Threatened and Endangered Fishes of New Mexico

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TECHNICAL REPORT NO. 1
1999
NEW MEXICO DEPARTMENT
OF GAME AND FISH

Propst, D.L. 1999. Threatened and endangered fishes of New Mexico.
Tech. Rpt. No. 1. New Mexico Department of Game and Fish, Santa Fe, NM. 84 pp.

Cover by NoBul Graphics, Albuquerque, NM.
Design and production by Janelle Harden, The Studio, Albuquerque, NM.

Publication and printing supported by the Turner Foundation, Atlanta, GA.

In part, a contribution of Federal Aid in Fish and Wildlife Restoration., Project FW–17–RD.

Complete copies may be purchased for $10.00 U.S. (see address below).
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FORWARD

Threatened and Endangered Fishes of New Mexico by Dr. David L. Propst represents the first in this new series of technical reports by the Department of Game and Fish. A treatise on the state's threatened and endangered fishes for the Department's first technical report is appropriate. With the exception of invertebrates, the native fish fauna is the most imperiled of the state's wildlife. For example, 43% of the native fishes of the Rio Grande in New Mexico have been extirpated or are extinct, one species is listed as endangered, and all others have declined substantially.

This report describes the biogeography and the native icythofaunal diversity of New Mexico, including extinct and extirpated species. The report presents an overview of the status, distribution, biology, threats and conservation initiatives for 23 fish species listed as threatened or endangered under New Mexico's Wildlife Conservation Act.

New Mexico is an inhospitable place for fishes, averaging 13 inches of rainfall per year; it is the third most arid state in the nation. Ninety-seven percent of the 88 million acre feet of water that enters the state annually is lost to evaporation. In spite of this, Dr. Propst notes that New Mexico supports one of the most diverse native icthyofauna of any interior southwestern state. Some 66 species of native fish are known to have occurred in New Mexico's waters, although 11 of these are presently extirpated or extinct.

Concern for the conservation and recovery of endangered fishes has grown in direct proportion to the increasing rate and scale of extinction and habitat loss. Many of the native riverine fish assemblages in New Mexico have been adversely affected by habitat modification resulting from stream impoundments, channelization, and diversions, which drastically altered natural flow regimes. The introduction of nonnative fish species has substantially changed community structure through competition, displacement, and hybridization. Impairment of surface water quality is a major concern. Over half of the rivers in New Mexico do not meet designated or attainable uses. One-sixth of the state's surface waters exceed the acute numeric water quality standards for toxic substances. The causes of surface water quality degradation include loss of riparian habitats, streambank destabilization, and siltation. Nonpoint source pollution is responsible for 96% of the impairment of New Mexico's streams.

Man and his activities have had a significant impact on New Mexico's aquatic ecosystems, resulting in negative impacts, directly or indirectly, to the native fishes of the state. Despite the passage of numerous state and federal laws to protect our environment, the quality and quantity of aquatic habitat continues to decrease. Habitat loss, habitat degradation, and fragmentation translate to decreased biological diversity. Thus, maintaining biological diversity is essential to prevent further extinction and for the recovery of New Mexico's threatened and endangered fishes.

The Department's strategy to increase public awareness of, and appreciation for, the state's wildlife prompted this technical reports series. We recognized that a great gulf of misunderstanding exists regarding conservation of endangered species. This contributes to the difficulty in implementing effective conservation and recovery programs. It is our sincere hope that this report will not only offer the scientific community and interested publics insight to the plight of our native fishes and the complex issues of endangered species conservation, but that it will also inspire further appreciation and support for their continuing conservation. With this report, Dr. Propst makes a significant contribution to the arena of endangered fishes biology and conservation in New Mexico. I am proud to be part of this important effort.

Andrew V. Sandoval,
Chief Conservation Services Division

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DIVERSITY OF NEW MEXICO FISHES AND AQUATIC HABITATS

Among the states of the arid American Southwest, New Mexico historically had a comparatively rich and diverse native fish fauna comprised of at least 66 species, and perhaps four others, representing 15 families. Since European settlement of New Mexico, at least 10, and perhaps 11, species and subspecies of native New Mexico fishes have been extirpated from the state or are extinct (Table 1).

The geographic position of New Mexico astride the Continental Divide and the diversity of biomes in the state contribute to its rich ichthyofaunal heritage. East of the Continental Divide, elements of the Mississippian-Missourian ichthyofauna reach their western distributional limits in New Mexico. A few representatives of families more common to the south in Mexico extend north into New Mexico. West of the Continental Divide, the fish fauna is less rich but has a higher level of endemism, and is composed mainly of representatives of two families, minnows and suckers.

The diversity of aquatic habitats, varying from isolated springs to large rivers with highly variable flows, also contributes to the ichthyofaunal richness of New Mexico. Aquatic habitats range in elevation from about 1000 m in the Pecos River valley of southeast New Mexico to more than 4000 m in the Sangre de Cristo Mountains of north-central New Mexico. Associated with elevational changes are differences in thermal conditions. Small, low-elevation warm springs and high-elevation, coldwater mountain streams each may support only one or two species. Larger, eurythermal mid- and low-elevation rivers, such as the Pecos, support more than 20 species. Some native fish species can survive salinities greater than that of seawater while others are intolerant of the slightest amounts of salt in their environments.

TABLE 1.

EXTINCT AND EXTIRPATED NATIVE FISH SPECIES OF NEW MEXICO.

SPECIES		NATIVE RANGE
ACIPENSERIDAE, STURGEONS		
Scaphirhynchus platorhynchus	shovelnose sturgeon	Rio Grande
ANGUILLIDAE, EELS		
Anguilla rostrata	American eel	Pecos River and Rio Grande
CYPRINIDAE, MINNOWS		
Cyprinella formosa	beautiful shiner	Mimbres River
Gila elegans	bonytail	San Juan River
Notropis amabilis	Texas shiner	Pecos River
Notropis orca[1]	phantom shiner	Rio Grande
Notropis simus simus[1]	Rio Grande bluntnose shiner	Rio Grande
CATOSTOMIDAE		
Xyrauchen texanus[2]	razorback sucker	San Juan and Gila rivers
SALMONIDAE, TROUTS		
Oncorhynchus clarki pleuriticus	Colorado River cutthroat trout	San Juan River
POECILIIDAE, LIVEBEARERS		
Poeciliopsis occidentalis occidentalis[2]	Gila topminnow	Gila River
CYPRINODONTIDAE, PUPFISHES		
Cyprinodon sp.	Palomas pupfish	Guzmán Basin

[1]Extinct.
[2]Extirpated, but repatriated.

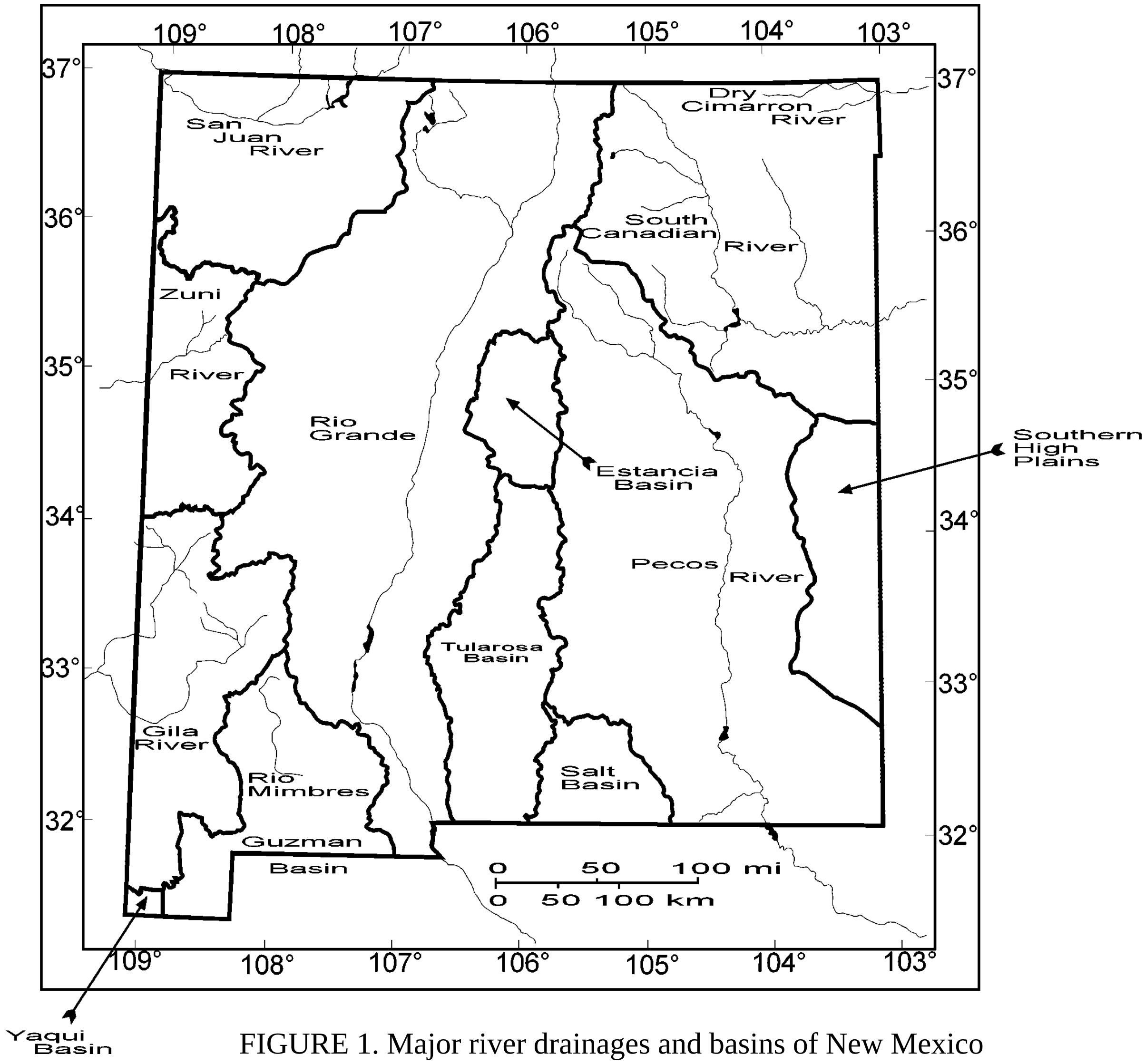


FIGURE 1. Major river drainages and basins of New Mexico

New Mexico's native fishes have evolved a suite of strategies to survive the harsh and unpredictable environments characteristic of aquatic habitats in an arid landscape and across a broad array of natural abiotic conditions that often change substantially at diural, seasonal, and annual scales. Some species migrate considerable distances to find suitable spawning habitat, but others spawn within a few meters of where they spend their entire lives. Many species spawn over brief periods of 2 or 3 weeks when the rising flows of spring runoff provide the appropriate environmental cues and some spawn numerous times over several months. The males of many species are brightly colored during the spawning season, and several species practice elaborate mating rituals. Some species provide parental protection for their eggs and larvae, but others leave the fate of their young to chance. The offspring of some species remain near their natal areas throughout their lives while others disperse considerable distances. Individuals of many species live only 12 to 24 months while those of a few species may survive more than 25 years. Most native fish species consume primarily aquatic invertebrates, particularly insects, but others feed on fish for most of their lives. A few feed almost exclusively on algae and several gain their sustenance from organic sediments. One native fish, the Colorado pikeminnow, grows to lengths in excess of 1 m and may weigh more than 20 kg; several such as flannelmouth sucker and razorback sucker grow to 500 mm or longer, but individuals of most species are never more than 100 to 150 mm in length.

♦ BIOGEOGRAPHY ♦

The native fishes of New Mexico inhabit five major river systems, several smaller drainages, and two endorheic basins (Figure 1). Among them, species diversity, richness, and endemism are variable and depend, in part, on geologic history, relative proximity to more mesic and species-rich regions, climatic factors, and relative size and complexity of each drainage.

South Canadian River

The South Canadian River drainage, in northeastern New Mexico, encompasses about one-sixth the land area of the state (almost 34,000 km^2, including Dry

Cimarron drainage). The tributaries of the South Canadian River flow east and southeast from their origins on the east slopes of the Sangre de Cristo cordillera of northern New Mexico and southern Colorado, to form the South Canadian River. As it traverses the Great Plains in a southerly and then easterly direction, several perennial tributaries, including the Cimarron, Mora, and Conchas rivers, join the South Canadian River before it exits New Mexico to Texas near Logan. Tributary streams meander across the low relief plains and often flow through narrow canyons: flow usually is permanent in canyon-bound reaches but may be seasonally intermittent in less restricted reaches. The South Canadian River also alternates between canyon bound reaches (e.g., Mills Canyon) and open plains reaches. Habitats in both the mainstem South Canadian River and its tributaries vary from deep pools formed around large boulders in canyon reaches to shallow, sand-bottomed runs. Conchas Dam on the Conchas River and Ute Dam on the South Canadian River impound reservoirs and modify natural flows.

The native fish fauna of the South Canadian River includes representatives of eight or nine families and at least 23 and perhaps 25 species (Table 2). This ichthyofauna is dominated by representatives of the Mississippian-Missourian fish fauna but includes Rio Grande cutthroat trout, a salmonid whose origins were west of the Continental Divide. Most fish species native to the South Canadian River drainage in New Mexico occur over a broad geographic area. Four (Arkansas River shiner, suckermouth minnow, Arkansas River speckled chub, and southern redbelly dace) are protected by New Mexico. Southern redbelly dace and suckermouth minnow have comparatively broad geographic ranges to the east and north of New Mexico, but Arkansas River shiner and Arkansas River speckled chub are restricted to the Arkansas River drainage of New Mexico, Texas, Oklahoma, and Kansas. The South Canadian River drainage in New Mexico continues to support all of its known historic fish species.

A short reach (about 120 km) of the Dry Cimarron River, which is tributary to the Arkansas River, drains a small portion (<1,500 km^2) of extreme northeastern New Mexico. The Dry Cimarron River flows east from its origins on Johnson Mesa through a broken mesa and low-hill landscape and exits New Mexico to Oklahoma north of Clayton. The native fish fauna of the Dry Cimarron River in New Mexico likely consisted of eight and perhaps nine species (Table 3). Of these, only suckermouth minnow is protected and this species has probably been extirpated from the Dry Cimarron River in New Mexico.

Pecos River

The Pecos River originates as high elevation streams in the southern Sangre de Cristo Mountains of northern New Mexico. The Pecos River and its montane tributaries anastomose and the river flows south, bisecting the Great Plains of eastern New Mexico, and exits the state to Texas south of Carlsbad. Almost all tributaries, such as the rios Hondo and Peñasco, that contribute to the flow of the Pecos River after it leaves the Sangre de Cristo Mountains arise in the north-south oriented string of mountain ranges that border the Rio Grande drainage to the west. Aquatic habitats range from small cascading headwater streams that support only trout species to broadly meandering, shallow, sand- and gravel-bottomed channels supporting a variety of warmwater species. In its lower course in New Mexico, limestone formations generally restrict the Pecos River to a narrow channel and flow alternates between moderate- to rapid-velocity riffles and naturally ponded reaches with almost imperceptible current. In the lower Pecos River valley of New Mexico, spring systems and limestone sinkholes provide additional aquatic habitats. Near its exit from New Mexico, the Pecos River is joined by the Black and Delaware rivers. Only a few eastward flowing tributaries of the Pecos River have permanent surface flow throughout their lengths; most are seasonally dry upon exiting the mountains of their origin. In permanently watered reaches, tributary habitats include cobbled riffles, undercut-bank pools, and shallow runs. The Pecos River drains slightly more than 49,000 km^2 of New Mexico. Three major dams (Santa Rosa, Sumner, and Brantley) and several low-head irrigation diversion dams interrupt the natural flow of the Pecos River in New Mexico.

At least 38 fish species of 13 families are native to the Pecos River drainage in New Mexico. Most species are of Mississippian-Missourian origin, but several (e.g., Mexican tetra and Pecos gambusia) are members of families richly represented in more southern latitudes. At least two, Rio Grande cutthroat trout and Rio Grande chub, originated in drainages to the west and probably gained access to the Pecos River drainage by exchanges among headwater streams during the Pleistocene. Since European settlement of the Pecos River valley, three species have been extirpated from the drainage. American eel and Texas shiner were eliminated by the 1940s and Rio Grande silvery minnow was gone by the early 1970s. Eight native fish species of the Pecos River (Mexican tetra, Pecos bluntnose shiner, blue sucker, gray redhorse, Pecos pupfish, Pecos gambusia, greenthroat darter, and bigscale logperch) are protected by New Mexico, Pecos bluntnose shiner and Pecos gambusia are federally protected, and Pecos pupfish is proposed for federal listing. At least two species, Rio Grande shiner and headwater catfish, may warrant state protection. The entire range of Pecos bluntnose shiner is in New Mexico while ranges of Pecos pupfish and Pecos gambusia are limited to the Pecos River drainage in southeastern New Mexico and northwestern Texas. Blue sucker is broadly distributed in major rivers of the Mississippi-Missouri drainage. All of the other protected species have limited ranges in the Pecos River, lower Rio Grande in Texas and adjacent Mexico, and streams of central Texas.

TABLE 2.

Native fishes of major drainages, east of the Continental Divide, in New Mexico

SPECIES		SOUTH CANADIAN	PECOS	RIO GRANDE
ACIPENSERIDAE, STURGEONS				
Scaphirhynchus platorhynchus	shovelnose sturgeon			X
LEPISOSTEIDAE, GARS				
Lepisosteus osseus	longnose gar	?	X	X
ANGUILLIDAE, EELS				
Anguilla rostrata	American eel		X	X
CLUPEIDAE, SHAD				
Dorosoma cepedianum	gizzard shad	X	X	X
CYPRINIDAE, MINNOWS				
Campostoma anomalum	central stoneroller	X	X	
Cyprinella lutrensis	red shiner	X	X	X
Dionda episcopa	roundnose minnow	?	X	
Machrybopsis aestivalis aestivalis	speckled chub		X	X
Machrybopsis aestivalis tetranemus	speckled chub	X		
Gila pandora	Rio Grande chub	X	X	X
Hybognathus amarus	Rio Grande silvery minnow		X	X
Hybognathus placitus	plains minnow	X		
Notropis amabilis	Texas shiner		X	
Notropis girardi	Arkansas River shiner	X		
Notropis jemezanus	Rio Grande shiner		X	X
Notropis orca	phantom shiner			X
Notropis simus simus	Rio Grande bluntnose shiner			X
Notropis simus pecosensis	Pecos bluntnose shiner		X	
Notropis stramineus	sand shiner	X	X	
Phenacobius mirabilis	suckermouth minnow	X		
Phoxinus erythrogaster	southern redbelly dace	X		
Pimephales promelas	fathead minnow	X	X	X
Platygobio gracilis	flathead chub	X	X	X
Rhinichthys cataractae	longnose dace	X	X	X
Semotilus atromaculatus	creek chub	X	X	
CATOSTOMIDAE, SUCKERS				
Carpiodes carpio	river carpsucker	X	X	X
Catostomus commersoni	white sucker	X	X	
Catostomus plebeius	Rio Grande sucker			X
Cycleptus elongatus	blue sucker		X	?
Ictiobus bubalus	smallmouth buffalo		X	X
Moxostoma congestum	gray redhorse		X	?
CHARACIDAE, TETRAS				
Astyanax mexicanus	Mexican tetra		X	
ICTALURIDAE, CATFISHES				
Ameiurus melas	black bullhead	X		
Ictalurus furcatus	blue catfish		X	X
Ictalurus lupus	headwater catfish		X	
Ictalurus punctatus	channel catfish	X		
Pylodictis olivaris	flathead catfish		X	X

TABLE 2, *continued*

SPECIES		SOUTH CANADIAN	PECOS	RIO GRANDE
SALMONIDAE, TROUTS				
Oncorhynchus clarki virginalis	Rio Grande cutthroat trout	X	X	X
FUNDULIDAE, TOPMINNOWS				
Fundulus zebrinus	plains killifish	X	X	
Lucania parva	rainwater killifish		X	
POECILIIDAE, LIVEBEARERS				
Gambusia affinis	western mosquitofish	X	X	?
Gambusia nobilis	Pecos gambusia		X	
CYPRINODONTIDAE, PUPFISHES				
Cyprinodon pecosensis	Pecos pupfish		X	
CENTRARCHIDAE, SUNFISHES				
Lepomis cyanellus	green sunfish	X	X	
Lepomis macrochirus	bluegill		X	X
Lepomis megalotis	longear sunfish	X	X	
Micropterus salmoides	largemouth bass		X	
PERCIDAE, DARTERS				
Etheostoma lepidum	greenthroat darter		X	
Percina macrolepida	bigscale logperch		X	
	TOTAL SPECIES	23 (2?)	38	21(3?)

Rio Grande

From its origins in the San Juan and Sangre de Cristo mountains of southern Colorado, the Rio Grande enters New Mexico, bisects the state as it flows south, and exits just north of El Paso, Texas. Most of the Rio Grande's tributaries join it upstream of Albuquerque; intermittent streams such as the rios Puerco and Salado and Animas Creek, only irregularly contribute to its flow in the southern half of its New Mexico course. The Rio Grande drains more than 72,000 km^2, about one-quarter the state's land area. In northern reaches, the Rio Grande and its primary tributary, the Rio Chama, flow mainly through canyons. South of Cochiti Pueblo, the Rio Grande is constrained by an extensive levee network. The river meanders within the levees and in some areas the channel is braided. Lotic habitats vary from small, high elevation coldwater streams to seasonally isolated pools with low dissolved oxygen and high water temperatures in the mainstem Rio Grande. Long reaches of the Rio Grande south of Isleta Pueblo are seasonally dry, particularly during dry years. El Vado and Abiquiu dams on the Rio Chama and Cochiti, Elephant Butte, and Caballo dams on the Rio Grande control flows in the system. Three cross-channel, low head, irrigation diversion dams seasonally interrupt Rio Grande flows between Angostura and San Acacia. Downstream of Caballo Dam, the river is tightly constrained in a regularly maintained canalized channel. Flows in this reach only occur during irrigation releases or after storm events.

The Rio Grande drainage in New Mexico historically supported at least 21 and perhaps 24 native fish species, representing nine or ten families. Most were derived from the Mississippian-Missourian fish fauna. Since European settlement along the Rio Grande, this system has lost a larger proportion of its native fish fauna than any other major drainage in New Mexico. Shovelnose sturgeon, longnose gar, American eel, speckled chub, and Rio Grande shiner have been extirpated from the Rio Grande in New Mexico and blue catfish, if it persists, occurs only in Elephant Butte Reservoir. Rio Grande bluntnose shiner and phantom shiner are extinct. Neither shovelnose sturgeon nor American eel survive anywhere in New Mexico, but speckled chub and Rio Grande shiner persist in the Pecos River. A subspecies of bluntnose shiner, the Pecos bluntnose shiner, still survives in the Pecos River. Rio Grande silvery minnow is the only state and federally protected species currently inhabiting the Rio Grande, but Rio Grande sucker and Rio Grande chub may warrant state protection.

Tularosa Basin

Permanent aquatic habitats of the endorheic Tularosa Basin (about 13,000 km^2) of south-central New

Mexico are limited to Malpais and Mound springs, Salt Creek, and Lost River. Water temperatures and salinity are elevated and comparatively constant in the springs, but highly variable in the streams. Large, shallow playa habitats are seasonally associated with the springs. White Sands pupfish, a state protected species, is endemic to the Tularosa Basin and is the only fish species native to the basin.

Mimbres River

The Mimbres River rises in the Black Range of southwestern New Mexico and flows southward about 100 km, draining nearly 1,200 km^2, to evaporate in the arid plains north of Deming. Generally considered to be part of the large endorheic Guzmán Basin of northern Chihuahua and southwestern New Mexico, the Mimbres River, alternatively, may have had a direct connection to the Rio Grande during the Pleistocene. After exiting the mountains of its origins, the Mimbres River meanders through a narrow valley for most of its permanent course. Habitats range from shaded pools and cobbled-riffles in small, cool-water tributary streams to shallow, gravel-bottomed runs and deep pools associated with uprooted trees in the stream's main course.

Only three fish species were native to the Mimbres River basin and one of these has been extirpated. Beautiful shiner was last found in the Mimbres River in the early 1950s, but remains locally common in streams of the Guzmán Basin in Chihuahua. An undescribed species, the Palomas pupfish historically occurred in springs (hydrologically connected to the Guzmán Basin, but not considered part of the Mimbres River) near Columbus on the US/Mexican border. This pupfish, last reported in New Mexico in the early 1970s, persists only in a few isolated habitats in the northwest portion of the Guzmán Basin in Chihuahua. Rio Grande sucker is common in much of the Mimbres River, but the Chihuahua chub survives only in a short reach of the river and an associated spring system.

San Juan River

The San Juan River originates in the San Juan Mountains of southwestern Colorado, enters New Mexico northeast of Farmington, flows westward for about 150 km, and exits the state near Four Corners. The Navajo, Animas, and Mancos rivers are the only permanently flow-

TABLE 3.

Native fishes of small drainages and endorheic basins, east of the Continental Divide, in New Mexico.

SPECIES		DRY CIMARRON	TULAROSA	MIMBRES
CYPRINIDAE, MINNOWS				
Campostoma anomalum	central stoneroller	X		
Cyprinella formosa	beautiful shiner			X
Cyprinella lutrensis	red shiner	X		
Gila nigrescens	Chihuahua chub			X
Hybognathus placitus	plains minnow	X		
Phenacobius mirabilis	suckermouth minnow	X		
Pimephales promelas	fathead minnow	X		
Platyogobio gracilis	flathead chub	X		
CATOSTOMIDAE, SUCKERS				
Catostomus plebeius	Rio Grande sucker			X
ICTALURIDAE, CATFISHES				
Ameiurus melas	black bullhead	X		
Ictalurus punctatus	channel catfish	?		
FUNDULIDAE, TOPMINNOWS				
Fundulus zebrinus	plains killifish	X		
CYPRINODONTIDAE, PUPFISHES				
Cyprinodon tularosa	White Sands pupfish		X	
Cyprinodon sp.	Palomas pupfish			X
	TOTAL SPECIES	8(1?)	1	4

ing tributaries to the San Juan River in New Mexico, although the LaPlata River historically had permanent flow. Despite its short course in New Mexico and comparatively small drainage area (about 28,000 km^2, including portions in Colorado), average annual discharge is the largest for any river in New Mexico. Upstream of Farmington, the San Juan River is restricted to a single, moderately-incised channel and habitats are mainly cobbled riffles, moderately deep runs, and large pools. As the river progresses downstream of Farmington to Shiprock, gradient diminishes and flow is typically within a single channel, but downstream of Shiprock the river's flow is often divided among two, three, or four channels. Habitat diversity increases with the increase in channel complexity. In addition to habitats common in upper reaches, isolated backwaters, embayments, shallow shoals, and small ephemeral and permanent secondary channels (having their own mix of habitats) are present. Navajo Dam, on the upper San Juan River in New Mexico, controls flow in the system and several low-head irrigation diversion dams seasonally diminish flows.

The native fish fauna of the San Juan River drainage in New Mexico consisted of at least eight and perhaps nine species representing four families (Table 4). All (except bonytail) were historically widespread in the Colorado River system prior to extensive habitat modification by human activity. Of the extant native fish fauna of the San Juan River, only speckled dace, flannelmouth sucker, and bluehead sucker remain comparatively common in the system. Colorado River cutthroat trout and razorback sucker were probably extirpated from the New Mexico portions of their range by the 1960s, but razorback sucker have been recently stocked within its historic range in the San Juan River. Colorado pikeminnow persists as a numerically small, reproducing population in the lower New Mexico reaches of the San Juan River and roundtail chub survives mainly in tributaries to the San Juan River. Colorado pikeminnow is state and federally protected, razorback sucker is federally protected, and roundtail chub is protected by New Mexico. Razorback sucker deserves and mottled sculpin may warrant state protection.

Zuni River

The rios Nutria and Pescado coalesce to form the Zuni River after their egress from the Zuni Mountains of west-central New Mexico. The Zuni River follows a westerly course and exits the state west of Zuni to join the Little Colorado River in Arizona. The Zuni River drains about 3,400 km^2 in New Mexico. Tributaries flow through mountain meadows and narrow canyons where habitats are mainly bedrock-bottomed pools in canyon-bound reaches, and runs and cobbled-riffles in meadows. Several permanent springs contribute to flows in tributary reaches. The Zuni River flows mainly in a channel incised through valley alluvium where habitats are deep runs and pools over sand and silt substrates. Several small impoundments interrupt flows in the Zuni River.

The documented historic fish fauna of the Zuni River drainage in New Mexico consists of only three species, roundtail chub, speckled dace, and Zuni bluehead sucker. Roundtail chub no longer occurs in the Zuni River system and speckled dace may be extirpated from the drainage. Zuni bluehead sucker survives only in the Rio Nutria and its small tributaries.

Gila River

The headwaters of the Gila and San Francisco Rivers (the primary upper-basin tributary of the Gila River) arise in the mountains of the Mogollon Rim of southeastern Arizona and southwestern New Mexico. The major New Mexico tributaries of the Gila River (East, Middle, and West forks) join in the mountains and the river follows a generally westerly direction through the remaining mountainous portion of its course and through broad valleys to exit New Mexico to Arizona near Virden. The San Francisco River enters New Mexico from the mountains of Arizona, is joined by its major New Mexico tributary, the Tularosa River, and flows south and then west to enter Arizona west of Pleasanton. The San Francisco River for much of its length in New Mexico flows through canyon-bound reaches. Habitats of high-elevation tributary streams include densely shaded plunge pools in high gradient reaches, cobbled-riffles, and bedrock-bottomed runs. Habitats in moderate- to low-gradient warmwater reaches of the East, Middle, and West forks of the Gila River, and the San Francisco, Tularosa, and Gila rivers consist of sand and gravel-bottomed runs interspersed with cobbled riffles and large pools formed around uprooted trees and large boulders. No dams interrupt the natural flow regime of the San Francisco or Gila rivers and their tributaries in New Mexico.

The native fish fauna of the Gila-San Francisco River drainage in New Mexico consisted of at least ten and perhaps 12 species representing four families. The New Mexico portion of the drainage supports three species endemic to the Gila drainage; Gila trout, spikedace, and loach minnow. Two other species, Sonora sucker and desert sucker are near-endemics. A third Gila basin endemic, the Gila topminnow, formerly inhabited at least the San Francisco River in New Mexico. Almost three-fourths of the extant native fish fauna of the Gila-San Francisco drainage in New Mexico is protected; three receive state and federal protection (Gila trout, spikedace, and loach minnow) and two others (Gila chub and roundtail chub) are protected by New Mexico. A sixth species, Gila topminnow, is federally and state listed and if it persists in New Mexico occurs only as a stocked population in the lower Gila River Valley near Redrock. While Sonora sucker and desert sucker persist in much of their New Mexico range, both have declined in Arizona and their status in New Mexico needs assessment.

♦ THREATS ♦

Few native fish species of New Mexico currently occupy all or even major portions of their historic ranges in the state. The White Sands pupfish, which has a very limited natural range, may be the only native fish that occupies all of its historic habitat. While the reductions of range and abundance have occurred at least since the arrival of Europeans, the rate of decline of the native fish fauna has accelerated dramatically in the past 100 years. Almost all of the native fish species present in New Mexico when the Spanish settled the region in the late sixteenth century persisted until the beginning of the twentieth century, and most species extirpations have occurred since mid-twentieth century. The survival of at least seven species (Pecos bluntnose shiner, Pecos pupfish, Pecos gambusia, Rio Grande silvery minnow, White Sands pupfish, Zuni bluehead sucker, and Gila trout) depends entirely or largely upon their persistence in New Mexico. The fate of spikedace, loach minnow, Arkansas River shiner, and Arkansas River speckled chub depends substantially upon their survival in New Mexico. The only U.S. population of Chihuahua chub is in the Mimbres River and the future of the species in Chihuahua is not assured. Restoration of viable populations of Colorado pikeminnow and razorback sucker to the San Juan River will be major accomplishments in the conservation of these species. Although roundtail chub remains locally common in several streams of the upper Colorado River basin, the species is rare throughout the lower Colorado River basin and the New Mexico populations are critical to its survival in the Gila River drainage. A few state-listed fish species remain relatively common elsewhere in their ranges, but these instances are the exception and most of these species have declined throughout their native ranges.

While the reasons for imperilment of each species are varied, all are the direct or indirect consequence of anthropogenic activities. Human induced habitat alterations have probably impacted every native fish species in New Mexico and are a major factor in the decline of almost all formally protected species. Dams impound streams and alter the natural thermal and hydrologic regimes of many streams and all major rivers except the Gila-San Francisco. Management of reservoirs for flood, agricultural, and municipal considerations often results in

TABLE 4.
NATIVE FISHES OF DRAINAGES, WEST OF THE CONTINENTAL DIVIDE, IN NEW MEXICO.

SPECIES		SAN JUAN	GILA	ZUNI
CYPRINIDAE, MINNOWS				
Agosia chrysogaster	longfin dace		X	
Gila elegans	bonytail	?		
Gila intermedia	Gila chub		X	
Gila robusta	roundtail chub	X	X	X
Meda fulgida	spikedace		X	
Ptychocheilus lucius	Colorado pikeminnow	X	?	
Rhinichthys osculus	speckled dace	X	X	X
Tiaroga cobitis	loach minnow		X	
CATOSTOMIDAE, SUCKERS				
Catostomus clarki	desert sucker		X	
Catostomus discobolus	bluehead sucker	X		
Catostomus discobolus yarrowi	Zuni bluehead sucker			X
Catostomus insignis	Sonora sucker		X	
Catostomus latipinnis	flannelmouth sucker	X		
Xyrauchen texanus	razorback sucker	X	?	
SALMONIDAE, TROUTS				
Oncorhynchus clarki pleuriticus	Colorado River cutthroat trout	X		
Oncorhynchus gilae	Gila trout		X	
POECILIIDAE, LIVEBEARERS				
Poeciliopsis occidentalis occidentalis	Gila topminnow		X	
COTTIDAE, SCULPINS				
Cottus bairdi	mottled sculpin	X		
	TOTAL	8(1?)	10(2?)	3

seasonally desiccated reaches and attenuation of spring runoff, which serves as an environmental cue for initiation of spawning by many species. Dams block natural up- and downstream dispersal corridors and fragment populations. Reservoir operations have diminished or eliminated flooding, which not only is critical to maintenance of native riparian plant communities but also serves to diminish the abundance of many undesirable nonnative fish species. Many streams now are bordered by alien plant species that reduce or eliminate channel migration. Livestock grazing in riparian areas has contributed to the decline in quality of many aquatic habitats and in some instances has been a major factor in eliminating native fishes from portions of their historic ranges. Livestock trample and consume vegetation that maintains stream bank integrity, hoof action destroys undercut banks and accelerates erosion, and feces elevate nutrients unnaturally, particularly in spring habitats. Substantial portions of some rivers have been canalized and levees restrict the naturally meandering character of low elevation and low gradient streams. Draining of wetlands and ciénegas for pest control or to gain arable land has eliminated habitats for several species. Groundwater mining has lowered the water table in several areas (e.g., lower Pecos River valley) with a consequent loss of springs and permanently flowing creeks.

Fragmentation of species ranges and impediments to panmixis have, in most instances, undetermined impacts on the genetic integrity and diversity of native fishes. Loss of genetic information limits species abilities to contend with changing and evolving environments. Where investigated, each imperiled native fish species has lost genetic information, which limits conservation options.

Much of the human population of New Mexico and many of its recreational and economic activities are concentrated along the major rivers of the state. As a result, contaminant-laden wastewater and runoff from urban areas, industries (including mining), and agricultural lands enter aquatic environments to the detriment of aquatic biota.

Human activities outside the streams and their immediate vicinities also have major impacts on the welfare of native fish communities. Livestock grazing has contributed to increased erosion in many watersheds and thus elevated sediment loads in virtually all river systems. A century of fire suppression has been responsible, in part, for wildfires of greater intensity and destruction than occurred under natural fire regimes. Loss of topsoils in burned areas impedes recovery and increases sediments in streams. Road construction also contributes to sediment loading of streams, and culvert crossings may fragment ranges. Mining activities in many instances have seriously degraded water quality by introducing heavy metals and other contaminants.

Believing that the native fish fauna was inadequate for recreational expectations, state, federal, and tribal agencies have introduced a plethora of nonnative species to fill the perceived void, and continue to do so. Introduction and establishment of nonnative salmonids were a major cause for the extirpation of Colorado River cutthroat trout and near-elimination of Rio Grande cutthroat and Gila trouts. In addition to preying upon and competing with native trouts, several nonnative trout species freely hybridize with native trouts, thereby causing the dilution and loss of valuable genetic information that enabled native fishes to survive millennia in highly variable environments. Other species, with no evaluation of the need, nor consideration of their impact on native fishes, were introduced to provide forage for introduced sport fish species. Some nonnative species were accidentally or intentionally established by bait bucket transfers. Grass carp has been introduced for vegetation control in numerous small impoundments and the lower Pecos River. Western mosquitofish has been introduced throughout the state to control mosquitoes and other nuisance insects. In almost every stream where nonnative fishes have become established (which is almost every water body in the state), the native fish fauna has suffered.

In a few instances, overharvest has contributed to the decline of native fish species. Most, if not all, such situations involved native salmonids. Rather than conserve and restore the native salmonid, the most frequent management response in the past was to introduce hatchery-reared nonnative salmonids. That management approach is, however, changing with a shift in emphasis to conservation of native salmonids.

♦ CONSERVATION ♦

All federally protected fish species that occur in New Mexico, except Gila topminnow and Rio Grande silvery minnow, have formally approved recovery plans and draft recovery plans have been completed for these two species. Critical habitat (under authority of the U.S. Endangered Species Act) has been designated for Colorado pikeminnow, razorback sucker, and Pecos bluntnose shiner and is proposed for several other species. A conservation plan has been formalized for the state-listed White Sands pupfish and plans are being developed for Zuni bluehead sucker and Pecos pupfish. Conservation plans have not been developed for any other state-listed species.

Among the state and federally listed species in New Mexico, Colorado pikeminnow, razorback sucker, Pecos bluntnose shiner, Rio Grande silvery minnow, White Sands pupfish and Gila trout are receiving considerable research and management attention. Others, such as spikedace, loach minnow, Chihuahua chub, Zuni bluehead sucker, and Pecos pupfish, receive some attention but few active recovery or conservation efforts are made on their behalf. Many listed and almost all other nongame native fish species, however, receive almost no attention. The U.S. Endangered Species Act (ESA) ensures that any proposed activity with a federal involvement receives consultation under the terms of Section 7 of the ESA, but there are no such provisions in the New Mexico Wildlife Conservation Act protecting state-listed species nor is there provision for protection of habitats of state-listed species. ♦

EXPLANATORY NOTES AND CONVENTIONS

In New Mexico, vertebrates, crustaceans, and molluscs are protected by the state under the authority of the Wildlife Conservation Act of 1974. The decision to protect a species in New Mexico is ultimately that of the State Game Commission. The State Game Commission receives recommendations to list species from the New Mexico Department of Game and Fish. These recommendations are developed using the best available scientific information and the State Game Commission bases its decisions solely upon scientific information concerning the status of the species. The cited authority for each listed species or subspecies is Chapter 19, Section 33.1 of the New Mexico Administrative Code (i.e., 19 NMAC 33.1). Currently, 23 fish species are listed as threatened or endangered by New Mexico. Nine of these species are federally listed. A tenth federally-listed species, the razorback sucker, is also native to the state and repatriated to the San Juan River, but it is not listed by New Mexico.

The scientific and common names of fishes follow Robins et al. (1991) except that Minckley (1973) is followed for loach minnow, *Tiaroga cobitis*. Families of fishes are arranged in phylogenetic order, as defined by Burr and Mayden (1992), and within each family genera and species are presented alphabetically by scientific name. In most instances Sublette et al. (1990) was the accepted authority for native status and range of fishes in New Mexico. Exceptions were when other authorities presented compelling evidence (published literature or personal communications) that a species was native or not native to a given drainage in New Mexico.

Distribution maps for each species delineate their historic (shaded) and current (open areas within shaded area) occurrence. Question marks indicate areas of uncertain status (historic or current). Open circles outside shaded areas indicate introduced populations of Gila trout and White Sands pupfish. Nonnative occurrence of other species (e.g.,Arkansas River shiner and bigscale logperch) is not indicated on the distribution maps.

All measurements are metric. Fish lengths are reported as total (tip of snout to posterior tip of caudal fin) or standard length (tip of snout to anterior base of hyplural plate). The lengths (total or standard) given in each account are those reported in citations. The nominal birthdate of fish is January 1; thus, in the year of its birth a fish is age-0, age-1 after January 1 of its first year, and so on. Additional information on the biology and taxonomy of fishes and definitions of terms used in the accounts may be found in several of the books listed in the Literature Cited section, particularly those dealing with the fish fauna of individual states (e.g., Sublette et al., 1990; Etnier and Starnes, 1993, and Jenkins and Burkhead, 1994).

Each species account consists of five sections. The first section, LISTING STATUS, provides information on the protected status of the species in New Mexico (threatened or endangered), its listing status in other states, whether it receives federal protection or is proposed for federal listing, its protected status on Native American lands, or if it is protected in the Republic of Mexico. The status given a species by the American Fisheries Society is also provided. The next section, CHARACTERISTICS, provides a brief description of the species and information useful for its identification. The third section, DISTRIBUTION, gives an overview of its entire historic and current range as well as its distribution (historic and current) in New Mexico. The BIOLOGY section presents basic information on the life history, habitat, and ecology of the species. A characterization of the relative well-being (distribution and abundance) of the species is presented in the STATUS section. The final section, CONSERVATION, provides information on the factors that have caused the imperilment of the species and suggests activities that may improve its status.

Readily available references such as The Fishes of New Mexico (Sublette et al., 1990), Fishes of Arizona (Minckley, 1973), The Fishes of Oklahoma (Miller and Robison, 1973), and The Fishes of Kansas (Cross and Collins, 1975) provide additional information on the fishes treated in this document as well as information on other native and nonnative fishes of New Mexico. These references are available in academic libraries. The citation 'NMGF files' refers to field notes or draft reports and documents. The professional affiliation of all individuals cited as personal communication (pers. comm.) are listed in Appendix I. ♦

ACKNOWLEDGEMENTS

Much of the information obtained in the past 15 years on native fishes in New Mexico was gathered during multi-agency research activities.

The author sincerely appreciates the efforts, shared knowledge, and cooperation of colleagues from the U.S. Fish and Wildlife Service (J. Bentley, H.M. Bishop [formerly NMGF], J.E. Brooks, M.J. Buntjer, G.L. Burton [retired], R.E. David, G. Divine [retired], J.A. Fowler-Propst, C.W. Hoagstrom, B.L. Jensen, J.E. Johnson [currently University of Arkansas], L. Kagen-Wiley, J.J. Landye, R. Maes, C. McAda, R. Major [retired], P. Mullane, D.B. Osmundson, F.K. Pfeifer, D.W. Ryden, J. Smith, S. Stefferud, and B.G. Wiley), U.S. Bureau of Reclamation (R. Clarkson, L. Crist, B. Pridgeon [currently USFWS], J. Wilbur, R. Williams [currently USFWS], and D. Young [currently USFWS]), U.S. Forest Service (B. Anderson, W.E. Britton, G. Jimenez, J.F. Kramer, D. Peters, J.N. Rinne, J.A. Stefferud, R.A. Ward, J.C. Whitney [currently USFWS], D.M. Whitney, and J. Zapata), Utah Division of Wildlife Resources (E. Archer, T. Chart, Y. Converse, L. Lentsch, M. Moretti, and M. Trammell), Texas Parks and Wildlife Department (G. Garrett), Arizona Game and Fish Department (J. Burton, D.A. Hendrickson [currently University Texas, Austin], D.L. Kubly, and K. Young), Colorado Division of Wildlife (R.M. Anderson, M. Japhet, and T. Nesler), New Mexico Department of Game and Fish (A.L. Ahlm, J.A. Bailey, M.D. Hatch, A.L. Hobbes, J.P. Hubbard [retired], E. Jaquez, J. Kelly, J. Klingel, B. Lang, R.D. Larson, M.A. McInnis, M. Medina, C.W. Painter, C.S. Pease [currently USFWS], A. Pino, J.S. Pittenger, R. Salazar-Henry, A.V. Sandoval, N.W. Smith, W. Stumpf, and C.M. Wethington), Secretaría de Desarrollo Urbano y Ecologia (P. Dominguez-Gonzales), University of New Mexico (C. Altenbach, H.W. Brandenburg, R. Dudley, K.B. Gido [currently University of Oklahoma], G. Liens, S.P. Platania, and A. Snyder), Colorado State University (K.R. Bestgen and D.E. Snyder), Oklahoma State University (A.A. Echelle, A.F. Echelle, and D.K. Brown), New Mexico Highlands University (J. Jacobi), University of Nevada, Las Vegas (B. Riddle), Arizona State University (T. Dowling, P.C. Marsh, and M.E. Douglas), University of Texas, Pan American (R.J. Edwards), New Mexico State University (P.R. Turner), University of Montana (R. Leary), Utah State University (T. Crowl), Savannah River Ecology Laboratory (C. Stockwell), Keller-Bliesner Engineering (R. Bliesner), Ecosystems Research, Inc. (V. Lamarra and K. Lawrence), Miller Ecological Consulting (W.J. Miller), Bio/West (P.B. Holden, W. Masslich, and R. Valdez), The Nature Conservancy (R. Johnson [currently Grand Canyon Trust], P. McCarthy, P. Russell, and R. Wallace), the Pueblo of Zuni (S. Albert and T.L. Stroh [currently Southern Ute Indian Tribe]), Navajo Nation (J. Nystedt and J. Cole), Trout Unlimited (M. Norte) and D.M. Vackar (Special Assistant to Governor Bruce King [currently Vermejo Park Ranch]).

The insights, historical perspective, biological knowledge, and conservation ethic of R.J. Behnke (Colorado State University), S. Contreras-Balderas (Universidad Autónoma de Nuevo León), C. Hubbs (University of Texas, Austin), R.R. Miller (University of Michigan), and W.L. Minckley (Arizona State University) are sincerely appreciated. Each has made, and continues to make, significant contributions to the conservation of southwestern fishes and their habitats.

Much of the information reported in this document would not have been gained without the gracious cooperation of numerous private landowners, particularly the Fowler, Goetz, Moreno, and Silva families.

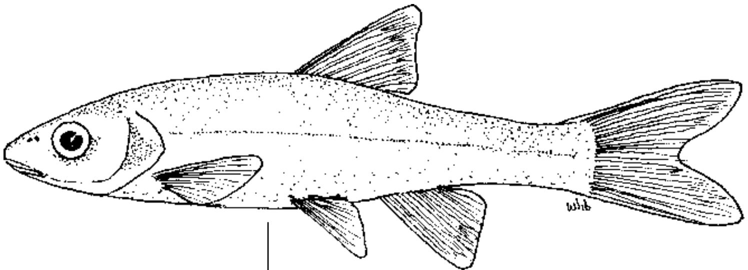
Funding to support research by NMGF on native fishes in New Mexico was provided primarily by the U.S. Fish and Wildlife Service (Sports Fish Restoration Act and Endangered Species Act Section 6 funds), U.S. Bureau of Reclamation, New Mexico Share with Wildlife, and New Mexico General Appropriation funds.

The reviews by A.A. Echelle (Canadian, Pecos, Tularosa, and Rio Grande fishes), A.F. Echelle (Canadian, Pecos, Tularosa, and Rio Grande fishes), K.R. Bestgen (all species), R.K. Dudley (all species), G. Garrett (Pecos and Rio Grande fishes), A.L. Hobbes (Zuni bluehead sucker), C. Hubbs (all species), R.D. Larson (plains minnow and Arkansas River shiner), W.L. Minckley (San Juan, Zuni, and Gila-San Francisco fishes), J.S. Pittenger (White Sands pupfish, Arkansas River shiner, and Arkansas River speckled chub), S.P. Platania (all species), and J.A. Stefferud (Gila-San Francisco fishes) contributed greatly to ensuring accurate and current information for all species. Their comments and suggestions improved each account and are sincerely appreciated. Any errors or misrepresentations in these accounts are solely those of the author. ♦

Gila Chub

Gila intermedia

(Girard, 1856)



LISTING STATUS

Gila chub, *Gila intermedia*, was listed by New Mexico as endangered (19 NMAC 33.1) in 1978 and it is a species of special concern in Arizona (AZGF, 1996). The Republic of Mexico lists it as endangered (SDS, 1994) and the American Fisheries Society considers Gila chub a species of concern (Williams et al., 1989).

CHARACTERISTICS

The Gila chub is a moderate-sized, chunky-bodied fish that typically attains 150 mm total length; females may exceed 200 mm (Minckley, 1973; Rinne, 1976; Weedman et al., 1996). Adults are dark steel-gray dorsally and usually lighter ventrally. A diffuse, broad lateral band is rarely present and there is no basicaudal spot. Fins are comparatively small and scales are large, thick, and strongly imbricated. The mouth is terminal and just slightly overhung by the rounded snout and the caudal peduncle is thick. Breeding males are red to red-orange on lower cheeks, posterior of lips, basally on paired fins, and on ventro-lateral surfaces. Both genders possess breeding tubercles although females are less extensively covered. Lateral-line scales usually number 75 (range = 61 to 79). There are usually 8 dorsal, 8 anal, and 8 or 9 pelvic fin rays. The pharyngeal dentition formula is 2,5-4, 2.

DISTRIBUTION

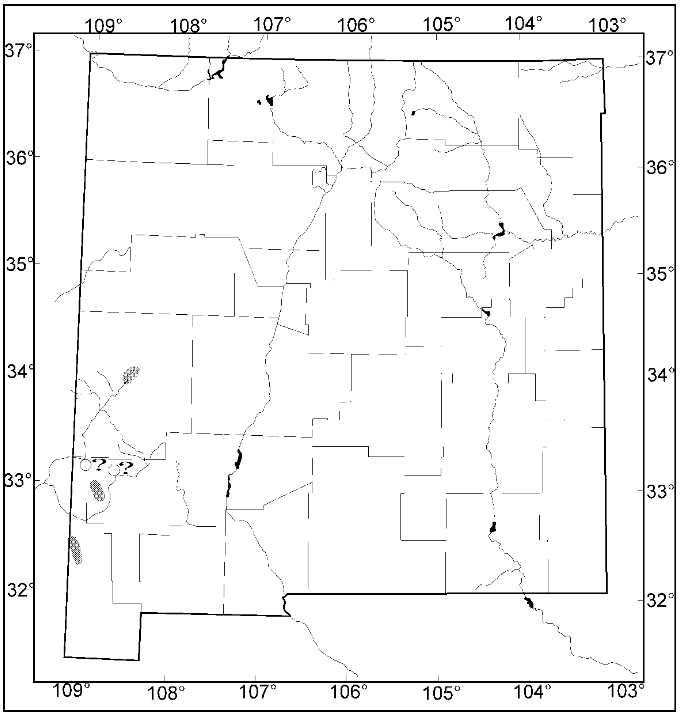
Gila chub historically occurred in suitable and rather specialized habitat throughout much of the Gila River drainage in southwestern New Mexico, central and southeastern Arizona, and northern Sonora (Minckley, 1973; Rinne, 1976; Bestgen and Propst, 1989; and Varela-Romero et al., 1992). Weedman et al. (1996) noted a strong correlation between the historic distribution of Gila chub and cienéga habitats (Hendrickson and Minckley, 1985).

Few records exist to document the precise historic distribution of Gila chub in New Mexico. It was formerly present in at least Apache Creek (a San Francisco River tributary), Duck Creek (a Gila River tributary), San Simon Cienega (a Gila River tributary), and the San Francisco River (Rinne 1976; Bestgen and Propst, 1989). While no reliable New Mexico records of the species have been produced for at least 50 years, anecdotal reports suggest a remnant population may persist in Mule Creek (a San Francisco River tributary). In addition, the *Gila* sp. population in Turkey Creek (a Gila River tributary) needs additional investigation to clarify its taxonomic status (Bestgen, 1985; Bestgen and Propst, 1989). Bestgen (1985) presented morphometric and meristic data supporting treatment of the Turkey Creek population as *Gila robusta* rather than *Gila intermedia*, albeit recognizing that the population shared traits of both species. However, W.L. Minckley (pers. comm.) believes the Turkey Creek population is more likely *Gila intermedia*.

Gila chub was recently rediscovered in two cienégas (tributaries to the San Pedro River) in Sonora (Varela-Romero et al., 1992). In Arizona, Gila chub persist in small headwater streams (many are springs or cienégas) tributary to the San Pedro, Santa Clara, San Francisco, Gila, Verde, and Agua Fria rivers. Most populations there were considered unstable (Weedman et al., 1996). Ichthyofaunal surveys of Mule Creek and taxonomic investigations of Turkey Creek *Gila* sp. are needed to determine if these two locations support the only New Mexico populations of Gila chub.

BIOLOGY

The secretive Gila chub mainly occupies pool habitats in small streams and cienégas but has been found in artificial impoundments in Arizona (Weedman et al., 1996). In pools, individuals are most commonly associated with cover (e.g., vegetated undercut banks, boulders, and fallen logs) and inhabit the deeper portions of pools (Rinne and Minckley, 1991). Age-0 Gila chub often are found among aquatic vegetation in shallow water and juveniles use moderate-velocity habitats (Minckley, 1973).



Most reproductive activity by Gila chub occurs during late spring and summer, but in some habitats it may extend from late winter through early autumn (Minckley, 1973). Minckley (1973) observed a single female being closely followed by several males over a bed of aquatic vegetation in a pond. Although some individuals may be mature by the end of their first year, most chubs in Redfield Canyon, Arizona were not mature until their second or third year (Griffith and Tiersch, 1989). Optimal water temperature for spawning is apparently 20 to 24°C (Weedman et al., 1996). No data on Gila chub fecundity have been reported.

Gila chub grow rapidly their first year of life, typically attaining total lengths of about 90 mm by winter (Griffith and Tiersch, 1989). Annual growth increments diminish thereafter. Female chubs may reach 250 mm, but males rarely exceed 150 mm (Rinne and Minckley, 1991). Griffith and Tiersch (1989) used scale analysis to back-calculate the age-structure of the Gila chub population in Redfield Canyon and found that the population was composed mainly of Age 1 and 2 individuals; Age 3 and 4 fish were about 10% of the population.

Adult Gila chub are crepuscular feeders, consuming a variety of terrestrial and aquatic invertebrates, and fishes (Griffith and Tiersch, 1989; Rinne and Minckley, 1991). Young Gila chub are active throughout the day and feed on small invertebrates as well as aquatic vegetation (especially filamentous algae) and organic debris (Griffith and Tiersch, 1989; Rinne and Minckley, 1991). The occurrence of small gravel in gastrointestinal tracts suggests Gila chub may also be benthic feeders (Weedman et al., 1996).

In unaltered habitats, Gila chub likely were associated with several common native fish species, particularly those preferring pool habitats. These species were longfin dace (*Agosia chrysogaster*), Sonora sucker (*Cutostomus insignis*), desert sucker (*Cutostomus clarki*), and Gila topminnow *(Poeciliopsis occidentalis*). In Redfield Canyon, Griffith and Tiersch (1989) found speckled dace (*Rhinichthys osculus*), longfin dace, and suckers (*Catostomus* spp.) with Gila chub. Numerous nonnative fish species currently occur within the historic range of Gila chub. Among these, channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*), green sunfish (*Lepomis cyanellus*), western mosquitofish (*Gambusia affinis*), and common carp (*Cyprinus carpio*) are the most widespread and common (Weedman et al., 1996).

STATUS

If the chub in Turkey Creek is determined to be Gila chub and the species persistence in Mule Creek is documented, these locations will have the only known populations of Gila chub in New Mexico. Chub currently inhabit only about a 3 km reach of Turkey Creek, but densities are comparatively high (Bestgen and Propst, 1989). Although Gila chub still occur in a moderate number of localities within its historic range in Arizona, its numbers are low at many locations (Weedman et al., 1996).

A variety of factors probably contributed to the decline of Gila chub, but loss of cienéga habitats by dewatering and channelization were probably the most detrimental. All areas of former occupancy in New Mexico were cienégas; these are now dry (San Simon Cienéga and Duck Creek) or channelized (Tularosa River). Introduction of nonnative piscivores also contributed to elimination of the chub from portions of its historic range. In Turkey Creek for example, smallmouth bass (*Micropterus dolomieui*) are common and chub are absent downstream of several hot springs and a 3 m waterfall. Upstream of the thermal "barrier," smallmouth bass are absent and chub are common.

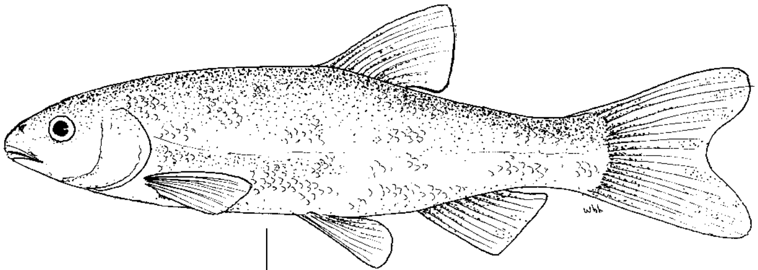
CONSERVATION

Gila chub has been recognized only recently as a valid species (Robins et al., 1991), despite being considered such by Minckley and Rinne for more than 20 years (Minckley, 1973; Rinne, 1976). This lack of "official" recognition undoubtedly inhibited efforts to protect and conserve the species. Arizona Game and Fish Department recently completed a status survey of the species (Weedman et al., 1996) and documented its extensive decline. This report considered protection of existing cienéga habitats having Gila chub critical to the survival of the species. Exclusion of nonnative piscivores from occupied Gila chub habitats or removal of nonnative predators from occupied and potential habitats also were recognized as activities needed to conserve Gila chub. For New Mexico, the most immediate conservation needs are determination of the taxonomic status of the chub population in Turkey Creek and inventory of Mule Creek to determine if the species persists there. If either or both locations support the species, a conservation plan that includes re-establishment of the species in other areas of historic occurrence needs development. If neither location supports Gila chub, the potential for translocation of the species from Arizona sites to suitable habitat in New Mexico should be investigated. ♦

Chihuahua Chub

Gila nigrescens

(Girard, 1856)



LISTING STATUS

Chihuahua chub, *Gila nigrescens*, was listed as endangered by New Mexico (19 NMAC 33.1) in 1976. It is federally listed as threatened (USFWS, 1983a) and is considered threatened by the Republic of México (SDS, 1994). The American Fisheries Society considers it a threatened species (Williams et al., 1989).

CHARACTERISTICS

Chihuahua chub has a fusiform but slightly chunky body and a terminal mouth. Adults may exceed 250 mm total length. The mouth extends back obliquely to about the anterior margin of the eye. Young Chihuahua chub are silvery to gray dorsally and whitish ventrally. Adults are mottled dark slate gray to dark olive green dorsally, gray laterally, and cream to white ventrally. Reproductively ripe males and females are orangish-red at the bases of paired fins, around the mouth, and ventrally; males are typically more intensely colored than females. Males in spawning condition have numerous small nuptial tubercles on the head. The caudal peduncle is thick and the moderately-forked caudal fin is rounded at tips. The dorsal fin has 9 rays, pelvic fin has 9, and the anal 8. There are 63-79 lateral line scales. The pharyngeal dentition formula is 2,5-4,2 (Sublette et al., 1990).

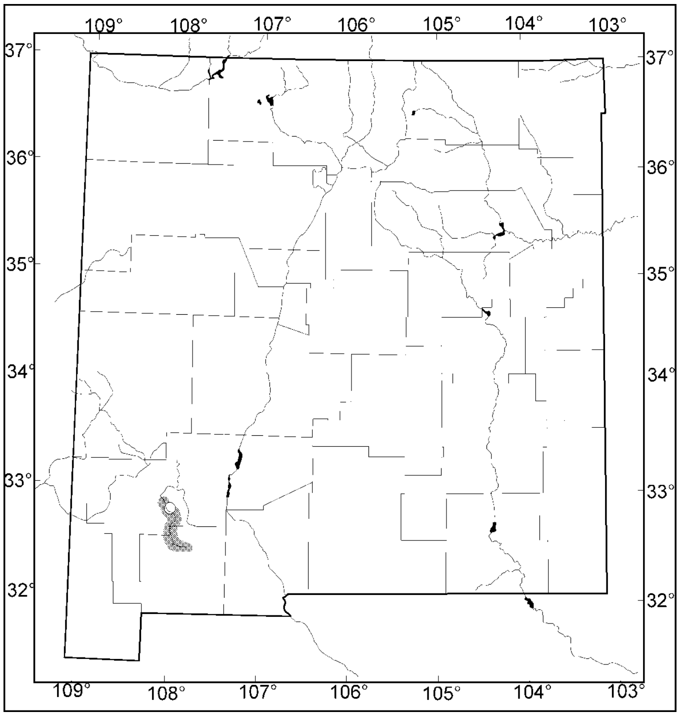
DISTRIBUTION

Chihuahua chub is native to the Mimbres River drainage in New Mexico and the Guzmán and Laguna Bustillos basins in Chihuahua (Smith and Miller, 1986). Specimens were first collected in the Mimbres River in 1851 (Baird and Girard, 1854), but it was not again found in the Mimbres River drainage until 1975 when Rogers (1975) found a small, reproducing population in Moreno Spring. In Chihuahua, the species was first found in the Rio Casas Grandes in 1854 (Girard, 1856); subsequently it was found in other Guzmán basin streams (Meek, 1902; 1903; Espinosa-Aguilar, 1988) and the Laguna Bustillos basin (Miller and Chernoff, 1979). Miller and Chernoff (1979) sampled sites of historic occurrence and found it at only eight of 16 historic collection localities and it was common at only three. Propst and Stefferud (1994) surveyed historic collection sites and other areas in its historic range likely to support the species. They found it had declined from that reported by Miller and Chernoff (1979), was moderately common only in remote reaches of the rios del Carmen, Santa Maria, and Casas Grandes in the Guzmán basin, and was moderately common in two isolated stream reaches in the Laguna Bustillos basin. Chihuahua chub probably occupied all warmwater reaches in the Mimbres River drainage, but they now are found regularly only in Moreno Spring. Its numbers there are typically less than 300 adults. They irregularly occur in about a 15 km reach of the Mimbres River from the confluence of Allie Canyon downstream to the New Mexico Department of Game and Fish Mimbres Property south of Mimbres. Ash-laden flows from a 1995 wildfire reduced Chihuahua chub abundance in the Mimbres River.

BIOLOGY

In streams, Chihuahua chub are found mainly in lateral-scour pools where flow is against or along undercut banks and pools around channel obstructions such as boulders and root wads (Propst and Stefferud, 1994). Pools are 1 to 2 m deep; water velocity is $\leq$ 15 cm/sec in the pool, but often $\geq$ 60 cm/sec in immediately adjacent runs. Substrate of pools occupied by Chihuahua chub is typically pea-gravel and sand. Cobble-bottomed riffles frequently are just upstream of pools occupied by Chihuahua chub. Chihuahua chub are found in other habitats (e.g., runs along undercut banks) only where density of the species is high.

Little is known of the reproductive biology of Chihuahua chub. In Chihuahua, reproductively ripe individuals were found in March at lower elevation sites (ca. 1500 m) and small Age 1 individuals (<20 mm SL) were found at higher elevations (ca. 2000 m) the same month. This sug-



gests that over its range, Chihuahua chub may have a spawning season that extends from early spring through autumn (Propst and Stefferud, 1994). Mature males are smaller (106 to 155 mm SL) than females (173 to 285 mm SL). Based on observations of captive stock, Chihuahua chub are mature at Age 2 or 3 (B.L. Jensen, pers. comm.). Most Chihuahua chub in sampled populations in Chihuahua were between 50 and 100 mm SL (Propst and Stefferud, 1994). Few individuals were longer than 130 mm SL; suggesting that most reproduction is by smaller and younger individuals. No information is available on the food habits of Chihuahua chub, but they probably consume mainly aquatic invertebrates.

Length-frequency data from Chihuahua chub populations in Chihuahua indicate that wild fish probably do not live more than 4 or 5 years (Propst and Stefferud, 1994); captive individuals, however, may live 7 or 8 years (B.L. Jensen, pers. comm.). Ectoparasites (*Lernaea* sp. and *Ichthyophthirius* sp.) were found on individuals in several Chihuahuan populations. The population in Moreno Spring has a heavy infestation of yellow grub (*Clinostomum marginatum*) (J.J. Landye, pers. comm.).

Only two species in addition to Chihuahua chub were native in the Mimbres River, (Propst and Stefferud, 1994). Rio Grande sucker (*Catostomus plebeius*) remains common in the river, but beautiful shiner has been extirpated. Several nonnative fish species are common in the Mimbres River. Of these, longfin dace are the most common and widespread. They often are found in the pool habitat preferred by Chihuahua chub. Rainbow trout are seasonally (autumn and winter) common and also occupy habitats preferred by Chihuahua chub. Other nonnative fish species reported in the Mimbres River are uncommon (speckled dace and fathead minnow) or irregularly escape from impoundments in the drainage (e.g., channel catfish and green sunfish). In the Laguna Bustillos basin, the native fish fauna consists of Chihuahua chub, fathead minnow, and an unde-scribed pupfish species (*Cyprinodon* sp.); each persists in the basin (Smith and Miller, 1986). Nonnative beautiful shiner, black bullhead (*Ameiurus melas*) and brown bullhead (*Ameiurus nebulosus*), and bluegill (*Lepomis macrochirus*) also were present (Propst and Stefferud, 1994). The native fish fauna of the Guzmán basin consisted of at least an undescribed trout (*Oncorhynchus* sp.), beautiful shiner, Mexican stoneroller (*Campostoma ornatum*), fathead minnow, Rio Grande sucker, an undescribed sucker species (*Catostomus* sp.), and two undescribed pupfish (*Cyprinodon*) species (Smith and Miller, 1986; Espinosa-Aguilar, 1988). Rio Grande sucker was the only native frequently found in or near habitats occupied by Chihuahua chub (Propst and Stefferud, 1994). Several nonnative fish species have been established in the basin (e.g., common carp and western mosquitofish), but none was widespread and only western mosquitofish was locally common (Propst and Stefferud, 1994). Chihuahua chub was rare or absent where nonnative piscivores (e.g., rock bass, *Ambloplites rupestris*) were present.

STATUS

The Chihuahua chub has declined substantially in abundance and range (Miller and Chernoff, 1979; Propst and Stefferud, 1994). Until 1975, it was believed to be extirpated from New Mexico (Koster, 1957; Rogers, 1975). It currently is found regularly only in Moreno Spring and it occurs irregularly in the Mimbres River. Ash-flows from recent wildfires in the Mimbres watershed diminished the riverine population, and presence of nonnative fishes in preferred pool habitats inhibits recovery of the population. The yellow grub infestation in the Moreno Spring population poses a serious threat. Channelization of much of the permanently-watered reaches and seasonal desiccation of others has destroyed considerable Chihuahua chub habitat in the Mimbres River. Removal of woody debris from the river channel deprives the system of material important to development of pool habitats.

The range of Chihuahua chub in Chihuahua, has contracted mainly to remote river reaches where habitat degradation is limited. Chihuahua chub is absent where streams are seasonally dry as a result of water diversion for agriculture. In stream reaches, where surface water is permanent but habitat degraded (channelization, sewage and refuse disposal, elevated sediment loads), Chihuahua chub are rare and those individuals are small ($\leq$ 100 mm SL). Several stream reaches in Chihuahua not physically degraded nevertheless had few Chihuahua chub. There, nonnative piscivorous fish species were present. The distribution and abundance patterns of Chihuahua chub in major rivers (rios Piedras Verdes, Casas Grandes, Santa Maria, and Santa Clara) of the Guzmán basin suggested that "core" populations, which persisted in remote, comparatively unmodified, stream reaches, was responsible for maintenance of the species in each river (Propst and Stefferud, 1994).

CONSERVATION

Chihuahua chub appears susceptible to habitat modification. Where pools with cover and in association with moderately deep, rapid velocity runs are absent, Chihuahua chub is absent. Several nonnative fish species either prey on Chihuahua chub or usurp its preferred habitats. In the Mimbres River, Chihuahua chub is absent from pools that appear suitable, if nonnative rainbow trout are present. Chihuahua chub were rare in unmodified reaches of the Piedras Verdes that also had low numbers of rock bass.

Habitat acquisition and protection in the Mimbres River, are essential to conserving the species in the United States. The New Mexico Department of Game and Fish specifically purchased property on the Mimbres River to provide habitat for the species, and The Nature Conservancy has purchased two properties that together encompass about 5 km of occupied Chihuahua chub habitat. A third Nature Conservancy property, upstream of occupied Chihuahua chub habitat, was acquired with the expectation that improvements in upland conditions would translate to habitat improvements within occupied stream reaches.

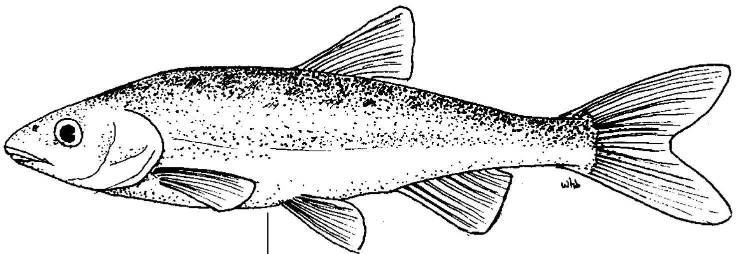
Limited efforts have been made to increase the range of Chihuahua chub in the Mimbres River drainage. In 1993, following habitat enhancement (instream placement of logs to create pools), Chihuahua chub from Dexter National Fish Hatchery & Technology Center (NFH & TC) were stocked in McKnight Creek downstream of a barrier waterfall. A second stocking of Chihuahua chub in this reach was made in 1997. Currently, a stock of Chihuahua chub is maintained at Dexter NFH & TC. Offspring of these fish are available to augment extant Chihuahua chub populations and to increase its range.

Conservation of Chihuahua chub in Chihuahua will depend upon maintenance of populations in remote stream reaches. There, the topography and land ownership discourage intensive agriculture and river channel modification. Transfaunation of nonnative fish species (particularly piscivorous forms) remains a threat to all populations of Chihuahua chub. Rainbow trout and longfin dace are established in the Mimbres River and their complete elimination is not feasible. However, intentional or accidental stocking of other nonnative fishes (for example, via baitbucket release) should be eliminated or discouraged in potential and occupied habitats. ♦

Roundtail Chub

Gila robusta

(Baird and Girard, 1853)



LISTING STATUS

Roundtail chub, *Gila robusta*, was listed as threatened in New Mexico (19 NMAC 33.1) in 1975 and uplisted to endangered in 1996. It is listed as a species of special concern by Arizona (AZGF, 1996) and by the Republic of Mexico as a rare species (SDS, 1994). The Navajo Nation lists roundtail chub as endangered (Group 2) (NFWD, 1997).

CHARACTERISTICS

The roundtail chub has a slender, fusiform body, oval in cross-section, with a moderately narrow caudal peduncle. It may attain total lengths in excess of 400 mm (Minckley, 1973; Bestgen and Propst, 1989). Juvenile roundtail chubs are light gray dorsally, silver-gray laterally, and white ventrally. A small black basicaudal spot usually is apparent. Adults are mottled dark slate gray to olive dorsally, mottled gray to dark gray laterally, and cream ventrally. The abdomen, bases of paired fins, and anal fin of males in spawning condition are bright orange to red-orange. Small breeding tubercles densely cover the body and fins of males anterior to the dorsal fin and may be present posteriorly to the caudal fin; females have breeding tubercles mainly on the head (Muth et al., 1985). The mouth is terminal and extends to the anterior margin of the eye. Scales are small; there typically are 80 to 85 in the lateral series (Minckley, 1973). The caudal fin is deeply forked and there typically are 9 anal fin rays. The pharyngeal dentition formula is 2,5-4,2.

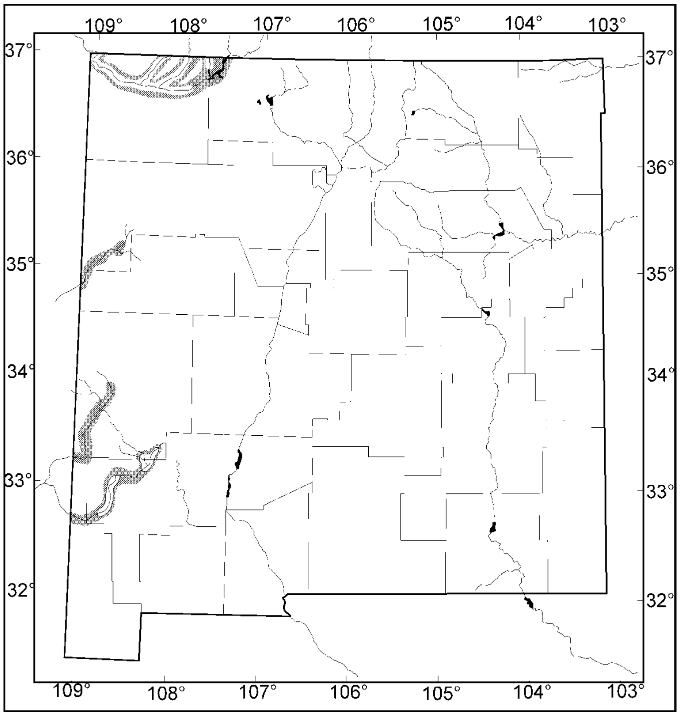
Based upon meristic and morphometric data, Bestgen (1985) concluded that the chub in Turkey Creek was more closely allied with roundtail chub than Gila chub but noted that additional work was required to clarify the taxonomic status of this population. Genetic work using allozymic and mitochondrial DNA techniques is needed to determine definitively to which species this population should be assigned.

DISTRIBUTION AND ABUNDANCE

Roundtail chub formerly inhabited the Colorado River and its primary tributaries from Wyoming south to the confluence of the Little Colorado River (Arizona), primary tributaries of the Colorado River downstream of the Little Colorado, and the rios Yaqui, Fuerte, and Sinaloa in northwestern Mexico (Minckley, 1973; Hendrickson et al., 1981; Tyus et al., 1982; Hendrickson, 1983). Throughout much of its native range, roundtail chub was typically common (Minckley, 1973; Holden and Stalnaker, 1975).

In New Mexico, the historic range of roundtail chub included the San Juan River and its tributaries (Platania, 1990), the Zuni River (a Little Colorado River tributary; Baird and Girard, 1853), and the Gila and San Francisco rivers (Koster, 1957; Bestgen and Propst, 1989). The Zuni River occurrence of roundtail chub is based upon a single collection of fishes from that river in 1851; W.J. Koster did not collect it during his sampling in 1948 and 1960 (UNM, Museum of Southwestern Biology). In the San Juan River and its tributaries, roundtail chub was moderately common through the early 1960s (Platania, 1990). In the Gila and San Francisco rivers (and tributaries), roundtail chub was common into the 1940s; Koster (1957) reported it being taken frequently by anglers and its desirability as a food fish during the Depression was expressed by a longtime resident of the area (pers. comm. to D.L. Propst).

Roundtail chub remains comparatively common in much of the upper Colorado River basin, particularly its major tributaries (Tyus et al., 1982; F.K. Pfeifer, pers. comm.). In the San Juan River system, roundtail chub persists in the Mancos (where it is common), LaPlata, and Florida rivers and the San Juan River upstream of Navajo Reservoir (Miller, 1994). The species apparently is absent from the Animas River (Miller, 1994) and the San Juan River between Navajo Dam and the Animas River confluence. It is rare in the San Juan River downstream of the Animas River confluence



(Ryden and Pfeifer, 1996). Most roundtail chub captured in the mainstem San Juan River in the past five years have been subadults or juveniles (Gido and Propst, 1994; Ryden and Pfeifer, 1996). Roundtail chub no longer inhabits the Zuni River drainage in New Mexico (Propst and Hobbes, 1996). The last documented occurrence of roundtail chub in the San Francisco River was 1948 (UNM, Museum of Southwestern Biology). LaBounty and Minckley (1972) suggested that roundtail chub may have been extirpated from the Gila River by the late 1960s. Subsequently, the species was confirmed to persist in several localities in the drainage (Anderson, 1978; Bestgen and Propst, 1989). In the Gila River drainage in New Mexico, roundtail chub are limited mainly to the upper East Fork Gila River, the lower Middle Fork Gila River, and lowermost West Fork Gila River (Bestgen and Propst, 1989; NMGF files). Elsewhere in the Gila River drainage roundtail chub are incidental or absent. Although surviving populations are small, recruitment by each has been documented in most years since 1988 (NMGF files).

BIOLOGY

Roundtail chub are most commonly found in pools with cover (boulders, uprooted trees, and undercut banks) having depths of 2 m or more with sand and gravel substrates (Bestgen and Propst, 1989; Rinne, 1992). Water velocity is typically less than 20 cm/sec. Minckley (1973) and Bestgen and Propst (1989) observed that roundtail chub congregated in certain pools but were not found in similar, nearby habitats. Juvenile and subadult roundtail chub (75 to 150 mm TL) are occasionally found in shallower and faster velocity water than adults; such areas typically are along undercut stream banks with overhanging vegetation (NMGF files).

In the East Fork Gila River, Bestgen and Propst (1989) observed roundtail chub spawning in May when water temperature was about 22°C (Bestgen, 1985). Spawning was in pool-riffles or in riffles immediately upstream of pools. Females do not spawn until Age 3 but males may spawn at Age 2 (Bestgen, 1985). Fecundity is size-dependent; an Age 5 female (300 mm TL) produced about 33,400 eggs (Bestgen, 1985).

Following emergence, young roundtail chub grow to about 70 mm total length by winter of their first year (Bestgen, 1985). Growth thereafter is about 50 mm per year until Age 4; after Age 4 annual growth rates slow and an Age 7 individual may be about 300 mm. Based upon operculum annulae, Scoppetone (1988), reported that a chub may live 20 or more years. Roundtail chub have nearly isometric growth. Bestgen (1985) provided data to support his contention that growth and maximum age are dependent upon habitat (pool) size; stream reaches with larger pools had larger and older roundtail chub than reaches with smaller pools.

Roundtail chub are omnivores, consuming a wide variety of aquatic and terrestrial invertebrates, aquatic plants, and detritus. Schreiber and Minckley (1981) and Bestgen (1985) reported the diet of larger individuals (>170 mm TL) included fish. Bestgen (1985) found that while algae was a major portion of the diet of individuals <100 mm TL, they also consumed aquatic insects. Seasonal changes in diet probably reflected the availability of food.

Over its broad historic range, roundtail chub was associated with a comparatively large proportion of the native warmwater fishes of the Colorado River basin. In the upper Colorado River, roundtail chub frequently was associated with humpback chub (*Gila cypha*), Colorado pikeminnow (*Ptychocheilus lucius*), speckled dace, flannelmouth sucker (*Catostomus latipinnis*), and bluehead sucker (*Catostomus discobolus*) (Vanicek and Kramer, 1969; Holden and Stalnaker, 1975; Karp and Tyus, 1990b). In lower Colorado River basin streams, roundtail chub was most commonly found with longfin dace, speckled dace, Sonora sucker, and desert sucker (Minckley, 1973; Bestgen and Propst, 1989; Rinne and Minckley, 1991). Longfin dace, beautiful shiner (*Cyprinella formosa*), and Yaqui sucker (*Catostomus bernardini*) were frequently with roundtail chub in the Rio Yaqui (Hendrickson et al., 1981).

A large number of nonnative fishes have been established throughout the historic range of roundtail chub. In the upper and lower Colorado River basins, the range of channel catfish almost completely overlaps that of roundtail chub. Red shiner, common carp (*Cyprinus carpio*), fathead minnow, black bullhead and yellow bullhead (*Ameiurus natalis*), and smallmouth bass occur in much of the historic habitat of roundtail chub (Minckley, 1973; Tyus et al., 1982; Bestgen and Propst, 1989). In the late 1970s, Hendrickson et al. (1981) collected comparatively few nonnative fish species within the Rio Yaqui range of the chub in Mexico.

Common carp, channel catfish, red shiner, and fathead minnow are the most common nonnative species within reaches of the San Juan River currently occupied by roundtail chub (Gido and Propst, 1994; Ryden and Pfeifer, 1996; Buntjer and Brooks, 1996). In the Gila River drainage in New Mexico, flathead catfish and smallmouth bass were believed by LaBounty and Minckley (1972) and Bestgen and Propst (1989) to be the nonnative species that had the greatest negative impact (predation) upon roundtail chub populations. In Turkey Creek, chub were common above a waterfall barrier, but were absent in suitable habitat downstream of the barrier where smallmouth bass were common.

STATUS

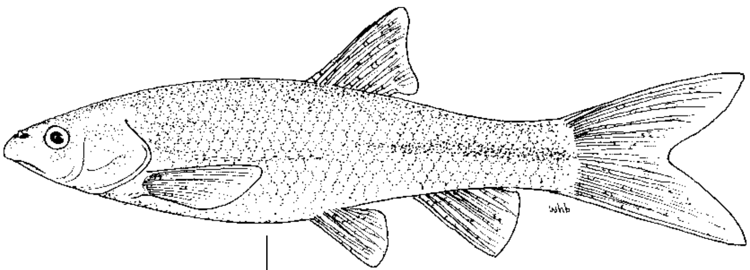
Roundtail chub, although reduced in range and abundance, remain comparatively widespread and common in much of the upper Colorado River basin, (Kaeding et al., 1990). The major exception in the upper basin is the San Juan River drainage. Several small, isolated populations persist in San Juan tributaries (Miller, 1994), but they are almost absent in the mainstem San Juan River (Gido and Propst, 1994; Ryden and Pfeifer, 1996). All individuals recently captured from the mainstem San Juan River were juveniles or subadults, indicating that the species is maintained in the mainstem by dispersal from tributary populations. Roundtail chub has been extirpated from the Zuni River drainage in New Mexico (Propst and Hobbes, 1996). In the Gila-San Francisco River drainage, the species has been extirpated from the San Francisco portion and persists mainly in four small populations in the upper Gila portion (Bestgen and Propst, 1989; NMGF files). Nonnative predators are sympatric with each extant New Mexico population.

CONSERVATION

Nonnative predators such as channel catfish, flathead catfish, sunfish (*Lepomis* spp.), and basses (*Micropterus* spp.), and loss of pool habitats with cover are the primary threats to surviving populations of roundtail chub in New Mexico. While it is not likely that nonnative predators can be eliminated from river reaches, efforts to control their abundance (liberalized creel limits and selective removal) and cessation of nonnative stocking are necessary to enhance the survival prospects of extant populations of roundtail chub. River channel modification (e.g., levee construction, channel cleaning, and channel straightening) deprives chub of essential pool habitat. Livestock grazing that results in loss of riparian gallery forests and increased bank erosion also contributes to habitat deterioration. Water diversions seasonally diminish habitat available to roundtail chub in portions of its range. Where this occurs, maintenance of instream habitat enhancing structures (e.g., downed trees) is essential to enabling roundtail chub to survive periods of reduced stream flow. Some anglers confuse roundtail chub with Gila trout, while others believe they compete with gamefishes or are otherwise undesirable (Koster, 1957). As a consequence of these misperceptions, roundtail chub often are destroyed. ♦

Rio Grande Silvery Minnow

Hybognathus amarus
(Girard, 1856)

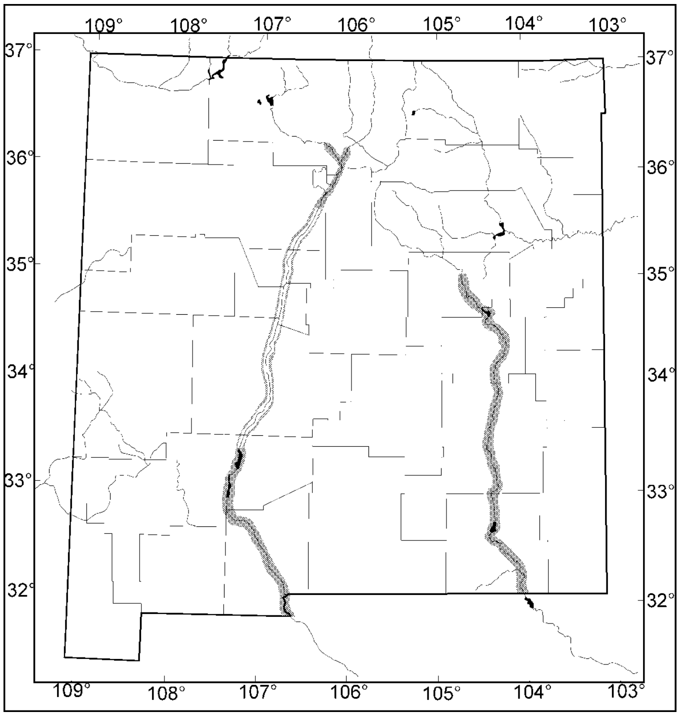


LISTING STATUS
The Rio Grande silvery minnow, *Hybognathus amarus*, was listed by New Mexico as an endangered species (19 NMAC 33.1) in 1979. It is federally listed as an endangered species (USFWS, 1994a) and the Republic of Mexico considers it an endangered species (SDS, 1994). The American Fisheries Society lists the Rio Grande silvery minnow as a species of concern (Williams et al., 1989).

CHARACTERISTICS
The Rio Grande silvery minnow is fairly small (typically less than 80 mm TL), subterete, relatively heavy-bodied, and ovate in cross-section (Bestgen and Propst, 1996). The minnow is greenish-yellow dorsally with emerald-like flecks, fading to yellow-tan laterally, and cream to white ventrally. The pale, comparatively broad lateral band extends from near the base of the caudal fin anteriorly above the lateral line and fades to a point near the head. Melanphores are generally above the lateral line. The snout is rounded and overhangs the upper lip of the comparatively small subterminal mouth. The eye is small and the mouth extends just to its anterior margin. The pectoral fin and lobes of the caudal fin are rounded. There are typically 8 dorsal, 8 anal, and 8 pelvic fin rays; the number of pectoral fin rays is variable (14 to 18). The lateral line typically has 35 to 38 scales. The pharyngeal filtering apparatus has a broad pharynx with short stubby papillae (Hlohowskyj et al., 1989). The intestine is relatively short for species of this genus (4.7 x standard length). The pharyngeal dentition formula typically is 0,4-4,0 and the teeth are relatively long with expanded and flattened grinding surfaces (Bestgen and Propst, 1996). The pharyngeal process of the basioccipital is broad and the posterior margin is only slightly concave. Rio Grande silvery minnow exhibit little sexual dimorphism beyond the somewhat longer pectoral fins of males. Cook et al. (1992) found fixed allozyme differences at two loci that differentiated Rio Grande silvery minnow from Mississippi silvery minnow (*Hybognathus nuchalis*) and plains minnow (*Hybognathus placitus*), species with which it formerly had been confused.

DISTRIBUTION
The Rio Grande silvery minnow historically occupied mainstream habitats of the Rio Grande from near its confluence with the Rio Chama in northern New Mexico downstream to the Gulf of Mexico and the Pecos River from near Santa Rosa downstream (except the reach between Red Bluff Reservoir and Sheffield) to its confluence with the Rio Grande (Bestgen and Platania, 1991). There are no historic data to document the occurrence of the species in the Rio Conchos of Chihuahua (G.P. Garrett, pers. comm.). The species was historically abundant in much of its native range. It was particularly common in the Rio Grande from about Cochiti downstream to near Socorro, in the Pecos River from near Fort Sumner downstream to Carlsbad (Bestgen and Platania, 1991), and in the Rio Grande downstream of the confluence of the Pecos River (Trevino-Robinson, 1959; Edwards and Contreras-Balderas, 1991). A single collection from the Rio Grande in the vicinity of Big Bend yielded a few specimens (Bestgen and Propst, 1996).

The Rio Grande silvery minnow currently occupies less than 10% of its historic range. It was eliminated from the Pecos River by the early 1970s (Bestgen et al., 1989; Bestgen and Platania, 1991) and from the Rio Grande downstream of Elephant Butte Reservoir by the 1950s (Propst et al., 1987; Edwards and Contreras-Balderas, 1991; Bestgen and Platania, 1991). It was not found in the Rio Conchos during recent surveys (G.P. Garrett, pers. comm.). It now is found only in the Rio Grande from Cochiti Pueblo downstream to the inflow of Elephant Butte Reservoir, and within this reach it is most common downstream of San Acacia Diversion Dam (Platania, 1991; Platania, 1993). Seasonal and annual abundance of the species vary considerably (Platania, 1993; S.P. Platania, pers. comm.).



BIOLOGY

Rio Grande silvery minnow typically occupy mainstream habitats where water depths are moderate (0.2 to 0.8 m), velocity is 0 to 30 cm/sec, and substrates are silt and sand (Dudley and Platania, 1997). Smaller individuals tend to occupy shallower and slower velocity waters than do large Rio Grande silvery minnows. During winter, the species is most commonly found in nearly still water with debris cover. During low flow periods it is found in isolated pools and in watered-reaches immediately downstream of diversion structures. Young individuals are occasionally found in irrigation ditches and canals, but adults do not typically inhabit such areas (Lang and Altenbach, 1994) or are found there only when large volumes of water are diverted (C.W. Hoagstrom, pers. comm.).

Rio Grande silvery minnow spawn during late spring-early summer, for about one month, coinciding with spring runoff when water is 20 to 24°C (S.P. Platania, pers. comm.). Rio Grande silvery minnows are pelagic broadcast spawners with semi-buoyant and non-adhesive eggs (Platania and Altenbach, 1998). Several males pursue a single female, nudging her abdomen. A single male wraps around the female mid-section and milt and eggs are released simultaneously. Individuals may have several spawning episodes, with at least 10-minute intervals between each event. Age-1 females produce about 210 ova per spawning event and Age-2 individuals produce about 315 ova (1 mm diameter). After fertilization, eggs swell to about 3 mm diameter. Each female produces 3 to 18 clutches in a 12-hr period; it is not known whether individual females produce additional clutches later in the season. Age-1 individuals constitute >90% of the spawning population. Spawning apparently exerts high mortality on Rio Grande silvery minnow; <2% of the population in late autumn is Age 1 or older.

Following fertilization, eggs drift with the current for about 50 hr; time to hatching is temperature dependent (Platania, 1995a). At hatching, larvae are about 3.7 mm SL and may continue to drift for 1 to 3 days. Larvae move to low velocity habitats (backwaters and embayments) where growth is rapid. Larvae mature to juveniles within about 50 days and average 18 mm SL. By late autumn, Rio Grande silvery minnow are 40 to 45 mm SL; some growth occurs during winter and Age-1 fish are 45 to 49 mm SL by initiation of the spawning season. Maximum size attained is about 85 mm SL. A few individuals may survive 25 months, but most (>90%) live about 13 months.

The Rio Grande silvery minnow is primarily a herbivore, as indicated by its elongated gastrointestinal tract. The presence of sand and silt in its gut suggests that epipsammatic algae is an important food (S.P. Platania, pers. comm.).

Historically, Rio Grande silvery minnow was most commonly associated with a guild of several mainstream cyprinids with similar life history strategies. In the Rio Grande and Pecos River within New Mexico, these included speckled chub (*Macrhybopsis aestivalis*), Rio Grande bluntnose shiner (*Notropis simus simus*), phantom shiner (*Notropis orca*), and Rio Grande shiner (*Notropis jemezanus*). Rio Grande bluntnose shiner and phantom shiner are extinct and Rio Grande shiner and speckled chub have been extirpated from the Rio Grande in New Mexico. Other native fish species common to stream reaches occupied by Rio Grande silvery minnow include flathead chub (*Platygobio gracilis*), red shiner, and fathead minnow.

STATUS

The Rio Grande silvery minnow now occurs in only about a 200-km reach of the Rio Grande from near Cochiti Pueblo downstream to the inflow area of Elephant Butte Reservoir in New Mexico. It has been extirpated from all other areas of historic occurrence in the Rio Grande and Pecos River. Within its currently occupied range, it is rare upstream of Albuquerque, uncommon between Albuquerque and Isleta, seasonally common between Isleta and San Acacia, and seasonally common to abundant from San Acacia to Elephant Butte inflow. Abundance of the Rio Grande silvery minnow is highly variable, seasonally and annually. For example, between 1987 and 1989 it was one of the most common native fish species in the Rio Grande between Albuquerque and Elephant Butte Reservoir, but in 1992 (following several low-flow years), it was absent from much of the river (Platania, 1993).

The elimination of Rio Grande silvery minnow from much of its historic range was caused by a variety of factors. Establishment of nonnative fish species, impoundments, diminished water quality, flow reductions, and range fragmentation contributed to extirpation of Rio Grande silvery minnow in the Rio Grande downstream of Amistad Reservoir (Edwards and Contreras-Balderas, 1991). Diminished water quality and flow diminution probably contributed to its elimination from the Big Bend reach of the Rio Grande (S.P.

Platania, pers. comm.). Competition and hybridization with a congener, the plains minnow, diminished water quality, and modified flow regimes contributed to its demise in the Pecos River (Bestgen and Platania, 1991; Cook et al., 1992). Status of the Rio Grande silvery minnow in its currently occupied range is greatly affected by flow modifications and diversion structures. If flow does not increase during spring, spawning is not likely to occur; if it occurs, few young survive. Diversion structures prevent Rio Grande silvery minnows from repatriating depopulated upstream reaches. Loss of one year's reproductive effort has devastating effects for short-lived species such as Rio Grande silvery minnow.

CONSERVATION

Survival of the Rio Grande silvery minnow depends upon maintenance of flows in occupied habitats, particularly flow pulses associated with spring runoff. Although the species can survive for brief periods in isolated pools with depleted oxygen and elevated temperatures, extended periods of no flow result in major population losses. For example, during spring 1996 all surface flows were diverted from much of the occupied habitat downstream of Isleta, forcing Rio Grande silvery minnow into isolated pools and watered reaches immediately downstream of diversions structures. Those in isolated pools were dead within a few days, but those below diversion structures survived where seepage maintained some surface water, temperature was not extreme, and dissolved oxygen was not completely depleted. Spawning and species persistence occurred with release of water from reservoirs.

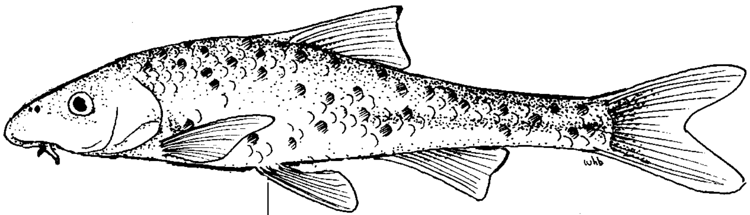
Maintenance of minimum flows (with spring flow spikes) is necessary to conserve the Rio Grande silvery minnow; however, diminished water quality and nonnative fish species also imperil the species. River operations to meet irrigation needs generally diminish habitat quality in much of the Rio Grande currently occupied by Rio Grande silvery minnow and concentrates the species with predators in isolated pools when surface flow is not continuous.

A multi-agency Rio Grande Silvery Minnow Recovery Team, with representatives from resource agencies, municipalities, Native American tribes, and water-user groups was formed to develop strategies to ensure the conservation of the Rio Grande silvery minnow. A critical effort of this group is to characterize the environmental needs of Rio Grande silvery minnow and to determine how to meet its life history requirements, while ensuring that all intra- and interstate and international water commitments are met. ♦

Arkansas River Speckled Chub

Macrhybopsis aestivalis tetranemus

(Gilbert, 1886)



LISTING STATUS

The Arkansas River speckled chub, *Macrhybopsis aestivalis tetranemus*, was listed by New Mexico as threatened (19 NMAC 33.1) in 1978 and is considered a species of concern by the American Fisheries Society (Williams et al., 1989).

CHARACTERISTICS

The Arkansas River speckled chub is a small, slender, ventrally depressed minnow that rarely exceeds 70 mm total length (Cross and Collins, 1975). The head and eyes are small, and the snout is elongate. Arkansas River speckled chub has four barbels (two pairs) at the corners of the small, subterminal mouth; the other subspecies of speckled chub (*Machybopsis aestivalis aestivalis*) that occurs in New Mexico (Pecos River) has only one pair of barbels. Arkansas River speckled chub is pale straw yellow dorsally, light tan to silvery laterally, and white ventrally. Small black spots are irregularly scattered over dorso-lateral surfaces. A faint mid-lateral band extends anteriorly from the base of the caudal fin. Little sexual dimorphism is expressed by Arkansas River speckled chub; minute nuptial tubercles are present on fins and body of both sexes. The dorsal and anal fins are slightly falcate and have 8 rays each. The lateral line is complete and there are 36 to 40 scales in the lateral series (Miller and Robison, 1973). Pharyngeal teeth are hooked at the tips and the dentition formula is 0,4-4,0 (Sublette et al., 1990).

DISTRIBUTION

The Arkansas River speckled chub is native to the Arkansas River drainage of southeastern Colorado, northeastern New Mexico, southwestern Kansas, the Texas Panhandle, northern Oklahoma, and western-most Arkansas (Wallace, 1980; Luttrell et al., 1993). In suitable habitat, the subspecies was at least moderately common (Luttrell et al., 1993). In New Mexico, Arkansas River speckled chub historically was limited to the South Canadian River from near the confluence of Ute Creek downstream; one record exists of its occurrence in Ute Creek near Bueyeros (Sublette et al., 1990; Pittenger and Schiffmiller, 1997).

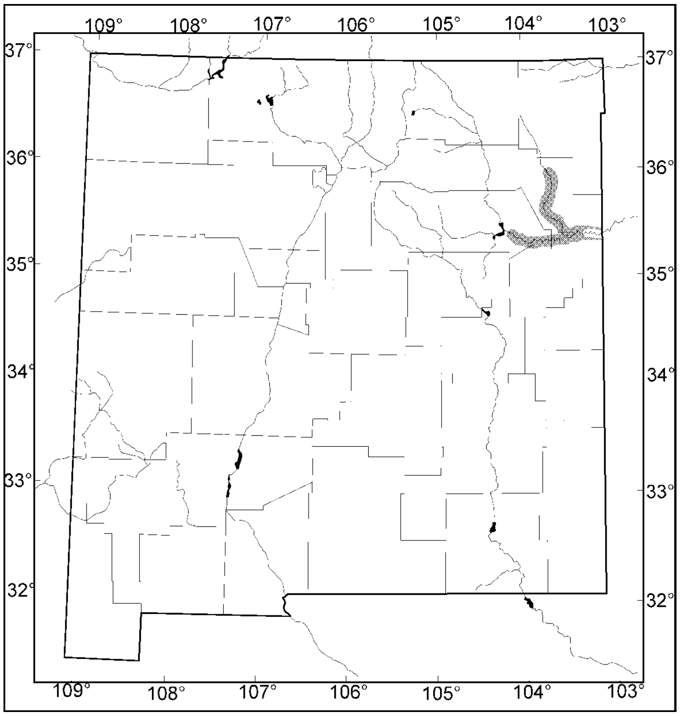
This chub has declined considerably in range and abundance. It no longer occurs in Colorado (Luttrell et al., 1993) or Arkansas (Robison and Buchanan, 1988). Its range and abundance in Kansas has contracted considerably (Cross et al., 1985) and in Oklahoma it now is limited mainly to the northcentral portion of the state (Luttrell et al., 1993). It was found at two locations on the South Canadian River in the Texas Panhandle during an extensive survey of its historic range (Luttrell et al., 1993). In New Mexico, it currently occurs only downstream of Ute Dam to the Texas/New Mexico border (Larson, 1988).

BIOLOGY

Arkansas River speckled chubs inhabit shallow, permanently-flowing plains streams in areas where the bottom is clean sand or small gravel (Miller and Robison, 1973). They are found most frequently in moderate-velocity habitats and apparently avoid low to zero velocity areas (Cross and Collins, 1975).

It is assumed that the reproductive biology of Arkansas River speckled chub is similar to that of Pecos River speckled chub (S.P. Platania, pers. comm.), which is a pelagic broadcast spawner producing non-adhesive, semi-buoyant eggs. After fertilization, eggs drift with the current and develop rapidly (Platania and Altenbach, 1998). Spawning occurs from late spring through early autumn during flow spikes (Platania and Altenbach, 1998). Arkansas River speckled chubs probably live 24 months or less.

Based upon observations of Davis and Miller (1967), Arkansas River speckled chubs for-



age above the stream bottom with their barbels in contact with the substrate. The subspecies probably feeds primarily on aquatic insects (mainly dipteran larvae) associated with the sandy substrate of its riverine habitats (Starrett, 1950; Miller and Robison, 1973).

In its native New Mexico range, Arkansas River speckled chub was most commonly associated with other small fishes characteristic of western Great Plains streams. These included red shiner, plains minnow, Arkansas River shiner (*Notropis girardi*), and sand shiner (*Notropis stramineus*) (Sublette et al., 1990). Each of these species is common in the South Canadian River downstream of Ute Dam (Larson et al., 1991; NMGF files).

STATUS

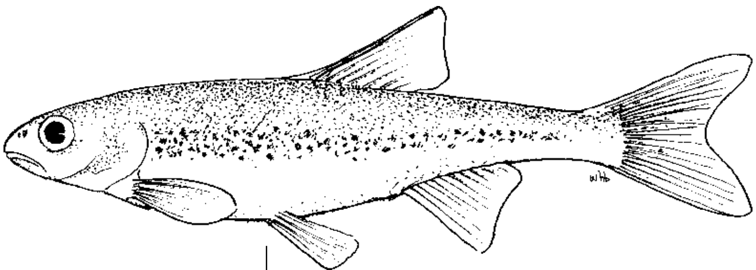
In New Mexico, Arkansas River speckled chub persists in the South Canadian River downstream of Ute Dam and the lower reaches of Reuvelto Creek. Within this river reach it is uncommon to common, depending upon the availability of its preferred habitat of moderate velocity, shallow, sand and gravel-bottomed runs.

CONSERVATION

Maintenance of surface flows throughout the year (Cross et al., 1985) and flow spikes (Platania and Altenbach, 1998) are essential to the survival of Arkansas River speckled chub in its remaining New Mexico range. Activities that reduce surface flows or elevate salinity are detrimental to the species. ♦

Spikedace

Meda fulgida
(Girard, 1856)



LISTING STATUS

The spikedace, *Meda fulgida*, was listed by New Mexico as a threatened species (19 NMAC 33.1) in 1975. It is federally listed as a threatened species (USFWS, 1986a) and is a species of special concern in Arizona (AZGF, 1996). The American Fisheries Society considers it a threatened species (Williams et al., 1989). Critical habitat for spikedace was revoked in 1998 (USFWS, 1998a).

CHARACTERISTICS

The spikedace is a small, sleek, spindle-shaped, and slightly laterally compressed minnow that may attain total lengths of about 70 mm (Minckley, 1973). Spikedace are light olive to brownish dorsally, light gray to silver laterally, and white ventrally. Small black flecks are common on dorsolateral surfaces. Breeding males are bright yellow to gold or "brassy," particularly on the sides. Both sexes have minute tubercles during the spawning season, and males are more intensely tuberculated than females (Barber et al., 1970). The large terminal mouth extends to the middle of a comparatively large eye. Scales are deeply embedded in the skin, giving the fish a naked appearance. The first two rays of the dorsal fin are partially "fused," the second fitting into a groove in the back of the first, creating a spine-like ray. There typically are 7 dorsal and 9 anal fin rays. The pharyngeal dentition formula is 1,4-4,1 (Miller and Hubbs, 1960).

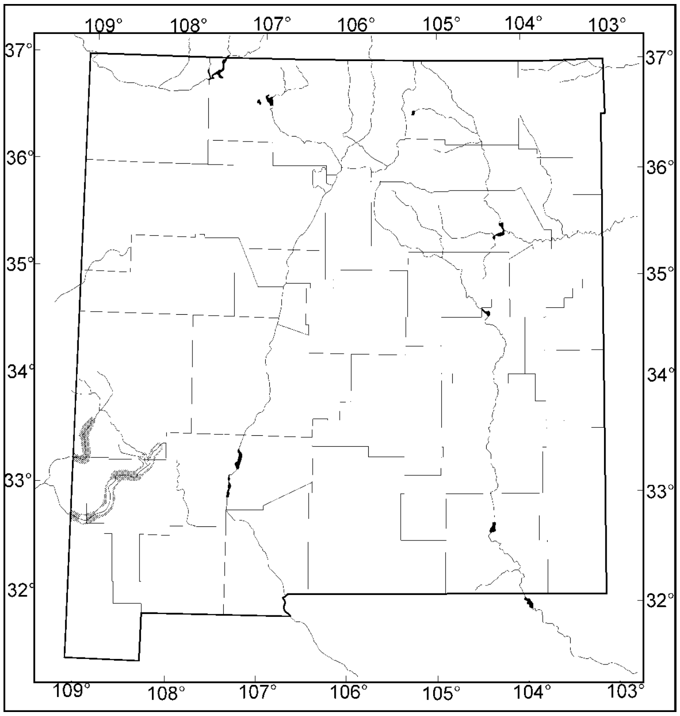
DISTRIBUTION

The spikedace is endemic to the Gila River drainage of southwestern New Mexico and southeastern and central Arizona, and perhaps northern-most Sonora (Koster, 1957; Minckley, 1973; Miller and Winn, 1951). No records exist of its historic occurrence in the San Carlos River or the Gila River downstream of the Agua Fria River (Minckley, 1973). Historically, it was one of the more common species in moderate to low gradient streams (Minckley, 1973). In New Mexico, spikedace was moderately common to abundant in the San Francisco River, the mainstem Gila River, and lower reaches of the three forks of the Gila River (Anderson, 1978; Propst et al., 1986).

The spikedace has been eliminated from much of its historic range in Arizona. Populations there persist only in the upper Verde River, Aravaipa Creek, and Eagle Creek (Minckley, 1973; Barber and Minckley, 1966; Marsh et al., 1991). Spikedace remains comparatively common in the first two of these areas, but abundance fluctuates seasonally and annually. The species was present in some numbers in Eagle Creek in the late 1980s, but has not been taken since (W.L. Minckley, pers. comm.). Spikedace have been extirpated from the San Francisco River (Anderson, 1978; Propst et al., 1986). The spikedace has a discontinuous distribution in the Gila River in New Mexico. It is irregularly collected in low numbers in the East Fork Gila River, regularly collected, but in declining numbers, in the West Fork Gila River, and may be extirpated from the Middle Fork Gila River (Propst et al., 1986; NMGF files). The Cliff-Gila Valley as recently as the mid 1980s supported the largest New Mexico population of spikedace (Propst et al., 1986), but its abundance there declined considerably in the late 1990s (NMGF files).

BIOLOGY

Although spikedace is commonly associated with sand and gravel-bottomed, moderate depth and velocity runs and riffles (Rinne, 1991), the specific habitat occupied by the species shifts geographically, seasonally, and ontogenetically (Propst et al., 1986). Spawning occurs in shallow riffles with small cobble and gravel substrates (Barber et al., 1970). Young spikedace ($\leq$25 mm TL) most commonly are associated with slow-velocity water (ca. 8 cm/sec) near stream margins at depths of 0.3 m or less (Propst et al., 1986). Subadult spikedace (26 to 35 mm TL) occur in a rela-



tively broad range of water velocities (0 to 58; mean = 17 cm/sec) at depths averaging 0.16 m. Adults ($\geq$36 mm TL) occur in water velocities ranging from 0 to 75 cm/sec (mean = 49) at average depths of 0.19 m. Propst et al. (1986) reported conflicting seasonal shifts in habitat use. At a site near the upstream limits of spikedace, they found that individuals tended to occupy shallower water during winter than during summer; no change in velocity of occupied habitats was noted. At a site near the center of the species current New Mexico range, seasonal shifts in velocity of habitats occupied changed (more rapid in summer), but no change in depth was noted. Geographic differences in habitat use were in part a reflection of habitat availability. Spikedace generally occupied areas with gravel substrate but the species also was found in areas dominated by sand and cobble.

Reproduction occurs from April through June; specific timing is dependent upon water temperature and flow regime (Anderson, 1978; Barber et al., 1970; Propst et al., 1986). Although males apparently are not territorial, they patrol in shallow, sand and gravel-bottomed riffles where current velocity is moderate. Females move into the riffle from up- and downstream pools. Several males attend each female and spawning apparently occurs over the sand-gravel substrate. The demersal, adhesive eggs presumably develop within the substrate (Barber et al., 1970). Fecundity is size and age-dependent; Propst et al. (1986) reported a 55 mm SL female (Age 2) having 319 mature ova and Age 1 females having an average of 101 mature ova. Diameter of mature ova averaged about 1.5 mm. Most mature individuals were Age 1; few Age 2 females were present in Gila River populations (Propst et al., 1986). Barber et al. (1970) reported similar reproductive data for the population of spikedace in Aravaipa Creek, Arizona, except that they had slightly higher fecundity estimates for Age 1 females. Both Barber et al. (1970) and Propst et al. (1986) reported a sex ratio near unity for Age 1 fish but that Age 2 females were much more common than males.

Incubation time for spikedace embryos is unknown, but probably similar to the 4 to 7 days reported for other western cyprinids (Snyder, 1981). Young spikedace are 5 to 7 mm TL at emergence and young grow about 1 mm per day for the first 15 days thereafter (Propst et al., 1986). Growth is rapid through summer and into early autumn; spikedace average 38 mm SL by autumn. There is little growth in winter. By autumn of their second year (Age 1), spikedace average 50 mm SL (Barber et al., 1970; Anderson, 1978; Propst et al., 1986).

Propst et al. (1986) found that the spikedace population in the Cliff-Gila Valley reach of the Gila River typically was dominated by one age-class. The population was composed largely of Age-0 individuals after spring reproduction. The next spring prior to spawning, Age 1 fish were most common and few Age-2 individuals were collected. After spawning, no Age-2 and few Age-1 fish survived and the population was predominantly Age-0 individuals. Maximum longevity of spikedace is about 24 months, but most individuals live only 13 months (Barber et al., 1970; Anderson, 1978; Propst et al., 1986). Barber et al. (1970) and Anderson (1978) found Age-2 individuals more common than Propst et al. (1986).

Ephemeropteran nymphs and adults are the major food item for spikedace throughout the year (Schreiber and Minckley, 1981; Barber and Minckley, 1983). Other important food items are dipterans and trichopterans; plecopterans were an important food item in winter (Schreiber and Minckley, 1981). Young spikedace consume a greater proportion of dipterans than older and larger individuals (Barber and Minckley, 1983; Propst et al., 1986). Most of the food is obtained by feeding on drifting organisms (Barber and Minckley, 1983).

Spikedace historically co-occurred with speckled dace, loach minnow (*Tiaroga cobitis*), longfin dace, Sonora sucker, and desert sucker (Koster, 1957; Minckley, 1973). Spikedace is often the only species present in some habitats it commonly occupies (shallow runs). Along low-velocity shorelines, young spikedace often are found with young speckled dace, Sonora sucker, and desert sucker. Longfin dace and spikedace often share riffle eddy habitats (Propst et al., 1986).

A variety of nonnative fishes have been introduced to the Gila River basin. Among these, red shiner, channel catfish, flathead catfish, black and yellow bullheads, and western mosquitofish are the most widespread and common (Minckley, 1973; Propst et al., 1986; Bestgen and Propst, 1989). Smallmouth bass and largemouth bass (*Micropterus salmoides*) are locally common in the historic range of spikedace. Ictalurids and centrarchids prey upon spikedace and may locally eliminate or greatly reduce spikedace populations (NMGF files). Red shiner has been hypothesized to negatively affect spikedace (Minckley and Deacon, 1968). Although Rinne (1991) did not find evidence that red shiner displaced spikedace from preferred habitats, Douglas et al. (1994) provided evidence that such occurred. Spikedace is rare or absent where nonnative species are comparatively common (Minckley, 1973; Propst et al., 1986; NMGF files).

STATUS

Spikedace currently occupies less than 10% of its historic range in Arizona and New Mexico (USFWS, 1991a). In Arizona, it persists in the upper Verde River (Minckley, 1973), Aravaipa Creek (Barber and Minckley, 1966; W.L. Minckley, pers. comm.), and Eagle Creek (Marsh et al., 1991; see, however, above). It is rare to moderately common in occupied Arizona habitats. New Mexico populations of spikedace have declined in the past 15 years. In the early 1980s, spikedace was found in the East, Middle, and West forks of the Gila River, the Gila River in the Cliff-Gila Valley, and irregularly in the Gila River downstream of the Middle Gila Box (Propst et al., 1986; NMGF files). It apparently has been extirpated from the Middle Fork Gila River, is rare in the East Fork Gila River, and uncommon in the West Fork Gila River (NMGF files). Abundance in the Cliff-Gila Valley reach of the Gila River has declined since the early 1990s and there it now is uncommon (NMGF files).

CONSERVATION

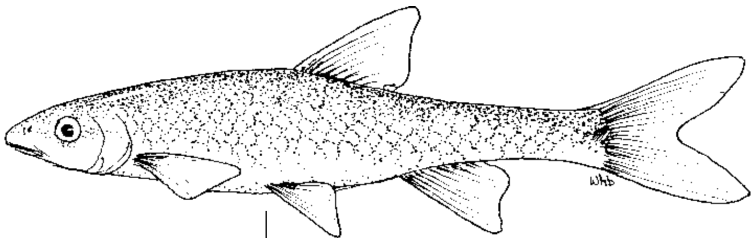
Habitat modification and establishment of nonnative fish species have caused the decline of spikedace. Although the relative impact of each factor on individual populations varies among locations, both probably have affected all populations. Habitat modification includes flow alteration (seasonal reductions or elimination), channelization, unnaturally high sediment loads (seasonal), and loss of riparian vegetation. Nonnative fish species compete with spikedace for resources (e.g., habitat) or prey upon them.

Conservation of remaining populations of spikedace requires reversing the increasing degradation of remaining habitats and cessation of nonnative fish stockings in habitats occupied by the species. Maintenance of natural flow regimes is critical to retaining habitat integrity and moderating the abundance of nonnative fishes. Meffe and Minckley (1987) demonstrated that floods reduce the abundance of nonnatives more than that of native fishes. While nonnative fishes might not be eliminated by floods, their abundance is regularly checked by floods (NMGF files).

A Spikedace Recovery Plan was finalized in 1991 (USFWS, 1991a). Although critical habitat was designated, its designation was challenged in federal court and the USFWS subsequently revoked critical habitat for the species (USFWS, 1998a). However, spikedace retains full protection under the Endangered Species Act and the New Mexico Wildlife Conservation Act. The Nature Conservancy has purchased land in the upper portion of the Cliff-Gila Valley and maintains this as a natural area. ♦

Arkansas River Shiner

Notropis girardi
(Hubbs and Ortenburger, 1929)



LISTING STATUS
The Arkansas River shiner, *Notropis girardi*, was listed as endangered by New Mexico (19 NMAC 33.1) in 1976 and is federally listed as threatened (USFWS, 1998b). The introduced population of Arkansas River shiner in the Pecos River, New Mexico is excluded from protection by New Mexico (19 NMAC 33.1) and the U.S. Fish and Wildlife Service (USFWS, 1998b).

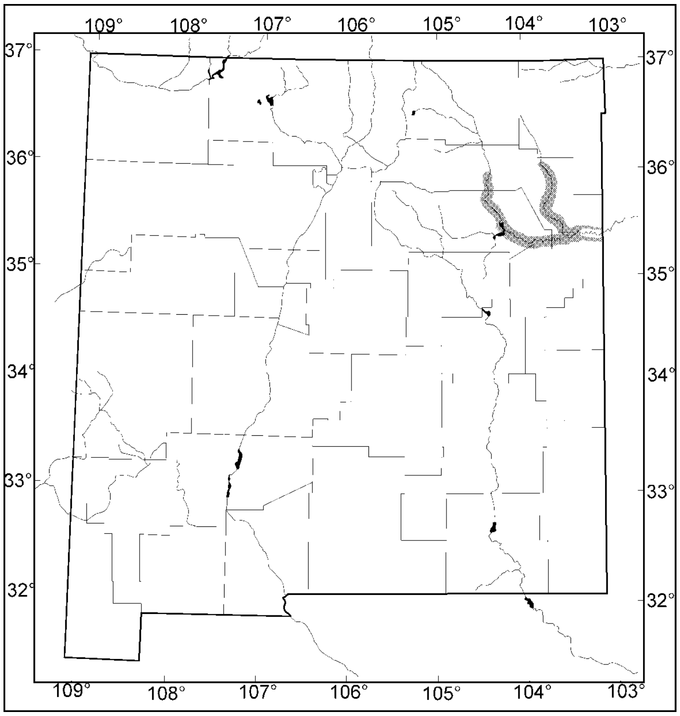
CHARACTERISTICS
The Arkansas River shiner is a small, compressed, and moderately heavy-bodied minnow that rarely exceeds 50 mm standard length (Bestgen et al., 1989). Coloration dorsally is sandy-yellow, silvery laterally, and whitish ventrally. A small black chevron typically is present at the base of the caudal fin. The anterior-most lateral line pores are faintly outlined with melanophores. The head is small and thick, the snout is rounded and barely overhangs the small, slightly oblique mouth (about as long as eye diameter). The pectoral and dorsal fins are weakly falcate. There are 8 rays in each of the dorsal, pelvic, and anal fins. There are 33 to 37 scales in the lateral series. The pharyngeal dentition formula is 0,4-4,0 (Cross and Collins, 1975).

DISTRIBUTION
The Arkansas River shiner formerly was common throughout the Arkansas River and its major tributaries in southwestern Kansas, southeastern Colorado, northeastern New Mexico, the Texas Panhandle, northern Oklahoma, and western Arkansas (Cross and Collins, 1975; Gilbert, 1980a; Matthews and Hill, 1980). In New Mexico, the shiner occurred in the South Canadian River drainage from near Sabinoso on the South Canadian River downstream to the Texas/New Mexico border, in Ute Creek in the vicinity of Bueyeros, Conchos Creek, and the lowermost reaches of Revuelto Creek (Sublette et al., 1990; Pittenger and Schiffmiller, 1997; K.R. Bestgen, pers. comm.). The species has never been reported from the New Mexico portion of the Dry Cimarron River (Sublette et al., 1990), although its type locality is in the Cimarron River just downstream from the New Mexico/Oklahoma border (Hubbs and Ortenburger, 1929).

The current distribution of the Arkansas River shiner is much reduced from its historic extent (Cross and Moss, 1987). It has been almost eliminated from its range in Kansas (Cross et al., 1983; Cross et al., 1985) and no longer occurs in Arkansas (Robison and Buchanan, 1988). It mainly occupies stream reaches with permanent surface flow in Texas and Oklahoma (Larson, 1988). The species has been extirpated from the Cimarron River in Colorado (K.R. Bestgen, pers. comm.). The native New Mexico range of Arkansas River shiner currently is limited to the South Canadian River downstream of Ute Dam and the lowermost reaches of Revuelto Creek (Larson, 1988). It is seasonally common in these stream reaches. Arkansas River shiner was introduced to the Pecos River about 1978 and has since become established in the river between Sumner Dam and Red Bluff Reservoir on the Texas/New Mexico border (Bestgen et al., 1989).

BIOLOGY
Arkansas River shiners inhabit the main channels of sand-bottomed streams and rivers where they most often are found on the downstream side of transverse sand ridges (Miller and Robison, 1973; Cross and Collins, 1975), but they occur in nearly all habitats characteristic of Great Plains streams (K.R. Bestgen, pers. comm.). These streams are generally broad and meandering with little shading, highly variable flows and water temperature, and high concentrations of dissolved solids (Cross et al., 1985).

Spawning by Arkansas River shiners occurs from late spring through early autumn and is closely linked to increases in flow (Moore, 1944; Platania and Altenbach, 1998). Spawning occurs in



the water column when water temperatures are about 25°C and the fertilized, semi-buoyant eggs drift with the current (Platania and Altenbach, 1998). Based upon length-frequency distributions of young fish, Bestgen et al. (1989) estimated that most spawning occurred in June and July and that several spawning events occur each summer. Incubation is about 48 hours (Moore, 1944) and larvae continue to drift with the current for 3 to 6 days (S.P. Platania, pers. comm.).

Arkansas River shiners grow rapidly their first summer, attaining an average standard length of 25 mm (Bestgen et al., 1989). Thereafter, growth rate diminishes; in Revuelto Creek, Age 1 individuals averaged 34 mm and Age 2 fish averaged 38 mm SL in February. Bestgen et al. (1989), used scale analysis and length-frequency distributions and reported that while a few Arkansas River shiners may live to Age 4, most do not live more than 18 months. Paucity of older individuals in late summer is likely a consequence of high mortality associated with spawning. Bestgen et al. (1989) found that in late summer Arkansas River shiner populations in the Pecos River were numerically dominated by Age 0 individuals and that Age 1 and older fish represented less than 2% of the population. However, they also presented some evidence to indicate that overwinter survival of Age 0 fish was lower than that of Age 1 individuals. Arkansas River shiners presumably feed on drifting aquatic invertebrates.

STATUS

The Arkansas River shiner currently occupies only about 25% of its historic range. It has been, or is nearly, extirpated from all of its range in the mainstem Arkansas, Cimarron, Salt Fork, and North Canadian rivers in Oklahoma and Kansas (Cross et al., 1985; Larson et al., 1991; Pigg, 1991; Luttrell et al., 1993), and it no longer occurs in Arkansas (Robison and Buchanan, 1988). In the South Canadian River, it occurs, and remains moderately common, from Lake Eufaula, Oklahoma upstream through Texas to Ute Dam in New Mexico (Larson, 1988; Larson et al., 1991). The species has been extirpated from the South Canadian River drainage in New Mexico upstream of Ute Reservoir (Larson, 1988; Pittenger and Schiffmiller, 1997).

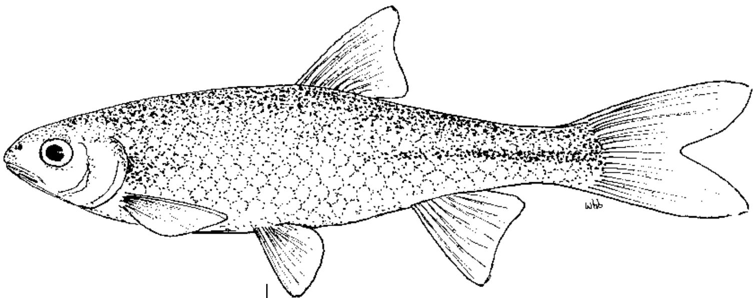
CONSERVATION

Cross et al. (1985) documented that stream desiccation (caused by groundwater pumping and diversion of surface water) and elimination of flow spikes (associated with spring runoff and summer storm events) were the primary factors contributing to the elimination of the Arkansas River shiner from its historic Kansas range. Although Felley and Cothran (1981) correlated decline of Arkansas River shiner in the Cimarron River in Oklahoma with the establishment of nonnative Red River shiner (*Notropis bairdi*), Bestgen et al. (1989) noted that populations of Arkansas River shiner had declined even where Red River shiner was not introduced. Success of introduced Arkansas River shiners in the Pecos River, New Mexico was believed by Bestgen et al. (1989) to be at least partially attributable to maintenance of flow spikes in that river. This hypothesis was corroborated by Platania and Altenbach (1998), who demonstrated that Arkansas River shiner spawns with flow spikes. Based upon this information, maintenance of flow spikes is critical to survival of the Arkansas River shiner in its historic range. In addition, Platania and Altenbach (1998) demonstrated that fish such as Arkansas River shiner that produce eggs and larvae that drift with the current require considerable lengths of flowing water to develop. Desiccation of stream channels and range fragmentation by dams also limit survival prospects for the species. Although the Arkansas River shiner, as well as other Great Plains fishes, can survive periods of greatly diminished flows (Deacon, 1961), it cannot survive extended periods of near-complete cessation of surface flow (Fausch and Bestgen, 1997). Dams prevent recolonization of upstream habitats that might be depopulated by natural or human-caused events (Winston et al., 1991).

With the federal proposal to list the Arkansas River shiner as endangered (USFWS, 1996), efforts were initiated to develop cooperation among responsible state and federal natural resource agencies and private entities to provide for the security of the species. These efforts failed and the species was consequently federally listed as threatened (USFWS, 1998b). ♦

Pecos Bluntnose Shiner

Notropis simus pecosensis
(Cope, 1875)



LISTING STATUS

The Rio Grande bluntnose shiner, *Notropis simus simus*, was listed by New Mexico as endangered in 1975, but because all evidence indicated the subspecies was extinct it was removed from the New Mexico list of protected species in 1998. The Pecos bluntnose shiner, *Notropis simus pecosensis*, was listed by New Mexico as threatened (19 NMAC 33.1) in 1976. The Pecos bluntnose shiner is federally listed as threatened, with critical habitat (USFWS, 1987). The species is listed as endangered in Texas (Campbell, 1995) and the Republic of Mexico (SDS, 1994).

CHARACTERISTICS

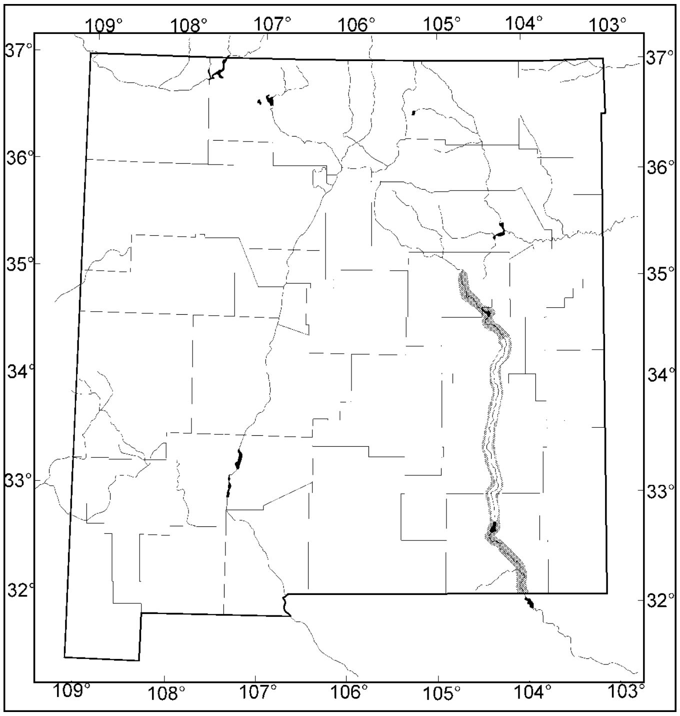
The bluntnose shiner is a relatively small, moderately deep-bodied minnow, rarely exceeding 80 mm TL (Chernoff et al., 1982; Bestgen and Platania, 1991). It is pallid gray to green-brown dorsally and whitish to silvery ventrally. A faint silvery lateral band extends broadly from the caudal fin and narrows anteriorly. Scales are outlined with melanophores, giving a diamond-grid lateral appearance. The snout is bluntly rounded and overhangs the subterminal mouth, which extends back to the anterior margin of the eye. The origin of the dorsal fin is slightly posterior to that of the pelvic fins. Breeding males have profuse, small tubercles on the head, breast, and pectoral fins; tuberculation on breeding females is less extensive. The lateral line is slightly decurved. There are 33 to 38 scales in the lateral series, usually 8 (range = 7 to 9) dorsal fin rays, and 8 to 10 anal fin rays. Pharyngeal dentition formula is typically 2,4-4,2 and the pharyngeal teeth are robust and moderately hooked distally. The short intestine has two loops and the peritoneum is silvery.

DISTRIBUTION

The bluntnose shiner is endemic to the Pecos River in New Mexico and the Rio Grande in New Mexico and the El Paso/Cuidad Juarez area of Texas and Chihuahua (Gilbert, 1980b; Chernoff et al., 1982). Records attributed to this species from downstream reaches of the Rio Grande in Texas (Gilbert, 1980b) are actually of a similar species, the now extinct phantom shiner (Chernoff, et al., 1982).

The Rio Grande bluntnose shiner (*Notropis simus simus*) formerly occurred in the Rio Chama from near Abiquiu downstream to the confluence with the Rio Grande (Bestgen and Platania, 1990). In upstream reaches of its former range, Rio Grande bluntnose shiner was uncommon; W.J. Koster (UNM, Museum of Southwestern Biology) collected 14 specimens of the species in the Rio Chama in 1949 (Platania, 1995b). Subsequently no specimen of the subspecies was collected in the uppermost portions of its range. Museum records indicate that the Rio Grande bluntnose shiner was common in a 95-km reach of the Rio Grande from just upstream of Albuquerque downstream to Bernado (Bestgen and Platania, 1990). There are no records of the subspecies between Elephant Butte and Caballo reservoirs, and none was found in 1986 (Propst et al., 1987). Downstream of Caballo Reservoir, the subspecies was historically uncommon and was extirpated from this reach by 1940 (Bestgen and Platania, 1990). The last record of Rio Grande bluntnose shiner in the Rio Grande was the collection of a single individual in 1964 from near Peña Blanca (immediately downstream of present-day Cochiti Dam). Considerable sampling effort in the past 10 years failed to yield Rio Grande bluntnose shiner (S.P. Platania, pers. comm.) and the subspecies is believed extinct (Miller et al., 1989; Bestgen and Platania, 1990).

Pecos bluntnose shiner (*N. s. pecosensis*) historically occupied the Pecos River from near Santa Rosa downstream to the vicinity of Major Johnson Springs (now inundated by Brantley Reservoir)(Hatch et al., 1985). There is one purported record of its occurrence in the Pecos River in Texas during the 1850s, but Platania (1995b) cautioned against accepting this as a valid record. Currently, this shiner is found only in the Pecos River from about the U.S. 60 Highway Bridge near



Fort Sumner downstream to the inflow area of Brantley Reservoir (Brooks et al., 1991; Platania, 1995b). Within this reach, all age-classes tend to be more common upstream of the U.S. Highway 70 bridge (near Roswell) and collections in downstream reaches are numerically dominated by Age-0 specimens (Brooks et al., 1991). Abundance of the Pecos bluntnose shiner has declined considerably in the past 50 years (Platania, 1995b); since the late 1980s, its abundance has remained low but fairly constant across years (S.P. Platania, pers. comm.).

<u>BIOLOGY</u>

The Pecos River meanders through a broad valley between Old Fort State Park and Roswell. Substrates are largely shifting sand and small gravel. Habitat consists mainly of shallow runs; pools are uncommon (Tashjian, 1997). In these stream reaches, Pecos bluntnose shiners are generally in all available habitats. Larger individuals tend to be more common in more rapidly flowing water (> 40 cm/sec), but preferences for particular depths were not found (Hoagstrom et al., 1995).

The Pecos bluntnose shiner is a pelagic broadcast spawner; females release their non-adhesive, semi-buoyant eggs in the water column and males immediately fertilize them (Platania and Altenbach, 1998). After fertilizatiion, the eggs drift with the current. Elevated flow (spring runoff and storm events) is an environmental cue to initiate spawning. Development of eggs is rapid and larvae hatch in 24 to 48 hrs (Platania and Altenbach, 1998).

As protolarvae, Pecos bluntnose shiners drift with the current and in 4 to 8 days move into protected, low-velocity habitats. Larvae and juveniles tend to be most common in slow-velocity shoreline habitats and small embayments and backwaters. Hatch et al. (1985) reported that Pecos bluntnose shiner may live three years, but most individuals probably survive less than two years (S.P. Platania, pers. comm.). Most growth occurs in the first year of life; Hatch et al. (1985) reported mean standard lengths of 32.5 for Age 0, 45 for Age 1, and 56.5 mm for Age 2 individuals. At least two or three age-classes normally are found in the Pecos River between Old Fort State Park and Roswell whereas the population between Roswell and Brantley Reservoir typically is composed of Age-0 or -1 fish. Maturity is attained by Age 1. Hatch et al. (1985) reported an Age-2 female with >1000 maturing and mature eggs, but most of each year's reproductive effort is by Age-1 individuals that produce fewer eggs (<500)/female). Recent studies on Pecos River larval fish drift ecology suggest that the spawning season for Pecos bluntnose shiner extends from May through September, with individuals spawning with each spike in river flows (Platania and Altenbach, 1998). It is not known, however, if an individual spawns several times each season or just once.

Young Pecos bluntnose shiners probably feed mainly on zooplankton and small aquatic insects associated with low-velocity habitats. The simple gut, with two flexures, indicates that adult Pecos bluntnose shiners are mainly insectivorous (e.g., Griswold, 1963).

Pecos bluntnose shiners are often found in aggregations with other minnows. The most common associates of Pecos bluntnose shiner are native red shiner, Rio Grande shiner, and sand shiner and nonnative Arkansas River shiner, and plains minnow. Pecos bluntnose shiners are prey to several piscivores in the Pecos River including native flathead catfish and nonnative white bass (*Morone chrysops*) (Larson and Propst, 1996).

<u>STATUS</u>

The Pecos bluntnose shiner occurs in the Pecos River between Fort Sumner and the inflow of Brantley Reservoir; there is one questionable record of its occurrence in Texas (Patania, 1995b). It has not been reported or found in the Rio Grande in Texas (S.P. Platania, pers. comm.). Pecos bluntnose shiner is most common in the river between Old Fort State Park (near Fort Sumner) downstream to Roswell. In this reach, its abundance varies annually, largely in response to variable flow regimes. Pecos bluntnose shiner abundance (as a proportion of the shiner guild, comprising red shiner, sand shiner, Arkansas River shiner, and Pecos bluntnose shiner) ranged from about 2 to 8% between 1991 and 1994 (Platania, 1995a). Downstream of Roswell, Pecos bluntnose shiner abundance is low in most years, and rarely comprises more that 1% of the shiner guild. Most individuals found in this reach are Age-0 or -1, and probably dispersed from upstream reaches (Hoagstrom et al., 1995).

Several factors have contributed to the imperiled status of Pecos bluntnose shiner, but the most important appears to be seasonal dewatering of substantial reaches of its historic habitat. Reservoirs regulate flows in the reaches of the Pecos River occupied by Pecos bluntnose shiner. Under traditional reservoir operations, no water is released from reservoirs unless there is a downstream demand (to meet irrigation needs or fulfill interstate compact requirements). Irrigation return-flows and convectional storms usually provide sufficient water to maintain surface flows in most years. However, intermittent flow may occur in years with below average precipitation. Successive years of flow-intermittency, coupled with lack or paucity of flow spikes, can eliminate short-lived species, such as this shiner, from all or a significant portion of their ranges.

Range fragmentation and inundation of habitat by impoundments also have contributed to the decline of Pecos bluntnose shiner. It has been eliminated from the Pecos River upstream of Sumner Reservoir to Santa Rosa Dam. Habitat modification and altered thermal regime probably contributed to its extirpation from this stream reach. Sumner Dam and Reservoir now block upstream dispersal into formerly occupied habitat. Pecos bluntnose shiner historically inhabited the Pecos River downstream of Lake McMillan in the vicinity of Major Johnson Springs (near Carlsbad). The breaching of McMillan Dam and filling of Brantley Reservoir inundated Major Johnson Springs and thus caused the extirpation of this downstream population.

River channel modification as a consequence of canalization, flow manipulations, and encroachment of nonnative woody plant species (mainly tamarisk, *Tamarix pentandra*) has reduced the suitability of some stream reaches for Pecos bluntnose shiner, particularly downstream of Artesia. Pecos bluntnose shiner is rare or absent where the river channel is incised and characterized by deep, high velocity runs.

Water quality has been degraded in several stream reaches of the Pecos River, particularly downstream of Hagerman (Schmitt and Brumbaugh, 1990; Schmitt et al., 1990). Effects of reduced water quality on Pecos bluntnose shiner have not been determined.

Predation and competition from nonnative species was suggested as a factor in the decline of Pecos bluntnose shiner (USFWS, 1987). Predation was believed to be of greatest concern during periods of flow intermittency when fish are concentrated in isolated pool habitats (Lang et al., 1995). Predation by native and nonnative fishes on Pecos bluntnose shiner has been confirmed, but the effect during periods of intermittent flow has not been characterized (Larson and Propst, 1996). Two potentially competitive nonnative cyprinids have been established throughout the current range of Pecos bluntnose shiner. Arkansas River shiner was apparently introduced into the Pecos River in the late 1970s and subsequently spread downstream to Brantley Reservoir (Bestgen et al., 1989). It is frequently found with, and in many areas is more common than, Pecos bluntnose shiner (Hoagstrom et al., 1995), but its effect has not been determined. Plains minnow also was established in the Pecos River in the late 1970s near Sumner Reservoir and spread rapidly downstream to Brantley Reservoir (Bestgen et al., 1989; Bestgen and Platania, 1991; Hoagstrom et al., 1995). Although this species was implicated in the elimination of Rio Grande silvery minnow from the Pecos River (Cook et al., 1992), its effect on Pecos bluntnose shiner is unknown.

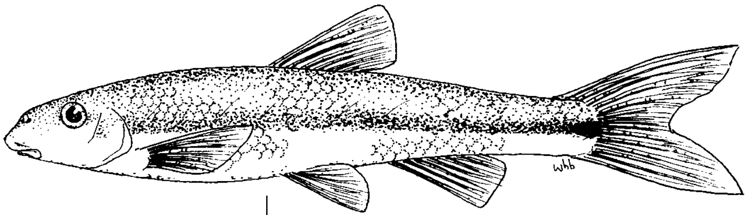
CONSERVATION

The Pecos Bluntnose Shiner Recovery Plan identifies several measures necessary to protect extant populations of the species and recommends actions for its recovery (USFWS, 1987). Considerable information has been obtained on the biology and habitat of the species under the auspices of a multi-agency five-year research program (1992 through 1997). Maintenance of a semi-natural flow regime, with spring runoff and summer flow spikes and avoidance of large "block" reservoir releases during the summer, is essential to the survival of extant populations. Partially in recognition of the importance of semi-natural flow regimes, agencies responsible for natural resource management in the Pecos River (U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, New Mexico Department of Game and Fish, New Mexico State Engineer's Office, and Carlsbad Irrigation District) entered a cooperative agreement that enables investigation of the life history requirements of Pecos bluntnose shiner, identification of seasonal flow needs of the species, evaluation of the effects of nonnative fish species (predation and competition), evaluation of flow delivery efficiencies, and manipulation of flows to improve water quality. The goal of this cooperative effort is to conserve the Pecos bluntnose shiner and the native fish community of the Pecos River and to concurrently ensure delivery of water to water-rights holders in the Pecos River valley. ♦

Suckermouth Minnow

Phenacobius mirabilis

(Girard, 1856)



LISTING STATUS

The suckermouth minnow, *Phenacobious mirabilis*, was listed as threatened in New Mexico (19 NMAC 33.1) in 1975.

CHARACTERISTICS

The suckermouth minnow is a comparatively large (up to 100 mm TL), terete minnow. It is straw-yellow to olive dorsally, grayish to silvery laterally, and silvery to white ventrally (Becker, 1983). A distinct black spot is present at the base of the caudal fin and a dusky lateral band extends the length of the body across the eye and onto the snout (Etnier and Starnes, 1993). The snout is blunt and the subterminal mouth and prominent lateral lobes of the lower lip give the mouth its sucker-like appearance. Breeding males have minute tubercles on anterior dorso-lateral surfaces and ventral fins; females also are tuberculate during spawning, but less so than males. Scales are lightly outlined with melanophores (particularly dorsally) and there are 43 to 51 scales in the lateral series. There are 8 dorsal, 14 pectoral, 8 pelvic, and 7 anal fin rays. The pharyngeal dentition formula is 0,4-4,0 (Becker, 1983).

DISTRIBUTION

Suckermouth minnow occurs throughout much of the central and lower Mississippi River system, including the Missouri and Ohio river drainages (Becker, 1983) and rivers tributary to the Gulf of Mexico in Texas (Hubbs et al., 1991). In the central portion of its range it often is common in suitable habitat (Miller and Robison, 1973). In New Mexico, the native range of suckermouth minnow includes only the South Canadian and Dry Cimarron rivers. The species there has a discontinuous distribution and is generally rare (Sublette et al., 1990; NMGF files). It has been introduced to the Pecos River (probably via bait bucket) and a few individuals are irregularly collected near Fort Sumner (J.E. Brooks, pers. comm).

BIOLOGY

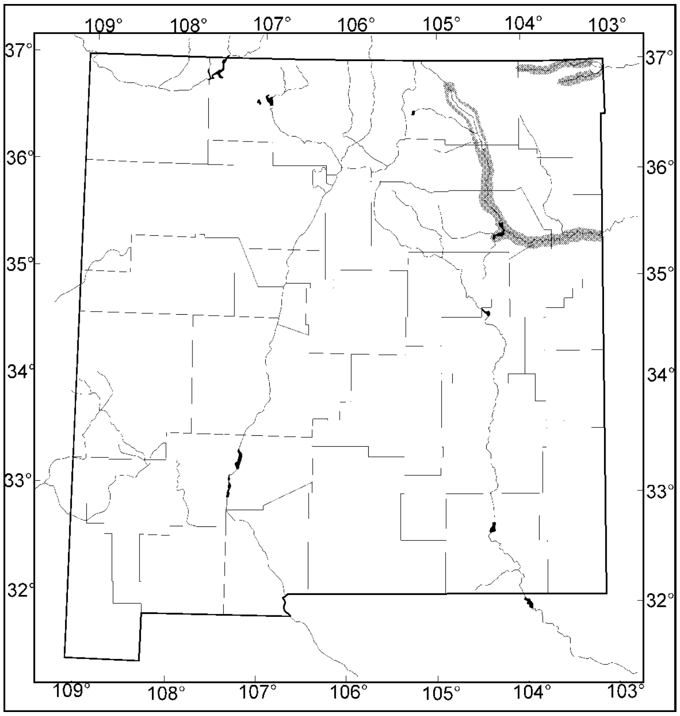
Suckermouth minnow most commonly occupy shallow to moderately deep (0.1 to 1.0 m), sand and gravel-bottomed riffles of low to moderate gradient, meandering streams (Minckley, 1959; Deacon, 1961; Becker, 1983). Minckley (1959) noted that it occurred where sand and gravel were clean, but both Miller and Robison (1973) and Becker (1983) noted its tolerance to elevated turbidity. In the Big Blue River basin of Kansas, juvenile suckermouth minnows were usually found in backwaters (Minckley, 1959).

Cross and Collins (1975) reported a reproductive season extending from April through August in Kansas, but Becker (1983) noted that spawning in Wisconsin was mainly during July and August. Spawning occurs when water temperature is 14 to 25°C (Cross, 1950). Fecundity is moderately high; Becker (1983) reported a 90 mm TL female having 1,640 mature eggs. Spawning habitat is unknown, but presumably is in the sand-gravel riffles occupied by adults.

Suckermouth minnows grow rapidly their first summer of life, attaining lengths of 40 to 50 mm TL by autumn (Becker, 1983). Thereafter, growth rate diminishes and Age-3 individuals average 90 mm by late summer-early autumn. The minnow is mature at Age 2 and may live 36 to 45 months (Becker, 1983; Etnier and Starnes, 1993).

Suckermouth minnows feed among the sand and gravel of riffles (Pflieger, 1975) and consume mainly aquatic dipteran larvae (Starrett, 1950). They also may consume detritus and plant material (Becker, 1983).

Over its wide range, the suckermouth minnow is associated with a variety of riffle-dwell-



ing cyprinids, catostomids, and percids (e.g., Becker, 1983). In New Mexico, it is found in stream reaches and habitats occupied by longnose dace (*Rhinichthys cataractae*), flathead chub, central stoneroller (*Campostoma anomalum*), and sand shiner (Sublette et al., 1990; NMGF files).

STATUS

Although suckermouth minnow remains comparatively common in much of its range (e.g., Miller and Robison, 1973), it has declined locally in abundance where habitats and stream flows have been modified to its detriment. Cross et al. (1985) reported its decline in the Cimarron River in Kansas and Propst and Carlson (1986) found its range reduced in the South Platte River in Colorado. Robison and Buchanan (1988) commented upon its rarity in Arkansas and stated that its decline there could not be attributed to a specific factor. Collection records for New Mexico are limited (Sublette et al., 1990); based upon these, the minnow occurs irregularly in the South Canadian River upstream of Conchos Reservoir and the lower Dry Cimarron. It is found rarely in either system (NMGF files).

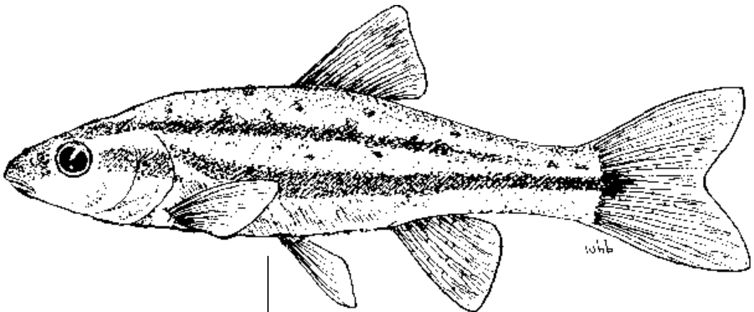
CONSERVATION

Limited information on the status of suckermouth minnow in New Mexico coupled with an overall paucity of data on its life history make determination of measures needed to conserve it in the state difficult. Systematic surveys to determine its current distribution and status and studies to characterize its biology are needed. Based upon this information, potential threats to its persistence can be identified and efforts to ensure survival of suckermouth minnow in New Mexico initiated. ♦

Southern Redbelly Dace

Phoxinus erythrogaster

(Rafinesque, 1820)



LISTING STATUS

The southern redbelly dace, *Phoxinus erythrogaster*, was listed by New Mexico as an endangered species (19 NMAC 33.1) in 1975.

CHARACTERISTICS

The southern redbelly dace is a comparatively thick-bodied, but fusiform, fish that rarely exceeds 80 mm TL (Etnier and Starnes, 1993). The head is elongate and the small, slightly oblique mouth is terminal. The dace is olivaceous dorsally. There are two dark lateral bands separated by a creamy area; the most-dorsal band is narrower than the mid-lateral band. The mid-lateral band extends through the eye onto the snout. A small dark spot is usually present at the base of the caudal fin and small black flecks are sprinkled over dorso-lateral surfaces. Male southern redbelly dace are among the most colorful of New Mexico's native fishes. They are intensely colored with the dorso-lateral bands sharp black, the area between the bands is bright gold, and ventral areas are brilliant red. The fins are bright yellow with white margins. Reproductively ripe females are less intensely colored than males; they are reddish above the pelvic fins and at the base of the pectoral fins. Cranial areas of males are densely covered with small tubercles and tubercles are present on anterior portions of the body (including fins). Females are less tuberculate than males (Robison and Buchanan, 1988). The lateral line is incomplete, ending over the pelvic fin. Scales are minute and 70 to 90 are in the lateral series. The caudal fin is moderately forked and its lobes are broadly rounded. There are 8 dorsal, 14 or 15 pectoral, 8 pelvic, and 8 anal fin rays (Phillips, 1969a; Hill and Jenssen, 1968). The pharyngeal dentition formula is 0,5-5,0 (Robison and Buchanan, 1988).

DISTRIBUTION

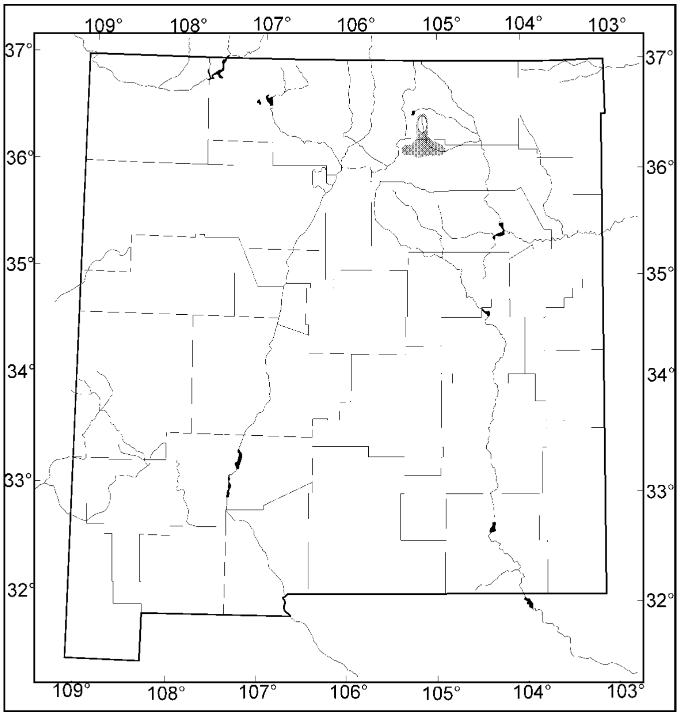
The southern redbelly dace naturally occurs in the upper Mississippi drainage, Great Lakes drainages, Ohio River drainage, and middle Mississippi River drainages (Becker, 1983; Cross et al., 1986). Disjunct populations occur in Kansas (Cross and Collins, 1975), Oklahoma (Miller and Robison, 1973), Arkansas (Robison and Buchanan, 1988), Colorado (Woodling, 1985), and New Mexico (Sublette et al., 1990). It often is common in suitable habitat.

Southern redbelly dace in New Mexico are limited to headwaters of the Mora River, particularly Coyote Creek, and tributaries to Black Lake (Sublette et al., 1990). They are comparatively common in spring and spring-run habitats, but are rare in stream habitats within the limited New Mexico range of the species (J.S. Pittenger, pers. comm.).

BIOLOGY

Southern redbelly dace are primarily a spring, spring-run, and small stream dwelling fish. They are most common in low-gradient habitats where water is cool and clear, and aquatic vegetation is abundant (Becker, 1983). Although they prefer pools with low velocity to still water, southern redbelly dace are occasionally found in aggregations in more rapidly flowing water. Undercut banks provide cover for southern redbelly dace; if undercut banks are not present, the species congregates in the center of pools when frightened (Becker, 1983).

Becker (1983) reported that spawning began in May in Wisconsin, but Miller and Robison (1973) found that spawning began in April in Oklahoma and Etnier and Starnes (1993) reported a reproductive season of April through July in Tennessee. Populations in New Mexico probably have a similar spawning season to those in Oklahoma and Tennessee. Spawning occurs over areas with small clean gravel or in abandoned nests of other fish species (e.g., creek chub, *Semotilus*



atromaculatus). Males congregate in spawning areas, a female enters the area from downstream, and is attended by two males. The males press the female to the gravel substrate, numerous males may participate in the spawning act (Etnier and Starnes, 1993). No aggression among males has been noted; competition generally is limited to efforts to gain position next to a ripe female (Becker, 1983).

Phillips (1969b) estimated total fecundity of 7,000 to 20,000 eggs per female, depending upon size and age. Settles and Hoyt (1978), however, found that most females contained only about 300 mature eggs at any time and Etnier and Starnes (1993) estimated that an individual female probably produces somewhat more than 1000 eggs per spawning season.

Fertilized eggs apparently develop among the gravel in which they are laid. In Tennessee, southern redbelly dace are about 38 mm TL by their first autumn (Age 0) and average 51 and 64 mm by autumn as Age-1 and -2 individuals, respectively (Settles and Hoyt, 1976). Age-1 individuals longer than 50 mm are mature, but those shorter than 50 mm are not (Becker, 1983). Based upon scale analyses, Becker (1983) determined that southern redbelly dace may live about 36 months.

Southern redbelly dace feed almost exclusively upon microscopic plant material, particularly diatoms (Phillips, 1969c); animal material represented a small proportion of stomach contents. The dace feeds by "nibbling or sucking the surface slime from stones and other objects on the bottom" (Forbes and Richardson, 1920). Phillips (1969c) reported that greatest feeding activity occurred during midday.

In the central portion of its range, southern redbelly dace typically are found with other spring and small stream fishes such as creek chub and central stoneroller and shiner species (*Notropis* spp) (Becker, 1983; Etnier and Starnes, 1993). In New Mexico, creek chub and central stoneroller occur within the Mora River drainage, but neither is regularly found in the same habitats as those occupied by southern redbelly dace. Nonnative brown trout (*Salmo trutta*) is, however, found in habitats (particularly Coyote Creek) occupied by southern redbelly dace (J.S. Pittenger, pers. comm.).

<u>STATUS</u>

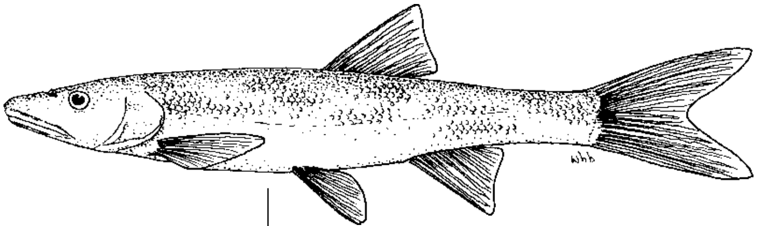
Southern redbelly dace has a very limited range in New Mexico. However, in suitable, unmodified habitat it is locally common. Although southern redbelly dace has persisted with a nonnative predator (brown trout) in Coyote Creek, the future of this population is uncertain.

<u>CONSERVATION</u>

The limited range of southern redbelly dace in New Mexico imposes a vulnerability on the species. Excessive groundwater pumping may lower spring levels to the detriment of the species. Sedimentation of spring and creek habitats reduces food availability and destroys spawning habitat. Nonnative predators, such as brown trout, may reduce its abundance in the small habitats it currently occupies. Security of the New Mexico populations of southern redbelly dace depends upon maintenance of spring and small stream habitats free of sedimentation and nonnative predators. ♦

Colorado Pikeminnow

Ptychocheilus lucius
(Girard, 1856)



LISTING STATUS

Colorado pikeminnow, *Ptychocheilus lucius*, was listed by New Mexico as endangered (19 NMAC 33.1) in 1975 and federally it is listed as endangered (USFWS, 1967). The Navajo Nation lists the species as endangered (Group 2) (NFWD, 1997). The species also receives protection by all states in which the species formerly or currently occurs and is considered an endangered species by the American Fisheries Society (Williams, et al., 1989). The common name of *Ptychocheilus lucius* was recently changed from Colorado squawfish to Colorado pikeminnow (Nelson et al., 1998).

CHARACTERISTICS

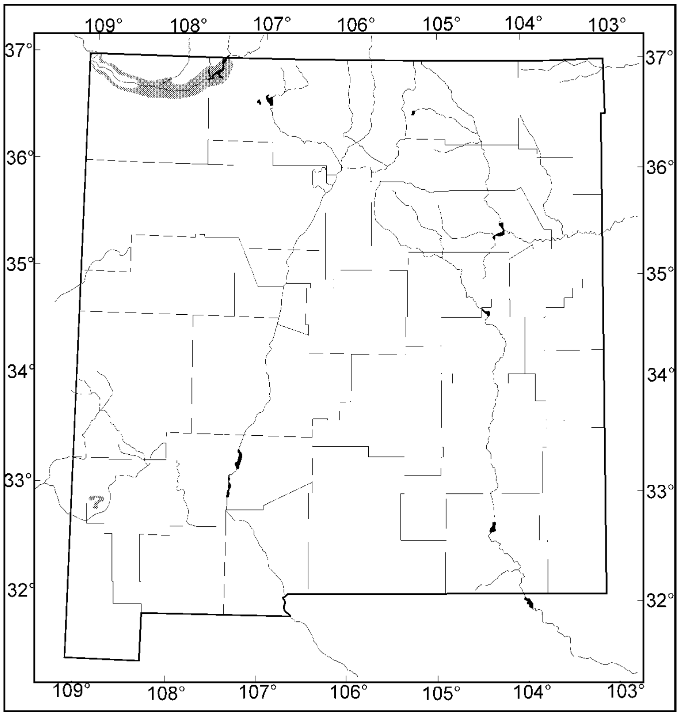
The Colorado pikeminnow is the largest native member of the minnow family (Cyprinidae) in North America (Miller, 1961; Behnke and Benson, 1980), growing to lengths in excess of 1.8 m and weights of 45 kg or greater (Minckley, 1973). It is an elongate, torpedo-shaped fish with a large terminal mouth and comparatively small eyes. The head is broad and flattened dorsally, and the maxillary extends backwards to at least the middle of the eye. Colorado pikeminnows are olive to dark green dorsally, straw yellow to light olive laterally, and silvery-white ventrally. Reproductively ripe males are densely tuberculated on the head and have a bronze coloration (Seethaler, 1978). Young Colorado pikeminnow ($\leq$ 200 mm TL) are silvery and have a diffuse wedge-shaped basicaudal spot. The lateral line is concave and there are 84 to 93 lateral line scales. The pharyngeal arch is large and the dentition formula is 2,5-4,2.

DISTRIBUTION

The Colorado pikeminnow is endemic to the Colorado River drainage from its mouth in Baja California upstream to southern Wyoming. It historically occupied all of the larger rivers of the drainage and was sufficiently abundant during the early 1900s to be commercially harvested from the Salt River near Phoenix, Arizona (Minckley, 1973). Minckley (1973) also provided accounts of several "old-timers" who attested to its abundance in much of the lower Colorado River basin (the division of the upper and lower Colorado River basins is Lee's Ferry, Arizona), but by the 1930s and 1940s it was rarely caught. A similar decline of Colorado pikeminnow abundance in the upper basin is revealed in "old-timer" accounts and agency records (Quartarone, 1993). The species was apparently extirpated from the lower Colorado River basin by the late 1960s (Minckley, 1973; Minckley and Deacon, 1968).

Colorado pikeminnows persist in several areas of the upper Colorado River Basin, with the largest population in the Green River, Utah (Holden and Stalnaker, 1975). Other upper basin populations occur in the Yampa and Little Snake rivers in Colorado (Tyus and Karp, 1989; Wick et al., 1991), the Colorado and Gunnison rivers in Colorado (Tyus and McAda, 1984; Osmundson and Kaeding, 1989), and the San Juan River in New Mexico, Colorado, and Utah (Minckley and Carothers, 1980; Platania et al., 1991).

Although the Colorado pikeminnow was never recorded from the Gila River in New Mexico, its occurrence in the river at Fort Thomas, Arizona (Kirsch, 1889) prompted LaBounty and Minckley (1972) to speculate that it might have seasonally entered the New Mexico portion of that stream. Jordan (1891) reported local accounts of Colorado pikeminnow in the San Juan River, but the earliest specimen documentation in New Mexico was that of Koster (1960). Just prior to closure of Navajo Dam on the upper San Juan River, Olson (1962) found the fish in the reach to be inundated by Navajo Reservoir. During extensive surveys of the San Juan River between 1987 and 1989, persistence of and reproduction by Colorado pikeminnow in the San Juan River was documented (Platania et al., 1991). Subsequent surveys confirmed a small, reproducing population of the species, apparently concentrated in the river reach between Shiprock, New Mexico and the Four Corners area



(Ryden and Pfeifer, 1996; Miller, 1995). Radiotelemtry studies confirmed concentration of the population in this 40 km river reach (Ryden and Ahlm, 1996).

BIOLOGY

The Colorado pikeminnow inhabits mainly the larger rivers of the Colorado River system (Tyus, 1991) and is adapted to life in highly variable systems with extremes in flow and turbidity (Tyus, 1990). Adults are found in a variety of water velocities, at a variety of depths, and over a variety of substrates (Holden and Wick, 1982). Seasonal habitat use by adults varies and is influenced by flow volume, water temperature and habitat availability (Holden and Wick, 1982; Tyus, 1990). During high flows associated with spring runoff, adults often are found in backwaters and flooded bottomlands (Tyus and Karp, 1989). With recession of spring runoff, adults return to the main channel and some mature individuals congregate near the mouths of tributaries, which may serve as staging areas prior to spawning migrations (Ryden and Ahlm, 1996). In response to a complex combination of endogenous factors and environmental stimuli, many adult Colorado pikeminnow make migrations to specific river reaches to spawn (Tyus and Karp, 1989, Tyus, 1990; McAda and Kaeding, 1991). Movement of individual fish of ≥300 km have been associated with spawning migrations (Tyus, 1985; 1986). Although directional movement of Colorado pikeminnow to spawning areas was noted for San Juan River fish, the distance moved was generally < 25 km (Ryden and Ahlm, 1996).

Spawning by Colorado pikeminnow occurs near the end of spring runoff recession, usually between late June and mid August when water temperatures are between 18 and 25°C (Vanicek and Kramer, 1969; Tyus, 1990), and peak spawning activity occurs between 22 and 25°C. Spawning areas are a complex of deep pools, eddies, and rapid velocity water (40 to 80 cm/sec) over cobble substrates (Tyus and Karp, 1989; Miller, 1995). The slower-velocity portions of such areas are apparently used for resting and feeding and spawning occurs over cobble substrate in rapid velocity water (Tyus and Karp, 1989).

The incubation period for Colorado pikeminnow embryos is about 102 h at 20°C (Marsh, 1985). Larvae emerge from spawning bars after a 6- to 10-day incubation (Haynes et al., 1984). Larvae are entrained in the current and drift downstream to nursery areas (Tyus and Haines, 1991). Backwaters and embayments are the primary nursery areas of larval Colorado pikeminnow (Haynes et al., 1984; Haines and Tyus, 1990). Survival and growth of larval Colorado pikeminnow are temperature dependent; growth is optimal at temperatures >25°C (Bestgen, 1996). In nursery areas, the diet of young Colorado pikeminnow (20 to 40 mm TL) is mainly zooplankton and aquatic insect larvae (Muth and Snyder, 1995).

Colorado pikeminnows grow rapidly their first years of life, attaining total lengths of 550 mm or more by Age 10 (Osmundson et al., 1996). Thereafter, growth rates decline. Annual growth increments are influenced by food availability and water temperature (Kaeding and Osmundson, 1988). Maturity is attained by males when they are about 555 mm, but females are not mature until they are about 650 mm TL (Tyus, 1990).

Colorado pikeminnows begin consuming fish at sizes as small as 30 mm TL (Muth and Snyder, 1995) and become progressively more piscivorous with age. As adults, Colorado pikeminnows are almost exclusively piscivores (Vanicek and Kramer, 1969) and feed upon most native and nonnative species of fishes present (Holden and Wick, 1982). Tyus and Minckley (1988) reported Colorado pikeminnow feeding on Mormon crickets (*Anabrus simplex*) during an outbreak of that terrestrial invertebrate.

In the large rivers of the Colorado River system, Colorado pikeminnows historically are associated with other "big river" species such as bonytail (*Gila elegans*), humpback chub, roundtail chub, razorback sucker (*Xyrachen texanus*), flannelmouth sucker, bluehead sucker, and speckled dace (Tyus et al., 1982). A large number of nonnative fish species have been introduced and established in the rivers and reservoirs of the Colorado River system (Minckley, 1973; Tyus et al., 1982) and several have contributed to the imperiled status of the Colorado pikeminnow. Among these, channel catfish, red shiner, and several centrarchid species (*Lepomis* spp.) have been implicated in the decline of Colorado pikeminnow (Karp and Tyus, 1990a; Haines and Tyus, 1990).

STATUS

The Colorado pikeminnow has declined throughout its historic range. The species was extirpated from the lower Colorado River basin by the early 1960s (Minckley, 1973) and it now is limited mainly to three areas in the upper Colorado River basin. Among the three primary areas of occurrence it is comparatively common only in the Green-

Yampa River system of northwestern Colorado and northeastern Utah (Tyus, 1990; Tyus, 1991). In the Grand Valley of western Colorado, a reproducing population of Colorado pikeminnow occurs in the Colorado and lower reaches of the Gunnison rivers (Osmundson and Kaeding, 1989; Osmundson and Burnham, 1996). A small population of Colorado pikeminnow persists in the San Juan River of northwestern New Mexico and southeastern Utah (Platania et al., 1991; Ryden and Ahlm, 1996). In the lower Colorado River basin, efforts to re-establish Colorado pikeminnow in the Salt and Verde rivers (Brooks, 1986) have been marginally successful (K. Young, pers. comm.).

Intensive sampling of the San Juan River in New Mexico and Utah has documented a small, reproducing population (probably < 200 adults) centered in the reach between Shiprock, New Mexico and Four Corners (Platania et al, 1991; Ryden and Ahlm, 1996). Reproduction has been documented for several years since 1987 (Archer et al., 1996) and recruitment to the adult population was documented in 1996 (D. Ryden, pers. comm.).

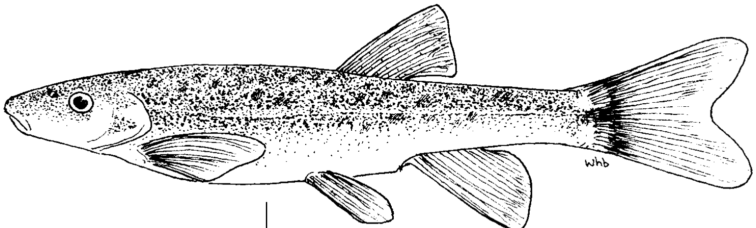
CONSERVATION

The Colorado pikeminnow has declined as a consequence of extensive habitat modifications of the rivers of the Colorado River basin and the introduction of numerous nonnative fish species (USFWS, 1991b). Native fish eradication efforts during the 1950s and early 1960s at least locally diminished populations of Colorado pikeminnow, also (Holden, 1991). Mainstem impoundments interrupt and regulate flows thereby depriving Colorado pikeminnow of essential habitats, blocking migration pathways, and extinguishing environmental cues for the initiation of critical life processes (e.g., spawning) (Tyus, 1984; Tyus, 1986; McAda and Kaeding, 1991). Kaeding and Osmundson (1988) speculated that depressed water temperatures contributed to the decline of Colorado pikeminnow in much of the upper Colorado River basin. Nonnative fishes may compete with Colorado squawfish for resources and habitat (Karp and Tyus, 1990a) or prey upon them (Nesler, 1992). Instances of Colorado pikeminnow choking on channel catfish have been reported (McAda, 1983). In addition to loss of habitat and environmental cues, modified flow regimes may enhance conditions for nonnative fishes to the detriment of native fishes (Gido et al., 1997; Gido and Propst, in press). The potential impacts of environmental contaminants such as heavy metals and pesticides on different life stages of Colorado pikeminnow, particularly eggs and larvae, have just begun to be investigated (Hamilton and Buhl, 1996).

In the upper Colorado River basin, most efforts to conserve and recover Colorado pikeminnow are conducted under the auspices of two recovery implementation programs that have dual goals of conserving endangered species while enabling water development to continue (Wydoski and Hamill, 1992). Efforts to recover the New Mexico population of Colorado pikeminnow are under the purview of the "San Juan River Basin Recovery Implementation Program" to which several federal agencies, the states of New Mexico and Colorado, and several Indian tribes are signatory (USFWS, 1990). The "San Juan River Basin Recovery Implementation Program" currently is conducting a variety of investigations (e.g., fluvial dynamics characterizations, native-nonnative interactions, effects of various flow regimes on different life stages of native and nonnative fishes, nutrient dynamics, and habitat dynamics) to characterize the factors that limit Colorado pikeminnow abundance in the basin and to recommend and implement methods by which the species may be conserved (USFWS, 1997). A basic premise of this program has been that mimickry of the natural hydrograph will enhance reproduction and recruitment of Colorado pikeminnow. Success of the "San Juan River Basin Recovery Implementation Program" will depend in part upon concurrently satisfying increasing demands for the limited water resources of the basin and providing the needs of the native fish community. ♦

Loach Minnow

Tiaroga cobitis
(Girard, 1856)



LISTING STATUS

The loach minnow, *Tiaroga cobitis*, was listed by New Mexico as a threatened species (19 NMAC 33.1) in 1975. It is federally listed as a threatened species (USFWS, 1986b). In Arizona it is listed as a species of special concern (AZGF, 1996) and it is considered a threatened species by the American Fisheries Society (Williams et al., 1989). Critical habitat for loach minnow was revoked in 1998 (USFWS, 1998a).

CHARACTERISTICS

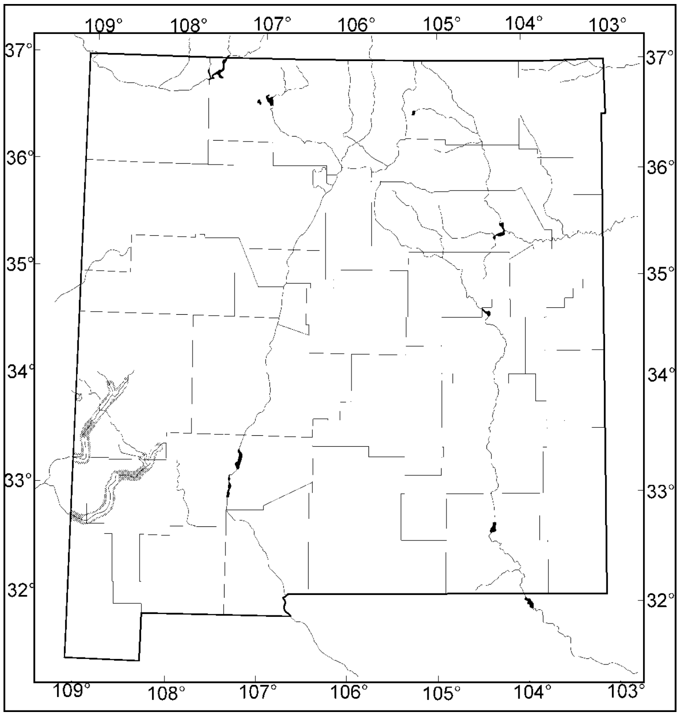
The loach minnow is a small, elongate and slightly dorso-ventrally flattened species that rarely exceeds 60 mm TL (Minckley, 1973; Propst et al., 1988). Dorsally and laterally, the coloration is mottled grayish-brown to olive and ventrally it is cream white. Two diffuse cream-white spots are present at the base of the caudal fin. The lips and abdomen of nuptial males are intense ruby-red and the bases of paired fins are red to red-orange. Breeding females have yellowish-orange paired fins and yellowish abdomens. During the spawning season the dorso-lateral mottling of both sexes is more intense and the dorsal surface of males is almost black (Minckley, 1965). Breeding males have minute tubercles on the head, fins, and caudal peduncle; females may have a few tubercles on the top of the head. The loach minnow has a small, obliquely oriented terminal mouth. The comparatively large eyes are dorsally located on the broadly flattened head. The lateral line is almost straight and there are 61 to 65 scales in the lateral series (Sublette et al., 1990). The fins are distally rounded or ovoid in shape; the pectoral fins have 12 to 14 rays, the pelvic 7 or 8, and the anal has 7 rays. The pharyngeal dentition formula is 1,4-4,1.

DISTRIBUTION

The loach minnow is endemic to the upper Gila River drainage of southwestern New Mexico, southeastern and east-central Arizona, and northeastern Sonora (Miller and Winn, 1951; Koster, 1957; Minckley, 1973). In Arizona, it historically occurred in the Gila River upstream of the confluence of the Agua Fria and in the Salt, Verde, San Pedro, San Francisco, and Blue rivers (Minckley, 1973). The only known location of loach minnow in Mexico was the uppermost reaches of the San Pedro River in extreme northern Sonora (Miller and Winn, 1951). The minnow was found throughout the San Francisco and Gila rivers in New Mexico, as well as lower elevation reaches of several tributaries (Koster, 1957; Propst et al., 1988).

The Loach minnow has apparently been extirpated from the San Pedro River in Sonora (Rinne and Minckley, 1991). In Arizona, it persists in Aravaipa Creek (Barber and Minckley, 1966), Eagle Creek (Marsh et al., 1991; Knowles et al., 1995), the upper reaches of the White River (Propst, et al., 1985), North Fork of East Fork Black River (Bagley et al., 1996), and Blue River (Minckley, 1973). Among these areas, it is comparatively common only in Aravaipa Creek (Rinne and Minckley, 1991), although it may be locally common in portions of the Blue River (Propst et al., 1988).

In New Mexico, loach minnow persists in the lower reaches of the Tularosa River, San Francisco River from near Reserve downstream to the Arizona/New Mexico border, the uppermost reaches of Dry Blue Creek (a Blue River tributary), the confluence area of the West, Middle, and East forks Gila River, and in the Cliff-Gila Valley reach of the Gila River. Loach minnow is generally absent downstream of the Cliff-Gila Valley (Propst et al., 1988; Propst and Bestgen, 1991). Among these areas, loach minnow is comparatively common only in about a 5-km reach of the Tularosa River, the San Francisco River near Glenwood, and the West Fork Gila River near Gila Hot Springs. In optimal habitat in these stream reaches, loach minnow density is usually about 5 individuals/ $10m^2$ and rarely exceeds $10/10m^2$ (Propst and Bestgen, 1991). Elsewhere in the Gila and San Francisco River drainages, it is rare or occurs irregularly.



BIOLOGY

The loach minnow is a cryptic species that is found almost exclusively among the cobble of riffles where the water velocity is moderate to rapid (Propst and Bestgen, 1991). Its large pectoral fins, reduced air bladder, and small scales adapt it to a life in rapid velocity water. Barber and Minckley (1966) observed that in riffle habitats in Aravaipa Creek in Arizona loach minnows were seasonally associated with filamentous algae, but Propst and Bestgen (1991) did not note such an association among New Mexico populations. Significant ontogenetic shifts in riffle habitat use were reported by Propst and Bestgen (1991). Eggs were found in water velocities averaging 32.0 cm/sec, but upon hatching larvae moved to riffle margins where the water velocity averaged 7.3 cm/sec. As individuals grew, they moved to more rapid-velocity water and as adults were found in water averaging 57.3 cm/sec. Rinne (1989) reported seasonal differences in water velocities of habitats occupied by loach minnow, but no pattern was apparent. Although significant differences were found among water depths occupied by each life stage, occupied depths by all life stages were between 0.10 and 0.25 m (Propst and Bestgen, 1991). All life stages were strongly associated with large gravel and cobble (Rinne, 1989; Propst and Bestgen, 1991). Where sand and silt filled the interstitial space among gravel and cobble in riffles, loach minnows were rare or absent (Propst et al., 1988).

Most reproduction by loach minnows in New Mexico occurs during a 4 to 6 week period in the spring when water temperatures are 16 to 20°C (Britt, 1982; Propst and Bestgen, 1991). Vives and Minckley (1990), however, documented autumn spawning by loach minnow in Aravaipa Creek, Arizona. Runoff volume (spring snowmelt or late-summer/early-autumn storms), timing, and duration probably influence the specific time of spawning (Propst and Bestgen, 1991).

The adhesive eggs of loach minnow are deposited in a single layer on the undersides of flattened rocks that are slightly elevated from the stream bottom (Britt, 1982; Propst and Bestgen, 1991). Flowing water is apparently important to egg survival as many eggs deposited on rocks in slow-velocity water (<5 cm/sec) were dead (Propst and Bestgen, 1991). Based upon the number of eggs deposited on rocks, clutch size ranged from 40 to 100. Examination of individuals, however, indicated that Age 1 females annually produce about 145 eggs and Age 2 produce between 160 and 300 (Propst and Bestgen, 1991). Most reproductively active females are Age 1. At water temperatures between 18 and 20°C, eggs hatch in 4 to 5 days and larvae average 5.4 mm TL at hatching.

Following hatching, growth of Age 0 loach minnows is rapid and by autumn individuals average 30 mm SL. Loach minnows grow little, if any, during winter. By the end of their second growing season, Age 1 fish average 48 mm SL. The maximum size reported by Propst and Bestgen (1991) was a 56 mm SL female (Age 2) and a 62 mm SL male. Populations of loach minnow are usually comprised of two or three age-classes; prior to spawning a typical population consists of Age 1 (ca. 70 %), Age 2 (ca. 25 %) and a few Age 3 (<5 %) individuals. After spawning (June through October), most populations have mainly Age 0 (ca. 70 %) and Age 1 (ca. 30 %) fish (Propst and Bestgen, 1991). Few loach minnow survive more than 24 months and spawning appears to be followed by high mortality of all breeding fish, particularly Age 2 individuals.

Loach minnows feed almost exclusively on aquatic insects that also inhabit their riffles. Larvae and juveniles consume mainly chironomid larvae and ephemeropteran nymphs. In addition to these food items, adult loach minnows eat plecopteran, trichopteran, and simuliid larvae (Schreiber and Minckley, 1981; Propst and Bestgen, 1991). Ephemeropteran nymphs were important food items throughout the year while dipteran larvae were consumed mainly in winter months.

The range of loach minnow historically overlapped that of at least six other native fishes (Minckley, 1973; Sublette et al., 1990). Among these, however, it probably regularly encountered only three. Speckled dace also inhabits riffles, but commonly is found in the water column whereas loach minnow is benthic. Small (75 to 150 mm TL) desert suckers share riffle habitats with loach minnows and small Sonora suckers are common near riffle shorelines. Other historically common native fish species (longfin dace, roundtail chub, and spikedace,) occupied habitats different from that of loach minnow (Rinne, 1992).

At least 15 nonnative fish species have been reported in the New Mexico portion of the range of loach minnow (Propst et al., 1988) and a similar or greater number occur in its historic Arizona range (W.L. Minckley, pers. comm.). Among nonnative fishes, ictalurids are believed to have the greatest potential to interact negatively (USFWS, 1991c). The omnivorous channel catfish feeds in riffles and at least occasionally consumes loach minnows (D.A. Hendrickson, pers.

comm.). The flathead catfish is mainly a piscivore and begins consuming fish at an early age. Where these two species are present in the Gila-San Francisco Drainage in New Mexico, loach minnows are rare or absent (NMGF files). Over the past five years, yellow bullheads have become common in the lower Middle Fork Gila River and loach minnows have declined considerably in abundance (NMGF files). Although red shiner is believed to have contributed to the decline of other native southwestern fishes (e.g., Minckley and Carufel, 1967; Minckley and Deacon, 1968; Douglas et al., 1994), its impact on loach minnow is uncertain; Marsh et al. (1989) found that the habitats of the two species were so different that competitive displacement did not appear to be the mechanism by which red shiner had replaced loach minnow. Red shiners are not present, however, in stream reaches in New Mexico where loach minnows remain comparatively common (NMGF files).

STATUS

The loach minnow has been eliminated from at least 80% of its historic range (Minckley, 1973; Propst et al., 1988; USFWS, 1991c). In Arizona, it remains comparatively common only in Aravaipa Creek and portions of the Blue River. In New Mexico, greatest densities of loach minnow are in about 5 km of the Tularosa River, the San Francisco River near Glenwood, and the West Fork Gila River near Gila Hot Springs (Propst et al., 1988; NMGF files). In the early to late 1980s, the loach minnow was moderately common and widespread in the Cliff-Gila Valley, but it now is rare in the lower half (NMGF files).

Annual sampling of the fish community at six permanent study sites in the historic New Mexico range of loach minnow indicates that the status of the species has eroded in the past 10 years (NMGF files). When study sites were selected in 1987, loach minnow was moderately common at those on the Tularosa, San Francisco, West Fork Gila, and Gila rivers, uncommon at the Middle Fork Gila River site, and rare at the East Fork Gila River site. Currently, it remains moderately common at the Tularosa and San Francisco sites, rare to uncommon at the West Fork Gila, Middle Fork Gila, and Gila sites, and absent at the East Fork Gila sites. It is most common at the San Francisco site where water diversion and instream channel modifications do not occur and nonnative piscivores are absent. It has declined where nonnative piscivores are present or habitats are modified by instream activities.

CONSERVATION

Maintenance of free-flowing, unaltered streams appears critical to conservation of loach minnow. Currently, it persists only where streamflow is unregulated and human-induced habitat modifications are minimal. Where nonnative fishes, particularly piscivores, are common (including unmodified stream reaches), loach minnow typically is rare or absent. Minckley and Meffe (1987) demonstrated the importance of floods to the maintenance of southwestern native fish communities and the role of floods in diminishing nonnative fish abundance. Propst et al., (1988) suggested that floods also function to “resuscitate” riffle habitats by mobilizing fine sediments thereby improving habitat quality. Although the mechanism by which loach minnows, as well as other native fish, avoid displacement by floods is not known, both Minckley and Meffe (1987) and Propst and Bestgen (1991) noted no substantial differences in native fish communities before and after major floods. Propst and Bestgen (1991) hypothesized that the relative position of loach minnow in riffles enabled individuals to avoid displacement by flood waters.

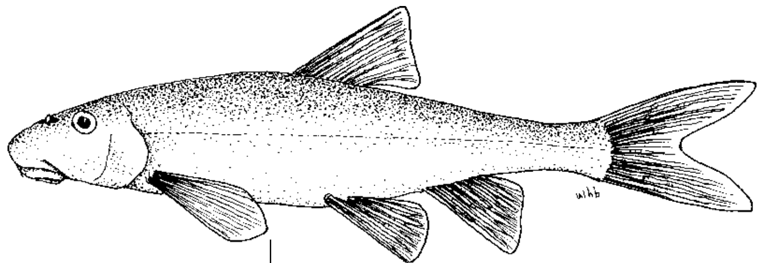
Watershed and instream activities that elevate fine sediment loads during spawning results in the suffocation of eggs and larvae. Dewatering stream reaches eliminates habitat and fragments populations; even partial dewatering reduces availability and quality of riffle habitats.

A Recovery Plan for loach minnow was finalized in 1991 (USFWS, 1991c). Although critical habitat was designated for it in Arizona and New Mexico, its designation in New Mexico was legally challenged and the U.S. District Court for New Mexico enjoined the U.S. Fish and Wildlife Service from enforcing consideration of critical habitat in New Mexico by other federal agencies. In 1998, the U.S. Fish and Wildlife Service revoked critical habitat for loach minnow in both Arizona and New Mexico (USFWS, 1998a). However, the species retains full protection as a federally and state listed species. ♦

Zuni Bluehead Sucker

Catostomus discobolus yarrowi

(Cope, 1874)



LISTING STATUS

Zuni bluehead sucker, *Catostomus discobolus yarrowi*, was listed by New Mexico as endangered (19 NMAC 33.1) in 1975 and it is considered of special concern by Arizona (AZGF, 1996). The American Fisheries Society also lists Zuni bluehead sucker as a species of concern (Williams et al., 1989).

CHARACTERISTICS

The Zuni bluehead sucker has a fusiform, generally slender body with a subterminal mouth. Most individuals in a population do not exceed 200 mm TL, but a few may attain 250 mm (Hanson, 1980; Propst and Hobbes, 1996). The mouth has fleshy lips covered with small protuberances (papillae), particularly on the lower lips. The lips are notched laterally and the medial separation of the lower lip extends nearly to its anterior margin. The posterior margin of the lower lip extends back at an acute angle to the ventral longitudinal median. The lower jaw has a well-developed cartilaginous mandibular ridge that parallels the curvature of the lower lip (Sublette et al., 1990). Young Zuni bluehead suckers are mottled dark gray-green dorsally and cream-white ventrally. Adults are slate-gray, almost black dorsally and cream-white ventrally. Males, in addition to coarse tubercles on the anal fin and ventral lobe of the caudal fin, develop a distinctive coloration during the spawning season; dorsally they are intense black with a bright red lateral band and a white belly (Propst and Hobbes, 1996). The caudal peduncle is comparatively thick (ca. 9% of standard length) and the dorsal fin usually has fewer than 10 principal rays (Smith, 1966). There are 42 or fewer post-Weberian vertebrae and 25 or more gill-rakers in the first row on the first pharyngeal arch (Smith et al., 1983). The Zuni bluehead sucker typically has fewer than 100 scales in the lateral series (Smith et al., 1983).

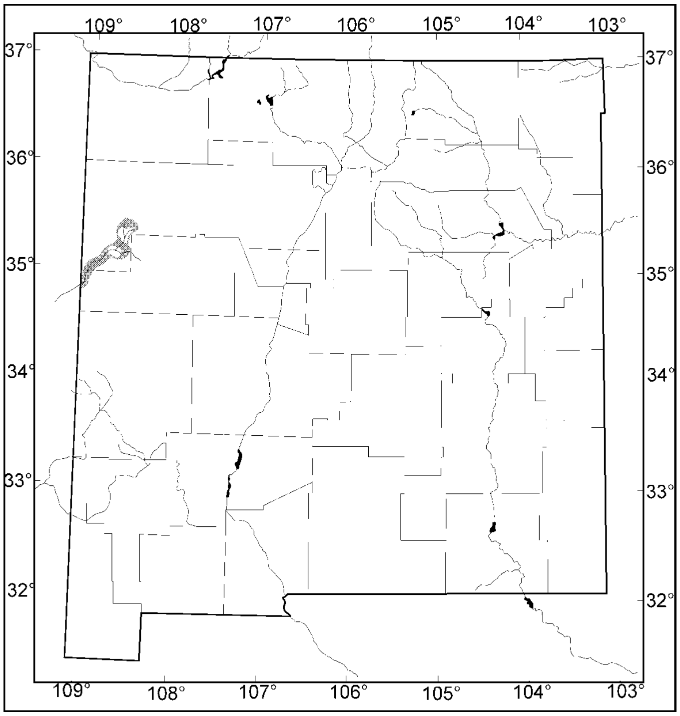
Smith (1966) and Smith et al. (1983) postulated a hybrid origin whereby a headwater stream of the Rio Grande was captured by upstream erosion of a headwater stream of the Zuni River during Late-Pleistocene. This vicariant event brought the Rio Grande sucker (*Catostomus plebeius)* into contact with a resident bluehead sucker. Based upon shared morphomeristic traits, Smith (1966) and Smith et al. (1983) believed this contact area was in the upper reaches of the Rio Nutria. While not disputing the hybrid character of the *Catostomus* occupying the upper reaches of the Rio Nutria, Crabtree and Buth (1987), provided allozymic data supporting subspecific differentiation of upper Little Colorado River *Catostomus discobolus* from its conspecifics prior to introgression of *Catostomus discobolus* and *Catostomus plebeius* in the upper Rio Nutria. Regardless of the mechanism for differentiation of *Catostomus discobolus yarrowi*, it is a recognized subspecies.

DISTRIBUTION

Zuni bluehead suckers historically inhabited headwater streams of the Little Colorado River in east-central Arizona and west-central New Mexico (Smith, 1966; Smith et al., 1983; Crabtree and Buth, 1987). The Zuni bluehead sucker was first collected from the Zuni River in New Mexico in 1873. It was not subsequently taken in New Mexico until W.J. Koster (UNM, Museum of Southwestern Biology) found it in the Rio Nutria in 1948 and Rio Pescado in 1960. In Arizona, Smith (1966) reported the subspecies in four small streams. The limited historic collection data provide insufficient information from which estimates of abundance might be made.

Several chemical treatments were made during the 1960s to remove green sunfish, fathead minnow, and suckers from the Rio Nutria, presumably to aid the establishment of a rainbow trout (*Oncorhynchus mykiss*) sport fishery in reservoirs on the Zuni Indian Reservation (Winter, 1979). The population of suckers in the Rio Nutria was, however, maintained by dispersal of individuals from upstream, untreated reaches.

Hanson (1980) conducted the first systematic survey of the Zuni River drainage in New



Mexico and found Zuni bluehead suckers limited mainly to the confluence area of the rios Nutria and Pescado, the upper reaches of the Rio Nutria, and Agua Remora (formerly Radosevich Creek). Although its range was fragmented, it was moderately common in the three primary areas of occurrence. By the late 1970s-early 1980s, the range in Arizona was apparently reduced to Kin Li Chee Creek (Smith, 1983). However, no recent systematic surveys have been made in its historic Arizona range to accurately document its current status (K. Young, pers. comm.).

The Zuni bluehead sucker currently is limited in New Mexico mainly to the Rio Nutria upstream of the mouth of the Nutria Box Canyon near the eastern boundary of the Zuni Indian Reservation and the Agua Remora (Propst and Hobbes, 1996). Its distribution is discontinuous within the Rio Nutria. It is moderately common only near the mouth of the Nutria Box Canyon, at the confluence of Tampico Draw and Rio Nutria, uppermost Agua Remora, and uppermost Rio Nutria. The sucker is found irregularly near the confluence of rios Nutria and Pescado (Propst and Hobbes, 1996), where Hanson (1980) found it common.

BIOLOGY

Hanson (1980) described the habitat of the Zuni bluehead sucker as stream reaches with abundant shade and primarily pool and riffle habitats with coarse substrates. Propst and Hobbes (1996) found the subspecies mainly in pools (1.0 to 2.0 m deep) and pool-runs (0.5 to 1.0 m deep) with water velocity ≤10.0 cm/sec. These habitats mainly had bedrock, boulder, and large cobble substrates. The Zuni bluehead sucker was rare or absent where the substrate was predominantly sand and silt. Periphytic and perilithic algae and diatoms were seasonally common in occupied habitats, and pools were often edged with cattails (*Typha* sp.).

Zuni bluehead suckers spawn from early April through late May or early June when water temperatures are 10 to 15°C (Propst and Hobbes, 1996). Individuals of both sexes may be mature at 100 mm SL, but mature females generally are larger than males. Propst and Hobbes (1996) found evidence for a bimodal reproductive season; elevated gonadosomatic index values were recorded in early April through early May and again in early June 1995. They were unable to determine whether a single female spawned twice each season or if different individuals were involved during each session. However, the mean size of ripe females in early April through early May was greater than the mean size of ripe females in early June, suggesting that different individuals were involved in each reproductive session. A large female (≥ 200 mm SL) may produce 450+ eggs, but most females produce 200 to 300 eggs. The spawning habitat is not known; presumably it spawns among the interstices of the cobble substrate of its preferred pool and pool-run habitat.

Although data are equivocal, Zuni bluehead suckers apparently grow to about 50 mm TL by the end of their first season (Propst and Hobbes, 1996). There is little or no growth during winter. By the end of their second growing season (Age 1), Zuni bluehead suckers are 50 to 80 mm TL and subsequent annual increments are about 30 mm. Hanson (1980) attempted to age Zuni bluehead suckers by scale annuli, but reported the effort to yield ambiguous results. Based upon his estimates, Zuni bluehead suckers may live 4 or 5 years and maturity is attained at Age 2.

Length-frequency data indicated that over-winter survival of Age 0 fish is often low (Propst and Hobbes, 1996). All extant populations (except the ephemeral population near the confluence of the rios Nutria and Pescado) were comprised mainly of individuals between 70 and 160 mm TL; Ages 1 through 3, or older.

Zuni bluehead suckers feed by scrapping diatoms and algae from bedrock, boulders, and cobble in its pool and pool-run habitats (D.L. Propst and A.L. Hobbes, pers. obs.). During periods of low flow, when habitats are reduced and fish concentrated, the substrates often are denuded of vegetation.

Historically, this sucker was associated with roundtail chub and speckled dace. The reported occurrence of bonytail in the Zuni River drainage in New Mexico (Baird and Girard, 1853b) is probably erroneous (Smith et al., 1983). Smith et al. (1983) suggested that the putative occurrence of bonytail in the Zuni River in New Mexico was the consequence of mislabeled specimens (Smith et al., 1983). However, at the time these fishes were collected, the Territory of New Mexico included all of present-day Arizona and the labeling was therefore likely correct, but the bonytail specimens were actually from downstream reaches of the Zuni River or the Little Colorado River in what was to become Arizona. In addition, bonytail is an obligate large-river form and it is unlikely the Zuni River in New Mexico ever provided habitat suitable for the species (Smith et al., 1983). Hanson (1980) did not find roundtail chub during his survey of the drainage and Propst and Hobbes (1996) found only one specimen of speckled dace during their survey. Seven nonnative fish species have been reported in the Zuni River drainage (Hanson, 1980; Propst and Hobbes, 1996), but only fathead minnow, green sunfish, and plains killifish (*Fundulus zebrinus*) were comparatively common and widespread. Nonnatives are uncommon or absent in reaches where Zuni bluehead suckers are common. The gut contents of two specimens of green sunfish, sympatric with Zuni bluehead suckers, were examined, but no fish remains were present (Propst and Hobbes, 1996).

STATUS

The Zuni bluehead sucker currently inhabits less than 10% of its probable historic range, and within its current range, its distribution is fragmented. It is comparatively common only in four short stream reaches (≤ 2 km each) in New Mexico and its status in Arizona is uncertain. Nonnative fishes are rare or absent in its four principal areas of occurrence in New Mexico. The habitat in these areas is relatively unimpacted by current human-associated activities, although livestock grazing causes local disturbance of habitats (bank chiseling and increased sediment loading).

Past timber-harvest practices and livestock overgrazing increased soil erosion in the watershed (T.L. Stroh, pers. comm.), thereby diminishing fish habitat quality. Fish-eradication efforts of the 1960s eliminated Zuni bluehead suckers from several formerly inhabited stream reaches; dispersal of individuals from upstream, untreated reaches enabled colonization of depopulated reaches. Several piscivorous nonnative fishes (e.g., northern pike, *Esox lucius*, and green sunfish) have been introduced to the drainage and may have contributed to the elimination of Zuni bluehead suckers from several reaches (e.g., Zuni River and Rio Nutria downstream of Rio Nutria Box Canyon).

CONSERVATION

The first documented effort to conserve the Zuni bluehead sucker involved two young boys in the 1920s who wished to have fish in a small headwater stream of the Rio Nutria. According to Winter (1979), the Radosevich brothers transported "minnows" from the headwaters of the Rio Nutria by bucket to the Agua Remora (formerly Radosevich Creek).

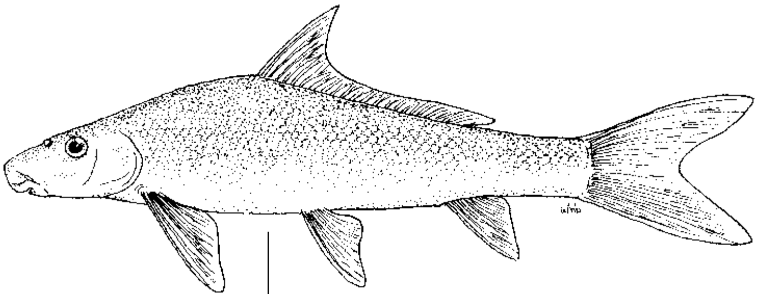
Following its recognition as endangered by the New Mexico Department of Game and Fish in 1975, the U.S. Forest Service (Cibola National Forest, Mt. Taylor Ranger District) and New Mexico Department of Game and Fish in the 1980s cooperatively fenced two reaches of uppermost Agua Remora to exclude livestock. During the early 1990s the Pueblo of Zuni and New Mexico Department of Game and Fish jointly surveyed the Zuni River drainage in New Mexico to determine the current status of this sucker and identify reaches where it might be re-established following habitat improvements. In 1992, The Nature Conservancy purchased land that encompassed the confluence of Tampico Draw and the Rio Nutria to protect sucker habitat. During 1996, the New Mexico Department of Game and Fish initiated efforts to develop a conservation plan. This effort involves the principal land managers/owners having Zuni bluehead sucker occupied habitats (U.S. Forest Service, Pueblo of Zuni, The Nature Conservancy, and the Silva Family) and key resource agencies (U.S. Fish and Wildlife Service and New Mexico Department of Game and Fish).

Loss of food (perilithic diatoms and algae) as a result of sediment deposition poses a threat to extant populations of Zuni bluehead sucker. Sediment mobilization during spring runoff (when the sucker spawns) and subsequent deposition during flow recession suffocates eggs and larvae. Livestock grazing in much of the upper Rio Nutria watershed contributes to sedimentation of occupied habitats.

Nonnative fishes are rare in habitats currently occupied by the Zuni bluehead sucker. However, several nonnative fish species are moderately common in formerly-inhabited reaches. Potential for expansion of the range of Zuni bluehead suckers remain limited as long as nonnative fishes, particularly piscivores, persist in stream habitats. The proposed introduction of grass carp (*Ctenopharyngodon idella*) for aquatic vegetation control in Ramah Reservoir and reservoirs on the Zuni Indian Reservation poses another unknown threat to the Zuni bluehead sucker. ♦

Blue Sucker

Cycleptus elongatus
(Lesueur, 1817)



LISTING STATUS

Blue sucker, *Cycleptus elongatus*, was listed as endangered by New Mexico (19 NMAC 33.1) in 1976 and is considered threatened by Texas (Campbell, 1995). The Republic of Mexico lists the species as rare (SDS, 1994) and the American Fisheries Society considers it a species of concern (Williams et al., 1989).

CHARACTERISTICS

The blue sucker is readily distinguished by its tubular body, relatively small, elongate head, and sickle-shaped dorsal fin (Becker, 1983). Although some individuals may grow to 800 mm TL and weigh over 1.6 kg (Moss et al., 1983, S.P. Platania, pers comm.), most blue suckers found in New Mexico are less than 500 mm long. Throughout most of the year, adult blue suckers are bluish to blue-gray dorsally and laterally, and whitish ventrally (Becker, 1983). Breeding males are almost black and have numerous minute tubercles over much of the head. Sub-adults ($\leq$ 200 mm) are slender and cigar-shaped and dusky orange to brown in color. The small mouth is subterminal and the lips are covered by five or six rows of papillae (Pflieger, 1975). There typically are 28 to 33 dorsal, 7 anal, and 9 pelvic fin rays. The lateral line is complete and there are 53 to 58 lateral line scales. Each pharyngeal arch has 34 to 40 teeth and the medial teeth are widely spaced (Becker, 1983).

DISTRIBUTION

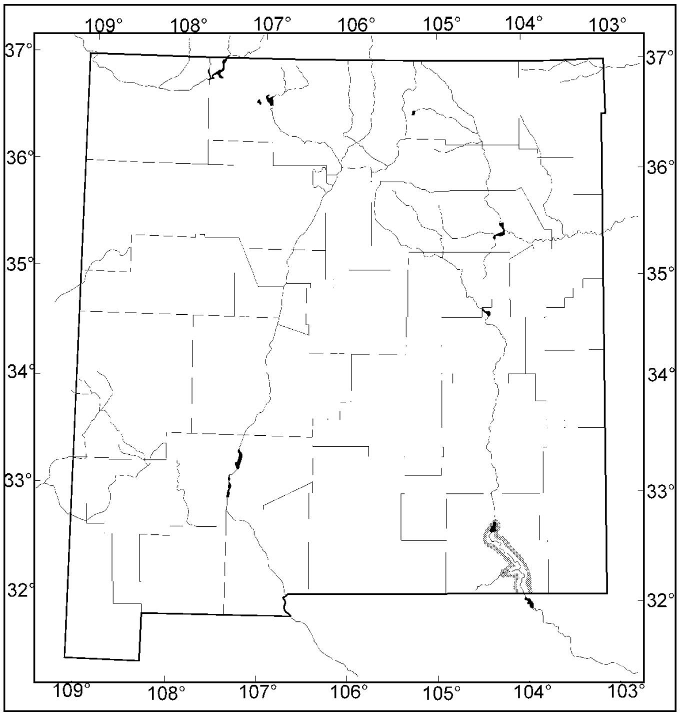
The blue sucker occurs in larger rivers throughout much of the Mississippi-Missouri River and Gulf coastal drainages (Gilbert, 1980c). Formerly common and commercially fished, blue suckers are now uncommon in their native range (Moss et al., 1983). Although archaeological evidence from Native American ruins indicates that the blue sucker inhabited the Rio Grande in New Mexico (Gehlbach and Miller, 1961), no specimens exist to confirm its historic occurrence there. Blue suckers were moderately common in the Texas/Mexico portions of the Rio Grande and occurred from the confluence of the Rio Conchos downstream to the confluence with the Pecos River (Gilbert, 1980c), but were absent in reaches downstream of Falcon Reservoir (Edwards and Contreras-Balderas, 1991). Blue suckers historically inhabited the Pecos River from just north of Carlsbad downstream to the Texas/New Mexico border and they may have occurred as far upstream as Santa Rosa (Sublette et al., 1990). Only one specimen is known from the Texas portion of the Pecos River (S.P. Platania, pers. comm.). Blue suckers also occupied lower reaches of the Black River in New Mexico (Cowley and Sublette, 1987a).

Blue suckers currently inhabit the Pecos River downstream of Brantley Dam to the Texas/New Mexico border, lower reaches of the Black River, and seasonally the larger irrigation canals of the Carlsbad Irrigation District (J.E. Brooks, pers. comm.). Among these areas, moderate numbers are found only in the Pecos River between Brantley Dam and Avalon Reservoir. They are uncommon or rare elsewhere.

BIOLOGY

Blue suckers are most frequently found in smooth, hard-bottomed reaches of larger streams where current velocity is rapid (100 to 260 cm/sec) and depths range from 1 to 2 m (Moss et al., 1983). Young blue suckers occupy shallower riffles with gravel and cobble substrates and rapidly flowing water. The streams occupied by the species in New Mexico are small in comparison to those it occupies in much of its range elsewhere.

Spawning occurs in the spring, apparently in response to rising water temperatures. In the Neosho River, Kansas, only tuberculate males were found on a spawning riffle in late April when water temperature was 17°C; in late May ripe males and females were found on the spawning riffle and water temperature was 20°C (Moss et al., 1983). Coker (1930) commented on spring runs of



blue sucker, which likely were movements to suitable spawning riffles. Spawning occurs in rapid-velocity water (180 cm/sec) over bedrock and cobble substrata. The eggs are adhesive and attach to the substrate. Yeager and Semmens (1987) reported hatching of artificially-reared blue suckers in 6 days. At hatching, larvae are about 7 mm long (Yeager and Semmens, 1987) and growth to juvenile size (33 to 46 mm TL) is rapid. By the end of their first autumn, individuals (Age 0) are sub-adults and may be 200 mm or longer. Total lengths at Age 1 and Age 2 are 265 mm and 323, respectively (Moss, et al., 1983). Maturity is attained at Age 2 by males and Age 3 by females. Females are generally larger than similar-aged males. Blue suckers may live 9 years and attain lengths in excess of 750 mm.

Age 0 blue suckers consume mainly small aquatic insects (trichopterans and dipterans) while adults have broader diets, ingesting aquatic insects, molluscs, filamentous algae, and leaf litter (Moss et al., 1983). Cowley and Sublette (1987b) reported similar food habits of blue suckers in the Black River in New Mexico, except that larval odonates also were important items. The absence of ephemeropterans and odonates in blue sucker stomachs was interpreted by Moss et al. (1983) to indicate habitat selection (rapid-velocity riffles and runs) rather than food preferences.

Little information is available on species associates of blue sucker. In the Pecos River in New Mexico, it occasionally is found with gray redhorse (*Moxostoma congestum*), river carpsucker (*Caripodes carpio*), and longnose gar (*Lepisosteus osseus*) (J.E. Brooks, pers. comm.).

STATUS

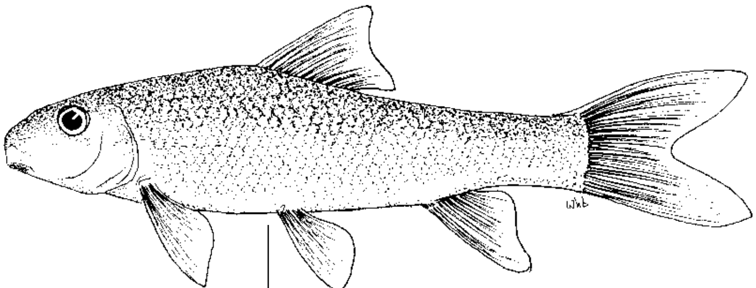
Although the blue sucker still occurs in much of its documented historic New Mexico range (lower Pecos and Black rivers), it is moderately common only in the 10-km reach of the Pecos River between Brantley Dam and Avalon Reservoir (J.E. Brooks, pers. comm.). This reach continues to have the preferred habitat of the species. The occurrence of blue sucker in larger canals of the Carlsbad Irrigation District probably is explained by the presence of conditions (concrete-bottomed canals with moderate to rapid velocity water) that approximate its preferred habitats. Rangewide decline in abundance of the species has been attributed to siltation and range fragmentation by dams (Pflieger. 1975) and inundation of spawning habitat by reservoirs (Moss et al., 1983). During annual drying (November through February) of Carlsbad Irrigation District canals, some suckers may escape canals to the Black River, but others are trapped and die in desiccating pools. Irregular rescues by NMGF and USFWS personnel have translocated some trapped suckers to Carlsbad Municipal Reservoir. Construction of Brantley Reservoir truncated the Pecos River range of blue sucker, and diversion dams (Carlsbad Municipal, Bataan, Six-Mile, and Ten-Mile) limit movement of the species.

CONSERVATION

Maintenance of flows in the Pecos River between Brantley Dam and Avalon Reservoir and annual rescue of fish trapped in Carlsbad Irrigation District Canals are important for maintaining blue sucker populations in New Mexico. The impact of recently stocked grass carp in Carlsbad Municipal Reservoir is not known. ♦

Gray Redhorse

Moxostoma congestum
(Baird and Girard, 1854)



LISTING STATUS
The gray redhorse, *Moxostoma congestum*, was listed by New Mexico as a threatened species (19 NMAC 33.1) in 1976 and the American Fisheries Society considers it a species of concern (Williams et al., 1989).

CHARACTERISTICS
The gray redhorse is a comparatively large, heavy-bodied sucker, round in cross-section but flattened ventrally, that may attain total lengths in excess of 500 mm. It is slate-gray to dark olive-brown dorsally, gray to silver-gray laterally, and white ventrally. Pectoral, pelvic, and anal fins may have a reddish-orange suffusion and the membranes between rays of the dorsal fin are typically tinged with black. Nuptial males have small tubercles on the anal fin and the ventral lobe of the caudal fin. The snout is blunt and slightly overhangs the small, subterminal mouth. Both lips have plicate folds and numerous small pores are on each plicum; the lower lip has a medial notch. Scales are large and there are 44 to 45 in the lateral series. The anal fin is long and the caudal fin is moderately forked. There are 11 or 12 dorsal fin rays, 15 or 16 pectoral rays, and 9 pelvic rays. There are about 55 teeth on the first pharyngeal arch (Sublette et al., 1990).

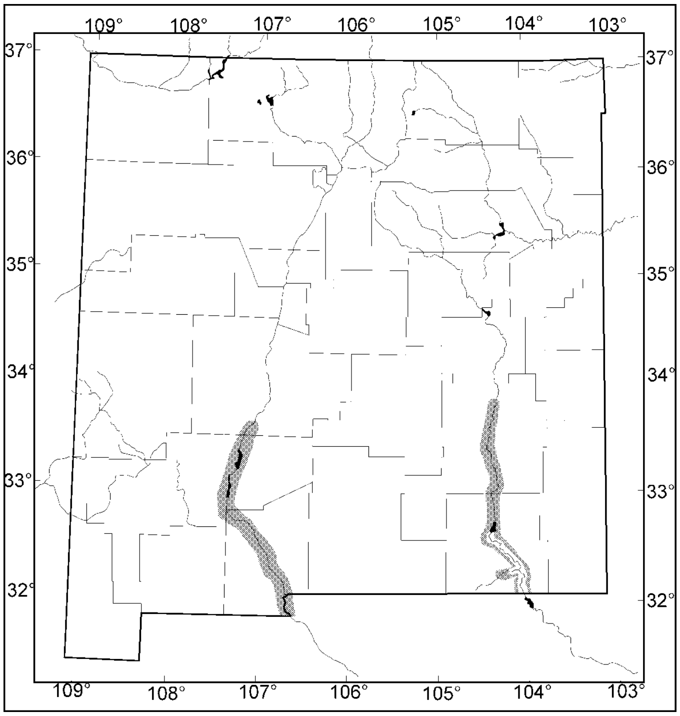
DISTRIBUTION
The historic range of the gray redhorse included Gulf Coastal drainages of central and west Texas, the Pecos River of New Mexico and Texas, the Rio Grande in New Mexico, and Mexican tributaries to the Rio Grande downstream of the Big Bend region (Jenkins, 1980). In New Mexico, it was historically present in the Rio Grande downstream of Socorro and in the Pecos River from about Roswell downstream to the Texas/New Mexico border. Its abundance was variable within its native range.

The gray redhorse persists in much of its historic range in Texas (Hubbs et al., 1991). No information is available on its status in Mexico. In New Mexico, it no longer occurs in the Rio Grande, and in the Pecos River it is limited to the reach from Carlsbad downstream to the Texas/New Mexico border, including Black River (Cowley and Sublette, 1987a; NMGF files). In the Pecos River, it is most frequently found in Carlsbad Municipal Reservoir and at the confluence of the Pecos and Black rivers (NMGF files), but is not common at either location.

BIOLOGY
In the Pecos and Black rivers in New Mexico, gray redhorse are most commonly found in deep (up to 3.0 m), slow-velocity (<0.01 cm/sec) water over a variety of substrates (most commonly silt or limestone bedrock). The species also is found in several impoundments on the lower Pecos River in New Mexico.

Gray redhorse spawn in late March and early April when water temperatures are 18 to 21°C. Spawning occurs when several ripe individuals aggregate at the downstream end of pools over gravel and small cobble substrates (Martin, 1986). Eggs presumably are demersal and develop among the interstices of the gravel and cobble spawning bars. No information is available on age, growth, and survival of gray redhorse. Small (<150 mm), and presumably Age 0, individuals were captured in September in a moderately deep (1.0 m) pool over a hard sand/silt bottom at the confluence of the Pecos and Black rivers (NMGF files).

Gray redhorse consume a variety of benthic aquatic invertebrates. Food items in gray redhorse stomachs led Cowley and Sublette (1987b) to suggest that the species sometimes feeds in



cobble riffles.

In the New Mexico portion of its range, gray redhorse are most often found in habitats also occupied by longnose gar, blue sucker, smallmouth buffalo (*Ictiobus bubalus*), river carpsucker, channel catfish, and several centrarchid species (NMGF files). Grass carp, a species native to eastern Asia, was recently introduced to Carlsbad Municipal Reservoir, where gray redhorse also occur.

STATUS

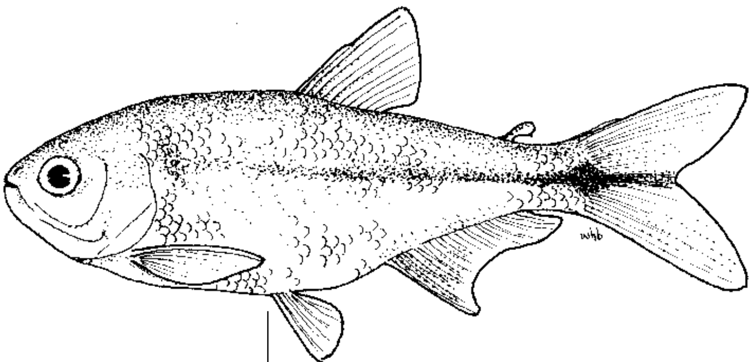
Although this species remains comparatively common in portions of its range in Texas, it is rare or uncommon in all portions of its New Mexico range (NMGF files). It is regularly found, albeit in low numbers, in Carlsbad Municipal Reservoir and at the confluence of the Pecos and Black rivers. Individuals also are found in Six-Mile and Ten-Mile reservoirs on the Pecos River (upstream of the Black River confluence) and in the mainstem Black River.

CONSERVATION

Past efforts to control or eliminate nongame fish (referred to as "rough" fish) contributed to the reduced abundance of gray redhorse in the lower Pecos River drainage (Sublette et al., 1990). While such activities have ceased, the introduction of grass carp (for aquatic vegetation control) to habitats occupied by gray redhorse may pose another threat to the species. Depletion of surface flows may inhibit reproductive success in some portions of its range, and water quality degradation may diminish its abundance. ♦

Mexican Tetra

Astyanax mexicanus
(DeFilippi, 1853)



LISTING STATUS
The Mexican tetra, *Astyanax mexicanus*, was listed by New Mexico as a threatened species (19 NMAC 33.1) in 1976.

CHARACTERISTICS
The Mexican tetra is a moderate-sized (attaining total lengths of 150 mm), deep-bodied fish with a large head and an adipose fin. The upwardly directed terminal mouth has numerous large and sharp teeth. The body is laterally compressed. Mexican tetras are light brown dorsally, silvery laterally, and whitish ventrally. A broad black band originates in the fork of the caudal fin, extends laterally along the caudal peduncle, and fades anteriorly (Sublette et al., 1990). Male Mexican tetras, in spawning condition, have yellowish to orange-red dorsal and anal fins. The caudal fin is deeply forked and the anal fin is long and falcate. There are 35 to 40 scales in the lateral series.

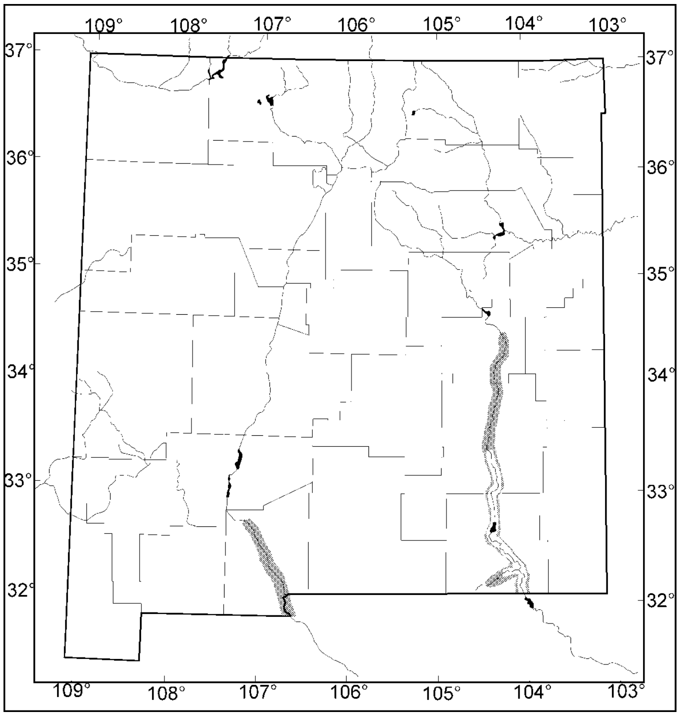
DISTRIBUTION
The native range of Mexican tetra extends from Gulf Coastal drainages of eastern and central Mexico northward to the Nueces River of Texas (Birkhead, 1980). It occurs in the Rio Grande from its mouth upstream to the Big Bend region. In the Pecos River, its native range extended from the confluence of the Rio Grande and Pecos River upstream to near Santa Rosa, New Mexico (Koster, 1957). It also occurred in the Rio Grande downstream of Caballo Reservoir.The Mexican tetra is the sole representative of its family that occurs in New Mexico and reaches the northermost limits of its range in the state.

Mexican tetras currently persist in New Mexico in the Pecos River and associated floodplain habitats from about Bitter Lake National Wildlife Refuge downstream to the Texas/New Mexico border (C.W. Hoagstrom, pers. comm.). Within this reach it is most commonly found in off-channel habitats such as Lea Lake in Bottomless Lakes State Park, Blue Spring, and a spring in upper Carlsbad Municipal Reservoir (C.W. Hoagstrom, pers. comm.; NMGF files). Mexican tetras are rare in the Black River (Cowley and Sublette, 1987a), but locally common in the Delaware River (NMGF files).

BIOLOGY
Although Mexican tetras occupy a variety of habitats, they tend to be more commonly found in low-velocity pool habitats in small streams and spring systems (C.W. Hoagstrom, pers. comm.; NMGF files). Young commonly occur along shallow shorelines with overhanging vegetation (Edwards, 1977) while adults are more common in open pools. In the Edwards Plateau of Texas, Mexican tetras are most common in stenothermal spring habitats (Edwards, 1977). In central Texas streams, Edwards (1977) reported that Mexican tetras seasonally migrate, seeking the warmest water available. Harrell (1978) found that Mexican tetras were resistant to displacement by floods, presumably a result of their mainly occupying spring and spring-like habitats associated with rivers.

Edwards (1977) reported spawning from late April through September in Waller Creek (a tributary of the Colorado River, Texas) when mean water temperatures were 17 to 30°C. In sheltered shoreline habitats, Edwards (1977) observed that the young fed voraciously on aquatic insects. Minckley (1973) reported that adults were highly carnivorous, feeding on any available prey.

STATUS
The Mexican tetra remains common in much of its historic range (Birkhead, 1980), has expanded its range in Texas (Edwards, 1977), and it has been introduced to Arizona (Minckley,



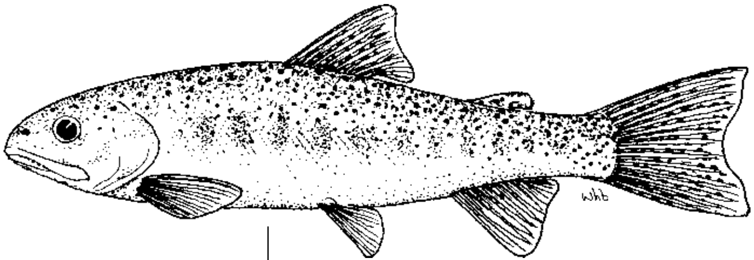
1973). In New Mexico, it is locally common in several spring systems and creeks but elsewhere in the lower Pecos River drainage it is rare. Groundwater pumping in the vicinity of Roswell and consequent drying of springs and spring brooks caused its general demise in this area.

<u>CONSERVATION</u>

Maintenance of natural flows in spring habitats and small streams (e.g., Blue Spring, Cottonwood Creek, and Delaware River) is essential for conservation of Mexican tetras in New Mexico. Rattlesnake Spring in Carlsbad Caverns National Park may be suitable for establishment of a population of Mexican tetra. ♦

Gila Trout

Oncorhynchus gilae
(Miller, 1950)



LISTING STATUS

Gila trout, *Oncorhynchus gilae*, was listed by New Mexico as endangered in 1975 and was downlisted to threatened in 1988 (19 NMAC 33.1). It is federally listed as endangered (USFWS, 1967). It is listed as a species of special concern by Arizona (AZGF, 1996). The American Fisheries Society lists Gila trout as a threatened species (Williams et al., 1989).

CHARACTERISTICS

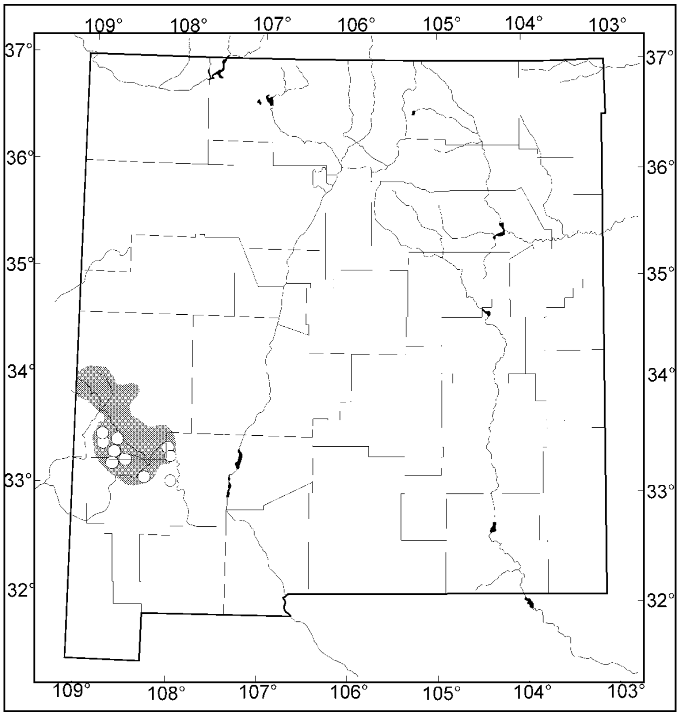
Gila trout is a moderate-sized, fusiform salmonid typically attaining lengths of 200 to 250 mm TL; older individuals may exceed 350 mm TL (Propst and Stefferud, 1997). The body is golden laterally and shades to dark gray-green dorsally (Miller, 1950). Ventrally, the body is cream to white. The opercle has a copper tinge and adults have a yellowish "cutthroat" mark in the first gular fold. The dorsal, pelvic, and anal fins have white to yellowish tips; this coloration may extend along anterior margins of the fins. Small, irregularly-shaped black spots profusely cover the body laterally and dorsally; spotting diminishes below the lateral line and none is found on the venter. Parr marks are retained by Gila trout throughout life, but they are less distinct in older, larger individuals. There are 140 to 155 scales in the lateral series (Miller, 1950; David, 1976). Gila trout in Gila River headwater streams lack basibranchial teeth but some specimens from the San Francisco drainage (Spruce Creek) have them (David, 1976). Gila trout has a diploid chromosome complement of 2n = 56 (Beamish and Miller, 1977). Loudenslager et al. (1986) characterized the allozymic diversity among several Gila trout populations and Riddle et al. (1998) characterized the phylogenetic relationships of Gila trout and its near-relative species using mitochondrial DNA.

DISTRIBUTION

Historically, Gila trout was native to the Gila River drainage (including the San Francisco) in New Mexico and the Verde River drainage in Arizona (Miller, 1950; 1972; Minckley, 1973; Behnke, 1992). Behnke and Zarn (1976) suggested it might be native to the Agua Fria in Arizona. Minckley (1973) speculated that Eagle Creek (a tributary of the Gila River in Arizona) historically supported Gila trout, but Marsh et al. (1991) concluded that the lack of historic specimens precluded definitive resolution of the taxonomic status of this salmonid (Gila or Apache, *Oncorhynchus apache*, trout).

At time of its description (Miller, 1950), Gila trout was known from two streams; Main Diamond Creek (Gila River drainage) and Spruce Creek (San Francisco River drainage). Although Miller (1950) doubted the native occurrence of Gila trout in Spruce Creek, subsequent researchers concluded that, based on morphomeristic characters, allozymic similarities, and mitochondrial DNA data, the species was native to the San Francisco drainage in New Mexico (David, 1976; Loudenslager et al., 1986; Riddle et al., 1998). Following its description, relict populations of Gila trout were found in South Diamond and Iron creeks (Hanson, 1971; David 1976). The reportedly pure population of Gila trout (based on morphomeristic characters, David, 1976) in McKenna Creek has since been found to be introgressed with rainbow trout (Riddle et al., 1998; R. Leary, pers. comm.). Based upon Leary's data, these fish are genetically about 90% Gila trout.

Gila trout was the first imperiled western North American fish to be actively managed to conserve it (Williams, 1991). In 1923, the New Mexico Department of Game and Fish recognized that the native trout of the Gila drainage in New Mexico was unique and that wild populations were declining and built Jenk's Cabin Hatchery in the Gila Wilderness to propagate the species for stocking. Poor rearing success led to the closing of Jenk's Cabin Hatchery in 1939, but a policy of not stocking rainbow trout in streams known to have Gila trout was followed (Propst et al., 1992). During the 1930s, the Civilian Conservation Corps installed log habitat improvement structures in Main Diamond Creek, which contributed to the survival of the species in that stream. In 1958,



the New Mexico Department of Game and Fish closed Main Diamond Creek to angling.

Since the early 1970's, portions of seven streams have been reclaimed for Gila trout. However, wildfire eliminated the relictual populations in Main Diamond Creek in 1989 (re-established in 1993) and South Diamond Creek in 1995, and the re-established population in Trail Canyon in 1996. In 1993, the re-established population in Mogollon Creek was found to be contaminated with rainbow and brown trouts. A second renovation of this stream was completed in 1996. The replicated population (from McKenna Creek stock) in Little Creek is genetically contaminated by rainbow trout (R.Leary, pers. comm.). Currently, wild populations (relictual and re-established) of Gila trout persist in nine streams and three will receive Gila trout when they have recovered from wildfire damage (South Diamond and Trail) and alien salmonids removed (Little). A re-established population in Arizona (Gap Creek) was eliminated during low-flow conditions. Almost all streams currently supporting, or reserved for, Gila trout are small headwater streams (collectively, about 89 linear km, Propst et al., 1992).

Abundance of Gila trout in each occupied habitat varies considerably seasonally and annually (Propst and Stefferud, 1997). Several streams, such as Sheep Corral Canyon, typically support fewer than 100 mature individuals. Larger streams, such as McKnight (outside native range of Gila trout) and Iron creeks may support more than 1000 mature individuals during years with average to above average precipitation. The largest stream reserved for Gila trout, Mogollon Creek, is thought capable of supporting 5000+ adults (Propst and Stefferud, 1997).

BIOLOGY

Although Gila trout historically occupied larger streams of the Gila River drainage in New Mexico (Miller, 1950), it currently is restricted mainly to small headwater streams (Propst et al., 1992). In these small streams, the relative availability and quality of pool habitat appears to be particularly important to Gila trout. McHenry (1986) and Rinne and Medina (1988) found that Gila trout biomass in a stream was correlated to availability and size of pools. In addition, Propst and Stefferud (1997) provided evidence that pools serve as refugia during periods of winter and summer low flow. Pools having Gila trout are 0.5 to 1.5 m deep with water velocities ≤20 cm/sec and typically provide structural cover. Young Gila trout are frequently found in riffles where depths are ≤0.3 m and water velocity is 20 to 70 cm/sec.

Gila trout spawn in redds composed of small pebbles and gravel (Rinne, 1980). Spawning typically occurs in April when water temperatures are 10 to 12°C (Propst and Stefferud, 1997) but may extend into May or June (Rinne, 1980). Females are mature at Age 3 or 4 and males at Age 2 or 3 (Rinne, 1982; Propst and Stefferud, 1997). In the McKnight Creek population, many individuals (mostly males) were mature at 150 mm TL and almost all fish were mature at 170 mm TL or greater (Propst and Stefferud, 1997). Most females in a population annually produce about 75 to 100 eggs, but large females (≥200 mm TL) may produce 150 to 200 eggs. After fertilization and deposition, the eggs develop among the pebbles and gravel of the redd, and young emerge within several weeks.

Gila trout grow to about 90 to 100 mm by autumn of their first year (Age 0). Thereafter annual growth increments decrease as the fish ages (Propst and Stefferud, 1997). Rinne (1982) reported average annual growth of 42, 24, 15 mm for Age 1, 2, and 3 fish, respectively. Length-frequency data indicate that about 25 to 40 % of most populations are juveniles (Age 0), 30 to 40 % are subadults (Ages 1 and 2), and about 30 % are adults (Propst and Stefferud, 1997). Most Gila trout live only 3 to 5 years, but a few individuals may live 6 to 8 years. In the small, headwater habitats currently occupied by most Gila trout populations, individuals ≥ 200 mm TL are not abundant. Fewer than 5 % of the individuals in most populations are ≥ 200 mm, but Gila trout ≥ 325 mm have been found in several streams. Gila trout feed mainly on terrestrial and aquatic invertebrates, but larger individuals may also consume other fish species, e.g., speckled dace or young Gila trout (Van Eimeren, 1988). Rinne (1982) found that most Gila trout have small home ranges of 100 m or less. Gila trout from McKnight Creek were found to host the helminths *Crepidostomum cooperi* and *Metabronema salvelini* (Mpome and Rinne, 1984).

Prior to the establishment of nonnative fish species in streams of the Gila River drainage, Gila trout was the only fish species present in higher-elevation streams, but it co-occurred with speckled dace, Sonora sucker, and desert sucker in intermediate-elevation streams. In the latter, it likely also was associated with roundtail chub, a formerly common pool-dwelling species. Currently, nonnative rainbow and brown trouts inhabit most streams within the historic range of Gila trout.

STATUS

Gila trout historically occupied much of the upper Gila River drainage and tributaries of the San Francisco River in New Mexico and the Verde River drainage in Arizona (Miller, 1950; Minckley, 1973; Behnke, 1992). By the mid-twentieth century, it was known only from two small headwater streams (Miller, 1950). Subsequent surveys reported pure populations in three additional streams in the upper Gila River drainage (Hanson, 1971; David, 1976; Mello and Turner, 1980).

Predation and competition by nonnative brown trout and hybridization with nonnative rainbow trout were major causes for the decline of Gila trout, but past land management practices (e.g., livestock grazing, timber harvest, mineral extraction, and road construction) also contributed to the imperiled status of the species (USFWS, 1993). Natural, stochastic events, such as wildfire and drought, historically reduced, and occasionally eliminated, some populations (Propst et al., 1992). Historically, decimated reaches were repopulated by trout from areas not affected by natural catastrophes. Currently, however, habitat alteration and establishment of nonnative fishes precludes potamodromy and thus colonization.

Efforts to recover Gila trout increased the small, headwater habitat available to the species from 19 km to about 70 km by the early 1990s (Propst et al., 1992). However, between 1989 and 1996 wildfire and associated impacts eliminated the species from about 14 km (20.0%) of this (Main Diamond and South Diamond creeks and Trail Canyon). Low flows contributed to the elimination of the species from Gap Creek in Arizona (2.4 km, 3.4%) and scouring flows destroyed about 2.5 km (3.6%) of habitat in Iron Creek. Introduction of rainbow trout contaminated pure Gila trout populations in about 25 km (35.7%) of habitat (McKenna, Little, and Mogollon creeks). The species has been re-established in Main Diamond and Mogollon creeks. Currently, Gila trout occupies about 51 (57.3%) of the 89 km dedicated to it and renovation efforts are underway to restore it to the remaining 38 km. A program to produce hatchery-reared fish to accelerate re-establishment of Gila trout in the wild has been initiated. Fish from Mescalero National Fish Hatchery were used to restore Gila trout to Main Diamond and Mogollon creeks.

CONSERVATION

Restoration of Gila trout to dedicated habitat (i.e., stream reaches legally protected for Gila trout) is necessary to preclude further deterioration of its status. For some streams, sufficient time must elapse for them to recover from the effects of wildfire and its impacts before Gila trout can be re-established. For others, nonnative salmonids (including most genetically contaminated populations of Gila trout) must be removed. Invasion of nonnative salmonids must be precluded by natural or artificial barriers for all streams currently dedicated to Gila trout. Wildfire in 1995 eliminated the nonnative salmonid populations in Black Canyon and with construction of a waterfall barrier (completed in 1998) the upper 19 km of the stream will be secured for Gila trout.

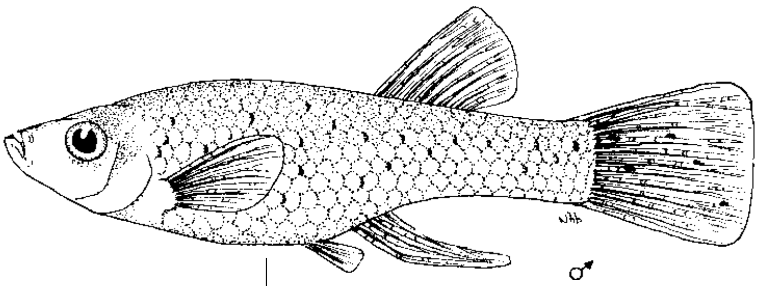
The current Gila Trout Recovery Plan (USFWS, 1993) identifies secure replication of each of the five relictual populations as necessary to biologically justify downlisting Gila trout from federal listing as endangered to threatened. Restoration of Gila trout to dedicated habitat will accomplish this goal for the relictual populations of the species in the Gila River drainage, but not for the relictual population in the San Francisco River drainage.

Recovery of Gila trout will require its re-establishment in hydrologically diverse drainages, in addition to those currently dedicated to it. Natural events between 1987 and 1996 demonstrated that the probability of a population surviving catastrophic natural events is greatly enhanced in streams with permanently-watered tributaries. For example, wildfire in 1989 burned much of the Main Diamond and South Diamond watersheds. Gila trout were eliminated from Main Diamond Creek, which had no permanently-watered tributaries, and the mainstem of South Diamond Creek. A small number of Gila trout survived the 1989 wildfire in a permanently-watered tributary (Burnt Canyon) of South Diamond Creek, and were therefore available to repopulate the mainstem, but for a 1995 wildfire that also eliminated this small population.

Although conservation strategies can be implemented to reduce the probability that natural events will eliminate the species, additional measures are necessary to protect extant and future populations from human activities. Illegal angling can greatly reduce abundance of Gila trout in the small habitats occupied by most populations. One recovery objective is to sufficiently recover the species so that it can be downlisted to threatened and some populations may be opened to special regulation angling. Presumably, this will discourage illegal angling in closed streams and enhance public support of recovery activities. ♦

Pecos Gambusia

Gambusia nobilis
(Baird and Girard, 1853)



LISTING STATUS

The Pecos gambusia, *Gambusia nobilis*, was listed in 1975 as endangered by New Mexico (19 NMAC 33.1) and it is federally listed as endangered (USFWS, 1970). It is listed as endangered by Texas (Campbell, 1995) and is considered threatened by the American Fisheries Society (Williams et al., 1989).

CHARACTERISTICS

The Pecos gambusia is a small, live-bearing fish with marked sexual dimorphism in size and other morphological characters. Males are 32 mm or less in total length while females may exceed 60 mm. The head is flattened dorsally and the superior mouth is strongly oblique with the lower jaw protruding and both jaws having teeth. The back is arched and the caudal peduncle is deep. Pecos gambusia are light reddish-brown with a somewhat paler venter. There are few or no small spots on the broadly rounded caudal fin (Bednarz, 1975). The anal fin of males forms an elongated gonopodium; the anal fin of females is smaller and ovate. There normally are 8 dorsal, 12 pectoral, and 6 pelvic fin rays; males typically have 9 anal fin rays while females have 10 (Echelle and Echelle, 1986). The Toyah Creek (Texas) and Blue Spring (New Mexico) populations were the most diverse of the extant populations, both morphologically (Echelle and Echelle, 1986) and genetically (Echelle et al., 1989; protein electrophoresis), and the Toyah Creek population had the highest genetic heterogeneity.

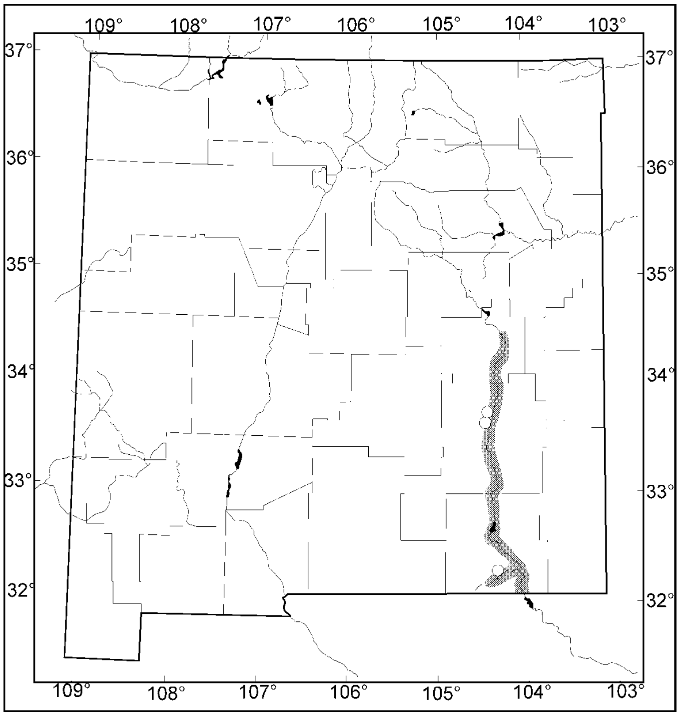
DISTRIBUTION

The Pecos gambusia is endemic to springs and spring systems of the Pecos River basin of southeastern New Mexico and western Texas (Hubbs and Springer, 1957). It apparently did not regularly inhabit the Pecos River (Echelle et al., 1989). In Texas, the species historically inhabited Comanche Springs and the Leon Creek drainage (also referred to as Diamond Y Draw in some publications) in and near Fort Stockton and a series of springs in the Toyah drainage near Balmorhea (Echelle and Echelle, 1980). Groundwater pumping dried Comanche Springs and that population no longer exists (Echelle and Echelle, 1980). In the Toyah Creek drainage, Pecos gambusia occur mainly in one gravity-flow spring (East Sandia) and in three artesian springs (Phantom, San Solomon, and Griffin) and their associated habitats. Echelle and Echelle (1980) reported Pecos gambusia mainly in two reaches of Leon Creek; the upper area near Diamond Y Spring and a lower stream reach. Generally, Pecos gambusia were common to abundant in spring habitats.

Springs and gypsum sinkholes on Bitter Lake National Wildlife Refuge (near Roswell) and Blue Spring and its outflow (near Whites City) apparently are the only areas of regular occurrence of Pecos gambusia in New Mexico (Bednarz, 1979; Echelle and Echelle, 1980). Bednarz (1975) reported natural populations of the species in sinkholes 7, 20, and 27, Sago Spring, and Dragonfly Spring and its associated spring run (= Lost River) on Bitter Lake National Wildlife Refuge. Bednarz (1975; 1979) also reported that a former refuge manager had, in 1971, stocked Pecos gambusia in several unoccupied sinkholes and impoundments on the refuge, but populations of the species were established only in one impoundment and two sinkholes. Where present on Bitter Lake National Wildlife Refuge, Pecos gambusia were usually common to abundant (Bednarz, 1979; Echelle and Echelle, 1980). In Blue Spring, Pecos gambusia were common in headwaters and diminished in abundance in the spring run as it flowed to its confluence with Black River (Bednarz, 1979; Echelle and Echelle, 1980).

BIOLOGY

Pecos gambusia is found almost exclusively in springs and spring runs (Echelle et al., 1989). On Bitter Lake National Wildlife Refuge, Echelle and Echelle (1980) found that Pecos gambusia



was only in habitats having permanent water, conductivity less than 35,000 µmhos/cm, relative thermal stability, and absence of western mosquitofish. Bednarz (1975; 1979) further characterized Bitter Lake National Wildlife Refuge habitats as having (during summer 1975) water temperatures of 23 to 30°C, dissolved oxygen of 5 to 10 mg/l, salinity of 1,600 to 12,000 mg/l (NaCl), and depths usually 1 to 8m. In sinkhole and spring habitats, Bednarz (1979) observed Pecos gambusia using submerged cliffs, overhanging banks, and aquatic vegetation for cover. He also commented that "any shallow area with aquatic vegetation seems suitable habitat if other factors are within the range of tolerance." Pecos gambusia does not occupy habitats on Bitter Lake National Wildlife Refuge with elevated hardness (>5,000 mg/l) and salinities in excess of 13,000 mg/l (Bednarz, 1979). Echelle and Echelle (1980) attributed the absence of Pecos gambusia from Lake St. Francis on that refuge to the presence of green sunfish. In contrast to the water of sinkholes and springs on Bitter Lake National Wildlife Refuge, the water of Blue Spring is fresh. Its chemical properties were 112 mg/l salinity (NaCl) and 1154 mg/l hardness (Bednarz, 1979). Habitats at Blue Spring range from those having zero-velocity water to the spring run where current velocities are rapid; Bednarz (1979) reported Pecos gambusia most common near the springhead in habitats having zero-velocity water. Gehlbach et al. (1978) reported that the upper thermal maximum of Pecos gambusia was 38 to 39°C and that the species preferred temperatures between 21 and 30°C. In Diamond Y Draw, Hubbs et al. (1978) found Pecos gambusia most common in thermally stable habitats (temperature not given).

Pecos gambusia produce live young. Bednarz (1979) reported a mean brood size of 38 and that the number of embryos produced was positively related to female length. Pecos gambusia from Texas weighed between 35 and 50 mg at birth (Hubbs, 1996). Pecos gambusia females may spawn several times each year; Hubbs (1996) reported an interbrood interval of 52 days.

There is little published information on the age, growth, and survival of Pecos gambusia, except that provided by Bednarz (1975) and Hubbs (1996). Bednarz (1975) found mature females (N = 19) 32 to 53 mm total length and weighing 0.4 to 2.5 g. In laboratory survival experiments conducted to determine levels of intra- and interspecific predation among populations of several *Gambusia* species, Hubbs (1996) found that predation by male and female Pecos gambusia on young congeners was higher than on young of their own species. Young Pecos gambusia were readily consumed by adults of other species of *Gambusia*.

In suitable habitats, Pecos gambusia abundance may be quite high. For example, Bednarz (1975) estimated that Sago Spring (300 m^2) supported 9,000 Pecos gambusia and that Blue Spring (>30,000 m^2) supported about 900,000.

Bedarz (1979) observed that the Pecos gambusia is a "carnivorous surface feeder," consuming any insect that alighted on the water surface. After grasping the prey item, an individual would move into deeper water or to cover, consumer the insect in 2 or 3 seconds, and resume foraging. Bednarz (1979) commented that insects were on the water surface rarely more than a second before a Pecos gambusia attacked it. While Bednarz (1979) noted that Pecos gambusia will prey on any suitable-sized prey item, Hubbs et al. (1978) reported a high incidence of amphipods (as well as a broad array of other food items) in their gastrointestinal tracts.

In occupied habitats on Bitter Lake National Wildlife Refuge, Bednarz (1979) found Pecos gambusia sympatric with Pecos pupfish (*Cyprinodon pecosensis*), plains killifish, rainwater killifish (*Lucania parva*), red shiner, and roundnose minnow (*Dionda episcopa*). In Blue Spring, he found it with Mexican tetra, western mosquitofish, roundnose minnow, and nonnative rock bass. Although Pecos gambusia appeared to coexist well with most small fishes of spring habitats, Bednarz (1979) noted that it tended to occupy mainly still-water and low-velocity habitats in the presence of western mosquitofish. In San Solomon Spring, Hubbs et al. (1995) found that Pecos gambusia occupied vegetated habitats and avoided open water in areas that also had largespring gambusia (*Gambusia geiseri*). Pecos gambusia in Texas spring systems are found with western mosquitofish, largespring gambusia (an introduced species), Leon Springs pupfish (*Cyprinodon bovinus*), Comanche Springs pupfish (*Cyprinodon elegans*), and sheepshead minnow (*Cyprinodon variegatus*) (an introduced species). Among these species, Pecos gambusia hybridizes with western mosquitofish and to a lesser extent with largespring gambusia (Echelle and Echelle, 1980).

STATUS

The historic range of Pecos gambusia was limited mainly to spring complexes on Bitter Lake National Wildlife Refuge, Blue Spring, Toyah Creek drainage, Leon Creek drainage, and Comanche Springs. Groundwater pumping dried Comanche Springs and thus extirpated this population by the 1950s (Echelle and Echelle, 1980). In the remaining spring complexes, Pecos gambusia is common to abundant (Bednarz, 1979; Echelle and Echelle, 1980; Brooks and Wood, 1988). However, Echelle and Echelle (1980) noted that in the Toyah Creek drainage the habitat occupied by Pecos gambusia was shrinking toward the spring heads. During the early 1970s and early 1980s, efforts were made to establish Pecos gambusia in unoccupied sinkholes on Bitter Lake National Wildlife Refuge (Bednarz, 1975; Brooks and Wood, 1988), but only one of these was successful (Brooks and Wood, 1988).

CONSERVATION

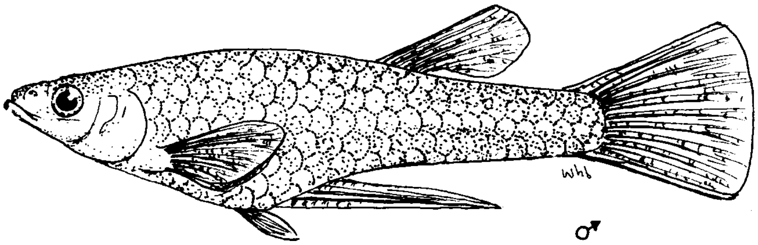
Hubbs and Echelle (1972) identified groundwater pumping as the greatest threat to extant populations of Pecos gambusia. This concern was subsequently expressed by Bednarz (1979), Echelle and Echelle (1980), and Echelle et al. (1989). Bednarz (1979) also noted that in habitats where "water conditions" fluctuate, western mosquitofish replace Pecos gambusia. In addition to physical displacement, Echelle and Echelle (1980) found that Pecos gambusia hybridize with western mosquitofish and largespring gambusia, particularly in modified habitats. Where predators such as green sunfish are present in otherwise suitable habitat (e.g., Lake St. Francis) Pecos gambusia are absent (Echelle and Echelle, 1980). Although efforts to establish additional Pecos gambusia populations in unoccupied sinkholes on Bitter Lake National Wildlife Refuge met with limited success, mainly because of unsuitable water quality (Bednarz, 1975), Echelle and Echelle (1980) identified criteria for selection of areas for establishment of additional Pecos gambusia populations. Given these restraints, they identified Lake St. Francis (Bitter Lake National Wildlife Refuge), Cottonwood Lake (Bottomless Lakes State Park) and the pupfish refugium at Balmorhea State Park (Toyah Creek drainage) as the only locations likely suitable for establishment of additional Pecos gambusia populations. Diamond Y Draw was successfully treated with rotenone to remove undesirable nonnative species and hybrids and restocked with native fishes, including Pecos gambusia (Hubbs et al., 1978). In the early 1990s, the concrete lined irrigation ditch at the outflow of Phantom Springs was successfully modified to provide additional habitat for Pecos gambusia (G.P. Garrett, pers. comm.). Over the past five years, the Texas Parks and Wildlife Department has successfully worked with the Reeves County Water Improvement District No. 1 to expand the native fish refugium at Balmorhea State Park (G.P. Garrett, pers. comm.). Rattlesnake Springs on Carlsbad Caverns National Park may provide suitable habitat for Pecos gambusia.

The current Pecos Gambusia Recovery Plan (USFWS, 1983b) has as its primary objective the security of the species in its four areas of occurrence. While security of each is not absolute, it has improved with management activities in most areas. Although the security of the Blue Spring population has been maintained by the family that owns the property, proposals by downstream water-rights holders to dredge the spring run remain a threat to this population. ♦

Gila Topminnow

Poeciliopsis occidentalis occidentalis

(Baird and Girard, 1853)



LISTING STATUS

The Gila topminnow, *Poeciliopsis occidentalis occidentalis*, was listed in 1990 by New Mexico as a threatened species (19 NMAC 33.1) and it is federally listed as endangered (USFWS, 1967). Arizona lists two subspecies of the topminnow (Gila topminnow, *P. o. occidentalis* and Sonora topminnow, *P. o. sonoriensis*) as species of special concern (AZGF, 1996) and the Republic of México lists it (no distinction of subspecies) as a threatened species (SDS, 1994). The American Fisheries Society considers the Gila topminnow a species of concern (Williams et al., 1989).

CHARACTERISTICS

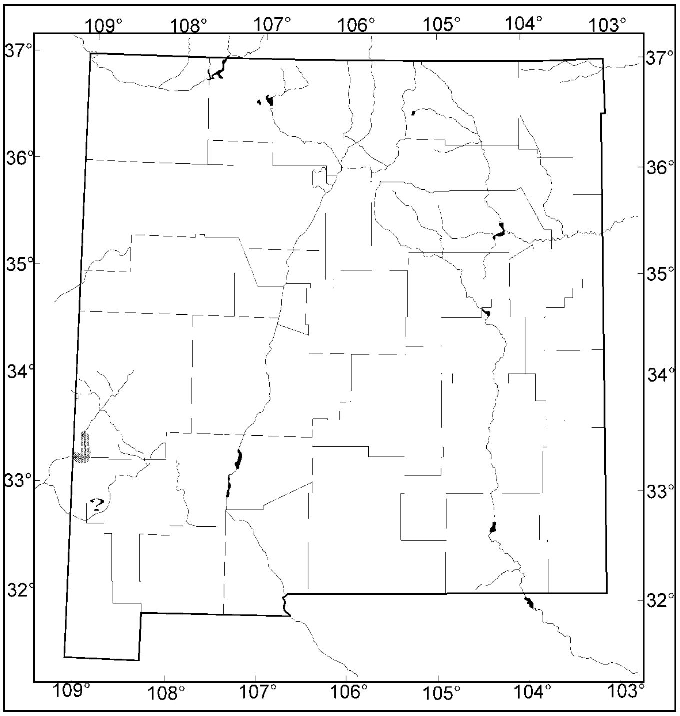
The Gila topminnow is a small, slightly curved dorsally, somewhat elongate fish (Minckley, 1973). The head is flat and the almost terminal mouth is turned upward. Females are larger than males and may grow to standard lengths of 50 mm whereas males rarely exceed 25 mm. This topminnow typically is tan to olivaceous with a distinct, dark lateral band and a cream-white to white abdomen. The scales, particularly those on the dorsum, are darkly outlined with melanophores. On the lower sides the coloration is whiter and melanophores are randomly scattered. The fin rays are outlined with melanophores. Gila topminnow express strong sexual dimorphism (in addition to size differences), with males becoming almost jet black during spawning and some having a golden tinge in the midline of the predorsum and an orange coloration at the base of the gonopodium. Females do not change markedly during spawning except for a darkening of the abdomen associated with the developing embryos. The gonopodium (modified rays of the male anal fin) is long and, when in a copulatory position, may extend past the snout. Other fins are broadly rounded and the distal margin of the caudal fin is almost straight.

DISTRIBUTION

The Gila topminnow was formerly widespread and considered one of the most common fishes of the lower Gila River drainage from its mouth near Yuma, Arizona (Hubbs and Miller, 1941; Minckley, 1973) upstream to the Frisco Hot Springs on the San Francisco River in New Mexico (Koster, 1957). In Gila River tributaries, it extended into Sonora via the ríos San Pedro and Santa Cruz (Minckley, 1973). In addition to the mainstem Gila River, Gila topminnow also occurred throughout much of the Verde and Salt River systems of central Arizona (Minckley, 1973).

The only documented historic occurrence of Gila topminnow in New Mexico was a series of stenothermal warm springs (Frisco Hot Springs) along the San Francisco River near Pleasanton (Koster, 1957). This population was extirpated during the early 1960s, either as a result of flooding or as a consequence of severe drought. In either situation, the habitat upon which the population was dependent was eliminated.

Currently, Gila topminnow naturally occcurs only as 11 scattered, isolated populations in Arizona (Weedman and Young, 1997). The security of these is variable and only three are considered relatively secure (Weedman and Young, 1997). Numerous attempts have been made to establish Gila topminnow in a variety of locations throughout its historic Arizona range (Brooks, 1985; Minckley and Brooks, 1985), but few have been deemed successful (Hendrickson and Brooks, 1991; Weedman et al., 1997). In 1989, Gila topminnow from Dexter National Fish Hatchery and Technology Center were stocked in a pond on the New Mexico Department of Game and Fish Red Rocks Wildlife Management Area. The success of this effort has not been verified.



BIOLOGY

In its broad historic range in the Gila River system, Gila topminnow probably was most common in protected stream shoreline habitats where water velocity was slow, depths shallow, water temperatures warm (typically >20°C), and aquatic vascular plants common (Minckley and Deacon, 1968; Minckley, 1973; Minckley et al., 1977). In addition to mainstem river habitats, Gila topminnow occupied numerous spring and spring-run habitats where emergent aquatic vegetation was dense along shores (Minckley et al., 1977; Williams et al., 1985). Minckley (1973), however, noted that he only observed the species in late summer in intermittent stream reaches that were downstream of spring habitats. Gila topminnow are tolerant of salinities approaching that of seawater (Schoenherr, 1974) and water temperatures from near freezing to 37°C (Meffe et al., 1983).

Spawning by Gila topminnow in its current range occurs from January through August (Minckley, 1973). The intensely-black and territorial males pursue females and copulation is frequent. The species is viviporous. Brood size is variable, typically ranging from 1 to 15 young (Minckley, 1973) and number of young per clutch apparently is related to food availability (Constantz, 1974). Each female typically has two broods developing simultaneously, with one more advanced than the other (Minckley, 1973). Number of embryos is dependent upon female size with a maximum of about 25 embryos for 45 mm (SL) females (Schoenherr, 1977). Sexual maturity may be attained in a few weeks (if born during summer) or several months (if born in autumn or winter) (Minckley, 1973). Gila topminnow probably do not survive more than 12 or 13 months under natural conditions (Minckley, 1973).

Food of Gila topminnow consists of bottom detritus, vegetation, and crustaceans (Minckley, 1973). Minckley (1973) also noted that topminnow feed voraciously on aquatic insect larvae (particularly mosquito) when available and Constantz (1974) related that a diet rich in amphipods apparently contributed to an increased number of embryos per female.

During summer months when spawning activity is intense, population densities of Gila topminnow may become quite high (Weedman and Young, 1997). Meffe et al. (1983), however, noted that populations of the species may undergo tremendous expansions in numbers and then crash for inexplicable reasons. Although Collins et al. (1981) documented the apparent elimination of Gila topminnow from Tule Creek in Arizona as a result of extreme flooding, Meffe (1984) and Minckley and Meffe (1987) found that a Gila topminnow population survived a series of intense floods in a spring system.

Over its historic range, Gila topminnow likely was associated with other small-bodied native fishes, such as spikedace, longfin dace, and desert pupfish (*Cyprinodon macularius*) and young of large-bodied species, such as Gila chub, desert sucker, and Sonora sucker (Minckley, 1973; Minckley et al., 1977). Each of these native fishes (at least early life stages of each) also inhabited slow velocity and vegetated shoreline habitats. A large number of nonnative fishes have been introduced to habitats historically occupied by Gila topminnow. Among these, sunfishes, catfishes (*Ameiurus* spp. and *Ictalurus* spp.), and western mosquitofish are found most commonly in habitats formerly or currently occupied by Gila topminnow (Minckley et al., 1977). Although sunfishes and catfishes likely prey on Gila topminnow, thereby reducing the latter's abundance, western mosquitofish has been implicated in the elimination of more topminnow populations than any other nonnative (Schoenherr, 1981).

STATUS

The Gila topminnow in the United States currently is limited to isolated populations scattered across southeastern Arizona in the Gila River drainage. Almost all of these are in springs, cienegas, and small streams (USFWS, 1994b). Efforts to repatriate the species to historic habitats began in the 1930s (Minckley and Brooks, 1985) and by 1981 over 50 sites were stocked with Gila topminnow (Weedman and Young, 1997). In 1981, the U.S. Fish and Wildlife Service and Arizona Game and Fish Department initiated an intensive effort to stock the species in suitable habitats throughout its historic Arizona range. The effort, to date, has had limited success. Of 175 locations stocked with Gila topminnow since 1936, only 17 still support the species (Weedman and Young, 1997). Security of each re-established population is tenuous. The effort in 1989 to re-establish Gila topminnow in New Mexico in a pond near Red Rock may have failed, but no effort has been made to determine the status of this population.

CONSERVATION

Loss of habitat and nonnative fishes remain the greatest impediments to conservation of Gila topminnow.

Although habitat loss (stream desiccation, wetland draining, and arroyo cutting) contributed considerably to the decline of the species (Miller, 1961; Minckley, 1973; Meffe et al., 1983; Hendrickson and Minckley, 1985), nonnative fishes, particularly western mosquitofish, remain the primary threat to survival of Gila topminnow (Minckley et al., 1977; Schoenherr, 1981; Weedman and Young, 1997). Schoenherr (1981) and Meffe et al. (1983) discounted competition for food or spawning location as reasons for the replacement of Gila topminnow by western mosquitofish. Schoenherr (1981), however, believed that the more aggressive behavior of western mosquitofish (causing reduced fecundity of Gila topminnow females) might partially explain elimination of Gila topminnow when the two species were in sympatry. Meffe et al. (1983) provided evidence that predation (particularly on juvenile Gila topminnow) by western mosquitofish was a major factor in elimination of Gila topminnow populations.

Recovery of Gila topminnow requires the repatriation of the species to suitable habitats in its native range and protection of these habitats. Since the early 1980s, considerable information has been acquired on factors that enhance the survival prospects of repatriated populations. In addition to exclusion or elimination of nonnative fishes, Brooks (1985) identified other factors that appeared important to the survival probability of repatriated populations; habitat stability, presence of aquatic vegetation, and a silt substrate were the most important.

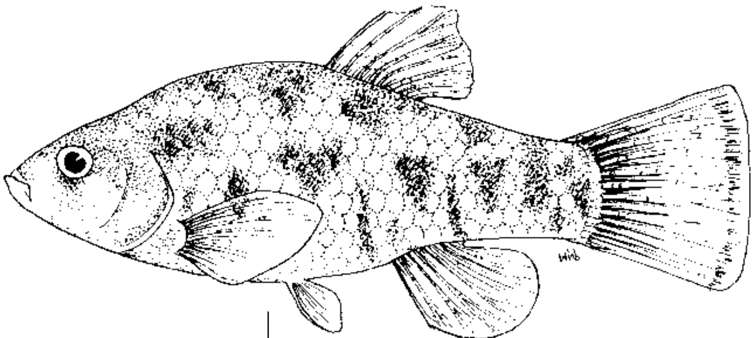
Recovery efforts must also incorporate genetic considerations. Genetic differences exist among extant populations (Meffe and Vrijenhoek, 1988) and appropriate husbandry of these differences may enhance survival prospects of repatriated populations (Vrijenhoek et al., 1985).

A Gila Topminnow Recovery Plan was finalized in 1984 (USFWS, 1984). A key element of this recovery plan was identification of criteria to achieve down- and delisting. A minimum of 20 repatriated populations was the requirement to justify downlisting. That goal was achieved in 1987, but the insecurity of these populations prompted postponement of plans to downlist the species. Since then, the number of successful replications has remained less than 20 and the species remains federally listed as endangered. With the adoption of guidelines for the selection of sites to re-establish the species, additional efforts were made to enhance the security of the species. However, disagreements among land management agencies and regulatory agencies over the status of repatriated populations (protected versus experimental, non-essential under terms of the Endangered Species Act) disrupted recovery efforts and progress was limited. A draft revision of the Gila Topminnow Recovery Plan (USFWS, 1994b) provided additional standards for assessing the relative well-being of extant (relictual and repatriated) populations and increased to 50 the number of repatriated populations necessary to justify downlisting. The 1994 Recovery Plan remains in draft form. In the meantime, Arizona Game and Fish Department has instituted a program to monitor the status of relictual and repatriated Gila topminnow populations, attempted to improve the security of extant populations, and has made efforts to establish additional populations.

Suitable aquatic habitats for Gila topminnow on the New Mexico Department of Game and Fish Red Rock Wildlife Area need to be secured (mainly by maintaining permanent water and excluding western mosquitofish) and stocked with Gila topminnow. Other suitable habitats may exist in the lower Gila River valley. These should be identified and, where feasible, stocked with Gila topminnow. The Frisco Hot Springs should also be evaluated for re-establishment of the species. Determination of the source populations for repatriation efforts should consider genetic issues and availability. ♦

Pecos Pupfish

Cyprinodon pecosensis
(Echelle and Echelle, 1978)



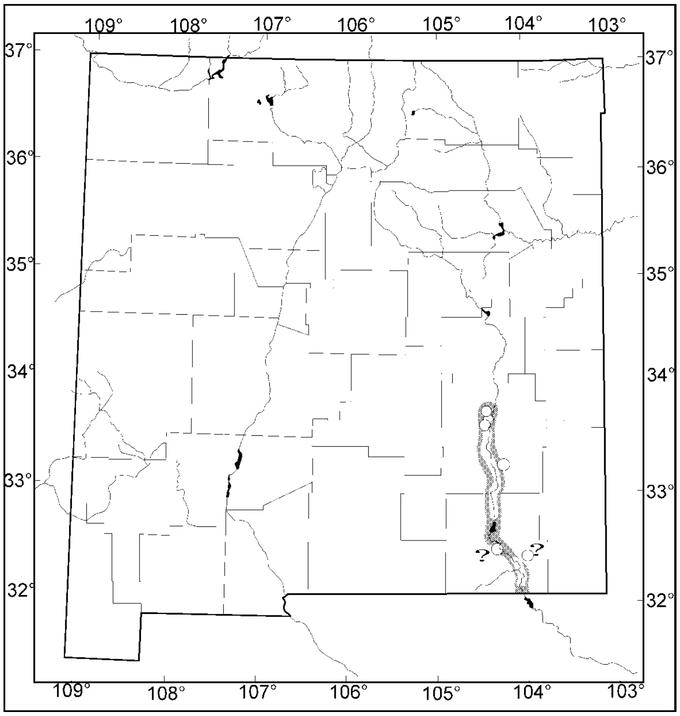
LISTING STATUS
The Pecos pupfish, *Cyprinodon pecosensis*, was listed as a threatened species by New Mexico (19 NMAC 33.1) in 1988 and it is proposed for federal listing as endangered (USFWS, 1996). It is listed as a threatened species by Texas (Campbell, 1995) and it is considered a species of concern by the American Fisheries Society (Williams et al., 1989).

CHARACTERISTICS
The Pecos pupfish is a small, stout-bodied fish that seldom exceeds 60 mm TL (Echelle and Echelle, 1978). Nonbreeding adults and juveniles have a dorsal and lateral background color of brown to greenish-gray and are creamy-white ventrally. The 7 to 9 dark lateral bars of females are broken into blotches whereas those of males are continuous but less distinct. Nuptial males are grayish blue dorsolaterally and dusky white ventrally. The dorsal and anal fins of breeding males are black almost to their posterior margins and the pectoral fin is pale yellow. A narrow black band edges the terminus of the caudal fin. Female colors do not intensify appreciably during the spawning season. The small, upward oriented mouth, has numerous tricuspid teeth on each jaw. The abdomen is scaleless except for a few scales just anterior to the pelvic fins and in a small area just behind the ishthmus. All fins are distally rounded; the dorsal fin usually has 10 rays, the pelvic 6 or 7, the pectoral 15, and the anal 10. There are usually 20 or 21 gill rakers (Echelle and Echelle, 1978). Echelle and Echelle (1992) presented allozymic data showing that Pecos pupfish was most closely related to Leon Springs pupfish (*Cyprinodon bovinus*), which occurs in the lower Pecos River valley in Texas.

DISTRIBUTION
The Pecos pupfish formerly occurred in the Pecos River valley from near Roswell, New Mexico downstream to the confluence of Independence Creek in Texas. Within this area, it occurred in the mainstem Pecos River, several small tributaries (e.g., Salt Creek, Texas), saline springs, and gypsum sinkholes (Echelle and Echelle, 1978). Although data are limited, it apparently was at least locally common in suitable habitat (e.g., Campbell, 1958; Echelle and Echelle, 1978).

The Pecos pupfish has been eliminated from the Pecos River in Texas (Echelle and Conner, 1989) and in the Pecos River, New Mexico upstream to at least Loving Crossing (Wilde and Echelle, 1992; Echelle et al., 1997). It remains common in Texas only in Salt Creek (Hoagstrom and Brooks, 1995). In the Pecos River, New Mexico, Pecos pupfish are irregularly collected from near Bitter Lake National Wildlife Refuge downstream to near Malaga Bend (Hoagstrom and Brooks, 1995). The largest extant populations of the species in New Mexico occur in gypsum sinkholes, isolated oxbow lakes, and artificial impoundments on Bitter Lake National Wildlife Refuge (Brooks and Wood, 1988; Hoagstrom and Brooks, 1995). Pecos pupfish persist abundantly in habitats associated with Bottomless Lakes State Park (Hoagstrom and Brooks, 1995). The Laguna Grande (east of Loving, New Mexico) population (Albeit, 1982) was believed extirpated (Hoagstrom and Brooks, 1995). Its persistence was confirmed in 1996 (J.E. Brooks, pers. comm.), but no pupfish was found in 1997 (C.W. Hoagstrom, pers. comm).

BIOLOGY
Although Pecos pupfish occur in a variety of habitats ranging from the mainstem Pecos River and associated off-channel habitats to small tributary streams and gypsum sinkholes, they are most common in habitats having elevated salinity (Echelle and Echelle, 1978). In gypsum sinkholes on Bitter Lake National Wildlife Refuge, Hoagstrom and Brooks (1995) reported it in habitats with salinities ranging from 3,000 to 50,000 mg/l. Pecos pupfish can survive periods of depressed dissolved oxygen concentrations; Hoagstrom and Brooks (1995) reported substantial numbers of Pecos pupfish in sinkholes on Bitter Lake National Wildlife Refuge with dissolved oxygen levels as



low as 2.5 mg/l. Sinkhole habitats typically have silt and limestone bottoms and dense growths of *Cladophora* and *Potamogeton*.

Spawning by Pecos pupfish occurs mainly during summer months when water temperatures may be 30°C or greater (Kodric-Brown, 1981). Males establish territories over rocky outcrops, submerged vegetation, and cobble scattered over silt substrates and attract females with a series of ritualized movements (Kodric-Brown, 1983). Females apparently prefer spawning over rocky outcrops. Duration of courtship behavior is briefest during summer when competition for females is most intense (Kodric-Brown, 1977). The territories defended by males are smallest where the density of pupfish is high. A single male may mate with four or more females in an hour (Kodric-Brown, 1981). Where Pecos pupfish densities are low, territories are not established and dominance hierarchy and consort pair associations are the prevalent spawning behavior (Kodric-Brown, 1988). Garrett (1982) reported that in variable environments, reproductive strategy varies.

Little research has been accomplished on the life history of Pecos pupfish. It presumably is similar to White Sands pupfish (*Cyprinodon tularosa*) and Red River pupfish (*Cyprinodon rubrofluviatilis*) (Echelle and Echelle, 1978). Pecos pupfish probably live two or three years. Pecos pupfish are omnivores, feeding principally on a diatom and detrital mixture likely obtained from the bottom of habitats they occupy (Davis, 1981).

Pecos pupfish are most commonly found with other halophilic fish species. Echelle and Echelle (1978) reported plains killifish, rainwater killifish, western mosquitofish, and red shiner to be the most common associates of Pecos pupfish and noted that densities of the species were low in habitats also occupied by green sunfish. Hoagstrom and Brooks (1995) reported a similar association of species in sinkhole habitats on Bitter Lake National Wildlife Refuge and Bottomless Lakes State Park.

STATUS

The Pecos pupfish currently occurs primarily and most commonly in three disjunct areas within its native range: sinkholes, isolated oxbow lakes, and artificial impoundments on Bitter Lake National Wildlife Refuge, sinkholes on Bottomless Lakes State Park, and Salt Creek, Texas (Hoagstrom and Brooks, 1995). On Bitter Lake National Wildlife Refuge and Bottomless Lakes State Park, its abundance in each habitat is seasonally and annually variable (Hoagstrom and Brooks, 1995). It occurs irregularly in the Pecos River upstream of Artesia and has been eliminated from the Pecos River in Texas (Echelle and Conner, 1989; Hoagstrom and Brooks, 1995).

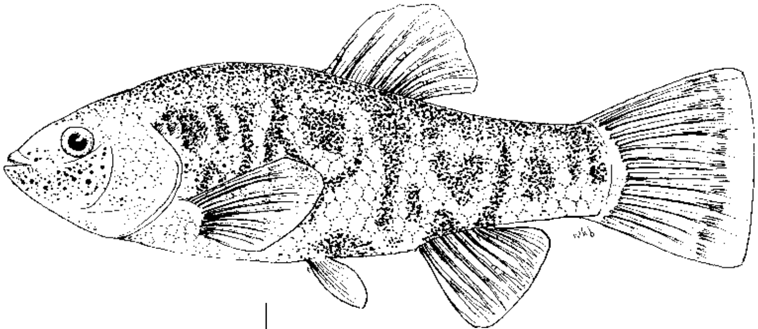
CONSERVATION

The introduction of nonnative sheepshead minnow between 1980 and 1984 to the Pecos River in Texas was responsible for the elimination of Pecos pupfish from the Pecos River downstream of Loving, New Mexico (Echelle and Conner, 1989; A.A. Echelle, pers. comm.). Sheepshead minnow hybridize with Pecos pupfish and no genetically pure populations of Pecos River pupfish persist in river reaches where sheepshead minnow or hybrids have been introduced. The initial introduction of sheepshead minnow was probably a bait-bucket release. The upstream dispersal of hybrids likely occurred, and continues to occur, by natural dispersal of fish within the river and by bait-bucket transport (Echelle and Conner, 1989). Widespread occurrence of sheepshead minnow and Pecos pupfish x sheepshead minnow hybrids in much of the Pecos River was apparently facilitated by massive fish kills in the river in the late 1980s (Rhodes and Hubbs, 1992). A confluence of suitable water temperature and salinity levels resulted in blooms of golden alga, *Prymnesium parvum*, in the Pecos River between Malaga Bend, New Mexico and Amistad Reservoir, Texas on several occasions. These blooms were associated with almost complete elimination (99 +%) of fishes in long reaches of the river (Rhodes and Hubbs, 1992). Prior to the fish kills, Pecos pupfish x sheepshead minnow hybrids were absent from much of the affected reach of the Pecos River, but following the blooms hybrid forms were widespread and common (Rhodes and Hubbs, 1992).

Conservation of the species will depend mainly upon exclusion of sheepshead minnow from habitats currently occupied by genetically pure populations of Pecos pupfish. This will require excluding pupfish species (*Cyprinodon* spp.) from the baitfish industry. Few, if any, sport fisheries exist in the saline habitats in which Pecos pupfish are most common. Most extant populations of Pecos pupfish are physically isolated from the Pecos River. In some instances (e.g., Salt Creek, Texas), this isolation needs enhancement to reduce the risk of invasion by sheepshead minnow. Management of Bitter Lake National Wildlife Refuge incorporates practices designed to protect Pecos pupfish habitats (W. Radke, pers. comm.) and the same should be instituted at Bottomless Lakes State Park. Balmorhed Lake, Texas was chemically treated in 1998 to eliminate a large population of sheepshead minnow (G.P. Garrett, pers. comm.). ♦

White Sands Pupfish

Cyprinodon tularosa
(Miller and Echelle, 1975)



LISTING STATUS

The White Sands pupfish, *Cyprinodon tularosa*, was listed by New Mexico in 1975 as a threatened species (19 NMAC 33.1). The American Fisheries Society considers it a species of concern (Williams et al., 1989).

CHARACTERISTICS

The White Sands pupfish is a small-bodied, chunky species that rarely exceeds 50 mm total length (Miller and Echelle, 1975; Pittenger and Springer, 1995). Several indistinct dark gray dorsal bands are evident on most individuals, particularly younger fish. Males are deep metallic blue dorsally, grayish blue laterally, and whitish to pale orange ventrally. Females are olivaceous dorsally, whitish to silvery laterally, and white ventrally; their pectoral and pelvic fins are pale yellow (Miller and Echelle, 1975). The dorsal fin of nuptial males is bright yellow-orange to deep orange distally, the distal two-thirds of the anal fin is orange, and the pectoral and pelvic fins are orange with dusky to blackish margins. Females do not change markedly in coloration during the spawning season. The small terminal, upward-oriented mouth has numerous tricuspid teeth on each jaw (Miller and Echelle, 1975). The breast and abdomen are fully scaled, or nearly so, and there are 26 to 28 scales in the lateral series. All fins are rounded; there are typically 10 dorsal, about 10 anal, typically 6 pelvic, and 16 pectoral fin rays. There are normally 21 to 25 gill rakers (Miller and Echelle, 1975).

DISTRIBUTION

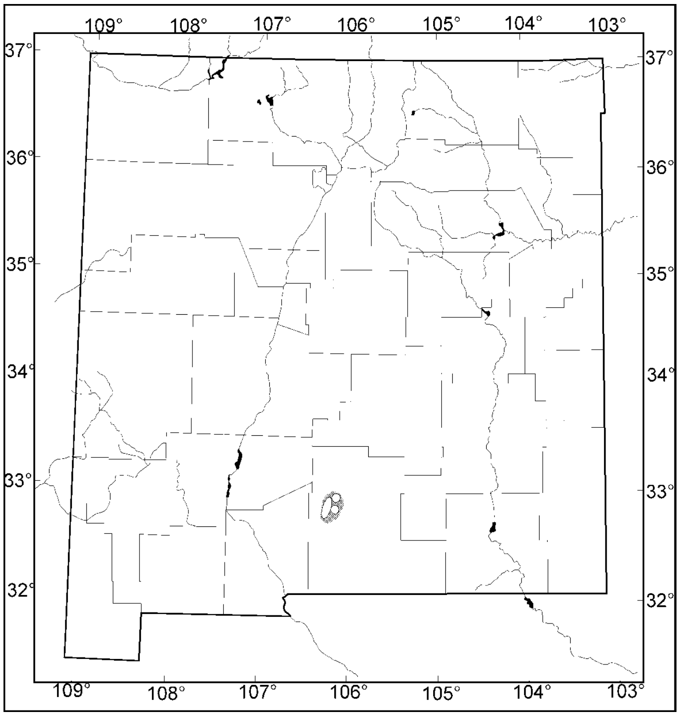
The White Sands pupfish is endemic to the endorheic Tularosa Basin of southcentral New Mexico (Miller and Echelle, 1975). Previously, it was believed to occur naturally in Mound and Malpais springs and Salt Creek (Miller and Echelle, 1975; Jester and Suminski, 1982). The population in Lost River (including Malone Draw) was believed to be introduced (Miller and Echelle, 1975; Echelle et al., 1987), but Jester and Suminski (1982) suggested it might be native. Recently, however, Pittenger and Springer (in press) demonstrated that White Sands pupfish historically occurred only in Malpais Spring (and its associated spring run and playa) and the lower reaches of Salt Creek. Populations in Lost River and Mound Spring were established by human translocation. Allozymic studies confirmed Pittenger and Springer's (in press) interpretation of the historic distribution of the species (C. Stockwell, pers. comm.).

Within occupied habitats, the White Sands pupfish typically is common. Dice (1940) commented upon the large number of "small fish" he observed in Malpais Spring. All workers since then have reported on the seasonally high densities of White Sands pupfish in each habitat (e.g., Miller and Echelle, 1975; Jester and Suminski, 1982; Pittenger, 1996). Pittenger (1996) reported a major reduction in White Sands pupfish abundance in Mound Spring during 1995 as a consequence of an outbreak of a diagenetic trematode (*Diplostomulum* sp. or *Neascus* sp.). Pittenger (1996) also reported seasonal variation in White Sands pupfish density with highest densities occurring in summer and autumn. Mean density in Malpais Spring during autumn was 4.9 fish/trap-hour while that at one location on Salt Creek during the summer exceeded 14 fish/trap-hour. During seasons of lowest abundance (winter or spring), densities as low as 1 fish/trap-hour were common.

Overall abundance of White Sands pupfish in Malpais Spring, Salt Creek, and Lost River also is dependent upon extent of wetted habitats. Increased wetted areas as a consequence of storm events was accompanied by increased abundance of White Sands pupfish (J.S. Pittenger, pers. comm.).

BIOLOGY

The White Sands pupfish is generally most abundant along the banks in lentic habitats (e.g., Mound Spring) and in shallow portions of low-velocity lotic habitats (e.g., Salt Creek). It also colonizes flooded playas (Pittenger, 1996). Salinity of all occupied habitats is high, commonly exceeding 15,000 mg/l (Miller and Echelle, 1975; J.S. Pittenger, pers. comm.). Seasonal variation in



water temperature of occupied habitats is considerable; summer water temperatures often exceed 35°C and in lower Salt Creek summer diel water temperature fluctuations of 30°C have been recorded (J.S. Pittenger, pers. comm.).

Spawning by White Sands pupfish begins in early spring when water temperature is about 18°C (Suminski, 1977) and may extend into early autumn (J.S. Pittenger, pers. comm.). Males establish and guard territories in the shallow vegetated littoral zones of springs and playa lakes and in low-velocity, vegetated margins of streams. Spawning behavior involves a series of ritualized movements by the male to entice a female into its territory. Eggs are released and fertilized while the male's anal fin is wrapped around the female's vent. Only one egg is released during each spawning event, but there may be 12 to 15 such events during a single bout of repeated spawnings (Suminski, 1977; A.A. Echelle, pers. comm.). Although Jester and Suminski (1982) reported a total fecundity ranging from 810 ova in small females to over 2900 in larger and presumably older individuals, they did not provide data on the number of eggs an individual female may release during a single spawning event. A female may spawn twice in a 24 hour-period, but it is unknown if an individual females spawns throughout the spawning season. Suminski (1977) suggested that within a population, spawning may be cyclic, with peaks occurring every three weeks. White Sands pupfish females are capable of spawning as Age 1 (Jester and Suminski, 1982) and probably as Age 0 (A.A. Echelle, pers. comm.). Fertilized eggs of White Sands pupfish probably incubate 4 to 8 days, a period reported for other *Cyprinodon* sp. (Able, 1984).

Upon hatching, White Sands pupfish grow rapidly during their first summer and by autumn attain total lengths of 25 to 30 mm (Suminski, 1977). Thereafter, the growth rate diminishes and maximum lengths are about 60 mm (Pittenger, 1966). Jester and Suminski (1982) did not find gender-based differences in growth. Although Jester and Suminski (1982) suggested that some individuals may live five years, J.S. Pittenger (pers. comm.) believed 24 months was the maximum longevity and that few White Sands pupfish live more than 12 months. Mortality is highest among Age 0 and Age 1 individuals; Jester and Suminski (1982) estimated that only 30,000 of almost two million Age 0 individuals survived to Age 1 and less than 500 survived to Age 2.

The White Sands pupfish is omnivorous, but feeds mainly on mosquito (Culicidae) larvae (Suminski, 1977). Although mosquito larvae are preferred, White Sands pupfish also consume organic detritus, algae, and other aquatic insects.

The White Sands pupfish is the only fish species native to the Tularosa Basin (Miller and Echelle, 1975). Western mosquitofish, goldfish (*Carassius auratus*), and largemouth bass have been introduced to several ponds in the Tularosa Basin, but none occurs in habitats currently occupied by White Sands pupfish.

STATUS

The White Sands pupfish currently occupies its entire historic range of Salt Creek and Malpais Spring (and associated habitats). Additional populations in Mound Spring and Lost River (including Malone Draw) were established by human translocation (Pittenger and Springer, in press). Abundance of White Sands pupfish changes within each of these small, seasonally variable habitats (Pittenger, 1996). The populations in the Malpais Spring system and Salt Creek are the largest and that of Mound Spring is the smallest.

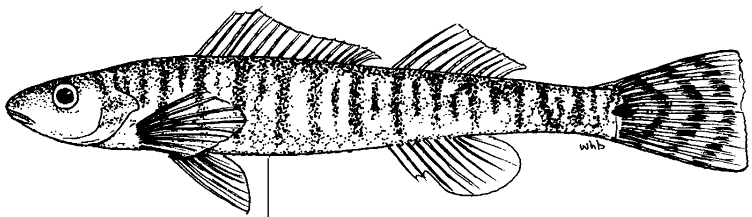
CONSERVATION

Security of the limited range and exclusion of nonnative fishes from its habitats are essential to the conservation of White Sands pupfish. The species receives considerable protection because of being located on federally protected areas (White Sands Missile Range, Holloman Air Force Base, or White Sands National Monument). Human access and activities are limited and strictly regulated within the boundaries of each facility (particularly on the military installations). Conservation of these populations was formalized in 1994 by execution of the Cooperative Agreement for Protection and Maintenance of White Sands Pupfish, to which the U.S. Army (White Sands Missile Range), U.S. Air Force (Holloman Air Force Base), National Park Service (White Sands National Monument), U.S. Fish and Wildlife Service, and New Mexico Department of Game and Fish were signatory. Among its conditions, the Cooperative Agreement delineated areas of proscribed activity around habitats occupied by the species, restricted transport of nonnative aquatic wildlife, and provided a framework for consultation among signatory agencies including the establishment of a White Sands Pupfish Conservation Team. In addition, the Cooperative Agreement involves regular monitoring and protection of all White Sands pupfish populations. Since its inception, quarterly monitoring of extant populations has been initiated, the population of feral horses was reduced from over 1,800 to less than 200, and additional research on the genetics and life history of the pupfish has been conducted. ♦

Bigscale Logperch

Percina macrolepida

(Stevenson, 1971)



LISTING STATUS

Bigscale logperch, *Percina macrolepida*, was listed as threatened by New Mexico in 1975 (19 NMAC 33.1).

CHARACTERISTICS

The bigscale logperch has an elongate, fusiform body with a small head and moderately pointed snout (Stevenson, 1971). Adults typically attain total lengths of 100 to 130 mm (Kuehne and Barbour, 1983; Page, 1983); Koster (1957), however, reported individuals up to 200 mm TL. The eye appears large relative to the small head (Kuehne and Barbour, 1983). Bigscale logperch adults are light olive to straw yellow with 20 or more narrow, green to green-black vertical bars on the sides (Page, 1983). The bars extend over the dorsum and a distinct basicaudal black spot is present. The caudal fin has 3 to 5 irregular vertical, narrow bands (Stevenson, 1971). In nuptial males, the head is darker and the pectoral and pelvic fins are dusky. The first dorsal fin has 13 to 15 spiny rays, second dorsal has 12 to 15 soft rays, and the anal has 2 spiny and normally 9 soft rays. Scales of this darter are comparatively large, and there are typically 79 to 86 lateral line scales. The supraoccipital and breast are scaled (Page, 1983). The recurved teeth are well-developed on both jaws (Stevenson, 1971).

DISTRIBUTION

The native range of bigscale logperch encompasses Gulf Coastal drainages of Texas, the Red River of Texas and Oklahoma, and the Pecos River of Texas and New Mexico (Kuehne and Barbour, 1983; Page, 1983). Stevenson and Thompson (1978) reported it in the Río San Carlos, Coahuila. The species has been introduced (probably via bait-bucket) and established in the Sacramento-San Joaquin system of California (Moyle, 1976) and Ute Reservoir on the South Canadian River, New Mexico (Sublette et al., 1990). In New Mexico, bigscale logperch occur in the Pecos River in the vicinity of Santa Rosa and Sumner reservoirs (as well as both reservoirs), the lower Pecos River near Brantley Reservoir (Sublette et al., 1990), and in the Black River (NMGF files). It is rare or absent in the Pecos River between Old Fort State Park (downstream of Fort Sumner) and Artesia (Larson and Propst, 1996).

BIOLOGY

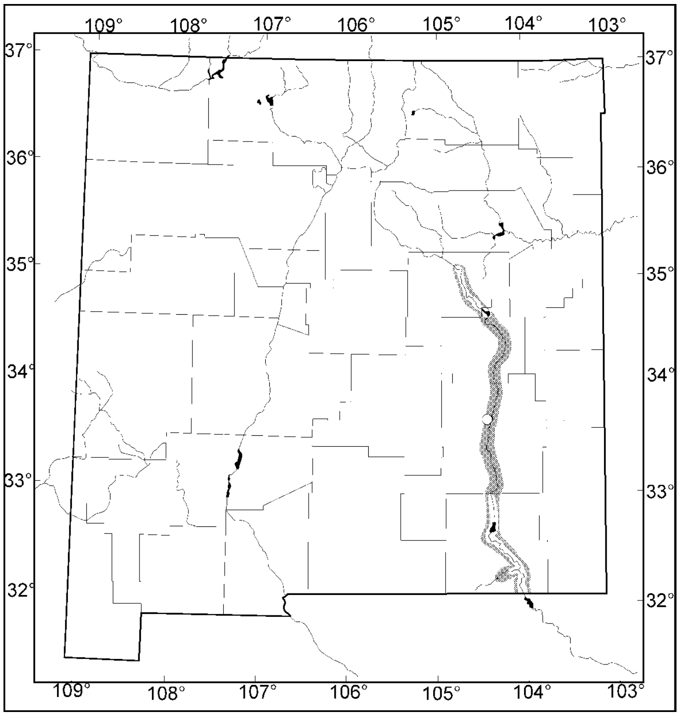
Bigscale logperch are most frequently found in fast flowing, non-turbulent, moderately deep water with large cobble substrate (Stevenson, 1971). In the Black River, they are found only in moderate velocity runs, where the substrate is mainly irregularly shaped limestone bedrock and aggregated conglomerate, that connect pools (NMGF files). In lentic environments, the species is found along wave-swept shorelines where the substrate is large gravel and cobble.

In central Texas, Hubbs (1985) reported a reproductive season from late-February through mid-April. In New Mexico, spawning probably occurs somewhat later in the spring. Spawning apparently occurs in cobbled, rapid-velocity runs (Stevenson, 1971). Although a sibling species, the logperch (*Percina caprodes*), migrates to spawning rapids (Winn, 1958), Stevenson (1971) did not note such behavior by bigscale logperch. Females produce comparatively small eggs (Hubbs, 1967); Stevenson (1971) reported 186 and 365 eggs in 72 and 83 mm SL specimens, respectivley.

Other than information on its reproductive biology, there is no published information on the biology of bigscale logperch. Sublette et al. (1990) suggested some aspects of its biology are similar to those of logperch.

STATUS

Although there were few data upon which to base their evaluation, Kuehne and Barbour (1983) opined that bigscale logperch was comparatively common over much of its Texas range. In



the Pecos River, New Mexico, bigscale logperch are regularly collected at several locations downstream of Santa Rosa Reservoir and near the Brantley Reservoir inflow area. The species is rarely collected elsewhere in the Pecos River (e.g., downstream of Carlsbad) and the Black River. Bigscale logperch are apparently less sensitive to turbid waters than logperch (Stevenson, 1971). Periodic stream dewatering and modification of preferred habitat (rapidly flowing runs) likely are the primary threats to bigscale logperch in New Mexico.

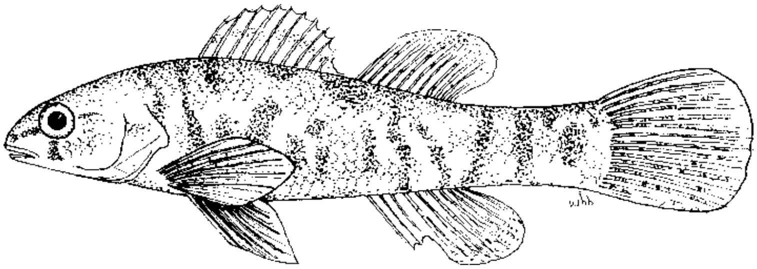
CONSERVATION

Development of appropriate conservation strategies requires improved knowledge of the biology and habitat associations of bigscale logperch. Accurate definition of its range and abundance in New Mexico is lacking. However, its documented affinity for moderately deep, rapidly flowing runs with large cobble substrates indicates that loss of such habitats would adversely affect its abundance. ♦

Greenthroat Darter

Etheostoma lepidum

(Baird and Girard, 1853)



LISTING STATUS

Greenthroat darter, *Etheostoma lepidum*, was listed as threatened by New Mexico in 1975 (19 NMAC 33.1).

CHARACTERISTICS

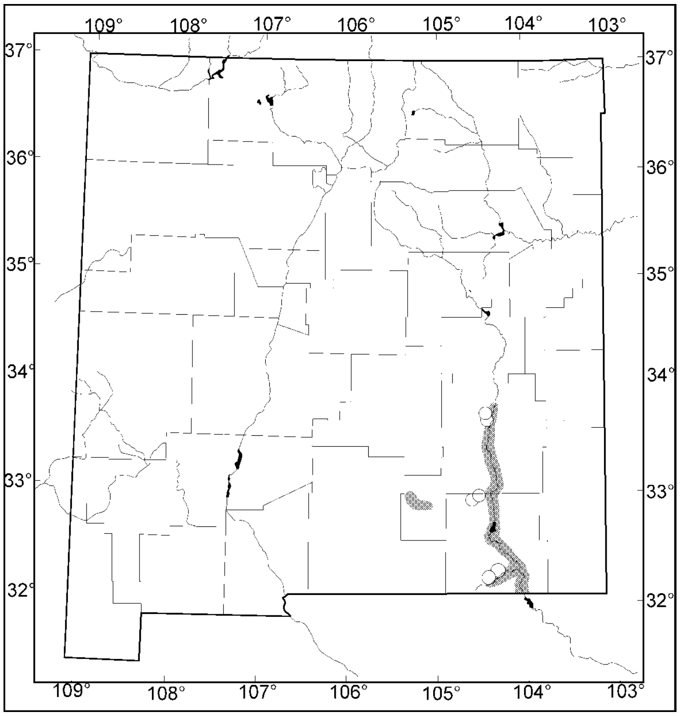
Greenthroat darter is a rather small, slender fish that rarely exceeds 65 mm total length (Kuehne and Barbour, 1983; Page, 1983). The dorsum of greenthroat darter is olive-green; ventrally males are orange and females are white to yellow (Page, 1983). Greenthroat darters have 6 to 9 small, dark dorsal saddles. Eight to 13 diffuse vertical dark green-brown bars extend laterally from the pectoral fin to the base of the caudal fin. The bars extend anteriorly just to the lateral edges of the belly, but posteriorly they encircle the caudal peduncle. The sides between the bars are yellowish and flecked with orange. The first dorsal fin of males has a blue-green margin, is clear submarginally, and has a broad red-orange band basally. In some portions of its range, the red-orange band is underlain by a basal blue-green band. During the spawning season, the coloration of males becomes more intense and their throat and breast are bright emerald-green (Page, 1983). Females are similarly but less brightly colored than males, particularly during the spawning season, and are rather drab in contrast. Greenthroat darters have 43 to 67 scales in the lateral series, 19 to 42 of which are pored. There are 8 to 10 spiny rays in the first dorsal fin and 10 to 13 soft rays in the second dorsal fin. Echelle et al. (1984) found meristic and morphometric differences between New Mexico and Texas populations of greenthroat darter. New Mexico greenthroat darters tend to have more pored lateral line scales, fewer dorsal fin spines, are generally deeper bodied, and have shorter caudal peduncles than Texas specimens. These differences, however, were not deemed sufficient to warrant recognition of separate subspecies.

DISTRIBUTION

Greenthroat darter occurs in two disjunct areas; the Edwards Plateau of south-central Texas and the lower Pecos River drainage of New Mexico. The species remains comparatively common in preferred habitats in Texas (C. Hubbs, pers. comm.), but overall its range has declined in Texas (Anderson, et al., 1995). In New Mexico, its range and abundance has declined. Formerly, it was at least irregularly found in the mainstem Pecos River downstream of Carlsbad and in the Black River (Cowley and Sublette, 1987a; Sublette et al., 1990). It has not been collected in either river for more than 10 years. Currently, it is found mainly in Bitter Creek and gravel-bottomed ponds on Bitter Lake National Wildlife Refuge (Brooks and Wood, 1988), Cottonwood Creek, and Blue Spring (NMGF files). Greenthroat darter historically inhabited the Rio Penasco (Sublette et al., 1990), but its persistence there has not been confirmed recently. A population of the species was established in Rattlesnake Springs (Carlsbad Caverns National Park) in 1991 with darters from Blue Spring. In currently occupied New Mexico habitats, its abundance is seasonally variable, ranging from rare to common.

BIOLOGY

Greenthroat darters are found mainly in springs, spring runs, and small impoundments in New Mexico. These habitats typically have clear water, the substrate is clean sand, gravel, and small cobble, and aquatic vegetation often is dense (Page, 1983; Brooks and Wood, 1988). Hubbs and Strawn (1957) reported the species most common in riffles having cobble covered with aquatic plants. Such habitats, however, are uncommon in the Pecos River drainage. Greenthroat darters occur in habitats with water velocities ranging from zero (impoundments on Bitter Lake National



Wildlife Refuge) to >20 cm/sec (Blue Spring effluent). Where water velocity is rapid, darters are found among aquatic vegetation along stream margins, presumably where water velocity is less.

The stenothermal habitats typically inhabited by greenthroat darter apparently contribute to its having an extended spawning season. In the Edwards Plateau region, Hubbs (1985) found that greenthroat darter spawn from October or November through May, with most activity between November and April. But he also reported reproductively ripe individuals in the remaining months of the year. The spawning season was briefer in eurythermal habitats (Hubbs and Strawn, 1957). The optimum spawning temperature for greenthroat darter is 20 to 23°C (Hubbs and Strawn, 1957).

Greenthroat darter females deposit their demersal, adhesive eggs on vegetation or other objects within the water column (Hubbs and Strawn, 1957). Eggs are fertilized as they are deposited and an individual female may spawn every 5 days during each season (Hubbs and Strawn, 1957). Thus, where the spawning season is extended a single female may deposit ≥50 clutches per year (Hubbs, 1985) and females average 74 eggs per clutch (Hubbs et al., 1968). Greenthroat darter apparently spawn only during daylight (Hubbs and Martin, 1965). Incubation time is temperature dependent; it is 6 to 10 days at temperatures between 18 and 23°C (Hubbs, 1961; Hubbs et al., 1969).

Although there is considerable information on the reproductive biology of greenthroat darter, there is no information on its life after hatching. Like related species (Page, 1983), it presumably consumes small aquatic invertebrates and lives about 2 yr.

Greenthroat darters in their preferred spring and spring run habitats in New Mexico are commonly found with Pecos gambusia, Mexican tetra, and roundnose minnow. Brooks and Wood (1988) reported green sunfish common in habitats occupied by greenthroat darters on Bitter Lake National Wildlife Refuge and speculated that green sunfish may prey upon greenthroat darters. However, they also noted that greenthroat darters were common, indicating that green sunfish predation was not suppressing greenthroat darter abundance.

STATUS

In New Mexico, greenthroat darters persist primarily in four areas; the springs, spring runs, and impoundments on Bitter Lake National Wildlife Refuge, the permanently-watered reach of Cottonwood Creek, Blue Spring and its spring run, and Rattlesnake Springs and its spring run on Carlsbad Caverns National Park. In these habitats, its abundance varies seasonally and annually. Elsewhere in the lower Pecos River drainage in New Mexico, it is rare or absent.

CONSERVATION

Maintenance of surface flows in the spring and spring run habitats currently occupied by greenthroat darter are essential to its persistence in New Mexico. Re-establishment of the species in unoccupied spring habitats may enhance its status in New Mexico. The successful establishment of greenthroat darter in Rattlesnake Springs suggests this conservation strategy likely would be successful in spring habitats if potential predator (e.g., green sunfish) abundance is suppressed and dense mats of aquatic vegetation are present. ♦

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APPENDIX I

Professional Affiliation of Personal Communicants

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J.J. Landye .... U.S. Fish and Wildlife Service, Pinetop Fish Health Center
R. Leary .... University of Montana
W.L. Minckley .... Arizona State University
J.S. Pittenger .... New Mexico Department of Game and Fish
S.P. Platania .... University of New Mexico
F.K. Pfeifer .... U.S. Fish and Wildlife Service, Colorado River Fishery Project
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T.L. Stroh .... Pueblo of Zuni
K. Young .... Arizona Game and Fish Department