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2015 INTEGRATED PIT TAG DATABASE SUMMARY OF COLORADO PIKEMINNOW AND RAZORBACK SUCKER IN THE SAN JUAN RIVER

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To Bureau of Reclamation

From

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ABSTRACT

I integrated and summarized the PIT tag data for endangered Colorado Pikeminnows and Razorback Suckers from all of the San Juan River Basin Recovery Implementation Program's management and monitoring efforts. Most Colorado Pikeminnows encountered in 2015 were stocked without PIT tags and as in past years, relatively few were encountered in the San Juan River three years post-stocking. Total numbers of Colorado Pikeminnow individuals detected in 2015 have remained similarly low in recent years compared to high numbers detected from 2009-2011, but the number of adults detected has increased over time. The total number of Razorback Sucker individuals detected has generally increased since 2008. Although the return rate of stocked Razorback Suckers has varied through time, numerous individuals were detected three or more years post-stocking in 2015. The proportion of Razorback Suckers captured during 2013-2015 without PIT tags was half that observed during 2010-2012, perhaps due to changes in PIT tagging protocol for fish stocked from the Navajo Agricultural Production Industry (NAPI) ponds. However, captures of 99 untagged Razorback Suckers in the San Juan River does not suggest widespread, wild recruitment because of their large size. Patterns observed in PIT tag data were typically consistent with patterns observed by the standardized large-bodied monitoring efforts. The San Juan Recovery Implementation Program should continue to integrate PIT tag data across all projects in order to inform the adaptive management process and evaluate the status of species' progress toward recovery.

INTRODUCTION

The San Juan River Basin Recovery Implementation Program (Program) conducts efforts in the San Juan River Basin to recover the endangered Colorado Pikeminnow (*Ptychocheilus lucius*) and Razorback Sucker (*Xyrauchen texanus*). These efforts include management actions such as stocking hatchery-reared endangered fishes, non-native fish removal, increased range expansion through removal of fish passage barriers, restoration of channel complexity, and managed releases of peak and base flows from Navajo Dam. Annual monitoring provides information on the fish community response to management actions. Endangered fishes are handled during management (non-native fish removal and PNM Fish Passage) and monitoring activities (larval,

small-bodied, and large-bodied fish monitoring). Information on individual fish is gathered through the reading of uniquely identified passive integrated transponder (PIT) tags implanted in these individuals. In addition to the PIT tag number, river mile (RM) location, length, weight, breeding condition, and other observations are recorded for each endangered fish captured. Colorado Pikeminnows are currently stocked into the San Juan River at a size too small (~50 mm TL) to be implanted with a PIT tag (Furr 2015), but these fish are implanted with a PIT tag when they are recaptured ≥ 150 mm TL in the river. Age 1+ Colorado Pikeminnows implanted with a PIT tag were previously stocked into the San Juan River (Furr 2015) but this augmentation effort ceased in 2011 (Durst 2009). In 2010 no age 0 Colorado Pikeminnow were stocked due to a quarantine at Southwestern Native Aquatic Resources and Recovery Center (SNARRC; formerly Dexter National Fish Hatchery and Technology Center). These fish were held overwinter at SNARCC and stocked without PIT tags at age 1 in May 2011. SNARCC also fulfilled its 2011 age 0 Colorado Pikeminnow stocking obligations in November 2011. In 2014 as part of an evaluation of the Hogback Fish Weir, 429 Colorado Pikeminnow implanted with PIT tags were stocked into that facility (M. McKinstry Biology Committee presentation 3 December 2014). Razorback Suckers have typically been stocked into the San Juan River with a PIT tag (Furr 2015), but in 2006 and 2007 about 10,000 untagged fish were stocked as part of an effort to start a single cohort strategy at the Navajo Agricultural Production Industry (NAPI) Ponds (Ryden 2008). Captures of untagged Razorback Sucker, presumably from these stockings, have confounded efforts to document wild recruitment in the San Juan River. Recaptures of PIT tagged individuals across the Program's monitoring and management efforts form the basis of a database that I used to create encounter histories of each individual to produce the summaries and analyses presented herein.

The information that can be produced from this database includes summaries detailing the recapture rate of stocked individuals to inform the Program's adaptive management process, mark-recapture analyses to estimate annual survival of stocked individuals (Bestgen et al. 2009), and population estimates that can be used to evaluate the Program's progress toward recovery for both species (Duran et al. 2011, Hines 2015). I used the integrated PIT tag databases to examine patterns across all management and monitoring projects that collect PIT tag information to present a broader view of the status of each species. The objectives of this report are to: (1)

describe and summarize the recaptures of stocked Colorado Pikeminnows and Razorback Suckers, (2) investigate patterns in captures of Razorback Suckers without PIT tags, and (3) compare temporal patterns observed for PIT tagged endangered fishes across all sampling efforts to catch-rates observed in standardized monitoring efforts.

METHODS

Field methods

All management and monitoring efforts in the San Juan River that collect PIT tag data contributed to this report except for antenna data. Data collected from various antenna systems in the San Juan River remain in various states of submission but are in the process of being integrated with the Species Tagging, Research, and Monitoring System (STReaMS), an online database for the San Juan Program and Upper Colorado River Endangered Fish Recovery Program. Data reported herein were provided by SNARRC; Uvalde National Fish Hatchery (Uvalde); Horsethief Canyon Native Fish Facility (Horsethief); NAPI Ponds; larval, small-bodied, and large-bodied monitoring; Lake Powell Razorback Sucker survey; upper, middle, and lower San Juan non-native fish removal; the fish passage at PNM Weir; and other studies funded outside the Program. These activities primarily covered the San Juan River from upstream of the Animas River confluence (RM 180.2) to Clay Hills Crossing (RM 2.9), but also included data from the lower Animas River, the San Juan River arm of Lake Powell, and some tributaries of the San Juan River (Figure 1).

Colorado Pikeminnows stocked at age 0 were too small to be implanted with a PIT tag. All Colorado Pikeminnows recaptured in the San Juan River without a PIT tag are thought to be the result of the Program's age 0 stocking efforts. Too few larval Colorado Pikeminnows are typically detected to assume there is recruitment of wild individuals to juvenile and adult life-stages (Farrington et al. 2015). Colorado Pikeminnow and Razorback Sucker $\geq$ 150 mm TL captured in the San Juan River without a PIT tag are typically implanted with a PIT tag (and entered in to the FIRST_ENC table as TAG records in the PIT tag database, i.e., the initial encounter of a newly tagged individual). I did not include Colorado Pikeminnow < 150 mm TL

that were captured and reported on during management and monitoring efforts in this study because they were too small to PIT tag.

Database methods

I received most source files in Excel formats. I confirmed all fields were in the same format as the integrated PIT tag databases, removed duplicate data, and ensured imported data did not violate the integrated databases' validation rules. Records in source files with duplicate or inappropriate PIT tag numbers I could not reconcile were not imported. I imported the proofed PIT tag data for Colorado Pikeminnow and Razorback Sucker into two separate MS Access files for each species (Microsoft Office 2010; Appendix 1). Each database contains a table recording each individual's unique first encounter in the San Juan River (FIRST_ENC). The FIRST_ENC table contains records of individuals stocked with a PIT tag, noted as "STOCK" in the CONTACT_TYPE field and individuals encountered in the San Juan River and implanted with a PIT tag, noted as "TAG" in the CONTACT_TYPE field. All records of individuals' subsequent recaptures are in a corresponding CAPTURE table. The PIT tag numbers between the two tables are linked via a one-to-many relationship that is referentially enforced, meaning that no record can appear in the CAPTURE table without a corresponding PIT tag number in the FIRST_ENC table (i.e., PIT tag numbers must be unique in the FIRST_ENC table but not in the CAPTURE table). I created a series of queries within and between the FIRST_ENC and CAPTURE tables to produce the raw data and summary tables used for subsequent analyses.

Data analysis

I summarized the total number of individuals captured by year from particular stocking classes for Colorado Pikeminnow stocked with and without PIT tags and for Razorback Sucker stocked with PIT tags. Total numbers of individuals captured by year were not adjusted for annual sampling effort or numbers stocked in previous years. I compared numbers of Colorado Pikeminnow and Razorback Sucker individuals captured with unscaled catch per unit effort (CPUE; fish/hour) from RM 180-77 using large-bodied monitoring standardized data (Schleicher 2016). I restricted unscaled CPUE data to RM 180-77 because that reach has been consistently

sampled through time. For Colorado Pikeminnows stocked without and with PIT tags, I reviewed recaptures from stocking classes since 2002 and 2003, respectively, and for Razorback Suckers, I summarized recaptures from stocking classes since 2000. I assigned Colorado Pikeminnow TAG records (when they were initially implanted with a PIT tag) a year class based on their length and the month when they were first encountered in the San Juan River (D. Ryden, personal communication; Table 1). This allowed me to assign individuals to a particular stocking year because untagged Colorado Pikeminnows were stocked at known ages (Table 2). However, Colorado Pikeminnows > 400 mm TL captured without a PIT tag could not be reliably assigned to an age class because of variation in growth rates of older fish, but these cases were relatively rare (only 161 of 10,790 Colorado Pikeminnow TAG records through 2015 could not be assigned to a year class). I also examined the length-frequency of all PIT tagged Colorado Pikeminnows captured in 2015 and compared it to previous years. The capture of untagged Razorback Suckers could be an indicator of wild recruitment but it can be difficult to distinguish among PIT tag loss, fish stocked without PIT tags, and wild recruitment based solely on PIT tag data. I examined the percentage of Razorback Sucker captured without PIT tags from 2004-2015 and the length-frequency histogram of untagged fish in 2015 to investigate potential wild recruitment. All raw data were based on queries of the Colorado Pikeminnow and Razorback Sucker MS Access databases (Microsoft Office 2010). I used MS Excel (Microsoft Office 2010) to summarize data and create tables and all figures were produced in SigmaPlot 12 (Systat Software Inc. 2012).

RESULTS AND DISCUSSION

Following the 2015 data update, the Colorado Pikeminnow and Razorback Sucker PIT tag databases contained 57,301 and 163,395 records, respectively. The FIRST_ENC tables, containing both STOCK and TAG records, had a total of 51,535 Colorado Pikeminnow records and 148,605 Razorback Sucker records. The CAPTURE tables had 5,766 and 14,790 records for Colorado Pikeminnow and Razorback Sucker, respectively. Because I considered recaptures of individual PIT tagged Colorado Pikeminnow and Razorback Sucker in this report, the number of encounters presented here may differ from other Program reports.

Recapture summaries

Across all management and monitoring efforts, a total of 696 individual Colorado Pikeminnow were captured in 2015 (Figure 2). Nearly 98% of these individuals were stocked without PIT tags (typically at age 0). Total numbers of individuals captured in any year seems to be sensitive to sampling conditions and spatial and temporal sampling effort, making it difficult to interpret year-to-year patterns. However, unscaled Colorado Pikeminnow CPUE from standardized large-bodied monitoring covering RM 180-77 showed similar trends to the individual capture data; increasing through 2011 and declining since then (Figure 2).

Based on the length-frequency distribution of the 696 PIT tagged individual Colorado Pikeminnow captured in 2015, the majority (75%) were recently stocked juveniles < 300 mm TL (Figure 3). The pattern of juveniles representing most of the population is consistent with past years (Figure 4). However, both the total number of adults (≥ 450 mm TL) captured and the proportion of adults captured has increased since 2008.

There were 680 individual Colorado Pikeminnow captured in 2015 that were stocked without PIT tags (Table 2). Most of these fish (79%) were assigned to the 2013 and 2014 year classes, i.e., ages 1 2. The total number of individuals captured in 2015 also included 26 Colorado Pikeminnow TAG records that could not reliably be assigned to a year class, but these fish were initially encountered at > 400 mm TL and thus represented individuals age 3+. The number of recaptured Colorado Pikeminnow that were stocked without PIT tags increased from 665 to 2,271 from 2008 to 2010 and generally decreased each year after 2010 with only 680 individuals detected in 2015. In 2015, approximately 21% of recaptured Colorado Pikeminnow stocked without PIT tags were age 3+.

Only 16 Colorado Pikeminnows stocked with PIT tags were recaptured in 2015 (Table 3). The low number of recaptures of Colorado Pikeminnow stocked with PIT tags is due to the cessation of age 1+ stocking in 2011. From 2009-2011, > 83% of Colorado Pikeminnows stocked with PIT tags were only recaptured in the same year that they were stocked. Although several hundred Colorado Pikeminnows stocked at age 1+ were recaptured each year, the Program ceased

production and stocking of age 1+ fish in 2011 based on the relatively higher cost and post-stocking persistence compared with fish stocked as age 0 (Durst 2009). Although not part of the Program's augmentation effort, PIT tagged Colorado Pikeminnow were stocked in 2014 as part of an evaluation of the Hogback Fish Weir (M. McKinstry Biology Committee presentation 3 December 2014) and six were subsequently recaptured in 2015.

A total of 1,768 Razorback Suckers were captured in 2015 across all management and monitoring efforts (Figure 5). Over 88% of all Razorback Suckers captured in 2015 were assigned to a stocking record (i.e., they received and retained the PIT tag implanted prior to stocking; Table 4). Total numbers of Razorback Sucker individuals captured have generally increased since 2000. This pattern is consistent with unscaled Razorback Sucker CPUE data from large-bodied monitoring.

Of Razorback Suckers stocked with PIT tags, 59% of recaptures in 2015 were from the 2012-2014 stocking classes and 37% of recaptures were from stocking events prior to 2012 (Table 5). The pattern of Razorback Suckers regularly being captured from multiple stocking classes has been consistent for many years. Documented spawning over 18 consecutive years in the San Juan River (M. Farrington Biology Committee presentation at 23 February 2016) indicates the long-term presence of reproducing adult Razorback Suckers. This diverse age-structure of reproducing adults is an important step to establish a self-sustaining population of Razorback Suckers within the San Juan River Basin.

Capture of Razorback Suckers without PIT tags

Untagged Razorback Suckers detected prior to 2006 were probably the result of tag loss because of limited evidence of natural recruitment (Golden et al. 2006, Farrington et al. 2015) and the few fish that had been stocked without PIT tags before 2006 (Furr 2015). The high proportion (> 30%) of Razorback Suckers captured 2006-2008 without PIT tags was likely the result of stocking approximately 10,000 untagged fish from NAPI ponds in 2006 and 2007 as part of the effort to start a single cohort harvest strategy at NAPI (Ryden 2008). The proportion of untagged Razorback Suckers captured declined and remained relatively constant from 2010-2012 as

presumably fewer untagged Razorback Suckers were available for capture from NAPI stocking events in 2006 and 2007 and PIT tag loss remained constant (Table 4). The percentage of Razorback Suckers captured without PIT tags from 2010-2012 declined by half in 2013 and remained relatively stable through 2015, possibly due to a change in PIT tagging protocol for fish stocked from NAPI. Prior to 2013 SNARCC delivered Razorback Suckers to NAPI for grow-out in spring each year and these fish were PIT tagged during passive and active harvest just prior to being stocked into the San Juan River. In 2013 Razorback Suckers were PIT tagged at SNARCC prior to being delivered to NAPI for grow-out. PIT tagging under controlled hatchery conditions may have resulted in improved PIT tag retention.

Because about 90% of the 99 Razorback Suckers captured in 2015 without PIT tags were > 400 mm TL (Figure 6), it is unlikely that many of these fish recruited from wild-hatched fish. However, efforts are currently underway to empirically determine the natal origin of untagged Razorback Suckers that have been captured in the San Juan River Basin and have confirmed the capture of a 224 mm TL Razorback Sucker as a wild recruit (S. Clark-Barkalow Biology Committee presentation 24 February 2016). While other Razorback Sucker were captured without PIT tags < 300 mm TL, over 550 Razorback Sucker were stocked from NAPI < 300 mm TL suggesting PIT tag loss as a likely explanation for the detection of the majority of these smaller fish.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Since 2010, the total number of individual Colorado Pikeminnow captured has declined, consistent with declines in unscaled CPUE from the Program's standardized large-bodied monitoring data. Yet, the total number of adult Colorado Pikeminnow captured and the proportion of adults captured has encouragingly increased over the same period. Because the numbers of individual captures are heavily influenced by variation in spatial and temporal sampling effort and sampling conditions, and CPUE metrics do not account for detection probability, determining population trends based on these data is difficult. However, the consistent downward direction of overall captures and CPUE for Colorado Pikeminnow is alarming. While the reasons for these observed declines are unknown, possible explanations

include the cessation of age 1+ stocking or increased stocking of age 0 Colorado Pikeminnow in upstream reaches that are not regularly sampled and have possible additional entrainment risks. The recent increasing trend in captures of adult Colorado Pikeminnow is likely the result of more individuals recruiting from previous stocking events. Improving the recruitment of stocked age 0 Colorado Pikeminnow into adult size classes will be an important step to increase wild reproduction in the San Juan River.

Captures of individual Razorback Suckers and unscaled CPUE data revealed consistent increasing trends through time. The Razorback Sucker augmentation program has resulted in multiple adult age-classes in the San Juan River that have spawned for 18 consecutive years (M. Farrington Biology Committee presentation 23 February 2016). Although the Razorback Sucker adult population is apparently robust and regularly reproducing in the San Juan River, documentation of widespread wild recruitment remains elusive despite the detection of some wild-spawned juveniles (Farrington et al. 2015, Hines 2015, S. Clark-Barkalow Biology Committee presentation 24 February 2016). Efforts to document recruitment have included expanded Razorback Sucker sampling at the San Juan River Lake Powell confluence and continued natal origin analysis of untagged fish.

Although previous PIT tag summary reports included Colorado Pikeminnow and Razorback Sucker abundance estimates in the San Juan River (Durst 2015), I abandoned those estimates in this report because data were not collected with the assumptions of a closed-capture population estimate in mind (White et al. 1982). A dedicated capture-recapture field effort to estimate population size could be conducted but limited within and between-year recaptures, especially for Colorado Pikeminnow, may result in imprecise estimates from closed or robust models. Increased sampling effort and passive PIT tag readers may result in higher numbers of recaptures (or detections in the case of passive detection techniques). The Program has installed remote PIT tag readers in various locations within the San Juan River (PNM Weir, PNM Fish Passage, Hogback Fish Weir, Phase 2 restored secondary channel, and the mouth of McElmo Creek), in addition to using passive detection methods such as raft-mounted antenna and temporarily installed remote readers. These passive detection techniques should result in higher detection probabilities and more robust demographic parameter estimates for PIT-tagged individuals

(Hewitt et al. 2010). However, data from PIT tag antennas is in various stages of submission and are not included in this report because they are not complete. Given the underlying population bottlenecks (i.e., the lack of sufficient wild reproduction and recruitment for Colorado Pikeminnow and Razorback Sucker), the cost of a dedicated field effort to estimate abundance may not provide sufficient recovery benefit to be prudent at this time.

Efforts are ongoing to evaluate the Program's Razorback Sucker augmentation efforts. Program MARK will be used to assess variation in Razorback Sucker survival and detection probability in order to guide augmentation efforts and improve the survival of hatchery-reared fish. An experimental design to reduce confounding interactions between stocking locations and sources, and to evaluate the effect of hard versus soft release stocking protocols was implemented in 2014. Additionally, improving post-stocking survival of Razorback Sucker via flow conditioning will be explored at SNARRC prior to stocking in 2016. Analysis of the protocols implemented in 2014 are planned to occur following three years of recapture data (after the 2017 field season). An evaluation of the Colorado Pikeminnow augmentation program is complicated by the fact that age 0 fish are stocked without PIT tags. However, identifying some means to test the efficacy of Colorado Pikeminnow stocking efforts should be a high Program priority because augmentation is one of the few management efforts that directly increase the number of endangered fish in the San Juan River.

The change in PIT tagging protocol for NAPI Razorback Suckers appeared to result in a lower percentage of untagged fish in the San Juan River. Starting in 2013 Razorback Suckers were PIT tagged at SNARCC prior to delivery to NAPI. In addition to determining short-term (4-6 months) PIT tag loss while these fish grew-out in the NAPI ponds (1.2-4.0%; Cheek 2014), it appears the reduced percentage of untagged Razorback Suckers captured in the San Juan River could be attributed to this revised protocol. Perhaps anesthetizing fish and tagging them under controlled hatchery conditions resulted in improved long-term (post six months) PIT tag retention for Razorback Suckers. Once wild recruitment becomes more widespread, a minimized rate of PIT tag loss will improve the Program's ability to distinguish between untagged fish resulting from wild recruitment and PIT tag loss in stocked fish. Reliable documentation of wild recruitment will be an important step in the recovery of Razorback Sucker in the San Juan River.

Capturing smaller untagged Razorback Sucker than are typically stocked and the continued use of isotopic or elemental analysis to determine natal origin will also be useful to document wild recruitment. However, the degree of wild recruitment that has been documented to date is far below levels necessary to sustain a population of 5,800 adult Razorback Suckers as specified in the recovery goals based on current annual survival estimates (N. Franssen Annual Meeting presentation 13 May 2015).

It is important to periodically summarize and analyze the Program's monitoring data to determine the biological response to management actions and inform adaptive management decisions. However, interpretation of population level trends based on PIT tag data is difficult because individual captures are sensitive to sampling conditions, location, and effort. Additionally, most PIT tag data are collected in a manner inconsistent with closed abundance estimates models that require multiple sampling passes over a finite study area in close temporal proximity (White et al. 1982). But PIT tag data collected across Program projects have been useful for estimating certain demographic parameters like survival and detection probability because all sampling efforts can be collapsed into a single annual event across an individuals' encounter history (Bestgen et al. 2009, Zelasko et al. 2010). Additionally, because the integrated PIT tag database details the capture history of individuals over time, it could be used to track movement, growth, and condition (Durst and Franssen 2014). As the entirety of the San Juan River's PIT tag data is uploaded to STReaMS, it will be available for analyses by interested researchers both within and outside the Program. Data collected via the various remote PIT tag antenna systems within the San Juan River Basin will likely be better utilized, analyzed, and understood once it is integrated with the Program stocking, capture, and recapture data. In the future, STReaMS should allow for more question-driven analyses of these data by a spectrum of researchers to inform the Program's adaptive management process and ultimately, benefit species recovery. Continued maintenance of this integrated PIT tag database will be essential to evaluate the Program's progress toward recovery in reaching Colorado Pikeminnow and Razorback Sucker demographic criteria in the San Juan River Basin for downlisting and delisting, yet specific studies and sampling efforts will be necessary to conduct these analyses. However, despite the lack of clarity on endangered species abundance estimates in the San Juan

River, until wild recruitment occurs at a level that replaces adult mortality, the long-term persistence of endangered fish is doubtful without continued stocking of hatchery-reared fish.

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LITERATURE CITED

Bestgen K.R., K.A. Zelasko, and G.C. White. 2009. Survival of hatchery-reared Razorback Suckers *Xyrauchen texanus* stocked in the San Juan River Basin, New Mexico, Colorado, and Utah. Larval Fish Laboratory Contribution 160. Colorado State University, Fort Collins, CO.

Cheek, C. 2014. Navajo Agricultural Products Industry (NAPI) Razorback Sucker rearing ponds 2013 annual report. Report to San Juan River Basin Recovery Implementation Program. Navajo Nation Department of Fish and Wildlife, Window Rock, AZ.

Duran, B.R., J.E. Davis, and E. Teller Sr. 2011. Endangered fish monitoring and nonnative species monitoring and control in the upper/middle San Juan River 2010. Final report to the San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service, New Mexico Fishery Resources Office. Albuquerque, New Mexico.

Durst, S.L. 2009. Evaluation of age-0 versus age-1+ Colorado Pikeminnow stocking. White paper report to the San Juan River Basin Recovery Implementation Program Biology Committee. San Juan River Basin Recovery Implementation Program, Albuquerque, NM.

Durst, S.L. 2015. 2014 Integrated PIT tag database summary of Colorado Pikeminnow and Razorback Sucker in the San Juan River. Final report to the San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service. Albuquerque, New Mexico.

Durst, S.L., and N.R. Franssen. 2014. Movement and growth of juvenile Colorado Pikeminnows in the San Juan River, Colorado, New Mexico, and Utah. Transactions of the American Fisheries Society 143:519-527.

Farrington, M.A., R.K. Dudley, J.L. Kennedy, S.P. Platania, and G.C. White. 2015. Colorado Pikeminnow and Razorback Sucker larval fish surveys in the San Juan River during 2014. Final report to the San Juan River Basin Recovery Implementation Program. American Southwest Ichthyological Researchers, Albuquerque, New Mexico.

Furr, D.W. 2015. San Juan River Razorback Sucker *Xyrauchen texanus* and Colorado Pikeminnow *Ptychocheilus lucius* population augmentation 2014. U.S. Fish and Wildlife Service, New Mexico Fish and Wildlife Conservation Office, Albuquerque, NM report to San Juan River Basin Recovery Implementation Program, Albuquerque, NM.

Golden, M.E., P.H. Holden, and B. Albrecht. 2006. Retention, growth, and habitat use of Colorado Pikeminnow stocking as age-0 fish in the San Juan River from 2002-2005. Report to the San Juan River Basin Recovery Implementation Program. BIO-WEST, Logan, UT.

Hewitt, D.A., E.C. Janney, B.S. Hayes, and R.S. Shively. 2010. Improving inferences from fisheries capture-recapture studies through remote detection of PIT tags. Fisheries 35(5):217-231.

Hines, B. 2015. Endangered fish monitoring and nonnative fish control in the Lower San Juan River 2014. Report to the San Juan River Basin Recovery Implementation Program. Utah Division of Wildlife Resources, Moab, UT.

Microsoft Office. 2010. Microsoft Access.

Ryden, D.W. 2008. Augmentation of the San Juan River Razorback Sucker population 2007. Report to the San Juan River Basin Recovery Implementation Program. Colorado River Fishery Project, U.S. Fish and Wildlife Service, Grand Junction, CO. Report to the San Juan River Basin Recovery Implementation Program. Colorado River Fishery Project, U.S. Fish and Wildlife Service, Grand Junction, CO.

Schleicher, B.J. 2016. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River 2015. Draft report to San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, CO.

White, G.C., D.R. Anderson, K.P. Burnham, and D.L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory Publications LA-8787-NERP. Los Alamos, NM.

TABLES

Table 1. Age matrix for untagged Colorado Pikeminnow based on length of fish and month of capture. Fish > 400mm TL without a PIT tag could not be reliably aged. The breakdown of age based on length at capture and month of capture was based on personal communication with D. Ryden.

	Month of capture											
Size at capture (TL)	Jan	Feb	Mar	April	May	June	Jul	Aug	Sept	Oct	Nov	Dec
150-190mm	Age 1											
191-240mm	Age 2									Age 1		
241-300mm	Age 2											
301-350mm	Age 3								Age 2			
351-400mm	Age 3											

Table 2. Number of Colorado Pikeminnow stocked at age 0 from 2002-2014 and recaptured from 2003-2015. The number of recaptures is based only on individuals large enough to be implanted with a PIT tag during their TAG record (≥ 150 mm TL). The total number of individuals recaptured may be less than the sum of the number of individuals recaptured by year because some individuals are recaptured in multiple years. The number of individuals from a particular stocking class can be examined looking across rows. The number of individuals captured by year from different stocking classes can be examined looking down columns. Note that the total number of Colorado Pikeminnow captured in any year includes those fish that could not be assigned to a particular year class. The 2010 year class Pikeminnow stocked in May 2011 without PIT tags were age 1 fish that should have been stocked in 2010 as age 0. For the purpose of this report, all Pikeminnow stocked into the San Juan River without PIT tags are considered age 0.

				Individuals captured by year												
Year stocked	Year class	Number stocked	Total captured	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	UNKNOWN		136	3	1	2	15	7	4	12	19	27	22	24	23	26
2002	2002	210,418	211	73	132	11	0	1	0	0	0	0	0	1	0	0
2003	2003	175,928	446	-	190	233	33	2	0	0	0	0	0	0	0	0
2004	2004	280,000	341	-	-	155	183	22	5	4	2	0	2	1	1	1
2005	2005	302,270	547	-	-	-	393	138	37	11	1	4	1	0	3	3
2006	2006	313,854	507	-	-	-	-	270	224	80	7	3	1	0	4	1
2007	2007	475,970	872	-	-	-	-	1	395	476	76	20	7	5	3	5
2008	2008	270,234	2,108	-	-	-	-	-	-	899	1124	353	9	3	2	4
2009	2009	468,000	1,950	-	-	-	-	-	-	-	1042	962	50	6	3	2
2011	2010	214,720	1,041	-	-	-	-	-	-	-	-	555	462	77	7	6
2011	2011	426,588	1,054	-	-	-	-	-	-	-	-	-	674	381	52	13
2012	2012	395,640	666	-	-	-	-	-	-	-	-	-	-	427	213	83
2013	2013	439,264	406	-	-	-	-	-	-	-	-	-	-	-	201	222
2014	2014	393,442	314	-	-	-	-	-	-	-	-	-	-	-	-	314
Total individuals captured				76	323	401	624	441	665	1,482	2,271	1,924	1,228	925	512	680

Table 3. Number of Colorado Pikeminnow stocked as age 1+ and recaptured by year, 2003-2015. The total number of individuals recaptured may be less than the sum of the number of individuals recaptured by year because some individuals are recaptured in multiple years. The number of individuals from a particular stocking class can be examined looking across rows. The number of individuals captured by year from different stocking classes can be examined looking across columns. Note that the relatively small number of age 1+ Colorado Pikeminnow stocked in 2010 was due to the detection of largemouth bass virus at SNARCC resulting in a quarantine of fish held at that hatchery. Those fish held over from 2010 were stocked in 2011. Also, 2011 was the last year that age 1+ Colorado Pikeminnow were stocked into the San Juan River until PIT tagged fish were stocked in 2014 as part of an evaluation of the Hogback Fish Weir.

			Individuals captured by year												
Year stocked	Number stocked	Total captured	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2003	1002	3	3	0	0	0	0	0	0	0	0	0	0	0	0
2004	1217	79	-	66	13	1	0	0	0	0	0	0	0	0	0
2005	4119	89	-	-	84	5	0	0	0	0	0	0	0	0	0
2006	12661	357	-	-	-	294	53	6	6	2	2	1	1	2	2
2007	3250	233	-	-	-	-	141	79	16	1	3	0	0	1	0
2008	4848	628	-	-	-	-	-	203	439	16	2	1	0	1	2
2009	8942	565	-	-	-	-	-	-	470	108	14	4	1	3	4
2010	353	43	-	-	-	-	-	-	-	35	8	0	3	0	1
2011	3724	296	-	-	-	-	-	-	-	-	269	25	1	1	1
2014	429	6	-	-	-	-	-	-	-	-	-	-	-	-	6
Total individuals captured			11	68	99	300	194	288	931	162	298	31	6	8	16

Table 4. Number of individual Razorback Sucker captured with and without PIT tags, 2004-2015. Percent without PIT tags represents the percent of Razorback Sucker captured without PIT tags out of total number of Razorback Sucker individuals captured.

	Individuals captured				Percent
Year	Total	with PIT tags (STOCK)	with PIT tags (TAG)	without PIT tags	without PIT tags
2004	415	381	0	34	8.2
2005	343	305	4	34	9.9
2006	561	340	8	213	38.0
2007	1,105	708	40	357	32.3
2008	605	382	39	184	30.4
2009	698	439	75	184	26.4
2010	1,117	873	80	164	14.7
2011	1,713	1,375	84	254	14.8
2012	2,210	1,797	96	317	14.3
2013	1,879	1,617	126	136	7.2
2014	1,467	1,256	118	93	6.3
2015	1,768	1,558	111	99	5.6

Table 5. Number of Razorback Sucker stocked and recaptured by year, 2000-2015. The total number of individuals recaptured may be less than the sum of the number of individuals recaptured by year because some individuals are recaptured in multiple years. The number of individuals from a particular stocking class can be examined looking across rows. The number of individuals captured by year from different stocking classes can be examined looking down columns. The total number of individuals captured in any year also includes individuals stocked before 2000.

			Individuals captured by year															
Year stocked	Total stocked	Total captured	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2000	1,044	62	0	26	7	9	8	12	7	7	5	7	5	4	2	1	3	4
2001	688	234	-	0	43	73	61	43	32	34	26	19	18	13	13	10	7	7
2002	140	36	-	-	5	13	12	3	6	2	3	2	3	4	1	2	1	0
2003	887	71	-	-	-	54	11	5	1	2	3	1	2	2	0	0	0	0
2004	2,979	595	-	-	-	-	288	173	114	65	48	56	33	55	46	26	22	18
2005	1,993	148	-	-	-	-	-	67	43	25	24	15	16	20	12	13	8	5
2006	13,764	259	-	-	-	-	-	-	133	72	38	38	24	33	28	15	15	13
2007	16,906	811	-	-	-	-	-	-	-	498	188	115	90	74	55	45	32	28
2008	4,424	242	-	-	-	-	-	-	-	-	45	144	46	31	29	16	17	15
2009	8,316	808	-	-	-	-	-	-	-	-	-	42	526	186	132	114	67	65
2010	28,419	1,573	-	-	-	-	-	-	-	-	-	-	108	862	479	373	230	193
2011	18,807	1,309	-	-	-	-	-	-	-	-	-	-	-	89	750	361	263	230
2012	15,822	685	-	-	-	-	-	-	-	-	-	-	-	-	248	368	113	76
2013	15,341	910	-	-	-	-	-	-	-	-	-	-	-	-	-	271	435	302
2014	6,545	584	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	548
2015	5,208	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54
Total individuals recaptured			14	43	68	156	381	305	340	707	381	439	873	1,375	1,797	1,617	1,256	1,558

FIGURES

Figure 1. Map of San Juan River including river mile (RM) and Reach designations. Top panel (A) shows the lower San Juan River and the bottom panel (B) shows the upper San Juan River.

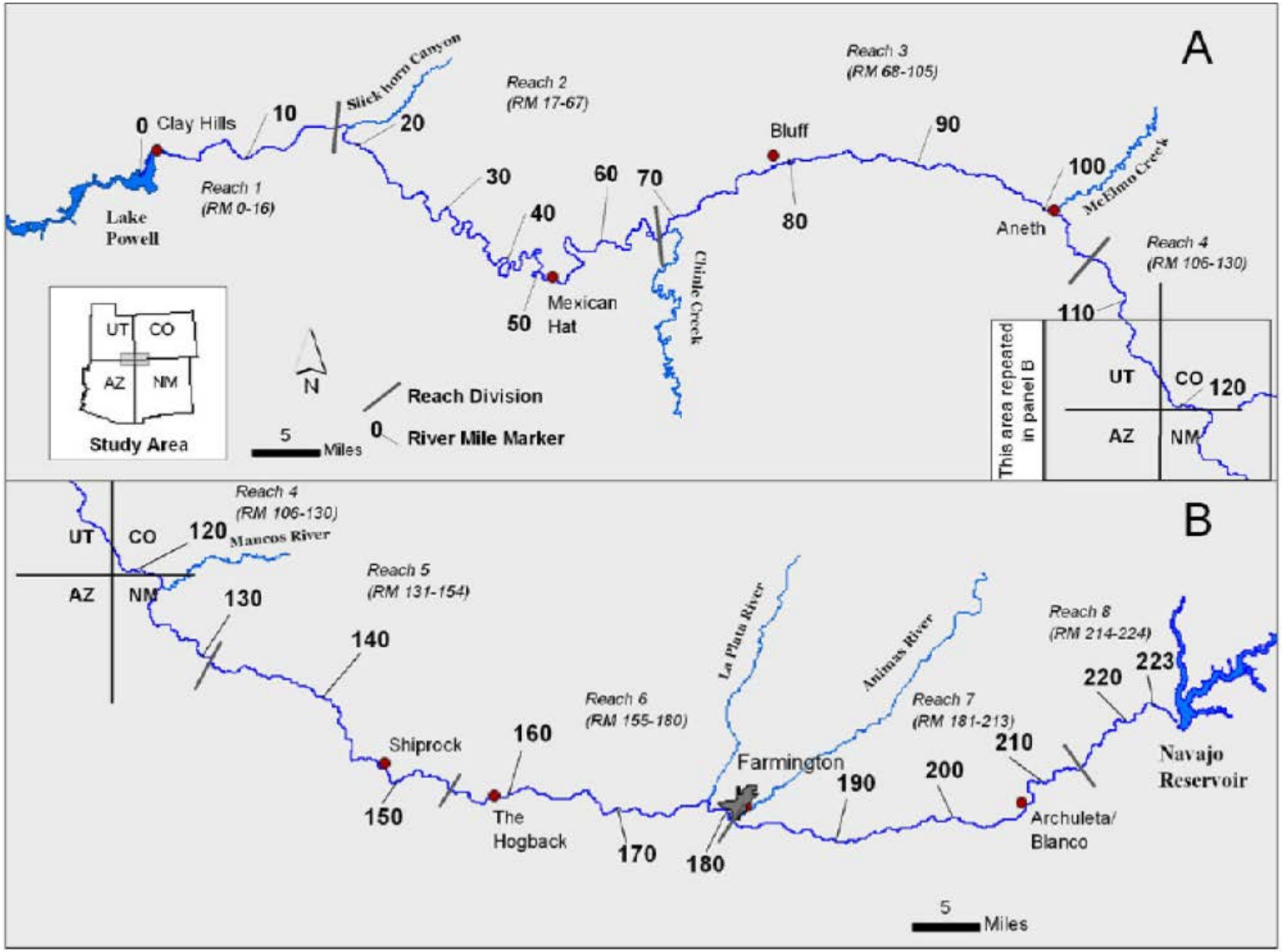


Figure 2. Total number of individual PIT tagged Colorado Pikeminnow captured by year across all Program projects and unscaled Colorado Pikeminnow catch per unit effort (CPUE; fish/hour) based on large-bodied monitoring data. Error bars represent 95% confidence interval.

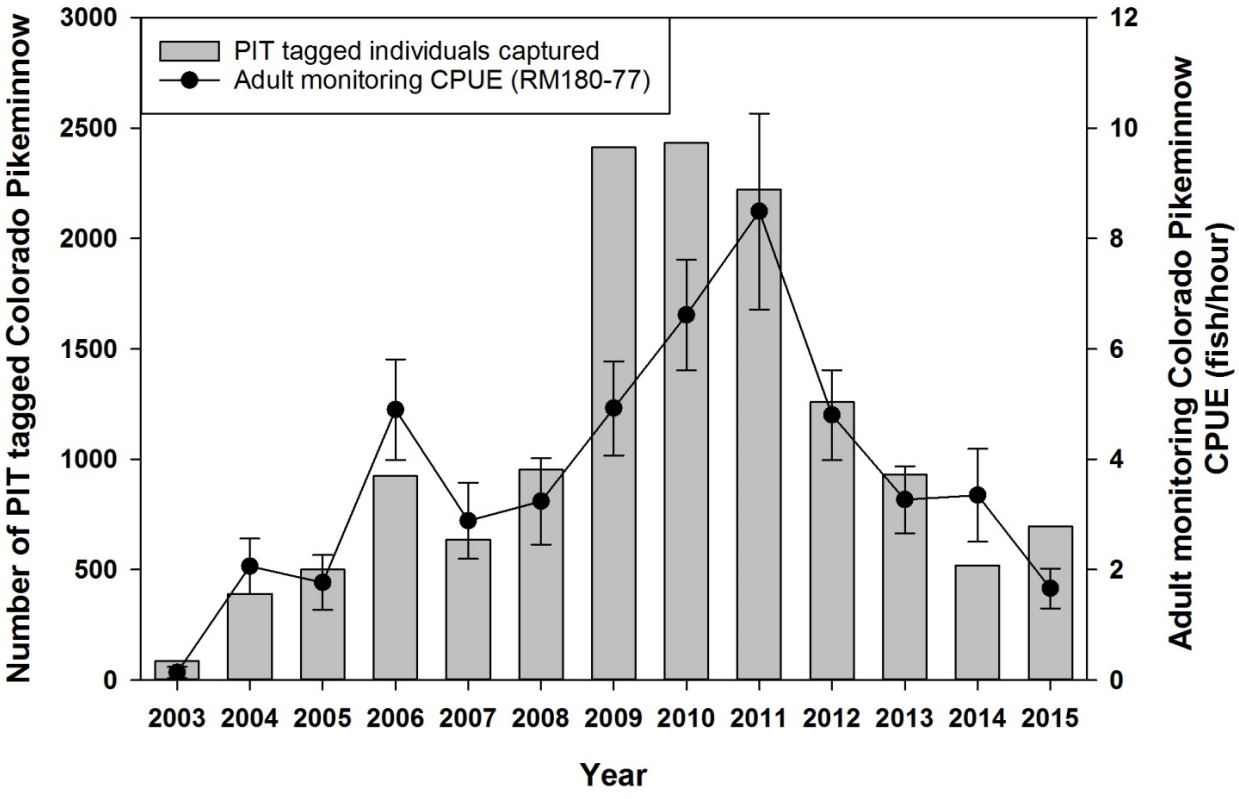


Figure 3. Length-frequency histogram of all PIT tagged Colorado Pikeminnow (across all projects) captured in 2015.

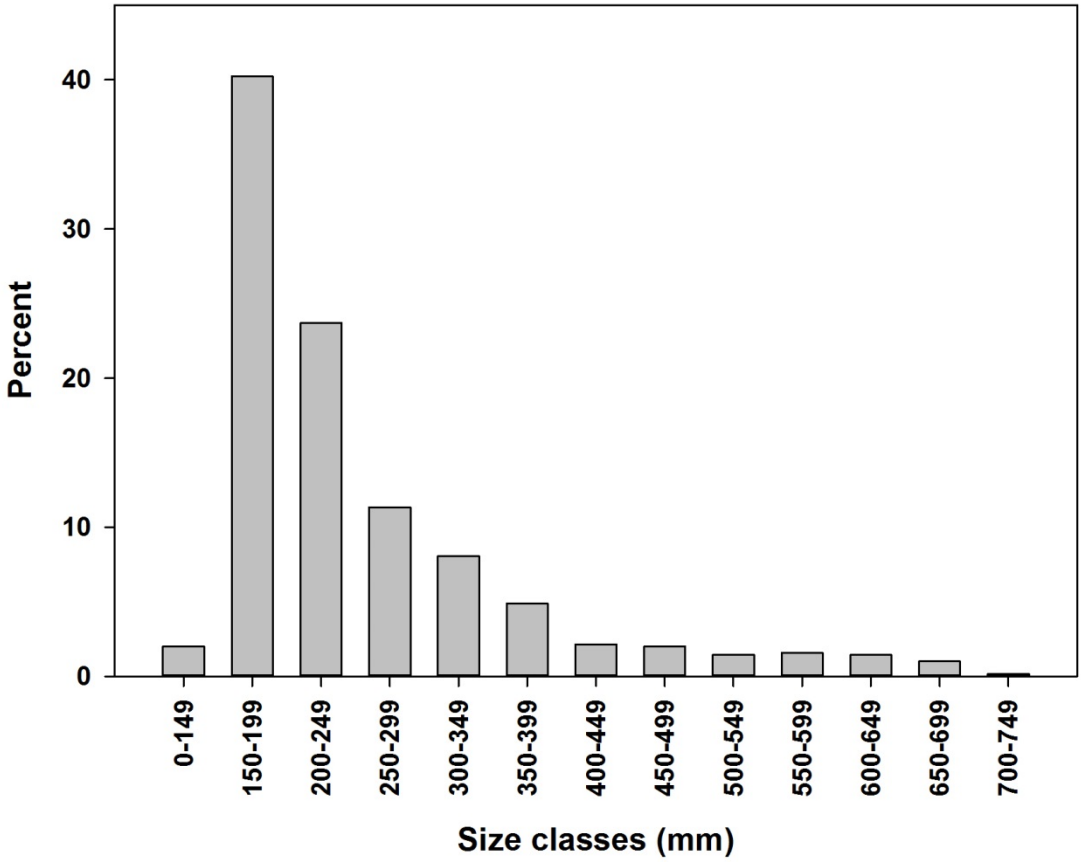


Figure 4. Size distribution of all PIT tagged Colorado Pikeminnow 2003-2015.

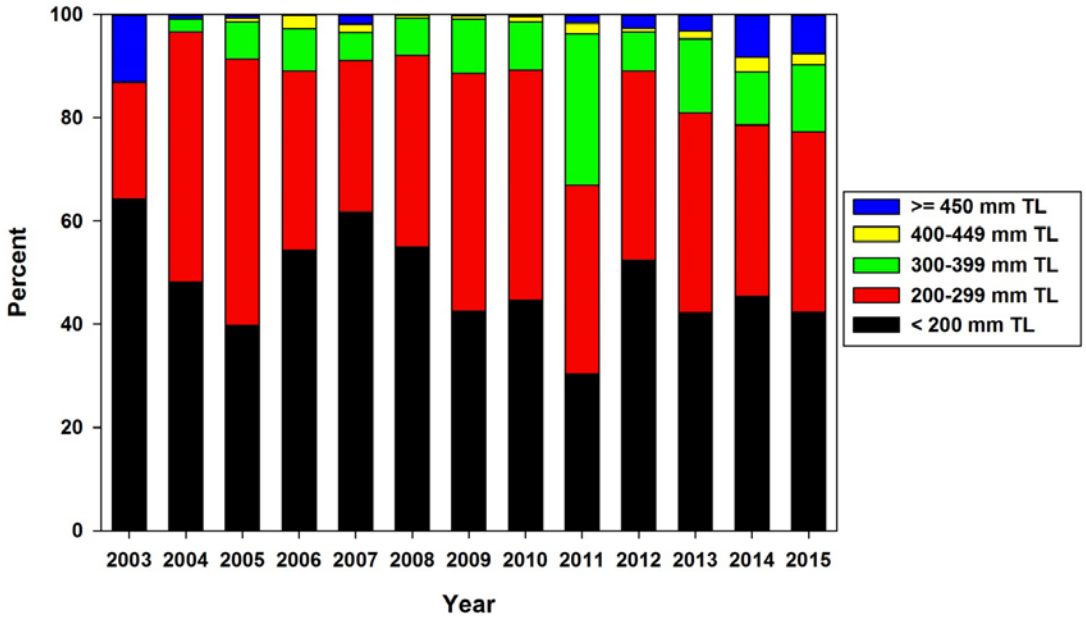


Figure 5. Total number of individual PIT tagged Razorback Sucker captured by year across all Program projects and unscaled Razorback Sucker catch per unit effort (CPUE; fish/hour) based on large-bodied monitoring data. Error bars represent 95% confidence interval.

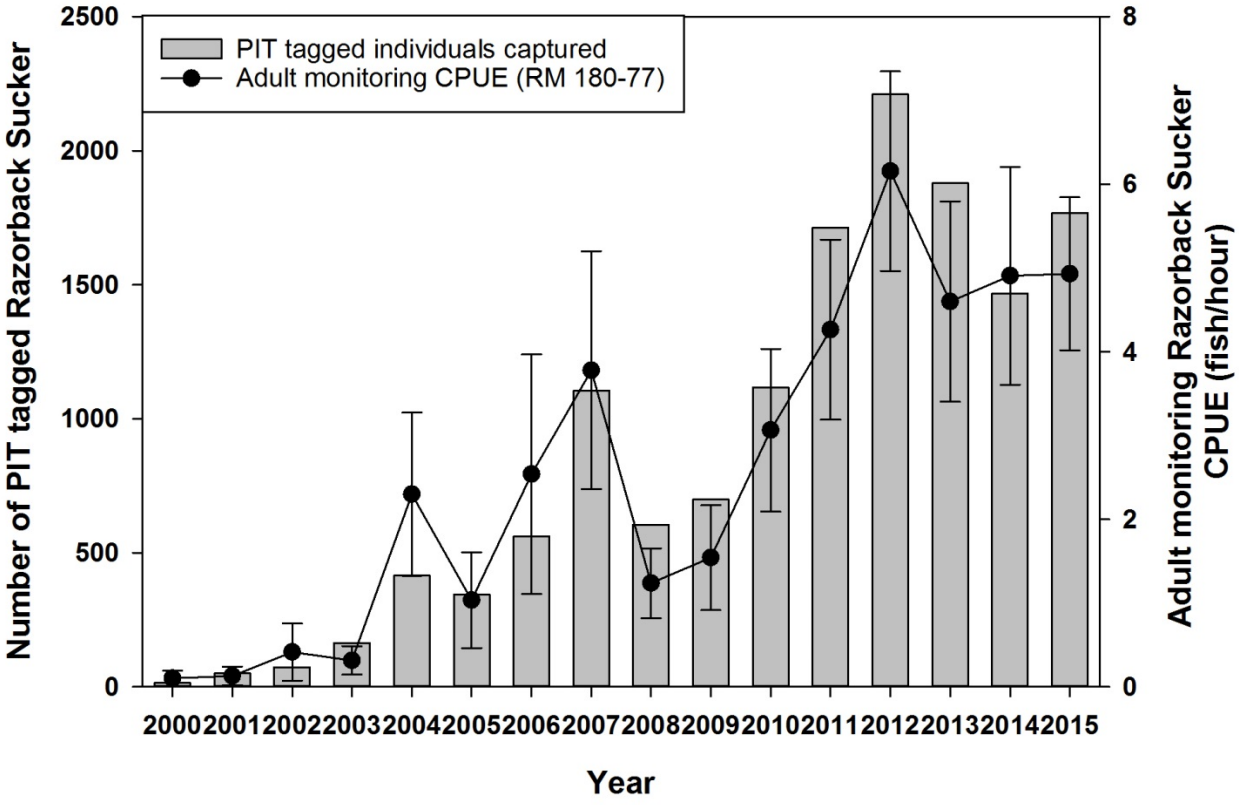
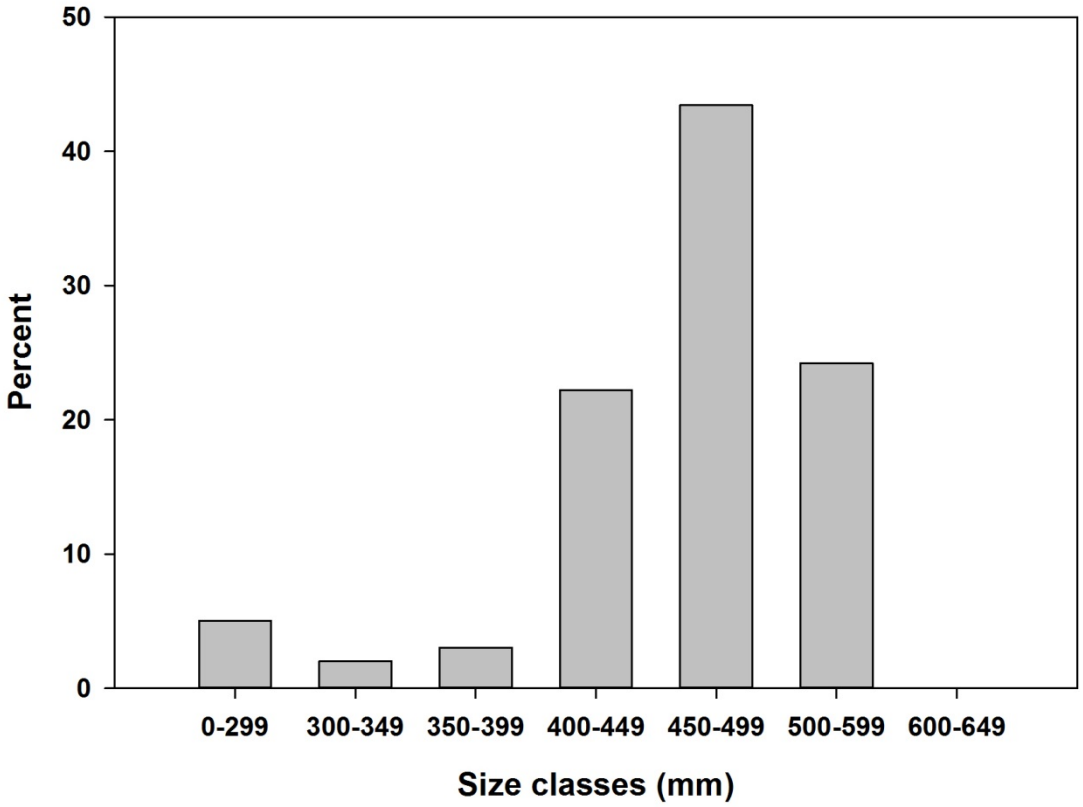


Figure 6. Length-frequency histogram of Razorback Suckers captured without PIT tags in 2015.



Appendix 1. The following table and field definitions are the metadata document that describes the FIRST_ENC and CAPTURE tables in both the Colorado Pikeminnow and Razorback Sucker databases. There is a one-to-many relationship on the MR_TAG field between the FIRST_ENC and CAPTURE tables.

Field name and data types for CAPTURE and FIRST_ENC Tables

Field Name	Data Type	Type	Size
MR_TAG	Text	Text	20
Species	Text	Text	6
Sample	Text	Text	50
Study	Text	Text	50
Date	Date/Time	Date/Time	
RIVER	Text	Text	50
RM	Number	Decimal	
Gear	Text	Text	50
PITIDNO_400khz	Text	Text	10
PITIDNO_134khz	Text	Text	13
Other_Tag	Text	Text	50
TL	Number	Decimal	
WT	Number	Decimal	
Sex	Text	Text	1
Tubercles	Text	Text	1
Ripe	Text	Text	1
YearClass	Number	Integer	
Source	Text	Text	50
ReCap_Number	Number	Integer	
Days_In_River	Number	Integer	
Contact_Type	Text	Text	10
Mortality	Text	Text	2
Harvest	Text	Text	1
Comments	Memo	Memo	

Field Descriptions:

MR_TAG = Most Recent Tag – If fish is implanted with 134 khz tag then this tag number appears here (superseding 400 khz tag if it is also present), if the fish has only been implanted with an older 400 khz tag then that number appears here. This field is used to link the CAPTURE and FIRST_ENC Tables. It is an indexed field in each table, duplicates are allowed in the CAPTURE Table but not the FIRST_ENC Table. I can update this field when I compile the data each January.

Species = Species – Fish species code: PYTLUC = *Ptychocheilus lucius* (Colorado Pikeminnow); XYRTEX = *Xyrauchen texanus* (Razorback Sucker). This field is limited to 6 characters.

Sample = Sample – Sample number of collection or sighting.

Study = Study – The name of the study that encountered this fish.

Date = Date – Date of fish encounter, formatted: yyyy/mm/dd. Note that if the date field is in numeric format it needs to be changed to the appropriate date format. To change number to date in Excel use formula: =DATE(LEFT(A1,4),MID(A1,5,2),RIGHT(A1,2)).

RIVER = River – River where encounter occurred.

RM = River Mile – River mile where encounter occurred recorded to one decimal point.

Gear = Gear – Method used to encounter fish.

PITIDNO_400khz = PIT Tag Number (400khz) – Old PIT tag number (10 digits). This field is formatted to only accept 10 digit entries.

PITIDNO_134khz = PIT Tag Number (134khz) – New PIT tag number (13 digits). This field is formatted to accept only 13 digit entries

Other_Tag = Other Tag – Other indentify tag or number on fish. PIT tags that are not in a 10 or 13 digit format should also be entered here.

TL = Total Length – Total length of fish (mm). No decimal places.

WT = Weight – Weight of fish (g). No decimal places.

Sex = Sex – Sex of fish; F = Female, M = Male, I = Indeterminate. The field has formatted to only accept F, M, or I values.

Tubercles = Tubercles? – Did the fish have tubercles (Y = Yes, N = No). The field is formatted to only accept Y or N. Consider null field as “No.”

Ripe = Ripe? – Was the fish freely expressing gametes (Y = Yes, N = No). The field is formatted to only accept Y or N. Consider null field as “No.”

YearClass = Year Class – Year class that fish was grown from prior to stocking. Note that Colorado Pikeminnow captured and tagged (TAG Contact Type) do not have a record of a stocking event and thus

do not have a known year class. Based on conversation with Dale Ryden, these Pikeminnow can be assigned a year class based on their size and the date of their first capture (TAG).

Source = Stocking Source – The source of stocked fish, including hatchery or grow-out pond.

ReCap_Number = Recapture Number – Number of times fish has been recaptured, stocked fish (STOCK) or new captures (TAG) have a recapture number of zero. I update this field using formula in Excel =COUNTIF(K2:K16,K2) with PIT tag number in first column and date in second column in order to get a count of number of records. PIT tags are arranged in alphabetical order and date is from newest to oldest.

Days_In_River = Days in river – Number of days between stocking (or initial capture) and this recapture. For TAG fish with estimated year class, this number is not back calculated to their estimated stocking date. It only reflects the difference in dates between a CAPTURE record and a FIRST ENCOUNTER record (TAG or STOCK). I use a query in Access to update this field.

Contact_Type = Contact type – How the fish was encountered; “STOCK” for initially stocked fish, “TAG” for an individual captured and implanted with a PIT tag (also includes individuals without stocking information), and “CAPTURE” for all subsequent encounters

Mortality = Mortality – Indicates a fish that was encountered dead or died during handling (M = Mortality, RA = Released alive). Any mortality should be detailed in the comments field. Consider null field as “RA.”

Harvest = Harvest – Indicate that the fish was actively (A) or passively (P) harvested out of grow-out ponds.

Comments = Comments – Any notes related to fish encounter.