AUGMENTATION PLAN FOR RAZORBACK SUCKER (*XYRAUCHEN TEXANUS*) IN THE SAN JUAN RIVER BASIN

Photo of a young Razorback Sucker, USFWS

Submitted By:

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To:
The San Juan River Basin Recovery Implementation Program
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Department of the Interior Policy for Controlled Propagation and Augmentation under the Endangered Species Act:

The U.S. Fish and Wildlife Service (USFWS) uses controlled propagation and augmentation for conservation and recovery of threatened and endangered species under the authority of the Endangered Species Act of 1973. The policy defines USFWS responsibility for use of controlled propagation as a component of a listed species recovery strategy when recommended in a recovery plan. This policy also allows for controlled propagation to reverse population declines and to restore listed species to habitats in the wild (Federal Register 65: 183, Policy Regarding Controlled Propagation under the Endangered Species Act). Specifically, this policy pertains to propagation of threatened or endangered species by: 1) Establishing or maintaining refugia populations; 2) Producing individuals for research and technology development needs, 3) Producing for supplementing extant populations and 4) Producing individuals for reintroduction to suitable habitat within the species' historic range.

The USFWS's Fish and Wildlife Conservation Offices are the primary conduit for satisfaction of policy requirements and ensure compliance with needs relative to fish health, stocking requests and priorities, deviation from approved stocking requests, pre-stocking treatments (e.g. nonnative fish removal from stocking sites), and applicable environmental regulation. New Mexico Fish and Wildlife Conservation Office is the pertinent field office for processing of SJRIP stocking requests.

The Southwest Regional Policy for Stocking of Fish and Other Aquatic Species (USFWS Regional Policy No. 03-06 memorandum April 2, 2003) specifies regional policy for these actions. Stocking of fish reared at USFWS hatcheries in the Southwest Region are subject to Regional Policy No. 03-06 April 2, 2003 "Stocking of fish and other aquatic species". This policy applies to production, transport, and stocking for USFWS hatchery production and incorporates guidance and requirements from USFWS Fish Health Policy (713 FWM 1-5). Specifically, the policy's main objectives are to 1) recover fish and other aquatic resources population protected under the Endangered Species Act, 2) Restore declining fish and other aquatic resource populations before they require listing under the Endangered Species Act and 3) Maintain healthy, diverse fish and other aquatic resource populations.

Goals and Recommendations:

The long-term goal of the San Juan River Basin Recovery Implementation Program (SJRIP) is to reestablish a self- sustaining population of Razorback Sucker (*Xyrauchen texanus*) within the historic range of the San Juan River and tributaries. Our objectives are to augment the wild

population to prevent extinction and to reach recovery goals. To meet these goals the SJRIP will stock all Razorback Sucker in any given year. The SJRIP has a range of 6,500-11,000 Razorback Sucker (≥300 mm TL) available annually for augmentation under current production capabilities. That level of augmentation is predicted to increase the San Juan Basin Razorback Sucker population, compensate for variability in apparent survival during the critical first over-winter period, and recover a self-sustaining population of this species. To maintain the augmented population of Razorback Sucker in the San Juan River we recommend, based on apparent survival estimates, an annual goal of stocking at least 4,800 fish annually. If the number of fish from all current sources consistently proves to be less than 4,800 a year, then the SJRIP should consider securing additional sources of Razorback Sucker due to the predicted decline of the estimated current population if augmentation falls below 4,800 fish/year. We also recommend that Razorback Sucker available to the SJRIP in addition to the 4,800 fish/year be stocked or used in support of experimental augmentation or research projects. All future proposed experimental augmentation or research that uses excess Razorback Sucker associated with a scope of work within the SJRIP annual work plan process will require review and recommendation by the Biology Committee, and approval by the Coordination Committee. Proposals to stock excess fish to support experimental augmentation or research projects outside of SJRIP funding will be reviewed by the Biology Committee to ensure that the action does not compromise existing augmentation or other recovery activities. These proposals and Biology Committee comments will be communicated to the Coordination Committee.

We recommend stocking Razorback Sucker into suitable habitat at multiple locations in the San Juan River Basin within its native range. We continue to recommend stocking Razorback Sucker at all sites currently stocked, both within and outside of Razorback Sucker critical habitat, as well as new sites. Sites that have been stocked include: in the San Juan River; Verde del Rio Park (RM 196), Wild Horse Rd (RM 186.7), Animas Confluence (RM 180.3), Hatch Trading Post (RM 168.3), PNM Weir (RM 166.6), Hogback Diversion (RM 158.6), Shiprock Bridge (RM 147.8), N 364 (RM 133.6), Four Corners Bridge (RM 119.0), Montezuma Creek (RM 93.0), Bluff (RM 79.6); and in the Animas River, at Penny Lane (A-RM 9.2), Animas/Berg Park (A-RM 4), Boyd Park (A-RM 1.0). The upstream limit of Razorback Sucker stocking locations will be dependent on access and physical water chemistry; where physical water chemistry (mainly water temperature) is not appropriate for all stages of Razorback Sucker life history, we will not stock fish. Currently, we do not anticipate stocking above Verde del Rio Park (RM 196) on the San Juan River. To promote expansion for this species' range we recommend that the SJRIP continues to evaluate suitable riverine locations within the species historic range, and promote natural upstream dispersal of Razorback Sucker by removing barriers to fish passage.

It is our goal to continue to collect and analyze Razorback Sucker population data and increase the accuracy of apparent survival and population estimates. As our understanding of the Razorback Sucker population within the San Juan Basin develops this augmentation plan will

adapt to meet recovery criteria for this species. This augmentation plan will therefore use an adaptive management approach to help create better outcomes for stocked fish by continuing to improve: the quality of fish stocked, the locations and habitats stocked, the methods for transport and releases, and incorporating new information as it becomes available.

Background

The Razorback Sucker is one of seven fishes native to the San Juan River Basin (Basin). Extremely low numbers of adult wild fish and long-term lack of recruitment led to the Razorback Sucker being listed as an endangered species on 22 November 1991 (U. S. Fish and Wildlife Service {USFWS} 1991). Subsequent to listing, a recovery plan was developed in 1998 (USFWS 1998). Augmentation of existing populations, and establishing new populations, including in the San Juan River, was identified as a necessary component for the recovery for this species. In 2002, recovery goals were written to "describe site-specific management actions/tasks; provide objective, measurable recovery criteria; and provide an estimate of time to achieve recovery…" (USFWS 2002). Management actions identified in that document also included the propagation and reestablishment of populations within the Basin. The criteria for downlisting is a minimum viable population (MVP) of 5,800 adult Razorback Sucker reproducing and recruiting young fish into the adult population at a rate sufficient to compensate for adult mortality over a 5-year period.

The San Juan River Basin Recovery Implementation Program began augmenting the Razorback Sucker population in the San Juan River Basin in 1994 (USFWS 1998). Previous augmentation efforts can be assigned into one of three periods (see Appendix 2):

1. **An Experimental Stocking Plan for Razorback Sucker in the San Juan River** (Ryden and Pfeifer 1994).
    a. Time period: 1994-1996
    b. A total of 940 Razorback Sucker was stocked into the San Juan River to assess dispersal, survival, and habitat use and preference.
    c. Fish size ranged from 100 to 482 millimeters (mm) total length (TL) and mean length was 275 ± 3.3 mm TL.
    d. The relative success of the experimental stocking initiated a five-year augmentation effort.

2. **Five-Year Augmentation Plan for Razorback Sucker in the San Juan River** (Ryden 1997).

a. Time period: 1997-2001
b. The plan called for 73,482 Razorback Sucker to be stocked over five years in order to establish a population of 15,900 fish below the Hogback Diversion to Clay Hills Landing, UT river miles (RM) 158.6-0.0; at a density of 100 fish/RM.
c. Fish size ranged from 104 to 560 mm TL and mean length was 223.8 ± 1.0 mm TL
d. A total of 5,896 (only 8% of the desired total) fish was stocked over the five-year period. This shortfall was due to a lack of available fish for augmentation. All fish were being grown-out and stocked from Navajo Agricultural Products Industries (NAPI) ponds. As a result, SJRIP began addressing the availability issue.
e. Even though the numbers stocked were limited, the stockings were considered to be the most successful riverine reintroduction effort implemented for this species to date. Adult survival and retention was high, and there was evidence that fish formed spawning aggregations after subsequent collections of larval fish.
f. The information collected during this period helped formulate an adaptive management approach to Razorback Sucker augmentation, and an addendum to the five-year plan was created in 2003.

3. **An Augmentation Plan for Razorback Sucker in the San Juan River** (2003); an addendum to the **Five-Year Augmentation Plan for Razorback Sucker in the San Juan River** (Ryden 1997). (Ryden 2003)
    a. Time period: 2009-2016
    b. Intended to be implemented from 2004-2011; due to continued fish availability issues, full implementation was delayed until 2009.
    c. Plan calls for the stocking of 91,200 age-2, 300 millimeters (mm) Total Length (TL) Razorback Sucker over 8 years (11,400 fish/year) in order to establish a population of >5,800 adult fish (i.e., age-4+; 400 mm TL) in the San Juan River.
    d. Augmentation target of 91,200 fish is exceeded by seventh year (2015); all fish are stocked with an implanted Passive Integrated Transponder (PIT) tag; recapture data indicates the adult population is increasing; sampling below the waterfall indicates that some fish stocked in the river are becoming entrained in Lake Powell; larval fish continue to be collected annually; extremely limited and infrequent captures of wild juvenile fish suggests a lack of recruiting year classes. All fish stocked were greater than 300 mm TL
    e. SJRIP database analysis and modeling provides better, basin specific, 'apparent survival' rates, and a preliminary population estimate are generated to guide future augmentation efforts.

4. **Period of Razorback Sucker Augmentation Plan Revision**
    a. Time period: 2017-2019
    b. Continuation of stocking protocols and target numbers from the previous Eight-year Plan.
    c. Evaluate previous augmentation efforts, calculate apparent survival rates from existing data, and incorporate information from experimental stocking studies into a new Augmentation Plan.

Razorback Sucker availability was an issue until 2009. Prior to 2009, the SJRIP Augmentation Program's source of Razorback Sucker had been from multiple year-classes, raised in grow-out ponds at NAPI. Fish were passively harvested with fyke nets and stocked into the San Juan River. This production method resulted in inconsistencies in numbers and sizes of fish. As a result, the SJRIP moved from this multiple cohort approach to single cohort management in 2006. Since 2008, Razorback Sucker greater than 200mm TL are stocked into each of the NAPI ponds in the spring. The fish are reared throughout the summer and stocked in the fall. Additionally, the SJRIP contracted with Uvalde National Fish Hatchery (Uvalde NFH) in 2009 to annually produce and stock 11,400 Razorback Sucker (≥300 mm TL) into the San Juan River. This decision would ensure that annual stocking targets would be met, regardless of the numbers available from the NAPI ponds. Comparatively low recapture rates from Uvalde NFH prompted the SJRIP to end stockings from that facility in 2013. In 2014, the SJRIP then entered into an agreement with the Horsethief Canyon Native Fish Facility (Horsethief Canyon NFF) to annually produce and stock 2,000-4,000 Razorback Sucker ≥300 mm TL. Southwestern Native Aquatic Resources and Recovery Center (Southwestern Native ARRC) is contracted to produce 4,500 to 11,000 Razorback Sucker ≥300 mm TL for stocking NAPI ponds, to be stocked into the San Juan Basin annually. Southwestern Native ARRC will end the delivery of the ~1,000 additional Razorback Sucker in 2020 that were produced separate from the fish for NAPI. Therefore, the two sources for Razorback Sucker for SJRIP augmentation are capable of routinely producing 6,500-11,000 fish/year. Please refer to Table 1 for the breakdown of fishes produced by the two remaining production facilities.

Previous augmentation focused on reaching the MVP of 5,800 Razorback Sucker (i.e., age 4+; ≥400 mm Total Length) in the San Juan River Basin (Ryden 2003 and SJRIP 2015). To achieve MVP of 5,800 Razorback Sucker, between-year survival estimates were used to predict how annual stocking efforts would impact overall population numbers. Since there was little specific data about the San Juan River Razorback Sucker population between-year survival estimates from the Upper Colorado River Basin were used. According to the best estimates of survival

available at that time, it was determined that stocking 91,200 Razorback Sucker in the San Juan River over an eight-year period (11,400 fish/year) would result in the establishment of ≥5,800 adults basin-wide. Only when the wild population of ≥5,800 is maintained from naturally produced fish will recovery criteria be met.

Since initiation of augmentation in 1994, over 140,000 Razorback Sucker have been stocked in the San Juan River Basin. Capture data have allowed the SJRIP to develop 'apparent survival' rates (explained in detail in Stocking Numbers section) specific to the San Juan Basin, along with some 'back-of-the-envelope' population estimates. A more robust population estimate using extensive, designated sampling effort was implemented in 2019. However, existing data, collected during other sampling and monitoring efforts, allowed the SJRIP to generate some population estimates for Razorback Sucker in the San Juan Basin. These apparent survival rates and current population estimates formed the basis for recommendations contained in this augmentation plan and it should provide guidance to the SJRIP Augmentation Program until new information becomes available.

Relationship to the Razorback Sucker Recovery Goals

The Razorback Sucker Recovery Goals (USFWS 2002) describes site-specific management actions/tasks; provide objective, and measurable recovery criteria to achieve recovery of the endangered Razorback Sucker. In addition, the SJRIP has a Long-Range Plan (LRP) (SJRIP 2016) identifies the need to implement and assess the augmentation of Razorback Sucker populations in the San Juan River Basin to help achieve the below Recovery Criteria.

Recovery Criteria: Objective, measurable criteria for recovery of razorback sucker in the Colorado River Basin are presented for each of two recovery units (i.e., the upper basin, including the Green River, upper Colorado River, and San Juan River subbasins; and the lower basin, including the mainstem and its tributaries from Glen Canyon Dam downstream to the southerly International Boundary with Mexico) because of different recovery or conservation programs and to address unique threats and site-specific management actions/tasks necessary to minimize or remove those threats. Recovery of the species is considered necessary in both the upper and lower basins because of the present status of populations and existing information on razorback sucker biology. Self-sustaining populations will need to be established through augmentation. Without viable wild populations, there are many uncertainties associated with recovery of razorback sucker. The razorback sucker was listed prior to the 1996

distinct population segment (DPS) policy, and the USFWS may conduct an evaluation to designate DPSs in a future rule-making process. These recovery goals are based on the best available scientific information and are structured to attain a balance between reasonably achievable criteria and ensuring the viability of the species beyond delisting. These recovery criteria will need to be reevaluated and revised after self-sustaining populations are established and there is improved understanding of razorback sucker biology.

Downlisting can occur if, over a 5-year period: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and EITHER in the upper Colorado River subbasin or the San Juan River subbasin such that — (a) the trend in adult (age 4+; ≥400 mm TL) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (300–399 mm TL) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults (5,800 is the estimated minimum viable population [MVP] needed to ensure long-term genetic and demographic viability); and (2) a genetic refuge is maintained in Lake Mohave of the lower basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that — (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can occur if, over a 3-year period beyond downlisting: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and EITHER in the upper Colorado River subbasin or the San Juan River subbasin such that — (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults; and (2) a genetic refuge is maintained in Lake Mohave; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that — (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and (4) when certain site

specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Augmentation

Efforts to improve the success of the augmentation program are ongoing. As an example, one study is investigating the effects of source of fish and location of stocking on apparent survival. This is for two sources of fish (NAPI and Horsethief) and stocked at four location (Montezuma Creek, Shiprock, Bloomfield and Lower Animas (Boyd Park). As more is understood about the influences that source, location, the risk entrainment has on recently stocked fish, and a variety of other factors relating to augmentation are considered, protocols will be modified in order to minimize these potential impediments to stocked Razorback Sucker apparent survival.

Sources of Razorback Sucker:

The SJRIP has three facilities producing Razorback Sucker used for augmentation (Table 1). These facilities produce fish under the authority of the previously mentioned USFWS policy regarding controlled propagation of species listed under the Endangered Species Act, specifically: Producing for supplementing extant populations and producing individuals for reintroduction to suitable habitat within the species' historic range with the intent of establishing or maintaining refuge populations.

If other fish become available, or are needed in support of recovery actions, in any given year, these fish are stocked on a case-by-case basis. Currently, the goal is to produce and stock only Razorback Sucker ≥300 mm TL (Schooley and Marsh 2007).

Table 1: Current sources of Razorback Sucker and the likely number available annually to the SJRIP Augmentation Program.

Source of Razorback Sucker	Number of Fish
Southwestern Native Aquatic Resources and Recovery Center (Southwestern Native ARRC)	10,500 fish, ~225-290 mm TL, delivered each spring to the NAPI Ponds for grow out, harvest, and stocking into the San Juan Basin.
Navajo Agricultural Products Industry (NAPI) ponds: East Avocet, West Avocet, & Hidden Pond	4,500-7,000 fish likely available* for stocking into the San Juan Basin
Horsethief Canyon Native Fish Facility (HCNFF)	2,000-4,000 fish likely available** for stocking into the San Juan Basin
Total Available	**6,500-11,000 fish + "opportunistically acquired"**

* availability from NAPI ponds is dependent on harvest return rates; return rates usually range between 43-67%.
** availability from HCNFF is dependent on return rates from two ponds dedicated to producing fish for the SJRIP; plus, any fish available once other HCNFF augmentation commitments are met.

Stocking Locations:

Previous to implementation of the eight-year augmentation effort in 2009, Razorback Sucker had exclusively been stocked immediately below the Hogback Diversion at river mile (RM) 158 (Ryden 2003). After an initial post-stocking dispersal, data indicated that a majority of Razorback Sucker recaptures were within (+/-) 10 river miles of their stocking location (Davis and Furr 2007, 2008). There was a concern of the potential negative impacts of overcrowding and intra-specific competition by continuing to only stock fish directly below Hogback Diversion, as this would result in 91,200 Razorback Sucker being stocked at a single location over an eight-year period. Therefore, it was determined that stockings would need to occur at multiple locations throughout the Basin.

In order to create a more longitudinally dispersed population of Razorback Sucker within the San Juan River Basin, to reintroduce this species into more of its historic range (USFWS propagation policy goal 4, producing fish for reintroduction to suitable habitat within the species' historic range), and to reduce the potential effects of overcrowding, competition, and to test for differences in survival rates, numerous sites upstream and downstream of Hogback Diversion were investigated. As a result of identifying suitable habitats and accessible stocking sites, stockings were conducted upstream of RM 158 to the Animas River confluence beginning in fall 2009 (Furr 2010). Further upstream expansion was considered a benefit for this species

so we identified additional stocking locations upstream of the Animas River confluence (Furr 2011). Since then, Razorback Sucker have routinely been stocked throughout much of the San Juan River Basin.

Currently, the plan is to continue the current source-site stocking design, which is to see how source of fish and location of stocking effect retention and overall apparent survival for Razorback Sucker. However, if we require alternative stocking locations, those locations will be considered on a case by case basis, and we will seek review and recommendation from the Biology Committee, and the Coordinating Committee will be informed of the stocking locations.

Stocking Methodology:

We have used two Razorback Sucker stocking methodologies in the San Juan and Animas rivers (Furr and Davis, 2009). The "hard release" methodology consists of thermally tempering fish in the hauling tanks to within 2°C of the receiving water temperature (thermal acclimation limited to 1°C every 30 minutes). Once fish have been tempered, they are then stocked directly into the river. This method is consistent with typical stocking procedures used all over the world by fisheries managers. The "soft release" methodology entails setting up an enclosure within the river by isolating a backwater, embayment, or slow-flowing side channel with block nets. The enclosure is then sampled (when possible) by backpack electrofishing unit or seine to record the fish community present and to remove piscivorous and/or nonnative fishes. Once fish have thermally tempered (similar to a hard release) they are then stocked into the enclosure and held for 24 hours. Holding fish within an enclosure allows them to acclimatize to the new habitat *in situ* and provides an opportunity to monitor any anomalies or mortalities resulting from handling and hauling stressors. Preliminary results from a study between hard vs. soft release methodologies indicates that any short term benefit to apparent survival from soft releasing fish may be minimal, but no negative effects were noted with either methodology (Furr, 2019). Therefore, soft releases (which are limited by site suitability, and incur extra costs and efforts) will be conducted on a limited basis in order to monitor handling and hauling stress.

Active and passive methods of harvest are implemented for removing fish from the NAPI pond. Fyke nets are used for passive harvest and active harvest consists of draining the ponds and capturing fish using a seine (10m x 1m x 8mm mesh). By reducing the total number of fish requiring immediate capture, passive harvest reduces stress that occurs when the ponds are drained. It also allows a more logistically feasible method for capturing many individuals with limited personnel. Passive harvest begins when at least 80% of the population has reached or surpassed the target stocking size of 300 mm TL. This usually occurs after approximately 4 ½ to

5 months of grow-out after receiving the fish from Southwestern Native ARRC in the spring. During passive harvest, nine fyke nets of the same size are set overnight, for a total of approximately 126 fyke-net hours. Captured fish are held in an aerated tank located on the boat and each fish is measured for TL (mm), SL (mm), and weight (g). Fish captured which do not meet target size are returned to the pond for further growing. Any fish harvested without a Passive Integrated Transponder (PIT) tag is implanted and placed into a hauling tank with aeration and supplemental oxygen.

Razorback Sucker are harvested generally from NAPI ponds during the first few weeks October (approximately 6 months of growing) when pond temperatures and river temperatures are relatively similar, target size has been met for all individuals, and the USFWS is available to aid with the effort. Each pond is drained separately for harvesting to avoid de-watering and stranding fish. Each pond drains in roughly 30 to 36 hours. As a pond drains, fish are funneled toward a kettle (a low-lying channel) where the siphon is located. The fish are then captured in a seine and hauled to portable aerated tanks where the fish are processed as described for passive harvest. Total length, standard length, and weight are recorded for a sample of the first 100 to 200 individuals, and total length is the only metric recorded for the remaining fish. All fish receive a PIT tag and are placed into an aerated, oxygenated hauling tank.

San Juan River stocking of passively harvested NAPI fish occurs in several areas of the river, generally between river mile 147.9 (Shiprock bridge) and 196.1 (Bloomfield Riverwalk Park) while actively harvested fish are stocked to support the previously described source-site design. Before releasing, water temperatures of the tank and river are measured and the fish are acclimated according to the temperature differential one hour for every three degrees Celsius (Manuel Ulibarri, personal communication).

Stocking Timing:

Stockings will be typically conducted in the fall (late October or November) of each year to provide sufficient time for growth (to reach the minimum required size of ≥300 mm TL) and to release fish nearer to the end of irrigation season in an attempt to minimize the risks of entrainment. Passively harvested fish from NAPI that reach the target size are stocked earlier than this timeline. If there are requests (e.g., in support of a stocking study) or instances that would require stocking Razorback Sucker at other sizes, times of the year, or in a way not currently covered by this plan, then those situations will be evaluated and handled by NMFWCO staff in accordance to USFWS and regional stocking policies.

Stocking Numbers

Through the analysis of recapture data, the SJRIP Program Office has calculated among-year apparent survival estimates for Razorback Sucker stocked as part of the SJRIP Augmentation Program. Apparent survival refers to a fish not only surviving but *remaining* in the areas currently being sampled in the San Juan River. Our sampling reaches are from Bloomfield, NM (RM 196) downstream to Clay Hills, UT (RM 3); and in the Animas from Aztec Park (A-RM 16) downstream to Boyd Park (A-RM 1) [limited sampling]. All Razorback Sucker that emigrates out of the sampling area (e.g. swims downstream of RM 3, upstream of RM 196, or resides in/moves into the Animas River) are lost to the system and classified as "dead" for the purpose of the model, because they cannot be detected. We have applied the term 'apparent survival', as opposed to simply 'survival', because the term makes no inference as to the ultimate fate of the fish.

When apparent survival was modeled, the models with the most support included different survival rates in two post-stocking periods. These periods were the first over-winter period post stocking and all subsequent years. The first over-winter period apparent survival rate has been calculated by the SJRIP Program Office using Program MARK (White and Burnham 1999) to be 0.41 (41%), and apparent survival for all subsequent years (i.e., post first over-winter period) to be 0.83 (83%).

Using the two apparent survival rates for future survival rates, coupled with the most current population estimates from the Demographic Monitoring effort, we can predict the population changes under various augmentation levels (Figure 1). Given the 2019 adult Razorback Sucker abundance estimate of 2,796 adult fish between Sand Island, Utah (RMs 76.4) and Shiprock Bridge (RM 147.8) (Schleicher et al., 2020) we can extrapolate a population estimate for the geomorphic reaches with the highest adult abundance from the PNM weir (RM 166.6) downstream to Sand Island. The density of Razorback Sucker calculated from the demographic monitoring is 39.15 fish/RM. Assuming density is similar from PNM downstream to Shiprock Bridge, multiplying that extra 18.8 RM's by that density adds another 736 Razorback Suckers to our starting population, for a total of 3,532 fish. This starting population estimate does not account for the fish above PNM weir, below Sand Island, or below the waterfall (i.e., Lake Powell dwelling fish).

The 2019, adult Razorback Sucker population estimate is still nearly 2,000 fish below the required minimum viable population size of 5,800 fish in the San Juan River Basin. In order to meet the required delisting criteria of the minimum viable population size it will remain necessary to continue augmentation in order to reach the prescribed goal of 5,800 adult Razorback Sucker. Despite the encouraging collections of age-0 Razorback Sucker in fall of 2018,

and in 2019 when the same cohort was found in the river as age-1 fish, there are still substantial obstacles to reaching the minimum viable population without augmentation. Recruitment failure remains the norm, and recruitment success is rare. All life stages of Razorback Sucker continue to be lost over the Piute Farms waterfall (Diver and Mussman 2018, Cathcart et al. 2018), habitat for recruitment into post larval life stages may be inadequate, the San Juan River still has barriers to fish passage and spring time, cold water, managed releases from Navajo Reservoir may be too cold to support larvae post spawning (Lamarra 2007, Bestgen 2008). With these obstacles to recovery in mind we recommend stocking a minimum of 4,800 fish annually until the minimum viable population size is reached in the San Juan River basin. However, even when the minimum viable population size is reached the delisting criteria also requires that delisting can happen "when certain site specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained". Thus, completing the task of reaching the MVP is only a single step in recovery. When 5,800 Razorback Sucker are established in the San Juan River, and threats to recovery have been minimized then conversations can begin to plan a reduction in numbers of Razorback Sucker to augment annually.

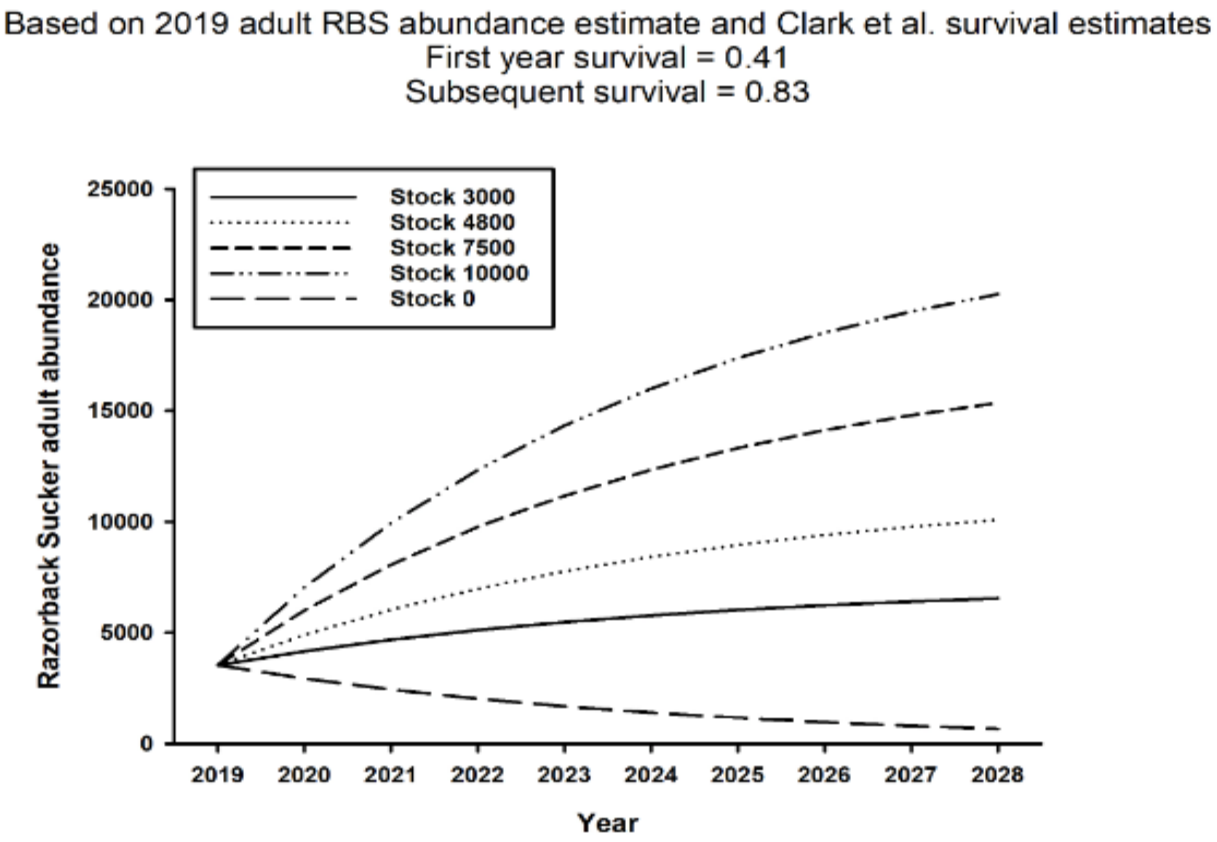

Figure 1- Projected population size with a starting population of 3,532 fish and various annual stocking rates: 0 to 10,000 fish, 2019-2028. First year apparent survival (A.S.) =.41, subsequent year A.S. =.83. Stocking rates >4,800 fish/year are expected to more effectively increase an augmented population over ten years

There are potential advantages of continuing to stock >4,800 fish/year and allowing the augmented population to increase beyond the MVP recovery target of 5,800 adult fish. Assuming the 5,800 fish goal has been met, continuing to stock >4,800 fish will create a buffer in the event of years with poor apparent survival post-stocking and/or years with low numbers of fish available due to production failure. This would also help to ensure that the population does not fall below 5,800 adults as set forth in the recovery goals. Another advantage would be the establishment of more reproductive adult fish in the population thus increasing recruitment within the Basin. During 2018 there were a total of 259 wild young-of-year juveniles captured across all sampling efforts (Duran et al., 2020 and Schleicher, 2020) and in spring 2019 sampling another 45 wild age-1 Razorback Sucker were collected (Schleicher, 2020), possibly because the current adult population size and longitudinal distribution may be reaching a level that has the potential for successful recruitment. The Razorback Sucker Recovery Goals (USFWS, 2002) quotes Thomas (1990) in reference to demographic population viability versus MVP, “There is

no single 'magic' population size that guarantees the persistence of animal populations." Therefore, it is a goal of this augmentation plan to continue increasing the Razorback Sucker population through augmentation until the basin-wide population becomes self-sustaining, regardless of the overall demographic population size it requires to reach self-sufficiency. If population estimates indicate that river-wide population size and density are reaching a maximum carrying capacity threshold, then stocking numbers will be re-evaluated and adjusted accordingly. Once the population has become self-sustaining augmentation will no longer be necessary.

The expectation for number of fish available from all three NAPI ponds is between 4,500-7,000 fish annually (1,500-2,333 fish/pond/year; 43-67% return rate/pond/year), Horsethief Canyon NFF is currently committed to provide 2,000-4,000 fish annually. Therefore, it is reasonable to expect a minimum of 6,500 fish (the sum of the lowest estimates from the NAPI ponds and Horsethief Canyon NFF) will be available to the SJRIP each year. With the potential to have upwards to 11,000 fish/year available, the "Stock 7,500" projection line may be the closest curve to what is expected over the next few years of augmentation.

It must be noted that none of the augmentation scenarios account for natural recruitment, revisions of the apparent survival rates, or alterations in biotic and abiotic conditions. Once the Razorback Sucker population is found to have achieved the MVP recovery goal of 5,800 adults the SJRIP will need to be committed to stocking approximately 2,450 fish annually in order to compensate for yearly mortality and maintain that MVP adult population if no wild recruitment is documented. In the absence of natural recruitment, and if augmentation for Razorback Sucker were to cease altogether, then all previous augmentation efforts would result in the San Juan River Basin Razorback Sucker population eventually declining to zero at a predicted rate of 17% loss of fish per year (Figure 1).

Data Collection and Augmentation Evaluation:

Evaluating any management action is critical in determining its efficacy. The SJRIP Program Office updates annually a PIT tag database for the San Juan River Basin. The Species Tagging, Research and Monitoring System (STReaMS) has been created and housed at Colorado State University with funding from the Bureau of Reclamation. This web-based system incorporates the SJRIP database with PIT tag data across the Upper Colorado River Basin also, allowing for researchers to access PIT tag data across studies and river basins.

We will continue to rely on existing data collection to help evaluate stockings, longitudinal movements, and retention in upstream areas. Ongoing monitoring during electro-fishing

efforts, in combination with annual large-bodied and small-bodied fish sampling conducted by the SJRIP, currently provide fish community data for the San Juan River from Bloomfield, NM (RM 196) downstream to Clay Hills, UT (RM 3). The lower 16 river miles of the Animas River is sampled during occasional raft mounted electro-fishing trips as part of the large-bodied fish monitoring. This monitoring will provide data on fish movement into the Animas River. We will also continue to use remote PIT tag antenna data to monitor movement of stocked PIT tagged, and wild captured and tagged, Razorback Sucker throughout the San Juan basin.

Conclusion

The immediate goal of this augmentation plan is to provide policy, background, and guidance for augmentation of Razorback Sucker in the San Juan River. The ultimate goal of reestablishing a long term (100 to 200 year) self- sustaining population of Razorback Sucker within the historic range of the San Juan River and tributaries may be reached through implementing this plan. All Razorback Sucker will be augmented into its native within the San Juan River. Based on the information provided in this plan the SJRIP will need to continue to augment the population of Razorback Sucker within the basin with all hatchery produced fish available in any given year; without continued augmentation the wild population of Razorback Sucker in the San Juan River is predicted to decline. Other recovery actions, such as habitat improvement, genetic monitoring, and investigation into the lack of successful recruitment will need to continue alongside augmentation to reach recovery goals.

Since new information and data are constantly being collected this augmentation plan will use an adaptive management approach to help create better outcomes for stocked fish by continuing to improve the quality of fish stocked, the locations and habitats stocked, and the methods for transport and releases. This plan will become effective upon final version and guide augmentation efforts until new information requires a re-evaluation of the augmentation process.

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Appendix 1. Yearly summary of Razorback Sucker stocked into the San Juan River, 1994-2019.

Year	Total number of Razorback Sucker stocked (Sizes of fish stocked)
Experimental Stocking Study: 1994-1996 (n= **942** fish stocked)	
1994	**688** (Mean TL =251 mm; Range = 100-446 mm TL)
1995	**16** (Mean TL = 424 mm; Range = 397-482 mm TL)
1996	**238** (Mean TL = 336 mm; Range = 204-434 mm TL)
Five-Year Augmentation Effort: 1997-2001 (n= **5,890** fish stocked)	
1997	**2,883** (Mean TL = 192 mm; Range = 104-412 mm TL)
1998	**1,275** (Mean TL = 250 mm; Range = 185-470 mm TL)
1999	**0** N/A
2000	**1,044** (Mean TL = 214 mm; Range = 111-523 mm TL)
2001	**688** (Mean TL = 410 mm; Range = 288-560 mm TL)
Interim Stocking Years: 2002-2008 (n= **41,093** fish stocked)	
2002	**140** (Mean TL = 319 mm; Range = 110-470 mm TL)
2003	**887** (Mean TL = 327 mm; Range = 100-495 mm TL)
2004	**2,979** (Mean TL = 353 mm; Range = 225-559 mm TL)
2005	**1,993** (Mean TL = 355 mm; Range = 223-534 mm TL)
2006	
2007	**16,906**** (Mean TL = 268 mm; Range = 110-573 mm TL)
2008	**4,424** (Mean TL = 307 mm; Range = 225-390 mm TL)
*18,793 total Razorback Sucker stocked but 5,029 fish either had no PIT tag or an error in recording PIT tag number. **22,836 total Razorback Sucker stocked but 5,930 fish either had no PIT tag or an error in recording PIT tag number. These untagged fish are not counted in the total fish stocked (n=) from 2002-2008.	

Appendix 1. – continued

Year	Total number of Razorback Sucker stocked (Sizes of fish stocked)
Eight-year Augmentation Effort: 2009-2016 (n= 103,413 fish recorded as stocked in the SJRIP database, to date)	
2009	**8,316*** (Mean TL = 412 mm; Range = 136-560 mm TL)
2010	**28,419** (Mean TL = 417 mm; Range = 222-575 mm TL)
2011	**18,782** (Mean TL = 363 mm; Range = 208-540 mm TL)
2012	**13,516**** (Mean TL = 378 mm; Range = 102-581 mm TL)
2013	**15,341** (Mean TL = 377 mm; Range = 222-582 mm TL)
2014	**6,165** (Mean TL = 377 mm; Range = 215-530 mm TL)
2015	**5,208** (Mean TL = 352 mm; Range = 195-487 mm TL)
2016	**7,666** (Mean TL = 361 mm; Range = 210-480 mm TL)
Razorback Sucker Augmentation Effort: 2017-2023 (n= 20,441 fish submitted as stocked in the SJRIP database, to date)	
2017	**10,326** (Mean TL = 354 mm; Range = 297-487 mm TL)
2018	**10,111** (Mean TL = 343 mm; Range = 300-473 mm TL)
2019	**6,716** (Mean TL = 341 mm; Range = 300-498 mm TL)
TOTAL: 1994-2019	**178,495**

* 4,021 Razorback Suckers stocked in Feb. 2010 are part of the 2009 stocking effort but are tallied in the 2010 stocking totals.
** 2,295 Razorback Suckers stocked on Nov. 14, 2012 not included in totals due to high observed mortality.
NOTE: All reported numbers for Razorback Sucker stocked 2000-2016 have been reconciled with the SJRIP database to discount fish with PIT tag record errors. Previous reports included all fish stocked regardless of PIT tag status.