RIO GRANDE SILVERY MINNOW AUGMENTATION IN THE MIDDLE RIO GRANDE, NEW MEXICO Annual Report 2021

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

Annual Report 2021

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EXECUTIVE SUMMARY

- This report covers New Mexico Fish and Wildlife Conservation Office (NMFWCO) Rio Grande Silvery Minnow (RGSM) augmentation activities for the 2021 cohort.
- Spring runoff in early 2021 was moderately low, resulting in a request of 240,000 hatchery-reared age-0 fish to supplement the wild 2021 cohort and an additional 12,000 for a movement study.
- The colors of visible implant elastomer (VIE) tags used for identifying RGSM released in 2021 were yellow right dorsal for the Albuquerque BioPark Aquatic Conservation Facility (BioPark), red right dorsal for the Southwestern Native Aquatic Resources and Recovery Center (Southwestern ARRC), and green right dorsal for the Los Lunas Silvery Minnow Refugium (LLSMR). Additionally, RGSM tagged with passive integrated transponders (PIT) for a fish movement study were tagged with blue VIE on the right dorsal. Fish were tagged to the extent possible within constraints during the COVID-19 pandemic.
- Based on September 2021 population monitoring, the Middle Rio Grande valley had less than 1.0 RGSM per $100m^2$ and greater than 50% occupied sites in the Angostura and Isleta reaches, leading to a final request of 124,000 RGSM. The San Acacia reach required no augmentation based on September 2021 monitoring; however, subsequent drying occurred and 41,000 additional RGSM were requested for release in the San Acacia reach in anticipation of the effects of drying on the wild population.
- Approximately 194,511 hatchery-reared age-0 Rio Grande Silvery Minnows were released in November and December 2021. Of these, 94,222 were given a VIE tag prior to release.
- 4,873 PIT tagged fish were released in March and another 9,338 were released in December 2021 in support of a fish movement study

- 337 VIE-marked fish were recaptured between January and December 2021, with 1 from the 2019 cohort, 272 from the 2020 cohort, 53 from the 2021 cohort, and 11 PIT-tagged RGSM. The majority of recaptures (N = 271) were during fish rescue activities, including the single fish from the 2019 cohort.

INTRODUCTION

In 2001, the U.S. Fish and Wildlife Service (USFWS 2001) developed methods and implemented a captive propagation and augmentation program (Augmentation Plan) for the Rio Grande Silvery Minnow *Hybognathus amarus* (RGSM). The Augmentation Plan (USFWS 2018a) was developed to help prevent extinction of the species by increasing their numbers in the Rio Grande and is updated every 5-years based on new information. Since that time, ~3.3 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 up to 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 has been limited to less than 300,000 per year since 2010 and stocking has occurred in all river reaches 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. In 2005, augmentation expanded to include the Isleta and San Acacia Reaches. Improved spring runoff and habitat conditions improved recruitment in 2005 allowing RGSM to naturally increase in abundance. Between 2005 and 2007, 100,000 to 400,000 RGSM were released annually throughout all reaches (Remshardt 2008). 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. In 2018, another revised 5-year RGSM Augmentation Plan was implemented, guiding augmentation efforts through 2022 (USFWS 2018a).

This report summarizes augmentation planning and release activities between April and December 2021, following the 2021 cohort through the 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 meeting recovery criteria outlined in the Recovery Plan (USFWS 2010), which identifies numerous actions supportive of reaching recovery. The goal of augmentation is to support the wild population of RGSM in the MRG by bolstering its resistance and resilience to disturbances until such time the population is self-sustaining. Augmentation accomplishes this by maintaining the abundance and distribution of RGSM in the MRG, thereby improving the demographic resilience of the species and maintaining genetic diversity (Osborne et al. 2012, 2020; USFWS 2018b). 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 2021 were to implement the 5-year augmentation and stocking protocol (USFWS 2018a), including assisting with spring production estimates, collection of eggs for broodstock and refuge populations, calculating the number of RGSM necessary to meet target densities of 1 fish/100m^2 within each reach, and assisting with PIT-tagging RGSM in support of movement and fish passage studies.

METHODS

Study Area

This investigation concentrated on areas within the Angostura, Isleta, and San Acacia reaches (Figure 1). The Angostura Reach (~40 mi) extends from Angostura Diversion Dam (River Mile [RM] 209.7) to Isleta Diversion Dam (RM 169.3) and includes the MRG near cities of Bernalillo, Corrales, and Albuquerque. The Isleta Reach (~54 km) extends from Isleta

Diversion Dam to San Acacia Diversion Dam and includes the MRG near 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 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 captive spawning by May of each year and estimates of numbers of fish are required to determine stocking in autumn. Spring planning numbers are estimated from the April 1 streamflow forecast of each year and are incorporated in a regression model that is updated with new data each year. We used the forecasted percent of average streamflow April through July at the Otowi gage[1] to predict the actual numbers of fish released in the autumn (described below). As more years are included, more parameters will be included in the model, such as 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.

[1] available at: https://www.nrcs.usda.gov/wps/portal/wcc/home/snowClimateMonitoring/snowpack/basinDataReports/

Collection of Wild-caught Eggs for Broodstock and Refuge Population

Rio Grande Silvery Minnow spawning typically occurs in May and June (Archdeacon et al. 2020a; Dudley et al. 2021c). Rio Grande Silvery Minnow release nearly neutrally 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 are then transported to rearing facilities to serve as broodstock or a refuge population (USFWS 2018b).

Autumn Estimation of Augmentation Needs

Following the revised Augmentation Plan (USFWS 2018a), augmentation efforts were focused on all three reaches (Angostura, Isleta, and San Acacia) in 2021. September catch-rates (e.g., catch-per-unit-effort; fish/100m^2) from RGSM Population Monitoring Program (Dudley et al. 2021b) 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 these criteria were not met, augmentation was deemed necessary and the total number of fish for the reach was calculated as given below (USFWS 2018a) and RGSM were stocked into various locations within a reach. Surface area between sites was estimated from aerial imagery and average wetted conditions.

The number of fish to augment at 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) the standard and total length of 50 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 (USFWS 2018a).

Tagging

Tagging followed the standard operating procedures for tagging Rio Grande Silvery Minnow with VIE tags (Appendix C of USFWS 2018a). For fish released in 2021, tags were placed in the right dorsal position. Yellow tags denote fish from the Albuquerque BioPark Aquatic Conservation Facility (BioPark), red tags denote fish from the Southwestern Native Aquatic Resource and Recovery Center (Southwestern ARRC), and green tags denote fish from the Los Lunas Silvery Minnow Refugium (LLSMR), Additionally, blue VIE tags represent RGSM tagged with PIT tags, which are being used in separate research. Implantation of PIT tags followed recommended procedures given in Archdeacon et al. (2009) and given a secondary blue right dorsal VIE mark.

Fish Releases

Rio Grande Silvery Minnow were loaded in large transport tanks at the hatcheries and are transported to a site where trucks are able to access the MRG. 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 these 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 (Archdeacon and

Thomas 2021) 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 RGSM Population Monitoring Program sites. A minimum of three release locations are chosen for each reach, based on the areas with the lowest densities and river access (USFWS 2018a).

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 volunteer 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 flow at Otowi for April through July 2021 was 58% of average (Figure 1). This resulted in a request for 180,000 age-0 RGSM to be spawned and reared for augmentation in autumn (Figure 1). The NMFWCO requested an additional 60,000 RGSM because of the uncertainty surrounding forecasted streamflow between 50 and 80%.

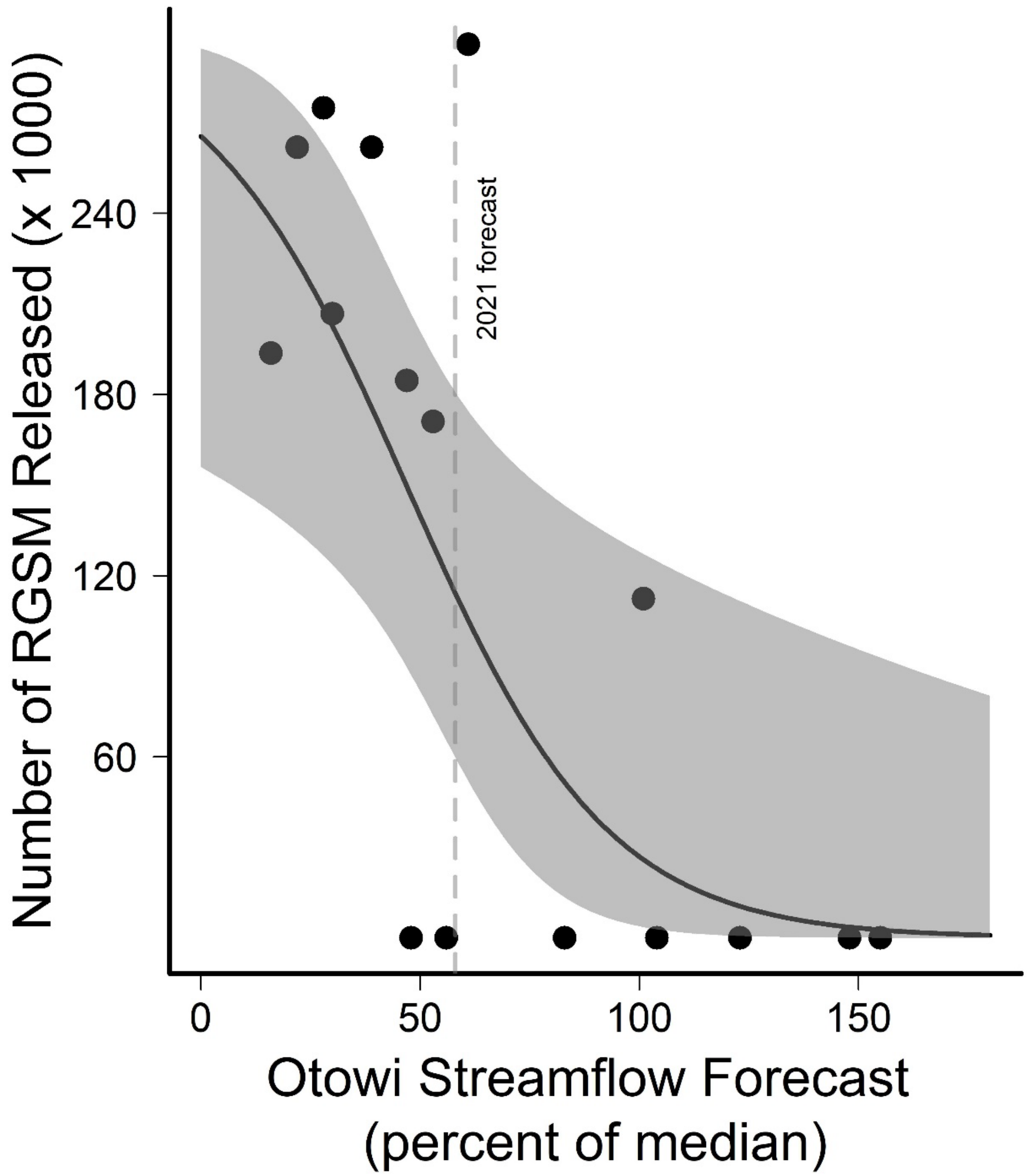

Figure 1- Association between numbers of Rio Grande Silvery Minnow released in autumn and the forecasted spring-summer streamflow at the Otowi gage in the Rio Grande, New Mexico. The gray area represents the 95% confidence interval for numbers of hatchery fish actually required in each year. The model is updated yearly. The dashed line represents the forecasted 2021 spring flows and is used to estimate production of age-0 RGSM in May.

Collection of Wild-caught Eggs for Broodstock and Refuge Population

Eggs of RGSM were collected on four days in 2021. In total, we collected 13,292 RGSM eggs in 2021 (Table 1). The overall fertilization rate of wild-caught eggs was 58% (Manuel Ulibarri, personal communication). The majority of eggs collected were transported to the Southwestern ARRC, and the majority of eggs came from site (Table 1).

Table 1-Numbers of Rio Grande Silvery Minnow eggs collected from the Rio Grande in 2021.

Date	Reach	River Mile	Number	Disposition
5/7/2021	San Acacia	86.6	6,878	Southwestern ARRC
5/11/2021	Angostura	176.0	324	Albuquerque BioPark
5/13/2021	San Acacia	86.6	4,083	Southwestern ARRC
5/14/2021	San Acacia	86.6	2,007	Southwestern ARRC

Estimation of Augmentation Needs

Based on September 2021 catch rates from the standard RGSM Population Monitoring program conducted by ASIR (Dudley et al. 2021b), Angostura and Isleta reaches had < 50% site occupancy and CPUE < 1.0 (Table 2). Angostura and Isleta reaches required augmentation with hatchery fish, totaling 124,000 fish. The San Acacia reach required no augmentation based on September 2021 monitoring; however, subsequent drying occurred and 41,000 additional RGSM were released in the San Acacia Reach in anticipation of the effects of autumn drying on wild RGSM populations.

Table 2-Rio Grande Silvery Minnow monitoring sites, approximate surface area (hectares) between it and the next site downstream during baseflows, observed CPUE (Density) in September 2021, and calculated fish required for augmentation in each reach of the Middle Rio Grande, New Mexico. DD = Diversion Dam, NWR = National Wildlife Refuge, RRWWTP = Rio Rancho Wastewater Treatment Plant, SM = San Marcial. *Reach average density and occupancy is below threshold and hatchery augmentation is required.

Reach	*Site*	*Area (ha)*	*Density (fish/100m²)*	*Fish required*
Angostura	Angostura DD	165.7	0.00	-
	Bernalillo	72.6	0.00	-
	RRWWTP	425.1	0.38	-
	Central	141.8	1.53	-
	Rio Bravo	428.1	1.17	-
	Reach Total/Average*	-	0.61	51,000
Isleta	Los Lunas	280.4	0.00	-
	Belen	148.9	0.41	-
	Jarales	235.4	0.00	-
	Bernardo	40.8	0.00	-
	La Joya	149.0	0.00	-
	Above San Acacia DD	20.4	0.00	-
	Reach Total/Average*	-	0.10	73,000
San Acacia	San Acacia DD	15.5	1.17	-

	Below San Acacia DD	218.9	0.17	-
	Socorro	167.5	3.76	-
	Neil Cupp	81.9	1.10	-
	San Antonio	97.8	4.06	-
	Bosque NWR	107.1	0.00	-
	San Marcial	70.6	0.00	-
	8 Mile below SM	15.6	0.00	-
	10 Mile below SM	77.9	0.00	-
	Reach Total/Average	-	1.14	0

Fish Condition Factor

Fish were weighed and measured 20 October 2021 (BioPark and LLSMR) or on 3 November 2021 (Southwestern ARRC). Fish from the BioPark averaged 58.4 mm TL but had an average K_{tl} = 0.73. Fish from Southwestern ARRC averaged 62.8 mm TL and had an average K_{tl} = 0.95. Fish from the LLSMR averaged 53.4 mm TL and had an average K_{tl} = 0.82. However, fish from the LLSMR that were raised in the outdoor refugium had significantly lower K_{tl}. See the data availability section for raw measurements.

Tagging

Tagging was completed at Southwestern ARRC, LLSMR and the BioPark. Fish were marked specific to their hatchery facility origin (Table 3). Due logistical constraints of the COVID-19 global pandemic, all fish from the BioPark and Los Lunas SMR were VIE-tagged, but approximately 20% of all fish from Southwestern ARRC were given a red right dorsal tag and the remaining fish were released without tags in 2021.

Fish Releases

Fish were released in November and December 2021 at 11 locations in the MRG (Figure 2; Table 3). In total, 194,511 RGSM were used for augmentation from the three facilities. The fish in excess of the requested 124,000 were released in the San Acacia Reach. Late drying, after the September monitoring efforts occurred in the San Acacia Reach. These drying events likely result in heavy mortality of any remaining RGSM (Archdeacon and Reale 2020; Archdeacon et al. 2020b), and the releases were intended to offset these losses. An additional 14,211 fish from Southwestern ARRC originally to be used for movement research were released into the San Acacia Reach based on river drying events that occurred after September surveys.

Recapture Data from Other Researchers

337 VIE-marked fish were recaptured between January and December 2021, with 1 from the 2019 cohort, 272 from the 2020 cohort, 53 from the 2021 cohort, and 11 PIT-tagged RGSM. The majority of recaptures (N = 271) were during fish rescue activities, including the single fish from the 2019 cohort that had been in the river 857 days.

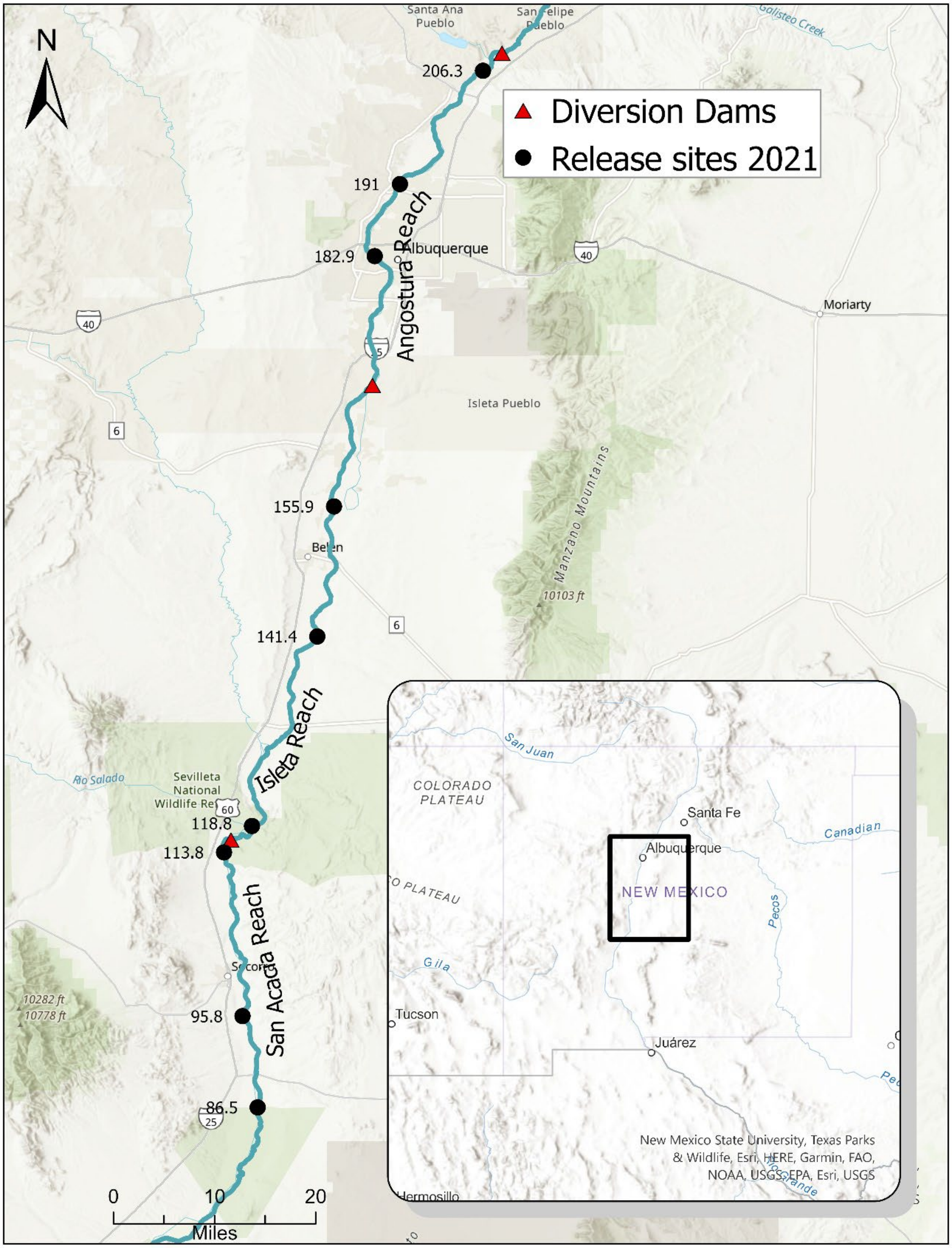

Figure 2-Locations in the Middle Rio Grande, New Mexico, where hatchery-reared Rio Grande Silvery Minnow were released in 2021.

Table 3-Sites in the Middle Rio Grande, New Mexico, where Rio Grande Silvery Minnow were released in March, November and December 2021, the color of the hatchery mark (RLD = Red Right Dorsal, YLD = Yellow Right Dorsal, GLD = Green Right Dorsal, BRD = Blue Right Dorsal), the source of the fish (Southwestern ARRC = Southwestern Native Aquatic Resources and Recovery Center, ABQ = Albuquerque BioPark Aquatic Conservation Facility, LLSMR = Los Lunas Silvery Minnow Refugium), date released, and the number released. SADD = San Acacia Diversion Dam, BDANWR = Bosque del Apache National Wildlife Refuge.

Reach	*Site*	*Source*	*Number*	*Date*	*RM*	*Mark*
Albuquerque	Santa Ana	Southwestern ARRC	6,134	11/10/2021	206.3	RRD
	Santa Ana	Southwestern ARRC	27,524	11/10/2021	206.3	No Mark
	Alameda	LLSMR	10,292	11/23/2021	191.1	GRD
	Central	ABQ	14,000	11/30/2021	182.8	YRD
Isleta	Peralta	LLSMR	10,290	11/23/2021	155.9	GRD
	Peralta	Southwestern ARRC	1,857	12/6/2021	155.9	BRD
	Jarales	ABQ	14,000	11/30/2021	141.3	YRD
	Jarales	Southwestern ARRC	1,974	12/6/2021	141.3	BRD
	U.S. 60	Southwestern ARRC	971	3/23/2021	131.3	BRD

	Sevilleta	Southwestern ARRC	967	3/23/2021	119	BRD
	Sevilleta	Southwestern ARRC	10,537	11/10/2021	119	RRD
	Sevilleta	Southwestern ARRC	51,523	11/10/2021	119	No Mark
	Sevilleta	Southwestern ARRC	2,105	12/6/2021	119	BRD
San Acacia	Below San Acacia	Southwestern ARRC	988	3/23/2021	113.7	BRD
	Below San Acacia	Southwestern ARRC	4,167	11/10/2023	113.7	RRD
	Below San Acacia	Southwestern ARRC	20,578	11/10/2023	113.7	No Mark
	Below San Acacia	Southwestern ARRC	3,402	12/6/2021	113.7	BRD
	Nine-mile Outfall	Southwestern ARRC	970	3/23/2021	103.2	BRD
	Brown’s Arroyo	LLSMR	10,290	11/23/2021	95.7	GRD
	Brown’s Arroyo	LLSMR	512	12/8/2021	95.7	Double GRD
	Brown’s Arroyo	LLSMR	664	12/8/2021	95.7	No Mark

	Bosque del Apache	ABQ	14,000	11/29/2021	86.6	YRD
	Bosque del Apache	Southwestern ARRC	977	3/23/2021	86.6	BRD
Total			208,722			

DISCUSSION

Over the preceding five years, RGSM densities have varied greatly from year to year. Beginning in 2016, 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, 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 (Dudley et al. 2021a; Archdeacon 2016). The spring 2021 estimate based on forecasted streamflow would have slightly underestimated the amount of fish needed; however, the actual number of fish released was higher based on September monitoring in an effort to make up for fish mortality during drying events occurring after the September surveys. There is still considerable variability and uncertainty in spring augmentation planning needs when average flows are between approximately 50 and 80%. As more data is collected, this relationship should be clarified, allowing for more precise estimates of augmentation needs in spring. The variability is likely linked to the abundance of the previous years' cohort. The similarity between September and October surveys should be evaluated to determine if September remains a useful proxy for October surveys, or if a correction should be added.

The vast majority of eggs collected in 2021 came from a single location. More locations and time periods should be added to diversify future collections, though flow conditions do not always allow for this. In most years, eggs are collected from all three reaches. Low flows and unpredictable spawning prevented spatially diverse collections in 2021. Possibly, samples of eggs should be evaluated to improve genetic diversity among broodstock and inform egg collections strategies.

Fish from Southwestern ARRC exhibited good body condition. Fish from the BioPark were generally in poor condition ($K_{tl} < 0.80$), whereas fish from LLSMR raised in raceways were in good condition but those raised in the refugium were in poor condition (see raw data). Future research should include studies on how body condition 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 high reproductive output but low batch fecundity (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. 2020a). Thus, continued augmentation will be necessary in some years if spring run-off continues to be low and below average.

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DATA AVAILABILITY STATEMENT

All Rio Grande Silvery Minnow release and recapture data are available on Mendeley Data at http://www.doi.org/10.17632/nwc7k6rm47.2

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