# Changes to the Fish Assemblage of the San Juan River

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## Introduction to the San Juan River

The San Juan River flows from southwest Colorado, through New Mexico and into Utah (Figure 1). More than 99,200 km2 of water travels from the San Juan mountains, braiding through floodplains and snaking through canyons, until it finally reaches the Colorado River via Lake Powell (Carlson & Carlson, 1982). Several tributaries join the San Juan River along its journey across the southwest, including the Animas River, La Plata River, and McElmo Creek.

The river is bookended with two dams: the Navajo Dam upstream to the east, and the Glen Canyon Dam downstream in the west. The San Juan River receives most of its seasonal flow from snowmelt, and like many other southwestern streams has historically seen high variability in its flow (Carlson & Carlson, 1982). However, due to the Navajo dam and several stakeholders exporting water, flows within the river have been reduced and have become less variable (Fig. 2) (Carman, 2006).

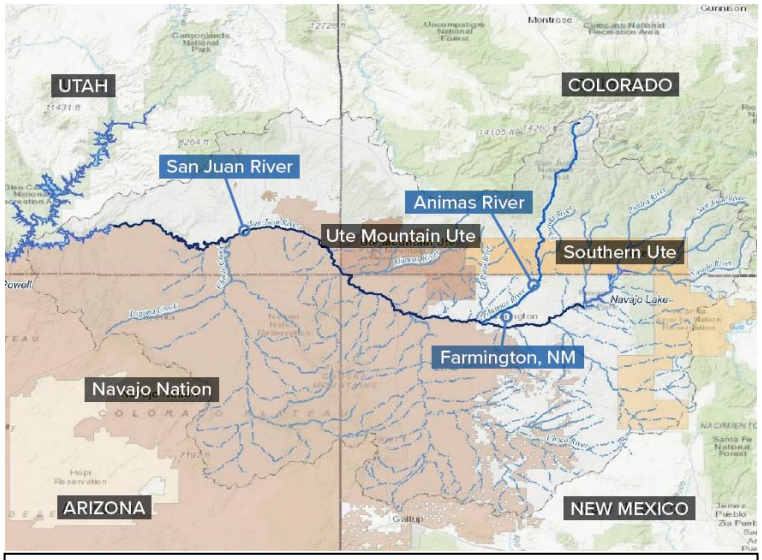


**Figure 1.** Map of the San Juan River. https://www.epa.gov/san-juan-watershed/basic-information-about-san-iuan-watershed

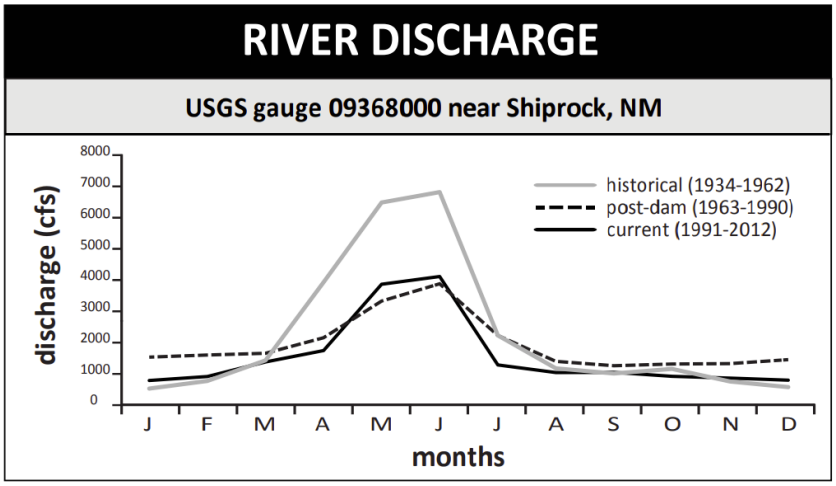


**Figure 2.** Discharge rates near Shiprock, NM pre-dam, post-dam, and current https://www.wildlife.state.nm.us/download/fishing/maps/San-Juan-River-Native-New-Mexico-Fish-Poster.pdf

## Historical San Juan Native Fish Assemblage

Historically the San Juan River was home to 9 native fishes, most of which were minnows and suckers (Propst & Gido, 2004). They include the Colorado pikeminnow (*Ptychocheilus lucius)*, mottled sculpin *(Cottus bairdii)*, flannelmouth sucker (*Xyrauchen texanus)*, bluehead sucker *(Catostomus discobolus)*, speckled dace *(Rhinichthys osculus)*, razorback sucker (Xyrauchen texanus, roundtail chub *(Gila robusta)*, Colorado River cutthroat trout *(Oncorhynchus clarki pleuriticus)*, and bonytail chub *(Gila elegans)* (Propst & Gido, 2004).

The flannelmouth sucker is endemic to the greater southwest, and the Colorado pikeminnow, roundtail chub, and razorback sucker are endemic to the Colorado River basin (Jones et al., 2020, Weiss et al., 1998). This means these fish can only be found in the mentioned region and are not widely distributed. Within the range of the San Juan River, the distribution of these native species is not uniform. Mottled sculpin, Colorado cutthroat trout, and roundtail chub typically stay in the upstream reaches, bluehead suckers prefer habitat with cobble, and flannelmouth suckers occupy a wide range with more variable habitat (Carman, 2006).

The native fishes here are predominantly large bodied, long-lived species adapted over time to be the ideal inhabitants of the murky waters of the San Juan. The flannelmouth sucker, for example, has small eyes because sight is not as useful in turbid water. To make up for this, they have large, fleshy papillose lips. These lips help them probe the benthos for prey, and scrape diatoms and algae off rocks (Carman, 2006). Additionally, due to their big size some native fishes have large ranges and rely on the ability to travel freely within the San Juan and its tributaries to access variable habitat. The Colorado pikeminnow has historically traveled long distances traveling not just within the San Juan Basin, but throughout the greater Colorado Basin (Jones et al., 2020).

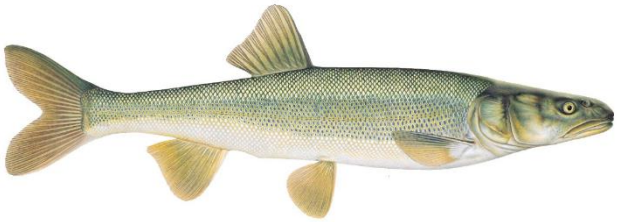

**Figure 3.** Native Colorado Pikeminnow
https://www.focusfishing.com/species/colorado-pikeminnow/

Habitat needs can vary by season, or throughout a lifetime. Fishes spawning may travel to tributaries where flow is slower to prevent eggs from getting washed away by the current (Cathcart et al., 2015). Young fish may prefer shallower, slower moving water in braided habitat as they do not have to expend as much energy fighting the current (Gido et al.,1997). Fishes also utilized natural floodplains caused by high season flow as spawning habitat and refuge. Over time, native fishes of the San Juan River have been negatively affected by anthropogenic changes to hydrology and the ecosystem (Joseph et. al, 1997).

**Current San Juan Fish Assemblage**

All nine historic native fishes can still be found in the San Juan River and its tributaries today. Unfortunately, over the last century some populations have declined almost to the point of extirpation, or local extinction (Jones et al., 2020). Currently, the most abundant native species are speckled dace, flannelmouth sucker, and bluehead sucker (Carman, 2006). Roundtail chub have become infrequent in the mainstem, maintaining higher numbers in tributaries. However, their population plummeted low enough to prompt agencies to recommend them as threatened under the Endangered Species Act (USFWS 2015b). The Colorado pikeminnow and razorback sucker fared so poorly that they were listed as federally endangered in the Endangered Species Act (Wethington & Wilkinson, 2006).

In the last few decades, the native assemblage has been joined by more than 23 different nonnative fish species (Propst & Gido, 2004) The most abundant nonnative fishes are

predominantly minnows and include common carp *(Cyprinus carpio)*, channel catfish *(Ictalurus punctatus)*, western mosquitofish *(Gambusia affinis)*, fathead minnows *(Pimephales promelas)*, and red shiners *(Cyprinella lutrensis)* (Ryden 2003, Paroz et al. 2005). All these fish are known to have potentially negative effects on native populations and ecosystems (Propst & Gido, 2004, Carey & Wahl, 2010). Many of these species overlap in used habitat, particularly in secondary channels of the San Juan where nonnatives are more abundant than native species (Gido & Propst, 1999, Cathcart et al., 2015). Secondary channels are common along the San Juan and are heavily used by native and nonnative fishes (Gido & Propst, 1999). Overlap between the two groups occurs at all life stages of native fish, indicating that populations constantly face harm from introduced fishes. In general, the biggest threats to naive fishes in the San Juan are introductions of nonnative species and altered hydrology.

**The Navajo Dam**

This biggest player in negatively impacting native fishes is the Navajo Dam, which finished construction in 1962 (Wethington & Wilkinson, 2006). This dam is upstream in the San Juan located near Archuleta, New Mexico, and created the Navajo Reservoir which impounded 37 miles of the river (Durst & Franssen, 2014). The water stored here is used for agriculture, floor control, and municipal purposes (Carlson & Carlson, 1982). Although the dam and reservoir are useful for humans, the dam has caused several issues for native fishes. The dam itself is a physical barrier, cutting off the natural range of native fishes. This has caused issues, especially for Colorado pikeminnow, which typically used the area now impounded by the dam for spawning (Jones et al., 2020). Many historical ranges for native fish were shunted after the Navajo Dam was created, and they were pushed further downstream and into tributaries (Carman, 2006).

The dam also caused a decrease in flow, of up to 61% of the pre-dam discharge, negatively affecting native fish populations (Propst & Gido, 2004). Historically, high seasonal flow from snowmelt would flood the bank of the river and create floodplain habitat. The decreased flow reduced flooding and stopped the formation of this habitat. It also allowed trees and large shrubs, that would have typically been washed away, to grow along the banks (Gido & Propst, 1999). The establishment of this vegetation stabilized the bank and further prevented flooding. Over time, a simpler channel was created due to the reduced flow (Carlson & Carlson, 1982).

In addition to reducing range due to physical barriers, the dam also limited range by altering the habitat directly below the reservoir. What was once a river is now a deep reservoir, and the water within the impoundment became stratified. The hypolimnion that was released from the dam was much cooler than the historical river water. This was no longer suitable for native fishes, but it was a perfect habitat for rainbow trout *(Oncorhynchus mykiss)* and brown trout *(Salmo trutta)*. Shortly after the completion of Navajo Dam salmonids were introduced to the San Juan River, adding new fishes to the ecosystem (Wethington & Wilkinson, 2006). The

river is now managed for trout habitat for 17 miles below the dam, with the immediate 4 miles designated as Special Trout Waters (Wethington & Wilkinson, 2006). This means there are bag limits for anglers that allow a steady supply of trophy fish. This fishery is now one of the most celebrated trout fisheries in the country.

The Navajo Reservoir was also stocked with a variety of sport fishes to entice anglers. Unfortunately, reservoir fishes are also notorious for escaping reservoirs, and while hypolimnion release can reduce this rate it does not eliminate the possibility entirely (Schultz et al., 2003). More troublesome however are the "midnight managers", anglers that illegally introduce fish to a system because they want to catch a certain fish in an area. Actions of these anglers can derail the hard work and highly expensive plans that agencies put into restoration (Johnson et al., 2009). Overtime, other nonnative fishes such as largemouth bass, catfish, and carp have made their way into the San Juan River. Unlike the salmonids which mostly stay in the cold, clear reaches directly below the Navajo Dam, these fishes share habitat with natives and can negatively affect them. Nonnative minnows such as common carp compete directly with native minnows for resources like food and space. Carp can be especially harmful because they can alter habitat and are aggressive, generalist invaders (Carey & Wahl, 2010). Catfish may not compete with native fishes as much as carp, but they are voracious predators and can reduce native fish populations (Tyus, 1992). Due to introductions diversity has increased in the San Juan River, but native diversity and abundance has been diminished. Given that several of these native fish are endemic, it's important to prioritize their populations.

**The Glen Canyon Dam**

The Glen Canyon Dam was completed on the Colorado River in 1963 and created Lake Powell. Lake Powell is a 400–660 km2 reservoir that serves as drinking water, utility, and irrigation (Cathcart et al., 2018). Prior to Lake Powell, several nonnative fishes were present in the waters (Carlson & Carlson, 1982). After the impoundment, these nonnative fishes remained in the reservoir, and were joined by other introduced sport fishes. A third group of smaller nonnative fish were introduced as food for the sport fishes. Although this reservoir was downstream of the San Juan and did not impact flow, it did cut off the native range of some fishes such as the Colorado Pikeminnow (Jones et al., 2020). Additionally, sediment build up in the water made it difficult to inhabit and pushed fish up into the flowing waters connected to the impoundment (Cathcart et al., 2018). Stocked Lake Powell fish such as striped bass and carp can be found in the San Juan River, suggesting that they have migrated from the reservoir into the river. Striped bass are another piscivorous fish, acting as a predator and threat to native fishes.

**Additional Diversions and Barriers**

In addition to the two large dams, the San Juan River is further affected by water diversions including Fruitland for irrigation, APS for power generation, and the PNM diversion dam (Carman, 2006). These create additional barriers and reductions in flow, and consequently harm fish. Weirs throughout the San Juan can pose as potential barriers to fish because once a

fish swims downstream, it may not be able to swim back over the structure (Durst & Franssen, 2014). High seasonal flows would remedy this as they would reduce the difference in water height over the structure, making the weirs only temporary barriers. Yet another impediment on fish movement is the Piute waterfall just upstream of Lake Powell. It began forming in the 1980's and by 2002 was over 19ft tall (Jones et al., 2020). This negatively affects any fish that swims downstream by limiting their habitat and range. While this prevents river fish from returning upstream, it also bars nonnative Lake Powell fish from entering the river.

**Efforts to restore Native Fishes**

In 1991, the San Juan River Basin Recovery Implementation Program (SJRBRIP) was formed and implemented reservoir releases to mimic snowmelt flows (Jones et al., 2020). This was primarily done to help the endangered Colorado pikeminnow and razorback sucker (Propst & Gido, 2004). Replicating natural flow regimes in altered stream systems has proven to be an effective way to improve native fish populations (Poff et al. 1997). In addition to mimicking flows that are beneficial to natives, they can also negatively affect non-natives that are not adapted to higher seasonal flow (Marchetti and Moyle 2001). These flows suppress introduced populations, lessening competition, and predation for native populations. From 1993 to 2010, researchers studied flow manipulations in the San Juan to determine if they benefited native fishes. Researchers determined that the manipulated flows did benefit native fishes, especially the higher discharge rates (Gido & Prost, 2012). Additionally, high flows had a negative correlation with the primary predator channel catfish. The study also found that summer flows that were very low had a positive correlation with nonnative abundance for competitors like common carp (Propst & Gido, 2004.)

While these mimicked flow regimes may benefit native fishes, concerns also arose over whether these flows would negatively impact the trout fishery below the dam. To determine if high flow releases would negatively affect prized trout populations, researchers monitored the movement of rainbow trout in the 4 mile stretch directly below the Navajo Dam. They found that most of the trout stayed close to where they were tagged and were not negatively affected by the high flows (Gido et al., 2000). When flows increased, the fish would move into preferred side channel or near-shore habitat (Gido et al., 2000). The two studies mentioned previously show that regulated flow regimes can be used to promote healthy native fish populations, without damaging the quality of the trout fishery. It also raises the importance of variation of habitat when maintaining the landscape for priority species.

In addition to the SJRBRIP altering flow regimes, the "Three Species Conservation Agreement & Strategy" was created in 2004. Its goal is to manage the Colorado River Basin for the persistence of flannelmouth sucker, bluehead sucker, and roundtail chub in Wyoming, Colorado, New Mexico, Arizona, Nevada, and Utah (Carman, 2006). Although the bluehead sucker and flannelmouth are some of the most abundant species among adult fishes caught during monitoring surveys, they face threat from habitat reduction as demand for water increases over time (Carman, 2006).

Altering habitat alone will not help promote native fishes so efforts to lessen the impacts of nonnative fishes are typically included in management as well. From 1994-2012, removal efforts were implemented and studied in the San Juan River to decrease the populations of common carp and channel catfish via e-backpack fishing and to understand the effect on native fishes. The study concluded that common carp densities were reduced in the targeted sites, but channel catfish populations were not greatly affected (Franssen et al., 2014). They also found no evidence that native populations benefited or increased from the removal. (Fig4).

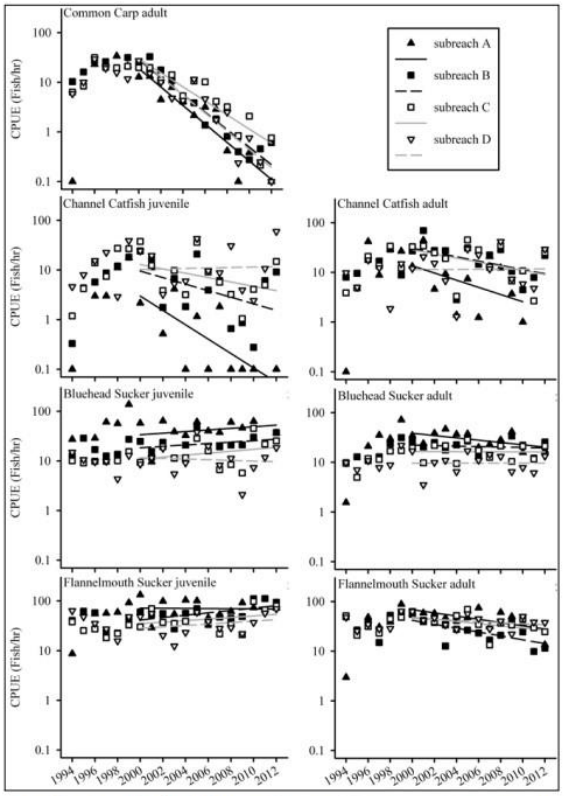


**Figure 4. Catch per unit effort of fishes over time at the four subreaches at the upper reach. A value of 0.1 was added to each data point to facilitate plotting on a log-scale. Least square regression lines are plotted for each subreach from 2000 to 2012 (when year or subreach was significant from each ANCOVA). Nonnative fish removal began in subreach A in 2001, subreach B in 2003, and subreaches C and D in 2006.**

**Figure 4.** Native and Nonnative Fish Abundance During Mechanical Removal (Franssen et al., 2014)

In addition to removing invasive species and improving flow regimes and habitat, management plans can also include restocking species of concern. In 1996, stocking efforts of young hatchery-raised Colorado pikeminnow began. After ten years of stocking researchers found that while the species has not disappeared, most of the population is made up of young, stocked fishes (Durst & Franssen, 2014). Individuals caught in the study typically were not older than three years, which is an issue considering females do not spawn until they are seven to ten years old (Fig 5) (Jones et al., 2020). This means that the entirety of the population is maintained by stocking, and not a wild population. The only wild population of Colorado pikeminnow in the San Juan right by the inflow to Lake Powell, but this is separated from the rest of the river by the unpassable Piute waterfall (Jones et al., 2020). Hatchery fish that have reached adulthood are found below the waterfall indicating that they migrate downstream, a noted part of their life history, but are then unable to return upstream for spawning (Cathcart et al., 2018). Endangered razorback suckers also face the same issue, although they have successful spawning in Lake Powell (Cathcart et al., 2018). Although these downstream populations are persistent, they are limited in range and resources, and can therefore only remain a certain capacity before intraspecific competition will become a problem.

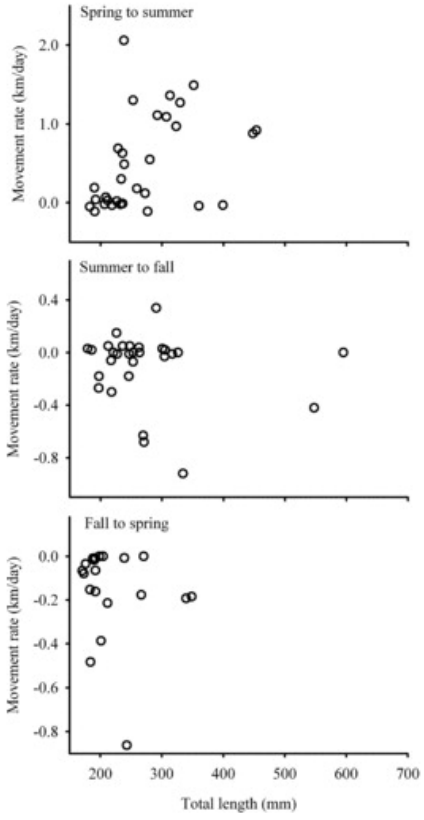


**Figure 5.** Total Length of Colorado Pikeminnow caught during study. Most are smaller than spawning age. (Durst & Franssen, 2014)

**Complications of Native Restoration & Management Considerations**

The initial response to dwindling native fish populations may be to completely eradicate introduced species, but this is not realistic. One main issue with removing unwanted fish from any body of water is that it is hard to ensure you have eliminated all individuals, especially in large bodies of water. In some instances, the poison Rotenone is used to eradicate unwanted fishes, but the poison affects all species and runs the risk of killing endangered native fishes (Meadows, 1973). Since the San Juan stretches for 227 miles, you can imagine how near impossible it is to ensure all nonnatives are gone (Durst & Franssen, 2014). The previously mentioned study also highlight how mechanical removal efforts may also have minute effects.

Aside from the logistical nightmare of removing all introduced fish, there is another issue of the value of these fish. It has been proven these species pose a threat to native fish, but they are beloved by anglers, who spend an estimated 217,000 hours per year just on fishing the Special Trout Water below the Navajo Dam (Wethington & Wilkinson, 2006). Money spent on licenses and tackle fund research to study native fishes. So, although they can be a nuisance, introducing fishes can indirectly support the restoration of native populations. Many of these introduced species have been present in the San Juan for decades now, and we must ask at what point do they become a natural part of the system.

Although the historic range and abundance of native fishes in the San Juan River has diminished due to introduced fishes and altered hydrology and habitat, all is not lost. Native fish are still established, and thanks to management efforts some have improved since post-dam times. Maintenance of ecosystems to benefit native fishes requires diligent and ongoing work from many different fronts. Like most restoration efforts, it is a balance of the species' needs alongside human needs. Continued monitoring of native abundance and distribution, alongside the reduction of introduced fishes will ensure the San Juan River fishes persist.

Works Cited

Carlson, C. A., & Carlson, E. M. (1982). Review of Selected Literature on the Upper Colorado River System and Its Fishes. *Fishes of the Upper Colorado River System: Present and Future*, 1–8. http://www.nativefishlab.net/library/textpdf/17415.pdf#page=7

Carman, S. M. (2006, July). *Bluehead Sucker Catostomus discobolus and Flannelmouth Sucker Catostomus latipinnis Conservation Strategy*. New Mexico Department of Game and Fish. https://www.wildlife.state.nm.us/download/conservation/species/fish/management - recovery-plans/NM-Sucker-Conservation-Strategy.pdf

Carey, M. P., & Wahl, D. H. (2010). Native fish diversity alters the effects of an invasive species on food webs. *Ecology*, *91*(10), 2965–2974. https://doi.org/10.1890/09-1213.1

Cathcart, C. N., Gido, K. B., & McKinstry, M. C. (2015). Fish Community Distributions and Movements in Two Tributaries of the San Juan River, USA. *Transactions of the American Fisheries Society*, *144*(5), 1013–1028. https://doi.org/10.1080/00028487.2015.1054515

Cathcart, C. N., Pennock, C. A., Cheek, C. A., McKinstry, M. C., MacKinnon, P. D., Conner, M. M., & Gido, K. B. (2018). Waterfall formation at a desert river-reservoir delta isolates endangered fishes. *River Research and Applications*, *34*(8), 948–956. https://doi.org/10.1002/rra.3341

Durst, S. L., & Franssen, N. R. (2014). Movement and Growth of Juvenile Colorado Pikeminnows in the San Juan River, Colorado, New Mexico, and Utah. *Transactions of the American Fisheries Society*, *143*(2), 519–527. https://doi.org/10.1080/00028487.2013.869258

Franssen, N. R., Davis, J. E., Ryden, D. W., & Gido, K. B. (2014). Fish Community Responses to Mechanical Removal of Nonnative Fishes in a Large Southwestern River. *Fisheries, 39*(8), 352–363. https://doi.org/10.1080/03632415.2014.924409

Gido, K. B., Larson, R. D., & Ahlm, L. A. (2000). Stream-Channel Position of Adult Rainbow Trout Downstream of Navajo Reservoir, New Mexico, Following Changes in Reservoir Release. *North American Journal of Fisheries Management*, *20*(1), 250–258. https://www.tandfonline.com/doi/pdf/10.1577/1548-8675%282000%29020%3C0250%3ASCPOAR%3E2.0.CO%3B2?needAccess=true

Gido, K. B., & Propst, D. L. (1999). Habitat Use and Association of Native and Nonnative Fishes in the San Juan River, New Mexico and Utah. *Copeia*, *1999*(2), 321. https://doi.org/10.2307/1447478

Gido, K. B., & Propst, D. L. (2012). Long-Term Dynamics of Native and Nonnative Fishes in the San Juan River, New Mexico and Utah, under a Partially Managed Flow Regime. *Transactions of the American Fisheries Society*, *141*(3), 645–659. https://doi.org/10.1080/00028487.2012.683471

Gido, K. B., Propst, D. L., & Molles, M. C. (1997). Spatial and temporal variation of fish communities in secondary channels of the San Juan River, New Mexico and Utah. *Environmental Biology of Fishes*, *49*(4), 417–434. https://doi.org/10.1023/a:1007371019190

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. U.S. Fish Wildl. Serv., FWS/OBS-77/62, Fort Collins, Colo.

Johnson, B. M., Arlinghaus, R., & Martinez, P. J. (2009). Are We Doing All We Can to Stem the Tide of Illegal Fish Stocking? *Fisheries*, *34*(8), 389–394. https://doi.org/10.1577/1548-8446-34.8.389

Jones, T., et. al. (2020, March). *Species Status Assessment Report for the Colorado pikeminnow Ptychocheilus lucius*. U.S. Fish and Wildlife Service, Department of the Interior, Upper Colorado Basin Region 7. https://ecos.fws.gov/ServCat/DownloadFile/174074#:~:text=Species%20Background,entirely%20piscivorous%20as%20an%20adult.

Meadows, B. S. (1973). Toxicity of rotenone to some species of coarse fish and invertebrates. *Journal of Fish Biology*, *5*(2), 155–163. https://doi.org/10.1111/j.1095-8649.1973.tb04444.x

Paroz, Y.M., D.L Propst, S.M. Carman, and R.D. Larson. 2005. Small-bodied fish monitoring, San Juan River, September-October 2004. New Mexico Department of Game and Fish. San Juan River Basin Recovery Implementation Program, U.S. Department of the Interior, Fish and Wildlife Service, Albuquerque, New Mexico.

Poff, N. L., Allan, J. D., Bain, M. B., Karr, J. R., Prestegaard, K. L., Richter, B. D., Sparks, R. E. and Stromberg, J. C. 1997. The natural flow regime: a paradigm for river conservation and restoration. *BioScience*, 47: 769–784.

Propst, D. L., & Gido, K. B. (2004). Responses of Native and Nonnative Fishes to Natural Flow Regime Mimicry in the San Juan River. *Transactions of the American Fisheries Society*, *133*(4), 922–931. https://doi.org/10.1577/t03-057.1

Rypel, A. L., Saffarinia, P., Vaughn, C. C., Nesper, L., O'Reilly, K., Parisek, C. A., Miller, M. L., Moyle, P. B., Fangue, N. A., Bell-Tilcock, M., Ayers, D., & David, S. R. (2021).

Goodbye to “Rough Fish”: Paradigm Shift in the Conservation of Native Fishes. *Fisheries*, *46*(12), 605–616. https://doi.org/10.1002/fsh.10660

Ryden, D. W. 2003. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 1999-2001 integration report. San Juan River Basin Recovery Implementation Program, U.S. Department of the Interior, Fish and Wildlife Service, Albuquerque, New Mexico.

Schultz, A. A., Maughan, O. E., Bonar, S. A., & Matter, W. J. (2003). Effects of Flooding on Abundance of Native and Nonnative Fishes Downstream from a Small Impoundment. *North American Journal of Fisheries Management*, *23*(2), 503–511. https://www.tandfonline.com/doi/pdf/10.1577/1548-8675%282003%29023%3C0503%3AEOFOAO%3E2.0.CO%3B2?needAccess=true

Tyus, H. M. (1992). An instream flow philosophy for recovering endangered Colorado River fishes. *Rivers*, *3*(1), 27–36. http://www.nativefishlab.net/library/textpdf/13064.pdf

USFWS (U.S. Fish and Wildlife Service). 2015b. Endangered and threatened wildlife and plants; threatened species status for the Headwater Chub and a distinct population segment of the Roundtail Chub. Federal Register 80:194(7 October 2015):60754–60783.

Wethington, C. M., & Wilkinson, P. (2006, September). *Management Plan for the San Juan River*. New Mexico Department Of Game and Fish Fisheries Management Division. https://www.wildlife.state.nm.us/download/fishing/hatcheries-fisheries/san-juan-river-fishery/San-Juan-River-Management-Plan.pdf