LIFE HISTORY AND PROSPECTS FOR RECOVERY OF THE HUMPBACK AND BONYTAIL CHUB

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ABSTRACT

The endangered humpback chub, *Gila cypha*, and bonytail chub, *Gila elegans*, occupy restricted areas of the Colorado, Green, and Yampa rivers in Colorado, Utah, and Arizona. Three self-sustaining populations of humpback chub indicate this species is capable of continued existence. But, low numbers of bonytail chub and the absence of natural reproduction strongly suggest a trend toward extinction. Much of the habitat of these endemic chubs is inundated by reservoirs or degraded by altered flow regimes. Their survival depends on maintaining the remaining deep, swift, rocky reaches inhabited by the species by curtailing further flow depletions. Introduction of non-native fishes must also cease. Habitat enhancement, including artificial backwaters, deepened river channels, and riprapped shorelines, is not a reasonable recovery step for either species because of the dynamics of river hydraulics and remoteness of most habitable areas. Recent success in rearing these two species in hatcheries may be important if supplemental stocking and reintroduction develop as feasible recovery steps. Introduction of hatchery-reared bonytail chub warrants consideration for recovering the species in the wild. Introduction of humpback chub, except in one area, is not recommended because of lack of suitable habitat presently unoccupied by the species.

INTRODUCTION

The humpback chub, *Gila cypha;* bonytail chub, *G. elegans;* and roundtail chub, *G. robusta* are large-river cyprinids endemic to the Colorado River System. Depletions of humpback chub and bonytail chub threaten their existence and have prompted their protection under federal and state statutes. The humpback chub and allied Colorado squawfish, *Ptychocheilus lucius*, were on the original list of endangered species prepared by the Office of Endangered Species in 1964. Strong legislation to protect these fishes and their habitat was afforded by the Endangered Species Act of 1973, P.L. 93-205 (87 Stat. 884). The bonytail chub was listed as endangered on 23 April 1980 (U.S. Fish and Wildlife Service 1980).

Life history studies of humpback chub, bonytail chub, Colorado squawfish, and the imperiled razorback sucker *Xyrauchen texanus*, began after 1960, and efforts intensified after 1970. The Fish and Wildlife Service (FWS) began an investigation of these fishes in the Upper Colorado River System in April 1979 (see Shields in this symposium). The Colorado River Fishery Project (CRFP) was designed to assess habitat and flow requirements of these endemics and is the source of much information presented herein. CRFP was funded by the Bureau of Reclamation, Bureau of Land Management, FWS, National Park Service, and Congress. The Colorado Division of Wildlife (CDW) and Utah Division of Wildlife Resources (UDWR) provided equipment, personnel, and technical assistance for various phases of the project.

DISTRIBUTION AND ABUNDANCE

The distribution and abundance of humpback chub and bonytail chub are summarized in several recent documents (Joseph *et al.* 1977; Joseph 1978; Smith *et al.* 1979; Behnke and Benson 1980; Colorado River Fishes Recovery Team 1981a, 1981b; Tyus *et al.* in this symposium). Some authors suggest the species were once abundant throughout the Colorado River System, based on reports at the turn of the century (Cope 1872; Cope and Yarrow 1875; Kirsch 1889; Jordan 1891; Jordan and Evermann 1896; Gilbert and Scofield 1898; Chamberlain 1904); fish collections by these investigators were too few and scattered to provide an accurate assessment of the status of these fishes. Bonytail chub were apparently common in collections from the Lower Basin around the turn of the century, but collections in the Upper Basin were too few to suggest more than the presence of the species. Confusion in vernacular and scientific nomenclature and a failure to recognize *G. cypha* until 1946 (Miller 1946) render tenuous an interpretation of historic distribution and, especially, abundance of the two species.

Bonytail chub were reported in decreasing numbers in the Lower Basin as early as 1960 (Miller 1961). Humpback chub were not known from the Upper Basin until 1950, when they were reported from Hideout Canyon on the Green River (Smith 1960). Pre- and post-impoundment studies (Bosley 1960; McDonald and Dotson 1960; Smith 1960) reported humpback chub in Flaming Gorge, but abundance is difficult to assess because of common use of the term "bonytail" for all members of the genus *Gila*. Similar investigations in Glen Canyon (McDonald and Dotson 1960) did not reveal the presence of either species, but humpback chub were collected in Lake Powell soon after closure of Glen Canyon Dam in 1962 (Holden and Stalnaker 1975). Both species of chubs were reported from Lake Powell in the late 1960's, but UDWR has not reported any in recent years.

Bonytail chub were numerous in the Green River within Dinosaur National Monument from 1964 to 1966 (Vanicek and Kramer 1969) but less common from 1968 to 1971 (Holden and Stalnaker 1975). The species was also reported in the latter period from the lower Yampa River within Dinosaur National Monument and from the Green River within Desolation Canyon.

The reported range of the humpback chub in the Green and Yampa rivers after 1970 (McAda and Seethaler 1975; Holden 1977; Joseph *et al.* 1977) was extended, but total numbers of bonytail chub continued to diminish. New populations of humpback chub were also found in the Colorado River at Black Rocks, Colorado (Kidd 1977) and Westwater Canyon, Utah (Valdez 1980). But, bonytail chub continued to be absent from samples in Colorado (Wick *et al.* 1981), despite reports of the species in the White and Colorado rivers by T.M. Lynch (Joseph 1978). These reports are discounted after interviewing biologists (G. Kidd, 3361 G Road, Clifton, Colorado, 1981 pers. comm.) with CDW at that time. Apparently, roundtail chub were commonly called "bonytail" by some Conservation Officers, and these reports were interpreted to mean that *G. elegans* was found in Colorado from 1940 to 1960.

Concentrations of humpback chub now occur in (1) Black Rocks, Colorado; (2) Yampa Canyon, Colorado; (3) Westwater Canyon, Utah; (4) Gray Canyon, Utah; and (5) Little Colorado River (LCR), Arizona (Fig. 1). Fishes of all age-groups have been recently identified from sites 1, 3 and 5 listed above. Adults and young, tentatively identified as *G. cypha*, were recently reported in site 2 by the CDW (Wick *et al.* 1981) and indicate a fourth self-sustaining population of humpback chub in the Colorado River System. Individual humpback chub were also found in Moab and Cataract canyons of the Upper Colorado River (Valdez and Mangan 1980) and Desolation Canyon of the Green River (Tyus *et al.* 1982). Bonytail chub are present in small numbers in Gray Canyon, Utah and Lake Mohave, Arizona.

HABITAT

Humpback Chub

The preferred habitat of humpback chub in the Green, Colorado, and Little Colorado rivers is very similar in these disjunct populations. The species prefer deep, swift water with rocky substrate.

Young and juvenile *Gila* sp. in the Green River (Holden 1978) showed a preference for firm silt substrates in water 0.6 m deep and 0-0.15 meter per second (mps) velocity. Most young were caught in backwaters, and juveniles were in backwaters and runs. Adults preferred depths of 0.6-1.2 m and velocities of 0-0.24 mps.

Collections from the same habitat in Gray Canyon in the Green River (Tyus *et al.* 1982) yielded *G. cypha*, *G. elegans*, and *G. robusta*. The area has deep, swift water and rock substrate. Humpback chub in the Lower Colorado River were also often found in the deeper pools (Kaeding and Zimmerman 1981).

Young fish tentatively identified as *G. cypha* in Black Rocks and Westwater Canyon were found in small, quiet pockets along steep rock walls, often adjacent to deep and swift water. These fish were also found in the few backwaters that occur in these areas (Fig. 2). Juveniles in the same area were found over sand-silt and boulder-bedrock substrates (Fig. 3) in water 0.4-10.7 m deep ($\bar{x}$ = 3.5) and velocities of 0.06-0.60 mps ($\bar{x}$ = 0.24). Most were found in small eddies and pools or in angular pockets along rock walls. A few age-group I fish were found in backwaters. Adult humpback chubs were found in depths of 0.7-12.2 m ($\bar{x}$ = 4.3) and velocities of 0.03-1.16 mps ($\bar{x}$ = 0.18). These adults preferred deep runs and eddies over bedrock, boulders, and sand.

CRFP investigations in 1980 and 1981 yielded ripe humpback chub from Black Rocks along intermittent sand beaches between protruding rock pillars. The fish were in depths of 1.8-3.8 m and velocities of 0.15-0.30 mps. Spawning may occur on nearby submerged gravel bars as indicated by observed spawning in cobble raceways at Willow Beach National Fish Hatchery (NFH) where adhesive eggs were deposited on cobble 4-10 cm in diameter in 35-45 cm of water (R. Hamman, Willow Beach National Fish Hatchery, Boulder City, Nevada. 1981 pers. comm.).

Bonytail Chub

Little is known about the habitat of bonytail chub, except that the few individuals caught recently in the Upper Basin occupied deep, swift, rock-sand areas in main channels. No difference in habitat selection was detected between roundtail and bonytail chubs in the Green River, nor were any seasonal changes observed (Vanicek 1967). Young *Gila* sp. (ages 0-II) were commonly captured in pools and eddies in the absence of (although often adjacent to) strong current and at varying depth over silt and silt-boulder substrate. Recent catches of bonytail chub in Gray Canyon in the Green River also suggest that the fish prefer areas adjacent to deep, swift water (Tyus *et al.* 1982). Small numbers of bonytail chub found in Lake Mohave are probably excluded from using the riverine habitat above the reservoir by the cold-water releases from Hoover Dam (Colorado River Fishes Recovery Team 1981a).

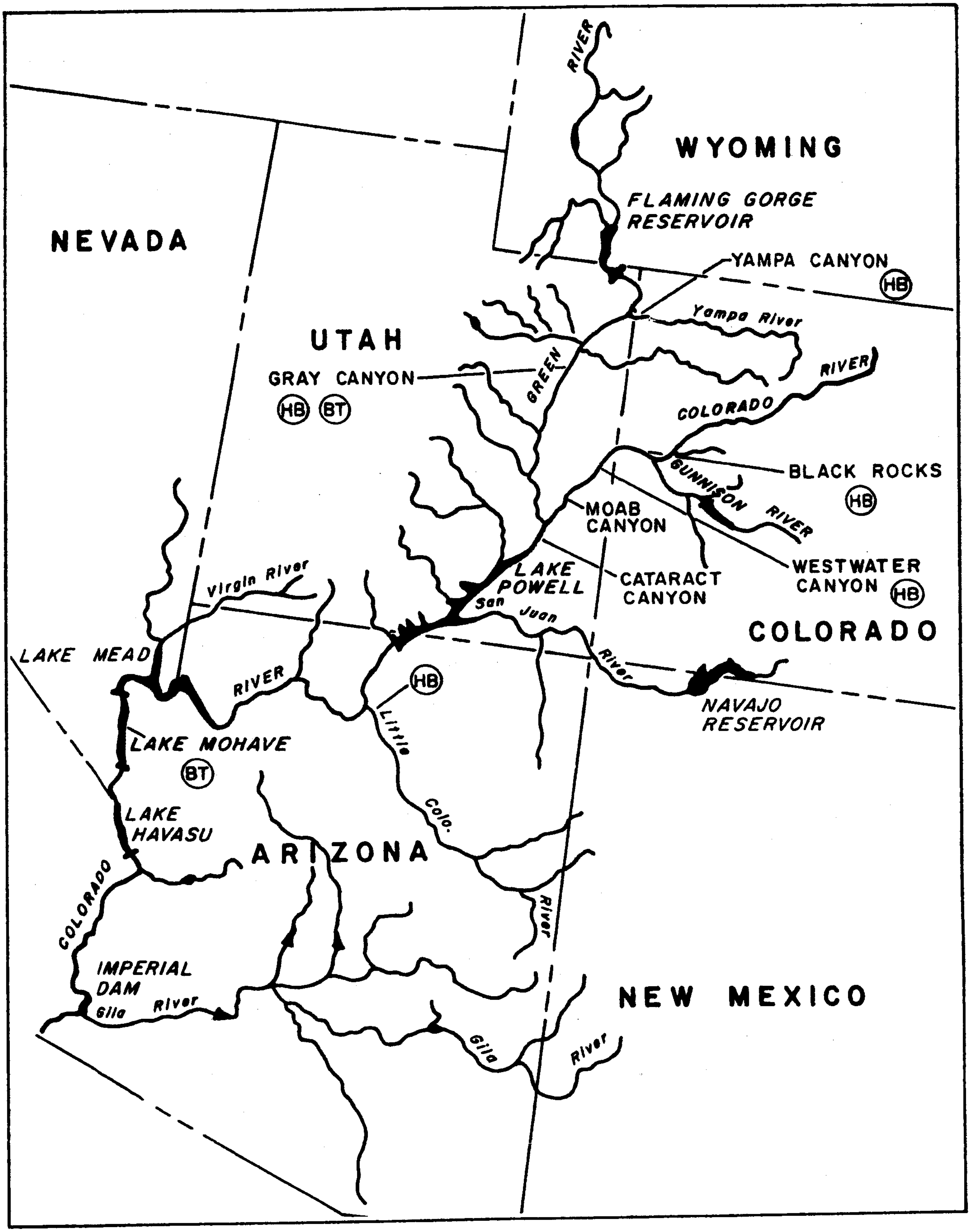

Figure 1. Concentrations of *Gila cypha* (HB) and *Gila elegans* (BT) in the Colorado River System.

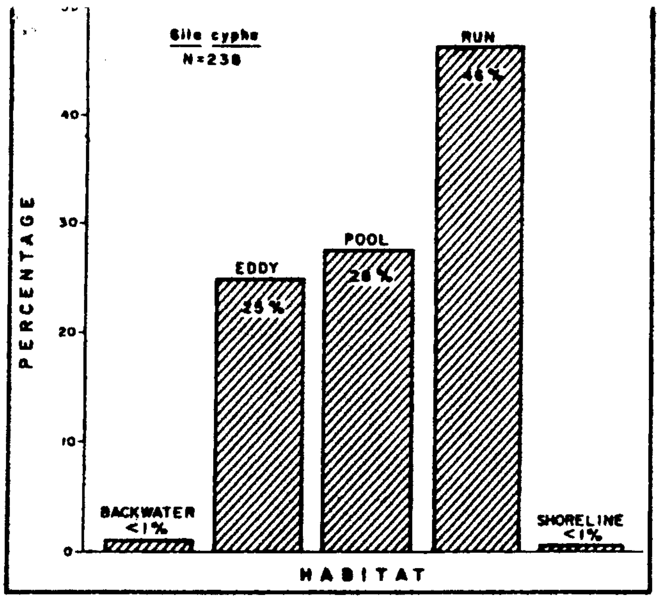

Figure 2. Habitats used by all ages of *Gila cypha*, as percent of total catch, in the Upper Colorado River.

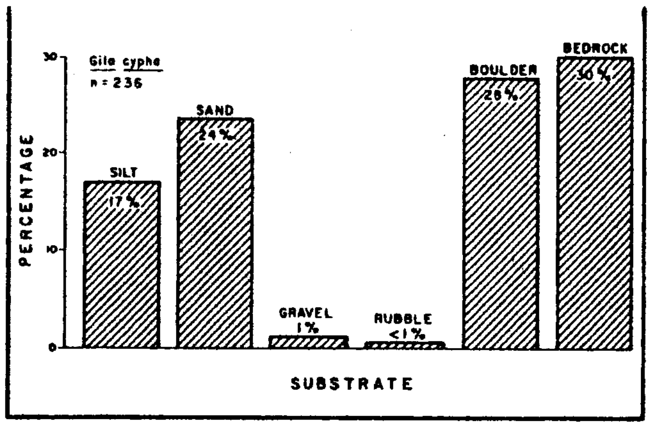

Figure 3. Substrate used by all ages of *Gila cypha*, as percent of total catch, in the Upper Colorado River.

MOVEMENT

Mark-recapture studies with Carlin tags indicate that humpback chub move little within Black Rocks, Westwater Canyon, Gray Canyon, and the Lower Colorado River. Sixteen of 218 fish tagged in Black Rocks and Westwater were recaptured between 1 and 434 days after release. Recapture sites ranged from 0 to 23 km from release sites, for an average distance of 1.6 km (Table 1). All but one fish were recaptured less than 0.7 km from their release site. One fish, initially tagged in Westwater Canyon 10 September 1980, was recaptured 232 days later 23 km upstream in Black Rocks. This was the greatest observed movement by a humpback chub and was the only recorded exchange of a fish between Westwater Canyon and Black Rocks.

TABLE 1. Movement of *Gila cypha* equipped with Carlin tags and radio transmitters in the Upper Colorado River, 1979-1981

Tag	Average movement per fish, km (Range)	Average days monitored (Range)
Carlin	1.6 (0-23.0)	137 (1-434)
Radio	0.8 (0-3.7)	38 (4-93)

Preliminary observations on *Gila* sp. in Gray Canyon of the Green River showed similar trends. One *G. robusta*, one *G. elegans*, and seven *G. cypha* were recaptured at the original capture sites 1.5 to 11 months after release (Tyus *et al.* 1982). Chubs caught in the Lower Colorado River 3.5 weeks to 13 months after tagging were 0-2.7 km ($x = 0.6$) from their release point (Kaeding and Zimmerman 1981).

Movement of fish equipped with radio transmitters was similar to movement observed with Carlin tags. Eight humpback chub with transmitters in Black Rocks moved 0-3.7 km, for an average of 0.8 km, over periods of 4-93 days (Table 1). The average net movement was less than 0.1 km upstream from the release point.

Movement of radio-equipped fish is illustrated by one individual that moved a total of 0.3 km upstream over a period of 67 days (Fig. 4). The fish spent 26 days near the release point and then moved for 2 days to the original capture site, where he spent the remaining 39 days of monitoring. A second fish returned to the original capture site 64 days after release and spent the remaining 34 days monitored within a 100-m radius. Similar movement was seen for all eight fish within the 3-km Black Rocks area, except for one fish that moved upstream nearly 2 km and returned within 2 weeks. Possible effects of the implant and transmitters on behavior is acknowledged but was not evaluated.

Three fish with transmitters exhibited patterned diurnal and nocturnal movements (Fig. 5). These fish were monitored for approximatley 24 hours on several occasions in May, June, and July 1981. Generally, the fish spent dawn (0600-0800) and evening (2000-2300) hours along the relatively shallow shore in less than 2 m of water. Their longitudinal position on shore often varied by 30-50 m daily, and they often remained for long periods in eddies formed by submerged rocks. Fish were found in midmorning (0800-1100) and midafternoon (1700-1800) in 3-5 m of water and farther toward midchannel at midnight (2400-0600) and midday (1100-1700), especially in warm, sunny weather. Signal reception varied inversely with depth, and constant monitoring for precise location was impossible in water deeper than 5 m.

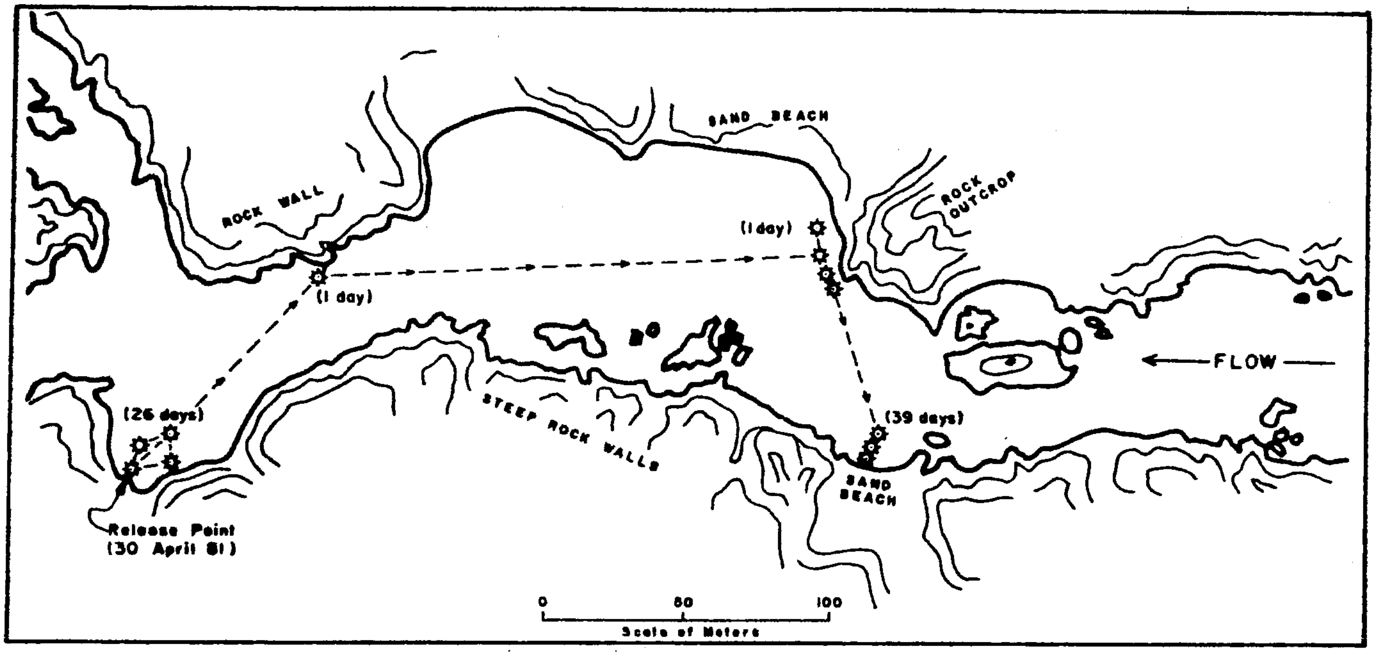

Figure 4. Movement of a male *Gila cypha* in Black Rocks, Colorado, monitored by radiotelemetry.

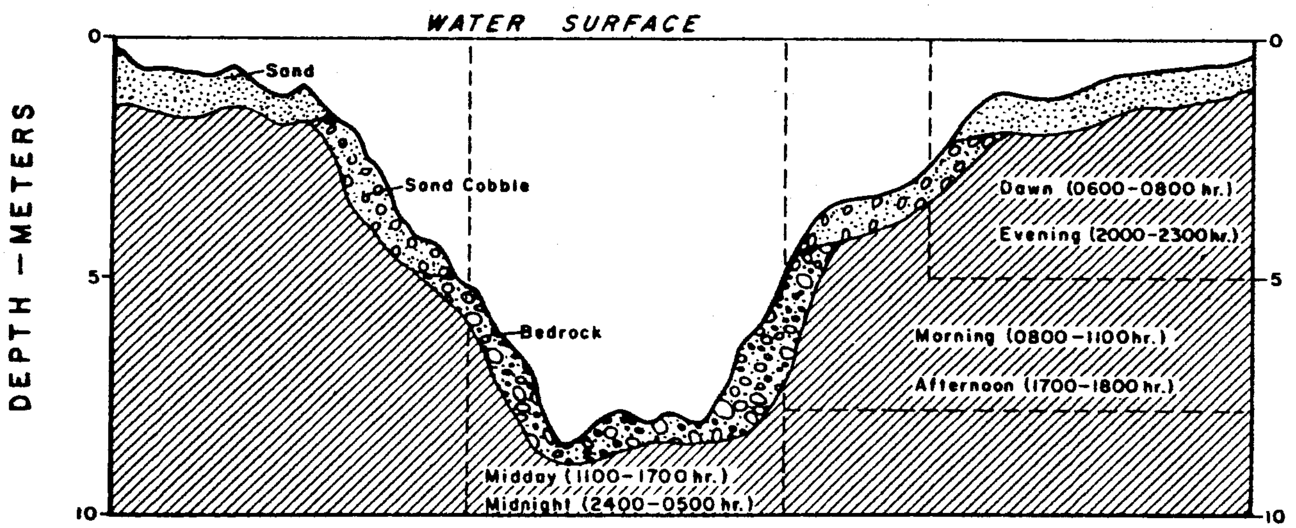

Figure 5. River depths and regions occupied by *Gila cypha* monitored by radiotelemetry in Black Rocks, Colorado, May-July 1981.

REPRODUCTION

Humpback Chub

Natural reproduction of humpback chub occurs in Black Rocks, Westwater Canyon, the Lower Colorado River, and, apparently, Yampa Canyon. Reproduction in these areas is indicated by recent collection of young, juveniles, and subadults in the presence of adults. Little is known about the natural reproduction of humpback chub, primarily because spawning occurs at or near spring runoff, a difficult time to sample the deep, turbulent waters inhabited by the species.

Spawning in the Little Colorado River was reported in June and July, based on captures of young-of-the-year and tuberculate adults (Suttkus and Clemmer 1977), and from March through June (and possibly July) at 16-19 C, based on fish in reproductive condition and on the collection of young in June and July (Minckley *et al.* 1979). Spawning was recently documented in the lower 11 km of the Little Colorado River in June 1980 and May 1981 (Kaeding and Zimmerman 1981).

Spawning time and water conditions for humpback chub were documented in Black Rocks in 1980 and 1981. In 1980, tuberculate fish were first seen 14

May at a water temperature of 11.5 C and flow of 18,000 cfs (510 m^3/s) (Fig. 6). Seven of eight males had light orange abdomens and tubercles on their heads and paired fins. But, only two of the six females exhibited these prenuptual features. Similar tuberculation and coloration were described for the species in the Grand Canyon area (Suttkus and Clemmer 1977). Eighteen fish collected on 2 June were all tuberculate and colored at a water temperature of 11.5 C and flow of 21,500 cfs (610 m^3/s). All males produced milt, but eggs could not be naturally stripped from females. Three females, injected with a preparation of carp pituitary released 18,000 eggs (4,000; 4,000; 10,000 per fish) for transport to the Willow Beach NFH. Eggs incubated at 12-13 C in the hatchery failed to develop and died after 110 hours, while those incubated at 20-21 C hatched in 120-160 hours (Hamman 1980). Maximum daily water temperature at Black Rocks in 1980 did not reach this hatchery incubation level of 20 C until 26 June, and a mean of 20 C was not recorded until 29 June. Spent fish were found 15 June, indicating that spawning in Black Rocks probably occurred 2-15 June 1980 at water temperatures of 11.5-16.0 C and flows of 21,500-26,000 cfs (610-740 m^3/s).

Flow in the Colorado River in 1981 was unusually low, and humpback chub spawned earlier than in 1980 (Fig. 6). Tuberculate fish were found in Black Rocks on 10 April at a mean daily water temperature of 14.0 C and a flow of 4,300 cfs (120 m^3/s). Tuberculation and coloration were extensive on 15 May at 16.5 C and a flow of 3,000 cfs (85 m^3/s). Spent fish were captured 27 May, indicating that spawning occurred 15-27 May at water temperatures of 16.0-16.5 C and flows of 3,000-5,000 cfs (85-140 m^3/s). Spawning in 1981 occurred about 2 weeks earlier than in 1980, probably because of the early warm-water temperatures and the absence of a high-volume runoff to cool the water as in normal water years. Relative survival of these two year-classes is yet unknown.

Bonytail Chub

The most recent report of natural reproduction of bonytail chub was in Dinosaur National Monument in the Green River in 1959, 1960, and 1961 (Vanicek and Kramer 1969). The presence of gravid and ripe fish indicated that spawning occurred from mid-June to early July at a water temperature of 18 C. Spawning by bonytail and roundtail chub was considered spatially separated because of the absence of ripe adults of both species in the same gillnet samples (Vanicek 1967).

Spawning was observed in Lake Mohave in May 1954 (Jonez and Sumner 1954) when about 500 bonytail chub congregated over a gravel bar in 9 m of water. Females seemed to be "escorted" by 3-5 males, and eggs were broadcast randomly on the gravel shelf. A sample of 42 males and 21 females included one female that yielded 10,000 eggs. A total of 35 young bonytail chub (13-26 mm SL, UMMZ 162846) were collected by R.R. Miller and H.E. Winn 15 June 1950 from 17 km east of Searchlight near Cottonwood Landing, Nevada in the then-filling Lake Mohave. Concentrations of 30-100 adult bonytail chub were observed in Lake Powell in 1965, but no spawning activity or young were observed (Colorado River Fishes Recovery Team 1981a). The species has not been reported from Lake Powell since about 1968.

The diminished numbers of bonytail chub throughout the basin prompted collections of brood stock to assess the feasibility of hatchery culture. Adults were collected in Lake Mohave in 1979 (two females), 1980 (three females), and 1981 (five males, three females), and transported to the Willow Beach NFH. Females were successfully stripped of eggs after injection of carp pituitary. Eggs of bonytail chub, like those of humpback chub, yielded higher hatching success when incubated at 20-21 C than when incubated at lower temperatures (16-17 C and 12-13 C) (Hamman 1980).

ASSOCIATED SPECIES

A total of 42 non-native fish species and 13 natives (including 8 endemics) inhabit the Upper Colorado River System (Tyus *et al.* in this symposium). The potential negative impacts of non-native fishes on native species are acknowledged as competition for food and space, and predation on eggs, larvae, and young (Miller 1961; Minckley and Deacon 1968; Holden and Stalnaker 1975). The possible effect of foreign pathogens, for which the native and endemic species may have little resistance, should also be considered. For example, the parasitic copepod, *Lernea cyprinacea*, introduced into the Colorado River via an unknown non-native host is often found on native and endemic species. The parasite was found near fin bases of 26% of the 234 humpback chub examined from the Upper Colorado River (Table 2). The parasite was not found on young fish, but 17% of juveniles and 31% of adults were infested with 1-13 copepods. A high incidence of this parasite was also reported in humpback chub of the

TABLE 2. Occurrence of *Lernea cyprinacea* on *Gila cypha* of the Upper Colorado River, 1979-1981

Fish age (No.)	Number infested	Percent infested	Number per fish Mean	Number per fish Range
Young (16)	0	0	--	--
Juvenile (36)	6	17	1.3	1-3
Adult (182)	56	31	2.8	1-13
Summary: (234)	62	26	2.7	1-13

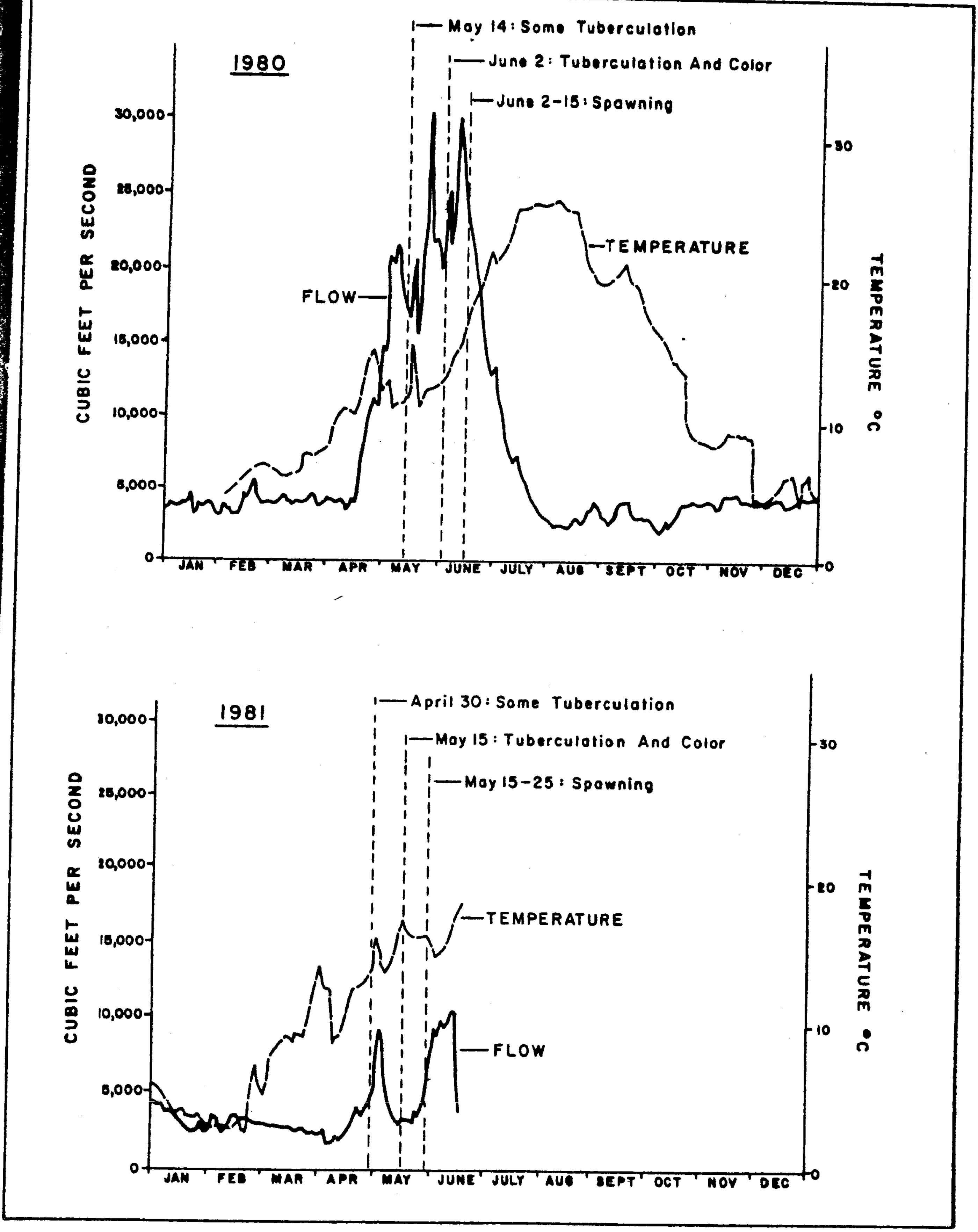

Figure 6. Water temperatures and flows associated with spawning of *Gila cypha* in Black Rocks, Colorado.

Lower Colorado River (Kaeding and Zimmerman 1981). The effect of this parasite on chubs is unknown, but it may contribute to stress that may lead to mortality.

Non-native and native fishes may be infringing upon the depleted habitat of the humpback and bonytail chub and contributing to competition, predation, and population stress. At least four sections of the Upper Colorado River, unique in depth, velocity, and fish composition, harbor humpback chub (Valdez 1980). Black Rocks and Westwater Canyon each harbors 14 species of fishes, including 6 and 5 natives, respectively (Table 3). Equal lengths of river adjacent to these restricted habitats harbor 19 and 18 species, respectively, with 6 and 4 natives. Similar differences in fish composition also occur in Cataract Canyon, an area similar to Westwater Canyon but with fewer humpback chub.

This difference in fish diversity and composition between the three restricted habitats and the surrounding river indicates that habitats unfavorable to some non-natives still exist. But, subtle depletions in flow could reduce velocities and depths and continue to render these areas favorable to more non-natives.

TABLE 3. Number of fish species associated with *Gila cy*... within and adjacent to three areas of the Upper Color... River. (Numbers of native species in parentheses)

Area	Number of associated species Within area	Outside area
Black Rocks	14 (6)	19 (6)
Westwater Canyon	14 (5)	18 (4)
Cataract Canyon	13 (6)	19 (6)

Non-natives most commonly associated with adult humpback chub in runs, eddies, and pools were channel catfish and common carp, while commonly associated natives were roundtail chub, bluehead sucker, and flannelmouth sucker. Juvenile and young humpback chub were often caught with channel catfish, common carp, red shiner, fathead minnow, and sand shiner. Native fishes often associated with juvenile and young humpback chub were bluehead sucker, flannelmouth sucker, and roundtail chub.

SYSTEMATICS

The genus *Gila* is represented in the Upper Colorado River System by *G. cypha*, *G. elegans*, and *G. robusta*. Variations or possibly hybrids of these species also occur. Adults of the three species are readily identified afield by gross morphology, but because the young and juveniles are difficult to examine afield, their identity is often considered 'tentative'. Variants or hybrids are also difficult to identify in the field. Several meristic features, including fin-ray counts, scale counts, fin lengths, nuchal hump depth, eye diameter, and squamation were used by CRFP to help identify the three species of *Gila* afield. No single meristic or set of meristics appear to readily identify young, juveniles, and intermediates.

The nuchal hump ratio, developed by Smith *et al.* (1979) for identifying adults, was used to help identify the three species. The ratio is derived by dividing the distance between the origin of the pelvic and pectoral fins by the greatest depth of the nuchal hump, which is the distance from a straight line between the highest part of the nuchal hump and dorsal tip of the snout and the frontal depression. Nuchal hump ratios for preserved specimens of *G. cypha* (6-13), *G. elegans* (15-29), and *G. robusta* (28-207) (Smith *et al.* 1979) were compared with those derived from live fish. Mean ratios for samples of *G. cypha* from Westwater Canyon (13.3) and Black Rocks (12.9) were near the upper range of ratios generally associated with the species (Fig. 7). A few small adults and large juveniles in the samples probably raised the means disproportionately; this reinforces application of the ratio only to mature adults. The methodology was further tested on a group of 35 humpback-like fish from DeBeque Canyon, Colorado. Of the 10 fish sent to R.R. Miller for examination, 6 were tentatively identified as hybrids of *G. cypha* and *G. robusta* and the remainder as *G. robusta*. The mean ratio of 18.5 for these 35 fish falls within the expected range of *G. elegans;* however, these fish fail to exhibit other features of the species, including anal and dorsal fin-ray counts. We are conducting a complete analyses of meristics, including a discriminant function analysis.

Identifying young, juveniles, and intermediates of the genus *Gila* is the paramount problem for field biologists in the Upper Colorado River System. We often capture specimens for which no confident field identification can be made, and the paucity of these endangered species precludes extensive collection and preservation for verification. Questionable specimens are being photographed for future examination.

PROSPECTS FOR RECOVERY

Bonytail Chub

The prospect for natural survival of the bonytail chub is poor. The present reduced wild population indicates a trend toward extinction, particularly since natural reproduction cannot be documented. Wild brood stock and progeny in hatcheries are the only large numbers of bonytail chub known today.

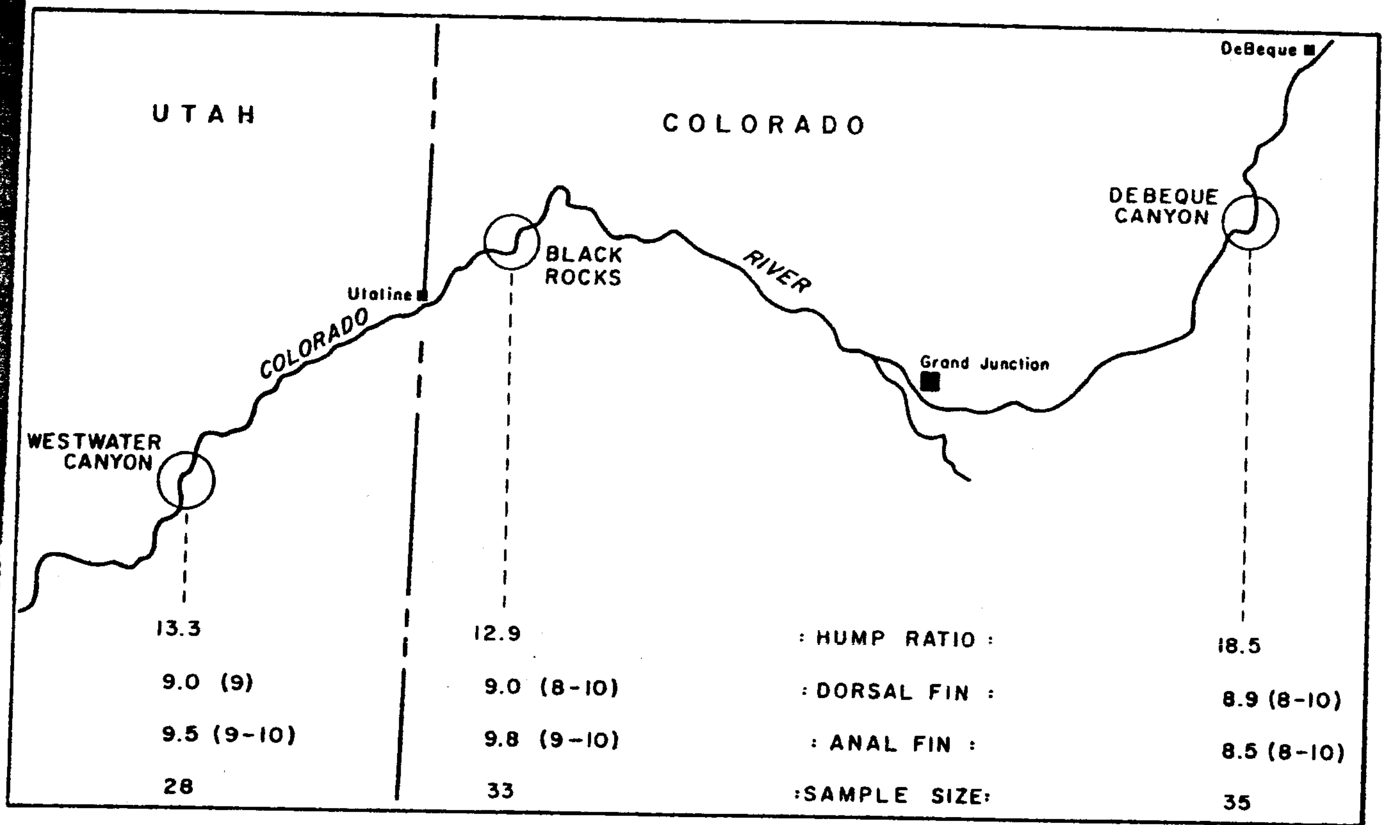

Figure 7. Mean nuchal hump ratios and fin-ray counts for adult *Gila cypha* from Black Rocks and Westwater Canyon and *G. cypha* X *G. robusta* from DeBeque Canyon.

Hatchery culture of large numbers of the species appears feasible, and release of hatchery-reared fish seems to be the only viable approach to recovery. However, the habitat presently occupied by the few surviving individuals is apparently unsuitable, as indicated by recent reductions in numbers.

Introductions of bonytail chub in Cataract Canyon on the Colorado River and either Gray or Desolation Canyon on the Green River warrant consideration. Releases would have to be made within a suitable habitat identified by experienced field biologists. This release program may be detrimental to wild stocks by increasing competition for limited habitat, introducing gene pools from a different part of the system, and enhancing the possibility of hybridization with humpback chub and roundtail chub.

The recent apparent success with hatchery-reared Colorado squawfish in the wild should not shed optimism on a similar program for bonytail chub. The Colorado squawfish is a mobile piscivore apparently capable of gaining access to most natural features of the basin, whereas bonytail chub may be like humpback chub — relatively sedentary insectivores that inhabit very restricted habitats.

Humpback Chub

The status of the humpback chub is more favorable than that of the bonytail chub. Four apparently self-sustaining populations exist in the Upper and Lower Colorado River basins. All are located in restricted habitats of relatively deep, swift water. Maintaining the biological, chemical, and physical integrity of these "islands" is critical to the survival of the species. Temperature regimes of "normal" water years (e.g., 1979, 1980) must be maintained for successful reproduction, since temperature appears critical in spawning and hatching success.

Changes in flow regime have reduced geographical barriers that isolated the species for centuries. This has allowed a breakdown of isolating mechanisms and permitted other native and nonnative fishes to invade their habitat. The presence of intermediate forms of *G. cypha* and *G. robusta* in Black Rocks, Westwater Canyon, and DeBeque Canyon, and of *G. cypha*, *G. elegans*, and *G. robusta* in Desolation, Gray, and Yampa canyons, suggests the possibility of hybridization as a result of habitat degradation. Such crosses are possible and have been documented at the Willow Beach NFH. This hybridization may threaten the integrity of the species' gene pools.

A habitat-enhancement program for humpback chub is inadvisable. Fish of all ages prefer runs, eddies, and pools near deep, swift water with silt-sand and boulder-bedrock substrate. Backwaters are also used, but few occur among the steep canyon walls. Enhancing these habitats in remote locales suitable for the species is not feasible because of limited access and the dynamic river hydraulics that can fill excavations or make unnatural changes. Boulder riprap associated with railroad and highway construction is sometimes occupied by humpback chub, but a high degree of variation, or possibly hybridization, is implicated; e.g., the population of apparent *G. cypha* x *G. robusta* hybrids in DeBeque Canyon lives among the boulder riprap of the highway system.

Supplemental introductions of hatchery-reared humpback chub are inadvisable except in one area. The introduction of hatchery-reared humpback chub into Cataract Canyon deserves consideration, since the area appears physically and biologically similar to others inhabited by the species. Introducing additional fish into areas already occupied by the species could intensify competition for food and space, and increase predation on young. Danger also exists of weakening wild stocks of one area by superimposing less rigorous stocks of another.

The problem of identifying young, juveniles, and intermediates of the genus *Gila* must be resolved if field biologists are to confidently identify live specimens. Many fish are now identified as *Gila* sp. in lieu of risking an erroneous judgement in identification. Even though the Endangered Species Act protects the listed species and their variations, an acceptable field identification procedure is necessary to enable continued protection and management of the species.

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