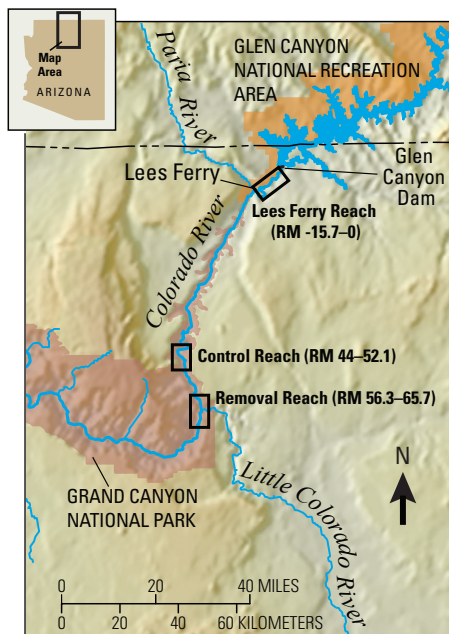


An Experiment to Control Nonnative Fish in the Colorado River, Grand Canyon, Arizona

The humpback chub (*Gila cypha*) is an endangered native fish found only in the Colorado River Basin. In Grand Canyon, most humpback chub are found in the Little Colorado River and its confluence with the Colorado River. For decades, however, nonnative rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), which prey on and compete with native fish, have dominated the Grand Canyon fish community. Between 2003 and 2006, scientists with the U.S. Geological Survey and Arizona Game and Fish Department experimentally removed 23,266 nonnative fish from a 9.4-mile-long reach of the Colorado River near where it joins the Little Colorado River. During the experiment, rainbow trout were reduced by as much as 90% and native fish abundance apparently increased in the reach. Concurrent environmental changes and a decrease in rainbow trout throughout the river make it difficult to determine if the apparent increase in native fish was the result of the experiment.

Conservation of native fish is a key goal of the Glen Canyon Dam Adaptive Management Program, a Federal initiative to mitigate impacts from dam operations to downstream resources in Glen Canyon National Recreation Area and Grand Canyon National Park, Arizona. A primary focus of the program's efforts is the endangered humpback chub (*Gila cypha*), a native fish found only in the Colorado River Basin. The Grand Canyon population of humpback chub is the largest of the six remaining populations of this endangered species. Most humpback chub in Grand Canyon are found in the Little Colorado River and its confluence with the Colorado River, likely because the Little Colorado River provides suitable spawning and rearing habitat.

For several decades, the Colorado River fish community in Grand Canyon has been dominated in terms of abundance by nonnative



In Grand Canyon, nonnative rainbow trout (*Oncorhynchus mykiss*; top right) prey on and compete with native fish, including the endangered humpback chub (*Gila cypha*, lower right). Between 2003 and 2006, U.S. Geological Survey and Arizona Game and Fish Department scientists experimentally removed nonnative fish from the Colorado River near its confluence with the Little Colorado River in the area called the "removal reach" (see map). The experiment's "control reach" and the Lees Ferry reach, a rainbow trout sport fishery, are also shown on the map. RM, river mile.

rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Rainbow and brown trout prey on juvenile native fish and also compete with native fish for available food and habitat.

Removal of Nonnative Fish

From January 2003 to August 2006, U.S. Geological Survey and Arizona Game and Fish Department scientists undertook an experiment to remove nonnative fish from the Colorado River near its confluence with the Little Colorado River. In addition to humpback chub, this area is used by other native fish—flannemouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), and speckled dace (*Rhinichthys osculus*). The experiment's goals were to evaluate the effectiveness of nonnative fish removal efforts in a large river like the Colorado River and to understand resulting changes in the fish community.

The scientists conducted 23 trips to remove



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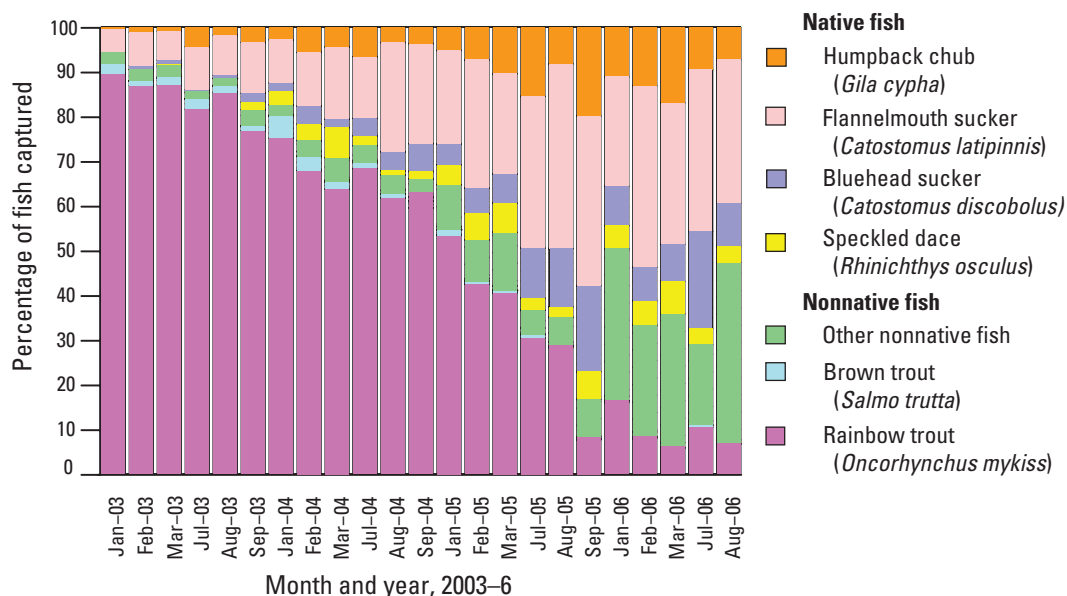


Arizona Game and Fish Department

nonnative fish from a reach that extended from river mile (RM) 56.3 to RM 65.7, as measured downstream from Lees Ferry at RM 0. More than 36,500 native and nonnative fish were captured in this "removal reach" during the study period using "electrofishing," a nonlethal capture method. Following capture, 23,266 nonnative fish were euthanized and 13,268 native fish were released alive back into the river. Additionally, a second sampling effort was made in an area of high rainbow trout density (RM 44 to RM 52.1) upstream of the removal reach, but all captured fish were released alive back into the river. This "control reach" was used to determine whether changes in fish abundance detected in the removal reach were the result of conditions other than removal efforts.

Findings

In 2003, nonnative fish represented more than 95% of fish caught in the removal reach, but after July 2005 nonnative fish were less than 50% of the catch. There were particularly



Graph showing the percentages of native and nonnative fish species captured in the experimental removal reach during 23 trips that occurred between January 2003 and August 2006. Native fish were returned to the river unharmed during the experiment, and nonnative fish were euthanized.

large catches of native flannemouth sucker and humpback chub in September 2005, causing the percentage of nonnative fish to fall to a low of 20% that month. The contribution of rainbow trout to the catch fell throughout the study period, despite high net rainbow trout immigration rates during 2003–4, which were followed by migration rate declines in 2005–6. Rainbow trout decreased from approximately 90% of the catch in 2003 to less than 10% in February 2006, before rebounding slightly in August 2006. Generally, the catch of nonnative fish in the removal reach fell throughout the study period; however, the number of nonnative cyprinids (fathead minnows and carp) caught increased in 2006.

In the control reach, a total of 11,221 fish were captured and released during the study period, 95% of which were rainbow trout. Throughout the study, rainbow trout numbers in the control reach declined, particularly after the spring of 2005. Rainbow trout numbers in the control reach were estimated to be between 7,000 and 10,000 during 2003–4 and between 2,000 and 5,000 during 2004–5, suggesting that rainbow trout abundance likely declined by 50% or more during the study period. This finding suggests that a decline in rainbow trout abundance throughout the river occurred independently of removal efforts.

The decline of rainbow trout abundance in 2005–6 in the removal and control reaches mirrors a similar decline recorded for the Lees Ferry reach (RM -15.7 to RM 0), a recreational trout fishery that is immediately downstream of Glen Canyon

Dam and the likely source of rainbow trout throughout the river. Seasonal flooding of the Paria River, a Colorado River tributary just downstream of Lees Ferry, from September 2004 to January 2005 may also have contributed to the reduced numbers of rainbow trout detected downstream. Tributary sediment inputs limit light availability and can reduce the production of algae, thereby reducing food for the aquatic invertebrates that trout eat. High sediment loads likely not only reduced the food available to trout but also may limit the ability of trout to see their prey.

Rainbow trout abundance declined in both the removal and control reaches but declined to a greater extent in the removal reach. Additionally, there is some indication that the abundance of juvenile native fish increased in the removal reach during the study period, suggesting increased survival rates, increased reproduction, or both. The most recent assessment of humpback chub data, which includes data from 1989 to 2008, shows that more juvenile fish survived to adulthood. This trend begins with fish spawned in 1998 and appears particularly strong for fish spawned in 2003. Although early signs that more humpback chub are surviving to adulthood are encouraging, it is not possible to know if this improvement is the result of removal efforts or other environmental factors. For example, the temperature of water released from Glen Canyon Dam increased during the study period to temperatures that may have improved humpback chub growth and survival.

Management Implications

The results of the experiment indicate that it was successful in reducing the abundance of nonnative fish, particularly rainbow trout, in the 9.4-mile-long removal reach. This outcome suggests that nonnative fish abundance can be reduced in a large segment of the Colorado River downstream from Glen Canyon Dam. However, reduced rainbow trout migration rates from the Lees Ferry reach and a decline in rainbow trout abundance throughout the river also contributed to the reduction. Removal efforts might not have been successful during a period of increasing rainbow trout abundance.

If removal efforts had been less intensive (for example, one removal trip per year), then reductions in overall rainbow trout abundance would likely have been much smaller and possibly undetectable. Additionally, concurrent environmental changes and the decrease in rainbow trout throughout the river make it difficult to confirm that the apparent increase in native fish abundance was the result of the experiment. Monitoring efforts continue and may be able to distinguish among these factors and to better inform future management actions.

Reference

Coggins, L.G., Jr., Yard, M.D., and Pine, W.E., III, 2011, Nonnative fish control in the Colorado River in Grand Canyon, Arizona—An effective program or serendipitous timing?: Transactions of the American Fisheries Society, v. 140, no. 2, p. 456–470.

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