Chapter 2

Fishes of Grand Canyon

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Introduction

Fishes of the Colorado River vary from coldwater trout species found in the river's mountainous headwaters to uniquely adapted desert river species found at lower elevations. Within the study area, the Colorado River corridor between Glen Canyon Dam and the western boundary of Grand Canyon National Park (hereafter Grand Canyon), the Colorado River was a seasonally warm and turbid river characterized by large seasonal variations in flow before it was altered by the closure of Glen Canyon Dam in 1963 (Topping and others, 2003). Although water temperatures fluctuated between 32°F (0°C) during winter to a high approaching 86°F (30°C) during late summer, several warmwater native fish species successfully inhabited this stretch of the river (Cole and Kubly, 1976). Because of the harsh environment created by dramatic seasonal fluctuations in the river's predam flow and temperature, only 8 of the 32 species of native fish historically found in the Colorado River were common in the Grand Canyon reach of the river. Other native fishes within the study area were restricted to small tributary streams or occurred only in transient or seasonal numbers. Of the eight fish species that were originally common to the study area, only four species are known to persist today.

The number of species that made up the original fish community of the Colorado River was altered well before the construction of mainstem dams because of the introduction of nonnative fishes by early European settlers. Nonnative fishes, from sport fishes to escapees from aquaria, have been intentionally and inadvertently stocked in the Colorado River for more than 100 yr (Mueller and Marsh, 2002). Today, nonnative fishes originating in many parts of the world are found in the Colorado River. Table 1 contains a list of the native and nonnative fishes of the Colorado River in Grand Canyon.

This chapter examines the status, trends, and recent condition of Grand Canyon fishes, focusing particular attention on the endangered humpback chub (*Gila cypha*) because of its prominence within the Glen Canyon Dam Adaptive Management Program (see Overview, this report). The chapter begins with a discussion of the conditions that led to the development of the Grand Canyon's unique native fish populations and then moves on to the reasons for their decline. The effects of the modified low fluctuating flow (MLFF) alternative on fish

Table 1. Historical and present relative abundance of fish species in the Colorado River from Glen Canyon to Separation Canyon. P = present, abundance unknown; A = abundant; C = common; LC = locally common; R = rare; and - = not encountered.

[Modified from Valdez and Ryel, 1995. Species that are federally listed as endangered are indicated by an asterisk (*). Species that are endemic to the lower basin of the Colorado River but occurred almost exclusively in smaller streams or rivers tributary to the mainstem Colorado River are indicated by a plus sign (+)]

Species	Pre-1850	1958–59	1970–73	1984–86	1990–93
Family: Clupeidae, shads (introduced)					
Threadfin shad	-	-	R	-	C
Family: Cyprinidae, minnows					
Native					
*Humpback chub	P	-	R	R	LC
*Bonytail chub	P	-	-	-	-
Roundtail chub	P	R	-	-	-
*Colorado pikeminnow	P	R	-	-	-
Speckled dace	P	A	A	A	C
Virgin spinedace+	P	-	R	-	-
Woundfin+	P	-	-	-	-
Introduced					
Red shiner	-	-	R	-	A
Common carp	-	C	A	A	A
Utah chub	-	R	-	R	-
Golden shiner	-	-	R	R	R
Fathead minnow	-	A	C	A	LC
Family: Catostomidae, suckers (all native)					
Bluehead sucker	P	C	C	C	C
Flannelmouth sucker	P	C	C	C	C
*Razorback sucker	P	R	-	R	-
Family: Ictaluridae, bullhead catfishes (all introduced)					
Black bullhead	-	C	-	R	R
Yellow bullhead	-	-	-	R	-
Channel catfish	-	A	C	R	LC
Family: Salmonidae, salmon and trout (all introduced)					
Cutthroat trout	-	-	-	R	-
Coho salmon	-	-	R	-	-
Rainbow trout	-	-	C	A	A
Brown trout	-	-	-	C	C
Brook trout	-	-	-	C	R
Family: Cyprinodontidae, killifishes (introduced)					
Plains killifish	-	R	C	R	LC
Family: Poeciliidae, livebearers (introduced)					
Mosquitofish	-	R	R	-	LC
Family: Percichthyidae, temperate basses (introduced)					
Striped bass	-	-	-	R	R
Family: Centrarchidae, sunfishes (all introduced)					
Green sunfish	-	C	R	R	R
Bluegill	-	R	R	-	R
Largemouth bass	-	R	R	R	R
Black crappie	-	-	-	-	R
Family: Percidae, perch (all introduced)					
Yellow perch	-	R	-	-	-
Walleye	-	-	-	-	R
Total number of species	**10**	**17**	**18**	**20**	**22**

populations are also examined. The chapter concludes with a discussion of possible management options to slow or reverse the decline of humpback chub numbers.

Background

The Colorado River was one of the last areas of the continental United States to be explored by Europeans; it was first traversed during the expedition headed by John Wesley Powell in 1869. For this reason, it is not surprising that scientific descriptions of many of the organisms in the Colorado River corridor, especially the fishes, did not begin until the 1930s and 1940s; earlier expeditions collected and described fishes generally rather than specifically. Emery and Ellsworth Kolb, explorers and photographers of the Colorado River in the early 1900s, reported that fishes were very abundant (Kolb and Kolb, 1914). The humpback chub was the last of the native fishes in Grand Canyon to be described in 1946 by Robert R. Miller from specimens taken from the Colorado River in Grand Canyon (Miller, 1946).

Scientific description of the native fishes of Grand Canyon showed that these species were unique in at least two ways. Most noticeably, several of the species share unusual body shapes, including large adult body size, small depressed skulls, large predorsal humps or keels, and small eyes, which presumably developed as adaptations to life in a large, turbid, and seasonably variable riverine environment. These features are perhaps best observed in the razorback sucker (*Xyrauchen texanus*) and the humpback chub (see accompanying text box, p. 51).

A second, and perhaps more important, measure of the uniqueness of Grand Canyon native fishes is that most of these species are not found elsewhere in the world. Organisms that are native to a certain location and do not occur anywhere else are called endemic species. Of the eight native species common to the Grand Canyon, six are species endemic to the Colorado River Basin. As early as 1895, scientists recognized the special nature of Colorado River fishes and the high rates of endemism (Minckley, 1991). Later research did not alter this conclusion, and despite a relatively low number of species compared to other drainages in the United States, the Colorado River Basin has a recognized endemism at the species level of approximately 75% and supports the most distinctive ichthyofauna in North America (Minckley, 1991).

Before European settlement, the native fishes found in the Grand Canyon portion of the Colorado River were exclusively minnows and suckers. The biggest of these fish was the Colorado pikeminnow (*Ptychocheilus lucius*), which is also the largest of all native minnow (cyprinid) species in North America and was found only in the Colorado River Basin (fig. 1). Called a white salmon by early settlers, the Colorado pikeminnow reached up to 6 ft (2 m) in length and had a weight of up to 80 lb (36 kg) (Mueller and Marsh, 2002).

Today, three of the eight native fish species have been eliminated from the Colorado River in Glen and Grand Canyons (roundtail chub (*Gila robusta*), bonytail chub (*Gila elegans*), and Colorado pikeminnow), and two are federally listed as endangered (humpback chub and razorback sucker) under the Endangered Species Act. Although listed as an endangered species with designated critical habitat in Grand Canyon, the razorback sucker has rarely been collected (Minckley, 1991; Valdez and Carothers, 1998) and is widely thought to no longer be found in Grand Canyon. The status of the flannelmouth sucker (*Catostomus latipinnis*) is common, and the species persists in the study area and throughout much of the upper Colorado River Basin. The remaining two fish (bluehead sucker (*Catostomus discobolus*) and speckled dace (*Rhinichthys osculus*)) are relatively common. Brief descriptions of the life histories of all the Grand Canyon native fishes can be found in Minckley (1991); this chapter provides text boxes (see p. 50) with summary information for the four native fishes that continue to inhabit Grand

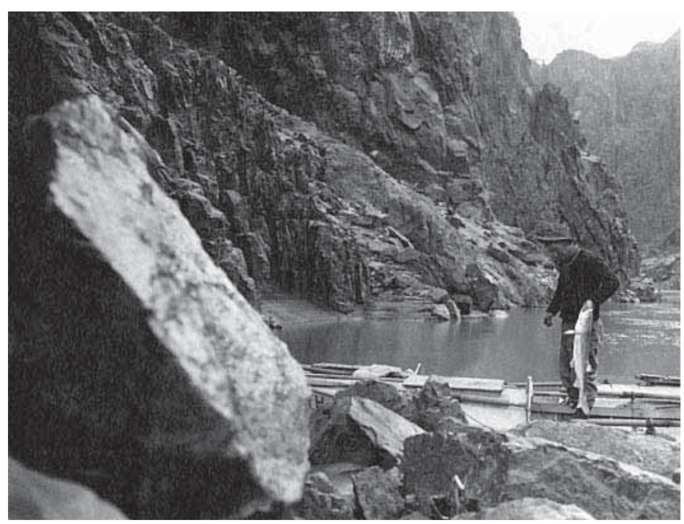


Figure 1. Historical photograph (date unknown) of someone identified as James Fagen holding a large Colorado pikeminnow in lower Granite Gorge (courtesy of the Kolb Collection, Cline Library, Northern Arizona University, NAU.PH.568.5737).

Canyon, as well as for the two most common nonnative species, rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*).

Decline of Native Fish

Introductions of Nonnative Fishes

There are a number of reasons for the decline of native fishes, including the potential effects of nonnative fish species. Nonnative fish have been found in the Colorado River since the 1800s (Minckley, 1991). These species are potential predators of and competitors with native fish and include common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), plains killifish (*Fundulus zebrinus*), rainbow trout, brown trout, red shiner (*Cyprinella lutrensis*), and channel catfish (*Ictalurus punctatus*). Nonnative species may share rearing habitats used by native fish, habitats which include complex shorelines, tributaries, backwater areas, and eddies. The presence of warmwater, coolwater, and coldwater nonnative fish species in the Colorado River is an issue of considerable importance (U.S. Department of the Interior, 1995) because there are now nonnative fishes that may negatively interact with native fishes under virtually any temperature regime and in any habitat of the river.

Today, the Colorado River has nearly twice as many nonnative species (60) as native species (32); in the Grand Canyon reach of the river the situation is even more extreme, where the ratio of native to nonnative species is more than 4 to 1 (Valdez and Carothers, 1998). The introduction of nonnative species to the Colorado River, both intentionally and unintentionally, was well underway before 1900. As such, the ratio of nonnative to native fishes was high in Grand Canyon before the construction of Glen Canyon Dam. For example, the National Park Service introduced both brown trout and rainbow trout to tributaries like Bright Angel Creek in the 1920s to provide sport fishing opportunities (Valdez and Carothers, 1998). Because of the continuous nature of the river and its tributaries before dam building, species introduced almost anywhere in the basin had the potential to find their way to the Grand Canyon portion of the river, and many did. Before Glen Canyon Dam, the Grand Canyon reach was dominated by a single introduced species, the channel catfish (Valdez and Carothers, 1998). Following construction of the dam in 1963, Federal and State agencies again introduced rainbow trout below Glen Canyon Dam to establish and maintain a sport fishery in the 15-RM reach between the dam and Lees Ferry. This stocking continued for more than 30 yr, until the mid-1990s. Numerous other species of nonnative fishes were also introduced into Lake Powell and Lake Mead to create or enhance recreational fishing (Mueller and Marsh, 2002).

The effects of nonnative fish on native species, including predation and competition, are important considerations when evaluating any management action intended to benefit native fishes. These considerations are particularly important given the proximity of Lake Powell and Lake Mead, reservoirs with diverse nonnative fish populations, to Grand Canyon. Any management action intended to improve habitat conditions for native warmwater fishes also runs the risk of providing additional habitat that is suitable for nonnative predators and competitors. Nonnative fish predators currently in the Grand Canyon reach of the Colorado River include striped bass (*Morone saxatilis*), channel catfish, largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), brown trout, and rainbow trout. Currently, nonnative coldwater species (trout) are abundant, while the nonnative warmwater species exist in relatively low numbers.

Glen Canyon Dam Effects

The predam success of nonnative species was, in part, due to the fact that the river was generally what fishery biologists term a “warmwater habitat.” The annual temperature cycle of the Colorado River through Grand Canyon was similar to temperate lakes and streams at lower elevations, where temperatures ranged from cold or cool in winter to warm in summer. Native species require warmer temperatures to spawn and reproduce successfully. This seasonal pattern also allowed many of the introduced species to complete their life cycle. One of the major impacts of Glen Canyon Dam on the Colorado River was the change in water temperature to a relatively cold, steady temperature that favored coldwater species like trout over native fishes and introduced, warmwater species. While most of the warmwater species can survive in these colder waters, they cannot reproduce and do not grow well, having been adapted to at least seasonally warmer temperatures.

Other possible effects of dam operations on the riverine environment that may affect fishes include increased water clarity, altered flow patterns, and reduced sediment. All species that are native to Grand Canyon evolved in highly turbid environments, so the clear water released from the dam may favor nonnative predators like trout, which are adapted to hunting in clear water (Valdez and Ryel, 1995). Similarly, the post-dam river hydrology is different from the predam river with respect to daily flow variation, flood frequency, and seasonal pattern and magnitude of maximum and minimum flows (Topping and others, 2003). These alterations in flow patterns potentially affect the spawning cues, habitat use, and distribution of native fish, as well as the suitability of mainstem Colorado River rearing habitat, in ways that are largely unknown and potentially complex (Korman and others, 2004). Finally, as Glen Canyon Dam blocks the majority of sediment transported by the Colorado River to the upstream portions of Lake Powell, the nearshore physical habitat available to native fish is fundamentally different from the predam river (Goeking and others, 2003; also see chapter 1, this report). Except for temperature, the other potential effects of the dam that are mentioned here are based on inferences about what is known regarding fishes from other river systems. Little direct scientific evidence from the Colorado River itself exists regarding these effects, and there remains considerable uncertainty regarding the potential effects of management actions associated with these factors (Walters and others, 2000).

Other Factors

New fish parasites in the system, changes in tributary hydrology, and alterations in the food base that support fish populations are additional environmental factors that may be affecting native and nonnative fish species in Grand Canyon. Asian tapeworm (*Bothriocephalus acheilognathi*), a parasitic cestode, is a prominent example of a recently introduced parasite. Introduced into the United States in the 1970s with imported grass carp (*Ctenopharyngodon idella*) from China, the Asian tapeworm was discovered in 1990 in the Little Colorado River, which is an important spawning area for humpback chub (Choudhury and others, 2004). The tapeworm can cause mortality, but most often it is responsible for reduced growth and poor condition of infected fish. This parasite is currently restricted to the Little Colorado River because cold mainstem temperatures preclude completion of its life cycle. The Little Colorado River is also an example of a tributary system in which upstream water use and development have changed the amount and timing of flows reaching the Colorado River. Such changes could affect fishes in the Little Colorado River and throughout Grand Canyon, especially below the tributary.

Status and Trends

Until the 1990s, there were few attempts to monitor the status and trends of fishes in Grand Canyon. Information before the mid- to late-1980s was anecdotal and was provided by explorers, river runners, and occasional scientific expeditions. As a result, few data are available for the first 20 yr after Glen Canyon Dam was closed. Early fish collection efforts were reviewed by Valdez and Carothers (1998), and where appropriate these earlier data are used in comparison to current data for fishes in Grand Canyon.

Efforts to estimate population size or relative abundance of fishes in Grand Canyon began under Glen Canyon Environmental Studies Phase II when private consulting firms, university researchers, the U.S. Fish and Wildlife Service (USFWS), and the Arizona Game and Fish Department conducted surveys and undertook population estimates in the mainstem Colorado River and in the Little Colorado River. Beginning in 1997, these efforts became the responsibility of the U.S. Geological Survey's (USGS) Grand Canyon Monitoring and Research Center, which has worked cooperatively on monitoring activities with the U.S. Fish and Wildlife Service, the Arizona Game and Fish Department, and consulting firms (SWCA Environmental Consultants, Inc., and Ecometric Research). For the purposes of monitoring, the study area is divided into three segments: the Lees Ferry reach (15 RM of Colorado River corridor from Glen Canyon Dam to Lees Ferry); the mainstem Colorado River (downstream of Lees Ferry, RM 0, and the Paria River to RM 226 at the confluence of Diamond Creek); and the Little Colorado River (the 8.7 mi (14 km) of the tributary upstream from the mainstem). The status and trends of fish found in each of these reaches will be discussed separately. Humpback chub are discussed in a separate section.

Lees Ferry

The Lees Ferry reach of the river is managed primarily as a rainbow trout sport fishery. The Lees Ferry reach is known as a tailwater trout fishery because it occurs downstream from a large dam where deepwater discharges afford cooler water temperatures that allow coldwater species like trout to survive. In fact, trout not only survived in the Lees Ferry reach following their initial stocking in 1964 but also flourished in the new habitat created by Glen Canyon Dam. The Lees Ferry rainbow trout fishery gained a reputation by the mid-1970s as a world class, blue ribbon fishery famous for its scenic grandeur and large, trophy-sized trout. Monitoring in this reach is primarily done through electrofishing and surveys of anglers by the Arizona Game and Fish Department in cooperation with the USGS Grand Canyon Monitoring and Research Center. The fishery was initiated with stocking efforts and was maintained primarily by stocking until the late 1990s.[1] Since closure of Glen Canyon Dam in 1963, however, this fishery has experienced variable success rates by anglers, and the trout populations have changed in response to stocking, dam releases, and food availability (McKinney and others, 1999, 2001).

Recently, more stable river flows, which are the result of the interim flows in 1991 and subsequent implementation of the MLFF alternative in 1996, have encouraged natural reproduction and made stocking unnecessary. Stable flows and increased natural reproduction resulted in an expanding number of fish (fig. 2), but the larger number of fish was offset by smaller average size and decreasing condition (plumpness) of the fish (fig. 3). Because the overall carrying capacity of the river remains relatively constant, the Lees Ferry reach is able to produce a smaller number of large fish or a greater number of small fish, a principle that is known as conservation of biomass. As early as 1996, the Arizona Game and Fish Department recognized the declining size of trout in this fishery and recommended changes in angling regulations to increase the size of fish; however, anglers appeared unwilling to accept lower catch rates of larger fish (Niccum and others, 1998). Average fish condition continued to decline for several more years but finally rebounded in 2002 (fig. 3).

As part of the Glen Canyon Dam Adaptive Management Program, fluctuating nonnative fish suppression flows were initiated beginning in 2003 and continued through 2005 in an effort to reduce the number of trout and increase their average size. The experimental flow treatment involved increased diurnal flow fluctuations of 5,000 to 20,000 cubic feet per second (cfs) from January through March of each year. Overall, these fluctuating flows were intended to disrupt spawning activity, to reduce egg survival, and to disadvantage young-of-year (YOY) trout that did survive. Early

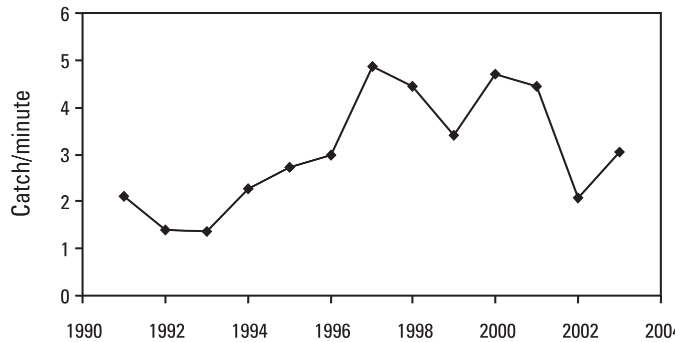


Figure 2. The average number of rainbow trout caught by using electrofishing at several fixed sampling locations in the Lees Ferry reach of the Colorado River from 1991 to 2003. Increasing catch-per-unit effort is thought to be indicative of an increasing number of fish in the population (Arizona Game and Fish Department and U.S. Geological Survey, unpub. data, 2005).

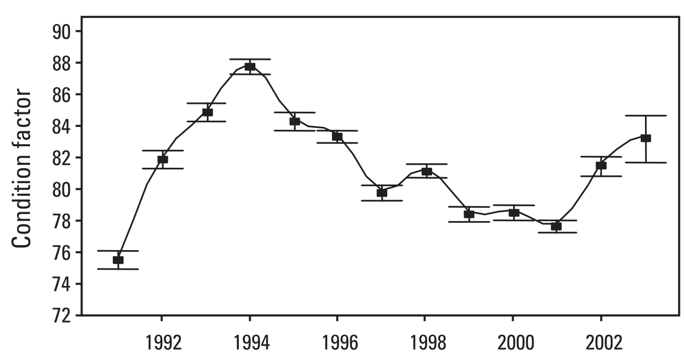


Figure 3. Condition factor, or relative weight, of Lees Ferry trout from 1991 to 2003. Condition factor expresses the length-to-weight relationship and is an attribute that reflects the health of individual fish as well as affects angler satisfaction. Relative weight declined with the increase in fish density in the late 1990s but increased in 2002–03. Present condition seems acceptable to anglers (Arizona Game and Fish Department and U.S. Geological Survey, unpub. data, 2005).

indications suggest that these experimental flows have had only minimal effects on the recruitment dynamics of rainbow trout. The total egg deposition loss because of Glen Canyon Dam operations in 2003 ranged from 30% to 40% in the Lees Ferry reach, with about half of this mortality being a direct consequence of the enhanced fluctuating flows in January through March (Korman and others, 2005); however, electrofishing catch rates began to increase in 2003 (fig. 2). There also appears to be a corresponding increase in angler use associated with

[1] Stocking of fingerling rainbow trout was reduced in the mid-1990s to about 20,000 fish per year and ended completely in 1999 when it was apparent that natural reproduction under the modified low fluctuating flow alternative was producing more than enough recruitment to sustain the fishery (William R. Persons, Arizona Game and Fish Department, oral commun., 2005).

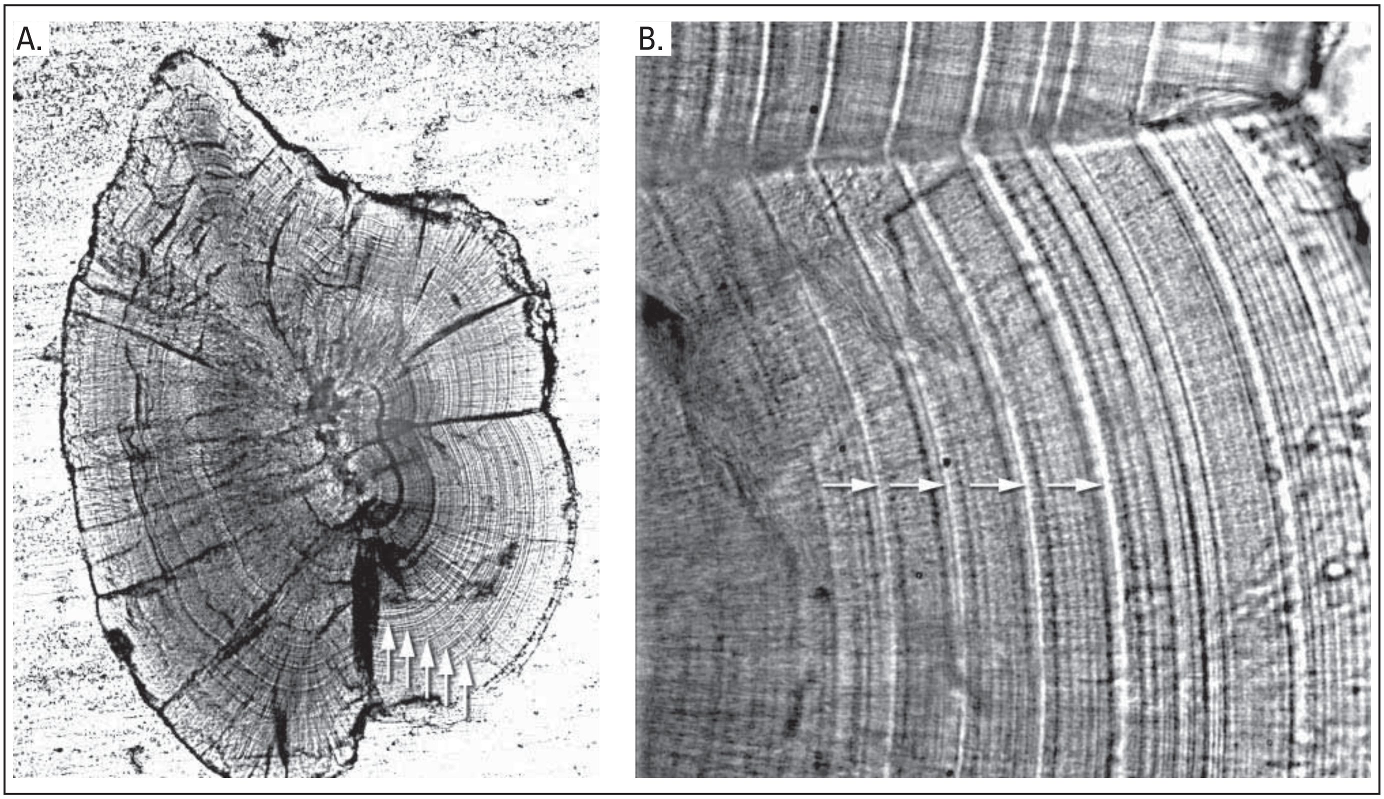


Figure 4. Photomicrograph of an otolith cross-section of young-of-year rainbow trout sampled from Glen Canyon in April 2003. Otoliths are minute boney structures found in the inner ear that show daily growth patterns in many fishes. The image shows the weekly striping pattern (identified by white arrows and shown at magnifications of 16x (A) and 400x (B)) caused by increased growth during lower peak Sunday flows (8,000 cfs) during April 2003 when normal weekday operations ranged from 7,000–13,000 cfs on a 24-h cycle (photographs courtesy of Steven Campana, Bedford Institute of Oceanography, Canada).

the increased electrofishing catch rate and the implementation of fluctuating flows (see chapter 9, this report).

Otoliths (minute boney structures found in the inner ear) of young rainbow trout (fig. 4) were examined in 2003 and 2004 to infer growth rate patterns during the late spring and summer months following the end of fluctuating nonnative fish suppression flows. Microscopic examination of these bony structures allows researchers to determine daily growth patterns. Results of these examinations suggest that YOY rainbow trout experienced more growth on Sundays than on other days of the week in 2003; however, otoliths collected in 2004 do not display increased growth on Sundays. Korman and others (2005) hypothesized that this difference was related to less severe flow fluctuations on Sundays during 2003 as compared to 2004.

Mainstem Colorado River

Management objectives of the Glen Canyon Dam Adaptive Management Program call for managing the mainstem Colorado River and its tributaries below the Paria River for the benefit of native fishes (GCDAMP, 2001, http://www.usbr.gov/uc/rm/amp/amwg/mtgs/02jan17/Attach_06.pdf, accessed July 14, 2005). Fish monitoring in the mainstem Colorado River is primarily conducted by electrofishing or with trammel nets, hoop nets, and beach seines. Each of these methods is "selective," or has higher efficiency for particular species or fish sizes. For instance, electrofishing is very effective in catching rainbow and brown trout and common carp but is inefficient in capturing adult humpback chub. Alternatively, trammel and hoop nets are more efficient than electrofishing in capturing humpback chub. These differences in sampling gear efficiency, coupled with differences in abundance, influence the ability of the monitoring program to detect differences in abundance over time and space.

The current monitoring program, which uses electrofishing for rainbow trout, brown trout, and common carp, is able to show trends in the abundance of these species over time and space (fig. 5 a, b, c). The abundance of rainbow trout declines as a function of distance

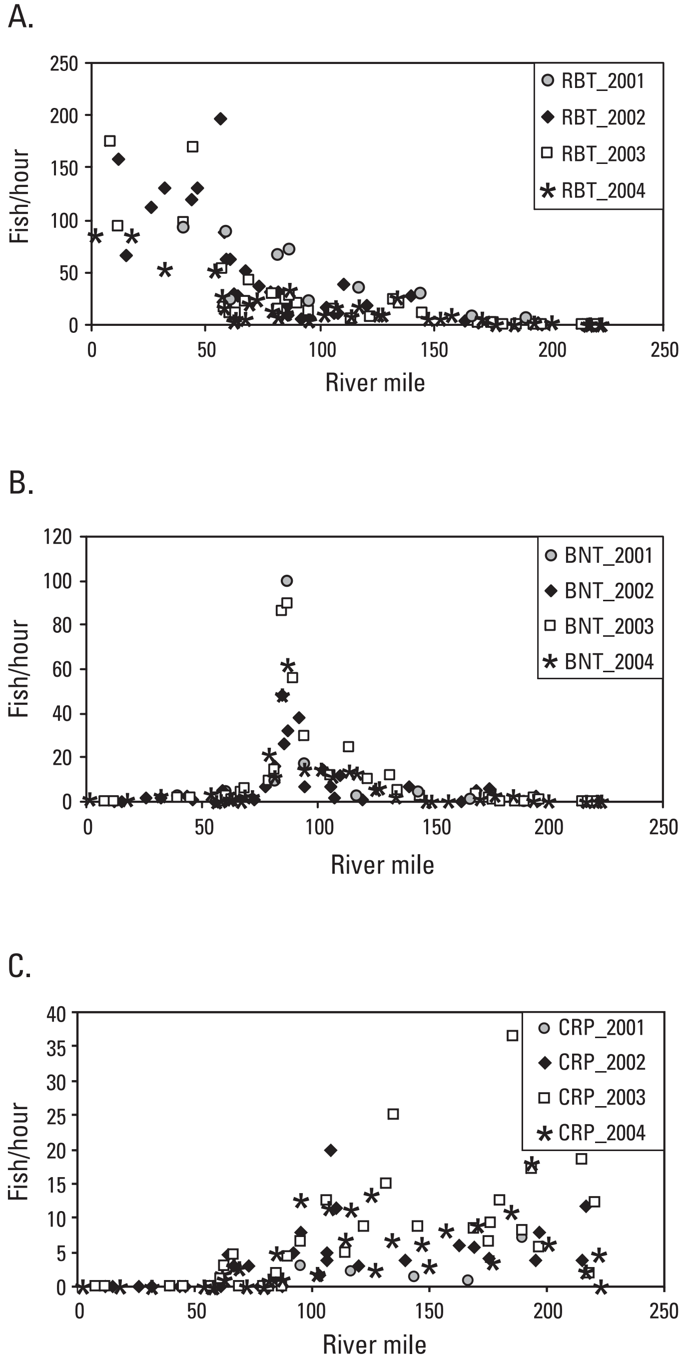


Figure 5. Relative abundance (mean catch-per-unit efforts, or fish/hour) of rainbow trout (A), brown trout (B), and common carp (C) as indicated by electrofishing catch rates from Lees Ferry (RM 0) to Diamond Creek (RM 226) (Arizona Game and Fish Department and U.S. Geological Survey, unpub. data, 2005). Note inverse abundance of coldwater trout to warmwater carp as distance from Lees Ferry and Diamond Creek increases. Increase in brown trout abundance in the middle of Grand Canyon is thought to be caused by spawning, which occurs in Bright Angel Creek, a tributary at RM 88. The National Park Service is trying to reduce spawning in Bright Angel Creek.

downstream of Glen Canyon Dam, but common carp increase downstream. Brown trout abundance is centered near RM 88 and declines with distance upstream or downstream of this location. This pattern is explained most readily by the occurrence of several tributaries in this reach that are suitable for spawning by this species.

Monitoring efforts in the mainstem Colorado River for both native and nonnative species have generally resulted in an adequate description of species distribution. In general, humpback chub distribution is centered near the Little Colorado River where successful spawning and rearing is known to occur (Douglas and Marsh, 1996; Gorman and Stone, 1999). Also, humpback chub occur in several other smaller aggregations throughout the river corridor (see below). Flannelmouth sucker, bluehead sucker, and speckled dace abundance typically increases with distance downstream of the Little Colorado River and is generally high near major tributary confluences (e.g., Little Colorado River, Paria River, Kanab Creek, and Bright Angel Creek) (Gorman and Coggins, 2000; Johnstone and others, 2003; Johnstone and Lauretta, 2004). Warmwater nonnative species such as channel catfish and striped bass increase in abundance with distance from Glen Canyon Dam, particularly below RM 160. Small-bodied, nonnative fish such as fathead minnow, red shiner, and plains killifish are found almost exclusively downstream of the Little Colorado River confluence, and all evidence suggests that this tributary is the dominant source of these fishes in the Colorado River ecosystem (Johnstone and others, 2003; Johnstone and Lauretta, 2004).

Although the current monitoring program is sufficient to describe these general patterns in distribution of native and certain nonnative fishes, it cannot provide a specific measure of trends in relative abundance. Despite sampling efforts that are randomly distributed over the 226 mi (364 km) of river from Lees Ferry to Diamond Creek, the monitoring program is unable to measure with any certainty the spatial or temporal trends in the relative abundance of native or nonnative fishes in the mainstem Colorado River. An exception is the abundance and distribution of rainbow trout, brown trout, common carp, and the Little Colorado River population of humpback chub previously discussed. Low abundance of these fishes coupled with the very poor sampling efficiency of current sampling gear make measuring trends in relative abundance difficult. Typically, monitoring efforts include over 600 trammel net sets each year and between 100 and 200 seining sites. Several examples of the low and highly variable catch rate experienced with trammel nets are illustrated for select species and sites in figure 6.

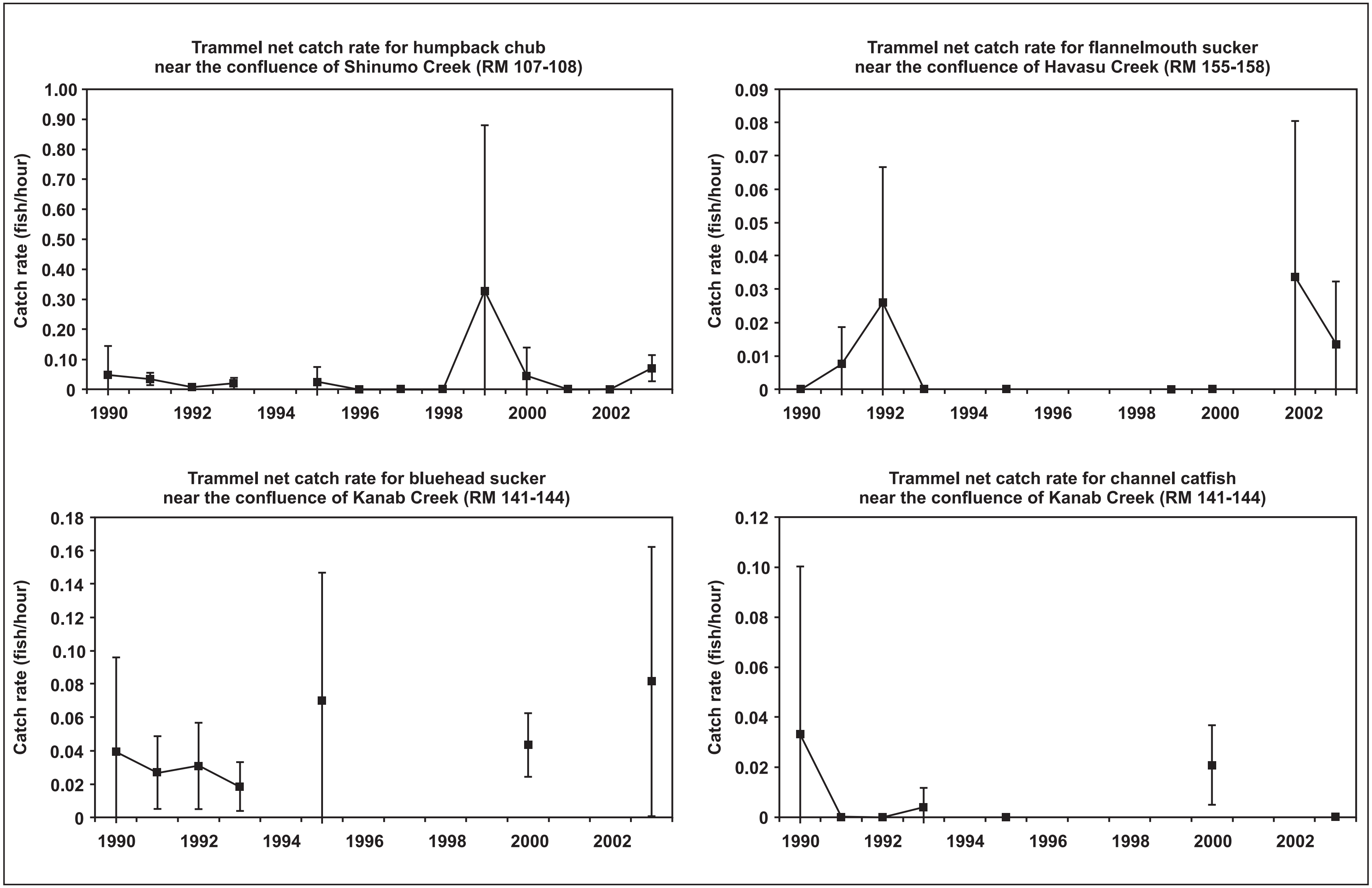


Figure 6. Trends in the relative abundance (trammel net catch rate, fish/hour) of selected species near the confluences of several tributaries where native fishes, particularly the suckers, attempt to reproduce. These figures illustrate the inability of the current monitoring program to detect all but extremely large changes in the relative abundance of key native and nonnative species in most areas of the Colorado River. Error bars depict 95% confidence intervals for mean catch rate. Note that catch rate estimates with overlapping confidence intervals are statistically insignificant and represent years of no statistically apparent difference in relative abundance (U.S. Geological Survey, unpub. data, 2005).

The presence of many nonnative fish in the system has created a substantial management challenge. It is known that some of these nonnative species, particularly brown trout, prey upon native fishes (Valdez and Carothers, 1998). Furthermore, nonnative species may compete for habitat and food with native species in ways that are difficult to document. Monitoring the relative abundance of nonnative fish in this part of the river provides some insight into the potential severity of the problem. Both coldwater nonnative species such as trout and warmwater fishes such as carp inhabit the river. Coldwater species dominate the upstream reaches of Grand Canyon, whereas warmwater species are more prominent further downstream because the temperature of the river water gradually increases after leaving the dam.

Little Colorado River

The Little Colorado River, which flows into the Colorado River at RM 61, represents perhaps the best remaining native fish habitat in Grand Canyon under the current temperature and flow management regimes in the Colorado River. Because native fish are abundant and the sampling gear is efficient in the Little Colorado River, relative abundance of native fish and some nonnative fish can be well determined in this tributary. Two kinds of fish sampling are conducted in the Little Colorado River: spring and fall hoop netting aimed primarily at collecting humpback chub to estimate population size and hoop netting conducted in April and May at fixed sites in the lower 0.75 mi (1,200 m) of the river. The humpback chub data are discussed separately below. Despite the presence of several nonnative fishes in the Little Colorado River, the catch in hoop nets suggests that native fish (>80%) dominate the fish community in most years (fig. 7). The data from the lower 0.75 mi (1,200 m) sampling depict trend information for the relative abundance of three native species: humpback chub (fig. 8), bluehead sucker (fig. 9), and flannelmouth sucker (fig. 10). These data represent the best time series regarding status and trends of flannelmouth and bluehead suckers in the Little Colorado River.

Humpback Chub

The life history and ecology of humpback chub in Grand Canyon have been intensively studied (Suttkus and Clemmer, 1979; Carothers and Minckley, 1981; Kaeding and Zimmerman, 1983; Maddux and others, 1987; Gorman, 1994; Valdez and Ryel, 1995; Valdez and Carothers, 1998). The humpback chub population in Grand Canyon is centered near the confluence of the Colorado and Little Colorado Rivers (Kaeding and Zimmerman, 1983; Douglas and Marsh, 1996; Gorman and Stone, 1999). Valdez and Ryel (1995) defined the humpback chub distribution as occurring in nine aggregations throughout Glen and Grand Canyons. Only the aggregation near the confluence of the Little Colorado and Colorado Rivers (hereafter referred to as the LCR population) is known to successfully reproduce. The other eight aggregations are much smaller in abundance, averaging from a few dozen to a few hundred fish. Most likely these eight aggregations are not supported from local reproduction but primarily from the emigration of juveniles and limited numbers of subadult and adult fish from the LCR population (Valdez and Ryel, 1995). Additionally, because of abiotic and biotic changes in the Colorado River following the construction of Glen Canyon Dam, the LCR population relies on the Little Colorado River as the primary spawning and juvenile-rearing habitat (Gorman and Stone, 1999).

Reproduction and Early Life History

Adult fish in the LCR population initially stage for spawning runs in large eddies near the confluence of the Little Colorado River in February and March and make spawning runs into the tributary that average 17 d from March through May. As the Little Colorado River's spring flows decrease and the water warms and clears, reproduction increases and larval fish appear (Valdez and Ryel, 1995). Spawning has not been observed, primarily because of the turbid water, but ripe males have been seen gathering in areas of complex habitat structure (boulders and travertine masses near gravel deposits); it is thought that ripe females move to these areas to spawn (Gorman and Stone, 1999). After spawning, some adult chub return to specific locations in the mainstem, while others remain in the Little Colorado River for unknown periods of time.

Humpback chub require warm water to reproduce successfully. Perennially cold mainstem water temperatures are thought to be the reason for unsuccessful mainstem reproduction. The minimum water temperature for successful reproduction is 61ºF (16ºC) (Hamman, 1982; Marsh, 1985), which is well above the summer mainstem temperatures commonly observed of 50°F–54ºF (10°C–12ºC). Mortality of larval and postlarval humpback chub emerging from the warm waters of the Little Colorado River has been attributed to thermal shock and their enhanced susceptibility to predation caused by the more protracted debilitating effects of cold water on swim-

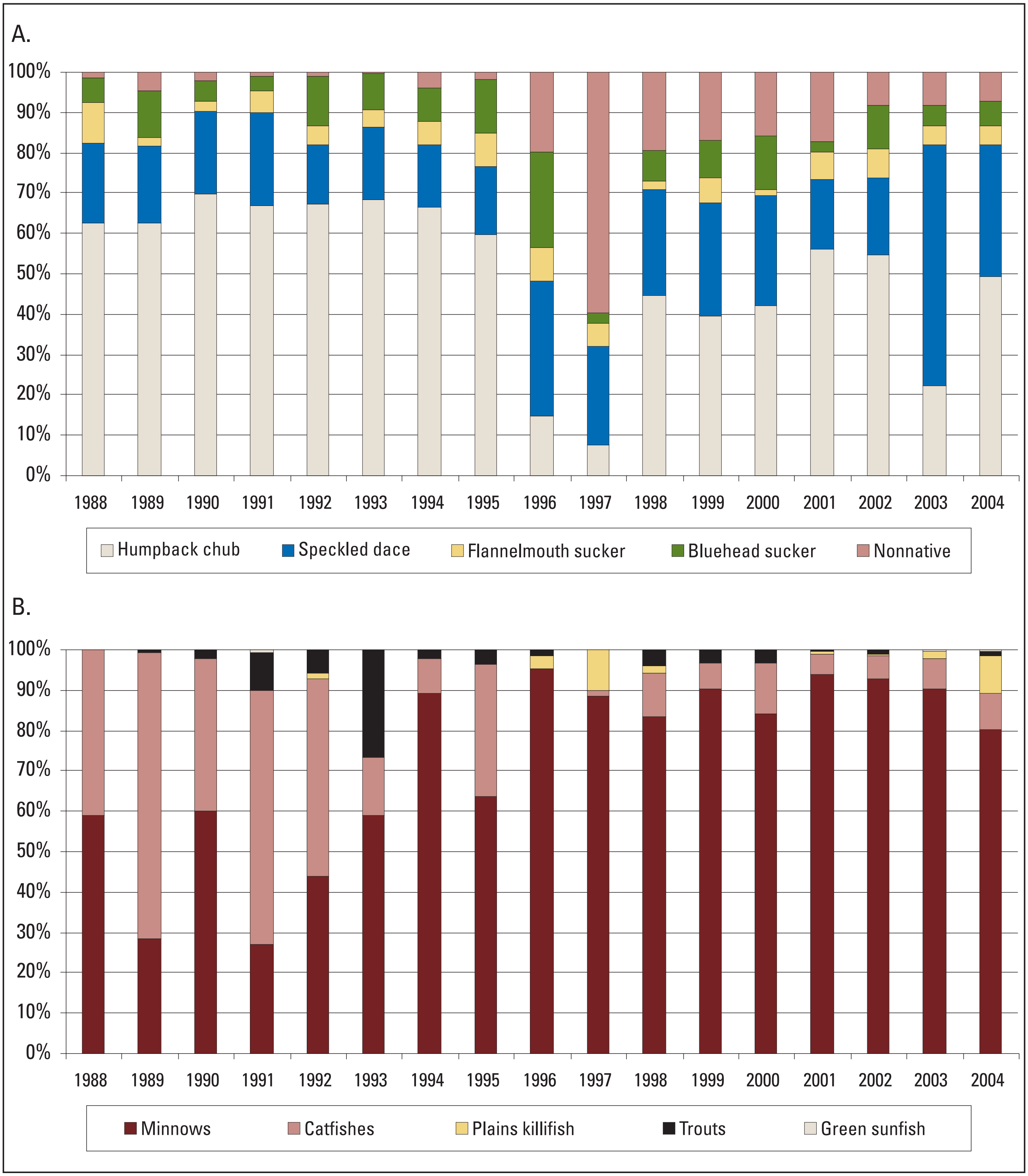


Figure 7. Observed species composition of all fish captured in hoop nets in the Little Colorado River, 1988–2004 (U.S. Fish and Wildlife Service, Arizona Game and Fish Department, Arizona State University, and U.S. Geological Survey, unpub. data, 2005). The top panel (A) includes species composition of the four native species and a pooled nonnative category. The bottom panel (B) displays the annual species composition of the nonnative catch. Dominant species of minnows include fathead minnow, red shiner, and common carp. Dominant species of catfishes include channel catfish and black and yellow bullheads.

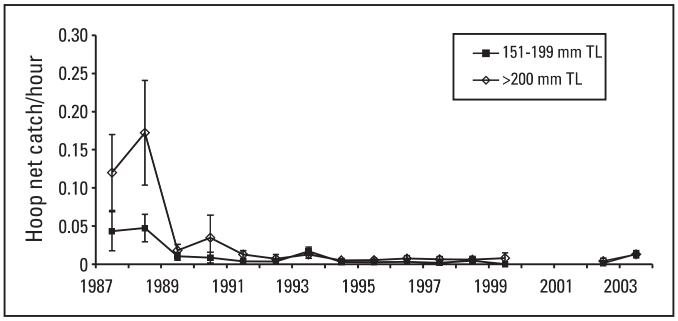


Figure 8. Humpback chub catch-per-unit effort (fish/hour) with 95% confidence intervals in the lower 0.75 mi (1,200 m) of the Little Colorado River using hoop nets, 1987–2003 (no sampling conducted 2000–01). Solid squares are for fish between 5.9 and 7.8 inches (151–199 mm) total length (TL) and open diamonds are for fish more than 7.9 inches (200 mm) total length (modified from Coggins and others, in press).

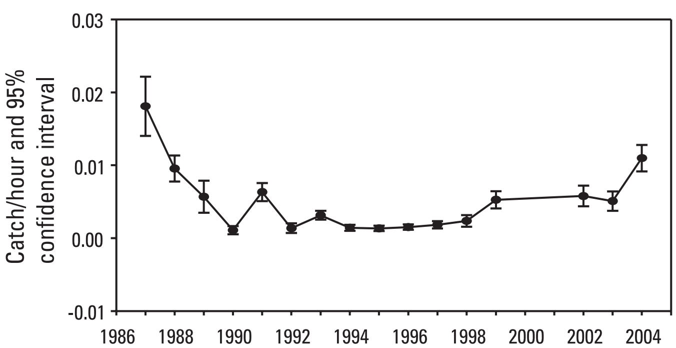


Figure 9. Hoop net catch (fish/hour) of adult bluehead sucker more than 7.5 inches (190 mm) in total length in the lower 0.75 mi (1,200 m) of the Little Colorado River (Arizona Game and Fish Department and U.S. Geological Survey, unpub. data, 2005).

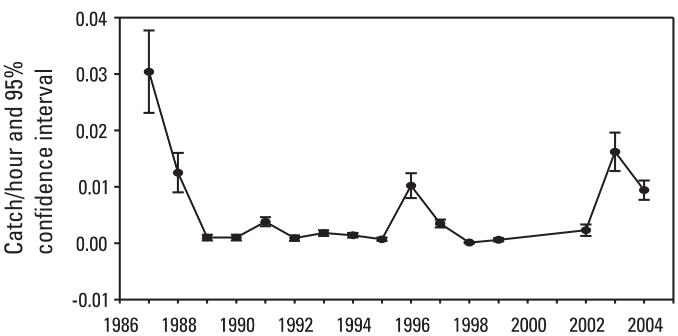


Figure 10. Hoop net catch (fish/hour) of adult flannelmouth sucker more than 13.8 inches (350 mm) in total length in the lower 0.75 mi (1,200 m) of the Little Colorado River, 1987–2004 (Arizona Game and Fish Department and U.S. Geological Survey, unpub. data, 2005).

ming ability and growth (Lupher and Clarkson, 1994; Clarkson and Childs, 2000; Robinson and Childs, 2001; Ward and others, 2002).

A key issue associated with humpback chub is lack of recruitment to the adult population because of the low survivorship of young fish (Valdez and Ryel, 1995). Young humpback chub remain in the Little Colorado River or drift and swim into the mainstem (Robinson and others, 1998). The lack of recruitment and documented predation indicate that mortality is extremely high in the mainstem (Lupher and Clarkson, 1994; Valdez and Ryel, 1995; Marsh and Douglas, 1997; Clarkson and Childs, 2000; Robinson and Childs, 2001). During summer, the young humpback chub that survive in the mainstem occupy low-velocity, talus, and vegetated shoreline habitats, including backwaters; however, low survivorship over the year virtually eliminates the YOY humpback chub in the mainstem. As a result, few if any humpback chub spawned during the previous year are present in the mainstem in March. Those YOY humpback chub that do survive, and ultimately recruit to the adult population, are fish that remain resident in the Little Colorado River during their early life history.

Limited breeding of humpback chub occurs among other subpopulations in the Colorado River. Valdez and Ryel (1995) documented limited spawning success at a warm underwater spring near RM 30, known locally as 30-Mile Spring, in upper Marble Canyon. YOY humpback chub in the size range of 0.4–1.2 inches (10–30 mm) have been sporadically collected at considerable distances below the Little Colorado River, usually beginning in June (Kubly, 1990; Arizona Game and Fish Department, 1996; Brouder and others, 1997). Some limited reproduction may occur in other smaller tributaries. Young humpback chub have been collected in or near Bright Angel Creek, Shinumo Creek, Kanab Creek, and Havasu Creek, but spawning success has not been well documented (Maddux and others, 1987; Kubly, 1990; Arizona Game and Fish Department, 1996; Brouder and others, 1997). These limited observations of spawning success among subpopulations outside of the Little Colorado have not been shown to lead to successful recruitment, likely because of the factors mentioned above.

Food Habits and Diseases

Dietary analyses reveal humpback chub to be opportunistic feeders, selectively feeding on algae, aquatic and terrestrial invertebrates, and small fish (Kaeding and Zimmerman, 1983; Kubly, 1990; Valdez and Ryel, 1995; Stone, 2004). Humpback chub diet changes over the course of the year in response to food availability and turbidity-related decreases in benthic-standing biomass over distance downstream from Glen Canyon Dam (Blinn and others, 1992). Nonnative scuds (*Gammarus lacustris*) and simuliid (black fly) larvae occasionally make up a large proportion of humpback chub diet. *Gammarus lacustris* selectively feeds on epiphytes (i.e., diatoms) associated with *Cladophora glomerata*, the dominant algae species in the upper reaches where clear water conditions often prevail. Chironomid (midge fly) larvae are also important in all areas of the river. As the river becomes more turbid downstream, simuliids become the dominant food source (see chapter 5, this report).

Kaeding and Zimmerman (1983) identified 13 species of bacteria, 6 protozoans, and 1 fungus from humpback chub in Grand Canyon. The role of these organisms in the life history of humpback chub is not known. In 1990, the Asian tapeworm was first identified from humpback chub in the Little Colorado River (Clarkson and others, 1997; Choudhury and others, 2004). This cestode is particularly worrisome because it infects humpback chub at a high rate and has been reported to be pathogenic and potentially fatal in a variety of other fish (Hoffman and Schubert, 1984; Hoffnagle and others, 2000).

Population Dynamics

Very large numbers of humpback chub, as well as of flannelmouth sucker and bluehead sucker, have been tagged in Grand Canyon since 1989. As a result, today most of the older humpback chub have been tagged. Previous analyses of the recapture data of tagged fish indicate that there is likely strong age-dependence in survival rates and that recruitment of humpback chub has likely declined considerably since the early 1990s (Coggins and others, in press). The USGS Grand Canyon Monitoring and Research Center uses an analysis method for the mark and recapture data that reinforces these results and allows recovery of information about likely recruitment changes that date back to the early 1980s. The mark and recapture data are analyzed by assigning each marked fish an age at first capture based on its size at that time and then performing mark-recapture analysis on the resulting age-structured data on first captures and later recaptures (Coggins and others, in press). Results of this open population mark-recapture model, known as age-structured mark recapture (ASMR), show decreases in the recruitment of young humpback chub into the adult population and as a consequence an overall decline in numbers of adult humpback chub (figs. 11 and 12).

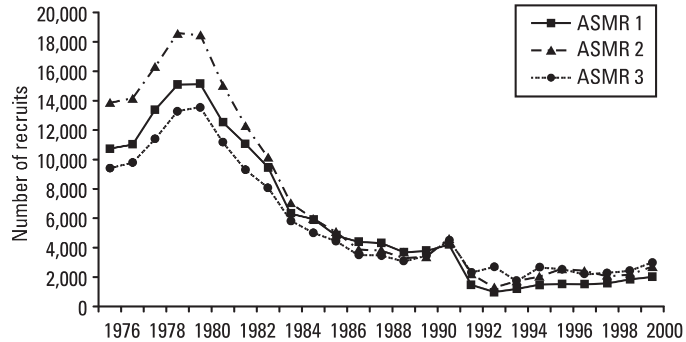


Figure 11. Age-2 humpback chub recruitment estimated by using the three formulations of the annual age-structured mark recapture (ASMR) model (from Coggins and others, in press).

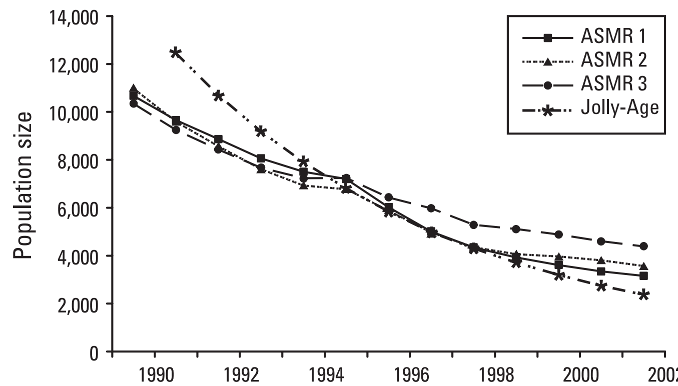


Figure 12. Adult (age-4+) humpback chub population estimates for 1989–2001 made by using the age-structured Jolly-Seber model and the three formulations of the annual age-structured mark recapture (ASMR) model (from Coggins and others, in press).

Overall, about 15%–20% of the adult humpback chub are dying each year. If this mortality rate and the dramatically reduced recruitment rate of young chub experienced since the early 1990s remain unchanged, there will be a decline in the adult population of humpback chub from the present 3,000–5,000 fish to a level of 1,500–2,000 adult fish over the next 10–15 yr.

Cause and Effect Relationships

The Glen Canyon Dam Adaptive Management Program has a goal of maintaining a self-sustaining population of humpback chub in Grand Canyon (GCDAMP, 2001, http://www.usbr.gov/uc/rm/amp/amwg/mtgs/02jan17/Attach_06.pdf, accessed July 14, 2005); however, this goal is qualitative and has no defined target population abundance levels. The U.S. Fish and Wildlife Service, which has jurisdiction over the humpback chub as a federally endangered species, promulgated recovery goals based on the known distribution of the species (U.S. Fish and Wildlife Service, 2002). These goals recognize the Grand Canyon population of humpback chub as the only potentially viable population in the lower Colorado River Basin and include it, along with at least one population from the upper Colorado River Basin, as having to attain certain population numbers before the species can be considered for downlisting or delisting under the Endangered Species Act. Briefly, these goals require that a viable population be attained and maintained for a period of at least 5 yr, with a minimum of 2,100 sexually mature individuals in each population. Furthermore, the recruitment of new individuals into the population must meet or exceed the adult mortality rate, thereby providing a stable or increasing adult abundance trend. In the case of the Grand Canyon population, sexually mature fish are assumed to be 4 yr old or older.

Of paramount importance in conserving the population of the federally endangered humpback chub is determining the factors contributing to population decline and implementing management actions designed to minimize or eliminate the effect of those factors. Not all of the factors that may be responsible for the recruitment decline of humpback chub beginning in the early 1990s are clear, but a list of likely factors that could be acting either singly or in combination include (1) Colorado River and Little Colorado River hydrology (discharge and temperature), (2) infestation of juvenile humpback chub by Asian tapeworm, (3) predation by or competition with warmwater native cyprinids and catostomids and nonnative cyprinids and ictalurids within the Little Colorado River, and (4) predation by or competition with coldwater nonnative salmonids within the Colorado River.

The body of evidence available to evaluate specific questions varies among these postulated factors. For instance, beginning in 1990 the operation of Glen Canyon Dam was changed through the implementation of research flows (a series of discharges and data collection programs conducted from June 1990 through July 1991) and the interim operating criteria. This hydrology, and the subsequent MLFF alternative that continues to present, can generally be characterized as having less severe daily flow fluctuations than the previous 28 yr of the no action period when the dam was managed primarily to maximize hydroelectric power revenue. This major change in Colorado River hydrology correlates closely to the decline in humpback chub recruitment. Also, it is possible that the decline in humpback chub recruitment in the early 1990s was caused by the nearly continuous flooding in the Little Colorado River that occurred during the summer of 1992, particularly during the early summer when larval humpback chub emerge (Robinson and others, 1998). It is also possible that the high infestation rate of juvenile humpback chub by the Asian tapeworm is a factor. Humpback chub infected with Asian tapeworm were first found in 1990, and infestation rates in 2001 exceeded 90% (Choudhury and others, 2004). Finally, predation and competition by nonnative fishes either in the Little Colorado River or in the Colorado River may be driving the humpback chub recruitment trend. Although robust relative abundance data do not exist for common carp and channel catfish within the Little Colorado River, there was a large increase in the abundance of nonnative salmonids in the Colorado River documented near the confluence of the Little Colorado River (RM 56.6–68.3) (Gorman and Coggins, 2000).

Recent Management Actions Undertaken or Proposed

While it is difficult to determine the factor most responsible for the humpback chub recruitment decline, a likely primary factor is negative interactions (predation and competition) with nonnative fish. Interaction with nonnative fish is implicated in the decline and extinction of native fishes throughout the Colorado River Basin. In response to the need to address this factor, a program of selective removal of nonnative fishes (known as mechanical removal) was implemented in 2003 near the confluence of the Little Colorado River and in other tributaries (work in Bright Angel Creek and other tributaries has been undertaken by the National Park Service). To complement these efforts, the work group also approved initiation of a multiobjective study to evaluate the potential effect of rainbow trout and brown trout predation on humpback chub recruitment and the efficacy of mechanical removal of nonnative fishes from the Colorado River near the confluence of the Little Colorado River.

In early 2003, a major effort was begun by the Glen Canyon Dam Adaptive Management Program to remove nonnative fish from the area of the river near the confluence of the Little Colorado River (RM 61), which is considered important habitat for native fish, especially humpback chub. A total of 16,045 rainbow trout and many other nonnative fish (fig. 13a) were removed from this river reach during 2003–04. While native fish contributed only approximately 5% of the overall catch in January 2003, native fish contributed greater than 35%

in September 2004, generally reflecting a reduction in nonnative fish abundance. Also, the overall abundance of rainbow trout has been reduced by more than 60% in this river reach (fig. 13b). Whether this reduction in nonnative fish density will benefit native fish is unknown at this time.

Moreover, an experimental program to move YOY humpback chub upstream of an impassable barrier (where few nonnative fish live) in the Little Colorado River was initiated and has shown some early signs of success (Stone and Sponholtz, 2005). Future introductions of humpback chub into other Grand Canyon tributary streams may help augment the population in Grand Canyon. Additional management options include potential hatchery rearing of humpback chub as a refugium population or for stocking in the river.

Other management options include the installation of a multilevel water intake structure(s) for Glen Canyon Dam to warm the water in Grand Canyon. The Bureau of Reclamation has developed preliminary plans and is scoping out the possible installation of a temperature control device, which would provide flexibility to release warmer water into the river. Warmer water could create more favorable habitat conditions for native fishes in general; however, its operation could also improve habitat conditions for nonnative, warmwater species and degrade habitat quality for trout inhabiting the Lees Ferry reach. Obviously the operation of such a device, if built, will need to be carefully considered and implemented experimentally.

Discussion and Future Research Needs

The salient findings of the research and monitoring programs undertaken by the Glen Canyon Dam Adaptive Management Program regarding fishes are twofold. First, there has been a dramatic and continuing decline in the number of adult humpback chub in the Grand Canyon ecosystem since at least the late 1980s. This decrease in adult fish is due to a steady decline in the recruitment of young fish into the population beginning in the early 1980s, with an additional reduction in the early 1990s. This decline in recruitment results in a dwindling population of adults as older age fish die off and are not replaced. It is currently estimated that if recruitment remains stable at this level, the adult population of humpback chub in the Grand Canyon ecosystem will stabilize at approximately 1,500–2,000 fish over the next decade or so. The current population decline combined with the low recruitment in this population relative to adult mortality indicates that this population will attain neither positive trends nor sufficient numbers of fish to meet USFWS recovery goals in the foreseeable future.

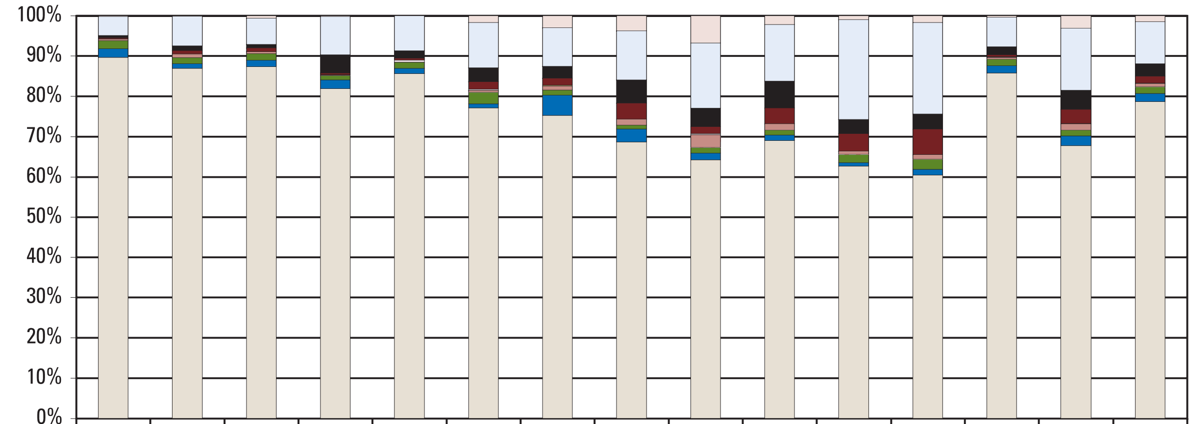
The second major result regarding fishes is the proliferation of rainbow trout in both the Lees Ferry reach and downstream as far as RM 75. Numbers of brown trout have also increased dramatically in the area around Bright Angel Creek and upstream to above the Little Colorado River confluence. Both of these species are known to prey on native fishes, and their substantial increase in abundance near the principal remaining native-fish habitat in Grand Canyon remains a concern. It has yet to be determined whether the experimental management action to reduce the numbers of nonnative fish in the area around the Little Colorado River confluence has resulted in any increase in survival and recruitment of the federally endangered humpback chub.

Dam Operations

It is not possible to say conclusively that the decline in humpback chub recruitment that began to occur in the early 1990s is because of the implementation of the MLFF regime; however, the flow regime has not reversed the decline in recruitment and adult abundance either. Approximately 15%–20% of the adult humpback chub population is dying each year. These fish are most likely being replaced, albeit at a lower rate, predominately by young humpback chub that have spent the first 3 to 4 yr of their lives in the Little Colorado River. In other words, the MLFF alternative had either a negative effect or no effect at all, but it has not had a measurable beneficial effect on humpback chub.

The MLFF alternative has not improved conditions for other native fishes as indicated by their stable or declining numbers. Different daily, seasonal, or annual changes in river flows could be considered on an experimental basis. Such flow options could include reduced daily fluctuations and equalized monthly volumes to provide a more stable environment for young native fishes. There is a good chance that juvenile humpback chub dispersing into the mainstem in summer and fall would be able to grow, survive, and return to the Little Colorado River for extended rearing if they were to encounter (1) reduced predation and competition by nonnative trout (trout would have to be removed by mechanical removal treatments) and (2) relatively warm refuges in nearshore locations (these locations could be created by steady flow conditions in late summer and fall). The low summer

A.



	Jan. 03	Feb. 03	Mar. 03	July 03	Aug. 03	Sept. 03	Jan. 04	Feb. 04	Mar. 04	July 04	Aug. 04	Sept. 04	Total 03	Total 04	Total 03-04
Speckled dace	7	2	8	6		18	53	34	92	47	7	19	41	252	293
Flannelmouth sucker	188	161	89	266	79	119	169	110	218	296	190	258	902	1,241	2,143
Humpback chub	26	26	13	126	17	37	51	52	61	142	27	43	245	376	621
Bluehead sucker	8	18	11	12	4	19	32	37	24	84	33	72	72	282	354
Unidentified sucker	2	0	0	3	5	4	3	0	3	0	0	0	14	6	20
Fathead minnow	17	21	8	4	0	4	18	13	44	32	6	13	54	126	180
Common carp	80	33	22	29	14	31	23	9	18	26	16	29	209	121	330
Brown trout	87	24	21	63	12	11	88	29	22	29	7	17	218	192	410
Rainbow trout	3,605	1,900	1,195	2,298	779	818	1,330	622	867	1,464	480	687	10,595	5,450	16,045

B.

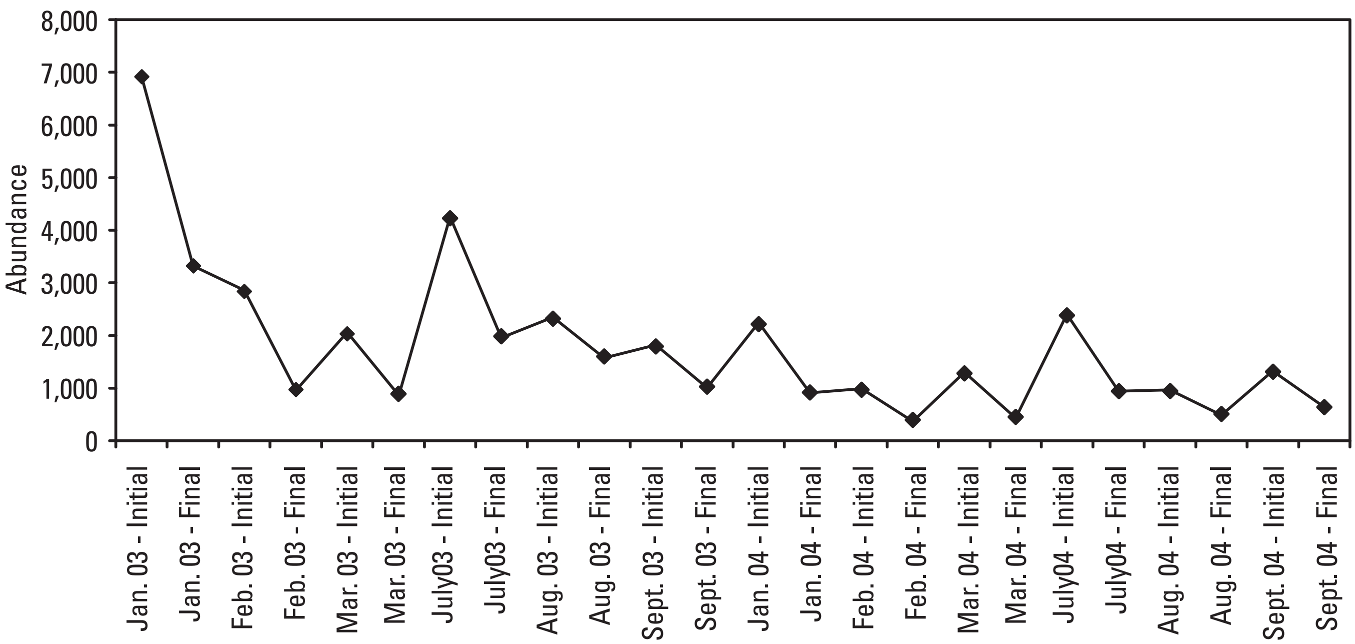


Figure 13. A. Total catch and percent contribution by species and month during mechanical removal efforts in the Little Colorado River removal reach, 2003–04. B. Estimated abundance of rainbow trout in the Little Colorado River removal reach before and after each mechanical removal effort, 2003–04 (U.S. Geological Survey, unpub. data, 2005).

steady flow (LSSF) experiment demonstrated that such lateral warming of backwater areas can be quite dramatic. A summer-fall steady flow experiment would need to maintain conditions for backwater warming from the time of the first summer high flow that disperses juveniles into the mainstem until around November 1, when the equilibrium temperature in standing backwaters decreases (because of nighttime cooling) to about the same as the mainstem temperature.

Three additional flow possibilities for Glen Canyon Dam could be made based on recommendations from the 2003 YOY rainbow trout surveys and analyses of otoliths: (1) fluctuating flows targeting YOY rainbow trout could be implemented from April through July to coincide with the timing of hatch, (2) summer steady flows could likely improve the growth of YOY rainbow trout, and (3) sudden reductions in the minimum daily flow could have the potential to strand or displace many YOY rainbow trout in the Lees Ferry reach. The latter recommendation was based on an almost complete absence of fry from low-angle shorelines after the reduction in the minimum flow from 10,000 cfs to 5,000 cfs in early September 2003 and a similar but less dramatic reduction in September 2004 (Korman and others, 2005). An event-based approach—in which flows are increased to approximately 20,000 cfs for 2 d, followed by a reduction to 5,000 cfs for 1 d, and implemented on a monthly basis from May through September—would almost certainly be much more effective at reducing recruitment in the Lees Ferry reach than the January–March fluctuating nonnative fish suppression flows implemented beginning in 2003. Steady flows could be conducted between events to increase water temperatures for native fish downstream and would not have beneficial effects for YOY rainbow trout, as their densities would be controlled through the temporary reductions in minimum flow.

Researchers have been unable to identify or implement an effective mainstem monitoring program for native fishes or most nonnative species (the exceptions are rainbow trout, brown trout, and carp). Because of this situation, the USGS Grand Canyon Monitoring and Research Center has called for a research initiative to investigate the utility of alternative sampling methods such as acoustic devices that may assist in providing better measures of relative abundance and change detection.

The most important research task associated with humpback chub conservation is determining the factors controlling the recruitment dynamics of this species. These factors can only be determined through an appropriately designed experiment that addresses the multiple important biotic and abiotic factors likely influencing humpback chub. As stated by Korman and others (2004, p. 395–396) in summary of an intensive modeling effort aimed at characterizing changes in nearshore humpback chub habitat with changes in Glen Canyon Dam operation,

> The interaction between habitat and ecosystem processes like competition and predation remain highly uncertain. Ultimately, questions regarding the effects of dam operations on juvenile humpback chub must be addressed by monitoring the response of critical population parameters to flow manipulations conducted within a sound experimental design.

Profiles of Selected Fish Species Found in the Grand Canyon Ecosystem

Information compiled by Jeffrey E. Lovich

Speckled dace (native)

Randall D. Babb, Arizona Game and Fish Department

Size–

rarely exceeds 3 inches (7.6 cm).

Distribution–

extensively distributed throughout Western United States.

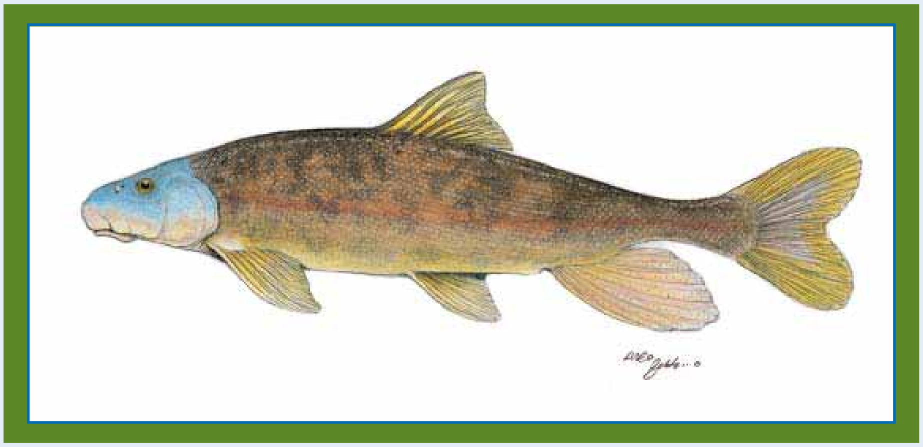
Status–

abundant in some areas and widely distributed. This species is represented by several subspecies.

Natural history–

The speckled dace (*Rhinichthys osculus*) is the only native dace in Arizona, although the genus is widely distributed elsewhere. Dace are widely distributed in the Colorado River, with many inhabiting backwaters in western Grand Canyon. Diet includes algae, insect larvae, small crustaceans, and small snails. Spawning occurs in spring and late summer. Large schools of dace congregate over gravel bottoms to spawn. Populations appear to be stable in Grand Canyon.

Bluehead sucker (native)



Randall D. Babb, Arizona Game and Fish Department

Size–

maximum of about 20 inches (51 cm).

Distribution–

found in fast-flowing river systems in Arizona, Colorado, New Mexico, Utah, and Wyoming.

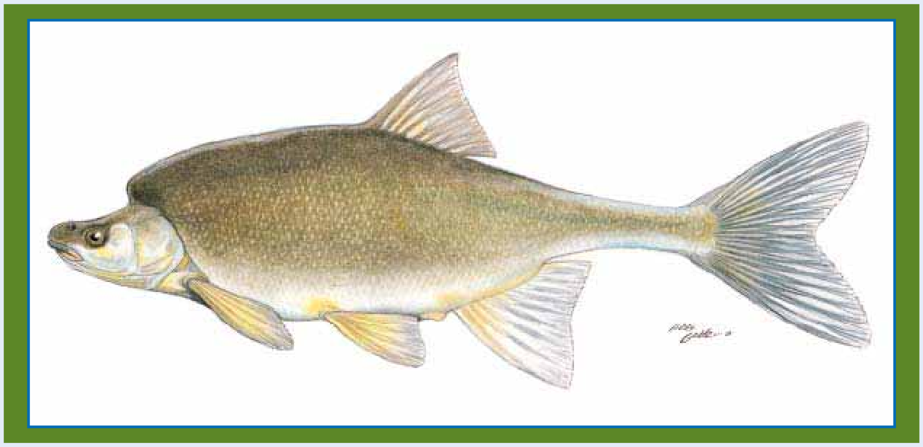
Status–

not uncommon in some areas.

Natural history–

This species (*Catostomus discobolus*) occurs in the Colorado River upstream from Lake Mead. Diet includes algae, diatoms, insects, amphipods, and organic debris that it scrapes from rocks with specialized cartilage lips. In Grand Canyon, spawning occurs over gravel, sand, and cobbles in April and May, when water temperatures exceed 61°F (16°C). Young inhabit backwaters in Grand Canyon. Bluehead suckers are known to hybridize with other sucker species. Populations appear to be stable in Grand Canyon. Individuals can live for more than 20 yr.

Humpback chub (native)



Randall D. Babb, Arizona Game and Fish Department

Size–

maximum of about 20 inches (51 cm).

Distribution–

found only in the Colorado River system.

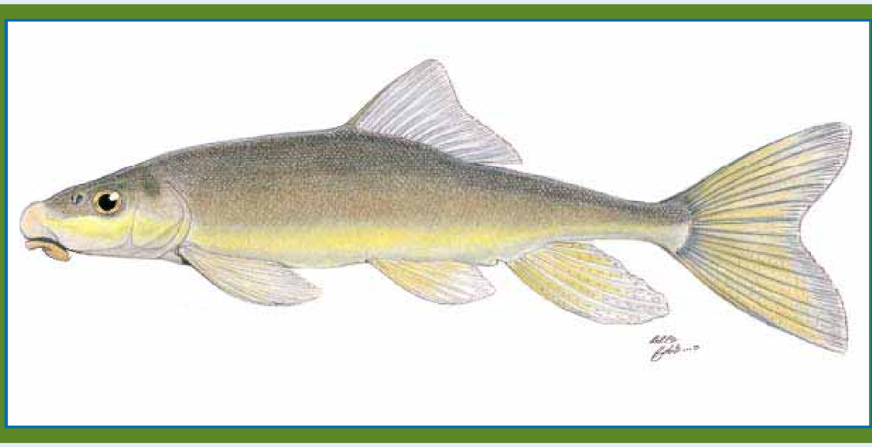
Status–

federally endangered.

Natural history–

The humpback chub (*Gila cypha*) formerly ranged downstream to the area now occupied by Lake Mohave, but it is now confined to several aggregations in Grand Canyon and isolated populations in various deep canyon stretches of the Colorado River and its major tributaries above Lake Powell. Most humpback chub in Grand Canyon are found in the vicinity of the Little Colorado River (LCR) and its confluence with the mainstem. Humpback chubs are omnivorous, and their diet includes a diversity of aquatic and terrestrial invertebrates, small fish, algae, and other plant material. In Grand Canyon the diet of the nonnative rainbow trout is almost identical, setting the stage for possible resource competition between the species. Spawning occurs in spring in the LCR, and young enter the mainstem during floods associated with storm events, most commonly in spring and late summer/fall. Aggregations of humpback chub, well upstream and downstream of the LCR population, may result from (1) emigration of juveniles, subadults, or adults from the LCR; (2) survival of relict fish from before the dam; or (3) mainstem spawning. The latter has not been documented in the postdam era, so additional research is needed to resolve this issue. The estimated adult population in Grand Canyon has declined sharply from about 10,000 a decade ago to about 3,000–5,000 today.

Flannelmouth sucker (native)



Randall D. Babb, Arizona Game and Fish Department

Size–

can exceed about 20 inches (51 cm).

Distribution–

Colorado River Basin in Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming. Extirpated from the Gila River Basin of Arizona.

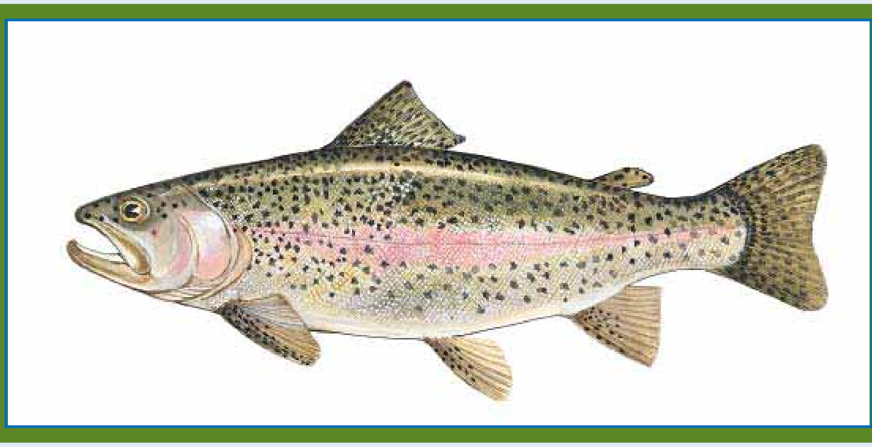
Status–

not uncommon in some areas.

Natural history–

This species (*Catostomus latipinnis*) occurs in the Colorado River upstream from Lake Mead. Flannelmouth suckers below Lake Mead exist because of the success of reintroduction from the Paria River in the mid-1970s. Diet varies with age class and size but includes algae, insects, plankton, ostracod, crustaceans, plant materials, and detritus. This species likely makes spawning runs in most of the major tributaries in Grand Canyon before returning to the mainstem. Spawning occurs from March to July, when water temperatures are between 43°F and 68°F (6°C and 20°C). Spawning occurs in shallow water over sand and gravel bottoms. Females lay from 4,000 to 40,000 eggs. Juveniles are frequently captured in the mainstem from lower Marble Canyon downstream to Lake Mead. Juveniles are also frequently captured in the Little Colorado River and other tributaries downstream. Known to hybridize with the razorback sucker, a species that is presumed to be gone from the Grand Canyon region. Populations appear to be stable in Grand Canyon.

Rainbow trout (nonnative)



Randall D. Babb, Arizona Game and Fish Department

Size–

up to 47 inches (120 cm). Arizona State record was 32.25 inches (81.9 cm).

Distribution–

extensively distributed throughout Western North America in river systems draining into the Pacific Ocean. Widely introduced worldwide, including into the Colorado River.

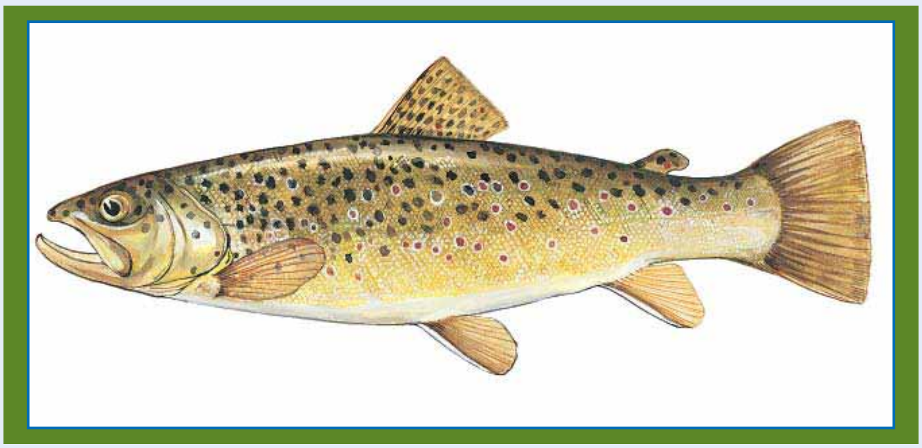
Status–

common.

Natural history–

Rainbow trout (*Oncorhynchus mykiss*) were introduced into the Grand Canyon area in the 1920s for sport fishing. Originally confined to clear tributary streams, the construction of Glen Canyon Dam created cold, clear conditions that allowed trout to colonize the mainstem. Trout were also stocked in the tailwaters of the dam by the State of Arizona shortly after construction was completed in the 1960s. The diet consists mainly of both aquatic and terrestrial insects and other aquatic invertebrates including amphipods. Spawning in Grand Canyon occurs in winter and early spring. After fertilization by males, females excavate a depression, or redd, in gravelly bottoms, and the eggs are buried in the substrate to hatch unattended. Rainbow trout like cold water temperatures and rarely live in water above about 77°F (25°C). The Lees Ferry reach of the Colorado River is where most spawning occurs in the Grand Canyon area and is managed as a "blue ribbon" trout fishery. Trout numbers have been increasing in recent years, possibly to the detriment of the endangered humpback chub.

Brown trout (nonnative)


Randall D. Babb, Arizona Game and Fish Department

Size–

Arizona State record is 36 inches (91.4 cm). The world record is a 40 lb, 4 oz (18.3 kg) specimen caught in Arkansas.

Distribution–

widely introduced worldwide, including into the Colorado River.

Status–

common.

Natural history–

Native to Europe and Asia, brown trout (*Salmo trutta*) were introduced into the Grand Canyon area in the 1920s for sport fishing. Originally confined to clear tributary streams, brown trout were able to colonize the mainstem of the Colorado River when the construction of Glen Canyon Dam created cold, clear conditions. Brown trout eat a variety of aquatic and terrestrial insects and other invertebrates. Large specimens are highly predaceous on other fish, including smaller trout. Reproduction is as in other species of trout (see text box for rainbow trout). Bright Angel Creek is an important spawning stream for mainstem trout that move into the smaller tributary for this purpose in winter and early spring. Brown trout are capable of tolerating slightly higher water temperatures than most other trout. Most brown trout in Grand Canyon today occur near the confluence with Bright Angel Creek.

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