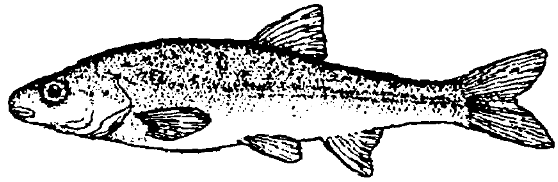
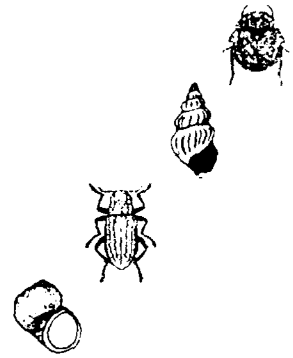
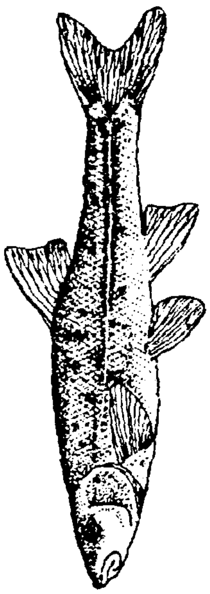
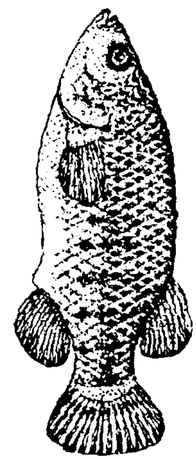
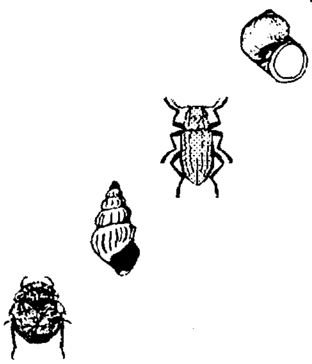
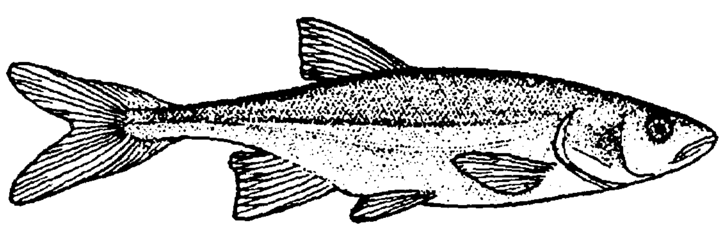







RECOVERY PLAN FOR THE RARE AQUATIC SPECIES OF THE MUDDY RIVER ECOSYSTEM

U.S. Fish and Wildlife Service
Region 1

Portland, Oregon




RECOVERY PLAN

FOR THE RARE AQUATIC SPECIES OF

THE MUDDY RIVER ECOSYSTEM

First Revision
(Original Approved: February 14, 1983)

Prepared by
Selena J. Werdon

for
U.S. Fish and Wildlife Service
Region 1
Portland, Oregon

Michael J. Spear

Approved: Michael J. Spear
Regional Director, U.S. Fish and Wildlife Service

Date: 5/16/96

This Recovery Plan covers one federally listed species (Moapa dace) and seven species of special concern in the Muddy River ecosystem.

DISCLAIMER

Recovery plans delineate reasonable actions believed to be required to recover and/or protect listed species. Plans published by the U.S. Fish and Wildlife Service or National Marine Fisheries Service are sometimes prepared with the assistance of recovery teams, contractors, State agencies, and other affected and interested parties. Recovery teams serve as independent advisors to the Services. Plans are reviewed by the public and submitted to additional peer review before they are adopted by the Services. Objectives of the plan will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not 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 and Wildlife Service/National Marine Fisheries Service. They represent the official position of the National Marine Fisheries Service/ U.S. Fish and Wildlife Service only after they have been signed by the Assistant Administrator/Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

By approving this document, the Director/Regional Director/Assistant Administrator certifies that the data used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the Nevada State Office of the U.S. Fish and Wildlife Service, Reno, Nevada.

Literature Citation of this document should read as follows:

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Fees for recovery plans vary depending on the number of pages.

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR THE RARE AQUATIC SPECIES OF THE MUDDY RIVER ECOSYSTEM

Current Species Status: The Moapa dace (*Moapa coriacea*) was listed as endangered on March 11, 1967 (32 Federal Register 4001). It occupies approximately 9.5 kilometers (6 miles) of stream habitat in five thermal headwater spring systems and the main stem of the upper Muddy (= Moapa) River, Clark County, Nevada. Critical habitat has not been designated. A range-wide survey documented 3,841 adult Moapa dace in August 1994. The Muddy River ecosystem is also inhabited by seven aquatic species of special concern (three fish, two snails, and two insects).

Habitat Requirements and Limiting Factors: Adult Moapa dace inhabit the main stem Muddy River, but only successfully reproduce in tributary thermal spring outflows (30-32° Celsius; 86-89.6° Fahrenheit). Larval and juvenile dace occur in low- to moderate-velocity areas in the spring outflows. Moapa dace are omnivorous drift feeders. Principle threats to the species are habitat alterations which have eliminated access to and/or destroyed spawning, nursery, and foraging areas; water loss; impoundments; and introductions of nonnative fishes and parasites.

Recovery Objective: Delisting.

Recovery Criteria: Moapa dace will be considered for reclassification from endangered to threatened when: 1) Existing instream flows and historical habitat in three of the five occupied spring systems (Apcar, Baldwin, Cardy Lamb, Muddy Spring, Refuge) and the upper Muddy River have been protected through conservation agreements, easements, or fee title acquisitions; 2) 4,500 adult Moapa dace are present among the five spring systems and the upper Muddy River; and 3) the Moapa dace population is comprised of three or more age-classes, and reproduction and recruitment are documented from three spring systems.

Moapa dace will be considered for delisting provided that all reclassification criteria have been met and when: 1) 6,000 adult Moapa dace are present among the five spring systems and the upper Muddy River for 5 consecutive years; 2) 75 percent of the historical habitat in the five spring systems and the upper Muddy River provides Moapa dace spawning, nursery, cover, and/or foraging habitat; and 3) nonnative fishes and parasites no longer adversely affect the long-term survival of Moapa dace. These recovery criteria are preliminary and may be revised on the basis of new information (including research specified as recovery tasks).

Actions Needed:

1. Protect instream flows and historical habitat within the upper Muddy River and tributary spring systems.
2. Conduct restoration/management activities.
3. Monitor Moapa dace population.
4. Research population health.
5. Provide public information and education.

Implementation Participants:

The Nevada Division of Wildlife and National Biological Service will be assisting the U.S. Fish and Wildlife Service in implementing recovery tasks. For activities occurring on private land, landowner participation is also needed.

Total Estimated Cost of Recovery (1996-2008): ($1,000's)

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1996	51	51	11	0	19	132
1997	TBD	15+TBD	11	7	21	54+TBD
1998	TBD	15+TBD	11	0	6	32+TBD
1999	TBD	15+TBD	11	0	6	32+TBD
2000	TBD	15+TBD	11	0	6	32+TBD
Total	51+TBD	126+TBD	132	7	106	422+TBD

Date of Recovery: Reclassification of Moapa dace from endangered to threatened could be initiated in 2000, if recovery criteria for threatened status are met. Delisting could be initiated in 2009, if reclassification to threatened status occurs as scheduled.

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I. INTRODUCTION

A. Brief Overview

The Muddy (= Moapa) River is located in northeastern Clark County, Nevada (Figure 1). The river originates from numerous thermal springs [30-32° Celsius (°C), 86-89.6° Fahrenheit (°F)] in an area known as Warm Springs. Historically, the river flowed 48.4 kilometers (km) [30 miles (mi)] into the Virgin River, a Colorado River tributary. However, when Hoover Dam was completed in 1935, the lower 8 km (5 mi) of the Muddy River were subsequently flooded by Lake Mead. The remaining riverine habitat has an average gradient of 1.6 meters (m) per kilometer [8.45 feet (ft) per mile] (Cross 1976).

Total discharge from the headwater springs is nearly constant at approximately 1.3 cubic meters per second (m^3/sec) [45.9 cubic feet per second (cfs)] (Eakin 1964). However, flow in the main stem Muddy River varies with precipitation events, seasonal water diversions, groundwater recharge, vegetation transpiration, evaporation, and irrigation return flows. Before reaching Lake Mead, nearly 75 percent of the annual inflow is lost to diversions, evaporation, and transpiration [Soil Conservation Service (SCS) 1993].

Streams in the Moapa Valley were originally bordered by willow (*Salix* spp.) and screwbean mesquite (*Prosopis pubescens*) (Longwell 1928, Harrington 1929). However, nonnative palm trees are now the dominant riparian tree species along spring systems in the Warm Springs area, and they are increasing in abundance along the upper Muddy River. Salt cedar (*Tamarix* spp.), another nonnative species, is currently the most common riparian species along the middle and lower river.

The Muddy River ecosystem supports eight rare, endemic aquatic species,

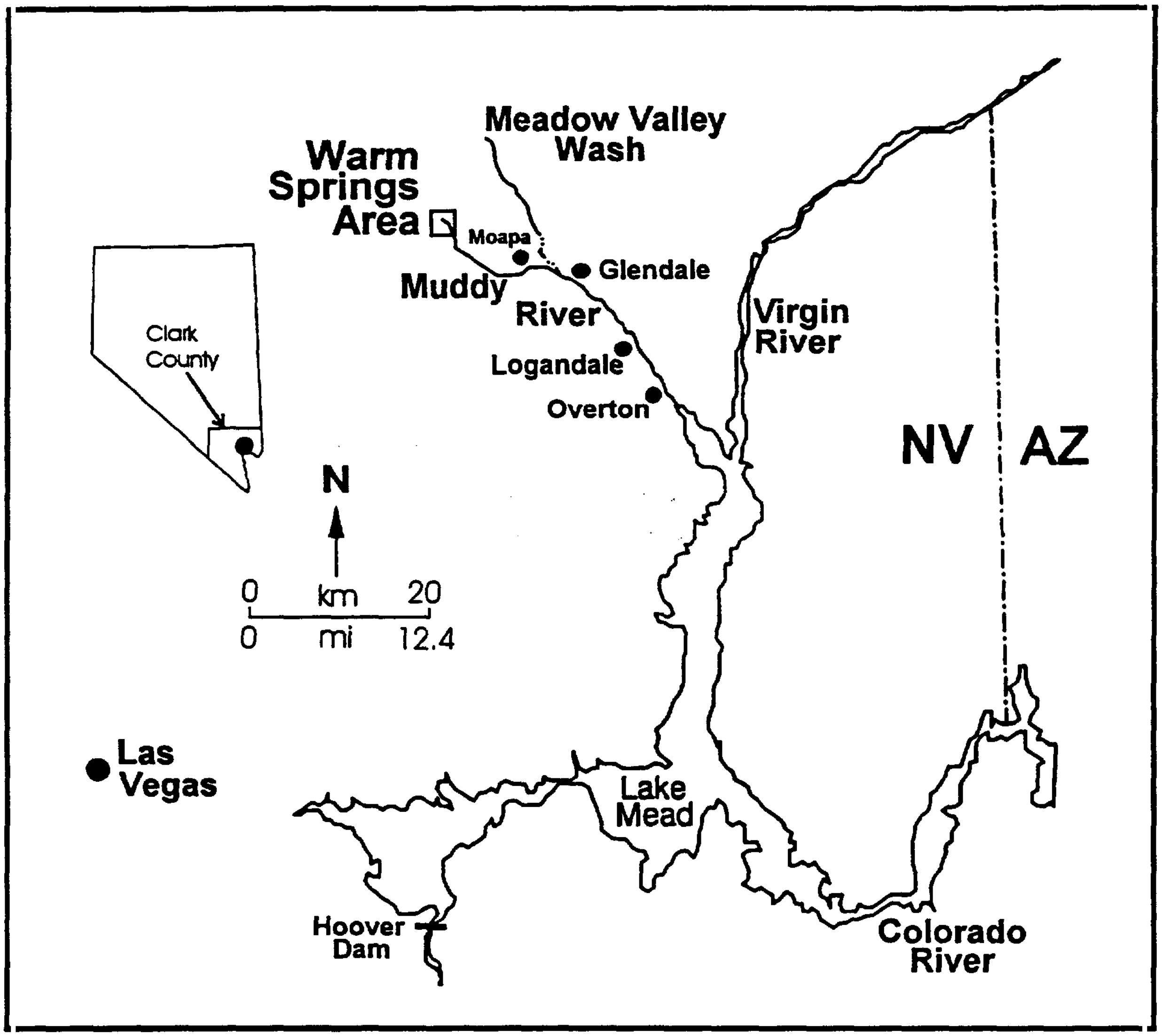

Figure 1. Geographic location of the Muddy River and the Warm Springs area, Clark County, Nevada.

including one endangered fish. The Moapa dace (*Moapa coriacea*) was federally listed as endangered under the Endangered Species Preservation Act of 1966 on March 11, 1967 (32 Federal Register 4001), and has been afforded the protection of the Endangered Species Act (ESA) since its inception in 1973. The U.S. Fish and Wildlife Service (USFWS) assigned Moapa dace a recovery priority of 1 [each listed species is ranked from 1 (highest) to 12] because it is the only species within the genus *Moapa*, there is a high degree of threat to its continued existence, and it has a high potential for recovery.

The USFWS prepared a recovery plan for Moapa dace in 1983, which specified research-related tasks to guide recovery. This document is a revision of the 1983 recovery plan and incorporates recent research data and addresses the species' current status, threats, and recovery needs. It also addresses the current status, threats, and recovery needs of the seven other rare aquatic species (three fish, two snails, and two insects) which occur with Moapa dace in the Muddy River ecosystem and are species of special concern. These species may warrant listing as either threatened or endangered, but status data are not conclusive at the present time. Implementation of recovery tasks included in this plan should reduce the threats to these species and may make listing unnecessary.

B. Species Description

The Moapa dace (Figure 2) was first collected in 1938 and was described by Hubbs and Miller (1948). Key identification characteristics are a black spot at the base of the tail and small, embedded scales, which create a smooth leathery appearance. Coloration is olive-yellow above with indistinct blotches on the sides; the belly is white. A diffuse, golden-brown side stripe may also be present. Maximum size is approximately 120 millimeters (mm) [4.7 inches (in)] fork length (FL; measured from the tip of the snout to the base of the fork in the tail), and the oldest specimen recorded is over 4 years old (Scoppettone et al. 1992). Technical descriptions of Moapa dace appear in Hubbs and Miller (1948) and La Rivers (1962).

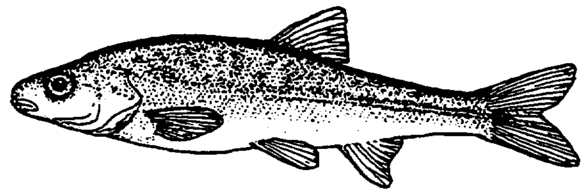

Figure 2. Moapa dace (*Moapa coriacea*).

Among North American minnows (Family: Cyprinidae), *Moapa* is regarded as being most closely related to the dace genera *Rhinichthys* (speckled dace) and *Agosia* (longfin dace) (Coburn and Cavender 1992). These three dace genera, along with the genera *Gila* (chub), *Lepidomeda* (spinedace), *Meda* (spikedace), and *Plagopterus* (woundfin), developed from a single ancestral type (monophyletic) and are only associated with the Colorado River Basin (Dr. Robert R. Miller, University of Michigan, pers. comm.).

C. Distribution

Moapa dace are endemic to the upper Muddy River and tributary thermal spring systems within the Warm Springs area. Historically, they may have inhabited as many as 25 individual springs and up to 16 km (10 mi) of stream habitat (Ono et al. 1983). Cooler water temperatures in the middle and lower Muddy River were likely a natural barrier to downstream movement of Moapa dace (La Rivers 1962).

Moapa dace currently inhabit approximately 9.5 km (5.9 mi) of stream habitat within five spring systems and the upper Muddy River (Figure 3). In the Muddy

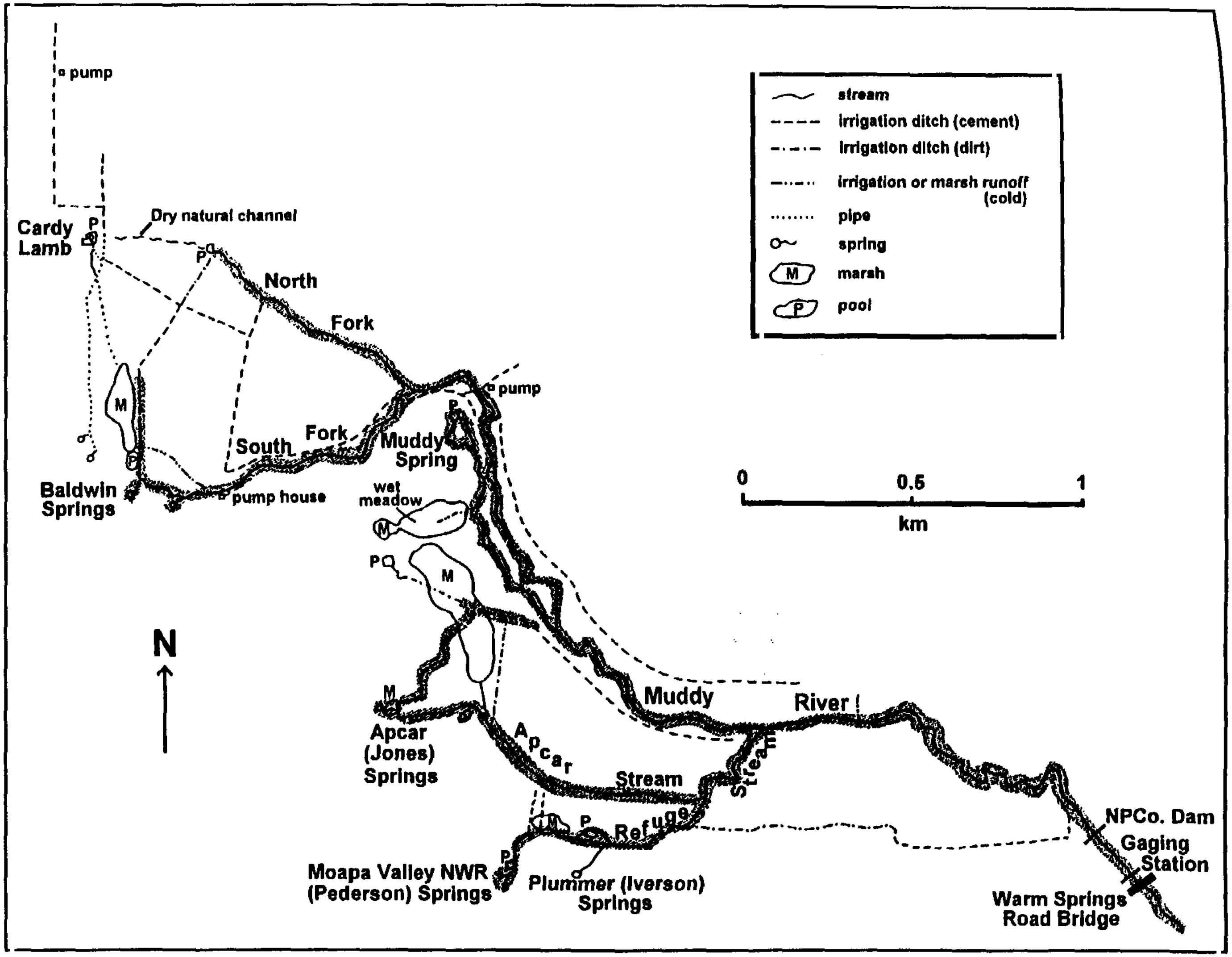

Figure 3. Distribution of Moapa dace (*Moapa coriacea*) (shaded) in the Warm Springs area, Clark County, Nevada. (Modified from: Scoppettone et al. 1987, 1992)

River, their range extends to approximately 300 m (1,000 ft) downstream of the Warm Springs Road bridge. Occupied habitat in the upper Muddy River and four spring systems (Apcar, Baldwin, Cardy Lamb, and Muddy Spring) is entirely on private land. The fifth spring system originates on Moapa Valley National Wildlife Refuge (NWR), but the outflow (Refuge stream) flows through private land before reaching the Muddy River.

D. Habitat and Life History

Habitat - Moapa dace occupy a variety of habitats in the Warm Springs area, including spring pools, tributaries (spring outflows), and the main stem Muddy River. Habitat use varies among larval, juvenile, and adult life stages. Larval dace are found only in the upper reaches of tributaries and occur most frequently in slack water. Juveniles occur throughout tributaries and occupy habitats with increasing flow velocities as they grow. Adult dace inhabit both tributaries and the main stem Muddy River, but occur more often in the river except during spawning (Scoppettone et al. 1987, 1992). Larger adults are typically associated with higher-velocity flows [0.8-0.9 meter per second (m/sec); 2.6-3.0 feet per second (ft/sec)] (Cross 1976), and the largest adults occur in the river (Scoppettone et al. 1987).

Aquatic plants such as *Chara* and other algae, spike rush (*Eleocharis* spp.), water nymph (*Najas* spp.), watercress (*Nasturtium* spp.), pondweed (*Potamogeton* spp.), and nonnative eel grass (*Vallisneria* spp.) are abundant in most spring pools and other slack water areas. Such vegetation is nearly absent from swift water areas inhabited by adult Moapa dace. Fibrous roots from nonnative palm trees (*Washingtonia filifera* and *Phoenix dactylifera*) also provide structure in spring pools and outflows, but negatively alter stream hydraulics for native fishes. General water quality characteristics within Moapa dace habitat are as follows:

Temperature 19.5-32°C (67-89.6°F) (USFWS 1983); dissolved oxygen 3.4-8.4 milligrams per liter (mg/L) [1 mg/L = 1 part per million (ppm)] (La Rivers 1962, Deacon and Bradley 1972, Scoppettone et al. 1992); total dissolved solids 606-867 mg/L (ppm) (USFWS 1983); and pH 7.1-7.9 (Deacon and Bradley 1972, Cross 1976). Turbidity is highly variable and increases with distance from the spring orifices; 39.7 Nephelometric Turbidity Units have been recorded during heavy agricultural run-off (Scoppettone et al. 1987). Spring pools typically contain pebble or organic silt substrates, while tributaries and the Muddy River have various combinations of clay, sand, pebble, and cobble substrates (USFWS 1983).

Reproductive Biology - Moapa dace spawn year-round; however, peak spawning activity occurs in the spring, with lesser activity in autumn (Scoppettone et al. 1992). Sexual maturity occurs at 1 year of age, at approximately 38-45 mm (1.5-1.75 in) FL (Hubbs and Miller 1948; Scoppettone et al. 1987, 1992). Fecundity is related to fish size; egg counts range from 60 in a 45 mm (1.75 in) FL dace to 772 in a 90 mm (3.5 in) FL dace (Scoppettone et al. 1992).

Moapa dace have only been found to successfully reproduce in water temperatures of 30-32°C (86-89.6°F). Therefore, sexually mature Moapa dace must migrate upstream from the Muddy River into thermal tributaries to spawn successfully (Scoppettone et al. 1987). Moapa dace have never been observed spawning; however, redds (nests) believed to be those of Moapa dace were found approximately 150 m (500 ft) downstream from a spring orifice (Scoppettone et al. 1992). The redds were in sandy-silt substrate at depths of 15-19 centimeters (cm) (5.9-7.5 in) and near-bed water velocities of 3.7-7.6 cm/sec (1.5-3.0 in/sec).

The duration of egg incubation is unknown, but is likely relatively short because of the high water temperatures. Emigration of young-of-the-year Moapa dace from the Refuge stream peaks in May (Scoppettone et al. 1987), and dispersal is likely similar in other tributaries with comparable water temperatures. Mortality rates have been estimated at 68 percent for the first year (juveniles) and 65 percent the second year (adults) (Scoppettone et al. 1987).

Food Habits - Moapa dace are omnivorous, as indicated by: Pharyngeal teeth (located in the throat) with both cutting and grinding surfaces (Hubbs and Miller 1948, La Rivers 1962); a gut length of 96 percent of body length (Scoppettone et al. 1987); and stomach contents. Stomach contents of Moapa dace include: Beetles, moths and butterflies, true flies, leaf hoppers, true bugs, caddisflies, mayflies, damsel and dragonflies, worms, scuds, crustaceans, snails, filamentous algae, vascular plants, detritus, and sand (Scoppettone et al. 1987, 1992).

Visual observations of Moapa dace have revealed that they feed primarily on drift items, but adults forage from the substrate as well. Larval dace feed on plankton in the upper water column, in areas with little or no current, and juvenile dace feed at mid-water level [Mr. G. Gary Scoppettone, National Biological Service (NBS), pers. comm.; Scoppettone et al. 1992]. Schools of 30 or more dace have been observed congregating at drift stations to feed (Scoppettone et al. 1987). They often use sites where cover is provided by overhanging vegetation or depth (Dr. Donald W. Sada, Aquatic Ecology and Conservation Consulting, pers. comm.). Drift stations are also located in reaches of low- to moderate-water velocity adjacent to depressions in the substrate. These depressions may be located downstream of a pebble riffle which creates turbulent flows. Moapa dace actively feed 24 hours a day, but peak feeding occurs around dawn and dusk (Scoppettone et al. 1987).

Species of Special Concern

In addition to Moapa dace, three other endemic minnows are present in the Muddy River ecosystem: Virgin River chub (*Gila seminuda*), Moapa speckled dace (*Rhinichthys osculus moapae*), and Moapa White River springfish (*Crenichthys baileyi moapae*). Also endemic to the Warm Springs area are the Moapa pebblesnail (*Fluminicola avernalis*), grated tryonia (*Tryonia clathrata*), Moapa Warm Spring riffle beetle (*Stenelmis moapa*), and Amargosa naucorid (*Pelocoris shoshone shoshone*). These seven species of special concern are discussed below.

Virgin River Chub

Virgin River chub (Figure 4) are silvery colored with olive shading on the back. Their fins are sometimes a pale yellow-orange. Scales on the back and belly are unusually small and deeply embedded; in some individuals they are missing entirely. These fish appear streamlined, and their tails are deeply forked. Their mouth is trout-like, and their diet consists of a variety of aquatic insects, algae, and crustaceans. Maximum size is approximately 46 cm (18 in).

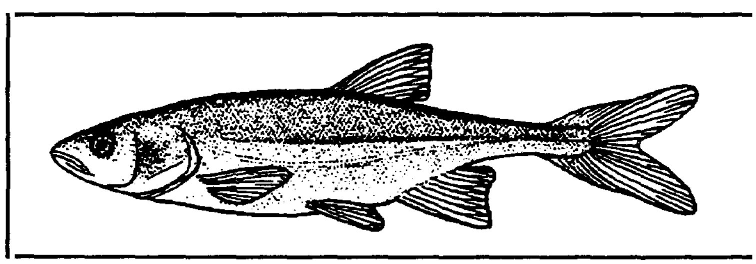

Figure 4. Virgin River chub (*Gila seminuda*).

Chub have been collected in water temperatures of 15-30°C (59-86°F) (Deacon and Bradley 1972, Cross 1976). They are typically found in deep channels and pools with sandy bottoms where there is cover in the form of large rocks, overhanging streambanks, or tree roots (Scoppettone unpubl. data). Virgin River chub apparently avoid shallow riffles (Cross 1976).

Virgin River chub in the Muddy River were formerly considered a unique subspecies of roundtail chub [Moapa roundtail chub (*G. robusta* ssp.)] (Holden and Stalnaker 1970, Minckley 1973, Smith et al. 1979). However, genetic research has shown these fish to be the same species as the federally endangered Virgin River chub in the Virgin River (DeMarais et al. 1992). No movement of chub between these two rivers has been documented since Lake Mead filled (Allan and Roden 1978), and these populations are considered distinct (DeMarais et al. 1992, 60 Federal Register 37866). The recovery needs of the listed Virgin River population are covered in the Virgin River Fishes Recovery Plan (USFWS 1995); therefore, only the Muddy River population is considered in this document. Virgin River chub have been collected throughout the Muddy River, but were historically most abundant between the Warm Springs area and Logandale (Deacon and Bradley 1972, Cross 1976). During a 1994 population census, 8,251 chub were observed in the upper Muddy River and the five tributary spring systems (Scoppettone unpubl. data). In subsequent trap netting surveys during 1994 and 1995, 973 chub were captured in the Muddy River between the confluence with the Refuge stream and the Warm Springs Road bridge, 854 between the Warm Springs Road bridge and White Narrows, 1,915 between White Narrows and Reid-Gardner Station, and 717 between Reid-Gardner Station and Interstate 15 (Figures 3 and 5) (Scoppettone unpubl. data). The chub population in the main stem Muddy River between the confluence with the Refuge stream and Interstate 15 was estimated at 20,593 (confidence interval ±7,339; adjusted Petersen method) (Scoppettone unpubl. data). Chub are rarely captured downstream of Interstate 15 and have been extirpated downstream of Wells Siding Diversion (Scoppettone unpubl. data; Mr. Jim Heinrich, Nevada

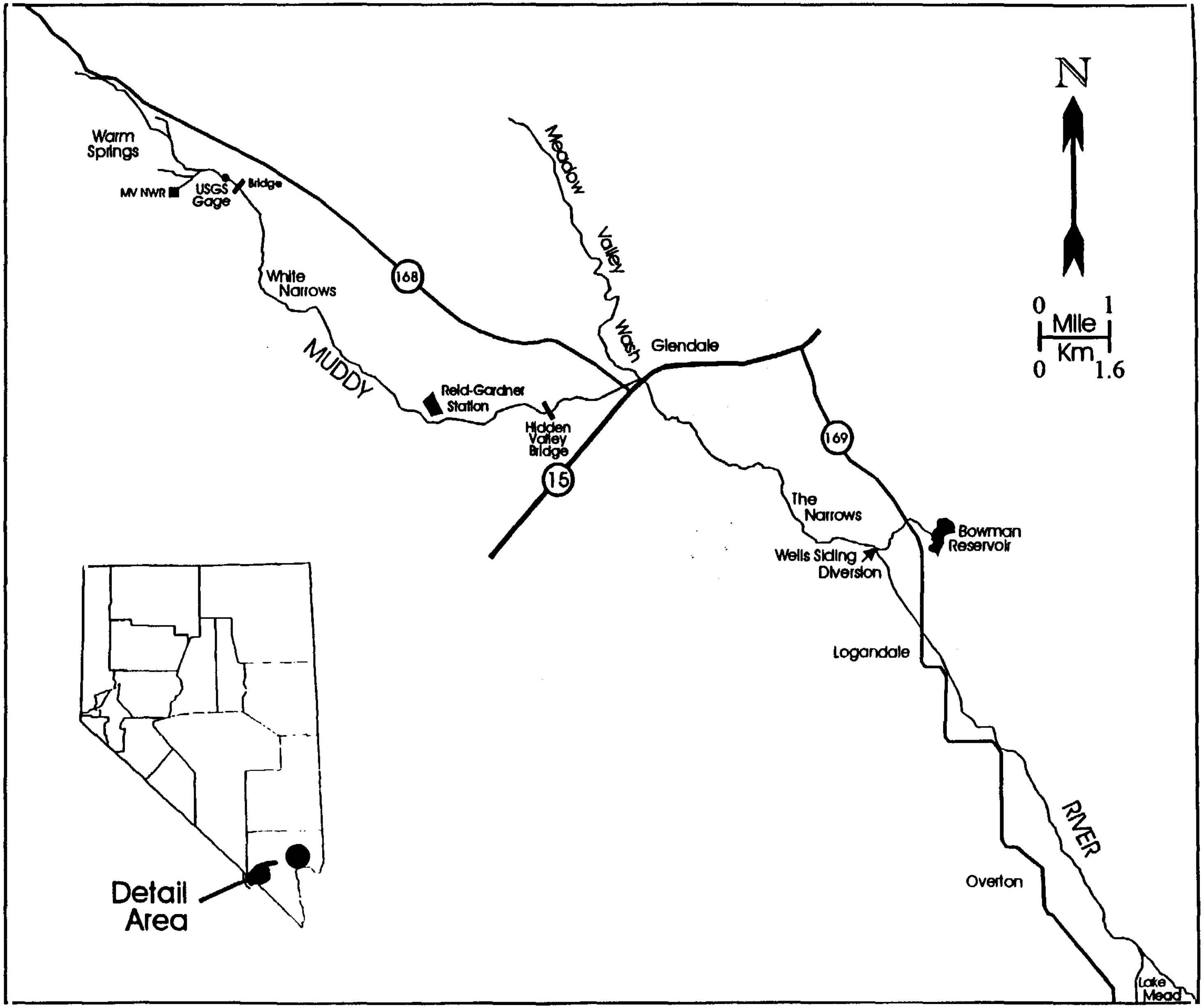

Figure 5. Geographic features of Moapa Valley, Clark County, Nevada.

Division of Wildlife, unpubl. data; Deacon and Bradley 1972; Cross 1976).

A decline in chub abundance in the Muddy River was first documented in the 1960's (Wilson et al. 1966, Deacon and Bradley 1972). By 1964, the abundance of chub at a 1938 collection site had decreased more than 83 percent; a similar decrease (approximately 92 percent) was documented at a 1942 collection site (Wilson et al. 1966). Between 1964 and 1968, Deacon and Bradley (1972) noted an upstream shift in chub distribution. By 1974-1975, the chub had been eliminated from the lower Muddy River and were further reduced in abundance in the middle portion of the river (Cross 1976). The species' decline may have been related to cumulative effects of changes in water quality and quantity, and substrate (Deacon and Bradley 1972, Cross 1976); channelization (Cross 1976); nonnative fish species (Deacon et al. 1964, Hubbs and Deacon 1964, Deacon and Bradley 1972, Cross 1976); and parasitism (Wilson et al. 1966).

Moapa Speckled Dace

Moapa speckled dace (Figure 6) are generally olive or tan colored on the back with faint darker specks. The lower sides and belly are yellowish or cream colored. They have a rounded, elongate body with a somewhat pointed head. Their tail is deeply forked, and all other fins are large and sickle shaped. During the spawning season, males may develop orange-red coloration on the mouth, gill covers, and fins. Maximum size is approximately 10 cm (4 in), and they typically live 3 years or less. Moapa speckled dace are considered most closely related to Pahranagat speckled dace (*R. o. velifer*) and Virgin River speckled dace (*R. o. yarrowi*).

These fish typically live on the bottom in shallow, cobble riffles, hiding in low flow velocity areas behind rocks (Cross 1976). Spawning habitat consists of

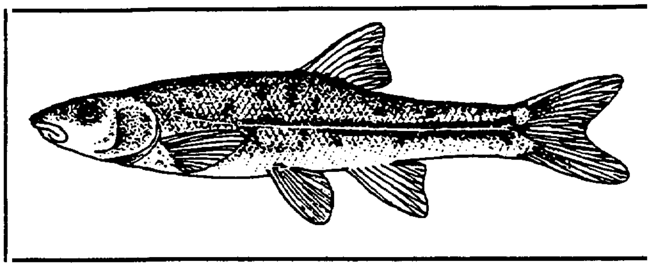

Figure 6. Moapa speckled dace (*Rhinichthys osculus moapae*).

small patches of bare rocks and pebbles which are cleared of debris by the males. Larval speckled dace remain down in the pebbles for a short time and then move into lower velocity areas. Young speckled dace feed primarily on plankton, while adults feed primarily on aquatic insects and algae.

Moapa speckled dace historically have occurred in relatively low numbers, primarily in the middle Muddy River (Deacon and Bradley 1972, Cross 1976). Moapa dace may exclude Moapa speckled dace from the upper river and spring systems because speckled dace are typically abundant in similar clear, thermal water habitats (Deacon and Bradley 1972). Lake Mead is a barrier to downstream dispersal because the habitat is unsuitable (Miller 1952, Williams 1978).

Speckled dace currently inhabit approximately 16.7 km (10.4 mi) of the Muddy River. In a 1994 survey, a total of 706 Moapa speckled dace were captured and released in the main stem Muddy River (Scoppettone unpubl. data). Of these, 28 percent were captured between the Warm Springs Road bridge and White Narrows, 64 percent between White Narrows and Reid-Gardner Station, and 8 percent between Reid-Gardner Station and Interstate 15 (Figure 5). Only one speckled dace was caught downstream of the Interstate 15 bridge. No estimate of total population size is available.

Deacon and Bradley (1972) noted that the distribution of Moapa speckled dace shifted upstream between 1964 and 1967, as did the Virgin River chub. Speckled dace have likely also been adversely affected by reductions in water quality and quantity, habitat modifications, parasites, and competition and/or predation by nonnative fish species.

Moapa White River Springfish

Moapa White River springfish (Figure 7) are generally olive colored on the back, while the lower sides and belly fade to almost white. The bases of the tail and the pectoral fins are yellow-orange. Two horizontal rows of black spots are present on the sides. The colors of female fish are not as intense as those of the males. Springfish are deep-bodied, and maximum length is approximately 5-7.6 cm (2-3 in). They typically live 3 to 4 years. Moapa White River springfish differ from the four other subspecies of White River springfish (*C. b. albivallis, C. b. baileyi, C. b. grandis,* and *C. b. thermophilus*) in body shape, numbers of fin rays, and coloration (Williams and Wilde 1981).

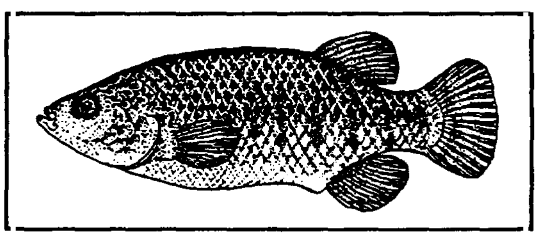

Figure 7. Moapa White River springfish (*Crenichthys baileyi moapae*).

Moapa White River springfish occur in five spring systems (Apcar, Baldwin, Cardy Lamb, Muddy Spring, Refuge) and the upper Muddy River, but are most abundant in the spring systems (Deacon and Bradley 1972, Cross 1976, Scoppettone et al. 1987, Sada pers. comm.). Springfish are extremely tolerant of high water temperatures and low dissolved oxygen levels. They typically live at or near the springheads and in pools and backwaters along spring outflow streams and the upper Muddy River until water temperatures become too cold in downstream reaches. However, springfish have historically (1941) been collected in the Muddy River as far downstream as the Hidden Valley Road bridge (Figure 5) (Deacon and Bradley 1972). Springfish were also documented downstream of the Hidden Valley Road bridge in an artificial pond near the river in 1986 (Scoppettone et al. 1987). Springfish primarily eat filamentous algae, but also eat aquatic insects.

Summer surveys in 1984 produced a springfish population estimate of nearly 25,000 fish from the spring systems; springfish in the upper Muddy River were not surveyed (Scoppettone et al. 1987). Threats to Moapa White River springfish are water loss, habitat modifications, and competition and predation by nonnative fishes.

Moapa Pebblesnail

Moapa pebblesnail shells are cone-shaped, but broad (Figure 8). They are sometimes called turban snails. The shells are less than 3.5 mm (0.14 in) long and 3.1 mm (0.12 in) wide (Landye 1973). The operculum (lid) is amber in color. Moapa pebblesnails are members of the Family Hydrobiidae.

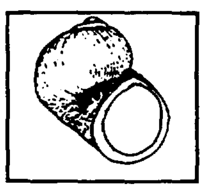

Figure 8. Moapa pebblesnail (*Fluminicola avernalis*).

Moapa pebblesnails have been collected at the Apcar, Refuge, and Plummer Springs, at springs on Warm Springs Ranch (likely the Baldwin, Cardy Lamb, and/or Muddy Spring systems), and at a number of other unnamed springs in the Warm Springs area. These snails occur on pebbles, cobbles, concrete surfaces, and submerged vegetation. In 1973, they were considered locally abundant in the Apcar spring system and springs on Warm Springs Ranch with approximately 5 snails per square centimeter (cm^2) [32 per square inch (in^2)]; other springs had fewer than $1/cm^2$ ($7/in^2$) (Landye 1973). No declines in abundance were noted because no baseline data were available. However, declines associated with recreational development of the springs were believed to have occurred, and further declines were anticipated due to the introduction of an Oriental snail (*Melanoides turberculatum*) (Landye 1973). Current population size and status are unknown.

Grated Tryonia

Grated tryonia shells are cone-shaped and less than 5 mm (0.2 in) long (Figure 9) (Landye 1973). Prominent ridges run the length of the shells, and finer growth lines can be seen between the ridges. Grated tryonia are members of the Family Hydrobiidae. This snail occurs most often in detritus and algae. In 1973, they were considered locally abundant in spring systems associated with the Muddy River (Landye 1973). Sada (pers. comm.) collected tryonia at Muddy and Cardy Lamb Springs in 1992. They also occur in spring systems to the north in the Pahranagat and White River Valleys, Nevada. Declines have been noted associated with the introduction of *M. turberculatum*, and habitat modification is

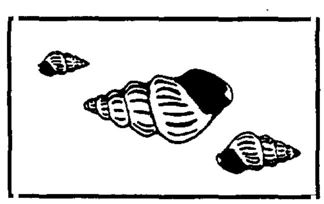

Figure 9. Grated tryonia (*Tryonia clathrata*).

also likely a threat. However, current population size and status are unknown.

Moapa Warm Spring Riffle Beetle

Moapa Warm Spring riffle beetles (Figure 10) are cylindrical and approximately 3.5 mm (0.14 in) long and 1 mm (0.04 in) wide (Schmude 1992). Their backs are reddish-brown, and the legs have a greenish tint. A dark stripe runs down the middle of the head. Although these beetles have wings they are undeveloped, and the beetles are flightless.

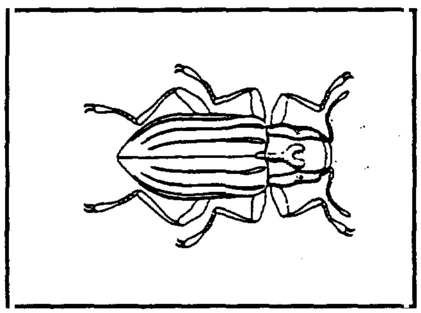

Figure 10. Moapa Warm Spring riffle beetle (*Stenelmis moapa*).

Adult riffle beetles typically occur in outflow streams immediately downstream of the spring sources in swift, shallow water on pebbles, algae-covered rocks within sand-pebble areas, aquatic vegetation, and especially bare tree roots (Schmude 1992). They have also been documented from the upper Muddy River and in marsh habitats connected to the spring systems, where the beetles live on submerged grass and under overhanging grassy streambanks. They may also live within submerged limestone (travertine) deposits. These beetles can live in water as warm as 31.7°C (89°F) and feed on algae.

As many as 149 riffle beetles have been collected at one time from the Plummer spring system (Schmude 1992). In 1986, adult beetles were abundant there, but uncommon in the Muddy River upstream of the confluence with the Refuge stream. Prior development of the Plummer spring system for recreation and modifications to other occupied habitats are the greatest threats to the species. Current population size and status are unknown. Moapa Warm Spring riffle beetles were once thought to occur in Ash Springs and Hiko Spring in the Pahranagat Valley (La Rivers 1949, 1950), but these specimens were likely *S. occidentalis* (Schmude 1992).

Amargosa Naucorid

Amargosa naucorids are oval shaped, flattened bugs with front legs that form pincers (Figure 11). The middle and back legs are modified for swimming. Many naucorid species have fully developed flight wings, but flight is rarely observed. Colors are variable and range from a blackish brown to yellow brown and even green or gray. Body size is approximately 8-9 mm (0.31-0.35 in) long and 5 mm (0.2 in) wide. The Amargosa naucorid is consistently smaller and has different coloration than the one other *Pelocoris shoshone* subspecies (*P. s. amargosus*) found in the Amargosa River system in southwestern Nevada and Death Valley, California (La Rivers 1956, Usinger 1956).

Figure 11. Amargosa naucorid (*Pelocoris shoshone shoshone*).

Naucorids eat various aquatic organisms including dragonfly, midge, and mosquito larvae; water boatmen; and mollusks. They carry a small air bubble under water with them to maximize diving time. In the Warm Springs area, Amargosa naucorids typically live among aquatic plants in pools and lower velocity stream reaches, often under overhanging banks associated with marshy habitats. Current population status is unknown, but habitat modification is likely the most significant threat.

Other Species

Two other endemic species present in the Warm Springs area are a naucorid (*Usingerina moapensis*) and a water strider (*Rhagovelia becki*). *Usingerina moapensis* occurs in pebble beds in stream habitats with water temperatures between 23.9-31.7°C (75-89°F) (Usinger 1956). *Rhagovelia* are typically around 4 mm (0.16 in) in length. They have six legs with tufts of hairs on the ends, which enable them to live on water without breaking through the surface. In general, these water striders inhabit swift riffle reaches (Usinger 1956). The current population size, distribution, and potential threats to these two species are unknown.

E. Reasons for Listing

Change in Abundance - Moapa dace were "rather common" throughout the Warm Springs area when discovered in 1938, inhabiting spring pools, tributaries, and the main stem Muddy River (Hubbs and Miller 1948). La Rivers (1962) considered Moapa dace a common species only until 1950. However, collections by Hubbs and Miller indicate that Moapa dace were still relatively abundant in the Warm Springs area as of 1959 (UMMZ 1994).

A decline in Moapa dace abundance was first noted shortly after the introduction of nonnative shortfin mollies (*Poecilia mexicana*) in 1963 (Deacon and Bradley

1972, Cross 1976). Except for an increase in abundance at two historical collection sites on the upper Muddy River in 1967, Moapa dace continued to decline in both the spring systems and the upper river in subsequent years (Deacon and Bradley 1972). Deacon and Bradley (1972) attributed the 1967 increase to Moapa dace temporarily overcoming the detrimental effects of the molly introduction. However, these data could reflect natural population level fluctuations, migration of dace between the spring systems and the main stem river, or unidentified environmental changes.

In 1969, the International Union for Conservation of Nature and Natural Resources (IUCN) estimated the Moapa dace population at 500-1,000 individuals (Ono et al. 1983), however, the basis for this population estimate is unknown. Field surveys of historical collection sites during 1974-75 documented substantial declines in Moapa dace abundance since the 1964-68 surveys (Cross 1976). The IUCN estimated only a few hundred Moapa dace remained by 1977 (Ono et al. 1983). When the original Moapa Dace Recovery Plan was written in 1983, the Moapa dace population was estimated to consist of less than 1,000 individuals, restricted to three springs and less than 3.2 km (2 mi) of tributary and main stem Muddy River habitat (USFWS 1983).

During 1984-87, USFWS's Seattle National Fisheries Research Center (NFRC, now part of the NBS) extensively surveyed historical Moapa dace habitat and estimated the adult dace population at 2,600 to 2,800 individuals (Scoppettone et al. 1992). This population estimate represented the most accurate data on abundance and distribution ever gathered on the species. The apparent increase in the Moapa dace population in the 1980's may have been related to differences in survey techniques between NFRC and previous researchers. NFRC estimated the Moapa dace population by snorkeling habitats within the Warm Springs area and counting the number of dace observed. Earlier surveys were done with seines or by electrofishing, methods which provide estimates of relative abundance, but are less reliable for estimating the size of the Moapa dace population (Scoppettone pers. comm.). A portion of the apparent population increase was also likely related to increased spawning habitat due to restoration of spring outflows on Moapa Valley NWR.

NBS resurveyed Moapa dace habitat in 1994, and a total of 3,841 adult dace were observed (Scoppettone unpubl. data). The number of dace would likely have been approximately 500 fish higher, if not for a catastrophic fire in June 1994 which nearly extirpated Moapa dace in the entire Refuge spring system (Scoppettone pers. comm.).

Habitat Alteration - Alteration of Moapa dace habitat in the Warm Springs area began before the species was discovered, primarily for irrigation purposes (Scrugham 1920). The spring systems and the upper Muddy River have since been developed for recreational, industrial, and municipal uses as well.

Natural spring pools in both the Plummer (Desert Oasis Warm Springs Resort) and Refuge (7-12 Warm Springs Resort; later Moapa Valley NWR) spring systems were enlarged and lined with concrete and/or gravel to create public swimming pools. Water discharging from these springs was chlorinated, as required by State regulations for public use; and aquatic vegetation was mechanically and/or chemically (copper sulfate) removed. Moapa dace were eliminated from both spring systems prior to 1979. Total discharge from the Refuge stream includes 100.5 L/sec (3.55 cfs) from the Refuge springs (USGS 1993), 64 L/sec (2.26 cfs) from the Plummer springs (Eakin 1964), and 83.2 L/sec (2.94 cfs) from the Apcar spring system (Eakin 1964) for a total potential discharge of 247.7 L/sec (8.75 cfs) at the confluence with the Muddy River.

One spring in the Apcar system has been enlarged and concreted to make a private swimming pool. Water rights from other springs in the Apcar system and approximately 0.26 hectare (ha) [0.64 acre (A)] of surrounding land (T. 14 S., R. 65 E., sec. 16, SE¼) were sold to the Moapa Valley Water District (MVWD). MVWD has channelized and piped these springs (since 1959) for local municipal use. Another outflow stream in the Apcar system flows through a culvert under Warm Springs Road and into dirt and cement irrigation ditches on Warm Springs Ranch.

At least two spring systems (Baldwin, Cardy Lamb) on Warm Springs Ranch were historically channelized and diverted for irrigation. Cardy Lamb (T. 14 S., R. 65 E., sec. 9, SW¼) discharges into a cement swimming pool, which overflows into an irrigation ditch. Flow from the Cardy Lamb system was 130.5 L/sec (4.61 cfs) in 1963 at the confluence with the Muddy River (Eakin 1964). Another swimming pool was constructed on Warm Springs Ranch in an overflow channel from the Muddy Spring stream (T. 14 S., R. 65 E., sec. 16, NE¼) in 1992. The 29 ha (72 A) of land surrounding this pool were set aside for private recreational use. Flows from the Muddy Spring system were 235.6 L/sec (8.32 cfs) in 1963 (Eakin 1964). Springs in the Baldwin system (T. 14 S., R. 65 E., sec. 16, NW¼ and sec. 15, NW¼) are currently piped by MVWD, and together with the Apcar spring system diversions, represent approximately 50 percent of MVWD's water supply. In 1963, flows from the Baldwin system into the Muddy River totaled 261 L/sec (9.21 cfs) (Eakin 1964)

Previously, irrigation return flows and runoff from fields on Warm Springs Ranch greatly increased turbidity and sediment loads in the spring outflows and upper Muddy River. Agricultural activity on Warm Springs Ranch has decreased in recent years, as the ranch is no longer operated as a church welfare farm. However, portions of the ranch are currently leased for horse and cattle grazing and alfalfa production. The landowner has indicated that no agricultural pesticides are being used on the property. A surface water right totaling approximately 56 L/sec (1.98 cfs) from springs near the southern and western property boundaries has been retained by the landowner for ranch use.

The main stem Muddy River is a vital component of Moapa dace habitat, especially for the larger and more fecund adults. It typically supports approximately 50 percent of the dace population (Scoppettone et al. 1987). Moapa dace move between the river and tributaries for spawning and to avoid periodically unfavorable water quality conditions in the river (i.e., high turbidity). Moapa dace habitat in the Muddy River has been adversely modified by human activities directly affecting the river and also indirectly by activities affecting the river's headwater springs, tributaries, and floodplain.

In addition to spring water leased from MVWD and groundwater leased from at least three wells on Warm Springs Ranch, Nevada Power Company (NPC) diverts water directly from the upper Muddy River (T. 14 S., R. 65 E., sec. 15, SE¼) for use at Reid-Gardner Station, an electrical generating facility near Moapa, Nevada. Diversions at this site have occurred since 1968, and current diversion rates are up to 260 L/sec (9.2 cfs) during the months of October through May and up to 50 L/sec (1.77 cfs) during the remainder of the year. Instream flow at the USGS gaging station immediately downstream averages 1,212 L/sec (42.8 cfs) (Eakin 1964, USGS 1993).

The existing NPC diversion dam on the Muddy River was constructed in 1988-89. It impounds approximately 140 m (450 ft) of the upper Muddy River and has reduced the overall suitability of this habitat for Moapa dace. Several riffles and drift feeding stations were likely eliminated by the impoundment, thereby reducing foraging opportunities for adult dace. Decreased flow velocities upstream of the dam have also increased silt deposition and promoted establishment of extensive beds of nonnative eel grass, both of which cover vital sand, pebble, and cobble substrates. Nonnative fish species, including shortfin mollies and mosquitofish (*Gambusia affinis*), are well established in this habitat. The dam also inhibits upstream movement of Moapa dace which are downstream of the structure, preventing access to spring systems for spawning. Sada (pers. comm.) has observed over 100 Moapa dace in the 300-m (1,000-ft) reach immediately downstream of the dam. These dace are lost to the reproductive population. NPC is preparing to replace the diversion dam with an intake specifically designed to not impound the river or restrict Moapa dace movement.

In 1944, the U.S. Bureau of Reclamation constructed a Cipoletti weir gaging station on the Muddy River at the Warm Springs Road bridge. The concrete weir is over 3 m (10 ft) high and impounds approximately 45 m (150 ft) of Moapa dace habitat in the upper Muddy River immediately downstream of NPC's diversion dam. It likely affects flows, substrate, aquatic vegetation, and fish species composition, but to a lesser extent than the NPC dam. The weir is a physical barrier to upstream movements of all fishes in the middle and lower Muddy River. The present range of Moapa dace extends downstream of this structure, and these dace are lost to the reproductive population as well.

Introduced Species - Through stocking, nonnative mosquitofish became established in the Muddy River system by 1938, but typically occupied pool habitats and did not appear to substantially impact the Moapa dace population. There is little spatial overlap between adult Moapa dace and mosquitofish; overlap with larval and juvenile dace is approximately 22-26 percent (Deacon and Bradley 1972, Scoppettone 1993).

Shortfin mollies were introduced into the Muddy River ecosystem in the early 1960's and had a much greater impact on Moapa dace than did mosquitofish. Shortfin mollies were common in the Muddy River by autumn 1963 (Hubbs and Deacon 1964), but were not the predominant species in the headwater spring systems until January 1965 (Deacon and Bradley 1972). The concurrent decline in the abundance of Moapa dace during these years was likely related to interactions between these two species.

Habitat use by mollies is similar to that of Moapa dace (Deacon and Bradley 1972, Scoppettone et al. 1987). Deacon and Bradley (1972) estimated spatial overlap between Moapa dace and shortfin mollies at 68 percent; Scoppettone (1993) estimated spatial overlap between adult shortfin mollies and larval and juvenile Moapa dace at 44-45 percent. Laboratory experiments have demonstrated that shortfin mollies are fish larvae predators (Scoppettone 1993), and this may have been the mechanism effecting the decline in Moapa dace abundance.

In addition to mosquitofish and shortfin mollies, numerous other nonnative fish species have been collected in the Muddy River. Common carp (*Cyprinus carpio*) were first collected in 1938; channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), and green sunfish (*Lepomis cyanellus*) were collected in 1942 (UMMZ 1994). Deacon and Bradley (1972) collected several additional nonnative fish species in the Muddy River during 1963-68 including: Red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*), and black bullhead (*Ameiurus melas*). Two additional nonnative fishes present during 1974-75 collections by Cross (1976) were golden shiners (*Notemigonus crysoleucas*) and a single rainbow trout (*Oncorhynchus mykiss*). Historically, nonnative fishes other than mosquitofish, mollies, and common carp have been collected only from the middle and lower Muddy River.

More recent additions to the Muddy River's fish fauna include blue tilapia (*Tilapia aurea*) and Koi (*C. carpio* domestic var.), discovered in 1991 and 1992, respectively (Sada 1992 *in litt.*). Limited numbers of both species were found upstream of the weir, but below the NPC dam. Weir passage was likely facilitated by human intervention. The blue tilapia population downstream of the weir has been estimated at over 200 fish, with documented reproduction in 1992 (Heinrich pers. comm.). Blue tilapia can increase turbidity, reduce the abundance of algae and aquatic vegetation, and alter natural forage bases (plankton) (Taylor et al. 1984). Thus, this nonnative species has the potential to cause substantial negative impacts to Moapa dace habitat as well as habitats of other native species in the Muddy River ecosystem.

The effects of nonnative fishes on Moapa dace have not been studied, other than those of mosquitofish and shortfin mollies. However, in addition to direct effects such as predation, prior nonnative fish introductions have introduced fish parasites including tapeworms (*Bothriocephalus acheilognathi*), nematodes (*Contracaecum* spp.), and anchor worms (*Lernaea* spp.) which have adversely affected native fishes of the Muddy River (Wilson et al. 1966, Heckman 1988). The anchor worm (*Lernaea* spp.) has been identified as a Moapa dace parasite (Wilson et al. 1966), however, the current extent of Moapa dace infestation by this copepod and other parasites is unknown. Anchor worm infestations cause tissue damage and blood loss and expose fish to secondary infections from bacteria, fungi, and viruses. Heavy infestations may cause reduced longevity, reduced fecundity, and even direct mortality. Tapeworms may cause fish to become listless, lose weight, or become sterile; severe infections may cause the abdomen to become distended and block the intestine (USFWS 1986). Nematodes may encyst in fish muscle tissue with detrimental effects on overall fish health (Wilson et al. 1966).

Adverse effects to Moapa dace from nonnative species other than fishes include predation by bullfrogs (*Rana catesbeiana*) and spiny soft-shelled turtles (*Trionyx spiniferus*) (USFWS 1989). The nonnative snail, *M. tuberculatum*, is extremely abundant in the spring systems, but their impact on Moapa dace, if any, is unknown.

F. Conservation Measures

Conservation measures for Moapa dace were initiated when the species was federally listed as endangered in 1967. The State of Nevada classified the species as rare in 1970, increasing recognition of its legal protection [General Register No. 1(8), 501.110 Nevada Revised Statute, 3-6-78]. Currently, the State of Nevada lists Moapa dace as endangered (Nevada Administrative Code 503.065-.06, 1988).

1. Refugia - A refugium is a natural or artificial habitat where an isolated population of a species is established and protected. Refugia populations can be used to restock a species into its historical habitat in the event the species is extirpated. Because Moapa dace were believed in danger of extinction in their historical habitat, attempts were made to establish new refugia populations. In September 1972, 20 juvenile and adult Moapa dace were transported to Shoshone Ponds, a U.S. Bureau of Land Management facility for endangered fish species located near Ely, Nevada. This transplant failed after a month for unknown reasons. A later transplant of Moapa dace to Hot Creek Springs, located approximately 322 km (200 mi) north of Las Vegas, Nevada, also failed possibly due to water quality differences or other habitat limitations (USFWS 1979, unpubl. data). In the 1970's, data on the life history and habitat requirements of Moapa dace were limited, thus, efforts to establish refugia populations failed. These data have since been collected, but no suitable refugia sites have been identified. There are currently no Moapa dace in refugia.

2. Moapa Valley National Wildlife Refuge - Essential habitat (36.4 ha; 90 A) for Moapa dace was described in an Environmental Assessment (EA) for land acquisition by the USFWS in the Warm Springs area (USFWS 1979). The EA identified four parcels of private land as essential habitat, which together contained six spring systems and the upper Muddy River. USFWS purchased one parcel (7-12 Warm Springs Resort) and associated water rights in September 1979 for the appraised value. Moapa Valley NWR was established on the property and initially consisted of 4.86 ha (12 A), with three distinct spring orifices. However, no Moapa dace were present due to habitat alterations and chlorination associated with prior resort operations.

The USFWS prepared an Aquatic Habitat Management Plan (HMP) to guide aquatic habitat development and restoration on Moapa Valley NWR. To increase available habitat on the refuge, a 320-m (1,050-ft) long artificial stream channel was constructed in 1980. Substrates and cover were strategically placed within this concrete channel to create pool, riffle, and run habitats. The artificial stream was first stocked with 50 Moapa dace in February 1981. Additional dace were placed in pool habitat on Moapa Valley NWR during July 1981 and again in February 1982. However, only 17 Moapa dace remained on Moapa Valley NWR by December 1983 (Scoppettone pers. comm.), indicating the marginal success of the transplants and the need for additional research on habitat requirements. Other activities performed under the HMP included filling an olympic swimming pool and modifying other smaller pools to provide more suitable habitat. Habitat within spring outflows was also restored to more natural conditions, and fish barriers were constructed at various sites to inhibit the upstream movement of nonnative fishes.

To protect Moapa Valley NWR's water supply and provide long-term protection of additional Moapa dace habitat, an adjacent land parcel (8.77 ha; 21.7 A) and water rights to two springs were purchased by the USFWS in October 1983. Acquisition of this habitat was a priority 1 task (an action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future) in the 1983 recovery plan because approximately 50 percent of the surface water on Moapa Valley NWR originated from the two springs on the adjoining property. With this addition to Moapa Valley NWR, the USFWS's water rights totaled approximately 12.5 percent of the tributary inflows to the upper Muddy River. In April 1984, the newly acquired habitat was chemically treated to eradicate nonnative fishes. Adult and juvenile Moapa dace were then stocked into the artificial stream; 120 individuals were in residence by January 1986 (Scoppettone et al. 1992).

Root masses from palm trees were encroaching into Moapa dace spawning, nursery, and adult foraging habitats and also constricting spring outflow channels on Moapa Valley NWR in the early 1980's. Channel constrictions produce increased flow velocities, which also affect the suitability of spawning and nursery habitats downstream. A limited number of nonnative palm trees were removed from riparian areas on Moapa Valley NWR in 1983-84, and 35 more were removed in 1990. The palm trees selected for removal were those immediately adjacent to or within the spring pools and outflow streams. Evapotranspiration by these trees was likely a significant source of water loss from the Moapa Valley NWR spring system. Their removal opened the overstory canopy, allowing more sunlight to reach the water, thereby increasing primary production within the spring system. This increased primary production likely increased the abundance of food items for Moapa dace. Moapa Valley NWR's draft Landscape Plan specified that approximately one-third of the remaining mature [height > 3 m (10 ft)] palm trees be removed from riparian areas on the refuge to benefit the dace (USFWS 1991).

On June 26, 1994, a fire originating on an adjacent resort property spread to the palm grove on Moapa Valley NWR. Although the fire passed quickly through the refuge due to high winds, the intense heat likely caused water temperatures in the spring system to reach levels lethal to fish, except at the spring orifices and in deep, artificial pools. Also, up to 1 m (3.3 ft) of ash and debris from burning palm fronds filled the spring pools and outflow streams, depleting dissolved oxygen and increasing the acidity of the water. NBS and USFWS biologists surveyed the refuge spring system on June 28 and July 5-6, 1994, and only 15 Moapa dace were observed (Scoppettone pers. comm.). The refuge was previously inhabited by as many as 500 adult Moapa dace; the number of larval and juvenile Moapa dace lost due to the fire is unknown. Once habitat conditions in the refuge spring system have stabilized, Moapa dace obtained from nearby spring systems and/or the Muddy River will be used to restock the refuge.

Since the fire, debris deposited throughout the spring system has been manually removed, and natural flows have flushed out ash and other fine particulates. Approximately 200 burned palm trees were removed from riparian areas to prevent future catastrophic fires and to improve stream and pool habitats. Native and nonnative riparian plants have reestablished themselves along the spring system. Additional native vegetation will be planted to protect the spring system from excess sedimentation from the barren uplands and to hinder repopulation of palm trees and invasion by salt cedar. Also, leaves from native deciduous trees will provide a source of nutrients through decomposition and will increase productivity of the spring system.

3. Recovery Plan - A recovery plan for Moapa dace was written in 1983 by USFWS, in cooperation with the Nevada Division of Wildlife. The primary objective of the 1983 plan was to "protect and rehabilitate adequate habitat within the historical range of the Moapa dace to delist the species" (USFWS 1983). It identified five priority research and recovery needs for Moapa dace: 1) Determine characteristics of a self-sustaining population, 2) rehabilitate habitats to support Moapa dace, 3) reintroduce Moapa dace, 4) monitor populations, and 5) protect habitat. The recovery plan provided a means whereby Federal agencies could fund and/or perform recovery actions identified in the plan. In the years immediately following publication of the recovery plan, much effort was directed toward restoring habitat on Moapa Valley NWR and reintroducing Moapa dace.

4. Research - Hubbs and Miller (1948) were first to report on the distribution, habitat, morphometrics (body size measurements), and meristics (i.e., scale counts) of Moapa dace, as well as associated species in the Muddy River ecosystem. Limited additional research was performed with regard to Moapa dace until they were listed in 1967. Deacon et al. (1964) reported on the introductions of nonnative fishes to the Muddy River and their effects on native fishes; Wilson et al. (1966) studied the incidence of parasitism; and Deacon and Bradley (1972) examined fish species composition, distributions, changes in abundance, and habitat use. Deacon and Bradley's 1964-68 study was repeated in 1974-75 by Cross (1976).

Completion of the 1983 recovery plan created a new Federal research initiative. NFRC completed many research tasks specified in the 1983 Plan, including studies during 1984-89 on Moapa dace life history, abundance and distribution, food habits, age and growth, habitat use, movement patterns, population dynamics, and inter- and intraspecific interactions (USFWS 1984, Scoppettone et al. 1987, 1992). This key research identified the need for habitat continuity between thermal spring systems and the Muddy River for the survival of Moapa dace.

5. Other Conservation Actions - Moapa Valley residents have formed a committee to develop a conservation strategy for the Muddy River ecosystem.

This committee, known as the Muddy River Regional Environmental Impact Alleviation Committee (MRREIAC), is identifying actions to restore and manage aquatic and riparian habitats to benefit endemic fish and wildlife and local residents. The USFWS is assisting MRREIAC by providing biological information on Moapa dace and the species of special concern, as well as data on general environmental conditions. This recovery plan should serve as a guide for MRREIAC in developing conservation actions benefitting rare aquatic species.

G. Recovery Strategy

The strategy for recovery that is detailed in the following stepdown narrative begins with the protection and management of Moapa dace habitat including existing instream flows. Recovery will be accomplished by protecting Moapa dace habitat from adverse physical, chemical, and biological modifications through the development of conservation agreements with private landowners. Comprehensive management plans for these areas will be developed to guide habitat restoration efforts. Nonnative fish removal is one priority restoration measure.

A monitoring program is proposed that will collect and analyze baseline data necessary for assessing population trends and habitat conditions. A research project is also recommended to study the prevalence of parasitic organisms and to determine their effects on the Moapa dace population. Public information and education outreach programs will be necessary to keep interested and affected parties informed of recovery activities and to create an avenue for their involvement.

II. RECOVERY ANALYSIS

A. <u>Objective and Criteria</u> - The objective of this Recovery Plan for the Rare Aquatic Species of the Muddy River Ecosystem is to improve the status of Moapa dace so that it may be delisted and to improve the status of seven associated aquatic species of special concern. Moapa dace only occupy the unique habitats of the Warm Springs area, and recovery tasks are focused on habitats within their historical range. However, recovery tasks that would benefit species of special concern throughout the Muddy River ecosystem are also included. All recovery criteria are preliminary and may be revised on the basis of new information (including research specified as recovery tasks). The estimated dates for reclassification of Moapa dace to threatened status and delisting are 2000 and 2009, respectively.

Moapa dace will be considered for reclassification from endangered to threatened when:

1) Existing instream flows* and historical habitat in three of the following five occupied spring systems and the upper Muddy River have been protected through conservation agreements, easements, or fee title acquisitions:

> **Apcar** - from the spring orifices to the confluence with the Refuge spring system [stream length of 1.08 km (0.67 mi)].
>
> **Baldwin** - from the spring orifices to the confluence with the North Fork of the Muddy River [stream length of 1.02 km (0.63 mi)].
>
> **Cardy Lamb** - from the spring orifices to the confluence with the South Fork of the Muddy River [stream length of 0.8 km (0.5 mi)].

Muddy Spring - from the spring orifices to the confluence with the Muddy River [stream length of 0.8 km (0.5 mi)].

Refuge - from the spring orifices on Moapa Valley NWR to the confluence with the Muddy River [stream length of 1.39 km (0.86 mi)].

Upper Muddy River - from the confluence of the North Fork and South Fork to approximately 300 m (1,000 ft) downstream of the Warm Springs Road bridge [stream length of 3.33 km (2.07 mi)].

* - Existing instream flow data are unavailable for four of the five spring systems, and thus, flows are not quantified here.

2) 4,500 adult Moapa dace are present among the five spring systems and the upper Muddy River; and

3) the Moapa dace population is comprised of three or more age-classes, and reproduction and recruitment is documented from three spring systems.

Moapa dace will be considered for delisting provided that all reclassification criteria have been met and when:

1) 6,000 adult Moapa dace are present among the five spring systems and the upper Muddy River for 5 consecutive years;

2) 75 percent of the historical habitat in the five spring systems and the upper Muddy River provides Moapa dace spawning, nursery, cover, and/or foraging habitat; and

3) nonnative fishes and parasites no longer adversely affect the long-term survival of Moapa dace.

Actions taken to recover Moapa dace and restore the upper Muddy River ecosystem will give due consideration to the needs of all species of special concern. One stated purpose of the ESA is to conserve ecosystems upon which endangered and threatened species depend. Actions taken to improve the status of Moapa dace should improve the status of the entire riverine ecosystem. Although not a criterion for reclassification or delisting of Moapa dace, the distribution and abundance of the seven species of special concern within their historical habitats in the Warm Springs area should be used as an indicator of overall ecosystem health and stability. Prior to implementing any task identified in this Plan, the lead agency must comply with all applicable provisions of the ESA, as well as the National Environmental Policy Act of 1966.

B. Narrative Outline for Recovery Actions Addressing Threats

1. Protect and restore Moapa dace habitat

Moapa dace are naturally restricted in distribution to the Warm Springs area. Because of their specific habitat requirements and limited distribution, habitat within the Warm Springs area needs to be protected and restored to recover the species. This habitat includes the upper Muddy River and five tributary spring systems, which together provide spawning, rearing, feeding, and cover habitat. Migration corridors between tributary spawning habitat and the main stem Muddy River are also an important component of Moapa dace habitat.

Moapa dace habitat in the upper Muddy River and tributary spring systems has been physically, chemically, and biologically modified, such that extensive restoration will be required to achieve delisting. Restoration needs for Moapa dace habitat are known; however, site specific restoration planning in coordination with the landowners is needed. Measures undertaken to restore habitat in the spring systems and the upper Muddy River for Moapa dace should benefit associated species of special concern and possibly eliminate the need for future listings of these species.

11. Develop and implement habitat protection agreements

Moapa dace habitat on Moapa Valley NWR is ensured long-term protection from adverse modifications by virtue of its Federal refuge status. However, the majority of habitat currently occupied by Moapa dace is on private property, and no protective measures are in place. Actions by private landowners are not subject to all of the same Federal regulations pertaining to endangered species as are actions funded, permitted, or performed by Federal agencies. Therefore, obtaining the cooperation and support of the landowners is essential to protect these habitats. Future adverse modifications (physical, chemical, and/or biological) to Moapa dace habitat on private land can be minimized or avoided through landowner coordination and participation. Similarly, actions to restore such habitat can only be accomplished with the cooperation of the landowners.

Long-term protection for Moapa dace habitat in at least three spring systems and the upper Muddy River is a criterion for reclassifying and delisting the species. Such habitat/species protection agreements, typically called conservation agreements, can cover a period as short as 5 years, but can extend into perpetuity depending upon the terms of the agreement reached with each individual landowner. Long-term agreements (i.e., 30 years) are most desirable for delisting purposes.

Conservation agreements should be negotiated with willing private landowners. These agreements are always voluntary on the part of the landowner. Conservation agreements could include access rights for management activities such as nonnative species eradication and Moapa dace population monitoring, maintenance of existing instream flow and habitat, habitat restoration activities, and any other appropriate measures. Monitoring implementation and success of agreed upon tasks would be part of the conservation effort.

Land acquisition and/or water rights acquisition from willing sellers at fair market value are other options to provide long-term protection to Moapa dace habitat. Purchasing privately owned Moapa dace habitat and associated water rights may permit more extensive habitat restoration than conservation agreements. If funding and willing sellers are available, Moapa dace habitat and associated water rights could be acquired and incorporated into Moapa Valley NWR. Refuge status would ensure long-term protection and management. Any water right ownership transfers from willing sellers would be subject to Nevada water law.

12. Minimize nonnative fish impacts

Nonnative fishes represent a serious threat to recovery and survival of Moapa dace. Surveys have documented the presence of shortfin mollies and/or mosquitofish within all occupied Moapa dace habitat (except within a portion of the Refuge spring system on Moapa Valley NWR protected by a fish barrier). Their continued presence may preclude delisting Moapa dace due to adverse effects on reproduction and recruitment. The invasion of blue tilapia throughout Moapa dace habitat appears imminent, and adverse effects are highly probable.

Wherever feasible, all nonnative fishes should be removed from Moapa dace habitat. Restoration of habitat to natural conditions will facilitate nonnative fish removal by reducing the availability and suitabililty of habitat for these species. Physical removal of nonnative fishes (e.g., trapping, seining, etc.) should be used whenever possible to minimize effects on Moapa dace and other aquatic species of special concern. However, chemical eradication (e.g., rotenone) might be necessary in some reaches where flows, depth, and/or cover make physical removal infeasible. All rare native aquatic species in the Warm Springs area should benefit by reducing or eliminating interactions with nonnative fishes.

The USGS weir is currently acting as a fish barrier and is restricting further unaided upstream movement of blue tilapia and other nonnative fishes into the upper Muddy River and subsequently into the spring systems. Monitoring of this gaging station is being discontinued by the USGS due to funding constraints. The weir should be evaluated for use as a permanent fish barrier, and responsibility for maintenance of the barrier would be assumed by USFWS. Any modifications to the weir must be designed to minimize debris accumulation, to not impound water, and to withstand frequent small-scale flood events without compromising barrier integrity. However, if the weir is compromised and tilapia become established in the Warm Springs area, strong consideration should be given to removing the weir in its entirity.

13. Develop and implement habitat restoration/management plans

Habitat restoration/management plans should be developed in cooperation with landowners for all occupied habitats (Apcar, Baldwin, Cardy Lamb, Muddy Spring, and Refuge spring systems and the upper Muddy River). The five spring systems will benefit most from restoration work as they have experienced more perturbations. The restoration work will be guided by available data on historical biological, physical, and chemical habitat conditions in these reaches.

Restoration and management needs vary among the spring systems and the river, but may include: Restoring natural hydrologic regimes (i.e., restore flows to dewatered, low flow, or intermittent tributary reaches, remove artificial impoundment structures, etc.); creating spawning and nursery habitats in the spring systems, and drift feeding stations in the spring systems and the upper river; improving water quality, particularly in reaches associated with agricultural land; removing nonnative aquatic and terrestrial vegetation encroaching into spring outflow channels; fire cleanup on the Refuge spring system and fire prevention measures throughout riparian areas associated with occupied habitat (i.e., palm tree thinning, revegetation with native species, etc.); and creating contiguous Moapa dace habitat from spawning areas near spring orifices to the upper Muddy River. Any restoration activities involving changes in water use would be of a non-consumptive nature (to maintain or increase instream flows).

2. Monitor Moapa dace population

Most earlier Moapa dace monitoring efforts have been sporadic and have not covered the entire range of the species, and monitoring techniques have varied. Monitoring should be performed annually by snorkeling all historical Moapa dace habitat and recording the individuals observed. Surveys should occur during the winter because of improved fish visibility (less turbidity and aquatic vegetation) and because spawning activity is reduced. This monitoring protocol will be used to develop a reliable long-term data set.

Monitoring data are necessary to determine whether or not recovery criteria for reclassification and delisting have been met. These criteria set requirements for Moapa dace abundance, population structure, and distribution. Monitoring will also provide data to evaluate the effectiveness of habitat restoration and management and nonnative species eradication measures. Also, potential problems such as nonnative species reinvasions can be identified in a timely manner during routine population monitoring.

3. Determine extent of parasitism in Moapa dace population

Parasites and disease-causing organisms are typically present in any environment; however, outbreaks among fish can frequently be linked to some form of stress, which increases their susceptibility. In the Muddy River, nonnative fishes have acted as vectors for new parasites including anchor worms, nematodes, and Asian fish tapeworms (Wilson et al. 1966, Heckman

1988). Wilson et al. (1966) suggested that the high incidence of parasitism in native fishes of the Muddy River was due to habitat deterioration. Moapa dace may also be experiencing some form of stress from interactions with increasing populations of nonnative fishes.

Moapa dace parasites should be identified and their impacts on Moapa dace health, reproduction, and recruitment should be determined. If documented as having a negative impact on Moapa dace, control and/or preventative measures should be developed. These measures may be linked to nonnative fish eradication activities and habitat restoration.

4. <u>Provide public information and education</u>

An outreach plan for public information and education regarding Moapa dace and other aquatic species of special concern should be developed. Outreach activities have a focal point in Moapa Valley NWR, but should cover recovery actions both on and off the refuge. Significant future recovery actions such as habitat restoration, conservation agreements, and even monitoring data will provide specific opportunities for public outreach. Press releases, feature articles, fact sheets, interviews, field trips, presentations, and brochures may be used to reach the local, regional, and scientific communities. Outreach materials such as fact sheets and brochures should be made available on site at Moapa Valley NWR and at local USFWS offices for distribution to the public.

Outreach activities must be directed at landowners with Moapa dace habitat, but should also involve the general public where appropriate. Public support for recovery efforts will be especially vital in limiting future adverse modifications to Moapa dace habitat, including reintroductions of nonnative fish species. Public information and education is also needed to prevent aerial, surface, and groundwater transport of pesticides and herbicides from agricultural or residential land into nearby Moapa dace habitat.

A self-guided, interpretive trail and corresponding exhibits are proposed for the spring system at Moapa Valley NWR. Due to their endangered status, Moapa dace will likely be the primary focus of such exhibits; however, information regarding other rare endemic fishes and invertebrates would be included to emphasize interrelationships among ecosystem components.

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III. IMPLEMENTATION SCHEDULE

This Implementation Schedule outlines actions and estimated costs for the Muddy River ecosystem recovery program. It is a guide for meeting the recovery objective discussed in Part II of this Plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs. These actions, when accomplished, should bring about the recovery of Moapa dace. It should be noted that the estimated monetary needs for all parties involved in recovery are identified and; therefore, Part III reflects the total estimated financial requirements for the recovery of this species.

Priorities in Column 1 of the following Implementation Schedule are assigned as follows:

Priority 1 - A short-term action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - A long-term action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

Recovery Plan Implementation Schedule

Priority Number	Task No.	Task Description	Task Duration (Years)	Responsible Parties	Total Cost ($1,000's) 1996-2008	Cost Estimates ($1,000's) FY 1996	FY 1997	FY 1998	FY 1999	FY 2000
NEED 1 - PROTECT INSTREAM FLOWS AND HISTORICAL HABITAT WITHIN THE UPPER MUDDY RIVER AND TRIBUTARY SPRING SYSTEMS										
1	11	Develop (FY 1996) and implement habitat protection agreements	6	FWS* NDOW	45+TBD 6+TBD	45 6	TBD TBD	TBD TBD	TBD TBD	TBD TBD
NEED 2 - CONDUCT RESTORATION/MANAGEMENT ACTIVITIES										
1	12	Minimize nonnative fish impacts	6	NDOW* FWS NBS	30 30 30	5 5 5	5 5 5	5 5 5	5 5 5	5 5 5
2	13	Develop (FY 1996) and implement habitat restoration/management plans	12	FWS* NDOW NBS	18+TBD 6+TBD 12+TBD	18 6 12	TBD TBD TBD	TBD TBD TBD	TBD TBD TBD	TBD TBD TBD
NEED 3 - MONITOR MOAPA DACE POPULATION										
2	2	Monitor Moapa dace population	12	NBS* FWS NDOW	96 24 12	8 2 1	8 2 1	8 2 1	8 2 1	8 2 1
NEED 4 - RESEARCH POPULATION HEALTH										
3	3	Determine extent of parasitism in Moapa dace population	1	NBS*	7	0	7	0	0	0
NEED 5 - PROVIDE PUBLIC INFORMATION AND EDUCATION										
1	4	Provide public information and education	Continual	FWS* NDOW	91 15	16 3	20 1	5 1	5 1	5 1

Definitions for terms and acronyms used in Implementation Schedule:
Continual = Task will be implemented on an annual basis once it is begun and will continue until no longer required for recovery.
To Be Determined (TBD) = Cost will be determined at a later date.
Total Cost = Projected cost of task from start to task completion.

Responsible Parties (* = Lead Agency):
FWS = Fish and Wildlife Service
NBS = National Biological Service
NDOW = Nevada Division of Wildlife

IV. APPENDICES

A. PUBLIC/PEER REVIEW

The draft recovery plan was made available to the public for comment as required by the 1988 amendments to the Endangered Species Act of 1973. The public comment period was announced in the Federal Register on October 5, 1993 and closed on December 6, 1993. Prior to the closing, numerous landowners requested additional time to comment on the plan. Therefore, the comment period was reopened in the Federal Register on December 29, 1993 and closed on February 14, 1994. Copies of the draft plan were provided to qualified members of the academic and scientific community for peer review. The U.S. Fish and Wildlife Service (Service) solicited and/or received comments on the document from the academic and scientific community, private individuals, industry representatives, and Federal, State, and local agencies listed below. Before completion of this final recovery plan, the Service received a total of 296 response letters, as indicated by an asterisk (*). The comments provided in these letters were considered in preparation of this final recovery plan and incorporated, as appropriate. Other significant comments are addressed by the Service in Appendix B. All letters of comment on the plan are on file at the Service's Nevada State Office in Reno.

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B. SIGNIFICANT PUBLIC COMMENTS AND SERVICE RESPONSES

This section consolidates, summarizes, and provides the Fish and Wildlife Service's (Service) response to *significant* comments *not* addressed by changes in the text. Specific comments that reoccurred in the letters are addressed only once.

Comment (C): The Service is in violation of the Endangered Species Act of 1973, as amended (ESA) [section 4.(a)(3)(A) and section 4.(b)(6)(C)(ii)], because critical habitat has not been designated for Moapa dace.

Response (R): Moapa dace were listed in 1967 under the Endangered Species Preservation Act of 1966 (ESPA). The ESPA did not require critical habitat designation. When Congress passed the ESA in 1973, it incorporated ESPA listed species such as Moapa dace. Critical habitat designation was not required until the 1978 amendment to the ESA and was not retroactive.

C: This recovery plan contains a "defacto" designation of critical habitat, without public notice, review, or consideration of economic impacts.

R: Recovery plans do not propose or designate critical habitat. However, the ESA requires that these plans are as specific as possible in identifying recovery tasks, including site-specific management actions. While five spring systems and the upper Muddy River were identified as areas for implementation of various recovery tasks, these areas are not being designated as critical habitat.

C: The Service has failed to comply with the National Environmental Policy Act of 1969 (NEPA) by not preparing an Environmental Impact Statement (EIS) for this Plan.

R: The Service is not required to comply with NEPA in development of recovery plans since they are only planning documents suggesting potential actions by the Service, other Federal agencies, State and local governments, the private sector, or a combination of the above. Recovery plans impose no obligations on any agency, entity, or persons to implement the various tasks. Implementation of recovery actions will be subject to NEPA compliance, as appropriate, at the time they are actually "proposed" and an environmental assessment or EIS would be completed at that time.

C: The Service should recover Moapa dace on Moapa Valley NWR instead of private land.

R: Moapa dace, as a species, cannot achieve recovery on Moapa Valley NWR alone. This spring system comprises only a fraction of Moapa dace historical habitat. In particular, the spring system does not provide foraging habitat suitable for larger adult Moapa dace, such as is found in the upper Muddy River. Also, Moapa dace must be distributed throughout their historical range in order to prevent a catastrophic event from causing the extinction of the species. This recovery plan, therefore, recommends actions that will recover the species across its historical range.

C: The draft recovery plan advocates flooding on the Muddy River which could impact private property.

R: The flooding that was mentioned in the draft plan is a frequent, periodic **natural** occurrence on the Muddy River. Impacts to private property in the floodplain do occasionally occur as a result of these natural events. The discussion in the draft recovery plan was merely to present information on how these natural flood events are beneficial to the riverine ecosystem. In particular, Moapa dace habitat benefits from sediment transport and nutrient inputs, nonnative aquatic vegetation removal, and creation of new spawning and foraging habitat. Also, nonnative fishes are typically unable to tolerate these high flow events as well as native species and their abundance and distribution may be reduced.

C: The Service has failed to comply with Executive Order 12630.

R: Executive Order 12630 requires Federal government agencies to carefully evaluate the effect of their administrative, regulatory, and legislative actions on constitutionally protected property rights to ensure that any potential taking must be subjected to an analysis known as a Takings Implication Assessment (TIA). However, in the Order, "policies that have takings implications" for which a TIA would be required do not include "studies or similar efforts or planning activities." Recovery plans are merely planning documents and, therefore, are exempted from a TIA. The Service would comply with all relevant regulations in implementing tasks in this recovery plan.

C: The Service has failed to comply with Executive Order 12291.

Executive Order 12291 requires Federal agencies to prepare regulatory impact analyses for any "major rule." A major rule is defined as any regulation that is likely to result in: (1) An annual effect on the economy of $100 million or more; (2) a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or (3) significant or adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets (46 Federal Register 13193). A recovery plan does not meet the definition of a regulation or rule as set forth in the Order. Therefore, the Service is not obligated to prepare a regulatory impact analysis for this plan. The Service would comply with all relevant regualtions in implementing tasks in this recovery plan.

C: The recovery plan does not address effects of Service purchases of land and/or water rights on the local economy and downstream water users.

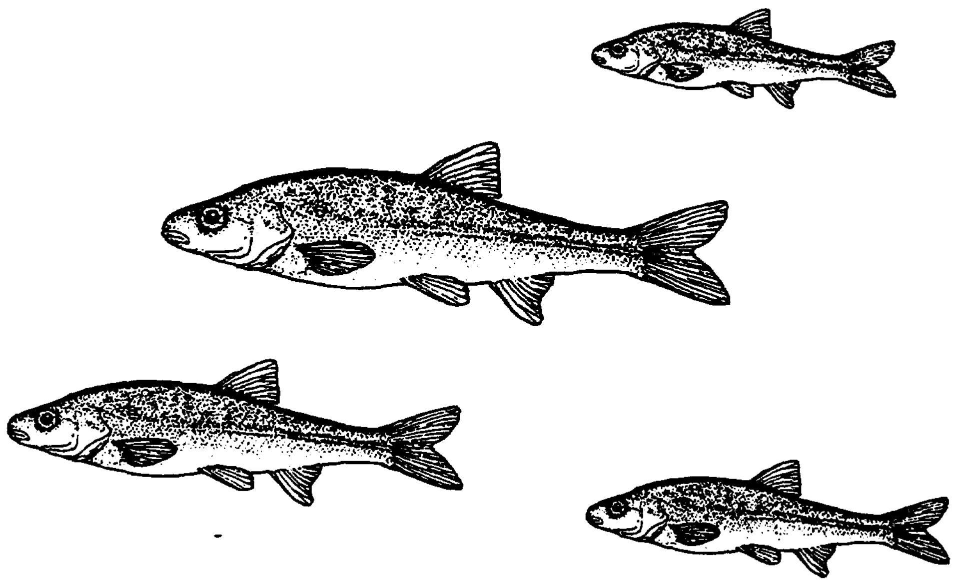
R: Any water right (or land) acquisitions would be from willing sellers at fair market value, therefore, the owners would not experience adverse economic effects. In addition, any water rights acquired or leased by the Service would be used to provide instream flows for Moapa dace and other endemic aquatic species, which would be a nonconsumptive water use with no adverse effect upon existing water diversions. Indeed, Muddy River flows downstream might actually increase, for example, if water in the Warm Springs area was converted from private agricultural use to instream flow use. Acquisitions by the Service would be subject to NEPA at the time they are actually proposed and an environmental assessment or EIS would be completed at that time. These documents would address any potential local economic impacts or effects on downstream water users. Land sold to the Service would result in loss of private property in the local tax base which could impact the local economy, but the Service makes payments in lieu of taxes on refuge lands to minimize these impacts. The Service is also interested in developing conservation agreements with willing landowners rather than purchasing property or water rights. With a conservation agreement, the landowner would retain ownership of the property and/or water rights, while allowing activities benefitting Moapa dace. Conservation agreements would minimize the potential for any adverse economic effects.

C: The Moapa dace population should be monitored before the recovery plan is implemented; it may currently be self-sustaining.

R: Funding to develop and implement a monitoring plan is not currently available. Identification of monitoring as a recovery task in the plan will assist the Service and other participating agencies in obtaining necessary funding for population status surveys.

C: Is the Service proposing to list any other species mentioned in the recovery plan?

R: The plan discusses seven species of special concern inhabiting the Muddy River ecosystem, specifically, three fish species and four invertebrate species. Implementation of tasks in this recovery plan should reduce threats to these species and may improve their status such that listing is not necessary to provide for their long-term protection.



"Conservation is sometimes perceived as stopping everything cold, as holding whooping cranes in higher esteem than people. It is up to science to spread the understanding that the choice is not between wild places or people. Rather, it is between a rich or an impoverished existence for man."

Thomas E. Lovejoy - Conservation Biology 1980