Chihuahua chub
(*Gila nigrescens*)

5-Year Review:
Summary and Evaluation

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U.S. Fish and Wildlife Service
Albuquerque, New Mexico

5-YEAR REVIEW
Chihuahua chub (*Gila nigrescens*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Southwest Regional Office, Region 2
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1.2 Methodology used to complete the review

The U.S. Fish and Wildlife Service (Service) conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.12) as required by section 4(c)(2)(A) of the Endangered Species Act (16 U.S.C. 1531 et seq.). This review was conducted through public review notification and a comprehensive review of all documents regarding Chihuahua chub that were available to the U.S. Fish and Wildlife Service's (Service) New Mexico Ecological Services Field Office (NMESFO). The Federal Register notice (72 FR 54059) announcing this review was published on September 21, 2007, and solicited new information about species biology, habitat conditions, conservation measures implemented, threats, and trends from other government agencies, nongovernmental organizations, academia, and the general public. Information compiled from monitoring data collected by the New Mexico Department of Game and Fish (NMDGF) and peer-reviewed literature provided the basis for the review. This review was drafted by Marilyn Myers, lead biologist for the Chihuahua chub, and was reviewed by Dr. David Propst, NMDGF.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review: 72 FR 54059; September 21, 2007.

1.3.2 Listing history:

Original Listing:
FR notice: 48 FR 46053
Date listed: October 11, 1983

Entity listed: Species, *Gila nigrescens*
Classification: Threatened

1.3.3 Associated rulemakings: A special 4(d) rule was part of the initial listing package that gave New Mexico Department of Game and Fish permitting authority (48 FR 46057).

1.3.4 Review History: This is the first 5-year review for this species since the species was listed in 1983.

1.3.5 Species Recovery Priority Number at start of review: 2
This priority number indicates a species with a high degree of threat and high potential for recovery, based on highly successful propagation efforts initially and the species' status in Mexico at the time of listing.

1.3.6 Recovery Plan or Outline
Name of plan: Chihuahua Chub Recovery Plan
Date issued: April 14, 1986
Dates of previous revisions: The recovery plan has not been revised.

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 plan? Yes. There is an approved final, recovery plan. However, it does not reflect the most up-to-date information on the species' biology, and does not address all of the five listing factors that are relevant to the species.

2.2.1.1 Does the recovery plan contain objective, measurable criteria? Yes. Two measurable criteria are given to consider delisting:

(1) conservation easements or other legal agreements have been obtained on the spring-fed tributary where the fish presently exist; and
(2) two additional secure populations are successfully established within its former range on the Mimbres River.

The definition of "secure" populations, the size of the populations, or the length of occupied habitat necessary for long-term persistence of the species were not provided. Recovery actions were provided only for the population in New Mexico; importance and status of populations in Mexico were not considered.

2.3 Updated Information and Current Species Status

2.3.1 New Information: Biology and Habitat

2.3.1.1 New information on the species' biology and life history:
The Chihuahua chub is a member of the minnow family (Cyprinidae) and has a long, narrow body that resembles a small trout. It has a terminal mouth that extends backward to about the margin of the eye (Sublette et al. 1990). In individuals over 100 millimeters (mm) (3.9 inches (in)) long, the back and sides are brassy green to slate gray, sometimes with two indistinct lateral stripes and the abdomen is whitish (Sublette et al. 1990). Males and females in reproductive condition are orange-red ventrally at the bases of the paired fins, and around the mouth (Propst 1999). Spawning males are typically more intensely colored than females and have numerous small tubercles on the head. The tail fin is rounded at the tips. Males tend to be smaller than females (Propst and Stefferud 1994). The largest individual caught in New Mexico in recent years was 308 mm (12.1 in) (Propst 2000). Young individuals are silvery to gray dorsally and whitish ventrally.

The reproductive biology of Chihuahua chub has not been studied; however observations of reproductive condition have been made during surveys. At lower elevations in Chihuahua, Mexico, reproductively ripe individuals were found in March (Propst and Stefferud 1994), while Sublette et al. (1990) indicate that spawning occurs in late April or May in New Mexico. Based on reproductive condition and size of individuals in various months, Propst (1999) suggests that spawning may extend from early spring through fall. Eggs are scattered over sand/silt substrates (Sublette et al. 1990). Sublette et al. (1990) suggest that Chihuahua chub is an opportunistic carnivore, feeding on invertebrates and possibly fish. However, no specific studies on food habits have been conducted.

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:
Information from Mexico is limited to the trend seen between historical collections and the three surveys that were done in 1964, 1979, and 1990 (Miller and Chernoff 1979, Propst and Stefferud 1994). Primarily because of water extraction and diversion (stream drying) and pollution, there was a downward trend in site occupancy over time in the streams of Chihuahua (Miller and Chernoff 1979, Propst and Stefferud 1994). Miller and Chernoff (1979) found the species at only 8 of 16 sites where it had formerly been

common and it was abundant at only 3 of the sites. Propst and Stefferud (1994) found the range and abundance of Chihuahua chub in Chihuahua had decreased dramatically and that the species was only comparatively common in remote areas relatively free of habitat modification.

Chihuahua chub was first collected from the Mimbres River in 1851 (Miller and Chernoff 1979). It was thought to be extirpated from that river (Koster 1957) but was rediscovered in 1975 (Propst and Stefferud 1994). Because of the very low number of fish in the river and destructive post-flood reclamation work on the river, 10 Chihuahua chub were collected in 1979 and taken to Dexter National Fish Hatchery and Technology Center (DNFHTC) to develop a broodstock (Service 1986). Fish from the Mimbres River have been taken to DNFHTC in 1987, 1995, 1997, 2000, and 2007 for broodstock maintenance (Propst 1997, Knight 2009). No fish from Mexico have been introduced into the broodstock.

Propagated Chihuahua chub have been stocked back into the Mimbres River and McKnight Creek, a tributary to the Mimbres River, to augment and expand the wild population. McKnight Creek was stocked in 1992 and 1998 with approximately 450 and 515 adult fish, respectively. Subsequent surveys of McKnight Creek found 4 specimens in 1993, none in 1997, 5 individuals in 2000, and 3 in 2001. However, there was no evidence of reproduction and the habitat was considered marginal because of very low flows. Subsequent surveys in McKnight Creek have not found Chihuahua chub. In the Mimbres River, Chihuahua chub occur sporadically, in a section approximately 15 km (9 miles) from the confluence of Allie Canyon to the TNC Dominguez tract, where they have been stocked.

The Mimbres River was stocked in 1998, 2000-2005, and in 2008 (Knight 2009). Typically fish 76-100 mm (3-4 in) are stocked on the NMDGF and The Nature Conservancy (TNC) properties along the river. Annual surveys of the Mimbres River are conducted by NMDGF in the fall. The monitoring indicates an increase in density in the last few years (Table 1). This also corresponds with the increased stocking effort, and in a case in 2004, fish were stocked on the same day as the survey, increasing the number of fish caught at the NMDGF site (Propst and Paroz 2007). However, natural recruitment has also been documented, indicating the Mimbres River continues to provide suitable habitat for the species. The population status in the Mimbres River is currently stable.

Table 1. Density (fish/square meter) of Chihuahua chub at NMDGF and TNC McAnally Tract, Mimbres River, 1997-2006. Data summarized from Propst and Hobbes 2002, Propst and Kingsbury 2003, and Propst and Paroz 2007.

Site	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
NMDG&F	0	0.03	0.02	0	0.09	0	0.13	0.24	0.21	0.26
TNC McAnally	0.08	0.01	0.02	0	0.04	0.03	0.03	0.05	0.26	0.12

Length frequency data indicate that the species lives approximately 4 to 5 years (Hatch 1981, 1982; Propst and Stefferud 1994); however, captive individuals may live up to 7 or 8 years (Propst 1999). Individuals appear to mature in their first year when they reach about 80 mm (3.1. in) (Miller and Chernoff 1980).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
There is no new information.

2.3.1.4 Taxonomic classification or changes in nomenclature:
There is no new information.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range, etc.):
The historical range of Chihuahua chub is difficult to determine because of the lack of early collections. Most likely all but the uppermost reaches of permanently watered portions of the Mimbres River, New Mexico, and streams in the Guzman and Laguna Bustillos basins in Mexico were occupied (Propst and Stefferud 1994). All of the streams within the historical range flow into a closed (endorheic) basin; none have a connection with the ocean. There are approximately 345 km (215 mi) of potentially occupied habitat in Chihuahua and about 15 km (9 mi) in the Mimbres River, New Mexico. Only a fraction of potentially occupied habitat in Chihuahua has been surveyed. Tributaries of the Mimbres River do not support the species (Propst and Stefferud 1994).

In the United States, Chihuahua chub was first collected in 1851 from the Mimbres River (Miller and Chernoff 1979). It was thought to be extirpated from that river (Koster 1957) but was rediscovered in 1975 (Propst and Stefferud 1994). In Chihuahua, Mexico, it was collected from the Casas Grandes drainages in 1854 and was incidentally collected in other drainages of the Guzman and Laguna Bustillos basins (Propst and Stefferud 1994). Miller and Chernoff (1979) made a systematic survey of historically occupied sites. They found Chihuahua chub at 8 of 16 localities where it had formerly been common, but found that it was abundant in only 3 localities (Miller and Chernoff 1979). They cited depletion of ground water, channelization, water diversion, pollution, and nonnative fish as reasons for the decline in the species.

In 2008 and 2009, Chihuahua chub was discovered in the Mimbres River near Cooney, approximately 16.5 km (10 mi) upstream from Allie Canyon (Monzingo 2009). It is not known if the Chihuahua chub at this location were missed in prior surveys because of very low numbers, whether they

dispersed to this location naturally during high flows, or if they were transported there by humans. The Mimbres River is typically intermittent between Allie Canyon and Cooney Canyon. In May of 2009, there were approximately 2.8 km (1.75 mi) of suitable habitat in the Cooney area but it was estimated that in June, appropriate habitat might shrink to about 1.2 km (0.75 mi) as the creek dried (Monzingo 2009). Within this river stretch, multiple size classes of the Chihuahua chub are present. Brown trout (*Salmo trutta*), longfin dace (*Agosia chrysogaster*), speckled dace (*Rhinichthys osculus*), and Rio Grande sucker (*Catostomus plebeius*) are also present. Of these species, only Rio Grande sucker is native to the Mimbres River (discussed below). A road (FR 150A) is located in and along the river at this location which should either be closed or relocated (Monzingo 2009).

In 1990, surveys within the historical range in Chihuahua and New Mexico were again conducted (Propst and Stefferud 1994). They found Chihuahua chub at 28 of 40 stream sites having fish, in 1 of 9 spring sites, and in neither of 2 lakes sampled (Propst and Stefferud 1994). The original collection sites of Baird and Girard (1854) and Girard (1856) were dry (Propst and Stefferud 1994). At another site on the Rio del Carmen where both Minckley and Miller had collected Chihuahua chub in 1964 the river was dry in 1990 (Propst and Stefferud 1994). Chihuahua chub was found 25 km (15 mi) upstream of the previously occupied site, but only 3 specimens were recovered (Propst and Stefferud 1994). Propst and Stefferud (1994) reported that in several areas, Chihuahua chub had declined compared to earlier collections. Reasons cited for the decline and loss of habitat were: channelization, dewatering, livestock over-grazing, municipal and agricultural pollution, habitat fragmentation, and nonnative species.

Although sampling occurs annually on the Mimbres River, rivers in Chihuahua have not been systematically surveyed since 1990; therefore, our current knowledge of the status of the species in Mexico is limited. However, articles published on the conservation of fishes in Mexico since the last survey indicate that threats are continuing or intensifying, especially in regards to exotic species, water extraction, groundwater pumping, and stream drying (Contreras-Balderas and Lozano-V. 1994, Edwards et al. 2002, Contreras-Balderas et al. 2008). In addition, the intense drought which occurred in the Southwest in the early 2000s, and led to the diminishment and drying of streams in Arizona and New Mexico, most likely affected the adjacent State of Chihuahua with similar stream water declines. Consequently, we have reason to believe that the status of Chihuahua chub in Mexico may be more imperiled at this time than it was when last surveyed in 1990.

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

Adult Chihuahua chub are considered habitat specialists. They are found primarily in lateral scour pools, beneath undercut banks, or under other solid objects (e.g., logs, boulders) adjacent to moderate to fast flowing water in small to medium sized streams (Miller and Chernoff 1979, Propst and Stefferud 1994). Corner and backwater pools containing large woody debris are also used as habitat. Almost all habitats occupied by Chihuahua chub have extensive cover composed of organic debris or root wads of large trees. Pools are typically 1-2 m deep with a water velocity of less than 15 cm/second, and substrates are small-grained (sand to pea-size) (Propst and Stefferud 1994, Propst 1999). Juveniles are found in shallower water with or without cover (Miller and Chernoff 1979).

Although critical habitat was initially proposed (45 FR 82474), it was not designated in the final rule. The final rule (48 FR 46053) states that critical habitat was not designated because the Governor of New Mexico, the NMDGF, and the New Mexico Department of Agriculture opposed designation. In addition, local landowners had expressed concern over how critical habitat designation might affect flood control and irrigation practices (48 FR 46053).

2.3.1.7 Other: Improved analytic methods resulted in new information.

No new analytical methods have produced new information.

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

Within the historical range of the Chihuahua chub, stream and wetland habitat have been destroyed or degraded, and loss of this habitat continues today (Miller and Chernoff 1979, Minckley and Deacon 1991, Contreras-Balderas and Lozano-V. 1994, Propst 1999, Edwards et al. 2002, Contreras-Balderas et al. 2008). Activities such as groundwater pumping, surface water diversions, impoundments, dams, channelization, improperly managed livestock grazing, wildfire, agriculture, mining, road building, timber harvest, and residential development all contribute to riparian and cienega habitat loss and degradation in New Mexico and Mexico (Miller and Chernoff 1979, Minckley and Deacon 1991, Contreras-Balderas and Lozano-V. 1994, Propst 1999, Edwards et al. 2002, Contreras-Balderas et al. 2008). The local and regional effects of these activities are expected to increase with increasing human population because a larger human population will result in increased development.

Of the activities listed, stream drying has caused the biggest loss of habitat. Miller and Chernoff (1979) and Propst and Stefferud (1994) provide many examples where historically occupied habitat is now dry. Diversion of streams for crop irrigation, dam installation, and groundwater pumping are the primary causes of stream drying. In addition, any activity that degrades or eliminates the preferred habitat of the adults (e.g., deep pools, undercut banks) such as removal of woody debris from rivers, trampling of banks by livestock, channelization, removal of riparian vegetation, or increased sedimentation will reduce or eliminate populations. Water pollution from agricultural and municipal sources and overgrazing by livestock also create unsuitable habitat. As a consequence of these developments, Chihuahua chub are comparatively common only in the remote areas of Chihuahua where habitat modification is less common (Propst and Stefferud 1994).

2.3.2.2 Overutilization for commercial, recreational, scientific or educational purposes

Although the Chihuahua chub from the Mimbres River may have served as a food source for Native Americans and early settlers (Service 1986), now it is protected by regulation from angling in New Mexico. However, it may still be an important food source for people in Mexico. Propst and Stefferud (1994) found evidence of, or witnessed imaginative techniques for fish capture in Chihuahua. When the researchers returned Chihuahua chub back to the creek after surveys, the children were dismayed, because the *charalitos* were the most desirable food fish in the stream (Propst and Stefferud 1994). The impact of human consumption in Mexico is unknown; however, it is unlikely that there is active protection of this species.

2.3.2.3 Disease or predation

Only two other fish species are known to have historically co-existed with Chihuahua chub in New Mexico; Rio Grande sucker and beautiful shiner (*Cyprinella formosa*) (Propst and Stefferud 1994). The beautiful shiner has been extirpated from New Mexico (Propst 1999). Chihuahua chub evolved in a fish community where no predatory fish existed and as a result developed no mechanisms to deal with predation from nonnative species. Most likely, Chihuahua chub was the top predator and experienced little or no predation or competition from other species. Introduction of nonnatives is considered a major factor in the decline of all native fish species (Koster 1957, Minckley and Deacon 1991, Miller et al.1989). In the Mimbres River, longfin dace became established in the 1960s (Sublette et al. 1990) and is the most abundant nonnative fish (Burton 1987). Speckled dace is also present (Propst and Paroz 2007). Competition between these two species and Chihuahua chub has not been studied. Rainbow trout (*Oncorhynchus mykiss*) is also present in the Mimbres River. Rainbow trout abundance has varied over time but has declined recently (Propst and Paroz 2007). Rainbow trout are potential predators of and competitors with Chihuahua chub. Other nonnative fish are uncommon in the Mimbres River (Propst 1999).

In Mexico, nonnative fish recorded in the habitat of Chihuahua chub included black bullhead (*Ictalurus melas*), brown bullhead (*I. nebulosus),* bluegill (*Lepomis macrochirus),* carp (*Cyprinus carpio*), western mosquito fish (*Gambusia affinis),* bullhead minnow (*Pimephales vigilax),* rock bass (*Ambloplites rupestris*), and largemouth bass (*Micropterus salmoides*) (Propst 1990). In the Bustillos basin, black bullhead, brown bullhead, and bluegill were present in one or two of the six sites sampled. In the Guzman basin, mosquito fish was the most abundant nonnative caught in the Santa Maria drainage and was found at 7 of 12 sites sampled. Black bullhead and carp were present in 2 of 12 sites. In the Santa Clara drainage, carp was found in three of nine sites and mosquitofish in one of nine. In the Casas Grandes drainage, black bullhead was the most commonly encountered nonnative, present at 6 of 17 sites sampled. Carp, bullhead minnow, mosquito fish, rock bass, bluegill, and largemouth bass were present in 3 or fewer of the 17 sites sampled (Propst 1990). Both Miller and Chernoff (1980) and Propst and Stefferud (1994) cite nonnative species as a threat to Chihuahua chub.

Anchor worm (*Lernaea cyprinacea*) (Copepoda), also a nonnative species, is an external parasite, and infects a wide range of fishes and amphibians. *Lernaea* infection has killed large numbers of fish due to tissue damage and secondary infection of the attachment site (Hoffnagle and Cole 1997) and was responsible for the loss of 21 Chihuahua chub captured at Moreno spring and transported to DNFHTC for use as brood stock (Burton 1988, Johnson and Jensen 1991). *Lernaea* infection also was documented from Chihuahua chub caught in Mexico (Propst and Stefferud 1994).

The population of Chihuahua chub in Moreno Springs is infected with yellow grub (*Clinostomum marginatum*). This parasite is a trematode with a complex life history that includes aquatic snails, freshwater fish, and wading birds (usually a heron) (Klaas 1963). The “yellow grub” is the encysted metacercaria that appears as a yellow, oval spot, 3-6 mm long (Klaas 1963). Common locations for the metacercaria are on the caudal, dorsal, and pectoral fins, on the inside surface of the operculum, and in the muscle tissue. Far fewer fish in the river are infected with yellow grub than those in Moreno Springs (Propst and Paroz 2007) and in general it has been found that even large infestations of yellow grub do not affect the condition factor of fish (Klaas 1963, Newman et al. 1976). However, it is unknown if heavy infestations have an effect on reproductive success (i.e., fewer or less fit offspring).

The nonnative parasite *Ichthyophthirius multifiliis* (‘‘ich’’) is a potential threat to Chihuahua chub. Development of ich is favored by high temperatures and physiological stress, which can occur during crowding as a result of drought (Mpoame 1982). This protozoan becomes embedded under the skin and within the gill tissues of infected fish. When the parasite

matures, it leaves the fish, causing fluid loss, physiological stress, and sites that are susceptible to infection by other pathogens. In heavily infected fish, respiration is impaired because of damaged gill tissue. Ich was documented on Chihuahua chub collected from Mexico (Propst and Stefferud 1994) and could become a problem in the Mimbres River under deteriorating water quality conditions (intermittency and warm water temperatures during periods of drought).

2.3.2.4 Inadequacy of existing regulatory mechanisms

Chihuahua chub is federally listed as threatened (45 FR 82474) and State listed as endangered (NMDGF 2006). New Mexico State law provides limited protection to endangered species. This designation provides protection under the New Mexico Wildlife Conservation Act of 1974 (i.e., State Endangered Species Act) (19 NMAC 33.6.8), but only prohibits direct take of species, except under issuance of a scientific collecting permit. The New Mexico Wildlife Conservation Act defines "take" or "taking" as harass, hunt, capture or kill any wildlife or attempt to do so (17 NMAC 17.2.38). In other words, New Mexico State status as an endangered species only conveys protection from collection or intentional harm to the animals themselves; it does not address habitat protection, indirect effects, or other threats to these species.

Because Chihuahua chub is federally listed as threatened, any project with a Federal nexus on the Mimbres River which may affect the species will receive section 7 consultation through the New Mexico Ecological Services Field Office. All research activities are regulated by permits issued by the NMDGF. The species is listed as threatened by the Republic of Mexico (Propst 1999) but it is unclear if there is any regulatory protection related to the listing. From the degradation of the habitat that has occurred and the documented desirability of Chihuahua chub as food (Propst and Stefferud 1994), it appears unlikely that any tangible protection is occurring in Chihuahua.

As described below, it is anticipated that climate change will have a significant impact on the water resources of the Southwest. Currently, there are no regulatory mechanisms that address climate change.

2.3.2.5 Other natural or manmade factors affecting its continued existence

Fragmentation

Chihuahua chub populations have become fragmented and isolated in small stream segments from stream diversion, stream drying, dam installation, and pollution. The isolated populations are vulnerable to natural or manmade factors that might further reduce their population size (Fagan et al. 2002, Noss et al. 2005). Random events, such as drought, floods, and wildfire, can decimate populations of Chihuahua chub. In addition, because of the lack of

gene flow, small, isolated populations are subject to genetic threats, such as inbreeding depression and genetic drift (Noss et al. 2005).

Wildfire

Wildfires are a natural disturbance in forested watersheds. However, since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average frequency during the period 1970–1986. The total area burned is more than six and a half times the previous level (Westerling et al. 2006). In addition, the average length of the fire season during 1987–2003 was 78 days longer compared to that during 1970–1986 and the average time between fire discovery and control was 29.6 days longer (Westerling et al. 2006). Although prescribed burns are being used in the United States to mimic the historical fire regime and improve watershed conditions on the Gila National Forest, many decades will likely pass before a natural fire cycle is restored. Fires in the Southwest frequently occur during, or just prior to, the summer monsoon season. As a result, fires are often followed by rain that washes ash-laden debris into streams (Rinne 1996, Brown et al. 2001). It is usually the debris flows, rather than the fires themselves, that impact and sometimes devastate fish populations (Rinne 1996, Brown et al. 2001). Indirect effects of fire also include watershed alteration that can change streamflow, water quality, riparian vegetation, and instream sediment loads, all of which can drastically alter habitat for Chihuahua chub. Ash flows affected the Mimbres River in occupied habitat from 1994-1996 (Burton 1994, Propst 1997). Initially it was thought that there was a complete fish kill (Burton 1994); however, a few Chihuahua chub survived (Burton 1994, Propst 1997). It is unknown if fire has affected populations in Chihuahua.

Climate change

According to the Intergovernmental Panel on Climate Change (IPCC 2007) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007). It is very likely that over the past 50 years cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). Data suggest that heat waves are occurring more often over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007).

The IPCC (2007) predicts that changes in the global climate system during the 21st century will very likely be larger than those observed during the 20th century. For the next two decades a warming of about 0.2°C (0.4°F) per decade is projected (IPCC 2007). Afterwards, temperature projections

increasingly depend on specific emission scenarios (IPCC 2007). Various emissions scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.6°C to 4.0°C (1.1°F to 7.2°F) with the greatest warming expected over land (IPCC 2007).

Localized projections suggest the Southwest may experience the greatest temperature increase of any area in the lower 48 States (IPCC 2007), with warming in southwestern states greatest in the summer (Christensen et al. 2007, Karl et al. 2009). The IPCC also predicts hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007). There is also high confidence that many semi-arid areas like the western United States will suffer a decrease in water resources due to climate change (IPCC 2007), as a result of less annual mean precipitation and reduced length of snow season and snow depth (Christensen et al. 2007). Milly et al. (2005) project a 10–30 percent decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

In consultation with leading scientists from the Southwest, the New Mexico Office of the State Engineer prepared a report for the Governor (State of New Mexico 2006) which made the following observations about the impact of climate change in New Mexico:

(1) Warming trends in the American Southwest exceed global averages by about 50 percent;
(2) Models suggest that even moderate increases in precipitation would not offset the negative impacts to the water supply caused by increased temperature;
(3) Temperature increases in the Southwest are predicted to continue to be greater than the global average;
(4) There will be a delay in the arrival of snow and acceleration of spring snow melt, leading to a rapid and earlier seasonal runoff ; and
(5) The intensity, frequency, and duration of drought may increase.

Consistent with the outlook presented for New Mexico, Hoerling (2007) states that, relative to 1990–2005, simulations indicate that a 25 percent decline in stream flow will occur from 2006–2030 and a 45 percent decline will occur from 2035–2060 in the Southwest. Seager et al. (2007) show that there is a broad consensus among climate models that the Southwest will get drier in the 21st century and that the transition to a more arid climate is already under way. Only one of 19 models has a trend toward a wetter climate in the Southwest (Seager et al. 2007). Stewart et al. (2005) show that timing of spring streamflow in the western United States during the last five decades has shifted so that the major peak now arrives one to four weeks earlier, resulting in less flow in the spring and summer.

Streams occupied by Chihuahua chub have already experienced water loss from diversions and groundwater pumping, and sites once occupied are now

dry (Miller and Chernoff 1979, Propst and Stefferud 1994). Records from the USGS site on the Mimbres River indicate that the lowest flows on record occurred from 2000-2003 in the months of June through September. From mid-June to early July 2002, the stream dried at the gauging station for the first time since operation of the gauging station began (1979) (summarized from the USGS web site: http://waterdata.usgs.gov/nm/nwis/uv/?site_no=08477110&PARAmeter_cd=00065,00060, viewed June 26, 2009). Most likely streams in Chihuahua were also affected by the drought. Chihuahua chub occupies small to medium-sized streams; consequently, we would expect them to be more susceptible to drying in the face of an intense or protracted drought. It is anticipated that the effects of climate change will lead to greater demands on scarce water sources while at the same time leading to decreasing water availability in the Chihuahuan desert.

There are two weather stations on the Mimbres River, just downstream of occupied habitat at Faywood (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nm3157; viewed June 26, 2009), and the other at the U.S. Forest Service Mimbres Ranger District Office (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nm5754; viewed June 26, 2009), just upstream of occupied habitat. Summaries of temperature records from these stations both show increases in air temperature but the pattern is slightly different. At the Mimbres Ranger District Station, the average maximum air temperature has increased by 1°F from 1971-2000 compared to 1961-1990. In Faywood, the average maximum temperature has only increased 0.1°F for that period of time but the average minimum temperature has increased by 1°F. As indicated above, even if precipitation were to increase, increased air temperatures are expected to lead to declining surface water flows. Consequently, we anticipate reduced surface water flows in the foreseeable future from warmer air temperatures alone or from a combination of warmer air temperatures in addition to decreasing precipitation and runoff.

The ancillary effects of increased temperature, such as increased habitat fragmentation (from stream drying), changes in invertebrate prey base (both species composition and availability) (Ries and Perry 1995, Harper and Peckarsky 2006, Bradshaw and Holazpel 2008), increased frequency and intensity of fire (Westerling et al, 2006), additional invasive species (IPCC 2002, Eaton and Scheller 1996), increased susceptibility and mortality from disease (Ficke et al. 2005, Hari et al. 2006), and effects on water quality (e.g., dissolved oxygen, nutrients, pH) (Meisner et al. 1988, Meyer et al. 1999, Ficke et al. 2005) may also have a negative impact on Chihuahua chub. Because water temperature is correlated to air temperature, it is predicted that water temperatures will rise. It is projected that warmer water temperatures will allow warmwater fishes (native and nonnative) to expand their range (Ficke et al. 2005). Given that Chihuahua chub evolved in a fish community with few species, if additional nonnative species were introduced into their

habitat, they may likely have a negative effect on Chihuahua chub.

2.3.2.5 Conservation Measures

At the time of listing, all of the land adjacent to occupied habitat was privately owned and the primary use was livestock and/or crop production. Protection of the stream through acquisition or easements was considered a high priority for recovery (Service 1986). Since that time NMDGF and TNC have purchased parcels of land in occupied habitat. The NMDGF parcel is south of the town of Mimbres and was purchased for the sole purpose of protecting Chihuahua chub. Only birdwatching and hiking are permitted on the parcel. TNC has one parcel north of Mimbres (McAnally tract), which protects approximately two miles of river and two parcels south of Highway 152 (Dominguez and Disert tracts), each of which protect about a mile of river. With the purchase of the parcels, TNC excluded grazing on the river to allow the riparian corridor to recover. Both NMDGF and TNC allow fallen trees to remain in the river to create habitat. Under prior management all trees were removed from the river. A Partners for Fish and Wildlife project provided funding to fence Moreno Spring in 1997. Private landowners recently purchased land encompassing a reach of the Mimbres River adjacent to the McAnally tract. They have contacted the Service about their interest in protecting and enhancing habitat for threatened and endangered species on their property. Consequently, additional stream habitat will be enhanced and protected in the future.

2.4 Synthesis

Habitat of the Chihuahua chub has been greatly reduced and degraded through depletion of ground water, water diversion, dewatering, channelization, dam construction, municipal and agricultural pollution, nonnative fish, and livestock grazing. These factors have led to stream drying, habitat fragmentation, unsuitable water quality, and loss of the deep pools and overhanging banks that the species requires. Although regulatory controls are protecting the species in New Mexico, the majority of historical habitat occurs in Mexico where it appears there is little protection for the species. Because Chihuahua chub evolved in a fish community with few other species, nonnative species likely have a negative impact on the Chihuahua chub. However, interactions with nonnative species have not been specifically investigated. Chihuahua chub is susceptible to disease and infection from nonnative parasites such as anchor worm, yellow grub, and ich. Of these, anchor worm has caused documented deaths of Chihuahua chub. Yellow grub and ich appear to be less harmful but may lead to reduced reproductive success.

If water temperatures rise in concert with air temperatures from climate change, it is anticipated that Chihuahua chub may become more susceptible to disease and infection because fish become stressed as water temperature increases and dissolved oxygen decreases. This would be especially true if the fish were caught in isolated pools that were drying. Climate change is projected to lead to decreased stream flow and increased conflict over a scarce resource. The intense drought which occurred in the Southwest in the early

2000s led to the diminishment and drying of streams in Arizona and New Mexico, and most likely affected the adjacent State of Chihuahua. Average maximum and minimum air temperatures measured at stations on the Mimbres River have increased during the period from 1991 to 2000, consistent with the overall increase in temperature documented in the southwest. Warmer water temperatures may lead to a variety of impacts on Chihuahua chub including changes in prey base, increased exposure to ash flows following forest fires, decreased water quality, and increased competition and/or predation from nonnative species.

The population of Chihuahua chub in the Mimbres River, New Mexico, currently appears to be stable. However, because of the extremely limited amount of occupied habitat, the dependence of the population on stocking, and the ongoing threats to the population, its status remains precarious. The purchase of parcels of property on the Mimbres River by TNC and NMDGF, which include occupied habitat, has improved habitat quality in those reaches. The propagation program at DNFHTC has provided a steady source of fish to augment the wild population. Annual surveys indicate that the density of Chihuahua chub is slowly increasing in the Mimbres River. Attempts to establish a self-sustaining population in McKnight Creek appear to have failed. However, surveys at Cooney Canyon, approximately 16.5 km (10 mi) upstream of Allie Canyon, discovered Chihuahua chub in 2008 and 2009. Whether this population represents a previously undiscovered population, is the result of dispersal from downstream, or is the product of human conveyance is not known.

The populations in Chihuahua, Mexico, have not been systematically surveyed since 1990. It is feared that because of the intense drought of the early 2000s, lack of regulatory control, depletion of groundwater, and diversion of surface water for agricultural and municipal demands, the status of Chihuahua chub is worse today than it was when it was surveyed in 1990. At that time, surveys indicated that historically occupied sites were unoccupied because of stream drying, pollution, and loss of appropriate adult habitat. Lack of regulatory control is most likely a problem, not only for minimizing the impact of development on stream habitat but also because of human consumption of the species. A follow-up survey is needed to determine the current status of the species in Mexico.

Chihuahua chub was proposed to be listed as endangered (45 FR 82474). In the final rule it stated that the proposed endangered status was changed to threatened because of the species' status in Mexico and the highly successful propagation efforts (48 FR 46054). However, in terms of its status in Mexico the final rule only states that several populations were present. Although populations were present in Mexico, Chernoff and Miller (1979) found that the distribution had declined from previous surveys. Since publication of the final rule in 1983, Propst and Stefferud (1994) found further declines in distribution and population size in Mexico. Although no systematic surveys have been conducted since 1990, there is reason to believe that further declines have occurred because of the loss of suitable habitat (Contreras-Balderas and Lozano-V. 1994, Propst 1999, Edwards et al. 2002, Contreras-Balderas et al. 2008).

Although DNFHTC has been successful in raising Chihuahua chub, the brood stock population was initiated with approximately 10 fish and supplemented only with fish from

the Mimbres River. No Chihuahua chub have been brought in from Mexico to increase the genetic diversity of the gene pool. In spite of stocking, additional populations have not been established in tributaries to the Mimbres River and the population within the Mimbres River remains very low. Total occupied habitat in the Mimbres River is about 9 mi (15 km). The threats to the species remain high, especially in light of climate change which will likely further reduce the amount of water in streams occupied by Chihuahua chub. For these reasons we recommend that the species be uplisted from threatened to endangered.

3.0 RESULTS

3.1 Recommended Classification: Uplist from threatened to endangered.

3.2 New Recovery Priority Number: 5

We recommend reclassification from a 2, indicative of a high degree of threat with a high chance of recovery, to a 5, indicative of a high degree of threat but a low probability of recovery. The change from a high chance of recovery to a low chance is based primarily on the increase of threats related to water depletion and habitat degradation, the extremely limited amount of occupied habitat, and the dependence upon stocking. Furthermore, continued efforts of annual stocking are maintaining a stable population of Chihuahua chub, but these are based on genetically limited stock possibly subjected to increased water temperatures. In Mexico, the chub occurred as only a few populations, which have not been systematically surveyed since 1990, and the chub's distribution has declined since listing likely due to drought, water development, and a lack of regulatory control. Lastly, attempts to establish a self-sustaining population in nearby McKnight Creek, in New Mexico, have been unsuccessful, highlighting the chub's possible lack of adaptability and long-term reproductive success within current conditions.

3.3 Listing and Reclassification Priority Number: 5

Reclassification to a 5 is based on evidence of a high degree of threat that is not imminent. This change is recommended because the Chihuahua chub continues to be subjected to a high degree of threat, but threats from water depletion and habitat degradation are chronic conditions impacting the fish and thus are not imminent.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Secure water rights in the Mimbres River for Chihuahua chub.
- Create additional suitable habitat through occupied reaches of the Mimbres River.
- Engage private land owners in the conservation of Chihuahua chub.
- Conduct systematic surveys of historical Chihuahua chub streams in Chihuahua, Mexico, to determine current status and monitor trends.
- Conduct a survey of the population genetics of the Mexico and New Mexico populations of Chihuahua chub.
- If appropriate, introduce fish from Mexico into the broodstock at DNFHTC.
- If the habitat is suitable and sustainable, introduce Chihuahua chub into additional tributaries of the Mimbres River.

- Investigate the possibility of introducing Chihuahua chub into stock tanks in the Mimbres basin that have permanent water.
- Investigate the opportunities for protecting populations in Chihuahua, Mexico.
- Revise the recovery plan.
- Investigate the thermal tolerances of Chihuahua chub.
- Investigate the diet of Chihuahua chub.
- Investigate the impact of nonnative species on Chihuahua chub.
- Improve and protect the habitat near Cooney Canyon, New Mexico.

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

Current Classification: Threatened.

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
_X_ Uplist to Endangered
____ Delist
____ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: 5

Review Conducted By: Marilyn Myers, Fish and Wildlife Biologist, New Mexico Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date 12-30-09

REGIONAL OFFICE APPROVAL:

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

Approve Nancy G Gloman Date 1-13-10