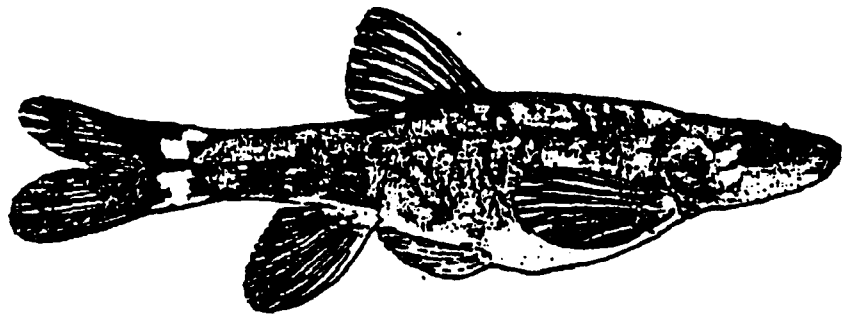
Loach Minnow



Tiaroga cobitis

Recovery Plan

September 1991

U. S. Fish and Wildlife Service
Phoenix, Arizona

LOACH MINNOW, Tiaroga cobitis

RECOVERY PLAN

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for

Region 2

U.S. Fish and Wildlife Service

Albuquerque, New Mexico

Approved: _____

Regional Director, U.S. Fish and Wildlife Service

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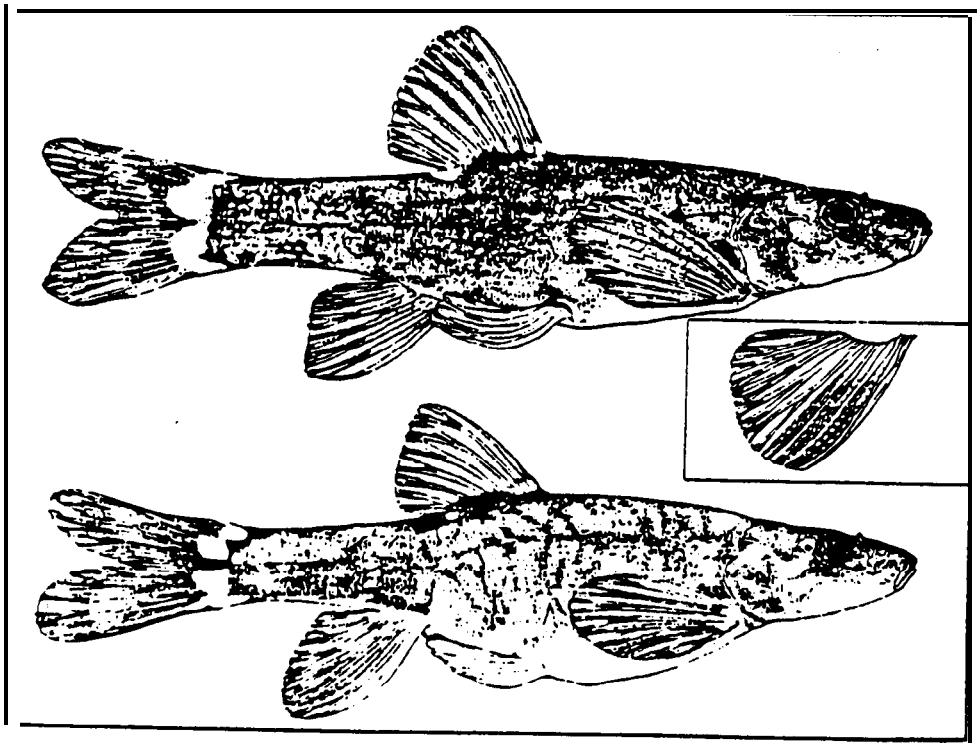

Loach minnow, Tiaroaa cobitis.

Upper: male, 45 mm standard length (SL), and detail of pectoral fin (inset); lower, female, 43 mm SL. Scalation omitted. From Hinckley (1965).

Frontispiece

DISCLAIMER

Recovery plans delineate 'reasonable actions which are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, ● ometimee with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, am well am the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plane are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1990. Loach Minnow Recovery Plan. Albuquerque, New Mexico. 38 pp.

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The fee for the plan varies depending on the number of pages in the plan.

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EXECUTIVE SUMMARY

Current Spociee Status: The loach minnow is a threatened fish which ham been extirpated from most of its historic range in the Gila River basin. It is presently found only in the upper Gila, San Francisco, and Tularosa rivers and Dry Blue Creek in New Mexico, and in Aravaipa and Campbell Blue creeks and the White, San Francieco, and Blue rivers in Arizona. All existing populations are under threat.

Habitat Requirement8 and Limiting Factors: Thie fieh is a bottom dwelling species which inhabits turbulent waters over gravel-cobble bottoms in faet-flowing streame. Major threat8 include dame, water diversion, waterehed deterioration, channeliration, and introduction of non-native predatory and competitive fishes.

Recovery Objective: Protection of existing populations, restoration of populations in portion8 of historic habitat, and eventual delisting, if possible.

Recovery Criteria: Thie plan mete forth mechanisms to obtain information necessary to determine quantitative criteria for describing a loach minnow population capable of sustaining itself in perpetuity. Delisting is dependent upon establishment of ouch populatione.

Act ions Needed:

1. Protection of existing populatione.
2. Monitoring of exieting populations.
3. Studies of interactions of loach minnow and non-native fishee.
4. Quantification of habitat and effects of habitat modification.
5. Enhancement of habitats of depleted populatione.
6. Reintroduction of loach minnow into historic range.
7. Quantification of characteristics of a self-sustaining population.
8. Captive propagation.
9. Information and education.

Total Estimated Cost of Recovery: Cost of recovery estimated over a minimum 20-year period yields a minimum total cost of $115,000.00 per year. This estimate is in 1989 dollars. The estimate does not include land or water acquisition. Although acquisition is a potential recovery action, it is not poesible to estimate costs until areas to be acquired, if any, are identified.

Date of Recovery: Until work is completed to allow quantification of delisting criteria, it is not possible to predict a date of recovery. However, based on the evaluation period of 10 years for determination of success of reintroduced populations, recovery of this species could not occur in less than 20 years.

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I. INTRODUCTION

The loach minnow, *Tiaroga cobitis* Girard, is a small, secretive fish endemic to the Gila River basin of Arizona and New Mexico, USA, and Sonora, Mexico. Although this unique, monotypic genus ha8 been known to science for more than a century, relatively little is understood 'of its basic ecology. The loach minnow was apparently not considered imperiled by Miller (1961) and later by Hinckley (1973). It once was locally abundant in suitable habitats *in* the Gila River system upstream of Phoenix, Arizona, but today is restricted to scattered tributary populations in Arizona and New Mexico. Present and historic distributions of the species are figured for Arizona by Minckley (1973, 1985) and for New Mexico by Propst et al. (1986) and for both in Figure 1, below.

The loach minnow was proposed (U.S. Fish and Wildlife Service [FWS] 1985) and subsequently listed (FWS 1966) se a threatened species under authority of the Endangered Specie8 *Act* of 1973, a8 amended. Listing was justified on the bases of diminution of it8 range and numbers *due to* habitat destruction, impoundment, channel downcutting, substrate sedimentation, water diversion, groundwater pumping, and the spread of exotic predatory and competitive fishes, and because *of* continued threats posed by proposed or ongoing dam construction, water loss, habitat perturbations, and exotic species (FWS 1985). Critical habitat was initially proposed (FWS 1985, Appendix A), but legal designation was deferred until 18 June 1987 (FWS 1986). Although that date expired with no action, proposed critical habitat is still in force, providing limited habitat protection. Final designation of critical habitat is currently under adminiatrative review.

Loach minnow is recognized by numerous scientists as biologically imperiled (e.g., Deacon *et* al. 1979, William8 et al. 1985, Johnson 1987). The species is classified by the State of New Mexico as a group 2 endangered species, which are thoee ". ..whose prospect8 of survival or recruitment within the State are likely to become jeopardized in the foreseeable future" (New Mexico Department. of Game and Fish 1988) which affords protection under the New Mexico Wildlife Conservation Act, and by the State of Arizona as a threatened species, defined as those "...whose continued presence in Arizona could be in jeopardy in the near future" (Arizona Game and Fish Department 1988). The epeciee can be taken only under a special collection permit in both States. Neither etate specifically protects habitats occupied by loach minnow.

Description

The loach minnow (Frontispiece) is a small, stream-dwelling member of the minnow family (Cyprinidae); it's description below is summarized from Cirard (1857) and Minckley (1973):

> The body is elongated, little compressed, and flattened ventrally. There are eight ray8 in the dorsal fin and seven in the anal fin, The lateral line has about 65 ecalee. The mouth is small, terminal, and highly oblique: there are no barbels. The upper lip is non-protractile, attached to the snout by a broad fold of tissue (the frenum). Opening8 to the gills are restricted. Pharyngeal teeth are in two rows, with formula 1,4-4,1.
>
> Coloration of the body is an olivaceoue background, highly blotched with darker pigment. Whitish (depigmented) spot8 are present at origin and

insertion of the dorsal fin and dorsal and ventral portions of the caudal fin base. A black, baaicaudal spot usually is present. Breeding males have bright red-orange coloration at the bases of the paired fins and on the adjacent body, on the base of the caudal lobe, about the mouth, near the upper portion of the gill opening, and often on the abdomen. Females in breeding become yellowish on thm fins and lower body.

Distribution and Abundance

Historical. Loach minnow is endemic to the Gila River basin of Arizona and New Mexico, USA, and Sonora, Mexico (Figure 1). The species was recorded Mexico only in Rio San Pedro, extreme northern Sonora (Miller and 1951). Distribution in Arizona included the Salt River mainstream and above Phoenix, White River, East Fork White River, Verde River, Gila River, San Pedro River, Aravaipa Cremk, San Francisco River, Blue River, and tagle Creek, plus major tributaries of larger streams (Hinckley 1973, 1980; University of Michigan Museum of Zoology, unpublished records). Population8 tranaplanted from Aravaipa Creek into Sonoita Creek (Santa Cruz County, Arizona) in 1968 and Seven-Springs Wash (Maricopa County, Arizona) in 1970 have since been extirpated (Minckley and Brooks 1985). Distribution in New Mexico included the Gila River (including East, Middle, and West forks), San Francisco River, Tularoaa River, and Dry Blue Creek; there have been no recorded transplants of loach *minnow* in New Mexico or Sonora.

There are subatantial gap8 in time and apace among data upon which to base estimates of historical abundance of loach minnow, but it is unlikely (because of it8 highly tapecialized nature) that the specie8 was ever abundant other than locally. However, the historical record indicate8 that suitable, presumably occupied habitat was widespread throughout the region. Like moat western cyprinida, distribution and abundance of loach minnow undoubtedly varied greatly in reaponme to natural changes in environmental conditions (Hinckley and Meffe 1987).

Preeent. Loach minnow is believed extirpated from Mexico, although the Gila River drainage in that Country still lacks adequate surveys. The specie8 persists in Arizona only in limited reSChe8 in White River (Gila County), North and East forks of the White River (Navajo County), Aravaipa *Creek* (Graham and Pinal counties), San Francisco and Blue river8 and Campbell Blue Creek (Greenlee County) (Figure 1). Loach minnow is rare to uncommon in Arizona, except in Aravaipa Creek and the Blue River drainage (Hinckley 1981, Nontgomery 1985, Propst et al. 1985, Propst and Bestgen 1991). Known population8 once present in other river8 and streams of the state have been eliminated. Unknown populations of the specie8 may 8till occur in place8 not surveyed or incompletely inventoried, especially in Mexic and within the expaneive San Carlos Apache and Fort Apache Indian reser tions, or on National Forest land8 in the United States.

In New Mexico, the specie8 still may be found in the upper Gila River, including the East, Middle, and West forks (Grant and Catron counties), San Francisco and Tularosa river8 (Catron County), lowermost Whitewater Creek (Catron County), and lowermost Dry Blue Creek (Catron County). In 1982-1985, the species was locally abundant in scattered reaches of these streams; population8 were small in Whitewater and Dry Blue Creek8 (Propst et al. 1988, Sublette et al. 1990, Propst and Bestgen 1991). Existing

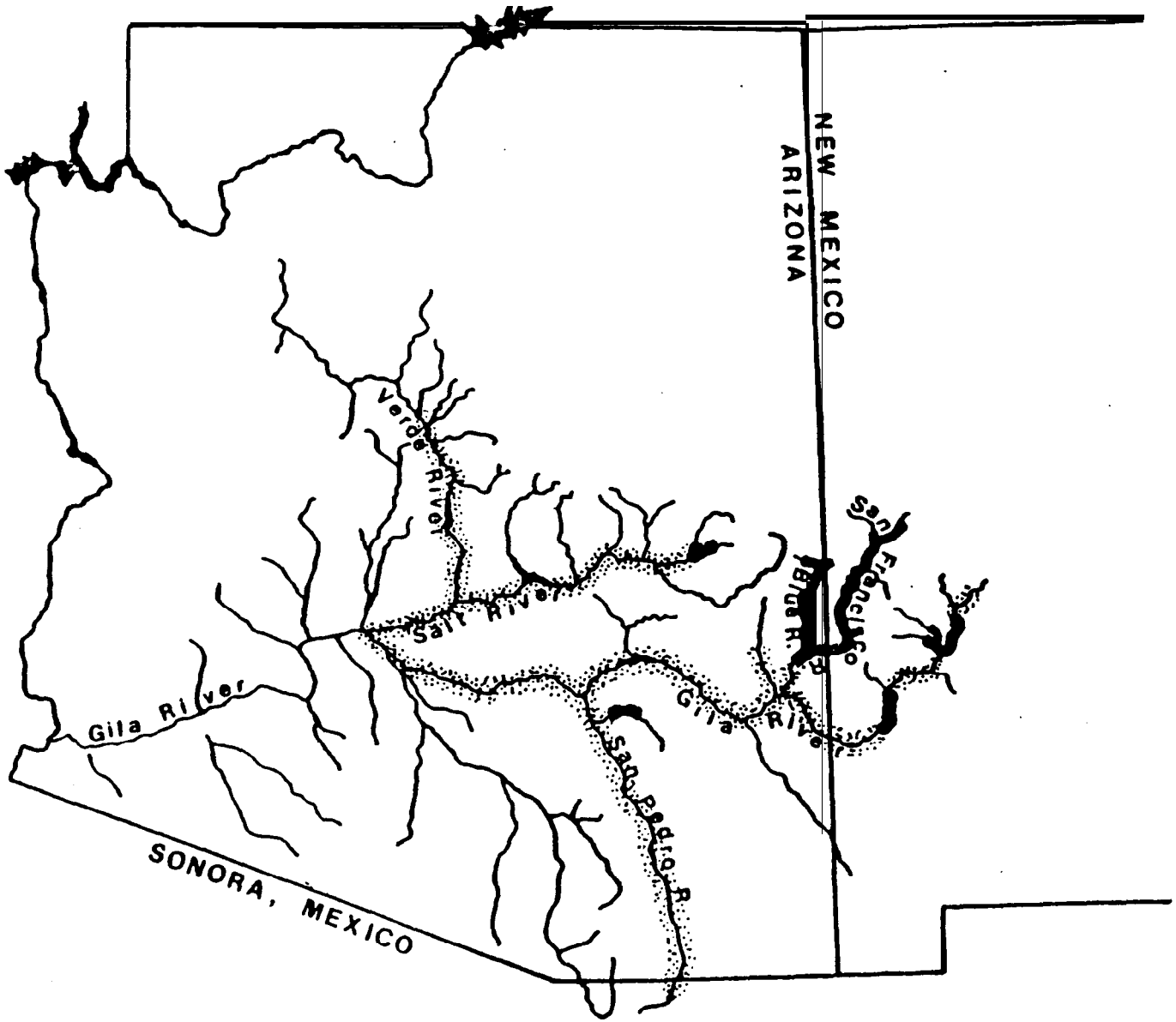

FIGURE 1. HISTORIC AND PRESENT DISTRIBUTION OF LOACH MINNOW
(Hislorlc distribution is represented by stippled areas; present distribution Is represented by solid black)

populations of loach minnow bra presumably reproducing and recruiting, but their potential for long-term stability is unknown.

Both the distribution and abundance of loach minnow have become dramatically reduced in thm last century (Minckley 1973, Propst st al. 1988). It is probably extirpated from Mexico. Major stream reaches in Arizona, including downstream reaches of Gila, Salt and Verde rivers, that once supported locally abundant populations are no longer occupied by the species, and its distribution in New Mexico is fragmented. Similar changes in abundance and range likely occurred in the past in response to temporal and spatial variations in the environment, but indications *are* that its current imperiled status is a direct or indirect result of activities of man.

Life History

Loach minnow has been intensively studied at only a few locations, resulting in an incomplete understanding of the species' ecology throughout its range. Arizona populations have received attention only in Aravaipa Creek (Barber and Minckley 1966, Hinckley 1965, 1973, 1981; Schreiber and Minckley 1981, Turner and Tafanelli 1983, Rinne 1985, 1989), largely because that stream contained the only accessible sizeable population in the State. Eritt (1982) examined populations in the Gila and San Francisco rivers in New Mexico, and Propst et al. (1988) concentrated investigations on the mainstem Gila River in the Cliff-Gila Valley and Tularosa River, New Mexico. Results and observations presented in this literature are summarized below; detailed information on individual populations is available in original source materials. Most other work on loach minnow has been survey-type monitoring to assess status of local populations or fish communities (e.g., Jester et al. 1968, Anderson and Turner 1977, Ecology Audits 1979, Montgomery 1985, Papoulias et al. 1989, Propst et al. 1985); these do not contribute significant new life history information.

Habitat. The loach minnow inhabits turbulent, rocky riffles of mainstream rivers and tributaries up to about 2200 meters (m) elevation. Because the species has-a reduced gas bladder, it is restricted almost exclusively to a bottom-dwelling habit, swimming in swift water is only for brief moments as the fish darts from place to place. Most habitat occupied by loach.minnow is relatively shallow, has moderate to swift current velocity and gravel-to-cobble dominated substrate (Barber and Hinckley 1966, Minckley 1973, Propst et al. 1988, Rinne 1989, Propst and Bestgen 1991). Loach minnow at some times and places (e.g., Aravaipa Creek, Arizona) is associated with dense growths of filamentous green algae (Barber and Hinckley 1966), while in other places this association has not been observed. In the upper Gila River, New Mexico, depth, velocity, and substrate of occupied habitats vary ontogenetically, eeaeonally, and geographically (Propst et al. 1988); the same is to be expected elsewhere.

Reproduction. Loach minnow first spawn at age I in late winter-early spring in Aravaipa Creek (Minckley 1973) and from late March into early June in New Mexico (Eritt 1982, Propst et al. 1988). Spawning is in the same riffles occupied by adults during the non-reproductive season, where sex ratios appear approximately equal. Adhesive eggs are deposited on the underside of flattened rocks; cavities usually ars open on the downstream side while the upstream portion of the rock is embedded in the substrate. Number of eggs per rock ranges from fewer than 5 to more than 250, with means among populations of 52 to 63. Fecundity of individual females

ranges from ● bout 150 to 250 mature ova, and generally *increameo* with increasing size. Mature ova are about 1.5 millimeters (mm) in moan diameter, but greater (1.55-1.67 vs. 1.44-1.56 mm) among females more than 60 mm long (presumably age II), thmn among smaller, age I fish (Britt 1982). Embryos retrieved *from* beneath ● pawning rooks and incubated at 18 to 20• c hatched yolk-•mc larvae in 5 to 6 daym.

Growth. Loach minnow larvae are ● pptoximat8ly 5 mm long at hatching. Growth rate varies with location mnd ● nvironmentml conditions, and among year classes (Britt 1982, Propmt ● t ml. 1988). Growth is momt rapid during thm first ● ummwr, with age 0 fish in New Mexico umually ● ttafning 30 to more thmn 40 mm ● tandmrd length (SL)[1] by mid-summer ♋■♎ ● lightly more than 50 ma SL by ● nd of the calendar *year.* Growth rate subsequently slows, with age I fimh averaging near 55 mm SL by end of ♦♒♏♓❐ ● econd growing season. Winter growth is negligible. Age II fish attain maximum lengths of about 68 mm SL, although much mime is infrequent. Longevity of moot fimh is probably 15 to 24 tmnthm, ● lthough exceptional individual8 may murvive 36 monthm. There is no evidence thmt male mnd female growth rate8 differ ● ubmtantially, although males appear to have higher survivorship than females (Propst ● t al. 1988).

Foods. Loach minnow *arm* opportunistic, bmnthic inmectivorem, largely deriving their food ● uppliom from among riffle-dwelling, larval mphemeropteranm and ● imuliid and chironomfd dipterans; larvae of other aquatic insect groups, much mm plocoptermnm, trichoptmranm, and occamionmlly pupae or emerging adults, *may* be ● oamonmlly *important* (Britt 1982, Propmt et ml. 1988, Propmt and Bestgen 1991). Chironomidm are relatively *more* important among the few food items utilized by larval and juvenile fishes; diversity of food types fncreamem am fish become larger, but the array of foodm eaten is umually small compared with other stream fishes (Schreiber and Minckley 1981, but mee Abarca 1987). Because loach minnow are not known to ● wim in turbulent riffles other than for brief periods, it appears that they actively meek their food among bottom mubmtratem, rather than pursuing animal8 entrained in the drift. Feeding habits therefore parallel ● eamonal changes in relative abundance, and thus availability, of riffle-inhabiting invertebrates.

Co-occurring fishes. Riffle8 that characterize habitats occupied by adult loach minnow are mhared wfth few other species. Native speckled dace, Rhinichthys osculus, often occupies riffle8 with loach minnow, but the dace is a strong-swimming, mid-water-column fish that likely ham little interaction with the benthic loach minnow. Native auckerm, especially demert sucker, Pantosteus clarki, frequent riffle habitats where they graze on attached algae and its ● mmociated microfauna. Among non-native (introduced) fimhem that co-occur in places with adult loach minnow, only ictalurid catfishes are likely to interact mtrongly with the native. Channel catfish, Ictalurus punctatus, of all sizes move onto riffles to feed, often on the same animals most important in diets of loach minnow. Juvenile flathead catfish, Pylodictis olivaris, almo feed in rif flee *in* darknemm. Channel catfish tend to be benthic omnivorem, but flathead catfish are notoriously pimcivoroum, even when small. Thum, potential for direct interaction (i.e., predation) between loach minnow and ncn-native catfishes im enhanced by motive (acquisition of food) and mpatial overlap in rifflem.

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[1] Standard and total lengths (TL) of loach minnow are convertible by the expremmion SL = 0.84TL + 0.56 (r^2 = 0.99, n = 100) (unpublished data).

Larval and juvenflm loach minnow, which occupy ● halloumr and slower habitats along riffle margins than adults (Propmt et al. **1988),** may encounter a suite of other **fishes.** However, when collected they **often** are the only species in **samples.** Among natives, larval ● uckorm (both desert **sucker** and Sonotan sucker, **Catostomus insignis)** and larval and adult cyprinidm **(especially the** ubiquitous **longfin dace, Agosia chrysogaster)** are **most** likely to *interact* with **small** loach minnow. Theme species have **co-**occurred for **millennia.**

Red shiner, **Cyprinella lutrensis, is** the non-native fimh moat likely to be found **along stream** margins in **places** occupied by **small** loach minnow. Red shiner now occurs in all places known to **be formerly** occupied by loach minnow, but the shiner is **absent** or rare in places where the native loach minnow **persists.** Although no **mechanism(s)** of *interaction* ham **been** identified. red shiner ham repeatedly been implicated in declines of loach minnow and other native fishes (Uinckley and 'Carufel 1967, **Minckley** and Deacon 1968, **FWS** 1985, **1986),** and stream **reaches** where loach minnow have declined or disappeared are ● umpicioumly **complementary** with range expansions of the shiner. **However,** Harsh ● ♦ al. (1989) found that habitat occupied by loach minnow was so **different** from that of the red shiner that interaction between the two ● peciem was unlikely to cause **shifts** in habitat use by loach minnow, and **Bestgen** and Propmt (1986) suggest that red shiner moves into voids left when native fimhem are extirpated in the area by habitat degradation. Exotic momquitofimh, **Gambusia affinis,** also occupies lateral habitats used by amaller loach **minnow,** and although potential **mosquitofish/loach** minnow interactions have yet to be examined, moaquitofimh ham been demonstrated to be detrimental to native topminnow, **Poeciliopsis** occidentalis, *in* both field and laboratory settings *(Heffe* 1983, 1985).

Reasons for Decline

Changes in distribution and abundance of loach minnow are directly or indirectly tied to man's uses of rivers, streams and landscapes, which have been variously modified by past and present activities (Hastings and Turner 1965, Hendrickeon and Minckley 1985). Direct impacts have resulted **from stream** habitat alterations accompanying a suite of land and water use practices; **most** often cited **are** dewatering, impoundment, and livestock grazing. Certain introduced and emtablimhad non-native fishes may interact negatively with native kinds, and independently or in concert with habitat alteration, result in their extirpation.

Dewatering of otream reaches may accompany groundwater pumping, stream channelization, water diversion, or damming. Absence of *water* obviously destroys fishes, and there can be no reestablishment of aquatic populations until flow is restored. Much historic loach minnow habitat is now dry (for example, reaches of the **Gila,** Salt, and San Pedro rivers in Arizona).

Impoundment **results** in creation of **lentic** habitat, which eliminates and excludes the swift-water loach minnow. Downstream effects of dams may include dewatering (above), alteration in flow regime, amelioration of natural flood events, changes in thermal and chemical character of the **stream,** elimination of organic drift typical of flowing waters, and other impacts, which may have a variety of lethal and sublethal effects on fiehem. Natural flooding of desert **streams** may play a significant role in life history of native fishes **because** it rejuvenates habitats (Propmt et al. **1988),** but perhaps more importantly because desert fishes effectively

withstand much diaturbancaa while non-native forma apparently do not (Meffe and Minckley 1987, Minckley and Heffe 1967). Major reachea of the Gila and Salt rivers are influenced by dams and their reservoirs and tailwatera; loach minnow no longer occur in theae affected watmra (e.g., Minckley 1973, unpubliahed data).

Livestock grazing that reaulta in wideapread removal of covering graaaea and shrubs from the waterahed, or denuding of riparian vegetation, may induce dramatic change8 in precipitation runoff, ● uapondod sediment, and bedload that incraaae stream turbidity, clog interstitial spaces of coarae aubatratea, and enhance ● roaion of stream channels and banks. Similar effects may be realized through poor timber harvest practices, mining operations (that may also contribute acute or chronically toxic levels of contaminant8 much am heavy metals), agriculture (that may also deliver toxic peaticidea or herbicides, or enriching fertilizers), and development for induatrial, commercial, or reafdential purposes. For example, wastewater diachargea from the Cananea Mine, Sonora, Mexico, into the San Pedro River in 1977-1979 killed aquatic life, including all fishes, in a 100-km reach downstream (Eberhrrdt 1981). Fishes that require unperturbed, natural habitats free of environmental contaminants may not maintain viable population8 when faced with much modifications, or, where impact8 are tolerated, such perturbations may weaken populations of native fiahea so that invading predatory and competing non-native8 effectively displace them.

It is clear that habitat8 supplied with water of sufficient quality and quantity, and which conform with other, specific environmental characteriatica, arm neceaaary for aurvival of loach minnow and other native fishes. Maintenance of stream flow8 uninterrupted by impoundment8 may be especially important for loach minnow, whoae populationa are often naturally small and disjunct.

Habitat alteration and interaction with non-native fiahea are both undoubtedly important in declines of loach minnow. However, it may not be possible to separate effects of these phenomena because in most places both occurred during approximately the same period of time. The scientific and management communities have not yet developed capabilities to examine an area from which a specie8 has been extirpated, or in moat cases of southwestern fishee even a habitat from which native8 are in active decline, and determine with certainty which factor(a) is responsible.

Habitats unimpacted by man's activities, which still support populations of loach minnow, do not exist. Even Aravaipa Creek, which aupporta a thriving community of seven native fishes including loach minnow, has been subjected to perturbations due to grazing and water management. Reachea of the Gila River and its major tributaries in New Mexico, which have been altered only by grazing, timber harvest, and/or mining, also are occupied by viable native populatione, and support few or no exotic fiahea. Both Aravaipa Creek and the Gila River presently aupport few exotic fiehea. Similar conditions characterize most streams and rivers that are still occupied by loach minnow: habitat alterations are relatively moderate and exotic fishes are few. On the other hand stream reaches from which loach minnow have been known to be extirpated are characterized by past or present moderate to aevere habitat alterations and by relatively large populations of exotic fishes. Thus, unlike dewatering or aevere habitat destruction, moderate habitat alteration alone does not appear sufficient to eliminate loach minnow. It is only when populations of non-native forms invade or are introduced and become established that the native taxa are aeverely

depleted or eliminated. However, habitat alteration appears to be a major factor in invasion and ● mtabliahment of exotic fish in the ● outhwemt.

II. RECOVERY

Objective

The primary objective of thia *recovery* plan is to identify steps and delineate mechanisms considered necessary to protect existing populations and restore depleted and extirpated population0 of loach *minnow* and their habitats, and to ensure the species' non-endangered, self-•ustanance in perpetuity. Realization of thia objective will constitute justification for daliating the loach minnow. This plan will require modification as new information becomes available; only at that time *can* quantitative criteria for deliating be elaborated. Interaction with *.non-native* fimhea and habitat modification, whether acting independently or in concert, are both considered contributory to decline and extirpation of loach minnow. This plan recognizes the need to deal with both impacts in order to achieve the recovery objective stated above.

Stepdown Outline

1. Protect existing populations of loach minnow.

   1.1 Identify extent of existing populations and level of protection afforded to each.
   1.2 Prioritize existing populationa as to need or imminent need for protect ion.
   1.3 Designate critical habitat.
   1.4 Enforce existing laws and regulations affecting loach minnow.
      1.4.1 Inform as neceaaary appropriate agencies of applicable management/enforcement rasponaibflitiea.
      1.4.2 Assure compliance with Section 7 of the Endangered Species Act.
      1.4.3 Assure compliance with Section 9 of the Endangered Species Act.
   1.5 Discourage detrimental land and water uae practices.
   1.6 Insure perennial flows with natural hydrographa.
   1.7 Curtail transport and introduction of non-native fishes.
      1.7.1 Discourage use of live bait and seining in streams occupied by loach minnow.
   1.8 Examine efficacy of barrier construction to protect existing populations from invasion by non-native fishes.
   1.9 Identify important, available private lands and water rights not already protected.
   1.10 Acquire important lands and associated water rights as they become available.
   1.11 Protect acquired lands.

2. Monitor status of existing populations.

   2.1 Establish standard monitoring locations for extant populations.
   2.2 Establish and implement standard techniques and their application.
   2.3 Establish and maintain a computerized database for tracking of monitoring and reintroduction information.

2.4 Determine rangr of natural variation in ebeolute abundance and age-clams structure.
2.4.1 Develop standard methods for quantif·ing abundance.
2.4.2 Conduct bi-•nnuel (epring, ● ◆◆◆ꝏ○① ꝑ ulation ● etimetee.
2.5 Monitor community compoᵢ:ion.
2.5.1 Apply standard mc ·toring locations and sampling techniques (see 2.1, 2.2).
2.5.2 Determine *range* of natural variation in relative abundances of community members.
2.6 Determine genetic charecteriatice of existing populations.

3. Identify nature and significance of interaction with non-native fiehea.

3.1 Direct interaction (predation, displacement).
3.1.1 Field inveetigetione and experimental manipulations.
3.1.2 Laboratory atudime.
3.2 Indirect *interaction* (medietmd by other fishes *or* the community).
3.2.1 Field investigations end ● *xporbwntal* manipulationa.
3.2.2 Laboratory ● tudiee.

4. Quantify, through research, loach minnow hebitet needs and the effects of physical habitat modification on life cycle completion.

4.1 Subetrate (siltation, armoring).
4.2 Velocity and depth.
4.3 Water temperature.
4.4 Water chemistry.
4.5 Watershed characteristica.
4.6 Interactions among 4.1-4.4.

5. Enhance or restore habitats occupied by depleted populations.

5.1 Identify target areas amenable to management.
5.2 Determine necessary habitat and landscape improvements.
5.3 Implement habitat improvement.

6. Reintroduce populations to selected streams within historic range,

6.1 Identify etocke amenable to use for reintroduction.
6.2 Identify river or stream ayetema for reintroductions.
6.2.1 Determine suitability of habitat.
6.2.2 Enhance habitat am necessary (4, S.3).
6.2.3 Aseeaa status of non-native fiahea in the watershed.
6.2.4 Assure closure of potential immigration routes to preclude reinvasion by non-native fishes.
6.2.5 Reclaim am neceeeary to remove non-native fishes.
6.3 Reintroduce loach minnow to selected reaches.
6.4 Monitor success/failure of reintroductions.
6.5 Determine reasons for success/failure.
6.6 Rectify as necessary cause(e) of failure and restock.

7. Determine quantitative criteria for describing *a* self-sustaining population.

7.1 Acceptable levels of natural variation.
7.1.1 Absolute numbers.
7.1.2 Age clams structure.
7.1.3 Reproduction.

7.1.4 Recruitment.
7.2 Minimum stock size.
7.3 Environmental variables.
7.3.1 Physical characteristics.
7.3.2 chemical characteristics.
7.3.3 Biological community.

8. Consider contingency planning and preliminary investigations for captive holding, propagation and rearing.

8.1 Determine wild stocks suitable for contribution to hatchery stocks.
8.2 collect And transfer wild stock to suitable facility.
8.3 Develop procedures and facilities for holding and maintaining.
8.4 Evaluate potential techniques for propagation.
8.5 Assess life-cycle requirements in hatchery environment.
8.6 supply individuals as needed for reintroduction, research, public education, etc.

9. Information and education.

9.1 Public sector.
9.1.1 Local media and target campaigns.
9.1.2 States of Arizona and New Mexico.
9.1.3 National exposure.
9.1.4 Assist Appropriate Mexican agencies and organizations in information And education.
9.1.5 Open communication Among States, Federal agencies, And local residents And water users.
9.2 Professional information.
9.2.1 Open circulation of information Among concerned parties.
9.2.2 Periodic information-exchange meetings.
9.2.3 Presentations at professional, scientific meetings.
9.2.4 Publication in peer-reviewed, open literature.

Narrative

1. **Protect existing populations of loach minnow.**

Remaining population8 of loach minnow contfnum to be threatened by destruction or modification *of* habitat, predation by non-native fishes, inadequacy of ● xi8ting regulations, and continued introduction and dispersal of non-native fishes. Recovery of the species cannot be effected without first protecting remaining loach minnow populations.

1.1 Identify extent of existing populations and level of protection afforded to each.

Undiscovered populations *of* loach minnow may occur in unsurveyed or incompletely inventoried habitats; these populations 8hould be identified so that the present distribution And range of the species is known to the extent practicable. General areas which should be thoroughly sampled to determine potential occurrence of loach minnow include the Gila River drainage in Sonora, Mexico and lands in the Unit‹ d State8 Owned or controlled by the U.S. Forest Service and the San Carlos and White Mountain Apache Tribes. *After* geographic locations of all population8 arm known, the existing level of protection afforded by any public or private entity ehould be determined for ● Ach population. Completion of these prelFminarie8 will enable prioritization of the various habitats/populati‹ns a8 regard8 implementation of specific recovery activities outlined below.

1.2 Prioritize existing populations as to need or imminent need for protection.

Population8 of loach minnow that presently occupy relatively unperturbed habitat and are afforded substantial protection by one or more governmental or private entities (e.g., Aravaipa Crook, Arizona) are considered in less imminent need of additional protection than those in degraded habitat8 and/or which are minimally protected. Prioritization of all known population8 *a8* regards need for protection should be accomplished so steps toward the species recovery can proceed in a logical manner. Recovery activi‹ies for population8 in most imminent danger of decline or extirpation sho ‹ be accomplished first.

1.3 Designate critical habitat.

Critical habitat (Appendix A) was proposed by FWS (1985), and eupported by Propst et al. (1988). FWS (1986) deferred deeignation until 18 June 1987, a date which has expired. That designation ham *not yet* occurred, and although the existin‹ proposal continue8 in force, it provide8 only limited protection. ›ending outcome of 1.1 (above), additional stream reaches *may* be a ›ropriate for future consideration for deeignation as critical habitat. Much of the land Adjacent to streams presently occupied by loach *minnow* is under full *or* partial jurisdiction and/or presumed protection by U.S. Bureau of Land Manag‹ment (Aravaipa Creek) ; The Nature Conservancy (Aravaipa Creek, Gila River, New Hexico); New Hexico Museum of Natural History (East *Fork* Gila River); New Mexico Department of Game And Fish (West Fork and Middle Fork Gila rivers); New Mexico State Land Office (Gila River); National Park Service (Wemt Fork Gila River, lands administered by U.S. Forest Service); U.S. Forest Service (Gila River in Gila Wilderness Area, Lower Gila Bird Xanagement Area, And

Gila River Research Natural Area, and Gila And Apache-Sitgreaves National Forest; Blue River in Apache-Sitgreaves National Forest and Blue Range Primitive Area); And Fort Apache Indian Reservation (White River And East Fork of the White River). However, protection of loach minnow on federal and other lAnd8 can be fully realized only when critical habitat is designated, and compliance with the Endangered Specie8 Act is implemented. Other reaches flow through private landm, And with exception *of certain* portion8 controllad by conservation organizations, may receive only minimal protection.

1.4 Enforce ● XiwU laws and regulations affecting loach minnow.

Failure of any entity to recognize and comply with law8 and regulation8 that protect loach minnow And it8 habitat may contribute to imperiled status, remult directly or indirectly in further population declines, and impede recovery of the ● pecie8.

1.4.1 Inform 88 necessary ● ueacier of applicable management/enforcement responsibilities.

Where not 80 informed, agencies and their personnel should be made aware of their responsibilities regarding the laws protecting listed species and their habitat8 And the Appropriate role8 each agency ehould play to most effectively insure their protection.

1.4.2 Assure compliance with Section 7 of the Endangered Species Act.

Federal agencies should comply with Section 7 of the Endangered Species Act and should consult with the U.S. Fish And Wildlife Service on any project that ha8 potential to affect loach minnow or adversely affect it8 proposed critical habitat.

1.4.3 Assure compliance with Section 9 of the Endangered Species Act.

Compliance of all private And public entities with the Section 9 prohibition8 And implementing regulations regarding take of A threatened Apeciee should be insured.

1.5 Discourage detrimental land And water use practices.

Wise use of water and land can benefit both the user and the physical and biotic natural resources of the Area. Practice8 which Are detrimental to or destructive of habitat8 *and* extant population8 of loach minnow ehould be discouraged in all placee. Information and education ehould be provided that will enable users to be aware of detrimental pract icom.

1.6 Insure perennial flows with natural hydrographs.

Loach minnow cannot exist in dewatered placee, And populations may be expected to decline or dieappear from stream reaches which are intermittent or ephemeral. Permanence Of flows must be assured to maintain integrity of loach minnow population8 and their habitate. Also, southwestern stream fishes Apparently *Are* enhanced relative to non-native species where streams are characterized by a natural hydrograph (Minckley and *Heffe* 1987). Formal agreement8 that stream flow8 will not be modified

8.1 Determine wild stocks suitable for contribution to hatchery stocks.

An aeeeeement should be made as to which extant populatione are most capable of contributing individuals for captive programs without suffering unnecessary depletion which could impair status of the parent stock. Consideration should be given to maintaining *genetic integrity of* captive etocke in context of existing wild populatione (Echelle 1988).

8.2 collect and transfer wild stocks *to* suitable facility.

Adult loach minnow should be collected and treneferred to an appropriate facility where investigations on holding, captive propagation, and maintenance can be pursued.

8.3 Develop procedures end facilities for holding and naintaiaing.

Standardized techniques and facilities should be developed by which loach minnow *of* all sizer and ages can be eafely held and maintained without threat of excessive mortality.

8.4 Evaluate ootential techniques *for* propagation.

Stream minnows may reproduce voluntarily if placed into suitable artificial habitat. Or, the specie6 may require induction of gamete maturation and expression, fertilization, and incubation. Techniques should be found that are effective and efficient, and which minimize mortality to adult fish.

8.5 Assess life-cycle requirements in hatchery environment.

Certain environmental requirements may need to be met to inaure successful life cycle completion in the hatchery. For example, specific temperatures may be neceeeary for spawning and normal larval development, or a certain sex ratio may be required if fish are to spawn voluntarily. Such factors should be determined and optimized where practicable.

8.6 Supply individuals as needed for reintroduction, research, public education, etc.

Loach minnow propagated and reared in a hatchery can serve many purposes. Fish can be transported to selected eitee for reestablishment of extirpated populatione, keeping in mind the genetic considerations outlined in 6.1, above. Research programs to answer basic queetione of loach minnow life history and ecology undoubtedly could utilize captive-reared individuals. And, progeny from hatchery stocks could be distributed to schools, museums, zoos, etc., where they could be displayed along with appropriate literature or other information on loach minnow in particular and endangered species in general. In each instance where hatchery fish were used, wild donor populations would be preserved againot any potential damage which could result from removal of individuals.

9. Information and education.

Free exchange of information and ideas among individuals representing both private concerns and the public sector including citizen's groups should be recognized as essential support for a successful recovery program. Information on goals, plans, and progress of recovery

implementation should be readily available to all interested partiee. Awareneae of the general public, in whose behalf the Endangered Species Act was conceived and paeeed *into* law, is critical to this plan *and* to conservation of all imperiled species.

9.1 public sector

Loach minnow repreeenta a national resource *of value* to all people. Because the laws designed to protect thfe animal, and by which thia recovery plan is enabled, originated with the deaitea of thm public, it ie eeeential that they be offered every opportunity to be informed and to participate in all aspects of loach minnow recovery. Public support has capability to greatly enhance and thereby ♋♏♏♎♦□♏ • ucceem of loach *minnow* recovery; ouch support is derived from informed people.

9.1.1 Local media and target campaigns.

Because people who reeide in proximity to habitats occupied by loach minnow *are* often those who express greatest interest in, and may be most affected by, • ctivitiee aeeociated with recovery, they should be informed and extended opportunity to participate in all • ♏□♏♍♦♋ of recovery. Local media including television, radio, nowepapere, and circulars should provide regular, timely, and accurate eummariee of plans and progreae toward loach minnow recovery. Local residents should be encouraged to make their opinion8 known, thereby providing input to improve the plan and enhance it's probability of success.

9.1.2 States of Arizona and New Mexico.

Media with statewide distribution and readership *in* Arizona and New Mexico should be targeted for receipt of periodic information on loach minnow recovery. In this way a larger audience with interest in the program can be acceeaed, and their support encouraged through education.

9.1.3 National exposure.

Federal laws that protect threatened and endangered plants and wildlife are of interest to all residents of the Nation. It thus is appropriate they be allowed to asseee efficacy of that legislation through information received on projects throughout the country. In this way, persons with interests in species conservation in general can be aeeured an opportunity to be informed on a diversity of plans and programe.

9.1.4 Assist • DProDriat8 Mexican agencies and organitations in information and education.

A significant portion of the San Pedro River is in Mexico, and stream reaches within that Country may be occupied by undiscovered populations of loach minnow. Moreover, health of aquatic biota including possible reintroduced populations of loach minnow in portions *of* that river in the United States may be dependent upon conditions upstream in Mexico. It thus is important that appropriate Mexican agencies and organizations be appraised of recovery efforts, and that assistance be provided to these groups to enhance awareness in Mexico of continuing threats to this threatened species.

9.1.5 Open communication among States. **Federal** • aencies **and local** residents and water **users.**

It **is** imperative that **all** parties interested *in* or affected by **recovery** actions in behalf of loach minnow **be** afforded an opportunity to **comment** on and participate in that program. **While** unanimity is unlikely to ever be the came, meaningful programs *is* **best** *assured when* all have access to complete information.

9.2 **Professional information.**

Professional *information,* including reaulte of field and laboratory reeearch, monitoring data, trip repotta, agency reports, and open literature must be readily available to all profeseionals involved in loach minnow *recovery.* **Ideas must** be exchanged freely • o that optimal strategies can be outlined and implemented. A central clearing house and repository for such information, with capability to distribute it as necessary, should be designated.

9.2.1 **Open** circulation of information **among** concerned **parties.**

All peraone working on loach minnow and/or their habitats should be encouraged to make information available to other concerned parties. They should be made aware of the clearing house (9.2) and requested to submit findings there for distribution.

9.2.2 Periodic **information-exchange** eeetiaas.

Face-to-face meetings of intereeted profeseionals and the public should be encouraged on a regular basis, or in response to Special **circumstances.** Such meetings provide opportunity to discuea ideas and resolve difficulties that otherwise could be difficult to accomplish.

9.2.3 Presentations at **professional,** *scientific* **meetings.**

Preliminary or refined research or monitoring data should be presented at local, regional, and national scientific gatherings so that a broader professional audience can have opportunity to comment on and thereby potentially enhance recovery of **loach** minnow.

9.2.4 **Publication in** Deer-reviewed. **open** literature.

Participanta in studies of loach minnow at all levele should be encouraged to publish their **findings** as appropriate within the peer-reviewed, open literature. Such publication indicates that results have had benefit of critical review and meet the standards of excellence to which professionals subscribe. It also enhances the credibility of individuals involved, and thus contributes to overall auccees of the recovery program.

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III. IMPLEMENTATION SCHEDULE

Definition of Priorities

Priority 1 - Those actions that are absolutely essential to prevent the extinction of the species in the foreseeable futura.
Priority 2 - Those actions necessary to maintain the present current population status.
Priority 3 - All other actions necessary to provide for full recovery of the species.

General Cateaories for Implementation Schedules

Information Gathering - I

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Land Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Dioease control
7. Other management

Abbreviations used

FWS - USDI Fish and Wildlife Service
FWE - Fish and Wildlife Enhancement
FR - Fisheries Resources
WR - Wildlife Resources
LE - Law Enforcement
DFRT - Desert Fiehee Recovery Team
PA - Public Affairs
AZG&F - Arizona Game and Fish Department
NMG&F - New Mexico Department of Game and Fish
FS - USDA Forest Service
BLH - USDI Bureau of Land Management
BR - USDI Bureau of Reclamation

Part III - IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY	TASK DURATION	RESPONSIBLE AGENCY FWA REGION	PROGRAM	OTHER	FISCAL YEAR COSTS (EST.) FY1	FY2	FY3	COMMENTS
1-1	Identify all populations and determine level of protection	1.1	1	3 years	2	FWE FR	AZG&F NMG&F FS BLM	4,000	4,000	4,000	
1-1	Prioritize populations bared on need for protection	1.2	2	1 year	2	FWE	DFRT			500	Task will be conducted by the DFRT
0-3	Designate critical habitat	1.3	1	1 year	2	FWE		1,000			Final rule Is under review
0-2	Enforce laws and regulations	1.4	1	Ongoing	2	FWE LE	FS BLM BR AZG&F NMG&F	5,000	5,000	5,000	
H-3	Discourage detrimental land and water uses	1.5	1	Ongoing	2	FWE	FS BLM BR AZG&F NMG&F	5,000	5,000	5,000	
A-7	Insure natural flows	1.6	1	Ongoing	2	FWE WR	FS BLM BR	----unknown----			Could Involve the purchase of instream flows
M-4	Curtail introductions of non-native fishes	1.7	1	Ongoing	2	FR FWE	NMG&F AZG&F				
n-4	Identify need for and construct barriers	1.8	1	Ongoing	2	FWE	BR AZG&F NMG&F BLM FS	100,000	100,000	100,000	
I-2	Identify available unprotected private lands and water rights	1.9	2	Ongoiing	2	FWE	WR DFRT NMG&F AZG&F	3,000	3,000	3,000	

Part III - IMPLEMENTATION SCHEDULE

GENERAL ATEGORY	PLAN TASK	SK #	PRIORITY	TASK DURATION	RESPONSIBLE AGENCY FI REGION	ROGRAM	OTHER	FISCAL YEAR (EST.) FY1	FY2	FY3	COMMENTS
A-1 through A-6	Acquire available lands and associated water rights	1.10	2	Ongoing	2	WR	FWE FS BLM	----unknown----			
o-2 & o-3	Protect ● ccpired lands	1.11	2	Ongoing	2	WR FWE LE	BLM FS	----unknown----			
t-1	Establish standard monitoring locations and techniques	2.1 2.2	1	1 year	2	FWE	FS BLM NMG&F AZG&F DFRT	1,500			
l-1 & I-2	Establish and maintain computerized database	2.3	2	Ongoing	2	FWE	AZG&F	2,000	2,000	2,000	
R-1	Determine natural variation in abundance and age-clssr structure	2.4	1	3 years	2	FWE	AZG&F NMG&F FS BLM	10,000	10,000	10,000	
R-1	Determine standard methods for quantifying abundance	2.4.1	1	2 years	2	FWE	NMG&F AZG&F FS BLM	2,500	2,500	2,500	
I-1	Conduct bl-amual population ● ↑♦ imates	2.4.2	1	Ongoing	2	FWE	NMG&F AZG7F FS BLM	3,000	3,000	3,000	
I-1	Monitor community composition including range of natural variation	2.5 2.5.1 2.5.2	1	Ongoing	2	FWE	NMG&F AZG&F FS BLM	5,000	5,000	5,000	Tasks 2.4.2 to 2.5.2 would be done simultaneously
1-14	Determine genetic characteristics of ● nisting populations	2.6	1	2 years	2	FWE	AZG&F NMG&F FS	0,000	8,000		

Pan III - IMPLEMENTATION SCHEDULE

GENERAL ATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	PROGRAM	OTHER	FISCAL YEAR COSTS (EST.) FY1	FY2	FY3	COMMENTS
R-9 & R-10	Determine significance of interaction with non-native fishes	3.1 through 3.2.2	2	3 years	2	FWE	AZG&F NMG&F FS BLM	25,000	25,000	25,000	
R-3	Quantify effects of physical habitat modification	4.1 through 4.6	2	3 years	2	FWE	NMG&F AZG&F FS BLM	25,000	25,000	25,000	
n-3	Identify management areas and determine necessary habitat improvements	5.1 5.2	2	1 year	2	FWE	DFRT NMG&F AZG&F FS BLM			5,000	To be done following completion of tasks 4.1 to 4.4
n-3	Implement habitat improvement	5.3	3	Ongoing	2	FWE	AZG&F NMG&F FS BLM	. .	--unknown----		
n-2	Identify stocks to be used for reintroduction	6.1	3	1 year	2	FWE	DFRT			2,000	
n-2	Identify and prepare sites for reintroduction	6.2 through 6.2.5	3	3 years	2	FWE	DFRT NMG&F AZG&F FS BLM	. . .	unknown . . .		cost will depen upon kind and amount of work
n-2	Reintroduce into selected reaches ard monitor	6.3 6.4	3	Ongoing	2	FWE	NMG&F AZG&F FS BLM				$7,000/yr once reintroduction
n-2	Determine reasons for success/failure and rectify as necessary	6.5 6.6	3	Ongoing	2	FWE	DFRT AZG&F NMG&F BLM FS				Evaluation will begin 5 years after reintroduction

Part III - IMPLEMENTATION SCHEDULE

GENERAL ATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY FWS REGION	FWS PROGRAM	OTHER	FISCAL YEAR COSTS (EST.) FY1	FY2	FY3	COMMENTS
R-I	Determine quantitative criteria for describing a self-sustaining population	7.1 through 7.3.3	2	3 years	2	FWE	AZG&F NMG&F FL BLM DFRT	20,000	20,000	20,000	
M-1	Select stocks to be used for hatchery brood stock	8.1	3	1 year	2	FWE FR	DFRT NMG&F AZG&F			1.000	
H-l	Collect hatchery stocks	8.2	3	1 year	2	FWE FR	AZG&F NMG&F			3,000	
M-1	Hold and maintain stocks in a hatchery	8.3	3	Ongoing	2	FR FWE					$10,000/yr once stocks are take
n-1	Evaluate ad assess propagation techniques ard life-cycle requirements	8.4 8.5	3	1 year	2	FR FWE	DFRT NMG&F AZG&F			8,000	
n-1	Supply hatchery reared fish as needed	8.6	3	Ongoing	2	FR FWE	AZG&F NMG&F				$1,500/yr once begun
o-1	Provide information and education relative to the species to the public sector	9.1 through 9.1.5	2	Ongoing	2	FWE PA FR	NMG&F AZG&F FS BLM BR	3,000	3,000	3,000	
o-1	Ensure all professional information is made available	9.2.1 through 9.2.4	2	Ongoing	2	FWE FR	BR AZG&F NMG&F BLM FS	2,sw	2,500	2,500	costs include information publication in scientific journals

IV. APPENDIX A: PROPOSED CRITICAL HABITAT

Propoeed critical habitat for loach minnow, Tiaroga cobitis, in Arizona and New Mexico, am originally proposed by FWS (1985). &gal doecriptione (township, range, ☐■☐ ● ection) arm not included hmrmin. All stream reaches are figured in FWS (1985). Additional ● ♦❐○☐○ rmachme occupied by yet undiscovered population8 of loach minnow may be coneidermd for future addition to the deeignatmd critical habitat. Any much addition8 will be subject to the etandard rulmmaking process, including publication of a propoeal in the Federal Regfeter and a public review period.

Arizona:

1. Graham and Pinal Countiee: Aravaipa Creek, approximately 24 kilometers (km)of stream.

2. Greenlee County:
   a. Blue River, approximately 78 km of river extending from the confluence with the San Francisco River upstream to the confluence of Campbell Blue Creek and Dry Blue Creeks in Catron County, New Mexico.
   b. Campbell Blue Creek, approximately 14 km of stream extending from the confluence with the Blue River upetream to the confluence with Coleman Creek (approximately 0.8 km of thie reach arm located in Catron County, New Mexico).
   c. San Francieco River, approximately 6 km of river, mxtending from thm confluence with Hickey Canyon upstream to the confluence with Blue River.

New Mexico:

1. Catron County:
   a. Dry Blue Creek, approximately 3 km of etrmam, extending from the confluence with the Blue River upstream.
   b. San Francieco River, approximately 15 km of stream, extending upstream from the U.S. Highway 180 bridge.
   c. Tularoea River, approximately 24 km of stream, extending from the confluence with Negrito Creek upstream to the town of Crurville.

2.. Grant and Catron Counties:
   a. East Fork Cila River, approximately 26 km of river, extending from the confluence with the West Fork upstream.
   b. West Fork Gila River, approximately 12 km of river, extending from the confluence with the East Fork upstream.
   c. Middle Fork Cila River, approximately 18 km of river, extending from the confluence of the West Fork upstream to the confluence with Brothers West Canyon.

3. Grant County: Gila River, approximately 37 km of river, extending from the confluence with Hogollon Creek downstream.

APPENDIX B: COMMENTS

Appendix B is combined for two recovery plans: the pikedace and the loach minnow. It contains a list of plan reviewers, copies of comment letters received, and Service responses to those comments. Comments for both plans were solicited at the same time, and all comment letters addressed both plans. Therefore, to reduce paper consumption, Appendix B has been printed under separate cover from the body of each recovery plan. Appendix B was distributed along with copies of the plans to a mailing list of interested parties, including Federal and State agencies and parties who submitted comments. Further distributions of either recovery plan will be made without Appendix B, unless it is requested. Separate copies of Appendix B are also available upon request.

by activities that ● ubmtantially altar natural flow regimes, much am damning *or* diversion, ● hould bm an integral part of insuring perennial flowm. *For example,* U.S. Bureau Of Land Management is in the final ● tagee of applying for an instream flow water right for Aravafpa Creek, Arizona.

1.7 Curtailtransport and introduction of non-native fishes.

State, Federal, *or* private stocking programs for non-native sport or other ● peciee must consider potential impacts of much plantingm on imperiled fishes, and ●⌘○⌘♦ ● ctivitiem to waters 80 am to preclude possibility for negative interactions. Where they do not already exist, appropримtе regulations ● hould be promulgated that dimcourage transport and ● tocking of non-native fimhem into habitats from which they have access to stream reaches occupied by loach *minnow.* State, Federal, or other management agencies and privatm entities should dimcontinue mtockingm of non-native, warmwater sport, *forage,* or bait fimhem into or upstream from streams occupied by loach *minnow,* and upmtream from the first absolute barrier to upmtream fish movement *into* loach *minnow* habitats.

Operation and future siting of State, Federal, or private facilities that hold, propagate, rear, or participate *in* other fish or aqua-cultural activities with non-native fimhem mhould be required to ensure that escapement to waters occupied by loach minnow im precluded.

1.7.1 Discourage use of live bait and seining in streams occupied by loach minnow.

Introduction8 of non-native fimhem may occur am a result of intentional or inadvertent release of bait fishes umed for sport angling. Where sport fishes and loach minnow are known to co-occur, responsible resource agencies should discourage or disallow use of live bait. Furthermore, baitfimh meining mhould not be allowed to occur in stream reaches occupied by loach minnow, which could unknowingly be taken and unneceeearily destroyed.

1.8 Examine ● ffiCnCV of barrier construction to protect existing populations from invasion by non-native fishes.

Construction of fish barriers ehould be considered am a preventive measure for protection of existing populations of loach minnow from contaminat ion by non-native fishes. For example, a cooperative effort has determined that placement of much a barrier on Aravaipa Creek, Arizona, would protect upstream populationa of native fishes, including loach minnow, from invaeion by red mhiner. Other mtreamm occupied by loach minnow may also be amenable to such management, and remponeible agencies should fully evaluate efficacy of thim action.

1.9 Identifv important, available private lands and water rights not alrsadv protected.

Although a significant proportion of lands adjacent to habitats occupied by loach minnow already receive at learnt some degree of protection from State, Federal, or private entities, other land8 through which potentially important stream reaches pass have no benefit of protection. Unwise land or water uee practice8 in and adjacent to occupied reaches could have detrimental impacte upon loach minnow residing in the same drainage. Also, because fishes require water to survive, provision must be made for acquisition of water rightm to inmure sufficient quantities for

the species to perpetuate. The U.S. Fish and Wildlife Service ahould designate the appropriate agencies to identify theme areas and water rights, determine their ownership, and aaaeaa the potential availability of neceaeary water rights.

1.10 Acquireimportant lands and associated water riahta as they become available.

A variety of mechanisms exist by which lands and water rights may be acquired by State, Federal, or private entities inclined to do so in behalf of protecting loach minnow and their habitat. Acquisition of theme lands and water rights will add to assurance that existing populationa of the apeciea and their habitats are secure.

1.11 protect • [illegible] lands.

Once important lands and stream reaches are in appropriate ownership, they must be administered and managed in ways consistent with perpetuation of loach minnow habitats and populations.

2. Honitor status of existing woulationa.

Standardized, long-term monitoring is neceaeary to detect changes in population status, aaaeaa aucceaa of recovery/management actions, and determine when applicable criteria for delisting have been fulfilled. The U.S. Fish and Wildlife Service and States of Arizona and New Mexico, with advice of the Deeert Fishes Recovery Team, ahould specify a standardized monitoring program baaed upon biological conaiderationm plum practical constraints to addreaa elements outlined below.

2.1 Establish standard ronitoring locationa for extant populations.

Stream and river reaches representing typical habitats actually or potentially occupied by loach minnow population6 in Arizona and New Mexico should be selected for routine monitoring. Only when data are obtained from standard monitoring areas can natural or other changes in habitat or population status be determined.

2.2 Establish and implement standard techniauea and their aoolication.

Techniques for aaaeaeing habitat and loach minnow population status should be coneietent spatially, temporally, and among investigators. Standard monitoring techniques ahould be developed and implemented to ensure that results are comparable among years, populationo, and groups responeible for this monitoring. Techniques should be based upon biological information, plus practical conatralntm. In some instances, use of specific techniques may be restricted, for example, use of motorized equipment in wilderness areas, and such constraints should be considered in selection of methodologiee.

2.3 Establish and maintain a comvuterited database.

Adequate data tracking would allow management actions to be based on the best up-to-date information and would insure rapid assessment of recovery progress. A centralized, computerized database should be established containing all available historic information on distribution and abundance of the loach minnow throughout its range. All monitoring

data on existing populations, plus information on • etabliehmont and monitoring of reintroduced populations should be placed into this database ae soon as the information becomes available.

2.4 Determine range of natural variation in absolute • bundence • oQ age-class structure.

Populations of loach minnow vary both spatially and temporally as a result of differing dynamic characterietice exhibited by individual populatione and in response to natural changes in their environment. Chanoes in statue of any givrn loach minnow population can be attributed to other than natural causes only when the range of variation expected *from* intact populations in relatively unperturbed habitats has been • [illegible] Chan es which occur under these last conditions are reasonably interpreted as d .to natural phenomena, and provide a template • geinet which to aeeeee chan• • due to *man's* activities. Population • tatue is most readily aeeeeeed by knowing absolute abundance of individuals in the population, and the distribution of individuals *among age* claeeee (cohorts).

2.4.1 Develop standard methods for quantifying abundance.

Several techniguee are available for determination of absolute abundance of fishes, including depletion sampling, mark-and-recapture, etc. A standard technique should be selected on a baeie of biological considerations, plus practical constraints.

2.4.2 Conduct bi-annual (spring, autumn) population estimates.

Population eetimatee should be conducted at times of year that are *most* likely to provide managers with most-useful *information* as regards statue of loach minnow. Spring sampling allows aeeeeement of reproductive condition of the population, while autumn sampling Qrovidee opportunity to evaluate recruitment derived from springtime spawning. Both are neceeeary to adequately determine population statue and characterize cyclic aepecte of population dynamics.

2.5 Honitor community corwsition.

Populations of loach minnow may be subject to influences of other members of the fish community. Changes in Status of other species, especially non-native kinds, may serve notice that loach minnow statue also may be expected to change. At least a minimum of predictability of change within a normal range of varietion is necessary to manage populations of loach minnow, and any information that will enhance that capability may enable management decision8 before potential negative impacts are realized.

2.5.1 Apply standard monitoring locations and sampling techniques (see 2.1, 2.2).

Techniques for aeeeeeing etatue of the fish community should be compatible with those specifically selected for loach minnow monitoring, and should be etandardited as regards place and method.

2.5.2 Determine range of natural variation in relative abundances of community members.

A most easily obtained and readily interpreted datum is relative abundance of fish community constituents. *However,* change caused

by other than natural factors cannot be reliably ● eseeeed unless an indication of the range of normal variation experienced by etable communities in relatively unperturbed habitats is first known. Baseline data already available should be augmented by information from future, routine sampling of fishes.

2.6 Determine aeaetic characteristics Of ● x&&ioa populations.

Baseline information on the genetic characteristics of existing loach minnow populations should be gathered to elucidate relationships among populations and to provide guidance in propagation and reintroduction programs (Echelle 1988; 6.1, 6.3, and 8.1, below). Results of an initial eurvey will be required to insure that any genetic differences among populations are considered in the implementation of this plan.

3. Identify nature and significance of interaction with non-native fishes.

Impacte of non-native fishes on loach minnow cannot be alleviated or otherwise managed until the mechanism(s) of such interactions are known, and an asseeement as to the qualitative and quantitative significance of the interaction has been completed.

3.1 Direct interaction (predation, displacement).

Research has shown that certain non-native fishes prey intensively upon native fishes (e.g., Heffe 1983, 1985). Likewise, inferential evidence euggeete that other non-natives spatially displace native fishes (e.g., Hinckley and Deacon 1968, Harsh et al. 1989). These kinds of interaction thus appear most fruitful for investigation in the case of loach minnow. Other potential mechanisms of interaction, such as competition for environmental reeourcee, ehould also be investigated where data suggest they may be important.

3.1.1 Field invertiaations and experimental manipulations.

Evidence of direct interaction is most convincing when derived from studies on in-situ populations. Because loach minnow and potentially detrimental non-native fishes co-occur in several places, these habitats and communities could be selected for intensive field studies. Experimental manipulations in which selected species are variously included or excluded among available habitats would provide a powerful tool for evaluating interactions (e.g., Power et al. 1985). Appropriate study reaches and specific experimental deeigne should be determined by consensus among knowledgeable individuals.

3.1.2 Laboratory studier.

Some aspects of direct interaction among loach minnow and non-native fishes can be determined best under controlled, laboratory conditions. These studies would provide a framework and direction for applied field investigations (3.1.1).

3.2 Indirect interaction lmediated by other fishes of the community).

Effects of non-native fishes upon loach minnow may not be caused by direct interaction, but rather indirectly by the effect of non-native fishes impacting other members of the fish community. Regardlese, prudent

management of loach minnow populatione cannot be implemented until the nature and ● ignificance *of* both *are* evaluated.

3.2.1 **xperimentaltigations** and **● manipulations**.

Field ● tudiee and in-stream experiments would be neceeeary to qualitatively and quantitatively **describe** indirect **interactions** among loach minnow and non-native fiehee (see 3.1.1).

3.2.2 **Laboratory studies.**

Studies of loach **minnow,** other native fiehee, plus non-native species under controlled, laboratory **conditions** could identify *a* range *of* biological and habitat paremeters important to indirect interactions; these then could be **applied** toward inteneive field studies (3.2.1).

4. **Quantify,** throuah research. loach **minnow** habitat needs and the **effects** of **physical** habitat **modification** or **ife cycle completion.**

Localized depletion **or extirpation** . loach minnow may be caused by changes in proximal physical habitat **acting** on one or wre life history stage or function. **Likewise,** wideepread **depletionor extirpation** may be caused by far-reaching alterationo of watershed characteristics acting on one or more life history stage or function. **Qualitative** and quantitative relationehipe among Specific kinds of habitat . **odification** and loach minnow biology **must be established** before **management can** be directed toward correcting and removing the cause(e) of **deleterious** habitat conditions. Such analyses will be dependent upon prior **determinations** of loach minnow habitat needs and usage. Research must consider all life history stages **as** well as variations in eeaeonal and diurnal use.

4.1 Substrate (siltation. ● rrorinal.

Erosion and siltation which result in filling of interstitial spaces of gravel-rubble riffles occupied by loach minnow may interfere w.. **successful** egg depoeition and incubation, and thus impact recruitment, population abundance, and age-class structure (**Propst** et al. 1988). Substrate armoring which renders egg deposition sites unavailable **to** loac minnow may **have** eimilar effects. Quantitative **relationships** must be established **so that** conditions characterizing suitable habitats can be described, **changes** can be assessed, and management strategies **for** reclamation of impaired habitat *can* be assessed and implemented.

4.2 Velocity and **depth.**

Land and water uee practices that alter water velocity and depth may affect loach minnow, which have demonstrated specializations for these factors (Turner and Tafanelli 1983, **Propst** and **Bestgen** 1991). Available data should be reviewed and augmented so that preferenda can be determined, and tolerance **limits** eetabliehed. This information will enable refinement of management strategy design and implementation.

4.3 Water ttmverature.

Water and land use practices may influence thermal regimes in habitats occupied by loach minnow. Relationehipe between loach minnow life history and temperature are poorly known, and should be established as

regards optima, preferenda, and tolerated extremes so that conditions characterizing suitable habitats can be deecrfbed, chengee can be aeeeeeed, and management strategies for reclamation Of impaired habitat can be evaluated and implemented.

4.4 Water chemistry.

Water and land use practices may influence various chemical parameters of the waters occupied by loach minnow. Preferenda and tolerance limits of loach minnow life history stages need to be established for basic parameters, such as pH, turbidity, alkalinity, and dissolved oxygen, 80 that the effects of change8 in those parameters may be assessed.

4.5 Watershed characteristics.

It has been speculated that loach minnow may be limited to occupation of streams with a certain minimum watershed site and/or water volume (Propst, pare. comm.), based on their absence from small tributary streams even when habitat is apparently available. Impoundment and/or diversion of upstream waters, watershed vegetation alteration resulting in changing runoff patterns, and other human actions functionally modify both watershed size and water volume. Flood frequency and volume is a major watershed characteristic and is frequently modified in southwestern streams during the course of water development. Flooding has been shown to be a major factor in.the relationship of native to non-native fishes (Heffe and Minckley 1987, Propst et al. 1986). Relationships between watershed characterietice and loach minnow biology must be established so that conditions characterizing suitable habitats can be described, effects of changes can be aeeeeeed, and management etrategiee can be prepared and implemented.

4.6. Interaction8 among 4.1-4.4.

Water and land use practices may affect one or several environmental parameters important to eucceeeful loach minnow life cycle completion. Thus, synergistic or antagonistic effects of changes in substrate, velocity, depth, and water temperature should be aeeeeeed to determine combinations repreeenting optima, preferenda, and tolerance limits.

5. Enhance or restore habitats occupied by depleted populations.

Management strategies developed to minimize or eliminate negative impacts resulting from habitat modifications and/or interactions with non-native fishes should be applied to habitats in which loach minnow populations have been depleted. Such management provides opportunity for continued etudy of relationehipe between loach minnow and its biological and physical environment, to assess efficacy and modify specific practices of management implementation, and contributes toward recovery of the epeciee.

5.1 Identify target areas amenable to management.

Some habitats occupied by depleted populations of loach minnow, and their adjacent landscapes, may be amenable to restoration, while others may be in a state of continuing degradation such that they cannot reasonably be revived to euitable condition. Theee former places should be

identified so that management can be implemented that will enhance or restore them to pre-impact conditions.

5.2 **Determine necessary habitat and landscape improvement s.**

Habitat improvements can be *effected* only when physical characterietice neceeeary *for* loach minnow occupation, reproduction, and self-sustenance ate known. **Moreover,** habitat reetoretion likely will **require** removal of conditions which have led to degradation. Some stream and river reaches **may "self-improve" if** natural **forces** are allowed to reign in **absence** □↗ • *ourcee* of perturbation. Examples include curtailment of overgrazing, **stabilization** of banklfne or **other** erosion **sites,** altered timber management strategies , *etc.:* removal or other control of non-netive fishes, where problematic, mey **also** be neceeeary (6.2.3-6.2.5).

5.3 **Implement** habitat **improvement.**

Once sources of impacts end habitat **parameters** in need *of* improvement have been identified, meaeuree should be implemented to remove impacts and restore damaged habitats.

6. Reintroduce **populations** to selected **streams** within **historic range.**

One **of** the most critical goals to be achieved toward loach minnow recovery is eetabliehment *of* **secure,** self-reproducing populations i habitats. *from* which the epeciee has been extirpated. **Successful** implementation of this management goal will provide a cle **indicat on t:** both the biology of the epeciee and the impacts reeulting :n its demise are well enough understood and that manegement etrategiee were effective enough that attainment of full *recovery* is probable.

6.1 **Identify stocks** amenable to use *for* **reintroduction.**

Stable, eelf-sustaining populations with capacity to contribute individuals for reintroduction without sustaining unneceeeary depletion should be identified. To the extent practicable, local stocks with affinities to thoee formerly occupying target etreame should be utilized (e.g., upper Gila River for Eagle Creek, Aravaipa Creek for San Pedro). Results *of* a genetic eurvey (2.6 above) will be used as guidance in selecting appropriate donor **stock.** If it is determined that existing populations do not have capability to supply sufficient individuals fox reintroductions, **hatchery-produced** fish may be used (8 below).

6.2 **Identify** river or stream **systems** for reintroductions.

Among **streams** from which loach minnow have been extirpated, Eagle Creek and San Pedro River, Arizona, represent those most amenable to reestablishment of the epeciee. Loach minnow occurred in Eagle *Creek* at leaet in 1950, when R. R. Miller collected 13 individuals (University of Michigan **Museum** of **Zoology,** unpublished record). Although the etream **contains relatively** large areas of apparently suitable habitat and supports a largely native fauna (Hinckley 1973, **Propst** et al. 1985, unpublished data) loach minnow apparently no longer occur there; reason(e) for its apparent extirpation are unknown. San Pedro River is the type locality for loach minnow (Cirard **1857),** but it and 10 other native fiehee were extirpated **as** a **result** of drastic habitat destruction, plus introduction of exotic fiehee, over the last 100 years (Minckley 1987). Not only the mainetream San Pedro may be readily amenable to restoration for loach

minnow; *certain* perennial reaches of major tributaries (e.g., Redfield Canyon, Babocomari River) also have potential for reestablishment of the epecieo. Aravaipa Creek, which is home to the largest remaining loach minnow population in *Arizona,* is tributary to the San Pedro River. Bonita Creek (tributary to the Gila River in Arizona), plus other, yet to be identified locations, should also be evaluated as potential recipient8 of reintroduced populations.

6.2.1 Determine ● uitabilftv of habitat.

Eagle *Creek* and San Pedro *River* systems, plus others when identified, ehould be evaluated as regards suitability to provide loach minnow habitat. *Specific* reaches that fulfill known requirements, plus areas amenable to reetoration, ehould be identified. *Caueee* and sources of former and continuing habitat degradatiod and of the original extirpation need to be evaluated and rectified if necessary.

6.2.2 Enhance habitat as necessary (4, 5.3).

Habitats amenable to physical restoration should be subject to management implementation to reetore them to pre-impact condition. This may require modification or diecontinuance of certain land or *water* use practicee if *it* ie determined that theee continue to contribute to habitat degradation.

6.2.3 Assess status of Iron-native fisher in the watershed.

Non-native fiehee poee potential threats to reeetabliehment of loach minnow. Theae *may* occupy the *stream* reach selected for reintroduction, tributaries, and isolated waters within the watershed. Assessment ehould be made of distribution, community composition, and relative abundances *of* non-native fiehee.

6.2.4 Assure *closure* of potential immigration routes to preclude reinvasion by non-native fishes.

Stream reaches identified to receive plantings *of* loach minnow should be isolated as much as practicable from non-native fishes, which might preclude or otherwiee interfere with successful reeetabliehment of the native. Closure of immigration routes might include construction of barrier dame or other etructuree to insure that downetream populations *of* exotics do not access habitats occupied by reintroduced etocka of loach minnow.

6.2.5 Reclaim as necessary to remove non-native fishes.

Non-native epeciee in places from which they could invade loach minnow habitat, or thoee occupying target areas themselves, should be removed or depleted ae completely as poseible. Removal from live stream reaches would likely be accomplished by pesticide application, while other waters, such as cattle tanks, could be reclaimed by either drainage *or* pumping, pesticide treatment or a combination thereof.

6.3 Reintroduce loach minnow to selected reaches.

Loach minnow ehould be collected, traneported, and reintroduced into selected stream reaches after habitat reetoration and non-native species removals have been accomplished. Stockings should be of sufficient numbers of individuals to assure maintenance of reaaonable genetic

heterogeneity of the reintroduced population (Echelle 1988, 2.6 and 6.1, above).

6.4 **Monitor** ● ucteeeff+i)ure of refntroductior.

Reintroduced loach *minnow* populatione ● hc:.-d be periodically monitored; location, **time** of year, and methode ● hould be standardized so data **are** comparable with previous **information** *for* other populatione and can be ueed to aeeeee **changes** in ● tatue (2, **above**). Preliminary evaluation of success should be made **five years after** reintroductions, and **periodically** thereafter until [illegible] for ● ucceee have been fulfilled.

6.f **Determine** [illegible] for ● ucceeaf **failure**.

Success of reintroductions will **be indicated** by ● etabliehment of reproducing, self-sustaining **populations** of loach minnow with characterietice **of** abundance, age-claee **structure,** and recruitment *in* the range of natural variation determined **from** extant **stocks.** Causes of reintroduction failure, indicated by ● berranciee in population characteristics *or* extirpation, must be identified and evaluated. These could be a result of incomplete implementation *of* identified management strategies, or due to other natural and anthropogenfc factors. Using monitoring data, preliminary evaluation of success should be made five years after reintroduction. Failed populations should then be **reaeeeec i** and decision8 regarding rectification *of* **problems,** restocking, **or** abandonment made. Populations which are **questionable** or eucceeeful at nat time should be monitored for an additional five **years** before being judged eucceesful or not.

6.6 **Rectify** am **necessary cause(s) of** failure and **restock.**

Identified cauaee **of** failure should be rectified. This may require implementation of the **same,** or refinements of, ● trategiee identified previously, or implementation of additional ones. Additional reintroduction **stocking** may be indicated once causes of initial failure are identified **and** removed. In some *instances,* repeated ● equencee of reintroduction, monitoring, aeeeeement, and refinement ray be necessary before local rnanagement **goals** are eatiefied.

7. **Determine quantitative criteria for describing a self-sustaining** pooulation.

Recovery goals call for protecting existing populationa, restoration of depleted stocks, and reestablishment of loach minnow in places from which the epeciee has been extirpated, and insurance that the animal ham opportunity for self-sustenance in perpetuity. Fulfillment of these goals will constitute **justification** *for* delisting of the species. Attainment of each can be determined only from quantifiable criteria applied to populations under consideration. In particular, acceptable **levels** of natural variation within certain parametere of stable, reproducing populationa **must** be determined (see Meffe and Hinckley 1987). Absolute and relative abundance, age-claee **structure,** and recruitment are variables most likely to provide needed data am regards population **status.** Theme must be interpreted within a context of security of the habitat and watershed **against** future detrimental change, and of integrity *of* the fish community as **regards** invaeion and eetabliehment of non-native species.

7.1 Acceptable level8 of natural variation.

Populations behave in response to normal variation8 in their physical and biological environments. Thus, population density, for example, can be expected to vary in time and space. Determination that a population la "healthy" can be made only when the range of normal variation of key population parameters is known.

7.1.1 Absolute numbers.

Presence/absence data provfdem valuable *information,* and usually can be assessed expediently. However, such data are not generally useful for evaluating change in population status relative to normal environmental variation. Abaolute abundance *can* be determined by any of several methods, such as depletion sampling or mark and recapture studies. When standardized as to location, time of year, and method, data are comparable among samples and populations and can be used to establish *average" conditions and acceptable limits of normal variation.

7.1.2 Aae-clams structure.

Age-class structure can readily be determined from measurements of individuals sampled during population abundance estimation. Relative health of the population is indicated by a normal distribution of individuals among age classes, i.e., natural mortality acts to diminish the number of individuals in each successive, older age-class. Obvious aberrancies, such as complete failure of a year-class or absence of *an* age class likely indicates substantial preesure on the population, and may require rapid remedial action.

7.1.3 Reproduction.

Populations can perpetuate themselvem only if reproduction replaces individuals lost to natural (or other) sources of mortality. Loach minnow reproduction ehould be assessed by determining that the population includes an adequate stock of reproductive fish of both sexes in a normal ratio, and that egg depoeition, embryo incubation, and larval hatch are successful.

7.1.4 Recruitment.

Larval fish must have opportunity to grow, mature, and eventually contribute their gametes to future generations. Thus, dynamics of a healthy population require that an appropriate number of offspring survive to reproduce. Assessment of recruitment would be in concert with evaluations of absolute numbers and age-class structure.

7.2 Hinimur stock size.

For each population in time and space, there is a minimum size (number) of reproductive adult fish necessary for perpetuation of the stock. When numbers dwindle below this minimum stock size, natural (and other) sources of mortality will eventually result in extirpation of the stock, even though (diminished) reproduction and recruitment occur up to the time of extirpation. While it is probably impractical to attempt to quantify minimum stock sire for all present and future populations of loach minnow, some consensus should be achieved among knowledgeable individuals as to what represents reasonable minimum stock size for loach minnow in various habitats. Depletion of a population below that minimum should be

taken am indication that one or more environmental factor8 is negatively impacting the population. Further investigation to determine and rectify the cause would be necessary. A self-sustaining population should not dwindle below a previously determined minimum stock • ire.

7.3 Environmental variables.

self-mumtenance in perpetuity requires that habitat at all times meet the minimum requirements for life cycle completion by the • peciem. Some habitats may support loach minnow populatione for a period of time, *then* fail to do so. It thur is important that characterirtice which demcribe suitable, long-term habitat be known.

7.3.1 Physical characteristics.

Basic habitat parameters include depth, current velocity, substrate, water *temperature, etc.* These, plus others determined significant, must be available within the tolerance range acceptable to loach minnow.

7.3.2 Chemical characterimticm.

Fishes require varying levelm of certain chemical mubmtancem to inmure completion of all life history functions. For example, dissolved oxygen must remain above certain minima for fiehem to survive. Also, levels of environmental chemicals, both natural and anthropoqenic, mumt be maintained much that they do not induce acute or chronic mymptomm or *toxicity* among loach minnow, or otherwise interfere with life cycle completion.

7.3.3 Biological community.

Maintenance of loach minnow populations in perpetuity requires that the composition and integrity of the biological community of which it is a member almo be maintained in a natural mtate. Loach minnow existence depends in varioum ways on parts of that community (e.g., aquatic insect food resources). Moreover, perturbation of the community may indicate future change8 about to occur in the • tatue of loach minnow. Invasion of the community by exotic forma, especially non-native fimhem, may have severe impacts upon loach minnow and other native fishes. Attempts should thus be made to ammesm, at least in general terms, the nature and condition of the biological communities that characterize habitats occupied by loach minnow.

8. Consider continssncv planninq and preliminary investiqations for captive holdinq, propaqation and rearinq.

Captive holding, propagation, and rearing proqramm are important aspects of recovery plans for moat mouthwestern fishes. At present, it does not appear necessary that much plan8 be instituted in behalf of loach minnow. This is because the species continue8 to occupy, in mubmtantial numbers, several dispersed habitata, and probability of protecting eximting populations and environment8 appear8 high. However, condition8 could change rapidly and existing populations could be meverely depleted or extirpated. In such event, availability of a viable hatchery plan could be indispensable to maintenance of the mpeciee.