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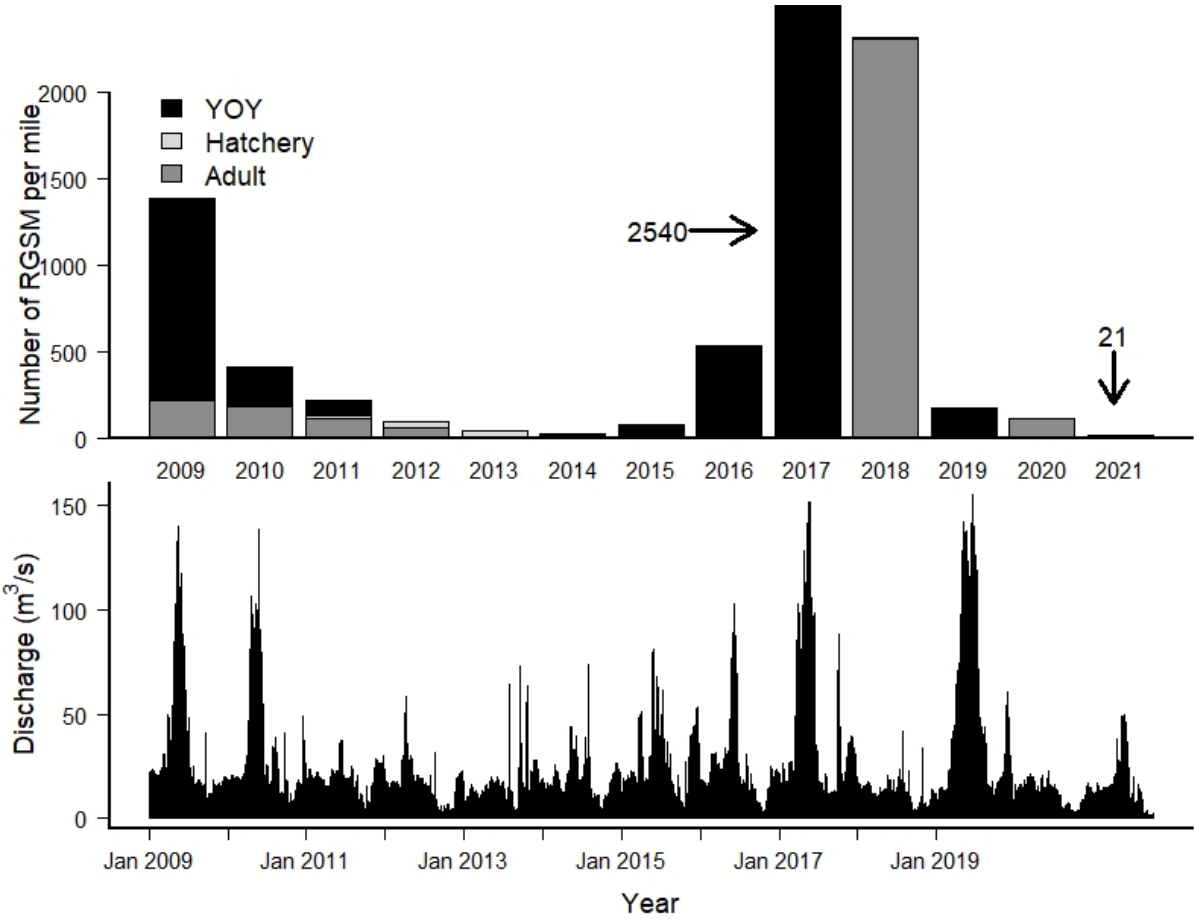

Thomas P. Archdeacon and Lyle I. Thomas

United States Fish and Wildlife Service

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2021 ANNUAL REPORT

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Prepared by:

Thomas P. Archdeacon and Lyle I. Thomas

U.S. Fish and Wildlife Service

New Mexico Fish and Wildlife Conservation Office

3800 Commons N.E.

Albuquerque, New Mexico 87109

Submitted to:

U.S. Bureau of Reclamation

Albuquerque Area Office

555 Broadway NE, Suite 100

Albuquerque, NM 87102

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EXECUTIVE SUMMARY

Rio Grande Silvery Minnow (RGSM) *Hybognathus amarus* are often trapped in isolated pools during times of river drying from June to October each year in the Middle Rio Grande (MRG) in New Mexico. Rescue of RGSM is performed by staff from the New Mexico Fish and Wildlife Conservation Office (NMFWCO) with assistance and coordination from several other agencies. Rio Grande Silvery Minnow are collected from isolated pools each day and transported on off-road utility vehicles equipped with water tanks and supplied with pure oxygen. Rescued RGSM are then transported and released into areas with continuous flows. Rescued RGSM are classified as either dead or alive, hatchery or wild origin, and adult or young-of-year based on their standard length.

During 2021 river drying began in June and the initial separation likely occurred between RM 74.0 and RM 67.0. Between 18 June and 26 August 2021, we conducted rescue activities on 38.7 unique miles of main channel of the MRG that became intermittent. Additionally, several miles were not rescued on Bosque del Apache National Wildlife Refuge due to dangerous driving conditions. During rescue activities, we rescued 818 live RGSM. Of these, 42 were young-of-year (YOY) RGSM, 271 were hatchery-reared RGSM, and 505 were unmarked RGSM (not all hatchery RGSM were marked during 2020). In addition, we found 51 dead RGSM during river intermittency. Spring run-off was low, resulting in few YOY in 2021. Combined with poor recruitment in 2020, the proportion of hatchery fish increased in 2021. Lack of spring runoff combined with extensive low flows may have contributed to lower than expected numbers of adult RGSM encountered during fish rescue in 2021.

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INTRODUCTION

Prior to the 1960s, the Rio Grande Silvery Minnow (RGSM) *Hybognathus amarus* was widespread through the Rio Grande and large tributaries from Brownsville, Texas to northern New Mexico (Treviño-Robinson 1959; Bestgen and Platania 1991). Currently, RGSM are extirpated from all of the Pecos River and are restricted to an approximately 300 km segment of the Middle Rio Grande (MRG) in central New Mexico (Bestgen and Platania 1991). In 1994, RGSM was listed as endangered by the U.S. Fish and Wildlife Service (USFWS 1994). One threat to RGSM persistence is the modified flow regime that results in streamflow intermittency and channel drying on an annual basis (Archdeacon and Reale 2020).

Since monitoring of river intermittency began in 2001, sections of the Middle Rio Grande have become intermittent due to water operations and drought in all years except 2008 (Archdeacon 2016). During those years, intermittent stream flow conditions occurred in significant portions (up to 68 miles) of the contemporary range of RGSM (Bestgen and Platania 1991; Archdeacon 2016). The areas of intermittent flow are located in the Isleta and San Acacia Reaches of the MRG (Figure 1). Rio Grande Silvery Minnow are frequently stranded in the isolated pools that form during streamflow intermittency (Archdeacon 2016; Archdeacon and Reale 2020).

The December 2, 2016, *Final Biological and Conference Opinion for Bureau of Reclamation, Bureau of Indian Affairs, and Non-Federal Water Management and Maintenance Activities on the Middle Rio Grande, New Mexico* (BiOp) describes several Survival Strategy Conservation Measures to minimize adverse effects to RGSM associated with project-related July to October water volume reductions. One measure is to rescue RGSM stranded in isolated pools during summer drying events and transport them to areas of perennial flow. Rescue of stranded RGSM is intended to reduce mortality during irrigation season, improve distribution of RGSM, and prevent further genetic losses by increasing survival of the current cohort. Each year since 2003 when river drying has occurred, fish rescue operations have been conducted. Here, we document our efforts to rescue RGSM during periods of stream flow intermittency during 2021.

METHODS

Rescue of RGSM

Each day during irrigation season (April through October), through coordination with other agencies, we determined if any sections of the MRG had dried. If new drying occurred, we used off-road utility vehicles to access these areas. During the 2021 season, only areas of new drying were rescued; there are typically fewer fish during subsequent wet and dry events (Archdeacon 2016) and survival of rescued fish declines through summer (Archdeacon et al.

2020). Thus, rescuing fish after repeated drying and wetting cycles is not beneficial, therefore rescue was limited to the first drying event only.

Once we arrived at areas reduced to isolated pools, we used seines (3.0 x 1.0 m, mesh size =3.2 mm) to collect RGSM from isolated pools. We recorded the river mile (nearest 0.1 mi), measured maximum pool depth (0.01 m), and recorded time of day. Next, we seined the pool and counted all RGSM captured. In some years, large numbers (e.g. > 1,000) of RGSM were collected from individual pools or found dead. In these cases, crews were forced to estimate numbers to prevent excessive mortality from handling. Crews counted several handfuls and then estimated total numbers. Estimates were purposely conservative, so the numbers reported can be considered minimums. Seining continued until crews judged that few or no RGSM remained in the pool. Smaller pools (e.g., < 50 m^2) were seined once, while larger pools were sampled with more effort.

We categorized each RGSM based on size as YOY (generally < 45 mm standard length [SL]), or adult (adults are generally >55 mm SL). All adults were examined for a visible implant elastomeric paint mark (VIE) given to all hatchery fish, recorded as either NS (naturally spawned, no mark) or hatchery origin. Colors and positions of any VIE tags were recorded to identify age and release locations (Archdeacon 2021). Not all fish released in 2020 were marked with VIE. We categorized each RGSM as alive or dead. We did not rescue RGSM that exhibited clinical signs of poor health (e.g., lethargy, lesions, moribund). Some dead RGSM were collected and fixed in 10% formalin solution and later transferred to 70% ethanol. Preserved RGSM and field notes were accessioned to the University of New Mexico Museum of Southwestern Biology.

We ensured that all RGSM rescued had the highest probability of survival. Prior to handling RGSM, personnel washed their hands to remove residue of lotions (e.g. sunscreen and insect repellant) to increase fish survival. Previous research on handling and transportation stress has refined our collection and transportation methods (Cho et al. 2009). Generally, we moved rescued RGSM immediately into five-gallon buckets filled with transport tank water. After all fish from a pool were counted, we transferred fish to a 50-gallon transport tank attached to an off-road utility vehicle. Each tank was fitted with an oxygen tank, and filled with filtered, deionized water from a municipal source when possible. In a few instances, we used water from flowing sections of river to fill tanks prior to rescue activities because municipal water was not available in the field. We supplied pure oxygen to transport tanks through diffusers, and adjusted rates depending on water temperature and number of fish in the tank to maintain oxygen levels near 100% saturation. We added salt (NaCl) to transport tanks to achieve a 1% NaCl solution to reduce stress to RGSM prior to fish collection.

During 2021, most rescued RGSM were kept in aquaria for observation. Those that were not were transported and released within the same reach, in the nearest section of river that we did not expect to dry. Prior to releasing RGSM, we tempered the transport tank water by slowly

adding river water until the temperature in the tank was within 1° C of the river water temperature.

Survival of Rescued Fish

In 2018, we began a pilot study examining rescued fish survival (Archdeacon et al. 2020). Survival appeared to be very low, and we attempted to collect more data in 2021 to help inform rescue protocols. We transported several groups of fish back to the New Mexico Fish and Wildlife Conservation Office in Albuquerque, New Mexico. Fish were temperature-acclimated and transferred to ~550-L tanks on a recirculating filtration system. Fish were held for a minimum of 21 days and monitored daily for dead fish. Any fish remaining alive were returned to the river. We were not able to collect fish from continuous flows to serve as controls in 2021; however, we saw no evidence of mortality caused by captivity in 2018 (Archdeacon 2019) and the system has been used in the past without undue mortality (Archdeacon et al. 2009). Fish from one day of rescue were also held in mesh cages (approximately 2 m x 0.75 m x 0.75 m) in the low-flow conveyance channel and observed for one week post rescue.

Analysis of Data

We calculated reach and overall totals for all categories of RGSM encountered during rescue activities. We also summarized the temporal and spatial extent of each drying period, number of days and number of pools rescued. For daily data, we totaled the RGSM observed each day of rescue, number of pools rescued, number of river miles rescued, and the amount of time required to rescue that distance. We plotted the number of YOY RGSM collected per mile each year from 2007 to 2021, separately for the Isleta and San Acacia Reaches, against the average May discharge at the Bosque Farms (USGS gage 08331160) or San Acacia (USGS gage 08354900) gages to show the importance of spring runoff for recruitment, as well as the variability in that relationship.

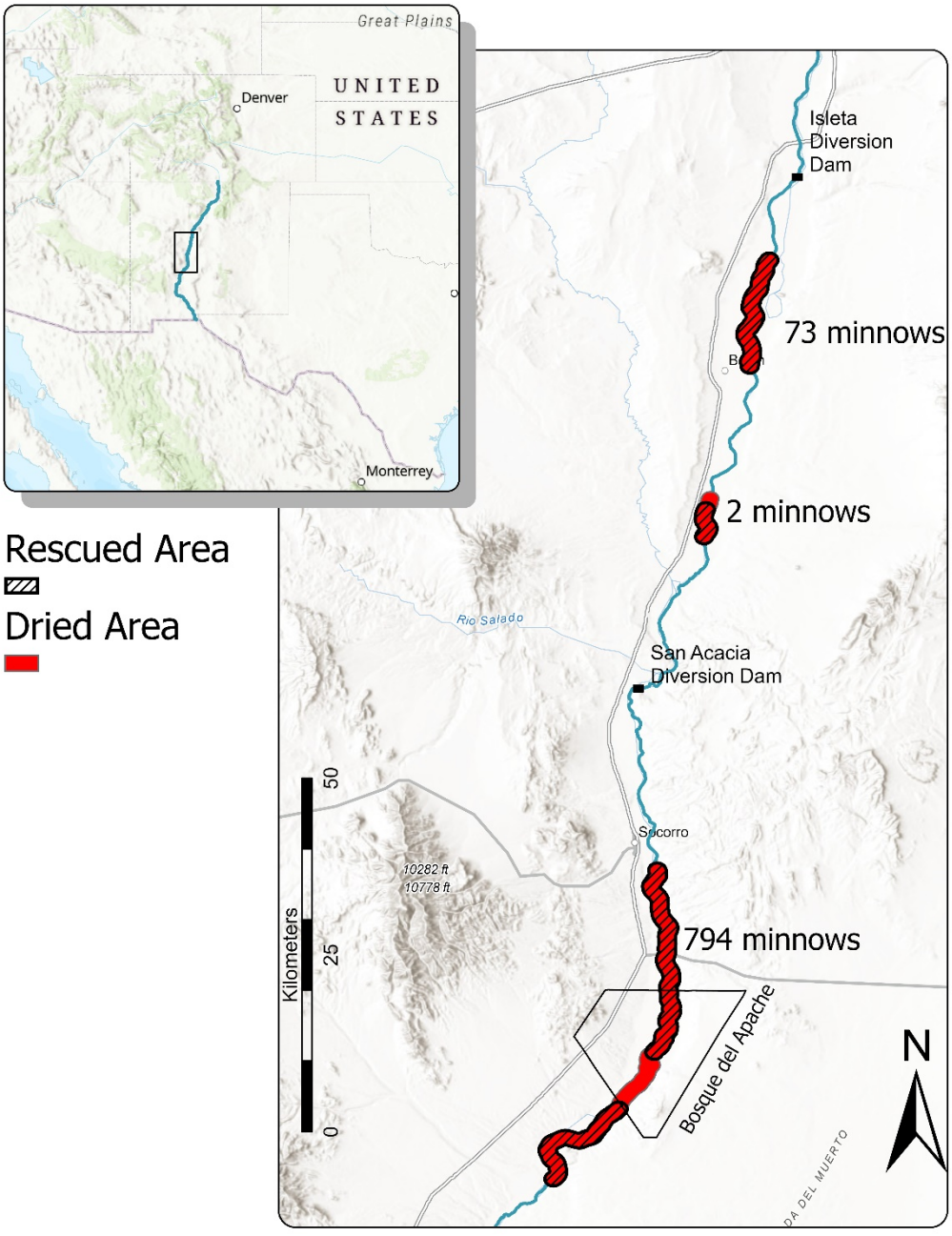

Figure 1-Map of the Middle Rio Grande and areas of channel drying and where Rio Grande Silvery Minnow were rescued in June through August 2021.

RESULTS

Rescue and Mortality of RGSM

Adult RGSM were less common in 2021 compared to 2020, whereas YOY were very rare in both years. We found 3,914 live RGSM during fish rescue in 2020, but only 819 alive in 2021. Of these 819 fish, only 42 were YOY, whereas 505 were adults and 271 were VIE tagged fish indicating hatchery origin (Table 1). However, approximately 60% of fish released in 2020 were not tagged with VIE due to logistical restrictions from the COVID-19 pandemic. In addition to the live RGSM, we found 51 dead RGSM in or near isolated pools.

Channel Drying

Rescue operations generally progressed in synchrony with river recession over the 2021 season. Fish rescue began June 18th in the San Acacia Reach and continued through August 26th. In total, 45.4 unique miles were rescued during first drying (Figure 1). Due to excessive drying on June 18th (approximately 16 miles) and channel conditions UTVs were not able to access and rescue the lower half of Bosque del Apache National Wildlife Refuge (Figure 1). Approximately 6 miles of drying occurred there that was not accessible to all-terrain vehicles and was not rescued.

In the San Acacia Reach, discontinuous flows occurred from the confluence with the low-flow conveyance channel to about three miles downstream of the city of Socorro, New Mexico (Figure 1). In the Isleta Reach, approximately 8 miles dried near the Peralta Wasteway and 3.5 miles near Abeytas, New Mexico. Multiple drying and rewetting cycles occurred in all areas. We conducted fish rescue operations on 19 days during the 2021 irrigation season (Table 2).

Table 1-Number of young-of-year (YOY), adults, and hatchery-marked adult Rio Grande Silvery Minnow collected during fish rescue in the Middle Rio Grande, 2021. Rescued numbers of RGSM do not include transport losses.

Reach	YOY	Wild Adults	Hatchery Adults	Dead	Total
Isleta	12	39	24	0	75
San Acacia	30	466	247	51	794
Total	42	505	271	51	869

Table 2-Number of days rescued, number of pools evaluated, number of miles rescued, and extent of drying per reach during 2021 rescue operations. The miles rescued include repeated drying events. Extent of drying is the number of unique river miles of discontinuous flow observed for the season.

Reach	Number of Days	Number of Pools	Miles Rescued	Extent of Drying (miles)
Isleta	8	348	10.5	11.5
San Acacia	11	577	28.2	33.9
Total	19	925	38.7	45.4

Monitoring Activities

Nearly all RGSM collected in 2021were adults following two years of low recruitment, and the fewest number of RGSM per mile since 2009 (Figure 2). Examining the annual spring discharge graphs reveals the importance that higher spring run-offs have on number of YOY collected during fish rescue, though there is much variation between reaches and among years (Figure 3). There are much greater numbers of YOY present in pools during years with higher spring run-off and reduced numbers of YOY in years with low spring run-off, and these relationships are statistically significant (Archdeacon 2016).

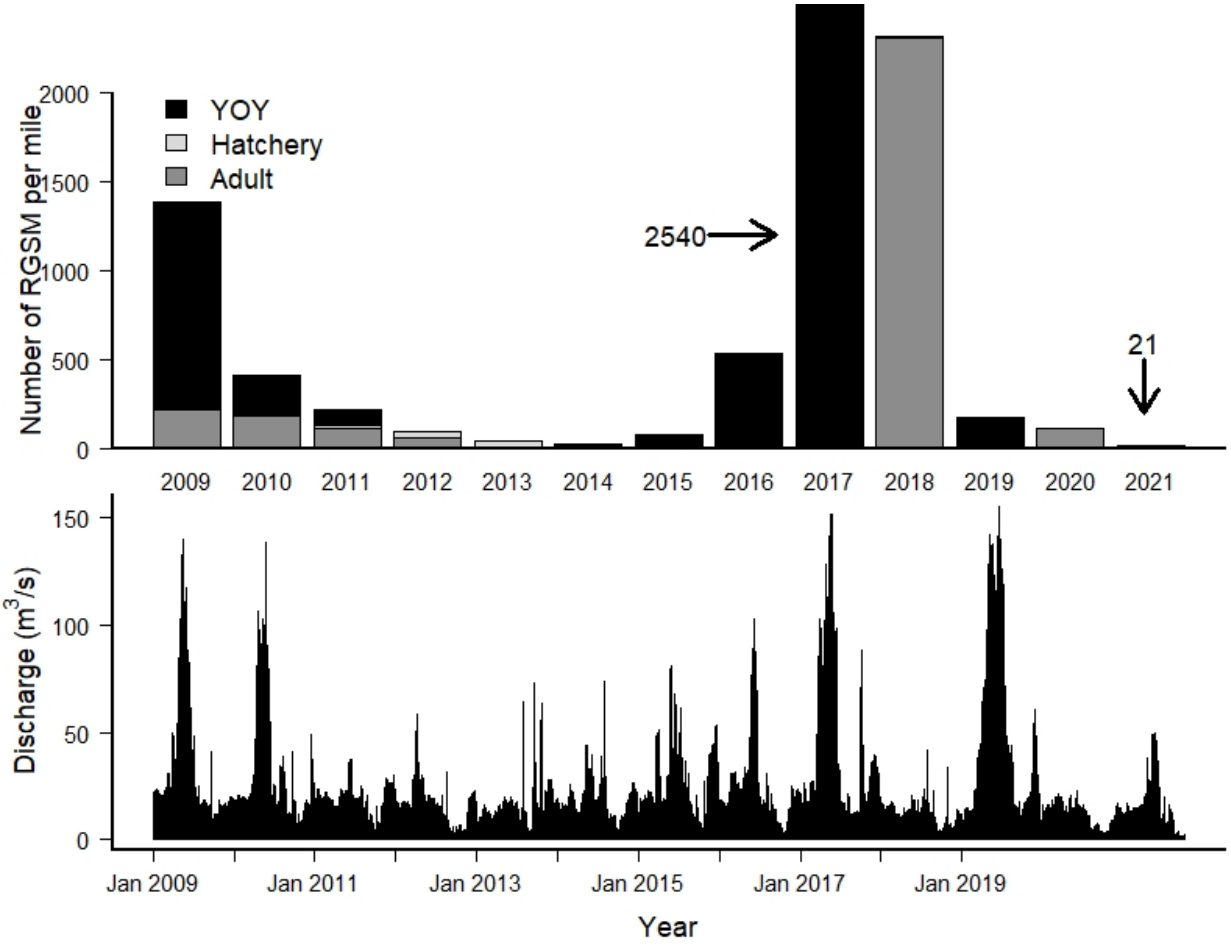

Figure 2-Number of young-of-year (YOY), hatchery marked adult, and wild adult Rio Grande Silvery Minnow collected per mile during rescue activities in the Middle Rio Grande, 2007-2021 and the average daily discharge in the Rio Grande at Albuquerque, NM (USGS gage 08330000).

Table 3- Summary of rescue activities in the Middle Rio Grande, New Mexico, during streamflow intermittency, 2007-2021. Total RGSM is the number of Rio Grande Silvery Minnow found, regardless of condition. †A sediment plug prevented the rescue of approximately 12 miles of dried channel. ‡A sediment plug prevented rescue of approximately 6.3 miles of dried channel. *Restrictions implemented during the COVID-19 pandemic prevented the rescue of approximately 20 miles.

Year	Extent of drying (miles)	Miles Rescued	Pools Rescued	Total RGSM
2007	30.0	119.2	1,052	15,636
2008	0.0	NA	NA	NA
2009	19.9	65.0	522	27,712
2010	28.2	118.2	1,232	12,349
2011	40.2	163.7	2,054	9,277
2012	51.0	204.0	2,774	5,014
2013	36.5	47.4	1,037	1,492
2014	24.5	62.6	754	614
2015	17.4	23.3	396	1,320
2016	28.6	35.4	549	29,222
2017	24.2	35.6	225	64,948
2018	40.6	98.2	1,308	93,607
2019	17.6†	9.0	85	1,127
2020	55.6*	34.0	740	4,050
2021	45.5‡	38.2	925	869

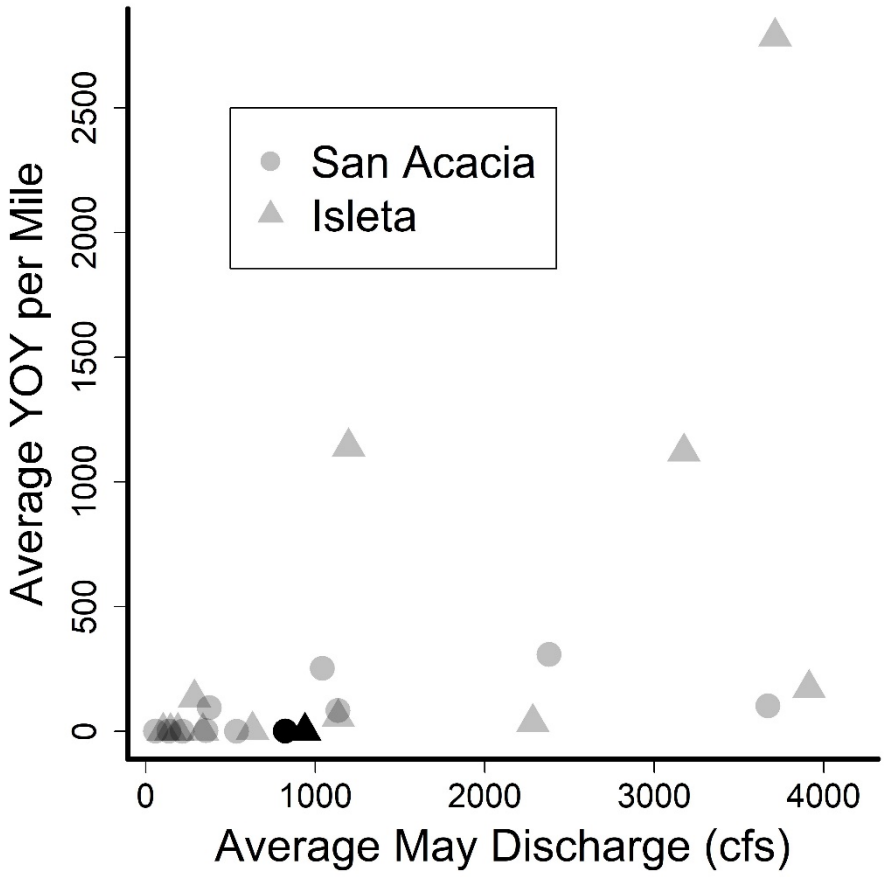

Figure 3-Scatterplot of the average number of young-of-year (YOY) Rio Grande Silvery Minnow collected per mile per year, 2007-2021, and the average May discharge (cfs) at the Bosque Farms (Isleta) and San Acacia gaging stations. Black points represent data from 2021.

Survival of Rescued Fish in Captivity

Survival of rescued fish held in captivity at NMFWCO was low, < 10% for almost all groups observed in captivity. Fish collected on 18 June 2021 were split into two groups, fish collected from pools < 30 °C (N = 19) and those from pools > 30 °C (N = 16). Though fish collected from pools < 30 °C higher survival than groups collected later in the year (i.e. > 30 °C), both groups had poor survival (21% and 13%, respectively) and had small sample sizes, preventing definitive conclusions. The two largest collections of fish, collected on 20 and 29 June 2021, both had very low survival (Figure 4). Too few YOY were rescued in 2021 to facilitate a comparison, but YOY survival appeared similar to adult survival. Twelve RGSM, six each from pools > 30 °C and < 30 °C held for one week post rescue showed equal survival at 33%.

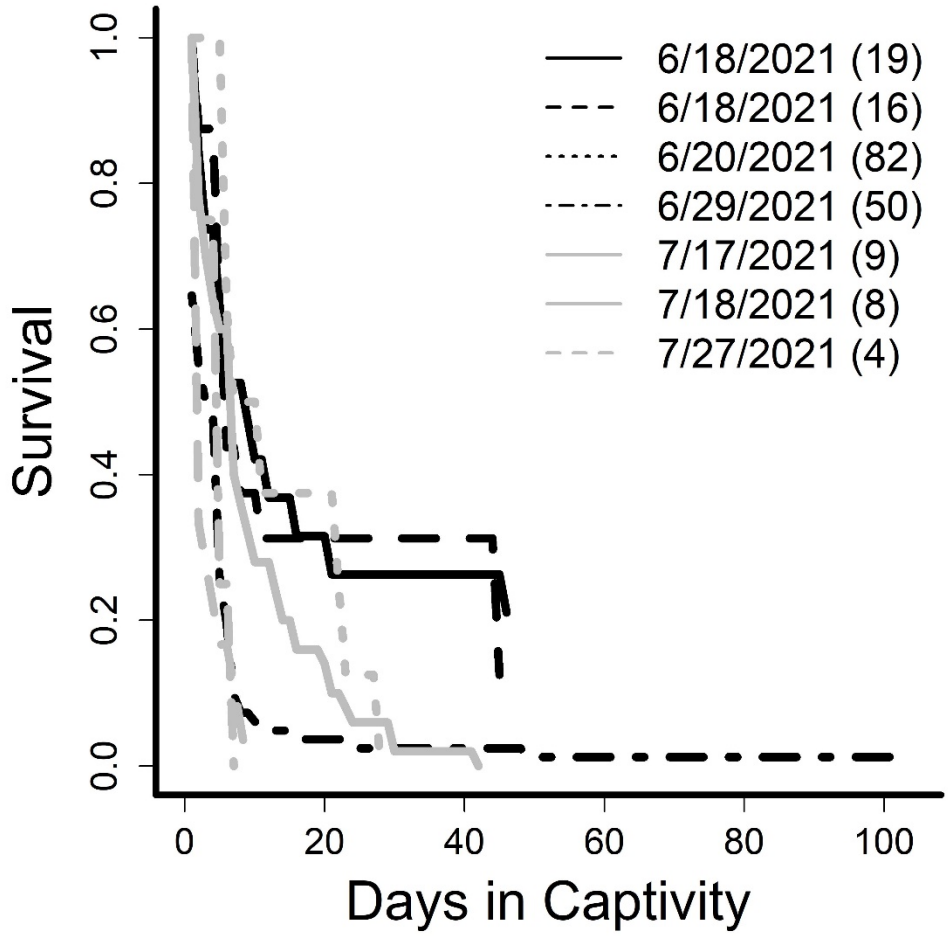

Figure 4-Dates and survival of Rio Grande Silvery Minnow rescued from isolated pools in the Middle Rio Grande, NM, during irrigation season in 2021. Numbers collected in each group are given in parentheses.

DISCUSSION

Rescue operations extended across the irrigation season in 2021. A marginal spring runoff led to drying in June, with extensive amounts dry channel present in June through September. Staff were not able to access Bosque del Apache National Wildlife Refuge due to both a sediment plug that prevented vehicle access and excessive drying on 18-19 June 2021. In total, approximately 38.2 of the 45.5 miles dried were rescued in 2021.

Large annual fluctuations in adults and YOY have been observed during fish rescue over the past several years. In 2020, the number of YOY was low given the small spring runoff. Following this, the number of adults collected in 2021 was also low, and the proportion of hatchery fish increased. Because not all hatchery fish released in 2020 were given a VIE mark, a significant proportion of the unmarked "wild" adult fish collected in 2021 were likely of hatchery origin. The spring runoff conditions were similar to 2016, yet far fewer YOY were collected in 2021, particularly in the Isleta Reach.

Spring runoff is important requirement for recruitment of RGSM. Higher spring runoff results in more fish in October standardized monitoring (Dudley et al. 2020) as well as more RGSM trapped in isolated pools during the summer (Archdeacon 2016). In past years, RGSM numbers have recovered in years of high spring runoff after prolonged drought (e.g. 2012-2014). However, it is apparent more than just spring run-off is important for RGSM. Early and prolonged channel drying in 2018 may have caused extremely high mortality in adults, and contributed to recruitment failure of the 2019 year class. As predicted from 2017 to 2020 fish rescue operations, the adult RGSM population shifted to hatchery fish detected in 2021.

Observations of survival of rescued adult RGSM was low. Although rigorous comparisons of adults and YOY were not possible, the limited comparisons between warmer and cooler pools were similar, suggesting fish are compromised prior to being rescued. A very limited number of rescued fish were held in cages in-stream, with 33% survival for 7 days (N = 12), which was similar to fish held in in aquaria and suggests the mortality is not related to captive conditions. Implementation of healthy control fish in 2022 will help verify this observation.

With the possibility of increased frequency of low spring runoff flows and increased duration and extent of summer drying, the continued existence of RGSM in the San Acacia and Isleta reaches may require increased annual augmentation efforts with hatchery fish if no other management actions addressing spring run-off and improved recruitment are made available.

ACKNOWLEDGMENTS

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DATA AVAILABILITY STATEMENT

All data used in this report are available at www.doi.org/10.17632/bz3dvhf95s.2 and www.doi.org/10.17632/c4j4dttksm.1

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