Rio Grande Silvery Minnow Fish Rescue

2023 Annual Report

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2023 ANNUAL REPORT

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Cover photo: USFWS staff Lyle Thomas (left) and Paige Dunnum (right) checking fish in hauling tanks. Credit: Diego Araujo, USFWS

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The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

EXECUTIVE SUMMARY

Rio Grande Silvery Minnow (RGSM) *Hybognathus amarus* are often trapped in isolated pools during of river drying from April 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 (YOY) based on their standard length.

During 2023, river drying began in July and the initial separation likely occurred between river kilometer (rkm) 240 and rkm 250 near the south boundary of Bosque del Apache National Wildlife Refuge. Between 21 July and 31 August, we conducted rescue activities on 26.9 unique kilometers of main channel of the MRG that became intermittent. During rescue activities, we relocated 3,621 live RGSM. Of these, 3,530 were YOY RGSM, 85 were hatchery reared RGSM, and 6 were unmarked RGSM. In addition, we found 283 dead RGSM during river intermittency. Spring run-off was high, and more fish were rescued compared to years 2020-2022. Overall, more YOY fish were rescued in 2023 and wild YOY made up the greatest proportions of RGSM caught. However, the number of wild adults reflected poor recruitment over the previous three years and a population reliant on hatchery augmentation.

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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 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). Channel intermittency due to drought and water abstraction (Blythe and Schmidt 2018) is one of many threats to RGSM persistence and channel drying now occurs on a nearly annual basis (Archdeacon and Reale 2020).

Prior to the 1900s, river drying was a relatively rare occurrence in the MRG, happening once or twice per decade (Scurlock 1998). Following extensive human development and abstractions, river drying became more common by the mid-20th century. Since regular monitoring of river intermittency began in 2001, sections of the MRG have become intermittent due to water operations and drought in all years except 2008 (Archdeacon 2016). Intermittent stream flow conditions occurred in significant portions (up to ~110 km) of the contemporary range of RGSM (Bestgen and Platania 1991; Archdeacon 2016). The areas of intermittent flow were generally in the Isleta and San Acacia Reaches of the MRG but can occur upstream of the Isleta Diversion Dam during extreme drought years (Figure 1). Rio Grande Silvery Minnow are frequently stranded in the isolated pools that form during streamflow intermittency (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 2023.

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 2023 season, only areas of new drying were rescued (e.g., “first drying”). 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 and 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 kilometer (nearest 0.1 km), measured maximum pool depth (0.01 m), temperature (0.1 C) 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.

We categorized each RGSM based on size as young-of-year (YOY; < 45 mm standard length [SL]), or adult (adults are >55 mm SL). All adults were examined for a visible implant elastomeric paint mark (VIE) given to all hatchery fish, recorded as either wild (naturally spawned, no hatchery mark) or hatchery origin. Colors and positions of any visible implant elastomeric (VIE) tags were recorded to identify age and release locations (Archdeacon 2023). Not all fish released in 2020 and 2021 were marked with VIE, but it is unlikely any survived to 2023. We categorized each RGSM as alive or dead. Some RGSM were collected and preserved in 95% ethanol for genetic materials. 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. 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 2023, rescued RGSM were transported and released within the same reach, in the nearest section of river that we did not expect to dry. A small number (< 50) were retained for broodstock and transferred to the Albuquerque BioPark Aquatic Conservation Facility. 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.

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 number of RGSM

observed in isolated pools, number of pools rescued, number of river kilometers rescued, and the amount of time required to rescue that distance. We plotted the number of YOY RGSM collected per kilometer each year from 2007 to 2022, separately for the Angostura, Isleta, and San Acacia Reaches, against the average May discharge at the Albuquerque (USGS gage 08330000), 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. We fit a generalized liner mixed effect model using a negative binomial function to examine the relationship between YOY per km and mean May discharge.

Archdeacon and Boro (2023) modeled the contribution of spatial unit to numbers of stranded RGSM to identify areas with more (or fewer) fish. We examined average numbers of adults and YOY per pool in 2023. Archdeacon and Boro (2023) used a relative 5-category ranking system, here we simplified to a 3-category system where “cold” spatial units had < 50% the expected average number of fish per pool and “hot” spatial units had > 200%.

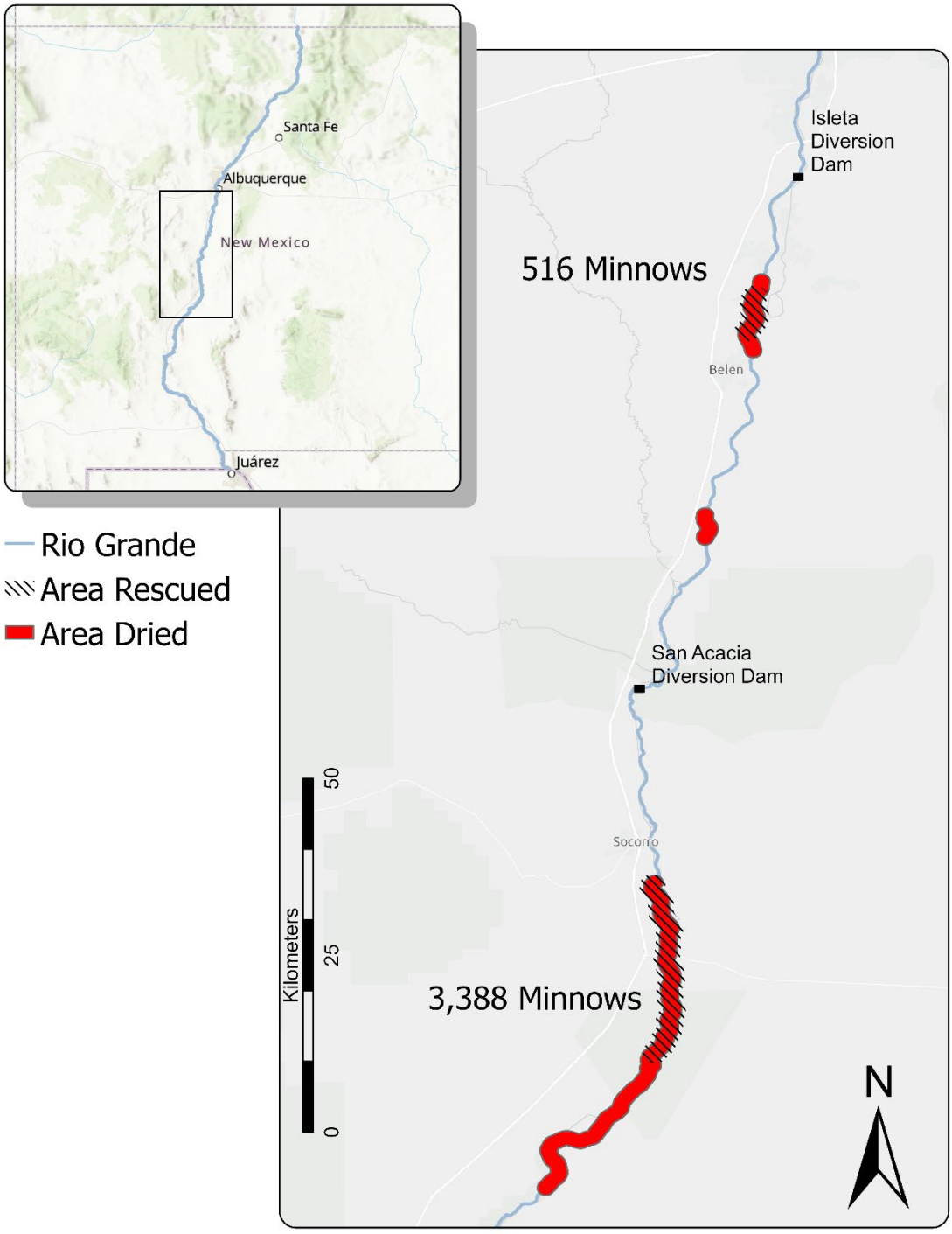

Figure 1- Map of drying and areas rescued (and number of live Rio Grande silvery minnow rescued) in the Middle Rio Grande, New Mexico, between June and July 2022.

RESULTS

Rescue and Mortality of RGSM

A total of 3,621 live RGSM were rescued during the 2023 season (Table 1). Most adult RGSM were found in the southernmost reach, below the San Acacia Dam (Table 1). The San Acacia Reach had the greatest rescue effort, with the most days, pools, and kilometers evaluated (Table 2). Tagged individuals, indicating hatchery origin, were found only in the San Acacia Reach, all were 2022 cohort fish. Out of the total number of RGSM found, 283 were found dead in or around pools that were salvaged. The largest number of dead RGSM were found on San Acacia Reach, though some dead individuals were also found along the Isleta Reach.

Table 1-Summary of rescue operations for Rio Grande Silvery Minnow in the Middle Rio Grande, 2023. Rescued numbers of RGSM do not include transport losses.

Reach	YOY	Adults	Hatchery	Dead	Total
Isleta	493	0	0	23	516
San Acacia	3,037	6	85	260	3,388
Total	3530	6	85	283	3,904

Table 2-Number of days rescued, number of pools evaluated, number of kilometers (KM) rescued, and extent of drying per reach during 2023 rescue operations. Extent of drying is the number of unique river kilometers of discontinuous flow observed for the season.

Reach	Number of Days	Number of Pools	KM Rescued	Extent of Drying
Isleta	2	58	4.8	8.8
San Acacia	11	438	22.1	47.5
Total	13	496	26.9	56.3

Channel Drying

Rescue operations generally progressed in synchrony with river recession over the 2023 season. Fish rescue began July 21st in the San Acacia Reach and continued through August 31st. In total, 26.9 unique kilometers were rescued during first drying (Figure 1). Over 30 km of the San Acacia Reach dried on July 21-22, most of which could not be rescued within 24 h.

In the San Acacia Reach, discontinuous flows occurred near the confluence with the Low Flow Conveyance Channel to the city of Socorro, New Mexico (Figure 1). Much of the reach dried on the first day (>20 km) and crews were not able to visit pools. In the Isleta Reach, approximately 9 kilometers in total dried near the Peralta Wasteway and near Abeytas, New Mexico. We conducted fish rescue operations on 13 days during the 2023 irrigation season (Table 2).

Monitoring Activities

Adult RGSM were much less common in 2023 compared to 2021-2022, but overall number of RSGM rescued was higher compared to previous years (Table 3). When broken down by life stage and origin, RGSM numbers varied among years, with 2023 YOY numbers above average (Figure 2 and Figure 3).

A similar number of adults and YOY were found during salvage, though YOY were only found in the Angostura Reach (Table 1). Spring run-off was comparable to 2021, though more YOY were rescued in 2022. 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 variation between reaches and among years (Figure 4). There are 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). The model developed by Archdeacon and Boro (2023) poorly predicted separated cold, average, and hot spatial units, likely due to collecting only six total adults (Figure 5). Conversely, the model predicted YOY moderately well, although the spatial units with the most fish were in the cold category. However, more pools containing ~25-250 YOY were classified as hot, rather than average. No units predicted to be cold spots for YOY were sampled in 2023.

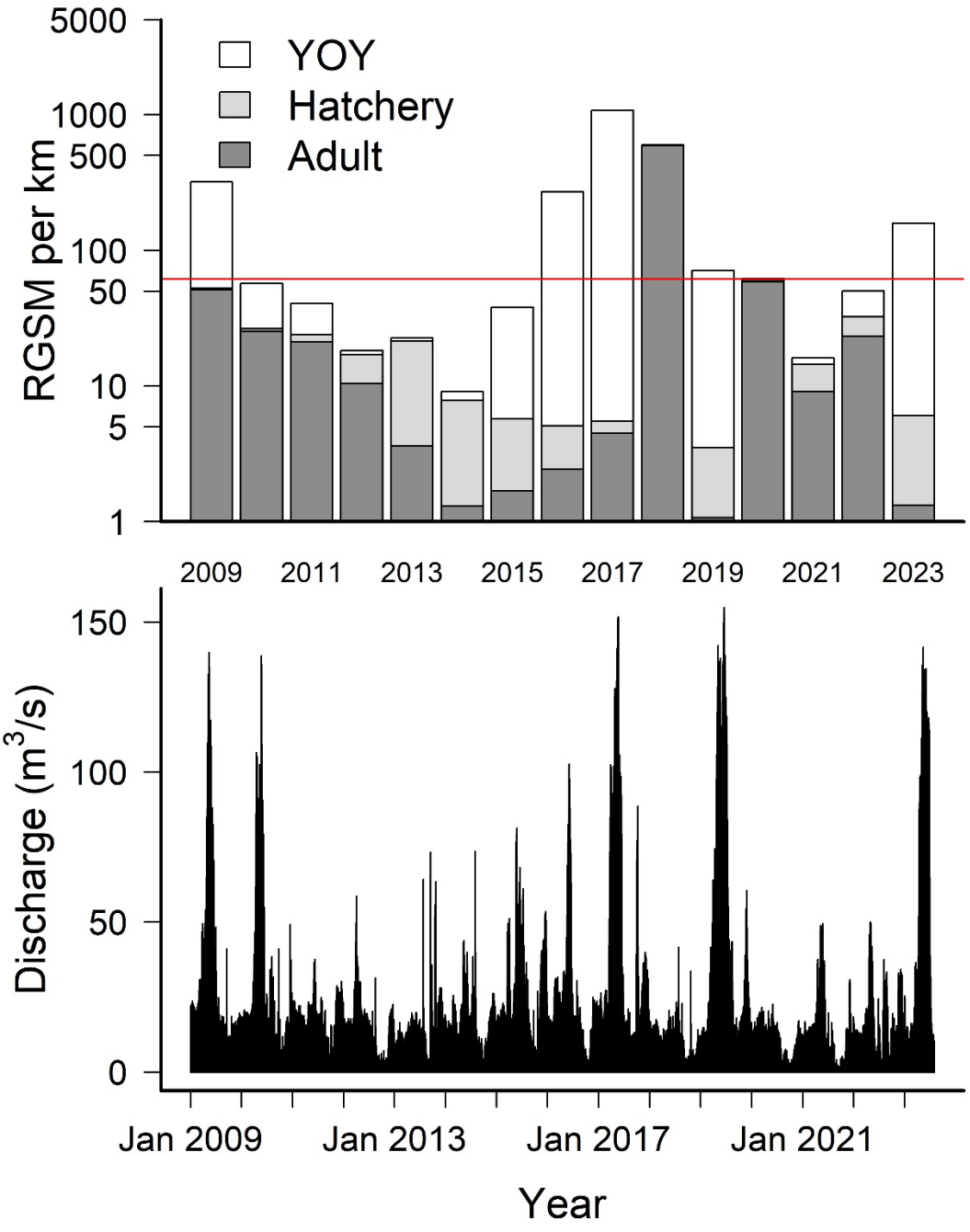

Figure 2- Number of young-of-year (YOY), hatchery marked adult, and wild adult Rio Grande Silvery Minnow observed per kilometer in the Middle Rio Grande, 2009-2022 (top) and the average daily discharge (bottom) in the Rio Grande at Albuquerque, NM (USGS gage 08330000). Red line indicates average Rio Grande Silvery Minnow per kilometer over all sampling occasions. Note y-axis is natural log transformed for number of RGSM per km.

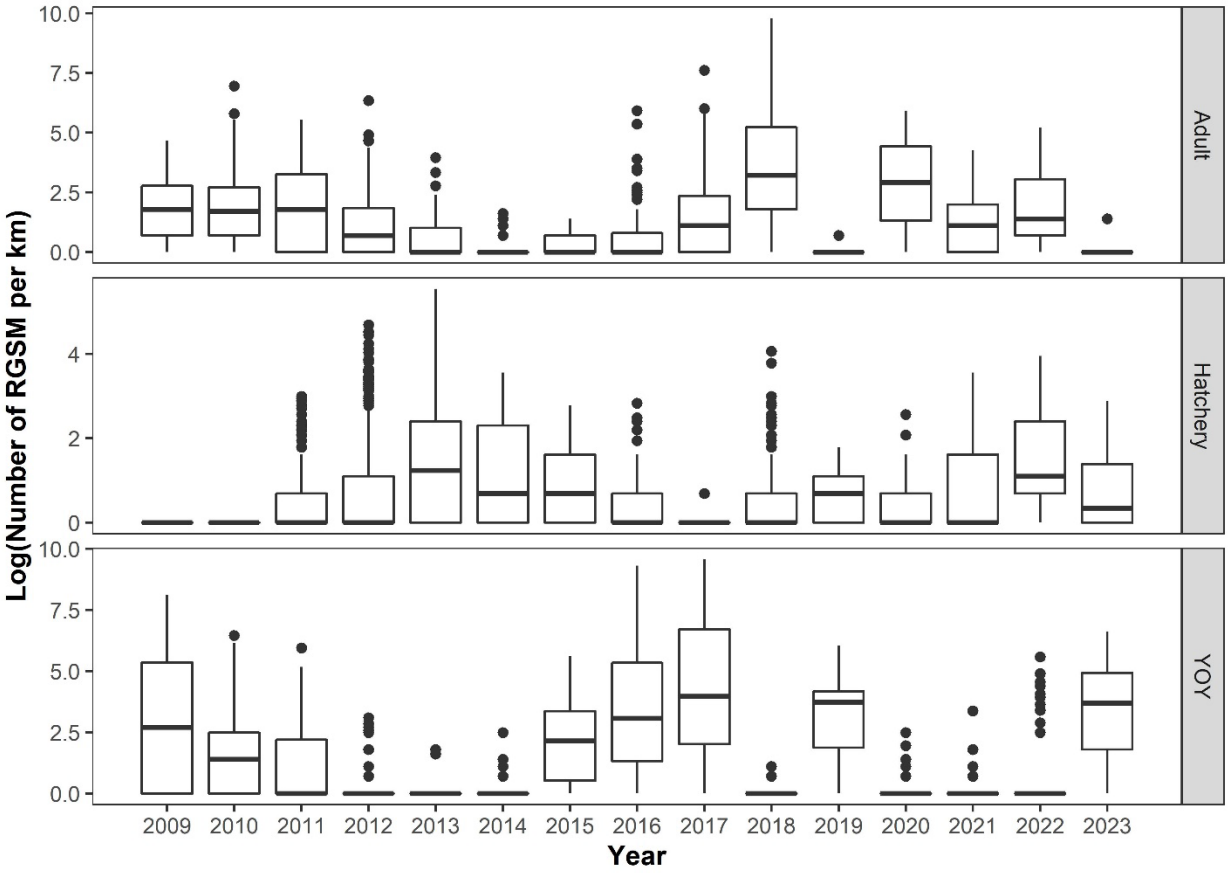

Figure 3- Box plot depicting the log of wild adult, hatchery marked adult, and young-of-year (YOY) Rio Grande Silvery Minnow collected per kilometer during rescue activities in the Middle Rio Grande, 2009-2022. Note y-axis is natural log transformed.

Table 3- Summary of rescue activities in the Middle Rio Grande, New Mexico, during summer drying, 2007-2023.

Year	Extent of drying (km)	KM Rescued	Pools Rescued	Total RGSM
2007	48.3	191.8	1,052	15,636
2008	0.0	NA	NA	NA
2009	32.0	87.5	522	27,712
2010	45.4	217.5	1,232	12,349
2011	64.7	235.8	2,054	9,277
2012	82.1	328.3	2,774	5,014
2013	58.8	76.3	1,037	1,492
2014	39.5	100.7	754	614
2015	28.0	37.5	396	1,320
2016	46.1	56.9	549	29,222
2017	39.0	57.3	225	64,948
2018	65.4	158.0	1,308	93,607
2019	28.3	14.5	85	1,127
2020	89.5	66.1	740	4,050
2021	73.3	62.3	935	869
2022	88.4	49.4	842	2,326
2023	56.3	26.9	496	3,904

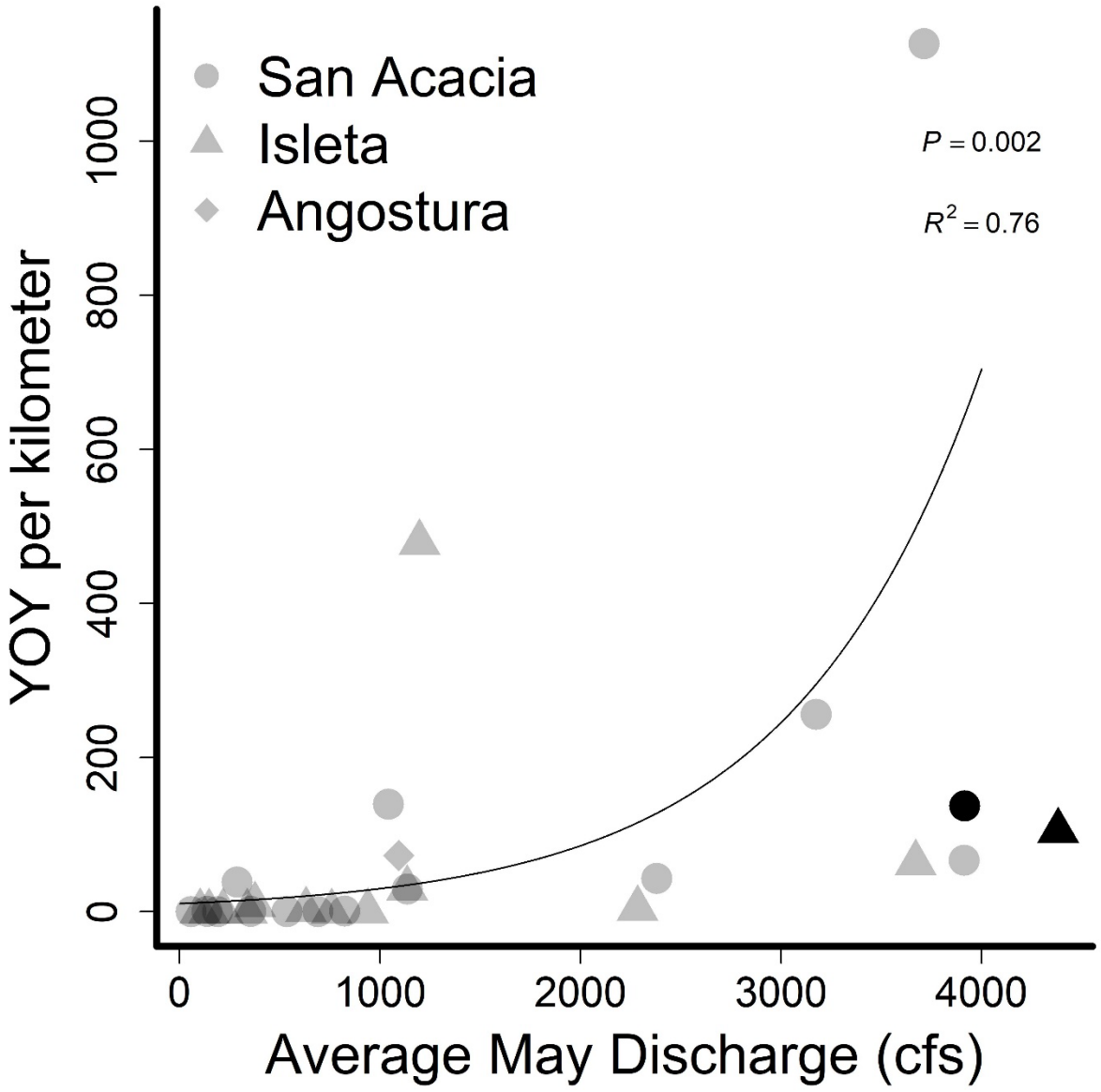

Figure 4- Scatterplot of the average number of young-of-year (YOY) Rio Grande Silvery Minnow collected per mile per year, 2007-2022, and the average May discharge (cfs) at the Albuquerque (Angostura), Bosque Farms (Isleta), and San Acacia gaging stations. Black points represent data from 2022.

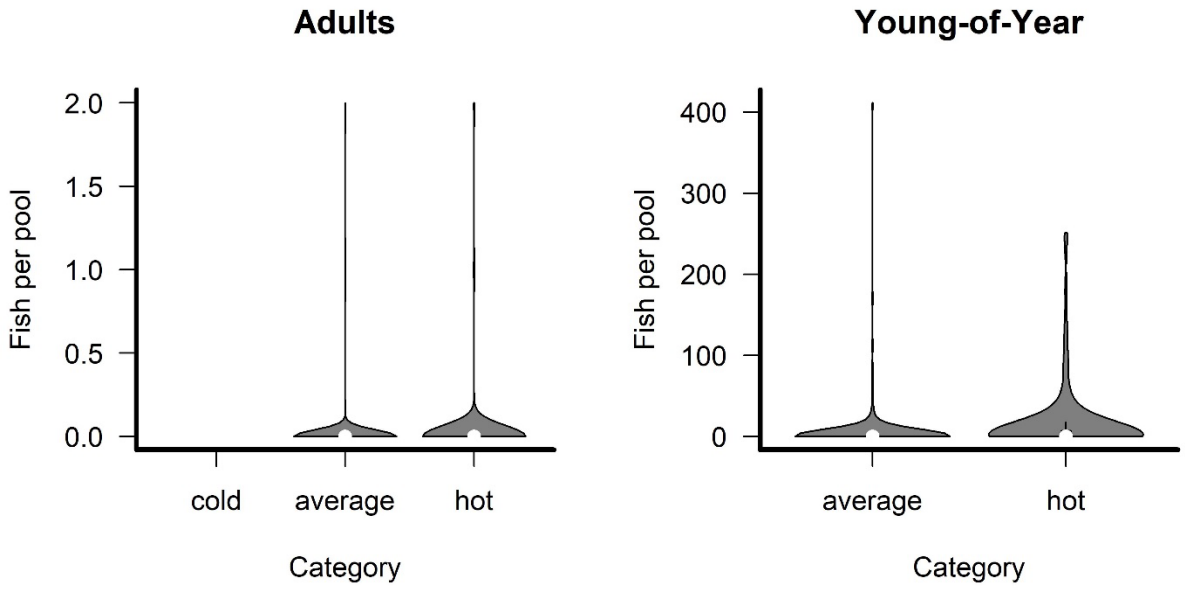

Figure 5-Violin plots (e.g., density kernels) of numbers of Rio Grande Silvery Minnow rescued in isolated pools in below average ("cold"), average, and above average ("hot") 2.5 km spatial units in the Middle Rio Grande, New Mexico, in 2023.

DISCUSSION

Rescue operations extended across the second half of the irrigation season in 2023. Higher and longer-lasting spring runoff extended well into July, but extensive amounts of river channel dried August through October. Much of the river downstream of Bosque del Apache National Wildlife Refuge downstream to the San Marcial USGS station was not rescued due to excessive drying during the first two days (>30 km). In total, 26.9 of 56.3 kilometers dried were rescued in 2023. Fish rescue operations began at approximately the middle of Bosque del Apache National Wildlife Refuge and will continue to begin there in future years when more drying occurs than is possible to rescue in a single day. Generally, there are many fewer RGSM below the refuge compared to upstream (Archdeacon et al. 2022).

Spring runoff is important requirement for recruitment of RGSM (Yackulic et al. 2022). Higher spring runoff results in more fish in October standardized monitoring 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 as numbers in the Isleta Reach appear to be lower compared to the other reaches. With declining wild populations since 2019, the adult RGSM population shifted to more adult hatchery fish than adult wild fish in 2023. Following 2023, the bulk of the population in 2024 should be made up of wild fish.

The model developed to predict higher and lower densities of RGSM based on spatial location performed poorly (Archdeacon and Boro 2023). The model was developed using > 10 years of data and represents long-term averages. There is considerable spatial and temporal variability in numbers of fish trapped in isolated pools. For example, in 2023 alone, 411 of the 493 fish in the Isleta Reach came from one pool. The model may still describe long-term trends but may not be useful for identifying priority areas for conservation because RGSM are dispersed over a large area. However, simply plotting raw numbers may be somewhat misleading, as the areas were not rescued during the same time of year, and there are fewer RGSM as the irrigation season progresses.

With the possibility of increased frequency of low spring runoff flows and increased duration and extent of summer drying, the continued presence 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. Augmentation with hatchery fish has proven useful for increasing the number of spawning adults following years of low natural recruitment (Archdeacon et al. 2023). Augmentation has slowed loss of genetic diversity, but not completely prevented it (Osborne et al. 2023). New conservation tools are needed to offset low natural recruitment and high summer mortality during moderate and extreme drought years.

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DATA AVAILABILITY

Data used in this study are available at Mendeley Data. The citation is:

Archdeacon, Thomas (2022), “Rio Grande Silvery Minnow salvage 2007-2022”, Mendeley Data, V3, doi: 10.17632/c4j4dttksm.4

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