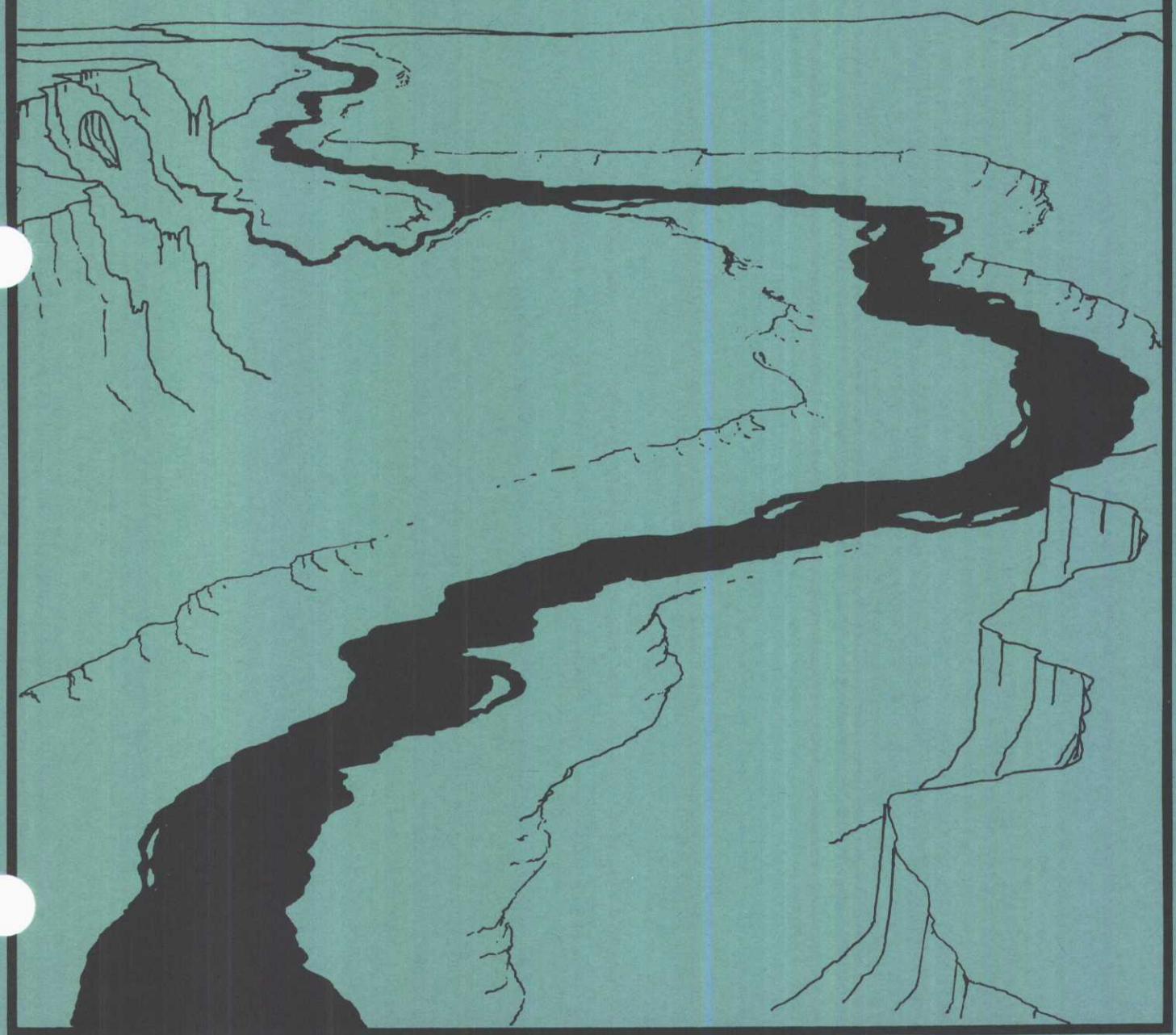
Humpback Chub Recovery Plan



HUMPBACK CHUB

2nd Revised
RECOVERY PLAN

(Original Approved: August 22, 1979)
(First Revision Approved: May 15, 1984)

Prepared by the Colorado River Fishes Recovery Team

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

Approved: Walter B. Stenbaugh
Regional Director, U.S. Fish and Wildlife Service

Date: 9-19-90

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

Literature Citations should read as follows:

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Numerous other persons provided reviews and/or information for the preparation of this plan. The Service greatly appreciates the invaluable assistance provided by team members (past and present), consultants, and other individuals who contributed to the preparation of this document.

EXECUTIVE SUMMARY

The humpback chub (Gila cypha) was listed as an endangered species by the U.S. Fish and Wildlife Service on March 11, 1967. The original recovery plan was approved on August 22, 1979, and revised on May 15, 1984. This is the second revision of the plan. The humpback chub is endemic to the Colorado River basin. Populations are currently located in the Colorado, Little Colorado, Green, and Yampa rivers. The largest population is located in the Little Colorado River in the Grand Canyon. The decline of the humpback chub may be due to a combination of factors such as: stream alteration (dams, irrigation, dewatering, and channelization); competition with and predation by introduced, nonnative fish species; hybridization with other Gila; and other factors.

The goal of this recovery plan is the protection or restoration of five viable, self-sustaining populations of the humpback chub within the Colorado River basin and the protection of the habitat utilized by these populations.

Downlisting will occur when five, viable self-sustaining humpback chub populations have been located or reestablished.

Delisting will be considered when five viable, self-sustaining populations and their habitats are protected.

Major actions needed to achieve the recovery of the humpback chub are:
- Resolve taxonomic problems in Colorado River basin Gila.
- Identify and define humpback chub populations.
- Implement monitoring programs to determine the status and trends of humpback chub populations.
- Investigate the life history and ecological requirements of the humpback chub.
- Protect humpback chub populations and their habitats.
- Assess potential reintroduction or augmentation sites and implement stocking when deemed necessary and feasible.
- Promote and encourage improved communication and information dissemination.
- Determine biological criteria/objectives for downlisting/delisting the humpback chub.

The humpback chub is being recovered in concert with the bonytail chub, Colorado squawfish, and the razorback sucker. The "Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin" (Recovery Program) identifies specific recovery tasks and strategies to be employed in recovering these fish in the Upper Colorado River Basin. The goal of the Recovery Program is to recover the Colorado River fishes in the Upper Colorado River Basin, excluding the San Juan River, by the year 2003 at an estimated cost of $59 million. The Service considers the Recovery Program a stepdown effort of the recovery plans for the listed Colorado River fish and the primary mechanism for implementing this plan in the Upper Colorado River Basin. Development of a coordinated recovery program for the Lower Colorado River Basin is being planned. An estimated recovery cost and recovery date will be established for the Lower Basin during the development of this program. Recovery activities planned to date for the Lower Basin will total at least $10 million for the humpback chub by the year 2003.

TABLE OF CONTENTS

DISCLAIMER..... i
ACKNOWLEDGEMENTS..... iii
EXECUTIVE SUMMARY..... iv

PART I. INTRODUCTION..... 1

History..... 1
General Description..... 1
Distribution and Abundance..... 3
Historic Distribution..... 3
Present Distribution and Abundance..... 5
Life History..... 8
Habitat Preference..... 8
Reproduction..... 9
Food Habits..... 10
Reasons for Decline..... 11

PART II. RECOVERY..... 14

Objective..... 14
Step-down Outline..... 14
Narrative..... 17
LITERATURE CITED..... 29

PART III. IMPLEMENTATION SCHEDULE..... 36

PART IV. APPENDIX..... 42

PART I

INTRODUCTION

History

The humpback chub was listed as endangered by the U.S. Fish and Wildlife Service on March 11, 1967 (U.S. Fish and Wildlife Service 1967). No critical habitat has been designated. The recovery priority for the humpback chub is ranked as a 2C which indicates a high degree of threat and a high recovery potential for a species which is or may be in conflict with some form of economic activity.

The humpback chub (*Gila cypha*) is endemic to the Colorado River basin and is part of a native fish fauna traced to the Miocene epoch in fossil records (Miller 1955, Minckley et al. 1986). The earliest known record of this species is from the Grand Canyon and is estimated to date from 4000 B.C. (Euler 1978). The humpback chub was described by Miller (1946) based upon a fish collected in the Grand Canyon, and from another whole specimen and a head from unknown locations. Miller (1955) also reported remains of this species from Indian ruins near Hoover (Boulder) Dam. Suttkus and Clemmer (1977) concluded that the earliest written record of the humpback chub dates from 1914--a fish originally called "bonytail" by Kolb and Kolb (1914).

The greatest numbers of humpback chub have been found in relatively inaccessible canyons. For this reason, it is not surprising that the species remained undiscovered until after World War II, when collections of fish in the Colorado River were made in conjunction with the planning of large dams. Availability of rubber rafts made traveling whitewater sections of the Colorado River system considerably less dangerous and opened these areas to visitors and scientists. Rubber rafts also allowed river travelers to carry more equipment and supplies, including heavy, more sophisticated fish sampling gear. However, the continued difficulty encountered in sampling the habitat of the humpback chub is the primary reason so little is known about its biology (Minckley 1973).

General Description

The humpback chub has been referred to as "remarkable" and "bizarre." It is certain that the humpback chub is an unusual and striking fish. It is a medium-sized (less than 500 mm [20 in.] total length [TL]), freshwater fish of the minnow family (Cyprinidae), with silvery sides and a brown or olivaceous back. It has a narrow, flattened head that may be dorsally concave, a long, fleshy snout with an inferior-subterminal mouth, and small eyes. Adults generally have a pronounced dorsal hump that begins approximately at the

dorsal origin of the gill covers (opercula), protrudes anteriorly, then ends at the origin of the dorsal fin. The fish's body tapers abruptly to the narrow caudal peduncle, then flares posteriorly into a deeply forked caudal fin.

It is generally believed that morphologic adaptations of the humpback chub aid the fish in negotiating turbulent waters in deep canyons of the Colorado River. The prominent hump is believed to aid the fish in fast water, since it would cause the fish to be pushed to the bottom where water velocities are lower and less energy is required to hold position. The ventral mouth and bulbous overhanging snout may allow the fish to feed without the mouth becoming filled with rushing water, and grooves associated with the hump may aid in directing water to the fish's gills (Minckley 1973).

Detailed descriptions of the humpback chub are found in Miller (1946), Holden and Stalnaker (1970), Minckley (1973), Suttkus and Clemmer (1977), and Smith et al. (1979). General morphological characteristics of adult humpback chub that aid in distinguishing them from adults of the related bonytail chub (G. elegans) and roundtail chub (G. robusta) include: (1) a prominent anterodorsal nuchal hump with lateral grooves; (2) flattened head with small eyes and ventral, almost horizontal mouth; (3) dorsal rays 8-10 (typically 9) and anal rays 9-11 (typically 10) (Suttkus and Clemmer 1977, Muth 1988); (4) total number of vertebrae 46-47 (range 44-47) (Muth 1988); (5) a caudal peduncle intermediate in depth between bonytail (slender) and roundtail chub (deep); and (6) lack of squamation on the nuchal hump.

Specimens of the Colorado River Gila complex that do not fit the descriptions for either bonytail, roundtail, or humpback chubs have been collected since the early 1950's (Holden and Stalnaker 1970; Wick et al. 1979, 1981). Most appear intermediate in gross morphology between one or the other pair of species, making it difficult to distinguish among the three species. Smith et al. (1979), in addressing the taxonomic problem of Gila species in the mainstem rivers of the Upper Colorado River Basin (Upper Basin), suggested that both humpback and bonytail chubs evolved from an ancestor of the roundtail chubs.

Taxonomic identification of all life stages of the Colorado River Gila complex remains a problem; many specimens have morphomeristic characteristics that overlap (Suttkus and Clemmer 1977; Smith et al. 1979; Valdez and Clemmer 1982). Even in the case of adults, identification may be questionable if intermediate characteristics are present. Morphometric analysis using principal component analysis indicates that certain measurements may have diagnostic value; however, Douglas et al. (1989) and Rosenfeld (1986a) found some overlap in quantitative characters. Discriminant function analysis of nine independent morphometric variables was used by Archer et al. (1985) to identify chubs from the Upper Basin, but 75 of 582 fish could not be classified (P=0.05) as humpback or roundtail chubs. Using existing keys and professional judgment, adult chubs in the Yampa River were recognized as either Gila cypha or G. robusta (i.e., no hybrids or morphological intermediates) by Tyus et al. (1987) and Tyus and Karp (1989), but some specimens from the Green River could not be accurately classified. A

principal component analysis of 243 specimens from the Green and Yampa rivers (Douglas et al. 1989) successfully differentiated chubs on the basis of an array of qualitative characters (27 G. cypha, 216 G. robusta).

Young chubs are especially difficult to identify, and techniques for positive identification have not been developed. Most identifications are qualified as "possible" or "tentative" (Valdez 1981). Muth (1988) provided a guide to the larvae and early juveniles of native Gila from the Upper Basin. He stated that meristic characters have limited value for separating humpback and roundtail chubs, but developmental and morphometric data, although not always definitive, provide useful discriminating criteria. Muth (1988) also pointed out that young-of-year Gila from the Green River, Utah, generally appeared intermediate for most characteristics.

Studies involving chromosome morphology, electrophoresis, and principal component analysis using box-truss and traditional morphometry have been used to differentiate Gila species (Rosenfeld 1983, 1986a, 1986b). Chromosome staining on small samples of fish indicated that humpback chubs can be separated from roundtail and bonytail chubs, and that humpback chub from Black Rocks in the Colorado River can be separated from fish taken from the Little Colorado River (Rosenfeld 1983). Electrophoretic analysis of various enzymes from fin samples did not detect any differences in Gila, but liver proteins from a small number of fish indicated some differences (Rosenfeld 1986b).

In summary, positive identification of all life stages of the Colorado River Gila complex remains a problem that requires further investigation. Rather than using keys based on general body shape, more sophisticated techniques must be developed to discriminate humpback chub from other Gila species (Suttkus and Clemmer 1977; Smith et al. 1979; Tyus et al. 1987; and Muth 1988). The Service and the Bureau of Reclamation are currently developing plans to investigate and clarify the taxonomic status of the humpback, bonytail, and roundtail chubs in the Colorado River basin. The work will entail the services of technical experts (taxonomists, geneticists, etc.) and field researchers and is intended to determine whether the humpback, bonytail, and roundtail chubs are distinct species. If they are determined to be distinct, key characteristics which separate them will be identified. The group of experts also will attempt to identify any recent changes in the genetic and/or morphological characteristics of the Gila complex and relate these changes to any environmental modifications.

Distribution and Abundance

Historic Distribution

Known historic distribution of the humpback chub included portions of the mainstem Colorado River and four of its tributaries: the Green, Yampa, White, and Little Colorado rivers (Figure 1). However, its original distribution throughout the Colorado River basin is not known with certainty. Considerable manmade alteration occurred in the Colorado River before the 1940's, especially in the Lower Colorado River Basin (Lower Basin) (Miller 1961), and humpback chub may have disappeared from some river reaches before their

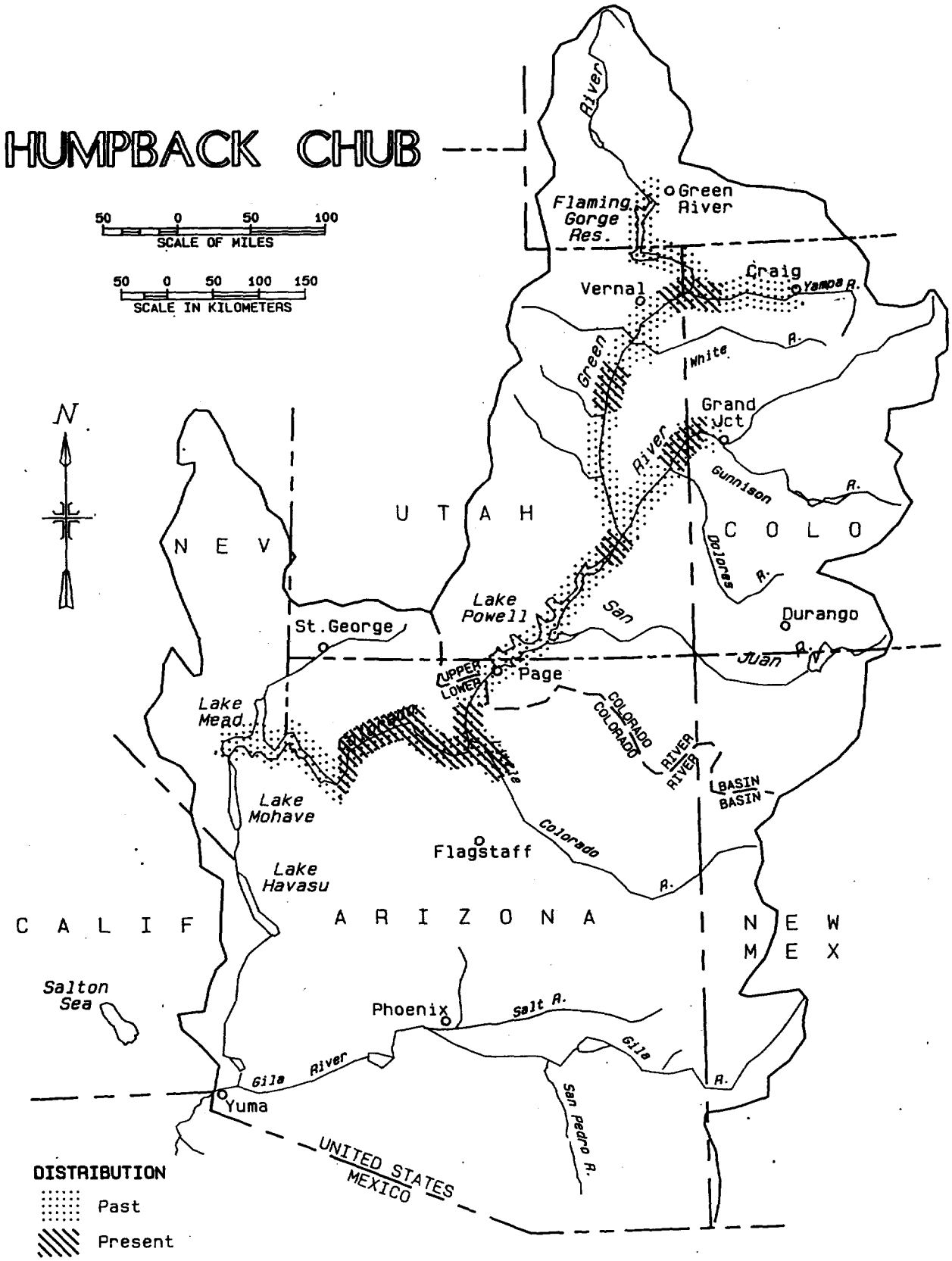

FIGURE 1: Distribution of the Humpback Chub in the Colorado River Basin

existence was documented. For example, Miller (1955) reported remains of this species from an Indian site near Hoover (Boulder) Dam. If the humpback chub historically inhabited this area, it may have been eliminated when Hoover Dam was built in the 1930's. Losses such as these would have been restricted originally to the Lower Basin because the Upper Basin was altered little by construction and operation of dams until the 1960's.

Interest in Colorado River endemic fishes increased in the 1960's, primarily because of the rapid disappearance of the fishes in the Lower Basin and new concerns regarding the impacts of Colorado River Storage Project dams in the Upper Basin. Until the 1950's, the humpback chub was known only from Grand Canyon (Miller 1946). A number of surveys were made in the Upper Basin (see Figure 2) in the 1950's and 1960's, primarily in conjunction with pre- and postimpoundment studies of Flaming Gorge Reservoir. Humpback chub subsequently were found in the upper Green River (Smith 1960). Vanicek et al. (1970) reported three specimens from the upper Green River, one each from Echo Park, Island Park, and Swallow Canyon. Specimens were taken from the lower Yampa River in 1969 (Holden and Stalnaker 1975) and one individual was reported from the White River in Utah (Sigler and Miller 1963). Specimens were collected from Desolation Canyon of the Green River in 1967 (Holden and Stalnaker 1970). One individual was reported from the Colorado River near Moab, Utah, in the 1950's (Sigler and Miller 1963) and other specimens have been collected from the Colorado River above and below Glen Canyon Dam (Holden and Stalnaker 1970, 1975; Minckley 1973).

Present Distribution and Abundance

The present distribution of humpback chub includes:

1. Little Colorado River, Arizona, from its mouth to 13 km (8 miles) upstream (Kaeding and Zimmerman 1983; Maddux et al. 1987);

2. Colorado River in Marble and Grand Canyons, Arizona, (Stone and Rothburn, 1969; Suttkus et al. 1976; Suttkus and Clemmer 1977; Minckley et al. 1981; Kaeding and Zimmerman 1983; Maddux et al. 1987; and Bureau of Reclamation 1988);

3. Colorado River in Cataract Canyon, Utah (Valdez 1981, 1987, 1988; Valdez and Williams 1986);

4. Colorado River in Black Rocks, Colorado, and Westwater Canyon, Utah (Archer et al. 1985; Kidd 1977; Miller et al. 1982c, Valdez and Clemmer 1982; Valdez et al. 1982);

5. Green River in Desolation and Gray Canyons, Utah (Holden 1978; Holden and Stalnaker 1975; Tyus et al. 1982a, 1982b, 1987);

6. Green River in Dinosaur National Monument, Colorado and Utah (Holden and Crist 1980; Holden and Stalnaker 1975; Miller 1964; Miller et al. 1982a; Tyus 1982b; Tyus et al. 1987); and

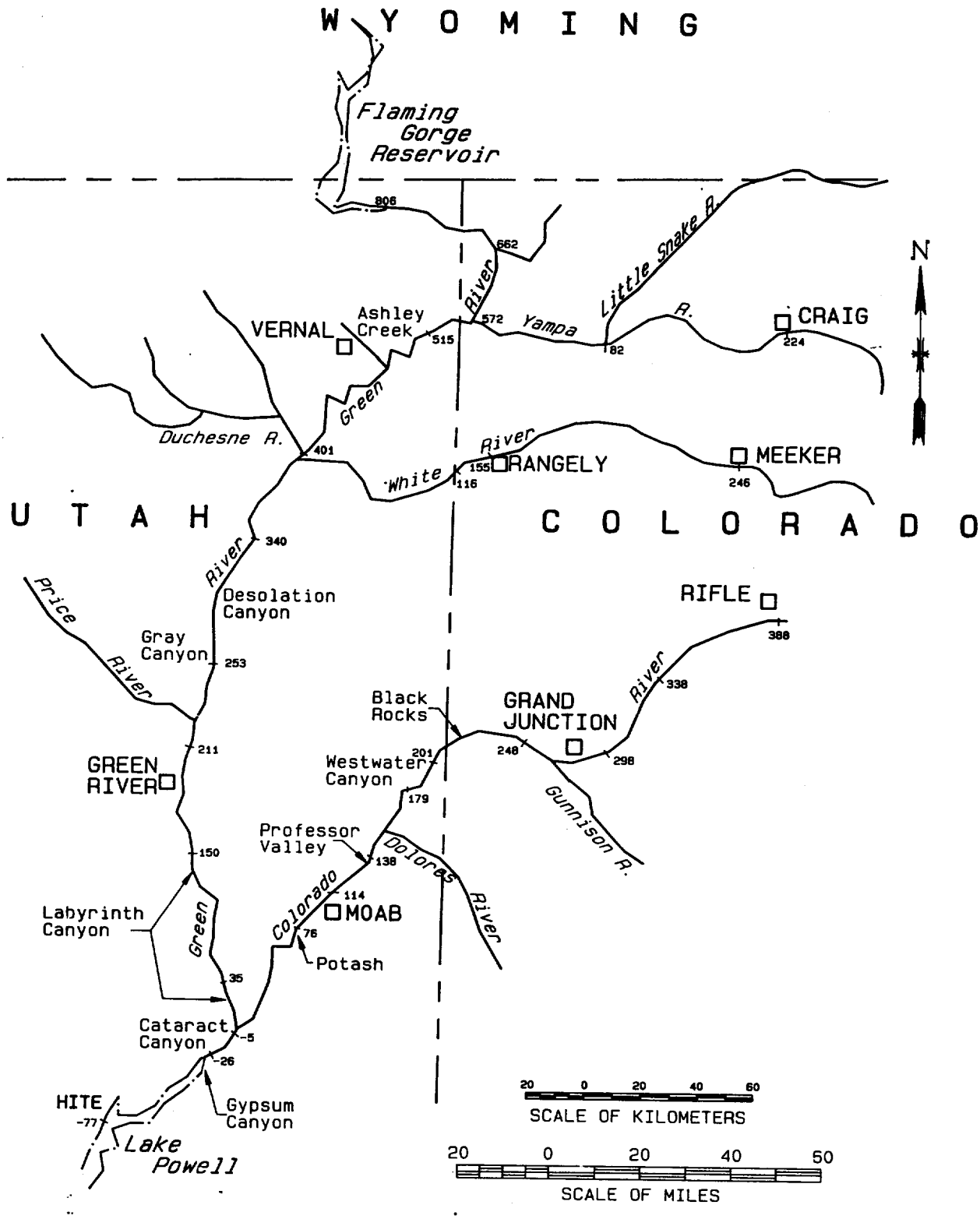

FIGURE 2. Upper Colorado River Basin showing river kilometers and major canyon areas.

7. Yampa River in Dinosaur National Monument, Colorado (Holden and Stalnaker 1975; Miller 1964; Miller et al. 1982b; Seethaler et al. 1979; Tyus et al. 1982a, 1987; Douglas et al. 1989).

The Little Colorado River, a tributary to the Colorado River in Grand Canyon, contains the largest population of humpback chub in the Lower Basin and is the only known area of humpback chub reproduction in the Grand Canyon region (Kaeding and Zimmerman 1983). A total of more than 4,000 specimens of humpback chub have been collected in the mainstem and Little Colorado Rivers in Grand Canyon since 1984. Over 600 are from mainstem localities which extend from 54 to 333 km (34 to 208 miles) below Glen Canyon Dam (Figure 2). Specimens also have been collected from Shinumo, Bright Angel, Kanab and Havasu Creeks (Maddux et al. 1987, Dean Hendrickson, Arizona Department of Game and Fish, pers. comm.). Collections made in mainstem backwaters suggest that these habitats serve as important rearing areas for young-of-year humpback chub (Maddux et al. 1987). In 1987, 196 young-of-year and juveniles were collected below the Little Colorado River, whereas in 1988, with comparable effort, only 7 individuals were captured (Dean Hendrickson, Arizona Department of Game and Fish, pers. comm.). There is concern that these observed differences between years may be related to degree of fluctuating flows from Glen Canyon Dam. Humpback chub were collected in Lake Powell after closure of the dam in the 1960's (Holden and Stalnaker 1970, Suttkus and Clemmer 1977), but only young-of-year fishes at the inflow area have been collected recently (Valdez 1987, 1988). The cold tailwaters of the dam and fluctuating flows have apparently caused major reductions in both the distribution and abundance of humpback chub in Marble and Grand Canyons (Minckley 1973; Holden and Stalnaker 1975; Suttkus et al. 1976; and Maddux et al. 1987).

In the Upper Basin, the highest known concentrations of humpback chub are found in the Black Rocks and Westwater Canyon reaches of the Colorado River near the Colorado/Utah State line (Valdez 1981; Wick et al. 1981; Valdez and Clemmer 1982; and Archer et al. 1985). Sampling has been conducted since 1974 in Black Rocks and since 1979 in Westwater Canyon; numbers indicating a large population of humpback chub consistently have been collected.

A population of humpback chub has been reported from Cataract Canyon on the Colorado River above the inflow area to Lake Powell. A total of 108 humpback chub, of which 22 were adult fish and 56 were juvenile, were collected during a 4-year investigation of Cataract Canyon from 1985 to 1988, by Valdez and Williams (1989). These findings and those of past studies (Valdez et al. 1982), indicate that there is a population of humpback chub in Cataract Canyon, although it may be small. Although actual spawning has not been documented, the presence of various size humpback chubs, including possible young-of-year fish, through the 19 km (12 miles) reach of Cataract Canyon, supports the hypotheses that chubs spawn in the canyon. Specimens also have been collected from the Colorado River in Professor Valley above Moab, in Elephant Canyon about 3 km (2 miles) above the confluence with the Green River, and in the inflow area of Lake Powell (unpublished U.S. Fish and Wildlife Service data; Valdez 1987, 1988). In December 1981, the Service stocked 7,600 Age-I humpback chub, marked with a coded nose-tag, (progeny from Black Rocks) into Cataract Canyon. One adult and one juvenile were collected in 1985, but neither contained a coded wire nose-tag (Valdez 1987).

Humpback chub were collected from the Desolation and Gray Canyons of the Green River in the early 1970's (Holden and Stalnaker 1975). Collections in 1979-81 (Tyus et al. 1982b) indicated that the humpback chub still existed in Desolation and Gray canyons but in low numbers.

The humpback chub also is rare in the Green and Yampa rivers of Dinosaur National Monument (Holden and Stalnaker 1975; Seethaler et al. 1979; Miller et al. 1982a). Tyus et al. (1987) reported that of 523 Gila specimens collected from the Green River basin during 1979-1986, humpback chub comprised 28 percent of those collected from the Green River and 12 percent of those from the Yampa River. Based on limited sampling, Vanicek et al. (1970) indicated that the humpback chub was adversely affected in the Green River above the mouth of the Yampa River after Flaming Gorge Dam became operational in 1962. However, a spawning population exists in the Yampa Canyon in Dinosaur National Monument. A total of 32 fish in breeding condition were captured in Yampa Canyon from 1986-1988, including 5 ripe females, 14 ripe males, and 13 fish with breeding tubercles (Tyus and Karp 1989). A single humpback was collected in 1980 at Cross Mountain Canyon of the Yampa River (U.S. Fish and Wildlife Service 1980; Wick et al. 1981), and several specimens were collected in 1988 from the Little Snake River about 10 km (6.25 miles) upstream from the confluence with the Yampa River (Ed Wick, Colorado State University, pers. comm.).

Life History

Habitat Preference

Humpback chub are found in a variety of habitats. Unfortunately, the humpback chub's habitat preferences are poorly understood. Their association with fast current and deep pool and boulder habitat (Holden and Stalnaker 1975; Kidd 1977; Seethaler et al. 1979; Valdez 1981; Valdez and Clemmer 1982) as well as the relatively quiet mouth of the Little Colorado River (Kaeding and Zimmerman 1983) suggests that they are versatile in their habits.

Humpback chub in the upper Colorado River (Valdez 1981; Valdez and Clemmer, 1982) occupy deep, swift riverine areas. Valdez et al. (1982) and Wick et al. (1979, 1981) found humpback chub in Black Rocks and Westwater Canyons in water averaging 15.2 m (50 feet) in depth with a maximum depth of 28 m (92 feet). In these localities, humpback chub were associated with large boulders and steep cliffs. Movements of mature-size humpback chub in Black Rocks on the Colorado River were essentially restricted to a 1.6 km (1 mile) reach. These results were based on the recapture of Carlin-tagged fish and radiotelemetry studies conducted from 1979 to 1981 (Valdez et al. 1982) and 1983 to 1985 (Archer et al. 1985; U.S. Fish and Wildlife Service 1986).

Information on depth, velocity, and substrate preferences of the humpback chub has been recorded by Valdez et al. (1982) who summarized probability-of-use criteria for adult, juvenile, and young-of-year humpback chub from the upper Colorado River. Adult humpback chub (over 260 mm [10.25 in.]) were generally captured in water less than 9.1 m (30 feet) deep over silt, sand, boulder, and

bedrock substrate and with water velocities usually less than 30 cms (1059.6 cfs). During 1985, 29 sets of habitat measurements of 10 adult humpback chub obtained by radiotelemetry indicated that the fish preferred eddies with sand substrate, a water depth mode of 1.5 m (5 feet) (range 0.3 to 4.6 m [1 to 15 feet]), and water velocities between 0 and 15 cms (525 cfs) (U.S. Fish and Wildlife Service 1986). Five humpback chub (age 2-3 years) were captured in water 6.1 m to 9 m (20 to 29 feet) deep. An additional 1-year-old humpback chub was caught in water less than 3 m (9.8 feet) deep. All young-of-year were captured in water less than 3 m (9.8 feet) deep with a silt bottom and a velocity of less than 30 cms (1059.6 cfs). These data indicate that in Black Rocks and Westwater Canyon of the Upper Basin, adult humpback chub inhabit deep, swift river regions but use microhabitats with low water velocity, and the young utilize shallow areas. Humpback chub captured with baited hooks in the Yampa River utilize shoreline eddies and runs over cobble and sand substrates in water about 1.5 m (5 feet) in depth (Tyus and Karp 1989).

In the lower Colorado River, Minckley (1973) indicated the same general habitat preferences (i.e., deep canyon habitat) as those indicated in the Upper Basin. Maddux et al. (1987) reported that adult and subadult humpback chub were associated with cliffs and boulders in main channel habitats. Minckley et al. (1981) found that humpback chub were collected in eddies adjacent to fast currents and in backwaters with sand substrates and water depths ranging from 2 to 5 m (6.5 to 16 feet). However, they found a different pattern in the Little Colorado River, where adult humpback chub were taken in a variety of habitats including pools adjacent to eddies, large pools with little or no current, and areas below travertine ($CaCO_3$) dams. Young-of-year occupied sandy runs and backwaters (Valdez and Clemmer 1982; Maddux et al. 1987). Kaeding and Zimmerman (1983) listed a range of physicochemical conditions for study sites where humpback chub were collected in the lower Colorado and Little Colorado rivers. The highest catch rates for the species have consistently occurred near the confluence of these rivers (Minckley et al. 1981; Kaeding and Zimmerman 1983; Maddux et al. 1987).

Reproduction

Kaeding and Zimmerman (1983) used a gonadosomatic index to evaluate gonad development during the year, and indicated that humpback chub reach sexual maturity in the Grand Canyon at total lengths of about 250 to 300 mm (9.8 to 11.8 in.). Charles O. Minckley (Museum of Northern Arizona, pers. comm.) found sexually mature males as small as 127 mm (5 in.) in total length. Suttkus and Clemmer (1977) concluded that spawning of humpback chub probably occurs in June and July in the Grand Canyon and lower Little Colorado River. Minckley (1977, 1978, 1979, 1980) collected mature fish from the Little Colorado River in March and April (at water temperatures of 16 to 20°C [61° to 68°F]) and young-of-year fish in July. Three ripe humpback chubs were taken in the mainstem Colorado River in April 1979 (Charles O. Minckley, pers. comm.). Ripe humpback chub were collected in Black Rocks on the Colorado River in June 1980 and May 1981 (Valdez et al. 1982).

The collection of ripe fish indicated that spawning occurred in Black Rocks during June 2-15, 1980, at water temperatures of 11.5-16.0°C (53° to 61°F) and flows of 610-740 cms (21,350 to 25,900 cfs); in 1981, spawning occurred May 15-25 at water temperatures of 16.0-16.5°C (61°to 61.7°F) and flows of 85-140 cms (3000 - 4990 cfs) (Valdez et al. 1982). Humpback chub spawned in Black Rocks on the Colorado River in 1983 when flows peaked from 1,060 to nearly 2,120 cms (37,100 to 74,200 cfs) and maximum daily water temperatures were 13 to 17°C (55° to 63°F) (Archer et al. 1985). Archer et al. (1985) also reported that humpback chub spawned in the area in 1984 when maximum daily water temperatures were 21 to 23°C (70° to 73°F) and flows were declining from 777 to 389 cms (27,195 to 13,615 cfs). In the Yampa River, ripe fish were collected at water temperatures of 16 to 23°C (61° to 73°F), and an average temperature of 19.9°C (68°F) (Tyus and Karp 1989). These data compare favorably with laboratory studies (Marsh 1985).

Under laboratory conditions, the hatching success of humpback chub eggs obtained from wild broodstock (Little Colorado River) was found to be dependent upon temperature, with the greatest hatch (60 percent) occurring at 20°C (68°F) (Marsh 1985). Hatch was only 0.8 percent at 15°C (59°F) and 2 percent at 25°C (77°F). Total embryonic mortality occurred at 5, 10, and 30°C (41°, 50°, and 86°F). Length of normal prolarvae was greatest at 15°C (59°F) (6.3 mm [.25 in.]) as compared with 5.5 mm (.22 in.) and 5.7 mm (.23 in.) at 20°C (68°F) and 25°C (77°F), respectively. The incidence of abnormalities was significantly greater at 15°C (59°F) (33 percent) than at 20°C (68°F) (13 percent) or 25°C (77°F) (17 percent) (Marsh 1985).

Food Habits

Miller (1946) suggested, because of its subterminal mouth, that the humpback chub was probably a bottom feeder. Analysis of stomach contents of a limited number of young-of-year humpback chub collected in the Little Colorado River indicated that they were bottom feeders (Minckley 1980; Minckley et al. 1981). This feeding habit also has been documented by visual observations of adults and young in the Little Colorado River (Minckley 1979, 1980; Minckley et al. 1981). Charles O. Minckley (Museum of Northern Arizona, pers. comm.) provided the following written comment:

> "Adult fish were observed to forage within an area, inspecting and taking material from Cladophora glomerata. They also readily took food dropped into the Little Colorado River. Young-of-year chubs were observed to forage much like adults, actively inspecting and taking material from the bottom, mid-water, and surface. Because of their small size (50 mm), it is assumed that they were foraging on epipelagic and epilithic diatoms, as well as on small invertebrates present in those areas. This behavior was observed from less than 1 meter."

Minckley (1973) noted that humpback chub captured below Glen Canyon Dam had fed primarily on planktonic crustaceans apparently originating from Lake Powell. Stomach contents of humpback chub in Grand Canyon taken by Kaeding

and Zimmerman (1983) were dominated by immature Chironomidae and Simuliidae, but other organisms also were present. Although Gammarus sp. were abundant in the Colorado River, they were uncommon in stomachs of humpback chub. Stomachs from humpback chub collected in the Colorado River had a larger amount of organisms than those collected from the Little Colorado River (Kaeding and Zimmerman 1983).

Rich Valdez (BIO/WEST, pers. comm.) reported seeing, in late August 1980, adult humpback chub finning just beneath the water surface of Westwater Canyon and rising to reach abundant large, black, adult mayflies that were floating on the surface. A fish would ingest a fly and slap the water surface with its tail as it retreated to deeper water, but return shortly to resume position near the surface and watch for other mayflies. Adult humpback or roundtail chub have been observed feeding on floating Mormon crickets (Anabrus simplex) in the Yampa River (Tyus and Minckley 1988), and many humpback chub were captured on the bottom with baited hooks.

Reasons for Decline

The apparent decline of humpback chub may be due to a combination of factors. Seethaler et al. (1979) outlined potential causes for the decline of endangered Colorado River fishes, including stream alteration (dams, irrigation, dewatering, and channelization), competition with and predation by introduced fish species, pollution, and other factors (parasitism, changes in food base, and fishing pressure). Using theories developed from island biogeography, Molles (1980) theorized that endemic species such as the humpback chub would have difficulty persisting under the combined stress of habitat alteration and competition with or predation by introduced fish species. He also suggested that fragmentation of the Colorado River system by dams isolated subpopulations and restricted gene flow, thereby reducing the ability of the subpopulations to adapt to changing conditions.

Humpback chub habitat likely has been lost due to the construction and operation of Flaming Gorge, Glen Canyon, and Hoover dams. Impoundments and cold tailwaters created by these dams have been implicated in the elimination of portions of the species' historic habitat (Vanicek et al. 1970; Holden and Stalnaker 1975; Suttkus and Clemmer 1977; Seethaler et al. 1979; Smith et al. 1979). The altered flows below dams also may adversely affect humpback chub and other rare fishes (Seethaler et al. 1979; Behnke 1980; Behnke and Benson 1980). Reductions in flows may have altered river hydraulics to the extent that humpback chub habitat has been reduced or altered significantly. Suttkus and Clemmer (1977) described the future of the humpback chub in the Grand Canyon as "questionable" due to man-controlled flows, which are colder and fluctuate more on a daily basis than those existing historically. Daily flow fluctuations to produce hydroelectric power produce cycles of inundation and dewatering in backwaters of the mainstem Colorado River in Grand Canyon. These changes in stage probably force young-of-year humpback chub from these rearing habitats into cold (10-15C [50°-59°]) mainstream waters with probable, but as yet inadequately known impacts.

Competition and predation related to introduced species may be important factors in the decline of the humpback chub. The introduction of nonnative fish species has tripled the number of fish species in the Colorado River basin (Holden and Stalnaker 1975; Tyus et al. 1982a). Species introduced into the Colorado River are ". . . good invaders and competitors . . . (having) . . . high productivity, generalized life cycles, and wide physiological tolerance" (Molles 1980). Although interspecific interactions are rarely documented, several nonnative species may have contributed to the decline of the humpback chub (Holden et al. 1974; Miller 1961). Kaeding and Zimmerman (1983) reported scars and wounds on humpback chub collected from the Little Colorado River and attributed them to channel catfish, indicating channel catfish prey on humpback chub.

The potential role of pesticides and other pollutants as depressants of Gila populations has been discussed by Wick et al. (1981). Over 16 percent of young-of-year G. robusta from the Yampa and Colorado rivers in 1981 showed spinal deformities (i.e., lordosis) (Haynes and Muth 1983). The deformities may be related to high pollution/pesticide levels, although no direct data are available to support such a hypothesis. Tyus and Minckley (1988) cautioned that spraying programs for the control of pests such as Mormon crickets may pose a threat to native Colorado River fishes. Elevated levels of radioactivity have been found in ground water associated with the Rio Puerco and Upper Little Colorado Rivers (Webb et al. 1987a, 1987b). Monitoring indicates contamination is moving downstream (Webb et al. 1987a, 1987b) and could pose a threat to the Grand Canyon humpback chub population.

Parasitism is another factor that may have contributed to the decline of the humpback chub. Wydoski (1980) reported that no data were available for evaluating parasitism as a cause for the decline of native species in the Upper Basin but that the possibility should not be discounted. Deacon and Bradley (1972) reported increased parasitism in roundtail chub after several fish species were introduced into the Moapa River in Nevada and suggested that parasitism was a factor in the decline of that species. Infestation as high as 50 percent of the introduced parasitic crustacean Lernaea cyprinacea has been reported in humpback chub taken from the Little Colorado River (Carothers et al. 1981; Kaeding and Zimmerman 1983). Lernaea infestation in chubs, which has been noted throughout the Colorado River basin, should be further investigated.

Although the presence of hybrid Gila has been suggested for some locations (Holden and Stalnaker 1970; Minckley 1973; Kaeding and Zimmerman 1983), the extent of hybridization is unknown. The high degree of morphologic variation among specimens in some locations makes the identification of suspected hybrids difficult (Miller et al. 1982c; Valdez and Clemmer 1982; Kaeding and Zimmerman 1983; Tyus et al. 1987). Hubbs (1955) indicated that hybridization of otherwise distinct species is usually traceable to disturbed, stressful, or otherwise unnatural conditions. Such changed conditions could force two or more species to exist syntopically, resulting in competition and the reduction of population-isolating mechanisms (Hubbs 1961, Behnke 1980). In this context, hybridization between the humpback chub and its relatives, if it occurs in nature, can be regarded as a warning that the preferred habitat is

being altered. In rivers with historic flow regimens (Little Colorado and Yampa Rivers) the incidence of intermediates is low to nonexistent (Douglas et al. 1989, C.O. Minckley, pers. comm.). The extent and significance of hybridization requires future study. Hybridization between fish species does not necessarily signify imminent loss of a species--a point made by Schwartz (1972), who listed 1,945 known fish hybrids, many of which are naturally occurring hybrids between highly distinctive species.

Spawning seasons of humpback and roundtail chubs overlap temporally and spatially, so reproductive isolation may involve behavioral cues (Archer et al. 1985). Since both species have 25 pairs of chromosomes (Rosenfeld 1983), crosses (i.e., hybrids) could easily occur among wild fish if reproductive isolating mechanisms were disrupted. Hamman (1981) reported high viability of artificially fertilized hybrid Gila embryos. The significance of Gila specimens with overlapping morphomeristic characteristics in some areas of the Upper Basin remains unresolved but suggests the possibility of a polymorphic Gila complex (Tyus et al. 1987). To explore this issue more thoroughly the Service is reviewing Gila systematics and developing studies to resolve the issue.

In summary, the humpback chub has suffered declines both in numbers and range. Although populations appear relatively stable in the Little Colorado River and in the Black Rocks/Westwater Canyon areas of the Colorado River, population trend data are not available to help determine if these populations will suffer the same decline as has been apparent in other locations.

PART II

RECOVERY

Objective

The objective of this recovery plan is the protection or restoration of five viable, self-sustaining populations of the humpback chub within the Colorado River basin and the protection of the habitat utilized by these populations. The goal for recovery in the Upper Colorado River Basin, excluding the San Juan River, is 2003. A recovery date for the Lower Colorado River Basin will be established during the development of a coordinated recovery program for the Lower Colorado River Basin.

Step-down Outline

1. Resolve taxonomic problems in Colorado River basin Gila.

2. Identify and define humpback chub populations.

3. Implement monitoring programs.

    31. Determine genetic and morphologic composition of humpback chub populations.

    32. Monitor relative abundance of juveniles and adults.

    33. Monitor relative abundance of young-of-year.

4. Investigate the life history and ecological requirements of humpback chub.

    41. Determine basic biology.

        411. Describe reproductive biology.

        412. Describe age-and-growth characters and food requirements and feeding habits for all life stages.

        413. Determine movements between and within populations.

        414. Determine population dynamics.

        415. Determine factors that affect survival with emphasis on recruitment.

42. Determine habitat requirements.

421. Determine the biological, chemical, and physical requirements of all life stages.

422. Determine criteria for identifying suitable and optimal humpback chub habitat.

5. Protect humpback chub populations and their habitats.

51. Establish and maintain refugia.

52. Remove or minimize threats to the continued existence of the humpback chub.

521. Assess impacts of development projects on biological, chemical, and physical requirements.

522. Determine if hybridization occurs with other *Gila* species and assess its significance.

523. Determine nature and extent of parasitism and its impact on species survival.

524. Develop and implement plan to avoid or deal with catastrophic and chronic contaminants.

525. Eliminate or minimize impacts from nonnative fishes.

53. Enforce established regulations to eliminate or minimize threats.

531. Inform appropriate agencies of their management and enforcement obligations.

532. Ensure compliance with Section 7 of the Endangered Species Act by all Federal agencies.

54. Acquire, appropriate, or otherwise preserve water rights to protect adequate humpback chub populations and their habitats to ensure the survival of the species.

55. Develop and implement cooperative interagency programs to protect and recover the humpback chub.

6. ~~Assess potential reintroduction or augmentation sites and implement~~ stocking when deemed necessary and feasible.

61. Establish and maintain adequate production facilities.

611. Provide and support appropriate production facilities.

612. Identify and secure adequate numbers of the proper broodstocks.

613. Maintain genetic variability and integrity in broodstocks.

614. Develop/refine rearing and handling techniques.

615. Establish production goals in terms of numbers and sizes that are needed for reintroduction or augmentation.

62. Implement and evaluate reintroductions and augmentations.

621. Identify areas for reintroduction.

622. Restore and prepare stocking sites as needed for reintroduction or augmentation.

623. Develop and implement a plan for stocking and monitoring activities.

6231. Determine optimum size and time for stocking.

6232. Determine stocking rates and schedules required to reestablish humpback chub populations.

6233. Establish a monitoring program to evaluate the success of reintroductions, or augmentations.

7. Promote and encourage improved communication and information dissemination.

71. Develop an information and education program to inform the public of the humpback chub's status and uniqueness.

72. Encourage and support publication of research and other recovery results in the technical literature.

73. Develop and conduct workshops to coordinate recovery efforts.

8. Determine biological criteria/objectives for downlisting/delisting the humpback chub.

NARRATIVE

The objective of this recovery plan is the protection or restoration of five viable, self-sustaining populations of the humpback chub within the Colorado River basin and the protection of the habitat utilized by these populations.

Downlisting from endangered to threatened will occur when five, viable self-sustaining humpback chub populations have been located or restored.

Delisting will be considered when five viable, self-sustaining populations and their habitats are protected (i.e., instream flows are secured, adequate water quality is maintained, and major threats to the habitat are removed).

In addition, a minimum of two refugia should be established as safeguards against a catastrophe that could devastate the humpback chub populations in reaches such as Black Rocks/Westwater Canyon and the Little Colorado River.

The above reclassification criteria are preliminary and may be revised on the basis of new information. The goal for recovery in the Upper Colorado River Basin, excluding the San Juan River, is 2003. A recovery date for the Lower Colorado River Basin will be established during the development of a coordinated recovery program for the Lower Basin.

Two high concentration areas of humpback chub currently are recognized: (1) the Little Colorado and Colorado rivers in the Grand Canyon; and (2) the Black Rocks/Westwater Canyon area of the Colorado River. Other areas where humpback chub populations currently exist and that should be considered as primary recovery sites include the Yampa and Green rivers in Dinosaur National Monument, Gray and Desolation Canyons in the Green River, and Cataract Canyon in the Colorado River. In addition, a site in the Grand Canyon may provide suitable habitat to expand a population. What constitutes a viable, self-sustaining population of humpback chub is unknown. This plan includes a recovery task for determining the criteria for defining a viable self-sustaining population.

1. Resolve taxonomic problems in Colorado River basin *Gila*.

   Taxonomic status of the humpback chub has been questioned, largely due to lack of definition of ontogenetic and interspecific variation between and among taxa. Genetic relationships among populations are unknown. Hybridization between humpback chub and other Colorado River basin *Gila* may be occurring. Morphological studies to date have failed to resolve these issues satisfactorily.

   Detailed studies on specimens collected throughout the Colorado River basin utilizing various approaches are needed to: (a) determine key characteristics which separate roundtail, humpback, and bonytail chub; (b) develop definitive criteria for field identification of species or hybrids; and (c) identify factors (e.g., environmental) that may influence the genetic and/or morphological characteristics of the *Gila* complex. These studies are essential to determining endangerment and distinction of various subgroups of the *Gila* complex, including the humpback chub; therefore, this is identified as a Priority 1 recovery task.

2. Identify and define humpback chub populations.

Known populations are to be described, defined, and characterized according to techniques developed under Task 1. All researchers and managers dealing with the Colorado River basin should be encouraged to report occurrences of humpback chub with at least photographic documentation. Newly discovered populations should be documented with general and specific surveys. These populations also will be defined and characterized according to the techniques developed under Task 1. Cost estimates cannot be established until after completion of Task 1.

3. Implement monitoring programs.

The status of identified populations of humpback chub will be monitored. Monitoring programs will be long-term efforts (i.e., a minimum of 10 years) designed to detect population changes. This information is critical for evaluating the success of management and recovery efforts. Results of monitoring programs will be useful in assessing when recovery objectives for downlisting have been accomplished and to assess the health of existing viable populations.

31. Determine genetic and morphologic composition of humpback chub populations.

Concern has been expressed that genetic changes may be occurring in some humpback chub populations that will compromise the integrity of the species. These changes may be the result of habitat changes or other stresses placed on the populations. To determine if these changes are occurring, the genetic and morphologic composition of humpback chub populations will be monitored using procedures derived as the result of Task 1. Material and information collected under Tasks 32 and 33 will be used for this purpose. Fish will be reared under controlled laboratory conditions to determine the effect of environmental conditions on morphology.

32. Monitor relative abundance of juveniles and adults.

Population status and trends of juvenile and adult humpback chubs will be monitored to assess the relative abundance of individuals and their stability. This information will be used to assess success of recovery implementation and management programs. Standard photographs and data from each fish will be taken prior to releasing the fish.

An interagency group has been organized by the Service to develop a monitoring program for adult humpback chub in Black Rocks/Westwater Canyon. Sampling intensity, sampling procedures, and data to be collected have been identified. The lead monitoring agency and cooperative agreements to identify agency responsibilities have been determined. Monitoring efforts have been initiated in the Little Colorado River (Bureau of Reclamation 1988; Minckley 1988) with

emphasis on monitoring adult humpback chub during the spawning season. Monitoring efforts should be continued and expanded to provide quantitative data on population size or trends. Monitoring procedures should be revised as needed based upon the results of Tasks 1 and 2.

33. Monitor relative abundance of young-of-year.

Upon development of identification criteria, reproductive success will be evaluated based upon numbers of young chub produced. Trends in reproductive success will be compared with environmental changes to establish cause-and-effect hypotheses that can be tested by separate research efforts. Reproductive success will be compared with recruitment success and habitat condition to aid in evaluating population stability and maintenance.

4. Investigate the life history and ecological requirements of humpback chub.

Recovery of the humpback chub will depend upon knowledge of the ways previous perturbations and current and proposed threats affect various life stages of the species. Understanding the relationships between ecological requirements of various life stages and their survival and recruitment is a prerequisite to recovery. Biologists will determine the best methods and procedures for obtaining essential information.

41. Determine basic biology.

Since this species has been known to scientists for only 40 years, there is limited life history information for some, if not all, life stages. Difficulty in gaining access, and the lack of suitable techniques to sample the fast-flowing, deep, and turbid environment of the Colorado River and its tributaries have contributed to the lack of adequate life history information.

411. Describe reproductive biology.

Little is known of the exact spawning and nursery requirements for the species in the natural environment. Habitat use by the humpback chub for reproduction differs in various river reaches. Environmental conditions such as depth of water, water temperature, water velocity, and substrate will be monitored and correlated with successful reproduction.

412. Describe age-and-growth characters and food habits for all life stages.

Research will be carried out to determine longevity of the species, age/size at sexual maturity, and types/sizes of food required by various life stages.

413. Determine movements between and within populations.

The movement patterns of the various life stages are not well known. Studies should be conducted to determine the ecological requirements and movements of spawning humpback chubs, young-of-year, and adults.

Two discrete populations of humpback chubs have been identified--one at Black Rocks/Westwater Canyon in the Upper Basin and one in the Grand Canyon/Little Colorado River in the Lower Basin. These populations contain the largest known aggregations of adult chubs and are separated by Glen Canyon Dam, Lake Powell, and many miles of river. In the Black Rocks/Westwater Canyon reach of the Colorado River, the chubs appear to remain in a confined reach during the entire year. However, humpback chubs move from the mainstem of the Colorado River into the lower reaches of the Little Colorado River to spawn. Many of these fish move into the confluence area of the Little Colorado and mainstem Colorado Rivers after spawning and into the mainstem channel during late summer. It is not known how far humpback chubs move or if populations are isolated in these reaches.

414. Determine population dynamics.

Factors limiting population size should be determined so that management techniques which will increase survival of the species can be developed.

415. Determine factors that affect survival with emphasis on recruitment.

Low recruitment appears to be a limiting factor to humpback chub populations in some areas. Identification of factors that limit survival during early life stages are essential to determine management strategies and techniques that can be used to improve recruitment.

42. Determine habitat requirements.

Investigations will be conducted to identify suitable and optimal habitats for humpback chubs. These tasks will utilize the information derived from Task 41.

421. Determine the biological, chemical, and physical requirements of all life stages.

Research will be conducted (Task 41) to determine the various biological, chemical, and physical requirements for all life stages of the humpback chub. The research will provide data on specific substrate components, hydraulic characteristics, water

temperatures, isolating factors, salinity, and other essential requirements. The effects of environmental contaminants on various life stages and species interactions also will be determined.

422. Determine criteria for identifying suitable and optimal humpback chub habitat.

Criteria for identifying suitable habitat for humpback chub will be derived using the information generated from the studies in Task 421. These criteria will be used to determine important river reaches for humpback chub.

5. Protect humpback chub populations and their habitats.

Changes in the environment of the humpback chub may pose threats to the species and its habitats (see Tasks 421 and 422). Humpback chub populations in the Little Colorado River, Black Rocks/Westwater Canyon, and Yampa Canyon are restricted to relatively short river reaches that could be decimated by a catastrophic event. Identification of these threats by river reach will allow agencies to develop management strategies to minimize adverse impacts or to prevent catastrophic losses of humpback chub. Emphasis should be placed on working cooperatively with State and Federal agencies and private groups to develop a coordinated program to protect and recover humpback chub.

51. Establish and maintain refugia.

Refugia should be established and maintained to guard against potential loss of existing humpback chub populations as the result of a catastrophic event. Between 50 and 100 fish should be established in two refugia--one for Upper Basin stock (Black Rocks/Westwater Canyon) and one for Lower Basin stock (Little Colorado River). Possible sites for refugia include Dexter National Fish Hatchery, New Mexico; Willow Beach National Fish Hatchery, Arizona; Page Springs, Arizona; Niland Native Fish Ponds, California; and Ouray National Wildlife Refuge, Utah.

52. Remove or minimize threats to the continued existence of the humpback chub.

Identification of threats must be done before actions can be taken in order to minimize their impacts on humpback chub populations.

521. Assess impacts of development projects on biological, chemical, and physical requirements.

Streamflow and temperature requirements of humpback chub are not well understood. Studies (both in the laboratory and the field) should be done to identify habitat requirements needed to sustain humpback chub populations. Preference studies in

the laboratory could be compared with field observations. Once these requirements are known, development projects that may adversely affect humpback chub can be assessed and actions taken to minimize/prevent impacts to the species.

522. Determine if hybridization occurs with other Gila species and assess its significance.

In some areas of the Colorado River basin (e.g. Black Rocks), the existence of apparent intergrades of the Gila complex suggest that hybridization may be a significant threat to the humpback chub genotype. Once taxonomic criteria are determined through implementation of Task 1, the significance of this threat to humpback chub populations can be identified. Factors that contribute to hybridization can then be identified so that management techniques can then be developed to reduce its occurrence.

523. Determine nature and extent of parasitism and its impact on species survival.

Parasites have been introduced into the Colorado River system with the introduction of nonnative fishes. Also, environmental changes have resulted that may favor certain parasites. Studies on the incidence and role of parasites should be made to determine if parasitism is limiting the survival of humpback chub.

524. Develop and implement a plan to avoid or deal with catastrophic and chronic contaminants.

The possibility of contaminant spills in the Colorado River system exists where catastrophic losses of humpback chub could occur. For example, several bridge crossings on the Little Colorado River and a major interstate highway upstream from Black Rocks/Westwater Canyon provide the potential for accidents which could eliminate the two known major humpback chub populations or their breeding areas. Also, the toxicity of uranium mine tailings has been shown to be devastating to aquatic life in the Colorado River system, and such threats from radionuclides exist in the Little Colorado River drainage (Webb et al. 1987a, 1987b; Tsivoglov et al. 1959). Identification of such threats and implementation of a plan to remove these threats will help prevent catastrophic or chronic stress on the species.

525. Eliminate or minimize impacts from nonnative fishes.

One of the suspected causes of the decline of humpback chub populations is the proliferation of nonnative species of fish in the Colorado River system. These species need to be identified and their impact on the humpback assessed. If predation or competition by nonnative species is found to be a significant factor, then methods of controlling nonnatives will be investigated and implemented. A cooperative agreement should be initiated by the Service and the States of Utah, Colorado, Wyoming, New Mexico, Arizona, and California to prohibit introduction of nonnative fishes that might further endanger the native species or jeopardize their recovery. Preliminary costs necessary to develop cooperative agreements are identified for this task. Funding requirements will increase as contract requirements are more clearly identified.

53. Enforce established regulations to eliminate or minimize threats.

Existing regulations have been established to control human activities that may adversely affect the species or its habitat. As studies are completed, new information may indicate that additional regulations and/or strategies are necessary. If additional control of human activities is needed, recommendations with justifications will be made to establish and enforce new regulations to minimize threats.

531. Inform appropriate agencies of their management and enforcement obligations.

Agencies and the public should be made aware of their responsibilities regarding the laws protecting listed species and their habitats (i.e., Endangered Species Act, Clean Water Act, Lacey Act).

532. Ensure compliance with Section 7 of the Endangered Species Act by all Federal agencies.

Section 7 will continue to play a role in the protection and recovery of the endangered fishes in the Colorado River basin. Every effort by conservation agencies should be made to ensure that Federal actions are not likely to jeopardize the continued existence of the humpback chub and that Federal agencies utilize their authorities to promote recovery of the species.

54. Acquire, appropriate, or otherwise preserve water rights to protect adequate humpback chub populations and their habitats to ensure the survival of the species.

All strategies necessary to protect the species' habitat should be investigated. Private conservation groups as well as State and Federal agencies should direct their efforts toward this goal. The amount and timing of flows that need to be protected will depend upon identifying the species' habitat requirements. Adequate streamflows needed to provide habitat will have to be protected for the humpback chub on a long-term basis.

55. Develop and implement cooperative interagency programs to protect and recover the humpback chub.

A major cooperative effort to recover endangered fish species in the Upper Basin was initiated in August 1984. The Upper Colorado River Basin Coordinating Committee consisted of representatives of the Service, Bureau of Reclamation, the States of Colorado, Utah, and Wyoming, private water development interests, and environmental groups, and had the goal of developing a plan to recover listed fish in the Upper Basin in a manner compatible with States' water rights allocation systems and interstate compacts. The "Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin" (Recovery Program) (U.S. Fish and Wildlife Service 1987) was the result. The Recovery Program applies to all drainages in the Upper Basin with the exception of the San Juan River. A cooperative agreement signed in January 1988 by the Governors of Colorado, Wyoming, and Utah, Secretary of the Interior Hodel, and the Administrator of the Western Area Power Administration formally implemented the program and created a 10-member Committee to oversee it. Five basic recovery elements are identified: (1) provision for instream flows; (2) habitat development and maintenance; (3) rearing and stocking of native fish; (4) management of nonnative species and sportfishing; and (5) research, monitoring, and data management. The projected annual budget for the Recovery Program is $2,300,000, and sources of funds will include Federal and State governments, power and water users, and private donations. A $10 million fund will be requested of Congress for purchase of water rights to protect instream flows, and another $5 million will be requested for construction of facilities such as a hatchery, fish passageways, etc. Private entities proposing water projects will support the program by providing a one-time contribution of $10 per acre-foot of the average annual depletion of the project.

The Recovery Program is intended to provide for the coordinated implementation of the Service's recovery plans for the three endangered fish, including this one for the humpback chub, in the

Upper Basin, excluding the San Juan River. Therefore, the Recovery Program will be considered a stepdown effort of this recovery plan and the primary mechanism for implementing the recovery plan in the Upper Basin.

A similar cooperative interagency plan for recovery actions for Colorado squawfish, bonytail chub, humpback chub, and razorback sucker in the Lower Basin is currently being drafted. When completed, this Lower Basin Recovery Action Plan will be considered the Lower Basin stepdown effort of this recovery plan and will be the primary mechanism for implementing this recovery plan in the Lower Basin.

The Service should ensure that the Upper Basin Recovery Program and the Lower Basin Recovery Action Plan currently being developed are fully coordinated. Additionally, the current cooperative effort of the Service, Bureau of Reclamation, National Park Service, Bureau of Indian Affairs, Navajo Nation, and Arizona Game and Fish Department to develop a protective management plan for humpback chub habitat in the Little Colorado River and mainstem Colorado River, should similarly be coordinated with the Lower Basin Recovery Action Plan.

6. Assess potential reintroduction or augmentation sites and implement stocking where deemed necessary and feasible.

Reintroduction of humpback chub into areas where they occurred, or may have occurred, and augmentation of existing stocks may be necessary to achieve recovery. Habitat assessment of potential reintroduction sites will be necessary prior to reintroduction or augmentation. Augmentation will be done only if warranted by special justification such as senescent adults, skewed sex ratios, or some other factor affecting the ability of the population to recover naturally. Reintroduction and potential habitat manipulation will be coordinated with the appropriate land managing agencies. Costs for these tasks cannot be identified until the results of Tasks 1 and 2 are analyzed.

61. Establish and maintain adequate production facilities.

The existence and availability of adequate production facilities and decisions on the quantity and quality of humpback chubs to be produced are of primary importance to reintroduction or augmentation efforts.

611. Provide and support appropriate production facilities.

Existing facilities at Dexter National Fish Hatchery and Willow Beach National Fish Hatchery should be evaluated for suitability in producing humpback chubs for required stocking. If needed, additional sites should be inventoried for suitability as rearing facilities.

612. Identify and secure adequate numbers of the proper broodstocks.

Broodstock selection should be based on taxonomic and stock evaluation (see Tasks 1, 2, 31), availability of adequate numbers, and absence of genetic contamination through hybridization (as determined in Task 522).

613. Maintain genetic variability and integrity in broodstocks.

Every effort should be made to maintain the genetic diversity of wild populations in broodstocks and in those fish produced for reintroduction or augmentation.

614. Develop/refine rearing and handling techniques.

Rearing and handling techniques will be developed or refined as needed to meet production goals. At the present time, rearing techniques appear adequate and the species is readily handled (Hamman 1982b). However, improvements for rearing and handling may be necessary to meet an expanded production schedule.

615. Establish production goals in terms of numbers and sizes that are needed for reintroduction or augmentation.

Production goals and such details as sizes at stocking should be based on area and complexity of selected stocking sites, goals of the stocking program (e.g., reestablishment or augmentation), and presence of deterrents to survival such as predators/competitors.

62. Implement and evaluate reintroductions and augmentations.

Habitats that appear suitable for supporting a self-sustaining population of humpback chub, but are presently either barren or support low densities, may benefit from the stocking of hatchery-produced fish.

621. Identify areas for reintroduction.

As new information is obtained under Task 4, criteria for identifying potential habitats for establishing and maintaining humpback chub populations can be determined. Using these criteria, suitable habitats for reintroduction or augmentation actions can be identified and prioritized.

622. Restore and prepare stocking sites as needed for reintroduction or augmentation.

Where necessary, potential sites for reintroduction or augmentation will be restored or prepared to maximize the chances for success in stocking humpback chubs. This action

may include physical habitat manipulation (i.e., channel maintenance, etc.) or biological actions (i.e., suppression or removal of nonnative fishes, etc.).

623. Develop and implement a plan for stocking and monitoring activities.

When a reintroduction or augmentation program is defined, an implementation plan will be developed for stocking fish and evaluating success of the effort. The plan will outline criteria and methods to be used in the program.

6231. Determine optimum size and time for stocking.

It is well known that survival of stocked fish increases with the size of the fish. Therefore, the optimum size needed for acceptable survival of stocked humpback chubs must be determined. In addition, the time of stocking may be critical to survival and will have to be determined.

6232. Determine stocking rates and schedules required to reestablish humpback chub populations.

In conjunction with Task 6231, the number of fish to be stocked by area and the duration of stocking must be determined to provide a reasonable expectation of success. Monitoring of humpback chub populations will provide the needed information. Generally, high stocking densities over an extended period may be necessary to ensure recovery success. Success will be achieved when the respective populations are sustained without further introductions.

6233. Establish a monitoring program to evaluate the success of reintroductions, or augmentations.

Systematic monitoring of stocked fish will be an essential element in reestablishing and maintaining humpback chub populations. Monitoring will be used to evaluate Tasks 6231 and 6232 as well as to determine if the populations are self-sustaining. Once the populations have been established, a long-term monitoring program as identified in Task 3 will be incorporated to monitor the status and well-being of these populations.

7. Promote and encourage improved communication and information dissemination.

Inter- and intra-agency communications, the sharing of information, and the education of the public about the goals, objectives, methods, and benefits of the recovery program are essential for achieving the objective of this recovery plan.

71. Develop an information and education program to inform the public of the humpback chub's status and uniqueness.

Support by the public will be necessary for a successful recovery effort. Therefore, an information and education program to inform the public will be developed by Federal and State conservation agencies. The information and education materials will be developed in formats that are appropriate for the target audiences. This may take the form of leaflets, newspaper and magazine articles, television presentations, or other similar media. The audiences will include cooperating agencies, interested organizations, and the general public. Environmental groups and the news media will be encouraged to participate in the dissemination of information.

72. Encourage and support publication of research and other recovery results in the technical literature.

All participating agencies and their contractors should encourage publication of research findings in technical literature. These agencies should provide support by funding printing or other necessary logistical needs.

73. Develop and conduct workshops to coordinate recovery efforts.

Agencies should encourage communication among their professional and managerial staffs to accelerate recovery efforts. Such communication should include coordination responsibilities for implementation of the humpback chub recovery program and conducting workshops for the exchange of information on recovery progress to keep staffs aware of state-of-the-art methods, progress, and new initiatives.

8. Determine biological criteria/objectives for downlisting/delisting the humpback chub.

Objective and measurable biological criteria must be developed by Federal and State conservation agencies to determine when humpback chub populations/recruitment are sufficiently high and humpback chub habitat is adequately protected to permit downlisting or delisting the species. Monitoring activities (Task 3) should be designed and results evaluated to define when various humpback chub populations have become self-sustaining. Criteria addressing population size and demography needed for sufficient recruitment to offset losses from mortality must be determined to ensure that the populations can persist through natural reproduction.

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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 ("ongoing" denotes a task that once begun should continue on an annual basis), and the responsible agencies, and lastly, estimated costs for Fish and Wildlife Service tasks. These actions, when accomplished, should bring about the recovery of the humpback chub and protect its 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 the species.

Abbreviations

FWE	Fish and Wildlife Enhancement
FR	Fishery Resources
AZ	Arizona
CA	California
CO	Colorado
UT	Utah
BR	Bureau of Reclamation
BLM	Bureau of Land Management
NPS	National Park Service
NM	New Mexico Game and Fish Department
NV	Nevada Department of Wildlife
NAV	Navajo Tribe

Other Definitions

Ongoing Task which is now being implemented, and should be continued on an annual basis.

Part III - Implementation Schedule
Humpback Chub

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	Resolve taxonomic status	3 yrs	6, 2	FWE,FR	CO,UT,AZ, BR	175,000	175,000	175,000	Done in conjunction with bonytail chub recovery plan
2	2	Identify and define populations	1 yr	6, 2	FWE,FR	CO,UT,AZ, NPS	---	---	---	Will begin upon successful completion of Task 1.
2	31 32 33	Implement monitor-ing procedures	10 yrs	6, 2	FWE, FR	CO,UT,AZ, NAV	--- 100,000 40,000	--- 100,000 40,000	--- 100,000 40,000	Costs are included in Task 1.
2	421 422	Determine habitat requirements	5 yrs	6, 2	FWE,FR	CO,UT,AZ, BR,NPS	20,000	20,000	40,000	
2	521	Assess impacts of development projects	On-going	6, 2	FWE	BR	3,000	3,000	3,000	In-house
2	522	Determine significance of hybridization	3 yrs	6, 2	FR,FWE	AZ,UT	15,000	15,000	15,000	Issue will also be addressed under Task 1
2	524	Develop and implement plan for contaminant spills	On-going	2, 6	FWE,FR	AZ,CO,UT, NM	5,000	5,000	5,000	Primary emphasis on the Little Colorado River
2	525	Eliminate impacts from nonnative fishes	On-going	2, 6	FWE,FR	AZ,CO,UT, NM,NV,CA, NPS	10,000	10,000	10,000	

Part III - Implementation Schedule
Humpback Chub

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	531	Inform agencies of management and obligations	On-going	6, 2	FWE,FR	AZ,CO,CA, UT,NPS	2,000	2,000	2,000	
2	532	Enforce Regulations	On-going	6, 2	FWE,FR	AZ,UT,CO, CA,BR,NPS	90,000	90,000	90,000	Primarily represents costs associated with Section 7 consultation.
2	55	Implement Co-operative Program	On-going	6, 2	FWE,FR	AZ,UT,CO BR	85,000	85,000	85,000	Covers costs associated with administrative and agency coordination.
3	411 412 413 414 415	Determine basic biology	5 yrs	6, 2	FWE,FR	CO,UT,AZ, BR,NPS,NAV	20,000 40,000 160,000 60,000 80,000	20,000 40,000 160,000 60,000 80,000	20,000 40,000 160,000 60,000 80,000	
3	51	Establish and maintain refugium	On-going	6, 2	FR	CO,UT,AZ, BR	10,000	10,000	10,000	Coordinated with refugium for other Colorado River Fishes
3	523	Determine nature and extent of parasitism	3 yrs	6, 2	FR,FWE	AZ,UT,CO	---	---	10,000	
3	54	Acquire/appropriate water rights	On-going	6, 2	FWE,FR	AZ,UT,CO, BR	---	---	---	Water rights purchase will begin after the third FY and will be accomplished through the cooperative recovery programs. Costs are likely to exceed $10 million in the upper basin.

Part III - Implementation Schedule
Humpback Chub

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
3	611 612 613 614 615	Establish and maintain production facilities	3 yrs.	6, 2	FWE,FR	AZ,UT,CO, BR	---	---	---	To be done upon completion of Tasks 1 & 2. Cost unknown until production requirements are determined.
3	621 622 6231 6232 6233	Implement and evaluate reintro-duction augmen-tations.	5 yrs.	6, 2	FWE,FR	AZ,UT,CO, BR	---	---	---	To be done upon completion of Tasks 1 & 2. Cost unknown until production requirements are determined.
3	71	Develop public in-formation and educational program	On-going	6, 2	FWE,FR	AZ,UT,CO, CA,BR,BLM NPS	20,000	20,000	20,000	Include as part of an I&E program for all the Colorado River Fishes.
3	72	Publish research findings	On-going	6, 2	FWE,FR	AZ,UT,CO, CA,BR,BLM NPS	---	---	---	Done by respective agencies and contractors.
3	73	Coordinate recovery efforts through workshops	On-going	6, 2	FWE,FR	AZ,UT,CO, CA,BR,BLM, NPS	---	---	---	Done through existing meetings, workshops, and committees.

Part III - Implementation Schedule
Humpback Chub

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
3	8	Determine biological criteria/ objectives for downlisting/delisting	1 yr	6, 2	FWE,FR	AZ,UT,CO, CA	10,000	10,000	10,000	Done in coordination with other Colorado River endangered fish.

APPENDIX I

This recovery plan was made available to the public for comment as required by the 1988 amendments to the Endangered Species Act of 1973 (Act), as amended. The public comment period was announced in the Federal Register on July 21, 1989, and closed on September 19, 1989. A press release was sent to over 300 print media located in the Colorado River basin.

During this 60-day public comment period, five 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 U.S. Fish and Wildlife Service have been sent to that agency, as required by the 1988 amendments to the Act.