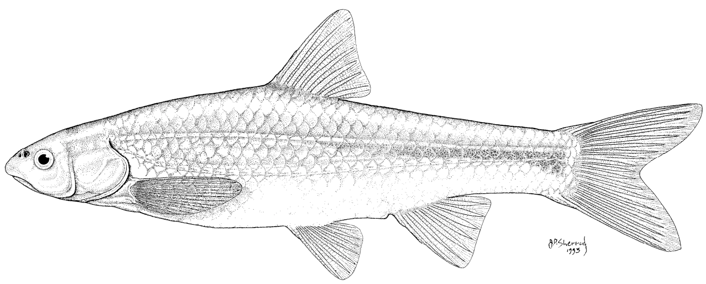
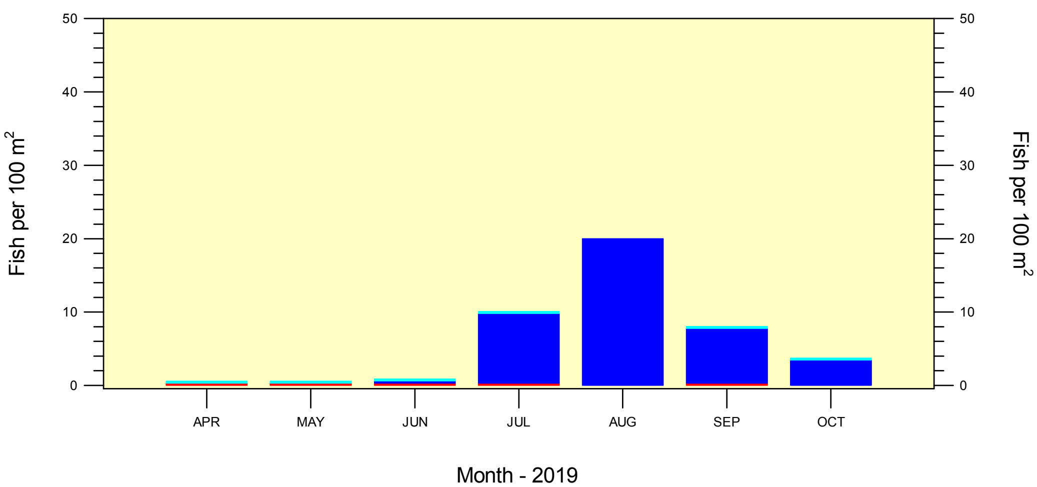
Rio Grande Silvery Minnow Population Monitoring during 2019

A U.S. Bureau of Reclamation Funded Research Program





Final Report
7 May 2020

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EXECUTIVE SUMMARY

As part of the Rio Grande Silvery Minnow Population Monitoring Program, the status of this imperiled species and the associated Middle Rio Grande ichthyofaunal community has been systematically monitored since 1993. This effort is unique among ichthyofaunal research studies in the Middle Rio Grande in that it has been providing consistent sampling of fishes over a very long duration. Long-term sampling studies, like this one, also provide the data necessary to test and compare different ecological hypotheses. Our primary research objective was to evaluate how seasonal and annual changes in river flows affect the distribution and abundance of Rio Grande Silvery Minnow throughout its current range over time (1993–2019).

The annual occurrence and density of Rio Grande Silvery Minnow, using October data (i.e., as required by USFWS's Biological Opinion), has fluctuated widely over the past two decades (1993–2019). While its estimated density ($E(x)$; fish per 100 m^2) was notably elevated from 2016 to 2017, there was a dramatic decline in 2018, followed by a marked rebound in 2019. Population monitoring efforts in 2019 revealed an elevated density (2.10), which represented a 2,285% increase from 2018 (0.09). While Rio Grande Silvery Minnow represented < 0.2% of the fish community in 2018, it had increased to 8.61% by 2019.

Changes in the occurrence and density of Rio Grande Silvery Minnow were reliably predicted by seasonal differences in river flows across years (1993–2019). Further, our findings were consistent regardless of whether dry sites or additional sites were or were not included in the analyses. Out of 444 models considered, we found that the top three models, which represented extended high flows during spring, were crucial (i.e., > 75% of cumulative model weight) in explaining why some years had dramatically elevated densities of Rio Grande Silvery Minnow. In contrast, we found that extended low flows during summer were key to explaining reductions in the occurrence of this species across years. Thus, prolonged high flows during spring were most predictive of increased density and prolonged low flows during summer were most predictive of decreased occurrence of Rio Grande Silvery Minnow over time.

Additional analyses revealed that population trends in different mesohabitats (October [2002–2019]), or on different days during repeated sampling (November [2005–2019]), were quite similar to population trends obtained from the long-term dataset (October [1993–2019]). These results indicate that the current sampling protocols are resulting in a reliable level of sampling precision and population trend consistency, especially when considering the substantial changes in the occurrence and density of Rio Grande Silvery Minnow over time. Further, the variance in estimated densities was consistently highest across years, followed distantly by river reach, sampling site, and sampling occasion. Thus, changes in the occurrence and density of Rio Grande Silvery Minnow were more closely related to seasonal flow conditions across years than to local/regional sampling conditions (i.e., across sampling occasions, sites, or reaches).

Site occupancy models further supported these findings. We found that Rio Grande Silvery Minnow occupancy probabilities progressively increased from 2013 (0.14) to 2017 (1.00), decreased markedly in 2018 (0.77), and then rebounded in 2019 (1.00). While estimated extinction probabilities were elevated during recent drought years (i.e., 2012–2014), they decreased substantially from 2014 to 2017, as seasonal river flows progressively improved. Likewise, estimated colonization probabilities increased considerably in recent years (2014–2017), as this species gradually repatriated multiple sites that had been previously unoccupied. However, these trends reversed in 2018 following poor spring and summer flow conditions. While the conservation status of Rio Grande Silvery Minnow declined from 2017 to 2018, site occupancy probabilities again improved in 2019.

Pronounced changes in the occurrence and density of Rio Grande Silvery Minnow over the past two decades were closely related to the timing, duration, and magnitude of river flows during spring and summer. Prolonged and elevated spring flows result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline pools and backwaters. The unique early life history of this species ensures that its propagules (drifting eggs and larvae) are rapidly dispersed throughout these low-velocity, warm, and productive habitats when spring flows begin to rise. These conditions, combined with a protracted spring runoff, help ensure the persistence of these nursery habitats, which are required for the successful growth, survival, and recruitment of newly spawned Rio

Grande Silvery Minnow. As growth from the egg phase through the vulnerable early larval phases (i.e., protolarvae and mesolarvae) requires about one month, the long-term persistence of these habitats appears essential for ensuring the successful recruitment of young to later life phases (i.e., metalarvae and juveniles).

Further, Rio Grande Silvery Minnow was consistently most abundant in downstream reaches (i.e., Isleta and San Acacia) of the Middle Rio Grande. This pattern has persisted over time (1993–2019) even though upstream reaches have been regularly augmented with large numbers of hatchery-reared fish. One explanation for this pattern is the cumulative downstream transport of propagules (drifting eggs and larvae) past instream barriers over time. Also, river channelization, habitat degradation, abandonment of the floodplain, and reductions in suspended sediments downstream of Cochiti Dam are likely limiting the amount of appropriate habitats available for the successful retention and recruitment of early life phases, especially in the Cochiti and Angostura reaches. While it is evident that seasonally elevated flows, combined with habitat restoration, should lead to increased recruitment success, the long-term efficacy of those efforts will also depend on assuring their utility and permanence by restoring a more dynamic flow regime and reestablishing river connectivity across fragmented reaches.

While extensive and diverse conservation-management efforts over the past two decades have provided protection against the extinction of Rio Grande Silvery Minnow, ongoing and planned efforts (e.g., restoring dynamic river flows, reconnecting fragmented reaches, and reestablishing a functional floodplain) should help to promote resilient and self-sustaining populations of this imperiled species in the future. Encouragingly, both the occurrence and density of Rio Grande Silvery Minnow increased markedly in 2019, as compared with a recent drought year (2018), following notably improved spring and summer flow conditions. Continued efforts to provide reasonable spring spawning and summer survival conditions will be essential for securing a self-sustaining wild population of this species in the Middle Rio Grande. Additionally, reestablishing resilient populations at other locations within its historical range would substantially help to further ensure its long-term persistence in the wild. Finally, future study of the relationships among aquatic species (i.e., from phytoplankton to fish), instream habitats, and seasonal river flows in the Rio Grande Basin should continue to elucidate key factors that regulate this complex ecosystem, which will be essential for developing and implementing successful management strategies for the long-term recovery of Rio Grande Silvery Minnow.

INTRODUCTION

The negative effects of dam-related modifications on the native fishes of the Great Plains and American Southwest have been well documented (Stanford and Ward 1979; Cross et al. 1983; Cross et al. 1985; Cross and Moss 1987; Winston et al. 1991; Luttrell et al. 1999; Dudley and Platania 2007; Perkin et al. 2015; Worthington et al. 2018). Flow regulation, habitat loss, and river fragmentation in these regions have led to the widespread decline or extirpation of several pelagic-spawning cyprinids, whose reproductive propagules often drift downstream of instream barriers or into unsuitable reservoir habitats (Dudley and Platania 2007; Hoagstrom 2015; Worthington et al. 2018). Many of the endemic pelagic-spawning cyprinids that historically occupied the Rio Grande Basin have been extirpated from large portions of their range (Speckled Chub, *Macrhybopsis aestivalis* and Rio Grande Shiner, *Notropis jemezanus*) or have become extinct (Phantom Shiner, *Notropis orca* and Rio Grande Bluntnose Shiner, *Notropis simus simus*) over the past century (Bestgen and Platania 1990; Platania and Altenbach 1998). Rio Grande Silvery Minnow, *Hybognathus amarus*, is the only extant pelagic-spawning cyprinid in the New Mexico portion of the Rio Grande (Bestgen and Platania 1991; Platania 1991).

As part of the Rio Grande Silvery Minnow Population Monitoring Program, data on Rio Grande Silvery Minnow and the associated ichthyofaunal community in the Middle Rio Grande (Rio Grande between Velarde, New Mexico and Elephant Butte Reservoir) have been gathered regularly since 1987. Platania (1993a) conducted the first comprehensive studies (1987–1992) to determine spatial and temporal changes in the Middle Rio Grande ichthyofaunal community and to provide resolution of species-specific habitat use patterns. An additional purpose of those initial studies was to provide information on the conservation status of Rio Grande Silvery Minnow. Sampling efforts during 1989 and 1990 revealed that Rio Grande Silvery Minnow population numbers had declined markedly since 1987 (Platania 1993a). Based on previous samples, reduced numbers of individuals indicated a rapid decline of this species across its already reduced range. The Rio Grande Silvery Minnow was listed as an endangered species primarily because there had been a 90–95% reduction in its historical range, and the remnant population in the Middle Rio Grande was threatened by several abiotic and biotic factors (USDOI 1994). Current threats to the persistence of Rio Grande Silvery Minnow have been identified, and a series of corrective actions have been proposed to help promote its future recovery (USFWS 2016).

From 1993 until the present, the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, and U.S. Army Corps of Engineers have cooperated to fund numerous studies of the Middle Rio Grande ichthyofauna. Among those studies was the long-term systematic monitoring of the Middle Rio Grande fish community at numerous sites between Angostura Diversion Dam and Elephant Butte Reservoir. Population monitoring efforts have documented wide fluctuations (i.e., order of magnitude increases and decreases) in the densities of Rio Grande Silvery Minnow over the past two decades. The abundance of this species has generally decreased during years with low spring discharge combined with prolonged summer low-flow/drying conditions, but it has generally increased following years with extended high spring flows combined with minimal summer low-flow/drying conditions (Dudley et al. 2009; Archdeacon 2016; Dudley et al. 2019b). While Rio Grande Silvery Minnow has been the primary focus of long-term monitoring efforts and subsequent hypothesis testing, our research activities have also provided valuable information on the associated Middle Rio Grande fish community.

The primary objectives of the Rio Grande Silvery Minnow Population Monitoring Program are to assess interannual trends in the distribution and abundance of this species, at standardized sites throughout the Middle Rio Grande, and evaluate how those trends are affected by changes in seasonal and annual discharge patterns. Additional objectives include determining mesohabitat use patterns, assessing variation in density estimates based on repeated sampling, documenting changes in relative abundance among native and nonnative fishes, and evaluating changes in site occupancy status across years. Seasonal and spatial differences in the population structure and abundance of native and nonnative fishes are also examined across reaches and years. Our ongoing research should also aid natural resource managers in obtaining a more thorough understanding of the key factors that regulate the conservation status and population dynamics of Rio Grande Silvery Minnow, which will be essential for implementing effective strategies for the long-term recovery of this species.

STUDY AREA

The headwaters of the Rio Grande are located in the San Juan Mountains of southern Colorado. The mainstem Rio Grande flows 750 km through New Mexico, draining an area of about 68,104 km^2 (excluding closed basins). The Rio Chama is the only major perennial tributary of the Rio Grande in New Mexico and confluences with it near the city of Española. Snowmelt from southern Colorado and northern New Mexico yields the majority of water for the Rio Grande, but transmontane diversions from the San Juan River (Colorado River Basin) supplement flow by providing water in route to downstream municipalities. The highest flow in the Rio Grande generally occurs shortly after spring snowmelt, while the lowest flow usually occurs in late summer and early autumn prior to the cessation of irrigation season (October 31). Summer rainstorms periodically augment low flows in discrete reaches but do not ensure that the river channel will remain wetted in its entirety.

Several large dams on the Rio Chama and Rio Grande, along with numerous smaller irrigation diversion dams, regulate flow in the Middle Rio Grande. A complex system of ditches, drains, and conveyance channels provides water for irrigated agriculture in the Rio Grande Valley. Cochiti Dam is the primary flood control structure that regulates discharge in the mainstem Middle Rio Grande. Cochiti Dam/Lake operations have led to notably lower peak flows, greatly reduced sediment supplies, and the progressive degradation, armoring, and narrowing of the river channel for up to 100 km downstream (Lagasse 1980; Massong et al. 2006). Additionally, river regulation, large levees, jetty jacks, and bank-stabilizing invasive vegetation have contributed to a dramatic reduction in seasonal floodplain habitats and river-floodplain connectivity over the past century (Adair 2016). While arroyos, backwaters, and other nursery habitats likely benefit native fishes (Porter and Massong 2004a, 2004b; Pease et al. 2006), these low velocity mesohabitats are relatively rare, particularly in incised sections of the river.

The study area (Figures 1 and 2) is a portion of the Middle Rio Grande, from Angostura Diversion Dam to the inflow of Elephant Butte Reservoir, which encompasses most of the current range of Rio Grande Silvery Minnow (i.e., below Cochiti Dam [although additional study is required to determine if Rio Grande Silvery Minnow still persists upstream of Angostura Diversion Dam] to the inflow of Elephant Butte Reservoir). The Cochiti Reach of the Rio Grande (between Cochiti Dam and Angostura Diversion Dam) passes first through Cochiti Pueblo, then Santo Domingo Pueblo, and finally San Felipe Pueblo. The last comprehensive ichthyofaunal surveys of the Cochiti Reach documented low numbers of Rio Grande Silvery Minnow on Santo Domingo and San Felipe Pueblos (Platania 1995a) and its absence on Cochiti Pueblo (Platania 1993b). While our current study does not include sampling sites within these areas, or the Sandia or Isleta Pueblos, the U.S. Fish and Wildlife Service conducts ongoing fish monitoring efforts in some of these areas (Archdeacon 2020).

Most of the standard sampling sites were selected from a list of nearly 100 Middle Rio Grande sites, which were monitored from 1987 to 1992 (Platania 1993a); these sites have been sampled consistently since 1993. Site locations were chosen based on spatial distribution, site accessibility, relative permanence of flow (or deep pools during drought), and the presence of reasonably suitable instream habitat. Although most sites have been consistently monitored over time, several localities were added (e.g., improving the spatial coverage within or among reaches [Dudley and Platania 1997b; Dudley and Platania 1999; Dudley and Platania 2002]) or removed (e.g., recognizing the loss of consistent land access [Dudley and Platania 1999]). Although our long-term population monitoring sites were not randomly selected, Archdeacon et al. (2015) found no meaningful differences in fish community composition or species-specific densities when using a random vs. nonrandom study design to sample fishes in the Middle Rio Grande.

The Angostura Reach had five standard sampling sites, the Isleta Reach had six sites, and the San Acacia Reach had nine sites. These 20 standard sampling sites (Appendix A [Table A - 1]) overlap the current documented range of Rio Grande Silvery Minnow and form the basis of the long-term monitoring efforts (1993–2019). In 2017, ten additional sampling sites were added to the study area. These sites were added to help fill in the largest sampling gaps between the standard sites, while ensuring that the sampling coverage remained spatially balanced within each reach. Also, all additional sites were located in areas that didn’t present unreasonable safety or access issues. This same site-selection rationale has been consistently used over the past two decades whenever additional sites were required to supplement the existing sampling coverage. To obtain a total of ten sites per reach, five sites

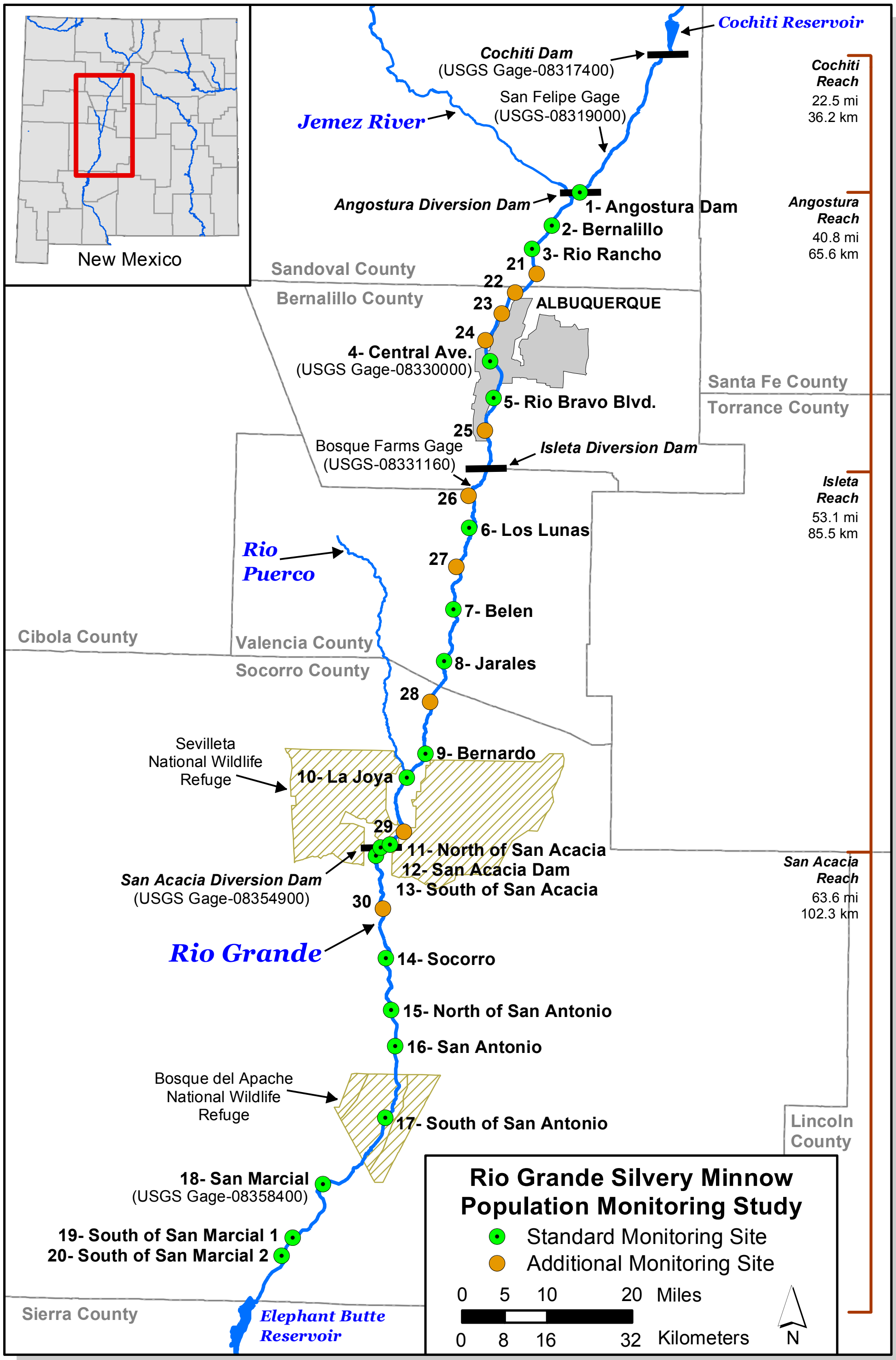

Figure 1. Map of the study area, standard sites, and additional sites for the Rio Grande Silvery Minnow population monitoring study. Sampling site descriptions are provided in Appendix A.

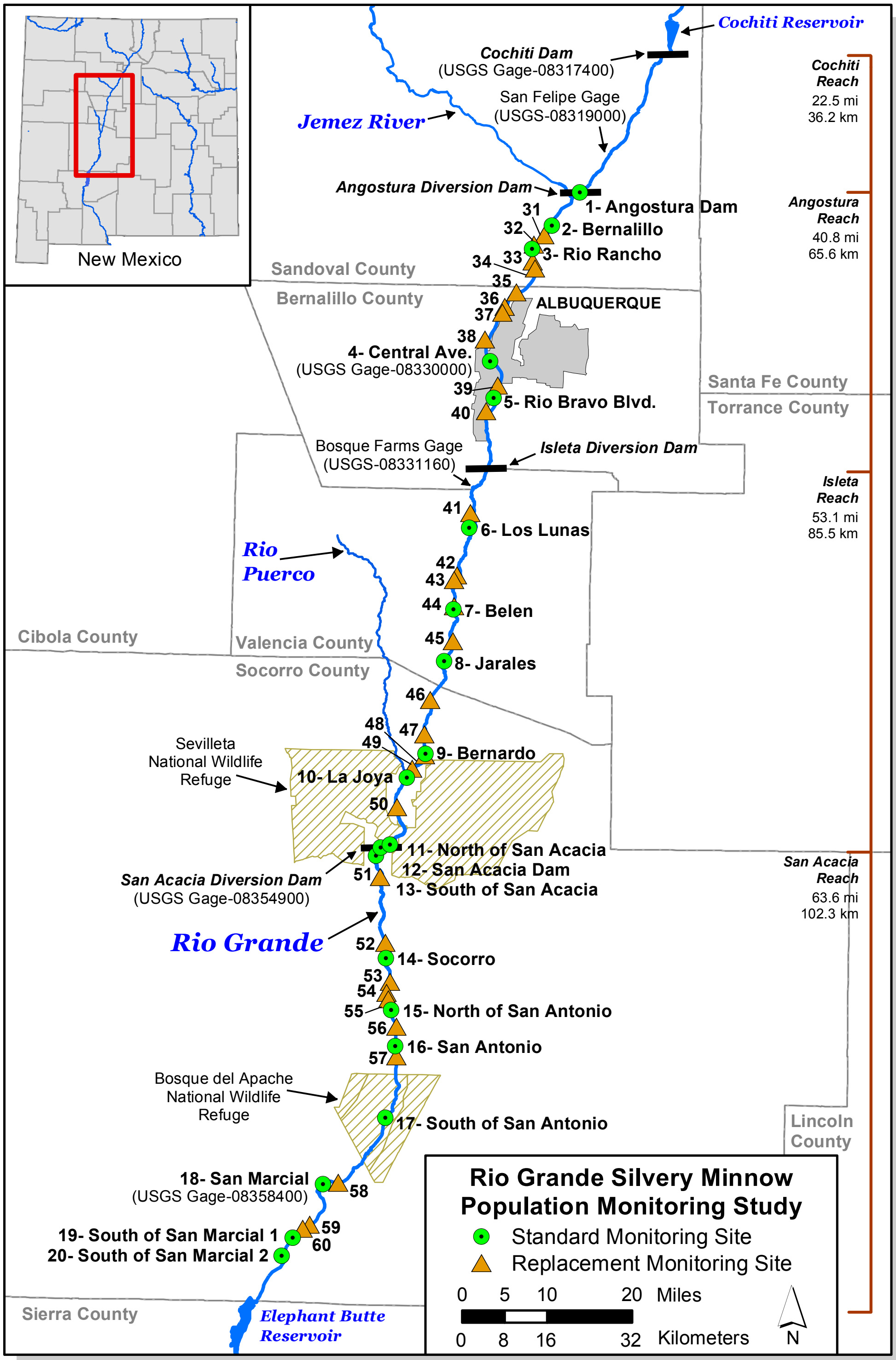

Figure 2. Map of the study area, standard sites, and replacement sites for the Rio Grande Silvery Minnow population monitoring study. Sampling site descriptions are provided in Appendix A.

were added to the Angostura Reach, four sites were added to the Isleta Reach, and one site was added to the San Acacia Reach (Figure 1; Appendix A [Table A - 2]). Since 2017, replacement sites were sampled whenever the river was dry at one of the standard/additional sampling sites (Figure 2; Appendix A [Table A - 3]). As these replacement sites were meant to supplement the established sampling sites during periods of river drying, and had to satisfy an extensive list of selection criteria, all replacements were selected randomly using a spatially-balanced statistical design (GRTS; Stevens and Olsen 1999, 2003, 2004). Any candidate replacement site had to meet all selection criteria, established by the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program), prior to the initiation of sampling (i.e., located in a wetted area, located in a non-isolated stretch of river, located within the river channel, located in an area with > 0.5 miles of continuous river flow, located in an area that didn't present unreasonable safety or access issues, located closest to the replaced dry site, located in the same reach as the replaced dry site, and located in an area where it would be likely to serve as a viable replacement over time).

Daily and seasonal discharge varied greatly during 2018 and 2019, especially in downstream reaches of the Middle Rio Grande (Figure 3). There was a general trend of lower flow in the San Acacia Reach (e.g., U.S. Geological Survey (USGS) San Acacia Gage [#08354900] and USGS San Marcial Gage [#08358400]), as compared to upstream locations (e.g., USGS San Felipe Gage [#08319000] and USGS Albuquerque Gage [#08330000]). In 2019, flows were elevated throughout the study area from late April until early July. Maximum flows in 2019 occurred during mid-June. Flows in 2018 and 2019 were persistently low from August through October, with the exception of periodically elevated flows from rainstorms. As compared to the generalized historical spring runoff (i.e., average mean-daily discharges since 1973 [Cochiti Dam operational]), there was no discernable spring runoff event in 2018. Flows were notably elevated throughout the spring, and most of the summer, during 2019.

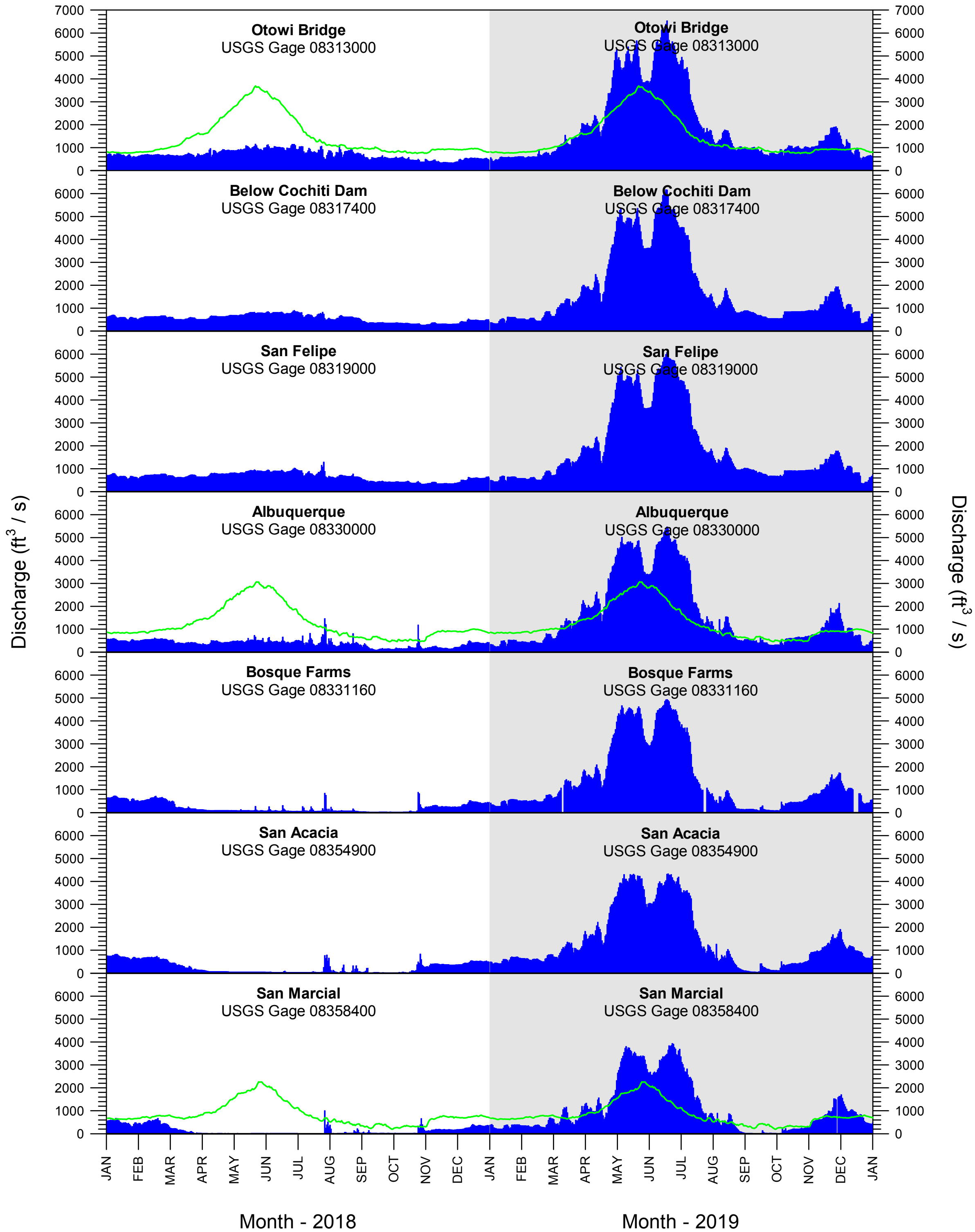

Figure 3. Rio Grande mean-daily discharge, by U.S. Geological Survey (USGS) gaging station, from January 2018 to December 2019. Green lines are the average mean-daily discharges across years (1973–2019). Discharge data are provisional and subject to change.

METHODS

Sampling Protocols

This study was designed to monitor long-term trends in the abundance of Rio Grande Silvery Minnow, and the associated fish community, at 20 sampling sites throughout the Middle Rio Grande. Monthly sampling efforts, from April to October, have allowed for ongoing determination of general spatial and temporal changes in population structure and species abundance since 1993. Ten additional sites have been sampled in April and October since 2017. Repeated sampling, across multiple sampling occasions, was conducted during November to estimate site occupancy rates (Appendix B) and to characterize sampling variation. Continued and uninterrupted monitoring, from April to November, is also required to satisfy key aspects of USFWS's Biological Opinion (USFWS 2016).

Fish were collected with a 3.1 m x 1.8 m small-mesh seine (ca. 4.8 mm) in 18 discrete mesohabitats (< 15 m long). Runs were sampled four times at each site, as were shoreline pools (when available); backwaters, pools, and riffles were sampled two times (when available); any remaining samples were taken in shoreline runs. A 1.2 m x 1.2 m fine-mesh seine (ca. 1.6 mm) was used to selectively sample shallow low-velocity mesohabitats for larval fish (two samples per site) from April to October. Seine hauls were spaced several meters apart to minimize disturbance of other mesohabitats during sampling. Mesohabitats with similar conditions, which did not exceed reasonable depths or velocities for efficient seining, were sampled regardless of flow conditions. Water quality metrics were recorded at each site (Appendix C [Table C - 1]), along with digital photographs of river conditions.

Fish were briefly handled for identification and enumeration purposes, kept in a submerged mesh enclosure (ca. 4.8 mm) during sampling (i.e., to avoid recapture), and released after sampling was completed. During repeated sampling, fish were released back into sampled mesohabitats after each seine haul to avoid disturbing the site for subsequent repeated sampling efforts. We examined Rio Grande Silvery Minnow for the presence of Visible Implant Elastomer (VIE) tags (i.e., stocked fish) and recorded all tag colors and anatomical-locations. Individuals with VIE tags matching known batches of Passive Integrated Transponder (PIT) tagged fish were scanned using handheld PIT tag readers to obtain their unique hexadecimal codes. All Rio Grande Silvery Minnow (i.e., wild and stocked fish) were measured (standard length (mm); individual measurements or a length range for large collections) and identified to age-class (based on age-length relationships by sampling month [Dudley et al. 2009; Horwitz et al. 2018]). Standard length was measured because of its wide acceptance in taxonomic studies, and because it is reliable even when the caudal fin is malformed or damaged (Jennings et al. 2012). While field measurements of Rio Grande Silvery Minnow total length (TL) are generally less reliable than standard length (SL), TL can be derived from SL based on a highly predictable relationship (TL = 1.203(SL) + 2.454; R^2 = 0.99; n = 257; Horwitz et al. 2018).

Analytical Considerations

Rio Grande Silvery Minnow with VIE tags were not included in data analyses of long-term population or occupancy trends, but they were included in the 2019 summary tables and figures. Fish too small to be accurately identified to species in the field (i.e., larvae or recently-transformed juveniles) were fixed in formalin and returned to the laboratory for further processing and identification. Laboratory personnel, with extensive larval fish identification experience, identified all preserved specimens using stereomicroscopes with transmitted light bases and polarized light filters. The developmental phase of all Rio Grande Silvery Minnow was determined to definitively separate larval from non-larval individuals (e.g., recently transformed juveniles). Scientific names and common names (ordered phylogenetically) of fishes in this report follow Page et al. (2013; Table 1).

Density (catch-per-unit-effort [CPUE]) was computed, for each site, by dividing the total number of individuals captured by the total area sampled, multiplied by 100 (i.e., fish per 100 m^2). Area was calculated by multiplying the seine width during sampling (regular = 2.5 m, larval = 1.0 m) by the seine haul length. Densities of larvae were based only on fine-mesh seine samples (ca. 1.6 mm), and densities of age-0 and age-1+ fish were based only on small-mesh seine samples (ca. 4.8 mm).

Table 1. Scientific names, common names, and species codes of fishes collected in the Middle Rio Grande since 1993.

Scientific Name	Common Name	Species Code
Order Clupeiformes		
Family Clupeidae	**herrings**	
Dorosoma cepedianum	Gizzard Shad	(DORCEP)
Dorosoma petenense	Threadfin Shad	(DORPET)
Order Cypriniformes		
Family Cyprinidae	**carps and minnows**	
Campostoma anomalum	Central Stoneroller	(CAMANO)
Carassius auratus	Goldfish	(CARAUR)
Cyprinella lutrensis	Red Shiner[1]	(CYPLUT)
Cyprinus carpio	Common Carp[1]	(CYPCAR)
Gila pandora	Rio Grande Chub	(GILPAN)
Hybognathus amarus	Rio Grande Silvery Minnow[1]	(HYBAMA)
Notemigonus crysoleucas	Golden Shiner	(NOTCRY)
Pimephales promelas	Fathead Minnow[1]	(PIMPRO)
Pimephales vigilax	Bullhead Minnow	(PIMVIG)
Platygobio gracilis	Flathead Chub[1]	(PLAGRA)
Rhinichthys cataractae	Longnose Dace[1]	(RHICAT)
Family Catostomidae	**suckers**	
Carpiodes carpio	River Carpsucker[1]	(CARCAR)
Catostomus commersonii	White Sucker[1]	(CATCOM)
Ictiobus bubalus	Smallmouth Buffalo	(ICTBUB)
Order Siluriformes		
Family Ictaluridae	**North American catfishes**	
Ameiurus melas	Black Bullhead	(AMEMEL)
Ameiurus natalis	Yellow Bullhead	(AMENAT)
Ictalurus furcatus	Blue Catfish	(ICTFUR)
Ictalurus punctatus	Channel Catfish[1]	(ICTPUN)
Pylodictis olivaris	Flathead Catfish	(PYLOLI)
Family Loricariidae	**suckermouth armored catfishes**	
Pterygoplichthys disjunctivus	Vermiculated Sailfin Catfish	(PTEDIS)
Order Salmoniformes		
Family Salmonidae	**trouts and salmons**	
Oncorhynchus mykiss	Rainbow Trout	(ONCMYK)
Salmo trutta	Brown Trout	(SALTRU)

Table 1. Scientific names, common names, and species codes of fishes collected in the Middle Rio Grande since 1993 (continued).

Scientific Name	Common Name	Species Code
Order Cyprinodontiformes		
Family Poeciliidae	**livebearers**	
Gambusia affinis	Western Mosquitofish[1]	(GAMAFF)
Order Perciformes		
Family Moronidae	**temperate basses**	
Morone chrysops	White Bass	(MORCHR)
Morone saxatilis	Striped Bass	(MORSAX)
Family Centrarchidae	**sunfishes**	
Lepomis cyanellus	Green Sunfish	(LEPCYA)
Lepomis gulosus	Warmouth	(LEPGUL)
Lepomis macrochirus	Bluegill	(LEPMAC)
Lepomis megalotis	Longear Sunfish	(LEPMEG)
Micropterus punctulatus	Spotted Bass	(MICPUN)
Micropterus salmoides	Largemouth Bass	(MICSAL)
Pomoxis annularis	White Crappie	(POMANN)
Pomoxis nigromaculatus	Black Crappie	(POMNIG)
Family Percidae	**perches**	
Perca flavescens	Yellow Perch	(PERFLA)
Percina macrolepida	Bigscale Logperch	(PERMAC)
Sander vitreus	Walleye	(SANVIT)
Family Sciaenidae	**drums and croakers**	
Aplodinotus grunniens	Freshwater Drum	(APLGRU)

[1] = Focal taxa were typically the 10 most abundant species collected during October.

Statistical Analyses

Long-term analyses (1993–2019)

Mixture models (e.g., combining a binomial distribution with a lognormal distribution) are particularly effective for modeling ecological data with multiple zeros (White 1978; Welsh et al. 1996; Fletcher et al. 2005; Martin et al. 2005). Long-term Rio Grande Silvery Minnow sampling-site density data during October (1993–2019) were analyzed using PROC NLMIXED (Nonlinear Mixed Models; SAS 2019), an advanced numerical optimization procedure that retains the key features of PROC FMM (Finite Mixture Models; SAS 2019), by fitting a mixture model consisting of the binomial distribution (i.e., based on presence-absence data) and the lognormal distribution (i.e., based on natural logarithms of nonzero data). We implemented this robust ecological modeling approach to quantitatively assess the effects of environmental variables on long-term trends in the occurrence and density of Rio Grande Silvery Minnow. Logistic regression was used to estimate the probability that a site was occupied (i.e., occurrence probability), and a lognormal model was used to estimate the lognormal density based on occupied sites (Appendix D). Models provided four parameter estimates for each year (δ = estimated occurrence probability, μ = estimated lognormal density, σ = standard deviation of the estimated lognormal density, and $E(x)$ = estimated density) based on the site-specific sampling data. Naive mean densities, computed using the method of moments (Zar 2010), were also added as a reference to all applicable figures. Analyses were conducted using four different versions of the dataset: (1) additional sites excluded and dry sites included, (2) additional sites and dry sites excluded, (3) additional sites and dry sites included, and (4) additional sites included and dry sites excluded.

Generalized linear models were based on the covariates and mixture-model parameter estimates (δ, μ, and σ), where a logit link was used for δ, an identity link for μ, and a log link for σ. In the simplest case with no covariates and no random effects, the mixture-model can be considered a zero-inflated lognormal model for the estimated density. In all analyses, a categorical covariate for sampling year (Year) was included in the model to represent the maximum variation attributable to time effects. As no other time-effects model can explain all the variation, the Year (or global) model represents the upper limit on the amount of explainable variation and the null (.) model represents the lower limit of that variation. Additionally, all nested environmental covariates (e.g., spring and summer flows) varied across Year and were assessed individually as to their effectiveness in explaining the total time-specific variation for both δ and μ (i.e., ecological models).

Flow covariates considered for modeling October sampling-site density data (1993–2019) included various hydrological variables based on data from USGS Gages (#08330000 [ABQ; Rio Grande at Albuquerque, NM] and #08358400 [SAN; Rio Grande Floodway at San Marcial, NM]). The upstream gage was chosen to represent prolonged high flows during spring, whereas the downstream gage was chosen to represent prolonged low flows during summer. Maximum daily discharge (ABQmax), days exceeding threshold discharge values (days > 1,000 [ABQ>1,000], 2,000 [ABQ>2,000], and 3,000 [ABQ>3,000] ft^3 / s), and mean daily discharge (ABQmean) were covariates that represented different spring runoff conditions (May–June). A modeled covariate (Inundation), that represented the total estimated inundation of the river floodplain, was based on an average of the five highest flow days in May (USACE 2010); models of recent conditions (2000–2009) were used to estimate inundation since 2010. Mean daily discharge (SANmean) and lower threshold discharge values (days < 200 [SAN<200] and < 100 [SAN<100] ft^3 / s) were covariates that represented different low-flow conditions, and served as proxies for river drying, during irrigation season (March–October). Fixed-effects models for each covariate were generalized linear models with the corresponding link function. These fixed effects assume that variation in the data is explained by the covariate (Appendix E [Table E - 1]). For δ, there is no over-dispersion or extra-binomial variation, and for μ, no extra variation provided beyond the constant σ model. Random-effects models (*R*) were also considered for δ and μ to provide additional variation around the fitted line where a normally-distributed random error with mean zero, and nonzero standard deviation, was used to explain deviations around the fitted covariates. All random effects were integrated out of the likelihood (see Pinheiro and Bates 1995) during fitting of the model.

Goodness-of-fit statistics (logLike = –2[log-likelihood] and AIC_c = Akaike's information criterion [Akaike 1973] for finite sample sizes) were generated to assess the relative fit of data to various mixture models across all sampling years. Lower values of AIC_c indicate a better fit of the data to the model. Models were ranked by AIC_c values, and the top ten ecological models, based on AIC_c weight (w_i), were presented. As nested environmental covariates were only used individually to model a single parameter (δ or μ), potential issues of multicollinearity were avoided. Further, AIC_c model selection ranks single-variable models appropriately, even if variables are highly correlated (i.e., resulting w_i values would be similar). An analysis of deviance (ANODEV) was used to determine the relative proportion of deviance explained by the environmental covariates, for both δ and μ models, and to assess whether those values were significantly different from zero ($P < 0.05$) based on an *F*-test (Skalski et al. 1993).

Kendall's *W* (Zar 2010) was used to test for the degree of concordance among the annual rank-abundance values of the 10 focal species, including Rio Grande Silvery Minnow, during October (1993–2019). This nonparametric statistical procedure was used to compute the *W* statistic, which ranges from zero (no concordance) to one (complete concordance). A chi-square statistic was calculated to evaluate whether the concordance (*W*) was significantly different from zero ($P < 0.05$).

Mesohabitat associations (2002–2019)

Rio Grande Silvery Minnow detailed density data during October (i.e., using mesohabitat-specific data from all sampling sites), have been consistently collected since 2002. Mesohabitats were simplified (i.e., combining main and side channel samples, coding debris piles as pools, and coding riffles as runs) and classified using channel-unit definitions (Armantrout 1998) for statistical analyses (backwaters [BW], pools [PO], runs [RU], shoreline pools [SHPO], and shoreline runs [SHRU]). The sampling unit for this analysis was mesohabitat (e.g., all shoreline run samples combined for each site), whereas the sampling unit for the long-term analysis (1993–2019) was site (e.g., all mesohabitat samples combined for each site). Mesohabitat-specific density data from October (2002–2019) were analyzed using PROC NLMIXED, employing the same methods outlined previously, to generate parameter estimates and assess differences among models. Categorical covariates considered were Year, mesohabitat (Mesohabitat), and reach (Reach). Random-effects models (*R*) were also considered. Both additive and multiplicative effects were considered for single combinations of the year covariate for both Mesohabitat (e.g., Year+Mesohabitat and Year*Mesohabitat, respectively) and Reach.

Sampling variation (2005–2019)

Sampling variation was evaluated using Rio Grande Silvery Minnow sampling-site density data from repeated sampling at the 20 standard sites during November (2005–2019). For the repeated sampling effort, sites were sampled once per day for four days, using Population Monitoring Program sampling protocols. Additionally, all sampling locations were flagged on the first day, and repeated samples were taken at the same or similar locations on subsequent days. Sampling-site density data from November (2005–2019) were analyzed using PROC NLMIXED, employing the same methods outlined previously, to generate parameter estimates and assess differences among models. Categorical covariates considered were Year, Reach, and Occasion (i.e., 1st, 2nd, 3rd, and 4th day of sampling). Random-effects models (*R*) were also considered. Both additive and multiplicative effects were considered for single combinations of the year covariate for both Occasion (e.g., Year+Occasion and Year*Occasion, respectively) and Reach. A variance components model was also used to assess the relative level of variance in estimated densities attributable to Year, Reach, Occasion, and sampling site (Site). Residual maximum likelihood (REML) was used to estimate the different variance components of the model parameters using PROC VARCOMP (Variance Components Estimation; SAS 2019).

RESULTS

Rio Grande Silvery Minnow

Current population status

The abundance of Rio Grande Silvery Minnow (all age-classes combined), from April to October 2019, varied widely across reaches, sites, and months (Table 2). Densities of larval Rio Grande Silvery Minnow (non-larval fish excluded) increased following spring spawning, reaching their highest levels in June, but then rapidly declined during summer (Figure 4). In August, one metalarval-phase individual was collected in the Angostura Reach. Post-spawning densities of age-0 individuals (larval fish excluded) were elevated throughout the summer, particularly during August (Figure 5). Densities of marked and age-1+ individuals were persistently low in all three reaches throughout the year, but overall densities (i.e., age-0 and age-1+ combined) were highest in the Isleta Reach (Figure 6).

Population trends (1993–2019)

Rio Grande Silvery Minnow densities ($E(x)$; estimated using October sampling-site data [1993–2019], as required by USFWS's Biological Opinion) were generated from the year model (δ[Year] μ[Year]). The estimated density of Rio Grande Silvery Minnow was notably lower in 2018, as compared with 2016 to 2017, but its density increased dramatically in 2019 (Figure 7). Estimated density could not be computed in 2003, as only a single nonzero value was recorded (i.e., precluding mixture-model estimation of σ). October population monitoring efforts revealed a greatly increased density of Rio Grande Silvery Minnow in 2019 ($E(x)$ = 2.10), which represented a 2,285% increase from 2018 ($E(x)$ = 0.09; P < 0.05). Naive mean densities, computed using the method of moments, were very similar to estimated densities ($E(x)$). Combining a plot of $E(x)$ and mean daily discharge (1993–2019) revealed a long-term recurrent pattern of increased densities during years with high spring runoff and decreased densities during years with low spring runoff (Figure 8). Estimates of $E(x)$ increased with maximum discharge, number of days with discharge exceeding an upper threshold value, estimated inundation of the river floodplain, and mean daily discharge (Figure 9: A–G). In contrast, there were inverse relationships between estimates of $E(x)$ and the number of days with discharge below a lower threshold value (Figure 9: H–I).

The estimated occurrence probability (δ) and the estimated lognormal density (μ), generated from the year model (δ[Year] μ[Year]), were also closely associated with hydrological variables over time (1993–2019). Estimates of δ increased with higher spring flows but decreased with lower summer flows (Figures 10 and 11). Similar and consistent results were obtained for relationships between μ and the hydrological variables (Figures 12 and 13).

Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates revealed that variation in μ, as compared with variation in δ, was more reliably predicted by changes in hydrological variables across years (1993–2019; Table 3). The top ecological model (δ[Year] μ[ABQmax+R]) received 34.6% of the AIC_c weight (w_i) out of the 444 models considered. This spring flow covariate accounted for 37.5% of the deviance explained by the μ(Year) model over the μ(.) model (P < 0.001). The top three models, which accounted for most of the cumulative w_i (ca. 76%), were related to the interaction between μ and hydrological variables representing elevated flows during spring.

In contrast, models relating to the interaction between μ and hydrological variables representing extended low flows during summer received a much lower cumulative value of w_i. The top δ covariate (SANmean) accounted for 66.6% of the deviance explained by the δ(Year) model over the δ(.) model (P < 0.001). Thus, prolonged high flows during spring were most predictive of increased density and prolonged low flows during summer were most predictive of decreased occurrence of Rio Grande Silvery Minnow over time.

Table 2. Rio Grande Silvery Minnow abundance (all age-classes combined), by reach, site, and month, during 2019. Marked individuals are shown in parentheses, as a subset of the site-specific total. Blank cells indicate months when a site was not visited.

Reach	Site	Locality	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Angostura	1	Angostura Dam	-	-	-	-	7(0)	5(0)	5(0)	17
Angostura	2	Bernalillo	1(1)	-	-	15(0)	236(0)	43(0)	33(0)	328
Angostura	3	Rio Rancho	2(2)	-	-	-	87(0)	9(1)	3(0)	101
Angostura	21	Site 21	2(1)						24(0)	26
Angostura	22	Site 22	-						76(0)	76
Angostura	23	Site 23	3(2)						22(0)	25
Angostura	24	Site 24	2(2)						37(0)	39
Angostura	4	Central Ave.	-	3(1)	-	117(0)	103(0)	22(0)	1(0)	246
Angostura	5	Rio Bravo Blvd.	-	-	5(0)	78(0)	290(0)	88(0)	21(0)	482
Angostura	25	Site 25	-						17(0)	17
Angostura Totals			*10*	*3*	*5*	*210*	*723*	*167*	*239*	*1,357*
Isleta	26	Site 26	-						27(0)	27
Isleta	6	Los Lunas	-	-	5(0)	59(0)	224(0)	61(0)	15(0)	364
Isleta	27	Site 27	-						45(0)	45
Isleta	7	Belen	-	1(1)	16(0)	61(0)	71(0)	22(0)	3(0)	174
Isleta	8	Jarales	-	-	5(0)	12(0)	115(0)	3(0)	-	135
Isleta	28	Site 28	-						10(0)	10
Isleta	9	Bernardo	-	1(0)	-	38(0)	375(0)	9(0)	9(0)	432
Isleta	10	La Joya	1(0)	1(1)	-	2(0)	212(0)	31(0)	26(0)	273
Isleta	29	Site 29	-						22(0)	22
Isleta	11	North of San Acacia	-	-	253(0)	122(0)	81(0)	-	3(0)	459
Isleta Totals			*1*	*3*	*279*	*294*	*1,078*	*126*	*160*	*1,941*
San Acacia	12	San Acacia Dam	-	-	4(0)	5(0)	29(0)	121(0)	14(0)	173
San Acacia	13	South of San Acacia	1(0)	-	-	34(2)	29(0)	49(0)	4(0)	117
San Acacia	30	Site 30	-						28(0)	28
San Acacia	14	Socorro	-	2(2)	-	24(0)	75(0)	23(0)	4(0)	128
San Acacia	15	North of San Antonio	2(1)	-	49(4)	200(1)	189(0)	55(1)	30(0)	525
San Acacia	16	San Antonio	-	-	2(2)	151(0)	17(0)	6(0)	4(0)	180
San Acacia	17	South of San Antonio	-	-	51(0)	7(0)	2(0)	154(0)	18(0)	232
San Acacia	18	San Marcial	-	-	20(0)	1(0)	87(0)	15(0)	6(0)	129
San Acacia	19	South of San Marcial 1	3(1)	2(1)	2(0)	67(0)	59(0)	38(0)	9(0)	180
San Acacia	20	South of San Marcial 2	-	-	-	1(0)	1(0)	3(0)	1(0)	6
San Acacia Totals			*6*	*4*	*128*	*490*	*488*	*464*	*118*	*1,698*
Monthly Totals			**17**	**10**	**412**	**994**	**2,289**	**757**	**517**	**4,996**

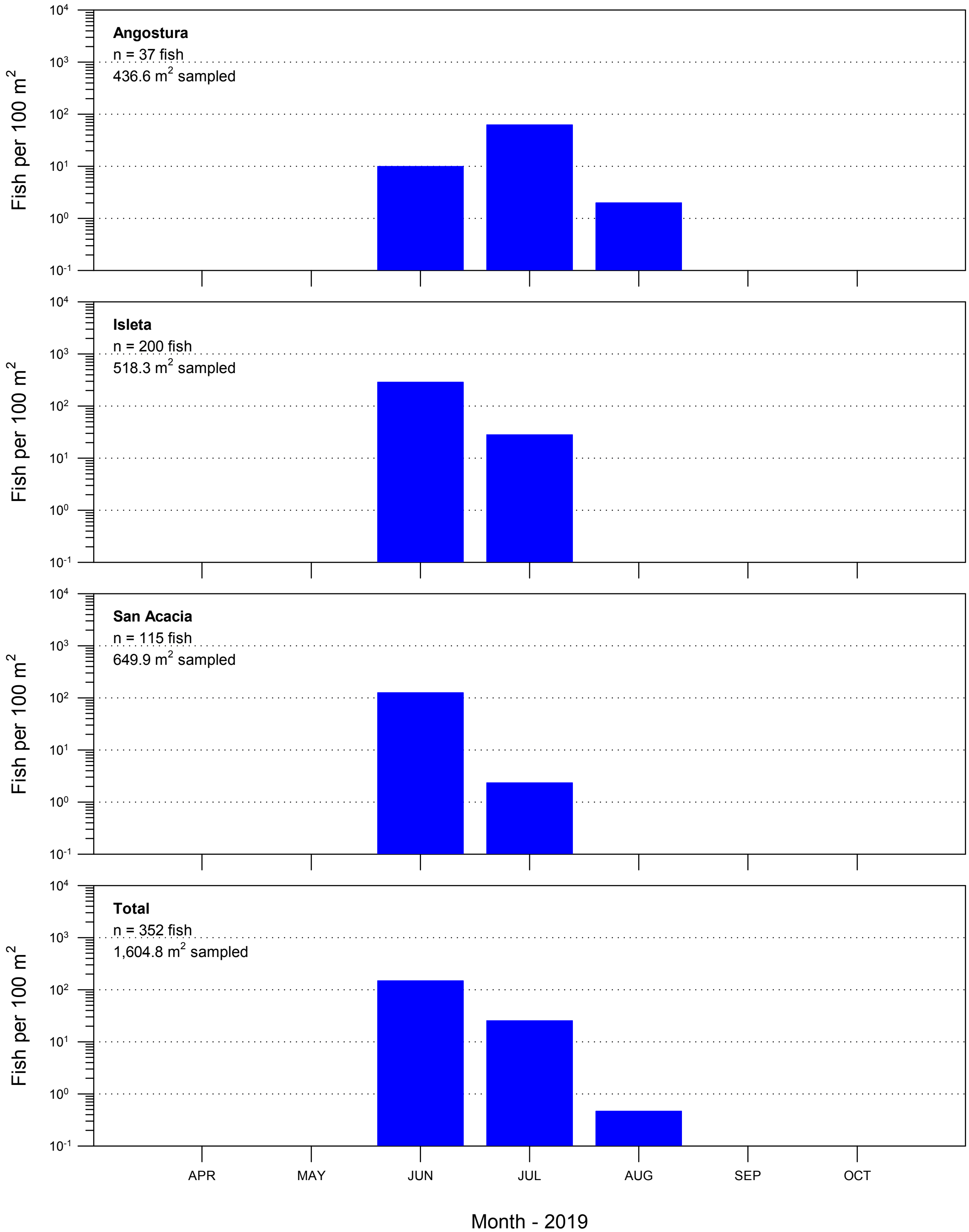

Figure 4. Rio Grande Silvery Minnow densities based on all sites (larval fish only [fine-mesh seine]; non-larval fish excluded), by reach and month, during 2019. Note: y-axis is logarithmic and larval sampling took place from April to October.

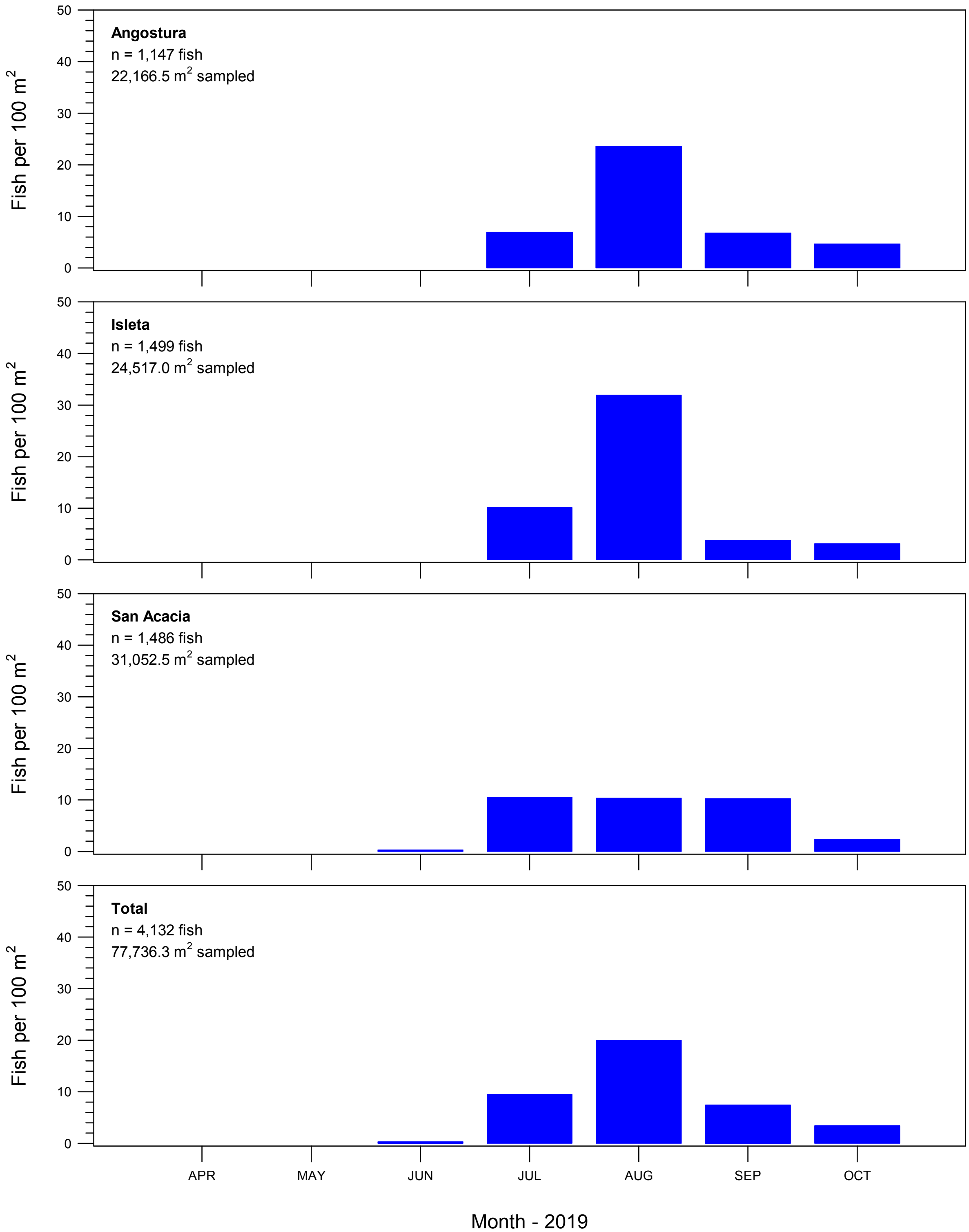

Figure 5. Rio Grande Silvery Minnow densities based on all sites (age-0 fish only [small-mesh seine]; larval fish excluded), by reach and month, during 2019. When present, marked (red) and unmarked (blue) individuals were included.

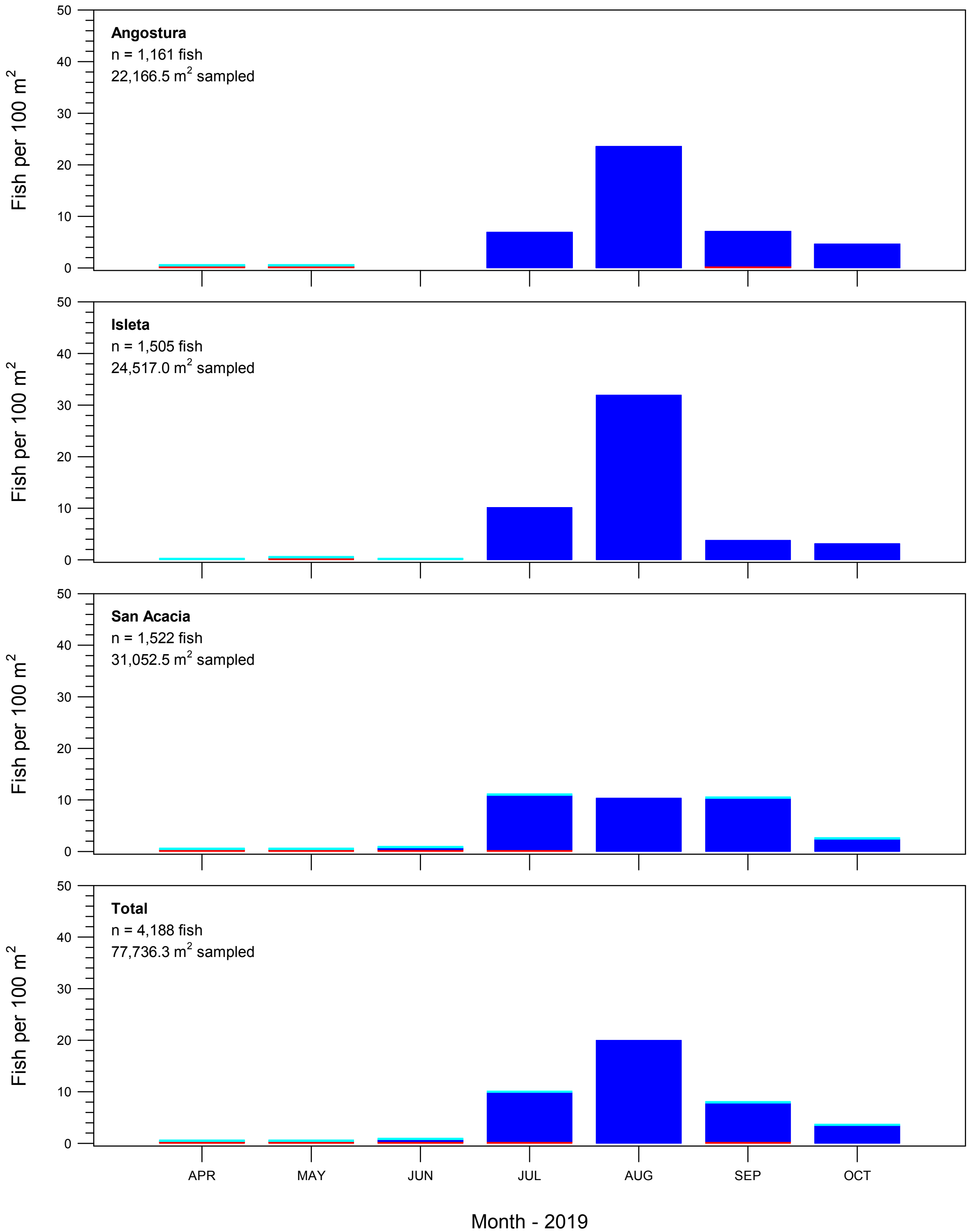

Figure 6. Rio Grande Silvery Minnow densities based on all sites (age-0 and age-1+ fish [small-mesh seine]; larval fish excluded), by reach and month, during 2019. When present, marked (red) and unmarked [(age-0 [blue] and age-1+ [cyan]) individuals were included.

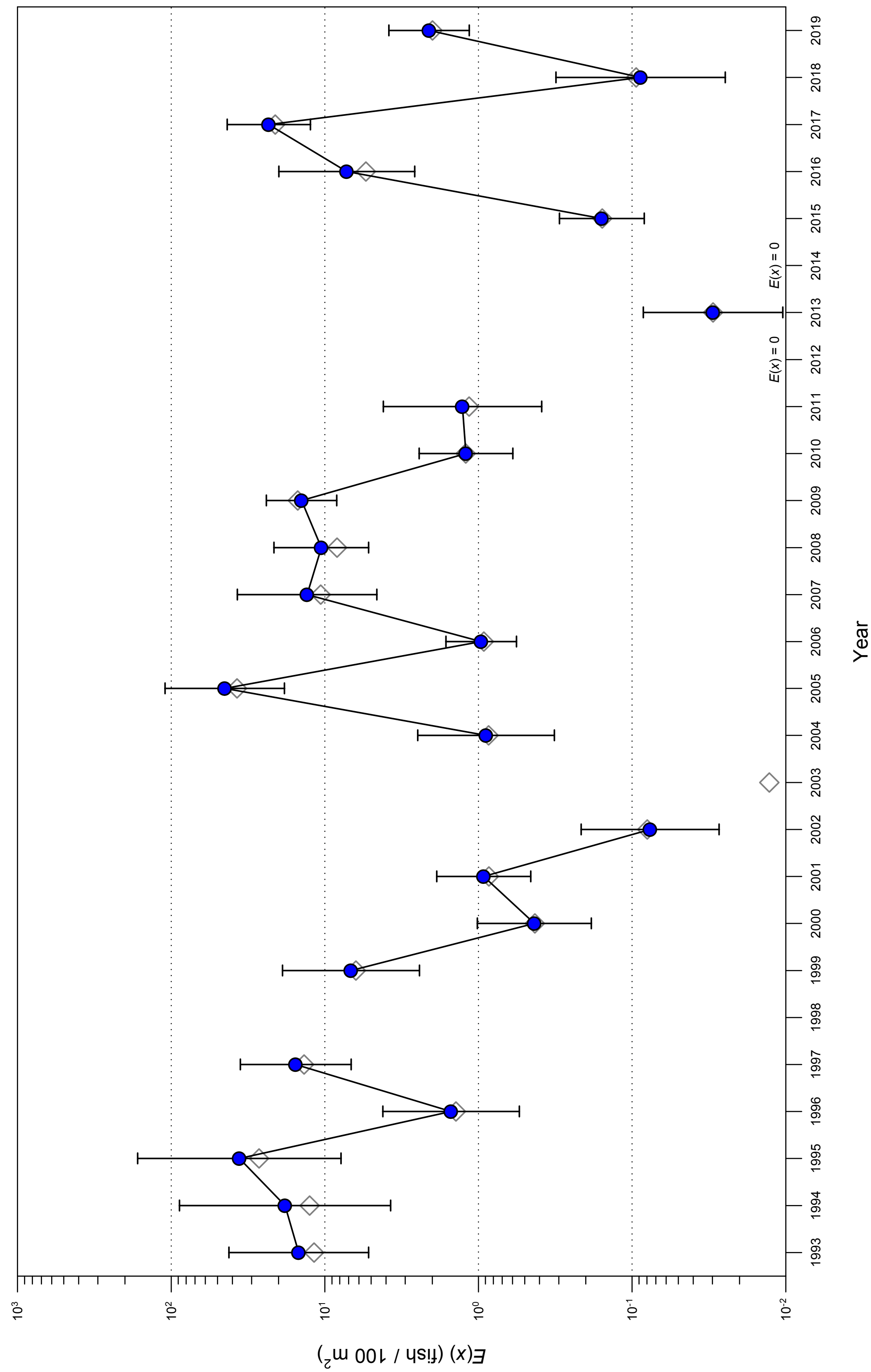

Figure 7. Rio Grande Silvery Minnow densities (*E*(*x*); estimated using October sampling-site data) across years (see Table 7). Sampling did not occur in 1998, and *E*(*x*) could not be computed for 2003. Modeled estimates (circles), 95% confidence intervals (bars), and method-of-moments estimates (diamonds) are illustrated. Additional sites were excluded and dry sites were included.

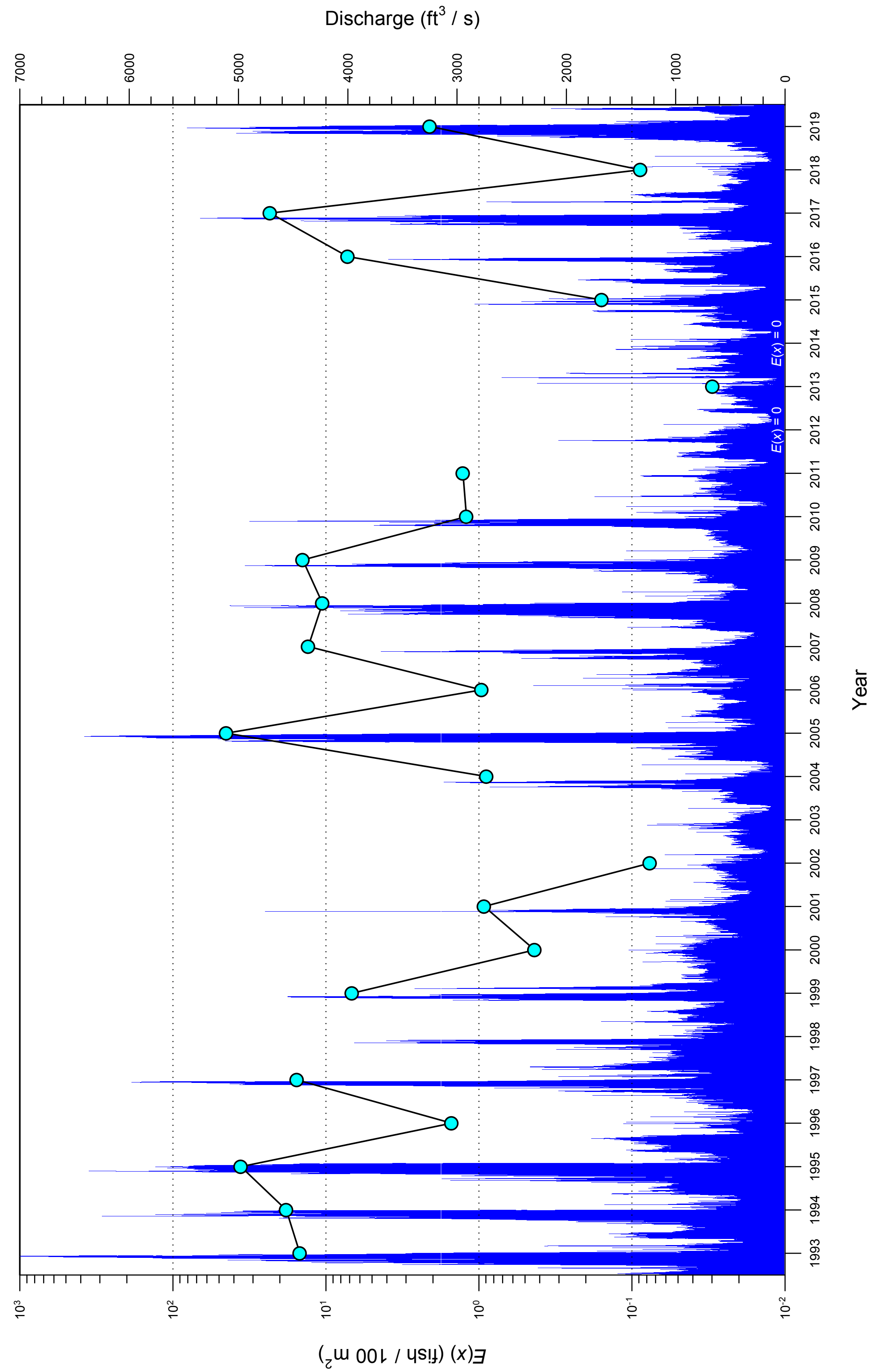

Figure 8. Rio Grande Silvery Minnow densities ($E(x)$; estimated using October sampling-site data), and mean daily discharge data from the Albuquerque Gage, across years. Sampling did not occur in 1998, and $E(x)$ could not be computed for 2003. Additional sites were excluded and dry sites were included.

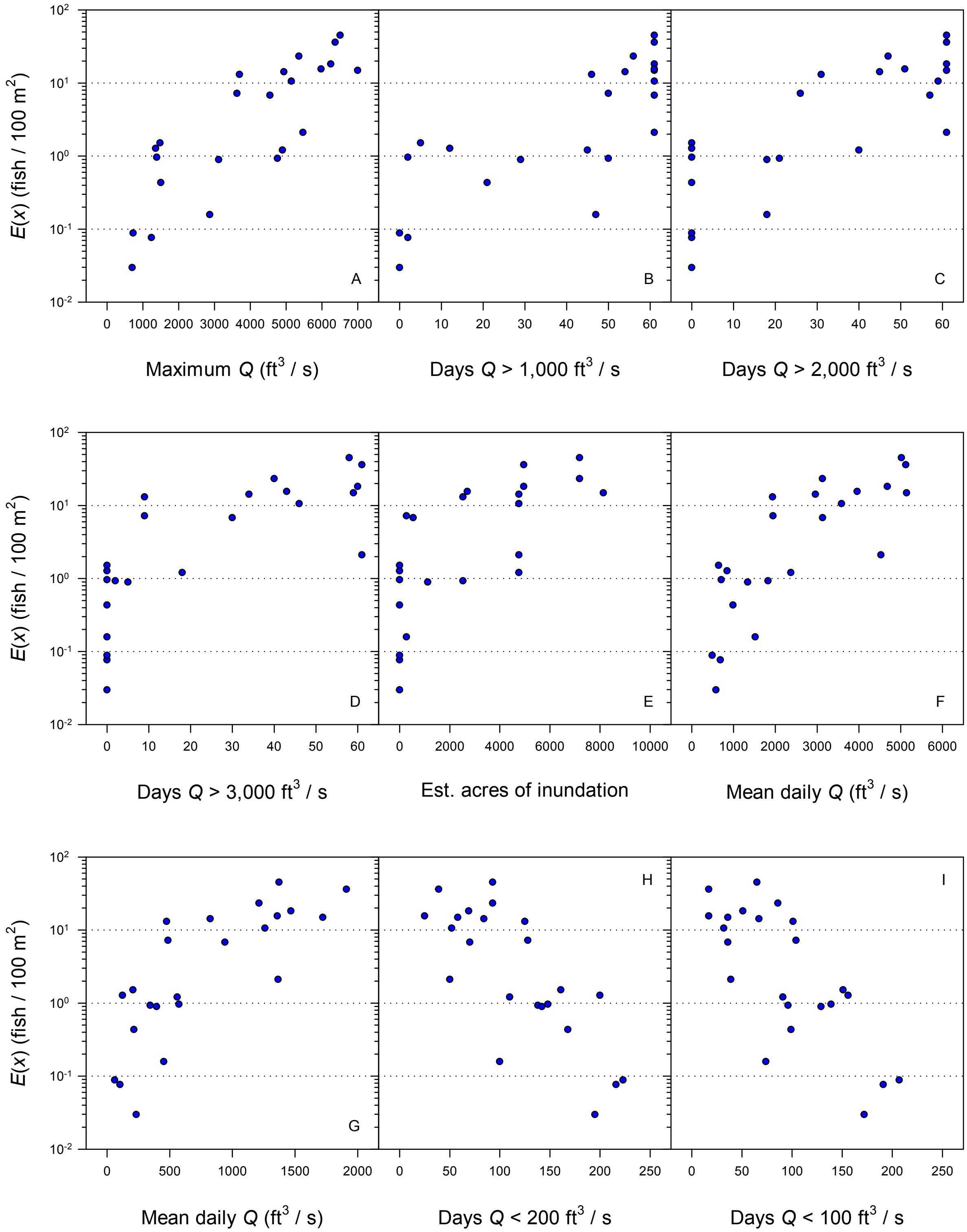

Figure 9. Bivariate plots of Rio Grande Silvery Minnow densities (*E*(*x*); estimated using October sampling-site data), Albuquerque Gage data (Figures A–F), and San Marcial Gage data (Figures G–I). Additional sites were excluded and dry sites were included.

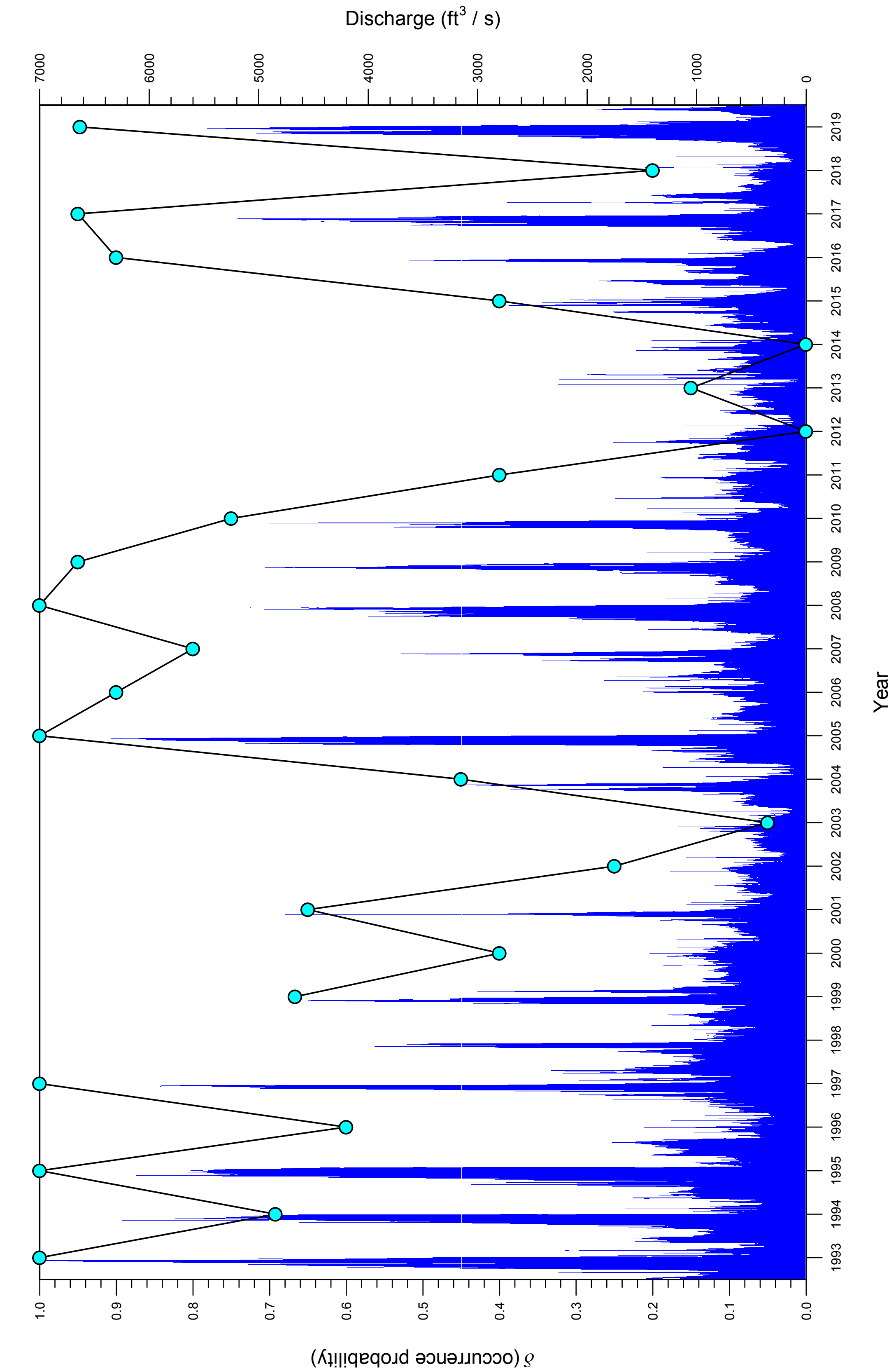

Figure 10. Rio Grande Silvery Minnow occurrence probabilities (δ; estimated using October sampling-site data), and mean daily discharge data from the Albuquerque Gage, across years. Sampling did not occur in 1998. Additional sites were excluded and dry sites were included.

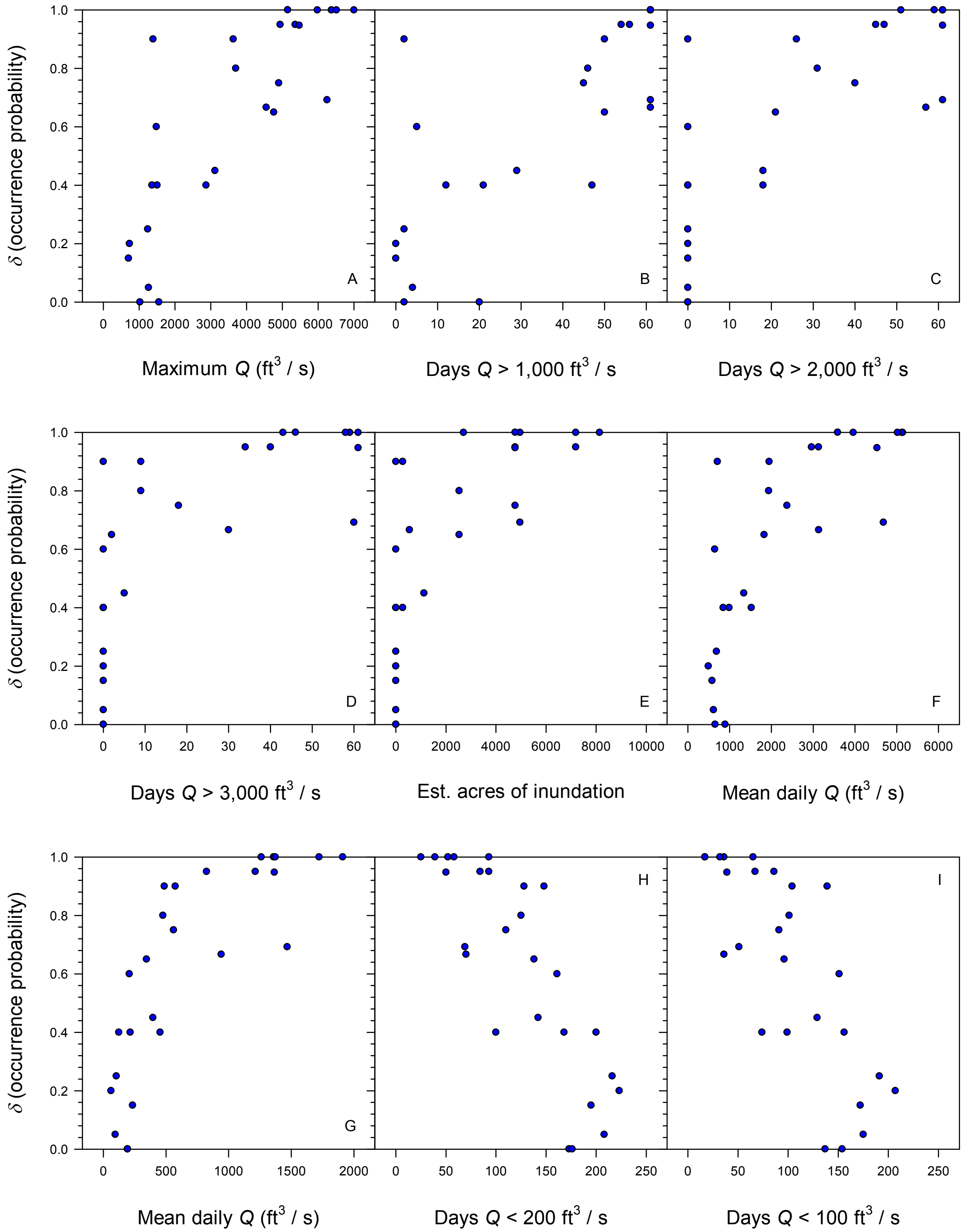

Figure 11. Bivariate plots of Rio Grande Silvery Minnow occurrence probabilities (δ; estimated using October sampling-site data), Albuquerque Gage data (Figures A–F), and San Marcial Gage data (Figures G–I). Additional sites were excluded and dry sites were included.

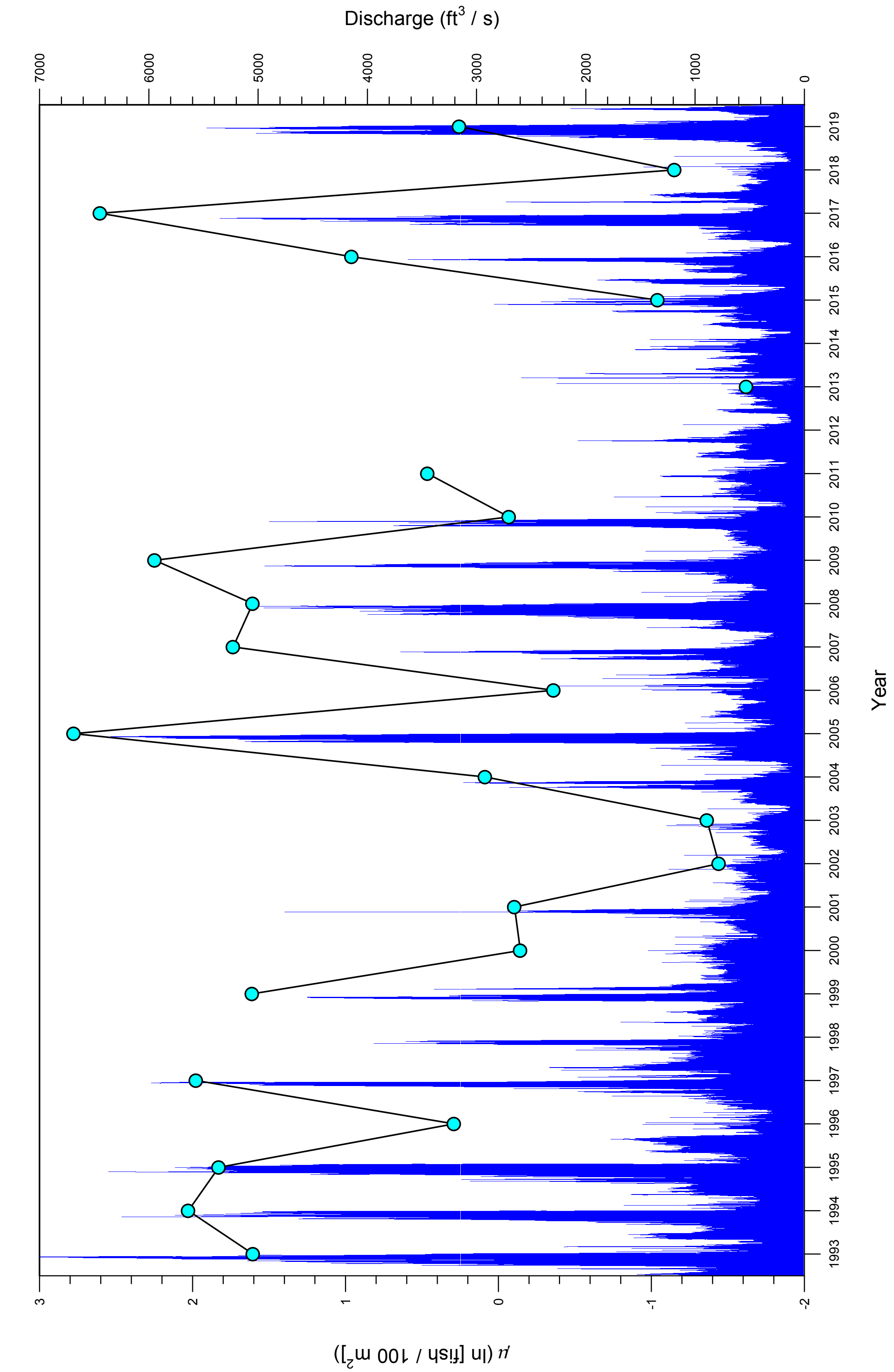

Figure 12. Rio Grande Silvery Minnow lognormal densities (μ; estimated using October sampling-site data), and mean daily discharge data from the Albuquerque Gage, across years. Sampling did not occur in 1998, and μ could not be computed for 2012 or 2014. Additional sites were excluded and dry sites were included.

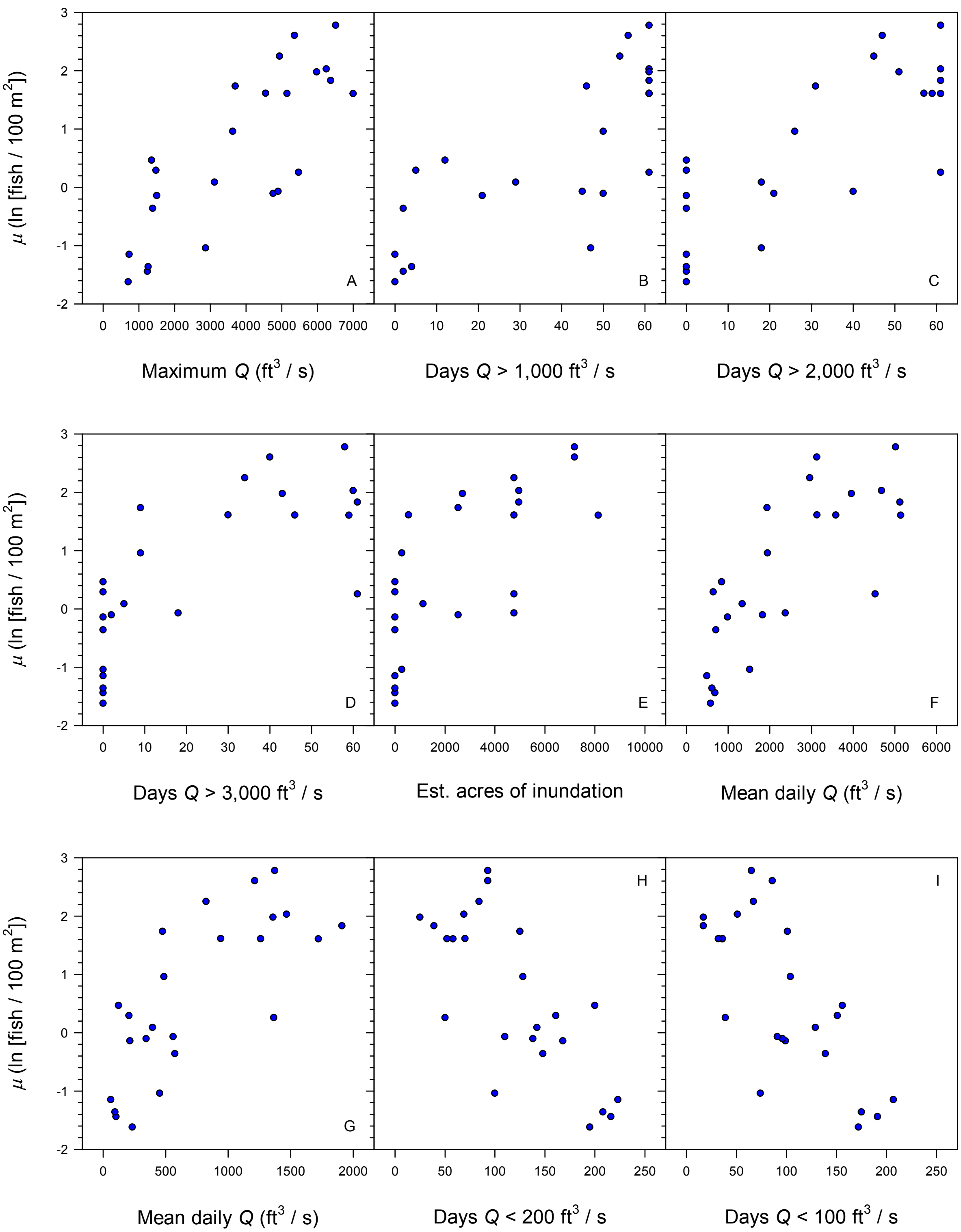

Figure 13. Bivariate plots of Rio Grande Silvery Minnow lognormal densities (μ; estimated using October sampling-site data), Albuquerque Gage data (Figures A–F), and San Marcial Gage data (Figures G–I). Additional sites were excluded and dry sites were included.

Table 3. Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates, using October sampling-site data (1993–2019). Additional sites were excluded and dry sites were included.

Model[1]	**logLike**[2]	**K**[3]	**AIC*c***[4]	***w_i***[4]
δ(Year) μ(ABQmax+*R*)	806.02	31	872.41	0.3458
δ(Year) μ(ABQ>2,000+*R*)	806.82	31	873.21	0.2311
δ(Year) μ(ABQmean+*R*)	807.31	31	873.70	0.1811
δ(Year) μ(ABQ>1,000+*R*)	809.48	31	875.87	0.0613
δ(SANmean+*R*) μ(Year)	764.66	50	876.44	0.0460
δ(Year) μ(SANmean+*R*)	810.22	31	876.61	0.0422
δ(Year) μ(ABQ>3,000+*R*)	811.27	31	877.66	0.0250
δ(ABQmax+*R*) μ(Year)	766.82	50	878.60	0.0156
δ(SAN<200+*R*) μ(Year)	767.39	50	879.17	0.0118
δ(ABQmean+*R*) μ(Year)	767.78	50	879.56	0.0097

[1] = Model variables included year (1993–2019), estimated inundation of the river floodplain, and other hydrological variables at USGS Gages (#08330000 [ABQ; Rio Grande at Albuquerque, NM] and #08358400 [SAN; Rio Grande Floodway at San Marcial, NM]), allowing for random effects (*R*).

[2] = Likelihood (–2[log-likelihood]) was estimated for each model.

[3] = Higher numbers of parameters indicate increased model complexity.

[4] = Top ten ecological models (i.e., containing environmental covariates) were ranked by Akaike's information criterion (AIC_c) and include the AIC_c weight (w_i).

Additionally, we evaluated the effects of excluding data from dry sites in a second analysis of Rio Grande Silvery Minnow estimated densities (*E*(*x*)). The estimated densities using this reduced dataset (Figure 14) were nearly identical to those using the standard long-term dataset (dry sites included). However, generalized linear models of Rio Grande Silvery Minnow mixture-model estimates revealed that variation in δ, as compared with variation in μ, was more reliably predicted by changes in hydrological variables when the dry sites were excluded (Table 4).

Similar analyses were conducted to evaluate the effects of including data from the additional sites (2017–2019). The estimated densities of Rio Grande Silvery Minnow using the additional sites (dry sites included) resulted in similar estimated densities (Figure 15), as compared to the dataset with the additional sites excluded (dry sites included). Likewise, the estimated densities using the additional sites (dry sites excluded) resulted in similar estimated densities (Figure 16), as compared to the dataset with the additional sites excluded (dry sites excluded). However, the analyses that included additional sites revealed a notably increased AIC_c weight on the μ(Year) models (Tables 5 and 6). Also, the 95% confidence intervals for *E*(*x*) were narrower (i.e., more precise) for both analyses when the additional sites were included, as compared to when they were excluded. To facilitate long-term comparisons among all model combinations (i.e., additional sites [included/excluded] and dry sites [included/excluded]), we provided a summary of the estimated densities across years (Table 7).

Mesohabitat associations (2002–2019)

Rio Grande Silvery Minnow densities (*E*(*x*); estimated using October sampling-site data [2002–2019]) were generated from the year-mesohabitat model (δ[Year*Mesohabitat] μ[Year*Mesohabitat]). Interannual density trends for the five mesohabitats (BW, PO, RU, SHPO, and SHRU) were very similar over the study period (Figure 17). Densities declined precipitously in all mesohabitats from 2009 to 2014, but then steadily increased from 2015 to 2017. There was a notable decrease in densities across all mesohabitats from 2017 to 2018, followed by a marked increase in 2019. Densities in slack-water mesohabitats (BW, PO, and SHPO) were generally higher than densities in swift-water mesohabitats (RU and SHRU). These differences were quite pronounced in years with the highest densities of Rio Grande Silvery Minnow, but were sometimes negligible in low-density years. Also, year-mesohabitat densities could not be estimated when only a single nonzero value was recorded (e.g., RU in 2015). While naive mean densities were still illustrated in those instances, the lack of any illustrated values indicates year-mesohabitat combinations when no individuals were collected (e.g., RU in 2014).

Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates revealed that changes in its occurrence and density were reliably predicted by differences across years and mesohabitats but much less so across reaches (Table 8). The top model (δ[Year+Mesohabitat] μ[Year+Mesohabitat]) effectively received all of the AIC_c weight out of the 41 models considered. A comparison of AIC_c values revealed that year (δ[Year] μ[Year]; AIC_c = 2,498.60) was more informative in explaining changes in model parameter values over time as compared with mesohabitat (δ[Mesohabitat] μ[Mesohabitat]; AIC_c = 3,193.87) or reach (δ[Reach] μ[Reach]; AIC_c = 3,433.29). The mesohabitat model (δ[Mesohabitat] μ[Mesohabitat]) demonstrated that estimated densities in several low velocity mesohabitats (BW [36.61] and SHPO [11.99]) were significantly higher ($P < 0.05$) than densities in higher velocity mesohabitats (RU [1.24] and SHRU [3.77]). Naive mean densities, computed using the method of moments, were very similar to estimated densities (*E*(*x*)) for different mesohabitats over time.

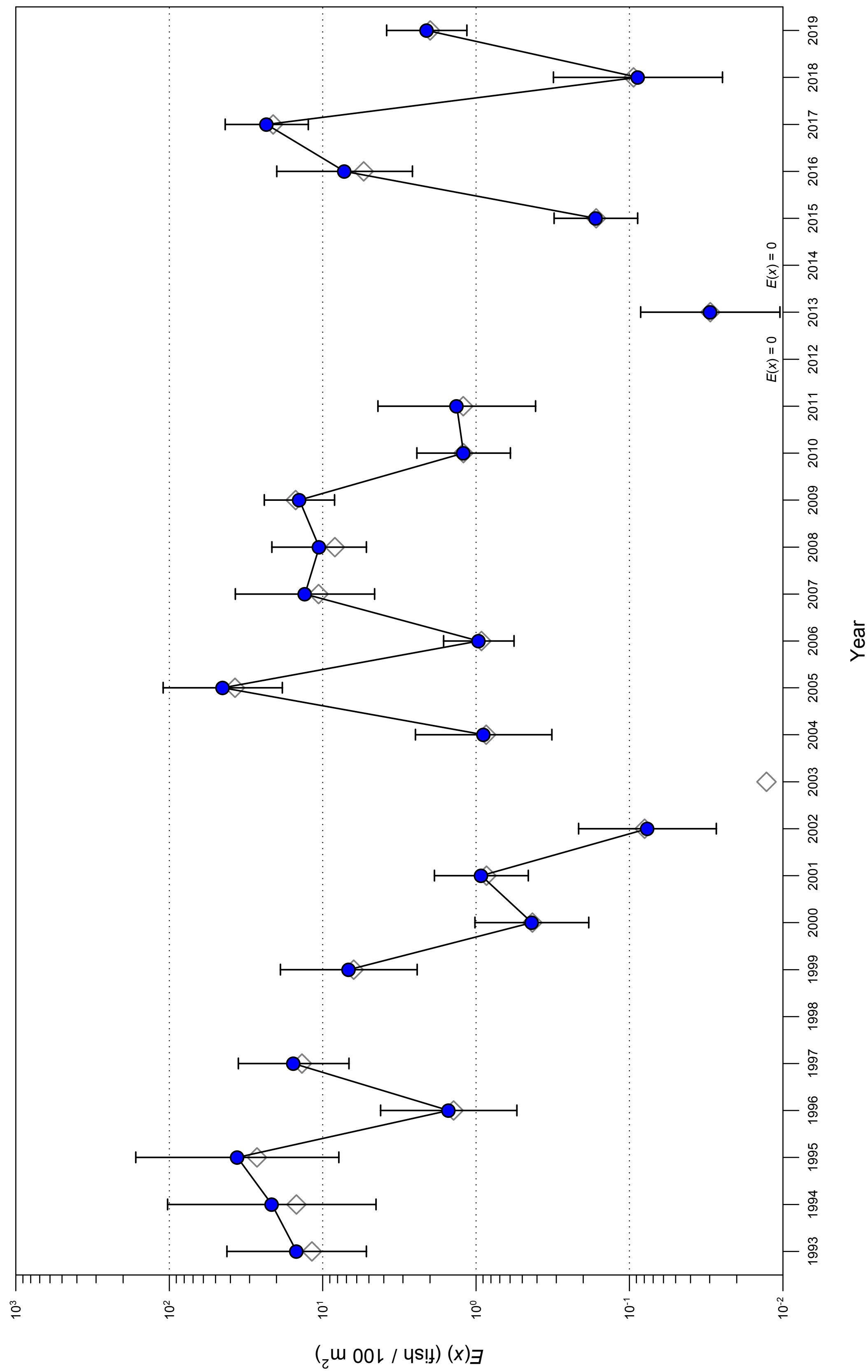

Figure 14. Rio Grande Silvery Minnow densities ($E(x)$; estimated using October sampling-site data) across years (see Table 7). Sampling did not occur in 1998, and $E(x)$ could not be computed for 2003. Modeled estimates (circles), 95% confidence intervals (bars), and method-of-moments estimates (diamonds) are illustrated. Additional sites and dry sites were excluded.

Table 4. Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates, using October sampling-site data (1993–2019). Additional sites and dry sites were excluded.

Model[1]	**logLike**[2]	**K**[3]	**AIC$_c$**[4]	**w_i**[4]
δ(SANmean+*R*) μ(Year)	752.48	50	864.51	0.2427
δ(Year) μ(ABQmax+*R*)	798.29	31	864.76	0.2135
δ(Year) μ(ABQ>2,000+*R*)	799.09	31	865.57	0.1427
δ(Year) μ(ABQmean+*R*)	799.58	31	866.06	0.1118
δ(ABQmax+*R*) μ(Year)	755.92	50	867.95	0.0434
δ(ABQmean+*R*) μ(Year)	756.17	50	868.20	0.0383
δ(Year) μ(ABQ>1,000+*R*)	801.75	31	868.23	0.0378
δ(SAN<200+*R*) μ(Year)	756.89	50	868.91	0.0268
δ(Year) μ(SANmean+*R*)	802.49	31	868.97	0.0261
δ(SANmean+*R*) μ(ABQ>2,000+*R*)	851.01	9	869.40	0.0211

[1] = Model variables included year (1993–2019), estimated inundation of the river floodplain, and other hydrological variables at USGS Gages (#08330000 [ABQ; Rio Grande at Albuquerque, NM] and #08358400 [SAN; Rio Grande Floodway at San Marcial, NM]), allowing for random effects (*R*).

[2] = Likelihood (–2[log-likelihood]) was estimated for each model.

[3] = Higher numbers of parameters indicate increased model complexity.

[4] = Top ten ecological models (i.e., containing environmental covariates) were ranked by Akaike's information criterion (AIC$_c$) and include the AIC$_c$ weight (w_i).

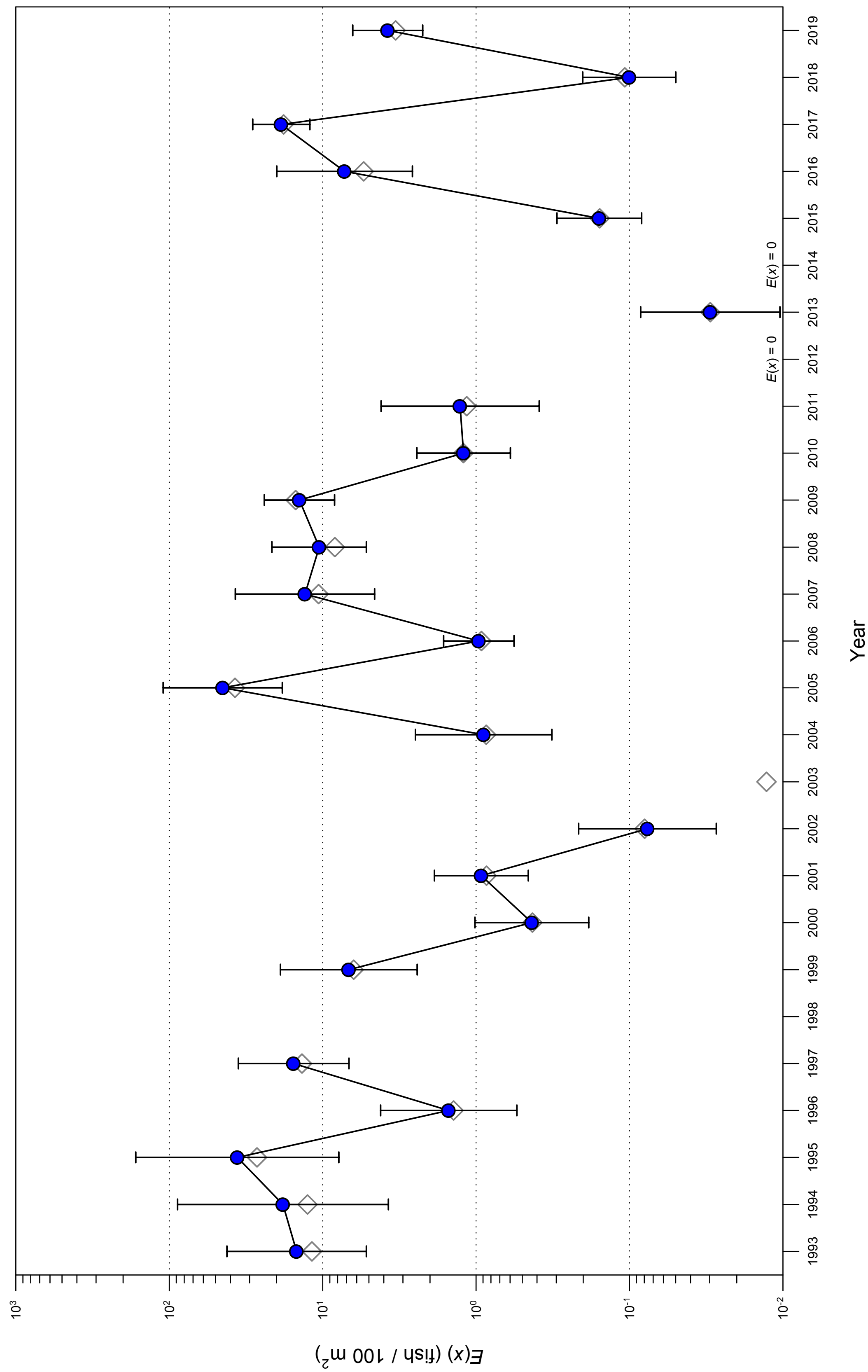

Figure 15. Rio Grande Silvery Minnow densities ($E(x)$; estimated using October sampling-site data) across years (see Table 7). Sampling did not occur in 1998, and $E(x)$ could not be computed for 2003. Modeled estimates (circles), 95% confidence intervals (bars), and method-of-moments estimates (diamonds) are illustrated. Additional sites and dry sites were included.

Table 5. Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates, using October sampling-site data (1993–2019). Additional sites and dry sites were included.

Model[1]	**logLike**[2]	**K**[3]	**AIC$_c$**[4]	***w_i***[4]
δ(SANmean+*R*) μ(Year)	800.48	50	911.49	0.3024
δ(Year) μ(ABQmax+*R*)	846.43	31	912.54	0.1788
δ(Year) μ(ABQ>2,000+*R*)	847.40	31	913.52	0.1097
δ(Year) μ(ABQmean+*R*)	847.60	31	913.72	0.0993
δ(ABQmax+*R*) μ(Year)	803.29	50	914.30	0.0741
δ(ABQmean+*R*) μ(Year)	803.75	50	914.77	0.0588
δ(SAN<200+*R*) μ(Year)	804.24	50	915.26	0.0460
δ(ABQ>2,000+*R*) μ(Year)	804.85	50	915.86	0.0340
δ(Year) μ(ABQ>1,000+*R*)	849.80	31	915.92	0.0330
δ(ABQ>3,000+*R*) μ(Year)	806.51	50	917.52	0.0148

[1] = Model variables included year (1993–2019), estimated inundation of the river floodplain, and other hydrological variables at USGS Gages (#08330000 [ABQ; Rio Grande at Albuquerque, NM] and #08358400 [SAN; Rio Grande Floodway at San Marcial, NM]), allowing for random effects (*R*).

[2] = Likelihood (–2[log-likelihood]) was estimated for each model.

[3] = Higher numbers of parameters indicate increased model complexity.

[4] = Top ten ecological models (i.e., containing environmental covariates) were ranked by Akaike's information criterion (AIC$_c$) and include the AIC$_c$ weight (w_i).

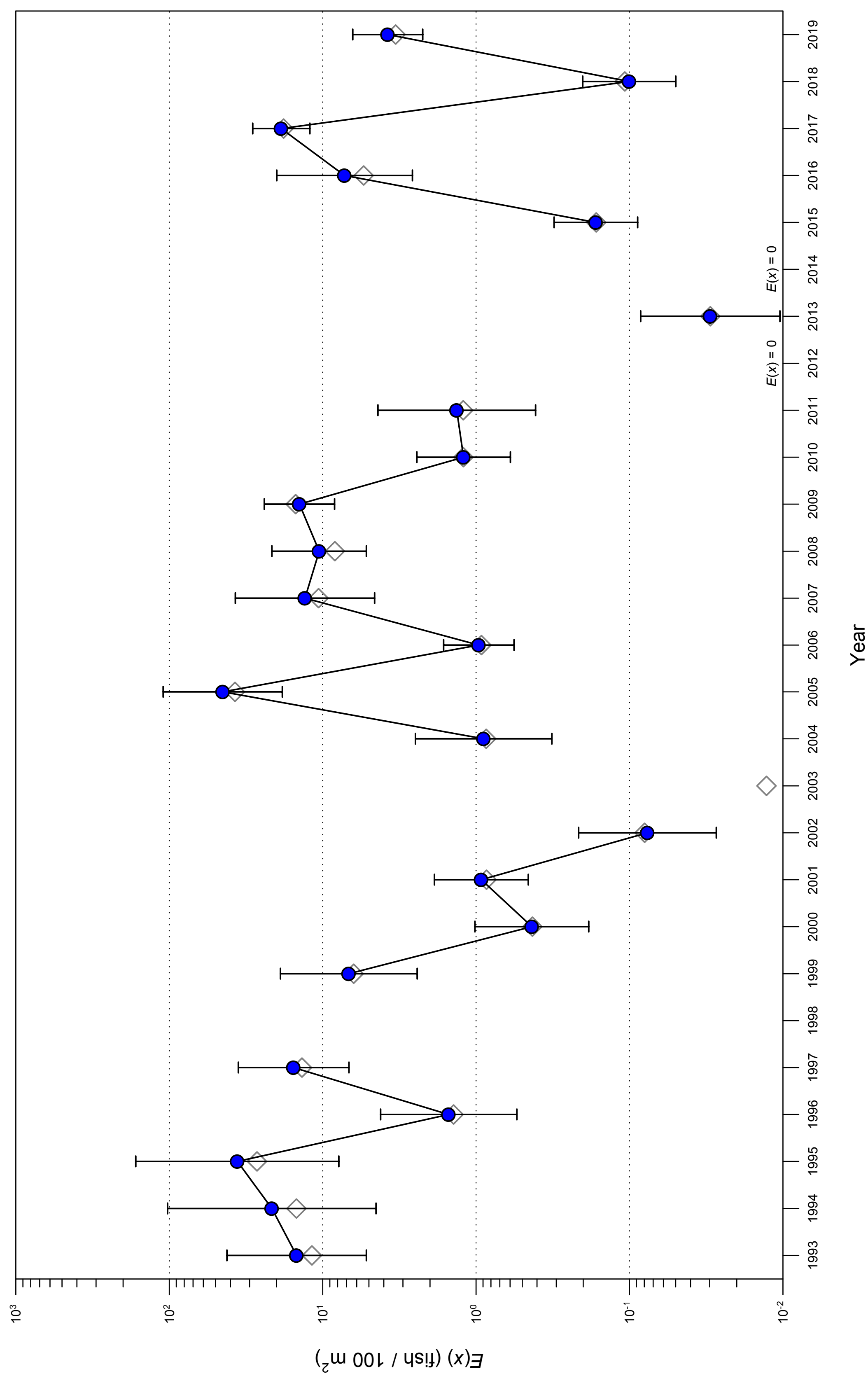

Figure 16. Rio Grande Silvery Minnow densities ($E(x)$; estimated using October sampling-site data) across years (see Table 7). Sampling did not occur in 1998, and $E(x)$ could not be computed for 2003. Modeled estimates (circles), 95% confidence intervals (bars), and method-of-moments estimates (diamonds) are illustrated. Additional sites were included and dry sites were excluded.

Table 6. Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates, using October sampling-site data (1993–2019). Additional sites were included and dry sites were excluded.

Model[1]	**logLike**[2]	**K**[3]	**AIC$_c$**[4]	w_i [4]
δ(SANmean+*R*) μ(Year)	788.15	50	899.39	0.6262
δ(ABQmean+*R*) μ(Year)	792.07	50	903.30	0.0883
δ(ABQmax+*R*) μ(Year)	792.39	50	903.63	0.0752
δ(Year) μ(ABQmax+*R*)	838.69	31	904.89	0.0400
δ(SAN<200+*R*) μ(Year)	793.79	50	905.02	0.0374
δ(ABQ>2,000+*R*) μ(Year)	794.05	50	905.28	0.0328
δ(Year) μ(ABQ>2,000+*R*)	839.67	31	905.87	0.0245
δ(Year) μ(ABQmean+*R*)	839.87	31	906.07	0.0222
δ(ABQ>3,000+*R*) μ(Year)	795.01	50	906.25	0.0203
δ(Inundation+*R*) μ(Year)	796.81	50	908.04	0.0083

[1] = Model variables included year (1993–2019), estimated inundation of the river floodplain, and other hydrological variables at USGS Gages (#08330000 [ABQ; Rio Grande at Albuquerque, NM] and #08358400 [SAN; Rio Grande Floodway at San Marcial, NM]), allowing for random effects (*R*).

[2] = Likelihood (–2[log-likelihood]) was estimated for each model.

[3] = Higher numbers of parameters indicate increased model complexity.

[4] = Top ten ecological models (i.e., containing environmental covariates) were ranked by Akaike's information criterion (AIC$_c$) and include the AIC$_c$ weight (w_i).

Table 7. Rio Grande Silvery Minnow densities *E*(*x*) and 95% confidence intervals (LCI–UCI), estimated using October sampling-site data, across years. Sampling did not occur in 1998, and *E*(*x*) could not be computed for 2003. All combinations of additional sites (included/excluded) and dry sites (included/excluded) are presented.

	***E*(*x*) and (LCI–UCI)**			
Year	**Add(N)Dry(Y)[1]**	**Add(N)Dry(N)[2]**	**Add(Y)Dry(Y)[3]**	**Add(Y)Dry(N)[4]**
1993	14.80 (5.20–42.13)	14.80 (5.20–42.13)	14.80 (5.20–42.13)	14.80 (5.20–42.13)
1994	18.16 (3.73–88.34)	21.46 (4.49–102.63)	18.16 (3.73–88.34)	21.46 (4.49–102.63)
1995	36.03 (7.85–165.42)	36.03 (7.85–165.42)	36.03 (7.85–165.42)	36.03 (7.85–165.42)
1996	1.51 (0.54–4.20)	1.51 (0.54–4.20)	1.51 (0.54–4.20)	1.51 (0.54–4.20)
1997	15.48 (6.75–35.50)	15.48 (6.75–35.50)	15.48 (6.75–35.50)	15.48 (6.75–35.50)
1999	6.76 (2.42–18.87)	6.76 (2.42–18.87)	6.76 (2.42–18.87)	6.76 (2.42–18.87)
2000	0.43 (0.18–1.02)	0.43 (0.18–1.02)	0.43 (0.18–1.02)	0.43 (0.18–1.02)
2001	0.92 (0.46–1.87)	0.92 (0.46–1.87)	0.92 (0.46–1.87)	0.92 (0.46–1.87)
2002	0.08 (0.03–0.21)	0.08 (0.03–0.21)	0.08 (0.03–0.21)	0.08 (0.03–0.21)
2003	-	-	-	-
2004	0.89 (0.32–2.49)	0.89 (0.32–2.49)	0.89 (0.32–2.49)	0.89 (0.32–2.49)
2005	44.84 (18.34–109.59)	44.84 (18.34–109.59)	44.84 (18.34–109.59)	44.84 (18.34–109.59)
2006	0.96 (0.57–1.63)	0.96 (0.57–1.63)	0.96 (0.57–1.63)	0.96 (0.57–1.63)
2007	13.05 (4.59–37.14)	13.05 (4.59–37.14)	13.05 (4.59–37.14)	13.05 (4.59–37.14)
2008	10.55 (5.19–21.43)	10.55 (5.19–21.43)	10.55 (5.19–21.43)	10.55 (5.19–21.43)
2009	14.18 (8.37–24.03)	14.18 (8.37–24.03)	14.18 (8.37–24.03)	14.18 (8.37–24.03)
2010	1.21 (0.60–2.44)	1.21 (0.60–2.44)	1.21 (0.60–2.44)	1.21 (0.60–2.44)
2011	1.27 (0.39–4.17)	1.34 (0.41–4.37)	1.27 (0.39–4.17)	1.34 (0.41–4.37)
2012	0	0	0	0
2013	0.03 (0.01–0.08)	0.03 (0.01–0.08)	0.03 (0.01–0.08)	0.03 (0.01–0.08)
2014	0	0	0	0
2015	0.16 (0.08–0.30)	0.17 (0.09–0.31)	0.16 (0.08–0.30)	0.17 (0.09–0.31)
2016	7.20 (2.60–19.92)	7.20 (2.60–19.92)	7.20 (2.60–19.92)	7.20 (2.60–19.92)
2017	23.17 (12.41–43.26)	23.17 (12.41–43.26)	18.64 (12.13–28.62)	18.64 (12.13–28.62)
2018	0.09 (0.02–0.31)	0.09 (0.02–0.31)	0.10 (0.05–0.20)	0.10 (0.05–0.20)
2019	2.10 (1.15–3.84)	2.10 (1.15–3.84)	3.77 (2.23–6.37)	3.77 (2.23–6.37)

[1] = Additional sites were excluded and dry sites were included.
[2] = Additional sites and dry sites were excluded.
[3] = Additional sites and dry sites were included.
[4] = Additional sites were included and dry sites were excluded.

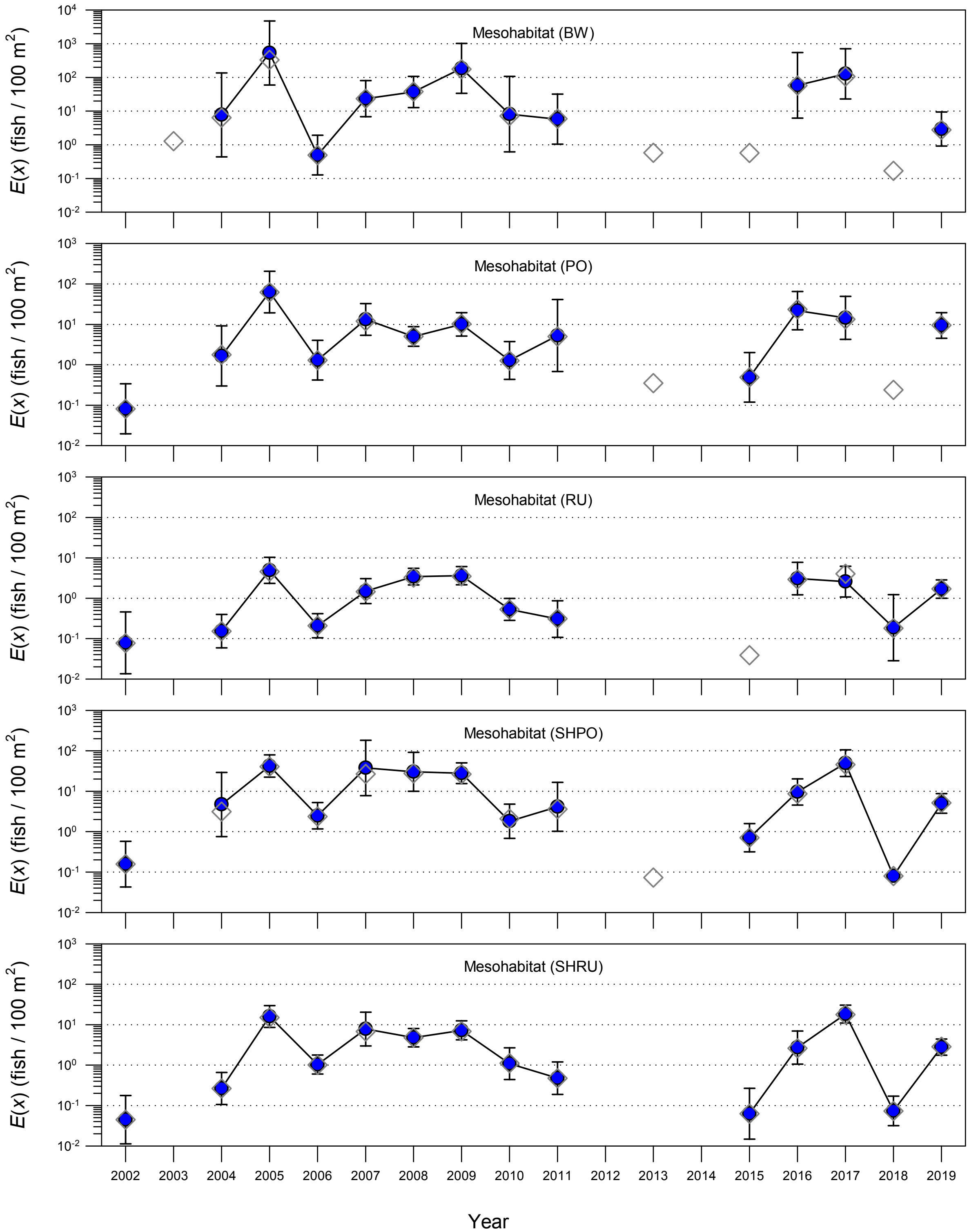

Figure 17. Rio Grande Silvery Minnow densities ($E(x)$; estimated using October mesohabitat-specific data from all sites) across years. Modeled estimates (circles), 95% confidence intervals (bars), and method-of-moments estimates (diamonds) are illustrated.

Table 8. Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates, using October mesohabitat-specific data from all sites (2002–2019).

Model[1]	**logLike**[2]	**K**[3]	**AIC$_c$**[4]	***w_i***[4]
δ(Year+Mesohabitat) μ(Year+Mesohabitat)	2,076.81	61	2,203.69	>0.9999
δ(Year) μ(Year+Mesohabitat)	2,126.59	57	2,244.84	<0.0001
δ(Year+Mesohabitat) μ(Mesohabitat)	2,318.96	32	2,384.30	<0.0001
δ(Year*Mesohabitat) μ(Year*Mesohabitat)	1,863.31	227	2,392.10	<0.0001
δ(Year) μ(Mesohabitat)	2,368.75	28	2,425.77	<0.0001
δ(Year+Mesohabitat) μ(Year)	2,347.68	53	2,457.36	<0.0001
δ(*R*) μ(Mesohabitat)	2,456.38	12	2,480.57	<0.0001
δ(Year) μ(Year+Reach)	2,386.96	53	2,496.64	<0.0001
δ(Year) μ(Year)	2,397.46	49	2,498.60	<0.0001
δ(Year+Reach) μ(Year+Reach)	2,386.76	55	2,500.71	<0.0001

[1] = Model variables included year (2002–2019), mesohabitat (backwater, pool, run, shoreline pool, and shoreline run), and reach (Angostura, Isleta, and San Acacia), allowing for random effects (*R*).

[2] = Likelihood (–2[log-likelihood]) was estimated for each model.

[3] = Higher numbers of parameters indicate increased model complexity.

[4] = Top ten models were ranked by Akaike's information criterion (AIC$_c$) and include the AIC$_c$ weight (w_i).

Sampling variation (2005–2019)

Rio Grande Silvery Minnow densities ($E(x)$; estimated using November sampling-site data [2005–2019]) were generated from the year-occasion model (δ[Year*Occasion] μ[Year*Occasion]). Interannual density trends for the sampling occasions (i.e., 1^{st}, 2^{nd}, 3^{rd}, and 4^{th} day of sampling) were very similar over the study period (Figure 18). While densities had notably improved for all sampling occasions from 2014 to 2017, there was precipitous decline in 2018. This decline was quickly followed by a marked increase in 2019. However, year-occasion densities could not be estimated when only a single nonzero value was recorded (e.g., 1^{st} day in 2013). While naive mean densities were still illustrated in those instances, the lack of any illustrated estimates indicates year-occasion combinations when no individuals were collected (e.g., 3^{rd} day in 2013).

Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates revealed that changes in its occurrence and density were reliably predicted by differences across years and reaches but much less so across sampling occasions (Table 9). The top model (δ[Year*Reach] μ[Year*Reach]) received nearly all of the AIC_c weight out of the 41 models considered. A comparison of AIC_c values revealed that year (δ[Year] μ[Year]; AIC_c = 2,140.34) was more informative in explaining changes in model parameter values over time as compared with reach (δ[Reach] μ[Reach]; AIC_c = 3,174.03) or sampling occasion (δ[Occasion] μ[Occasion]; AIC_c = 3,223.74). Further, a variance components analysis revealed that Year accounted for the highest variance (59.15) in estimated densities, followed distantly by Reach (3.79), Site[Reach] (2.94), and Occasion (0.00). Also, there were no significant differences in estimated densities across the four sampling occasions for any year (2005–2019). Naive mean densities, computed using the method of moments, were very similar to estimated densities ($E(x)$) for different sampling occasions over time.

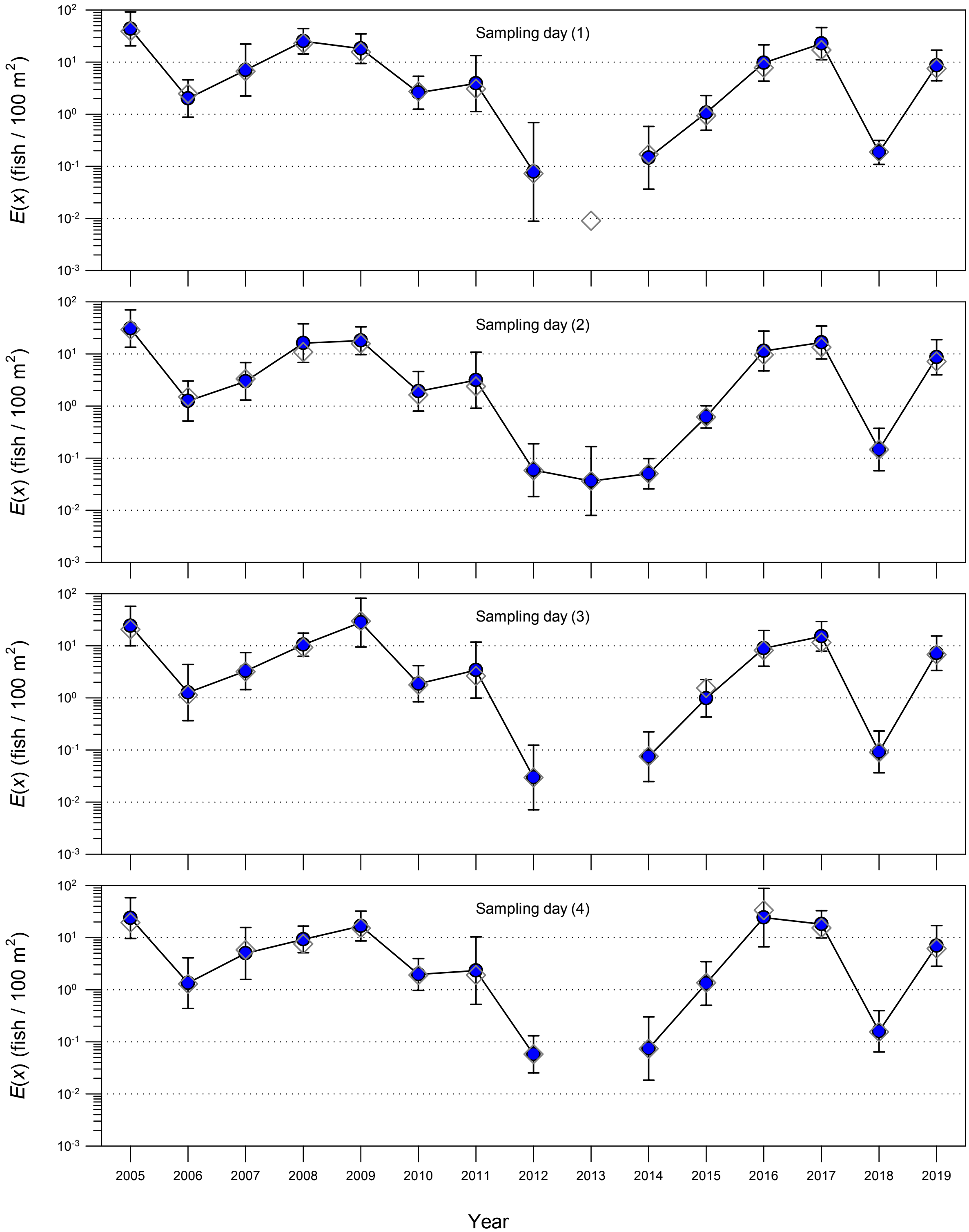

Figure 18. Rio Grande Silvery Minnow densities ($E(x)$; estimated using November sampling-site data from all sites) across years. Modeled estimates (circles), 95% confidence intervals (bars), and method-of-moments estimates (diamonds) are illustrated.

Table 9. Generalized linear models of Rio Grande Silvery Minnow mixture-model estimates, using November sampling-site data from all sites (2005–2019).

Model[1]	**logLike**[2]	**K**[3]	**AIC$_c$**[4]	**w_i**[4]
δ(Year*Reach) μ(Year*Reach)	1,606.51	129	1,895.86	>0.9999
δ(Year+Reach) μ(Year+Reach)	1,909.51	51	2,016.13	<0.0001
δ(Year) μ(Year+Reach)	1,968.38	49	2,070.64	<0.0001
δ(Year+Reach) μ(Year)	1,987.89	47	2,085.80	<0.0001
δ(Year) μ(Year)	2,046.75	45	2,140.34	<0.0001
δ(Year) μ(Year+Occasion)	2,036.38	51	2,143.00	<0.0001
δ(Year+Occasion) μ(Year)	2,043.39	48	2,143.48	<0.0001
δ(Year+Occasion) μ(Year+Occasion)	2,033.02	54	2,146.21	<0.0001
δ(*R*) μ(Year)	2,113.08	32	2,178.89	<0.0001
δ(Year) μ(*R*)	2,172.37	18	2,208.95	<0.0001

1 = Model variables included year (2005–2019), sampling occasion (i.e., 1st, 2nd, 3rd, and 4th day of sampling), and reach (Angostura, Isleta, and San Acacia), allowing for random effects (*R*).
2 = Likelihood (–2[log-likelihood]) was estimated for each model.
3 = Higher numbers of parameters indicate increased model complexity.
4 = Top ten models were ranked by Akaike's information criterion (AIC$_c$) and include the AIC$_c$ weight (w_i).

Fish Community

Population status (1993–2019)

The ichthyofaunal community in the Middle Rio Grande during 2019 was numerically dominated by cyprinids (Tables 10 and 11; Appendix F). The native ichthyofauna comprised 12 species (Gizzard Shad, Red Shiner, Rio Grande Chub, Rio Grande Silvery Minnow, Fathead Minnow, Flathead Chub, Longnose Dace, River Carpsucker, Smallmouth Buffalo, Blue Catfish, Flathead Catfish, and Freshwater Drum). Red Shiner was the most abundant native species collected (n = 18,473), followed by Rio Grande Silvery Minnow (n = 4,996), and Flathead Chub (n = 2,650). We also documented the presence of Freshwater Drum (n = 1), a native species that hasn't been previously captured in the Middle Rio Grande as part of this study. The nonnative ichthyofauna comprised 11 species. The most abundant nonnative species were Channel Catfish (n = 2,481), Western Mosquitofish (n = 1,842), and White Sucker (n = 1,531).

There were notable seasonal changes in the relative abundance of the 10 focal taxa from April to October 2019 (Figures 19 and 20). Densities of all fish species generally increased during summer. Rio Grande Silvery Minnow abundance was highest in August but had declined considerably by October. Other focal species typically reached their highest densities from June to August, following their respective spawning periods.

In addition to temporal variation in the relative abundance of fish species during 2019, there were also pronounced differences in the densities of species across reaches (Figure 21). Fathead Minnow, Flathead Chub, Longnose Dace, and White Sucker were most common in the Angostura Reach. The most common species in the Isleta Reach were Red Shiner, Rio Grande Silvery Minnow, and Western Mosquitofish. Common Carp, River Carpsucker, and Channel Catfish were most common in the San Acacia Reach.

The abundance of the ten focal species, during October, has fluctuated markedly across years (Table 12). Several species, including Rio Grande Silvery Minnow, have periodically declined to very low numbers (< 10). In contrast, other species (e.g., Red Shiner and Western Mosquitofish) have never declined to fewer than 100 individuals. Different species also varied widely in their abundance trends over time, and it was not uncommon for some species to increase dramatically, while others decreased dramatically, within one or two years. The annual abundance of Rio Grande Silvery Minnow was particularly volatile, fluctuating from a high of 3,939 in 2005 to a low of 0 in 2012 and 2014.

Rio Grande Silvery Minnow composed a higher fraction of the ichthyofaunal community, during October, from 2016 to 2017 than from 2018 to 2019 (Figure 22). Notable changes in the relative abundance of this species mirrored similar changes in its estimated occurrence and density over the study period (1993–2019). While Rio Grande Silvery Minnow represented < 0.2% of the fish community in 2018, it had increased to 8.61% by 2019.

The magnitude of change in the relative abundance of Rio Grande Silvery Minnow was particularly evident when compared to other focal species across all study years (Table 13). Rio Grande Silvery Minnow had decreased from being the 2nd most common focal species in 2009 to being the least common focal species from 2012 to 2014. While its rank abundance declined precipitously from 2017 (1st) to 2018 (10th), it again improved dramatically in 2019 (3rd). The coefficient of concordance (W = 0.66) for the ten focal species indicated high overall agreement among ranks over time (1993–2019; X^2 = 155.0; P < 0.001) despite marked changes in ranks for some species (e.g., Rio Grande Silvery Minnow and River Carpsucker).

Table 10. Ichthyofaunal summary based on all sites (all age-classes combined), by species, during 2019. Marked and unmarked Rio Grande Silvery Minnow were included.

Family	Common Name	Residence Status[1]	Total Number of Individuals	Percent (%) of Total	Frequency of Occurrence[2]	% Frequency of Occurrence[2]
Clupeidae	Gizzard Shad	N	29	0.08	8	5.00
Clupeidae	Threadfin Shad	I	-	-	-	-
Cyprinidae	Central Stoneroller	I	-	-	-	-
Cyprinidae	Goldfish	I	-	-	-	-
Cyprinidae	Red Shiner	N	18,473	52.87	156	97.50
Cyprinidae	Common Carp	I	1,335	3.82	89	55.63
Cyprinidae	Rio Grande Chub	N	2	0.01	2	1.25
Cyprinidae	Rio Grande Silvery Minnow	N	4,996	14.30	112	70.00
Cyprinidae	Golden Shiner	I	-	-	-	-
Cyprinidae	Fathead Minnow	N	362	1.04	65	40.63
Cyprinidae	Bullhead Minnow	I	13	0.04	6	3.75
Cyprinidae	Flathead Chub	N	2,650	7.58	112	70.00
Cyprinidae	Longnose Dace	N	779	2.23	37	23.13
Catostomidae	River Carpsucker	N	57	0.16	31	19.38
Catostomidae	White Sucker	I	1,531	4.38	55	34.38
Catostomidae	Smallmouth Buffalo	N	41	0.12	13	8.13
Ictaluridae	Black Bullhead	I	14	0.04	4	2.50
Ictaluridae	Yellow Bullhead	I	181	0.52	33	20.63
Ictaluridae	Blue Catfish	N	97	0.28	30	18.75
Ictaluridae	Channel Catfish	I	2,481	7.10	108	67.50
Ictaluridae	Flathead Catfish	N	1	0.00	1	0.63
Loricariidae	Vermiculated Sailfin Catfish	I	-	-	-	-
Salmonidae	Rainbow Trout	I	-	-	-	-
Salmonidae	Brown Trout	I	-	-	-	-
Poeciliidae	Western Mosquitofish	I	1,842	5.27	89	55.63
Moronidae	White Bass	I	2	0.01	2	1.25
Moronidae	Striped Bass	I	-	-	-	-
Centrarchidae	Green Sunfish	I	5	0.01	4	2.50
Centrarchidae	Bluegill	N	-	-	-	-
Centrarchidae	Longear Sunfish	I	-	-	-	-
Centrarchidae	Smallmouth Bass	I	-	-	-	-
Centrarchidae	Largemouth Bass	I	23	0.07	11	6.88
Centrarchidae	White Crappie	I	28	0.08	13	8.13
Centrarchidae	Black Crappie	I	-	-	-	-
Percidae	Yellow Perch	I	-	-	-	-
Percidae	Bigscale Logperch	I	-	-	-	-
Percidae	Walleye	I	-	-	-	-
Sciaenidae	Freshwater Drum	N	1	0.00	1	0.63
Annual Total			**34,943**	**100.00**		

[1] = N (native); I (introduced)
[2] = Frequency and % frequency of occurrence were based on 160 samples taken during 2019.

Table 11. Ichthyofaunal summary based on all sites (all age-classes combined), by species and month, during 2019. Marked and unmarked Rio Grande Silvery Minnow were included.

Family	Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Clupeidae	Gizzard Shad	-	1	1	-	-	23	4	29
Clupeidae	Threadfin Shad	-	-	-	-	-	-	-	0
Cyprinidae	Central Stoneroller	-	-	-	-	-	-	-	0
Cyprinidae	Goldfish	-	-	-	-	-	-	-	0
Cyprinidae	Red Shiner	3,766	1,794	2,807	2,146	2,439	2,194	3,327	18,473
Cyprinidae	Common Carp	34	6	286	371	107	435	96	1,335
Cyprinidae	Rio Grande Chub	-	1	1	-	-	-	-	2
Cyprinidae	Rio Grande Silvery Minnow	17	10	412	994	2,289	757	517	4,996
Cyprinidae	Golden Shiner	-	-	-	-	-	-	-	0
Cyprinidae	Fathead Minnow	57	8	91	110	29	16	51	362
Cyprinidae	Bullhead Minnow	5	3	-	3	2	-	-	13
Cyprinidae	Flathead Chub	363	211	447	269	254	623	483	2,650
Cyprinidae	Longnose Dace	95	58	86	89	201	83	167	779
Catostomidae	River Carpsucker	22	4	4	5	6	12	4	57
Catostomidae	White Sucker	27	545	364	549	37	1	8	1,531
Catostomidae	Smallmouth Buffalo	-	5	21	2	-	13	-	41
Ictaluridae	Black Bullhead	-	-	-	-	-	14	-	14
Ictaluridae	Yellow Bullhead	5	1	-	-	142	11	22	181
Ictaluridae	Blue Catfish	-	8	19	15	6	33	16	97
Ictaluridae	Channel Catfish	244	23	9	9	1,498	315	383	2,481
Ictaluridae	Flathead Catfish	-	-	-	-	-	1	-	1
Loricariidae	Vermiculated Sailfin Catfish	-	-	-	-	-	-	-	0
Salmonidae	Rainbow Trout	-	-	-	-	-	-	-	0
Salmonidae	Brown Trout	-	-	-	-	-	-	-	0
Poeciliidae	Western Mosquitofish	66	12	13	43	290	499	919	1,842
Moronidae	White Bass	-	-	-	1	-	-	1	2
Moronidae	Striped Bass	-	-	-	-	-	-	-	0
Centrarchidae	Green Sunfish	1	-	-	2	-	1	1	5
Centrarchidae	Bluegill	-	-	-	-	-	-	-	0
Centrarchidae	Longear Sunfish	-	-	-	-	-	-	-	0
Centrarchidae	Smallmouth Bass	-	-	-	-	-	-	-	0
Centrarchidae	Largemouth Bass	1	-	-	1	14	7	-	23
Centrarchidae	White Crappie	3	-	-	-	3	16	6	28
Centrarchidae	Black Crappie	-	-	-	-	-	-	-	0
Percidae	Yellow Perch	-	-	-	-	-	-	-	0
Percidae	Bigscale Logperch	-	-	-	-	-	-	-	0
Percidae	Walleye	-	-	-	-	-	-	-	0
Sciaenidae	Freshwater Drum	-	-	-	-	-	1	-	1
Monthly Totals		**4,706**	**2,690**	**4,561**	**4,609**	**7,317**	**5,055**	**6,005**	**34,943**

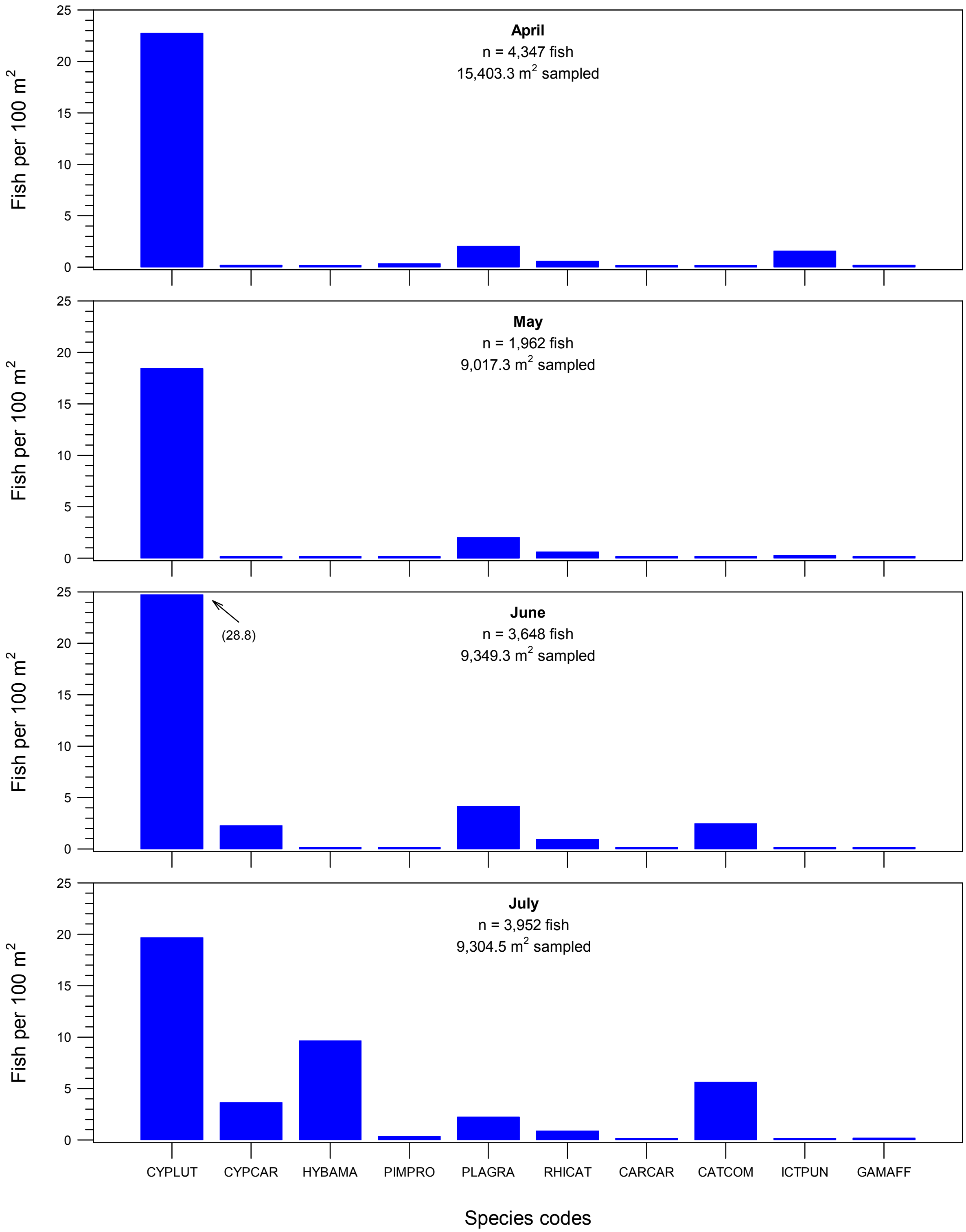

Figure 19. Fish densities based on all sites (age-0 and age-1+ fish [small-mesh seine]; larval fish excluded), by month and focal taxa, from April to July 2019.

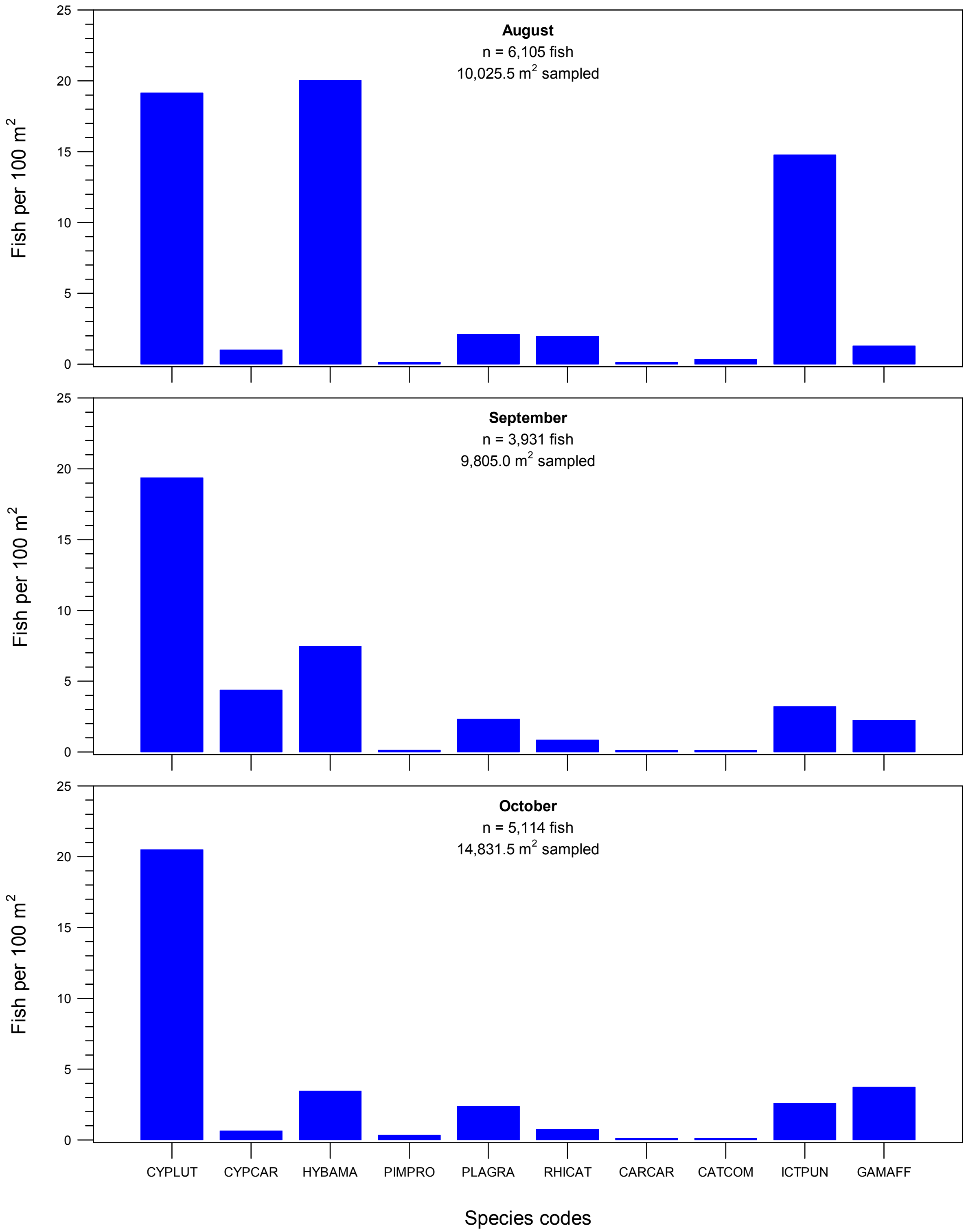

Figure 20. Fish densities based on all sites (age-0 and age-1+ fish [small-mesh seine]; larval fish excluded), by month and focal taxa, from August to October 2019.

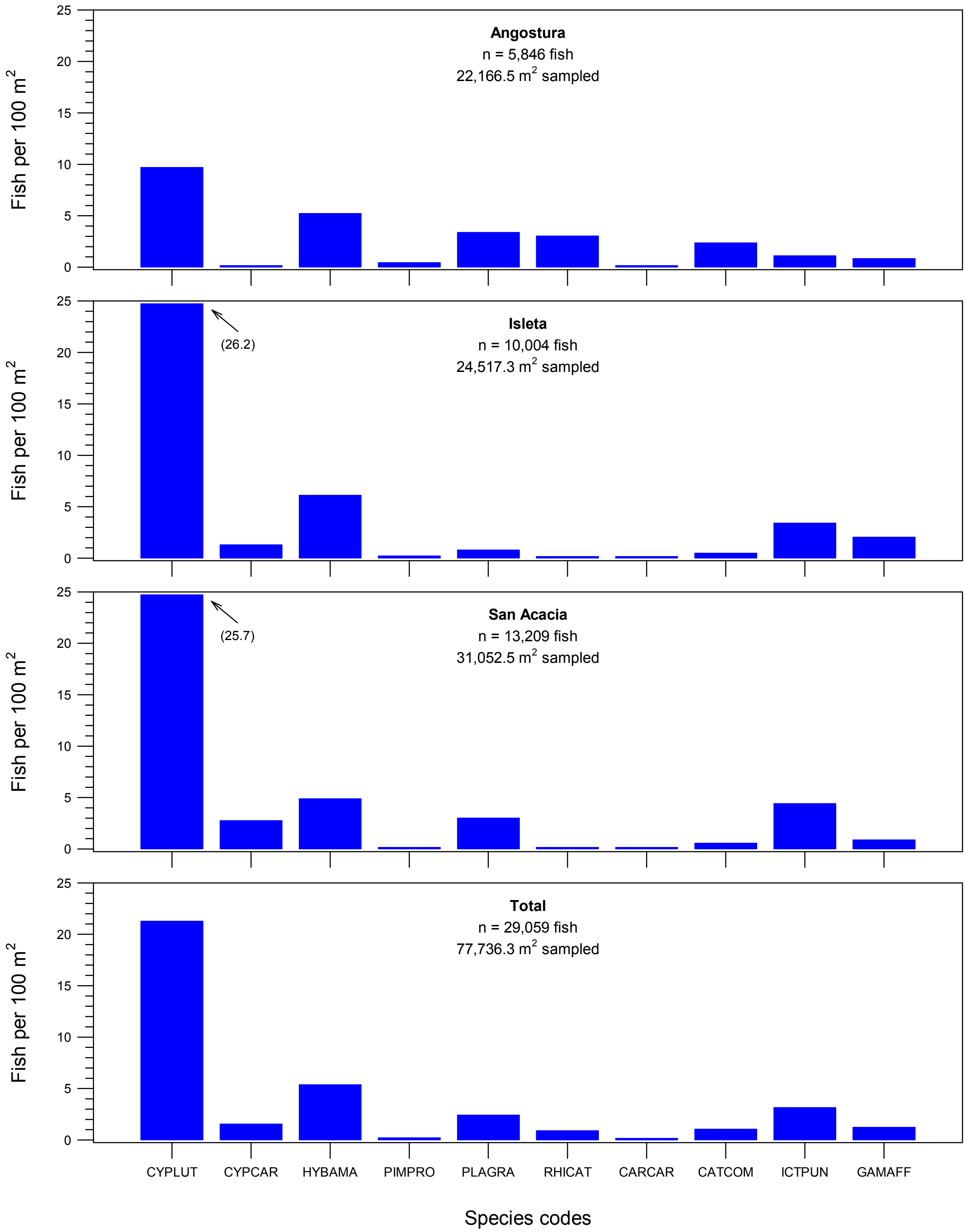

Figure 21. Fish densities based on all sites (age-0 and age-1+ fish [small-mesh seine]; larval fish excluded), by reach and focal taxa, during 2019.

Table 12. Fish abundance based on all sites during October, by year and focal taxa, from 1993 to 2019. Sampling did not occur in 1998.

	Species Codes									
Year	CYPLUT	CYPCAR	HYBAMA	PIMPRO	PLAGRA	RHICAT	CARCAR	CATCOM	ICTPUN	GAMAFF
1993	3,585	24	939	315	297	11	322	48	174	185
1994	1,091	26	906	131	139	58	108	27	465	122
1995	510	13	1,292	97	308	35	29	71	170	142
1996	1,994	43	956	396	295	46	316	38	386	869
1997	724	18	606	82	196	54	100	70	257	351
1999	1,522	11	412	63	259	60	180	11	74	297
2000	7,511	13	37	399	48	53	251	78	313	2,443
2001	5,769	88	112	740	158	53	284	21	242	3,984
2002	8,054	25	11	1,564	126	198	150	43	253	1,843
2003	5,042	25	2	757	126	31	123	24	38	2,508
2004	3,436	7	78	447	194	24	42	5	60	781
2005	399	47	3,939	115	61	32	2	2	48	829
2006	1,669	1	162	76	204	23	3	3	160	192
2007	5,287	6	1,166	129	543	55	142	19	174	557
2008	1,635	41	868	114	239	29	18	12	82	745
2009	2,314	2	1,835	144	210	16	60	20	321	811
2010	2,518	6	137	54	503	41	15	4	162	489
2011	3,121	16	118	44	122	28	79	17	64	430
2012	5,272	84	0	154	781	28	73	19	184	1,237
2013	3,265	6	3	307	127	317	7	25	218	959
2014	1,506	8	0	52	215	58	12	2	167	338
2015	690	6	16	18	169	68	12	0	129	639
2016	1,574	37	584	18	183	39	9	2	135	206
2017	2,631	102	2,867	44	300	69	24	26	1,126	810
2018	6,552	55	17	188	662	179	298	20	338	1,920
2019	3,327	96	517	51	483	167	4	8	383	919

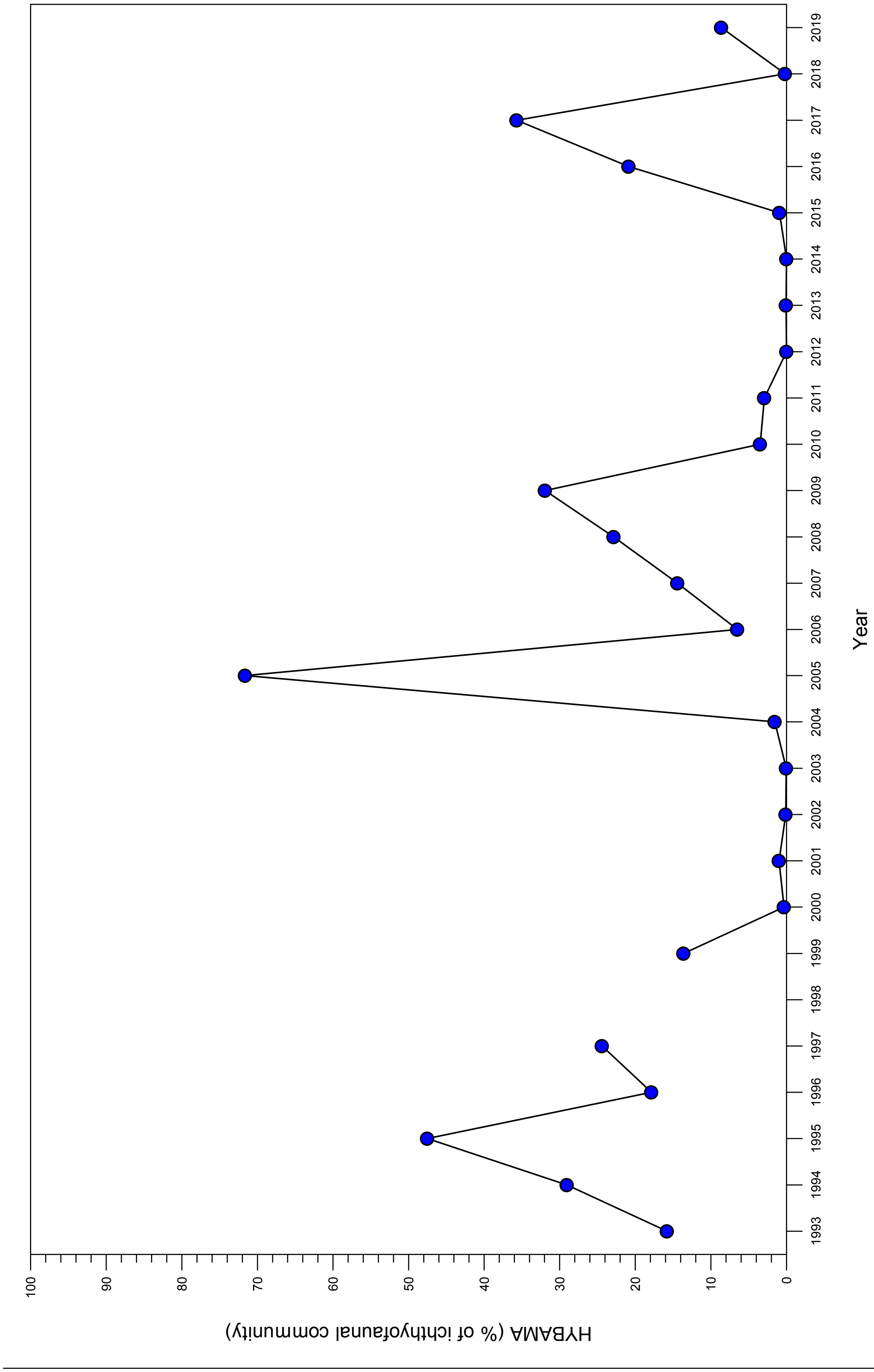

Figure 22. Relative abundance of Rio Grande Silvery Minnow as a percentage of the ichthyofaunal community, based on all sites during October, across years. Sampling did not occur in 1998.

Table 13. Fish rank-abundance based on all sites during October, by year and focal taxa, from 1993 to 2019. Sampling did not occur in 1998.

	Species Codes									
Year	CYPLUT	CYPCAR	HYBAMA	PIMPRO	PLAGRA	RHICAT	CARCAR	CATCOM	ICTPUN	GAMAFF
1993	1	9	2	4	5	10	3	8	7	6
1994	1	10	2	5	4	8	7	9	3	6
1995	2	10	1	6	3	8	9	7	4	5
1996	1	9	2	4	7	8	6	10	5	3
1997	1	10	2	7	5	9	6	8	4	3
1999	1	9.5	2	7	4	8	5	9.5	6	3
2000	1	10	9	3	8	7	5	6	4	2
2001	1	8	7	3	6	9	4	10	5	2
2002	1	9	10	3	7	5	6	8	4	2
2003	1	8	10	3	4	7	5	9	6	2
2004	1	9	5	3	4	8	7	10	6	2
2005	3	7	1	4	5	8	9.5	9.5	6	2
2006	1	10	4	6	2	7	8.5	8.5	5	3
2007	1	10	2	7	4	8	6	9	5	3
2008	1	7	2	5	4	8	9	10	6	3
2009	1	10	2	6	5	9	7	8	4	3
2010	1	9	5	6	2	7	8	10	4	3
2011	1	10	4	7	3	8	5	9	6	2
2012	1	6	10	5	3	8	7	9	4	2
2013	1	9	10	4	6	3	8	7	5	2
2014	1	8	10	6	3	5	7	9	4	2
2015	1	9	7	6	3	5	8	10	4	2
2016	1	7	2	8	4	6	9	10	5	3
2017	2	6	1	8	5	7	10	9	3	4
2018	1	8	10	6	3	7	5	9	4	2
2019	1	7	3	8	4	6	10	9	5	2

DISCUSSION

Research Goals and Objectives

The population status of Rio Grande Silvery Minnow, and the associated Middle Rio Grande ichthyofaunal community, has been systematically monitored since 1993. This effort is unique among ichthyofaunal research studies in the Middle Rio Grande, as it has been providing consistent sampling of fishes over a very long duration. Determining changes in fish population trends is best accomplished by analyzing the suite of available data over the full study period. Long-term sampling studies also provide the data necessary to test specific ecological hypotheses. While this study was initially designed to monitor the long-term population trends of fish species in the Middle Rio Grande, its scope has expanded to address some of the evolving data needs of natural resource managers. Examples of key study components that have been added over time include: 1) evaluating the influence of river flows on population fluctuations, 2) determining mesohabitat use patterns, 3) assessing variation in density estimates based on repeated sampling, 4) documenting changes in relative abundance among native and nonnative fishes, and 5) evaluating changes in site occupancy status across years. The primary objective of the Rio Grande Silvery Minnow Population Monitoring Program is to assess interannual trends in the abundance of this imperiled species at standardized sites throughout the Middle Rio Grande and evaluate how those trends are affected by changes in annual discharge patterns over time. Our primary research objective was to evaluate how seasonal and annual changes in river flows affect the distribution and abundance of Rio Grande Silvery Minnow throughout its current range over time (1993–2019).

Population Trends vs. Population Estimates

While the primary purpose of this study was to estimate fish population trends over time using a density index (i.e., CPUE), there are important distinctions between estimating population trends vs. estimating population size. Both the accuracy and precision of population size estimates, based on mark-recapture or multiple-pass sampling techniques, are likely to be better than estimates based on a density index (Otis et al. 1978). However, the practical budgetary constraints of agencies, charged with the long-term monitoring of imperiled species, often preclude the utilization of more statistically-robust sampling techniques (e.g., mark-recapture or multiple-pass studies). Despite these challenges, density indices have repeatedly been shown to be appropriate for assessing population trends and can be a practical and cost-effective approach for long-term monitoring studies (Johnson 2008; Al-Chokhachy et al. 2009; Cao et al. 2016; Crane and Kapuscinski 2018).

Statistical analyses revealed a close relationship between Rio Grande Silvery Minnow population trends (2008–2011) obtained from the population-monitoring and population-estimation studies (Dudley et al. 2012). Despite similarities in population trends obtained from these two studies, each study has its own unique objectives that address different research needs. Systematic population monitoring provides an assessment of recruitment success within years, a basis for comparing changes in recruitment success across years, and timely information about the status of the species during periods of reduced abundance. Additionally, this dataset has been used to assess seasonal survivorship rates (e.g., Dudley et al. 2009) and could be used to evaluate the effectiveness of future adaptive-management activities on both native and nonnative fishes. In contrast, the population estimation study was more narrowly focused to provide statistically-robust population estimates of Rio Grande Silvery Minnow across years. For the purpose of assessing population changes over time, that study generally resulted in a higher degree of precision and accuracy, as compared to the population monitoring study (Dudley et al. 2012). Further, the substantial methodological differences between these studies (e.g., multiple-pass sampling with enclosures [estimation] vs. single-pass sampling without enclosures [monitoring]) meant that any population size estimate generated from population monitoring data would be biased. While density estimates generated from the population monitoring study should not be used to derive population size estimates, they have proven to be a reliable index of Rio Grande Silvery Minnow population trends over time (Dudley et al. 2012).

Analytical Considerations

The mixture models used to estimate Rio Grande Silvery Minnow densities in this study employed two separate statistical components, an approach that is particularly effective for modeling zero-inflated ecological data (White 1978; Welsh et al. 1996; Fletcher et al. 2005; Martin et al. 2005). Logistic regression was used to estimate the probability that a site was occupied, and a lognormal model was used to estimate the lognormal density based on occupied sites. The two processes (i.e., occurrence [δ] vs. density [μ]) that generated $E(x)$ were clearly separated when using the mixture-model approach. Also, it was unnecessary to add some arbitrary positive constant onto observations of zero values, as is commonly done for simple linear regression models using log-transformed data. Further, our approach fully accounts for over-dispersion (e.g., extra-binomial variation around δ, non-constant σ in the lognormal distribution, or additional variation around the linear covariate model). Thus, we have produced estimates using a robust, yet highly flexible, approach that avoids many assumptions typically required for traditional statistical analyses (Appendix E [Table E - 1]).

One assumption required for our analyses is that capture probabilities are reasonably similar across sampling sites and years. As mark-recapture or multiple-pass data were not collected as part of this study, this assumption cannot be directly evaluated. However, it seems highly unlikely that pronounced downward density trends were caused by low capture efficiencies, as our methods have remained consistent to ensure that comparable mesohabitats (i.e., depths and velocities) were sampled across different sites and annual flow conditions. As an example, a substantial decline (> 90%) in density between years (e.g., 1995–1996, 1999–2000, 2001–2002, 2005–2006, 2009–2010, and 2017–2018) would require a seemingly unreasonable decrease (> 90%) in capture probability (e.g., 0.5 to 0.01) between those years. Additionally, seining has been shown to be quite effective and reliable in sand-bottomed rivers, such as the Rio Grande, where habitat complexity is relatively low (Rabeni et al. 2009). Thus, it seems more reasonable that any differences in capture efficiencies across sites or years would tend to average out because of the substantial sampling effort required for this study. Further, environmental conditions during October (e.g., water temperatures, flows, depths, velocities, and turbidities) have been quite stable and suitable for efficient sampling as compared to other times of the year (i.e., spring runoff or summer monsoons), making it an ideal time of year for evaluating long-term trends in the occurrence and density of Rio Grande Silvery Minnow. We have also maintained a steadfast consistency in our crew leaders, training procedures, and sampling protocols over the past two decades. Finally, we found that population trends in different mesohabitats (October [2002–2019]), or on different days during repeated sampling (November [2005–2019]), were remarkably similar to population trends obtained from the long-term dataset (October [1993–2019]).

Although we used frequentist statistical methods (i.e., mixture models and generalized linear models) to analyze the long-term data in our study, we also evaluated the merits of the Bayesian method of statistical inference. Frequentist and Bayesian approaches both use the same general analytical framework (i.e., parametric likelihood models supplemented with linear covariate models) to generate parameter estimates and make ecological inferences from the data. However, Bayesian techniques rely on subjective assumptions about prior distributions, and require additional Markov chain Monte Carlo (MCMC) statistical analyses to obtain model estimates (Burnham and Anderson 2002). Therefore, conducting Bayesian analyses based on a non-hierarchical framework, as was used in our study, will not result in different conclusions, but does raise the issues of including subjective data and interpreting additional statistical results. While the Bayesian approach might seem preferable for reach-specific analyses, using informative priors to substitute for sparse reach-specific data seems contrary to objective monitoring. Thus, we have used the frequentist statistical approach to rigorously analyze long-term trends in the occurrence and density of Rio Grande Silvery Minnow and evaluate how those trends were affected by environmental changes over time (1993–2019).

Additional, Dry, and Replacement Sites

Based on recommendations by Hubert et al. (2016) and the Collaborative Program, we conducted statistical analyses using four different datasets: (1) additional sites excluded and dry sites included, (2) additional sites and dry sites excluded, (3) additional sites and dry sites included, (4) and additional sites included and dry sites excluded. Replacement sites were also sampled (i.e., since 2017) and used as surrogates within any analyses where dry sites were excluded. While these four analyses were based on different versions of the long-term dataset (1993–2019), our estimated densities of Rio Grande Silvery Minnow were reasonably consistent regardless of whether additional/dry sites were or were not included. However, we found that analyses that included additional sites had an increased AIC_c weight on the μ(Year) models. This difference was likely caused by the increased effective sample size of these analyses (i.e., more samples since 2017), which coincided with widely disparate estimates of μ from 2017 to 2019.

While we have included these additional-site analyses for comparative purposes, they should not be used to make inferences regarding long-term ecological relationships. Only the analyses based on the long-term monitoring data (i.e., additional sites excluded and dry sites included) should be used to make these inferences, as the number and spatial distribution of sites have remained consistent over time. In contrast, the additional-site analyses include a recent 50% increase in the number of sampling sites, which are most concentrated in the Angostura Reach and least concentrated in the San Acacia Reach. This altered, and spatially biased, distribution of sampling renders the additional-site analyses unsuitable for long-term inference of range-wide ecological changes, as a spatially-balanced sampling design (1993–2016) was combined with a spatially-unbalanced sampling design (2017–2019). Over time, however, the additional-site sampling design will become more suitable and robust for estimating reach-specific densities and assessing reach-specific ecological relationships.

Despite these limitations, we found that the 95% confidence intervals of estimated densities were consistently narrower when the additional sites were included in the analyses, which allowed for more robust comparisons of densities across recent years (i.e., since 2017). In contrast, the densities of Rio Grande Silvery Minnow were uniformly low throughout the study area during years characterized by low flows and dry sampling sites. Thus, the removal of dry-site data from the analyses did not meaningfully change our interpretation of the long-term population trends or ecological relationships.

While these extra analyses demonstrated the consistency of our research findings using four different datasets, the exclusion of data from dry sampling sites may yield biased results, particularly in years with extensive river drying. Consider the following hypothetical example: In year one, fish occupy the 20 standard sites with an estimated density of 10. In year two, fish occupy only 10 standard sites (e.g., the lower half of the study area dried). However, the estimated density at the wetted sites (i.e., 10 standard sites plus 10 replacement sites) might still be 10. It seems problematic to ignore the data from dry sites, as that would lead to an ecological model that is unchanged between years one and two (i.e., occurrence = 1.0 and density = 10 for both years). Instead, the inclusion of data from dry sites would lead to more realistic estimates (i.e., occurrence = 0.5 and density = 5 in year two). Similarly, a population estimate, based on this same scenario, would also show a 50% decline between years one and two because of the absence of fish in the lower half of the study area. We find it more reasonable that zeros at dry sites are true zeros (see Martin et al. [1995]), as there is a temporary loss of suitable habitat and the organism is truly absent, and we conclude that only the long-term monitoring data (i.e., all standard sites included) should form the basis of any inference regarding the long-term ecological relationships of Rio Grande Silvery Minnow.

Sampling Precision and Timing

Over the past two decades, there have been remarkable changes (e.g., over three orders of magnitude [> 100,000% increase or > 99.9% decrease]) in the estimated densities of Rio Grande Silvery Minnow. Despite these substantial changes, the relative precision of estimates was adequate to frequently detect significant increases or decreases in densities across years. Further, analyses of sampling variation across days (based on repeated sampling during November [2005–2019]) revealed that sampling occasion, site, and reach were far less informative in explaining changes in the density of

Rio Grande Silvery Minnow over time as compared with year. These repeated-sampling analyses also generated population trends that were remarkably similar to those obtained from the long-term October density data (1993–2019). Thus, the current sampling protocols are resulting in a reliable level of sampling precision and population trend consistency, especially when considering the substantial changes in the occurrence and density of Rio Grande Silvery Minnow over time.

While October and November sampling efforts revealed very similar trends in the estimated densities of Rio Grande Silvery Minnow over time (2005–2019), its densities tended to be somewhat higher in November than in October. One possible explanation for this pattern could be the tendency of Rio Grande Silvery Minnow to congregate more in deeper and lower velocity habitats when water temperatures are cooler (Dudley and Platania 1997a). November repeated-sampling data were particularly useful during years when this species was very rare (e.g., 2012–2014), as these data provided another metric by which to assess subtle changes in its occurrence and density during periods of low abundance. For example, the November repeated-sampling efforts (i.e., sites sampled four times) yielded at least some individuals each year from 2012 to 2014, whereas the October sampling efforts (i.e., sites sampled once) yielded no individuals in 2012 or 2014. Further, the November data are even more powerful when considered collectively as part of the site occupancy study (2005–2019; Appendix B), as those analyses provide a robust long-term assessment of the conservation status of Rio Grande Silvery Minnow.

The timing of sampling also likely affected the accuracy of age-class designations, which were based on the standard length of Rio Grande Silvery Minnow. Although different age-classes (i.e., age-0, age-1, and age-2+) are presented in this report (e.g., Appendix F), those designations should be interpreted very cautiously. For example, the length-based distinction between age-1 and age-2+ individuals is quite unclear across both reaches and seasons (Horwitz et al. 2018). While age-0 and age-1+ fish can be confidently distinguished following spawning until about July of each year, this length-based distinction becomes progressively less certain throughout the remainder of the year (e.g., Dudley and Platania 1996; Dudley and Platania 1997b; Horwitz et al. 2018). Mixture models were not constructed for different age-classes (e.g., age-0, age-1, or age-2+) because of the uncertainty in assigning age-class based strictly on standard length, particularly during autumn when the lengths of individuals broadly overlapped across reaches and annual cohorts (e.g., Dudley and Platania 1996; Dudley and Platania 1997b; Horwitz et al. 2018).

Mesohabitat Associations

A qualitative examination of the mesohabitats occupied by Rio Grande Silvery Minnow was conducted to obtain general information on the habitat-use patterns of this species. While the physical locations of mesohabitats shift around considerably over time, established sampling protocols for this study ensured that similar mesohabitats (i.e., depths and velocities) were sampled across years. We sampled a wide variety of mesohabitats to ensure balanced monitoring of the ichthyofaunal community and all life phases of Rio Grande Silvery Minnow. Population trends in the five different mesohabitats (BW, PO, RU, SHPO, SHRU) were quite similar over the study period (2002–2019), despite notable differences in the estimated densities of Rio Grande Silvery Minnow among mesohabitats. Densities were typically highest in lower velocity mesohabitats and lowest in higher velocity mesohabitats. General mesohabitat-use patterns observed during this study were similar to those documented during past studies (e.g., Dudley and Platania 1997a).

Encouragingly, the population trends generated from the mesohabitat-specific density data (2002–2019) and sampling-site density data (1993–2019) were remarkably consistent even though they were measured on two widely different spatial scales. While either mesohabitat-specific or sampling-site density data can be used to evaluate population trends since 2002, any evaluation from 1993 to 2001 is solely dependent on sampling-site density data. As the sampling-site density data have been collected over a much longer period (1993–2019), they are more appropriate than the mesohabitat-specific density data for modeling the effects of different seasonal flow patterns (e.g., increased spring runoff or decreased summer flows) on the October occurrence and density of Rio Grande Silvery Minnow.

Spatial Distribution Patterns

Sampling efforts during October (1993–2019) indicated that the highest densities of Rio Grande Silvery Minnow were almost always in the Isleta and San Acacia reaches. This pattern has persisted over time even though upstream reaches have been regularly augmented with large numbers of hatchery-reared fish since 2002 (Archdeacon 2020). The exceptions to this pattern have occurred in years when flows in the San Acacia Reach were unusually low during spring and summer (e.g., 2002 and 2012), or following notable augmentation efforts and improved flow conditions in the Angostura Reach (e.g., 2019).

One explanation for this pattern of increasing densities in downstream reaches is the cumulative longitudinal transport of propagules (drifting eggs and larvae) past instream barriers over time (Dudley and Platania 2007). Also, river channelization, habitat degradation, abandonment of the floodplain, and reductions in suspended sediments downstream of Cochiti Dam (Lagasse 1980; Massong et al. 2006) are likely limiting the amount of appropriate habitats available for the successful retention and recruitment of early life phases, especially in the Cochiti and Angostura reaches. Further, it is evident that seasonal inundation of side-channel and floodplain habitats, combined with extensive restoration of aquatic habitat complexity, should lead to increased propagule retention and recruitment success for Rio Grande Silvery Minnow and other pelagophils in Southwestern rivers (Dudley and Platania 2007; Widmer et al. 2012; Medley and Shirey 2013; Gonzales et al. 2014; Valdez et al. 2019; Dudley et al. 2019a). However, the long-term efficacy of these management and restoration efforts will also depend on assuring their utility and permanence by restoring a more dynamic flow regime and reestablishing river connectivity across fragmented reaches (Dudley and Platania 2007).

Additionally, we have analyzed larval and non-larval fish data separately since 2016 (i.e., based on developmental phases), to more closely examine the seasonal patterns of distribution and abundance for Rio Grande Silvery Minnow. While nearly all larvae have been collected during June or July, we have occasionally collected a few metalarvae during August. The late larval developmental phase of these individuals suggests that they were likely spawned in late June or early July, but a targeted study (i.e., otolith examination) would be required to more precisely determine the timing of spawning or specific age-growth relationships.

Although larval densities of Rio Grande Silvery Minnow were similarly elevated in all three reaches following spring spawning from 2016 to 2019, densities of age-0 fish (non-larval) were sometimes lower in the Angostura Reach throughout the summer and autumn. The ensuing observations relate only to sampling in 2016 and 2017, however, as very few individuals were collected in 2018 and the pattern was atypical in 2019. Densities of age-0 fish (non-larval) generally peaked somewhat later, and subsequently remained higher, in the San Acacia Reach than in the two upstream reaches. These findings seem to suggest that (1) survival of young was relatively lower in the Angostura Reach than in the two downstream reaches, (2) young were progressively dispersing downstream, either passively or actively, during the spring and summer, or (3) these patterns were caused by some combination of the first two factors. However, these seasonal reach-specific patterns were based only on recent data (i.e. since 2016), do not account for variation across sites within a reach (i.e., no confidence intervals), and could change over time depending on annual spring and summer flow conditions. Further, fish densities across reaches are not a direct reflection of population size, as the amount of wetted area is often higher in the Angostura Reach than in the downstream reaches, which can lead to higher population estimates despite lower density estimates (Dudley et al. 2012). Thus, potential differences in recent reach-specific densities of Rio Grande Silvery Minnow should be interpreted cautiously.

Long-Term Ecological Relationships

There were notable changes in the relative and rank abundance of Middle Rio Grande fish species over time (1993–2019). Several species (e.g., Rio Grande Silvery Minnow and River Carpsucker) changed dramatically in rank abundance across years. However, the overall rank abundance of fishes remained remarkably consistent over time. The dynamic changes in species rank abundance could indicate that key environmental conditions are controlling species-specific abundance over time. It is likely that changes in the timing, magnitude, and duration of flows could be an important factor leading to the observed spatiotemporal differences in fish species abundance. For the purpose of this study, an intense and focused effort was made to elucidate possible flow patterns that could account for the variation observed in the occurrence and density of Rio Grande Silvery Minnow across years. However, additional study would help further determine those environmental factors that most influence the spatial and temporal patterns of occurrence and density for other Middle Rio Grande fish species (Hoagstrom et al. 2010).

Comparison of changes in Rio Grande Silvery Minnow occurrence and density during October (1993–2019) with hydrological variables revealed several strong ecological relationships. Elevated and prolonged flows during the spawning season (i.e., primarily May–June) were related to the increased occurrence and density of Rio Grande Silvery Minnow. In contrast, extended low flows during summer were related to its decreased occurrence and density. Modeling these two separate population responses (occurrence vs. density) provided valuable insights into long-term population trends for this species. While these hydrological variables were not chosen to provide detailed assessments of seasonal flows across sites or reaches, our analyses indicated that elevated and extended spring flows were most predictive of range-wide increases in the occurrence and density of this species over time. Similarly, higher numbers of young Rio Grande Silvery Minnow, collected in isolated pools during periodic river-drying events from June to October (2009–2015), were associated with elevated mean May discharge during the same year (Archdeacon 2016).

Prolonged and elevated spring flows result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline pools and backwaters. These shallow low-velocity habitats, which typically increase in number and extent during spring runoff, are essential for the successful recruitment of larvae for many freshwater fishes throughout the world (Welcomme 1979; Junk et al. 1989; Matthews 1998). In the absence of adequate spring flows (e.g., during extended droughts), however, pelagic-spawning cyprinids appear to be particularly susceptible to recruitment failure (Perkin et al. 2019). It is likely that similar processes are also affecting the survival and recruitment of native fishes in the Middle Rio Grande, including early life phases of Rio Grande Silvery Minnow (Pease et al. 2006; Turner et al. 2010; Hoagstrom and Turner 2013; Dudley et al. 2019a).

For Rio Grande Silvery Minnow, years with elevated and extended spring flows typically result in a decreased frequency of spawning, along with a reduced downstream transport of eggs, as compared to years with short-duration flow increases (Dudley et al. 2019a). The timing and frequency of spawning may differ across years, in part, because of specific flow-related reproductive strategies. For example, it might be more beneficial for Rio Grande Silvery Minnow to concentrate spawning at the onset of elevated and sustained flows (i.e., creation of nursery habitats), whereas more frequent spawning (i.e., bet-hedging) might be more beneficial when flows are reduced and more variable (Dudley et al. 2019a). Specially, high and sustained flows result in the creation of inundated/productive nursery habitats, which are crucial for early life phases of this species (Dudley and Platania 1997a; Magaña 2012; Medley and Shirey 2013; Hutson et al. 2018; Tave et al. 2018; Valdez et al. 2019; Dudley et al. 2019a). Although short-term floodplain inundation, based on five-day peak flows in May (USACE 2010), was related to the elevated occurrence and density of Rio Grande Silvery Minnow, this relationship was considerably weaker than relationships with long-term elevated flows (i.e., May–June). As growth from the egg phase through the vulnerable early larval phases (i.e., protolarvae and mesolarvae) requires about one month (Platania 1995b), the long-term persistence of nursery habitats appears essential for ensuring the successful recruitment of young to later life phases (i.e., metalarvae and juveniles).

Conclusions and Implications

Despite recurring and sometimes sustained declines in the occurrence and density of Rio Grande Silvery Minnow following periods of poor spring runoff and prolonged low flows during summer (e.g., 2002–2003 and 2012–2014), it is encouraging that this species has rebounded relatively quickly following consecutive years with improved spawning and recruitment conditions (e.g., 2004–2005 and 2015–2017). Similarly, the genetic effective population size of this species was very low during the drought years of the early 2000s (Alò and Turner 2005), but increased in subsequent years following improved seasonal flow conditions, intense augmentation efforts, and the implementation of a robust propagation management plan (Osborne et al. 2012; Osborne and Turner 2019). While there was an increase in the genetic effective population size of Rio Grande Silvery Minnow from 2015 to 2017, this was followed by a notable decrease from 2017 to 2019 (Osborne and Turner 2019). These rising and falling trends in genetic diversity closely reflect the underlying trends in population dynamics that we have documented in our study of this species over the past two decades. However, exceptionally low levels of genetic diversity, combined with periods of vastly reduced occurrence and density, continue to threaten the ongoing persistence of Rio Grande Silvery Minnow in the Middle Rio Grande.

While extensive and diverse management efforts over the past two decades have provided protection against the extinction of Rio Grande Silvery Minnow, ongoing and planned efforts (e.g., restoring dynamic river flows, reconnecting fragmented reaches, and reestablishing a functional floodplain) should help to promote resilient and self-sustaining populations of this imperiled species in the future. Encouragingly, both the occurrence and density of Rio Grande Silvery Minnow increased markedly in 2019, as compared with a recent drought year (2018), following notably improved spring and summer flow conditions. Continued efforts to provide reasonable spring spawning and summer survival conditions will be essential for securing a self-sustaining wild population of this species in the Middle Rio Grande. Additionally, reestablishing resilient populations at other locations within its historical range would substantially help to further ensure its long-term persistence in the wild. Finally, future study of the relationships among aquatic species (i.e., from phytoplankton to fish), instream habitats, and seasonal river flows in the Rio Grande Basin should continue to elucidate key factors that regulate this complex ecosystem, which will be essential for developing and implementing successful management strategies for the long-term recovery of Rio Grande Silvery Minnow.

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APPENDIX A (Sampling Sites)

Middle Rio Grande Fish Sampling Sites

Table A - 1. Sampling reaches and standard sites for population monitoring of Rio Grande Silvery Minnow in the Middle Rio Grande.

Reach and Site	Locality
Angostura Reach	
1	New Mexico, Sandoval County, Rio Grande, just downstream of Angostura Diversion Dam, Algodones. River Mile: 209.9; UTM Easting: 363665; UTM Northing: 3916331; Zone: 13; Datum: NAD83
2	New Mexico, Sandoval County, Rio Grande, at US HWY 550 bridge crossing, Bernalillo. River Mile: 203.9; UTM Easting: 358457; UTM Northing: 3909887; Zone: 13; Datum: NAD83
3	New Mexico, Sandoval County, Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho. River Mile: 199.9; UTM Easting: 354728; UTM Northing: 3905587; Zone: 13; Datum: NAD83
4	New Mexico, Bernalillo County, Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque. River Mile: 183.4; UTM Easting: 346719; UTM Northing: 3884331; Zone: 13; Datum: NAD83
5	New Mexico, Bernalillo County, Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque. River Mile: 178.4; UTM Easting: 347468; UTM Northing: 3877400; Zone: 13; Datum: NAD83
Isleta Reach	
6	New Mexico, Valencia County, Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas. River Mile: 161.7; UTM Easting: 343149; UTM Northing: 3853187; Zone: 13; Datum: NAD83
7	New Mexico, Valencia County, Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen. River Mile: 150.8; UTM Easting: 340105; UTM Northing: 3837722; Zone: 13; Datum: NAD83
8	New Mexico, Valencia County, Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales. River Mile: 143.2; UTM Easting: 338020; UTM Northing: 3827545; Zone: 13; Datum: NAD83
9	New Mexico, Socorro County, Rio Grande, at US HWY 60 bridge crossing, Bernardo. River Mile: 130.6; UTM Easting: 334578; UTM Northing: 3809921; Zone: 13; Datum: NAD83
10	New Mexico, Socorro County, Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo. River Mile: 126.8; UTM Easting: 330946; UTM Northing: 3805307; Zone: 13; Datum: NAD83
11	New Mexico, Socorro County, Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia. River Mile: 117.3; UTM Easting: 328152; UTM Northing: 3792564; Zone: 13; Datum: NAD83

Table A - 1. Sampling reaches and standard sites for population monitoring of Rio Grande Silvery Minnow in the Middle Rio Grande (continued).

Reach and Site	Locality
San Acacia Reach	
12	New Mexico, Socorro County, Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia. River Mile: 115.6; UTM Easting: 325960; UTM Northing: 3792183; Zone: 13; Datum: NAD83
13	New Mexico, Socorro County, Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia. River Mile: 114.1; UTM Easting: 325390; UTM Northing: 3790397; Zone: 13; Datum: NAD83
14	New Mexico, Socorro County, Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro. River Mile: 99.6; UTM Easting: 327231; UTM Northing: 3771432; Zone: 13; Datum: NAD83
15	New Mexico, Socorro County, Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio. River Mile: 92.0; UTM Easting: 328151; UTM Northing: 3761487; Zone: 13; Datum: NAD83
16	New Mexico, Socorro County, Rio Grande, at US HWY 380 bridge crossing, San Antonio. River Mile: 87.8; UTM Easting: 328907; UTM Northing: 3754926; Zone: 13; Datum: NAD83
17	New Mexico, Socorro County, Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio. River Mile: 79.0; UTM Easting: 327219; UTM Northing: 3740906; Zone: 13; Datum: NAD83
18	New Mexico, Socorro County, Rio Grande, at San Marcial Railroad bridge crossing, San Marcial. River Mile: 68.3; UTM Easting: 315091; UTM Northing: 3728487; Zone: 13; Datum: NAD83
19	New Mexico, Socorro County, Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial. River Mile: 60.1; UTM Easting: 309441; UTM Northing: 3718309; Zone: 13; Datum: NAD83
20	New Mexico, Socorro County, Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial. River Mile: 58.5; UTM Easting: 307767; UTM Northing: 3716360; Zone: 13; Datum: NAD83

Table A - 2. Sampling reaches and additional sites for population monitoring of Rio Grande Silvery Minnow in the Middle Rio Grande.

Reach and Site	Locality
Angostura Reach	
21	New Mexico, Sandoval County, Rio Grande, ca. 4.4 miles upstream of Alameda Blvd. (NM State Hwy. 528) bridge crossing, Corrales. River Mile: 196.6; UTM Easting: 355531; UTM Northing: 3900626; Zone: 13; Datum: NAD83
22	New Mexico, Sandoval County, Rio Grande, ca. 1.1 miles upstream of Alameda Blvd. (NM State Hwy. 528) bridge crossing, Corrales. River Mile: 193.1; UTM Easting: 351562; UTM Northing: 3897190; Zone: 13; Datum: NAD83
23	New Mexico, Bernalillo County, Rio Grande, ca. 1.0 miles downstream of Paseo del Norte Blvd. (NM State Hwy. 423) bridge crossing Albuquerque. River Mile: 190.0; UTM Easting: 349214; UTM Northing: 3893063; Zone: 13; Datum: NAD83
24	New Mexico, Bernalillo County, Rio Grande, ca. 1.1 miles upstream of I-40 bridge crossing, Albuquerque. River Mile: 186.1; UTM Easting: 346011; UTM Northing: 3887973; Zone: 13; Datum: NAD83
25	New Mexico, Bernalillo County, Rio Grande, ca. 1.5 miles upstream of I-25 bridge crossing, Isleta. River Mile: 174.0; UTM Easting: 345900; UTM Northing: 3870990; Zone: 13; Datum: NAD83
Isleta Reach	
26	New Mexico, Valencia County, Rio Grande, ca. 4.1 miles upstream of NM State Hwy. 6 bridge crossing, Los Lunas. River Mile: 165.2; UTM Easting: 342799; UTM Northing: 3858637; Zone: 13; Datum: NAD83
27	New Mexico, Valencia County, Rio Grande, ca. 6.2 miles upstream of NM State Hwy. 309 bridge crossing, Belen. River Mile: 156.0; UTM Easting: 340647; UTM Northing: 3845146; Zone: 13; Datum: NAD83
28	New Mexico, Socorro County, Rio Grande, ca. 6.3 miles upstream of US Hwy. 60 bridge crossing, Bernardo. River Mile: 137.1; UTM Easting: 335554; UTM Northing: 3819543; Zone: 13; Datum: NAD83
29	New Mexico, Socorro County, Rio Grande, ca. 1.5 miles upstream of confluence with the Rio Salado, San Acacia. River Mile: 120.1; UTM Easting: 330498; UTM Northing: 3795053; Zone: 13; Datum: NAD83
San Acacia Reach	
30	New Mexico, Socorro County, Rio Grande, ca. 2.6 miles upstream of Pueblitos Rd. bridge crossing, Escondida. River Mile: 107.1; UTM Easting: 326303; UTM Northing: 3781123; Zone: 13; Datum: NAD83

Table A - 3. Sampling reaches and replacement sites for population monitoring of Rio Grande Silvery Minnow in the Middle Rio Grande.

Reach and Site	Locality
San Acacia Reach	
52	New Mexico, Socorro County, Rio Grande, ca. 2.2 mi. downstream of Pueblitos Rd. bridge crossing, Escondida. River Mile: 101.7; UTM Easting: 327091; UTM Northing: 3773950; Zone: 13; Datum: NAD83
53	New Mexico, Socorro County, Rio Grande, ca. 3.1 mi downstream of the Socorro Low Flow Conveyance Channel bridge crossing, Socorro. River Mile: 96.0; UTM Easting: 327928; UTM Northing: 3766570; Zone: 13; Datum: NAD83
54	New Mexico, Socorro County, Rio Grande, ca. 4.7 mi. downstream of Socorro LFCC bridge crossing, Socorro. River Mile: 94.2; UTM Easting: 327288; UTM Northing: 3764453; Zone: 13; Datum: NAD83
56	New Mexico, Socorro County, Rio Grande, ca. 2.1 miles upstream of San Antonio bridge crossing, San Antonio. River Mile: 89.3; UTM Easting: 329188; UTM Northing: 3758027; Zone: 13; Datum: NAD83
58	New Mexico, Socorro County, Rio Grande, ca. 1.8 mi. upstream of San Marcial Railroad bridge crossing, San Marcial. River Mile: 70.1; UTM Easting: 318083; UTM Northing: 3728535; Zone: 13; Datum: NAD83
60	New Mexico, Socorro County, Rio Grande, ca. 6.4 mi. downstream of San Marcial Railroad bridge crossing, San Marcial. River Mile: 61.8; UTM Easting: 311422; UTM Northing: 3719873; Zone: 13; Datum: NAD83

APPENDIX B (Rio Grande Silvery Minnow Site Occupancy)

INTRODUCTION

The Rio Grande Silvery Minnow site occupancy study was initiated as a result of our initial analyses of its estimated densities across multiple sampling days. This extensive dataset provided an opportunity to further study the site occupancy patterns of this imperiled species over time. The site occupancy dataset was based on repeated-sampling efforts at our 20 long-term monitoring sites during November. While the first few years of sampling yielded only preliminary results and relatively simplistic models, this study now includes a series of robust occupancy models that generate annual estimates of the occupancy, extinction, colonization, and detection probabilities for Rio Grande Silvery Minnow. Although these estimates are based on data collected at numerous sampling sites and are indicative of range-wide trends, they are not absolute measurements of conservation status (i.e., extinction probability refers to loss of the species from individual sites [extirpation] vs. complete loss of the species from the wild [extinction]). Further, these long-term conservation status assessments are dependent on the ongoing and consistent monitoring of Rio Grande Silvery Minnow, as part of the November repeated-sampling efforts (2005–2019).

Techniques to estimate the presence-absence and abundance of organisms, which do not require full site depletion or mark-recapture of individuals, have been shown to be reliable for a variety of species (see Royle and Nichols 2003). Statistical methods have been developed that account for the inherent heterogeneity of population abundance across sites. Presence-absence data provide crucial information for estimating the probabilities that underlie spatial patterns of species abundance in the environment (MacKenzie et al. 2003). In other words, the absence of a species during sampling does not necessarily mean that the species is truly absent from the area (MacKenzie et al. 2002; Finley et al. 2005; White 2005).

By fully incorporating these complexities into our site occupancy models, we have generated robust estimates of the occupancy, extinction, colonization, and detection probabilities for Rio Grande Silvery Minnow over time (2005–2019). Our site occupancy analyses also complement and enhance the ecological insights provided by the long-term population monitoring study (1993–2019). In contrast to the population monitoring study, which documents trends over multiple intervals (i.e., monthly and annual) for the entire ichthyofaunal community, this study provides targeted estimates of Rio Grande Silvery Minnow site occupancy rates across years. The primary objectives of this study were to (1) evaluate annual changes in the occupancy, extinction, colonization, and detection probabilities for Rio Grande Silvery Minnow and (2) assess the dynamic conservation status of this imperiled species over time.

METHODS

Repeated sampling data from population monitoring efforts (multi-day sampling efforts during November [2005–2019]) were used to generate estimates of site occupancy rates based on methods developed by MacKenzie et al. (2002, 2003, 2006). This study was conducted using the same sampling protocols and 20 standard sites established for the long-term population monitoring study. In our study, mesohabitats were sampled at the same locations on subsequent days, except in rare cases (e.g., location moved slightly because of increased water velocity). Developing site occupancy rates for Rio Grande Silvery Minnow enabled assessment of the likelihood of detecting its presence or absence (i.e., detection probability) based on the encounter history. The encounter history of wild Rio Grande Silvery Minnow at the sampling sites was based on the four repeated-sampling efforts. For example, an encounter history of 1101 at a particular site meant that individuals were collected on days one, two, and four but not on day three. A higher proportion of presence encounters indicated that individuals were more consistently detected at the site over time.

We constructed a multiyear statistical model, based on patterns of occupancy (Appendix D), to better understand Rio Grande Silvery Minnow population dynamics and conservation status over time. Site occupancy was the proportion of sites occupied relative to those surveyed. The estimated occupancy probability for each site was based on the raw site-occupancy data and the estimated detection probability (and its associated variance). In this way, the occupancy probability was appropriately corrected based on the detection probability (MacKenzie et al. 2006). A higher degree of consistency across days (either 0000 or 1111) will result in a site occupancy model with results that more closely match those obtained from the original estimate of site occupancy probability based on a single survey. We assumed that sampling sites were large enough (ca. 200 m) that it was unlikely that a site would change in status from occupied to unoccupied across sequential days. Additional assumptions included that there could be no false detections, that there could be sites where the species was present but undetected, and that species detection at any site was independent of species detection at other sites (Appendix E [Table E - 2]). The encounter history data from the sampling sites allowed for a robust-design model of occupancy (MacKenzie et al. 2003), based on annual sampling efforts, to estimate the probability of occupancy (ψ), the probability of extinction at occupied sites (ε), the probability of colonization at unoccupied sites (γ), and the probability of detection (p).

Site occupancy models were constructed, using Program MARK (White and Burnham 1999), with year (Year) and sampling occasion (Occasion) as covariates. Models were not constructed for different age-classes (e.g., age-0, age-1, or age-2+) because of the uncertainty in assigning age-class based strictly on standard length, particularly during autumn when the lengths of individuals broadly overlapped across reaches and annual cohorts (e.g., Dudley and Platania 1996; Dudley and Platania 1997; Horwitz et al. 2018). Different models were considered that allowed detection probabilities to vary by site and reach. Likewise, the occupancy probability was allowed to vary by reach. Akaike's information criterion (Akaike 1973), corrected for finite sample sizes (AIC_c), was used to select the most parsimonious site occupancy model based on the encounter history data. Models were not averaged because some annual parameter estimates had a standard error of zero. Annual estimates of the occupancy, extinction, colonization, and detection probabilities were generated based on the year model (i.e., ψ[.] ε[Year] γ[Year] p[Year]). Associated measures of sampling variance, and profile-likelihood confidence intervals, were generated for all parameter estimates, following the methods of MacKenzie et al. (2006).

RESULTS

Multiyear models, based on patterns of site occupancy, were developed for Rio Grande Silvery Minnow using long-term (2005–2019) sampling-site data (Table B-1). The top AIC_c model (AIC_c weight > 0.99) had constant occupancy (psi, ψ), extinction (epsilon, ε), and colonization (gamma, γ) probabilities, but detection probabilities (*p*) that varied across years. The second and third ranked models had extinction/detection probabilities and colonization/detection probabilities that varied across years, respectively. Models that included sampling occasion (e.g., $\psi(.)\ \varepsilon(.)\ \gamma(.)\ p(\text{Year*Occasion})$) received essentially no AIC_c weight (<0.0001), indicating that the day of sampling was not informative in explaining variation in *p* over time.

Estimates of occupancy probability (ψ) were consistently high from 2005 to 2009, progressively declined from 2009 to 2013, and steadily increased from 2013 to 2017 (Figure B - 1). While ψ decreased from 1.00 in 2017 to 0.77 in 2018, it increased back to 1.00 in 2019. There was, however, increased uncertainty in occupancy probabilities during years when individuals were absent from many sites over multiple sampling days (e.g., 2012–2014 and 2018). The progressive decline, or rebound, of occupancy probabilities typically unfolded slowly over several years. Further, these occupancy patterns coincided closely with the underlying hydrological patterns of the Middle Rio Grande over time (2005–2019; Figure B - 2). Consecutive years with reduced spring and summer flows (e.g., 2012–2014) were associated with the lowest estimates of occupancy probability. In contrast, years with elevated flows (e.g., 2017 and 2019) often had the highest estimates of occupancy probability.

Estimates of extinction probability (ε) were consistently low from 2006 to 2010, progressively increased from 2010 to 2013, and remained elevated in 2014 (Figure B - 3). However, so few sites were occupied from 2012 to 2014 that there were not many sites left where the species status could change from present to absent (or vice versa), which led to uncertain estimates during this period. While the extinction probability increased markedly from 2017 to 2018, there was a notable decrease from 2018 to 2019. Since 2006, estimated colonization probabilities (γ) were generally highest following extended periods of elevated extinction probabilities. While the colonization probability was relatively low from 2006 to 2013, it increased notably from 2013 to 2017, as individuals were progressively detected at sites that were unoccupied in 2013. As all 20 sites were occupied in 2017, the colonization probability dropped to zero in 2018 (i.e., no further colonization possible). Similarly, the colonization probability increased to 1.00 in 2019 because all sites that were unoccupied in 2018 became reoccupied in 2019. The relatively slow transition between elevated extinction and colonization probabilities mirrored patterns observed for occupancy probabilities over time. In general, extinction probabilities were highest during low flow periods (i.e., droughts) that persisted over several years (Figure B - 4). In contrast, colonization probabilities often peaked when extended high flows, during spring and summer, persisted over several years. The dramatic and rapid changes in extinction and colonization probabilities from 2017 to 2019 contrasted with the more gradual changes observed during earlier periods (e.g., 2011–2014).

Table B - 1. Site occupancy models for Rio Grande Silvery Minnow, using November sampling-site data (2005–2019).

Site Occupancy Models[1]	**logLike**[2]	**K**[3]	**AIC$_c$**[4]	**w_i**[4]
ψ(.) ε(.) γ(.) *p*(Year)	700.56	18	739.00	0.9950
ψ(.) ε(Year) γ(.) *p*(Year)	680.26	31	749.66	0.0048
ψ(.) ε(.) γ(Year) *p*(Year)	686.25	31	755.65	0.0002
ψ(.) ε(Year) γ(Year) *p*(Year)	658.28	44	761.81	<0.0001
ψ(.) ε(.) γ(.) *p*(Year*Occasion)	656.34	63	816.51	<0.0001
ψ(.) ε(Year) γ(.) *p*(Year*Occasion)	633.80	76	838.29	<0.0001
ψ(.) ε(.) γ(Year) *p*(Year*Occasion)	641.77	76	846.25	<0.0001
ψ(.) ε(Year) γ(Year) *p*(Year*Occasion)	608.41	89	862.70	<0.0001
ψ(.) ε(Year) γ(Year) *p*(.)	888.64	30	955.55	<0.0001
ψ(.) ε(Year) γ(.) *p*(.)	921.66	17	957.83	<0.0001

[1] = Model variables included year (2005–2019) and sampling occasion (i.e., the 1st, 2nd, 3rd, or 4th day of sampling).
[2] = Likelihood (–2[log-likelihood]) was estimated for each model.
[3] = Higher numbers of parameters indicate increased model complexity.
[4] = Top ten models were ranked by Akaike's information criterion (AIC$_c$) and include the AIC$_c$ weight (w_i).

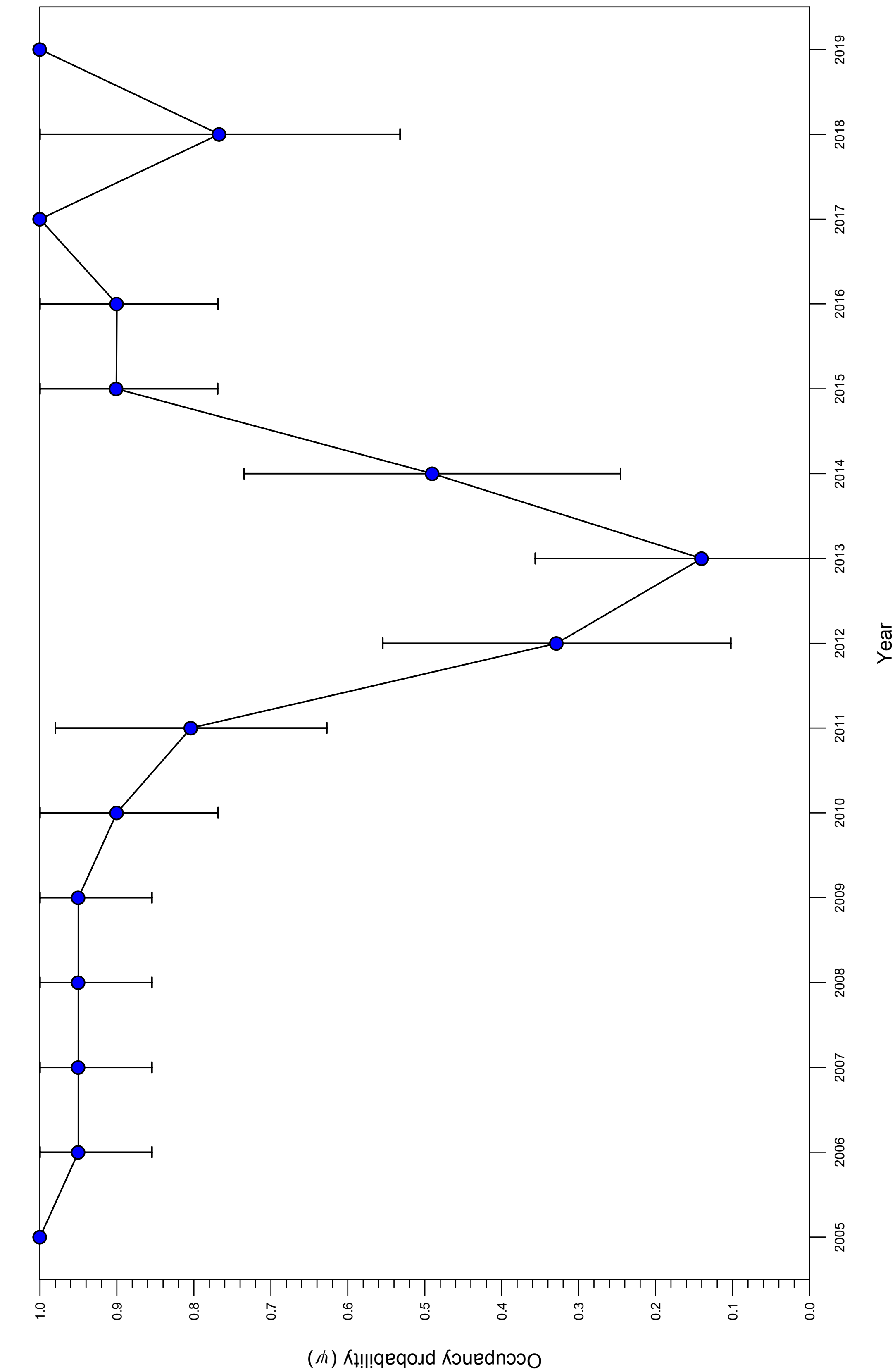

Figure B - 1. Rio Grande Silvery Minnow occupancy probabilities (ψ; estimated using November sampling-site data) across years. Modeled estimates (circles) and 95% confidence intervals (bars) are illustrated.

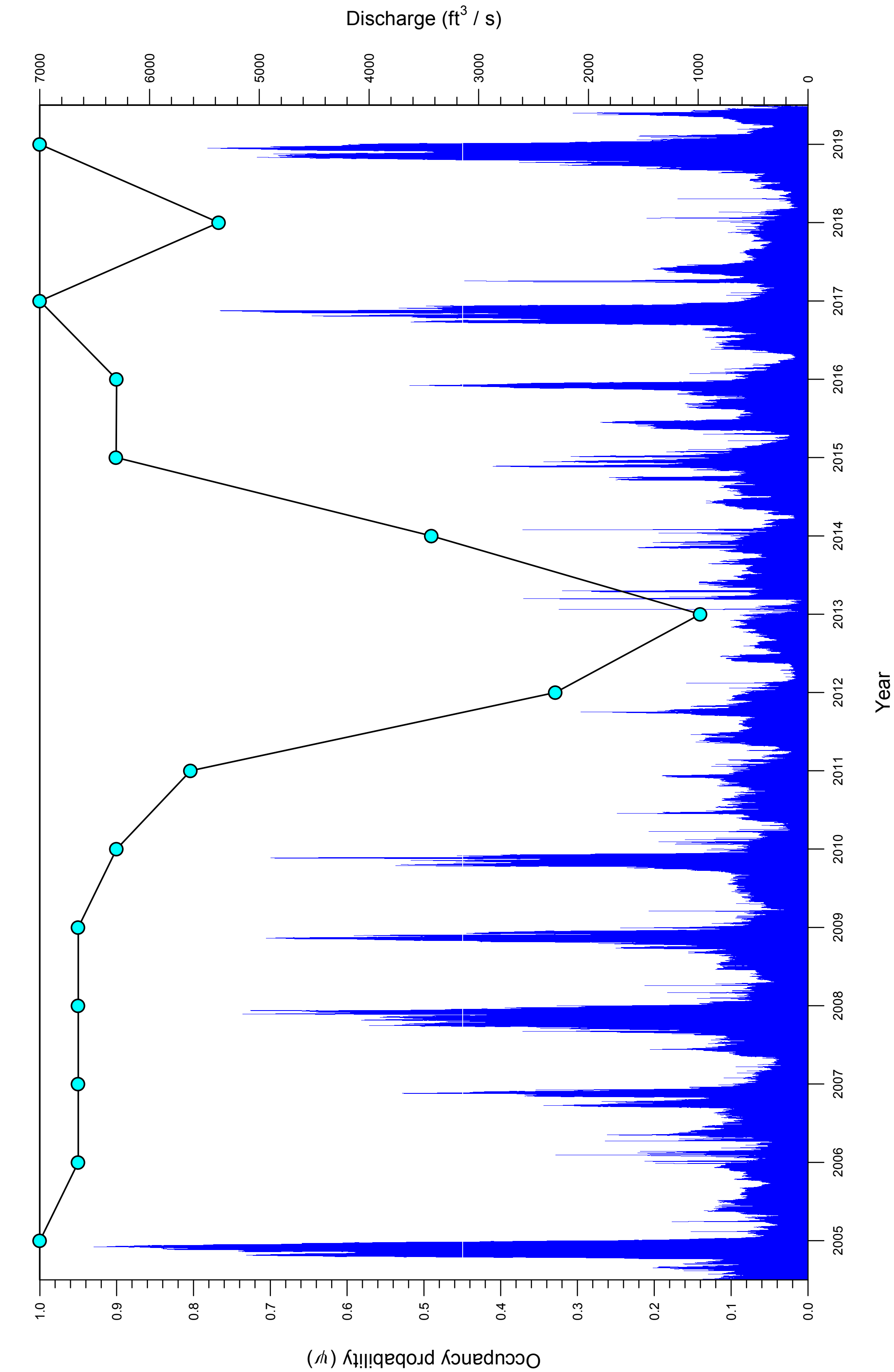

Figure B - 2. Rio Grande Silvery Minnow occupancy probabilities (ψ; estimated using November sampling-site data), and mean daily discharge data from the Albuquerque Gage, across years.

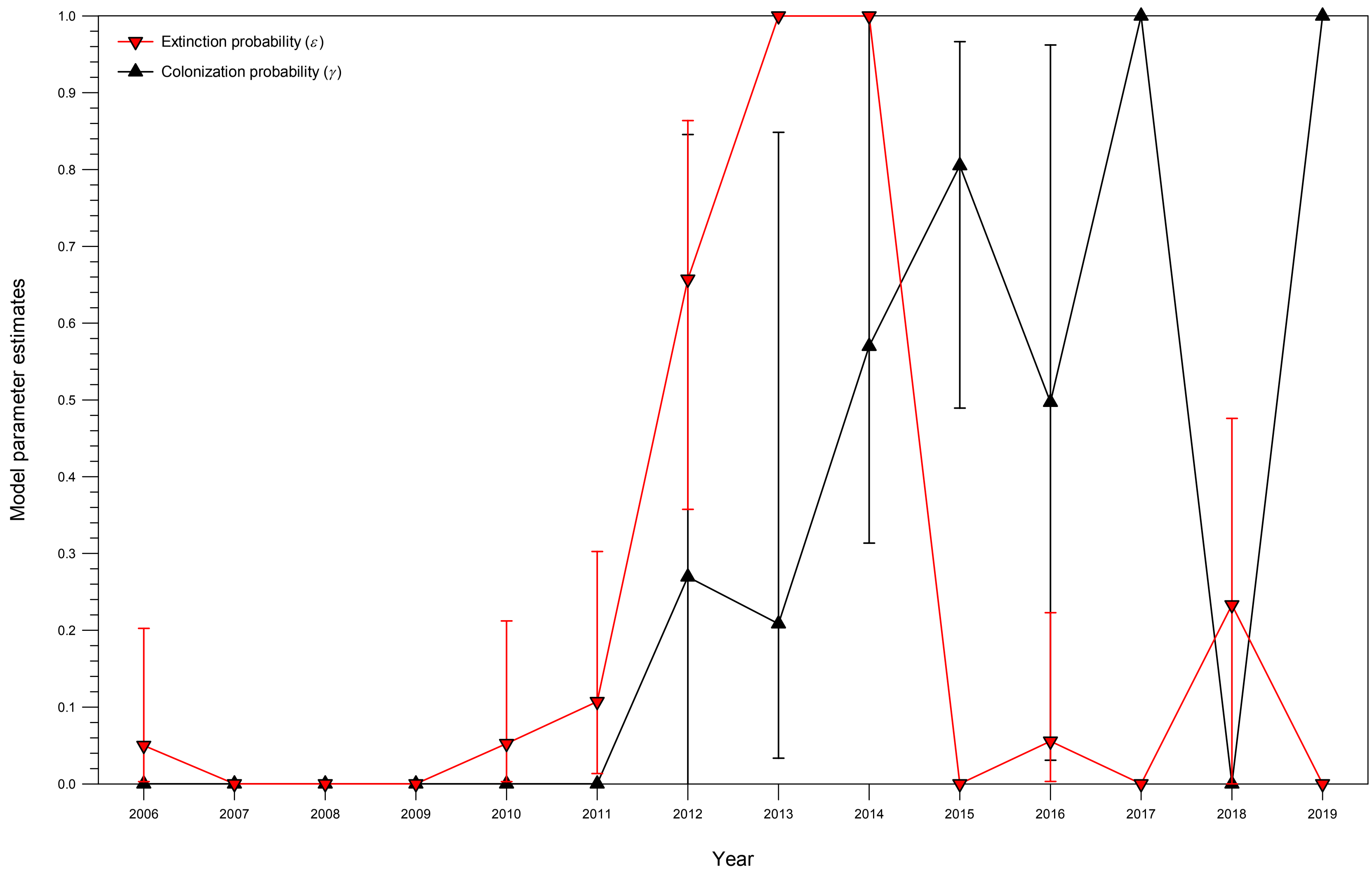

Figure B - 3. Rio Grande Silvery Minnow extinction/colonization probabilities (ε and γ; estimated using November sampling-site data) across years. Modeled estimates (symbols) and 95% confidence intervals (bars) are illustrated.

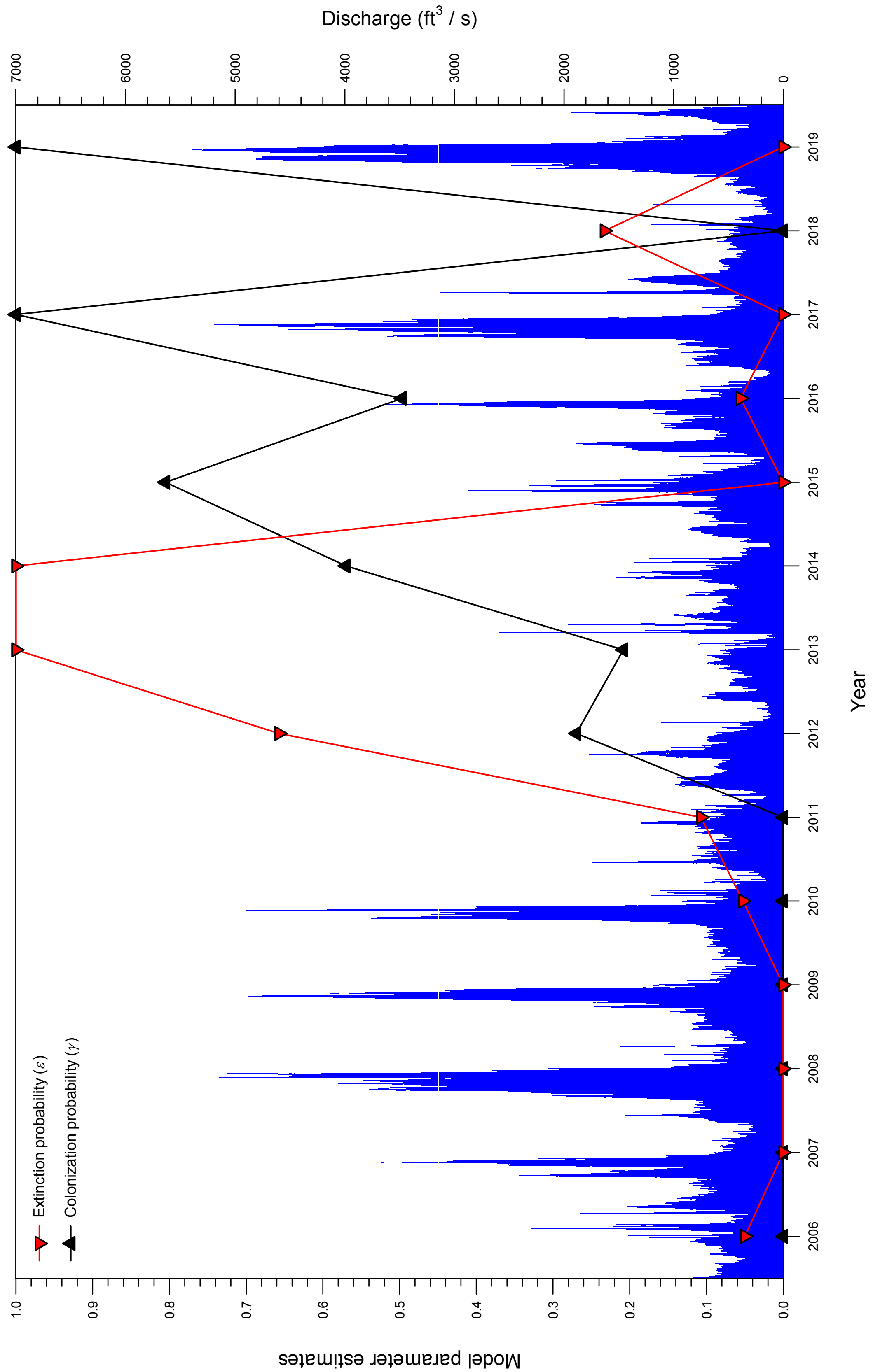

Figure B - 4. Rio Grande Silvery Minnow extinction/colonization probabilities (ε and γ; estimated using November sampling-site data), and mean daily discharge data from the Albuquerque Gage, across years.

DISCUSSION

There are numerous benefits to documenting long-term trends in site occupancy rates, particularly for rare species like Rio Grande Silvery Minnow, which may be difficult to detect using traditional single-survey monitoring efforts. From 2005 to 2019, we estimated the occupancy, extinction, colonization, and detection probabilities for Rio Grande Silvery Minnow based on repeated sampling efforts in November. By evaluating trends in these probabilities over time, we were able to assess the changing conservation status of this imperiled species across a wide range of environmental conditions (e.g., high spring flows vs. low summer flows).

While detection probability was one of the parameter estimates for the site occupancy analyses, it was not possible to generate an estimate of capture probability (i.e., a related but separate concept) for Rio Grande Silvery Minnow from either the detection probability or from the underlying repeated-sampling dataset. Also, there was strong positive covariance between detection and occupancy probability, so we chose to illustrate occupancy probability because it was more relevant, accurate, and meaningful. One established method for estimating the capture probability of individuals would be to conduct removal sampling using instream enclosures (e.g., Dudley et al. 2012), but this would require substantial fieldwork outside of the current objectives of this study. Additionally, we found a close statistical relationship between Rio Grande Silvery Minnow population trends (2008–2011) obtained from the population-monitoring and population-estimation studies (Dudley et al. 2012). Thus, it seems highly unlikely that fluctuating capture efficiencies, or detection probabilities, would meaningfully influence long-term density or occupancy trends. Further, our established and statistically-robust monitoring and occupancy studies have both proven essential for assessing the long-term population dynamics and conservation status of Rio Grande Silvery Minnow across a broad range of fish densities and fluctuating environmental conditions.

Our multiyear statistical models illustrated that occupancy, extinction, colonization, and detection probabilities generally had larger confidence intervals during years when this species was rare, as compared to when it was abundant. While the sampling design for this study matched that of the long-term population monitoring study, the 20 sites were sampled four times per month for the site occupancy study vs. once per month for the population monitoring study. Although the site-occupancy sampling intensity seemed appropriate during periods of modest occurrence and density, the ability to precisely estimate site occupancy rates was reduced during periods of very low occurrence and density (e.g., drought years [2012–2014]). During periods of extreme rarity, however, we were still able to reliably estimate site occupancy probabilities and their associated confidence intervals. While occupancy probabilities increased substantially from 2013 to 2017, there was a marked decline in 2018, followed by a rapid rebound in 2019. These recent occupancy trends, even when Rio Grande Silvery Minnow was rare, appeared closely related to fluctuating hydrological conditions across years (i.e., occupancy was highest following elevated flows and lowest following reduced flows).

Extinction probabilities reached some of their highest levels, and colonization probabilities reached some of their lowest levels, during an extended drought (2012–2014) in the Middle Rio Grande. This pronounced extinction/colonization pattern was likely indicative of the exceptionally reduced spring and summer flows that characterized that period. While the improved spring and summer flows of recent years (2015–2017) apparently led to increased colonization probabilities and decreased extinction probabilities, these trends again reversed in 2018 following poor spring and summer flow conditions. Similarly, the notably improved seasonal flows of 2019 coincided with a marked reduction in the extinction probability and a rebound in the colonization probability for this imperiled species.

The current conservation status of Rio Grande Silvery Minnow could change dramatically, however, if there are consecutive years of persistently low flows during the crucial spring-spawning and summer-survival periods. Further, site occupancy rates can change dramatically and rapidly across years (e.g., 2011–2015 and 2017–2019) depending on unforeseen changes in seasonal flow conditions. Thus, the occupancy, extinction, colonization, and detection probabilities for Rio Grande Silvery Minnow should only be viewed as an analysis of historical data as opposed to a prediction of future trends.

The site occupancy results can also be used in combination with the population monitoring results to provide a more robust understanding of the dynamic conservation status of Rio Grande Silvery Minnow over time. Specifically, the extinction probability is a particularly valuable metric by which to assess the vulnerability of the Middle Rio Grande population during extended periods of poor flow conditions, decreasing numbers of individuals, and declining occupancy probabilities. Consistently high extinction probabilities, particularly when accompanied by low colonization/occupancy probabilities and reduced densities (e.g., 2012–2014), indicate severe and imminent threats to the persistence of Rio Grande Silvery Minnow in the wild.

Although the combined results of the site-occupancy and population-monitoring studies should facilitate a more comprehensive assessment of the conservation status of Rio Grande Silvery Minnow, an increase in sampling effort (e.g., more sites or more samples per site) would increase both the accuracy and precision of the resulting estimates. The strength of inference will ultimately be strongly dependent on these fundamental aspects of the overall study design (Burnham and Anderson 2002; MacKenzie et al. 2006). However, we found that hypothetically doubling the number of sampling sites, as compared to doubling the sampling effort within existing sites, was much more effective in increasing the precision of Rio Grande Silvery Minnow population estimates (Dudley et al. 2012). Despite the inherent challenges of monitoring rare species, our site occupancy study has provided statistically-robust estimates of the long-term occupancy probability for Rio Grande Silvery Minnow, even during periods of unusually low abundance (e.g., 2012–2014). Although the site-occupancy/population-monitoring sites were not randomly selected, Archdeacon et al. (2015) found no meaningful differences in fish community composition or species-specific densities when using a random vs. nonrandom study design to sample fishes in the Middle Rio Grande. Finally, it is apparent that the synergistic combination of the site-occupancy and population-monitoring studies, despite the practical limitations of extensively modifying the existing study designs, has vastly improved our ability to accurately discern trends in the occurrence and density of Rio Grande Silvery Minnow over the past two decades.

It is well established that simply having large numbers of individuals is inadequate to ensure the long-term persistence of a species in the wild (Groom et al. 2006). This is particularly true for short-lived and highly-fecund species, such as Rio Grande Silvery Minnow. The dramatic population fluctuations of this species, often within a short duration, underscore the need to ensure the presence of individuals over a broad geographical range. Different seasonal flow conditions have resulted in substantial changes in the occurrence and density of Rio Grande Silvery Minnow over time (Archdeacon 2016; Dudley et al. 2019). For example, poor spring runoff may inhibit spawning and limit recruitment to such a degree that its densities decline several orders of magnitude within a single year (Dudley et al. 2019). Additionally, extensive river drying (i.e., during drought years) has regularly resulted in the loss of Rio Grande Silvery Minnow over substantial portions of its occupied range in the Middle Rio Grande. The short life span of this species means that, following periods of poor recruitment, the population is inadequately buffered by surviving members of older age-classes (Horwitz et al. 2018). Thus, the establishment of resilient populations of Rio Grande Silvery Minnow, at multiple locations within its current and historical range, would substantially help to ensure its long-term persistence in the wild.

Although the success of this study will be evaluated annually, insight into the efficacy of estimating occupancy, extinction, colonization, and detection probabilities for Rio Grande Silvery Minnow will require a long-term commitment to consistent and systematic monitoring. Data from future monitoring efforts will provide valuable information that will supplement current site-occupancy analyses and facilitate accurate assessments of the conservation status of this imperiled species over time. Ultimately, insights gained from the site-occupancy and population-monitoring studies can collectively be used to objectively evaluate progress towards achieving the long-term recovery of Rio Grande Silvery Minnow, following both targeted management actions and stochastic environmental events.

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APPENDIX C (Water Quality Summary)

Table C - 1. Water quality statistics based on standard sites (April to October), by reach and site, during 2019.

Reach	Water Quality Measurements[1]: Mean (Standard Error)						
(Site & Locality)	Sec.	Temp.	Sal.	D.O.	Con. T.	Con. S.	pH
Angostura Reach							
1 Angostura Dam	20.6 (3.6)	18 (1.7)	0.1 (0)	9.4 (0.5)	197.4 (9.6)	230.2 (16.4)	7.9 (0.2)
2 Bernalillo	16 (2.8)	19.3 (1.8)	0.1 (0)	9.4 (0.5)	221 (20.5)	234.5 (15.8)	7.8 (0.2)
3 Rio Rancho	15.9 (3.1)	19.1 (1.7)	0.1 (0)	9.2 (0.5)	207.5 (10.6)	235.4 (15.8)	7.7 (0.1)
4 Central Ave.	13.4 (2.9)	17.9 (1.7)	0.1 (0)	9 (0.4)	232.3 (19.4)	269.3 (19.5)	8.2 (0.1)
5 Rio Bravo Blvd.	11.3 (2.4)	17.5 (1.7)	0.1 (0)	8.6 (0.6)	251.9 (47.7)	290.7 (47)	8.5 (0.2)
Isleta Reach							
6 Los Lunas	14.3 (3)	21.5 (2.7)	0.2 (0)	6.7 (0.7)	293.2 (27.9)	323.2 (24.7)	8 (0.2)
7 Belen	13.4 (3.1)	22.4 (2.4)	0.1 (0)	8 (0.7)	290.7 (34.8)	314.9 (26.2)	8.3 (0.3)
8 Jarales	13.1 (2.6)	20.2 (1.9)	0.2 (0)	8.4 (0.7)	307.3 (35.9)	338.6 (32)	8.4 (0.4)
9 Bernardo	12.7 (3.1)	19.4 (1.8)	0.2 (0)	8.3 (0.5)	286.1 (29.7)	335.7 (30)	8.6 (0.4)
10 La Joya	14.3 (4.2)	18.1 (1.7)	0.2 (0)	7.5 (0.8)	309.7 (47.3)	364.9 (39.2)	8.8 (0.4)
11 North of San Acacia	9.7 (1.8)	21.3 (2.1)	0.2 (0)	8.7 (0.7)	373.1 (53.3)	409.9 (58.2)	7.8 (0.2)
San Acacia Reach							
12 San Acacia Dam	10.3 (2.3)	20.6 (1.9)	0.2 (0)	8.2 (0.6)	385.4 (47.9)	403.6 (50)	8 (0.2)
13 South of San Acacia	10 (2.5)	20.9 (2.1)	0.2 (0)	8.8 (0.6)	387.2 (64.6)	417.3 (57.4)	7.9 (0.3)
14 Socorro	9.3 (3.2)	20.4 (2.1)	0.2 (0)	8.4 (0.6)	385.1 (58.3)	420.2 (56.6)	7.7 (0.2)
15 North of San Antonio	6.3 (1.5)	19.8 (2)	0.2 (0)	8.3 (0.6)	379.2 (55.2)	417.5 (54.2)	8.1 (0.2)
16 San Antonio	7.4 (2.1)	23 (2.4)	0.2 (0)	7.6 (0.7)	423 (67.4)	443.2 (56.7)	7.4 (0.2)
17 South of San Antonio	9.3 (2.7)	22 (2.1)	0.3 (0.1)	7.4 (0.6)	574.6 (139.8)	582.6 (120.6)	7.3 (0.3)
18 San Marcial	9.6 (3.2)	21.3 (1.8)	0.2 (0.1)	7.8 (0.6)	504.3 (97)	538.4 (94.7)	7.2 (0.3)
19 South of San Marcial 1	9 (2.6)	20.8 (1.7)	0.2 (0)	8 (0.4)	474.7 (91.9)	512.8 (94)	7.3 (0.3)
20 South of San Marcial 2	9.7 (3.1)	20.3 (1.8)	0.2 (0)	7.9 (0.5)	470 (92.8)	512.1 (95.3)	7.3 (0.5)

[1] = Water quality descriptions were based on USGS definitions (i.e., National field manual for the collection of water-quality data):
Sec. = Secchi depth (cm); Disk with black and white quadrants for measuring water clarity
Temp. = Water temperature (°C); Accurate measurements taken to compute other water quality parameters
Sal. = Salinity (ppt); Concentration of dissolved salts in the water
D.O. = Dissolved oxygen (mg/l); Concentration of dissolved oxygen in the water
Con. T. = True conductivity (µS/cm); Electrical conductance of the water
Con. S. = Specific conductance (µS/cm); Con. T. corrected for water temperature
pH = pH; Concentration of hydrogen ions in the water

APPENDIX D (Statistical Methods)

POPULATION MONITORING

Density data (fish per 100 m^2), for Rio Grande Silvery Minnow, comprise either zeros (i.e., fish not detected) or positive (nonzero) values (i.e., fish detected) at each of the 20 standard sites. The nonzero data range widely across sites and can include very large values, particularly when a sampling site contains an unusually high density of fish. The lognormal probability density function is most appropriate for modeling these wide-ranging values:

$$f(x) = \frac{1}{\sigma\left(x\sqrt{2\pi}\right)} \exp\left[\frac{-\left(\log(x)-\mu\right)^2}{2\sigma^2}\right]$$

where x is a continuous covariate > 0, with scale parameter $\sigma > 0$, and location parameter $-\infty < \mu < \infty$. The parameter μ can be thought of as the mean (on the log scale). However, the lognormal distribution has no probability mass function for zeros (i.e., $x > 0$). To appropriately model the zeros, a mixture distribution is needed for the probability of a positive value (δ) and the probability of a zero value $(1-\delta)$. Thus, each observation is evaluated with the Bernoulli distribution and, if positive, evaluated with the lognormal distribution.

The resulting log-likelihood function of this mixture-model distribution for a single site is computed using the following equations:

$$\text{if } x_i = 0,\quad \log L(x_i) = \log(1-\delta)$$

$$\text{else for } x_i > 0,\quad \log L(x_i) = \log(\delta) - \frac{\left(\log(x_i)-\mu\right)^2}{2\sigma^2} - \log(\sigma)$$

where x = fish density at a site, δ = probability of a nonzero value, and where μ and σ are the lognormal parameters. The following term is not included in the log-likelihood function, as it is constant and not a function of the model parameters:

$$\log\left(x\sqrt{2\pi}\right)$$

The log-likelihood for an entire sampling month is then the sum of the log-likelihoods from all sampling sites:

$$\log L = \sum_{i=1}^{n} \log L(x_i)$$

However, some modifications of the $\log L(x)$ function are required for sparse data. When no $x > 0$ are observed, only δ is estimated. When only one $x > 0$ is observed, only δ and μ can be estimated. Thus, the $\log L(x)$ function is modified to just $\log(\delta) - \left(\log(x_i)-\mu\right)^2$ for a single positive value of x.

Numerical maximization of this log-likelihood is computed using PROC NLMIXED (Nonlinear Mixed Models; SAS 2019) to obtain the maximum likelihood estimates of δ, μ, and σ. Further, PROC NLMIXED can be structured to provide generalized linear models for each of these parameters based on the appropriate link functions:

$$\delta = \text{expit}\left[\beta_{\delta 0} + \beta_{\delta 1} \times \text{Covariate}\right]$$
$$\mu = \beta_{\mu 0} + \beta_{\mu 1} \times \text{Covariate}$$
$$\sigma = \exp\left[\beta_{\sigma 0} + \beta_{\sigma 1} \times \text{Covariate}\right]$$

The link function for δ is the logit link (i.e., reverse logit specified as the expit function), for μ is the identity link, and for σ is the log link. While the covariate used could possibly differ for all three parameters, we felt it was more reasonable to maintain the same covariate for μ and σ. Conversely, we reasoned that covariates best related to fish density $(\mu \text{ and } \sigma)$ might be quite different than covariates best related to the occurrence probability (δ).

In addition, random effects are considered by year:

$$\delta = \text{expit}\left[\beta_{\delta 0} + \text{Normal}(0, \sigma_\delta^2)\right]$$
$$\mu = \beta_{\mu 0} + \text{Normal}(0, \sigma_\mu^2)$$

where we assume a normal distribution with a mean of zero and a nonzero standard deviation. The associated variances (σ) are estimated from the data, using PROC NLMIXED to numerically integrate out the random effect in the log-likelihood function. When both δ and μ have random effects, a covariance term is included in addition to the variances. Also, generalized linear models can either include or ignore random effects when assessing the relative fit of data using goodness-of-fit statistics (logLike = –2[log-likelihood] and AIC_c = Akaike's information criterion [Akaike 1973] for finite sample sizes).

The estimated fish density $E(x)$, and its standard deviation $\text{SD}\left(E(x)\right)$, are generated from PROC NLMIXED using these equations:

$$E(x) = \delta \exp\left[\mu + \frac{\sigma^2}{2}\right]$$
$$\text{SD}\left(E(x)\right) = \left[\exp\left(\sigma^2 - \delta\right)\delta \exp\left(2\mu + \sigma^2\right)\right]^{1/2}$$

Also, profile-likelihood confidence intervals for $E(x)$ are obtained by using a log transformation to maintain LCI > 0:

$$\text{LCI} = \exp\left[\log\left(E(x)\right) - 1.96 \times \text{SE}\left(E(x)\right) / E(x)\right]$$
$$\text{UCI} = \exp\left[\log\left(E(x)\right) + 1.96 \times \text{SE}\left(E(x)\right) / E(x)\right]$$

where LCI is the lower 95% confidence interval and UCI is the upper 95% confidence interval. Values of $\mathrm{SE}\left(E(x)\right)$ are obtained numerically using PROC NLMIXED.

An essential benefit of our mixture-model approach is that the estimated parameters, and accompanying generalized linear models, provide direct and meaningful insight into key factors affecting the long-term population dynamics of Rio Grande Silvery Minnow. This is because we estimate, and individually analyze, both the occurrence probability (based on δ) and fish density (based on μ and σ). Additionally, diverse environmental covariates are used to model the key parameters (δ and μ), which collectively lend insight into the fundamental, yet complex, long-term ecological relationships of Rio Grande Silvery Minnow.

SITE OCCUPANCY

Site occupancy data, for Rio Grande Silvery Minnow, comprise values of either 1 (species detected during a site visit) or 0 (species not detected during a site visit). The sampling protocol consists of four sequential visits per year (primary occasions) to each of the 20 standard sites (secondary occasions). These repeated-sampling efforts are conducted annually during November.

The likelihood function is constructed based on the probability of observing each site's encounter histories (h_s), across the $t = 1, 2, \cdots, K$ years (primary occasions) and l_t site visits (secondary occasions), for each of the *K* primary occasions, following the statistical methods of MacKenzie et al. (2003, 2006):

$$L(\Psi_t, p_{jt} | h_1, h_2, \cdots, h_s) = \prod_1^s \Pr(h_s)$$

where the estimated parameters are Ψ_t (probability a site is occupied in year *t*) and p_{jt} (probability of detection during visit j, $j = 1, 2, \cdots, l_t$, and year *t*). This model assumes closure within a site (i.e., if the site is occupied on the 1st visit in year *t*, the site remains occupied for the 2nd , 3rd, and 4th visits). Also, the model assumes that sites that are unoccupied in year *t* remain unoccupied during all four visits.

Because we are interested in modeling the probability of occupancy through time, as a function of the probability of extinction of occupied sites and the probability of colonization of unoccupied sites, we incorporate two new parameters: ε_t = probability an occupied site in year *t* is unoccupied by the species in year *t* + 1 (i.e., extinction); and γ_t = probability an unoccupied site in year *t* is occupied by the species in year *t* + 1 (i.e., colonization).

The likelihood is thus reparameterized following MacKenzie et al. (2003, 2006):

$$L(\Psi_1, \varepsilon_t, \gamma_t, p_{jt} | h_1, h_2, \cdots, h_s) = \prod_1^s \Pr(h_s)$$

where matrix algebra is used to compute the transitions from occupied to unoccupied (i.e., extinction) and, conversely, from unoccupied to occupied (i.e., colonization).

Program MARK (White and Burnham, 1999) is used to estimate the three key model parameters $(\Psi_1, \varepsilon, \text{and } \gamma)$, based on the Robust Design Occupancy Estimation (RDOccupEG) statistical procedure. With this model, estimates of Ψ_t for the primary occasions ($t = 1, 2, \cdots, K$) are obtained as derived parameters because only Ψ_1 is in the likelihood.

A key benefit of our site occupancy approach is that the data only consist of values of 1 or 0, which eliminates the uncertainty associated with occasionally wide-ranging fish densities. Additionally, simple patterns of species presence-absence are quite robust when considered over multiple site-sampling efforts across years. Most importantly, these analyses lend insight into the dynamic extinction and colonization processes that affect the long-term conservation status of Rio Grande Silvery Minnow.

APPENDIX E (Statistical Assumptions)

Table E - 1. Statistical assumptions, violation implications, violation risks, and mitigation precautions for Rio Grande Silvery Minnow population monitoring analyses.

Statistical assumptions	Violation implications	Violation risks	Mitigation precautions
Seine hauls composed a reasonably representative sample for each site.	This would reduce our ability to detect meaningful year-to-year differences in fish densities.	Low: All available mesohabitat types (e.g., pools, runs, etc.) were represented during site-specific sampling.	Monitoring was highly standardized (i.e., mesohabitat-specific sampling quotas) across sites and years.
Fish were sampled with similar effort over time and space.	This would reduce our ability to detect meaningful year-to-year differences in fish densities.	Low: Conditions during October (e.g., temperature, discharge, and turbidity) were suitable for efficient and standardized sampling across sites and years.	Monitoring was highly standardized (i.e., numbers and lengths of samples per site) across sites and years.
Fish were not recaptured during the same sampling effort.	This would reduce our ability to detect meaningful year-to-year differences in fish densities.	Negligible: Fish were not released back into the sampling site until the sampling efforts were completed.	All fish were kept in a submerged mesh enclosure during each sampling effort.
Zero data represented samples where no individuals of a species were collected (i.e., none were present in the sampled mesohabitats or all mesohabitats were dry).	This would reduce our ability to detect meaningful year-to-year differences in fish densities.	Negligible: We have extensive experience in identifying all fish to species in the Rio Grande. We walked the length of all dry sites to confirm the absence of any isolated pools.	Biologists with extensive experience, in both fish identification and mesohabitat sampling, were present on all sampling efforts.
Species detection probability was reasonably similar across sites.	This would reduce our ability to detect meaningful site-to-site and year-to-year differences in fish densities.	Low: We routinely detected remarkably large site-to-site differences in fish densities.	Past population estimation studies showed no site-to-site differences in detection probabilities. Monitoring was highly standardized across sites.
Species detection probability was reasonably similar across years.	This would reduce our ability to detect meaningful year-to-year differences in fish densities.	Low: We routinely detected remarkably large year-to-year differences in fish densities.	Past population estimation studies showed no year-to-year differences in detection probabilities. Monitoring was highly standardized across years.

Table E - 1. Statistical assumptions, violation implications, violation risks, and mitigation precautions for Rio Grande Silvery Minnow population monitoring analyses (continued).

Statistical assumptions	Violation implications	Violation risks	Mitigation precautions
Nonzero data fit a lognormal distribution reasonably well.	This would reduce our ability to detect meaningful year-to-year differences in fish densities.	Low: Goodness-of-fit tests failed to reject the lognormal distribution for nonzero data.	The distributions were fit with two parameters (mean and variance), providing statistically-robust analyses.
Generalized linear models were appropriate for the type of data and covariates included in the analyses.	This would reduce our ability to detect meaningful species-specific ecological relationships over time.	Low: Generalized linear models were the simplest models to fit, and the data did not warrant overly complex models.	Random-effects models were also included, providing more robust ecological models than simple fixed-effects models.

Table E - 2. Statistical assumptions, violation implications, violation risks, and mitigation precautions for Rio Grande Silvery Minnow site occupancy analyses.

Statistical assumptions	**Violation implications**	**Violation risks**	**Mitigation precautions**
There were no false detections of the species.	This would result in an overestimation of ψ in the site occupancy models.	Negligible: We have extensive experience in identifying all fish to species in the Rio Grande.	Biologists with extensive experience, in both fish identification and mesohabitat sampling, were present on all sampling efforts.
Site-specific occupancy status did not change across sampling days (e.g., occupied to unoccupied or unoccupied to occupied).	This would change the interpretation of ψ from probability of occupancy to probability of use.	Low: Long sampling sites (ca. 200 m) made it unlikely that the occupancy status would change across days. All fish were immediately returned to their occupied mesohabitats (i.e., available for recapture on subsequent days).	Samples were taken on four consecutive sampling days, which yielded an extensive and robust dataset to detect any potential issues regarding unusual changes in site occupancy status over time.
Species detection probability was independent across sites.	This would result in an underestimation of the variance of ψ in the site occupancy models.	Low: Information was not transferred from day to day in the site occupancy models.	Relative to the lengths of individual sites (ca. 200 m), different sites were spaced very far apart from each other (i.e., many kilometers).
Species detection probability was reasonably similar across sites.	This would result in an underestimation of the variance of ψ, but only in the simplest site occupancy models.	Negligible: More complex and robust site-occupancy models, as were used and presented in this study, did not make this assumption.	For annual samples, we modeled species detection probability as a function of species density. Site heterogeneity was considered for our multiyear site occupancy models.
Species detection probability was reasonably similar across years.	This would only be an assumption for site occupancy models with *p* constant across years.	Negligible: Site occupancy models with *p* constant across years never adequately fit the data.	We used AIC_c to discriminate against models that were either too simple or too complex.

APPENDIX F (Site-Specific Population Monitoring Data)

Site-specific data, collected in 2019, as part of the
Rio Grande Silvery Minnow Population Monitoring Program

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-018**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 04 April 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 505.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	1
76	*Pimephales promelas*	12
76	*Platygobio gracilis*	25
76	*Rhinichthys cataractae*	41
81	*Catostomus commersonii*	6

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-019**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 04 April 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 545.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	5
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	27
76	*Rhinichthys cataractae*	15
81	*Catostomus commersonii*	1

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-020**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 04 April 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 519.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	65
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	15
76	*Platygobio gracilis*	18
76	*Rhinichthys cataractae*	15
81	*Catostomus commersonii*	9
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	1
294	*Lepomis cyanellus*	1
294	*Pomoxis annularis*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	2
age-2+	

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Sandoval County, RIO GRANDE Drainage **RKD19-030**
Rio Grande, ca. 4.5 mi upstream of Alameda Blvd. bridge crossing (NM State HWY 528), Corrales.

Site Number: 21 River Mile: 196.5 10 April 2019
UTM Easting: 355670 UTM Northing: 3900620 Zone: 13 Quad: Alameda
A.L. Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 552.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	67
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	89
76	*Rhinichthys cataractae*	13
81	*Catostomus commersonii*	3
93	*Ictalurus punctatus*	11
294	*Pomoxis annularis*	1

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	1

NEW MEXICO: Sandoval County, RIO GRANDE Drainage **RKD19-029**
Rio Grande, ca. 1.0 mi upstream of Alameda Blvd. bridge crossing (NM State HWY 528), Corrales.

Site Number: 22 River Mile: 193.0 10 April 2019
UTM Easting: 351565 UTM Northing: 3897088 Zone: 13 Quad: Los Griegos
A.L. Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 567.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	31
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	16
76	*Rhinichthys cataractae*	5
81	*Catostomus commersonii*	3
93	*Ictalurus punctatus*	12

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Bernalillo County, RIO GRANDE Drainage **RKD19-028**
Rio Grande, ca. 1.2 mi downstream of Paseo del Norte Blvd. bridge crossing (NM State HWY 423), Albuquerque.

Site Number: 23 River Mile: 189.9 10 April 2019
UTM Easting: 349121 UTM Northing: 3893113 Zone: 13 Quad: Los Griegos
A.L. Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 517.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	40
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	7
76	*Platygobio gracilis*	27
76	*Rhinichthys cataractae*	3
81	*Catostomus commersonii*	2
93	*Ictalurus punctatus*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	2
age-2+	1

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Bernalillo County, RIO GRANDE Drainage **RKD19-027**
Rio Grande, ca. 1.1 mi upstream of US Interstate HWY I-40 bridge crossing, Albuquerque.

Site Number: 24 River Mile: 186.1 10 April 2019
UTM Easting: 346011 UTM Northing: 3887973 Zone: 13 Quad: Albuquerque West
A.L. Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 509.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	20
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	13
76	*Rhinichthys cataractae*	3
93	*Ictalurus punctatus*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	2
age-2+	

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-017**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 04 April 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 506.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	447
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	19
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	2
93	*Ictalurus punctatus*	14

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-016**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 04 April 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 437.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	133
76	*Cyprinus carpio*	6
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	1
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	21

NEW MEXICO: Bernalillo County, RIO GRANDE Drainage **RKD19-026**
Rio Grande, ca. 1.4 mi upstream of US Interstate HWY I-25 bridge crossing, Isleta.

Site Number: 25 River Mile: 174.0 09 April 2019
UTM Easting: 345874 UTM Northing: 3870990 Zone: 13 Quad: Isleta
S.L. Clark Barkalow, A.C. Wedemeyer, J.G. Mortensen Effort: 582.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	179
76	*Platygobio gracilis*	1
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	2

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Valencia County, RIO GRANDE Drainage **RKD19-025**
Rio Grande, ca. 4.1 mi upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 26 River Mile: 165.2 09 April 2019
UTM Easting: 342799 UTM Northing: 3858637 Zone: 13 Quad: Los Lunas
S.L. Clark Barkalow, A.C. Wedemeyer, J.G. Mortensen Effort: 576.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	454
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	2
93	*Ictalurus punctatus*	26
212	*Gambusia affinis*	26

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-015**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 03 April 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
A.L Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 548.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	250
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	30

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Valencia County, RIO GRANDE Drainage **RKD19-024**
Rio Grande, ca. 6.5 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 27 River Mile: 156.0 09 April 2019
UTM Easting: 340512 UTM Northing: 3845124 Zone: 13 Quad: Tome
S.L. Clark Barkalow, A.C. Wedemeyer, J.G. Mortensen Effort: 579.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	171
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	34
294	*Micropterus salmoides*	1

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-014**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 03 April 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
A.L Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 579.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	234
76	*Pimephales promelas*	5
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	8

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-013**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 03 April 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
A.L Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 584.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	513
76	*Pimephales promelas*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	2

NEW MEXICO: Socorro County, RIO GRANDE Drainage **RKD19-023**
Rio Grande, ca. 3.8 mi downstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 28 River Mile: 137.0 08 April 2019
UTM Easting: 335506 UTM Northing: 3819543 Zone: 13 Quad: Veguita
M.A. Farrington, T.O. Robbins, A.D. Urioste Effort: 497.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	212
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	35

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-012**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 03 April 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
A.L Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 595.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	19
76	*Cyprinus carpio*	1
81	*Carpiodes carpio*	4
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	6

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-011**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 03 April 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
A.L Barkalow, A.C. Wedemeyer, A.D. Urioste Effort: 546.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	4
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	1
81	*Carpiodes carpio*	3
93	*Ictalurus punctatus*	13

***Hybognathus amarus* (age-classes):**

age-0	
age-1	
age-2+	1

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Socorro County, RIO GRANDE Drainage **RKD19-022**
Rio Grande, ca. 1.4 mi upstream of the Rio Salado confluence, San Acacia.

Site Number: 29 River Mile: 120.0 08 April 2019
UTM Easting: 330550 UTM Northing: 3795050 Zone: 13 Quad: La Joya
M.A. Farrington, T.O. Robbins, A.D. Urioste Effort: 403.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	68
76	*Cyprinus carpio*	6
93	*Ictalurus punctatus*	3

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-010**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 02 April 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
M.A. Farrington, M.J. Chavez, T.O. Robbins Effort: 562.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	6
76	*Platygobio gracilis*	16
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	5

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-009**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 02 April 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
M.A. Farrington, M.J. Chavez, T.O. Robbins Effort: 532.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	62
76	*Platygobio gracilis*	9
81	*Carpiodes carpio*	5
93	*Ictalurus punctatus*	24

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-008**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 02 April 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
M.A. Farrington, M.J. Chavez, T.O. Robbins Effort: 517.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	231
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	82
81	*Carpiodes carpio*	2
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	4

***Hybognathus amarus* (age-classes):**

age-0	
age-1	
age-2+	1

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: Socorro County, RIO GRANDE Drainage **RKD19-021**
Rio Grande, ca. 2.1 mi upstream of Pueblitos Rd. bridge crossing, Lemitar.

Site Number: 30 River Mile: 106.3 08 April 2019
UTM Easting: 326666 UTM Northing: 3780246 Zone: 13 Quad: Lemitar
M.A. Farrington, T.O. Robbins, A.D. Urioste Effort: 526.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	9
76	*Platygobio gracilis*	2

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-007**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 02 April 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
M.A. Farrington, M.J. Chavez, T.O. Robbins Effort: 514.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	214
76	*Cyprinus carpio*	8
76	*Platygobio gracilis*	7
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	12

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-006**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 02 April 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
M.A. Farrington, M.J. Chavez, T.O. Robbins Effort: 501.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	37
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	6

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	1

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-005**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 01 April 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
S.L.Clark Barfkalow, A.C. Wedemeyer, T.O. Robbins Effort: 538.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	19
76	*Cyprinus carpio*	1

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-004**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 01 April 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
S.L.Clark Barfkalow, A.C. Wedemeyer, T.O. Robbins Effort: 528.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	2

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKd19-003**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 01 April 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
S.L.Clark Barfkalow, A.C. Wedemeyer, T.O. Robbins Effort: 318.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	45
76	*Cyprinus carpio*	5
93	*Ictalurus punctatus*	1

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-002**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 01 April 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
S.L.Clark Barfkalow, A.C. Wedemeyer, T.O. Robbins Effort: 478.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	70
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	3
76	*Pimephales vigilax*	1
93	*Ictalurus punctatus*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	3
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-001**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 01 April 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
S.L.Clark Barfkalow, A.C. Wedemeyer, T.O. Robbins Effort: 514.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	158
76	*Pimephales vigilax*	4

Rio Grande Silvery Minnow Population Monitoring
May 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-048**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 02 May 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
M.A. Farrington, S.L. Clark Barkalow, A.C. Wedemeyer Effort: 499.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	3
76	*Gila pandora*	1
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	20
76	*Rhinichthys cataractae*	41
81	*Catostomus commersonii*	259

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-049**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 02 May 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
M.A. Farrington, S.L. Clark Barkalow, A.C. Wedemeyer Effort: 497.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	10
76	*Rhinichthys cataractae*	14
81	*Catostomus commersonii*	242

Rio Grande Silvery Minnow Population Monitoring
May 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-050**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 02 May 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
M.A. Farrington, S.L. Clark Barkalow, A.C. Wedemeyer Effort: 447.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	26
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	13
76	*Rhinichthys cataractae*	3
81	*Catostomus commersonii*	7
93	*Ictalurus punctatus*	3

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-047**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 02 May 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
M.A. Farrington, S.L. Clark Barkalow, A.C. Wedemeyer Effort: 492.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	11
76	*Hybognathus amarus**	3
76	*Platygobio gracilis*	13
93	*Ictalurus punctatus*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	2

Rio Grande Silvery Minnow Population Monitoring
May 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-046**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 02 May 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
M.A. Farrington, S.L. Clark Barkalow, A.C. Wedemeyer Effort: 445.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	21
76	*Cyprinus carpio*	2
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	32
93	*Ictalurus punctatus*	6

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-045**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 01 May 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 427.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	6
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	1

Rio Grande Silvery Minnow Population Monitoring
May 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-044**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 01 May 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 433.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	19
76	*Hybognathus amarus**	1
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-043**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 01 May 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 457.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	200
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	2

Rio Grande Silvery Minnow Population Monitoring
May 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-042**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 01 May 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 409.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	27
76	*Hybognathus amarus**	1
81	*Carpiodes carpio*	1
212	*Gambusia affinis*	3

***Hybognathus amarus* (age-classes):**

age-0	
age-1	
age-2+	1

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-041**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 01 May 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 398.3 sq. m

Family	Species	Total
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	1

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-040**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 30 April 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
R.K. Dudley, M.A. Farrington, M.J. Chavez Effort: 554.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	17
76	*Platygobio gracilis*	27
93	*Ictalurus punctatus*	3

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-039**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 30 April 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
R.K. Dudley, M.A. Farrington, M.J. Chavez Effort: 424.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	187
76	*Platygobio gracilis*	27
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	2
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	2

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-038**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 30 April 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
R.K. Dudley, M.A. Farrington, M.J. Chavez Effort: 466.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	383
76	*Platygobio gracilis*	94
93	*Ictalurus punctatus*	3

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-037**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 30 April 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
R.K. Dudley, M.A. Farrington, M.J. Chavez Effort: 491.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	64
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	3
81	*Catostomus commersonii*	3
93	*Ictalurus punctatus*	1

***Hybognathus amarus* (age-classes):**

age-0	
age-1	2
age-2+	

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-036**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 30 April 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
R.K. Dudley, M.A. Farrington, M.J. Chavez Effort: 408.0 sq. m

Family	Species	Total
81	*Ictiobus bubalus*	4
93	*Ictalurus punctatus*	1

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-035**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 29 April 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 491.6 sq. m

Family	Species	Total
	No Fish Collected	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-034**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 29 April 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 346.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	1
76	*Cyprinus carpio*	1

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-033**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 29 April 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 474.7 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	74
76	*Cyprinus carpio*	1
76	*Platygobio gracilis*	3
81	*Ictiobus bubalus*	1
93	*Ictalurus furcatus*	5

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-032**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 29 April 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 496.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	214
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	2
76	*Pimephales vigilax*	2
81	*Carpiodes carpio*	1
93	*Ictalurus furcatus*	1
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	
age-1	2
age-2+	

Rio Grande Silvery Minnow Population Monitoring
April 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-031**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 29 April 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
M.A. Farrington, S.L. Clark Barkalow, M.J. Chavez Effort: 534.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	540
76	*Pimephales vigilax*	1
76	*Platygobio gracilis*	1
93	*Ictalurus furcatus*	2

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-068**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 06 June 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
A.C. Wedemeyer, J.G. Mortensen, A.D. Urioste Effort: 373.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	2
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	17
76	*Rhinichthys cataractae*	59

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-069**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 06 June 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
A.C. Wedemeyer, J.G. Mortensen, A.D. Urioste Effort: 541.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	15
76	*Gila pandora*	1
76	*Platygobio gracilis*	10
76	*Rhinichthys cataractae*	10
81	*Catostomus commersonii*	21

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-070**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 06 June 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
A.C. Wedemeyer, J.G. Mortensen, A.D. Urioste Effort: 436.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	4
76	*Cyprinus carpio*	1
76	*Platygobio gracilis*	28
76	*Rhinichthys cataractae*	15
81	*Catostomus commersonii*	29

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-067**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 06 June 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
A.C. Wedemeyer, J.G. Mortensen, A.D. Urioste Effort: 514.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	82
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	12
81	*Catostomus commersonii*	2
93	*Ictalurus punctatus*	1

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-066**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 06 June 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
A.C. Wedemeyer, J.G. Mortensen, A.D. Urioste Effort: 488.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	87
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	5
76	*Pimephales promelas*	40
81	*Catostomus commersonii*	16
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	2

***Hybognathus amarus* (age-classes):**

age-0	5
age-1	
age-2+	

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-065**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 05 June 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 497.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	26
76	*Cyprinus carpio*	14
76	*Hybognathus amarus**	5
76	*Rhinichthys cataractae*	1
81	*Catostomus commersonii*	9

***Hybognathus amarus* (age-classes):**

age-0	5
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-064**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 05 June 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 499.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	218
76	*Cyprinus carpio*	46
76	*Hybognathus amarus**	16
76	*Pimephales promelas*	44
76	*Platygobio gracilis*	4
81	*Catostomus commersonii*	27

***Hybognathus amarus* (age-classes):**

age-0	16
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-063**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 05 June 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 450.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	159
76	*Cyprinus carpio*	8
76	*Hybognathus amarus**	5
76	*Pimephales promelas*	4
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	5

***Hybognathus amarus* (age-classes):**

age-0	5
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-062**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 05 June 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 482.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	57
76	*Cyprinus carpio*	2
81	*Catostomus commersonii*	2
212	*Gambusia affinis*	2

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-061**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 05 June 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 455.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	30
81	*Carpiodes carpio*	1

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-060**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 04 June 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
A.L. Barkalow, A.C. Wedemeyer, M.J. Chavez Effort: 578.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	49
76	*Cyprinus carpio*	7
76	*Hybognathus amarus**	253
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	89
81	*Catostomus commersonii*	48

***Hybognathus amarus* (age-classes):**

age-0	251
age-1	1
age-2+	1

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-059**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 04 June 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
A.L. Barkalow, A.C. Wedemeyer, M.J. Chavez Effort: 300.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	345
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	4
76	*Platygobio gracilis*	59
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	1
93	*Ictalurus furcatus*	2
212	*Gambusia affinis*	3

***Hybognathus amarus* (age-classes):**

age-0	4
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-058**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 04 June 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
A.L. Barkalow, A.C. Wedemeyer, M.J. Chavez Effort: 535.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	213
76	*Platygobio gracilis*	175
93	*Ictalurus furcatus*	4
93	*Ictalurus punctatus*	2

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-057**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 04 June 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
A.L. Barkalow, A.C. Wedemeyer, M.J. Chavez Effort: 550.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	411
76	*Cyprinus carpio*	1
76	*Platygobio gracilis*	2
76	*Rhinichthys cataractae*	1
81	*Ictiobus bubalus*	1
93	*Ictalurus punctatus*	1

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-056**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 04 June 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
A.L. Barkalow, A.C. Wedemeyer, M.J. Chavez Effort: 516.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	237
76	*Cyprinus carpio*	161
76	*Hybognathus amarus**	49
76	*Platygobio gracilis*	29
81	*Carpiodes carpio*	2
81	*Catostomus commersonii*	156
93	*Ictalurus furcatus*	2
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	44
age-1	5
age-2+	

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-055**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 03 June 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 544.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	51
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	15
81	*Ictiobus bubalus*	1
93	*Ictalurus furcatus*	1

***Hybognathus amarus* (age-classes):**

age-0	
age-1	2
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-054**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 03 June 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 409.9 sq. m

Family	Species	Total
76	*Cyprinus carpio*	24
76	*Hybognathus amarus**	51
76	*Platygobio gracilis*	1
81	*Catostomus commersonii*	52
81	*Ictiobus bubalus*	4
93	*Ictalurus furcatus*	2

***Hybognathus amarus* (age-classes):**

age-0	51
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-053**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 03 June 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 507.2 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	168
76	*Cyprinus carpio*	5
76	*Hybognathus amarus**	20
76	*Platygobio gracilis*	2
81	*Ictiobus bubalus*	9

***Hybognathus amarus* (age-classes):**

age-0	20
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
June 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-052**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 03 June 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 520.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	502
76	*Cyprinus carpio*	10
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	4
81	*Ictiobus bubalus*	6
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	1

***Hybognathus amarus* (age-classes):**

age-0	2
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-051**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 03 June 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 348.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	151
76	*Cyprinus carpio*	1
93	*Ictalurus furcatus*	6
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	1

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-088**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 05 July 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 446.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	39
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	11
76	*Rhinichthys cataractae*	13
81	*Catostomus commersonii*	4
294	*Lepomis cyanellus*	2

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-089**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 05 July 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 553.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	17
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	15
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	13
76	*Rhinichthys cataractae*	46
81	*Catostomus commersonii*	402

***Hybognathus amarus* (age-classes):**

age-0	15
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-090**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 05 July 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 478.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	49
76	*Cyprinus carpio*	12
76	*Pimephales promelas*	12
76	*Platygobio gracilis*	20
76	*Rhinichthys cataractae*	30
81	*Catostomus commersonii*	38

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-087**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 05 July 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 495.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	46
76	*Cyprinus carpio*	11
76	*Hybognathus amarus**	117
76	*Pimephales promelas*	9
81	*Catostomus commersonii*	8

***Hybognathus amarus* (age-classes):**

age-0	117
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-086**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 05 July 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
R.K. Dudley, A.C. Wedemeyer, A.D. Urioste Effort: 472.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	22
76	*Hybognathus amarus**	78
76	*Pimephales promelas*	15
76	*Platygobio gracilis*	8
81	*Catostomus commersonii*	20

***Hybognathus amarus* (age-classes):**

age-0	78
age-1	
age-2+	

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-085**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 03 July 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 468.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	63
76	*Cyprinus carpio*	77
76	*Hybognathus amarus**	59
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	5
81	*Catostomus commersonii*	8
212	*Gambusia affinis*	7

***Hybognathus amarus* (age-classes):**

age-0	59
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-084**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 03 July 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 463.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	456
76	*Cyprinus carpio*	39
76	*Hybognathus amarus**	61
76	*Pimephales promelas*	50
81	*Catostomus commersonii*	20
212	*Gambusia affinis*	8

***Hybognathus amarus* (age-classes):**

age-0	61
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-083**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 03 July 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 476.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	188
76	*Cyprinus carpio*	72
76	*Hybognathus amarus**	12
76	*Pimephales promelas*	7
81	*Catostomus commersonii*	4
212	*Gambusia affinis*	2
294	*Micropterus salmoides*	1

***Hybognathus amarus* (age-classes):**

age-0	12
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-082**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 03 July 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 475.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	22
76	*Cyprinus carpio*	26
76	*Hybognathus amarus**	38
76	*Platygobio gracilis*	1
81	*Catostomus commersonii*	23
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	38
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-081**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 03 July 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 370.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	11
76	*Hybognathus amarus**	2

***Hybognathus amarus* (age-classes):**

age-0	2
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-080**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 02 July 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 499.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	10
76	*Cyprinus carpio*	21
76	*Hybognathus amarus**	122
76	*Platygobio gracilis*	13
81	*Catostomus commersonii*	4

***Hybognathus amarus* (age-classes):**

age-0	122
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKd19-079**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 02 July 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 498.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	128
76	*Hybognathus amarus**	5
76	*Platygobio gracilis*	70
93	*Ictalurus furcatus*	2
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	5
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-078**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 02 July 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 517.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	150
76	*Cyprinus carpio*	8
76	*Hybognathus amarus**	34
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	96
81	*Catostomus commersonii*	2
93	*Ictalurus furcatus*	4
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	6

***Hybognathus amarus* (age-classes):**

age-0	21
age-1	2
age-2+	11

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-077**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 02 July 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 511.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	318
76	*Cyprinus carpio*	5
76	*Hybognathus amarus**	24
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	3
81	*Catostomus commersonii*	1
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	24
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-076**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 02 July 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 499.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	86
76	*Cyprinus carpio*	20
76	*Hybognathus amarus**	200
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	10
81	*Carpiodes carpio*	2
81	*Catostomus commersonii*	13
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	4
283	*Morone chrysops*	1

***Hybognathus amarus* (age-classes):**

age-0	199
age-1	1
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-075**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 01 July 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 560.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	1
76	*Cyprinus carpio*	6
76	*Hybognathus amarus**	151
76	*Platygobio gracilis*	3
93	*Ictalurus furcatus*	2
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	151
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-074**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 01 July 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 454.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	40
76	*Cyprinus carpio*	37
76	*Hybognathus amarus**	7
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	8
81	*Catostomus commersonii*	2
81	*Ictiobus bubalus*	1
93	*Ictalurus furcatus*	1
212	*Gambusia affinis*	11

***Hybognathus amarus* (age-classes):**

age-0	7
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-073**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 01 July 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 510.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	102
76	*Cyprinus carpio*	13
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	6
81	*Carpiodes carpio*	2
93	*Ictalurus furcatus*	3

***Hybognathus amarus* (age-classes):**

age-0	
age-1	1
age-2+	

Rio Grande Silvery Minnow Population Monitoring
July 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-072**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 01 July 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 438.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	356
76	*Cyprinus carpio*	20
76	*Hybognathus amarus**	67
76	*Pimephales vigilax*	3
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	1
81	*Ictiobus bubalus*	1
93	*Ictalurus punctatus*	1

***Hybognathus amarus* (age-classes):**

age-0	67
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-071**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 01 July 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
S.L. Clark Barkalow, M.J. Chavez, A.C. Wedemeyer Effort: 298.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	42
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	1
93	*Ictalurus furcatus*	2

***Hybognathus amarus* (age-classes):**

age-0	1
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-108**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 08 August 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
M.J. Chavez, A.D. Urioste, T.O. Robbins Effort: 445.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	28
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	7
76	*Platygobio gracilis*	11
76	*Rhinichthys cataractae*	49
81	*Catostomus commersonii*	3
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	15
294	*Micropterus salmoides*	7

***Hybognathus amarus* (age-classes):**

age-0	7
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-109**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 08 August 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
M.J. Chavez, A.D. Urioste, T.O. Robbins Effort: 457.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	205
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	236
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	34
76	*Rhinichthys cataractae*	110
81	*Catostomus commersonii*	14
93	*Ictalurus punctatus*	10
212	*Gambusia affinis*	42
294	*Micropterus salmoides*	2

***Hybognathus amarus* (age-classes):**

age-0	236
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-110**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 08 August 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
M.J. Chavez, A.D. Urioste, T.O. Robbins Effort: 554.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	44
76	*Cyprinus carpio*	8
76	*Hybognathus amarus**	87
76	*Platygobio gracilis*	7
76	*Rhinichthys cataractae*	11
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	5
93	*Ameiurus natalis*	3
93	*Ictalurus punctatus*	33
212	*Gambusia affinis*	32
294	*Micropterus salmoides*	1

***Hybognathus amarus* (age-classes):**

age-0	87
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-107**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 08 August 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
M.J. Chavez, A.D. Urioste, T.O. Robbins Effort: 497.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	39
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	103
76	*Pimephales promelas*	15
76	*Platygobio gracilis*	2
81	*Catostomus commersonii*	6
93	*Ameiurus natalis*	6
93	*Ictalurus punctatus*	12
212	*Gambusia affinis*	17
294	*Micropterus salmoides*	3
294	*Pomoxis annularis*	3

***Hybognathus amarus* (age-classes):**

age-0	103
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-106**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 08 August 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
M.J. Chavez, A.D. Urioste, T.O. Robbins Effort: 534.1 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	72
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	290
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	51
76	*Rhinichthys cataractae*	12
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	6
93	*Ictalurus punctatus*	27
212	*Gambusia affinis*	8
294	*Micropterus salmoides*	1

***Hybognathus amarus* (age-classes):**

age-0	290
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-105**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 07 August 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
R.K. Dudley, T.O. Robbins, A.D. Urioste, E.S. DeArmon Effort: 463.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	185
76	*Cyprinus carpio*	7
76	*Hybognathus amarus**	224
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	3
81	*Catostomus commersonii*	2
93	*Ameiurus natalis*	3
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	12
212	*Gambusia affinis*	8

***Hybognathus amarus* (age-classes):**

age-0	224
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-104**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 07 August 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
R.K. Dudley, T.O. Robbins, A.D. Urioste, E.S. DeArmon Effort: 500.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	176
76	*Cyprinus carpio*	6
76	*Hybognathus amarus**	71
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	1
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	49
212	*Gambusia affinis*	25

***Hybognathus amarus* (age-classes):**

age-0	71
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-103**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 07 August 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
R.K. Dudley, T.O. Robbins, A.D. Urioste, E.S. DeArmon Effort: 549.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	417
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	115
76	*Pimephales promelas*	1
93	*Ameiurus natalis*	3
93	*Ictalurus punctatus*	37
212	*Gambusia affinis*	59

***Hybognathus amarus* (age-classes):**

age-0	115
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-102**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 07 August 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
R.K. Dudley, T.O. Robbins, A.D. Urioste, E.S. DeArmon Effort: 514.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	146
76	*Cyprinus carpio*	11
76	*Hybognathus amarus**	375
76	*Platygobio gracilis*	1
76	*Rhinichthys cataractae*	1
93	*Ameiurus natalis*	23
93	*Ictalurus punctatus*	35
212	*Gambusia affinis*	5

***Hybognathus amarus* (age-classes):**

age-0	375
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-101**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 07 August 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
R.K. Dudley, T.O. Robbins, A.D. Urioste, E.S. DeArmon Effort: 495.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	192
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	212
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	1
93	*Ameiurus natalis*	5
93	*Ictalurus punctatus*	69
212	*Gambusia affinis*	18

***Hybognathus amarus* (age-classes):**

age-0	212
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-100**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 06 August 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 529.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	19
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	81
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	17
93	*Ameiurus natalis*	6
93	*Ictalurus punctatus*	171
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	81
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-099**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 06 August 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 556.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	59
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	29
76	*Platygobio gracilis*	35
76	*Rhinichthys cataractae*	18
93	*Ameiurus natalis*	59
93	*Ictalurus punctatus*	319
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	29
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-098**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 06 August 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 476.1 sq. m

Family	**Species**	**Total**
76	*Cyprinella lutrensis*	61
76	*Cyprinus carpio*	9
76	*Hybognathus amarus**	29
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	57
93	*Ameiurus natalis*	12
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	292

***Hybognathus amarus* (age-classes):**

age-0	29
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-097**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 06 August 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 499.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	162
76	*Cyprinus carpio*	11
76	*Hybognathus amarus**	75
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	12
93	*Ameiurus natalis*	10
93	*Ictalurus punctatus*	98
212	*Gambusia affinis*	18

***Hybognathus amarus* (age-classes):**

age-0	75
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-096**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 06 August 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 510.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	36
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	189
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	6
81	*Carpiodes carpio*	1
93	*Ameiurus natalis*	4
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	26
212	*Gambusia affinis*	11

***Hybognathus amarus* (age-classes):**

age-0	189
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-095**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 05 August 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 583.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	41
76	*Cyprinus carpio*	18
76	*Hybognathus amarus**	17
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	7
93	*Ameiurus natalis*	7
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	122
212	*Gambusia affinis*	7

***Hybognathus amarus* (age-classes):**

age-0	17
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-094**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 05 August 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 446.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	13
76	*Cyprinus carpio*	9
76	*Hybognathus amarus**	2
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	9
212	*Gambusia affinis*	3

***Hybognathus amarus* (age-classes):**

age-0	2
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-093**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 05 August 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 526.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	113
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	87
76	*Platygobio gracilis*	7
93	*Ictalurus punctatus*	29
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	87
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-092**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 05 August 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 563.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	366
76	*Cyprinus carpio*	6
76	*Hybognathus amarus**	59
76	*Pimephales promelas*	1
76	*Pimephales vigilax*	2
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	14
212	*Gambusia affinis*	14

***Hybognathus amarus* (age-classes):**

age-0	59
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
August 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-091**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 05 August 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 535.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	65
76	*Hybognathus amarus**	1
93	*Ictalurus furcatus*	2
93	*Ictalurus punctatus*	133
212	*Gambusia affinis*	3

***Hybognathus amarus* (age-classes):**

age-0	1
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-128**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 06 September 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 434.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	27
76	*Hybognathus amarus**	5
76	*Platygobio gracilis*	17
76	*Rhinichthys cataractae*	33
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	7
294	*Micropterus salmoides*	3
294	*Pomoxis annularis*	1

***Hybognathus amarus* (age-classes):**

age-0	5
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-129**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 06 September 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 508.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	98
76	*Hybognathus amarus**	43
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	32
76	*Rhinichthys cataractae*	36
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	46
294	*Micropterus salmoides*	1

***Hybognathus amarus* (age-classes):**

age-0	43
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-130**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 06 September 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 499.1 sq. m

Family	**Species**	**Total**
76	*Cyprinella lutrensis*	24
76	*Hybognathus amarus**	9
76	*Pimephales promelas*	7
76	*Platygobio gracilis*	14
76	*Rhinichthys cataractae*	14
93	*Ameiurus natalis*	4
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	23
294	*Lepomis cyanellus*	1
294	*Pomoxis annularis*	4

***Hybognathus amarus* (age-classes):**

age-0	8
age-1	1
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-127**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 06 September 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 517.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	38
76	*Cyprinus carpio*	4
76	*Hybognathus amarus**	22
76	*Platygobio gracilis*	3
212	*Gambusia affinis*	7
294	*Pomoxis annularis*	1

***Hybognathus amarus* (age-classes):**

age-0	22
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-126**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 06 September 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 518.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	18
76	*Hybognathus amarus**	88
76	*Platygobio gracilis*	9
81	*Carpiodes carpio*	4
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	6
294	*Micropterus salmoides*	2

***Hybognathus amarus* (age-classes):**

age-0	88
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-125**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 05 September 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 551.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	109
76	*Hybognathus amarus**	61
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	4
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	31
294	*Micropterus salmoides*	1

***Hybognathus amarus* (age-classes):**

age-0	61
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-124**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 05 September 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 548.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	172
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	22
76	*Pimephales promelas*	2
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	77
212	*Gambusia affinis*	77

***Hybognathus amarus* (age-classes):**

age-0	22
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-123**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 05 September 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 506.4 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	138
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	3
93	*Ameiurus natalis*	3
93	*Ictalurus punctatus*	16
212	*Gambusia affinis*	79
294	*Pomoxis annularis*	1

***Hybognathus amarus* (age-classes):**

age-0	3
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-122**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 05 September 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 503.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	71
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	9
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	11
212	*Gambusia affinis*	59

***Hybognathus amarus* (age-classes):**

age-0	9
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-121**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 05 September 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 484.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	22
76	*Hybognathus amarus**	31
81	*Carpiodes carpio*	1
93	*Ictalurus furcatus*	2
93	*Ictalurus punctatus*	10
212	*Gambusia affinis*	4

***Hybognathus amarus* (age-classes):**

age-0	31
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-120**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 04 September 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 440.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	70
76	*Cyprinus carpio*	1
76	*Platygobio gracilis*	395
93	*Ameiurus melas*	2
93	*Ictalurus punctatus*	35
212	*Gambusia affinis*	23
294	*Pomoxis annularis*	8

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-119**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 04 September 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 526.5 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	212
76	*Hybognathus amarus**	121
76	*Platygobio gracilis*	33
81	*Catostomus commersonii*	1
93	*Ameiurus melas*	7
93	*Ictalurus furcatus*	3
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	12

***Hybognathus amarus* (age-classes):**

age-0	121
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-118**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 04 September 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 513.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	107
76	*Hybognathus amarus**	49
76	*Platygobio gracilis*	17
93	*Ameiurus melas*	1
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	21

***Hybognathus amarus* (age-classes):**

age-0	49
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-117**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 04 September 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 545.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	264
76	*Hybognathus amarus**	23
76	*Platygobio gracilis*	3
93	*Ameiurus natalis*	1
93	*Ictalurus furcatus*	9
93	*Ictalurus punctatus*	9
212	*Gambusia affinis*	5

***Hybognathus amarus* (age-classes):**

age-0	23
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-116**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 04 September 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 537.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	67
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	55
76	*Platygobio gracilis*	11
93	*Ameiurus melas*	4
93	*Ictalurus punctatus*	8

***Hybognathus amarus* (age-classes):**

age-0	55
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-115**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 03 September 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 552.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	157
76	*Hybognathus amarus**	6
76	*Platygobio gracilis*	20
93	*Ictalurus furcatus*	13
93	*Ictalurus punctatus*	31
93	*Pylodictis olivaris*	1
212	*Gambusia affinis*	4

***Hybognathus amarus* (age-classes):**

age-0	6
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-114**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 03 September 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 356.5 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	11
76	*Cyprinella lutrensis*	226
76	*Cyprinus carpio*	162
76	*Hybognathus amarus**	154
76	*Platygobio gracilis*	61
81	*Carpiodes carpio*	7
81	*Ictiobus bubalus*	9
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	4
294	*Pomoxis annularis*	1
326	*Aplodinotus grunniens*	1

***Hybognathus amarus* (age-classes):**

age-0	153
age-1	1
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-113**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 03 September 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 451.6 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	2
76	*Cyprinella lutrensis*	161
76	*Cyprinus carpio*	225
76	*Hybognathus amarus**	15
76	*Platygobio gracilis*	1
81	*Ictiobus bubalus*	1
93	*Ictalurus furcatus*	6
93	*Ictalurus punctatus*	51
212	*Gambusia affinis*	6

***Hybognathus amarus* (age-classes):**

age-0	15
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-112**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 03 September 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 495.4 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	7
76	*Cyprinella lutrensis*	105
76	*Cyprinus carpio*	17
76	*Hybognathus amarus**	38
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	3
81	*Ictiobus bubalus*	2
93	*Ictalurus punctatus*	6
212	*Gambusia affinis*	26

***Hybognathus amarus* (age-classes):**

age-0	38
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
September 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-111**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 03 September 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 516.0 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	2
76	*Cyprinella lutrensis*	108
76	*Cyprinus carpio*	19
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	1
81	*Ictiobus bubalus*	1
93	*Ictalurus punctatus*	38
212	*Gambusia affinis*	59

***Hybognathus amarus* (age-classes):**

age-0	3
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-148**
Rio Grande, just downstream of Angostura Diversion Dam, Algodones.

Site Number: 1 River Mile: 209.9 04 October 2019
UTM Easting: 363665 UTM Northing: 3916331 Zone: 13 Quad: San Felipe Pueblo
S.L. Clark Barkalow, T.O. Robbins, A.D. Urioste Effort: 484.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	74
76	*Hybognathus amarus**	5
76	*Platygobio gracilis*	6
76	*Rhinichthys cataractae*	2
81	*Catostomus commersonii*	1
212	*Gambusia affinis*	86
294	*Lepomis cyanellus*	1

***Hybognathus amarus* (age-classes):**

age-0	5
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-149**
Rio Grande, at US HWY 550 bridge crossing, Bernalillo.

Site Number: 2 River Mile: 203.9 04 October 2019
UTM Easting: 358457 UTM Northing: 3909887 Zone: 13 Quad: Bernalillo
S.L. Clark Barkalow, T.O. Robbins, A.D. Urioste Effort: 488.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	55
76	*Hybognathus amarus**	33
76	*Platygobio gracilis*	18
76	*Rhinichthys cataractae*	15
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	20

***Hybognathus amarus* (age-classes):**

age-0	33
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SANDOVAL County, RIO GRANDE Drainage **RKD19-150**
Rio Grande, ca. 4.0 mi downstream of US HWY 550 bridge crossing, Rio Rancho.

Site Number: 3 River Mile: 199.9 04 October 2019
UTM Easting: 354728 UTM Northing: 3905587 Zone: 13 Quad: Bernalillo
S.L. Clark Barkalow, T.O. Robbins, A.D. Urioste Effort: 547.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	36
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	32
76	*Rhinichthys cataractae*	35
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	9
294	*Pomoxis annularis*	2

***Hybognathus amarus* (age-classes):**

age-0	3
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Sandoval County, RIO GRANDE Drainage **RKD19-160**
Rio Grande, ca. 4.5 mi upstream of Alameda Blvd. bridge crossing (NM State HWY 528), Corrales.

Site Number: 21 River Mile: 196.5 09 October 2019
UTM Easting: 355670 UTM Northing: 3900620 Zone: 13 Quad: Alameda
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 515.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	36
76	*Hybognathus amarus**	24
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	53
76	*Rhinichthys cataractae*	53
81	*Catostomus commersonii*	1
212	*Gambusia affinis*	12

***Hybognathus amarus* (age-classes):**

age-0	24
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Sandoval County, RIO GRANDE Drainage **RKD19-159**
Rio Grande, ca. 1.0 mi upstream of Alameda Blvd. bridge crossing (NM State HWY 528), Corrales.

Site Number: 22 River Mile: 193.0 09 October 2019
UTM Easting: 351565 UTM Northing: 3897088 Zone: 13 Quad: Los Griegos
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 525.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	60
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	76
76	*Pimephales promelas*	14
76	*Platygobio gracilis*	54
76	*Rhinichthys cataractae*	4
81	*Catostomus commersonii*	1
93	*Ameiurus natalis*	4
93	*Ictalurus punctatus*	11
212	*Gambusia affinis*	17

***Hybognathus amarus* (age-classes):**

age-0	76
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Bernalillo County, RIO GRANDE Drainage **RKD19-158**
Rio Grande, ca. 1.2 mi downstream of Paseo del Norte Blvd. bridge crossing (NM State HWY 423), Albuquerque.
Site Number: 23 River Mile: 189.9 09 October 2019
UTM Easting: 349121 UTM Northing: 3893113 Zone: 13 Quad: Los Griegos
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 535.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	17
76	*Hybognathus amarus**	22
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	9
76	*Rhinichthys cataractae*	1
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	17
294	*Pomoxis annularis*	2

***Hybognathus amarus* (age-classes):**

age-0	22
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Bernalillo County, RIO GRANDE Drainage **RKD19-157**
Rio Grande, ca. 1.1 mi upstream of US Interstate HWY I-40 bridge crossing, Albuquerque.

Site Number: 24 River Mile: 186.1 09 October 2019
UTM Easting: 346011 UTM Northing: 3887973 Zone: 13 Quad: Albuquerque West
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 548.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	43
76	*Hybognathus amarus**	37
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	25
76	*Rhinichthys cataractae*	2
93	*Ictalurus punctatus*	50

***Hybognathus amarus* (age-classes):**

age-0	37
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-147**
Rio Grande, at Central Ave. bridge crossing (US HWY 66), Albuquerque.

Site Number: 4 River Mile: 183.4 04 October 2019
UTM Easting: 346719 UTM Northing: 3884331 Zone: 13 Quad: Albuquerque West
S.L. Clark Barkalow, T.O. Robbins, A.D. Urioste Effort: 505.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	3
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	12
81	*Catostomus commersonii*	1
212	*Gambusia affinis*	25
283	*Morone chrysops*	1
294	*Pomoxis annularis*	1

***Hybognathus amarus* (age-classes):**

age-0	1
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: BERNALILLO County, RIO GRANDE Drainage **RKD19-146**
Rio Grande, at Rio Bravo Blvd. bridge crossing (NM State HWY 500), Albuquerque.

Site Number: 5 River Mile: 178.4 04 October 2019
UTM Easting: 347468 UTM Northing: 3877400 Zone: 13 Quad: Albuquerque West
S.L. Clark Barkalow, T.O. Robbins, A.D. Urioste Effort: 536.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	22
76	*Hybognathus amarus**	21
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	8
81	*Catostomus commersonii*	2
212	*Gambusia affinis*	40

***Hybognathus amarus* (age-classes):**

age-0	21
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Bernalillo County, RIO GRANDE Drainage **RKD19-156**
Rio Grande, ca. 1.4 mi upstream of US Interstate HWY I-25 bridge crossing, Isleta.

Site Number: 25 River Mile: 174.0 08 October 2019
UTM Easting: 345874 UTM Northing: 3870990 Zone: 13 Quad: Isleta
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 521.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	10
76	*Hybognathus amarus**	17
76	*Pimephales promelas*	5
76	*Platygobio gracilis*	7
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	2

***Hybognathus amarus* (age-classes):**

age-0	17
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Valencia County, RIO GRANDE Drainage **RKD19-155**
Rio Grande, ca. 4.1 mi upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 26 River Mile: 165.2 08 October 2019
UTM Easting: 342799 UTM Northing: 3858637 Zone: 13 Quad: Los Lunas
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 516.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	326
76	*Cyprinus carpio*	9
76	*Hybognathus amarus**	27
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	11
76	*Rhinichthys cataractae*	1
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	23
212	*Gambusia affinis*	84
294	*Pomoxis annularis*	1

***Hybognathus amarus* (age-classes):**

age-0	27
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-145**
Rio Grande, just upstream of NM State HWY 6 bridge crossing, Los Lunas.

Site Number: 6 River Mile: 161.7 03 October 2019
UTM Easting: 343149 UTM Northing: 3853187 Zone: 13 Quad: Los Lunas
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 522.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	271
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	15
76	*Platygobio gracilis*	2
93	*Ictalurus punctatus*	6
212	*Gambusia affinis*	13

***Hybognathus amarus* (age-classes):**

age-0	15
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Valencia County, RIO GRANDE Drainage **RKD19-154**
Rio Grande, ca. 6.5 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 27 River Mile: 156.0 08 October 2019
UTM Easting: 340512 UTM Northing: 3845124 Zone: 13 Quad: Tome
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 538.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	204
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	45
76	*Pimephales promelas*	12
76	*Platygobio gracilis*	5
93	*Ictalurus punctatus*	11
212	*Gambusia affinis*	55

***Hybognathus amarus* (age-classes):**

age-0	45
age-1	
age-2+	

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-144**
Rio Grande, ca. 1.0 mi upstream of NM State HWY 309 bridge crossing, Belen.

Site Number: 7 River Mile: 150.8 03 October 2019
UTM Easting: 340105 UTM Northing: 3837722 Zone: 13 Quad: Tome
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 499.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	147
76	*Hybognathus amarus**	3
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	6
212	*Gambusia affinis*	6

***Hybognathus amarus* (age-classes):**

age-0	3
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: VALENCIA County, RIO GRANDE Drainage **RKD19-143**
Rio Grande, ca. 2.2 mi upstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 8 River Mile: 143.2 03 October 2019
UTM Easting: 338020 UTM Northing: 3827545 Zone: 13 Quad: Veguita
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 512.8 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	124
76	*Cyprinus carpio*	1
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	11

NEW MEXICO: Socorro County, RIO GRANDE Drainage **RKD19-153**
Rio Grande, ca. 3.8 mi downstream of NM State HWY 346 bridge crossing, Jarales.

Site Number: 28 River Mile: 137.0 07 October 2019
UTM Easting: 335506 UTM Northing: 3819543 Zone: 13 Quad: Veguita
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 495.3 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	300
76	*Hybognathus amarus**	10
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	30
212	*Gambusia affinis*	153

***Hybognathus amarus* (age-classes):**

age-0	10
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-142**
Rio Grande, at US HWY 60 bridge crossing, Bernardo.

Site Number: 9 River Mile: 130.6 03 October 2019
UTM Easting: 334578 UTM Northing: 3809921 Zone: 13 Quad: Abeytas
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 493.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	182
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	9
76	*Pimephales promelas*	11
76	*Platygobio gracilis*	1
93	*Ameiurus natalis*	2
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	89

***Hybognathus amarus* (age-classes):**

age-0	9
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-141**
Rio Grande, ca. 3.7 mi downstream of US HWY 60 bridge crossing, Bernardo.

Site Number: 10 River Mile: 126.8 03 October 2019
UTM Easting: 330946 UTM Northing: 3805307 Zone: 13 Quad: Abeytas
R.K. Dudley, A.C. Wedemeyer, T.O. Robbins Effort: 492.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	192
76	*Hybognathus amarus**	26
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	14

***Hybognathus amarus* (age-classes):**

age-0	26
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Socorro County, RIO GRANDE Drainage **RKD19-152**
Rio Grande, ca. 1.4 mi upstream of the Rio Salado confluence, San Acacia.

Site Number: 29 River Mile: 120.0 07 October 2019
UTM Easting: 330550 UTM Northing: 3795050 Zone: 13 Quad: La Joya
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 493.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	217
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	22
76	*Platygobio gracilis*	2
93	*Ameiurus natalis*	3
93	*Ictalurus punctatus*	66
212	*Gambusia affinis*	29

***Hybognathus amarus* (age-classes):**

age-0	22
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-140**
Rio Grande, ca. 1.2 mi upstream of San Acacia Diversion Dam, San Acacia.

Site Number: 11 River Mile: 117.3 02 October 2019
UTM Easting: 328152 UTM Northing: 3792564 Zone: 13 Quad: La Joya
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 512.9 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	1
76	*Hybognathus amarus**	3
76	*Platygobio gracilis*	52
93	*Ictalurus punctatus*	27

***Hybognathus amarus* (age-classes):**

age-0	3
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-139**
Rio Grande, just downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 12 River Mile: 115.6 02 October 2019
UTM Easting: 325960 UTM Northing: 3792183 Zone: 13 Quad: San Acacia
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 534.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	42
76	*Hybognathus amarus**	14
76	*Platygobio gracilis*	97
76	*Rhinichthys cataractae*	46
93	*Ictalurus punctatus*	20
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	11
age-1	3
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-138**
Rio Grande, ca. 1.5 mi downstream of San Acacia Diversion Dam, San Acacia.

Site Number: 13 River Mile: 114.1 02 October 2019
UTM Easting: 325390 UTM Northing: 3790397 Zone: 13 Quad: Lemitar
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 505.7 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	32
76	*Hybognathus amarus**	4
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	59
76	*Rhinichthys cataractae*	8
93	*Ictalurus punctatus*	16

***Hybognathus amarus* (age-classes):**

age-0	4
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: Socorro County, RIO GRANDE Drainage **RKD19-151**
Rio Grande, ca. 2.1 mi upstream of Pueblitos Rd. bridge crossing, Lemitar.

Site Number: 30 River Mile: 106.3 07 October 2019
UTM Easting: 326666 UTM Northing: 3780246 Zone: 13 Quad: Lemitar
R.K. Dudley, T.O. Robbins, A.D. Urioste Effort: 553.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	100
76	*Hybognathus amarus**	28
76	*Platygobio gracilis*	9
93	*Ameiurus natalis*	4
93	*Ictalurus punctatus*	3

***Hybognathus amarus* (age-classes):**

age-0	28
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-137**
Rio Grande, ca. 0.5 mi upstream of Socorro Low Flow Conveyance Channel bridge crossing, Socorro.

Site Number: 14 River Mile: 99.6 02 October 2019
UTM Easting: 327231 UTM Northing: 3771432 Zone: 13 Quad: Loma de las Canas
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 575.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	31
76	*Hybognathus amarus**	4
76	*Platygobio gracilis*	17
93	*Ameiurus natalis*	5
93	*Ictalurus punctatus*	27

***Hybognathus amarus* (age-classes):**

age-0	4
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-136**
Rio Grande, ca. 4.5 mi upstream of US HWY 380 bridge crossing, San Antonio.

Site Number: 15 River Mile: 92.0 02 October 2019
UTM Easting: 328151 UTM Northing: 3761487 Zone: 13 Quad: San Antonio
S.L. Clark Barkalow, M.J. Chavez, A.D. Urioste Effort: 517.6 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	60
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	30
76	*Platygobio gracilis*	2
93	*Ameiurus natalis*	2
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	3

***Hybognathus amarus* (age-classes):**

age-0	30
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-135**
Rio Grande, at US HWY 380 bridge crossing, San Antonio.

Site Number: 16 River Mile: 87.8 01 October 2019
UTM Easting: 328907 UTM Northing: 3754926 Zone: 13 Quad: San Antonio
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 513.0 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	22
76	*Hybognathus amarus**	4
76	*Platygobio gracilis*	2
93	*Ictalurus furcatus*	11
93	*Ictalurus punctatus*	12
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	4
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-134**
Rio Grande, east of Bosque del Apache NWR headquarters, San Antonio.

Site Number: 17 River Mile: 79.0 01 October 2019
UTM Easting: 327219 UTM Northing: 3740906 Zone: 13 Quad: San Antonio SE
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 116.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	37
76	*Cyprinus carpio*	21
76	*Hybognathus amarus**	18
212	*Gambusia affinis*	12

***Hybognathus amarus* (age-classes):**

age-0	18
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-133**
Rio Grande, at San Marcial Railroad bridge crossing, San Marcial.

Site Number: 18 River Mile: 68.3 01 October 2019
UTM Easting: 315091 UTM Northing: 3728487 Zone: 13 Quad: San Marcial
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 499.5 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	228
76	*Cyprinus carpio*	7
76	*Hybognathus amarus**	6
93	*Ictalurus furcatus*	5
93	*Ictalurus punctatus*	9
212	*Gambusia affinis*	1

***Hybognathus amarus* (age-classes):**

age-0	6
age-1	
age-2+	

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-132**
Rio Grande, ca. 8.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 19 River Mile: 60.1 01 October 2019
UTM Easting: 309441 UTM Northing: 3718309 Zone: 13 Quad: Paraje Well
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 551.8 sq. m

Family	Species	Total
69	*Dorosoma cepedianum*	4
76	*Cyprinella lutrensis*	263
76	*Cyprinus carpio*	13
76	*Hybognathus amarus**	9
93	*Ictalurus punctatus*	7
212	*Gambusia affinis*	182

***Hybognathus amarus* (age-classes):**

age-0	9
age-1	
age-2+	

Rio Grande Silvery Minnow Population Monitoring
October 2019

NEW MEXICO: SOCORRO County, RIO GRANDE Drainage **RKD19-131**
Rio Grande, ca. 10.0 mi downstream of San Marcial Railroad bridge crossing, San Marcial.

Site Number: 20 River Mile: 58.5 01 October 2019
UTM Easting: 307767 UTM Northing: 3716360 Zone: 13 Quad: Paraje Well
A.C. Wedemeyer, A.D. Urioste, T.O. Robbins Effort: 515.2 sq. m

Family	Species	Total
76	*Cyprinella lutrensis*	192
76	*Cyprinus carpio*	32
76	*Hybognathus amarus**	1
93	*Ictalurus punctatus*	29
212	*Gambusia affinis*	37

***Hybognathus amarus* (age-classes):**

age-0	1
age-1	
age-2+	