ENDANGERED and THREATENED FISHES of the UPPER COLORADO RIVER BASIN

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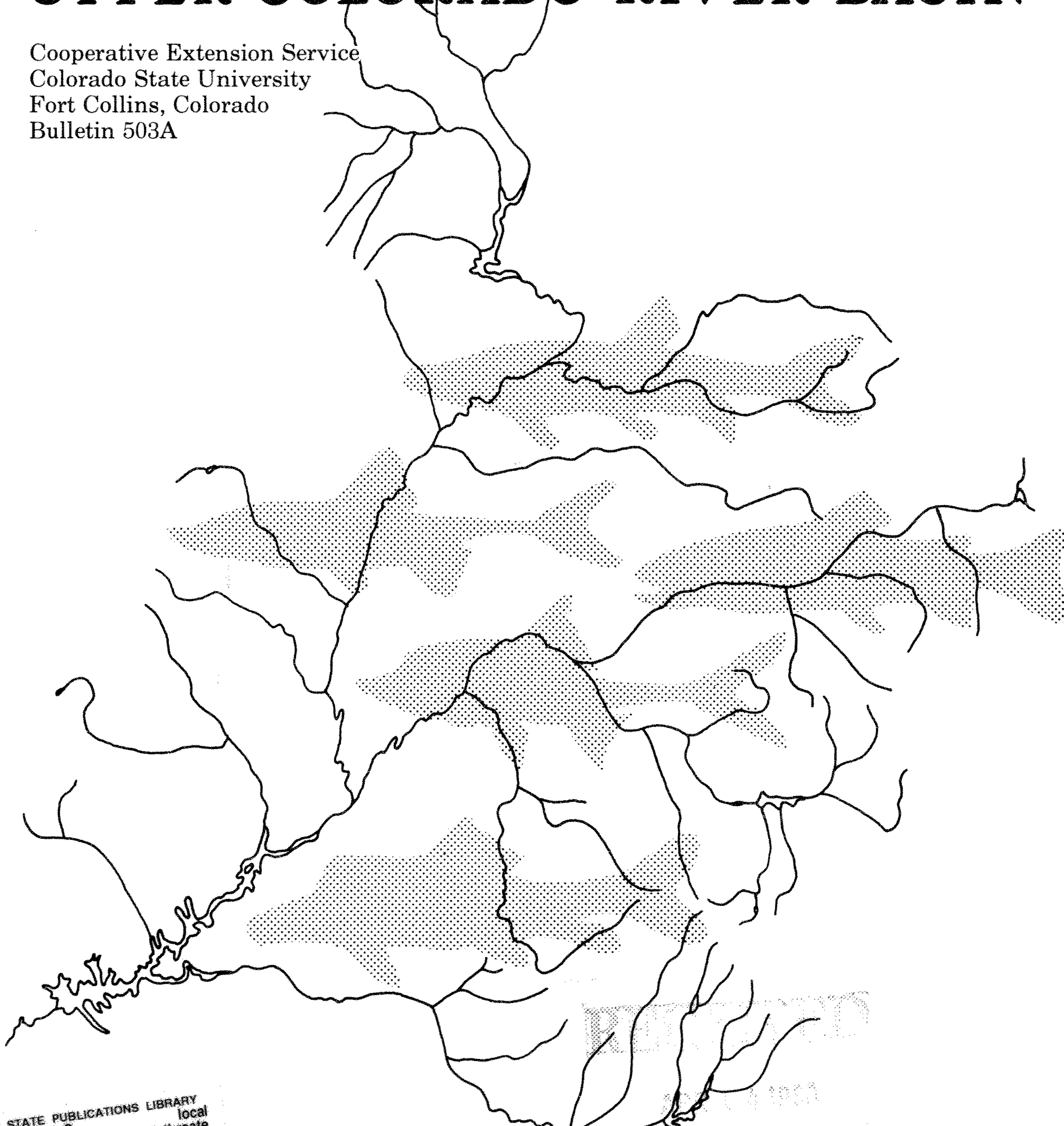

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Endangered and Threatened Fishes of the Upper Colorado River Basin

by
R.J. Behnke
and
D.E. Benson

Illustrations by Mrs. Doris Rust

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PREFACE

Endangered species often generate controversies, raise emotions, and polarize opinions when the preservation of endangered species conflicts with economic development. This is particularly true for the endangered fish species of the Colorado River basin. The water of the Colorado River is in urgent demand for agriculture and energy production. The greatest known concentrations of oil shale and enormous coal deposits occur within the basin. Three species of fish, the Colorado River squawfish, the bonytail chub, and the humpback chub, are now listed as endangered under the federal Endangered Species Act. One additional species, the razorback sucker, has been proposed for listing. The Colorado state list of endangered and threatened species includes the four above fishes plus the Colorado River cutthroat trout.

It is often asked: of what good are endangered species? How can they be beneficial to man -- especially fishes such as the squawfish, the bonytail and humpback chubs, and the razorback sucker, species of the minnow and sucker families that have so long been categorized as "rough" or "trash" fish that should be controlled or eliminated for the benefit of game fish? There are no simple answers to these questions. There are standard responses concerning the need to maintain species diversity in nature and diverse populations within a species and thus provide the raw material for evolution. It is true that the effects on many animal species from such chemical pollutants as DDT, PCB, mercury, and Kepone provided an early warning system to the dangers these chemicals hold for man. As such, endangered species may act as an indicator or barometer of environmental influences of potential harm to man. To many, the responsibility of preventing extinction as a result of man's influence is considered a duty of man's stewardship of the earth, and more practical reasons are not necessary.

When Congress passed the Endangered Species Act of 1973, it was in response to demands by the American people that the accelerated trend toward species extinction be reversed. It often is argued that extinction of species is a natural consequence of evolution and that man should not interfere with this natural process by preserving ill-adapted species that nature intends to get rid of. After all, the argument goes, dinosaurs, pterodactyls, and sabertooth tigers are no longer here. Who misses them? What must be recognized is the difference between slow natural rates of extinction (balanced with the slow evolution of new species) and a highly accelerated rate caused by man's modifications of the earth's environments.

During the past century, as the human population has increased in geometric proportions and with the rise of modern technology, the human species has claimed an ever greater portion of the earth and its resources. Man has dramatically changed the original environments on an enormous scale to provide food, energy, and the amenities of life to an ever-expanding population. The creation of urban centers for living and business, the conversion of vast land areas to agricultural production (which in turn demands irrigation and dams and chemical treatment), and pollution of soil, air, and water are all aspects of the population increase of the human species that result in harmful effects to other species.

It must also be recognized that the accelerated extinction rate caused by man differs from much of natural extinction in that the extinction of a species caused by man's influence "dead-ends" an evolutionary line. Most extinct species in the fossil record are "extinct" only because of slow, gradual change in the evolutionary line. That is, continual evolutionary change led to the creation of new species. The germ plasm or hereditary material has been continuous through time, but gradually changed from an ancestral species into its descendant species. For example, the direct ancestor of man a million years ago or more is considered to be a different species from modern man, *Homo sapiens*. If man's ancestral species had become extinct by a dead-end type of extinction, rather than a gradual evolutionary change, we would not be here. This distinction between the two types of extinction -- a dead-ending of an evolutionary line, as contrasted to the transformation of one species into another by evolutionary change -- is critical for the continued maintenance of the diversity of life.

The purpose of this bulletin is to provide basic information on the endangered and threatened fishes of the upper Colorado River basin, the reasons for their present condition, and what is being done and what might be done to enhance their chances for survival. The federal Endangered Species Act is examined and interpreted to explain where potential conflicts may arise due to the occurrence of an endangered species.

It is hoped that this bulletin will stimulate interest and appreciation of some of the unique and unusual fishes of the Colorado River that are found nowhere else in the world. The continued existence of these rare fishes will require the cooperation of diverse interest groups, as well as improved communication between persons of diverse fields of knowledge and expertise.

All future development will not grind to a halt because of such unusual fishes as the squawfish and the humpback chub, as claimed by some alarmists. Some delay, compromises, and modifications in future projects may be necessary, however, to maintain certain environmental conditions and avoid the extinction of the rare fishes.

Concerned citizens are urged to assist in gathering information on the fishes discussed in this bulletin. The areas involved cover vast expanses of habitat. Scientific collecting gear has not been highly effective in capturing fishes such as squawfish, razorback suckers, and bonytail and humpback chubs. Fishermen catching any of these endangered or threatened species must, according to the law, release them unharmed; however, a report of the catch, giving size of fish and location and date of capture should be made to a local District Wildlife Manager or to a regional office of the State Division of Wildlife. Squawfish and humpback chubs are being tagged as part of current research projects. If a tagged fish is caught, the tag number should be included in the report of the catch. Such information may provide new distribution records for a species or may lead to the discovery of a species such as the bonytail chub -- now believed extinct in Colorado.

The native fishes of the Colorado River basin received little attention until recent times. The area involved is large and the physical, chemical, and biological interactions affecting the well-being of the native fishes are complex. Thus, detailed data and documentation on cause and effect relationships to explain the decline of rare fishes are largely lacking. The assessments we make here on the basis of available information, must be considered in the realm of speculation.

1982 UPDATE

Since this bulletin was written in the summer of 1980 a considerable amount of new information has been obtained. The U.S. Fish and Wildlife Service's Colorado River Fishery Project completed three years of studies on endangered species and issued its final reports in 1982. This work will be continued until 1985 as the Colorado River Fishery Monitoring Program to refine and verify aspects of the earlier study. The Colorado Division of Wildlife's endangered species monitoring and larval fish sampling program was continued in 1981 and 1982. The use of minute radio transmitters implanted in specimens of squawfish, humpback chub, and razorback sucker, allowed for the tracking of movement which confirmed that the squawfish is a highly mobile species, capable of utilizing 200 miles or more of river during an annual cycle. The Endangered Species Act was reauthorized and amended in October, 1982.

At the end of each section we incorporate a synthesis of the new information updated to December, 1982.

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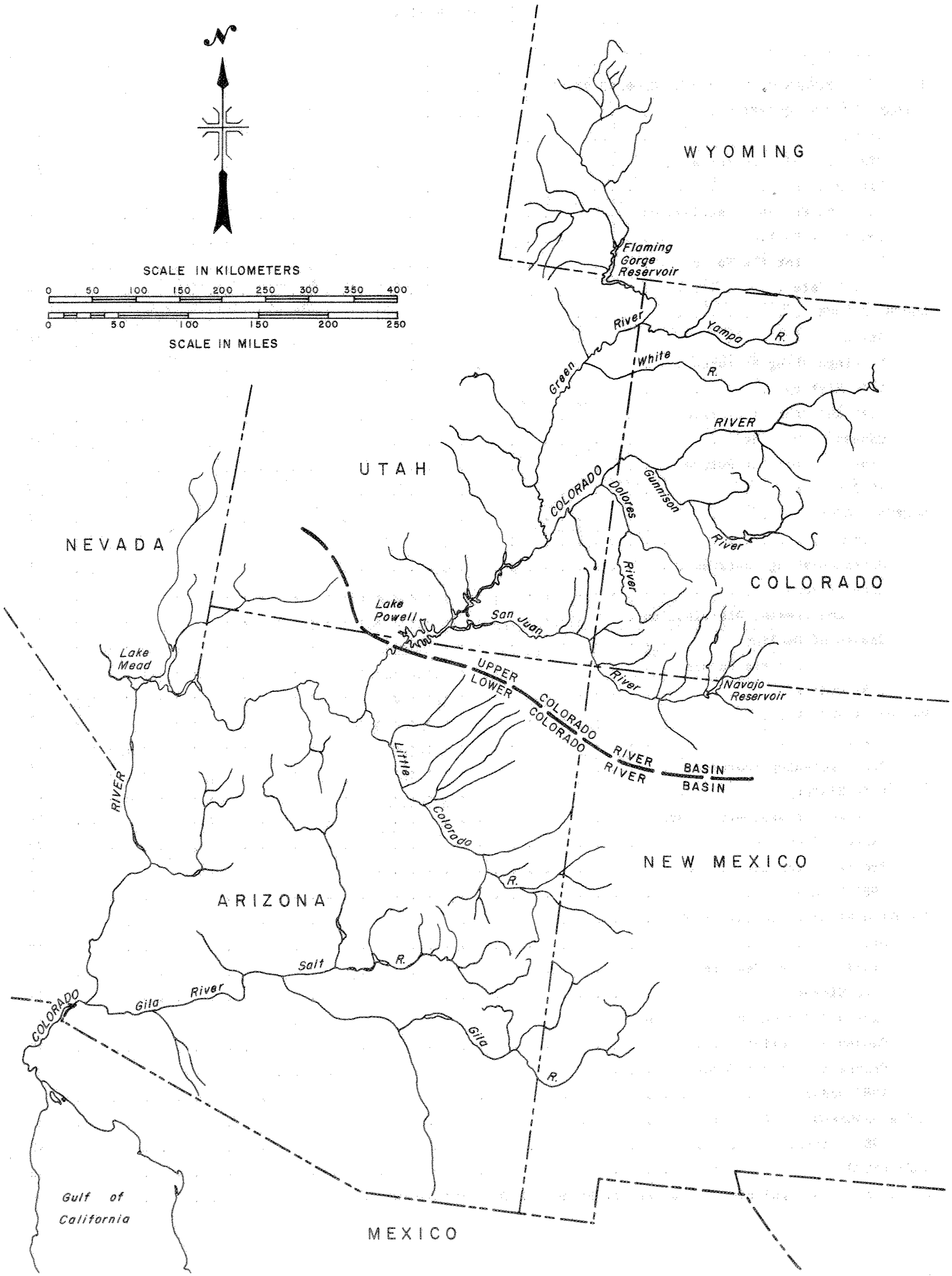
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SCALE IN KILOMETERS
0 50 100 150 200 250 300 350 400
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SCALE IN MILES
WYOMING
Flaming Gorge Reservoir
Green River
Yampa R.
White R.
COLORADO RIVER
Gunnison River
Dolores River
UTAH
NEVADA
COLORADO
Lake Powell
San Juan River
Lake Mead
Navajo Reservoir
UPPER COLORADO RIVER BASIN
LOWER COLORADO RIVER BASIN
RIVER
Little Colorado R.
NEW MEXICO
ARIZONA
Salt R.
Gila River
COLORADO
Gila R.
Gulf of California
MEXICO

ENDANGERED AND THREATENED FISHES OF THE UPPER COLORADO RIVER BASIN

INTRODUCTION

The Colorado River basin forms its headwaters high in the Rocky Mountains of northcentral Colorado (headwaters of Colorado River) and southwestern Wyoming (headwaters of Green River). Its journey from the source of the Green River to the Gulf of California extends for more than 1700 miles, and the drop in elevation exceeds 2 miles. The erosive energy of the ancient river carved tremendous canyons -- including the Grand Canyon.

The official demarcation point for water use that separates the upper Colorado River basin from the lower basin is at Lee's Ferry, Arizona, about 15 miles below Glen Canyon Dam, which forms Lake Powell. This bulletin contains information on the endangered and threatened fishes of the upper Colorado River basin. The demands for water in the lower basin, however, have greatly influenced the environmental changes in the upper basin -- namely, the creation of large dams and reservoirs.

Except for the mountainous areas, most of the Colorado River basin consists of arid and semiarid land, and much of it is true desert. Flows fluctuate wildly during a year and between wet and dry years. Historical flows at Yuma, Arizona, have ranged from lows of a few hundred cubic feet per second (cfs) to almost 400,000 cfs. Erosion is high in the basin, and enormous sediment loads are transported in most of the major tributaries to the mainstream of the Colorado. It has been estimated that before major dams tamed this wild river and settled out most of the sediment, more than 100,000 acre feet of sediment was deposited in the Gulf of California each year.

Thus, it can be surmised that fishes living, adapting, and evolving in this harsh environment, characterized by great extremes in flows, turbidity, velocities, and temperatures, would form a unique group of species. The Colorado River has had no broad connections with surrounding river basins such as the Missouri and Columbia for millions of years. This great time of isolation promoted the development of unique, often bizarre fishes specifically adapted to harsh environments. Most of the native fishes of the basin have long been isolated from their closest relatives and have undergone sufficient evolutionary change to be recognized as species endemic to the Colorado River basin -- that is, species that are native only to the Colorado basin and found nowhere else in the world. The Colorado River basin, as a whole, has the highest percentage of endemic species of any river basin in North America.

Among the unusual mainstream fishes specialized for living in the Colorado and Green River and their major tributaries are the squawfish, the bonytail and humpback chubs, and the razorback sucker. The squawfish is a predatory, pike-shaped minnow, reputedly reaching lengths of 5 to 6 feet and weights of 60 to 80 pounds. The bonytail chub and humpback chub, with their oddly streamlined shapes, are designed to cope with turbulent flows. The razorback or humpback sucker, one of the largest species in the sucker family, is characterized by a pronounced body hump with a sharp edge.

It was recognized long ago that much of the arid land in the basin could be converted to agriculture if irrigated. With the start of construction of Hoover Dam in 1930, a series of large dams and reservoirs were constructed during the next 30 years to insure a reliable supply of water for irrigation and for power generation and flood control. These dams and reservoirs extend along the mainstream from Imperial Dam, just north of Yuma, Arizona, to Fontenelle Dam, which backs up the Green River to near its source in the Wind River Mountain Range of Wyoming. The man-made reservoirs such as Lake Mohave, Lake Havasu, Lake Mead, Lake Powell, and Flaming Gorge Reservoir are completely new aquatic environments unlike any environment that the native fishes have evolved in or are adapted to. These reservoirs provide enormous recreational use and sustain attractive sport fishing for non-native species, introduced by man. Native fishes are essentially gone from the impoundments and from the cold, clear tailwaters below the dams.

The introduction of non-native fishes began almost 100 years ago, when it was recognized that the popular food and sport fishes of the sunfish family (such as the largemouth bass and crappie), the perch family, and the catfish family were completely absent from the Colorado River basin. Also, carp, several species of minnows and suckers, and rainbow, brown, and brook trout have been widely introduced.

The environmental alterations resulting from large dams converted a turbulent river of great extremes of flow, temperature, and turbidity into a series of great ponds from which cold, clear water is released below the dams at a relatively constant flow and temperature, year round. The native fishes were ill-adapted for these new conditions and were placed at a great disadvantage in competition with the non-native fishes.

The large dams and reservoirs, however, cannot be wholly blamed for the present rare status of the native fishes. Man's influence on the land and the watersheds from logging, livestock grazing, agriculture, and irrigation removed the natural vegetation, caused accelerated erosion, and greatly increased the amplitudes of flood peaks. These watershed alterations, in turn, caused great changes in the size and shape of river channels and reduced the amount of lagoon or quiet backwater habitat so important as nursery areas for the native fishes. Thus, squawfish and several other native fish species disappeared from the Gila River of Arizona and were replaced by non-native fishes. Three major interacting factors explain the present status of the native fishes of the Colorado River basin: 1) Reservoirs; 2) land and water use; and 3) the environmental changes resulting from 1 and 2 which give a competitive advantage to non-native fishes.

THE NATIVE FISHES OF THE UPPER COLORADO RIVER BASIN

Because of the long and effective isolation of the Colorado River basin from invasion of fishes from neighboring basins, only 13 species of fishes (Table 1) are native to the upper basin (that is, they occurred in the basin naturally before man introduced new species). Table 1 lists the common and scientific names of the native fishes and their status on the federal and Colorado state lists.[1]

The seven species that occur in headwater streams (cutthroat trout, mountain whitefish, the two sculpins, the two mountain suckers, and the speckled dace) also are native to other river basins such as the Columbia and Missouri river basins and the Great Basin (several separate basins where the streams never reach the ocean but drain to internal sumps, This distribution indicates that these species have invaded the Colorado River basin (or escaped from it) in relatively recent geological times, and have not been isolated long enough to evolve into different species. The remaining six species -- squawfish, three chubs, and razorback and flannelmouth suckers -- are endemic species. They have been isolated much longer, and have evolved into species markedly different from their nearest relatives in other river basins. Fossils of some endemic species more than 3 million years old have been found. All of the six endemic species also occur (or did until recently) in the lower Colorado River basin. Of the seven native but nonendemic species, only the speckled dace and the bluehead mountain sucker occur in the lower basin.

The native species have adaptive specializations that enable them to live in different environments. They are associated with specific types of habitats and are not randomly distributed throughout the system. For example, the cutthroat trout originally was limited to clear, cold waters at high elevation before it was replaced by non-native species of trout. The six endemic species, with the exception of the roundtail chub, were largely restricted to the large, main river channels of the Colorado and Green rivers and their major tributaries, such as the Yampa, Gunnison, and San Juan rivers below the foothills, where the water is warm in the summer. The roundtail chub's optimum habitat seems to be the intermediate size tributary streams.

Table 1. Common and scientific names of the native fishes of the upper Colorado River basin, and status of the species that are endangered or threatened.

Family and common	Scientific	Status[a/] Federal	Status[a/] Colorado
Salmonidae: Trout, whitefish and grayling family			
Colorado River cutthroat trout	*Salmo clarki pleuriticus*		T
Rocky Mountain whitefish	*Prosopium williamsoni*		
Cyprinidae: Minnow family			
Colorado River Squawfish	*Ptychocheilus lucius*	E	E
Humpback chub	*Gila cypha*	E	E
Bonytail chub	*Gila elegans*	E	E
Roundtail chub	*Gila robusta*		
Speckled dace	*Rhinichthys osculus yarrowi*		
Kendall Warm Springs dace	*Rhinichthys osculus thermalis*	E	
Catostomidae: Sucker family			
Razorback sucker	*Xyrauchen texanus*		E
Flannelmouth sucker	*Catostomus latipinnis*		
Bluehead mountain sucker	*Catostomus discobolus*		
Mountain sucker	*Catostomus platyrhynchus*		
Cottidae: Sculpin family			
Mottled sculpin	*Cottus bairdi*		
Paiute sculpin	*Cottus beldingi*		

[a/] E: endangered
T: threatened

Great changes in the original river environments of the Colorado River basin have favored the non-native fishes. More than 30 species have been introduced into the upper basin and now dominate most of the basin's fish communities. All of the 13 native fishes still occur in the upper basin but all have been depleted in numbers. Five species have been reduced sufficiently to be listed as endangered or threatened in Colorado (Table 1). The squawfish, bonytail chub, and humpback chub are also on the federal list of endangered species. These five species are discussed in detail in the following sections.

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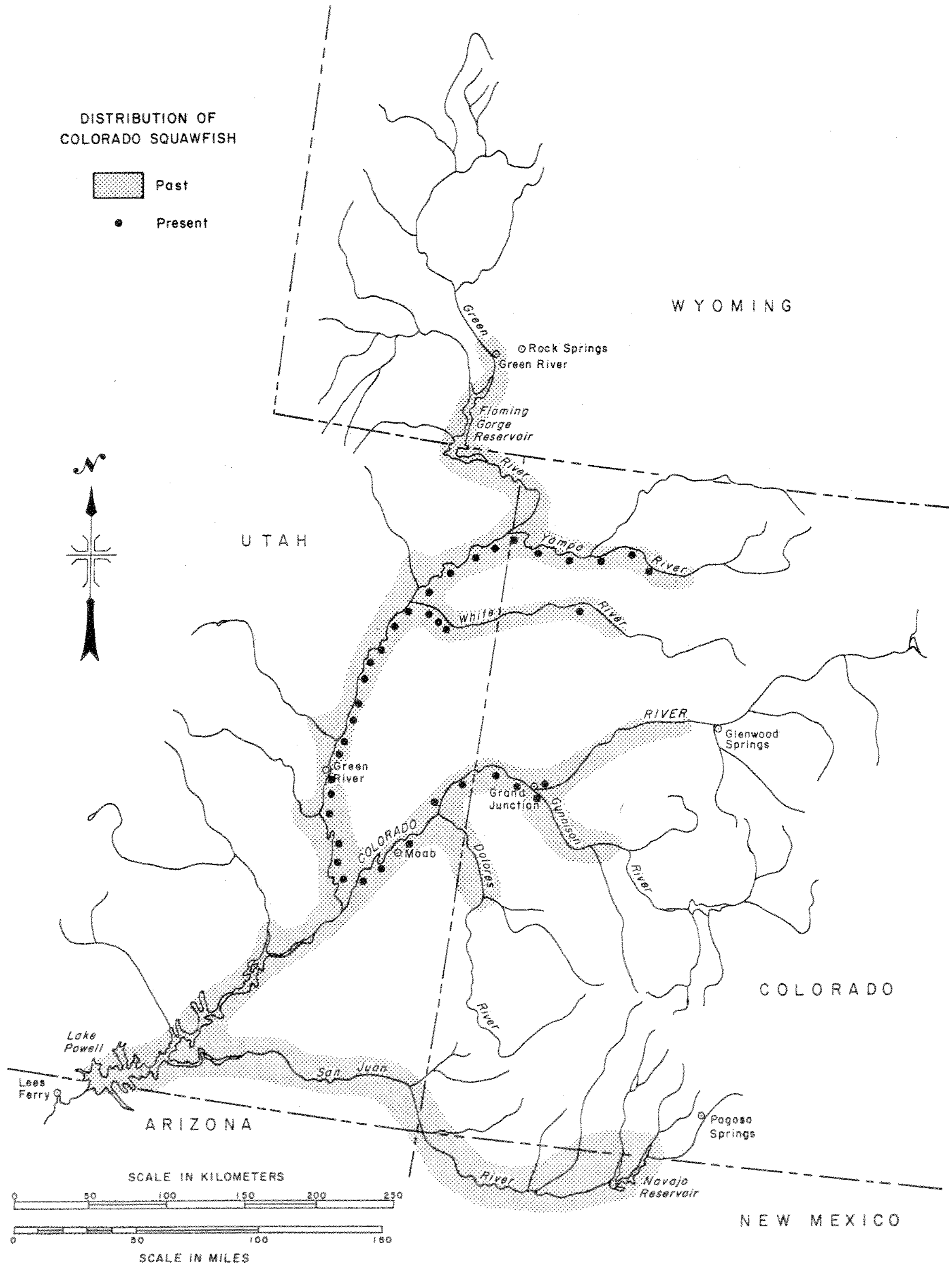
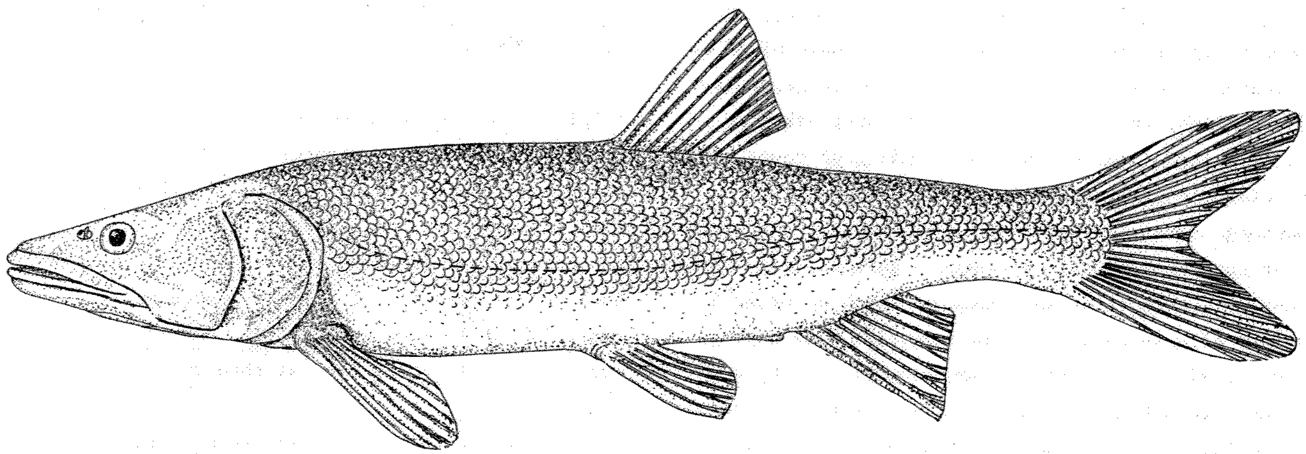
[1] The 14 fishes listed in Table 1 include 13 species with 2 subspecies of dace.

The federal list of endangered species also includes the Kendall Warm Springs dace, a subspecies of speckled dace. The Kendall dace lives only in the outflow of Kendall Warm Springs in Wyoming. The entire habitat of this peculiar population of speckled dace consists of less than 1000 feet of a small stream before it plunges over a ledge into the Green River. The Kendall Warm Springs dace is classified as endangered because of its restricted habitat and the possibility that the entire population could be wiped out from pollution of the spring.





Colorado River Squawfish
Ptychocheilus lucius

Status

Endangered on federal and Colorado lists.

Distinguishing Features

This is the largest species of the minnow family native to North America. Specimens 18 inches long or longer are easily identified by their large mouth, pike-like body shape, and olive-green back and silvery-white belly. Small specimens might be confused with the roundtail chub by inexperienced persons. Confusion is promoted because fishermen in Colorado commonly, but incorrectly, use the name squawfish for the roundtail chub. Among old-timers who once knew the squawfish, the names "Colorado salmon," "white salmon," or simply "salmon" were frequently used as the common name for the squawfish. The upper jaw extends to or beyond the middle of the eye in the squawfish, but only to a point in front of the eye in the roundtail chub. Also, in young squawfish to a length of 8 to 10 inches, a dark blotch occurs on the base of the tail. This blotch is absent in the roundtail chub. Appendix I illustrates the characters useful for distinguishing the squawfish from the roundtail chub.

Life History

The largest known specimens of squawfish seen in recent years have been about 3 feet long and have weighed about 15 pounds. It appears that the present growth rate is much less than it was under the original, unmodified conditions in the Colorado River basin and before non-native fishes became predominant over the native species. The reduced growth rate in squawfish may be due, in part, from a change in the prey species they consume, which was a result of a replacement of the larger, native prey species by smaller, non-native fishes. The possible introduction of non-native parasites, brought into the basin in non-native fishes, might also contribute to reduced growth rates. Unverified weights of 80 to 100 pounds are given in the literature. Judging by statements in the literature and from the size of squawfish bones found in ancient Indian sites, the length the largest squawfish once attained was about 5 to 6 feet. The plotting of a length and weight curve based on squawfish specimens between 1 and 10 pounds, and projection of the curve to 5- and 6-foot lengths, indicates that a squawfish 5 feet long would weigh nearly 80 pounds and a 6-foot specimen about 130 pounds. There is much room for error in such projected calculations, but it can be surmised that the largest squawfish once attained a weight of 60 to 80 pounds.

The squawfish is a predator; its food is mainly other fishes. In its first year of life, young squawfish feed on small invertebrate animals in quiet backwater areas and side channels off the main river. As it grows, fish become more important in its diet. After it reaches a length of about 8 inches, fish become the predominant food.

The maximum age of squawfish collected in recent years is about 10 to 12 years. The fish mature and spawn at an age of 6 or 7 years and a length of 18 to 20 inches. Because no one has observed the spawning of squawfish, the precise type of habitat selected for spawning is not known. The finding of young squawfish in quiet backwater areas suggests that spawning takes place in river sections near the backwater nursery habitat. Spawning occurs in early or midsummer, when water temperatures reach about 70°F. It generally is believed that squawfish made major spawning migrations before they were blocked by dams, and that this behavior was the reason for their being called "salmon." Adult squawfish favor deep areas of large river channels from which they can move out to adjacent reaches and feed on other fishes. Squawfish and razorback suckers were the fish most highly valued as food by the early settlers and miners in the Colorado River basin. They were caught and marketed by local commercial fishermen. When they were abundant, squawfish were frequently caught on bait or lures by anglers.

The nearest living relatives of the Colorado River squawfish are three other species of squawfish native to the Columbia River, Sacramento River, and Oregon coastal rivers. None of the other species reach a size comparable to that of the Colorado River squawfish. The other species are not such strict predators (feeding more readily on invertebrate animals), and occupy a wider variety of habitats. In contrast to the Colorado River squawfish, the related species are flourishing to such an extent that they are considered a nuisance because they compete with game fishes. When reservoirs are constructed in the Columbia River basin, the Columbia squawfish often becomes the dominant species, despite efforts to control its numbers. It responds in a most positive manner to man's alteration of the environment and to the presence of non-native fishes. Although the general appeareance of all four species of squawfish is similar, there obviously must be large differences in life history and ecology between the Colorado River squawfish and its relatives that have caused the Colorado River squawfish to fare so poorly when subjected to environmental change and non-native fishes.

Past and Present Distribution

Originally, the squawfish was found throughout the Colorado River basin, in the mainstream channels of the Colorado and Green rivers and the large tributaries such as the Gila, San Juan, Gunnison, and Yampa. Historically, the distribution of squawfish would begin in the larger, warmer waters at lower elevation, at the lower limits of distribution of trout and whitefish. The habitat of the squawfish was originally shared with the bonytail chub, the flannelmouth sucker, and the razorback sucker. Negative environmental changes causing the decline in squawfish distribution and abundance can be grouped into two categories: dramatic and catastrophic changes, such as the creation of a large impoundment; and gradual, cumulative changes from land and water use practices influencing habitat through changing flow regimes.

The advent of large mainstream dams, initiated by Hoover Dam in 1930 and proceeding to the completion of Glen Canyon and Flaming Gorge dams in 1963, caused a rapid decline in squawfish abundance and distribution. Only one squawfish has been found in the entire lower Colorado Colorado River basin since 1968. After the closure of Flaming Gorge Dam and the subsequent releases of cold water, squawfish were eliminated from the upper Green River downstream to a point below the confluence with the Yampa River. This section of the Green River, from the Yampa River to the confluence with the Colorado, is about 200 miles long and is now the greatest stronghold of the squawfish. This is the only area where successful reproduction (as indicated by the collection of young fish 1 or 2 years old) has been consistently found in the past few years. From 1975 through 1979 several adult squawfish were found in the Yampa River, upstream to a point above Juniper Canyon. In the White River, adults were frequently found in the lower reaches in Utah, and two were captured just above Piceance Creek in Colorado. In the Gunnison River, a few adult squawfish still occur in the lower reaches near the town of Whitewater. A remnant population may occur in the San Juan River between Lake Powell and Navajo Reservoir in Utah and New Mexico. Squawfish are found sporadically in the Colorado River up to Plateau Creek, about 15 miles above Grand Junction. In recent years many captures along the Colorado River have been from gravel excavation ponds connected to the main river.

Except in the Green River below Jensen, Utah, and the Colorado River below Westwater Canyon, Utah, there has been little evidence of successful reproduction for the past several years in any of the locations where adult squawfish are found. Most specimens have been at least 6 years old or older.

Causes of Decline

The most obvious and clearly identifiable factor contributing to the decline of squawfish is the large dams and reservoirs that converted hundreds of miles of large-river habitat into great impoundments. The preservation of native fishes was not considered in the planning and operation of these projects. Squawfish and other native fishes do not reproduce successfully in large reservoirs. The adults present in the river when a dam is constructed may continue to live in a reservoir, and may thrive and grow, but the population consists of fewer, larger, and older fish each successive year until they all die of old age. The largest known squawfish caught in relatively recent times (34 pounds) was taken in Lake Mead about 35 years ago. Thus, there is no doubt that squawfish can live in reservoirs but they have not maintained themselves by natural reproduction.

Reservoirs release cold water (40° - 50°) from great depths. These cold tailwaters below dams support trout fisheries but they are avoided by squawfish. Releases of cold water from Flaming Gorge Dam effectively eliminated squawfish from 65 miles of the Green River below the dam. Only after the Green River is warmed by the flow from the Yampa River do temperatures reach 70° F or more in the summer and make reproduction possible. Cold-water releases from Glen Canyon Dam apparently eliminated the last squawfish from the Grand Canyon area of the Colorado River.

Land-use practices, irrigation, and channelization drastically alter flow patterns and river channel characteristics, and eliminate the quiet backwater nursery areas to a point that suitable squawfish habitat is no longer present. Evidently, this sequence of events led to the elimination of squawfish from the Gila River of Arizona. These gradual, cumulative impacts on habitat are much less dramatic and not as obvious as the more sudden changes created by a large dam and reservoir, but the end result can be similar in relation to the continued existence of squawfish.

In other instances, such as in the Yampa River, squawfish have declined in abundance, and virtually no young squawfish have been found for several years. Yet, no large dams are directly involved nor have any great changes occurred in the flows, temperatures, or water quality of the Yampa River. That is, for the Yampa River, no physical or chemical changes can be pointed to as suggesting a cause-and-effect relationship acting against the squawfish. After 1968, the increasing volume of cold water from Flaming Gorge Reservoir became an effective block to squawfish moving up the Green River and into the Yampa River for spawning. This must be taken into account when considering the causes of squawfish decline in the Yampa River. However, there is good habitat for adult squawfish in certain deepwater sections of the Yampa River such as Cross Mountain Canyon and Juniper Canyon. Adult squawfish (6 to 10 years old) are found throughout the year in the Yampa River. No indication of successful reproduction and recruitment of young squawfish into the Yampa River population has been found despite intensive search. In this case, a biological change must be considered -- namely, the influence of non-native fishes.

Inasmuch as non-native fishes have lived with the squawfish in the Yampa River for a long time and the squawfish formerly reproduced successfully there, one possible cause of reproductive failure in recent years might be attributable to a non-native species that has become established in the Yampa River in relatively recent times -- the redside shiner. This species was introduced from the Columbia River basin and was first recorded in the Yampa River in 1961. It rapidly proliferated to become a dominant species by the 1970's. It prefers waters of low velocity -- the quiet side channels and backwater habitat that are required as a nursery area for newly hatched squawfish. Because the redside shiner spawns earlier in the year than the squawfish, the young shiners get a head start and quickly saturate the habitat needed by young squawfish. The redside shiner is absent from the Desolation Canyon area of the Green River, where the most consistently successful reproduction of squawfish still occurs.

However, the cause-and-effect relationship of the redside shiner on squawfish is actually not as clear-cut as it might appear. Squawfish reproduction has been severely limited in the Colorado River above and below Grand Junction for several years; yet the redside shiner does not occur in the Colorado River. Redside shiners provide an abundant food supply for Yampa River squawfish. Previous studies in the Green River revealed that the redside shiner was the major component in the diet of squawfish. The key to restoring a viable, self-perpetuating squawfish population in the Yampa River appears to be a matter of finding ways to favor reproduction and survival of young squawfish to 2 and 3 years of age when they would become effective predators on the small non-native fishes. The evidence of harmful effects of non-native species on the squawfish is largely circumstantial and much is yet to be learned on the subject.

Prospects for the Future

When a species is listed as endangered by the federal government a Recovery Team is usually appointed, made up of state and federal biologists and often biologists from universities to develop a Recovery Plan. The objective of a Recovery Plan is to provide directions and guidelines for management. If successful, the abundance of the species will increase to a point where it is no longer endangered or threatened and can be removed from the list.

The development of a workable Recovery Plan for squawfish is not a simple matter. Although such a plan has been written, the only clearly defined program in the plan to increase squawfish abundance is artificial propagation in hatcheries. The complex issue of interaction of the squawfish with its physical and biological environment, and how various factors may be manipulated to benefit the squawfish, is included under the title of "development of habitat management plans" in the Recovery Plan. The problems of developing a workable habitat management plan and implementing it have not yet been resolved. Toward this goal, the U.S. Fish and Wildlife Service, supported by funds from the U.S. Water and Power Resources Services (formerly Bureau of Reclamation), has initiated a large-scale study of squawfish and humpback chubs. This study is designed to obtain the information needed to develop habitat management plans, to provide the basis for the planning and operation of future water development projects in the upper basin, and to seek ways in which future environmental modifications might benefit the squawfish. The U.S. Bureau of Land Management and the Colorado Division of Wildlife have also been conducting studies and monitoring programs on the squawfish.

Squawfish can be readily propagated in hatcheries. Hormone injections are necessary to induce spawning. Young squawfish feed on the same food fed to trout, and large squawfish feed on fish. Squawfish have been spawned and raised at the Willow Beach National Hatchery, Arizona. Hatchery propagation, however, must be considered only as a stopgap measure in the preservation of squawfish. It is obvious that the stocking of hatchery reared fish in areas where the squawfish once occurred but is now gone will not result in a self-sustaining population unless the factors causing the elimination of the squawfish in the first place can be reversed or modified. Ways must be found to favor successful reproduction of squawfish in natural environments. Merely trying to maintain the status quo by strict protection of habitat where squawfish still occur will not do the job of getting the squawfish off the endangered species list.

Squawfish will play an important role in the planning and operation of any future dams and water development projects in the upper basin. Flow and temperature releases from dams can be planned to favor squawfish instead of trout. Successful reproduction might be favored by the creation of artificial areas where natural nursery sites no longer exist. Methods of control and replacement of potentially harmful non-native fishes will probably be necessary in areas such as the Yampa River, before successful reproduction of squawfish can be established.

The prognosis is that the squawfish can probably maintain a healthy and viable population indefinitely in the Green River below the mouth of the Yampa as long as the present environmental conditions are maintained. The probability of increasing the abundance and distribution into other areas, where the squawfish has been eliminated or exists in only small numbers, depends on the successful application of creative and holistic thinking and work.

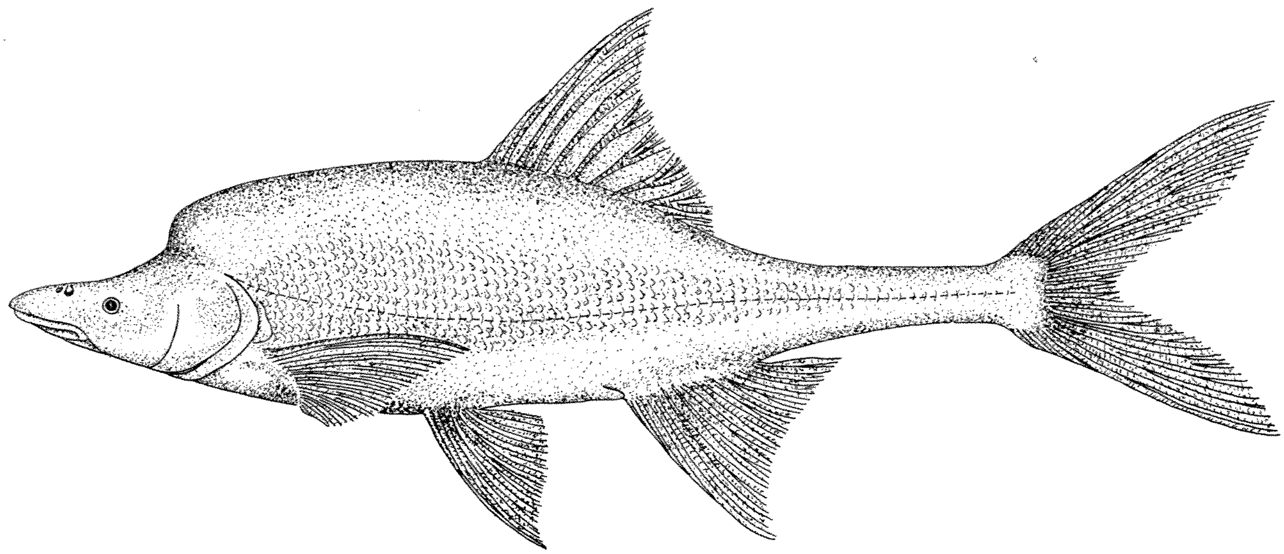
1982 UPDATE

During recent years a great amount of both field work and laboratory studies have been devoted to the Colorado squawfish. Radio transmitters inserted into the body cavity of large specimens allowed their movements to be tracked. Long distance movement was found to be common, especially as spawning season approached. Some squawfish moved up the Green River into the Yampa River; down the White River, up the Green River, and into the Yampa; from the upper Yampa to the lower Yampa. One squawfish implanted with a radio transmitter in the upper end of Lake Powell in 1982, moved about 200 miles up the Colorado River to a probable spawning site near Clifton, Colorado. A significant finding of the radio tracking study indicates that preferred spawning habitat for squawfish is evidently rare in the upper basin and the spawning fish will travel great distances to find these preferred sites with the proper combination of depth, velocity and substrate type. Two major spawning areas have been identified; one area is the lower 20 miles of the Yampa River, and the other occurs in the Colorado River above the state line to Clifton. After spawning, movements of the adult fish are less pronounced and more sporadic.

The White and Gunnison rivers and the Upper Yampa River provide areas for feeding and growth for some fish. The Green River was found to be extremely important for young squawfish. Thousands of young squawfish, born the same year (young-of-year fish), were found in the Green River. Young-of-year squawfish were found in much lesser abundance in the Colorado River and lower Yampa River. The Green River below the mouth of the Yampa is the principal nursery area for squawfish. After the outlet works at Flaming Gorge Dam were modified to increase downstream water temperatures in 1978, the average summer water temperatures in the Green River increased to historic pre-Flaming Gorge levels, as recorded at Jensen, Utah. In subsequent years, a dramatic increase in the abundance of young-of-year squawfish occurred in the Green River from Ouray, Utah, to the confluence with the Yampa River.

It was mentioned in the previously written section that virtually no young squawfish had been found in the lower Yampa River since 1968. In late 1980 fish collections in the lower Yampa River found that the non-native redside shiner was rare and was being replaced by the non-native red shiner, another minnow species of relatively small size. The 1980 collections also found several young-of-year squawfish in the lower Yampa River. More young-of-year were found in the Yampa in 1981 and 1982. Young-of-year squawfish most commonly are found together with red shiners, but almost never with redside shiners. Evidently, red shiners and young squawfish are compatible when coexisting in the same habitat.

Continued advancements have been made in hatchery propagation of squawfish. The Dexter, New Mexico, National Fish Hatchery is now devoted to the propagation of endangered and threatened species of Southwestern fishes. The Dexter Hatchery provided 30,000 squawfish of 2-3 inches in length for stocking in the Colorado River below Grand Junction during October, 1982. These hatchery-reared squawfish each had a minute magnetic tag implanted in their snout before stocking so that their subsequent movement and fate could be monitored. It was found that largemouth bass and sunfishes preyed heavily on the newly stocked squawfish where they had the opportunity. The prevalence of bass and sunfishes in the larger, deeper backwater and off-channel habitats along the Colorado River and the virtual absence of these species in the Green River, suggests why the Green River produces so many more young squawfish than does the Colorado River.



Humpback Chub
Gila cypha

Status

Endangered on both federal and Colorado lists.

Distinguishing Features

As the name implies, a prominent hump on the body immediately behind the head characterizes this species. The hump of the humpback chub differs from that of the razorback sucker in being rounded and not supported by internal bone; in the razorback sucker the hump is sharp edged and has a bony structural support. The degree of development of the hump is highly variable. The humpback chub has a fleshy snout which protrudes over the lower jaw; large, streamlined fins; and a small eye -- smaller than the eye of roundtail or bonytail chubs of similar size. The caudal peduncle (the thinnest part of the body, just in front of the tail) is thicker in the humpback chub than in the bonytail chub, but thinner than in the roundtail chub. Hybridization of the humpback chub with both the bonytail chub and the roundtail chub has been reported. As a result, positive field identification of the humpback chub is not always possible, even for the experienced biologist.

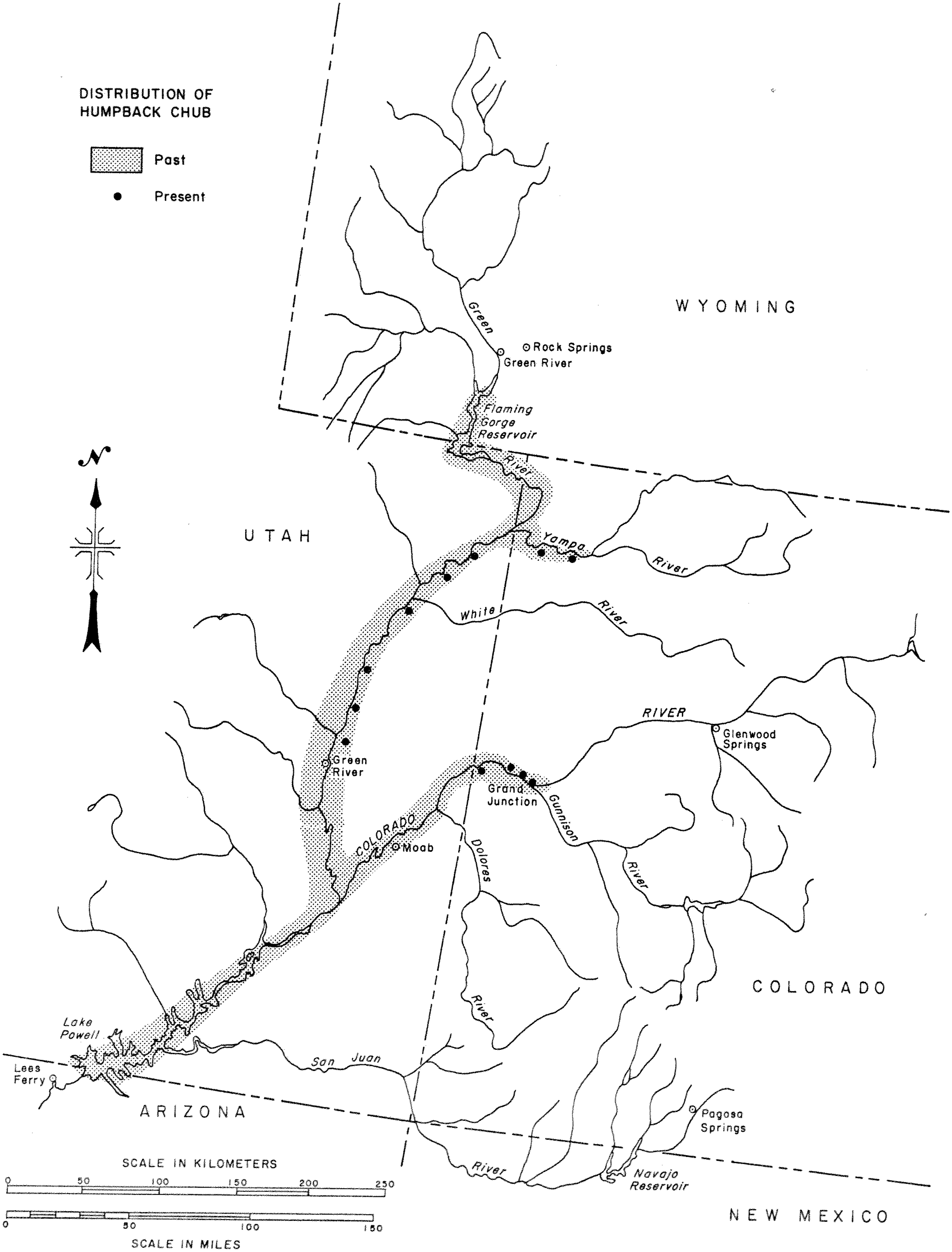
Life History

The humpback chub was not known to science until 1946, when a specimen from the Grand Canyon was described as a new species. It was never a common fish because of its habitat restrictions. Humpback chubs occur in river sections that contain swift, deepwater areas, typically in canyons. Because of its rareness, little is known about its biology. Apparently it feeds on invertebrate animals and is sometimes caught by fishermen on bait such as grasshoppers or worms. In the Little Colorado River of Arizona, humpback chubs have been observed feeding on food scraps thrown into the water by picnickers. The humpback chub may feed on the surface of the water, although the peculiar body shape seems designed to maintain stability on the bottom in turbulent flow. Its body may be designed to facilitate up and down movements, so that it can feed on a variety of foods at different depths from the bottom to the surface.

The maximum size attained by humpback chubs is about 16 to 18 inches. Young humpback chubs prefer quiet backwater areas similar to those used by young squawfish. No one has yet observed the spawning of this species, but chubs ready to spawn were observed in water of about 65° F, suggesting that they spawn slightly earlier than squawfish. Most of the prime humpback chub habitat in the canyon areas of the basin is now covered by reservoirs. As with the squawfish, adult humpback chubs continued to live in reservoirs, but they became older and fewer until they finally disappeared because they did not reproduce.

Past and Present Distribution

The original distribution of the humpback chub is not known with certainty, but it is assumed to be


DISTRIBUTION OF
HUMPBACK CHUB
Past
Present
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
Green
Rock Springs
Green River
Flaming
Gorge
Reservoir
River
Yampa
River
White
River
RIVER
Glenwood
Springs
Green
River
Grand
Junction
Gunnison
River
COLORADO
Moab
Dolores
River
San Juan
River
Lake
Powell
Lees
Ferry
Pagosa
Springs
Navajo
Reservoir
SCALE IN KILOMETERS
0
50
100
150
200
250
0
50
100
150
SCALE IN MILES

similar to that of the squawfish in the main river channels of the Colorado and Green rivers. Chubs were restricted to swift, deepwater areas, mainly in canyons, and did not occur far up tributary streams. The greatest known concentration of this species now occurs in the lower few miles of the Little Colorado River, in the Grand Canyon area of Arizona. Perhaps the releases of cold water from Lake Powell have forced most of the humpback chubs from the main Colorado River in Grand Canyon into the warmer Little Colorado.

In the upper basin, humpback chubs occur sporadically in the Colorado River up to Palisade, Colorado, about 10 miles above Grand Junction. The greatest concentration occurs in the Black Rocks area of Ruby Canyon, about 25 miles below Grand Junction, where turbulent flows create a pool almost 60 feet deep at low water levels. In the Green River, the humpback chub occurs below the mouth of the Yampa, and is concentrated in the Desolation Canyon area. It has been recorded from the lower Yampa River in Dinosaur National Monument.

Causes of Decline

Because the humpback chub had a restricted distribution and thus was always relatively rare, there is not much evidence of a decline except where reservoirs were constructed. The deepwater habitat favored by this species is not easily sampled by standard methods of fish collecting. As sampling techniques improve and more is learned about humpback chubs, more populations probably will be discovered. The most abundant known population, in the Little Colorado River, was not discovered until 1975.

There has been considerable concern that the humpback chub may lose its identity as a result of hybridization with bonytail and roundtail chubs. It now seems probable that most of the specimens formerly believed to be hybrids actually showed only normal variation in the degree of hump development. Some specimens, however, probably are hybrids. The bonytail chub now is so rare that it can be discounted as a significant source of possible hybridization. The roundtail chub, however, is common in the Colorado River in Colorado and occurs with the humpback chub in Ruby Canyon, where some intermediate (hybrid?) specimens have been taken. The roundtail chub is absent or occurs rarely in humpback chub habitat in the Green River or in the Little Colorado River. Thus, overall, the threat to the integrity of the humpback chub species from hybridization is probably not as great as was once believed.

The deepwater areas preferred by humpback chubs are also a preferred habitat for non-native channel catfish. Large populations of catfish and carp share the Ruby Canyon habitat with the humpback chub.

Prospects for the Future

A Recovery Plan has been written for the humpback chub, but, as with the squawfish, the main emphasis was placed on hatchery propagation as the only clearly defined technique to increase abundance. Humpback chubs have been transported to the Willow Beach National Fish Hatchery, Arizona, for an attempt at artificial propagation. It is likely that additional populations will be found when more of the deepwater canyon areas in the upper basin are more thoroughly sampled. Fishermen can be of assistance in this regard by reporting catches of humpback chubs. Good humpback chub habitat is also good channel catfish habitat, and the chub can be caught on the same bait often used for catfish. Humpback chubs must, of course, be released, but the Colorado Division of Wildlife should be notified of the catch, particularly if it is outside of the Ruby Canyon area of the Colorado River. A documented angler's catch (with a photo, if possible) may provide new distribution records and lead to the discovery of new populations of this rare fish.

A humpback chub preservation and restoration program is yet to be started, but it will probably consist of the identification of all areas where populations still occur, so that the present environmental conditions in those areas can be maintained. It would be extremely difficult to establish humpback chubs where they do not now exist. They may now inhabit all suitable areas where self-sustaining populations can be maintained under present environmental conditions. The outlook is not encouraging for expanding the distribution and abundance of humpback chubs by establishing new self-sustaining populations. Their habitat requirements are highly restrictive. Possibilities should be looked for, however, where deep channel areas have been created by bridge or highway construction, forming suitable habitat beyond the present limits of distribution. In such situations, introduction of the humpback chub might result in the successful establishment of a new population. Valuable information could be obtained from experimentation designed to establish new populations. There is little doubt that the humpback chub lost most of its best habitat to reservoirs such as Lake Powell and Flaming Gorge, but the prognosis is that this species is not as close to extinction as was commonly believed a few years ago.

1982 UPDATE

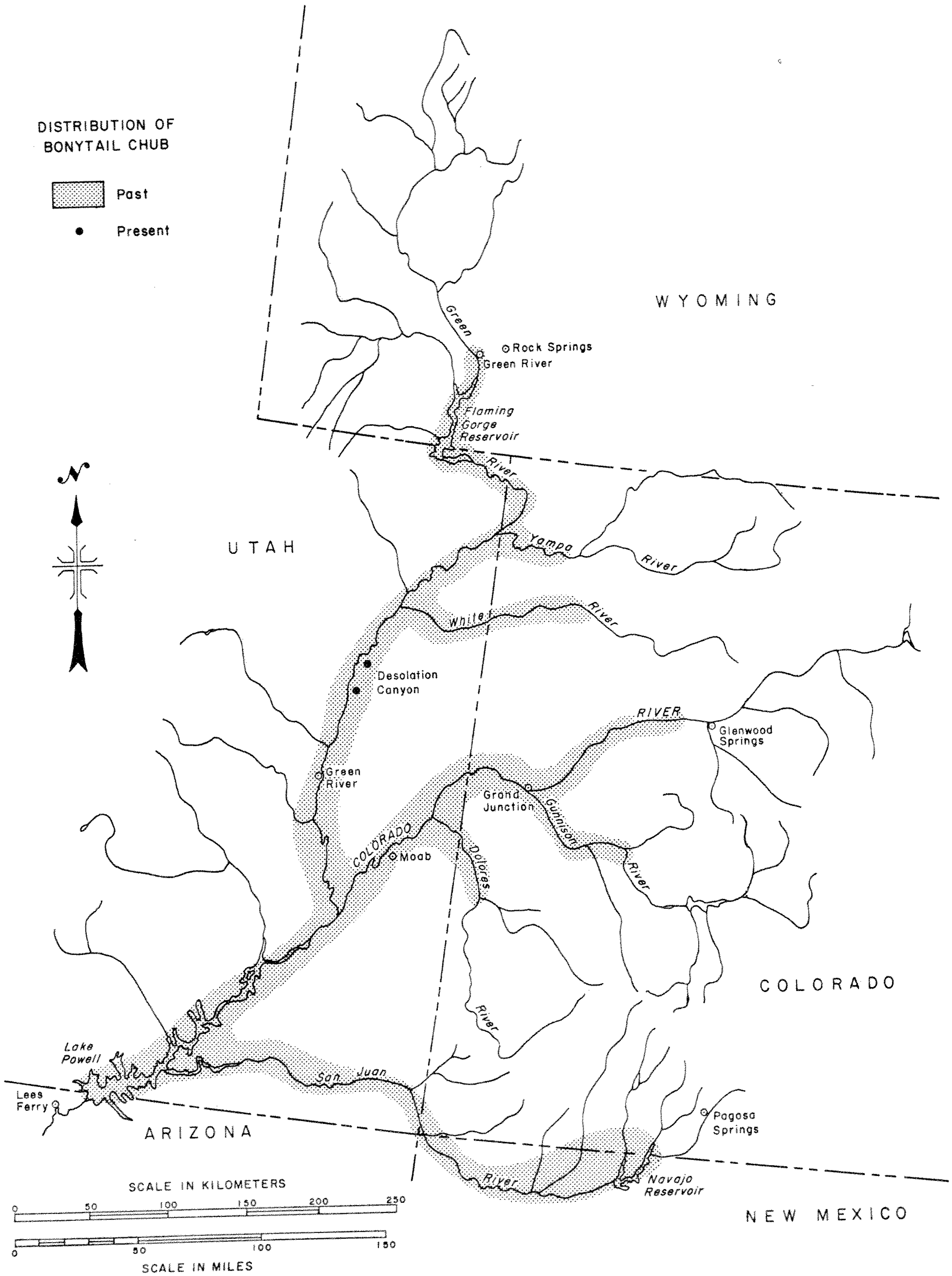
Intensive sampling since 1980 failed to discover any new concentrations of humpback chub except for the Colorado River in Westwater Canyon, Utah a few miles below the state line. Movement of a tagged humpback chub from Westwater Canyon to Ruby Canyon, a distance of 13 miles, indicates that the humpback chub of Ruby Canyon and Westwater Canyon can be considered as a single population because of interchange between the two habitats. Most humpback chub, however, exhibited little movement as revealed by tagged fish. Most of the tagged fish that were recaptured moved less than half a mile from the point of original capture. Evidently, all life history needs can be met in the relatively restricted zone of the Colorado River in the Black Rocks area of Ruby Canyon.

Humpback chub were found in deep areas of the Green and lower Yampa rivers in 1981 and 1982 but only sporadically. There has been no indication that any other sites contain a high abundance of humpback chub comparable to their numbers in the Colorado River at Black Rocks.

Laboratory studies demonstrated that the humpback chub is a hardy species. It proved more resistent to the effects of organic and inorganic toxic compounds than did non-native fishes such as channel catfish, fathead minnow, and bluegill. Humpback chub tested for tolerance to total dissolved solids (salinity) showed no avoidance of the highese levels used in the experiments, 11,600 parts per million, or about one-third the salinity of the ocean.

The hardiness of the humpback chub as revealed by the laboratory studies indicate why it is so abundant in the Little Colorado River, Arizona. The environmental extremes characterizing the Little Colorado River are so harsh for fish life that few other species are able to tolerate these conditions.

The peculiar body shape of the humpback chub essentially restricts high population abundance in the upper basin to the unique deepwater habitat sites of the Colorado River in Westwater and Ruby Canyons. A flow regime for the Colorado River, necessary to maintain the unique habitat characteristics in the canyon areas, is, as yet, unknown. The U.S. Fish and Wildlife Service stocked several thousand hatchery-raised humpback chub into the Colorado River in Cataract Canyon, Utah, in 1980 and 1982 in an attempt to increase humpback chub abundance in this section of the Colorado River.



DISTRIBUTION OF
BONYTAIL CHUB
Past
Present
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
Green
Rock Springs
Green River
Flaming
Gorge
Reservoir
River
Yampa
River
White
River
Desolation
Canyon
RIVER
Glenwood
Springs
Green
River
Grand
Junction
Gunnison
River
COLORADO
Moab
Dolores
River
Lake
Powell
Lees
Ferry
San Juan
River
Pagosa
Springs
Navajo
Reservoir
SCALE IN KILOMETERS
0
50
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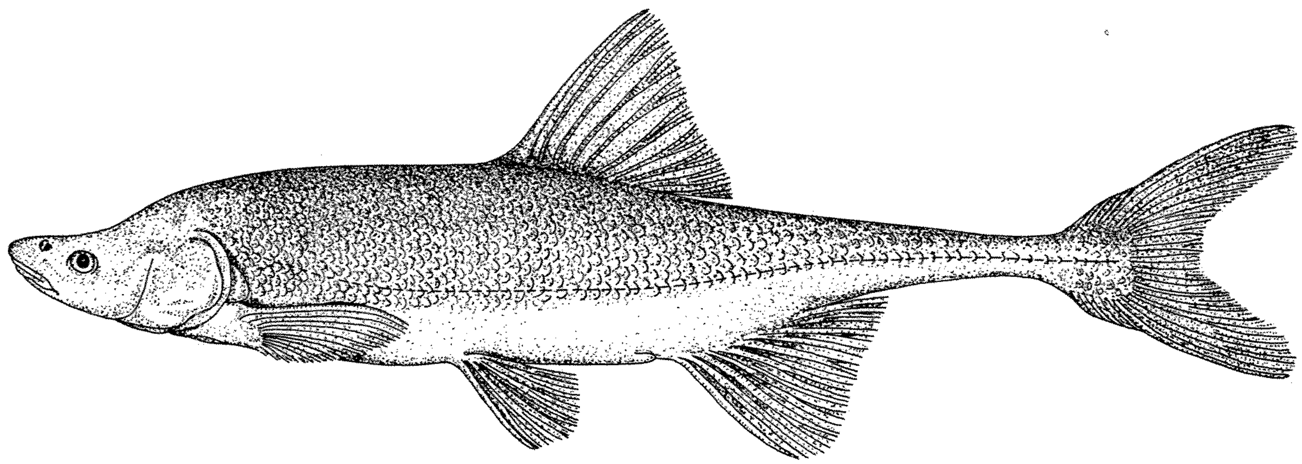
150
200
250
0
50
100
150
SCALE IN MILES



Bonytail Chub
Gila elegans

Status

Endangered on both federal and Colorado lists. Many recent studies clearly indicate that the bonytail chub is the rarest of the Colorado River native fishes and the species nearest extinction.

Distinguishing Features

Large fins and a streamlined body with a very thin caudal peduncle (the thinnest part of the body just in front of the tail) distinguish the bonytail chub. The bonytail chub might be confused with both roundtail and humpback chubs. The body is more streamlined and the caudal peduncle much thinner in the bonytail chub than in the roundtail chub. Bonytail chubs may develop a slight hump on the back, which would cause confusion with the humpback chub. The bonytail chub typically has 10 rays in both the dorsal fin and the anal fin, whereas the roundtail chub typically has 9 dorsal and anal fin rays; the humpback chub most frequently has 9 dorsal rays and 10 anal rays, but is more variable. Many unusual specimens collected in the 1960's suggested hybridization between the bonytail and humpback chubs. The current consensus is that, although some of these specimens do represent hybrids, most merely represent normal variation in the humpback chub.

Considerable confusion surrounds the identification and classification of bonytail chubs. The bonytail and roundtail chubs were described as separate species in the 19th century, but later were considered only as environmental modifications of a single species. That is, it was believed that a roundtail chub, leaving a tributary stream for life in the main river channel of the Colorado or Green River, would turn into a bonytail chub under the direct influence of a different environment. When it was discovered that both roundtail and bonytail chubs were frequently found living together, with both of them maintaining distinctions from each other and not hybridizing, the two chubs were again recognized as separate species.

Confusion also surrounds the common name. In former times, professional biologists typically used the name 'bonytail' for both roundtail and true bonytail chubs. Consequently, many literature references to the bonytail chub refer, in fact, to the roundtail chub.

Life History

Until large dams were constructed, the bonytail chub was probably the most abundant species in the main river channels of the Colorado and Green rivers and in the lower reaches of the larger tributary rivers. The bonytail chub was most common in the open-river areas of large river channels, the humpback chub in or near deepwater areas, and the roundtail chub in tributary streams. However, where suitably diverse habitat occurred, all three species might be found together.

The optimum habitat of bonytail chubs, based on former collections when they were abundant, appears to be the open river areas of relatively uniform depth and current velocity. This type of habitat typically consists of a shifting sand bottom water depths of 3 to 4 feet, and a relatively constant, moderately swift current. The streamlined body and large fins of the bonytail chub seem to make it well adapted to live in this type of habitat.

The bonytail chub is a relatively long-lived species. It does not spawn until it reaches an age of 5 to 7 years; like the other chub species, it spawns when the water reaches about 65° F. Little is known about the life history of the bonytail chub because it rapidly disappeared before intensive studies were made. It feeds on insects, often terrestrial insects taken on the surface of the water. Fragments of debris and algae in the stomachs of the relatively few specimens examined suggest that the bonytail chub may feed intensively after a sudden storm cause floodwaters to wash food out of tributaries into the main river channels. The maximum size attained by the bonytail chub is, in general, 16 to 18 inches. However, small numbers have continued to exist in the lower basin reservoirs, Lake Mohave and Lake Havasu, where they may attain a large size. A specimen about 3 feet long and weighing 8 pounds was reported caught by an angler in 1975 from Lake Mohave.

Present and Past Distribution

The original distribution included the large-river environments of the entire basin from Mexico to Wyoming. In the Gila River, Arizona, bonytail chubs were last recorded in 1926. They declined in the lower basin after the construction of lakes Mead, Havasu, and Mohave. Although they persisted in large numbers in these reservoirs for several years, and large numbers were observed spawning in Lake Mohave in 1954, their numbers continued to decline, because its spawning did not result in the survival of young fish. The bonytail chub was still abundant in the Green River until after the completion of Flaming Gorge Reservoir in 1963. By the late 1960's bonytail chubs became very rare. Except for the few specimens that may yet persist in lakes Havasu and Mohave, the only bonytail chubs reported in the last 3 years were from the Green River in Utah. If it were not for the stark example provided by the passenger pigeon, such rapid disappearance of a species once so abundant would be almost beyond belief.

Causes of Decline

The lack of successful reproduction in reservoirs explains the disappearance of bonytail chubs from the segments of their former range that were converted into impoundments. Their absence from the Colorado River of Colorado and Utah and from most of the Green River where apparently suitable habitat still exists is not so easily explained. There is little in the way of documented evidence about the occurrence or abundance of bonytail chubs in the Colorado River in Colorado and Utah, but it is assumed that they were common in this large-river environment. The open river or "run" type of habitat does not seem to be extensively used by non-native fishes. Thus, the "bonytail niche" would be expected to be less impaired than the niches of some other native fishes. Yet, the bonytail chub has suffered greater declines than any other native species and is now the rarest member of the original fish fauna.

Controlled water releases from Flaming Gorge Dam eliminated the great seasonal peaks of high and low flows of the original Green River and also cause daily fluctuations due to power generation. These changes in flow undoubtedly have influenced subtle changes in channel configuration and altered optimum bonytail chub habitat. Although there are no large dams on the Colorado River above Lake Powell (except in the headwaters), tributary reservoirs such as the Curecanti Project on the Gunnison, Ruedi Reservoir on the Frying Pan River, and Dillon and Green Mountain reservoirs on the Blue River alter the historical flow regime in the Colorado by reducing the peak spring flows. Large amounts of water are diverted for irrigation, and the return flows are diminished and the water quality altered.

The extent of the quantitative and qualitative changes in the flows of the upper Colorado River basin can be understood from the following facts and figures. The annual average virgin flow of the upper Colorado River basin at Lee's Ferry was 14,900,000 acre feet of water. By 1975, 3,823,900 acre feet of water (26% of the average virgin flow) were lost to the basin by consumptive irrigation use, transmountain diversions out of the basin, reservoir evaporation, and by cities and industry. Due to reservoir storage, the peak flushing flows of May and June are now at all time low discharge levels in the Green and

Colorado rivers. According to a 1978 U.S. Bureau of Land Management report on salinity problems in the Colorado River, irrigated agricultural lands in the Grand Valley region of Colorado return 8 tons of salts to the Colorado River for each acre under irrigation. Overgrazed rangelands in the basin, characterized by greatly accelerated erosion and high salt content, can contribute up to 30 tons of salts to the rivers per acre of watershed. Salinity concentrations have doubled and tripled in some sections of the Colorado River in comparison to virgin flow conditions. Such changes in the flows and water quality exert influences downstream on channel structure and fish habitat. The loss of great numbers of bonytail chubs from the areas inhabited by squawfish must have severely depleted the potential food supply of squawfish, and may be a major cause of the reduced growth rates of squawfish in recent times.

Prospects for the Future

Realistically, the prospects for restoring the abundance of bonytail chubs to a semblance of their former numbers in any part of the original range must be viewed as dim. This species is now the rarest of the native fishes and the species in most imminent danger of extinction. Biologists have been attempting to obtain live specimens from lakes Mohave and Havasu to hold in a hatchery for artificial propagation. Captive propagation may prove to be the only way this species can be maintained. Unless the factors causing the elimination of bonytail chubs are understood, and some action is taken to modify or eliminate these factors, the restoration of the bonytail chub in its historic range cannot be expected from stocking hatchery reared fish. Even if the factors causing elimination from a river section became clearly understood, it is not likely that remedial action would be possible. For example, the dismantling of Flaming Gorge Dam to restore the original flow and temperature regime of the Green River must be considered beyond the realm of possibility.

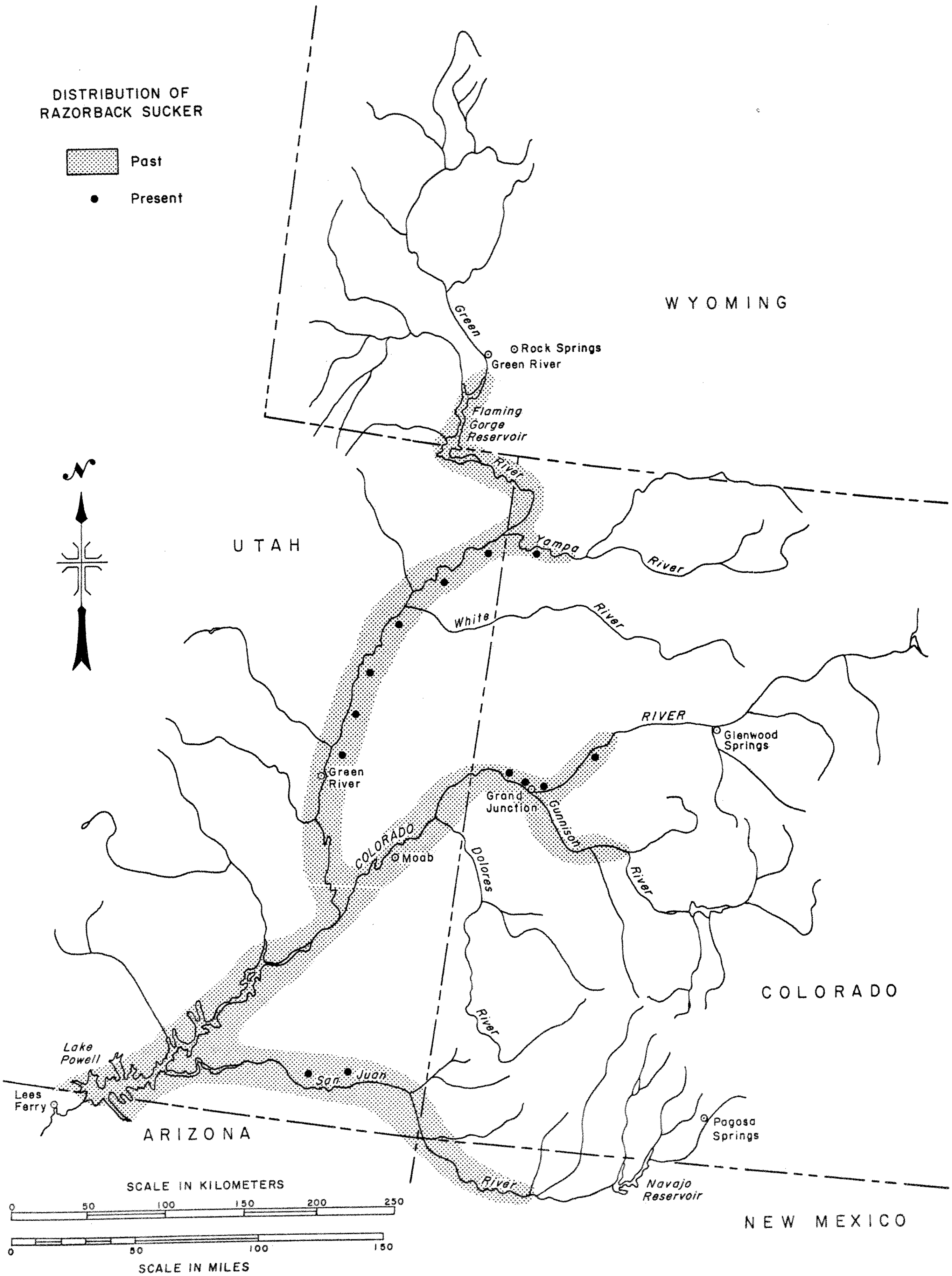
If bonytail chubs occur in an area, it is likely that an occasional specimen would be caught by fishermen fishing for catfish. If fishermen become familiar with the appearance of bonytail chubs, and if a specimen believed to be of this species is caught, it should be photographed before release and reported to the Colorado Division of Wildlife. There have been no verified records of the bonytail chub in Colorado for many years. The discovery of a population would be a significant event.

1982 UPDATE

Intensive sampling by federal and state agencies and private consulting firms throughout the Colorado and Green rivers in 1981 and 1982 failed to find a viable population of bonytail chub. The only site where fish sampling obtained specimens bearing a resemblance to bonytail chub was Coal Creek Rapids of the Green River in Gray Canyon, Utah. Detailed examination of these specimens, however, indicated they were the result of hybrid combinations between humpback, bonytail, and roundtail chubs. Evidently, the last remnants of the bonytail chub species in the upper basin is in the process of being "absorbed" into populations of humpback chub and roundtail chub by hybridization.

Experimental hybridization between the three chub species were carried out at the Willow Beach, Arizona, National Fish Hatchery. All hybrid combinations among the three species proved to be fully fertile, confirming their close genetic relationships.

Bonytail chub still occur in Lake Mohave. Specimens from Lake Mohave were taken to Willow Beach Hatchery to initiate artificial propagation of the species. Large numbers of bonytail chub have been produced at the Willow Beach and Dexter, New Mexico, national hatcheries. Some of these young were used in laboratory studies to determine environmental preferences and tolerances. In November, 1981, 42,000 hatchery-reared bonytail chub were stocked into Lake Mohave to supplement the natural population.


DISTRIBUTION OF
RAZORBACK SUCKER
Past
Present
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
Green
Rock Springs
Green River
Flaming
Gorge
Reservoir
River
Yampa
River
White
River
RIVER
Glenwood
Springs
Green
River
Grand
Junction
Gunnison
River
COLORADO
Moab
Dolores
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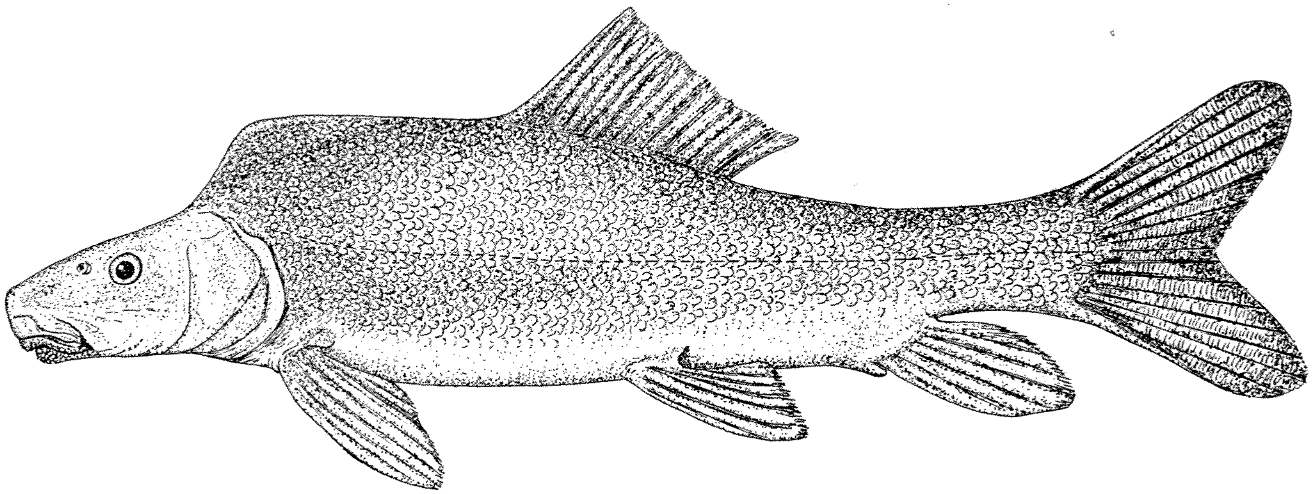


Razorback Sucker
Xyrauchen texanus

Status

The razorback sucker is listed as endangered on the Colorado list and has been proposed for threatened status on the federal list.

Distinguishing Features

The abrupt, sharp-edged hump on the back immediately posterior to the head identifies the razorback sucker from all other suckers and from all other fishes. The hump of the humpback chub is rounded and lacks the sharp leading edge.

The size and development of the hump is related to size and age. Young razorback suckers less than 6 to 8 inches long have only a slight hump, and might therefore be confused with the flannelmouth sucker. Hybrids between razorback and flannelmouth suckers are common in some areas. The razorback sucker typically has 14 or 15 dorsal fin rays vs. the typical 12 or 13 in the flannelmouth sucker. The razorback sucker has the larger number of gillrakers (small protuberances on the upper surface of the gill arches): typically the first gill arch has 45 or more gillrakers in razorback suckers and about 35 in flannelmouth suckers. Hybrid specimens are intermediate in the size of the hump and in other characters.

Life History

The peculiar body shape of the razorback sucker, which suggests a design for stability on the bottom in turbulent flow, may be a useful adaptation for migration during high river flows; however, virtually all captures of razorback suckers have been from essentially still water, particularly off channel ponds created from gravel excavation or for irrigation storage.

As is typical of species in the sucker family, the razorback sucker has fleshy lips that enable it to suck up small invertebrate animals and organic debris from the bottom. Also, numerous gillrakers make the razorback sucker well adapted for straining small animals (zooplankton) from the water passed over the gills for respiration. The food is sifted by the gillrakers and funneled into the throat, where it is finely ground by rows of pharyngeal teeth. The razorback sucker attains an old age (probably more than 20 years) and can reach a large size (more than 10 pounds). When formerly abundant, the razorback sucker and the squawfish were the most common and desirable food fish of the Colorado River basin, and supported local commercial fisheries.

Although the razorback sucker is well adapted to thrive in reservoirs, reproduction has not been sufficiently successful to maintain its numbers. When impoundments were created in the lower basin, razorback suckers soon established large populations; however, the populations declined as the fish became fewer and older each succeeding year. Razorback suckers have been observed spawning along the shores in the lower basin reservoirs, but no young fish have been found. With a long evolutionary background in a river environment, young razorback suckers might lack the instincts necessary to avoid predation in a lake environment. Reservoirs have predatory species in abundance. Schools of feeding carp have been observed in the lower basin reservoirs over areas where the razorback sucker had spawned.

Most observations of spawning have been in reservoirs. Spawning is reported to occur at temperatures of 54° F to 68° F, in water 1 to 20 feet deep. In river environments, groups of spawning razorback suckers have been observed on gravel bars in the Colorado and lower Yampa rivers when the water temperature reached about 62° F. Ripe and spent fish found in off-channel ponds suggests that spawning also occurs in such habitats. Along the Colorado River in Colorado, razorback suckers are most frequently found in ponds, created by gravel excavation, adjacent to and connected with the river.

Past and Present Distribution

The original range of the razorback sucker was approximately that of the squawfish and bonytail chub, in the large-river environments from Mexico to Wyoming. Historically, it was more common in the lower than in the upper Colorado River basin. In the lower basin large populations built up in the reservoirs during the early years of impoundment, but they gradually declined and now mainly consist of old, large fish.

In the upper basin, razorback suckers disappeared from the Green River above the mouth of the Yampa River after the completion of Flaming Gorge Dam and the release of cold water. Some razorback suckers persist in the Green River below its confluence with the Yampa River, and are occasionally found in the lowermost reaches of the Yampa. In the Colorado River in Colorado, razorback suckers occur upstream to De Beque, about 30 miles above Grand Junction. In 1977 an estimated 250 razorback suckers were found stranded when a small irrigation reservoir, connected to the San Juan River near Bluff, Utah, was drawn down.

Causes of Decline

For the razorback sucker, like the other species discussed, dams and impoundments can be pointed to as the major cause of decline. Land-use and water-use practices, changing flow regimes, and river channel characteristics that eliminated the lagoon or backwater type habitat can also be blamed. This seems evident from the intensive use of artificially created, off-channel pond habitat by razorback suckers. Non-native fishes such as carp, largemouth bass, and green sunfish also typically thrive in these pond areas, and they can effectively suppress successful reproduction of razorback suckers by predation on the eggs and young in such habitat.

In seeking clues bearing on the reasons for the decline of the razorback sucker, interpretation from an evolutionary perspective can be made. It is known that before environmental changes occurred and before non-native fishes became widely established in the Colorado River basin, two species of large suckers, the razorback and the flannelmouth, were both abundant. This means that the razorback sucker and flannelmouth sucker must have different niches. That is, the two species avoided direct competition with each other; because of differences in their life histories and ecologies, the food and space resources of their environment were divided in such a way that both maintained abundant populations.

The ecological distinctions between flannelmouth and razorback suckers can be interpreted from the differences in the way the two species are put together -- the differences in body shape, lip structure, and gillrakers. These distinctions in body parts are a reflection of the different evolutionary pathways followed by the two species to make maximum use of a certain part of their environment and to avoid direct competition when populations of the two species occupy the same waters.

The flannelmouth sucker still maintains abundant populations under the present altered environmental regime, but the razorback sucker is rare. Obviously, then, the evolutionary specializations adopted by the razorback sucker to best use its historical niche have placed the species at a severe disadvantage in the modified environment of the Colorado River basin. What factors in the original environment characterized optimum habitat for razorback suckers? How have these factors been lost, impaired, or modified?

As the razorback sucker became rarer, the incidence of hybridization with flannelmouth suckers apparently increased. Almost half of the specimens captured, mainly in the Green River, from 1967 to 1973 were identified as hybrids. The proportion of hybrids taken from the Colorado River in recent years varies from site to site. Some populations seem to be pure, but others contain a high percentage of hybrids.

Prospects for the Future

Because of its more widespread distribution and greater abundance, and its utilization of artificially created habitat, the razorback sucker seems to have a more hopeful future than do the three species previously discussed. The problem of successful reproduction must be solved before the continued existence can be assured and increased abundance can be effected. Adult razorback suckers flourish in reservoirs and pond type environments, but the young have not been found in such environments. It would be most important to know what the optimum spawning conditions are, in regard to depth, velocity, and substrate. It will also be important to learn what associated non-native fishes are least harmful and what species are most harmful to successful reproduction.

Artificial propagation of razorback suckers has been conducted for several years at the Willow Beach Federal Hatchery, Arizona. Populations could be maintained in reservoirs by stocking fish reared in a hatchery, but if reproduction is not successful in a reservoir or a section of a river, reproduction by stocked razorback suckers cannot be expected.

Because the razorback sucker has not yet been listed as endangered or threatened by the federal government, it has not been eligible for federally funded projects on endangered species, and has received much less attention than have the squawfish and humpback chub. It would be useful, for a better understanding of the species, to document its occurrence in all off-channel pond habitats, correlating the abundance of razorback suckers with habitat characteristics such as size, shape, depths, and associated fish species. An analysis of the common demoninators of the factors that favor the success of the species could then be made. If this were done, future man-made modifications might be designed to benefit the razorback sucker and perhaps the squawfish.

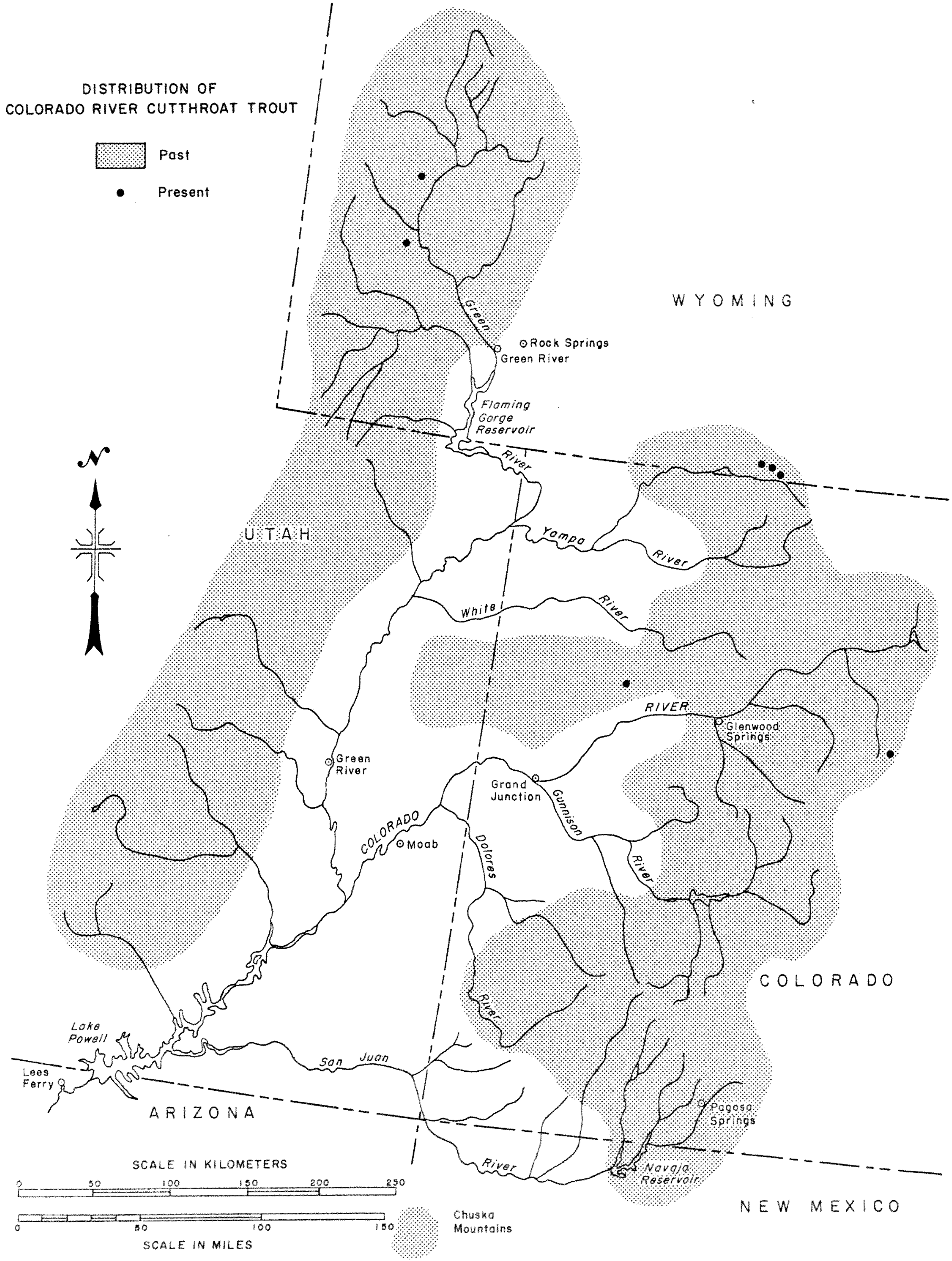
1982 UPDATE

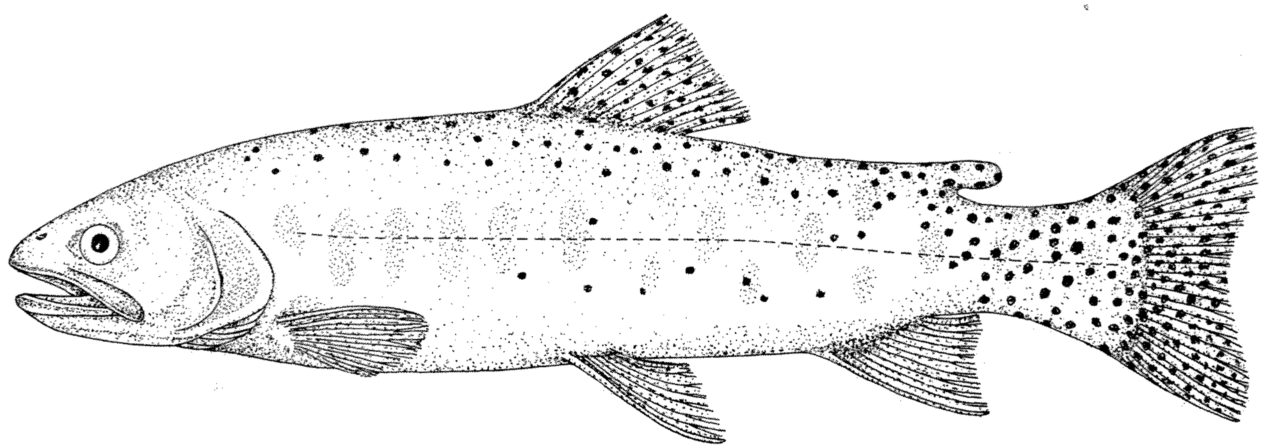
Studies by California Fish and Game Department biologists in Senator Wash Reservoir, California, and by biologists of the University of Nevada's Lake Mead Laboratory in Lake Mohave, have provided some documentation on the spawning of razorback suckers and the role of non-native fish predation as a limiting factor for successful reproduction.

Razorback suckers were observed to spawn over rocky-gravel bottems along lake shores. The spawning attracted many non-native fishes such as bass, sunfish, carp, and channel catfish which rapidly consumed the newly spawned eggs. In Senator Wash Reservoir, predation evidently was completely effective in suppressing reproductive success -- no young razorback suckers have yet been found. In Lake Mohave, some eggs do escape predation and a few newly hatched fish have been found. More intensive sampling of Lake Mohave has revealed the abundance of razorback suckers is much greater than previously thought and the wide range of sizes represented in collections indicate that past reproduction has been successful, at least in some years.

The aggregations of razorback suckers noted every spring in the Walter Walker pond and the Clifton gravel pond along the Colorado River near Grand Junction can now be interpreted as fish seeking these pond type environments for spawning. The problem is, however, that these man-made environments also harbor the same array of non-native fish predators observed consuming razorback sucker eggs in the lower basin reservoirs. The recovery of the razorback sucker will depend on eliminating or controlling the numbers of non-native fishes in preferred spawning sites or constructing sites that would fill during the runoff period, allowing spawning and rearing of the newly hatched razorback suckers, and then drain during low flow to prevent the establishment of non-native fishes.

The artificial propagation program for the razorback sucker is now carried out at the Dexter, New Mexico, National Hatchery. Large numbers of hatchery-produced fish were stocked into the Salt, Verde, and Gila rivers of Arizona in 1981 and 1982, and future introductions are planned for the San Juan River of New Mexico.


DISTRIBUTION OF
COLORADO RIVER CUTTHROAT TROUT
Past
Present
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
Green
Rock Springs
Green River
Flaming
Gorge
Reservoir
River
Yampa
River
White
River
RIVER
Glenwood
Springs
Green
River
Grand
Junction
Gunnison
River
COLORADO
Moab
Dolores
River
Lake
Powell
Lees
Ferry
San Juan
River
Pagosa
Springs
Navajo
Reservoir
SCALE IN KILOMETERS
0
50
100
150
200
250
0
50
100
150
SCALE IN MILES
Chuska
Mountains



Colorado River Cutthroat Trout
Salmo clarki pleuriticus

Status

Threatened on Colorado state list. Rare throughout its original range.

Distinguishing Features

The cutthroat trout that is native to the upper Colorado River basin can be distinguished from non-native trout by its red or orange slash marks beneath the lower jaws and by the spotting pattern. Relatively large spots, rounded in outline and typically concentrated on the posterior part of the body, characterize the native cutthroat trout. The native trout has the hereditary basis to develop brilliant coloration, but the color pigments must be derived from its food. Thus, a native trout living in a lake with crustaceans (water fleas, "shrimps," etc.) expresses bright red, orange, and golden-yellow coloration when sexually mature, but the same fish living in a small stream with only insects in its diet is more dully colored.

The cutthroat trout species is made up of about 15 subspecies or geographical races distributed widely throughout the western United States and western Canada. The Colorado River cutthroat is a geographical race that has been isolated in the upper Colorado River basin. It is closely related to the greenback cutthroat trout native to the headwaters of the South Platte and Arkansas River basins, and to the Rio Grande cutthroat trout. There are no consistent differences that can separate all Colorado River cutthroat trout from all greenback cutthroat trout except for geographical distribution -- one is native to the Colorado River basin, the other to the South Platte and Arkansas basins.

Hybrid populations between the native trout, rainbow trout and non-native subspecies of cutthroat trout are much more common than are pure populations of native trout.

Life History

There are no obvious ecological differences between the Colorado River cutthroat trout and other trout species in feeding, spawning, optimum habitat, etc. In tolerance of environmental disturbance, the cutthroat trout is like the canary in the mine -- it is usually the first species to go.

Spawning occurs in the spring, when water temperatures reach about 45° F. The female digs out a nest in gravel in flowing water. After fertilization, the eggs are covered with gravel and left to hatch later in the summer. Like most trout species, the cutthroat is opportunistic in its feeding. A wide range of invertebrate animals are eaten and the larger cutthroat trout prey on fish if they are available. The largest size attained by this subspecies is not known but probably was about 15 pounds. In small streams, however, few cutthroat trout exceed a length of 10 inches.

Past and Present Distribution

A hundred years ago the cutthroat trout inhabited all of the colder waters of the upper basin, from the headwaters of the Green and Colorado rivers to the San Juan River system on the east and the Dirty Devil River drainage on the west. The Green River below the town of Green River, Wyoming, and the Colorado River below Glenwood Springs, Colorado, were too warm in the summer for cutthroat trout. The main distribution was in the colder tributary systems at the higher elevations. The distribution of cutthroat trout began above a point where the distribution of the warmwater species such as the squawfish left off.

The early settlers found the native cutthroat trout in great numbers in all of the suitable trout waters of the basin. After the introduction of non-native trouts, the native cutthroat rapidly declined. Now only a few pure populations are found in small, isolated headwaters in Wyoming and Colorado.

In Trappers Lake, Colorado, a native cutthroat trout population still occurs. The Trappers Lake cutthroat has been exposed to hybridization from the Yellowstone Lake subspecies of cutthroat trout and from rainbow trout, and thus cannot be strictly regarded as constituting a "pure" population; however, the effect of past hybridization is not evident. The present Trappers Lake cutthroat trout are typical of the native subspecies, and are correctly classified as the Colorado River cutthroat trout. Trappers Lake cutthroat are propagated and stocked each year into high-elevation lakes in the northwest region of Colorado; thus, besides those caught in Trappers Lake itself, fishermen have the opportunity to catch the native trout from numerous lakes because of the stocking program. Most of the cutthroat trout now occurring in the Rocky Mountain region, are in high-elevation lakes. Consequently, many fishermen assume that this is their native habitat. However, almost all of the high mountain lakes in Colorado are isolated by formidable waterfalls, and no fish occurred in them naturally. Most of these lakes lack suitable tributary spawning streams, and the cutthroat trout populations are maintained by regular stocking.

Causes of Decline

Virtually all of the subspecies of cutthroat trout native to the interior regions of western North America have suffered the same fate as the Colorado River cutthroat trout. A hundred years ago, the cutthroat trout was the only trout that occurred in all of the famous Colorado trout streams, such as the Gunnison, Roaring Fork, Arkansas, South Platte, the upper Yampa, and the upper Colorado rivers. After stocking of non-native fishes, the cutthroat trout was replaced by brown trout and rainbow trout in the larger streams and by brook trout in the higher elevation small streams. Hybridization between native cutthroat trout and non-native rainbow trout occurred on a massive scale in all waters where rainbows became established. Unlike most hybrids between animal species, the hybrid of cutthroat and rainbow trout is fertile and can reproduce. Thus, once hybridization was started it rapidly spread. Non-native subspecies of cutthroat trout, mainly from Yellowstone Lake, Wyoming, were stocked into Colorado waters by the millions to hybridize with the native cutthroat trout. Early fish cultural practices commonly mixed native and non-native trout indiscriminantly. The introduction of non-native trouts was the major cause of the virtual elimination of pure populations of Colorado River cutthroat trout.

Prospects for the Future

Fortunately the highly generalized ecology of the native cutthroat trout allows the species to flourish in a variety of habitats, including very small headwater streams. Thus, a restoration program for native trout is far simpler than one for the previously discussed species. If all non-native trout can be eliminated from a lake or an isolated stream section by chemical treatment, native cutthroat trout from a known pure population can be transplanted and a new population established. This method of restoration has been used to establish several new populations of the greenback cutthroat trout in the South Platte River basin.

The cutthroat trout is more easily caught by fishermen than other trout species. Consequently it is the only trout that consistently responds to restrictive fishing regulations by increasing its numbers. Regulations designed to recycle all or most of the catch by requiring the release of all fish, or all fish within certain size limits, have worked well with cutthroat trout. The use of special regulations allowing the catching of native cutthroat trout, but restricting the kill, will probably become an important part of the management of the several subspecies of cutthroat trout native to the Rocky Mountain region.

1982 UPDATE

The Grand Junction office of the Colorado Division of Wildlife initiated an ambitious program in 1980 to determine the status of the native cutthroat trout. Many remote headwater streams and lakes were surveyed in 1980, 1981, and 1982, in an attempt to find populations of S. c. pleuriticus. Although most of the effort found only brook trout or hybrid populations, 12 new populations of pure or virtually pure S. c. pleuriticus were located. These newly discovered populations, however, are limited to localized sections of small headwater streams.

The Colorado River cutthroat trout has been stocked into Timber Lake, Rocky Mountain National Park to re-establish the native trout to the Colorado River drainage of the Park. Successful reproduction was noted in 1982.

In the 1960's the environmental movement gathered momentum from increasing concern over accelerated extinction rates of life on earth. The U.S. Fish and Wildlife Service created an Office of Endangered Species and prepared the first list of endangered species in 1964. The Colorado River squawfish and the humpback chub were included on the first list. Congress passed an endangered species preservation act in 1966, as an expression of concern and awareness, but it lacked enforcement provisions to protect endangered species where conflicts might arise. In December 1973, Congress passed new endangered species legislation, P.L. 93-205, known as the Endangered Species Act of 1973. The 1973 Act contains strong provisions to protect species on the list when they or their environment are in conflict with any federal action or project which might have negative impacts. These provisions are detailed in Section 7 of the Act, which states that all federal agencies are to use their authority in furtherance of the Act by carrying out conservation programs for endangered and threatened species. Federal agencies are directed to "insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of endangered and threatened species or result in the destruction or modification of these species habitat that is determined to be critical by the Secretary of Interior after consultation with the affected States."

It was violation of Section 7 of the Endangered Species Act that caused the conflict between the snail darter and Tellico Dam in Tennessee. This project was deemed to jeopardize the continued existence of the snail darter, an endangered species, because the dam would modify the snail darter's critical habitat.

For a clearer understanding of the ramifications of Section 7 of the Endangered Species Act, two aspects must be differentiated -- that of private vs. federal jurisdiction and that of the endangered species and its critical habitat. Section 7 of the Endangered Species Act does not apply to private actions unless a federal agency or federal funding is involved. If a dam for electrical power generation is to be constructed with private funds on private property, permits from the Corps of Engineers and licensing by the Federal Energy Regulatory Commission must be obtained for the work; the private project then becomes subject to the provisions of Section 7 of the Endangered Species Act. Irrigation projects of the Water and Power Resources Service and land modifications funded by the Soil Conservation Service are also subjected to the provisions of Section 7.

There has been considerable confusion over the term "critical habitat." The legal ramifications of critical habitat apply only to the endangered and threatened species that have had critical habitat designated by the Secretary of Interior. In an attempt to allay fears and to more clearly explain the meaning of "critical habitat," Keith M. Schreiner, former Associate Director of the Fish and Wildlife Service, published the following statement in the August 1976 issue of the Endangered Species Technical Bulletin (published by the Office of Endangered Species):

> The most important point I can make about critical habitat is that in no way does it place an iron curtain around a particular area; that is, it does not create a wilderness area, inviolable sanctuary, or sealed-off refuge. Furthermore, I would stress that it does not give the Fish and Wildlife Service or any other government agency an easement on private property nor will it affect the ultimate jurisdiction regarding any public lands.
>
> Critical habitat is provided for by Section 7 of the Endangered Species Act of 1973, which charges Federal agencies -- and only Federal agencies -- with the responsibility for ensuring actions authorized, funded, or carried out by them do not either 1) jeopardize the continued existence of Endangered or Threatened Species or 2) result in destruction of adverse modification of the habitats of these species. (State and private actions that do not involve Federal money or approval do not come under the terms of the Act.)
>
> Simply stated, critical habitat is the area of land, water, and airspace required for the normal needs and survival of a species. As published in the Federal Register on April 22, 1975, the Service has defined these needs as space for growth, movements, and behavior; food and water; sites for breeding and rearing of offspring; cover or shelter; and other biological or physical requirements.

Mr. Shreiner added that each situation is unique and must be decided on a case-by-case basis. He emphasized the great amount of effort and expertise that forms the basis of a biological opinion for a project impact where a potential conflict with the Endangered Species Act occurs.

Amendmants were made to the Endangered Species Act in 1978. One calls for an economic analysis to be prepared before any critical habitat is designated. This amendment is designed to reveal negative economic impacts from the designation of critical habitat that might retard or block future development. Critical habitat had been proposed for the squawfish, but was withdrawn until an economic analysis can be prepared. Thus, the squawfish and humpback chub are endangered species, but neither has "critical habitat" in the legal sense of the term. Any future development project or environmental modification in the upper Colorado River basin, to be compatible with the Endangered Species Act, would be subjected to the provision that its construction and operation do not "jeopardize the continued existence" of the squawfish or humpback chub, but would not be subjected to the critical habitat provision until such critical habitat is defined and designated by the Secretary of Interior. Another 1978 amendment stipulates that, in the future, any species proposed for the federal list of endangered or threatened species must, "to the maximum extent prudent", have the critical habitat designated at the time it is listed.

The effects of the listing of a species as endangered or threatened by the Colorado Wildlife Commission consist mainly of the recognition of the plight of a species and the ordering or priorities for funding, study and restoration. No provisions in the state law are likely to conflict with the activities of state or federal agencies or private individuals, except that endangered species cannot be killed, transported, or sold. The three subspecies of native cutthroat trout in Colorado (Colorado River, greenback, and Rio Grande cutthroat trout) are all listed as threatened by the state, but they are covered by game fish regulations. It is not illegal to fish for, catch, and eat the native cutthroat trout except in waters where all angling has been prohibited, such as those in Rocky Mountain National Park where greenback cutthroat trout occur. Some streams have been set aside for catch-and-release angling for the Rio Grande cutthroat trout, and more of these special regulation trout fisheries are likely to be established as part of restoration programs.

The federal Endangered Species Act defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range. A "species" is defined to include subspecies and smaller units of a species. Thus, the Kendall Warm Springs dace and several subspecies of cutthroat trout, including the greenback cutthroat in Colorado, have been listed as endangered or threatened species on the federal list, even though the species as a whole was not endangered. A "threatened species" is defined as any species that is likely to become an endangered species in the foreseeable future. Insofar as the Endangered Species Act is concerned, there is little difference in the legal protection given endangered and threatened species. A threatened species, however, may be the object of a properly regulated sport fishery.

When a potential conflict arises with the occurrence of an endangered species in an area where a federal project or action is deemed to pose a threat to the species, a consultation process with the U.S. Fish and Wildlife Service is initiated. The consultation process is an attempt to find ways that would allow the planning, construction, and operation of a proposed project to be compatible with the Endangered Species Act.

Fair and equitable administration of the Endangered Species Act to protect a species and at the same time allow new development projects to proceed is not a simple matter. It is generally realized that an uncompromising, ultraprotectionist stance should not be taken with endangered species to block future economic development. Such action would create a backlash in public opinion concerning the need to preserve endangered species. The official view of the U.S. Fish and Wildlife Service was presented by the former Associate Director, K. M. Shreiner, to the 1977 annual meeting of Western State Game and Fish Commissioners:

> We must stop our traditional adversary role in water development, power development, agricultural expansion, energy production, etc., and start trying to help the developers locate the site, design the structure and develop the operational regime that will do the least harm to wild plant and animal species and their habitats. It is likely that we can enhance the habitat and ultimately the species if we accept the fact that development must and will continue.

So I repeat, realistic endangered species administration means all of us helping developers to locate, design and operate their projects in a manner that is least harmful to species and their habitats. Almost all conflicts between development and endangered species have been resolved to date by the consultation process. In a situation where a conflict cannot be resolved (as in the case of Tellico Dam and the snail darter), a 1978 amendment to the Endangered Species Act provides for an exemption process. A Review Board consisting of persons appointed by the Secretary of Interior and by the President, with a third member represented by a judge appointed by the Civil Service Commission, decides if an irresolvable conflict exists. If the Review Board decides that an irresolvable conflict exists, the exemption application is considered by a seven-member Endangered Species Committee made up of the Secretary of Agriculture, the Secretary of Army, the Secretary of Interior, the Chairman of the Council of Economic Advisors, the Administrator of the Environmental Protection Agency, the Administrator of the National Oceanic and Atmospheric Administration, and a person appointed by the President after consultation with the Governor of the state concerned. An exemption to the Endangered Species Act can be granted if five of the seven members of the Committee agree to exempt the project. In their judgment, the Committee considers if there are reasonable alternatives to the project or if the benefits of exemption clearly outweigh the values of endangered species protection, and determines the overall significance of the project to the region and to the nation. The final decision is subject to a review by the U.S. Court of Appeals. Any person is entitled to bring action to obtain this judicial review. If the Committee votes against exemption and the decision is upheld by the court, only special legislation passed by Congress can create an exemption.

There is no doubt that there are many situations of potential conflict in the upper Colorado River basin in relation to future water and energy projects as they may modify the environment and impact the squawfish and the humpback chub. Although each project must be examined individually, a holistic view of the future is necessary to predict combined effects if all projects planned were allowed to proceed. The ultimate objectives are to guide and direct future environmental modifications so that changes in flow regime, temperature, and water quality will have a beneficial impact on the endangered species. The present research efforts of the U.S. Fish and Wildlife Service and the Colorado Division of Wildlife on the life history, ecology, and habitat preference of the squawfish and humpback chub are designed to provide the basis for resolving conflicts between the endangered species and future development in the basin.

There are likely to be delays, compromises, and increased costs associated with some new projects in the upper Colorado River basin. If conflict with the Endangered Species Act is to be avoided, any future environmental modification should not be harmful and, preferably, of course, it should be designed to be beneficial to endangered species.

1982 UPDATE

On October 13, 1982, President Reagan signed the Endangered Species Act Amendments of 1982 reauthorizing and further amending the Endangered Species Act of 1973. In addition to specifying shorter time periods for the listing and exemption processes, several significant changes were made. Critical habitat designation and economic evaluation are no longer required prior to the listing of a species. Biological criteria determining a species status are now the only considerations for the listing of species as endangered or threatened.

The U.S. Fish and Wildlife Service must now act on a petition to list or delist a species, "to the maximum extent practical", within 90 days and to publish their findings on the scientific merit of the petition. Final action on listing, delisting or critical habitat proposals must now be accomplished within one year instead of the two years previously allowed.

A new amendment creates a category of "experimental population" for a population of an endangered or threatened species intorduced outside of its present range. If the "experimental population" is determined to be not essential for the continued existence of the species then it will be protected in the same manner as species proposed for endangered or threatened status and will not receive the full protection of the Act unless it occurs in a National Park or National Wildlife Refuge. This amendment should facilitate the introduction of endangered species such as squawfish, humpback and bonytail chubs into parts of their original range where they no longer exist because the introduced "experimental populations" would not be listed as endangered. Vigorous objection to the introduction of endangered species into areas where they do not now exist has effectively limited all stocking of squawfish and humpback chub to areas where they presently occur. The stocking of the razorback sucker into three rivers in Arizona was possible only because this species is not a federally listed species.

REFERENCES

Comprehensive bibliographies on the upper Colorado River basin were compiled by Wydoski et al. (1980) and by Joseph et al. (1977). Most of the pertinent literature pertaining to the current status of the rare native fishes of the upper Colorado River basin is in the form of theses and agency reports that are not generally available in libraries. The following list of references includes those that have appeared since the above-mentioned bibliographies were completed, and some of the significant older publications that are in journals or serials available in the larger academic libraries.

Behnke, R. J., and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. U.S. Forest Service, Rocky Mtn. For., Rng. Exp. Sta., Gen. Tech. Rep. RM-28:45p.

Carlson, C. A., W. H. Miller, and H. M. Tyus (eds.). 1982 (in press). Fishes of the upper Colorado River system: Present and future. Proceedings of symposium at Am. Fish. Soc. Annual Meeting, Sept. 18, 1981, Albuquerque, N.M.

Carlson, C. A., C. G. Prewitt, D. E. Snyder, and E. J. Wick. 1979. Fishes and macroinvertebrates of the White and Yampa Rivers, Colorado. Final Report Baseline Survey for U.S. Bureau Land Management, Denver, Co.:276p.

Deacon, J. E., G. Kobetich, J. D. Williams, and S. Contreras. 1979. Fishes of North America endangered, threatened, or of special concern:1979. Fisheries (Bull. Am. Fish. Soc.) 4(2):29-44.

Ehrenfeld, D. W. 1976. The conservation of non-resources. Am. Sci. 64:648-656.

Evermann, B. W., and C. Rutter. 1895. Fishes of the Colorado basin. U.S. Fish Comm. Bull. 14:473-486.

Fradkin, P. L. 1981. A River No More, the Colorado River and the West. Alfred A. Knopf, New York: 360p.

Hammann, R. L. 1981A. Spawning and culture of Colorado squawfish in raceways. Progressive Fish-Culturist, 43(4_:173-177.

Hamman, R. L. 1981B. Hybridization of three species of chub in a hatchery. Ibid. 43(3):140-141.

Haynes, C. M., T. A. Lytle, E. J. Wick, and R. T. Muth. 1982 (in press). Larval Colorado squawfish (Ptychocheilus lucius) in the upper Colorado River basin, Colorado, 1979-81. S.W. Nat.

Holden, P. B. 1979. Ecology of riverine fishes in regulated stream systems with emphasis on the Colorado River In J. V. Ward and J. A. Stanford, eds. The ecology of regulated streams. Plenum Publishing Corp., N.Y., N.Y.

Holden, P. B., and L. W. Crist. 1979. Documentation of changes in the macroinvertebrate and fish populations in the Green River due to inlet modification of Flaming Gorge Dam. U.S. Fish and Wildlife Ser., Biol. Ser. Program, Fort Collins, Col., PR-16-2:112p.

Holden, P. B., and D. A. Selby. 1978. A study to determine spawning requirements of Colorado squawfish. Ibid. PR-17-1:29p.

Holden, P. B., and C. B. Stalnaker. 1975a. Distribution and abundance of mainstream fishes of the middle and upper Colorado River basin, 1967-1973. Trans. Am. Fish. Soc. 104(2):217-231.

Holden, P. B., and C. B. Stalnaker. 1975b. Distribution of fishes in the Dolores and Yampa river systems of the upper Colorado basin. Southwest. Nat. 19(4):403-412.

Johnson, J. E. and J. N. Rinne, 1982. The Endangered Species Act and Southwest Fisheries. Fisheries (bulletin of Amer. Fish. Soc.) 7(4):2-8.

Jordan, D. S. 1891. Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined. U.S. Fish Comm. Bull. 9:1-40.

Joseph, T. W., J. A. Sinning, R. J. Behnke, and P. B. Holden. 1977. An indexed annotated bibliography of the endangered and threatened fishes of the upper Colorado River system. U.S. Fish and Wildlife Ser., Office of Biol. Ser., Fort Collins, CO., FWS/OBS Rep. 24, part 1:168p.

Joseph, T. W., J. A. Sinning, R. J. Behnke, and P. B. Holden. 1977. An evaluation of the status, life history, and habitat requirements of endangered and threatened fishes of the upper Colorado River system. Ibid., part 2:183p.

Lanigan, S. H., C. R. Berry, and D. Robinson. 1979. Distribution and abundance of fishes in the White River, Utah. U.S. Bur. Land Mgt., Utah St. Office, interim rep.:72p.

Lytle, T. and E. J. Wagner. 1981. Colorado River cutthroat trout inventory. Colo. Div. Wildlife, Endangered Wildlife Investigations Performance Rep. SE-3-3:45p.

McAda, C. W., and R. S. Wydoski. 1980. The razorback sucker. *Xyrauchen texanus*, in the upper Colorado River basin. U.S. Fish Wildl. Serv., Tech. Pap. 99:15p.

McAda, C. W., C. R. Berry, and R. S. Wydoski. 1977. A survey of endangered, threatened, and unique fish in southeastern Utah streams within the coal planning area. Pages 1-265 in T. C. Bonner, W. A. Heggen, C. McAda, C. Phillips, C. R. Berry, and R. S. Wydoski. A survey of endangered, threatened, and unique terrestrial and aquatic wildlife in Utah's coal planning area. Utah Dept. Nat. Res., Div. Wildlife, Salt Lake City.

Miller, R. R. 1961. Man and the changing fish fauna of the American Southwest. Mich. Acad. Sci. Arts Lett. 46:365-404.

Miller, R. R. 1963. Is our native underwater life worth saving? Natl. Parks Mag. 37(188):4-9.

Minckley, W. L., and J. E. Deacon. 1968. Southwest fishes and the enigma of "endangered species". Science 159 (3822):1424-1432.

Myers, N. 1977. Garden of Eden to weed patch: the earth's vanishing genetic heritage. Nat. Resour. Defense Counc. Newsl. 6(1):1-15.

Pister, E. P. 1976. A rationale for the management of nongame fish and wildlife. Fisheries (Bull. Am. Fish. Soc.) 1(1):11-14.

Seethaeler, K. 1978. Life history and ecology of the Colorado squawfish (*Ptychocheilus lucius*) in the upper Colorado River basin. M.S. Thesis, Utah St. Univ., Logan, Utah:155p.

Snyder, D. E. 1981. Contribution to a guide to the cypriniform fish larvae of the upper Colorado River system in Colorado. USDI Bureau of Land Mgt. Bio. Sci. Ser. No. 3, Denver, CO:81p.

Spofford, W. O., A. L. Parker, and A. V. Kneese (eds.). 1980. Energy development in the Southwest, problems of water, fish and wildlife in the upper Colorado River basin. Resources for the future, Res. Pap. R-18 (two volumes).

Stanford, J. A., and J. V. Ward. 1983 (in press). The Colorado: North America's desert river in B. R. Davies and K. F. Walker (eds.). Ecology of river systems. Monogr. Biologicae. Dr. W. Junk, the Hague.

Suttkus, R. D., and G. H. Clemmer. 1977. The humpback chub, *Gila cypha*, in the Grand Canyon area of the Colorado River. Occas. Pap. Tulane Univ. Mus. Nat. Hist. 1:30p.

U.S. Dept. Int. Fish and Wildl. Service, various authors. 1982. Final reports of Colorado River Fisheries Project to Bur. Rec. The results of investigations 1979-1981 are presented as follows: Part 1, summary report; part 2, field studies.

Vanicek, C. D., and R. H. Kramer. 1969. Life history of the Colorado squawfish, *Ptychocheilus lucius*, and the Colorado chub, *Gila robusta*, in the Green River in Dinosaur National Monument, 1964-1966. Trans. Am. Fish. Soc. 98(2):193-208.

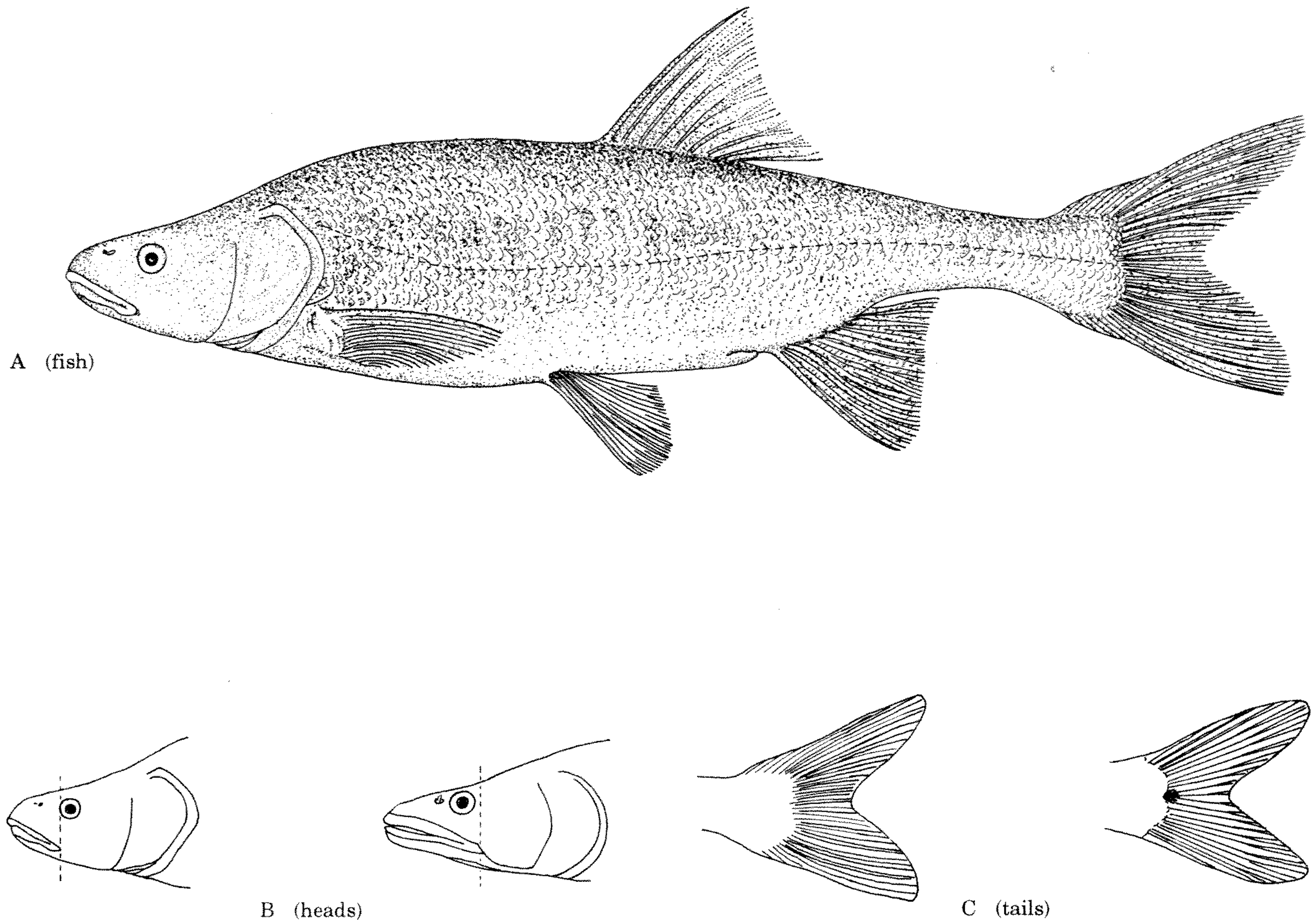
Vanicek, C. D., R. H. Kramer, and D. R. Franklin. 1970. Distribution of Green River fishes in Utah and Colorado following closure of Flaming Gorge Dam. Southwest Nat. 14(3):297-315.

Wick, E. J., T. A. Lytle, and C. M. Haynes. 1981. Colorado Squawfish and humpback chub population and habitat monitoring. Colorado Division of Wildlife, Denver. Federal Aid Endangered Wildlife Program Report SE-3-3:156p.

Williams, J. D., and D. K. Finnley. 1977. Our vanishing fishes, can they be saved? Frontiers, Summer, 1977:12p.

Wiltzius, W. J. 1978. Some factors historically affecting the distribution and abundance of fishes in the Gunnison River. Final Rep. to U.S. Bur. Recl. Fish Invest. Lower Gunnison R. drainage:215p.

Wydoski, R. S., K. Gilbert, K. Seethaeler, C. W. McAda, and J. A. Wydoski. 1980. Annotated bibliography for aquatic resource management of the upper Colorado River ecosystem. U.S. Fish Wildlf. Serv. Resource Publ. 135:186p.



APPENDIX 1

Distinguishing characters of roundtail chub and squawfish.

A. The roundtail chub, *Gile robusta*.

B. Heads of roundtail chub (left) and squawfish (right) showing the length of the jaw in relation to the eye.

C. Tails of roundtail chub (left) and young squawfish (right) showing the dark blotch on the base of tail in squawfish.

Abstract

Behnke, R.J., and Benson, D.E.
1980 Endangered and Threatened Fishes of the Upper Colorado River Basin. Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Bulletin 503A.

Discusses the biology, distribution, current status and reasons for decline of five species native to the upper Colorado River basin: Colorado River squawfish, *Ptychocheilus lucius;* humpback chub, *Gila cypha;* bonytail chub, *Gila elegans;* razorback sucker, *Xyraucken texanus;* and Colorado River cutthroat trout, *Salmo clarki pleuriticus.* An interpretation of the Endangered Species Act is included.