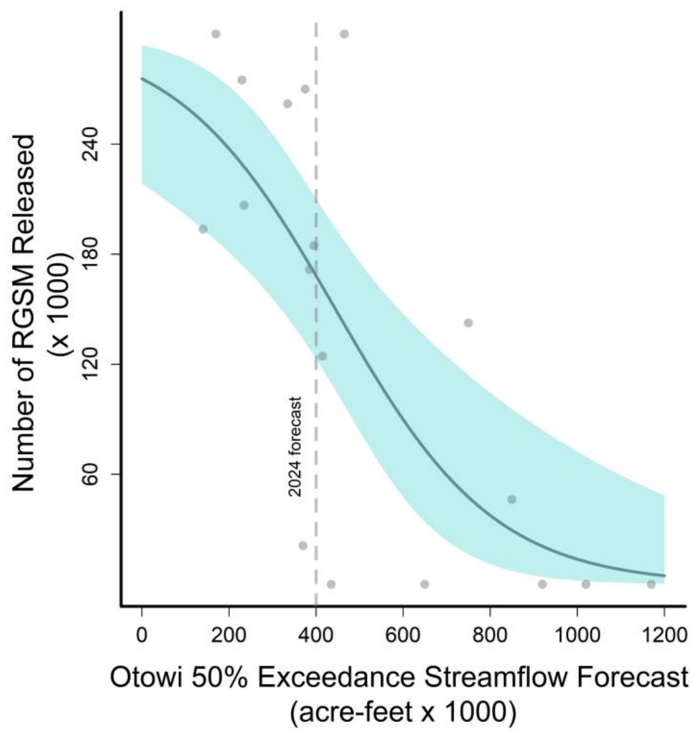
RIO GRANDE SILVERY MINNOW AUGMENTATION IN THE MIDDLE RIO GRANDE, NEW MEXICO

Annual Report 2024



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DISCLAIMER

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

- This report covers New Mexico Fish and Wildlife Conservation Office (NMFWCO) Rio Grande Silvery Minnow (RGSM) augmentation activities for the 2024 cohort.
- Spring runoff in early 2024 was moderate, resulting in a request of 210,000 hatchery-reared age-0 fish to supplement the wild 2024 cohort.
- Broodstock collections April through July 2024 resulted in 220 RGSM eggs (transported to the Albuquerque BioPark), ~2,500 larval RGSM (transported to the Albuquerque BioPark), and ~750 juvenile RGSM (transported to Southwestern Native Aquatic Resources and Recovery Center). This resulted in approximately 1,800 surviving broodstock, with only 300 housed at Southwestern Native Aquatic Resources and Recovery Center.
- Based on September 2024 population monitoring, the San Acacia and Angostura Reaches had > 1.0 RGSM per $100 m^2$ but <50% occupied sites and CPUE = 0.07 in the Isleta Reach. Because the Angostura Reach was only slightly above 1.0, the NMFWCO requested additional fish be released there, leading to a final request of 130,000 RGSM for release in the San Acacia Reach.
- 163,206 hatchery-reared age-0 Rio Grande Silvery Minnows were released in October, November, and December 2024. All were given a red left VIE tag prior to release.
- 109 VIE-marked fish were recaptured between January and December 2024, all from the 2023 cohort. The majority of recaptures (N = 105) were during fish rescue activities.
- A pilot mark-recapture study continued in 2024 to determine the feasibility of robust-design mark recapture to estimate monthly survival, movement, and capture efficiency of Rio Grande Silvery Minnow. A total of 962 Rio Grande Silvery Minnow was captured in 2024 with 26 recaptures.

INTRODUCTION

In 2001, the Rio Grande Silvery Minnow *Hybognathus amarus* (RGSM) Augmentation Plan (USFWS 2001) was developed to help prevent extinction of the species by increasing their numbers in the Rio Grande. Since that time, >3 million hatchery reared RGSM have been released into the Middle Rio Grande (MRG), New Mexico. The initial goal of the RGSM Augmentation Plan was to produce 500,000 RGSM each year for release based on the expected capacities of propagation facilities, along with current population status and suggestions from geneticists. Stocking and monitoring efforts were focused on the Angostura Reach (also known as the Albuquerque Reach) where catch rates of wild RGSM were extremely low and the expected benefit of augmentation could be maximized (Remshardt and Davenport 2003). However, actual production and tagging has been limited to 300,000 or less per year since 2010 and stocking has occurred in the Angostura, Isleta, and San Acacia Reaches when needed based on autumn abundance.

Varying numbers of RGSM have been released in the MRG each year ranging from 0 to 400,000 depending on river conditions. Between 2002 and 2004, 100,000 to 200,000 RGSM were released annually in the Angostura Reach. Annual releases were based on calculations to reach target densities of 1 fish/100m^2. Starting in 2005, augmentation expanded to include the Isleta and San Acacia Reaches. In addition to augmentation and other conservation measures such as habitat improvement, improved spring runoff and habitat conditions improved survival in 2005 allowing RGSM to increase in abundance. Between 2005 and 2007, 100,000 to 400,000 RGSM were released annually throughout all reaches (Remshardt 2008). In 2008, USFWS began implementing a revised 5-year RGSM Augmentation Plan, in which the Angostura Reach was purposely not stocked in order to evaluate the effect of hatchery augmentation. Favorable spring run-off conditions for recruitment beginning in 2008 meant that no augmentation was needed that year; however, the number of RGSM stocked during the low spring run-off years of 2012 to 2014 was near maximum capacity of production facilities. Following slightly increased recruitment in 2015 and 2016, the 2017 cohort of RGSM was one of the strongest observed in the MRG. Declines during the drought years of 2020-2021 lead to an increase in the numbers of hatchery fish released.

This report summarizes augmentation planning and release activities during the 2024 calendar year. This effort addresses management needs identified in Item A.2.2 of the Middle Rio Grande Endangered Species Collaborative Program (MRGESCP), Tasks 8b and 8d of the Rio Grande Silvery Minnow Recovery Plan, 1st Revision, (Recovery Plan; USFWS 2010), and Reasonable and Prudent Measure #5 of the Biological Opinion (USFWS 2016). These tasks include development and refinement of augmentation protocols for use in the Middle Rio Grande (Task 8b) and annual monitoring of augmented populations is identified as a needed task (Task 8d).

A recovery outcome of a self-sustaining population of RGSM in the Middle Rio Grande requires numerous actions outlined in the Recovery Plan. The goal of augmentation is to support the wild population of RGSM in the Middle Rio Grande by bolstering resistance and resilience to disturbance and other environmental stressors (Archdeacon et al. 2023), until such time the population is self-sustaining. Augmentation accomplishes this goal by improving the abundance and distribution of RGSM in the Middle Rio Grande, thereby improving the demographic resilience of the species. Long-term objectives of this project are to promote the recovery of RGSM through 1) augmenting populations within the MRG with hatchery-raised fish as necessary; and 2) evaluating stocking efforts and methods to improve effectiveness of these actions.

Specific objectives of augmentation in 2024 were to implement the 5-year augmentation and stocking protocol (Archdeacon 2022), including assisting with spring production estimates, collection of eggs for broodstock and refuge populations, and calculating the number of RGSM necessary to meet target densities of 1 fish/100m^2 within each reach.

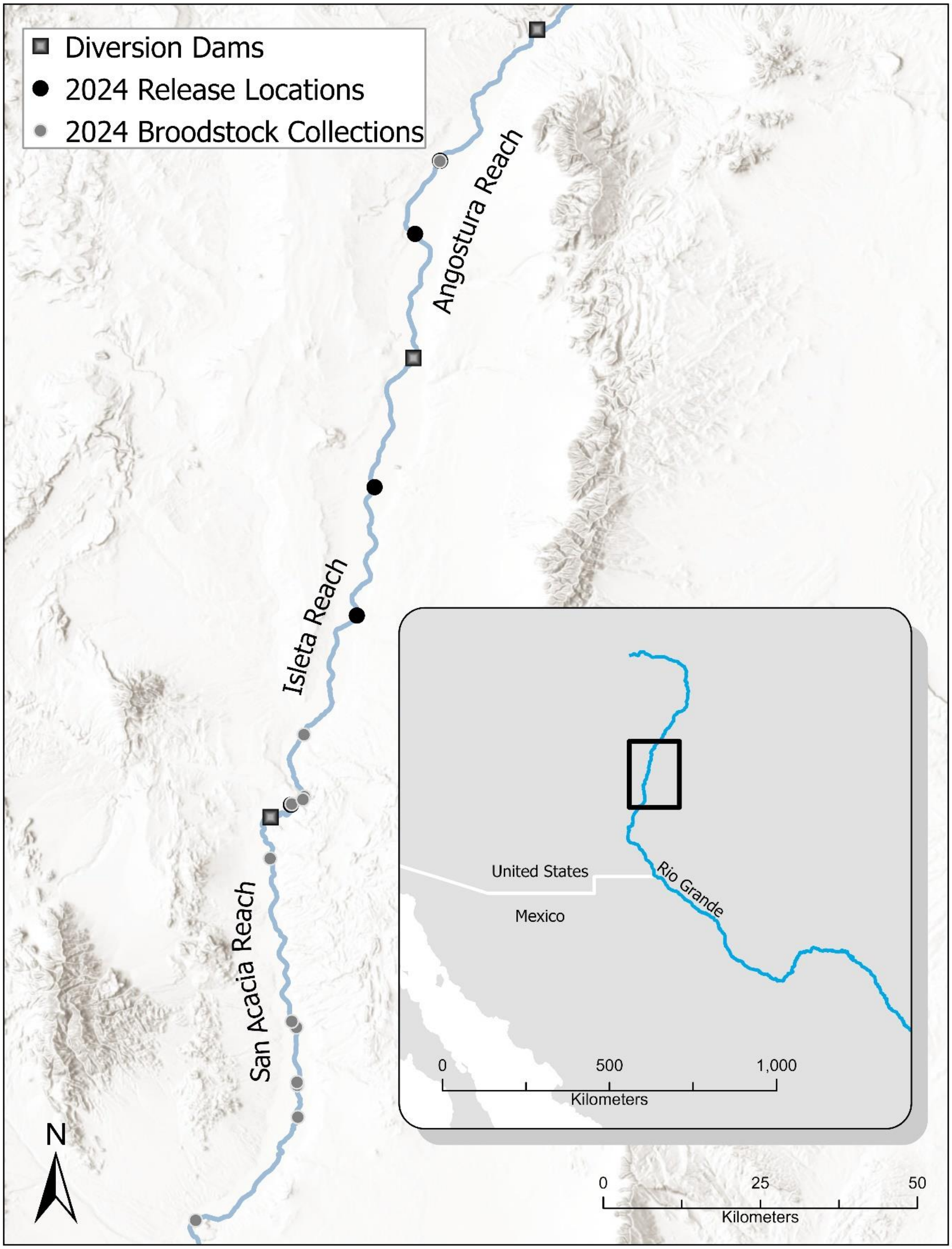

Figure 1-Locations in the Middle Rio Grande, New Mexico, where larval and juvenile fish were collected for broodstock and hatchery-reared Rio Grande Silvery Minnow were released in 2024.

METHODS

Study Area

This investigation concentrated on areas within the Angostura, Isleta, and San Acacia reaches (Figure 1). The Angostura Reach (~65 km) extends from Angostura Diversion Dam to Isleta Diversion Dam and includes the cities of Bernalillo, Corrales, and Albuquerque. The Isleta Reach (~54 km) extends from Isleta Diversion Dam to San Acacia Diversion Dam, and includes the southern portion of Isleta Pueblo, cities of Bosque Farms, Valencia, Los Lunas, Belen, and smaller villages such as La Joya, and Bernardo, along with Sevilleta National Wildlife Refuge, all within Bernalillo, Valencia, and Socorro Counties. The San Acacia Reach (~76 km) extends from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir (the exact location of the lower boundary varies depending upon reservoir water-surface elevation). This reach is relatively remote, including only the city of Socorro and villages of San Acacia, Lemitar, Escondida, and San Antonio along with Bosque del Apache National Wildlife Refuge, within Socorro and Sierra Counties.

Spring Estimation of Production Needs

Hatchery facilities must plan for spring spawning by May of each year and require estimates of numbers of fish needed for autumn augmentation. Spring planning numbers are estimated from the April 1 streamflow forecast of each year and are incorporated in a generalized linear regression model that is updated with new data each year (Figure 2). The forecasted 50% exceedance streamflow, in thousands of acre-feet (KAF), March through July at the Otowi gage (available at https://www.nrcs.usda.gov/wps/portal/wcc/home/snowClimateMonitoring/snowpack/basinDataReports/) is used to predict the actual numbers of fish released in the autumn (described below). As more years are included, the model will be able to incorporate other parameters, including existing numbers of fish from previous cohorts, which should improve both the precision and accuracy of predictions. A generalized linear regression model was used to relate actual numbers of fish needed to the spring forecast. As a conservative measure, the upper 95% confidence interval is used for the spring estimation of augmentation needs.

Collection of Wild-caught Eggs for Broodstock and Refuge Population

Rio Grande Silvery Minnow spawning typically occurs in May and June (Archdeacon et al. 2023a). Rio Grande Silvery Minnow release semi-buoyant, non-adhesive eggs directly into the water column (Platania and Altenbach 1998). During times of high spawning activity and lower discharge, eggs can be easily collected from the river (Altenbach et al. 2000). These eggs may be transported to rearing facilities to serve as broodstock or a refuge population or returned to the river in years when large numbers are collected (Archdeacon et al. 2023). During high-flow years, larvae or juveniles are collected during summer and autumn months.

Autumn Estimation of Augmentation Needs

Following the revised RGSM Augmentation Plan 2018-2022 (Archdeacon 2022), augmentation efforts were focused on all three reaches (Angostura, Isleta, and San Acacia) in 2024. September catch-rates (e.g., catch-per-unit-effort; fish/100m^2) from preliminary population monitoring results (R. Dudley, personal communication) were used as criteria to determine the need for augmentation and the number of fish required. If the entire reach average was >1.0 fish/100m^2 and >50% of monitoring sites were occupied, then augmentation was not required. If either of the criteria were not met, augmentation occurred and the total number of fish for the reach was calculated as given below (Archdeacon 2022). Surface area between sites was estimated from aerial imagery and average wetted conditions.

The number of fish to augment for each site (S_i) was determined using the following formula:

$$S_i = (C_t - C_o) \times (\text{total estimated area m}^2 \text{ between } S_i \text{ and } S_{i+1})$$

where; C_t = Target catch rate at each site, or 1 fish / 100 m^2,

C_o = Observed catch rate at site i in September

S_i = Number of fish to release at site i

S_{i+1} = Next downstream site of site i

Once the required number of fish per site was determined, it was summed per reach. The total number of fish per reach was spread among at least three release locations per reach.

Fish Condition Factor

We weighed (0.01 g) and measured (1 mm) standard and total length of at least 100 haphazardly selected (and assumed representative) fish from each facility. We calculated Fulton's condition factor (K_{tl}; see Froese 2006) for these fish; augmentation guidelines are that fish should be 45 mm TL and have a condition factor of $K_{tl} > 0.80$ to improve survival and reproduction post-release (Archdeacon 2022).

Tagging

Tagging followed the standard operating procedures for tagging Rio Grande Silvery Minnow with VIE tags. For fish released in 2024, tags were placed in the left dorsal position. All facilities used red VIE tags for marking.

Fish Releases

Rio Grande Silvery Minnow are loaded in large transport tanks at the hatcheries and are transported to a site where trucks can get close to flowing water. River water was used to temper the tanks to within 1°C of the river water. The RGSM are then released directly from the trucks into areas of low or zero velocity water at stocking sites. If the transport trucks are unable to get access to the river, RGSM are loaded into smaller transport tanks in the back of off-road vehicles following transport protocols developed for RGSM fish rescue along with the tempered water, and then driven to the river and released into low velocity habitats. Specific timing and release sites are chosen to avoid releasing fish directly at standard monitoring sites. A minimum of three release locations are chosen for each reach, based on the areas with the lowest densities and river access (Archdeacon 2022).

Recapture Data from Other Researchers

Recapture data collected from other researchers continue to provide valuable information on movement and survival of VIE marked fish. Included in this year's summary are collections from standard population monitoring work for RGSM conducted by ASIR (American Southwest Ichthyological Researchers, LLC), data from NMFWCO RGSM fish rescue projects, the U.S. Bureau of Reclamation, and the University of New Mexico (UNM) genetic monitoring. These researchers were asked to provide recapture information on VIE-marked RGSM. These projects have varying objectives and methods, but a summary of recaptures can provide an overall view of RGSM movement and retention in release areas.

RESULTS

Spring Estimation of Production Needs

The forecasted 50% exceedance flow at Otowi for March through July was 400 KAF (Figure 2). This resulted in a request for 210,000 age-0 Rio Grande Silvery Minnow to be spawned and reared for augmentation in autumn.

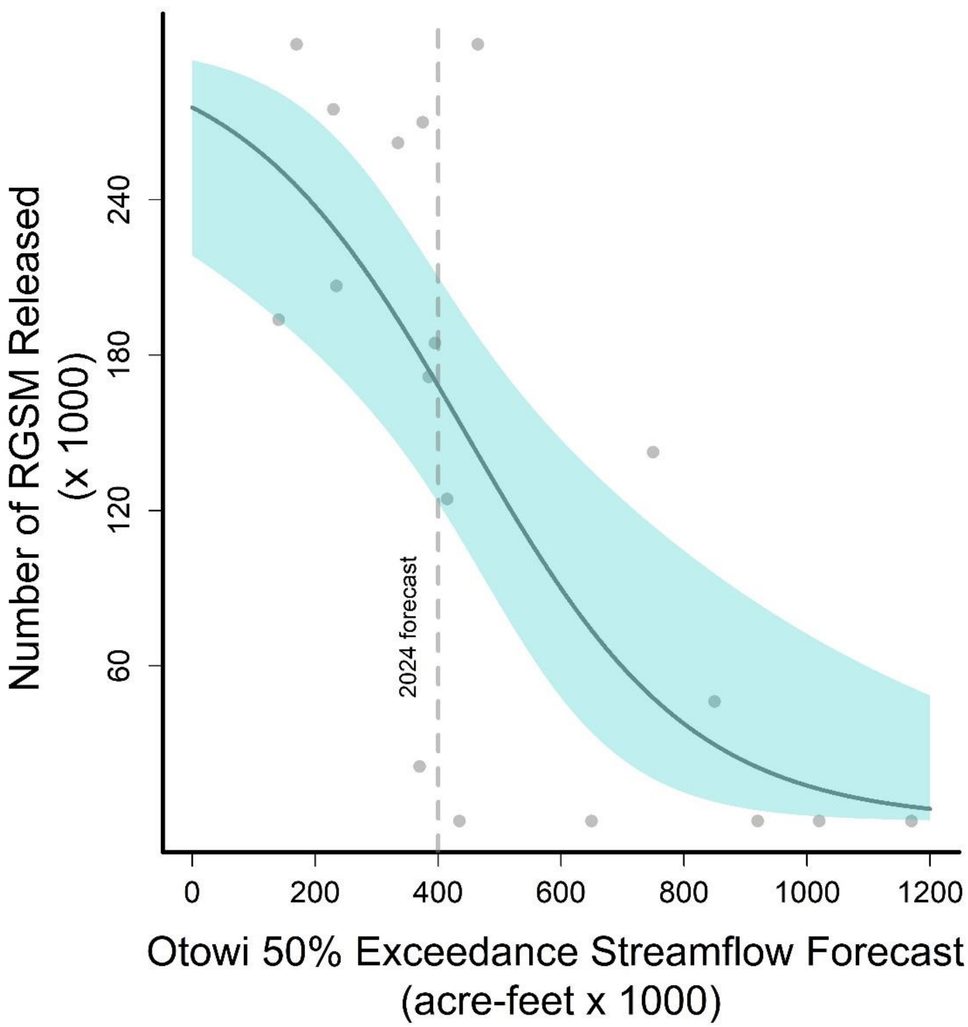

Figure 2- Association between numbers of Rio Grande Silvery Minnow released in autumn and the forecasted spring-summer streamflow at the Otowi gage in the Rio Grande, New Mexico. The gray area represents the 95% confidence interval for numbers of hatchery fish actually required in each year. The model is updated yearly. The dashed line represents the forecasted 2024 spring flows and is used to estimate hatchery production of age-0 RGSM in May.

Collection of Wild-caught Eggs for Broodstock and Refuge Population

An early peak of flows in April stimulated spawning. Few eggs were collected as staff were not prepared for collections that early. In total, NMFWCO staff collected 220 eggs on 8 separate days were observed, and 64 transported to the Albuquerque BioPark for rearing. Use of larval light traps resulted in ~1,000 RGSM transferred to the Albuquerque BioPark for rearing. Staff were able to collect 772 young-of-year with seines in June and July (Appendix A). These fish were treated for infections and reared to a size large enough to identify. After identification, these fish were transferred to the Albuquerque BioPark or SNARRC.

Estimation of Augmentation Needs

Based on September 2024 catch rates from the standard RGSM monitoring program conducted by ASIR, the Angostura and San Acacia Reaches had CPUE > 1.0 fish 100 m^{-2}, but the Isleta Reach had < 50% site occupancy and CPUE = 0.07 (Table 1). The Isleta Reach required 79,000 RGSM for augmentation. However, the Angostura Reach CPUE was only 1.06 and an additional 50,000 were released there were excess fish from the spring request.

Table 1- Rio Grande Silvery Minnow monitoring sites, approximate surface area (ha) between it and the next site downstream during baseflows, and observed CPUE in September 2024, in the Middle Rio Grande, New Mexico. DD = Diversion Dam, NWR = National Wildlife Refuge, RRWWTP = Rio Rancho Wastewater Treatment Plant, SM = San Marcial. *No stocking was necessary because CPUE was > 1.0 fish 100 m^{-2} and reach occupancy > 0.50.

Reach	*Site*	*Area (ha)*	*Density (fish/100m^2)*	*Fish required*
Angostura	Angostura DD	165.7	0.00	17000
	Bernalillo	72.6	1.20	0
	RRWWTP	425.1	0.36	27000
	Central	141.8	0.61	6000
	Rio Bravo	428.1	3.13	0
	Reach Total/Average	-	1.06	0*
Isleta	Los Lunas	280.4	0.00	28000
	Belen	148.9	0.23	11000
	Jarales	235.4	0.19	19000
	Bernardo	40.8	0.00	4000
	La Joya	149.0	0.00	15000
	Above San Acacia DD	20.4	0.00	2000
	Reach Total/Average	-	0.07	79,000
San Acacia	San Acacia DD	15.5	4.82	0
	Below San Acacia DD	218.9	0.99	10000
	Socorro	167.5	0.38	2000
	Neil Cupp	81.9	0.78	10000
	San Antonio	97.8	0.00	0
	Bosque NWR	107.1	5.36	0
	San Marcial	70.6	5.06	0
	8 Mile below SM	15.6	7.68	6000
	10 Mile below SM	77.9	0.18	0
	Reach Total/Average	-	2.81	0*

Fish Condition Factor

Fish were weighed and measured 23 October (LLSMR and BioPark), or 20 November 2024 (Southwestern ARRC). Fish from Southwestern ARRC averaged 48.6 mm TL and had an average K_{tl} = 0.93. Fish from the LLSMR averaged 60.8 mm TL and had an average K_{tl} = 0.81. However, fish from the LLSMR 2023 (age-1) captive spawned fish averaged 66.8 mm TL and K_{tl} = 0.80, whereas the 2024 (age-0) captive spawned fish and in the outdoor refugium averaged 54.8 mm TL and K_{tl} = 0.82. Fish from the Albuquerque BioPark averaged 51.1 mm TL and had an average K_{tl} = 0.90.

Tagging

Tagging was completed at Southwestern ARRC, Albuquerque BioPark, and Los Lunas SMR. All fish were given red left VIE markings.

Fish Releases

A total of 163,206 RGSM were released at five sites in 2024 (Figure 1, Table 2). Two sites were located in the Angostura Reach (N = 50,145) and the remaining three sites in the Isleta Reach (N = 113,061). Additional fish were available and released in the Isleta Reach, above and beyond the requested amount.

Recapture Data

A total of 109 VIE-marked fish were recaptured between January and December 2024. Of these, 105 were from the 2023 release cohort. The majority of recaptures (N = 1055) were during fish rescue activities.

Table 2-Sites in the Middle Rio Grande, New Mexico, where Rio Grande Silvery Minnow were released in November and December 2024, the color of the hatchery mark, the source of the fish (Southwestern ARRC = Southwestern Native Aquatic Resources and Recovery Center, ABQ = Albuquerque BioPark Aquatic Conservation Facility, date released, and the number released.

Reach	*Site*	*Source*	*Number*	*Date*	*RM*	*Mark*
Angostura	Alameda	Southwestern ARRC	25,145	11/25/2024	191.1	Red Left
Angostura	Central	Albuquerque BioPark	25,000	10/24/2024	182.8	Red Left
Isleta	Los Chaves	Albuquerque BioPark	25,000	11/26/2024	155.6	Red Left
Isleta	Jarales	Los Lunas SMR (age-0)	13,023	12/2/2024	141.3	Red Left
Isleta	Jarales	Los Lunas SMR (age-1)	9,694	12/2/2024	141.3	Red Left
Isleta	Sevilleta	Southwestern ARRC	63,664	11/25/2024	118.7	Red Left
Total			163,206			

DISCUSSION

Over the preceding decade, RGSM densities have varied greatly from year to year. Beginning in 2015, numbers began to increase through 2017. In 2017, high spring runoff led to very high densities of RGSM. However, after poor recruitment in 2018 and 2020-2022, the annual numbers of fish needed for augmentation increased. The association between the spring hydrograph and the density of RGSM detected the following October is well established Yackulic et al. 2022). The spring 2023 estimate based on forecasted streamflow suggested no fish would be needed in the autumn, but 60,000 were requested as minimum production. The high spring runoff peak prevented large egg collections, but many larvae and juveniles were collected when flows began to recede. However, considerable drying in the San Acacia Reach resulted in the need to stock fish, as <50% of the monitoring sites had RGSM present. There is still considerable variability and uncertainty in autumn planning needs when average flows are between approximately 50 and 80%, though the years 2010 and 2018 appear to be outliers. As more data is collected, this relationship should be clarified, allowing for more precise estimates of augmentation needs in spring. The variability may be linked to the abundance of the previous years' cohort.

Fish from all Southwestern ARRC, LLSMR, and the BioPark were generally in good condition ($K_{tl} < 0.80$). Approximately 30,000 age-0 fish were held back at the Southwestern ARRC to help evaluate how body condition and size of hatchery fish influences survival and performance after release. Making these determinations will help guide and improve propagation practices.

Rio Grande Silvery Minnow exhibit an opportunistic life-history with high demographic resilience (Winemiller 2005), with short generation times, high reproductive effort (Caldwell et al. 2019), high mobility (Archdeacon et al. 2018, Platania et al. 2020), and a short lifespan (Horwitz et al. 2018). Having high demographic resilience allows the population to rebound quickly after disturbance. Over the previous five years, populations increased in 2017, followed by four years of extreme annual variability in spring runoff. Populations rebounded in 2019 after poor runoff and recruitment conditions in 2018 (Archdeacon et al. 2020). Thus, continued augmentation will be necessary in some years if spring run-off continues to be low and below average and no other options to improve recruitment exist. However, continued and heavy hatchery augmentation to stave off extinction has eroded RGSM genetics (Osborne et al. 2024).

Further refinement of production, release, as well as refining release numbers may help improve the effectiveness of augmentation but will not replace habitat and flow restoration.

ACKNOWLEDGEMENTS

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DATA AVAILABILITY STATEMENT

All Rio Grande Silvery Minnow release and recapture data are available upon request.

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Appendix B:

Broodstock Collection Summary

CollectionID	Date	Gear	RKM	Lat	Long	Notes
TPA24-006	4/23/2024	3 MEC 4 hours	292	34.19681	-106.888	64 eggs
TPA24-006b	4/24/2024	quadrafoil larval light trap	292	34.19681	-106.888	No visible fish
TPA24-007	4/24/2024	4 MEC 3 hours	292	34.19681	-106.888	14 eggs
TPA24-007b	4/24/2024	quadrafoil larval light trap	292	34.19681	-106.888	No visible fish
TPA24-007c	4/25/2024	5 MEC 4 hours	292	34.19681	-106.888	86 eggs
TPA24-008	4/26/2024	4 MEC 1 hours	292	34.19681	-106.888	0 eggs
TPA24-009	5/1/2024	3 MEC 4 hours	253.9	33.82755	-106.848	34 eggs
TPA24-010	5/2/2024	quadrafoil larval light trap	258.5	33.87288	-106.849	No fish observed
TPA24-011	5/2/2024	3 MEC 4 hours	253.9	33.82755	-106.848	16 eggs
TPA24-012	5/3/2024	4 MEC 3 hours	253.9	33.82755	-106.848	6 eggs
TPA24-013	5/3/2024	quadrafoil larval light trap	258.9	33.87716	-106.849	No visible fish
TPA24-013b	5/3/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	No visible fish
TPA24-014	5/6/2024	2 MEC 3 hours	253.9	33.82755	-106.848	0 eggs
TPA24-016	5/7/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	Some visible fish
TPA24-020	5/8/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	No fish observed
TPA24-021	5/9/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	No fish observed
TPA24-023	5/10/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	No
TPA24-024	5/14/2024	quadrafoil larval light trap	303.8	34.27473	-106.857	2 in return drain, 1 in river
TPA24-025	5/14/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	Some fish but likely carp
TPA24-026	5/14/2024	quadrafoil larval light trap	305.8	34.28511	-106.839	Many fish, too small to ID
TPA24-027	5/15/2024	quadrafoil larval light trap	303.8	34.27473	-106.857	2 in return drain, 1 in river, some fish
TPA24-028	5/15/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	Some fish but likely carp
TPA24-029	5/15/2024	quadrafoil larval light trap	305.8	34.28511	-106.839	Some fish
PMD24-001	5/16/2024	quadrafoil larval light trap	305.8	34.28511	-106.839	few fish, likely carp
PMD24-002	5/16/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	some fish, unidentifiable
PMD24-003	5/16/2024	quadrafoil larval light trap	303.8	34.27473	-106.857	few fish visible
PMD24-004	5/17/2024	quadrafoil larval light trap	305.8	34.28511	-106.839	few fish visible
PMD24-005	5/17/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	few fish visible
PMD24-006	5/17/2024	quadrafoil larval light trap	303.8	34.27473	-106.857	few fish visible
TPA24-030	5/21/2024	quadrafoil larval light trap	292	34.19681	-106.888	Some fish, non-carp
TPA24-031	5/21/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	Few fish
TPA24-032	5/22/2024	quadrafoil larval light trap	292	34.19681	-106.888	Many fish
TPA24-033	5/22/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	Some fish
TPA24-034	5/23/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	lots of fish
TPA24-035	5/23/2024	quadrafoil larval light trap	292	34.19681	-106.888	Some fish

TPA24-036	5/24/2024	quadrafoil larval light trap	305.4	34.28128	-106.841	lots of fish
TPA24-037	5/24/2024	quadrafoil larval light trap	292	34.19681	-106.888	some fish
TPA24-038	5/29/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	lots of fish, possibly carp
TPA24-039	5/30/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	lots of fish, possibly carp
TPA24-040	5/31/2024	quadrafoil larval light trap	266.6	33.95574	-106.85	some fish, possibly carp
PMD24-007	6/4/2024	quadrafoil larval light trap	267.6	33.9642	-106.857	some fish, possibly carp
PMD24-008	6/5/2024	quadrafoil larval light trap	267.6	33.9642	-106.857	carp visible
PMD24-009	6/6/2024	quadrafoil larval light trap	267.6	33.9642	-106.857	few fish, carp
TPA24-043	6/17/2024	Seine hauls	231.7	33.68012	-106.994	120-150 RGSM YOY
JLS24-001	6/18/2024	Seine hauls	231.7	33.68012	-106.994	50 YOY RGSM
JLS24-002	6/18/2024	Seine hauls	224.8	33.6216	-107.006	150 YOY RGSM
TPA24-044	6/20/2024	Seine hauls	292	34.19681	-106.888	only adult RGSM no YOY, 50 cyplut for Phil
TPA24-045	6/20/2024	Seine hauls	224.8	33.6216	-107.006	100-150 YOY RGSM
JLS24-003	6/25/2024	seine hauls	405.4	35.19284	-106.645	No silvery minnow
JLS24-004	6/26/2024	seine hauls	315.3	34.3736	-106.839	75 RGSM
JLS24-005	7/8/2024	seine hauls	224.8	33.6216	-107.006	122 RGSM
JLS24-006	7/9/2024	seine hauls	315.3	34.3736	-106.839	120 RGSM

Appendix B:
Feasibility of Robust-Design Mark-Recapture for Rio Grande Silvery Minnow
Year 3

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Introduction

The Rio Grande Silvery Minnow is a small-bodied minnow that currently only found in the Rio Grande in central New Mexico. The range of the Rio Grande Silvery Minnow (*Hybognathus amarus)* has been severely reduced and it now inhabits only 5% of its historical range, occurring from Cochiti Dam downstream to Elephant Butte Reservoir (Bestgen and Platania 1991). This loss of habitat has been caused by fragmentation due to dams constructed for water diversions, which has also led to modified flow regimes and periodic channel drying during summer months. Due to this decline, the Rio Grande Silvery Minnow was listed as endangered in 1994 (USFWS 1994) and since then has been the focus of regular monitoring, augmentation, and relocation during dewatering (USFWS 2010). In order to evaluate recovery efforts, catch per unit effort (CPUE) is used as a metric as part of both the Rio Grande Silvery Minnow Recovery Plan and Annual Augmentation Plan.

In support of improving the knowledge of the biology and ecology of Rio Grande Silvery Minnow, the New Mexico FWCO will work to improve the reliability of the CPUE metric. Several reviews of the long-term population monitoring program (e.g., Dudley et al. 2022) have recommended determining additional studies on the relationship between CPUE and abundance and developing correction factors to account for variable capture efficiencies among sites, years, and discharges (Hubert et al. 2016; Noon et al. 2017) improve the reliability of CPUE.

Capture-recapture is the gold standard in wildlife and fisheries studies for making inferences about demographic rates and overall abundance. While it is possible to estimate these quantities without marking individuals, approaches that rely on unmarked fish are less precise and less robust to violations of assumptions. For managers, the costs of imprecise estimates are a poorer understanding of the drivers of population dynamics and less clarity regarding the appropriate management responses. In recent years, modelling approaches have been developed to integrate intensive capture-recapture data collected over limited spatial scales and temporal scales with more extensive, but less informative data (e.g., catch per unit effort data) to reach robust inferences that build on the relative strengths on these two data types. Survival and abundance estimate from RGSM capture-recapture would be invaluable for evaluating estimates from models based on cruder data and would be integrated to improve our overall understanding of RGSM demography and the impacts of various management actions on RGSM population dynamics.

Objectives

The overarching objectives of this mark-recapture study is to estimate abundance of Rio Grande Silvery Minnow within a small section of the MRG, estimating and accounting for survival between sampling periods, immigration and emigration between sampling periods, and capture efficiency. After sampling in multiple areas and years, we plan to synthesize results to improve the utility of CPUE, which can be collected on a much larger spatial scale with less effort. We determined that an initial pilot study would be beneficial to determine the feasibility of initial study design and expected recapture rates. Full methodology will be developed after this initial study and yearly review. Here, we examined sub-reach lengths and number of hauls that would be reasonable to sample to determine expected capture and recapture rates. These may need to be adjusted during years of high abundance. Visible implant elastomer (VIE) tags will be used to mark RGSM and surrogate species greater than 30 mm standard length (SL), the color and placement of the tag indicating the time period and sub-reach in which it was caught. Thus, both capture history and movement among sub-reaches can be determined and used to estimate population size, capture efficiency of seines, monthly survival, and to a limited extent, movement. Here we summarize the 2024 efforts and compare changes in methodology as well as RGSM catch rates.

Methods

For the third year of the initial pilot study, a 1.6 km portion of the San Acacia reach was chosen and divided into four equal-length sections of 400 m (Figure 3). The sampling location was chosen arbitrarily with the intention of having relatively more RGSM present for capture because it has not experienced river drying in at least the past two decades (Archdeacon and Reale, 2020) and had a variety of mesohabitats present. This was the same area used in 2022 and 2023. We conducted sampling four times, one week apart, covering a total sampling period of four weeks. Sampling began on September 23 and concluded October 16. On the first day, sub-reaches 1 and 2 were sampled by conducting 10 seine hauls per 100 m of stream length, totaling 40 seine hauls per sub-reach. We employed a seine (3.0 x 1.0 m, mesh size = 3.2 mm) and varied the habitat and length evaluated as much as possible. On the second day, sub-reaches 3 and 4 were sampled with the same methodology. All RGSM captured were >30 mm in length and VIE tagged.

Fish were marked with a unique VIE color in one of several locations, allowing movement among sub-reaches to be inferred. We used yellow VIE for sampling trip 1, green VIE for sampling trip 2, and orange VIE for sampling trip 3. The location of the VIE mark indicated which sub-reach the fish was caught in, starting with the right pre-dorsal for sub-reach 1 and moving clockwise around the dorsal fin for the other three reaches (Figure 4). Methods on days 1 and 2 were repeated on days 3 and 4 to increase the numbers of marked fish (i.e., no fish were double-tagged with the same color and position during the second pass). During the fourth sampling trip, we did not mark any new fish and only noted if the fish did or did not have a VIE tag from a previous trip.

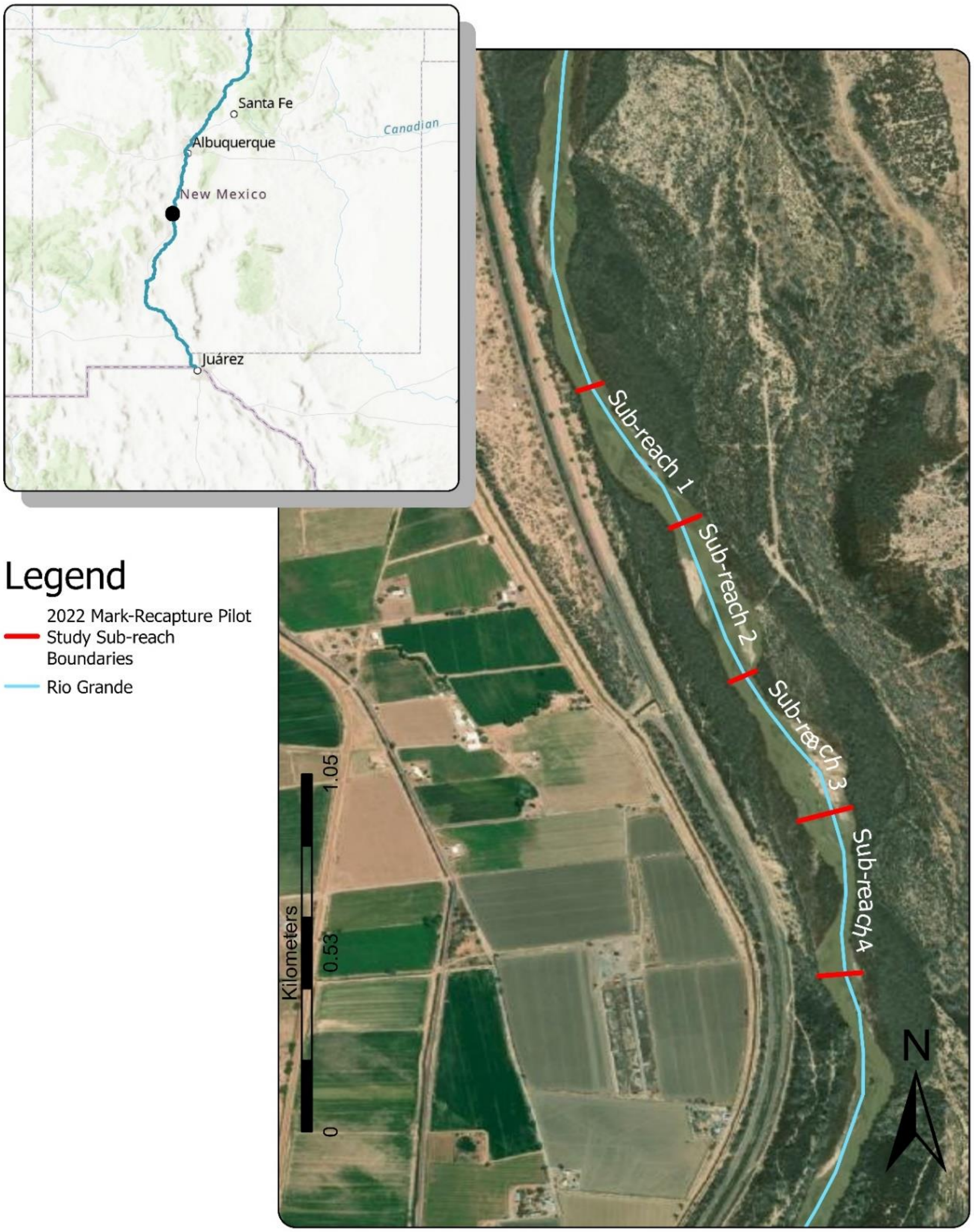

Figure 3- Map depicting the location of the 2022-2024 mark-recapture study and the division of the sub-reaches along the 1.6 km long reach.

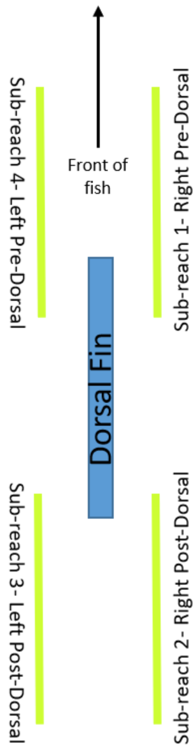

Figure 4- Location of visible implant elastomer (VIE) marks used during the study to indicate the sub-reach where the fish was captured.

Results, Discussion, and Recommendations

We caught fewer RGSM in 2024 compared to 2023, but still captured a considerable number of RGSM. Among 6 total marking passes (960 seine hauls), we collected 792 unmarked RGSM. No fish were marked in the seventh and final pass, and we collected an additional 144 Rio Grande Silvery Minnow. We recaptured 26 RGSM in total. All RGSM were large enough to be marked. Summary of capture histories are given Table 1.

The number of target species may allow use of mark-recapture models. Despite capturing three orders of magnitude more fish in 2023, the length of stream and number of seine hauls is reasonable to sample in a 4-day sampling period. Unfortunately, recaptures were still relatively low. Potentially, shortening the time interval between marking events may increase the number of recaptures, as our results make it evident that capture probability*availability is low, fish are moving among segments and likely out of the study area, and we are increasing mortality by handling fish.

Table 1-Frequency of mark-recapture histories for batch-marked Rio Grande Silvery Minnow in September and October of 2023. Fish were captured in four contiguous 400-m sections of the Middle Rio Grande during three marking periods (T1, T2, and T3) with two passes each (P1 and P2), and one recapture period sampled with a single pass (T4). Cell number indicate in which of the four sections fish were marked and recaptured.

t1p1	t1p2	t2p1	t2p2	t3p1	t3p2	t4	frequency
1							72
2							36
3							45
4							53
	1						51
	2						31
	3						27
	4						33
		1					19
		2					22
		3					23
		4					25
			1				39
			2				16
			3				32
			4				37
				1			29
				2			18
				3			27
				4			35
					1		47
					2		20
					3		18
					4		37
						1	69
						2	28
						3	15
						4	32
1	1						2
1					1		1
1					4		1
2		4					1
2						1	1

t1p1	t1p2	t2p1	t2p2	t3p1	t3p2	t4	frequency
4	1						3
4			3				1
4			4				1
4					1		2
		1			1		1
		1			4		1
		1		1		1	1
		1				1	2
		3		3			1
		4		3			1
		4		4			1
		4			3		1
				1	1		1
				1	4		1
				1		4	1
				3		1	1

Streamflow was relatively stable among sampling periods (Figure 3). However, a small flow pulse occurred between time period 1 and 2. Number of fish captured remained similar, but fish may have redistributed during flow increases (Franssen), reducing the number of recaptures. Accounting for movement during lower, stable flows will be critical to determining fish turnover due to movement during floods. Our primary recommendation for 2024 is to condense sampling to consecutive weeks and begin in autumn to improve survival and recapture. Regardless of the sampling methods, if there are not sufficient numbers of Rio Grande Silvery Minnow in the sampling segment to allow recapture within and among time periods, no estimates of survival, movement, or abundance can be made.

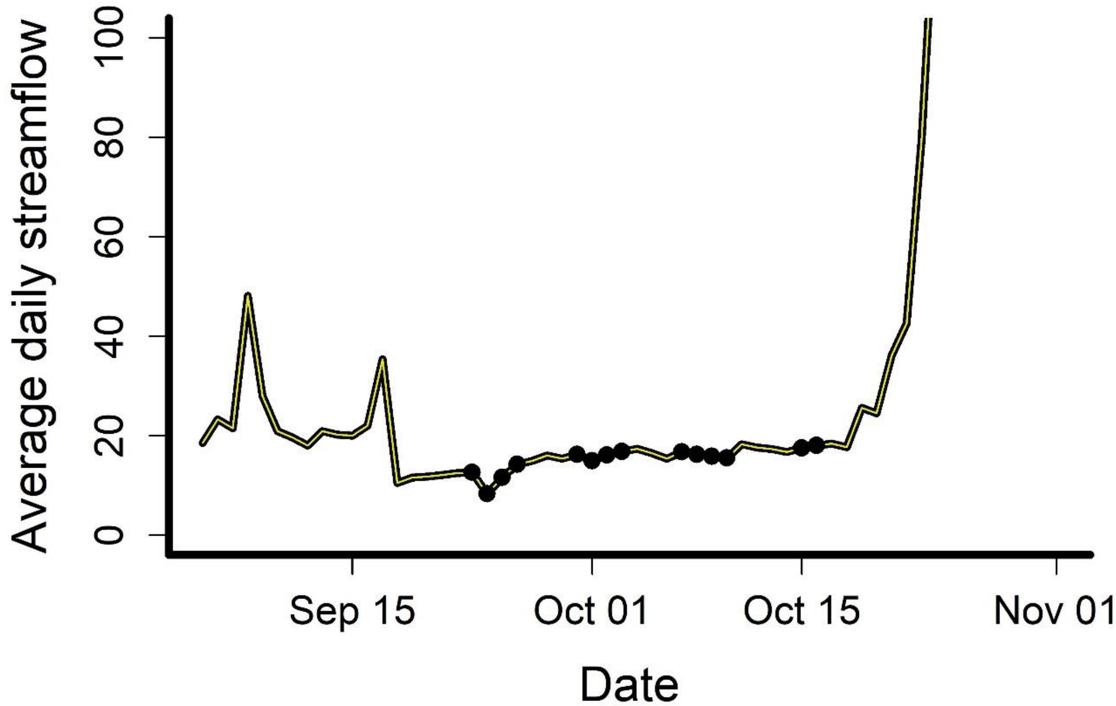

Figure 3-Streamflow (cfs) at the Escondida gage (U.S.G.S. gage 08355050) during the mark-recapture study period in the Middle Rio Grande, 2023. Points indicate days sampling occurred.

Fish lengths over the entire three years were variable by year reflecting patterns of both recruitment and growth (Figure 4). In 2022, very few fish were captured. In 2023, nearly all fish captured were age-0, with a modal standard length around 45 mm. However, in 2024, there appears to be a bi-modal distribution of lengths, with peaks around 57 mm and 70 mm, suggesting two age classes of Rio Grande Silvery Minnow present. However, age-2 fish would have been hatched in 2022, during a year of low recruitment. Other explanations for the bi-modal peak overserved in 2024 could be different growth rates among fish within a cohort leading to the bi-modal pattern, or simply sampling error. Without the context of the time-series, the two peaks could easily be mistaken for two different year-classes, but this is unlikely as only seven fish were captured in 2022, and a clear peak of age-1 fish does not appear in 2023.

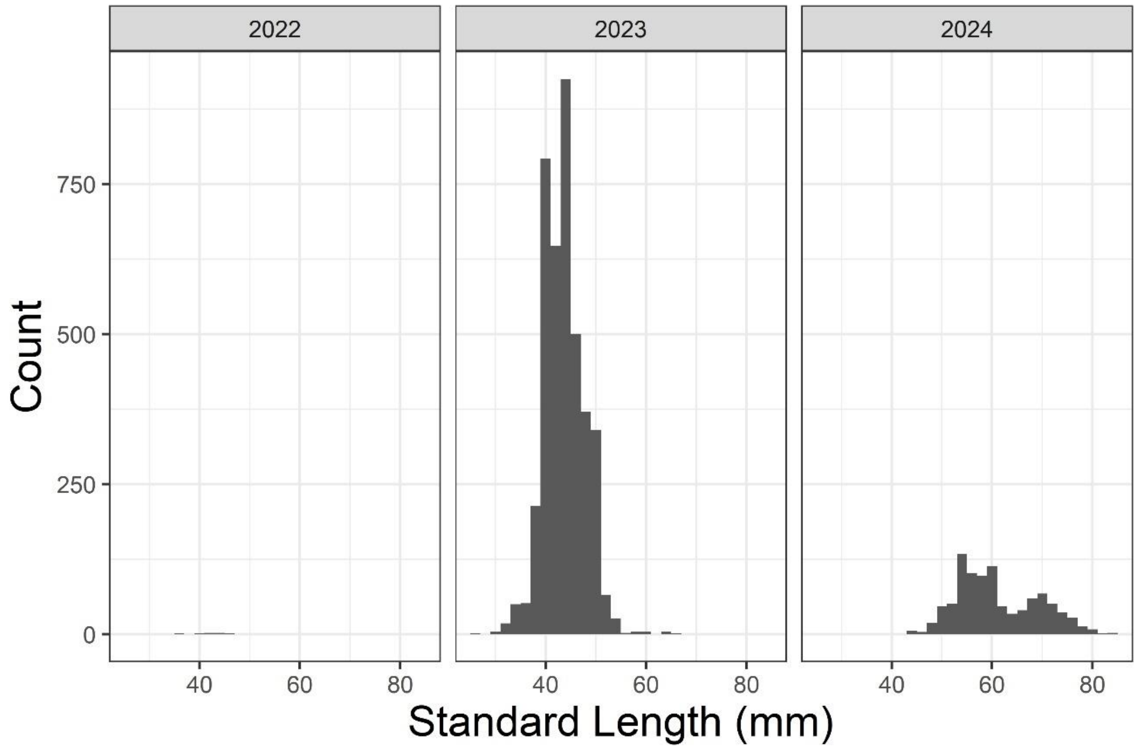

Figure 4-Standard lengths of Rio Grande Silvery Minnow captured by year during a mark-recapture study in the San Acacia Reach during September and October each year.

In 2024, we sampled weekly as opposed to bi-weekly as in 2022 and 2023. Decreasing the time period between sampling events may have increased the number of recaptured fish. The low number of recaptures is likely attributable to movement outside the study area, low weekly survival, and low capture efficiency.

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