observations based on a few individuals and to spawning observations based on the presence of young in various collections (Minckley 1973). Information on the aquatic and adjoining riparian ecosystems was provided in earlier works by R.R. Miller (1945), and the characterization of the physical and chemical features of Sycamore Creek was summarized in the C. Minckley's 1983 status report on the species.

Information regarding the status of the Sonora chub in México was similarly limited at the time of listing. Miller's 1940 type locality for his 1945 description of the species was the Río Magdalena near La Casita, Sonóra, Mexico. At that time, the Río Magdalena was a clear stream 1.2 to 1.5 meters (m) (4 to 5 feet [ft]) wide, about 0.3 m (1 ft) deep, with a fairly swift current over a bottom of sand and gravel. The principal vegetation was watercress, found in backwaters along the stream. As of 1991, it was not known if habitat for Sonora chub still existed at that location. Sonora chub had been collected as recently as 1990, with a previous collection in 1981 from the Río Magdalena drainage at Campo Carretero and Cienega La Atascosa (Hendrickson 1983, D. Hendrickson, L.R. Juarez-Romero 1990). The fish collected in 1990 (Hendrickson and Juarez-Romero 1990) were typically found in lotic waters, less than 0.60 m (2 ft.) deep, and not believed to be hybrids.

Carpenter (1992) described the Sonora chub's microhabitat use and the species' ability to exploit marginal and/or intermittently available habitats; this master's thesis' findings were included in the Recovery Plan. Spawning ecology was described in Hendrickson and Juarez-Romero's report (1990) as Sonora chub having multiple spawning times during the spring and summer. Fish with mating coloration were found into the fall, which indicated that breeding was not limited

to a particular season, but rather might follow spring and summer rains (D.A. Hendrickson, L.R. Juarez-Romero 1990). The USFWS is aware of one, post-Recovery Plan publication regarding the biology or life history of the species, Carpenter and Maughan (1993), a journal publication that expanded on the findings in Carpenter’s 1992 thesis.

Anecdotal observations are frequently included in field notes, as discussed below. Recovery task II (B) would provide additional information on the species’ biology and life history if fully implemented.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

There currently exists no survey protocol for Sonora chub, though development of a rigorous protocol was identified as a recovery task [Task II (A)] in the Sonora Chub Recovery Plan. AZGFD developed a draft Sonora chub monitoring plan and the CNF has proposed a linear habitat sampling protocol for Sycamore Canyon in 1993. Neither protocol has been finalized as of 2012.

Coronado National Forest

A monitoring and evaluation report done by the CNF in 2011 documented the number of pools/runs and the percent of pools occupied by the Sonora chub from 1997-2001 (Table 1) in Sycamore Canyon. The survey data show a flux in the number of pools and runs available to the chub, which would correspond to the weather events in those years. The percentage occupied in those pools remains relatively consistent. The monitoring report also notes that the Sonora chub present in the known pools were of different sizes representing reproduction and recruitment, and had sufficient numbers to populate the available habitat if conditions are suitable (USFS 2011b).

Table 1:
Sonora chub habitat survey results, 1997-2001, in Sycamore Canyon, Coronado National Forest

	1997	1998	1999	2000	2001
No. of pools/runs	112	76	114	86	146
Percent of pools occupied by fish	83	87	79	85	96

The CNF also completes Annual Monitoring Reports (USFS 1999-2007, 2009, 2011a, 2012). These reports give basic presence or absence information on the Sonora chub (Table 2). Population trends cannot be inferred from these data, but confirm the consistent presence of the Sonora chub within Sycamore Canyon, and the re-colonization of California Gulch. The presence-absence data can infer that the population in Sycamore Canyon is persisting at a level with a degree of variation in life stages to repopulate an area successfully.

Table 2:

Sonora chub presence and absence surveys, 1999-2012, Coronado National Forest (P=Presence. A=Absence)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009	2011	2012
Sycamore Canyon	P	P	P	P	P	P	P	P	P	P	P	P
California Gulch	A	A	P	P	P	P	P	P	P	P	P	P

The absence of rigorous and repeatable species abundance surveys renders it difficult to definitively determine population trends either through direct measures of abundance or the surrogate of habitat availability. Like Sonora chub surveys in the historical record, the recent survey history is composed primarily of field notes from site visits, many of which were contained in information submitted during the preparation of this review. Notes from site visits conducted by CNF, USFWS, and other entities' staffs indicate that Sonora chub are detected reliably when habitat is available (USFS 1999-2012), though the upstream limits of the species' occurrence in California Gulch appear to vary, based on the presence of non-native fish - largemouth bass (*Micropterus salmoides*) in particular - at a site referred to as the tinaja, a deep, perennial pool situated just below a small dam (USFWS 2012a). There are no data to indicate that Sonora chub numbers are increasing nor decreasing in abundance in the wild within the United States, nor does it appear that threats have been appreciably ameliorated (see section 2.3.2, below).

Arizona Sonoran Desert Museum

The Arizona-Sonoran Desert Museum has maintained an assurance population of Sonora chub since 1988 under Section 4(d) of the Endangered Species Act. The AZGFD provides the Museum every three to four years with wild caught fish to maintain genetic diversity within the captive population. Information on the numbers of fish is not available except for the year 2009, the most recent transfer, when 50 wild caught fish were incorporated into the captive population (Poulin, ASDM, pers. Comm. 2013). Wild fish are quarantined before being placed with the museum's population. The population at the Museum is approximated to be between 400-500 fish. Population demographic patterns have not been studied at the Museum. The fish are kept in outdoor enclosures where the water temperature is kept around 80° Fahrenheit (F) (26.6° Celsius (C)) in the summer and 60°F (15.5°C) in the winter. The temperature is kept no less than 50°F (10°C) and no more than 88°F (31.1°C). The fish's diet consists of standard dry flake food (Poulin, ASDM, pers. comm. 2013).

The present management style of keeping the fish separated from other fish with which Sonora chub could hybridize, the population size, and the maintenance of genetic diversity through coordination with the AZGFD are manageable with the Museum's budget. Outside funding would be needed to implement genetic

testing, obtain size class information and habitat and population dynamic information, and initiate a structured breeding program (Poulin, ASDM, pers. comm. 2013).

This assurance population has not been used as a source to repopulate any areas to date. An assurance population is one developed and maintained as a representative captive stock to ensure the retention of genetic diversity in the event of a catastrophic decline that would then require a wild population to be restocked (USBR 2010). This definition is congruent with the USFWS definition of a refugium population.

If fully implemented, recovery tasks II (B) (1) through (6) (see Section 2.2.3, above) would provide new information on Sonora chub abundance, population trends, and demographic trends.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

The Sonora Chub Recovery Plan (USFWS 1992) identified hybridization with an undescribed species of *Gila* as a threat to Sonora chub. Surveys in Campo Carretero and Cienega La Atascosa of Sonora, Mexico, in 1981 identified potential hybrid individuals between Sonora chub and Yaqui chub (*G. purpurea*) by Hendrickson (1983). More recent information (Miller *et al.* 2005) states that an undescribed species of *Gila* is sympatric and hybridizing with Sonora chub in La Atascosa in Sonora, Mexico. Hendrickson and Juárez-Romero (1990) and DeMarais and Minckley (1992) stated that hybrid influence exists, but that its effect upon Sonora chub is limited.

Recovery task III (B) (1) (see Section 2.2.3, above) is to determine the genetic variability of the species. If implemented, this would provide new information regarding this aspect of the species' biology and provide a basis for a more structured breeding program into the future. The ASDM and Hank and Yank's Tank, have stable populations that could be tested if funding is available.

2.3.1.4 Taxonomic classification or changes in nomenclature:

The USFWS is aware of no publication proposing taxonomic changes for the Sonora chub, though Hendrickson and Juárez-Romero (1990) did recommend taxonomic analysis to determine the relationship of the Arizona population to that of Sonora.

Genetic information, such as would be collected if recovery task III (B) were implemented, would provide additional data to confirm taxonomic status.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historical range (e.g. corrections to the historical range, change in distribution of the species' within its historical range, etc.):

Absence of a standardized, repeatable population or habitat assessment makes it difficult to determine if there have been appreciable changes in the species' distribution. Present-day distribution data are primarily anecdotal due to safety concerns around the U.S.-Mexico border where the Sonora chub is located. There is a lack of data on the status of populations in Mexico. The CNF Annual Monitoring Reports mentioned above provide presence or absence information which track the species' persistence on Forest Service lands without assistance from the assurance population at the ASDM.

Critical habitat was designated along Sycamore Creek, with a riparian zone of 7.62 m (25 ft) wide along each side of the creek, from Yank's Spring downstream to the International Border with Mexico, which is around 8 kilometers (km) (5 miles [mi]) long. Other critical habitat around Yank's Spring consists of Penasco Creek with a riparian zone 7.6 m (25 ft) wide along each side of the creek, from its convergence with Sycamore Creek and an unnamed tributary to Sycamore Creek, from its convergence with Sycamore Creek (USFWS 2012a). We do not have information on the implementation of conservation measures for the Rio de La Concepcion, or the Rio Cocospera at Rancho el Aribabi in Mexico. Please refer to Figure 3 for a map of critical habitat within the U.S.

California Gulch, Santa Cruz County, Arizona

AZGFD (1995) first documented Sonora chub in California Gulch, a stream located approximately 4.8 kilometers (km) (3 miles [mi]) west of Sycamore Canyon in Santa Cruz County, Arizona. This area is within the Coronado National Forest. The Sonora chub found in this area are most likely a part of the metapopulation of this watershed. California Gulch has been surveyed infrequently since the initial discovery, and Sonora chub are reliably present in suitable habitat from the International Boundary upstream to the tinaja, a deep perennial pool just below a small dam (USFWS 2012a). In the AZGFD's initial report documenting Sonora chub in California Gulch, AZGFD (1995) recommended that other drainages in the Rios Altar and Magdalena watershed in the United States be investigated. To date, no additional populations of Sonora chub have been confirmed in these waters, though we note that drought conditions have likely reduced the extent of surface water in the region.

Sycamore Canyon, Santa Cruz County, Arizona

In 2002, Sonora chub were detected in three new locations within the Sycamore Canyon watershed: one site was within an unnamed side canyon, one in Sycamore Canyon proper, and the third was in Atascosa Canyon (USFWS 2002). Sycamore Canyon is within the Coronado National Forest, within Santa Cruz County of Arizona, U.S.A.

Río de La Concepción, Sonora, México

Hendrickson and Romero (1990) surveyed Sonora chub in the Río de La Concepción basin in Sonora, México, and posited that threatened status was appropriate for the peripheral and geographically isolated population of Sonora chub in Arizona, while rangewide the species' status was secure. No rangewide studies have been completed since then and the current status of Sonora chub in Mexico is unknown. Based on limited information it is presumed that predatory and competitive non-native fishes noted by these authors are still present within the species' range and that drought has affected Sonora to an extent similar to Arizona.

Río Cocóspera at Rancho el Aribabi, Sonora, Mexico

In May 2006, USFWS staff confirmed the continued presence of Sonora chub in the headwaters of the Río Cocóspera at Rancho el Aribabi in Sonora (Duncan 2006).

Please refer to Figures 1 and 2 for maps of the Sonora chub's range, and historical records of the species.

Recovery task I (F) (see Section 2.2.3, above) is to survey all existing and potential habitats. Full implementation of this task would contribute to an increased understanding of the Sonora chub's spatial distribution, population trends, and historical range.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Climate variations and several projects have impacted Sonora chub habitat and ecosystem conditions. The study of climate change and its effects on ecosystems has expanded greatly since Sonora chub was listed in 1986. The new information regarding climate change is explained in greater detail in Section 2.3.2.5. Projected drought severity is expected to reduce the amount of habitat within the United States and potentially worsen habitat conditions throughout the species' range. It is likely that there has been a reduction in the amount of wetted habitat due to ongoing drought conditions in the region (ADWR 2012a).

A few projects have occurred in Sonora chub habitat, and from these some knowledge is known of the relationships among the occurrence of the Sonora chub and various habitat parameters, such as substrate, overhead and in-stream cover, and habitat type (USFWS 1992, USFWS 2012a, USFWS 2012b). For example, in Sycamore Canyon, physical habitat conditions likely improved incrementally as a result of the CNF's 1998 project to stabilize the Hank and Yank's Tank, which impounds Yank Spring, within which Sonora chub occurs. In 1999, a bridge was constructed to replace the low water crossing of Ruby Road at Sycamore Canyon, thus reducing direct mortality of Sonora chub, decreasing sediment erosion, as well as improving the delivery of sediment to the stream in a

more natural way. These projects are discussed in greater detail in Section 2.3.2.1, below.

Implementation of recovery tasks II(C) (1) through (3) (see Section 2.2.3, above) would increase the understanding of Sonora chub's habitat parameters.

2.3.1.7 Other:

As discussed in Section 2.2.1.1, above, the Recovery Plan contains recovery objectives, the implementation of which are intended to: maintain populations of Sonora chub in all extant locations, monitor for presence of non-native fishes and remove these fish as necessary, protect existing habitat from degradation, and implement public education in the United States and México.

The Recovery On-line Activity Reporting (ROAR) database was queried to determine the current state of recovery implementation. Task I.A. (Recognize critical habitat) was completed at the time of listing on April 30, 1986 (51 FR 16042, April 30, 1986). We note that California Gulch and its tributaries were not known to be occupied by Sonora chub until 1995 (see section 2.3.1.5); thus, these waters were not evaluated for inclusion as critical habitat under Task I.A. Recovery Task I.F. (Survey all existing and potential habitats) has been partially completed, but must be conducted repeatedly with a standardized protocol in order to meaningfully assess trends. The remaining recovery tasks (see Section 2.2.3, above) have not been completed. Recovery implementation has thus had a limited positive influence on the status of the Sonora chub.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The USFWS is aware of the following new information.

Mining

Water development, including water usage and impacts to water quality from mines, has been described as a threat to the Sonora chub (USFWS 1986, USFWS 1992). There are currently inactive mines located within the watershed of California Gulch which do not appear to threaten the species. However, should these be allowed to operate, there could be impacts to Sonora chub habitat. And while there is no mining presently planned, there are claim sites where uranium exploration occurred along the eastern slopes of Sycamore Canyon. Uranium was found at some of these sites, and the claims are being maintained (USFWS 1992).

The USFWS (2012a) has also discovered that unknown mining wastes and/or drilling compounds are entering California Gulch from a series of drilling pads immediately across the international boundary in Sonora during at least November 2009 through October 2010. Visual inspection of these compounds indicates that they are sufficiently fine-grained as to be capable of occluding the gills of Sonora chub. Depending on the chemical compositions, they may be acutely and/or chronically toxic to the species (USFWS 2012a). The discharges may also fill pools wherein Sonora chub seek refuge from intermittently-dry stream reaches, and/or embed sediments to the extent that the species' aquatic macro-invertebrate food base is appreciably reduced. In any event, this mine waste discharge represents an additional threat from mining, as had been identified in the Final Rule (USFWS 1986). The USFWS also notes that the relatively recently discovered metapopulation of Sonora chub in California Gulch (AZGFD 1995) also exists in a mining district, though levels of activity vary. The threat from mining and mine discharge is moderate for the Sonora chub given the limited locations in which the chub occurs, and the potential for toxicity that could take numerous fish at once. Given the discovery of drilling pads in 2009 and 2010 immediately across the international border, the lack of knowing the specific distance of the pads (USFWS 2012a), and the potential for other drilling pads to be constructed, we recommend that water quality tests be completed once a year, and analysis for chemical compounds of mine wastes and drilling compounds be completed to determine potential levels of impact.

Grazing

Some adverse impacts continue associated with cattle grazing, which have the potential of setting back recovery. The degradation, siltation, and water pollution caused primarily by livestock grazing within the riparian corridors remain threats in areas where grazing is not properly managed (USFWS 2012a). The Sonora chub prefers pools of clear water created by cliffs, boulders, and other cover in intermittent streams. It is difficult for cattle to reach areas like these, but upstream grazing can affect downstream habitat conditions. Grazing activities associated with the CNF's Rangeland Management Program may result in adverse effects to the Sonora chub's critical habitat. Livestock grazing activities can contribute to changes in surface runoff quantity and intensity, sediment transport, and water holding capabilities of the watershed (USFWS 2002, USFWS 2012a). This occurs especially where cattle tend to congregate, often near water sources (USFWS 2012a). According to the 1999 USFWS Biological Opinion, cattle had regularly gained access to Sycamore Canyon through an un-maintained section of fence along the international border (USFWS 2012a) and degraded the riparian vegetation in the lower 4.0 kilometers (2.5 miles) of the stream (Carpenter 1992). This fence was repaired with the permittee responding to trespass cattle in a timely manner; monitoring data from the CNF have not seen evidence of cattle within the past five years in this area (USFWS 2002, USFWS 2005). The potential for upstream effects from grazing and potential for trespass of cattle into restricted areas remains (USFWS 2002, USFS 2000-2012). Ongoing consultations and coordination with the Forest Service will continue as needed.

As those efforts continue, the threat of grazing would remain moderate for the Sonora chub.

Roads and Infrastructure

Construction, maintenance, and heavy use of roads can displace vegetation, disturbing sediments and introducing chemicals into the environment (USFWS 2005, USFWS 2012b). If a road is being constructed, there may be loss of vegetation and displacement of sediment. When weather events occur there is less cover to catch suspended material and absorb moisture, which increases the runoff potential. Runoff with an increased sediment load ends up in drainages and can have negative impacts on the Sonora chub by causing sub-lethal effects to the Sonora chub, which can include respiration difficulties and diminishing their ability to find food (USFWS 2005).

As discussed in section 2.3.3, a bridge was constructed on Ruby Road to replace a low water crossing that was causing adverse effects to the chub. Although the long-term goal of constructing the bridge is to reduce threats to the Sonora chub by allowing clean water to pass freely below the road area, the construction phase of the bridge and associated maintenance as described in the CNF's Standards and Guides (S&G) may cause sub-lethal effects to the Sonora chub due to the decreased water quality (USFWS 2005, USFWS 2012a).

Both Sycamore Canyon and California Gulch, the areas of Sonora chub habitat in the U.S., occur on the CNF. These areas in the National Forest are used for recreation, which requires the construction and use of roads and trails. Road repair and use have the potential to cause the degradation, siltation, and pollution of corridors and channels that could negatively impact the Sonora chub (USFWS 1992). Furthermore, high levels of border activity by both undocumented immigrants and border patrol in this area, coupled with recreational use of these roads and trails, increase the potential for non-natural contaminants to enter the water supply (see discussion below) (USFWS 2012a). Continued collaboration with State and Federal agencies will work to minimize effects that construction or heavy use of roads might have, but given ongoing human uses, this threat is high.

Fire

Several recent fires in the Southwest have burned at stand-replacing intensities and proportions, while others have been smaller and burned in a mosaic pattern that is healthier for forests (USFWS 2012a). The 2011 Murphy Fire burned through 68,079 acres including portions of the CNF (May 30, 2011 to June 14, 2011). The Murphy Fire burned at low-moderate intensity over 97% of its area. The fire did burn part of Sycamore Canyon, including Sonora chub critical habitat. Given that the fire was at low-moderate intensity in the canyon, effects to both the Sonora chub and critical habitat likely included ash and sediment deposits. The USFS stated, and we agreed, that these effects have not significantly changed the amount of suitable habitat for the Sonora chub (USFWS

2012a). A national fire retardant Biological Opinion has also been done (USFWS 2011b), and is discussed in 2.3.3. This study and consultation resulted in the addition of buffer zones around water ways to prevent retardant drops from jeopardizing the fish. Fire will continue to be a severe threat to the Sonora chub since there are only two known metapopulations in the U.S. One severe fire or misplaced fire retardant drop could severely impact or possibly remove one of the populations, or significantly affect the species' genetic diversity, and limit the recovery potential of Sonora chub. However, if a fire is in an area, and fire retardants need to be utilized, the translocation of fish to either Hank and Yank's Tank and/or the ASDM could decrease the amount of take from the fire and the impacts of related suppression activities on the fish.

Border Activities

Illegal immigration and associated interdiction activities within Sycamore Canyon and California Gulch have been ongoing since prior to the 1986 listing of the Sonora chub (USFWS 2012a). Biological Opinions regarding the Land and Resource Management Plan for the CNF (USFWS 2012a), and the Biological Opinion on the maintenance of tactical infrastructure for the border patrol, which include Sycamore Canyon (USFWS 2012b), noted the negative impacts that human traffic has had on the Sonora chub's habitat. These impacts are discussed in detail in Section 2.3.2.5 below.

Consultations regarding border activity have been increasing over time, and have involved much of southern Arizona. While most of these consultations have not included Sycamore Canyon or California Gulch, it is important to note that impacts to watersheds from this human traffic and activity have resulted in significant ground disturbance. Continued interagency cooperation and coordination are needed to conserve the Sonora chub's critical habitat and remaining populations.

It should be noted also that there is a safety concern associated with surveying for this species. The canyons where Sonora chub occurs (California Gulch/Warsaw Canyon and Sycamore Creek) are known routes for drug traffickers and undeclared immigrants; therefore, border security issues make it difficult to monitor Sonora chub populations. As a result, recent population surveys in California Gulch have generally been limited to simple inspections for the presence or absence of the species in a major pool near a small dam structure in the upper reaches of the stream and, occasionally, other sites in which water persists (USFWS 2012b). Because of the level of human activity and the persistence of these activities, this threat is high for the Sonora chub.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Human Fishing and Unregulated Transporting

Although the status of this as a threat to the species is likely insignificant, in July

2009, Sonora chub were captured in Ronquillo Pond, a restored native ranid (leopard frog) locality located less than one mile from, and within the watershed of Peña Blanca Lake (USFWS 2011a). This is being treated as an unauthorized transfer of this listed species and is under investigation by the USFWS. We cannot ascertain the purpose of this unlawful transfer but it could represent a new threat if additional attempts to establish sources of bait fish to use elsewhere are documented. At this time, this appears to be an isolated event and we consider the threat of human fishing and transportation of the fish to be low.

The USFWS is aware of no new information that would alter the findings made regarding overutilization at the time of listing. This threat was not an issue as concluded in the 1986 listing (USFWS 1992).

2.3.2.3 Disease or predation:

Asian tapeworm

The presence of Asian tapeworm (*Bothriocephalus acheilognathi*) in fishes of the Río Yaqui watershed, including the Yaqui chub (*Gila purpurea*), represents new information to the USFWS regarding disease or predation (Miller *et al.* 2005, Kline 2007). Yaqui chub is present only in the headwaters of the Rio Yaqui but is sympatric with desert chub (*Gila eremica*), with the latter species currently being noted as present in the Río Sonora (Miller *et al.* 2005). Yaqui chub and Sonora chub have the potential to hybridize as discussed above (Miller *et al.* 2005). The Asian tapeworm is non-host specific and has been found in various other *Gila* throughout the American Southwest (Miller *et al.* 2005). Given that the tapeworm is present in the Yaqui chub, which can hybridize with the chub, the potential for the Sonora chub to be exposed is high. However, as discussed below, exposure does not result in mortality; therefore the threat to the Sonora chub at this time is low.

No studies of Asian tapeworm and Sonora chub have been completed to date; however, according to a study in 2007, Asian tapeworm can affect the growth rate of Yaqui chub, and can cause intestinal blockage (Kline 2007). The Yaqui chub is in the same genus as the Sonora chub, so we infer that if Sonora chub are infected with the tapeworm, the effects would be similar. The concentrations of tapeworms did not result in high mortality of the Yaqui chub (Kline 2007). We recommend that a similar study be done for the Sonora chub since the Yaqui chub study yielded information on how the tapeworm affects the fish, and how to breed the fish in captivity. Given the present information, we conclude that the Asian tapeworm is a low threat to the Sonora chub since mortality in a similar species is low, and the Sonora chub has persisted in areas even though probability of exposure is high.

Non-native fishes

The hypothetical vector for the non-host-specific Asian tapeworm to reach the range of Sonora chub is not only congeneric *Gila*, but non-native fish that may be

moved between infested and non-infested watersheds in the U.S. and Mexico. For example, bluegill has been reported in California Gulch, yet the origin of these individuals is unknown. Information from AZGFD stocking records does not indicate bluegills were ever stocked by AZGFD into either nearby recreational lake (Arivaca or Peña Blanca lakes), but they were reported to be present in those waters (USFWS 2011c). There are tanks and private lakes in the upper portions of the Sycamore Creek and California Gulch watershed that may also be sources of these and other non-native fish found (USFWS 2001, USFWS 2011c). The potential for cestode (tapeworm) infestations of Sonora chub by these non-natives of uncertain origin and health is a threat not previously evaluated.

Non-native fish have been present in the occupied Sonora chub habitat for years (USFWS 2012a). While the presence of non-natives increases the probability of exposure to Asian tapeworm and competition for resources and possibility of predation, Sonora chub have persisted in numbers great enough to recolonize California Gulch and survive in an environment where conditions are dynamic (USFWS 2012a). The main threats posed by non-native fish are predation and competition. It is known that bluegill and largemouth bass (discussed briefly in Section 2.3.1.2) compete with and predate upon Sonora chub. We have no information indicating that this threat has increased since the time of listing.

Climate change impacts could reduce shared resources, thus increasing competition, and possibly predation. Identifying the origin of the non-native fish would assist with controlling their populations. If the populations of non-native fish can be controlled to preemptively prepare for the increased competition risk, this threat is moderate.

Bullfrogs

Efforts have been taken to remove bullfrogs (*Lithobates catesbeianus*) from areas surrounding Sycamore Canyon and California Gulch and within both drainages (USFWS 2012a). Bullfrogs are known predators of native fish, fish eggs, other ranids, and birds (Mueller *et al.* 2006, USFWS 2011b, USFWS 2012a.). While no documents specifically show bullfrog predation on Sonora chub or Sonora chub eggs, the documentation showing predation on native fishes supports the inference that bullfrogs are a threat (Mueller *et al.* 2006). Prior to removal efforts, Sonora chub persisted in good numbers in Sycamore Canyon despite the large population of bullfrogs. Surveys conducted in 1997, 1998, 1999, 2000, and 2001, indicate that there was no known net loss of populations detected during the reporting period, nor a reduction of pool or spring habitat (USFWS 2012a). The risk of predation by ranid frogs upon the Sonora chub would be lowered but not eliminated, as we note that the intent of bullfrog removal is to encourage proliferation of Chiricahua leopard frogs (*L. chiricahuensis*), lowland leopard frogs (*L. yavapaiensis*), and/or Tarahumara frogs (*L. tarahumarae*). The threat of bullfrogs on both the Sonora chub, and other native fauna is ongoing.

Management of bullfrog populations has improved, and if these management actions continue to be proactive, then the threat on Sonora chub by bullfrogs is low.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The majority of habitat occupied by Sonora chub within the U.S. exists within the CNF. Portions of Sycamore Canyon and its tributaries are critical habitat, and also include the Pajarito Wilderness and Goodding Research Natural Area, each of which lends a high degree of administrative protection for the species. Land ownership patterns in México are variable, and the species has comparatively little administrative protection there.

The USFWS is aware of new information that would alter the findings made regarding the adequacy of existing regulatory mechanisms at the time of listing. Specifically, we note that Sonora chub has been omitted from the Regional Forester's list of sensitive species (USFS 2007b), though the species did have such status in the past (AZGFD 2001).

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Border Activities

Cross-border activity and enforcement actions have increased since the Sonora chub was listed in 1986. The increased traffic associated with illegal activities and the DHS responses have served to increase both on- and off-highway vehicular traffic throughout the Sycamore Canyon and California Gulch watersheds (USFWS 2012a, USFWS 2012b). Most section 7 consultations with DHS have been informal, resulting in USFWS concurrence with DHS's determination that their proposed actions were not likely to adversely affect the species. Some consultations regarding the DHS patrol and interdiction and operations and their effects have been completed; others, we note, are still pending. The combination of repeated Federal actions and the cumulative effects of the illegal activity itself, however, are likely to be contributing to indirect impacts to Sonora chub, including bank trampling, increased sedimentation, and other impacts associated with cross-country foot and vehicle travel.

Additional impacts to the Sonora chub may occur from DHS cross-border activities along the U.S./Mexico border. Cross-border activities that could impact the species include, but may not be limited to, the following: human traffic, deposition of trash, new trails from human traffic, soil compaction and erosion, increase fire risk from human traffic, water depletion and contamination, introduction and spread of disease, and interference of surveying/monitoring and research (USFWS 2012b).

Climate Change

Lastly, as discussed above in Section 2.3.1.6, climate change presents a previously undiscussed threat to the species. Our analyses under the Endangered Species Act include attempts to incorporate the emerging science of climate change into ongoing and new projects. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions. (For these and other examples, see IPCC 2007a; and Solomon *et al.* 2007). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a, Solomon *et al.* 2007). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007, Ganguly *et al.* 2009, Prinn *et al.* 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a, Meehl *et al.* 2007, Ganguly *et al.* 2009, Prinn *et al.* 2011). (See IPCC 2007b, for a summary of other global projections of climate-

related changes, such as frequency of heat waves and changes in precipitation. Also see IPCC 2007a for a summary of observations and projections of extreme climate events.)

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007b). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a, Glick *et al.* 2011). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Although many species already listed as endangered or threatened may be particularly vulnerable to negative effects related to changes in climate, we also recognize that, for some listed species, the likely effects may be positive or neutral. In any case, the identification of effective recovery strategies and actions for recovery plans, as well as assessment of their results in 5-year reviews, should include consideration of climate-related changes and interactions of climate and other variables. These analyses also may contribute to evaluating whether an endangered species can be reclassified as threatened, or whether a threatened species can be delisted.

Projections presented for the Southwest speculate warmer, drier, and more drought-like conditions (Hoerling and Eischeid 2007, Seager *et al.* 2007). For example, simulations from the Palmer Drought Severity Index, a calculation of the cumulative effects of precipitation and temperature on surface moisture balance, for the Southwest show an increase in drought severity with surface warming. Furthermore drought severity will increase even under wetter condition simulations because of the effect of heat-related moisture loss through evaporation and evapotranspiration (Hoerling and Eischeid 2007). Tree ring data suggests that the drought over the last decade in the western U.S. represents the driest conditions in 800 years (Karl *et al.* 2008, Schwalm *et al.* 2012). Overall annual mean precipitation is likely to decrease in the Southwest, as well as the length of the snow season, and the snow depth (IPCC 2007b). Temperatures in the Southwest are projected to rise by 2.5 to 3.9° C (4.5 to 7° F) during this century (IPCC 2007a). This rate of 0.56° C (1.0° F) every 14 years has already been surpassed by Arizona since the 1970s (Lenart *et al.* 2007). In summary, changes in temperature (Weiss and Overpeck 2005) and stream flow (Seager *et al.* 2007) are anticipated to reduce the amount of habitat available to the Sonora chub

within the United States, worsen habitat conditions throughout the species' range, strengthen effects of other threats, and have both direct and indirect ecological impacts on the species. The effects of climate change, particularly those associated with drought and rising temperatures, have the potential to be a severe threat to the Sonora chub.

2.3.3. Conservation Measures

The conservation measures described below have been highly important to the continued existence of the species.

Captive Population

The only known captive population of Sonora chub in the U.S. is at the Arizona-Sonora Desert Museum as described above in Section 2.3.1.2. The ASDM has played an important role in conservation with having 20 threatened or endangered species in their collection (ASDM 2013), and has been conserving a population of Sonora chub since 1988. This assurance, or refugium population of Sonora chub, is highly important in the conservation of the species. The presence of a captive population will ensure the persistence of the species in an environment where the threats described above do not apply, and allow for potential emergency conservation actions to be taken. The establishment of this captive population, and establishment of other captive populations if possible, is the greatest conservation measure taken to preserve this species since its listing. We do not know of any refugia or captive populations of Sonora chub in Mexico, nor do we know of any refugia or captive populations of individual Sonora chub from Mexico.

Consultations

Since 1990, we have conducted approximately 42 interagency consultation and technical assistance efforts involving Sonora chub and/or the species' critical habitat (Tracking and Integrated Logging System {TAILS} 2013). Eleven of these consultations were technical assistance letters in which we provided review comments or recommendations to non-Federal project proponents. Four of the consultations were species list letters providing the requesting party with a county species list to inform their project.

We conducted 15 informal Federal interagency consultations, wherein the Service concurred that the Federal actions' effects were insignificant, discountable, or wholly beneficial and thus, not likely to adversely affect Sonora chub. In one case, the action - an intra-Service investigation of a potential Safe Harbor Agreement - has not been completed. These informal consultations included bullfrog removals, power-line constructions, border patrol emergency actions, a bridge construction, cell tower construction, and an emergency fire consultation.

We also conducted 11 formal Federal interagency consultations, wherein the Federal actions were found to adversely affect Sonora chub and/or its critical habitat. Of the 11 formal consultations, 4 had effects of sufficient scale to affect the status of the species. Brief descriptions of these projects and the respective biological opinions' conclusions

follow. The other seven included tactical border infrastructure maintenance, radio modernization for communication purposes, the Sycamore Canyon Sonora chub project, Tarahumara frog reintroduction, a fire management plan for Altar Valley, exotic species removal in the San Rafael Valley, and the SBInet Tucson West Project; these will not be described further.

Leak Repaired at Hank and Yank's Tank –

Hank and Yank's Tank is a concrete springbox that impounds Yank Spring and is located adjacent to the stream in Sycamore Canyon; it is perennially watered and supports an unknown number of Sonora chub. Flooding in January of 1993 eroded the banks upon which the tank was situated and exposed leaking pipes and fittings beneath the structure. Two attempts were made to locate and halt the leak. The former involved entry into the tank with SCUBA gear and the latter, which was successful, involved repair of the pipes. Emergency consultation (under consultation file number 22410-1994-F-0183) was concluded on June 2, 2004. The off-channel site was secured and we anticipated that no incidental take had occurred.

The emergency repair to Hank and Yank's Tank addressed only the leaking pipe fittings; the site's footings remained eroded and unstable. The Forest Service proposed repairs to the tank as well as range improvements and relocation of a trailhead to restore stability to the tank and improve habitat conditions within Sycamore Canyon's stream. On November 20, 1997, we transmitted a Biological Opinion (File number 22410-1998-F-0039) to the Forest Service in which we anticipated that all Sonora chub occupying Hank and Yank's Tank could be incidentally taken if the tank should fail during construction, thus necessitating capture and relocation to Sycamore Canyon. Once the action was completed, it was determined that no Sonora chub were incidentally taken. The repaired tank has had a beneficial effect on the chub by providing a stable, perennially watered habitat. Furthermore there is not much grazing around the Hank and Yank's tank, allowing the habitat to stabilize, and contaminants concentrations to be kept low.

Livestock Grazing Impact Managed on Montana Allotment, Coronado National Forest –

Our June 6, 2001, biological opinion (and June 12, 2001, amendment) on the renewal of the Coronado National Forest's Montana Allotment grazing management plan determined that the proposed action would reduce, but not eliminate, the adverse effects of livestock grazing to Sonora chub in California Gulch and Warsaw Canyon, a tributary stream. We anticipated that implementation of grazing under the proposed action would incidentally take all Sonora chub in the 2.8 km (1.75 mi) of unprotected, occupied habitat subject to grazing impacts. The Coronado National Forest's 2010 Annual Monitoring Report (USFS 2011b) includes post-project monitoring in association with this biological opinion and noted that the species was still present in California Gulch. The USFWS thus assumes these individuals are still being incidentally taken by continuing livestock grazing; however the population is sufficiently protected to allow for the fish in the area to reproduce and sustain the population's numbers

Land and Resource Management Plans –

On December 19, 1997, we completed a program-scale consultation (file number 000087RO) on the Land and Resource Management Plans (LRMP) for the 11 National Forests in the Southwestern Region, which included the Coronado National Forest. The consultation analyzed the effects of the implementation of Standards and Guidelines, which serve to guide on-the-ground actions. As part of the 1997 consultation for all LRMPs, the Forest Service implemented additional conservation measures for the Sonora chub. Roadways in Sycamore Canyon south of Ruby Road have been closed to traffic and OHVs. Furthermore, livestock have been eliminated from the riparian corridor of Sycamore Canyon and in portions of the riparian corridor of California Gulch. Sonora chub are also now a primary consideration in the development of allotment management plans for grazing allotments in both Sycamore Canyon and California Gulch, south of Ruby Road. In addition, the LRMP discussed a bridge which was constructed on Ruby Road to replace the low-water crossing that was causing adverse impacts to the Sonora chub (USFWS 2012a, USFWS 1999). We transmitted a reinitiated formal consultation on the 1997 biological opinion to the Forest Service on June 10, 2005 (file number 2-22-03-F-366). No special projects outside of the Standard and Guidelines were implemented. The Forest Service requested re-initiation of formal consultation on the LRMPs in 2011. A final biological opinion was issued on April 30, 2012.

Sportfish Stocking in Sonora Chub Habitat Avoided –

A Biological Opinion on the Federal funding of the AZGFD sportfish stocking program was completed in 2011 (USFWS 2011c). No stocking actions were proposed for occupied Sonora chub habitats or connected waters, so no direct effects of introducing non-native sportfish to the habitat were anticipated. The potential for illegal transport of stocked non-native sportfish, bait fish, or other live bait (crayfish) to Sonora chub habitat was not deemed significant due to the lack of habitat to maintain non-native sportfish and prohibitions on use of live bait at stocked waters in the vicinity of Sycamore Creek.

Fire Retardant Effects Buffered in Critical Habitat –

A nationwide, program-scale Biological Opinion (file number 22410-2008-F-0149) was prepared for the Forest Service's use of fire retardant in 2008 (USFWS 2011b). The proposed action was found to be capable of jeopardizing the survival and recovery of Sonora chub in the wild due to the effects of acute toxicity to fish and other aquatic organisms; critical habitat was not anticipated to be adversely modified or destroyed. Site-specific determinations regarding the effects of incidental take associated with retardant application in and near Sonora chub habitat were deferred to future, emergency consultations. This nationwide consultation was revisited in 2011. Analyses of the proposed modifications to application of fire retardant concluded that action, with buffers around waterways as conservation measures, will not jeopardize Sonora chub nor adversely modify or destroy the species' critical habitat. The proposed action also included the development of a Sonora chub salvage protocol, where fish would be removed during a fire event before suppression actions occur. The other modification was that the Forest Service would assist the USFWS and the AZGFD with the development of a captive rearing protocol in order to provide stock for repatriation for the Sonora chub if there is a retardant drop that extirpates a Sonora chub population within

the U.S. We also noted that the application of fire retardant could contribute to reducing the areal extent of wildfires that may adversely affect Sonora chub, and any effects of a misapplication of the retardant would be temporary.

Taken together, the actions consulted upon have made incremental contributions to the recovery of Sonora chub, primarily via implementation of recovery task I (E) - Ensure Habitat Integrity. Improved habitat, however, is unlikely to mitigate the threats posed by water development (see section 2.3.2), and has no influence on threats in Sonora (see section 2.3.2.1 regarding mining activity) nor the heretofore unidentified risk posed by climate change (see section 2.3.1.6). The coordination between agencies and cooperators has resulted in mitigation of adverse impacts in coordination with technical assistance, informal consultations, and formal consultations. These consultations include the management of cattle in riparian corridors, the construction of a bridge, cell tower projects, stream restoration, mitigating border patrol activity in critical habitat areas, and the repair of the Hank and Yank's Tank.

2.4 Synthesis

As discussed in Section 2.3, Sonora chub was known to occur in Sycamore Creek of Santa Cruz County of Arizona at the time of listing in 1986, and the captive population at the ASDM within the U.S. was established in 1988. A second population, or more likely a metapopulation that includes Sycamore Creek, is now known to occur in California Gulch and its tributary streams. The threats faced by the Sonora chub at the time of listing and during the preparation of the recovery plan including habitat loss, non-native fishes and parasites, and water developments, continue to exist in both Sycamore Canyon and California Gulch. Cross-border incursions and the law enforcement response to them represent factors that have been present since before the 1986 listing, and which continue to affect the species. Climate change, a threat not identified during listing and recovery planning, along with water development which was previously known, threaten to alter the hydrologic conditions which sustain the streams in which Sonora chub occurs, potentially reducing the species' resilience and ability to persist through stochastic events such as drought and floods. Drought is becoming prevalent throughout the Southwest; as mean annual temperatures increase precipitation become more variable. As discussed in Section 2.3.1.6, drought conditions are ongoing, with 'severe drought' predicted for the south of Arizona (ADWR 2012c). The degradation, siltation, and water pollution caused primarily by livestock grazing within the riparian corridors, road construction, runoff from roads, construction of infrastructure, and repair of infrastructure, human use, and mining operations are determined to have potential adverse effects on the Sonora chub.

The Sonora chub is a desert fish adapted to the fluctuations of a desert environment; after drought conditions it has been known to rapidly expand and recolonize California Gulch and newly re-wetted reaches. If habitat conditions along water ways can be maintained, then this ability to respond to favorable water conditions is encouraging for the population to avoid the danger of extinction. Construction of roads or bridges as described above might have temporary adverse effects, but long-term effects can be beneficial to the chub if it reduces off road use. The use of fire retardant buffers around habitat will potentially minimize adverse effects from those chemicals, and potentially prevent severe fires from causing adverse habitat modifications. As

described above, Sycamore Canyon and California Gulch are not suitable terrain for grazing, but effects have occurred from trespass cattle (USFWS 2012a). If consultations continue to evaluate and minimize the use of allotments upstream from Sonora chub habitat, adverse effects from siltation and water quality degradation can be kept to a minimum. Furthermore, if a catastrophic decline or an adverse take event occurs, the ASDM population can serve as a source of fish to repopulate the area once the habitat returns to favorable conditions. Given that there are two known wild populations within the U.S., a captive population, designated critical habitat, and the threats against the population can be managed with possible response procedures, the Sonora chub meets the definition of threatened for the foreseeable future.

The underlying conclusion based on the history of survey work, and our understanding of impacts is that the status of the Sonora chub is unlikely to have measurably declined or improved since 1984 and should maintain the designated threatened status, as a species in danger of becoming endangered. Further data collection, and a revision of the recovery plan with updated recovery criteria are needed.

3.0 RESULTS

3.1 Recommended Classification

- Downlist to Threatened**
- Uplist to Endangered**
- Delist**
 - Extinction*
 - Recovery*
 - Original data for classification in error*
- No change is needed**

3.2 New Recovery Priority Number: No change, retain 2C classification.

Brief Rationale: A 2C Recovery Priority classification is appropriate because the Sonora chub is a distinct species within a polytypic genus, existing under a high degree of constant threats, while maintaining a degree of recovery potential. The threats that the Sonora chub faces are constant, and show little evidence of amelioration. The threat of drought and climate change has the potential to increase in severity. Furthermore, there is the potential that conflict due to increased water development to meet human needs will lower water availability and decrease quality of habitat.

These threats however have very low effect on the Hank and Yank's Tank where there is a consistent presence of individuals, and at the ASDM. The approximated number of individuals (between 400 and 500) at the Museum, and unknown but self-sustaining population at the tank are strong counterbalances. If one of the threats described above takes those fish, then the population at Hank and Yank's Tank, and the population at the Museum can be used to repopulate an area once the habitat is deemed suitable. Both Hank and Yank's Tank and the ASDM can also be used as an area to put displaced fish if preemptive action is taken prior to a known activity. These refugia populations at the Museum and the continued presence of the Hank and Yank's Tank allow potential flexibility for recovery.

Current information on the population sizes in the two metapopulations within the U.S., the populations in Mexico, habitat dynamics, population dynamics, and information on how to effectively address the threats to the species is unknown. This information needs to be accumulated and addressed to achieve recovery.

3.3 Listing and Reclassification Priority Number: N/A

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- The 1996 Sonora chub Recovery Plan should be revised to incorporate new information that has been gathered since it was finalized, including a full threats analysis. Objective, measurable recovery criteria should be established based on the need to eliminate and/or reduce the effect of those threats, as the current plan states only that "... [d]elisting the species is unlikely".
- Refine and finalize a standardized survey protocol for the Sonora chub to provide a method for rigorous and repeatable species abundance surveys and determine population trends.
- Systematic species and habitat surveys to evaluate population and physical habitat trends should be established under the direction of the current recovery plan, and should be implemented throughout the species' range in the U.S. and Mexico. These studies should be conducted to obtain quantified data in order to support the development of baseline species information and the development of eventual recovery criteria.
- Conduct studies focused on: ecological factors that influence distribution, density-dependence issues, resource requirements for survival, demographic trends, population biology, and the amount and condition of suitable habitat.
- Model climate factors to a scale (i.e. the Río de La Concepción watershed) whereby changes in the biological and physical environment occupied by the Sonora chub can be ascertained. The uncertainty regarding climate change equates with an ecological risk to Sonora chub. The Southwestern Regional Climate Change Team has already recommended, and the Arizona Ecological Services Office agrees, that the Sonora chub Recovery Plan is a high priority for revision in order to address the effects of climate change.
- The USFWS should strengthen cooperative relationships with agencies and organizations in Mexico to facilitate studies and future recovery planning and implementation efforts for the Sonora chub.

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Informal Note:

Written by Nichole Engelmann with assistance from Jason Douglas and comments from Lesley Fitzpatrick and Debra Bills of the Arizona Ecological Services Office.

Figure 1. Species Range Map of Sonora chub sites in the U.S. and historically observed sites in Mexico.

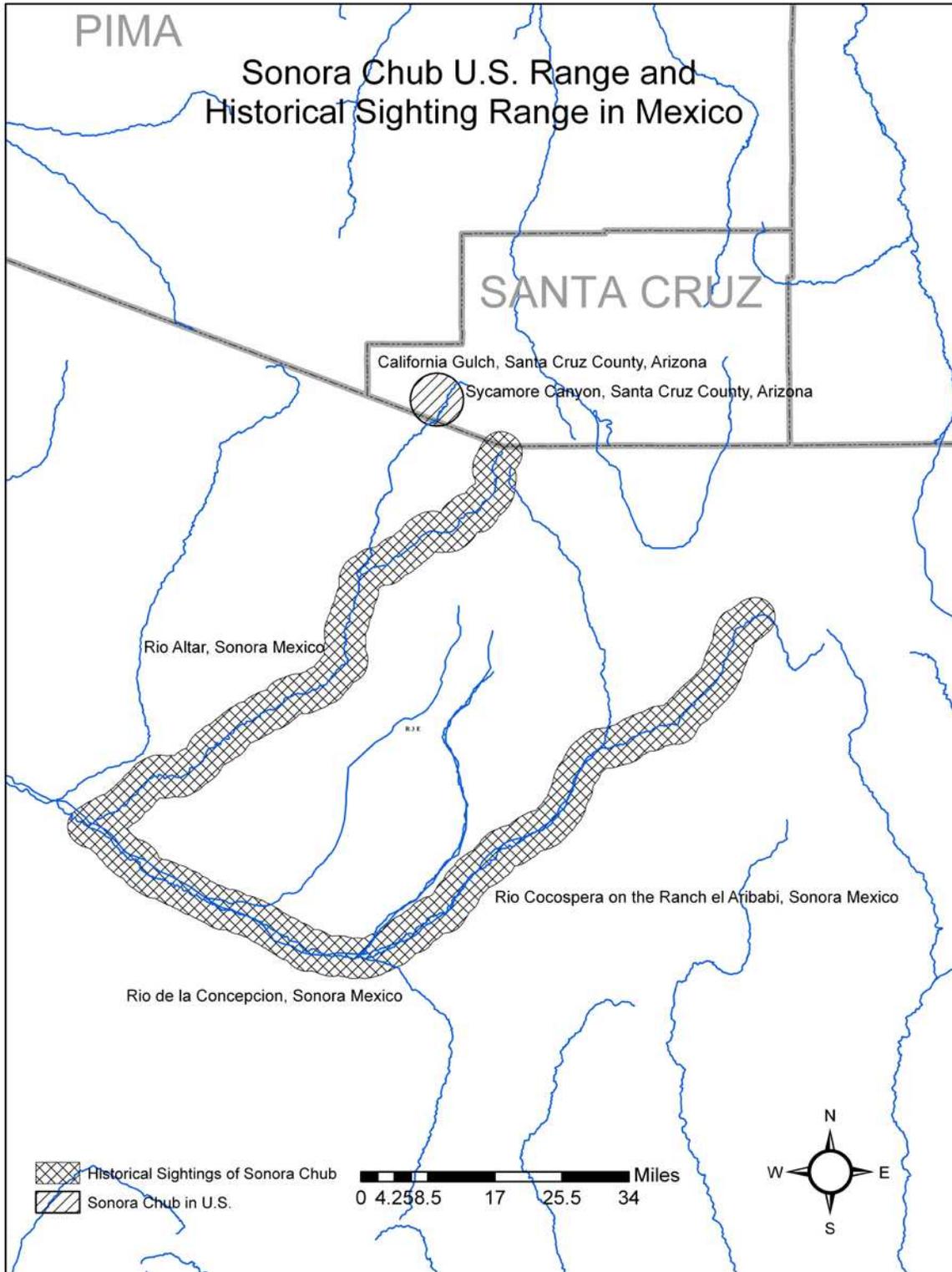


Figure 2. Historical observations of Sonora chub in the U.S. and Mexico

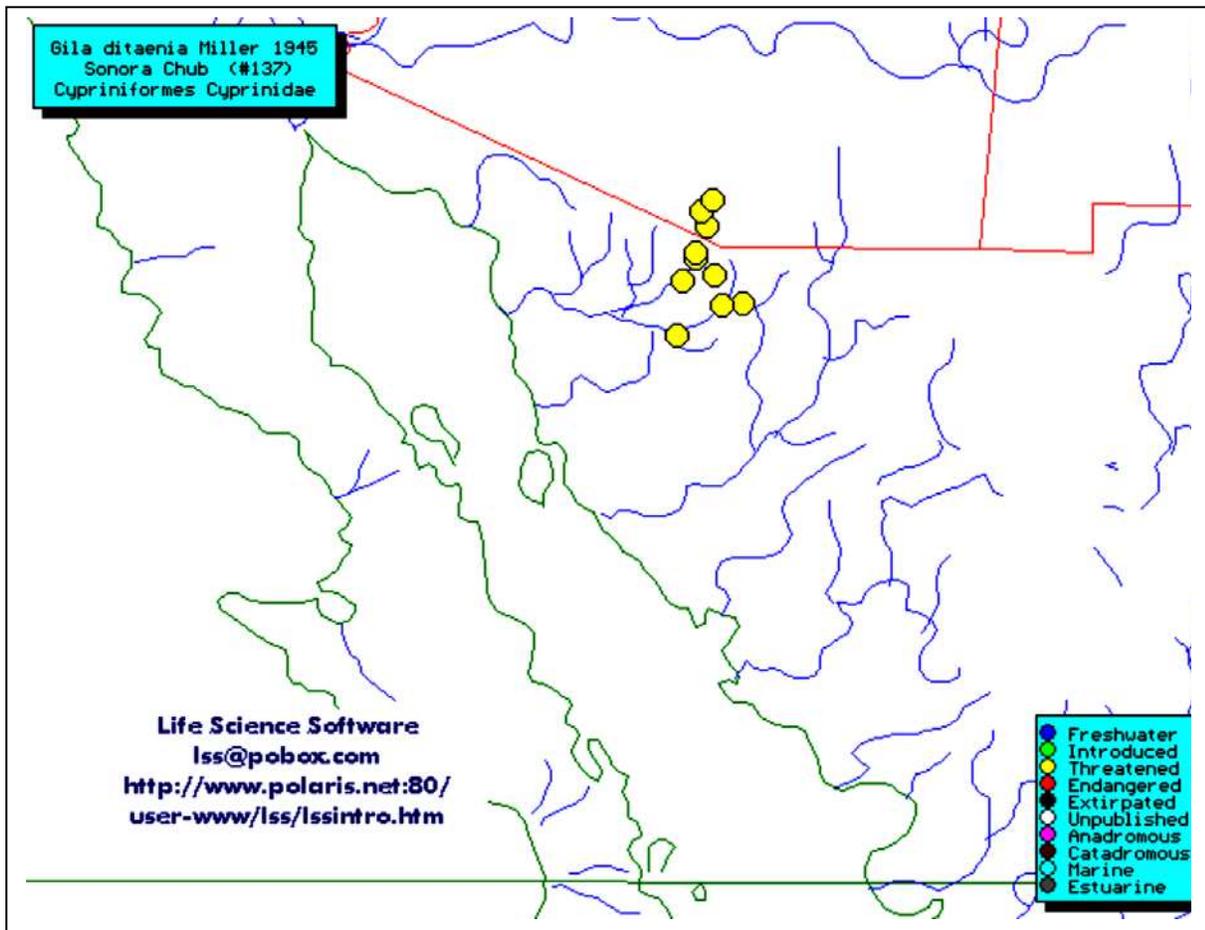


Figure 3. Designated critical habitat for the Sonora chub in the U.S. including Yanks Spring, Penasco Creek, the unnamed tributary to Sycamore Canyon, and Sycamore Canyon. A 200 ft. wide buffer was done to highlight the area. The critical habitat designated is only 25 feet on either side of the spring, creek, canyon and tributary.



U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Sonora chub (*Gila ditaenia*)

Current Classification: Threatened with critical habitat.

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Unchanged, remain as 2C; the listed entity is a species that is under a high degree of threat, with a low recovery potential.

Review Conducted By: Nichole Engelmann and Jason M. Douglas

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve *Dalton T. Bill* Date *8/5/13*

REGIONAL OFFICE APPROVAL:

Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, Region 2

Approve *Michelle Graynes* Date *8/16/13*