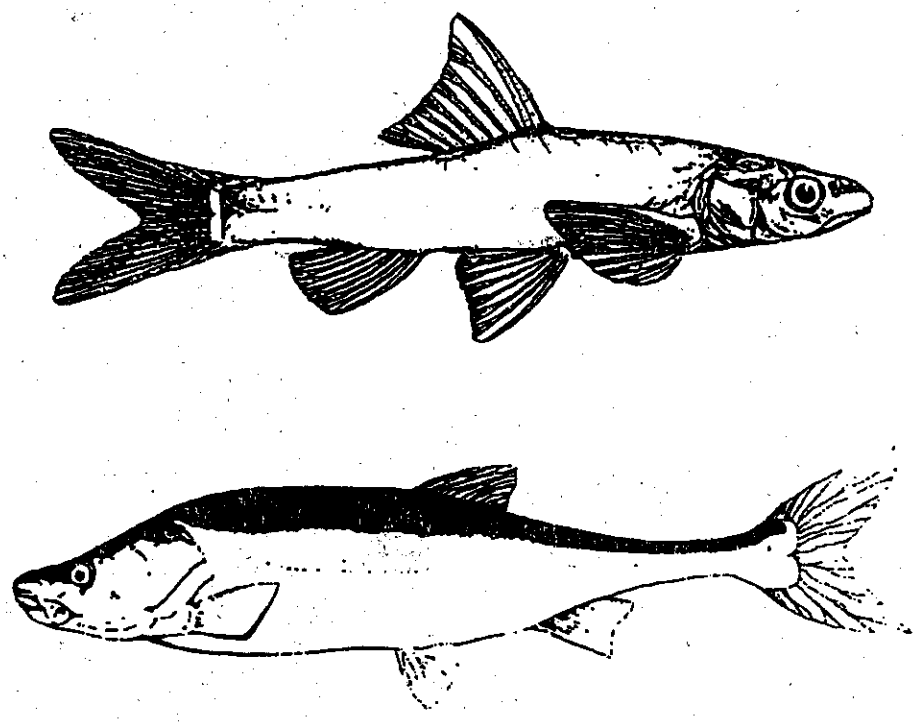
VIRGIN RIVER FISHES

RECOVERY PLAN



Department of the Interior ● U.S.Fish and Wildlife Service

Recovery Plan

for the

Virgin River Fishes

(Woundfin Original Plan Approved: July 9, 1979)

(Woundfin First Revision Approved: March 1, 1985)

Prepared by the Virgin River Fishes Recovery Team

for

Region 6
U.S. Fish and Wildlife Service
Denver, Colorado

Approved: Ralph O. Morgenweck
Regional Director

April 19, 1995
Date

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EXECUTIVE SUMMARY

Current Species Status: The woundfin, *Plagopterus argentissimus*, and Virgin River chub, *Gila seminuda*, are listed as endangered. These fish presently occur in the mainstem Virgin River in Utah, Arizona, and Nevada. The Virgin River chub also has been recently described in the Moapa (Muddy) River in Nevada. The woundfin historically occurred in the Salt River, Arizona; the Gila River near Yuma, Arizona; the Colorado River near Yuma, Arizona; and the Moapa River, Nevada, but it no longer occurs in these rivers. Both the woundfin and Virgin River chub have declined in the Virgin River, especially in the reaches downstream of Washington Fields Diversion near St. George, Utah. The Virgin River chub also may have declined in the Moapa River.

Habitat Requirements and Limiting Factors: Woundfin are most often collected in run and quiet water habitats with sand substrates. Virgin River chubs are most often collected in deep run or pools associated with instream cover. Alteration of flow regimes from construction of dams and diversions, decreased water quality, and introduction of nonnative species are the principal threats to these species.

Recovery Objective: Downlisting.

Recovery Criteria: Downlisting. The woundfin may be downlisted to threatened status when (1) Virgin River flows essential to survival of all life stages are protected, (2) degraded Virgin River habitat from Pah Tempe Springs (also called La Verkin Springs) to Lake Mead is upgraded and maintained to allow continued existence of all life stages at viable population levels, and (3) barriers to upstream migration of introduced fishes are established, red shiner (*Notropis lutrensis*) is eliminated, and other nonnative species which present a major threat to the continued existence of the fish community are reduced.

Virgin River chub have recently been described in the Moapa River in Nevada. Virgin River chub are listed as endangered in the Virgin River, Utah, Arizona, and Nevada; they are not currently listed in the Moapa River, Nevada. If the fish is not listed in the Moapa River, downlisting criteria will be identical to those discussed above for the woundfin. If the Virgin River chub is listed in the Moapa River, recovery criteria that address the fish in both rivers will be developed in the future.

Delisting. Interim criteria established for the possible delisting of the woundfin are: (1) establishment of two additional self-sustaining populations within its historical range. This will require that adequate protection of available habitat and instream flows are maintained and the populations have expanded to the carrying capacity of the habitat for a minimum of a 10-year period; (2) essential habitats, important migration routes, required streamflows and water quality of both the Virgin River and the habitat of the transplanted populations are legally protected, and other significant threats associated with physical, chemical, or biological modification that might make the habitat unsuitable for the two endangered fish are removed.

Delisting criteria for the woundfin are considered interim because the opportunity and the potential locations for reestablishment of additional populations is uncertain. Delisting criteria for the Virgin River chub cannot presently be determined.

Actions Needed:

1. Monitor existing populations.
2. Eliminate red shiners from the Virgin River system from Johnson Diversion to Lake Mead.
3. Develop a viable operating protocol for regulated flows within the Virgin River affected by the Quail Creek Reservoir System and other proposed systems.
4. Recommend specific sites suitable for reintroduction of additional populations of woundfin.
5. Secure appropriate habitat and flow protection for the selected introduction sites.
6. Introduce woundfin to selected sites.
7. Develop and implement appropriate monitoring programs for reintroduced woundfin populations.
8. Conduct research on the life history of woundfin and Virgin River chub.
9. Conduct research on the potential for habitat improvements within the Virgin River.

Recovery Cost: unknown.

Date of Recovery: 2015.

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VIRGIN RIVER FISHES RECOVERY PLAN

PART I

INTRODUCTION

This recovery plan addresses the status, threats, and recovery needs of the woundfin (*Plagopterus argentissimus*) and the Virgin River chub (*Gila seminuda*). The woundfin was listed as endangered on October 13, 1970 (35 FR 16047). A Woundfin Recovery Plan was originally prepared in July 1979, then revised on March 1, 1984. The Virgin River chub was listed as endangered on August 24, 1990 (54 FR 35305), under the scientific name *(Gila robusta seminuda)*. This document constitutes the second revision of the Woundfin Recovery Plan and incorporates recovery actions for the Virgin River chub within the mainstem Virgin River into a combined Virgin River Fishes Recovery Plan. The recovery plan identifies specific threats to the continued existence of these species and outlines recovery needs.

Current research has confirmed that the Virgin River chub, once considered a subspecies, is a full species, *Gila seminuda*. The Moapa River chub, originally classified as an undescribed form of *Gila robusta*, is conspecific with *G. seminuda* (DeMarais et al. 1992). When the Virgin River chub was listed as endangered in 1990, the Moapa River form was omitted due to uncertainty regarding its taxonomy. The Fish and Wildlife Service (Service) is investigating the status of the Virgin River chub in the Moapa River in order to determine if it should be listed under the Endangered Species Act.

The Virgin spinedace (*Lepidomeda mollispinis*), which also occurs in the Virgin River, was proposed for listing as a threatened species on May 18, 1994 (59 FR 25875). Many of the threats facing the woundfin and Virgin River chub also impact the Virgin spinedace. Recovery actions identified in this recovery plan are designed to improve habitat conditions for all native fishes in the Virgin River, and therefore also will benefit the Virgin spinedace. This recovery plan will need to be amended to more specifically address the Virgin spinedace if that species is listed as threatened.

Description of the Virgin River Basin

The Virgin River flows generally along the boundary between the Colorado Plateau and the Great Basin, which are roughly separated by the Hurricane Fault. These two geologic features are quite dissimilar. The Colorado Plateau is characterized by horizontal-lying strata eroded into canyons, plateaus, and mesas. Long, isolated mountain ranges separated by broad alluvial valleys typify the Great Basin province. The Virgin River flows southwest between these two large basins for approximately 320 km (200 mi) before flowing into Lake Mead. Before the completion of Boulder (Hoover) Dam in 1935, the Moapa (Muddy) River joined the Virgin River before the latter flowed into the Colorado River. These two rivers now flow separately into the Overton Arm of Lake Mead.

The Virgin River is characterized by steep-walled, narrow canyons. It cuts through the Hurricane Fault, the Virgin anticline, and the Beaver Dam Mountains. There are four major canyons along the Virgin River. Zion Canyon, including the "Narrows" section, was formed by the North Fork of the Virgin

River. The lower reaches of the East Fork are contained in Parunuweap Canyon. Timpoweap Canyon lays near Virgin, Utah. Finally, the Virgin River Gorge cuts through the Beaver Dam mountains south of St. George. Various tributaries of the Virgin River also formed steep canyons. Other characteristics of the Virgin River include the widely variable discharges (floods often follow summer thunderstorms), high sediment load, and sparse vegetation along the river banks.

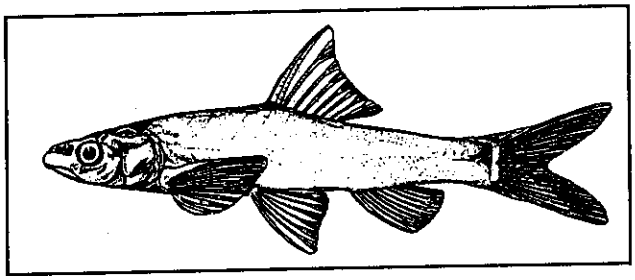
Vegetation in the Virgin River Basin includes four distinct communities. The basin lies at the intersection of the Great Basin Desert to the north and the Mojave Desert to the south. Beginning at the headwaters, the river flows down through a fir-pine community into a juniper-pinon zone, a blackbrush zone, and finally a desert community dominated by creosote bush. Along the riverbanks, the transzonal riparian community contains typical stream and desert riparian vegetation. Aquatic vegetation is uncommon due to the river's high sediment load (description of basin taken from Cross 1975).

WOUNDFIN

Taxonomic Status

The woundfin is considered the most highly specialized species in the cyprinid tribe Plagopterini, subfamily Leuciscinae (Miller and Hubbs 1960). This unique tribe is composed of three genera, two of which, *Meda* and *Plagopterus*, are monotypic, while the third, *Lepidomeda*, is composed of four species, one of which comprises two subspecies. The present taxonomic ranking of the group was initiated by Hubbs (1955) and is generally accepted. The uniqueness of this compact group of fishes has always impressed ichthyologists. Cope (1874) erected a full subfamily, the Plagopterinae, for the genera and has been widely followed (Jordan and Gilbert 1883; Jordan and Evermann 1896). Jordan et al. (1930) even erected a separate family, the Medidae, for the group, an action followed only by Tanner (1936). The entire taxon is endemic to the lower basin of the Colorado River and its ancestral tributary, the White River.

Description



The woundfin is a streamlined, silvery minnow with a flat head and a conspicuous, sharp dorsal spine, from which its common name was derived. The type specimen was described by Cope in 1874 from a collection apparently made in Washington County, Utah (Miller and Hubbs 1960). The woundfin is the most silvery of all American minnows (Miller and Hubbs 1960), reflecting blue in bright sunlight. The only breeding color noted has been a wash of light-yellow at the bases of the pectoral and pelvic fins. The species rarely achieves a standard length of more than 7.5 centimeters (cm) (3 inches).

The head and belly of the woundfin are flattened, and the overall aspect of the fish is one of an anteriorly depressed, streamlined torpedo. This body shape is characteristic of fish inhabiting swift, shallow, sand-bottomed streams. Other adaptations to this type of habitat (Moore 1950; Branson 1963, 1966; Cross 1967) include expansive, falcate fins, barbels on the lips, reduced eyes, and extensive sensory buds--presumably chemoreceptors--on the lower part of the head (the gular region in woundfin) (Snyder 1915) and along the leading pectoral fin-rays. Woundfin are essentially scaleless, with the exception of small plates of bone situated in the leathery skin, especially near the nape. Adaptive features unique to the woundfin include a modification of the two anterior fin-rays of the dorsal fin into enlarged, elongated, and solidified spinose rays, the second of which fits into a groove in the first. Also, the branched pelvic rays are thickened and spine-like on the basal half to three-fourths of each ray. A further specialization in woundfin is a spine-like development near the base of the first few pectoral fin-rays.

Historical Distribution

On the basis of early records, the original range (Figure 1) of woundfin extended from near the junction of the Salt and Verde Rivers at Tempe, Arizona, to the mouth of the Gila River at Yuma, Arizona (Gilbert and Scofield 1898). Woundfin were also likely found in the mainstream Colorado River from Yuma ("Fort Yuma"; Jordan and Evermann 1896; Meek 1904; Follett 1961) upstream to the Virgin River in Nevada, Arizona, and Utah, and into La Verkin Creek, a tributary to the Virgin River in Utah (Gilbert and Scofield 1898, Snyder 1915, Miller and Hubbs 1960, Cross 1975). However, from biological considerations alone, there is reason to believe that woundfin occurred further upstream on the Verde, Salt, and Gila Rivers in Arizona. As detailed by Miller and Hubbs (1960), the stated type locality "San Luis Valley, Western Colorado (Cope and Yarrow 1875)," was an obvious error, many of which were committed by collectors associated with the Wheeler Survey in 1871 to 1874. Miller and Hubbs also rejected records from the "Colorado Chiquito River, Arizona" (Bohlke 1953) as erroneous on the basis of no other indications that the fish ever inhabited that stream. The Wheeler expedition maintained a base at Toquerville, Washington County, Utah, in 1872 on La Verkin Creek (Wheeler 1889), from where they worked on the Virgin River Canyon and traveled to St. George. It seems likely that the type series of *P. argentissimus* was taken from the mainstream Virgin River (Miller and Hubbs 1960).

Present Distribution

Woundfin have been extirpated from almost all of their historical range except the mainstem Virgin River. Woundfin presently range from Pah Tempe Springs (also called La Verkin Springs) on the mainstream of the Virgin River and the lower portion of La Verkin Creek in Utah, downstream to Lake Mead (see Figure 2). A single specimen was taken from the middle Moapa (Muddy) River, Clark County, Nevada, in the late 1960's (Deacon and Bradley 1972) but none have been collected there since, and the species is considered extirpated from this river. The Moapa River was formerly a tributary to the Virgin River, but both streams now flow into Lake Mead. The species has been transplanted by the Arizona Game and Fish Department into four localities in Arizona, the

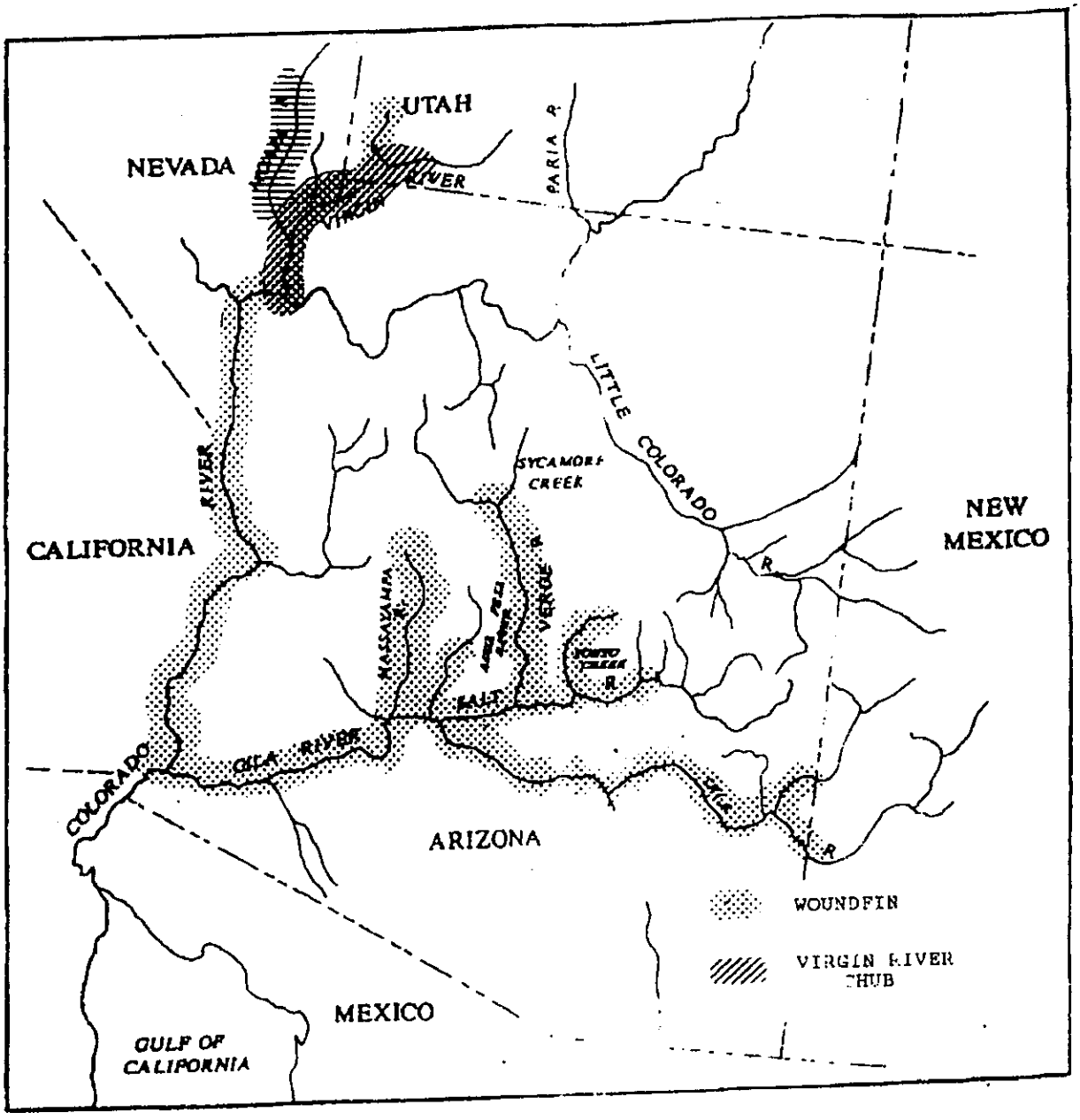


Figure 1. Historical distribution of woundfin and Virgin River chub.

Hassayampa River, Salt River, Sycamore Creek, and Paria River (Arizona Game and Fish Stocking Records, unpub. data). In February of 1972, 500 fish were stocked in the Hassayampa River. Reproduction occurred in the summer of 1972 (W.L. Minckley, University of Arizona, pers. comm. 1977) but a flood in September of 1972 destroyed the entire population. In March 1972, 350 woundfin were also stocked in the Salt River, Arizona, but none have been taken since. In Sycamore Creek, Agua Fria drainage, a few specimens stocked in spring 1972 (Arizona Game and Fish, Stocking Records, unpub. data) survived severe flooding of 1972-1973, and two individuals collected in late August 1973 were gravid. However, none have been collected in Sycamore Creek since 1973. The fourth locality, the Paria River along the Arizona-Utah border was stocked several times between 1969 and 1972 for a total of 650 fish. No woundfin were found during surveys in May 1974 and May 1975 (Arizona Game and Fish Stocking Records, unpub. data). In addition, a captive population was established in 1988 at Dexter National Fish Hatchery and Technology Center, New Mexico, to assist in research to develop rearing protocols and for propagation studies.

Life History/Ecology

Hickman (1987b) compiled an annotated bibliography for the woundfin and summarized most available published papers and government reports on this species. Principal taxonomic works are contained in Cope (1874), La Rivers (1962), Miller and Hubbs (1960), and Uyeno and Miller (1973). Distribution and status of woundfin are contained in Cross (1975, 1978, 1985), Deacon (1988), Hickman (1985, 1986, 1987a, 1988), and Hardy et al. (1989). Life history, reproductive biology, and ecology can be found in Deacon (1977a, 1977b), Deacon and Hardy (1980, 1984), Deacon et al. (1987), Greger and Deacon (1982, 1986), and Heckman et al. (1986, 1987). The following four sections summarize current information concerning the species habitat, food habits, reproductive biology, and movement based on this available literature.

Habitat

Woundfin adults and juveniles are most often collected from runs and quiet waters adjacent to riffles. Juveniles use habitats which are generally slower and deeper than those characteristic of the adults. Woundfin larvae are collected in backwaters or slow-velocity habitat along stream margins, often associated with dense growths of filamentous algae. Woundfin greater than 4.0 cm (1.6 in) total length (TL) utilize depths between 0.15 m (0.48 ft) and 0.43 m (1.4 ft) in velocities between 0.24 m/s to 0.49 m/s (0.78 to 1.6 ft/sec) over sand and sand/gravel substrates (Hardy et al. 1989). Field observations have indicated that if the water clarity is high, adult woundfin tend to congregate in deeper sections of the river, possibly to minimize exposure to avian predators (T.B. Hardy, unpub. field notes).

Deacon et al. (1987) reported the preferred water temperature for adults was approximately 18 °C (64 °F), indicating the species is eurythermal. Lockhart (University of Nevada at Las Vegas, pers. comm. 1977) reported that when water temperatures approach 30 °C (86 °F), woundfin leave shallow water areas and congregate in the deeper, cooler portions of streams.

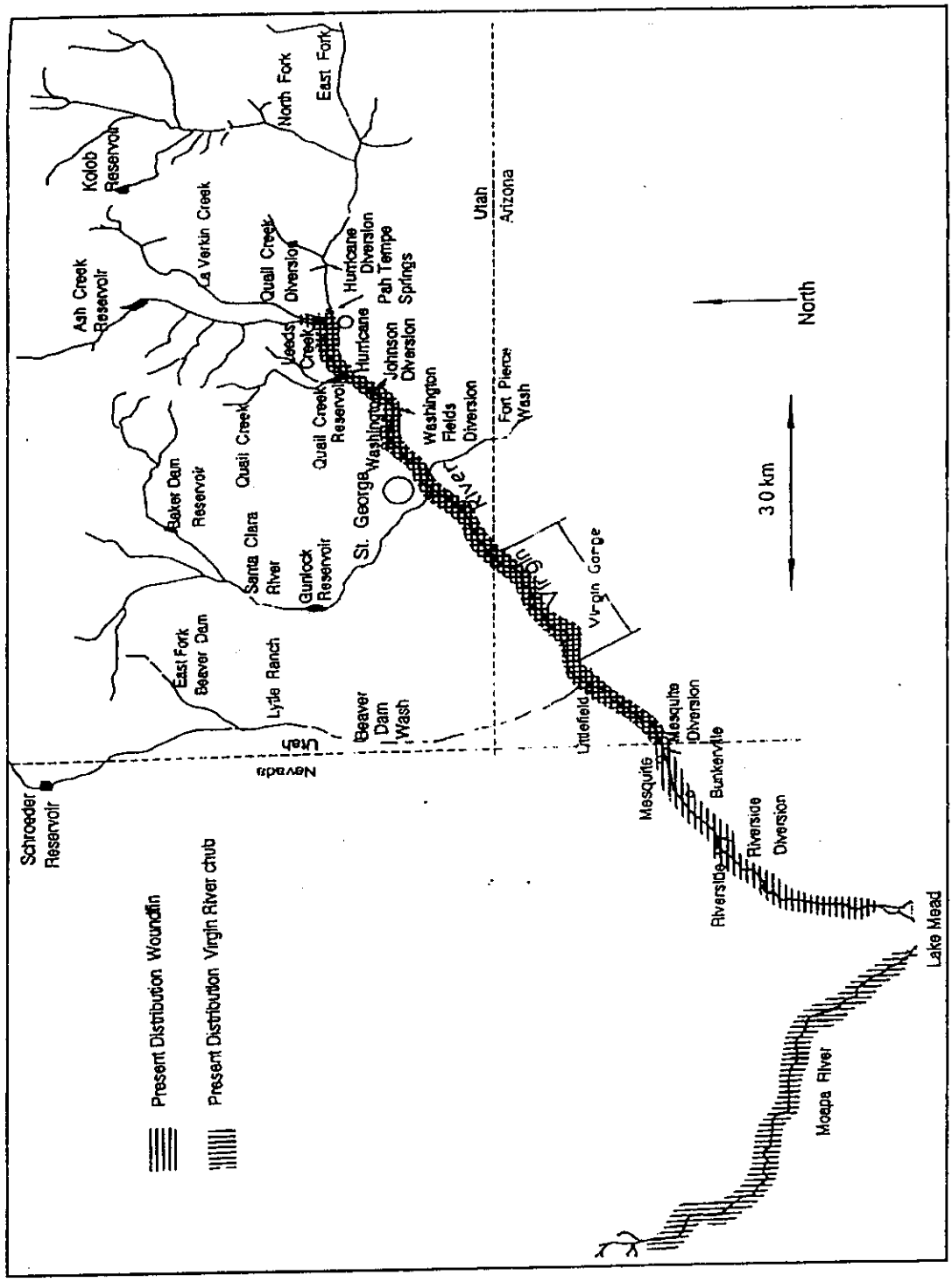


Figure 2. Present distribution of woundfin and Virgin River chub in the Virgin River.

Food Habits

Woundfin are omnivorous and shift their food habits in response to changing food availability. Food found in woundfin stomachs include filamentous algae, detrital material, tamarisk seeds, and insects (i.e., Ephemeroptera, dipteran adults, chironomid larvae, ceratopogonids, and simuliids) (Cross 1975, Lockhart 1979, Winget and Baumann 1977, Greger and Deacon 1988). Greger and Deacon (1988) suggested that seasonal shifts in food selectivity correspond to shifts in habitat foraging areas. They also documented dietary differences between woundfin populations in disturbed versus undisturbed segments of the lower river. These authors indicated that there were significant dietary overlaps between woundfin and red shiners (*Notropis lutrensis*).

Reproductive Biology

Some information on the reproductive biology of woundfin is presented by Peters (1970), Greger and Deacon (1982), and from recent work conducted at the Dexter National Fish Hatchery and Technology Center. The reproductive cycle of the woundfin appears to be initiated by some combination of increasing water temperatures, lengthening daylight and declining spring runoff. It would appear advantageous for woundfin to spawn as the high spring runoff is declining because eggs spawned prior to this would likely be carried away by the current or buried in silt. Limited spawning may occur in sheltered areas during high spring flows.

Gonadal maturation has been observed in March, April, and May (Peters 1970), and larvae have appeared in May, June, July, and August (Cross 1975, Deacon 1977a, Hickman 1987a, Hardy et al. 1989). Spawning occurs during April to July depending on the timing of the snow melt runoff; late summer spawning in August has also been observed (Hickman 1987a, Hardy et al. 1989). This second spawn may be represented by late maturing adults and precipitated by increased flows associated with late summer thunderstorm events (Virgin River Fishes Data Base at Utah State University). Hardy et al. (1989) and Deacon and Hardy (1984) found that spawning success increased as the magnitude of flows during the spawning period increased from 2.83 m^3/sec to 22.66 m^3/sec (100 to 800 cfs). Observations by Deacon (1977a) indicated that woundfin in downstream reaches of the Virgin River begin spawning more than 1 month earlier than fish in the upper reaches near La Verkin Creek. This variation of spawning time is probably related to warmer water temperatures.

In 1977, the first appearance of young occurred in the lower river in early June and in the upper river in late July. Deacon (1977a) reported apparent spawning activities on April 17, 1977, in the Virgin River south of Mesquite, Nevada, when water temperature was 14.5 °C (59 °F). Greger and Deacon (1982) observed spawning behavior in an artificial stream at water temperatures ranging from 20 to 25 °C (68 to 77 °F). These investigators observed spawning behavior similar to Lockhart and Schumann as reported by Deacon (1977a). A female would leave a pool to join a group of males in swifter flowing water over cobble to gravel-sized substrates. Following spawning, the female returned to the pool. Hickman (1987a) noted that gravid females congregated in deeper water adjacent to riffle habitats during spawning periods.

Greger and Deacon (1982) found that spawning in an artificial stream system occurred at velocities from 0.06 to 0.09 m/sec (0.20 to 0.30 ft/sec) and in depth ranging from 0.07 to 0.10 m (0.23 to 0.33 ft). The choice of substrates appeared to be fairly specific to cobble or gravel. Spawning observations at Dexter, however, indicated little preference for substrates (G. Divine, U.S. Fish and Wildlife Service, pers. comm.). Deacon and Hardy (1982) and Hardy and Deacon (1982) also found that highest population densities and greatest spawning success occurred in more suitable habitats. Deacon and Hardy (1982) indicated that spawning failed in suboptimal habitats even when flow conditions were adequate. This indicates that when habitats are impacted by water diversions and other habitat modifications spawning success will be reduced.

When larvae appear, they are generally found in shallow areas lateral to the main current. Larvae are conspicuously absent from pools containing potential predators such as mosquitofish (Gambusia affinis), green sunfish (Lepomis cyanellus), largemouth bass (Micropterus salmoides), and Virgin River chub. By late August, young-of-the-year woundfin are 20 to 30 mm TL (0.8 to 1.2 in). Growth occurs through October, and perhaps through December. Greger and Deacon (1982) found that woundfin grow approximately 3 mm (0.12 in) per week based on observations in an artificial stream.

Deacon and Hardy (1982) showed reduced survival of young woundfin at flows below 5.66 m^3/sec (200 cfs). Another source contradicts this. Monitoring data compiled in the Virgin River Fishes Data Base indicate high initial survival below the Washington Fields Diversion near St. George, Utah, at flows less than 0.57 m^3/sec (20 cfs). Deacon and Hardy (1982) also noted that mean monthly flows of 22.66 m^3/sec (800 cfs), or higher during the reproductive period, resulted in diminished recruitment. Deacon and Hardy (1982) showed that population density and structure were affected by both level of habitat destruction and flow conditions in the river. Reduced recruitment below major diversions has been attributed to water depletions (Deacon and Hardy 1982). These authors also found that when woundfin populations were severely depleted, such as during the 1977 drought, a 2-year period of favorable water conditions was required to rebuild population densities.

High mortality can also be associated with periods of high discharge during late summer and early autumn due to stochastic thunderstorm events (T.J. Hickman and T.B. Hardy, unpub. field notes). Additionally, Hardy et al. (1989) found that an average winter mortality of approximately 30 percent was observed and seemed to be independent of population density.

Movement

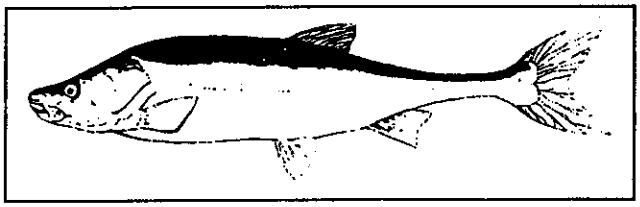
Little information presently exists on movement of woundfin. Downstream movement within the river by adults and other life stages has been noted (T.B. Hardy and J.E. Deacon, unpub. data) but the extent of upstream movement, if any, is not known.

VIRGIN RIVER CHUB

Taxonomic Status

The Virgin River chub was first collected from the Virgin River near Washington, Utah, in the 1870's by members of the Wheeler Survey and described as a species intermediate between *Gila robusta* and *Gila elegans* (Cope and Yarrow 1875). Authors have also treated this chub as a subspecies of *G. Robusta* (Ellis 1914; Miller 1946; LaRivers and Trelease 1952). Holden and Stalnaker (1970) showed that the subspecific name *seminuda* should refer only to the chub in the Virgin River, and that specimens from other localities represent other subspecies of *Gila robusta*. Holden and Stalnaker (1970) and Minckley (1973) indicated that the Virgin River population is a valid subspecies, and Smith et al. (1979) supported this conclusion with extensive taxonomic analyses. Current research confirms that the Virgin River chub and the Moapa River chub are a full species, *Gila seminuda* (DeMarais et al. 1992). Because of the recentness of this taxonomic change, the Virgin River chub population in the Moapa River has not been integrated into recovery planning activities but will be addressed in the future if the chub in the Moapa River is listed.

Description



The Virgin River chub is a silvery, medium-sized minnow that averages about 20 cm or 8 inches in total length but can grow to a length of 45 cm (18 in). The Virgin River chub can be distinguished from subspecies of *G. robusta* by the number of rays (9 to 10) in the dorsal, anal, and pelvic fins, and the number of gill rakers (24 to 31). The back, breast, and part of the belly have small, deeply embedded scales that are difficult to see and may be absent in some individuals, hence the name *seminuda*.

Historical Distribution

Virgin River chubs historically were collected within the Moapa River in Nevada and within the mainstem Virgin River from Pah Tempe Springs (also called La Verkin Springs), Utah, downstream to the confluence with the Colorado River in Nevada (Cope and Yarrow 1875, Cross 1975) (Figure 1). It is likely that Virgin River chubs historically occurred well above Pah Tempe Springs.

Present Distribution

At present, the Virgin River chub occurs within the Moapa River and within the mainstem Virgin River from Pah Tempe Springs downstream to the Mesquite Diversion (Figure 2). Virgin River chub have not been collected below this point, except for a few individuals, since the late 1970's (Virgin River Fishes Data Base). The Virgin River chub also occurs within the Moapa River

in Nevada. A captive population of Virgin River chub is currently maintained at the Dexter National Fish Hatchery and Technology Center as a refugium population and for propagation studies.

Life History/Ecology

Unlike the woundfin, very little information exists on the life history and ecology of the Virgin River chub. Most literature deals primarily with the taxonomy and distribution of the species. Discussions on the taxonomy of Virgin River chub include Cope and Yarrow (1875), Ellis (1914), Snyder (1915), Tanner (1936), Miller (1946), LaRivers and Trelease (1952), Holden and Stalnaker (1970), and Minckley (1973). Information on the distribution of Virgin River chubs is documented in Miller (1946), Holden and Stalnaker (1970), Minckley (1973), Cross (1975), Hickman (1985, 1986, 1987a, 1988), and Hardy et al. (1989). Life history and habitat requirements are discussed in La Rivers (1962), Minckley (1973), Deacon and Minckley (1973), Cross (1978), Schumann (1978), Hickman (1987a), and Hardy et al. (1989). Hickman (1987c) compiled an annotated bibliography for the Virgin River chub which contains most of the known publications and government reports dealing with the species. The following four sections summarize current information concerning the species habitat, food habits, reproductive biology, and movement.

Habitat

Virgin River chubs are most often associated with deep runs or pool habitats of slow to moderate velocities with large boulders or instream cover, such as root snags. Adults and juveniles are often associated together within these habitats; however, the larger adults are collected most often in the deeper pool habitats within the river. Hardy et al. (1989) indicated that Virgin River chubs less than 80 mm TL (3.2 in) utilize depths greater than about 0.18 m (0.6 ft) in velocities between 0.08 to 0.15 m/sec (0.25 to 1.6 ft/sec) over sand substrates in association with large boulders or instream cover. Virgin River chubs between 80 mm (3.2 in) and 140 mm (5.5 in) TL utilize depths greater than 0.30 m (1.0 ft) in velocities ranging between 0.00 to 0.76 m/sec (0.0 to 2.5 ft/sec) over sand substrates with boulders or instream cover. Virgin River chubs greater than 140 mm (5.5 in) TL utilize depths greater than 0.61 to 0.91 m (2.0 to 3.0 ft) in velocities from 0.00 to 0.55 m/sec (0.0 to 1.8 ft/sec) with similar substrates as the other size classes noted above. Schumann (1978) and Deacon et al. (1987) found that the final adult thermal preferendum was approximately 24 °C (75 °F), and suggested the species was more stenothermal than woundfin.

Food Habits

Virgin River chubs are omnivorous, showing considerable dietary shifts with age. In general, Virgin River chubs feed mainly on debris and chironomids in February; *Cladophora* and debris in June; debris and *Spyrogyra* and *Cladophora* in September; and unidentified drift animals, dragonfly larvae, debris, and *Cladophora* in December. Young fish (< 70 mm; 2.8 in TL) feed almost entirely on macroinvertebrates while adults (> 110 mm; 4.3 in TL) feed almost

exclusively on algae and debris (Greger and Deacon 1988). Cross (1975) reported that up to 90 percent of the diet consisted of filamentous algae.

Reproductive Biology

Very little is known about the reproductive biology of the Virgin River chub. Hickman (1987a) reported ripe females and males in April, May, and June, but the time of spawning has not been determined. He noted that good spawning years for Virgin River chub coincided with good spawning years for woundfin. Virgin River chubs are known to successfully spawn in both artificial pond habitats and in the mainstem Virgin River (Utah Division of Wildlife Resources and Dexter National Fish Hatchery and Technology Center, unpub. data). More specific information on the reproductive biology of the Virgin River chub will be required in order to recover this species.

Movement

Little information presently exists on movement of the Virgin River chub. Downstream movement within the river by adults and other life stages has been noted (Virgin River Fishes Data Base, unpub. data), but the extent of upstream movement is not known.

ASSOCIATED SPECIES

Native Species

Several other native fish occurring in the Virgin River are found in association with the woundfin and the Virgin River chub. The desert sucker, *Catostomus clarki*, shows a marked proclivity for swifter waters and more solid substrates than woundfin. The flannelmouth sucker, *Catostomus latipinnis*, usually is collected in deeper, slower waters behind boulders or other debris. Flannelmouth suckers commonly occur in association with adult Virgin River chub. The Virgin spinedace and the speckled dace, *Rhinichthys osculus*, are most abundant in the mainstem Virgin River above Pah Tempe Springs and in the various tributaries. However, these fish also can be found downstream of the springs: spinedace in association with spring and tributary inflows and speckled dace in association with shallow, low gradient riffle habitats with gravel or small cobble substrates.

The flannelmouth sucker is a candidate for listing by the Service. The flannelmouth sucker, a category 2 candidate species, is found in various places throughout the lower Colorado River Basin, but its numbers are declining. The Virgin spinedace, a species proposed for listing, is endemic to the Virgin River Basin. Recent research has shown a precipitous decrease in Virgin spinedace populations throughout the basin (Valdez et al. 1991). Many of the impacts affecting woundfin and Virgin River chub are also having a negative impact on these other native species.

Introduced Species

Although greater than 10 introduced fish species are known from the Virgin River, the red shiner, *Cyprinella lutrensis*, and the black bullhead, *Ameiurus*

melas, are the most abundant. Red shiner appear to have the greatest negative impacts on woundfin, apparently through competition for food and space, and possibly predation on larvae. In 1984, four red shiner were collected from the Virgin River adjacent to St. George for the first time. By 1986, the red shiner was the most abundant species within this same reach of the Virgin River, while woundfin populations had decreased significantly during this same time interval. The degree of influence by red shiners on Virgin River chubs is at present unknown.

Predators on woundfin and Virgin River chub include piscivorous birds such as kingfishers and herons, soft-shelled turtles, and other vertebrate species. This is especially true during periods of low flow and clear water. Fish that feed on all life history stages of woundfin, in addition to the Virgin River chub, include the introduced channel catfish (*Ictalurus punctatus*) and black bullhead. Largemouth bass (*Micropterus salmoides*) and green sunfish (*Lepomis cyanellus*), in addition to native Virgin spinedace, probably prey on larvae. The introduced mosquitofish (*Gambusia affinis*) may prey on larval life stages of both species.

LIMITING FACTORS

The major limiting factors for the woundfin, Virgin River chub, and other native fish species today are modification and loss of habitat and the introduction and establishment of nonnative fish, particularly red shiner. Building of dams and associated reservoirs, water diversion structures, canals, laterals, aqueducts, and the dewatering of streams causes loss or degradation of available habitat. The decline in both species' range and population numbers is due to the physical reduction in available habitats within the various river systems caused by these water projects. This loss of habitat has been exacerbated due to the introduction and establishment of exotic species, further reducing the suitability of remaining habitats for woundfin and Virgin River chubs.

Water Use

The history of water use in the Virgin River Basin is associated with early settlers in the valley. The success of the early settlers depended directly on their ability to "tame" the Virgin River. However, historical records show that this was not a simple task (Hickman 1985).

One of the first records of exploration in the Virgin River Basin was made by two Spanish clerics, Fathers Escalante and Dominguez. They noted in 1776 that the Native Americans along Ash Creek were irrigating small plots of corn (Warner 1977). White settlers first began using the Virgin River system for irrigation in 1854 (Hinton 1961). During this year, a dam was built on Santa Clara Creek which lasted 8 years. On the mainstem Virgin River, a canal and diversion system was built in 1857 near Washington, Utah. The Washington Fields Diversion and canal was completed in 1891; the La Verkin Diversion and canal were completed in 1901. Between 1854 and 1910, numerous dams and hundreds of miles of canals were built on the Virgin River and its tributaries, at enormous cost. Many had to be rebuilt or repaired several times a year.

The Virgin River system underwent dramatic changes as a result of irrigation and livestock grazing. During summer months, the demand for water often exceeded the available supply. It was common for entire sections of the river to be diverted into irrigation canals. About 99 percent of all major water rights to the Virgin River system were already allocated by 1910 and probably being fully used (Hickman 1985). In addition, livestock grazing depleted most of the riparian vegetation along the Virgin River drainage increasing erosion and siltation, which led to a decrease of available fish cover.

Since 1910, there have been only slight modifications to the Virgin River. This is not the case for the tributaries. Several small reservoirs have been constructed during this century on Kolob Creek, Ash Creek, Quail Creek, Santa Clara River, and Beaver Dam Wash. These reservoirs are mainly used for irrigation water storage. The demand for new water sources and storage components remains high; numerous additional sites for reservoir construction are being evaluated. The construction of reservoirs affects the Virgin River by reducing water flows, altering natural flow patterns, and affecting water quality.

Changes in Abundance

Collections and field notes examined at the University of Nevada, Las Vegas; Brigham Young University; the University of Michigan Museum of Zoology; and the U.S. National Museum indicate that the abundance of woundfin and Virgin River chubs in the mainstem above Mesquite, Nevada, may have remained relatively stable during the 1930's. Populations in the mainstem below Mesquite, however, have declined significantly in the intervening period. When C.L. Hubbs (unpublished field notes, University of Michigan) collected woundfin and Virgin River chubs at Bunkerville, Nevada, in July 1942 (UMMZ 141655) he found woundfin scarce but generally distributed in the main channel and more abundant in pools near the bank (which also contained flannelmouth sucker, desert sucker, Virgin River chub, and speckled dace).

Above Mesquite, woundfin and Virgin River chub populations have declined subsequent to the invasion of red shiner. Red shiners were first collected from the upper Virgin River near St. George in 1984. By 1986, the red shiner had become the most abundant species from the Washington Fields Diversion to Lake Mead. Since 1984, woundfin and Virgin River chub populations have declined, and the red shiner has nearly replaced most native fish in the Virgin River up to the Johnson Diversion.

Habitat Alterations

Today, six major dams on the Salt and Verde Rivers, and two on the Gila River, effectively have cut off natural flows in the lower reaches of both the Salt and Gila Rivers. From older records and reports, it is certain that woundfin lived as far up the Gila River system as the Salt River at Tempe, Arizona. It can be surmised from those records that woundfin also lived in most reaches of the Salt and Gila Rivers between Tempe and Yuma, Arizona, in the Gila River above Phoenix, and the Salt and Verde Rivers above Tempe. Potential woundfin habitat still exists in the Gila River above San Carlos Reservoir and the Verde River above Horseshoe Reservoir.

The seven dams constructed along the Colorado River below the Virgin River confluence have eliminated all woundfin habitat in the Colorado River. Following the completion of Boulder (Hoover) Dam and the subsequent creation of Lake Mead in the 1930's, the lower portions of the Virgin and Moapa Rivers were flooded, resulting in additional loss of habitat.

Reduction in flows below major irrigation diversions has resulted in further reductions of available physical habitat for both species throughout much of the Virgin River. Altered flow regimes both above and below major irrigation diversions at Washington Fields, Mesquite, and Riverside have resulted in loss of habitat due to complete dewatering of the river during low flow periods. During late summer in both 1989 and 1990, over 4.8 km (3 miles) of the Virgin River below the Washington Fields Diversion was completely dewatered resulting in the loss of all fish species within that part of the river. Similar dewatering below the Riverside Diversion also has been observed. Significant alterations in the physical structure of the Virgin River also has occurred due to the failure of the Quail Creek dike on January 1, 1989. The river below Quail Creek was subjected to an estimated 1,700 m^3/sec (60,000 cfs) flood event that is believed to have impacted fish populations throughout the lower 136.8 km (85 miles) of the Virgin River both through direct loss of fish and through alteration of the physical structure of the river.

REASONS FOR LISTING

The woundfin and Virgin River chub were listed due to their restricted distributions, loss of significant portions of historical range, and deterioration of much of the remaining habitats. The construction of dams and diversions and the introduction of nonnative species in their remaining habitats were major contributing factors.

CONSERVATION MEASURES

The woundfin was listed as an endangered species on October 13, 1970 (35 FR 16047). The Woundfin Recovery Team was formed in August 1975, and the first Woundfin Recovery Plan was approved in July 1979. With the listing of the Virgin River chub, the team was expanded in 1990 and renamed the Virgin River Fishes Recovery Team. Since 1971, major conservation efforts for woundfin have been undertaken through the initiation of several studies relative to population distribution, community structure, ecological requirements, and abundance. These studies have been funded by the Service, the Bureau of Reclamation, the City of St. George, Utah, and the Washington County Water Conservancy District. Critical habitat has not been designated for either species. In April 1976, the recovery team recommended the Virgin River from Pah Tempe Springs, Utah, to Lake Mead in Nevada be designated as critical habitat for the woundfin. The Service contacted appropriate agencies and forwarded the recommendation to Washington. On November 2, 1977, critical habitat was proposed (42 FR 57329). The proposal was not finalized but was withdrawn on March 6, 1979 (44 FR 12382), due to the changed requirements in the 1978 amendments to the Endangered Species Act (Act). On April 5, 1995, the Service proposed critical habitat for three species--woundfin, Virgin River chub, and Virgin spinedace.

The Bureau of Land Management has initiated Habitat Management Plans (HMP) on several sections of the Virgin River. These plans, when completed, will delineate resources of the Virgin River Valley and discuss steps which must be taken to maintain those resources. The woundfin and Virgin River chub and their habitat requirements are given special emphasis in the HMP's. The recovery team has worked with the Bureau of Land Management to ensure that the HMP's contain the most recent information available concerning woundfin and Virgin River chub biology.

As a condition of the December 1982 biological opinion issued by the Service for the Quail Creek Reservoir Project, the Washington County Water Conservancy District agreed to fund a 5-year study completed in 1988 on the distribution and habitat use of native fishes in the Virgin River in Utah. This effort also resulted in the establishment of the Virgin River Fishes Data Base at Utah State University, which contains known collection data on the fishes within the Virgin River since 1976. This data base is updated each year as part of ongoing recovery efforts.

The Service, in cooperation with the Virgin River Fishes Recovery Team, made three attempts in 1988 and 1989 to eliminate red shiner from Washington Fields Diversion downstream to the Virgin River Gorge. The attempts were not 100 percent effective; however, they were successful in creating a buffer zone from Washington Fields Diversion downstream to Johnson Diversion that inhibits upstream migration of red shiner (Virgin River Fishes Data Base).

The first treatment, from Johnson Diversion downstream to the fish barrier at the mouth of Virgin River Gorge, occurred on October 4-7, 1988. The river was treated with a chemical concentration of 2ppm Noxfish® (5 percent) for 12 hours. The detoxification rate was 2ppm potassium permanganate. Unfortunately, the detoxification did not start until after some of the rotenone had passed the detox area. Dead and distressed fish were found as far downstream as Mesquite, Nevada.

The second treatment, from Washington Fields Diversion to the fish barrier, occurred on November 1-4, 1988. Irrigation canals, ponds, and marshes missed during the first operation were also treated. The detoxification rate was increased to 5ppm potassium permanganate; crews reported that no rotenone passed the detox station. The third and final treatment ran on August 29-31, 1989. This was a followup treatment, as the 1988 operations did not achieve 100 percent kill in the target area. The crew treated the reach of river between Johnson Diversion and the fish barrier but did not treat the adjacent ponds.

Red shiner reinvaded the river below Johnson Diversion when the fish barrier upstream of the Virgin River Gorge failed during flooding in 1990. However, the treatments successfully eliminated red shiner between Washington Fields Diversion and Johnson Diversion; currently, there are no red shiners above Johnson Diversion. The fish barrier was subsequently rebuilt, but no additional treatment efforts have been undertaken. At present, the Utah Division of Wildlife Resources, the Nevada Department of Wildlife, the Arizona

Game and Fish Department, and the Service have a joint effort to monitor population status of both the Virgin River chub and the woundfin within the Virgin River.

Brood stocks of woundfin and Virgin River chubs were moved to Dexter National Fish Hatchery and Technology Center in 1988 in order to establish refuge broodstock and to develop rearing protocols. Woundfin were successfully propagated in 1993. Virgin River chub were successfully spawned in 1989, but potential problems with the genetic constitution of the Virgin River chub F1 offspring resulted in the destruction of the offspring rather than using them for reintroduction to the Virgin River. Research to resolve these genetic problems is being conducted at Dexter.

The State of Arizona has attempted reintroduction of woundfin to the Paria River and Sycamore Creek on several occasions. To date none of these attempts have succeeded. After the transplanting efforts for woundfin in the early 1970's, there have been numerous discussions on attempting to reestablish the woundfin in other streams within its historic range. Potential sites have been identified and other governmental agencies have been contacted; however, no agreements have been reached. Future reintroduction efforts should be pursued. The actual introduction into these sites should begin when suitable numbers of woundfin are available for this purpose. Potential transplant sites should not be designated nonessential experimental, as was formerly the practice. Populations designated nonessential experimental do not receive the full protection of the Act. Furthermore, the nonessential experimental designations that currently exist on several river reaches in Arizona (50 FR 30188) should be withdrawn. Since these designations were made in 1985, the status of the woundfin has declined dramatically. Any future reintroduced populations must have the full protection of the Act to succeed. Finally, additional research must be initiated to fill in gaps of knowledge relative to the woundfin as well as other native Virgin River fishes. Recommended studies are given in Part II of the recovery plan.

PART II

RECOVERY

OBJECTIVE AND CRITERIA

The primary objective of the recovery plan is to prevent the extinction of the woundfin and Virgin River chub and then to secure each species' survival. Achievement of these objectives involves securing and enhancing currently occupied habitats so that they will support self-sustaining populations and reestablishing self-sustaining populations in other locations. The long-term goal is to downlist these species to threatened status. This will occur through implementation of the recovery actions and tasks proposed below and is expected to occur by 2015. It is not certain that the two species can be recovered sufficiently to the point where delisting is possible. This is due to the irretrievable loss and degradation of the majority of their habitat and the existing and future pressures from water development. The following reclassification criteria are preliminary and may be revised on the basis of new information.

Downlisting Criteria

The woundfin may be considered for downlisting to threatened when:

(1) Virgin River flows essential to the survival of all life stages of the species are ensured. This will include development and implementation of operational criteria for existing dams, reservoirs, and diversions that provide for flows sufficient to sustain all life stages near historic levels of abundance; acquisition of priority water rights to ensure instream flows of sufficient water quality and quantity from Pah Tempe Springs downstream to Lake Mead to ensure the species' survival; and agreements to ensure passage, timing, and magnitude of flows necessary for channel maintenance during appropriate periods of the year;

(2) Degraded Virgin River habitats from Pah Tempe Springs to Lake Mead are improved and maintained to allow continued existence of all life stages at viable population levels; and

(3) Barriers to upstream movements of introduced fishes are established, and red shiners and other nonnative species that present a major threat to the continued existence of the native fish community are eliminated upstream of those barriers.

Virgin River chub have recently been described in the Moapa River in Nevada. Virgin River chub are listed as endangered in the Virgin River, Utah, Arizona, and Nevada; they are not currently listed in the Moapa River, Nevada. If the fish is not listed in the Moapa River, downlisting criteria will be identical to those discussed above for the woundfin. If the Virgin River chub is listed in the Moapa River, recovery criteria that address the fish in both rivers will be developed in the future.

Interim Delisting Criteria

The woundfin may be considered for delisting when:

(1) Two additional self-sustaining populations are established in the wild within its historical range. This will require that adequate protection of available habitat and instream flows are maintained, the populations have been self-sustaining for a minimum of 10 consecutive years, and a plan for genetic exchange between the populations has been developed and implemented. Quantitative criteria and timeframes for defining self-sustaining in more detail will be determined as more information becomes available.

(2) Essential habitats, important migration routes, required streamflows, and water quality of both the Virgin River habitat and the habitat of transplanted populations are legally protected, and the threats of other significant physical, chemical, or biological modification such that the habitat would become unsuitable for the woundfin are removed.

Delisting criteria for the woundfin are considered interim because the opportunity and the potential locations for reestablishment of additional populations are uncertain. Delisting criteria for the Virgin River chub cannot presently be determined.

The estimated date for downlisting of both species is 2015. A delisting date cannot be determined until final criteria are developed for both species.

This plan will be utilized by the Service and should be used by all agencies working with the woundfin and Virgin River chub to coordinate management activities. As the plan is implemented, it should be understood that revisions will be necessary and may be expanded if the Virgin spinedace is listed. Plan implementation is the task of the managing agencies (Utah Division of Wildlife Resources, Arizona Game and Fish Department, Nevada Department of Wildlife, Service, Bureau of Reclamation, and Bureau of Land Management). Sound management of the resource and close coordination between management agencies should provide more stable habitat for woundfin and Virgin River chub and restore them to threatened status in the Virgin River.

NARRATIVE OUTLINE FOR RECOVERY ACTIONS ADDRESSING THREATS

Step Down Outline

1.0 **Maintain and enhance native fish communities of the Virgin River chub and woundfin.**

1.1 Monitor fish communities throughout the Virgin River Basin with emphasis on Virgin River chub and woundfin.

1.11 Review and update existing population and genetic monitoring protocols and sampling stations within the Virgin River.

1.12 Implement monitoring procedures.

1.13 Maintain and update Virgin River Fishes Data Base.

1.14 Prepare a standardized annual report on population trends.

1.2 Eliminate nonnative fish species and reestablish the native fish community in the Virgin River system.

1.21 Establish fish barriers at suitable sites.

1.22 Eradicate or reduce nonnative fish species from below Johnson Diversion to Lake Mead.

1.23 Reestablish native fishes from below Johnson Diversion to Lake Mead.

1.3 Culture Virgin River chub and woundfin.

1.31 Perfect propagation techniques for Virgin River chub and woundfin.

1.32 Develop propagation protocols and establish production goals for Virgin River chub and woundfin.

1.33 Conduct propagation and reintroduction programs.

2.0 **Protect and enhance habitat for the native Virgin River fish communities.**

2.1 Monitor habitat conditions for the native Virgin River fishes.

2.11 Review and update existing habitat and water quality monitoring protocols and sampling stations.

2.12 Implement monitoring procedures.

2.13 Expand Virgin River Data Base to include habitat data.

2.14 Develop a standardized annual report on habitat and water quality changes.

2.2 Develop and implement habitat improvements to enhance native Virgin River fishes.

2.21 Identify and define degraded habitats.

2.22 Develop habitat restoration plans.

2.23 Implement and monitor habitat restoration projects.

2.3 Develop instream flow recommendations needed for the preservation of native fish communities and their habitats within the Virgin River.

2.4 Implement flows and monitor response of the native fish community.

2.5 Establish gaging stations and monitor instream flows at appropriate monitoring sites within the Virgin River.

2.6 Identify existing water use and legal water rights in the Virgin River Basin.

2.7 Acquire high priority water rights for instream flows from Pah Tempe Springs to Lake Mead.

2.8 Develop legally binding agreements to maintain instream flows from Pah Tempe Springs to Lake Mead.

2.9 Acquire land and/or protective easements along the Virgin River for preservation of important habitats for woundfin and Virgin River chub.

3.0 Establish additional populations of woundfin and Virgin River chub within their historic range.

3.1 Maintain genetically appropriate broodstocks and refugia populations of woundfin and Virgin River chub at a minimum of two facilities.

3.2 Identify and prioritize proposed reintroduction sites.

3.3 Conduct baseline habitat assessments of proposed reintroduction sites.

3.4 Develop and establish reintroduction protocols for woundfin and Virgin River chub.

3.5 Implement and monitor reintroduction of woundfin and Virgin River chub.

4.0. Determine ecological requirements of native Virgin River fishes with emphasis on woundfin and Virgin River chub.

4.1 Define the genetic identity of Virgin River chub and woundfin.

4.2 Determine historical variation in population abundance of Virgin River fishes, particularly the Virgin River chub and woundfin.

4.3 Determine relationship between environmental conditions and recruitment.

4.4 Determine effects of habitat conditions on various life stages of native Virgin River fishes.

4.5 Assess interaction between flow dynamics and food production.

4.6 Determine effects of timing, magnitude, and duration of flows and physical habitat within the Virgin River.

4.7 Determine native fish community structure and interactions.

4.8 Determine migration movements.

4.9 Prevent loss of fish in irrigation canal diversions.

4.10 Further define downlisting and delisting criteria.

5.0 Develop and implement educational and informational programs highlighting recovery needs and ongoing efforts for Virgin River fishes.

Narrative

1.0 Maintain and enhance native fish communities of the Virgin River chub and woundfin.

At present, the only naturally occurring populations of woundfin and the majority of the Virgin River chub population are limited to the Virgin River. A priority of the recovery effort should be to protect, maintain, and enhance these existing populations and their habitats as an integral part of the Virgin River fish community.

1.1 Monitor fish communities throughout the Virgin River Basin with emphasis on Virgin River chub and woundfin.

Population monitoring provides a means to assess the well-being of a species or fish community and obtain information on the success of management techniques. Although some information exists on historic woundfin population numbers, little is known about historic Virgin River chub population dynamics in the Virgin River. No quantitative analyses of existing data have been conducted on the population dynamics of the other native fish species. These analyses should be undertaken to provide essential information on community dynamics and to understand interrelationships within the fish community. Continued long-term monitoring activities of the populations are essential if sound management decisions are to be made regarding the protection and recovery of these species. Population monitoring of the native fish community is ongoing and should continue. As part of the regular monitoring efforts for the two endangered fish, data are also collected on other native fishes.

1.11 Review and update existing population and genetic monitoring protocols and sampling stations within the Virgin River,

Population monitoring procedures for both woundfin and Virgin River chub have been prepared along with a list of historic and current sampling station locations. Procedures and sampling locations should be reviewed every 2 years to evaluate their effectiveness and appropriateness to meet existing population monitoring and recovery needs. In addition, inclusion of genetic monitoring protocols and sampling strategies for the Virgin River is being evaluated.

1.12 Implement monitoring procedures.

To evaluate the current status of woundfin, Virgin River chub, and other native fish against historical observed changes in population levels, trend data for all populations should be gathered. Application of long-term population monitoring protocols developed under task 1.11 will be necessary. Population monitoring is presently conducted twice yearly (spring and fall) by the recovery team. These efforts provide essential information

required to maintain and enhance existing woundfin and Virgin River chub populations and their habitats. When a genetic monitoring protocol has been developed, it should be implemented.

1.13 Maintain and update Virgin River Fishes Data Base.

An important aspect of assessing the present population status, long-term trends, and effectiveness of recovery and management actions is the maintenance of the existing Virgin River Fishes Data Base. This data base encompasses fisheries collection data from 1977 through the present for the Virgin River below Pah Tempe Springs. This data base has proved valuable in aiding assessment of existing population status, long-term population trends, spawning and recruitment success, and support for analyses of key life history aspects for all the native fishes within the Virgin River. This data base will need to be expanded to accommodate the habitat monitoring activities outlined under task 2.0.

1.14 Prepare a standardized annual report on population trends.

A standardized annual report format for reporting the annual population monitoring activities should be developed to allow rapid and consistent review and interpretation of current and long-term trends in population and habitat status. The format and content of this report should be periodically reviewed and updated to reflect current needs and goals of management and recovery efforts and accomplishments. Population monitoring data should be analyzed and a report prepared using the standardized annual report format for dissemination to the recovery team and appropriate State, Federal, and private agencies/individuals. Timely analysis and report preparation is essential to assess ongoing recovery and management activities and establish priority needs for each year.

1.2 Eliminate nonnative fish species and reestablish the native fish community in the Virgin River system.

The introduction and establishment of the red shiner and other nonnative fish species within the Virgin River has resulted in long-term population reductions for all native species within the Virgin River from Johnson Diversion downstream to Lake Mead. Dramatic increases in red shiner population densities and distribution within the Virgin River, concurrent with significant reductions in the native populations, has occurred since 1984. Elimination of the red shiner and reduction of other nonnative fish species from the Virgin River is essential to the continued existence and recovery of woundfin and Virgin River chub. Recruitment from upstream populations of woundfin and Virgin River chub is insufficient to repopulate downstream reaches, even in reaches where nonnative fishes have been eradicated. Reestablishment of native fishes will require the continuation of programs to propagate and rear sufficient stocks of woundfin and

Virgin River chub as discussed under task 1.3 below. After treatments to remove red shiners and following subsequent reintroduction of native fish species, monitoring of populations within the treated reaches will be needed to evaluate the success of the reintroduction efforts and to identify possible problems such as reoccurrence of red shiner and increase of other nonnative species. This can be accomplished through expansion of the monitoring program identified in task 1.12.

1.21 Establish fish barriers at suitable sites.

Upstream migration and unauthorized transplants of red shiner and other nonnative species poses a significant long-term hazard for existing native fish populations within the Virgin River, including the endangered fish. Establishment of additional fish barriers along the Virgin River at suitable locations is needed to facilitate red shiner eradication in sequential segments of the river. Barriers and subsequent eradication of red shiners and other nonnative species will be required to ensure adequate protection and recovery for woundfin and Virgin River chub. Several potential sites within the Virgin River that may be suitable for the establishment of additional fish barriers have been identified. Additional sites may need to be identified in the future. Engineering feasibility studies to identify the location, design, and cost associated with fish barrier construction and maintenance should be initiated as soon as potential sites have been identified. Once the feasibility studies have been conducted, funding and necessary State and Federal permits should be secured for the construction of the fish barriers. After the appropriate funding and permits have been secured, construction should be initiated.

1.22 Eradicate or reduce nonnative fish species from below Johnson Diversion to Lake Mead.

In 1988, red shiner were successfully eliminated from the Washington Fields Diversion downstream to Johnson Diversion. The next priority is the elimination of red shiner and reductions of other nonnative species from Johnson Diversion downstream to the fish barrier near the upstream end of the Virgin River Gorge. Eradication programs should follow protocols established in task 3.4. It may be necessary to partition this reach into smaller segments to ensure successful eradication. These actions will reduce the potential for accidental transfer of shiners and other nonnative species above Johnson Diversion and will facilitate reestablishment of the native fish community within this section of the Virgin River. Historical data suggests that selective advantages of red shiners over all native species will preclude the establishment of normal population densities and community composition of native species within this reach of the Virgin River as long as red shiner remain. The presence of red shiner within this segment of the Virgin River significantly

imperils the continued existence of the woundfin and Virgin River chub. Once red shiners have been eradicated successfully from Johnson Diversion to the barrier at the upstream end of the Virgin River Gorge, eradication should proceed downstream to Lake Mead within each segment as delineated by the proposed fish barriers discussed under task 1.21.

1.23 Reestablish native fishes from below Johnson Diversion to Lake Mead.

Once the reintroduction protocols have been established in task 3.4 and successful eradication of red shiner and other nonnative species has been accomplished in task 1.22, woundfin and Virgin River chub should be reintroduced to suitable habitats. At present, insufficient recruitment is anticipated from upstream populations of woundfin and Virgin River chub to repopulate downstream locations. It is anticipated that other native species within the Virgin River are presently at sufficiently high population densities and that natural recruitment will allow reestablishment within the treated reaches. However, to expedite the reestablishment of the native fish community, methods and locations for holding and releasing other native fishes will be examined.

1.3 Culture Virgin River chub and woundfin.

Successful propagation of both woundfin and Virgin River chubs has been accomplished, but genetic problems with Virgin River chubs need to be resolved before the captive produced progeny can be used for reintroduction. The need to continue and expand these efforts for both species is essential given the existing low population numbers of woundfin and Virgin River chubs and the need for a resource pool of individuals for stocking efforts.

1.31 Perfect propagation techniques for Virgin River chub and woundfin.

Development of a viable propagation program for both woundfin and Virgin River chub at Dexter National Fish Hatchery and Technology Center should be continued to support reintroduction of these species into reaches of the Virgin River that have undergone red shiner eradication, as well as for introduction to support establishment of viable populations into historically occupied rivers.

1.32 Develop propagation protocols and establish production goals for Virgin River chub and woundfin.

Development of propagation protocols and establishment of production goals are needed to support rehabilitation and reintroduction of populations within the Virgin River and other historically occupied rivers. Based on the successful

completion of task 1.31, viable production goals for woundfin and Virgin River chub should be set to meet current management objectives for these species. The production goals should be reviewed and modified each year according to the existing conditions and projected need.

1.33 Conduct propagation and reintroduction programs.

Once propagation protocols and production goals have been developed, programs to reintroduce the woundfin and the Virgin River chub can begin. Reintroduction should follow reintroduction protocols established under task 3.4. Reintroduction will take place within reaches of the Virgin River where red shiners have been successfully eradicated and where other habitat features have been restored when needed. Programs to reintroduce woundfin to historically occupied habitats also will be implemented where possible.

2.0 Protect and enhance habitat for the native Virgin River fish communities.

The long-term success for recovery of woundfin, Virgin River chub, Virgin spinedace, and the other native fishes of the Virgin River will depend on the protection and enhancement of their habitat. A significant proportion of the existing habitat within the Virgin River for both woundfin and Virgin River chub has been degraded by construction of dams and diversions, alterations in timing and quantity of flows, changes in-stream channel morphology, riparian vegetation, sediment loads, habitat diversity, etc. Consequently, lower population densities of native fishes presently are supported in these altered habitats rather than under historical conditions. Habitats within other historically occupied rivers also may be similarly affected. The existing populations of all native fish species in the Virgin River could be enhanced by rehabilitation of portions of the river that currently provide marginal habitat.

2.1 Monitor habitat conditions for the native Virgin River fishes.

No quantitative data currently exist on what habitat conditions are believed essential for survival of all life stages of woundfin, Virgin River chub, and other native species within the Virgin River. Therefore, development of a habitat monitoring protocol and implementation of a program to monitor habitat conditions for native Virgin River fishes is needed. This effort should also include identification of essential macroinvertebrate habitats as part of the overall ecological needs of the fish community. Water quality monitoring also should be included as part of the established monitoring activities. Quantitative information on water quality modifications caused by reservoir operations, agricultural return flows, or wastewater discharges within the river will need to be obtained through habitat monitoring efforts.

2.11 Review and update existing habitat and water quality monitoring protocols and sampling stations.

The development of a habitat and water quality monitoring protocol for the Virgin River is considered a high priority because this information is essential for proper management of the species and the Virgin River. At present, no formal protocols to monitor habitat conditions over the long-term have been established or utilized for the Virgin River. A test protocol for habitat monitoring was tested during October 1990. This protocol should be reviewed and updated to include water quality and other changes as needed.

2.12 Implement monitoring procedures.

Once appropriate habitat and water quality monitoring protocols have been established, monitoring programs following these protocols should be implemented immediately.

2.13 Expand Virgin River Data Base to include habitat data.

The existing Virgin River Fishes Data Base should be expanded to include the incorporation of the habitat and water quality data. This will be essential to track trends in habitat quantity and quality as well as water quality. Access to these data will allow the integration of biological information with these physical data and will lead to a better understanding of the mechanisms that may influence and/or control fish community dynamics.

2.14 Develop a standardized annual report on habitat and water quality changes.

A standardized annual report format for reporting habitat and water quality monitoring activities should be developed to allow a rapid and consistent review and interpretation of trends in population and habitat status. The format and content of this report should be reviewed periodically and updated to reflect the current needs and goals of the management and recovery of the species. Habitat monitoring data collected each year should be analyzed and the results integrated with the annual population results discussed in task 1.14 into a standardized annual report.

2.2 Develop and implement habitat improvements to enhance native Virgin River fishes.

Specific reaches within the Virgin River and/or potential introduction sites in other historically occupied rivers where habitat conditions may be limiting life stages of woundfin and Virgin River chub need to be identified. Programs to improve these marginal habitats should be developed and implemented.

2.21 Identify and define degraded habitats.

Studies are needed to determine habitat requirements, to identify habitats essential to the survival of both endangered species, and to identify degraded habitats. This effort will be aided in part by existing information in the Virgin River Fishes Data Base, from information gathered as part of the ongoing population monitoring activities, and from habitat and water quality monitoring protocols that are being proposed.

2.22 Develop habitat restoration plans.

The data collected in task 2.21 will be used to develop site specific habitat improvement plans to upgrade existing degraded habitats and to achieve a quantifiable increase in the carrying capacity of the habitats for woundfin and Virgin River chubs.

2.23 Implement and monitor habitat restoration projects.

Once the habitat improvement plans have received the necessary private, State, and Federal review and approvals, habitat improvement projects will be implemented. Population and habitat monitoring activities will be necessary as part of the habitat improvement activities in order to assess the effectiveness of the measures and to guide further recommendations for the recovery efforts of woundfin and Virgin River chub.

2.3 Develop instream flow recommendations needed for the preservation of native fish communities and their habitats within the Virgin River.

Existing and future water projects on the Virgin River will continue to have a significant impact on the magnitude and timing of flows within the Virgin River. Water use and the resulting alterations of flow regimes have the potential to significantly affect woundfin and Virgin River chub populations. For example, some reaches of the Virgin River at various times of the year are completely dewatered due to water diversions. Analyses should be undertaken to quantify the magnitude and timing of instream flows necessary to ensure the preservation of the endangered and other native fish species and/or enhancement of fish habitat within the Virgin River. The Bureau of Land Management has initiated the Virgin River Instream Flow Assessment project designed to determine the instream flows necessary for protection of the two endangered species.

2.4 Implement flows and monitor response of the native fish community.

Once instream flow recommendations have been developed, the recommended flows should be implemented for each reach of the Virgin River. Habitat conditions within the river and the long-term responses of woundfin, Virgin River chub, and other native fish need to be monitored to assess the effectiveness of the recommended instream flows. Based on the results of the long-term monitoring studies, recommendations for refinements of the instream flows will be formulated and implemented.

2.5 Establish gaging stations and monitor instream flows at appropriate monitoring sites within the Virgin River.

At present, insufficient gaging stations exist within all reaches of the Virgin River to quantitatively assess water use by specific river reaches. The establishment of gaging stations will be necessary to assess water use, to monitor instream flows, and to ensure regulatory compliance with adjudicated water rights. Continuous flow monitoring should be initiated as soon as gaging station locations have been identified.

2.6 Identify existing water use and legal water rights in the Virgin River Basin.

As an initial step to meet the requirements for legal protection of habitat and flows within the Virgin River, the identification of all private, State, and Federal entities with permitted and/or regulatory jurisdiction over flows within the Virgin River should be identified. This information will be used to identify water rights that are high priority for acquisition.

2.7 Acquire high priority water rights for instream flows from Pah Tempe Springs to Lake Mead.

Successful long-term protection and ultimate recovery of woundfin and Virgin River chub is dependant on the acquisition of high priority water rights throughout the Virgin River. In some areas of the Virgin River, water diversion for human use exceeds the amount of water in the river. This overallocation of available water places a high priority on acquisition of water rights in order to ensure maintenance of appropriate instream flows. The availability and costs for acquisition of high priority water rights within the Virgin River need to be identified. Acquisition of high priority water rights should be initiated once funds have been secured for that purpose.

2.8 Develop legally binding agreements to maintain instream flows from Pah Tempe Springs to Lake Mead.

To ensure the survival and recovery of woundfin and Virgin River chub, it is imperative that legally binding agreements for

maintaining instream flows be reached with all private, State, and Federal entities that control or regulate flows within the Virgin River. Legally binding agreements should be negotiated with all responsible parties to ensure that the acquired water rights are maintained within the stream channel. These agreements should specify allowable types and locations of water and land development and usage that are compatible with woundfin and Virgin River chub protection and recovery. They should also set up binding agreements on diversion and regulation of flows within the Virgin River. The Bureau of Land Management has initiated the Virgin River Instream Flow Assessment to identify the water rights necessary for the fishes protection.

2.9 Acquire land and/or protective easements along the Virgin River for preservation of important habitats for woundfin and Virgin River chub.

A comprehensive delineation of landownership in and adjacent to the lands along the Virgin River should be undertaken in order to identify private, State, and Federal responsibilities for the protection of woundfin and Virgin River chub habitat within the Virgin River. Where possible, acquisition of lands and/or protective easements along critical stretches of the Virgin River should be acquired to protect existing habitat in the Virgin River. This is important for long-term protection and recovery efforts for woundfin and Virgin River chub.

3.0 Establish additional populations of woundfin and possibly Virgin River chub within their historic range.

Due to the existing and potential threats to woundfin and Virgin River chub within the Virgin River, establishment of additional populations of woundfin and possibly Virgin River chub within their historical range is essential. Potential reintroduction sites will be prioritized with needed enhancement features recommended. Potential sites for woundfin will include but will not be limited to the reach of the Verde River between Perkinsville and Sycamore Creek, the Gila River mainstream above Safford, and the San Francisco River above its confluence with the Gila. In addition, Tonto Creek and the Hassayampa River will be evaluated for their suitability for woundfin reintroduction. Potential reintroduction sites for Virgin River chub should be identified. Due to the precarious status of these two species, any habitat chosen for possible reintroduction should not receive a experimental nonessential designation. Any areas now under the experimental nonessential designation no longer warrant the classification, which should be withdrawn.

3.1 Maintain genetically appropriate broodstocks and refugia populations of woundfin and Virgin River chub at a minimum of two facilities.

It is recommended that genetically appropriate broodstocks and refugia populations of woundfin and Virgin River chub be maintained at a minimum of two different facilities. Historical problems with the successful maintenance of woundfin broodstock at Dexter National Fish Hatchery and Technology Center, compounded with the species' restricted range, requires that at least one additional site be developed for protection of the species. At such time that any reintroduction locations have maintained adequate populations of woundfin and Virgin River chubs for a 10-year period and populations within the Virgin River have recovered and are stable, the status of these refugia and broodstock populations will be reevaluated.

3.2 Identify and prioritize proposed reintroduction sites.

Conduct a survey of all potential reintroduction habitats, and use this information to develop a finalized list of recommended reintroduction sites for woundfin and Virgin River chub.

3.3 Conduct baseline habitat assessments of proposed reintroduction sites.

Prior to any introduction, a complete population and habitat assessment of the proposed introduction sites should be conducted in order to document baseline conditions.

3.4 Develop and establish reintroduction protocols for woundfin and Virgin River chub.

Protocols for reintroduction of the woundfin and Virgin River chub will need to be developed. The protocols will include the development and evaluation of reintroduction procedures, such as size, number, timing, and frequency of introductions at each specific reintroduction site. In most cases, they also will include the identification and implementation of habitat and instream flow protection measures as applicable. Development of protocols to maintain the genetic integrity of woundfin and Virgin River chubs at reintroduction sites also will be needed.

3.5 Implement and monitor reintroduction of woundfin and Virgin River Chub.

Following the reintroduction protocols developed in task 3.4, locations suitable for the reintroduction of woundfin and the Virgin River chub will be identified and reintroduction programs will be implemented. Monitoring of all reintroduced populations will be required for at least 10 years, and possibly longer, to document the success and stability of the reintroduced

populations. Monitoring should include studies to compare the genetic structures of reintroduced populations with the genetic baseline structures of woundfin and Virgin River chub, as established in task 4.1.

4.0 Determine ecological requirements of native Virgin River fishes with emphasis on woundfin and Virgin River chub.

Although a considerable amount of knowledge has been gained on the life history requirements of woundfin and Virgin River chub over the past 15 years, several key aspects of life history requirements essential for continued protection and ultimate recovery of these species are still unknown. Certain information on ecological requirements of other native fishes also may be needed to assist in restoration of the native fish community. Research needs are identified in the tasks outlined below. As new information is obtained, new research needs may be identified.

4.1 Define the genetic identity of the Virgin River chub and woundfin.

Studies are needed to define the genetic identity of the woundfin and Virgin River chub for comparison with genetics of reestablished populations within reaches treated for eradication of red shiners, of populations reintroduced to historical reaches, and of refugia populations and broodstocks. Genetic studies of reestablished and reintroduced populations, in conjunction with monitoring efforts established under task 3.5, are needed to ensure that no significant alteration in the natural gene frequencies has occurred. Genetic comparisons also should be performed on broodstocks and refugia populations. Based on the results of these genetic comparisons, recommendations for the management of the genetic structure of Virgin River chub and woundfin populations will be developed, reviewed, and implemented.

4.2 Determine historical variation in population abundance of Virgin River fishes, particularly the woundfin and Virgin River chub.

Information on natural variation in population abundance and numbers necessary for maintenance of viable populations over the long-term is needed to derive realistic target levels of population abundance for recovery, to interpret population trends, and to guide long-term recovery strategies. The information contained in the Virgin River Fishes Data Base provides the most readily available data to examine population trends over time. Information from ongoing monitoring programs also will be valuable. In addition, population viability analyses also should be conducted, using the information on population trends, to determine population numbers necessary to ensure long-term viability of the endangered species.

4.3 Determine relationship between environmental conditions and recruitment.

A relationship exists between the timing and magnitude of discharge, water temperature, and spawning success for woundfin. Little information exists on spawning requirements for Virgin River chub and for other native species. Recruitment of woundfin and Virgin River chub may be severely impacted by the magnitude and frequency of flood events during late summer and early fall. In addition, species numbers also may be limited by a scarcity of habitats available to sustain adult Virgin River chub. Using information within the Virgin River Fishes Data Base, as well as ongoing monitoring studies and historic hydrographic information from Geological Survey gaging stations, a study should be undertaken to quantify the timing and magnitude of discharge associated with spawning success and survival of young, and the water temperature characteristics associated with these flows.

4.4 Determine effects of habitat conditions on various life stages of native Virgin River fishes.

Studies also are needed to quantify the relationships between habitat conditions and survival of various life stages of the endangered fish. This information is essential for determining instream flows required for survival and maintenance of the woundfin and Virgin River chub in specific reaches of the river, especially those affected by existing or proposed water management strategies.

4.5 Assess interaction between flow dynamics and food production.

These studies should include an assessment of the interaction between flow dynamics and food production within the aquatic ecosystem. They also should focus on quantifying specific microhabitat/macrohabitat needs of the various life stages of the native species within the Virgin River. The results of these studies will be important in establishing estimates of carrying capacity of the Virgin River for the native species, and in providing essential information on potential habitat improvements for presently degraded Virgin River habitat.

4.6 Determine effects of timing, magnitude, and duration of flows on physical habitat within the Virgin River.

Studies are needed to describe how timing and magnitude of flows effect channel formation within the Virgin River. This information is necessary to identify the instream flow levels needed to restore and maintain the physical habitat features required by the endangered fishes within the Virgin River.

4.7 Determine native fish community structure and interactions.

Inadequate work has been conducted on community structure and interactions of native fishes within the Virgin River. This information will be used to guide reestablishment of native communities in reaches where red shiners have been eradicated.

4.8 Determine migration movements.

Efforts should be made to determine the extent and seasonal periodicity of migration movement of the respective life stages of these species.

4.9 Prevent loss of fish in irrigation canal diversions.

Significant numbers of woundfin and Virgin River chub potentially could be lost into existing canal diversions. Studies should be initiated to determine the nature and extent of fish loss in the diversions and to determine methods to prevent these losses if they are occurring. Measures need to be undertaken by agencies funding, permitting, or otherwise involved in such water diversions to prevent this loss.

4.10 Further define downlisting and delisting criteria

Accomplishment of the various tasks in this recovery plan will provide additional information on the habitat requirements, instream flow requirements, population viability, and other aspects of the biology and ecology for the woundfin and the Virgin River chub. As this information becomes available, the downlisting and delisting criteria for each species can be reevaluated and final criteria can be developed.

5.0 Develop and implement educational and informational programs highlighting recovery needs and ongoing efforts for Virgin River fishes.

To inform the public about the woundfin and Virgin River chub and about ongoing recovery efforts, an information pamphlet should be prepared describing these species and their biology. The pamphlet also should describe the Virgin River and its importance to these species and other fish and wildlife. A section giving reasons for preserving species in nature should also be included. Along with the pamphlet, a short film (15-20 minutes) should be prepared on the Virgin River ecosystem. This film should present a view of the ecosystem as a whole, in which the woundfin and Virgin River chub are an integral part. The pamphlet and video could be used at visitor centers and provided to schools and civic organizations to distribute information on the native fish communities within the Virgin River.

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PART III

IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and costs for the recovery program. It is a guide for meeting the objectives elaborated in Part II of this plan. This schedule indicates recovery plan tasks, corresponding outline numbers, task priorities, duration of tasks, the responsible agencies, and lastly, estimated costs for Service tasks. These actions, when accomplished, should bring about the recovery of woundfin and Virgin River chub and protect their habitat.

KEY TO IMPLEMENTATION SCHEDULE COLUMNS

Definition of Priorities

Priority 1: All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: All actions 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 provide for full recovery of these species.

Abbreviations

ES	Ecological Services
FFA	Fisheries and Federal Aid
AGFD	Arizona Game and Fish Department
NDOW	Nevada Department of Wildlife
UDWR	Utah Division of Wildlife Resources
BR	Bureau of Reclamation
BLM	Bureau of Land Management
USU	Utah State University
UNLV	University of Nevada Las Vegas
WCWCD	Washington County Water Conservancy District

Other Definitions

Ongoing Task which is now or will in the near future be implemented, and should be continued on an annual basis.

Unknown The cost and/or duration of this task is yet to be determined; may require completion of other tasks to determine amount of effort required.

Plagopterus argentissimus (woundfin) and Gila robusta seminuda (Virgin River Chub) Recovery Implementation Schedule

Priority	Task	Task Description	Task Duration	Responsible Party FWS Region	Responsible Party FWS Program	Responsible Party Other	Cost Estimates FY-01	Cost Estimates FY-02	Cost Estimates FY-03	Comments
1	1.21	Establish fish barriers at suitable sites	3 years	1,2,6	ES	all agencies	100,000	100,000	100,000	
1	1.22	Eradicate or reduce nonnative fish species from below Johnson Diversion to Lake Mead	ongoing	1,2,6	ES	UDWR, AGFD, NDOW, BLM, WCWCD,BR	100,000	100,000	100,000	
1	1.23	Reestablish native fishes from below Johnson Diversion to Lake Mead	ongoing	1,2,6	ES	UDWR, AGFD, NDOW, BLM, WCWCD,BR	Cost covered in task 1.2.2	Cost covered in task 1.2.2	Cost covered in task 1.2.2	
1	2.3	Develop instream flow recommendations needed for the preservation of native fish communities and their habitats within the Virgin River	2 years	1,2,6	ES	USU, UDWR, AGFD, NDOW	unknown	unknown	---	
1	2.4	Implement flows and monitor response of the native fish community	ongoing	1,2,6	ES	all agencies	unknown	unknown	unknown	
1	2.5	Establish gaging stations and monitor instream flows at appropriate monitoring sites within the Virgin River	ongoing	1,2,6	ES	all agencies	30,000	30,000	30,000	This task will continue until recovery is obtained
1	2.6	Identify existing water use and legal water rights in the Virgin River Basin	ongoing	1,2,6	ES	all agencies	23,000	11,000	11,000	Will continue until instream flows are established and legally protected for Virgin River fishes
1	2.7	Acquire high priority water rights for instream flows from Pah Tempe Springs to Lake Mead	Unknown	1,2,6	ES	all agencies	unknown	unknown	unknown	
1	2.8	Develop legally binding agreements to maintain instream flows from Pah Tempe Springs to Lake Mead	ongoing	1,2,6	ES	all agencies	---	---	---	Will be done as part of ongoing agency programs

Plagopterus argentissimus (Woundfin) and Gila robusta seminuda (Virgin River Chub) Recovery Implementation Schedule

Priority	Task	Task Description	Task Duration	Responsible Party FWS Region	FWS Program	Other	Cost Estimates FY-01	FY-02	FY-03	Comments
1	3.1	Maintain genetically appropriate broodstocks and refugia populations of woundfin and Virgin River chub at a minimum of two facilities	ongoing	1,2,6	ES	WCWCD, UDWR, AGFD, NDOW	30,000	30,000	30,000	
1	4.1	Establish baseline genetic structure of Virgin River chub and woundfin	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	---	30,000	30,000	
1	4.6	Determine effects of timing, magnitude, and duration of flows and physical habitat within the Virgin River	5 years	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
1	4.7	Determine native fish community structure and interactions	3 years	1,2,6	ES	UDWR, NDOW, AGFD	25,000	25,000	25,000	
1	4.8	Determine migration movements	2 years	1,2,6	ES	UDWR, NDOW, AGFD	25,000	25,000	---	
1	4.9	Prevent loss of fish in irrigation canal diversions	3 years	1,2,6	ES	all agencies	20,000	20,000	20,000	
2	1.11	Review and update existing population and genetic monitoring protocols and sampling stations within the Virgin River	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	---	---	---	This project has been initiated with UDWR taking the lead
2	1.12	Implement monitoring procedures	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	10,000	10,000	10,000	
2	1.13	Maintain and update Virgin River Fishes Data Base	ongoing	6	ES	USU, UDWR, AGFD, NDOW	1,000	2,000	2,000	Data base has been maintained by Utah State University but will be transferred to ES, SLC
2	1.14	Prepare a standardized annual report on population trends	ongoing	6	ES	UDWR, AGFD, NDOW	---	---	---	Part of ongoing agency efforts
2	1.31	Perfect propagation techniques for Virgin River chub and woundfin	ongoing	1,2,6	FFA, ES	UDWR,BR, WCWCD, UNLV,	30,000	unknown	unknown	

Plagopterus argentissimus (woundfin) and Gila robusta seminuda (Virgin River Chub) Recovery Implementation Schedule

Priority	Task	Task Description	Task Duration	Responsible Party FWS Region	Responsible Party FWS Program	Responsible Party Other	Cost Estimates FY-01	Cost Estimates FY-02	Cost Estimates FY-03	Comments
2	1.32	Develop propagation protocols and establish production goals for Virgin River chub and woundfin	1 year	1,2,6	ES	UDWR, AGFD, NDOW	---	---	---	This task will be accomplished as part of ongoing Recovery Team efforts upon successful completion of tasks 1.3.1
2	1.33	Conduct propagation and reintroduction programs	unknown	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
2	2.11	Review and update existing habitat and water quality monitoring protocols and sampling stations	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
2	2.12	Implement monitoring procedures	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	---	---	---	To be done as part of ongoing agency programs
2	2.13	Expand Virgin River Data Base to include habitat data	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	---	---	---	To be done as part of ongoing agency programs
2	2.14	Develop a standardized annual report on habitat and water quality changes	ongoing	1,2,6	ES	AGFD, NDOW, UDWR	---	---	---	To be done as part of ongoing agency programs
2	2.9	Acquire land and/or protective easements along the Virgin River for preservation of essential habitat for woundfin and Virgin River chub	Unknown	1,2,6	ES	all agencies	unknown	unknown	unknown	
2	3.2	Identify and prioritize proposed reintroduction sites	2 years	1,2,6	ES	BLM, BR, NDOW, AGFD, UDOW	---	10,000	10,000	
2	3.3	Conduct baseline habitat assessments of proposed reintroduction sites	ongoing	1,2,6	ES	BLM, BR, NDOW, AGFD, UDOW	---	10,000	10,000	
2	3.4	Develop and establish reintroduction protocols for woundfin and Virgin River chub	1 year	1,2,6	ES	AGFD, NDOW, UDWR	---	---	---	Part of ongoing agency efforts

Plagopterus argentissimus (woundfin) and Gila robusta seminuda (Virgin River Chub) Recovery Implementation Schedule

Priority	Task	Task Description	Task Duration	Responsible Party FWS Region	Responsible Party FWS Program	Responsible Party Other	Cost Estimates FY-01	Cost Estimates FY-02	Cost Estimates FY-03	Comments
2	3.5	Implement and monitor reintroduction of woundfin and Virgin River chub	ongoing	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
2	4.2	Determine historical variation in population abundance of Virgin River fishes, particularly the Virgin River chub and woundfin	1 year	1,2,6	ES	UDWR, AGFD, NDOW	---	20,000	---	
2	4.3	Determine relationship between environmental conditions and recruitment	3 years	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
2	4.4	Determine effects of habitat conditions on various life stages of native Virgin River fishes	3 years	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
2	4.5	Assess interaction between flow dynamics and food production	3 years	1,2,6	ES	UDWR, AGFD, NDOW	unknown	unknown	unknown	
3	2.21	Identify and define degraded habitats	unknown	1,2,6	ES	UDWR, AGFD, NDOW, WCWCD, BR	unknown	unknown	unknown	
3	2.22	Develop habitat restoration plans	unknown	1,2,6	ES	UDWR, AGFD, NDOW, WCWCD, BR	unknown	unknown	unknown	
3	2.23	Implement and monitor habitat restoration projects	unknown	1,2,6	ES	UDWR, AGFD, NDOW, WCWCD, BR	unknown	unknown	unknown	
3	4.10	Further define downlisting and delisting criteria	1 year	1,2,6	ES	all agencies	---	---	---	
3	5.0	Develop and implement educational and informational programs highlighting recovery needs and ongoing efforts for Virgin River fishes	3 years	1,2,6	ES	WCWCD,BR, UDWR, AGFD, NDOW, BLM	unknown	unknown	unknown	This task will continue until recovery is obtained

This 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 (57 FR 47475) on October 16, 1992, and closed on December 15, 1992. Over 150 press releases were sent to the print media located in Arizona and Utah.

During the public comment period, 20 comment letters were received. The comments provided in these letters have been considered and incorporated as appropriate. Comments addressing recovery tasks that are the responsibility of an agency other than the Fish and Wildlife Service have been sent to that agency as required by the 1988 amendments to the Act.

This recovery plan was finalized and in the final stage of editing when the Secretary of the Department of the Interior's new policies regarding recovery plans were published in the Federal Register on July 1, 1994 (59 FR 34270). However, during development of the recovery plan, the Service distributed drafts to peers and affected interest groups for review and comment. Once the Service has developed guidance regarding participation planning, the appropriate Service personnel will work with affected interest and appropriate agencies to minimize the social and economic impacts of implementing recovery actions.