

**Colorado Pikeminnow
(*Ptychocheilus lucius*)**

**5-Year Status Review:
Summary and Evaluation**



Photo credit: left, UDWR; right, P. Williams/NPS

U.S. Fish and Wildlife Service
Department of the Interior
Upper Colorado Region
Lakewood, Colorado

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR STATUS REVIEW for COLORADO PIKEMINNOW (*Ptychocheilus lucius*)

Species Reviewed: Colorado pikeminnow (*Ptychocheilus lucius*)

Federal Register Notice of Listing Determination and Designation of Critical Habitat:

- March 11, 1967. List of Endangered Species (32 FR 4001).
- March 21, 1994. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Colorado River Endangered Fishes: razorback sucker, Colorado squawfish, humpback chub, and bonytail chub (59 FR 13374)

Federal Register Notice Announcing Initiation of this Review:

- May 27, 2016. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 21 Species in the Mountain-Prairie Region (81 FR 33698).

Lead Region: Legacy Region 6, Interior Regions 5 and 7, Upper Colorado River Endangered Fish Recovery Program, Tom Chart, Program Director, 303-236-9885.

Classification: Endangered

Methodology used to complete the review: In accordance with section 4(c)(2) of the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*), as amended (Act), the purpose of a 5-year status review is to assess each threatened species and endangered species to determine whether its status has changed and it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service (Service) evaluated the biology and status of the Colorado pikeminnow as part of a Species Status Assessment (SSA) to inform this 5-year status review. Our SSA report for Colorado pikeminnow included input from species experts and agency biologists who work with the species, and was independently reviewed by peer reviewers and partners, including State wildlife agencies, Federal agencies, stakeholders involved in water management of the Colorado River Basin, and non-governmental organizations (Service 2020, entire). The SSA report represents our evaluation of the best available scientific information, including the resource needs and the current and future condition of the species. We developed four future scenarios of potential population responses to conservation activities, which we used to analyze a range of plausible future conditions of the species. Our SSA report provides the scientific basis for this 5-year status review.

Additionally, we solicited data for this review from interested parties through a May 27, 2016, Federal Register Notice announcing this review (81 FR 33698). Information we received from that data call included responses from two nongovernmental organizations whose comments reiterated the previously identified threats and summarized existing information from the Upper

Colorado River Endangered Fish Recovery Program documents. We considered the previously identified threats and existing information as we developed our SSA.

REVIEW ANALYSIS

Updated Information and Current Species Status

Biology and Habitat:

The SSA report (Service 2020, entire) provides a detailed summary of the biology, habitats, and current and future conditions for the Colorado pikeminnow, which we summarize below. The Colorado pikeminnow is a large, long-lived fish and the largest member of the taxonomic family Cyprinidae native to North America, and a species endemic to warmwater reaches of large rivers in the Colorado River basin in Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming. Prior to the arrival of non-native predatory fish species, the Colorado pikeminnow was the apex predator within these reaches and is believed to be almost entirely piscivorous (eats fishes) as an adult. The species can grow to a large size, historically greater than 5 feet (1.5 meters) in length, and can live over 50 years in the wild. Colorado pikeminnow make long distance migrations to spawn and return to their home range after spawning, where they inhabit deep runs, pools, and eddies. Colorado pikeminnow eggs hatch within the river substrate as spring peak flows decline, and the larvae are carried long distances by river flows to low velocity nursery habitats downstream of the cobble spawning bars. In these reaches, larvae and juveniles seek low to zero velocity backwaters that provide warm temperatures for growth and abundant food supply in the form of macroinvertebrates and small fish prey. Individual Colorado pikeminnow become sexually mature between 7 and 10 years of age and can spawn repeatedly as adults. Both adult and nursery habitats, as well as spawning bars, are formed and maintained by high, snowmelt-driven spring flows that move sediment, clean cobble substrates, and maintain channel complexity to provide a diversity of habitats. Colorado pikeminnow inhabit river reaches that historically experienced extremes in both flow and temperature on an annual basis, in addition to high turbidity from sediment inputs as a result of spring snow melt or flash floods.

Historically, Colorado pikeminnow occurred throughout the warmwater reaches of the Colorado River basin, including the Green, Colorado, and San Juan river subbasins of Wyoming, Colorado, Utah, and New Mexico; downstream through the Colorado River mainstem in Arizona, Nevada, California, and Mexico; and the Gila River subbasin in Arizona and New Mexico. In the lower Colorado River basin (LCRB or ‘lower basin’) downstream of Glen Canyon Dam, the construction of dams and water projects diverted river flows, fragmented river reaches, reduced peak flows, dewatered some reaches, and channelized the river starting in the early 20th century. As a result of extensive water development, modified hydrology, and reduced habitats, Colorado pikeminnow were extirpated from the LCRB by the 1960s. In the upper Colorado River basin (UCRB or ‘upper basin’), including Lake Powell and its tributaries, the

construction of large dams and diversions was more diffuse, leaving longer reaches of river available in downstream areas. Dams converted sections of rivers to coldwater tailraces, altered hydrology through reduced spring peaks, and presented barriers to migration. Nonnative sport fishes were also introduced into reservoirs and riverine habitats throughout the entire Colorado River basin, and these nonnative fish both compete with and prey upon Colorado pikeminnow. The range of the Colorado pikeminnow in the UCRB contracted and populations declined in the Green and upper Colorado river subbasins, and the species was functionally extirpated from the San Juan River subbasin in the late 1990s. In the LCRB, flow and habitat modifications and predation and competition from nonnative species resulted in population declines and local extirpations, which contributed to the Colorado pikeminnow being included in the 1967 List of Endangered Species and as an endangered species on the original 1973 Endangered Species Act.

Two recovery programs were established to enhance populations of the Colorado pikeminnow, one for the Green and upper Colorado river subbasins, and one for the San Juan River subbasin. The Upper Colorado River Endangered Fish Recovery Program (UCREFRP) was established to maintain and recover wild, self-sustaining populations of Colorado pikeminnow in the Green and upper Colorado rivers and their major tributaries. The San Juan River Basin Recovery Implementation Program (SJRIP) has reintroduced Colorado pikeminnow through an augmentation program, with the goal of establishing a wild, self-sustaining population that is not dependent on stocking. An experimental, non-essential population of Colorado pikeminnow was also designated in the Salt and Verde rivers of the Gila River subbasin, but individuals stocked into these two tributaries since the 1980s do not appear to have established a population. Stocking efforts in the Gila River subbasin have recently ceased.

In our SSA report, we examined the current and future condition of 6 Colorado pikeminnow analysis units (Figure 1), by evaluating the current and future conditions of habitat and demographic factors in the Green, upper Colorado, and San Juan river subbasins. The SSA also describes and summarizes habitat conditions in the LCRB reaches of the Grand Canyon, lower Colorado River mainstem, and the Gila River subbasin, but no demographic information is available for these extirpated populations to make an assessment of future viability in these reaches. Even if an analytical unit provides potentially suitable habitat, its overall condition could not exceed extirpated if the Colorado pikeminnow was extirpated from this analytical unit.

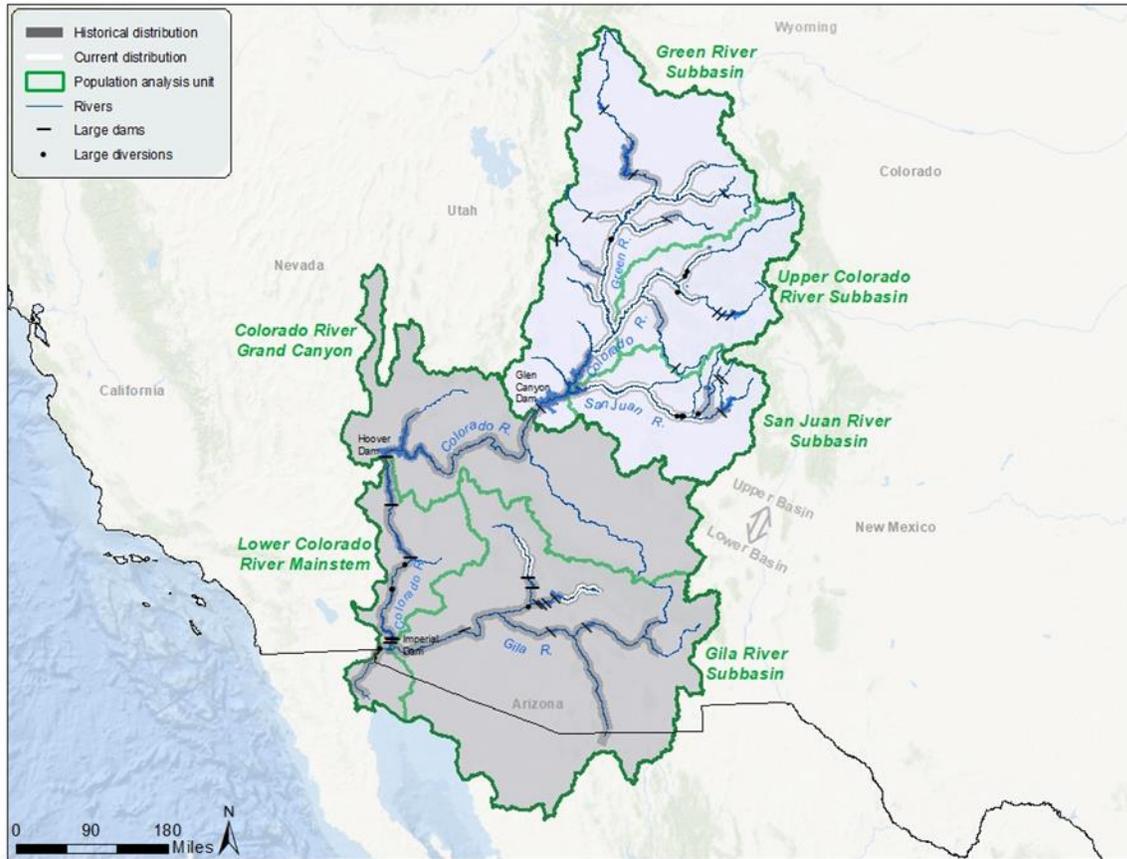


Figure 1. Historical and current distribution of Colorado pikeminnow. Analysis units are indicated by green borders and labels.

Summary of Species Needs

Our SSA report considers the species' needs during seven discrete life stages: spawning adults, egg and larvae within spawning substrates, age-0 and juvenile fish in nursery habitats, sub-adults, and adults. Because of the Colorado pikeminnow's complex life history, each life stage has specific and often unique resource needs. The SSA summarizes the following resource, population, and species needs which are most influential to species viability:

1. Variable flow regimes, specifically spring peak flows to maintain channel complexity and spawning habitats
2. Summer base flows to provide suitable nursery habitats
3. Suitable water temperatures for spawning and growth
4. Complex, redundant riverine habitats that provide a combination of the necessary elements of spawning, nursery, and foraging areas
5. Abundant, suitable forage base
6. Population size and demographic rates including

- a. Sufficient numbers of adults to reproduce
 - b. Stable or increasing adult abundance over a multiple year timeframe
 - c. Consistent annual reproduction
 - d. Age-0 survival and recruitment
 - e. Sub-adult (recruit) abundance sufficient to replace adult mortalities
7. Multiple naturally recruiting and resilient populations spread across the species' range
 8. Genetic and behavioral diversity

Summary of Stressors and Conservation Measures

The SSA report also summarizes stressors that may affect the species, as well as conservation measures that may reduce those stressors. The stressors identified are reductions to natural flow regimes, water temperature depression as a result of hypolimnetic (deep water) releases from large dams, physical barriers to movement and the resulting loss of habitat and connectivity, entrainment into water diversion facilities, nonnative fish competition and predation, contaminants, channel simplification, and climate change. Conservation measures that reduce these stressors are the implementation of flow and temperature recommendations, installation and operation of fish passages, exclusions from entrainment into water infrastructure, nonnative fish management, and population augmentation. Our SSA report for the Colorado pikeminnow provides more details on our evaluation of stressors, conservation measures, and cumulative effects (Service 2020, pp. 27 — 80).

Current Condition

Our SSA report evaluated the current condition for the Colorado pikeminnow by first identifying the individual, population, and species needs, and then analyzing their availability and suitability within the context of current stressors and conservation measures. We evaluated current condition for six analysis units that we delineated by geographic subbasins. Analysis units are delineated by dams and reservoirs, and further refined by reaches where population size is estimated and demographic processes are thought to be largely independent. The six analysis units that we used to evaluate condition are the Green, upper Colorado, and San Juan river subbasins in the UCRB, and the Grand Canyon, Gila River, and lower Colorado River mainstem reaches in the LCRB. We evaluated the current condition of the demographic variables using a categorical scale of resiliency, and then evaluated the current condition for the habitat and demographic factors that we identified as needs. We developed our categories for resiliency by compiling recent data and measuring those summary data against criteria developed by a technical team of experts from each of the three subbasins where Colorado pikeminnow still occur. The ranking system categorizes demographic and habitat factors into high, medium, low, or functionally extirpated rankings based on the pre-determined criteria. A high ranking indicates the factor either met delisting criteria (demographic factors) or represented the best condition to

support species viability based on available data. A functionally extirpated ranking indicates a factor was not suitable or available to support a resilient, viable population. Low and medium categories are intermediate rankings indicating incremental conditions between high and extirpated.

For subbasins in the upper Colorado River basin, overall current conditions for demographic factors range from moderate to low (Table 1). Since the initiation of robust monitoring about two decades ago, the Green River subbasin has supported the largest population of adult Colorado pikeminnow. The population consists of wild Colorado pikeminnow that have not been supplemented by stocking, except in isolated instances for experimental purposes. Spawning has been documented annually at two sites in the Green and Yampa rivers, with variable larval production and transport linked to environmental conditions, particularly flow and temperature. Recruitment to the age-0 juvenile stage has been low compared to the period before year 2000 in the middle Green River and variable in the lower Green River, but overall recruitment has not been sufficient to replace adult mortality. While adult abundance has been relatively high, exceeding downlisting criteria in some years, population estimates have been declining since about year 2000. The declining adult trend is attributed to insufficient recruitment due to nonnative fish predation and timing and magnitude of base flow management to support nursery habitats. Based on low adult numbers in the most recent abundance estimates (2016–2018), efforts to collect and develop a broodstock for possible future augmentation have been initiated.

In the upper Colorado River subbasin, the wild adult population consists of several hundred individuals, but this population has also been declining in recent years. Captures of age-0 fish indicate spawning occurs annually, but recruitment is generally low despite a “spawning spike” documented in 2015 where juvenile abundance was an order of magnitude higher than all other collected data. While broodstock development is also underway for this population, the need for augmentation is not clear at this time.

The San Juan River subbasin consists of adult fish resulting from augmentation efforts after the wild population of Colorado pikeminnow was nearly extirpated in the late 1990s. Adult abundance has only recently been estimated; estimates indicate a relatively small adult population comprised of stocked individuals, which appears to be increasing in the last few years. Reproduction has been documented annually since 2013, with increasing catch rates of larval fish, but recruitment of wild fish beyond their first year appears to be limited. Currently, the available data suggest persistence of Colorado pikeminnow in the San Juan River is reliant on stocking.

Since their extirpation in the 1960s, Colorado pikeminnow in the lower Colorado River basin have only been reintroduced as a nonessential, experimental population in the Gila River subbasin, specifically in the Verde River. Fish were stocked in the upper reaches of the Gila

River subbasin starting in the mid-1980s, but survival of these fish has been low and of limited duration. As a result, Arizona Game and Fish Department stocked the remaining Colorado pikeminnow from their Bubbling Ponds Hatchery in 2018, and has no plans to continue stocking in the future. With the low survival of stocked fish and lack of subsequent captures, this population is considered to be functionally extirpated. No Colorado pikeminnow have been documented downstream of Glen Canyon Dam since the mid-1970s and thus all demographic factors for all populations are in extirpated condition (Table 1).

Table 1. Current conditions for demographic factors of the six Colorado pikeminnow analysis units. Overall current condition scores were derived by averaging extirpated (0), low (1), moderate (2), and high (3) condition values. The overall condition (average of all scores) was then identified as functionally extirpated (0.0-0.75), low (0.76-1.5), moderate (1.51-2.25), or high (2.26-3). Definitions and rating criteria are described in detail in Table 19 and Section 5.1 of Service (2020, pp. 82 — 85).

Analysis unit	Adult abundance	Population stability (wild recruited adults)	Reproduction	Age-0 Abundance (wild fish)	Abundance of wild recruit-sized fish	Overall condition
Green River subbasin	MODERATE	LOW	HIGH	MODERATE	LOW	MODERATE (1.8)
Upper Colorado River subbasin	MODERATE	LOW	HIGH	MODERATE	LOW	MODERATE (2.0)
San Juan River subbasin	LOW	Ø	MODERATE	LOW	Ø	LOW (0.8)
Colorado River, Grand Canyon	Ø	Ø	Ø	Ø	Ø	Ø Extirpated
Lower Colorado River mainstem	Ø	Ø	Ø	Ø	Ø	Ø Extirpated
Gila River subbasin	Ø	Ø	Ø	Ø	Ø	Ø Extirpated

Our SSA report also summarized our evaluation of habitat factors to determine if the resource needs of Colorado pikeminnow are being met and the effects of conservation measures in addressing those needs. The assessment includes a summary of habitat factors for both the UCRB, where the species still occurs, and the unoccupied LCRB to determine if the remaining reaches of river could potentially support Colorado pikeminnow (Table 2). The Green River subbasin ranks high for habitat conditions. As a result of being the least regulated subbasin, the Green River subbasin maintains variable peak flows from tributary inputs, and provides prescribed peak and base flows through the U.S. Bureau of Reclamation’s reoperation of Flaming Gorge Dam (as per their 2006 Record of Decision). The Green River subbasin also

possesses complex habitats, encompasses two major tributaries with a large extent of connected, warmwater riverine habitat, and provides at least two independent spawning sites located upstream of corresponding nursery reaches with extensive backwater habitat. Despite these habitat attributes, the Green River subbasin also has multiple problematic nonnative fish species in high densities that pose competitive and predatory risks to Colorado pikeminnow of various ages from larvae to adults. For the upper Colorado River subbasin, the overall habitat factor condition is moderate. This rating resulted from peak flows, water temperatures, the extent of available riverine habitat, and forage base being suitable to some extent in recent years. Base flows that provide nursery habitat and larval transport are suitable to support recruitment in most years. The San Juan River subbasin also has an overall moderate rating for habitat factors. Water temperatures and nonnative fish impacts are generally considered to be conducive to Colorado pikeminnow population resilience, but peak flows sufficient to maintain channel morphology and the extent of connected, complex riverine habitat have occurred less frequently than anticipated over the last 20 years. These high flows are also associated with creating and maintaining backwater habitats that are important nursery habitats of the species. As a result, this factor is considered to be in a moderate condition.

In the LCRB, extensive modification of the Colorado River and its tributaries during a dam construction period in the 1930s to 1960s led to drastic changes in flow, water temperature, and connected riverine habitats. Both the lower Colorado River mainstem and the Gila River subbasin are considered unsuitable for Colorado pikeminnow in several key habitat features. Peak and base flows are highly regulated and do not resemble historical flow regimes that were variable and functioned to maintain and create key habitats. These reaches are also fragmented by dams and their impoundments, which create cold, tailwater reaches that preclude spawning. In addition, multiple species of nonnative fishes inhabit the river in sufficient densities to pose significant threats to Colorado pikeminnow and reduce densities of all native fishes. In the Gila River subbasin, nonnative species are implicated as an impediment to re-establishing Colorado pikeminnow there. Finally, large reaches of the lower Colorado River are channelized and armored, all but eliminating nursery habitats for young Colorado pikeminnow. These two rivers may provide suitably warm water temperatures in some reaches, but the lack of other key habitat features makes their overall suitability low. The Grand Canyon reach of the Colorado River ranked moderate for habitat factors. While peak flows and base flows are not managed in consideration of Colorado pikeminnow needs, recent warming of water temperatures, large increases in native fish abundance and distribution, particularly in the western Grand Canyon, and the near absence of cool or warm water predatory nonnative fish have improved the suitability of this river reach. This segment of river is also relatively long, and has some tributary habitat, but the upstream extent is likely cold for most life stages of Colorado pikeminnow, and it is not clear to what extent spawning and nursery habitats might be available.

Table 2. Summary of current conditions for habitat factors. Overall current condition scores were derived by averaging extirpated (Ø), low (1-orange), moderate (2-yellow), and high (3-green) condition values. The overall condition was then identified as extirpated (0.0-0.75), low (0.76-1.5), moderate (1.51-2.25), or high (2.26-3). Definitions and rating criteria are described in detail in Table 28 and Section 5.4 of Service (2020, pp. 104 — 120).

Analysis Unit	Peak flows	Base flows	Water temperature	Complex, redundant habitat	Forage base	Overall habitat condition
Green River subbasin	HIGH	MODERATE	HIGH	HIGH	LOW	HIGH 2.4
Upper Colorado River subbasin	MODERATE	HIGH	MODERATE	MODERATE	MODERATE	MODERATE 2.2
San Juan River subbasin	LOW	MODERATE	HIGH	LOW	HIGH	MODERATE 2.0
Colorado River, Grand Canyon	LOW	LOW	MODERATE	LOW	HIGH	MODERATE 1.6
Lower Colorado River mainstem	Ø	Ø	HIGH	Ø	Ø	Ø 0.6
Gila River subbasin	Ø	Ø	HIGH	LOW	Ø	Ø 0.5

When we averaged the demographic and habitat factors, the overall condition scores for each analytical unit are similar to an average of demographic factors alone. The Green and upper Colorado river subbasins still ranked “moderate” with the San Juan River subbasin ranking “low,” despite generally higher habitat factor rankings for all three units (Figure 2).

Currently, the species is spread across three populations in the upper basin, which contributes to redundancy, although the extirpation in the lower basin limits the species’ geographic distribution compared to its historic range. Genetic data indicate Colorado pikeminnow are genetically similar in the Green and upper Colorado rivers, but geneticists have recommended developing broodstocks for each subbasin to preserve possible local adaptations and unique alleles. The San Juan River population is augmented with offspring produced by fish collected from the Colorado River, and the genetic composition of that river basin reflects that origin. Recent genetic analyses, however, found limited genetic diversity in the existing broodstock, and the genetic composition of these fish was not representative of wild populations. In short, Colorado pikeminnow from the San Juan River are closely related to the upper Colorado River

broodstock. The species also exhibits some diversity in behavior, with both migratory and localized spawning displayed across the three remaining populations. The Green River basin fish display more migratory behavior, moving to specific spawning reaches each year, whereas individuals in the upper Colorado River spawn in more diffuse areas closer to their home ranges. Adults in the San Juan River basin exhibited both types of spawning behavior before the species declined in that system. Fish in the Green and upper Colorado subbasins can move freely between the two units as evidenced by recapture data, and genetic studies suggest this occurs frequently enough that the two populations do not exhibit significant genetic differentiation. The San Juan River subbasin is largely isolated from the other units by long distances of reservoir habitat and the presence of an impassable waterfall near its downstream inflow into Lake Powell.

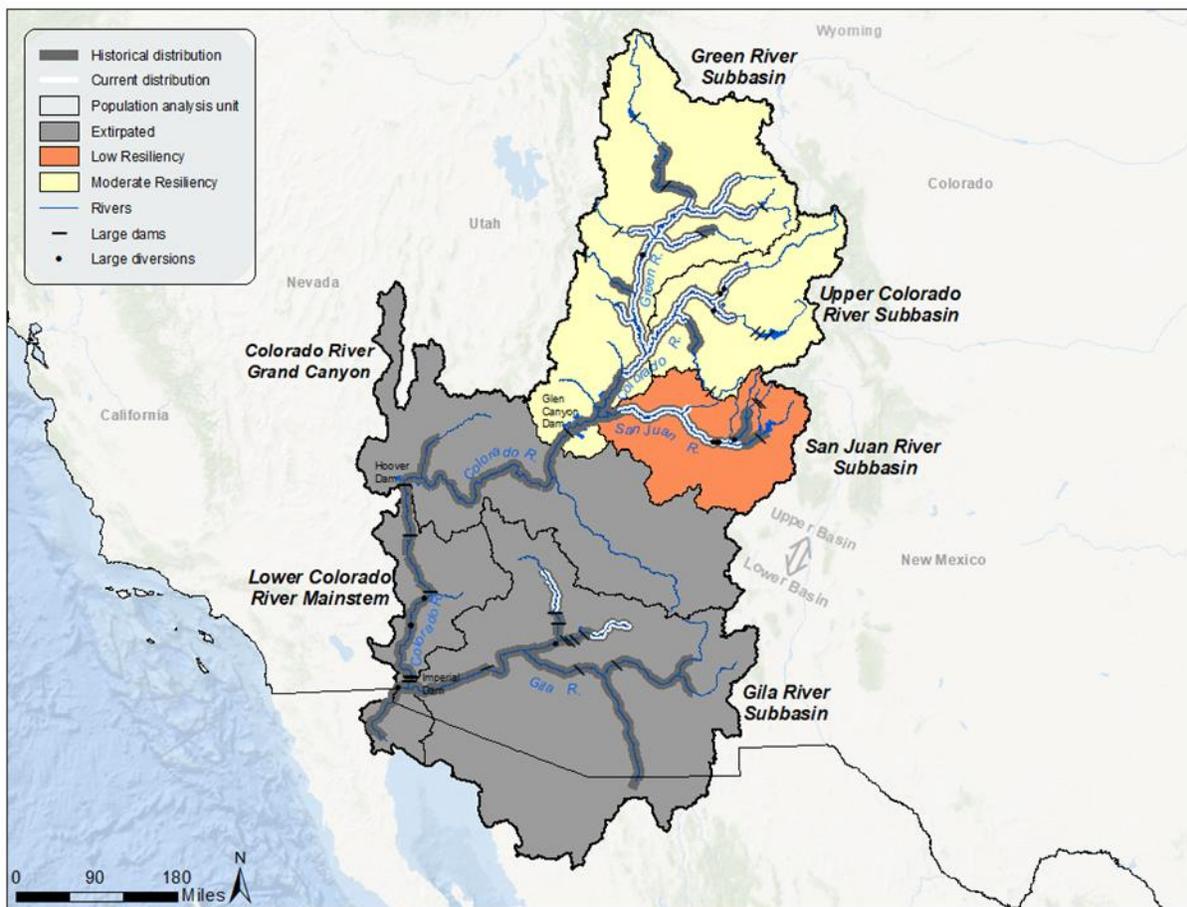


Figure 2. Historical and current distribution of Colorado pikeminnow in the Colorado River basin. Analysis units are colored based on overall condition derived by averaging condition ratings.

Future condition

Future conditions for Colorado pikeminnow were evaluated using population viability analysis (PVA) projections for the three occupied analytical units in the upper basin using empirical data collected from monitoring for the species and input from a panel of experts. The PVA analyzed past adult abundances, and their relationship to underlying demographic rates, to project future adult abundances under multiple future scenarios (Miller 2018, entire). While these models did not explicitly include habitat factors, they did change demographic rates based on relationships observed for specific habitat conditions. For example, the PVA modeled a reduction in reproduction and recruitment based on observed relationships between base flow management and age-0 fish densities in nursery habitats, and the projections incremented demographic parameters based on the frequency of achieving base flows that improved age-0 densities. In other instances, relationships between a habitat factor and demographic rates were not known (i.e. nonnative fish reduction), so demographic rates were adjusted to reflect a presumed response to conservation actions. Models for the Green and upper Colorado river subbasins included what was termed “single” and “dual” phase dynamics based on observed abundances of adults, which showed an increasing trend in early years, followed by a decline in the recent period. The single-phase models treated annual fluctuations in adult abundance as variability around a long-term decline. The dual phase dynamic assumed the initial population growth followed by subsequent decline reflected actual population trends and a corresponding change in underlying demographic rates. The upper Colorado River subbasin models also incorporated “spawning spikes,” based on an event observed in 2015 where age-0 abundance was significantly higher than all other collections. The SSA examines population responses over a 40-year period, based on an average generation time of 13 years and extending the analysis over 3 generations to detect trends in abundance. The PVA models extended to 100 years into the future, which the SSA briefly summarizes (Service 2020, pp. 128 — 141), but predicting habitat changes and conservation measures that far into the future produced a high level of uncertainty in the projections. Based on the extent and magnitude of water development in the lower basin, and recent decision documents related to the management of that system, the assessment concludes habitat conditions in the lower basin will largely persist unchanged, and those analysis units will remain extirpated.

As summarized in our SSA report, we selected models from the PVA to include a plausible range of future scenarios for the species (Service 2020, pp. 129 — 139). The scenarios include a status quo, or continuation, projection (Scenario 1), a reduction in conservation (Scenario 2), a slight increase in conservation based on the effective implementation of current management actions (Scenario 3), and a significant increase in conservation where multiple management actions successfully occur in concert (Scenario 4). The SSA predicts future conditions based on the 40-year projections from the PVA, and the condition of underlying demographic factors that

would produce predicted trends. The overall future condition for each scenario resulted from averaging ratings across the demographic factor conditions.

- Scenario 1—status quo: Recently observed trends in adult abundance and the underlying demographic rates that produce them continue into the future— For the Green and upper Colorado river subbasins this scenario assumed the frequency of recent base flow management and the resulting reproductive output observed for those flows would continue. Therefore, age-specific mortality rates remain the same as those derived from observed trends in adult abundance. Carrying capacity, which was estimated from the highest observed adult estimates in each basin, remains constant. Although the PVA identified specific management actions or stressors that could influence these demographic rates, changes in reproduction, mortality, or carrying capacity could be the result of any of the factors discussed as stressors or actions intended to reduce their impacts. The upper Colorado River subbasin models included varying levels of “spawning spikes” occurring into the future. For the San Juan River projections, stocking continues at current levels (400,000 age-0 fish annually), and age-specific mortality rates do not change. For this scenario, all of the extant analysis units in the upper basin are predicted to rate as a low condition, with reduced representation and redundancy similar to current conditions.
- Scenario 2—conservation reduction: Conservation measures for Colorado pikeminnow are reduced in their implementation or effectiveness— This could result from a new stressor emerging, increasing effects from existing stressors, a lapse in authorizing legislation, reduced funding for recovery programs, or a reduction in the implementation or effectiveness of management actions. Scenario 2 was not modeled in the PVA, but assumes lower abundance for adults and lower demographic rates than the status quo scenario. The status quo projections incorporated generally low demographic rates and predicted long-term declines. A reduction in these rates would be expected to exacerbate those declines and lead to the functional extirpation of all three upper basin analysis units. This scenario projects that individuals will persist in the three extant units, but the processes necessary to support viable populations would diminish to ineffective levels. Redundancy and representation would also be reduced from current condition under this scenario.
- Scenario 3—slight conservation increase: Slight increases in the implementation or effectiveness of existing management actions improve underlying demographic rates— This scenario incorporates pairs of actions currently being implemented throughout the basin, and assumes these actions result in a positive population response. For the Green River subbasin, the PVA modeled improved reproduction and recruitment to age-0 as a result of preferred base flows being implemented more frequently. The Green River

projection also increased survival for all age classes as a result of more effective nonnative fish management and reduced entrainment into an irrigation canal system. The upper Colorado River subbasin models maintained current base flow regimes, which appear to be within the preferred range for age-0 first summer survival, and improved survival for ages 0-4. This projection also increased carrying capacity based on more effective fish use of passages to expand the currently occupied range. Models for the San Juan River subbasin included increased reproduction, improved survival through age-4, and continued stocking at current rates. While the PVA attributed changes in demographic rates to specific management actions based on observed relationships, it is important to note that increased reproduction, recruitment, and survival could be the result of many management actions or improved resource conditions. In some cases it is not clear to what extent a management action may need to occur to produce the modeled demographic response. The result of these improvements in demographic rates is a high rating for the Green and upper Colorado units' condition, and a low condition for the San Juan River subbasin unit, largely due to the reliance on stocking to maintain a population. Redundancy for this scenario would remain unchanged from the current condition, and representation would improve with more individuals throughout the current range.

- Scenario 4—considerable conservation increase: Significant increases in conservation result from the successful implementation of multiple management actions in concert— For the Green River subbasin, this included higher rates of reproduction and survival to age-0 at more frequent intervals, and improved survival across all age classes. Models for the upper Colorado River subbasin included the continuation of occasional “spawning spikes” where age-0 abundance is significantly higher than the mean densities typically observed. The upper Colorado River models also increased survival of ages 0-4 and increased carrying capacity. San Juan River projections were based on estimates of demographic rates that would be necessary to maintain the population in the absence of stocking. These changes included increased reproduction, higher survival to age-0, and improved survival for juvenile through sub-adult fish, but as noted above for Scenario 3, it is not clear exactly what level of management actions would produce the modeled demographic rates. Given the assumptions described above, the projections for this scenario resulted in a high condition for all three analysis units in the upper basin. Under this scenario, representation would improve across the upper basin with more individuals in all three populations. Redundancy would also improve with a larger, more viable San Juan River population in addition to those in the Green and upper Colorado rivers.

As summarized in our SSA report, our assessment of potential future scenarios produced a wide range of possible future outcomes for Colorado pikeminnow within its current range, from a potential improvement in condition for all extant populations (Scenario 4) to the potential functional extirpation of the species (Scenario 2; Figure 3; Service 2020, pp. 129 — 141).

Currently, despite ongoing efforts to improve the condition of the species in the rivers of the upper basin, populations in the Green and upper Colorado rivers have declined in recent years. Augmentation efforts in the San Juan River have prevented the extirpation of Colorado pikeminnow in that subbasin, but the current population appears to rely on continued stocking. A continuation of these recent trends and underlying demographic parameters into the future (Scenario 1) indicates that the species could be in a low condition across the upper basin, which represents approximately one-third of its former range. Reductions in conservation activities or elimination of current recovery programs are likely to result in the species becoming functionally extirpated across its range (Scenario 2). Successful implementation of additional management actions could improve the condition of at least two populations in the Green and upper Colorado rivers, with even further improvements in the San Juan River if underlying demographic rates respond to those activities. It is not clear, however, the magnitude or extent of specific management actions that would be required to elicit such population responses.

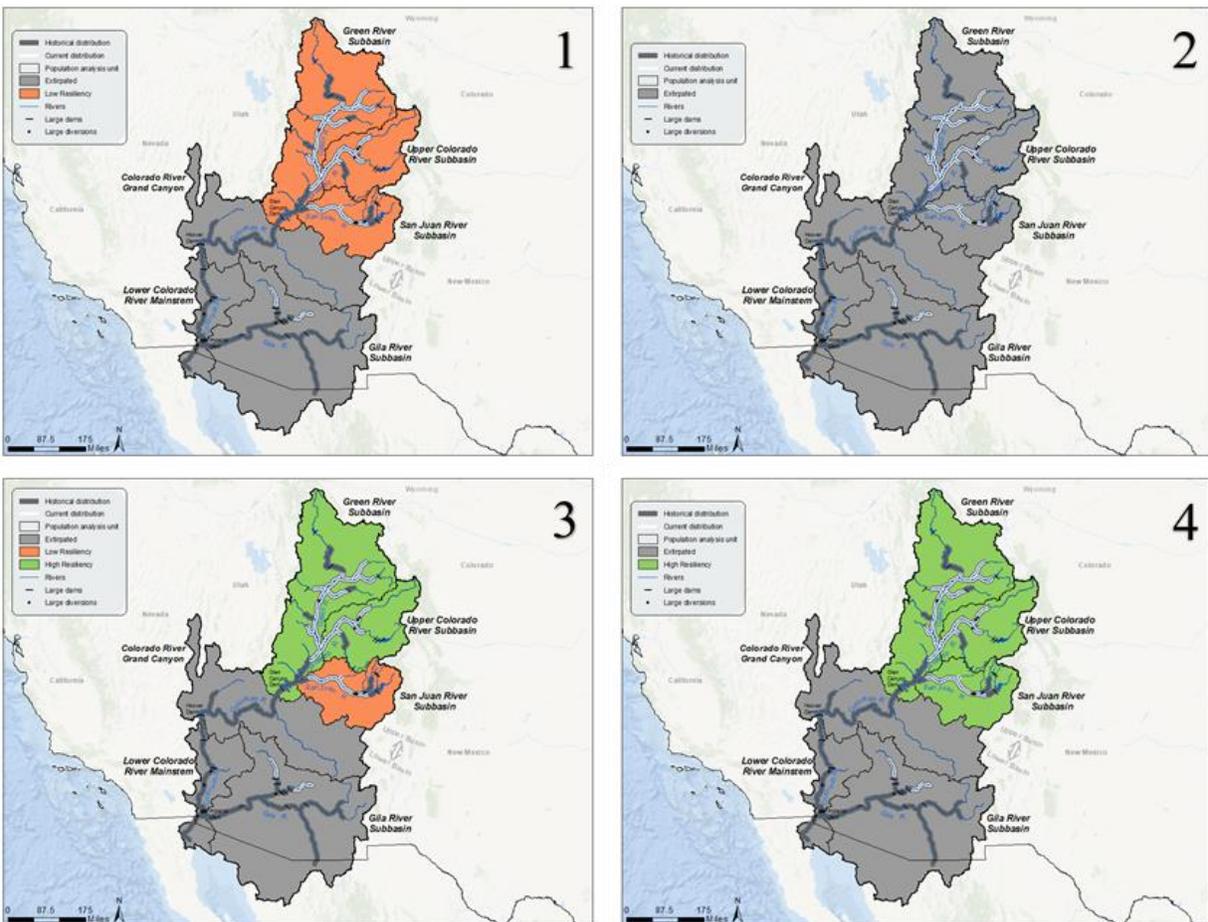


Figure 3. Overall demographic condition of Colorado pikeminnow analysis units for four future scenarios modeled in a PVA: (1) status quo, (2) conservation reduction, (3) slight increase in conservation, and (4) significant increase in conservation.

THREATS ANALYSIS (THREATS, CONSERVATION MEASURES, AND REGULATORY MECHANISMS):

The Colorado pikeminnow was listed as an endangered species prior to the Endangered Species Act, so a listing package as identified under the Act was not created at the time of listing. The most recent recovery goals (Service 2002, pg. 22) identified streamflow regulation and habitat modification (Factor A; including cold-water dam releases, habitat loss, and blockage of migration corridors), competition with and predation by nonnative fish species (Factor C), and pesticides and pollutants (Factor E) as the primary threats to the species (Table 3).

The SSA considered these stressors and also considered several additional stressors that affect the resiliency of extant Colorado pikeminnow populations. All stressors were evaluated in an analysis of rangewide threats, and were evaluated cumulatively (Service 2020, pp. 81 — 126). Additional current and future rangewide threats to Colorado pikeminnow considered in the SSA include a loss of channel complexity as a result of reduced peak flows and channelization (Factor A), entrainment into water delivery systems (Factor E), and potential climate change effects to water supplies (Factors A and E). The SSA also considered existence of two Recovery Programs that coordinate conservation activities in the upper basin; of particular importance is the protection and management of riverine flows to support the species, which are regulated under Records-of-Decisions and other legal frameworks (Factor D). Currently, Colorado pikeminnow is not used for scientific or commercial purposes (Factor B), so neither the 2002 recovery goals nor the SSA considered this as a species stressor. Despite being a threat listed in the 2002 recovery goals, pesticides and pollutants were not addressed in detail in the SSA. Instead, contaminants such as mercury and selenium were reviewed, but the relationship between these contaminants and population dynamics is not clear for subbasins outside of the San Juan River basin, where some models have been developed. That modeling (Miller 2014) projected that the San Juan River population of Colorado pikeminnow could experience slight declines compared to current trajectory due to mercury, but those effects might be offset by the implementation of conservation measures that addressed other factors. The other threats were determined to have a more immediate and direct influence on the current status of the species and were thus considered as the primary threats to species' current and future condition. The SSA also evaluated the potential cumulative effects of these stressors (Service 2020, pp. 81 — 141).

Table 3. Summary of threats affecting Colorado pikeminnow and the associated listing factors under the Act.

Listing Factor under the Act	Threat Description
Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range	Streamflow regulation and water development has modified habitats through fragmentation and inundation of riverine systems. Dam releases of cold water have also rendered some river reaches unsuitable for reproduction and growth of the Colorado pikeminnow. Despite the implementation of flow recommendations for endangered fishes in some reaches, much of the former range is not available or suitable for recolonization by the Colorado pikeminnow. Future projections of hydroclimate show mixed effects of warming temperatures, but could include reduced run-off and water availability.
Factor B: Overutilization for Commercial or Scientific Purposes	The species is not used for commercial or scientific purposes.
Factor C: Disease or predation	Nonnative fishes prey upon and compete with Colorado pikeminnow throughout their current and historic range. The number and variety of nonnative species pose competitive and predatory threats at every life stage for Colorado pikeminnow. The effects include reduced growth, recruitment, and survival.
Factor D: The inadequacy of existing regulatory mechanisms	Two recovery programs have been established in the upper basin to coordinate conservation activities. These measures include flow protection and management to benefit Colorado pikeminnow. This factor is not considered a threat.
Factor E: Other natural or manmade factors affecting its survival	Entrainment into water delivery systems pose direct mortality risks. Contaminants and pollutants were previously listed as poorly understood threats to Colorado pikeminnow. Recent data show Colorado pikeminnow may exhibit elevated mercury and/or selenium levels.

In the lower Colorado River basin, the modification of habitat and reduction in range as a result of water development and the construction of mainstem dams (Factor A) played a major role in the extirpation of Colorado pikeminnow from the lower Colorado River mainstem, the Grand Canyon, and the Gila River subbasin. In addition, the introduction and proliferation of nonnative fish species throughout lower basin reaches (Factor C) present additional threats to stocked (Gila River subbasin) or potentially repatriated Colorado pikeminnow. In the upper Colorado River basin, water development occurred more in tributary and upstream reaches (Factor A), which has restricted the range of Colorado pikeminnow to mainstem portions of the Green, upper Colorado, and San Juan river basins. Cold water releases from dams has rendered other reaches thermally unsuitable (Factor A) for Colorado pikeminnow to complete their life cycle.

The 2002 Recovery Goals identified nonnative fishes as a primary threat (Factor C), but subsequently this threat has exacerbated, as additional species such as smallmouth bass and walleye have established throughout large portions of the Green and upper Colorado river subbasins. These more recent invasions have posed additional threats to Colorado pikeminnow, particularly for young life stages. Streamflow regulation and water development has modified the natural hydrograph such that peak flows are generally diminished and base flows during summer are reduced (Factor A). The combined effects of these changes are loss of habitat features such as backwater nursery habitats and reduced range when base flows are too low to allow fish movement between reaches. Despite a suite of conservation measures implemented through the Upper Colorado River and San Juan River Basin recovery programs, populations of Colorado pikeminnow in the Green River basin have declined since about 2000, while upper Colorado and San Juan river populations remain low (Service 2020, pp. 85 — 100).

The demographic criteria for downlisting outlined in the recovery goals have not been met in the most recent 5-year period, and populations in the Green and Colorado rivers have declined since the last review. The Green River subbasin population has declined since 2000, and consists of fewer than 1,000 individuals. Recruitment of age-6 fish has not been sufficient to offset adult mortality. The upper Colorado River subbasin population has not exceeded 700 adults since 2008 and has declined since that estimate. Recruitment has been variable annually and estimated to approximate adult mortality over several sampling periods, however, a declining adult population suggests it has not been sufficient to offset mortality in the long term. Despite estimates that suggest the San Juan River basin population has been increasing, abundances over a five year period do not indicate that population has met recovery criteria.

While many of the management actions identified in the recovery goals have also been addressed, some have only been implemented partially or recently, such as reducing entrainment into the Green River canal at the Tusher Diversion Dam. Flow recommendations have been instituted in most reaches of the upper basin, but researchers are still refining these based on the species' response. Finally, the programs have reduced stocking and escapement of nonnative fishes into Colorado pikeminnow habitats, but new nonnative species have emerged and expanded in the same period.

RECOMMENDATION ON SPECIES STATUS

The Act defines an endangered species as any species that is “in danger of extinction throughout all or a significant portion of its range” and a threatened species as any species that is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” We completed a robust, up-to-date scientific review of the current and future condition of the species, as documented in our SSA report (Service 2020, entire) and summarized in this 5-year status review. Threats affecting the species under the factors in 4(a)(1)

of the Act from our last and most recent review of the species (Service 2011, pp. 11 — 19) have remained the same in most cases, but have increased in the case of predation by nonnative fish species. The diversity of nonnative fish species in the upper basin has increased since the last 5-year status review, and the number and distribution of some species, such as walleye (*Sander vitreus*), have increased. In addition, while some threats such as habitat modification have been addressed through flow recommendations, in some cases these recommendations are being evaluated and revised to ensure they are producing the intended effects (LaGory *et al.* 2019, entire). This evaluation indicated that flow recommendations may not be providing the habitats required by Colorado pikeminnow during certain critical life stages, such as nursery backwaters for larvae.

In the Green River subbasin, what was once the largest wild population has been declining since the year 2000 (Bestgen *et al.* 2018, entire). In the upper Colorado River subbasin, adult numbers have declined, although not as drastically. Despite some recent evidence that the number of adults may be increasing in the San Juan River, the average adult abundance over the last 7 years has been low (n=180), with no evidence of wild recruitment (SJRIP 2017, pp. 20 — 29; Diver and Mussman 2019, pp. 2 — 17). In addition, recent genetic analyses have raised concerns over lower genetic diversity in the San Juan River and in the broodstock used for augmentation in that population. While resiliency is considered moderate in the Green and upper Colorado river subbasins, it has been decreasing, and long term resiliency of the San Juan River subbasin has been low based on a continued reliance on stocking to maintain that population. Projections of future resiliency in 40 years from the PVA (Miller 2018, entire), as summarized in the SSA, suggest all populations will be in a low condition if current conditions and trajectories continue (status quo—Scenario 1; Service 2020, p. 129 — 132). The reduced conservation scenario (Scenario 2) projections indicate the species will become functionally extirpated should conservation activities decrease or fail to produce anticipated outcomes. Projections from both scenarios 1 and 2 underscore the importance of continuing conservation activities to recover Colorado pikeminnow, and the long generation time of this species means positive population responses will require many years. Redundancy is limited to three populations in the upper basin, with the San Juan River population isolated from the other upper basin rivers by Lake Powell and a waterfall near the lake inflow. Genetic and behavioral diversity is represented by populations in the Green and upper Colorado river subbasins, and the San Juan River population is derived from broodstock collected from the other two populations. Currently, the San Juan River is stocked with fish derived solely from the Colorado River, however, the broodstock used for this augmentation is less diverse and not representative of that source population. Based on these factors, our evaluation finds that Colorado pikeminnow continues to meet the definition of an endangered species under the Act.

After evaluating threats to the species and assessing the cumulative effects of the threats under the section 4(a)(1) factors, we conclude that Colorado pikeminnow is currently in danger of

extinction throughout all of its range. Therefore, we recommend no change in status to the species at this time. Recent declines in the Green and upper Colorado river subbasins, in addition to low adult populations in recent years, were important factors in this recommendation. These trends are occurring despite ongoing activities to address threats throughout the species' current distribution.

New information discovered in the past few decades point to the need to revise the recovery plan for the Colorado pikeminnow to update objective and measurable criteria, especially for threats that have increased since 2002, and how best to address these threats through site-specific management actions. Recent assessments of flow recommendations suggest that base flow management is important to create and maintain nursery habitats that improve recruitment for age-0 Colorado pikeminnow, and revised base flow recommendations have been proposed. New invasive fish species have emerged as threats throughout the basin since we finalized the 2002 Recovery Goals, which also highlights the need to update the recovery plan. Estimates of carrying capacity will assist in determining the numbers of Colorado pikeminnow that a river basin can support and criteria for recovery. Finally, declines in the Green River population point to the possibility that stocking may be necessary in the future, but the current broodstock does not represent the genetic composition of that population. The recovery programs are beginning to create a new broodstock that captures the genetic diversity of the wild populations, but further effort will be needed to develop and propagate these fish, which a revised recovery plan could consider.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
COLORADO PIKEMINNOW (*Ptychocheilus lucius*)

CURRENT CLASSIFICATION: Endangered

RECOMMENDATION RESULTING FROM THE 5-YEAR REVIEW:

- Downlist to Threatened
- Uplist to Endangered
- Delist:
 - Extinction
 - Recovery
 - Original data for classification in error
- No change is needed

APPROPRIATE LISTING/RECLASSIFICATION PRIORITY NUMBER, IF APPLICABLE: No change from 8C.

RECOMMENDATIONS FOR FUTURE ACTIONS:

- Revise the recovery plan, beginning in late 2020
- Update Species Status Assessment report, as needed
- Secure wild Colorado pikeminnow from the Green and Colorado rivers for broodstock development in order to improve hatchery representation and to serve as a refuge population should wild populations decline further
- Investigate potential conservation actions that might be implemented in the lower basin

FIELD OFFICE APPROVAL:

Approve: _____ Date: _____

Thomas Chart
U.S. Fish and Wildlife Service
Director, Upper Colorado River Endangered Fish Recovery Program

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

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