RISK LEVELS OF NON-NATIVE AQUATIC SPECIES IN GLEN CANYON NATIONAL RECREATION AREA AND GRAND CANYON NATIONAL PARK: ANNUAL UPDATE 2021

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The 2019 Expanded Non-native Aquatic Species Management Plan (ENASMP, U.S. Department of The Interior 2018) includes consideration for the risk or threat associated with non-native aquatic species (Appendix F, Table F-1) for the initiation of management actions to protect and conserve resources within the National Park Service (NPS) units. Threat levels were identified for a list of non-native aquatic species in Grand Canyon National Park (GCNP) and Glen Canyon National Recreation Area (GCNRA) based on their potential for predation, competition, or other adverse interactions with native and federally listed species, or to the rainbow trout established and maintained in GCNRA for sport fishing. Threat levels for species already present, or likely to be introduced into or invade the NPS units, were originally evaluated and assigned by NPS technical staff with input from GCMRC, cooperating agencies, and stakeholders. Threat levels were assigned based on their current abundance and distribution and following reviews of published literature on their potential for adverse impact. The ENASMP threat level assessments were established with the allowance for annual updates when new information was gained, or when distributional changes were documented.

In 2021, updates to the species-specific risk levels were completed using the best available science regarding species-specific threats, and considered new information gleaned from studies completed since the completion of the EA, including potential future changes in habitat (e.g, Dibble et al. 2021). Input provided by agency biologists with the NPS, USGS-GCMRC, and Arizona Game and Fish Department (AZGFD) was incorporated into the updated risk assessment. A summary and rationale for changes or additions to Appendix F are summarized below for each species.

Species-specific Risk Level Changes

Smallmouth bass *Micropterus dolomieu* (Very High threat level) – No changes were made to the threat level, however, new literature indicates significant increases in abundance in Lake Powell (Pennock and Gido 2021), upstream from the project area.

Walleye *Sander vitreus* (Very High threat level) – No changes were made to the threat level, however, new literature indicates significant increases in abundance in Lake Powell (Pennock and Gido 2021), upstream from the project area.

Flathead catfish *Pylodictis olivaris* (Very High threat level) – While present in neighboring rivers in the Colorado River Basin, including the Verde, Gila, and Lower Colorado Rivers, flathead catfish was not included in the initial threat assessment due to its absence in waters connected directly to the project area. The large-bodied species is among the least gape-limited of potential predators (Slaughter and Jacobson 2008), can consume large amounts of native fish biomass (Hedden et al. 2016), and can potentially limit the distribution of native fishes (Whitney et al. 2014). Ward and Vaage (2018) found that flathead catfish were more successful in capturing native fish prey in turbid waters, which may provide important cover for endangered fish from sight-feeding piscivores in river inflow areas of Lake Mead (Albrecht et al. 2017). Current (cool) temperatures in GCNP may currently limit the expansion of the species; however,

projected future warming may allow for suitable warm temperatures that may enhance survival of flathead catfish.

Brown trout *Salmo trutta* (Very High threat level) – The level of threat to native fishes and rainbow trout remains unchanged. Additional literature review suggests the potential for impacts to the rainbow trout population may include predation and competition (Gatz et al. 1987; Tabor and Wurtsbaugh 1991; Van Zwol et al. 2012; Hasegawa 2016). In addition, research in Bright Angel Creek found that native fish increased in abundance by >400% following suppression of brown and rainbow trout by ~60%, providing additional support for hypothesized negative impacts to populations of native fishes (Healy et al. 2020b). NPS Field data collection in 2020 also found brown trout inhabiting Tapeats Creek (NPS, unpublished data).

Rainbow trout *Oncorhynchus mykiss* (High threat level) – Rainbow trout are among the most-widely introduced vertebrate (reviewed in Crawford and Muir 2008), commonly implicated in the declines of native fishes through predation and competition where they are introduced (e.g., Crowl et al. 1992; Shelton et al. 2015). Management actions meant to lessen the impact of rainbow trout on humpback chub and other native fishes have been ongoing since the mid-2000s by the Glen Canyon Dam Adaptive Management Program (Coggins et al. 2011; U.S. Department of Interior 2016), and removal of rainbow trout is a priority for NPS managers in GCNP tributaries (U.S. Department of the Interior 2013). Additional research in GCNP completed and published since the ENASMP EA provides further support for findings of previous studies documenting the negative impacts of rainbow trout on native and endangered fishes in GCNP (Yard et al. 2011; Whiting et al. 2014; Spurgeon et al. 2015). Yackulic et al. (2018) found negative relationships between rainbow trout abundance and survival and growth of humpback chub, but environmental factors were also important (temperature, turbidity). The suppression of both rainbow and brown trout resulted in substantial increases in native fish abundance (>400%), and trout density (combined density of both species) was consistently retained in top models predicting native fish abundance and distribution in Bright Angel Creek (Healy et al. 2020b). This new research provides further support for previous findings showing the potential for significant predation of native fish by both species of trout (Whiting et al. 2014) in the mainstem and tributaries.

Rainbow trout are distributed throughout GCNP in the Colorado River and in the tailwater below Glen Canyon Dam in GCNRA (McKinney et al. 2001; Rogowski and Boyer 2019). Self-sustaining populations of rainbow trout are also found in Bright Angel Creek (Healy et al. 2020b), Shinumo Creek (Spurgeon et al. 2015), Havasu (Healy et al. 2020a), and Tapeats Creeks (NPS unpublished data). Given its widespread distribution and abundance, relative to other invasive fishes (Yard et al. 2011), and its documented impacts on native fishes in GCNP and elsewhere, rainbow trout have been assigned a “High” threat level.

Green sunfish *Lepomis cyanellus* (High threat level) – The threat level for green sunfish has been increased to a “high” based on new studies of predation (Ward and Vaage 2018), food web-trophic level interactions between invasive green sunfish and native fishes (Rogosch and Olden 2020), potential for population expansion under increasing drought frequency projected for the region (Rogosch et al. 2019), and positive responses in native fishes following removal of green sunfish (Hickerson et al. 2021). New GCNP distributional information for green sunfish was also added through monitoring in 2020. Evidence for green sunfish reproduction was detected in Kanab Creek and in a large backwater at River Mile 243 (presence of recently hatched juveniles, NPS unpublished data).

Northern crayfish *Faxonius virilis* (Low threat level) – The threat level remains unchanged for this species. Additional distributional information to include Glen and Marble canyons was provided by D. Rogowski (AZGFD, written communication). Also, taxonomic changes were noted (Crandall et al. 2017).

Red swamp crayfish *Procambarus clarkii* (Low threat level) – The threat level remains unchanged for this species. Additional distributional information to include GCNP downstream of Diamond Creek was provided by D. Rogowski (AZGFD, written communication), and to include occurrences in Lake Mead (Peck et al. 1987, Leavitt et al. 1989).

Future Research

Laboratory or mesocosm experiments are in progress by the U.S. Geological Survey – Grand Canyon Monitoring and Research Center (GCMRC) to understand the relative piscivory risk of additional warmwater small- and large- bodied (e.g., common carp) non-native fishes. Preliminary laboratory study results indicate potential for important impacts to humpback chub eggs and larvae by common carp. Field studies are in progress to gain a greater understanding of the potential impacts of invasive brown trout (*Salmo trutta*) on rainbow trout populations in GCNRA, and rainbow trout impacts to translocated humpback chub growth, survival, and recruitment in tributaries in GCNP (Healy et al. *in prep.*).

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