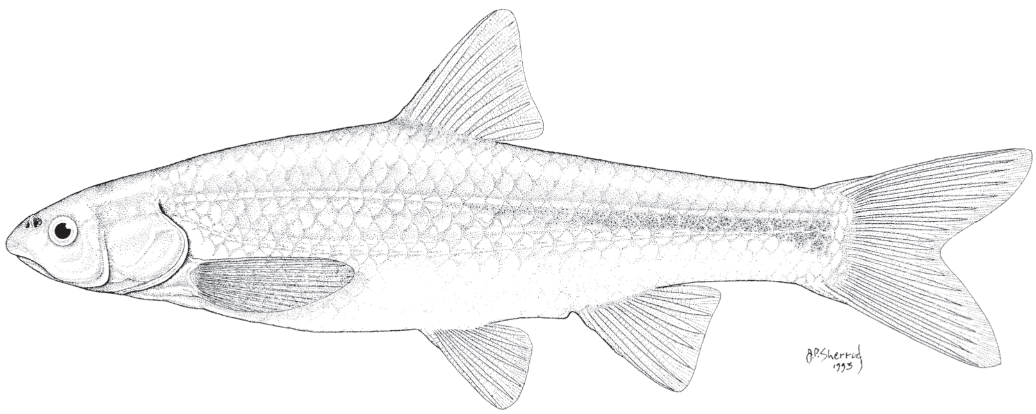
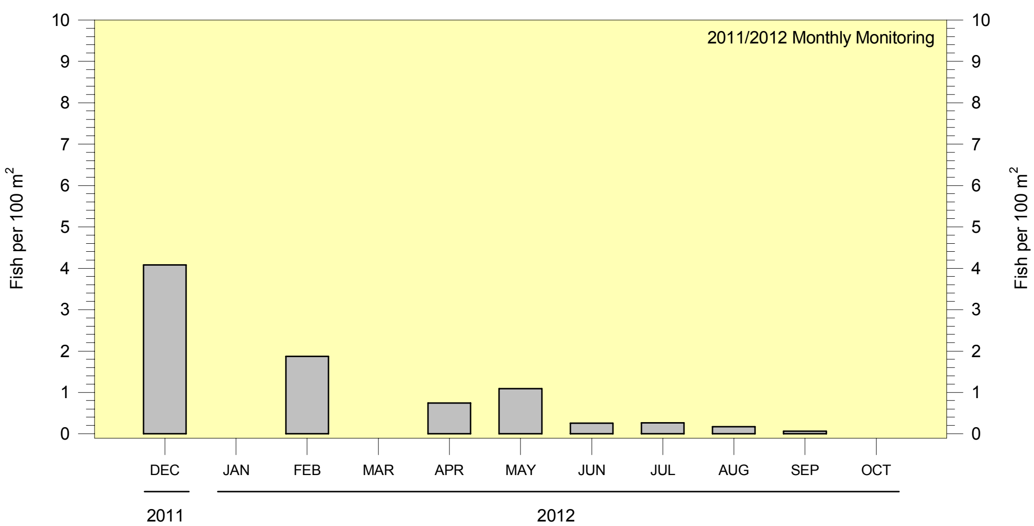
RIO GRANDE SILVERY MINNOW POPULATION MONITORING PROGRAM RESULTS FROM DECEMBER 2011 TO OCTOBER 2012

FINAL

A Middle Rio Grande Endangered Species Collaborative Program Funded Research Project





Robert K. Dudley[1], Steven P. Platania[1], and Gary C. White[2]

[1] American Southwest Ichthyological Researchers, L.L.C.
800 Encino Place NE; Albuquerque, NM 87102-2606
&
[2] Department of Fish, Wildlife, and Conservation Biology
239 Wagar, Colorado State University; Fort Collins, CO 80523-1474

26 April 2013

Rio Grande silvery minnow Population Monitoring Program Results from December 2011 to October 2012

FINAL

Funded through the Middle Rio Grande Endangered Species Collaborative Program

Prepared by:

Robert K. Dudley[1], Steven P. Platania[1], and Gary C. White[2]

[1] American Southwest Ichthyological Researchers, L.L.C.
800 Encino Place NE; Albuquerque, NM 87102-2606
&
[2] Department of Fish, Wildlife, and Conservation Biology
239 Wagar, Colorado State University; Fort Collins, CO 80523-1474

under USBR contract (Number R09PC40005):

U.S. Bureau of Reclamation
Upper Colorado Regional Office
125 South State Street, Room 6107
Salt Lake City, UT 84138-1102

Submitted to:

U.S. Bureau of Reclamation
Albuquerque Area Office
555 Broadway, NE; Suite 100
Albuquerque, New Mexico 87102-2352

26 April 2013

TABLE OF CONTENTS

INTRODUCTION 1

STUDY AREA 1

METHODS 5

RESULTS 8
- Rio Grande Silvery Minnow 8
  - Population status 8
  - Population trends (1993–2012) 13
  - Mesohabitat associations (2011–2012) and population trends (2002–2012) 20
- Fish Community 20
  - Population status 20
- Sampling Variation 26
  - November (2005–2012) 26

DISCUSSION 35

ACKNOWLEDGMENTS 40

LITERATURE CITED 41

APPENDIX A (Fish sampling sites) 44

APPENDIX B (Site occupancy analysis) 48

APPENDIX C (Water quality summary) 60

APPENDIX D (Ichthyofaunal composition) 61

LIST OF TABLES

Table 1. Scientific and common names and species codes of fishes collected in the Middle Rio Grande from 1993 to 2012 6

Table 2. Summary of the monthly catch of Rio Grande silvery minnow, by site and reach, from December 2011 to October 2012 12

Table 3. General linear models of Rio Grande silvery minnow mixture-model estimates (Delta (δ) and Mu (μ)), using October sampling-site density data (1993–2012), and hydraulic variables (allowing for random effects). 19

Table 4. Codes used for mesohabitat type classification in the Middle Rio Grande 21

Table 5. Summary of the Rio Grande silvery minnow population monitoring program fish samples from December 2011 to October 2012 25

Table 6. Summary of rank abundance for focal species collected in the Rio Grande during October over the past decade (2003–2012) 28

Table 7. Summary of the December 2011 to October 2012 Rio Grande silvery minnow population monitoring program fish samples 31

LIST OF FIGURES

Figure 1. Map of the study area and sampling sites for the December 2011 to October 2012 Rio Grande silvery minnow population monitoring program 3

Figure 2. Discharge in the Rio Grande from January 2011 through November 2012 as recorded at seven U.S. Geological Survey (USGS) gauge stations 4

Figure 3. Rio Grande silvery minnow densities from December 2011 to May 2012 for each sampling site in the Middle Rio Grande 10

Figure 4. Rio Grande silvery minnow densities from June to October 2012 for each sampling site in the Middle Rio Grande 11

Figure 5. Rio Grande silvery minnow densities by river reach for the December 2011 to October 2012 samples in the Middle Rio Grande 14

Figure 6. Inter-month fluctuations in densities of Rio Grande silvery minnow from December 2011 to October 2012 15

Figure 7. Rio Grande silvery minnow mixture-model estimates ($E(x)$), using October sampling-site density data (1993–2012) 16

Figure 8. Bivariate relationships among Rio Grande silvery minnow estimates of Delta (δ), using October sampling-site density data (1993–2012), and hydraulic variables for USGS Gauge #08330000 and USGS Gauge #08358400) 17

Figure 9. Bivariate relationships among Rio Grande silvery minnow estimates of Mu (μ), using October sampling-site density data (1993–2012), and hydraulic variables for USGS Gauge #08330000 and USGS Gauge #08358400) 18

LIST OF FIGURES (continued)

Figure 10. Percent total of mesohabitats sampled and those occupied by Rio Grande silvery minnow in the Middle Rio Grande as part of population monitoring from December 2011 to October 2012 for each river reach and the annual total 22

Figure 11. Rio Grande silvery minnow mixture-model estimates (*E*(*x*)) by mesohabitat, using October mesohabitat density data (2002–2012) 23

Figure 12. Rio Grande silvery minnow mixture-model estimates (*E*(*x*)), using October mesohabitat density data (2002–2012) 24

Figure 13. Relative abundance of Rio Grande silvery minnow as a percentage of the total ichthyofaunal community during October, at all sampling sites, by sampling year (1993–2012) 27

Figure 14. Fish densities from December 2011 to May 2012 for each focal species in the Middle Rio Grande 29

Figure 15. Fish densities from June to October 2012 for each focal species in the Middle Rio Grande 30

Figure 16. Fish densities by river reach for each focal species in the Middle Rio Grande from December 2011 to October 2012 32

Figure 17. Rio Grande silvery minnow mixture-model estimates (*E*(*x*)) by year, using mesohabitat density data from repeated sampling during November (2005–2008) 33

Figure 18. Rio Grande silvery minnow mixture-model estimates (*E*(*x*)) by year, using mesohabitat density data from repeated sampling during November (2009–2012) 34

LIST OF TABLES (APPENDICES)

Table A-1. Sampling sites for December 2011 to October 2012 population monitoring of Rio Grande silvery minnow 45

Table B-1. Rio Grande silvery minnow encounter history summary, probability of detection estimate, and probability of occupancy estimates based on repeated mesohabitat sampling efforts in November 2012 51

Table B-2. Rio Grande silvery minnow site occupancy analysis among years for all sampling sites combined in the Middle Rio Grande based on repeated site sampling efforts in November (2005–2012) 53

Table B-3. Rio Grande silvery minnow detection probability estimates among years for all sampling sites combined in the Middle Rio Grande based on repeated site sampling efforts in November (2005–2012) 54

Table C-1. Water quality summary statistics [Mean (Standard Error)], by sampling site and reach, during the December 2011 to October 2012 population monitoring of Rio Grande silvery minnow 60

LIST OF FIGURES (APPENDICES)

Figure B-1. Site occupancy model estimates (site occupancy (ψ) and extinction probabilities (ε)) for Rio Grande silvery minnow based on repeated site sampling efforts from 2005 to 2012 55

EXECUTIVE SUMMARY

Rio Grande silvery minnow estimated densities ($E(x)$), using October sampling-site density data (1993–2012), were highest in 1995 (36.03) and 2005 (44.84) and lowest in 2003 (0.02) and 2012 (0.00). The estimated densities of Rio Grande silvery minnow were significantly lower ($p < 0.05$) in 2010, 2011, or 2012 as compared with 2007, 2008, or 2009. October population monitoring efforts in 2012 yielded no Rio Grande silvery minnow, which was the first and only sampling effort (in any month) that yielded no individuals of this species since the population monitoring study was initiated in February of 1993.

Bivariate relationships among Rio Grande silvery minnow estimates of Delta (δ = probability of absence) and Mu (μ = mean of the lognormal distribution), using October sampling-site density data (1993–2012), revealed general positive or negative associations with several hydraulic variables. Estimates of δ decreased with hydraulic variables indicative of higher flows but increased with variables indicative of lower flows. Estimates of μ exhibited the opposite relationships with hydraulic variables (i.e., positive relationships with higher-flow hydraulic variables but negative relationships with lower-flow hydraulic variables).

General 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 hydraulic variables (allowing for random effects) over the period of study (1993–2012). The top model (δ(Year) μ(ABQ>3,000+random)) received about 34% of the AIC_C weight and had a scaled r^2 value of 0.61 ($p < 0.001$). The top two models, which accounted for about 56% of the cumulative w_i, were related to the interaction among μ and hydraulic variables representing spring flows in the Angostura Reach. However, models relating to the interaction among μ and hydraulic variables representing flows during irrigation season in the San Acacia Reach also received modest values of w_i. Models relating to the interactions among δ and hydraulic variables received much lower values of w_i but the top model represented mean flows during irrigation season in the San Acacia Reach.

Rio Grande silvery minnow mesohabitat density data during October (2002–2012) revealed that population trends in the different mesohabitats were generally similar over the period of study. The overall estimated densities generated from the mesohabitat density data were significantly lower ($p < 0.05$) in 2010, 2011, or 2012 as compared with 2007, 2008, or 2009, which agreed with the analyses using the sampling-site density data. Also, there were no significant differences in estimated densities between individual sampling years when comparing results generated from the mesohabitat or sampling-site density data. However, the estimated densities of Rio Grande silvery minnow had narrower 95% confidence intervals when calculated using mesohabitat density data as compared with sampling-site density data, except in 2003 when only two individuals were collected.

The native ichthyofauna consisted of eleven species (gizzard shad, red shiner, Rio Grande silvery minnow, fathead minnow, flathead chub, longnose dace, river carpsucker, smallmouth buffalo, blue catfish, flathead catfish, and bluegill). Red shiner was the most abundant native species collected (n = 31,787), followed by flathead chub (n = 3,240), river carpsucker (n = 1,122), fathead minnow (n = 1,000), and Rio Grande silvery minnow (n = 834). The most abundant introduced species were western mosquitofish (n = 7,360), channel catfish (n = 1,168), white sucker (n = 837), and common carp (n = 415).

While the rank abundance of Rio Grande silvery minnow increased notably from 2003 (10th) to 2007–2009 (2nd), it dropped precipitously in 2010 (5th). In 2012, Rio Grande silvery minnow rank abundance decreased (10th) as compared with 2011 (4th). The coefficient of concordance (W = 0.73) for the ten focal species indicated high overall agreement in ranks (X^2 = 66.1; $p < 0.001$) over time (2003–2012) despite broad changes in ranks for some taxa (e.g., Rio Grande silvery minnow, common carp, fathead minnow, and river carpsucker).

Density of all fish species increased during spring or summer. Rio Grande silvery minnow abundance in samples was highest in December of 2011 and then slowly declined until October

2012. Most species reached their highest densities from June to September, following spawning. The highest densities of red shiner were recorded in September/October although the abundance of this taxon was relatively high throughout the year. An accounting of species-specific temporal abundance revealed similar trends and documented the seasonal occurrence of certain taxa (e.g., gizzard shad).

Besides temporal variation in the relative abundance of fish species within the community, there were also longitudinal changes in the densities of species among reaches. Flathead chub, longnose dace, white sucker, and channel catfish were most common in the Angostura Reach. The most common species in the Isleta Reach included red shiner, fathead minnow, river carpsucker, and western mosquitofish. Common carp and Rio Grande silvery minnow were most common in the San Acacia Reach. Rio Grande silvery minnow was more common in the Isleta and San Acacia reaches as compared to the Angostura Reach.

Values of the coefficient of variation (*CV*) for estimated densities of Rio Grande silvery minnow, using sampling-site density data (1993–2012), ranged from 0.27 (2009) to 0.81 (1994) with a median of 0.49. Calculated values of *CV*, using the mesohabitat density data (2002–2012), ranged from 0.12 (2008) to 0.73 (2003) with a median of 0.18. Similarly, median *CV* values (based on repeated sampling during November 2005–2012) ranged from 0.11 (2008) to 0.58 (2012) and only exceeded 0.21 during 2012. It appears that current sampling protocols are resulting in a reasonable level of sampling precision (with the exception of years with very low densities), especially when considering the typically substantial changes in Rio Grande silvery minnow abundance among years.

Estimates of the probability of extinction in 2011 for all age-classes (0.0634) and age-0 (0.1913) individuals were elevated, particularly when considering their upper 95% confidence intervals (0.6568 and 0.8428, respectively). The probability of extinction in 2011 was higher for both age-1 and age-2 individuals (0.4693 and 0.3065, respectively) as compared to age-0 individuals. Estimates of site occupancy indicated about a 3% per year decline in the number of sampling units occupied by Rio Grande silvery minnow since 2005 (ca. 23% decline).

The dramatic increases and decreases in the abundance of Rio Grande silvery minnow over the past two decades appear to be closely related to the timing, magnitude, and duration of flows during spring and summer. The physical conditions produced by prolonged and elevated flows result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline and island backwaters. These conditions, combined with the delayed onset of low flows following spring runoff, appear to help ensure the successful recruitment of Rio Grande silvery minnow by prolonging the persistence of warm and productive nursery habitats required by larval fishes to complete their early life history. However, the extensive river channelization, habitat degradation, abandonment of the floodplain, and associated reductions in water turbidity downstream of Cochiti Dam are limiting the amount of appropriate habitat available for the successful retention and early recruitment of Rio Grande silvery minnow, especially in the Cochiti and Angostura reaches.

The extremely low densities of Rio Grande silvery minnow in 2012 appear to indicate that current management efforts (e.g., stocking, salvage, habitat restoration, flow manipulation etc.) are not sufficiently buffering the population against substantial declines. While the suite of ongoing management efforts appears to be providing some degree of protection against extinction, it appears that additional efforts/activities will be required to yield robust populations of Rio Grande silvery minnow in the Middle Rio Grande over time. Additionally, securing the long-term persistence of Rio Grande silvery minnow in the wild will likely depend on attaining self-sustaining populations at multiple locations within its current and historical range. Future study of the ecological interactions among fish species and their environment in the Rio Grande Basin should further elucidate the factors that control this complex aquatic ecosystem, which will be essential in providing the information required to develop and implement successful management strategies for the long-term recovery of Rio Grande silvery minnow.

INTRODUCTION

Population 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 since 1987. The first studies were conducted by Platania (1993a) from 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 preliminary 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 in its already reduced range. The 90–95% reduction in the range of Rio Grande silvery minnow and threats to its continued persistence in the Middle Rio Grande were central to this species being listed as endangered by the U.S. Fish and Wildlife Service (U.S. Department of Interior, 1994).

From 1992 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 (initiated in 1993). Population monitoring efforts have documented wide fluctuations (i.e., order of magnitude increases and decreases) in the abundance 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 has generally increased following years with extended high spring flows and minimal summer low-flow/drying conditions (Dudley et al., 2009; Dudley and Platania, 2012a). While Rio Grande silvery minnow was the focus of monitoring efforts and subsequent hypothesis testing, research activities also provided information about the associated Middle Rio Grande fish community.

The primary objective of the December 2011 to October 2012 sampling activities was to monitor temporal trends in the abundance of Rio Grande silvery minnow at 20 standardized sites throughout the Middle Rio Grande. Additional objectives included evaluating the influence of discharge patterns on population fluctuations, determining general habitat use patterns, documenting changes in relative abundance among fish species over time, and determining variation in density estimates based on repeated sampling. Seasonal and spatial differences in the population structure and abundance of native and nonnative Middle Rio Grande fishes were also examined. This study should aid natural resource managers in obtaining a more thorough understanding of the factors that influence the conservation status and population dynamics of Rio Grande silvery minnow, both of which are important components for the 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 agricultural users and 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. Precipitation in the region is low, averaging < 25 cm/year (Gold and Denis, 1985).

Several large dams on the Rio Chama and Rio Grande and 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. The construction and operation of Cochiti Dam has contributed to floodplain abandonment along with the progressive degradation, armoring, and narrowing of the river channel, particularly in areas up to about 100 km downstream of the dam (Lagasse, 1980; Massong et al., 2006).

The study area (Figure 1) is a portion of the Middle Rio Grande, from Angostura Diversion Dam to the inflow of Elephant Butte Reservoir, that 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. Access is currently restricted or unreliable in the Cochiti Reach, precluding long-term fish monitoring in this area. The last comprehensive ichthyofaunal surveys of the Rio Grande in the Cochiti Reach documented the presence, at low abundance, of Rio Grande silvery minnow on Santo Domingo and San Felipe pueblos (Platania, 1995). Rio Grande silvery minnow was not found within the boundaries of Cochiti Pueblo during similar surveys (Platania, 1993b).

Sampling localities were located from Angostura Diversion Dam to just upstream of Elephant Butte Reservoir. Most of the sampling localities were selected from a list of nearly 100 Middle Rio Grande sites, which were sampled from 1987 to 1992 (Platania, 1993a); these localities 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 adequate instream habitat. While most sites have been consistently monitored over time, several localities were added (e.g., to increase the spatial coverage within and among reaches) or removed (e.g., loss of consistent land access), primarily during the first decade of the study.

Reach names were derived from the diversion structure at the upper portion of the reach. The Angostura Reach (Angostura Diversion Dam to Isleta Diversion Dam) had five sampling sites and the Isleta Reach (Isleta Diversion Dam to San Acacia Diversion Dam) had six sampling sites. There were nine sampling sites in the San Acacia Reach (San Acacia Diversion Dam to inflow of Elephant Butte Reservoir). The 20 sampling sites in the Middle Rio Grande (Appendix A, Table A-1) overlap the current documented range of Rio Grande silvery minnow.

Diel and seasonal discharge varied greatly during 2011 and 2012, especially in southern reaches of the Middle Rio Grande (Figure 2). There was a general trend of lower flow at downstream locations (e.g., U.S. Geological Survey (USGS) San Acacia Gauge [#08354900] and USGS San Marcial Gauge [#08358400]) compared to upstream locations (e.g., USGS Albuquerque Gauge [#08330000]). Mean annual discharge in the southern reaches was relatively low in 2011 and 2012. During May 2012 and June 2012, flows were particularly low in the San Acacia Reach. Peak flows in 2012 occurred during April. Flow conditions in 2011 and 2012 included periodic intervals of very low discharge from July through October. However, summer rains periodically resulted in elevated flow events during 2011 and 2012. As compared with the generalized historical spring runoff (based on mean daily discharge values from 1973 [Cochiti Dam operational] to 2011), the timing of this event was late in 2011 and early in 2012, the flow magnitude was low in both 2011 and 2012, and the duration was truncated in both years. Also, summer flows in both 2011 and 2012 were relatively low over an extended period as compared with historical flows.

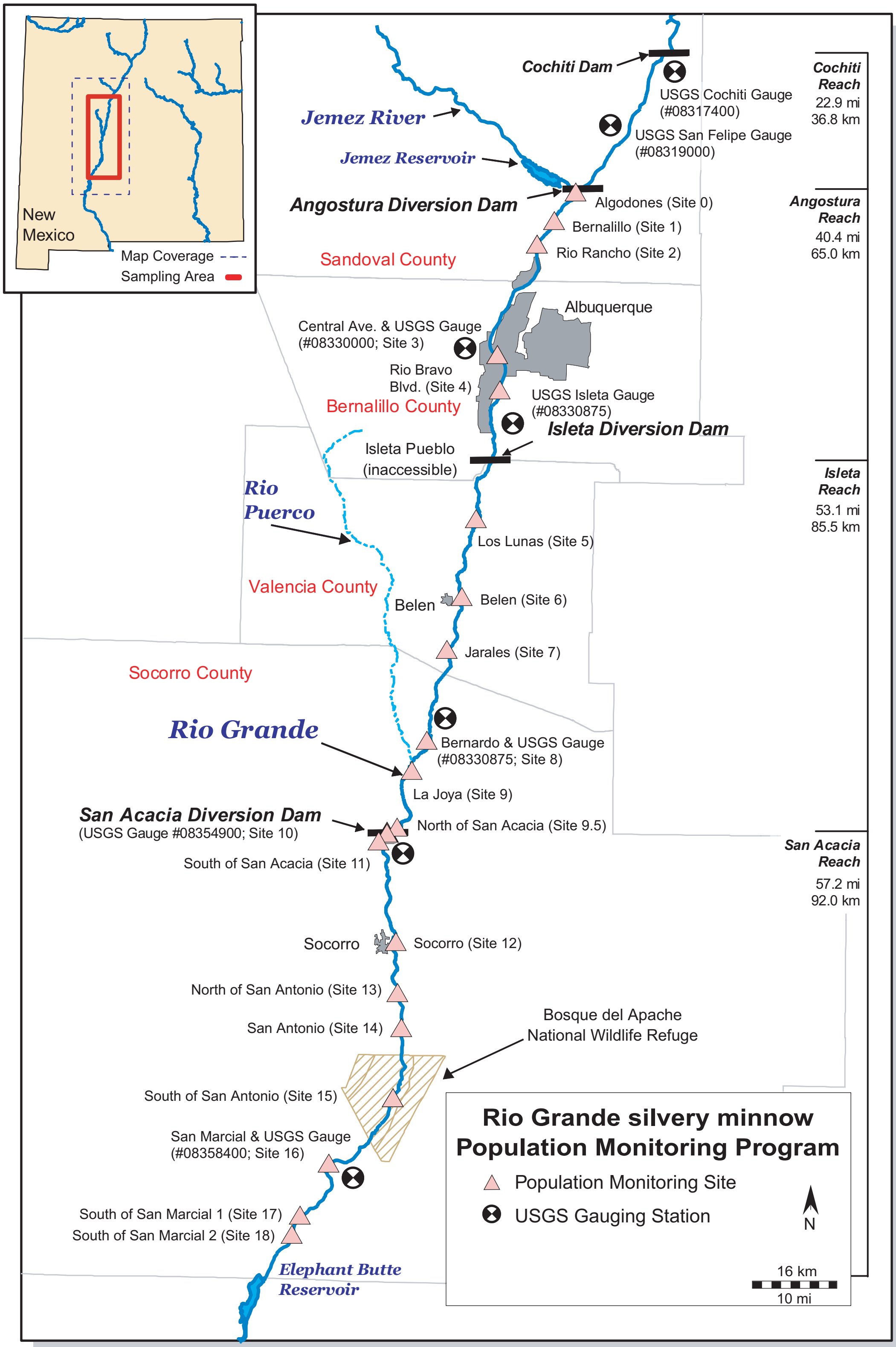


Figure 1. Map of the study area and sampling sites (numbered) for the December 2011 to October 2012 Rio Grande silvery minnow population monitoring program. Sampling site information is provided in Appendix A (Table A-1).

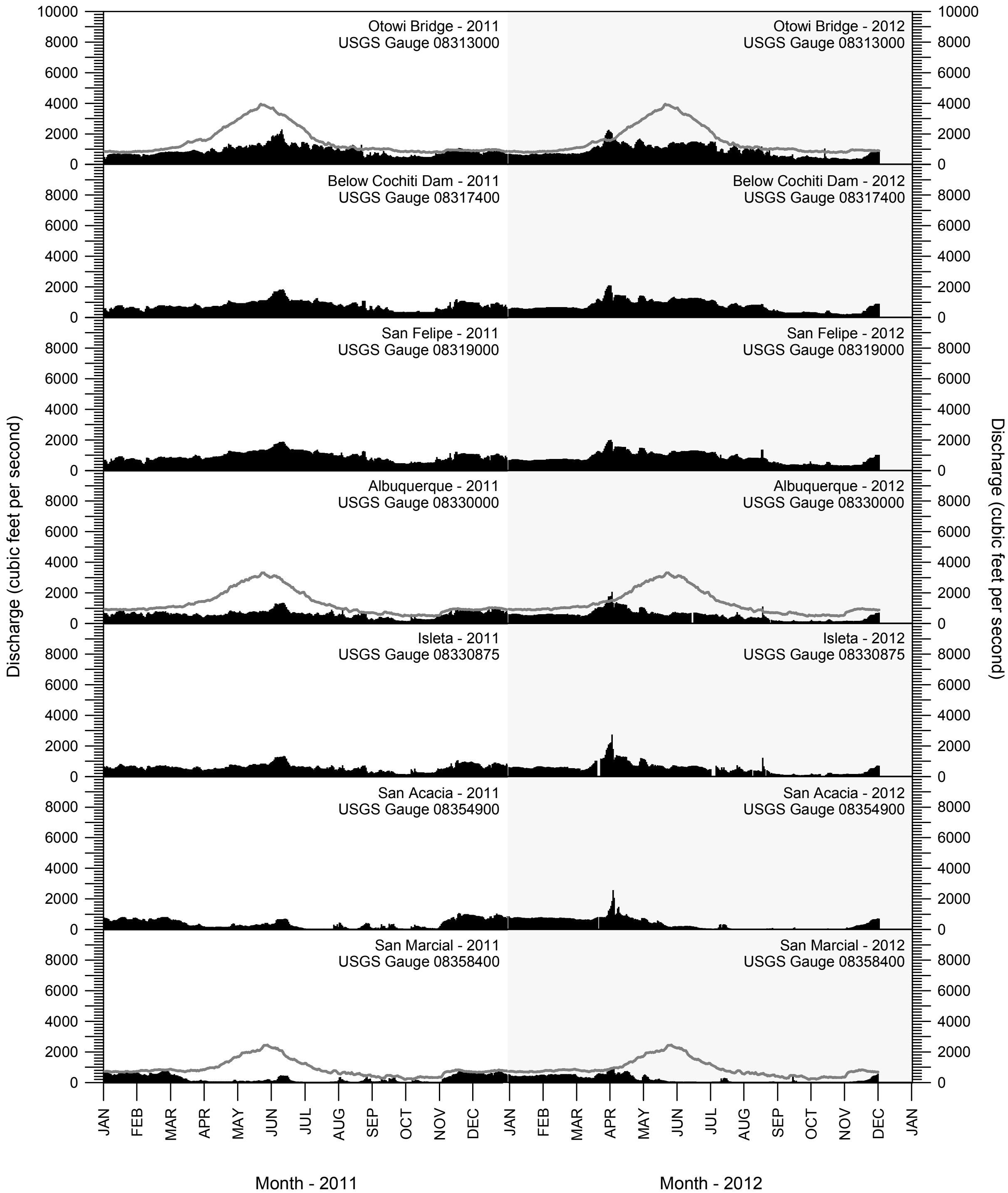


Figure 2. Discharge in the Rio Grande from January 2011 through November 2012 as recorded at seven U.S. Geological Survey (USGS) gauge stations. Solid gray lines are historical mean daily discharge values (from 1973 [Cochiti Dam operational] through 2011) from the upper, middle, and lower portions of the study area. Discharge data are provisional and subject to change.

METHODS

This investigation was structured to monitor the population of Rio Grande silvery minnow and the associated fish community in the study area over time. Monthly sampling efforts at 20 sites allowed for determination of general spatial and temporal changes in population structure and species abundance. Sampling was conducted in December 2011, February 2012, and monthly from April 2012 to October 2012. Additional intensive sampling was conducted during November (2012) to generate estimates of site occupancy rates (Appendix B) and to characterize sampling variation. For the intensive sampling effort, sites were sampled once per day for four days (i.e., 80 site samples), using regular population monitoring sampling protocols. Mesohabitat samples were taken at the same or similar locations on subsequent days.

Fish were collected by rapidly drawing a two-person 3.1 m x 1.8 m small mesh (ca. 5 mm) seine through 18 (April to October) to 20 (December and February) discrete mesohabitats (< 15 m long). Runs, pools, and shoreline pools were sampled four times at each site (when available); backwaters and riffles were sampled two times (when available); any remaining samples (to obtain a total of 18 to 20) were taken in shoreline runs. From April to October, a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine was used to selectively sample shallow low velocity mesohabitats for larval fish (two samples). Mesohabitats with similar conditions, which did not exceed reasonable depths/velocities for efficient seining, were sampled regardless of flow conditions. Density or catch-per-unit-effort (CPUE) was estimated for each species and each sample as the number of individuals collected per 100 m^2 (surface area) of water sampled (i.e., fish per 100 m^2). Effort was calculated by multiplying the seine width during sampling (regular = 2.5 m, larval = 0.25 m) by the length of the seine haul. Samples obtained from isolated pools were not included in data analyses as densities in these confined mesohabitats were artificially elevated. Prior to release, all Rio Grande silvery minnow collected were examined for Visible Implant Elastomer (VIE) tags (i.e., stocked fish), measured (standard length range), and identified to age-class (based on reach-specific standard length and age-length relationships during the same time of year [Dudley et al., 2009; Horwitz et al., 2011]). Selected water quality parameters (Secchi depth, temperature, salinity, dissolved oxygen, true conductivity, specific conductance, and pH) were obtained (see Appendix C) as well as digital photographs of physical river conditions. Scientific names and common names (phylogenetic order) of fishes in this report follow Nelson et al. (2004; Table 1).

Mixture models (e.g., combining a binomial distribution with a lognormal distribution) have been shown to be 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 (1993–2012) were analyzed using PROC NLMIXED (SAS, 2013), a numerical optimization procedure, by fitting a mixture model consisting of the binomial and lognormal distributions using the methods outlined in White (1978). Logistic regression was used to model the probability a site was occupied, and the lognormal model was used to model the distribution of abundance given that the site was occupied. Models provided estimates of Delta (δ = probability of absence, i.e., a zero value when present at all sampling sites), Mu (μ = mean of the lognormal distribution), Sigma (σ = standard deviation of the lognormal distribution), and $E(x)$ (estimated density of Rio Grande silvery minnow). General linear models were used to incorporate covariates to model δ, μ, and σ.

Covariates considered to model October sampling-site density data were various hydraulic variables (e.g., peak discharge and days > or < a threshold discharge value). Maximum discharge and days exceeding threshold discharge values in 1,000 cfs increments (days > 1,000, 2,000, 3,000, and 4,000 cubic feet per second, cfs) represented the typical range of spring runoff conditions (May–June). The onset of lower flows (i.e., first day with discharge < 200 cfs after 1 June), mean daily discharge, and lower threshold discharge values (days < 200 and < 100 cfs)

Table 1. Scientific and common names and species codes of fish collected in the Middle Rio Grande from 1993 to 2012.

Scientific Name	Common Name	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)
Order Salmoniformes		
Family Salmonidae	trouts and salmons	
Oncorhynchus mykiss	rainbow trout	(ONCMYK)
Salmo trutta	brown trout	(SALTRU)

Table 1. Scientific and common names and species codes of fish collected in the Middle Rio Grande from 1993 to 2012 (continued).

Scientific Name	Common Name	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)
Order Perciformes		
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(LEPCYA)
Lepomis macrochirus	bluegill	(LEPMAC)
Lepomis megalotis	longear sunfish	(LEPMEG)
Micropterus dolomieu	smallmouth bass	(MICDOL)
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)

[1] Focal taxa represent the ten most commonly abundant species present in Middle Rio Grande samples; these species are illustrated in monthly plots of data.

represented some general characteristics of low flow conditions during irrigation season (March–October). Covariate models included both fixed effects models (i.e., the covariate is assumed to explain all the variation in density with only an additive sampling error included in the model) and random effects models (i.e., a normally distributed random error with mean zero and non-zero standard deviation is used to explain deviations around the fitted covariate). The Gauss-Hermite numerical integration was used to integrate out sampling-site random effects in 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 models among 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 all models with an AIC_C weight (w_i) > 0.1% were presented. A scaled r^2 value was calculated based on methods outlined in Nagelkerke (1991). Differences among null and alternative models were assessed using a log-likelihood ratio goodness-of-fit test (Zar, 2010).

Rio Grande silvery minnow detailed density data during October (i.e., using mesohabitat-specific sampling data within a site), have been available since 2002. These data provide information on the general mesohabitat preferences of Rio Grande silvery minnow but also allow for a more detailed (i.e., mesohabitat-specific) examination of recent population trends (2002–2012). Rio Grande silvery minnow mesohabitat density data during October (2002–2012) were also analyzed using PROC NLMIXED (SAS, 2013), using the same methods outlined previously, to generate density estimates ($E(x)$) for specific mesohabitats and for all sites combined. A simplified list of mesohabitats (i.e., combining main and side channel samples, coding debris piles as pools, and coding riffles as runs) was used for the purpose of statistical analyses. General linear models were used to incorporate covariates to model δ, μ, and σ. Covariates considered to model detailed density data during October were mesohabitat and sampling site. 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 (lower values indicate better fit) to various models among all sampling years.

Kendall's *W* (Zar, 2010) was used to test for the degree of concordance among the annual rank abundance of 10 focal species (including Rio Grande silvery minnow) over time. This nonparametric statistical procedure was used to generate the *W* statistic, which ranges from zero (no concordance) to one (complete concordance). A Chi-Square statistic was calculated to evaluate whether the degree of concordance was significantly different ($p < 0.05$) from zero.

Sampling variation was evaluated using estimated densities and coefficient of variation values generated from multi-day sampling efforts at each of the 20 sites during November (2005–2012). Estimate densities ($E(x)$) for each daily sample were generated with PROC NLMIXED (SAS, 2013), using the same methods outlined previously. The coefficient of variation (*CV* = ratio of the standard error to the mean) was calculated based on estimated densities of Rio Grande silvery minnow during the repeated sampling effort (2005–2012). Values of *CV* were also calculated for estimated densities of Rio Grande silvery minnow over time, using both the sampling-site density data (1993–2012) and mesohabitat density data (2002–2012).

RESULTS

Rio Grande Silvery Minnow

Population status

The December 2011 to October 2012 abundance of Rio Grande silvery minnow at reach-specific sampling sites varied within and among seasons. Density of this species also varied noticeably within and among sampling reaches (Figures 3 and 4). Post-spawning densities (June–October) were exceptionally low in all three sampling reaches.

In December 2011, sampling covered 9,666.5 m^2 and Rio Grande silvery minnow (n = 395) composed 14.0% of the total catch. This species was present in 108 of the 215 seine hauls that yielded any fish. Rio Grande silvery minnow was present at 15 of 20 localities and was most abundant in the San Acacia Reach and portions of the Isleta reaches.

February 2012 population monitoring efforts (10,741.8 m^2) yielded a modest number of Rio Grande silvery minnow (n = 201). This species composed 12.0% of the total catch and was present in 73 of the 180 seine hauls that yielded any fish. Rio Grande silvery minnow was present at all sampling localities in the San Acacia Reach but at none of the localities in the Angostura Reach.

The April 2012 sampling efforts covered 8,650.9 m^2. Rio Grande silvery minnow (n = 64) was relatively rare, composing 2.5% of the total catch. This species was present in 41 of the 245 seine hauls that yielded any fish. Rio Grande silvery minnow was present in samples at 12 of 20 sampling localities and was most abundant in the San Acacia Reach.

During May 2012, Rio Grande silvery minnow (n = 108) was infrequently captured in the 9,901.3 m^2 of water sampled. This species composed 1.9% of the total fish catch. Rio Grande silvery minnow was present in 31 of the 286 seine hauls that yielded any fish. Rio Grande silvery minnow was present at 12 of 20 localities. The May cumulative catch of Rio Grande silvery minnow was composed mostly of individuals from the San Acacia Reach with lesser numbers in the Isleta and Angostura reaches.

Monitoring of Rio Grande silvery minnow during June 2012 yielded 24 individuals in 9,459.2 m^2 of aquatic habitat sampled. Rio Grande silvery minnow composed 0.5% of the total catch. This species was present in 17 of the 269 seine hauls that yielded any fish. This species was collected at 9 of the 20 sampling sites. During June, Rio Grande silvery minnow was most abundant in the San Acacia Reach.

Rio Grande silvery minnow was relatively rare in July 2012 (n = 24; 9,116.0 m^2) and composed 0.3% of the total catch. Rio Grande silvery minnow was present in 15 of the 318 seine hauls that yielded any fish. Rio Grande silvery minnow was collected at 10 of 20 sampling sites. The highest densities of this species were recorded in the San Acacia Reach.

The August 2012 sampling effort produced a low number of Rio Grande silvery minnow (n = 13; 7,416.7 m^2). Rio Grande silvery minnow composed 0.3% of the total catch and was present in 10 of the 264 seine hauls that yielded any fish. Individuals were collected at 7 of the 20 sampling sites. The August cumulative catch of Rio Grande silvery minnow was composed mostly of individuals from the Angostura Reach.

Lower numbers of Rio Grande silvery minnow (n = 5) were collected during September 2012, as compared to August, in the 7,610.4 m^2 (surface area) of water sampled. Rio Grande silvery minnow composed 0.1% of the total catch. Rio Grande silvery minnow was present in 4 of the 289 seine hauls that yielded any fish species. Individuals were collected at 3 of the 20 sampling sites. Rio Grande silvery minnow was only collected in the Angostura Reach during September.

No Rio Grande silvery minnow were collected at the sampling sites during October 2012 (n = 0; 7,380.0 m^2). This species composed 0.0% of the total catch and was present in 0 of the 259 seine hauls that yielded any fish. Rio Grande silvery minnow was present at 0 of 20 localities. The October 2012 sample was the first and only sampling effort (in any month) that has yielded no Rio Grande silvery minnow since the population monitoring study was initiated in February 1993.

A month-by-month summary of Rio Grande silvery minnow densities provides reference to trends in relative abundance observed from December 2011 to October 2012 (Table 2). Large numbers of Rio Grande silvery minnow (n = 395) were collected in the San Acacia Reach during December 2011 (although most were recently stocked individuals). The overall abundance of this species declined steadily during the early half of 2012. The density of Rio Grande silvery minnow did

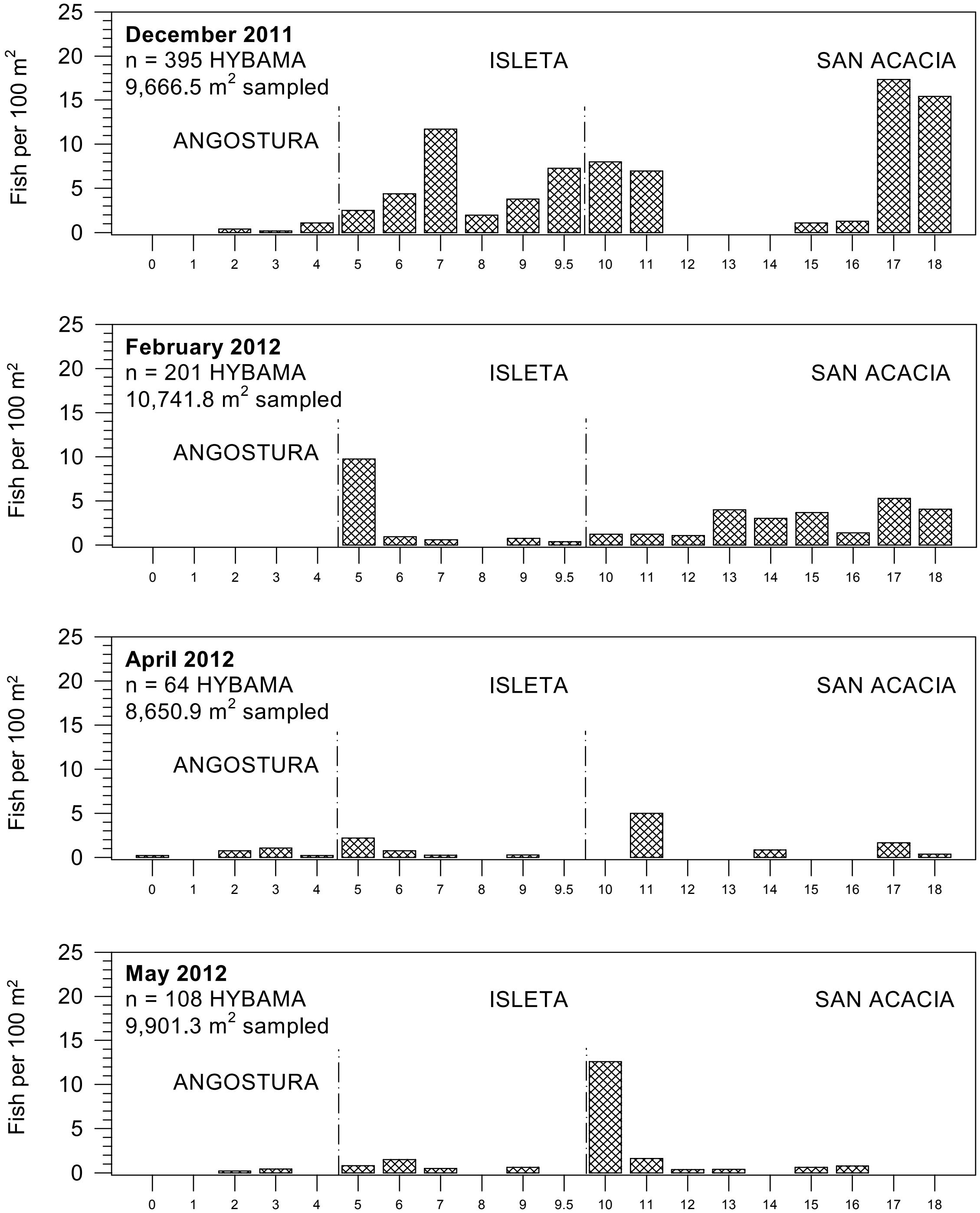


Figure 3. Rio Grande silvery minnow densities from December 2011 to May 2012 for each sampling site in the Middle Rio Grande.

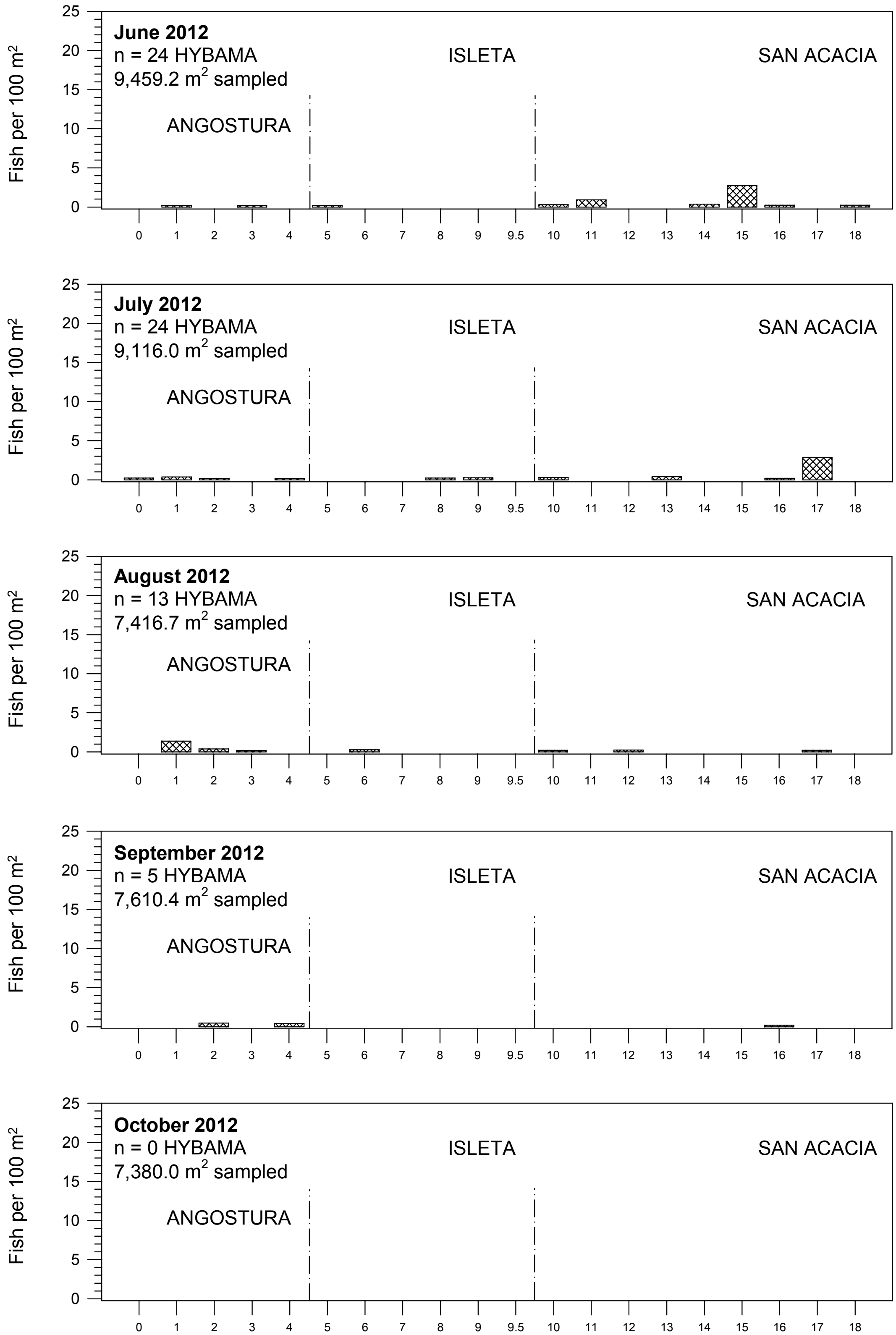


Figure 4. Rio Grande silvery minnow densities from June to October 2012 for each sampling site in the Middle Rio Grande.

Table 2. Summary of the monthly catch of Rio Grande silvery minnow, by site and reach, from December 2011 to October 2012. Numerals in pararentheses are the number of individuals at a sampling site that were marked (subset of the total).

REACH	SITE #	SITE NAME	DEC	FEB	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
Angostura	0	Algodones	-	-	1	-	-	1	-	-	-	2
Angostura	1	Bernalillo	-	-	-	-	1	2	6	-	-	9
Angostura	2	Rio Rancho	2	-	3	1	-	1	2	2	-	11
Angostura	3	Central Ave.	1	-	5	2	1	-	1	-	-	10
Angostura	4	Rio Bravo Blvd.	5	-	1	-	-	1	-	2	-	9
Angostura Totals			8	0	10	3	2	5	9	4	0	41
Isleta	5	Los Lunas	13	50	11	4	1	-	-	-	-	79
Isleta	6	Belen	19	5	3	7(1)	-	-	1	-	-	35
Isleta	7	Jarales	46	3	1	2	-	-	-	-	-	52
Isleta	8	Bernardo	9(2)	-	-	-	-	1	-	-	-	10
Isleta	9	La Joya	16(11)	4(4)	1	3(2)	-	1	-	-	-	25
Isleta	9.5	North of San Acacia	38(34)	2(2)	-	-	-	-	-	-	-	40
Isleta Totals			141	64	16	16	1	2	1	0	0	241
San Acacia	10	San Acacia Dam	35(35)	7(7)	-	71(59)	1(1)	1	1(1)	-	-	116
San Acacia	11	South of San Acacia	36(36)	7(7)	26(16)	8(7)	4(1)	-	-	-	-	81
San Acacia	12	Socorro	-	6(5)	-	2	-	-	1	-	-	9
San Acacia	13	North of San Antonio	-	23(23)	-	2(2)	-	2	-	-	-	27
San Acacia	14	San Antonio	-	18(18)	3(2)	-	2(1)	-	-	-	-	23
San Acacia	15	South of San Antonio	5(5)	20(19)	-	3(2)	12(9)	-	-	-	-	40
San Acacia	16	San Marcial	6	7	-	3	1	1	-	1	-	19
San Acacia	17	South of San Marcial 1	91	29(2)	7(2)	-	-	13	1	-	-	141
San Acacia	18	South of San Marcial 2	73(53)	20(2)	2(1)	-	1	-	-	-	-	96
San Acacia Totals			246	137	38	89	21	17	3	1	0	552
MONTHLY TOTALS			395	201	64	108	24	24	13	5	0	834

not increase following spring spawning and the abundance of this species dropped rapidly from July to October 2012.

Densities of Rio Grande silvery minnow from December 2011 to October 2012 were generally highest in the Isleta and San Acacia reaches. The San Acacia Reach yielded the most individuals (n = 552) (Figure 5), followed by the Isleta Reach (n = 241), and Angostura Reach (n = 41). The abundance of Rio Grande silvery minnow was relatively higher in the San Acacia Reach by May but never seemed to peak in the upstream reaches. Age-0 individuals composed a modest proportion of the catch from June through September (Figure 6).

Population trends (1993–2012)

Rio Grande silvery minnow estimated densities ($E(x)$), using October sampling-site density data (1993–2012), were highest in 1995 (36.03) and 2005 (44.84) and lowest in 2003 (0.02) and 2012 (0.00). The estimated densities of Rio Grande silvery minnow were significantly lower ($p < 0.05$) in 2010, 2011, or 2012 as compared with 2007, 2008, or 2009 (Figure 7). Values of the coefficient of variation (*CV*) ranged from 0.27 (2009) to 0.81 (1994) with a median of 0.49. October population monitoring efforts in 2012 yielded no Rio Grande silvery minnow, which was the first and only sampling effort (in any month) that yielded no individuals of this species since the population monitoring study was initiated in February of 1993.

Hydraulic variables that represented different flow conditions were compared at upstream (USGS Gauge #08330000; Rio Grande at Albuquerque, NM) and downstream (USGS Gauge #08358400; Rio Grande Floodway at San Marcial, NM) localities in the Middle Rio Grande. Extended periods of higher flows were generally recorded in certain years (e.g., 1993–1995, 1997, 1999, 2004–2005, and 2007–2009). These years had notably different hydrological patterns as compared with lower flow years (e.g., 1996, 2000–2003, 2006, and 2010–2012). For example, there were more high flow days at upstream sampling sites during high flow years. Conversely, there were more low flow days at downstream sampling sites during low flow years.

Bivariate relationships among Rio Grande silvery minnow estimates of Delta (δ) and Mu (μ), using October sampling-site density data (1993–2012), revealed general positive or negative associations with several hydraulic variables. Estimates of δ generally decreased with maximum discharge and all combinations of number of days with discharge (as measured at USGS Gauge #08330000) exceeding a threshold value (Figure 8). Similarly, estimates of δ also decreased with delayed onset of low flows and increased mean daily discharge (as measured at USGS Gauge #08358400). However, there were generally positive relationships among estimates of δ and number of days with discharge below a certain threshold value (i.e., < 200 cfs and < 100 cfs; as measured at USGS Gauge #08358400). In contrast, estimates of μ (Figure 9) exhibited the opposite relationships with hydraulic variables (i.e., positive relationships with variables representing higher flows but negative relationships with variables representing lower flows).

General linear models of Rio Grande silvery minnow mixture-model estimates (Delta (δ) and Mu (μ)) revealed that variation in μ, as compared with variation in δ, was more reliably predicted by changes in hydraulic variables (allowing for random effects) over the period of study (1993–2012). The top model (δ(Year) μ(ABQ>3,000+random)) received about 34% of the AIC_C weight (w_i) and had a scaled r^2 value of 0.61 ($p < 0.001$; Table 3). The top two models, which accounted for about 56% of the cumulative w_i, were related to the interaction among μ and hydraulic variables representing spring flows in the Angostura Reach (i.e., ABQ>3,000 and ABQ>2,000). However, two models relating to the interaction among μ and hydraulic variables representing flows during irrigation season in the San Acacia Reach (i.e., SANmean and SAN<200) also received modest values of w_i (ca. 25% cumulatively). Models relating to the interactions among δ and hydraulic variables received much lower values of w_i but the top model represented mean flows during irrigation season in the San Acacia Reach (i.e., SANmean).

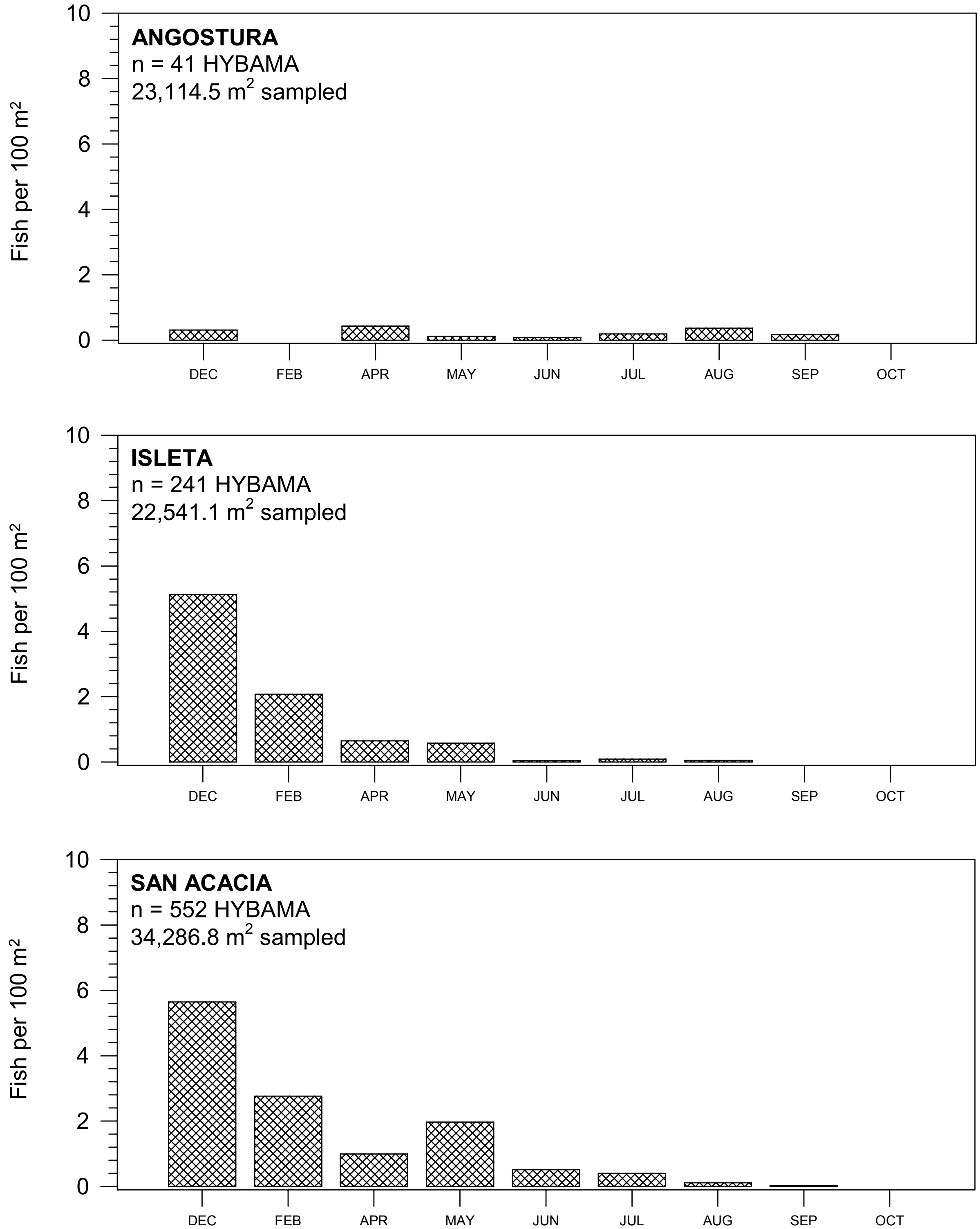


Figure 5. Rio Grande silvery minnow densities by river reach for December 2011 to October 2012 samples in the Middle Rio Grande.

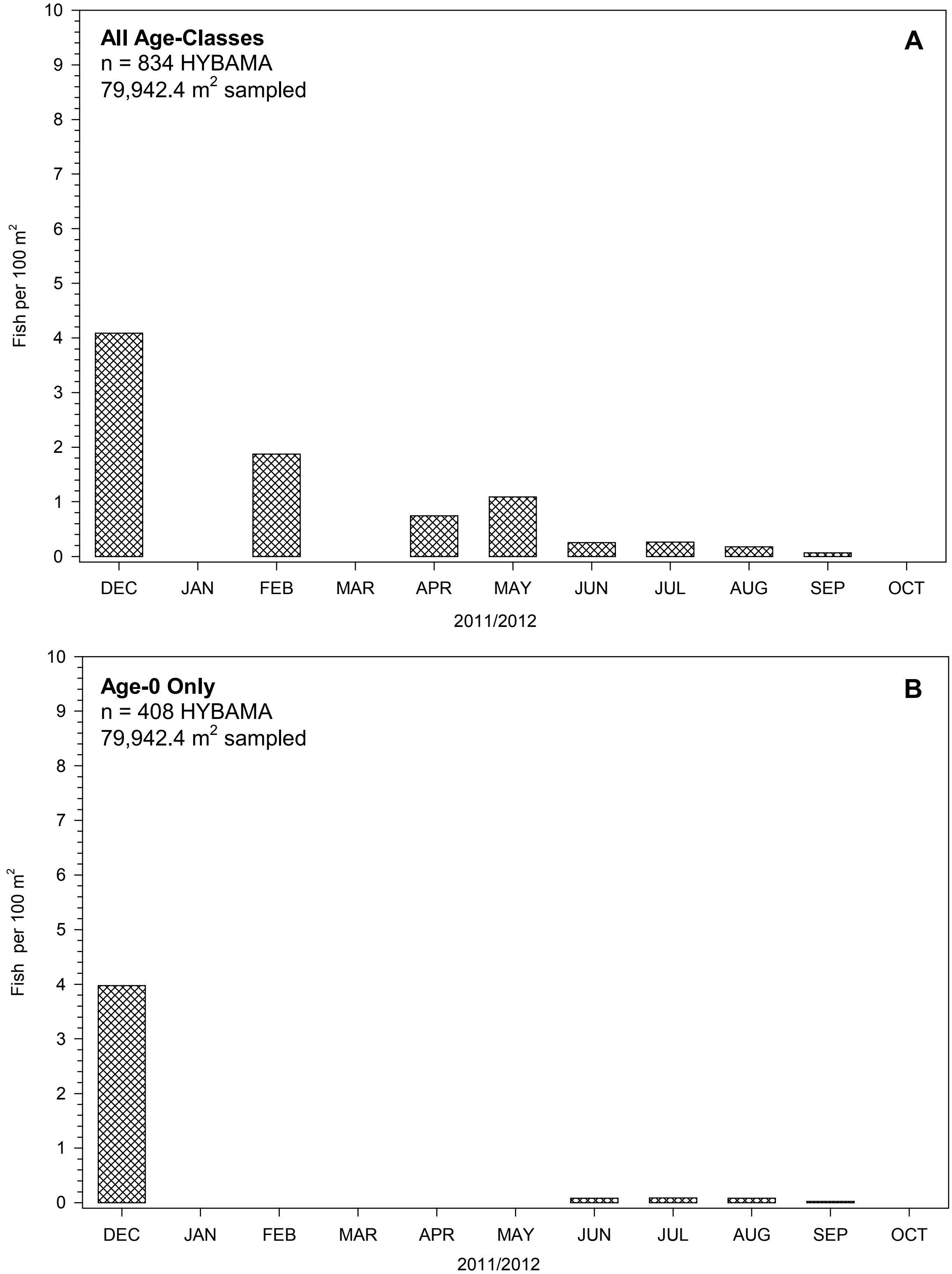


Figure 6. Inter-month fluctuations in densities of Rio Grande silvery minnow from December 2011 to October 2012 (**A** = all age-classes; **B** = age-0 only).

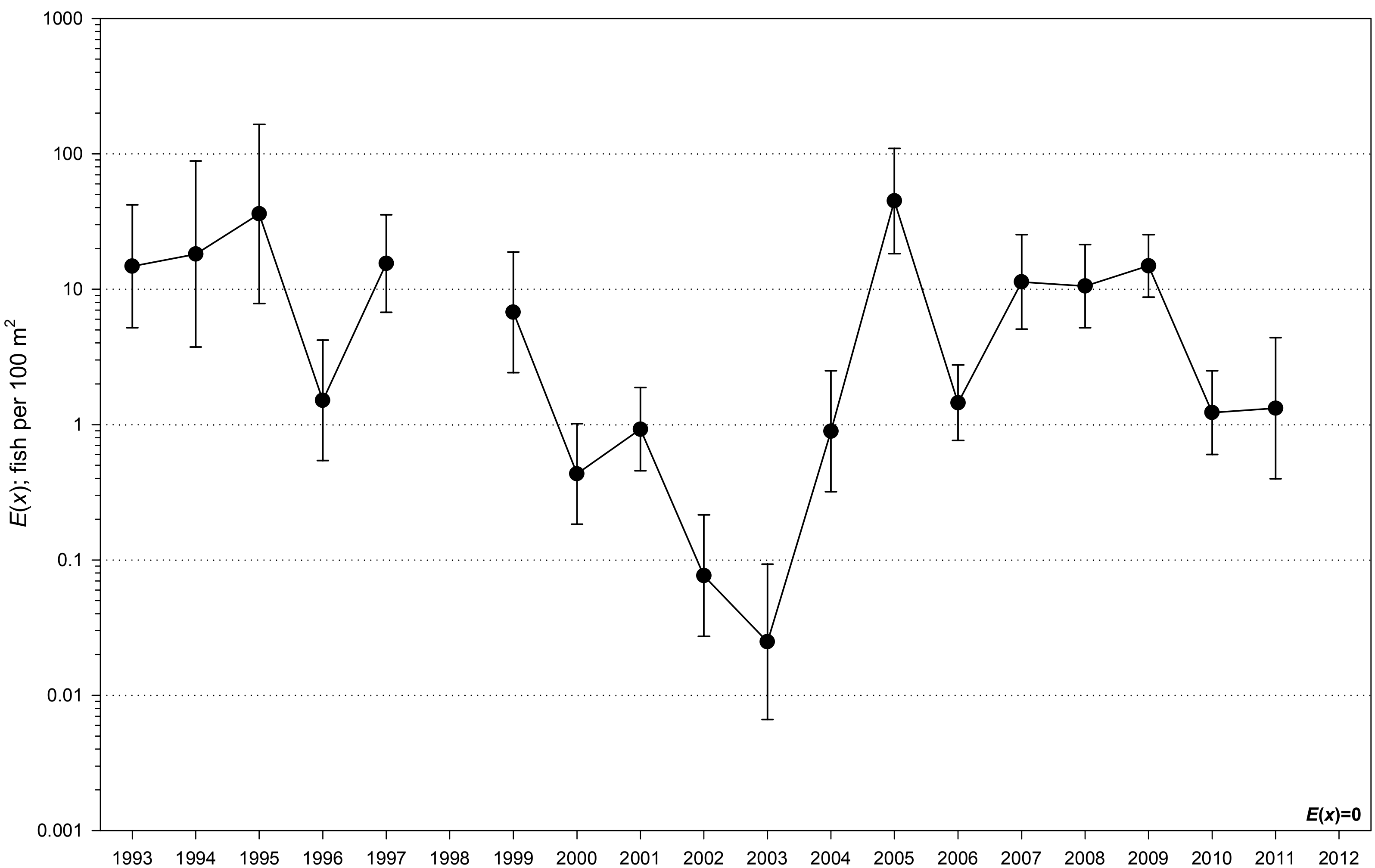


Figure 7. Rio Grande silvery minnow mixture-model estimates ($E(x)$), using October sampling-site density data (1993–2012). Solid circles indicate modeled estimates and bars represent 95% confidence intervals. Dotted horizontal lines represent orders of magnitude.

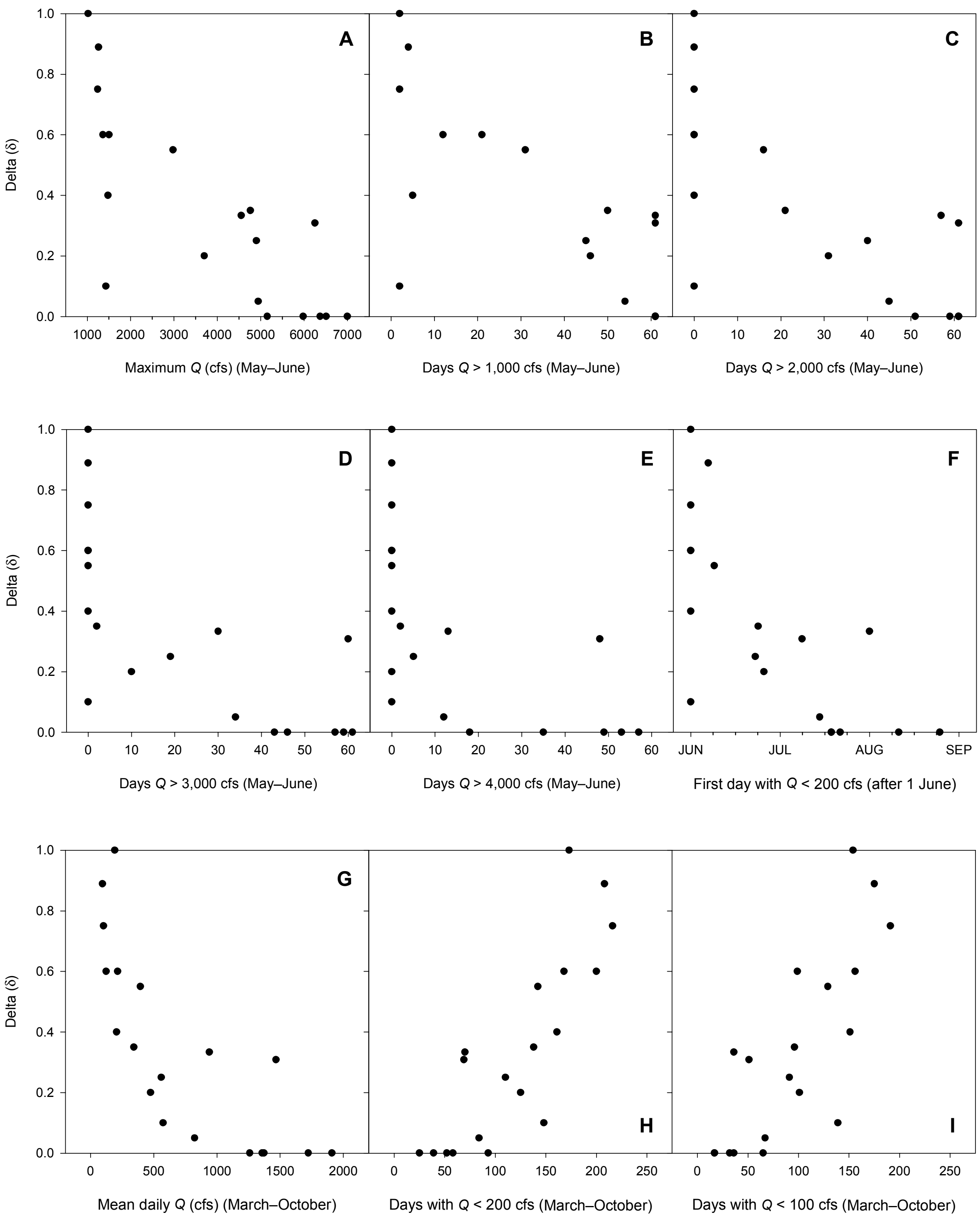


Figure 8 A–I. Bivariate relationships among Rio Grande silvery minnow estimates of Delta (δ), using October sampling-site density data (1993–2012), and hydraulic variables for USGS Gauge #08330000 (Figures A–E) and USGS Gauge #08358400 (Figures F–I).

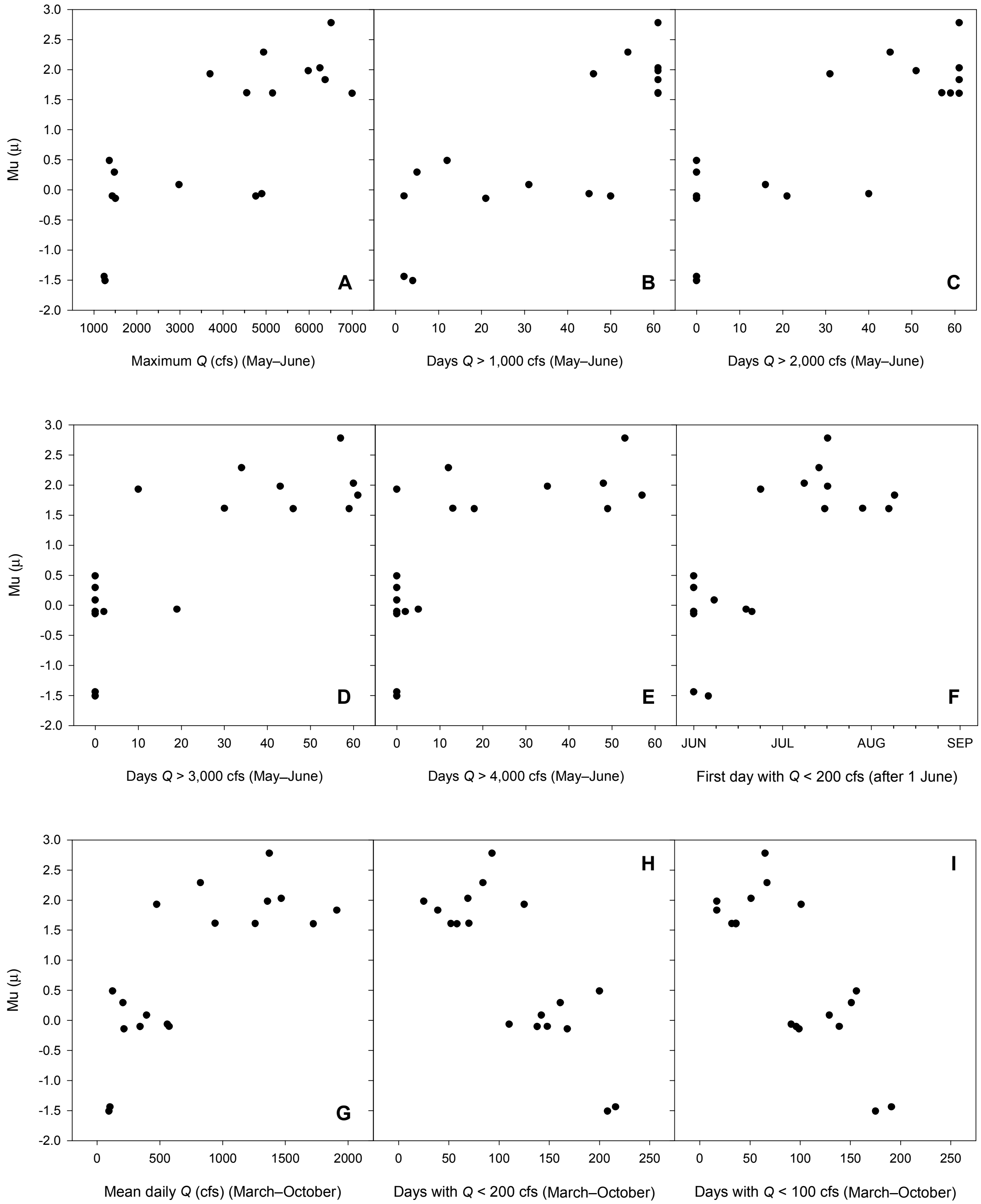


Figure 9 A–I. Bivariate relationships among Rio Grande silvery minnow estimates of Mu (µ), using October sampling-site density data (1993–2012), and hydraulic variables for USGS Gauge #08330000 (Figures A–E) and USGS Gauge #08358400 (Figures F–I).

Table 3. General linear models of Rio Grande silvery minnow mixture-model estimates (Delta (δ) and Mu (μ)), using October sampling-site density data (1993–2012), and hydraulic variables (allowing for random effects). Models are ranked by Akaike's information criterion (AIC_C) and all models with an AIC_C weight (w_i) > 0.1% are presented.

Model[1]	logLike[2]	K[3]	AIC_C	w_i
δ(Year) μ(ABQ>3,000+random)	609.76	25	663.86	0.338
δ(Year) μ(ABQ>2,000+random)	610.60	25	664.70	0.222
δ(Year) μ(SANmean+random)	610.93	25	665.03	0.189
δ(Year) μ(SAN<200+random)	613.34	25	667.44	0.057
δ(Year) μ(ABQ>4,000+random)	613.97	25	668.07	0.041
δ(Year) μ(SAN<100+random)	614.02	25	668.12	0.040
δ(Year) μ(SAN1st day<200+random)	614.32	25	668.42	0.035
δ(Year) μ(ABQ>1,000+random)	614.82	25	668.92	0.027
δ(Year) μ(ABQmax+random)	615.00	25	669.10	0.025
δ(SANmean+random) μ(SANmean+random)	653.52	9	672.06	0.006
δ(Year) μ(ABQ>5,000+random)	618.78	25	672.88	0.004
δ(ABQmax+random) μ(ABQ>2,000+random)	654.54	9	673.08	0.003
δ(ABQmax+random) μ(ABQ>1,000+random)	655.63	9	674.17	0.002
δ(SANmean+random) μ(SAN<200+random)	656.61	9	675.15	0.001
δ(ABQmax+random) μ(ABQ>3,000+random)	656.61	9	675.15	0.001
δ(ABQ>3,000+random) μ(ABQ>3,000+random)	656.69	9	675.24	0.001

[1] = Model variables include year (1993–2012) and various hydraulic variables at USGS Gauges (#08330000 [ABQ; Rio Grande at Albuquerque, NM)] and #08358400 [SAN; Rio Grande Floodway at San Marcial, NM])
[2] = -2[log-likelihood] of the model
[3] = Number of parameters in the model

Mesohabitat associations (2011–2012) and population trends (2002–2012)

Mesohabitats sampled in the Middle Rio Grande were classified during field sampling and given unique codes to identify their hydraulic features (Table 4). The overall distribution of mesohabitats generally did not differ notably among reaches although there were a few exceptions (Figure 10). For example, backwaters were more commonly sampled in the Isleta Reach while riffles were more commonly sampled in the Angostura Reach. The actual mesohabitats occupied by Rio Grande silvery minnow were diverse and included all of the mesohabitat types sampled. Mesohabitats most frequently used by Rio Grande silvery minnow (relative to those sampled) included pools and shoreline runs.

Rio Grande silvery minnow mesohabitat density data during October (2002–2012) were also used to generate density estimates ($E(x)$) for specific mesohabitats and for all sites combined. Population trends in the five different mesohabitats (BW, PO, SHPO, SHRU, and RU) were similar over the period of study (Figure 11). The highest estimated densities were observed in 2005 for all mesohabitats and densities were significantly lower ($p < 0.05$) in 2010, 2011, or 2012 as compared with 2007, 2008, or 2009 in nearly all cases. However, densities in BW and PO mesohabitats were more variable and resulted in fewer significant differences among years as compared with the other mesohabitats (RU, SHPO, and SHRU). Also, densities in BW and PO mesohabitats could not be estimated in 2003 since there was only a single non-zero density value recorded in each of these mesohabitats, which precluded mixture-model estimation of σ.

General linear models of Rio Grande silvery minnow mixture-model estimates (Delta (δ) and Mu (μ)), using October mesohabitat density data (2002–2012), revealed that variation in δ and μ was reliably predicted by differences in mesohabitat but not by sampling site. The top model (δ(Year+Mesohabitat) μ(Year+Mesohabitat)) received 100% of the AIC_C weight (w_i). All models that included sampling site had w_i values of 0. Thus, October mesohabitat density data was determined to be suitable for the calculation of overall Rio Grande silvery minnow estimated densities ($E(x)$) over the period of study (2002–2012), particularly since the sampling site effect was insignificant.

Rio Grande silvery minnow estimated densities ($E(x)$), using October mesohabitat density data (2002–2012), fluctuated widely among sampling years (Figure 12). The highest densities were in 2005 and 2009 while the lowest densities were in 2002–2003 and 2012. The estimated densities of Rio Grande silvery minnow were significantly lower ($p < 0.05$) in 2010, 2011, or 2012 as compared with 2007, 2008, or 2009, which agreed with the analyses using the sampling-site density data. Also, there were no significant differences in estimated densities between individual sampling years when comparing results generated from the mesohabitat or sampling-site density data (e.g., 2009 estimated densities calculated using either data set did not differ significantly). However, the estimated densities of Rio Grande silvery minnow had narrower 95% confidence intervals when calculated using mesohabitat density data as compared with sampling-site density data, except in 2003 when only two individuals were collected. As a result, there were significant differences in estimated densities among some years when using the mesohabitat data that were not significantly different when using the sampling-site data (e.g., estimated density was higher [$p < 0.05$] in 2009 as compared with 2007–2008 when using the mesohabitat data). Values of the coefficient of variation (CV), using mesohabitat density data, ranged from 0.12 (2008) to 0.73 (2003) with a median of 0.18.

Fish Community

Population status

The ichthyofaunal community in the Middle Rio Grande between Angostura Diversion Dam and Elephant Butte Reservoir was numerically dominated by cyprinids (Table 5; Appendix D). The

Table 4. Codes used for mesohabitat type classification in the Middle Rio Grande.

MESOHABITAT TYPES	
Primary	
MC	**Main channel-** the section of the river which carries the majority of the flow; there can be only one main channel.
SC	**Secondary channel-** all channels not designated as the main channel; there can be zero or several secondary channels at a site.
BW	**Backwater-** a body of water, connected to the main channel, with no appreciable flow; often created by a drop in flow which partially isolates a former channel.
DE	**Debris piles-** any habitat that has associated organic cover (e.g., grasses, woody vegetation etc.).
RI	**Riffle-** a shallow and high velocity habitat where the water surface is irregular and broken by waves; generally indicates gravel-cobble substrata.
Secondary	
SH	**Shoreline-** usually a shallower, lower velocity area that is adjacent to shore. This designation precedes other secondary mesohabitat types (e.g., MCSHRU= main channel shoreline run or SCSHPO= side channel shoreline pool).
PO	**Pool-** the portion of the river with very little velocity compared to the rest of the river channel (e.g., downstream of islands, instream sand dunes, debris piles, or shoreline peninsulas).
RU	**Run-** a reach of relatively fast velocity water with laminar flow and a non-turbulent surface.

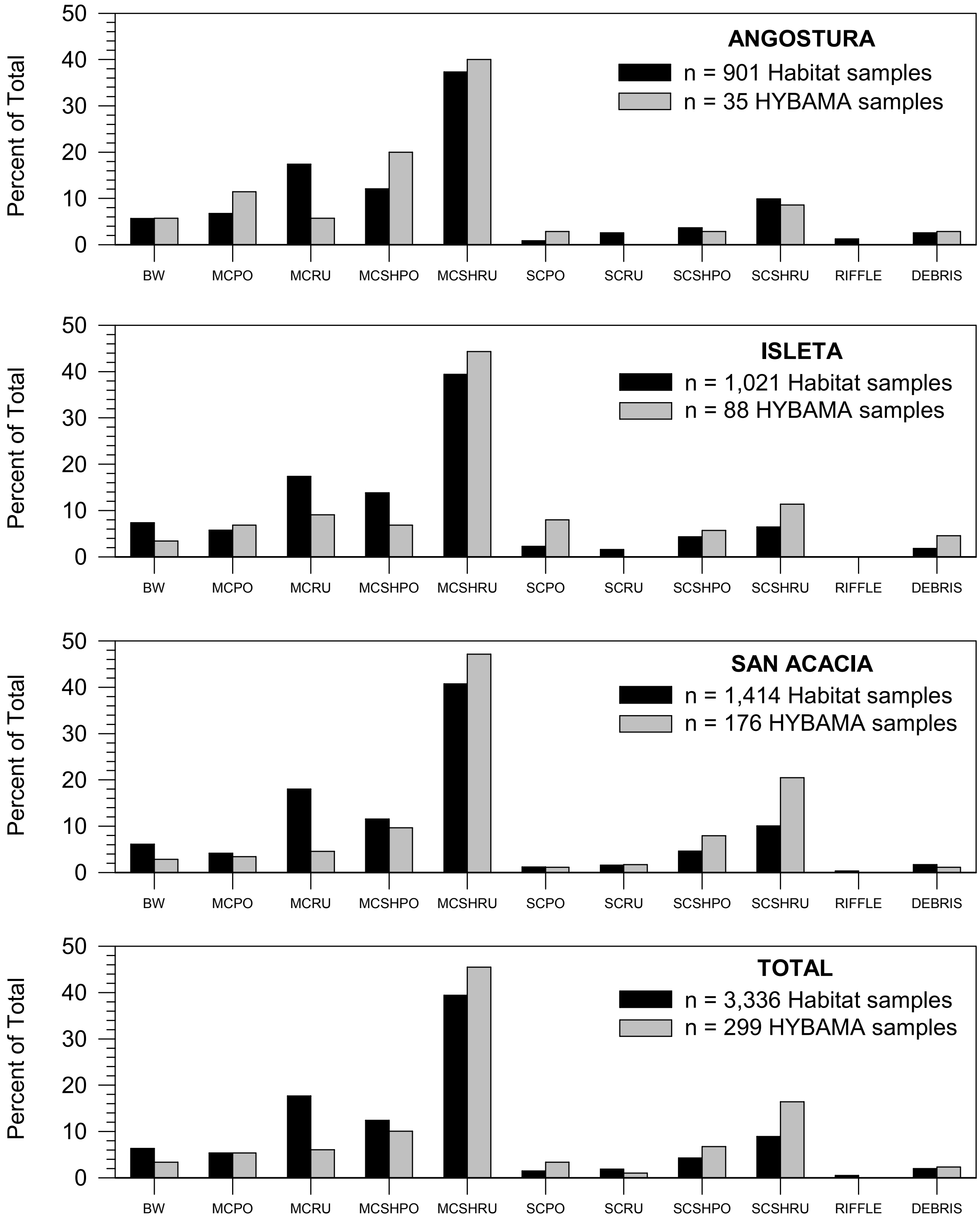


Figure 10. Percent total of mesohabitats (see Table 3 for codes) sampled and those occupied by Rio Grande silvery minnow in the Middle Rio Grande as part of population monitoring from December 2011 to October 2012 for each river reach and the annual total.

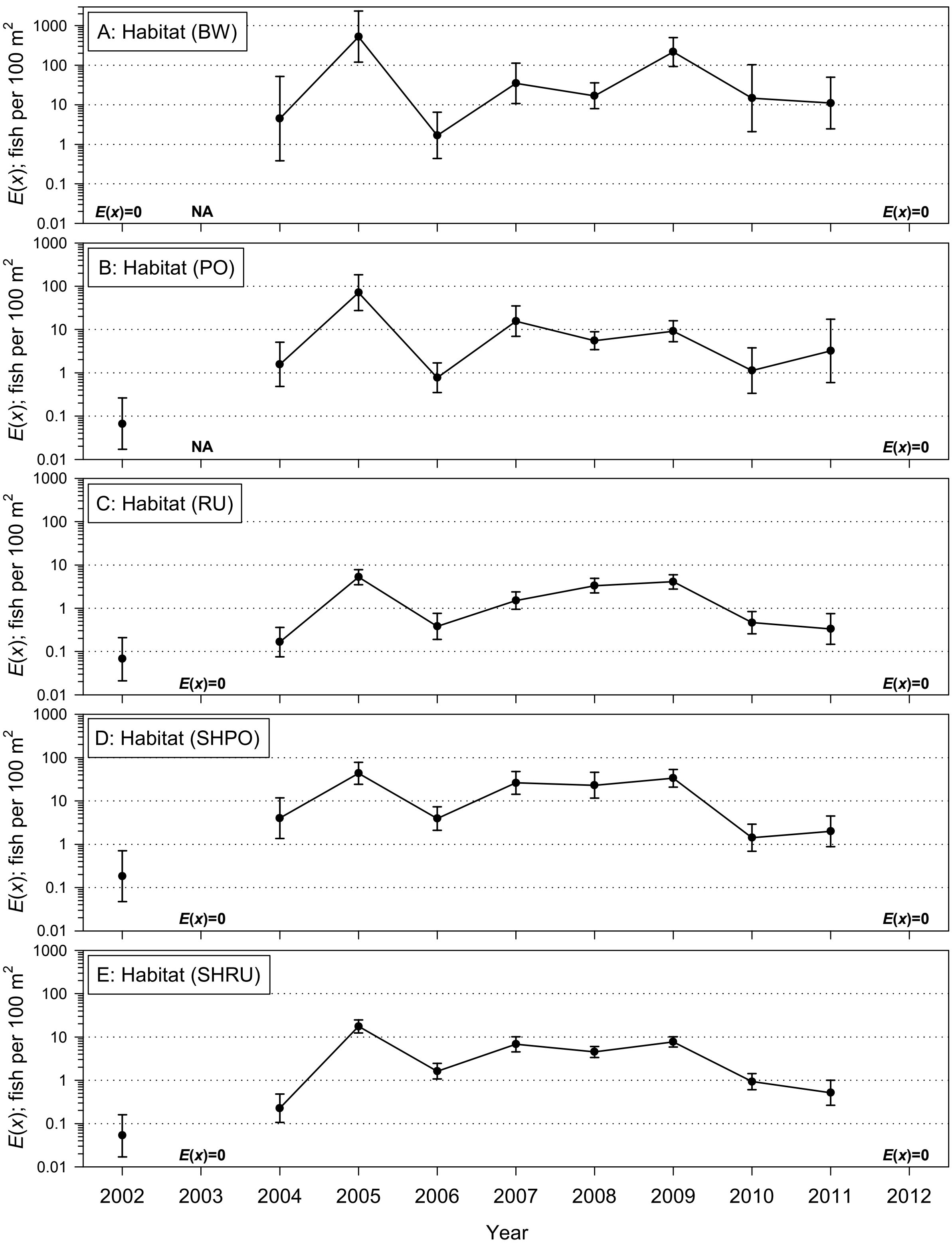


Figure 11 A–E. Rio Grande silvery minnow mixture-model estimates ($E(x)$) by mesohabitat, using October mesohabitat density data (2002–2012). Solid circles indicate modeled estimates and bars represent 95% confidence intervals. Dotted horizontal lines represent orders of magnitude.

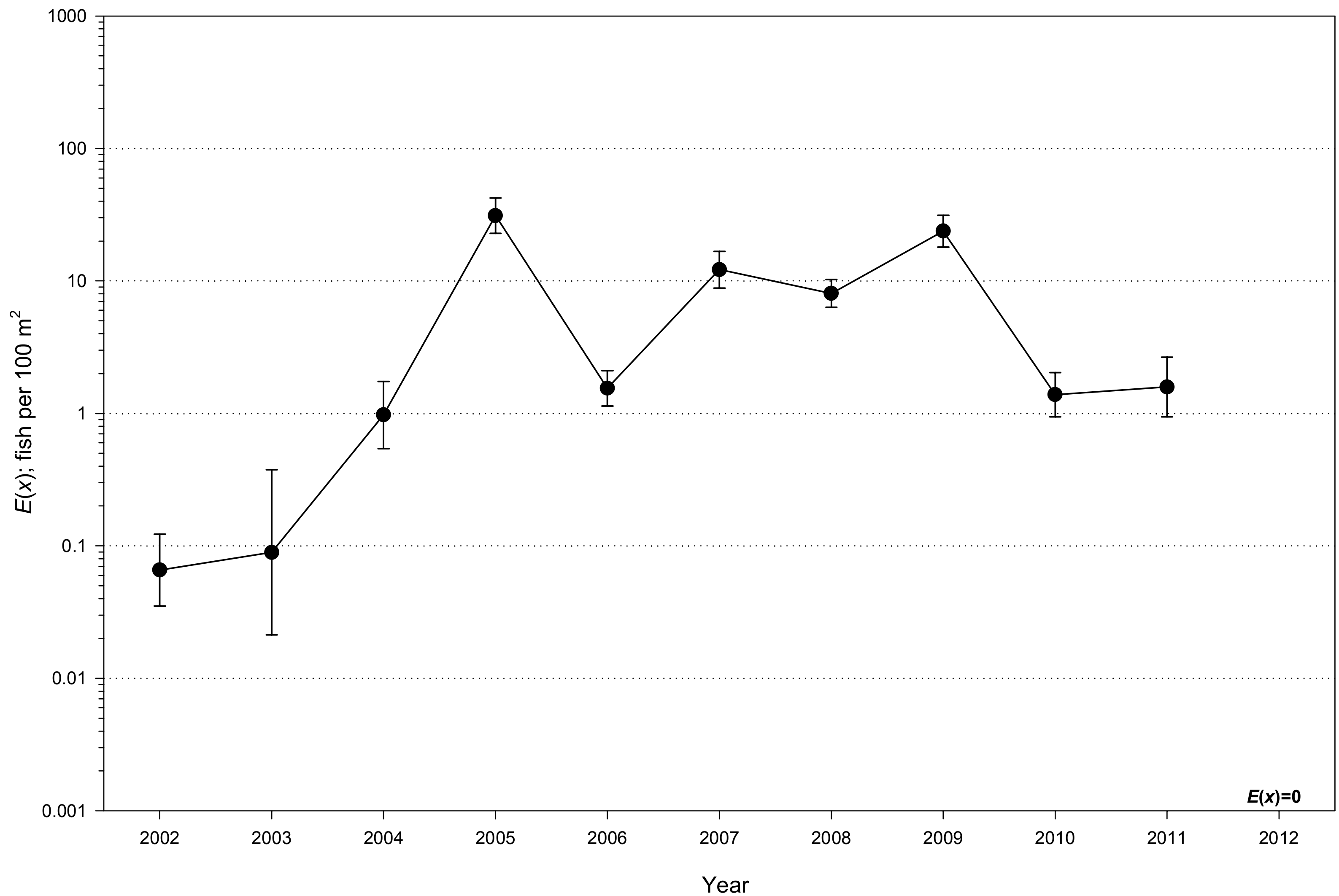


Figure 12. Rio Grande silvery minnow mixture-model estimates ($E(x)$), using October mesohabitat density data (2002–2012). Solid circles indicate modeled estimates and bars represent 95% confidence intervals. Dotted horizontal lines represent orders of magnitude.

Table 5. Summary of the Rio Grande silvery minnow population monitoring program fish samples from December 2011 to October 2012.

FAMILY	SPECIES COMMON NAME	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT (%) OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OCCURRENCE[2]
Clupeidae	gizzard shad	N	19	0.04	8	4.44
Clupeidae	threadfin shad	I	-	-	-	-
Cyprinidae	central stoneroller	I	-	-	-	-
Cyprinidae	goldfish	I	-	-	-	-
Cyprinidae	red shiner	N	31,787	66.01	160	88.89
Cyprinidae	common carp	I	415	0.86	54	30
Cyprinidae	Rio Grande chub	N	-	-	-	-
Cyprinidae	Rio Grande silvery minnow	N	834	1.73	82	45.56
Cyprinidae	golden shiner	I	-	-	-	-
Cyprinidae	fathead minnow	N	1,000	2.08	91	50.56
Cyprinidae	bullhead minnow	I	3	0.01	3	1.67
Cyprinidae	flathead chub	N	3,240	6.73	92	51.11
Cyprinidae	longnose dace	N	251	0.52	23	12.78
Catostomidae	river carpsucker	N	1,122	2.33	83	46.11
Catostomidae	white sucker	I	837	1.74	43	23.89
Catostomidae	smallmouth buffalo	N	20	0.04	10	5.56
Ictaluridae	black bullhead	I	3	0.01	2	1.11
Ictaluridae	yellow bullhead	I	37	0.08	14	7.78
Ictaluridae	blue catfish	N	5	0.01	4	2.22
Ictaluridae	channel catfish	I	1,168	2.43	93	51.67
Ictaluridae	flathead catfish	N	1	0	1	0.56
Salmonidae	rainbow trout	I	-	-	-	-
Salmonidae	brown trout	I	-	-	-	-
Poeciliidae	western mosquitofish	I	7,360	15.28	115	63.89
Moronidae	white bass	I	-	-	-	-
Moronidae	striped bass	I	-	-	-	-
Centrarchidae	green sunfish	I	7	0.01	3	1.67
Centrarchidae	bluegill	N	4	0.01	3	1.67
Centrarchidae	longear sunfish	I	-	-	-	-
Centrarchidae	smallmouth bass	I	-	-	-	-
Centrarchidae	largemouth bass	I	12	0.02	7	3.89
Centrarchidae	white crappie	I	10	0.02	6	3.33
Centrarchidae	black crappie	I	-	-	-	-
Percidae	yellow perch	I	14	0.03	3	1.67
Percidae	bigscale logperch	I	-	-	-	-
Percidae	walleye	I	6	0.01	6	3.33
TOTAL			48,155			

1 N = native; I = introduced
2 Frequency and % frequency of occurrence are based on 180 samples (i.e., 9 months at 20 sites)

native ichthyofauna consisted of eleven species (gizzard shad, red shiner, Rio Grande silvery minnow, fathead minnow, flathead chub, longnose dace, river carpsucker, smallmouth buffalo, blue catfish, flathead catfish, and bluegill). Blue catfish, flathead catfish, and bluegill were the least abundant native fishes (N < 10 for each species). Red shiner was the most abundant native species collected (n = 31,787), followed by flathead chub (n = 3,240), river carpsucker (n = 1,122), fathead minnow (n = 1,000), and Rio Grande silvery minnow (n = 834). The most abundant introduced species were western mosquitofish (n = 7,360), channel catfish (n = 1,168), white sucker (n = 837), and common carp (n = 415). The eight remaining nonnative fish species were present at much lower numbers (N < 40 for each taxon) than were the aforementioned nonnative species.

Rio Grande silvery minnow composed a higher fraction of the total ichthyofaunal community from 2005–2009 than from 2010–2012. While this percentage had dropped precipitously from 1995 to 2000 and remained low through 2004, it improved dramatically in 2005 (Figure 13). There were, however, notable declines from 2005 to 2006 and from 2009 to 2010.

The magnitude of change in the relative abundance of Rio Grande silvery minnow over time is particularly evident when compared to other fish species over the past decade (Table 6). For example, Rio Grande silvery minnow had increased from being the 10^{th} most common focal species in 2003 to being the most common focal species in 2005. While the rank abundance of Rio Grande silvery minnow increased notably from 2003 (10^{th}) to 2007–2009 (2^{nd}), it dropped precipitously in 2010 (5^{th}). In 2012, Rio Grande silvery minnow rank abundance decreased (10^{th}) as compared with 2011 (4^{th}). The coefficient of concordance ($W = 0.73$) for the ten focal species indicated high overall agreement in ranks ($X^2 = 66.1$; $p < 0.001$) over time (2003–2012) despite broad changes in ranks for some taxa (e.g., Rio Grande silvery minnow, common carp, fathead minnow, and river carpsucker).

There were notable seasonal changes in the relative abundance of the 10 focal fish species from December 2011 to October 2012 (Figures 14 and 15). Density of all fish species generally increased during spring or summer. However, Rio Grande silvery minnow abundance steadily declined from December 2011 to October 2012. In contrast, other focal species typically reached their highest densities from June to September, following spawning. The highest densities of red shiner were recorded in September/October although the abundance of this taxon was relatively high throughout the year. An accounting of species-specific temporal abundance revealed similar trends and documented the seasonal occurrence of certain taxa (e.g., gizzard shad and smallmouth buffalo; Table 7).

In addition to temporal variation in the relative abundance of fish species within the community, there were also longitudinal changes in the densities of species among reaches (Figure 16). Flathead chub, longnose dace, white sucker, and channel catfish were most common in the Angostura Reach. The most common species in the Isleta Reach included red shiner, fathead minnow, river carpsucker, and western mosquitofish. Common carp and Rio Grande silvery minnow were most common in the San Acacia Reach. Rio Grande silvery minnow was more common in the Isleta and San Acacia reaches as compared to the Angostura Reach.

Sampling Variation

November (2005–2012)

Rio Grande silvery minnow mixture-model estimates ($E(x)$), using mesohabitat density data, were calculated for each day of repeated sampling during November (2005–2012). Density estimates were generally consistent among multiple days of sampling over the period of study (Figures 17 and 18). However, estimated densities were sometimes higher during the first day of sampling as compared to subsequent days of sampling. For example, the estimated density of Rio

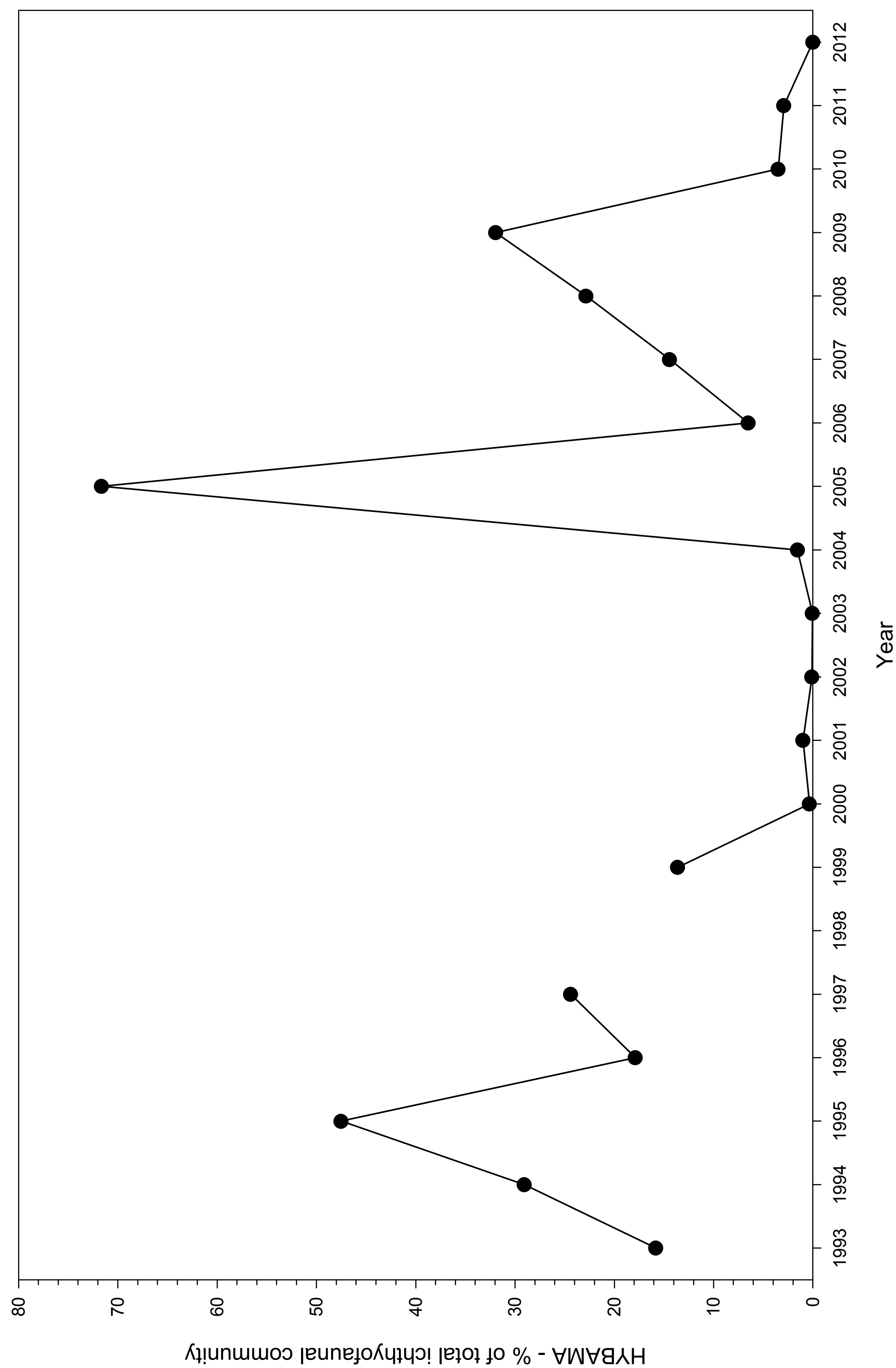


Figure 13. Relative abundance of Rio Grande silvery minnow as a percentage of the total ichthyofaunal community during October, at all sampling sites, by sampling year (1993–2012).

Table 6. Summary of rank abundance for focal species collected in the Rio Grande during October over the past decade (2003–2012).

FAMILY common name	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CYPRINIDAE										
red shiner	1	1	3	1	1	1	1	1	1	1
common carp	8	9	7	10	10	7	10	9	10	6
Rio Grande silvery minnow	10	5	1	4	2	2	2	5	4	10
fathead minnow	3	3	4	6	7	5	6	6	7	5
flathead chub	4	4	5	2	4	4	5	2	3	3
longnose dace	7	8	8	7	8	8	9	7	8	8
CATOSTOMIDAE										
river carpsucker	5	7	9	8	6	9	7	8	5	7
white sucker	9	10	9	8	9	10	8	10	9	9
ICTALURIDAE										
channel catfish	6	6	6	5	5	6	4	4	6	4
POECILIIDAE										
western mosquitofish	2	2	2	3	3	3	3	3	2	2

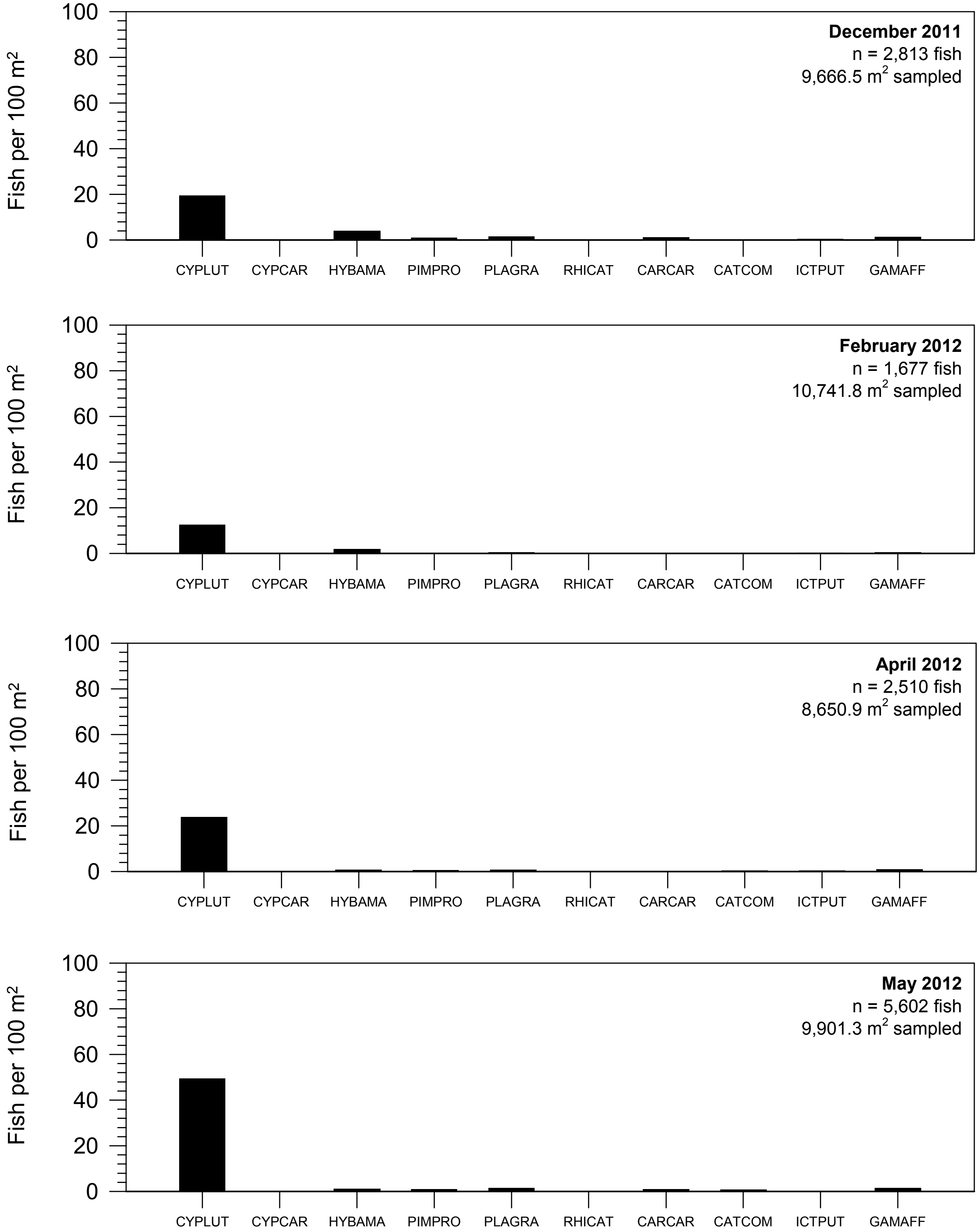


Figure 14. Fish densities from December 2011 to May 2012 for each focal species (see Table 1 for species codes) in the Middle Rio Grande.

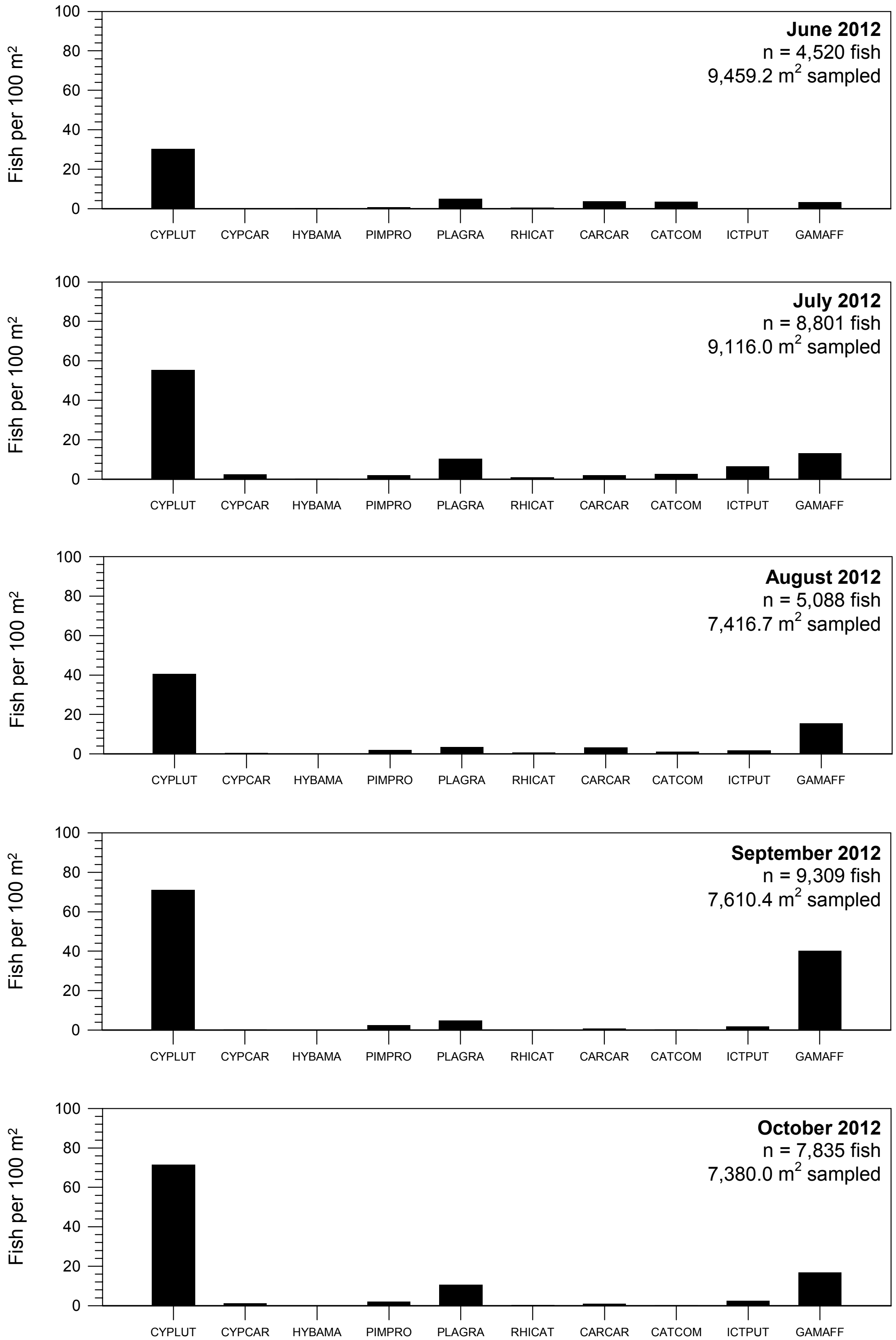


Figure 15. Fish densities from June to October 2012 for each focal species (see Table 1 for species codes) in the Middle Rio Grande.

Table 7. Summary of the December 2011 to October 2012 Rio Grande silvery minnow population monitoring program fish samples.

FAMILY	SPECIES COMMON NAME	DEC	FEB	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
Clupeidae	gizzard shad	1	-	8	3	-	2	4	1	-	19
Clupeidae	threadfin shad	-	-	-	-	-	-	-	-	-	0
Cyprinidae	central stoneroller	-	-	-	-	-	-	-	-	-	0
Cyprinidae	goldfish	-	-	-	-	-	-	-	-	-	0
Cyprinidae	red shiner	1,876	1,339	2,073	4,890	2,867	5,043	3,013	5,414	5,272	31,787
Cyprinidae	common carp	7	1	14	4	20	223	35	27	84	415
Cyprinidae	Rio Grande chub	-	-	-	-	-	-	-	-	-	0
Cyprinidae	Rio Grande silvery minnow	395	201	64	108	24	24	13	5	-	834
Cyprinidae	golden shiner	-	-	-	-	-	-	-	-	-	0
Cyprinidae	fathead minnow	96	4	59	94	68	192	144	189	154	1,000
Cyprinidae	bullhead minnow	2	-	1	-	-	-	-	-	-	3
Cyprinidae	flathead chub	151	41	83	140	475	949	257	363	781	3,240
Cyprinidae	longnose dace	2	-	6	20	47	85	44	19	28	251
Catostomidae	river carpsucker	105	10	20	92	347	179	231	65	73	1,122
Catostomidae	white sucker	-	-	46	88	334	245	81	24	19	837
Catostomidae	smallmouth buffalo	-	-	-	1	5	6	6	2	-	20
Ictaluridae	black bullhead	-	-	-	-	-	1	-	2	-	3
Ictaluridae	yellow bullhead	1	-	1	-	1	26	7	-	1	37
Ictaluridae	blue catfish	-	-	-	4	1	-	-	-	-	5
Ictaluridae	channel catfish	50	26	43	16	3	597	117	132	184	1,168
Ictaluridae	flathead catfish	-	-	-	-	-	1	-	-	-	1
Salmonidae	rainbow trout	-	-	-	-	-	-	-	-	-	0
Salmonidae	brown trout	-	-	-	-	-	-	-	-	-	0
Poeciliidae	western mosquitofish	126	51	88	140	311	1,209	1,134	3,064	1,237	7,360
Moronidae	white bass	-	-	-	-	-	-	-	-	-	0
Moronidae	striped bass	-	-	-	-	-	-	-	-	-	0
Centrarchidae	green sunfish	-	-	-	-	2	5	-	-	-	7
Centrarchidae	bluegill	1	-	3	-	-	-	-	-	-	4
Centrarchidae	longear sunfish	-	-	-	-	-	-	-	-	-	0
Centrarchidae	smallmouth bass	-	-	-	-	-	-	-	-	-	0
Centrarchidae	largemouth bass	-	-	-	-	1	8	1	1	1	12
Centrarchidae	white crappie	-	4	-	2	1	3	-	-	-	10
Centrarchidae	black crappie	-	-	-	-	-	-	-	-	-	0
Percidae	yellow perch	-	-	1	-	11	2	-	-	-	14
Percidae	bigscale logperch	-	-	-	-	-	-	-	-	-	0
Percidae	walleye	-	-	-	-	2	1	1	1	1	6
MONTHLY TOTALS		2,813	1,677	2,510	5,602	4,520	8,801	5,088	9,309	7,835	48,155

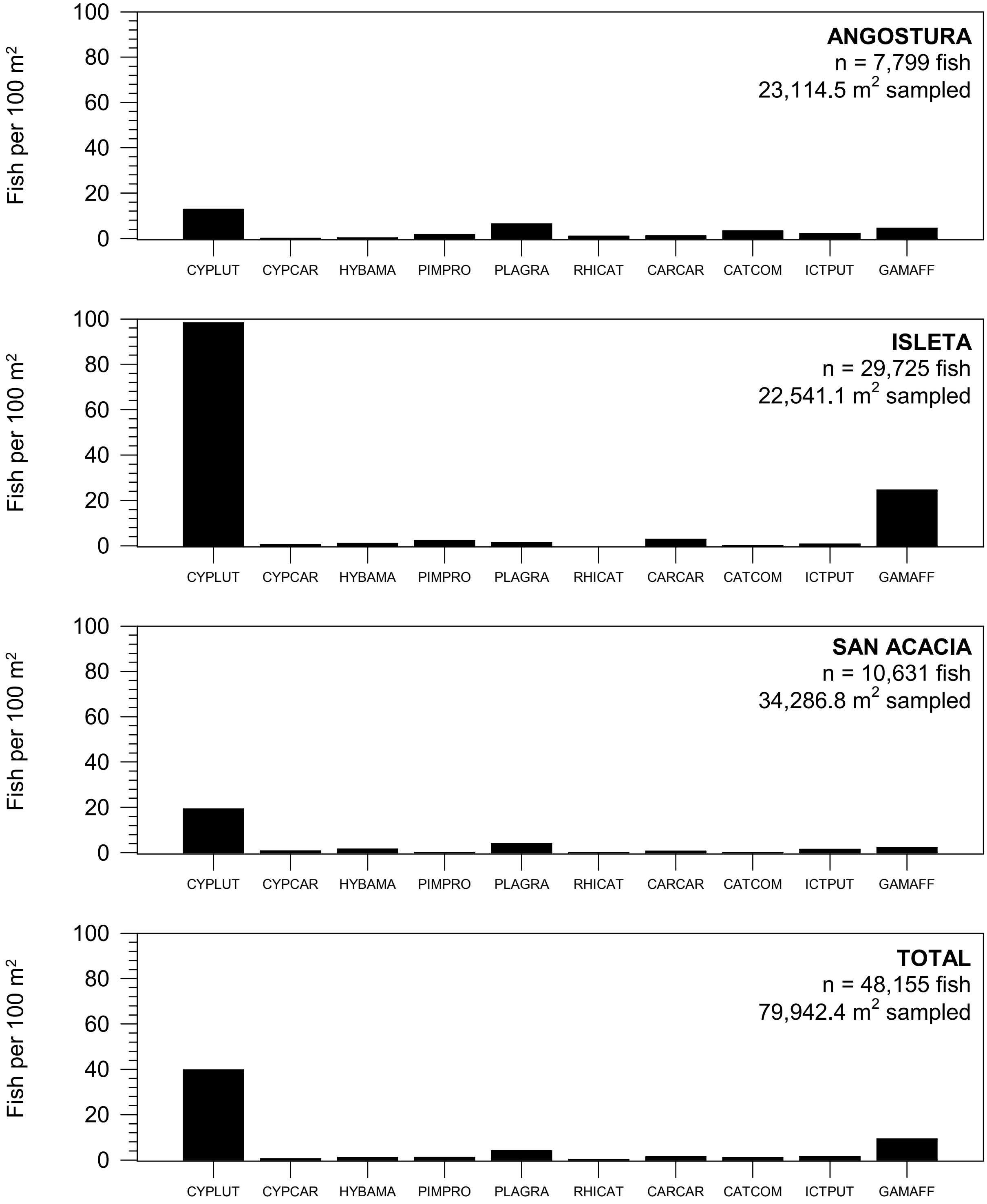


Figure 16. Fish densities by river reach for each focal species (see Table 1 for species codes) in the Middle Rio Grande from December 2011 to October 2012.

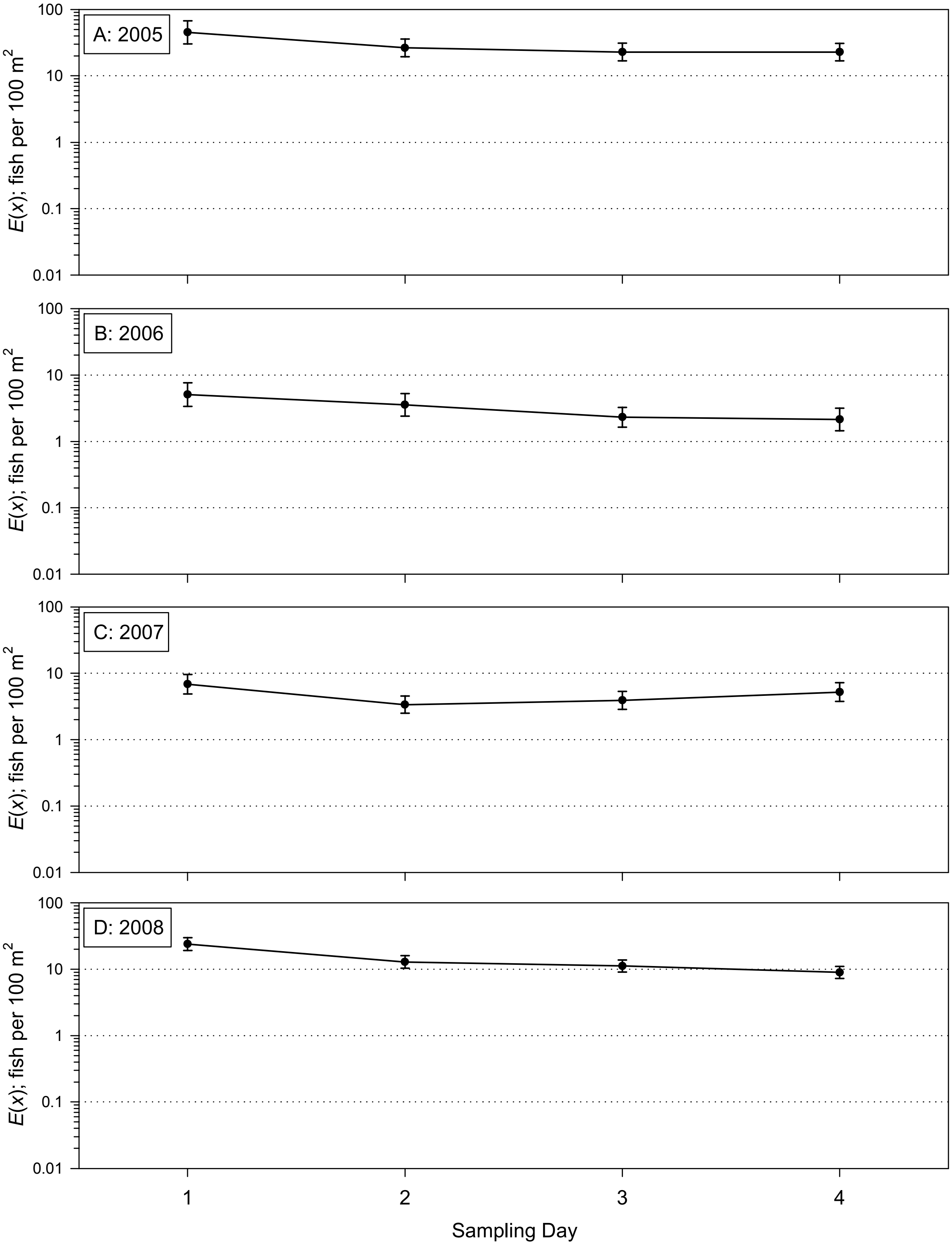


Figure 17 A–D. Rio Grande silvery minnow mixture-model estimates ($E(x)$) by year, using mesohabitat density data from repeated sampling during November (2005–2008). Solid circles indicate modeled estimates and bars represent 95% confidence intervals. Dotted horizontal lines represent orders of magnitude.

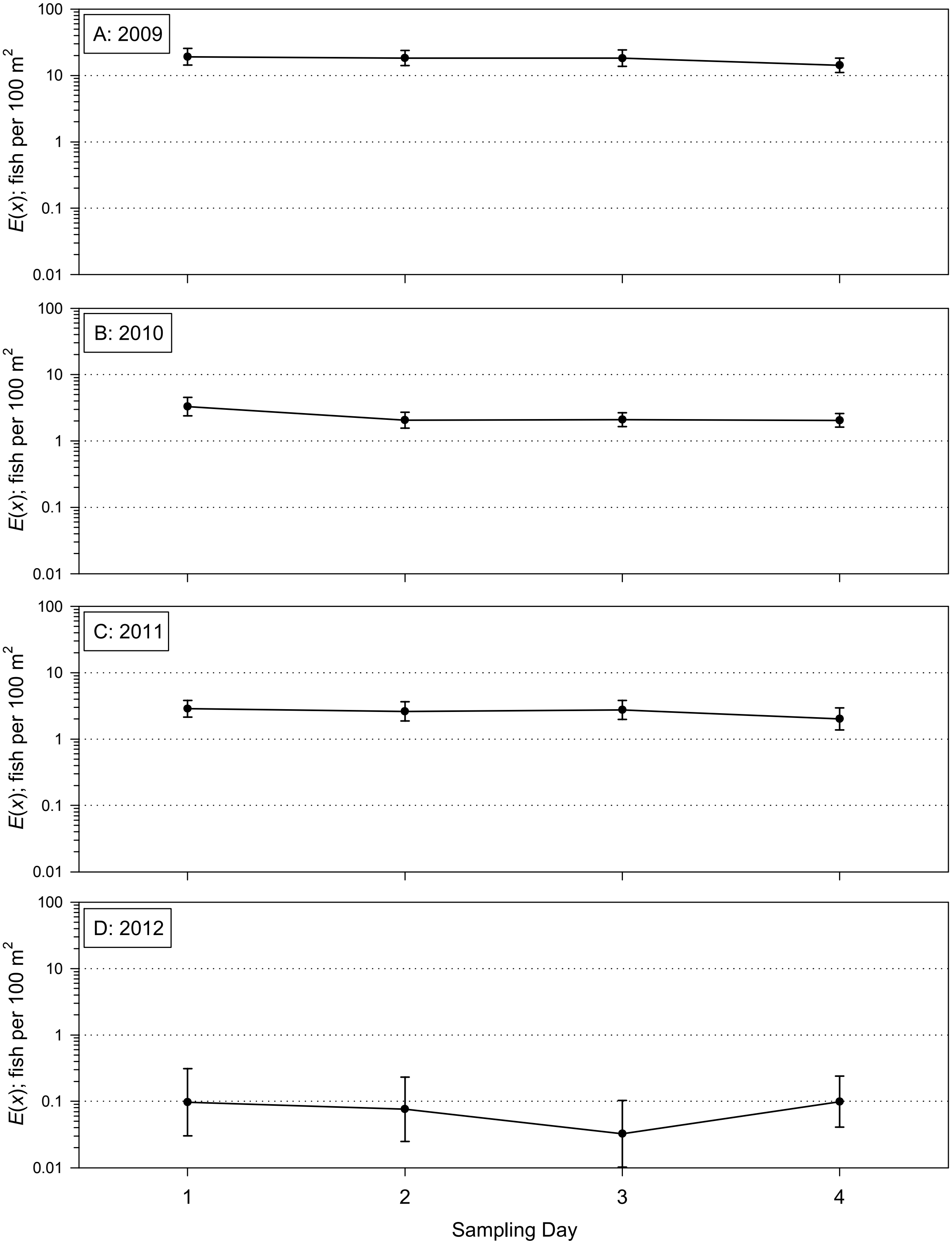


Figure 18 A–D. Rio Grande silvery minnow mixture-model estimates (*E*(*x*)) by year, using mesohabitat density data from repeated sampling during November (2009–2012). Solid circles indicate modeled estimates and bars represent 95% confidence intervals. Dotted horizontal lines represent orders of magnitude.

Grande silvery minnow was higher ($p < 0.05$) on the 1st day of sampling as compared one or several subsequent days of sampling during 2006, 2007, and 2008. There were, however, no differences in estimated densities ($p > 0.05$) among the 2nd, 3rd, or 4th days of sampling during any of the years of the repeated sampling study.

There were consistent differences among the estimated densities of Rio Grande silvery minnow when comparing different years, using data from either the 1st, 2nd, 3rd, or 4th days of sampling. For example, when using the data from the same sampling day, estimated densities were consistently higher ($p < 0.05$) in 2005 and 2009 as compared with 2006–2007 or 2010–2012. In contrast, estimated densities in 2012 were lower ($p < 0.05$) than during any other year of the study (i.e., 2005–2011). The coefficient of variation (*CV*) for Rio Grande silvery minnow was consistent among sampling days even when estimated densities differed among days. The median *CV* (calculated from four repeated days of sampling) ranged from 0.11 (2008) to 0.20 (2006) from 2005–2011. However, the extremely low densities in 2012 appeared to markedly change *CV* values during that year (range = 0.45 to 0.60; median = 0.58).

DISCUSSION

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 in that it has been providing consistent sampling of fishes over a long duration. Determining changes in fish population trends is best accomplished by analyzing the full suite of available data over the period of record. Long-term population monitoring sampling programs also provide the data necessary to test specific ecological hypotheses. While this study was initially designed to monitor the long-term trends of fish species in the Middle Rio Grande, the scope of this project has expanded to address some of the information needs of natural resource managers. Examples of key components that were added to this project over time include: 1) Evaluating the influence of discharge patterns on population fluctuations, 2) Determining general mesohabitat use patterns, 3) Documenting the changes in relative abundance among fish species over time, and 4) Examining seasonal and spatial differences in population structure and abundance of native and nonnative Middle Rio Grande fishes.

The use of catch-per-unit-effort (CPUE) to monitor temporal and spatial changes in fish populations is well established in fisheries science. Some of the first important theoretical contributions were provided in the mid-1900s (Ricker 1940, 1944). The relationship between CPUE and abundance has received considerable attention in the literature (see contrasting reviews by Otis et al. 1978, Bannerot and Austin 1983). Experimental and statistical treatment of the issue suggests that CPUE may be a valid estimator of abundance (Richards and Schnute, 1986). Extensive reviews of the various methods for estimating animal abundance identify CPUE as one of the most widely used and well-researched techniques in fisheries science (e.g., Seber 1992, Schwarz and Seber 1999).

However, there are important differences between estimating population trends vs. estimating population size. Both the accuracy and precision of estimates based on mark-recapture or removal sampling techniques are likely to be improved as compared with estimates based on CPUE sampling techniques (Otis et al. 1978). However, the practical budgetary constraints of agencies charged with monitoring populations of imperiled species may often preclude the long-term utilization of more statistically robust sampling techniques (e.g., mark-recapture or removal studies). Despite these challenges, monitoring programs will undoubtedly be enhanced by including at least some short-term efforts to quantify how closely population trends track based on data collected using CPUE techniques vs. mark-recapture or removal techniques.

Recent analyses revealed a relatively close relationship among the 2008–2011 overall population trends for Rio Grande silvery minnow obtained from Population Monitoring Program and Population Estimation Program studies (Dudley et al., 2012). While this suggests that CPUE (i.e., density of fish) reflects general changes in population size over time, additional data collected in future years will be needed to more precisely determine the strength of this association. However, the Population Estimation Program was not funded in 2012, which meant that there were no population estimate data to compare for this year. If the Population Estimation Program study is funded again in the future, those data will be integral to further revealing the relationship between these parallel sampling efforts. Despite similarities in population trends obtained during the Population Estimation Program and Population Monitoring Program studies, those studies have unique objectives that address different research needs. Systematic Population Monitoring Program activities provide an assessment of recruitment success over short time periods, a basis for comparing the changes in monthly recruitment success among years, insight to seasonal mortality rates, timely information about the status of the species during periods of reduced abundance, and a valuable tool to assess the real-time effectiveness of adaptive management activities. In contrast, the Population Estimation Program provides a statistically robust annual estimate of the Rio Grande silvery minnow population during a single time-period (e.g., October) and is important for more precisely evaluating inter-annual population changes.

While both the Population Monitoring Program and Population Estimation Program studies yielded Rio Grande silvery minnow density estimates, only those estimates derived from the Population Estimate Program data should be used to generate population estimates. Mesohabitat-specific density estimates calculated from Population Monitoring Program data were likely substantial underestimates of true density since mesohabitats were not enclosed or depleted during sampling. In contrast, site-specific density estimates, using data combined across all mesohabitats, were likely substantial overestimates of true density since mesohabitats were not sampled in proportion to their availability (e.g., high-density mesohabitats, such as backwaters, were sampled twice when present even though they were quite rare). While density estimates generated from the Population Monitoring Program data should not be used to derive population size estimates, they do appear to be reflective of Rio Grande silvery minnow population trends over time.

The mixture models used to estimate Rio Grande silvery minnow densities in this study utilized two separate components, an approach which has been shown to be 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 model the probability that a site was occupied while a lognormal model was used to model the estimated densities given that the site was occupied. While the estimated densities ($E(x)$) of Rio Grande silvery minnow were approximately the same as those calculated during previous years using means of log-transformed data (Dudley and Platania, 2012a), the two processes (i.e., presence-absence vs. density) that generated $E(x)$ were clearly separated when using the mixture model approach. Further, it was unnecessary to make the arbitrary addition of some positive constant onto observations of zero CPUE values as is commonly done for simple regression models using log-transformed data.

The Population Monitoring Program has documented notable changes in densities of Rio Grande silvery minnow among years (i.e., more than two orders of magnitude [> 1,000%]) since 1993. Despite large differences in the estimated densities of Rio Grande silvery minnow among sampling years, the coefficient of variation (CV) values were relatively low and consistent. Pollock et al. (1990) suggested that CV values should ideally be < 0.20 for population monitoring studies but that achieving this level of precision would be cost prohibitive in many cases. It appears that the current sampling protocols are resulting in a reasonable level of sampling precision (with the exception of years with very low densities), especially when considering the typically substantial changes in Rio Grande silvery minnow abundance among years. While the current sampling methodology appears to provide a reasonable estimate of Rio Grande silvery minnow population trends over time, additional data from future years will be required to adequately address the validity of this assumption. For example, it is possible that increased sampling efforts would be required to detect significant changes in estimated densities of Rio Grande silvery minnow during periods of extended low flows (e.g., 2002–2003). Also, the level of resolution required for specific hypothesis testing (e.g., differences in site-specific or reach-specific densities over time) could necessitate similarly increased sampling efforts.

Repeated sampling of Rio Grande silvery minnow during November (2005–2012) also indicated that *CV* values remained consistently low over multiple days of sampling during most years. The exception occurred during 2012 when very few individuals were collected, resulting in increased variation in estimated densities as compared with previous years. Differences in estimated densities among years were consistent when using data from any of the repeated days of sampling (e.g., estimated densities on the 1st, 2nd, 3rd, or 4th days of sampling were all higher in 2009 as compared with 2010), indicating that variability in estimated densities among days within a year was far less than the variability in estimated densities among years. However, estimated densities of Rio Grande silvery minnow during November (2005–2012) were often higher, sometimes significantly higher, during the 1st day of sampling as compared with the 2nd, 3rd, or 4th days of sampling. It is possible that the initial sampling effort resulted in some disturbance/dispersal of fish, resulting in lower estimated densities on subsequent sampling days. It appears that the 2nd, 3rd, and 4th days of sampling are most suitable for characterizing sampling variation among days within a particular year.

A qualitative examination of the mesohabitats occupied by Rio Grande silvery minnow was provided to obtain general information on the habitat use patterns of this species. While the physical locations of mesohabitats shift around considerably among years, established sampling protocols for this study ensure that similar mesohabitats (depths and velocities) are sampled among years. In this study, a wide variety of mesohabitats were sampled to ensure balanced monitoring for the Middle Rio Grande ichthyofaunal community and all life stages of Rio Grande silvery minnow. However, this was a cursory study of mesohabitat associations and is no substitute for the more rigorous approach used to quantify Rio Grande silvery minnow mesohabitat use (including seasonal and ontogenetic shifts) in the past (e.g., Dudley and Platania, 1997).

The types of mesohabitats occupied by Rio Grande silvery minnow in 2012 were comparable to those occupied in past years (e.g., Dudley and Platania, 1997, 2012a). The distribution of sampled mesohabitats among reaches and the mesohabitats occupied by Rio Grande silvery minnow among reaches were relatively consistent. Rio Grande silvery minnow were most frequently found in shoreline pools and shoreline runs as compared with other mesohabitats. Main channel runs were the least occupied mesohabitat relative to their sampled abundance. Rio Grande silvery minnow was not found to occupy any of the riffle mesohabitats sampled, perhaps because of the elevated water velocities found in those areas. General mesohabitat use patterns observed during this study were similar to those documented during past studies (e.g., Dudley and Platania, 1997).

Rio Grande silvery minnow estimated densities, using mesohabitat density data (2002–2012), resulted in population trends that were very similar to those generated using sampling-site density data (1993–2012). However, mesohabitat density data generally resulted in much narrower confidence intervals as compared with the sampling-site density data, making the former more sensitive to detecting smaller changes in Rio Grande silvery minnow estimated densities over time. The notable exception to this pattern occurred in 2003 when only two individuals were collected, resulting in broad confidence intervals around estimated densities when using either mesohabitat or sampling-site density data. It is likely that in years of very low abundance, increased sampling efforts (both at the mesohabitat and sampling-site level) would be required to detect significant population changes among years (e.g., 2002 vs. 2003).

Encouragingly, the estimated densities and resulting population trends generated from the mesohabitat or sampling-site density data appear to be generally consistent even though they were measured on two widely different spatial scales (i.e., individual mesohabitats vs. individual sampling sites). The lack of spatial autocorrelation among sampling sites, using October mesohabitat density data, indicated that these data were suitable for the calculation of annual Rio Grande silvery minnow estimated densities over the period of study (2002–2012). While either mesohabitat or sampling-site density data can be used to evaluate population trends since 2002, any evaluation of population trends from 1993 to 2001 are solely dependent on sampling-site density data. Also, the sampling-site density data are more appropriate than are the mesohabitat density data for modeling the effects of different seasonal flow patterns (e.g., increased spring runoff) on the autumnal presence-absence and abundance of Rio Grande silvery minnow since they have been collected over a much longer period of time (1993–2012).

There were notable changes in the relative and rank abundance of Middle Rio Grande fish species over the past decade (2003–2012). The species that changed most in rank abundance over time included Rio Grande silvery minnow, common carp, fathead minnow, and river carpsucker. Despite these occasionally large changes in the abundance of individual species, the combined densities of Middle Rio Grande fishes remained relatively constant over time. The dynamic changes in species rank abundance over time could indicate that key environmental conditions are controlling species-specific abundance over time. It is possible that changes in the timing, magnitude, and duration of flows (especially during and immediately following spawning season) could be an important factor leading to some of the observed differences in fish species abundance over time and space. 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 densities of Rio Grande silvery minnow over time. However, additional study will be required to determine those environmental factors that most influence the spatial and temporal patterns of abundance for other fish species and how those changes might affect ichthyofaunal community dynamics over time.

The annual reproductive effort of Rio Grande silvery minnow normally occurs during spring and is initiated, in part, by large-scale increases in stream discharge associated with high-mountain snowmelt. Rio Grande silvery minnow releases relatively large numbers of eggs (up to several thousand per female) into the water column during spawning and these eggs are passively dispersed with the current. Increased discharge as a result of spring runoff, combined with increasing water temperatures, were likely the historical sources of this reproductive stimulus (Platania and Altenbach, 1998). During years of sufficient snowpack, flow in the Middle Rio Grande peaked in late spring and sometimes resulted in several months of sustained flooded habitats. However, dam operations now moderate the magnitude and duration of spring discharge. Water that is stored in reservoirs or seasonally diverted from the river for agricultural/municipal purposes, along with the associated evapotranspiration from those activities, substantially reduces the total volume of water that would have normally flowed through the Rio Grande. These issues are further compounded in drought years when a large portion of the available water is diverted from the Rio Grande in early spring, reducing the sustained and elevated flows that appear to facilitate early recruitment success of Rio Grande silvery minnow.

The timing of the 2012 spring runoff was earlier than usual (as compared to historical flow data) and overall discharge was relatively low. Runoff began in April and there was only a small secondary peak in May for a few weeks. The lack of elevated and extended flows during 2012 likely resulted in less favorable conditions for the growth and survivorship of newly hatched Rio Grande silvery minnow larvae. In contrast, it is possible that recruitment success was increased in previous years with high spring flows (e.g., 2008) because of the extended inundation of shoreline pools and backwaters where larval fish were most likely to persist (see Dudley and Platania, 2012b).

Comparison of Rio Grande silvery minnow mixture-model estimates (Delta (δ) = probability of absence and Mu (μ) = mean of the lognormal density distribution) during October (1993–2012) to hydraulic variables measured at two Middle Rio Grande discharge gauges revealed several strong relationships. Peak discharge and duration of high flows during the spawning season (May-June) were negatively correlated with Rio Grande silvery minnow δ but were positively correlated with μ. In contrast, early and extended low flows were positively correlated with δ but were negatively correlated with μ. Modeling these two separate population responses (presence-absence vs. density) provided valuable insights to the relative importance of multiple hydraulic covariates in explaining the variability of Rio Grande silvery minnow distribution and abundance trends over time. General linear models suggested that extended and elevated spring flows were most predictive of increased abundance of Rio Grande silvery minnow as compared to any of the other hydraulic variables analyzed. The physical conditions produced by prolonged and elevated flows result in overbank flooding of vegetated areas, formation of inundated habitats within the river channel, and creation of shoreline and island backwaters. Shallow low-velocity habitats (e.g., shoreline pools, backwaters, overbank floodplains etc.) are well known to be essential for the successful recruitment of early life history stages of many freshwater fish species throughout the world (for review see Welcomme, 1979). It is quite likely that similar processes are important for the successful survival and recruitment of the Middle Rio Grande ichthyofaunal community, including early life stages of Rio Grande silvery minnow (Pease et al., 2006; Turner et al., 2010).

Population Monitoring Program sampling efforts during October indicated that the highest densities of Rio Grande silvery minnow were in the San Acacia Reach and that the lowest densities were in the Angostura or Isleta reaches for the majority of years sampled since 1993 (12 of 19 years). The exceptions to this pattern generally occurred in years when there was either extensive drying of the river channel in the San Acacia Reach (e.g., 2002 and 2003) and/or notable augmentation efforts in the Angostura and Isleta reaches (e.g., 2005 and 2006). One possible explanation for this apparent upstream to downstream pattern of abundance is the cumulative longitudinal transport of some portion of Rio Grande silvery minnow propagules (drifting eggs and larvae) below instream barriers (i.e., Angostura, Isleta, and San Acacia diversion dams) or into irrigation networks (Dudley and Platania, 2007). Also, the extensive river channelization, habitat degradation, abandonment of the floodplain, and associated reductions in suspended sediments downstream of Cochiti Dam (Lagasse, 1980; Massong et al., 2006) are likely limiting the amount of appropriate habitat available for the successful retention and early recruitment of this species, especially in the Cochiti and Angostura reaches. Rio Grande silvery minnow augmentation efforts in the Angostura Reach apparently reversed this trend from 2002 to 2007 (i.e., October densities were highest in the Angostura Reach during five of six of those years). However, a cessation of augmentation efforts in the Angostura Reach from 2008 to 2012 may have contributed to the reemergence of the San Acacia Reach as the reach supporting the highest October densities of Rio Grande silvery minnow since 2008.

Despite periodic and sometimes sustained declines in the abundance of Rio Grande silvery minnow, it is encouraging that this species can apparently rebound so quickly following years with good spawning/recruitment conditions. The dramatic increase in the abundance of Rio Grande silvery minnow from 2003 to 2005 (over two orders of magnitude) is indicative of the ability of this species to rebound quickly following favorable conditions. However, the rapid increases in abundance documented after consecutive years of good spring runoff contrast with the equally rapid decreases in abundance documented after consecutive years of poor spring runoff and prolonged summer low-flow/drying conditions. Despite the large fluctuations in the abundance of Rio Grande silvery minnow over the past decade, the overall genetic diversity of this species has apparently been maintained in the wild population, perhaps as a result of the current propagation management plan (Alò and Turner, 2005; Osborne et al., 2012). The lack of any wild or hatchery-reared Rio Grande silvery minnow in samples taken in October of 2012, however, creates considerable uncertainty about the future conservation status of this species. Based on the results obtained from the repeated sampling efforts in November of 2012 (where some wild individuals were collected), it appears likely that increased sampling efforts will be required to adequately detect Rio Grande silvery minnow when this species reaches very low densities.

The extremely low densities of Rio Grande silvery minnow in 2012 appear to indicate that current management efforts (e.g., stocking, salvage, habitat restoration, flow manipulation etc.) are not sufficiently buffering the population against substantial declines. Several drought years in sequence (e.g., similar to what occurred during 2002–2003) have provided the natural experiment necessary to glean insight into just how much current management efforts are buffering against potentially catastrophic population declines during periods of extended low flows. While ongoing management efforts appear to be providing some protection against extinction, it appears that additional efforts/activities will be required to yield robust self-sustaining populations of Rio Grande silvery minnow in the Middle Rio Grande over time. Additionally, securing the long-term persistence of Rio Grande silvery minnow in the wild will likely depend on attaining self-sustaining populations at multiple locations within its current and historical range. Future study of the ecological interactions among fish species and their environment in the Rio Grande Basin should further elucidate the factors that control this complex aquatic ecosystem, which will be essential in providing the information required to develop and implement successful management strategies for the long-term recovery of Rio Grande silvery minnow.

ACKNOWLEDGMENTS

Many people collaborated with us to make this project possible. Adam L. Barkalow, W. Howard Brandenburg, Michael A. Farrington, Austin L. Fitzgerald, Jennifer L. Hester, Richard C. Keller, Kylie R. Naegele, Sarah J. Sasek, and Stephen A. Zipper (American Southwest Ichthyological Researchers, L.L.C.; Museum of Southwestern Biology-UNM) were instrumental in field and laboratory portions of this study. Additional field assistance was provided by Kelly M. Oliver-Amy (U.S. Bureau of Reclamation), Alexandra M. Snyder (Museum of Southwestern Biology-UNM), and Luke M. Strickland (Museum of Southwestern Biology-UNM). Helpful reviews of an earlier draft were provided by Michael D. Porter and Dana M. Price (U.S. Army Corps of Engineers) and by Jennifer A. Bachus and Thomas P. Archdeacon (U.S. Fish and Wildlife Service). Continued assistance with all aspects of curation of specimens was provided by Alexandra M. Snyder (Museum of Southwestern Biology-UNM). Much of the logistical support for this project was provided by Jericho E. Lewis, Kelly M. Oliver-Amy, and Yvette M. Paroz (U.S. Bureau of Reclamation). Any handling or collection of Rio Grande silvery minnow as part of this study was authorized by the U.S. Fish and Wildlife Service (Permit TE001623-0). This study was funded by the Middle Rio Grande Endangered Species Collaborative Program and funds were administered by the U.S. Bureau of Reclamation Area Offices (Albuquerque, New Mexico and Salt Lake City, Utah).

LITERATURE CITED

Akaike, H. 1973. Information theory as an extension of the maximum likelihood principle. *In*: B. N. Petrov and F. Csaki (eds.). Second International Symposium on Information Theory. Akademiai, Budapest.

Alò, D., and T. F. Turner. 2005. Effects of habitat fragmentation on effective population size in the endangered Rio Grande silvery minnow. Conservation Biology 19:1138–1148.

Bannerot, S. P., and C. B. Austin. 1983. Using frequency distributions of catch per unit effort to measure fish-stock abundance. Transactions of the American Fisheries Society 112: 608–617.

Dudley, R. K., and S. P. Platania. 1997. Habitat use of Rio Grande silvery minnow. Report to the New Mexico Department of Game and Fish, Santa Fe, and U.S. Bureau of Reclamation (Albuquerque Projects Office), Albuquerque, NM. 96 pp.

Dudley, R. K., and S. P. Platania. 2007. Flow regulation and fragmentation imperil pelagic-spawning riverine fishes. Ecological Applications 17: 2074–2086.

Dudley, R. K., D. A Helfrich and S. P. Platania. 2009. Effects of river intermittency on populations of Rio Grande silvery minnow. Report to the Middle Rio Grande Endangered Species Collaborative Program and the U.S. Bureau of Reclamation, Albuquerque, New Mexico. 55 pp.

Dudley, R. K. and S. P. Platania. 2012a. Rio Grande silvery minnow population monitoring program results from December 2010 to October 2011. Report to the Middle Rio Grande Endangered Species Collaborative Program and the U.S. Bureau of Reclamation, Albuquerque, New Mexico. 146 pp.

Dudley, R. K. and S. P. Platania. 2012b. Spatial spawning periodicity of Rio Grande silvery minnow during 2012. Report to the Middle Rio Grande Endangered Species Collaborative Program and the U.S. Bureau of Reclamation, Albuquerque, New Mexico. 42 pp.

Dudley, R. K., G. C. White, S. P. Platania, and D. A Helfrich. 2012. Rio Grande silvery minnow population estimation program results from October 2011. Report to the Middle Rio Grande Endangered Species Collaborative Program and the U.S. Bureau of Reclamation, Albuquerque, New Mexico. 87 pp.

Fletcher, D., D. Mackenzie, and E. Villouta. 2005. Modelling skewed data with many zeros: A simple approach combining ordinary and logistic regression. Environmental and Ecological Statistics 12: 45–54.

Gold, R. L., and L. P. Denis. 1985. National water summary-New Mexico surface-water resources. U.S. Geological Survey water-supply paper 2300:341–346.

Horwitz, R. J., D. H. Keller, P. F. Overbeck, S. P. Platania, and R. K. Dudley. 2011. Age and growth of Rio Grande silvery minnow. Final report to the Middle Rio Grande Endangered Species Collaborative Program & the U.S. Bureau of Reclamation, Albuquerque, New Mexico. 74 pp.

Lagasse, P. F. 1980. An assessment of the response of the Rio Grande to dam construction-Cochiti to Isleta reach. A technical report for the U.S. Army Engineer District, Albuquerque, Corps of Engineers, Albuquerque, New Mexico. 133 pp.

Martin, T. G., B. A. Wintle, J. R. Rhodes, P. M. Kuhnert, S. A. Field, S. J. Low-Choy, A. J. Tyre, and H. P. Possingham. 2005. Zero tolerance ecology: improving ecological inference by modelling the source of zero observations. Ecology Letters 8: 1235–1246.

Massong, T., P. Tashjian, and P. Makar. 2006. Recent Channel Incision and Floodplain Evolution within the Middle Rio Grande, NM. Joint 8th Federal Interagency Sedimentation Conference and 3rd Federal Interagency Hydrologic Modeling Conference, Reno, NV.

Nagelkerke, N. J. D. 1991. A note on a general definition of the coefficient of determination. Biometrika 78: 691–692

Nelson, J. S., E. J. Crossman, H. Espinosa-Peréz, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, Maryland. 386 pp.

Osborne, M. J., E. W. Carson, and T. F. Turner. 2012. Genetic monitoring and complex population dynamics: insights from a 12-year study of the Rio Grande silvery minnow. Evolutionary Applications 5:553–574.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monograph 62. 135 pp.

Pease, A. A., J. J. Davis, M. S. Edwards, and T. F. Turner. 2006. Habitat and resource use by larval and juvenile fishes in an arid-land river (Rio Grande, New Mexico). Freshwater Biology 51:475–486.

Platania, S. P. 1993a. The fishes of the Rio Grande between Velarde and Elephant Butte Reservoir and their habitat associations. Report to the New Mexico Department of Game and Fish, Santa Fe, and U.S. Bureau of Reclamation (Albuquerque Projects Office), Albuquerque, NM. 188 pp.

Platania, S. P. 1993b. Ichthyofaunal survey of the Rio Grande and Santa Fe River, Cochiti Pueblo, New Mexico, July 1993. Report to the U.S. Army Corps of Engineers, Albuquerque, NM. 28 pp.

Platania, S. P. 1995. Ichthyofaunal survey of the Rio Grande, Santo Domingo and San Felipe pueblos, New Mexico, July 1994. Report to the U.S. Army Corps of Engineers, Albuquerque, NM. 56 pp.

Platania, S. P., and C. S. Altenbach. 1998. Reproductive strategies and egg types of seven Rio Grande Basin cyprinids. Copeia 1998: 559–569.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs 107: 1–97.

Richards, L. J., and J. T. Schnute. 1986. An experimental and statistical approach to the question: is CPUE an index of abundance? Can. J. Fish. Aquat. Sci. 43:1214–1227.

Ricker, W. E. 1940. Relation of “catch per unit effort” to abundance and rate of exploitation. J. Fish. Res. Board Can. 5:43–70.

Ricker, W. E. 1944. Further notes on fishing mortality and effort. Copeia 1944: 23–44.

SAS software, Version 9.2 of the SAS System for Linux. Copyright © 2013 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

Schwarz, C. J., and G. A. F. Seber. 1999. Estimating animal abundance: review III. Statistical Science 14:427–456.

Seber, G. A. F. 1992. A review of estimating animal abundance II. International Statistical Review 60:129–166.

Turner, T.F., T.J. Krabbenhoft, and A.S. Burdett. 2010. Reproductive phenology and fish community structure in an arid-land river system. Pages 427-446 in K.B. Gido and D.A. Jackson, editors. Community ecology of stream fishes: concepts, approaches, and techniques. American Fisheries Society, Symposium Series 73, Bethesda, MD. 664 pp.

U.S. Department of the Interior. 1994. Endangered and threatened wildlife and plants: final rule to list the Rio Grande silvery minnow as an endangered species. Federal Register 59: 36988–36995.

Welcomme, R. L. 1979. The fisheries ecology of floodplain rivers. Longman, London. 317 pp.

Welsh, A. H., R. B. Cunningham, C. F. Donnelly, and D. B. Lindenmayer. 1996. Modelling the abundance of rare species: statistical models for counts with extra zeros. Ecological Modelling 88: 297–308.

White, G. C. 1978. Estimation of plant biomass from quadrat data using the lognormal distribution. Journal of Range Management 31:118–120.

Zar, J. H. 2010. Biostatistical Analysis. Fifth edition. Prentice Hall Inc., Upper Saddle River, New Jersey. 944 pp.

Appendix A.

Middle Rio Grande fish sampling sites

Table A-1. Sampling sites for December 2011 to October 2012 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality
	ANGOSTURA REACH SITES
0	New Mexico, Sandoval County, Rio Grande, directly below Angostura Diversion Dam, Algodones. River Mile 209.7 SAN FELIPE PUEBLO QUADRANGLE UTM Easting: 363811 UTM Northing: 3916006 Zone: 13
1	New Mexico, Sandoval County, Rio Grande, at NM State Highway 44 bridge crossing, Bernalillo. River Mile 203.8 BERNALILLO QUADRANGLE UTM Easting: 358543 UTM Northing: 3909722 Zone: 13
2	New Mexico, Sandoval County, Rio Grande, ca. 4.0 miles downstream of NM State Highway 44 bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho. River Mile 200.0 BERNALILLO QUADRANGLE UTM Easting: 354772 UTM Northing: 3905355 Zone: 13
3	New Mexico, Bernalillo County, Rio Grande, at Central Avenue bridge crossing (US Highway 66), Albuquerque. River Mile 183.4 ALBUQUERQUE WEST QUADRANGLE UTM Easting: 346840 UTM Northing: 3884094 Zone: 13
4	New Mexico, Bernalillo County, Rio Grande, at Rio Bravo Boulevard bridge crossing, (NM State Highway 500), Albuquerque. River Mile 178.3 ALBUQUERQUE WEST QUADRANGLE UTM Easting: 347554 UTM Northing: 3877163 Zone: 13
	ISLETA REACH SITES
5	New Mexico, Valencia County, Rio Grande at Los Lunas bridge crossing (NM State Highway 49), Los Lunas. River Mile 161.4 LOS LUNAS QUADRANGLE UTM Easting: 342898 UTM Northing: 3852531 Zone: 13
6	New Mexico, Valencia County, Rio Grande, ca. 1.0 miles upstream of NM State Highway 309/6 bridge crossing, Belen. River Mile 151.5 TOME QUADRANGLE UTM Easting: 339972 UTM Northing: 3837061 Zone: 13
7	New Mexico, Valencia County, Rio Grande, ca. 2.2 miles upstream of NM State Highway 346 bridge crossing, Jarales. River Mile 143.2 VEGUITA QUADRANGLE UTM Easting: 338136 UTM Northing: 3827329 Zone: 13
8	New Mexico, Socorro County, Rio Grande, at US Highway 60 bridge crossing, Bernardo. River Mile 130.6 ABEYTAS QUADRANGLE UTM Easting: 334604 UTM Northing: 3809726 Zone: 13

Table A-1. Sampling sites for December 2011 to October 2012 population monitoring of Rio Grande silvery minnow (continued).

Site #	Site Locality
	ISLETA REACH SITES (continued)
9	New Mexico, Socorro County, Rio Grande, ca. 3.5 miles downstream of US Highway 60 bridge crossing, Bernardo. River Mile 127.0 ABEYTAS QUADRANGLE UTM Easting: 331094 UTM Northing: 3805229 Zone: 13
9.5	New Mexico, Socorro County, Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia River Mile 116.8 LA JOYA QUADRANGLE UTM Easting: 327902 UTM Northing: 3792603 Zone: 13
	SAN ACACIA REACH SITES
10	New Mexico, Socorro County, Rio Grande, directly below San Acacia Diversion Dam, San Acacia. River Mile 116.2 SAN ACACIA QUADRANGLE UTM Easting: 326162 UTM Northing: 3791977 Zone: 13
11	New Mexico, Socorro County, Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. River Mile 114.6 LEMITAR QUADRANGLE UTM Easting: 325263 UTM Northing: 3790442 Zone: 13
12	New Mexico, Socorro County, Rio Grande, east of Socorro, 0.5 miles upstream of the Socorro Low Flow Conveyance Channel bridge; east and upstream of Socorro Wastewater Treatment Plant, Socorro. River Mile 99.5 LOMA DE LAS CANAS QUADRANGLE UTM Easting: 327097 UTM Northing: 3771043 Zone: 13
13	New Mexico, Socorro County, Rio Grande, ca. 4.0 miles upstream of US Highway 380 bridge crossing, San Antonio. River Mile 91.7 SAN ANTONIO QUADRANGLE UTM Easting: 328140 UTM Northing: 3761283 Zone: 13
14	New Mexico, Socorro County, Rio Grande, at US Highway 380 bridge crossing, San Antonio. River Mile 87.1 SAN ANTONIO QUADRANGLE UTM Easting: 328914 UTM Northing: 3754471 Zone: 13
15	New Mexico, Socorro County, Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters, San Antonio. River Mile 79.1 SAN ANTONIO, SE QUADRANGLE UTM Easting: 327055 UTM Northing: 3740839 Zone: 13
16	New Mexico, Socorro County, Rio Grande, at San Marcial Railroad bridge crossing, San Marcial. River Mile 68.6 SAN MARCIAL QUADRANGLE UTM Easting: 315284 UTM Northing: 3728347 Zone: 13

Table A-1. Sampling sites for December 2011 to October 2012 population monitoring of Rio Grande silvery minnow (continued).

Site #	Site Locality
	SAN ACACIA REACH SITES
17	New Mexico, Socorro County, Rio Grande, at its former confluence with the Low Flow Conveyance Channel; ca. 8 miles downstream of San Marcial Railroad bridge crossing. River Mile 60.5 PARAJE WELL QUADRANGLE UTM Easting: 309487 UTM Northing: 3718178 Zone: 13
18	New Mexico, Socorro County, Rio Grande, ca. 10 miles downstream of San Marcial Railroad bridge crossing. River Mile 57.7 PARAJE WELL QUADRANGLE UTM Easting: 307380 UTM Northing: 3714740 Zone: 13

Appendix B.

Site occupancy analysis of Rio Grande silvery minnow (2005–2012)

Note: This information was included in the Rio Grande silvery minnow Population Estimation Program annual reports (from 2006–2011) but that study was not funded in 2012.

INTRODUCTION

Techniques to estimate the presence-absence and abundance of organisms, which do not require full site depletion or marking and recapture of individuals, have been shown to be reliable for a variety of species (e.g., Royle and Nichols, 2003). Statistical methods have been developed that account for the inherent heterogeneity of population abundance among different sites. Data on the presence-absence of organisms provides useful information about the probabilities that underlie spatial patterns of abundance in the environment, and for detecting trends in population status (MacKenzie et al. 2003). Occupancy surveys provide a way to assess the likelihood of detecting the presence or absence of an organism by calculating the probability based on the detection history (i.e., previous information on presence-absence can be used to predict likelihood of non-detection vs. absence). Failure to detect a species during sampling does not mean that the species is truly absent from the area (MacKenzie et al., 2002, Finley et al., 2005, White 2005). An estimate of historical patterns of site occupancy can be used to complement data collected during the long-term Population Monitoring Program (1993–2012) for the Middle Rio Grande ichthyofaunal community. In contrast to population monitoring that documents trends over multiple time intervals (i.e., monthly or annual) for the entire ichthyofaunal community, this study has supplemented the Population Monitoring Program by providing annual estimates of Rio Grande silvery minnow site occupancy rates since 2005.

METHODS

Intensive sampling data from population monitoring efforts (repeated sampling efforts in November [2005–2012]) were used to generate estimates of site occupancy rates based on methods developed by MacKenzie et al. (2002, 2003, 2006). Developing site occupancy rates of Rio Grande silvery minnow enabled assessment of the likelihood of detecting the presence or absence of Rio Grande silvery minnow by calculating the detection history probability. This study was conducted using the same sampling protocols established for regular population monitoring efforts. Site occupancy was calculated separately based on two different spatial scales (mesohabitat-specific and site-specific). All data were derived from intensive sampling efforts where mesohabitats (and sites) were sampled once per day for four days.

The encounter history, using mesohabitat data, was compiled from intensive repeated monitoring of the same sample locations. A variety of mesohabitats were sampled on the first day and samples were taken at the same locations on subsequent days; in rare cases the location of the sample had to be shifted to a different area with similar mesohabitat conditions if there was a notable change in flow. Data were organized into categories based on the presence-absence of wild Rio Grande silvery minnow over the four day sampling effort. The encounter history was based on the presence of Rio Grande silvery minnow at individual mesohabitat locations. For example, an encounter history of {1101} meant that individuals were collected in a particular mesohabitat on days one, two, and four but not on day three. A higher proportion of presence encounters was interpreted as indicating that individuals were more consistently detected within the mesohabitat over time. While the sampling scale (mesohabitat) was relatively small, it was unlikely that mesohabitats regularly changed in status from occupied to unoccupied among days. In most cases, only a relatively small portion of a much larger mesohabitat was sampled and all fish were immediately returned to the place of capture. Also, fish were nearly always collected at the same sampling sites over multiple days of sampling during past years (Dudley et al., 2012). However, mesohabitats were more likely to have violated the closure assumption (i.e., occupancy state remained constant) as compared to sampling sites and so these data should be interpreted cautiously. Additional assumptions included that there could be no false detections, that there could be mesohabitats where the species was present but undetected, and that species detection within a specific mesohabitat was independent of species detection in other mesohabitats.

The probability of detection was calculated for Rio Grande silvery minnow at mesohabitat sample locations along with the standard error and confidence intervals, following methods of MacKenzie et al. (2006). Estimates of the probability of detection were computed for all individuals and then separately for the different age-classes using Program MARK (White and Burnham 1999). Site occupancy was the proportion of mesohabitat locations occupied relative to those surveyed. The site occupancy estimate for each mesohabitat location was based on the probability of detection estimate (and its associated variance) and the actual site occupancy data calculated from the raw data. In this way, the site occupancy was corrected using the detection estimate (MacKenzie et al., 2006). A higher degree of consistency among days (either 0000 or 1111) will result in a site occupancy model that yields results that more closely match those obtained from the original estimate of site occupancy based on a single survey. The specific pattern of presence-absence (i.e., 0010 vs. 0101) was incorporated into the model to determine the likelihood of detection over time for a particular mesohabitat location. A measure of the variance associated with the resulting site occupancy estimate based on mesohabitat locations occupied was calculated, following methods of MacKenzie et al. (2006) for single sample locality surveys.

In addition to calculating the site occupancy estimates using mesohabitat data, we also constructed a multi-year statistical model based on patterns of occupancy using sampling-site data. Unlike mesohabitats, sampling sites were large enough (ca. 200 m) that it was quite unlikely that the site would change in status from occupied to unoccupied among 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 within a specific site was independent of species detection at other sites. Encounter histories were constructed on the presence or absence of wild Rio Grande silvery minnow at the sampling sites based on four repeated sampling efforts. The encounter history data from the 20 sampling sites over time allowed for a robust-design model of occupancy (MacKenzie et al. 2003) to estimate the probability of occupancy each year (ψ_i, i = 1,2,3...), the probability of extinction given a sampling site was occupied (ε_i, i = 2,3...), and the probability of colonization given a sampling site was not occupied (γ_i, i = 2,3...). Site occupancy models were constructed for age-classes (all fish, age-0, age-1, age-2; each age-class was a separate attribute group [*g*]), with covariates of year (*y* = 2005–2012), and a discharge covariate (*d*) for measured flow (from the nearest USGS gauging station) during sampling. Models were considered that allowed detection probabilities to vary by site and reach. Likewise, probability of occupancy was allowed to vary by reach. The Akaike Information Criterion, corrected for small sample sizes (AIC_C; Akaike, 1973; Burnham and Anderson, 2002), was used to select the most parsimonious site occupancy model based on the encounter history data. In addition to the basic parameter estimates ordered by the age-class variable, detailed estimates of the probability of occupancy were also generated by group and year. Associated measures of sampling variance (SE = standard error) and profile likelihood confidence intervals (LCI = 95% lower confidence bound, UCI = 95% upper confidence bound) were generated for all parameter estimates.

RESULTS

The encounter history for Rio Grande silvery minnow during November 2012, based on mesohabitat data (Table B-1), was dominated by one sampling category (0000 [96.5%]). This represented visits to the same mesohabitat location where Rio Grande silvery minnow were not collected on any of the four days of sampling. The percentage of encounter histories where Rio Grande silvery minnow was collected on more than one day (e.g., 1100) was very low (ca. 0.8%).

Table B-1. Rio Grande silvery minnow encounter history summary, probability of detection estimate, and probability of occupancy estimates based on repeated mesohabitat sampling efforts in November 2012.

RGSM encounter history (all age-classes)

Encounters*	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1100	**1**	**0.25**	**1**	**0.25**
1001	**1**	**0.25**	**2**	**0.50**
1000	**2**	**0.50**	**4**	**1.00**
0101	**1**	**0.25**	**5**	**1.25**
0100	**2**	**0.50**	**7**	**1.75**
0010	**3**	**0.75**	**10**	**2.50**
0001	**4**	**1.00**	**14**	**3.50**
0000	**386**	**96.50**	**400**	**100.00**

*1 = present and 0 = absent over four repeated sampling efforts (e.g., 1001 = present on days 1 and 4 but absent on days 2 and 3).

RGSM probability of detection and probability of occupancy estimates

Parameter	Estimate	Standard Error of Estimate	Lower 95% CI of Estimate	Upper 95% CI of Estimate
***p*: All RGSM**	**0.1020**	**0.0415**	**0.0447**	**0.2163**
ψ: All RGSM	**0.1001**	**0.0433**	**0.0416**	**0.2219**
ψ: Age-0 RGSM	**0.0143**	**0.0112**	**0.0030**	**0.0646**
ψ: Age-1 RGSM	**0.0214**	**0.0144**	**0.0057**	**0.0774**
ψ: Age-2 RGSM	**0.0786**	**0.0357**	**0.0314**	**0.1833**

*Where p = detection probability and ψ (psi) = probability of occupancy.

The other sampling encounter categories had a relatively even probability distribution and there were not strong patterns in the combinations of encounters. The rarest combinations were where individuals were collected on two of the four collection days. Probability of detection and probability of occupancy estimates during 2012 were calculated for all Rio Grande silvery minnow and for the respective age-classes. Age-2 Rio Grande silvery minnow dominated the relative abundance of age-classes and so there were only very minor differences between the calculations for this age-class and for all age-classes combined. The probability of detection estimate for all Rio Grande silvery minnow was 0.1020. The probability of occupancy estimate for all Rio Grande silvery minnow was 0.1001 while the estimate for age-0 individuals was 0.0143. The occupancy estimate for age-1 individuals was 0.0214 and the occupancy estimate for age-2 individuals was 0.0786.

A multi-year statistical model based on patterns of occupancy was also developed using long-term (2005–2012) sampling site data (Table B-2 and Figure B-1). This was different than the preceding analysis (i.e., Table B-1) in that spatial scale was different (i.e., site-specific as opposed to mesohabitat-specific). The minimum AIC_C model had constant occupancy (psi, ψ), extinction (epsilon, ε) and colonization (gamma, γ) parameters varying by year (*y*), and detection probabilities (*p*) varying by year and discharge (*d*). The "group" variable (*g*) was the age-class category (age-0, age-1, age-2, and all age-classes combined). The 2005 site occupancy estimate was 1.0 for all age-classes combined and for the separate age-classes. Estimates of the probability of extinction in 2011 for all age-classes (0.0634) and age-0 (0.1913) individuals were elevated, particularly when considering their upper 95% confidence intervals (0.6568 and 0.8428, respectively). The probability of extinction in 2011 was higher for both age-1 and age-2 individuals (0.4693 and 0.3065, respectively) as compared to age-0 individuals. Estimates of the probability of colonization in 2012 were zero for all age-classes combined and for the separate age-classes. Estimates of the probability of occupancy varied among years and age-classes but were most variable for group/year combinations with fewer data (e.g., age-0 in 2012 and age-2 in 2011). Detailed Rio Grande silvery minnow detection probability estimates among years and for individual sampling occasions (for all sampling sites combined) were generally lowest during years when this species was rare (e.g., 2012) and highest when this species was common (e.g., 2009; Table B-3).

DISCUSSION

Probability of detection values were used to estimate both the proportion of mesohabitat locations and sampling sites occupied by Rio Grande silvery minnow during repeated sampling efforts in November (2005–2012). There are numerous benefits in being able to document the estimated site occupancy rate of species over time. Probability of detection estimates provide insight to patterns of site occupancy of Rio Grande silvery minnow both within and among sampling sites. Site occupancy models can subsequently be developed over time to incorporate changes in the probability of detection and the presence-absence patterns at a particular site.

Site occupancy analyses, based on sampling-site data, revealed that the most parsimonious model had constant occupancy, extinction and colonization varying by year, and detection probabilities varying by year and discharge (during November). One reason that detection probabilities varied with discharge could be that flows during November were unusually high in 2006 (possible outlier), which was also a year with relatively low detection probabilities. Also, the second-most parsimonious model, which had a similar AIC_C weight (w_i) as the most parsimonious model, did not include discharge at all. Further, the w_i values for models with detection probabilities varying by discharge have changed over time (e.g., top model had w_i = 0.88 in 2007 but w_i = 0.38 in 2012). Additional data from future years may result in some changes to the structure of the model since it is based on a relatively short-term data set. Models were not averaged (i.e., only minimum AIC_C

Table B-2. Rio Grande silvery minnow site occupancy analysis among years for all sampling sites combined in the Middle Rio Grande based on repeated site sampling efforts in November (2005–2012). Model parameters: **ψ** = probability of occupancy, **ε** = probability of extinction, **γ** = probability of colonization, *p* = detection probability, *y* = year, *d* = discharge, and *g* = age-class.

RGSM Site Occupancy Models

Models	AIC_c	Delta AIC_c	AIC_c Weights	Model Likelihood	Number of Parameters	Deviance
A: {ψ(*g*) ε(*g+y*) γ(*g+y*) *p*(*g*y+d*)}	1634.1331	0.0000	0.3785	1.0000	57	1508.7723
B: {ψ(*g*) ε(*g+y*) γ(*g+y*) *p*(*g*y*)}	1634.3347	0.2016	0.3422	0.9041	56	1511.3844
C: {ψ(*g*) ε(*g+y*) γ(*g*) *p*(*g*y*)}	1635.8369	1.7038	0.1615	0.4266	50	1527.1781
D: {ψ(*g*) ε(*g*) γ(*g+y*) *p*(*g*y*)}	1637.4752	3.3421	0.0712	0.1880	50	1528.8165
E: {ψ(*g*) ε(*g*) γ(*g*) *p*(*g*y*)}	1638.8408	4.7077	0.0360	0.0950	44	1544.1853

Parameter Estimates from Minimum AIC_c Model (A)

Parameter	Estimate	SE	LCI	UCI
ψ All Fish (2005)	1.0000	0.0000	0.9085	1.0000
ψ Age-0 (2005)	1.0000	0.0000	0.9085	1.0000
ψ Age-1 (2005)	1.0000	0.0003	0.2201	1.0000
ψ Age-2 (2005)	1.0000	0.0000	1.0000	1.0000
ε All Fish (2011)	0.0634	0.0938	0.0000	0.6568
ε Age-0 (2011)	0.1913	0.2022	0.0000	0.8428
ε Age-1 (2011)	0.4693	0.3047	0.0000	0.9461
ε Age-2 (2011)	0.3065	0.2059	0.0000	0.7432
γ All Fish (2012)	0.0000	0.0000	0.0000	0.0000
γ Age-0 (2012)	0.0000	0.0000	0.0000	0.0000
γ Age-1 (2012)	0.0000	0.0000	0.0000	0.0000
γ Age-2 (2012)	0.0000	0.0000	0.0000	0.0000

Derived estimates of ψ by Year (last four years) from Minimum AIC_c Model (A)

Group	Year	Estimate	SE	LCI	UCI
All Fish	2009	0.9385	0.0401	0.7963	0.9835
All Fish	2010	0.9166	0.0526	0.7403	0.9770
All Fish	2011	0.8268	0.0965	0.5604	0.9470
All Fish	2012	0.7743	0.1525	0.3827	0.9500
Age-0	2009	0.9449	0.0380	0.8039	0.9863
Age-0	2010	0.8913	0.0503	0.7479	0.9577
Age-0	2011	0.6776	0.0918	0.4798	0.8273
Age-0	2012	0.5480	0.1718	0.2374	0.8252
Age-1	2009	0.8320	0.0823	0.6095	0.9401
Age-1	2010	0.6833	0.0908	0.4865	0.8309
Age-1	2011	0.3589	0.0911	0.2048	0.5489
Age-1	2012	0.1905	0.1225	0.0473	0.5275
Age-2	2009	0.8494	0.0902	0.5861	0.9574
Age-2	2010	0.7584	0.1038	0.5083	0.9051
Age-2	2011	0.4739	0.1533	0.2126	0.7504
Age-2	2012	0.3287	0.1343	0.1293	0.6174

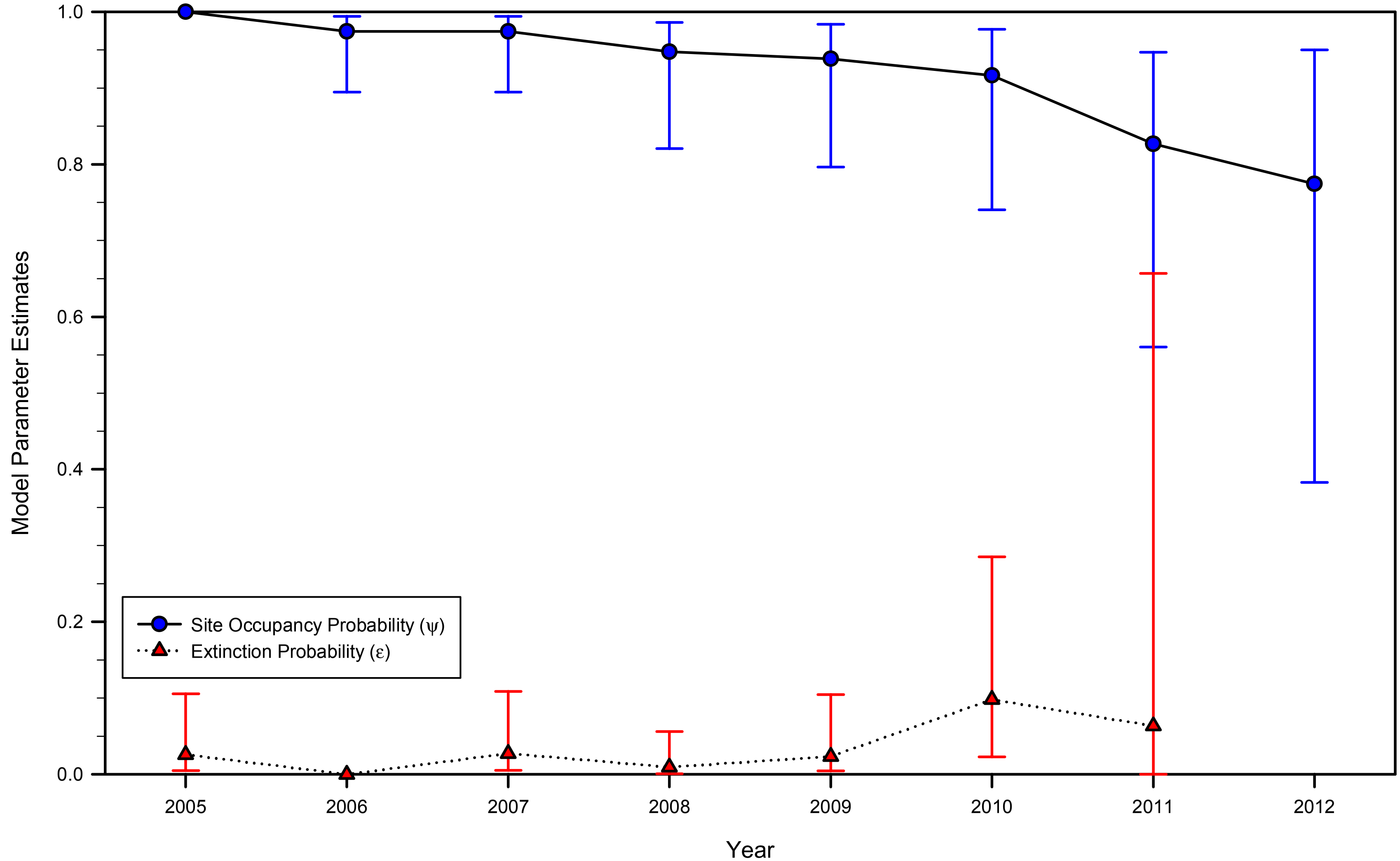


Figure B-1. Site occupancy model estimates (site occupancy (ψ) and extinction probabilities (ε)) for Rio Grande silvery minnow based on repeated site sampling efforts from 2005 to 2012. Symbols indicate means and capped-bars represent 95% confidence intervals.

Table B-3. Rio Grande silvery minnow detection probability estimates among years for all sampling sites combined in the Middle Rio Grande based on repeated site sampling efforts in November (2005–2012).

Detection Probability Estimates from Minimum AIC_c Model (A)

Group*	Estimate	SE	LCI	UCI
p 2005 All Day 1	0.9752	0.0173	0.9061	0.9938
p 2005 All Day 2	0.9751	0.0174	0.9060	0.9938
p 2005 All Day 3	0.9751	0.0174	0.9058	0.9938
p 2005 All Day 4	0.9749	0.0175	0.9052	0.9937
p 2005 Age-0 Day 1	0.9752	0.0173	0.9061	0.9938
p 2005 Age-0 Day 2	0.9751	0.0174	0.9060	0.9938
p 2005 Age-0 Day 3	0.9751	0.0174	0.9058	0.9938
p 2005 Age-0 Day 4	0.9749	0.0175	0.9052	0.9937
p 2005 Age-1 Day 1	0.1877	0.0437	0.1164	0.2884
p 2005 Age-1 Day 2	0.1875	0.0437	0.1163	0.2881
p 2005 Age-1 Day 3	0.1872	0.0436	0.1161	0.2878
p 2005 Age-1 Day 4	0.1863	0.0434	0.1154	0.2865
p 2005 Age-2 Day 1	0.0125	0.0124	0.0018	0.0834
p 2005 Age-2 Day 2	0.0125	0.0124	0.0018	0.0833
p 2005 Age-2 Day 3	0.0125	0.0124	0.0018	0.0832
p 2005 Age-2 Day 4	0.0124	0.0123	0.0017	0.0827
p 2006 All Day 1	0.8907	0.0353	0.8003	0.9431
p 2006 All Day 2	0.8816	0.0372	0.7874	0.9373
p 2006 All Day 3	0.8806	0.0374	0.7859	0.9368
p 2006 All Day 4	0.8784	0.0380	0.7824	0.9356
p 2006 Age-0 Day 1	0.8341	0.0478	0.7187	0.9082
p 2006 Age-0 Day 2	0.8212	0.0504	0.7010	0.9000
p 2006 Age-0 Day 3	0.8198	0.0507	0.6989	0.8992
p 2006 Age-0 Day 4	0.8168	0.0515	0.6941	0.8975
p 2006 Age-1 Day 1	0.7126	0.0546	0.5951	0.8071
p 2006 Age-1 Day 2	0.6938	0.0550	0.5769	0.7901
p 2006 Age-1 Day 3	0.6918	0.0552	0.5747	0.7885
p 2006 Age-1 Day 4	0.6874	0.0557	0.5696	0.7851
p 2006 Age-2 Day 1	0.0630	0.0322	0.0225	0.1639
p 2006 Age-2 Day 2	0.0579	0.0298	0.0206	0.1519
p 2006 Age-2 Day 3	0.0574	0.0296	0.0204	0.1508
p 2006 Age-2 Day 4	0.0563	0.0291	0.0200	0.1485
p 2007 All Day 1	0.9872	0.0127	0.9145	0.9982
p 2007 All Day 2	0.9871	0.0128	0.9144	0.9982
p 2007 All Day 3	0.9869	0.0130	0.9131	0.9982
p 2007 All Day 4	0.9862	0.0137	0.9085	0.9981
p 2007 Age-0 Day 1	0.9872	0.0127	0.9145	0.9982
p 2007 Age-0 Day 2	0.9871	0.0128	0.9144	0.9982
p 2007 Age-0 Day 3	0.9869	0.0130	0.9131	0.9982
p 2007 Age-0 Day 4	0.9862	0.0137	0.9085	0.9981
p 2007 Age-1 Day 1	0.0926	0.0334	0.0447	0.1819
p 2007 Age-1 Day 2	0.0924	0.0333	0.0446	0.1816
p 2007 Age-1 Day 3	0.0910	0.0329	0.0439	0.1792
p 2007 Age-1 Day 4	0.0865	0.0315	0.0415	0.1716
p 2007 Age-2 Day 1	0.0000	0.0000	0.0000	0.0000
p 2007 Age-2 Day 2	0.0000	0.0000	0.0000	0.0000
p 2007 Age-2 Day 3	0.0000	0.0000	0.0000	0.0000
p 2007 Age-2 Day 4	0.0000	0.0000	0.0000	0.0000

*Where *p* = detection probability and day is the sampling occasion sequence for a particular year.

Table B-3. (continued) Rio Grande silvery minnow detection probability estimates among years for all sampling sites combined in the Middle Rio Grande based on repeated site sampling efforts in November (2005–2012).

Detection Probability Estimates from Minimum AIC_c Model (A)

Group*	Estimate	SE	LCI	UCI
p 2008 All Day 1	1.0000	0.0000	1.0000	1.0000
p 2008 All Day 2	1.0000	0.0000	1.0000	1.0000
p 2008 All Day 3	1.0000	0.0000	1.0000	1.0000
p 2008 All Day 4	1.0000	0.0000	1.0000	1.0000
p 2008 Age-0 Day 1	1.0000	0.0000	1.0000	1.0000
p 2008 Age-0 Day 2	1.0000	0.0000	1.0000	1.0000
p 2008 Age-0 Day 3	1.0000	0.0000	1.0000	1.0000
p 2008 Age-0 Day 4	1.0000	0.0000	1.0000	1.0000
p 2008 Age-1 Day 1	0.6181	0.0802	0.4541	0.7590
p 2008 Age-1 Day 2	0.6200	0.0800	0.4561	0.7604
p 2008 Age-1 Day 3	0.6211	0.0799	0.4573	0.7613
p 2008 Age-1 Day 4	0.6226	0.0798	0.4589	0.7624
p 2008 Age-2 Day 1	0.1382	0.0591	0.0571	0.2979
p 2008 Age-2 Day 2	0.1391	0.0595	0.0575	0.2997
p 2008 Age-2 Day 3	0.1397	0.0597	0.0577	0.3007
p 2008 Age-2 Day 4	0.1404	0.0600	0.0581	0.3021
p 2009 All Day 1	1.0000	0.0000	1.0000	1.0000
p 2009 All Day 2	1.0000	0.0000	1.0000	1.0000
p 2009 All Day 3	1.0000	0.0000	1.0000	1.0000
p 2009 All Day 4	1.0000	0.0000	1.0000	1.0000
p 2009 Age-0 Day 1	1.0000	0.0000	1.0000	1.0000
p 2009 Age-0 Day 2	1.0000	0.0000	1.0000	1.0000
p 2009 Age-0 Day 3	1.0000	0.0000	1.0000	1.0000
p 2009 Age-0 Day 4	1.0000	0.0000	1.0000	1.0000
p 2009 Age-1 Day 1	0.7339	0.0551	0.6134	0.8275
p 2009 Age-1 Day 2	0.7324	0.0553	0.6115	0.8263
p 2009 Age-1 Day 3	0.7327	0.0552	0.6120	0.8266
p 2009 Age-1 Day 4	0.7322	0.0553	0.6114	0.8262
p 2009 Age-2 Day 1	0.2221	0.0633	0.1222	0.3692
p 2009 Age-2 Day 2	0.2207	0.0629	0.1214	0.3672
p 2009 Age-2 Day 3	0.2210	0.0630	0.1216	0.3676
p 2009 Age-2 Day 4	0.2205	0.0629	0.1213	0.3670
p 2010 All Day 1	0.8885	0.0372	0.7925	0.9433
p 2010 All Day 2	0.8897	0.0368	0.7944	0.9439
p 2010 All Day 3	0.8894	0.0369	0.7940	0.9438
p 2010 All Day 4	0.8877	0.0374	0.7912	0.9428
p 2010 Age-0 Day 1	0.9212	0.0339	0.8238	0.9669
p 2010 Age-0 Day 2	0.9220	0.0336	0.8255	0.9673
p 2010 Age-0 Day 3	0.9218	0.0337	0.8252	0.9672
p 2010 Age-0 Day 4	0.9206	0.0342	0.8226	0.9666
p 2010 Age-1 Day 1	0.7125	0.0596	0.5836	0.8142
p 2010 Age-1 Day 2	0.7149	0.0593	0.5865	0.8160
p 2010 Age-1 Day 3	0.7144	0.0593	0.5859	0.8156
p 2010 Age-1 Day 4	0.7109	0.0598	0.5816	0.8130
p 2010 Age-2 Day 1	0.3976	0.0698	0.2715	0.5389
p 2010 Age-2 Day 2	0.4004	0.0701	0.2737	0.5419
p 2010 Age-2 Day 3	0.3998	0.0700	0.2733	0.5413
p 2010 Age-2 Day 4	0.3957	0.0697	0.2700	0.5369

*Where *p* = detection probability and day is the sampling occasion sequence for a particular year.

Table B-3. (continued) Rio Grande silvery minnow detection probability estimates among years for all sampling sites combined in the Middle Rio Grande based on repeated site sampling efforts in November (2005–2012).

Detection Probability Estimates from Minimum AIC$_c$ Model (A)

Group*	Estimate	SE	LCI	UCI
p 2011 All Day 1	0.7095	0.0554	0.5906	0.8053
p 2011 All Day 2	0.7009	0.0563	0.5806	0.7986
p 2011 All Day 3	0.7019	0.0561	0.5819	0.7994
p 2011 All Day 4	0.7050	0.0558	0.5855	0.8017
p 2011 Age-0 Day 1	0.7704	0.0546	0.6470	0.8600
p 2011 Age-0 Day 2	0.7630	0.0557	0.6377	0.8548
p 2011 Age-0 Day 3	0.7639	0.0555	0.6389	0.8554
p 2011 Age-0 Day 4	0.7665	0.0551	0.6422	0.8572
p 2011 Age-1 Day 1	0.6301	0.1291	0.3652	0.8346
p 2011 Age-1 Day 2	0.6204	0.1300	0.3565	0.8282
p 2011 Age-1 Day 3	0.6216	0.1298	0.3576	0.8289
p 2011 Age-1 Day 4	0.6250	0.1295	0.3606	0.8312
p 2011 Age-2 Day 1	0.1825	0.0735	0.0783	0.3695
p 2011 Age-2 Day 2	0.1763	0.0712	0.0757	0.3589
p 2011 Age-2 Day 3	0.1771	0.0715	0.0760	0.3601
p 2011 Age-2 Day 4	0.1792	0.0723	0.0769	0.3638
p 2012 All Day 1	0.1944	0.0600	0.1022	0.3385
p 2012 All Day 2	0.1938	0.0599	0.1018	0.3376
p 2012 All Day 3	0.1928	0.0597	0.1012	0.3362
p 2012 All Day 4	0.1917	0.0595	0.1005	0.3347
p 2012 Age-0 Day 1	0.0413	0.0308	0.0093	0.1653
p 2012 Age-0 Day 2	0.0412	0.0307	0.0093	0.1648
p 2012 Age-0 Day 3	0.0409	0.0305	0.0092	0.1639
p 2012 Age-0 Day 4	0.0406	0.0303	0.0091	0.1630
p 2012 Age-1 Day 1	0.4670	0.2048	0.1487	0.8146
p 2012 Age-1 Day 2	0.4660	0.2047	0.1482	0.8140
p 2012 Age-1 Day 3	0.4644	0.2046	0.1474	0.8130
p 2012 Age-1 Day 4	0.4627	0.2045	0.1466	0.8119
p 2012 Age-2 Day 1	0.3097	0.1087	0.1421	0.5486
p 2012 Age-2 Day 2	0.3088	0.1085	0.1416	0.5476
p 2012 Age-2 Day 3	0.3075	0.1082	0.1409	0.5459
p 2012 Age-2 Day 4	0.3060	0.1079	0.1401	0.5441

*Where *p* = detection probability and day is the sampling occasion sequence for a particular year.

model was used) because some parameters had SE = 0, which precluded model averaging and required that profile likelihood confidence intervals (range = 0–1) be used. Also, the estimates did not change appreciably among the models, as demonstrated by the year-specific estimates of *p* among the repeated sampling efforts. Parameter estimates from the model suggest that site occupancy is highest for age-0 fish but lower for age-1 and age-2 fish. However, the low number of all age-classes in 2012 individuals added notable variation to the estimates for these age-classes. Estimates of site occupancy indicated about a 3% per year decline in the number of sampling sites occupied by Rio Grande silvery minnow since 2005 (ca. 23% decline). This suggests that Rio Grande silvery minnow have been cumulatively lost from more than 20% of their occupied localities within the Middle Rio Grande since 2005. Parameter estimates from the model could, however, change dramatically if there are sequential years of either persistently high or low flows. Thus, the overall extinction probability and site occupancy estimates should be viewed only as an historical analysis of past data as opposed to a prediction of future trends.

The site occupancy results should be used in combination with population monitoring results to provide a more complete understanding of the conservation status of Rio Grande silvery minnow. It is well known that simply having large numbers of a particular species in an area doesn't ensure its long-term survival. This is particularly true for short-lived species such as Rio Grande silvery minnow. The dramatic population fluctuations of this species within short time periods underscore the need to consistently ensure the presence of individuals over a broad geographical range. Changing environmental conditions can have rapid and severe impacts to local populations of Rio Grande silvery minnow (e.g., San Acacia Reach of the Middle Rio Grande). For example, poor spring runoff conditions often appear to inhibit spawning and limit recruitment to such a degree that reach-specific populations may decline several orders of magnitude within a year. Additionally, river drying during drought years has regularly resulted in the apparent 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 low recruitment, the total population is not well buffered by surviving age-classes. For these reasons, it is imperative that populations of Rio Grande silvery minnow are established at multiple locations within its current and historical range to help ensure its long-term persistence in the wild.

Multi-year statistical models suggest that site occupancy and extinction probabilities will be difficult to predict even when Rio Grande silvery minnow is present at most of the existing sampling sites. The current number of sampling sites for the site occupancy analysis was chosen during 2005 when Rio Grande silvery minnow was abundant and present at all sites. While this sampling protocol was adequate during periods of relatively high abundance and presence at nearly all sites, the ability to precisely estimate site occupancy and extinction probabilities was compromised during periods of relatively low abundance and presence at only a fraction of the sampling sites, which also corresponded to low detection probabilities. This uncertainty was compounded during drought years (e.g., 2010–2012) when individuals were only occasionally present at extremely low densities. Additional sampling sites would provide a more precise and meaningful estimate of site occupancy and extinction probabilities, particularly during years with low numbers and an uncertain distribution of Rio Grande silvery minnow.

The success of this project will be evaluated annually but insight into the efficacy of estimating site occupancy rates of Rio Grande silvery minnow will require a multi-year commitment. Data from future year's efforts will provide additional information that will supplement recent site occupancy analyses and furnish valuable information necessary to gauge recovery of Rio Grande silvery minnow in the Middle Rio Grande. Ultimately, these data will be used to evaluate progress towards meeting Rio Grande silvery minnow recovery goals, following both planned management actions and stochastic environmental events.

LITERATURE CITED

Akaike, H. 1973. Information theory as an extension of the maximum likelihood principle. *In*: B. N. Petrov and F. Csaki (eds.). Second International Symposium on Information Theory. Akademiai, Budapest.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd Edition. Springer-Verlag, New York, New York, USA. 488 pp.

Dudley, R. K., G. C. White, S. P. Platania, and D. A Helfrich. 2012. Rio Grande silvery minnow population estimation program results from October 2011. Report to the Middle Rio Grande Endangered Species Collaborative Program and the U.S. Bureau of Reclamation, Albuquerque, New Mexico. 87 pp.

Finley, D. J., G. C. White and J. P. Fitzgerald. 2005. Estimation of swift fox population size and occupancy rates in eastern Colorado. Journal of Wildlife Management 69:861–873.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

MacKenzie, D. I., J. D. Nichols, J. E. Hines, M. G. Knutson, and A. B. Franklin. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84:2200–2207.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy Estimation and Modeling : Inferring Patterns and Dynamics of Species Occurrence. Elsevier, Burlington, MA.

Royle, J. A., and J. D. Nichols. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777–790.

White, G. C. 2005. Correcting wildlife counts using detection probabilities. Wildlife Research 32: 211–216.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 Supplement:120–138.

Appendix C

Table C-1. Water quality* summary statistics [Mean (Standard Error)], by sampling site and reach, during the December 2011 to October 2012 population monitoring of Rio Grande silvery minnow.

REACH Sampling Site and Name	Sec.	Temp.	Sal.	D.O.	Con. T.	Con.S.	pH
ANGOSTURA REACH							
0 Angostura Dam	38.1 (9.2)	15.1 (2.3)	0.1 (0)	7.8 (0.7)	229.2 (20.5)	287.1 (19.1)	8.1 (0.2)
1 Bernalillo	25.9 (4.1)	16.5 (2.4)	0.1 (0)	8.3 (0.5)	241.5 (20.1)	285.7 (22.5)	8.1 (0.2)
2 Rio Rancho	24.1 (4.2)	17.1 (2.6)	0.2 (0)	8.2 (0.5)	266.1 (19.5)	319.8 (9.6)	8.2 (0.2)
3 Central Ave.	14.8 (3.3)	16 (2.7)	0.2 (0)	7.9 (0.6)	274.4 (26.4)	334.1 (14.6)	8.1 (0.2)
4 Rio Bravo Blvd.	12.6 (2.9)	16.6 (2.8)	0.2 (0)	7.8 (0.6)	279 (26.2)	327.2 (23.8)	8.1 (0.3)
ISLETA REACH							
5 Los Lunas	12.2 (3.1)	19.1 (4.8)	0.2 (0)	8.2 (1.6)	347.9 (58.3)	380.2 (35.6)	8.5 (0.2)
6 Belen	15.3 (2.9)	21.3 (3.6)	0.2 (0)	7.3 (0.8)	400.4 (54.4)	413.9 (33.8)	8.7 (0.2)
7 Jarales	14.1 (1.9)	19.9 (3.3)	0.2 (0)	8.5 (0.7)	456.4 (86.7)	484.4 (63.1)	8.6 (0.2)
8 Bernardo	14 (2.6)	18 (2.9)	0.2 (0)	8.1 (0.6)	452.9 (62.5)	475.3 (62.7)	8.6 (0.1)
9 La Joya	15.2 (2.4)	16.1 (2.8)	0.3 (0.1)	8.1 (0.6)	590.2 (123.5)	660.5 (108.7)	8.4 (0.2)
9.5 North of San Acacia	6.6 (1.6)	19.7 (2.6)	0.4 (0.1)	8.1 (0.7)	706 (170.9)	774.4 (133.2)	8.4 (0.2)
SAN ACACIA REACH							
10 San Acacia Dam	8.4 (2.5)	18.1 (2.1)	0.4 (0.1)	8.2 (0.7)	815.8 (232)	919 (225.9)	8.2 (0.2)
11 South of San Acacia	7 (1.7)	17.8 (2.8)	0.4 (0.1)	8.4 (0.8)	745.1 (210.8)	826.3 (197)	8.3 (0.1)
12 Socorro	6.1 (2)	18.2 (3.1)	0.3 (0.1)	8.9 (0.7)	670.1 (165)	733.2 (140.8)	8.4 (0.2)
13 North of San Antonio	5.8 (2.4)	14.6 (3.2)	0.2 (0)	9.3 (1.2)	441.3 (162.5)	546.8 (158.7)	8.2 (0.2)
14 San Antonio	5.7 (2.3)	18.3 (3.8)	0.2 (0)	8 (0.8)	396.1 (70)	462.2 (56.5)	7.8 (0.4)
15 South of San Antonio	5.7 (2.5)	17.7 (3.8)	0.3 (0.1)	7.9 (1)	567 (189.7)	629.6 (167.4)	7.8 (0.4)
16 San Marcial	10.3 (2.7)	19.6 (3)	0.4 (0.1)	8.6 (0.6)	767.6 (145.9)	826.5 (119.9)	8 (0.3)
17 South of San Marcial 1	11.8 (3.9)	18.1 (2.8)	0.3 (0.1)	7.7 (0.7)	659 (95.2)	732.5 (88.7)	8 (0.3)
18 South of San Marcial 2	14.1 (5.1)	17.9 (2.9)	0.4 (0.1)	7.5 (0.8)	633.7 (111.6)	733.4 (100.8)	7.8 (0.2)

*Water quality codes:
Sec. = Secchi depth (cm)
Temp. = Water Temperature (°C)
Sal. = Salinity (ppt)
D.O. = Dissolved Oxygen (mg/l)
Con. T. = True Conductivity (µs)
Con. S. = Specific Conductance (µs)
pH = pH (dimensionless measure of the acidity or basicity of a solution)

Appendix D.

Ichthyofaunal composition of the December 2011 to October 2012
Rio Grande silvery minnow population monitoring samples

Monthly trip reports and associated data are available at:
http://www.asirllc.com/rgsm/rgsm2011/
and
http://www.asirllc.com/rgsm/rgsm2012/

Rio Grande silvery minnow Population Monitoring
December 2011

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0

02 December 2011 **RKD11-278** River Mile: 209.7

UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 522.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	6
76	*Rhinichthys cataractae*	1

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1

02 December 2011 **RKD11-279** River Mile: 203.8

UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 537.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	26
76	*Platygobio gracilis*	31
76	*Rhinichthys cataractae*	1

Rio Grande silvery minnow Population Monitoring
December 2011

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho. Site Number: 2
River Mile: 200.0
02 December 2011 **RKD11-280**
UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 508.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	76
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	3
212	*Gambusia affinis*	21

*** *Hybognathus amarus* by age class:**

age-0: 2
age-1:
age-2:

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3
02 December 2011 **RKD11-277** River Mile: 183.4
UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 519.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	27
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	6
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring

December 2011

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4
River Mile: 178.3
02 December 2011 **RKD11-276**
UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 467.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	4
76	*Hybognathus amarus**	5
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	8
212	*Gambusia affinis*	1

*** *Hybognathus amarus* by age class:**

age-0: 5
age-1:
age-2:

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5
02 December 2011 **RKD11-275** River Mile: 161.4
UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas
W.H.Brandenburg, M.A.Farrington, J.L.Hester Effort: 521.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	12
76	*Hybognathus amarus**	13
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	3
93	*Ictalurus punctatus*	2

*** *Hybognathus amarus* by age class:**

age-0: 12
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring

December 2011

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

02 December 2011 **RKD11-274** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome

W.H.Brandenburg, M.A.Farrington, J.L.Hester Effort: 434.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	183
76	*Hybognathus amarus**	19
76	*Pimephales promelas*	21

*** *Hybognathus amarus* by age class:**

age-0: 19
age-1:
age-2:

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

02 December 2011 **RKD11-273** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

W.H.Brandenburg, M.A.Farrington, J.L.Hester Effort: 392.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	661
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	46
76	*Pimephales promelas*	50
81	*Carpiodes carpio*	31
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0: 41
age-1: 4
age-2: 1

Rio Grande silvery minnow Population Monitoring
December 2011

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8

02 December 2011 **RKD11-272** River Mile: 130.6

UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas

W.H.Brandenburg, M.A.Farrington, J.L.Hester Effort: 459.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	396
76	*Cyprinus carpio*	4
76	*Hybognathus amarus**	9
76	*Pimephales promelas*	9
81	*Carpiodes carpio*	40
212	*Gambusia affinis*	65
294	*Lepomis macrochirus*	1

*** *Hybognathus amarus* by age class:**

age-0: 7

age-1: 1

age-2: 1

Rio Grande silvery minnow Population Monitoring
December 2011

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9

02 December 2011 **RKD11-271** River Mile: 127.0

UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas

W.H.Brandenburg, M.A.Farrington, J.L.Hester Effort: 422.8 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	426
76	*Hybognathus amarus**	16
76	*Pimephales promelas*	12
81	*Carpiodes carpio*	22
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	37

*** *Hybognathus amarus* by age class:**

age-0: 15
age-1: 1
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia Site Number: 9.5

01 December 2011 **RKD11-270** River Mile: 116.8

UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 521.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	5
76	*Hybognathus amarus**	38
76	*Platygobio gracilis*	30
81	*Carpiodes carpio*	2

*** *Hybognathus amarus* by age class:**

age-0: 38
age-1:
age-2:

Rio Grande silvery minnow Population Monitoring

December 2011

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, directly below San Acacia Diversion Dam, San Acacia. Site Number: 10

01 December 2011 **RKD11-269** River Mile: 116.2

UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 437.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	7
76	*Hybognathus amarus**	35
76	*Platygobio gracilis*	44
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0: 35

age-1:

age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

01 December 2011 **RKD11-268** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 517.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	9
76	*Hybognathus amarus**	36
76	*Platygobio gracilis*	25
81	*Carpiodes carpio*	1

*** *Hybognathus amarus* by age class:**

age-0: 36

age-1:

age-2:

Rio Grande silvery minnow Population Monitoring

December 2011

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. Site Number: 12 River Mile: 99.5
01 December 2011 **RKD11-267**
UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 551.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	15
76	*Platygobio gracilis*	5

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13
01 December 2011 **RKD11-266** River Mile: 91.7
UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 460.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14
30 November 2011 **RKD11-265** River Mile: 87.1
UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 468.5 sq. m

FAMILY		N
	No Fish Collected	

Rio Grande silvery minnow Population Monitoring

December 2011

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15

30 November 2011 **RKD11-264** River Mile: 79.1

UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 459.5 sq. m

FAMILY		N
76	*Hybognathus amarus**	5

*** *Hybognathus amarus* by age class:**

age-0: 5
age-1:
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16

30 November 2011 **RKD11-263** River Mile: 68.6

UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 467.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	8
76	*Hybognathus amarus**	6
76	*Platygobio gracilis*	4

*** *Hybognathus amarus* by age class:**

age-0: 5
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring

December 2011

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing — Site Number: 17
30 November 2011 — **RKD11-262** — River Mile: 60.5
UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well
R.K.Dudley, R.C.Keller, S.A.Zipper — Effort: 524.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	3
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	91
76	*Pimephales vigilax*	1
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	5
93	*Ictalurus punctatus*	14

*** *Hybognathus amarus* by age class:**

age-0: 91
age-1:
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18
30 November 2011 — **RKD11-261** — River Mile: 58.8
UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well
R.K.Dudley, R.C.Keller, S.A.Zipper — Effort: 473.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	11
76	*Hybognathus amarus**	73
76	*Pimephales vigilax*	1
93	*Ictalurus punctatus*	21

*** *Hybognathus amarus* by age class:**

age-0: 73
age-1:
age-2:

Rio Grande silvery minnow Population Monitoring

February 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0
02 February 2012 **RKD12-018** River Mile: 209.7
UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 538.3 sq. m

FAMILY		N
	No Fish Collected	

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1
02 February 2012 **RKD12-019** River Mile: 203.8
UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 530.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	23
76	*Platygobio gracilis*	2

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho. Site Number: 2 River Mile: 200.0
02 February 2012 **RKD12-020**
UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 550.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	14
76	*Platygobio gracilis*	1

Rio Grande silvery minnow Population Monitoring

February 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

02 February 2012 **RKD12-017** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 522.3 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	1
76	*Platygobio gracilis*	2

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4

River Mile: 178.3

02 February 2012 **RKD12-016**

UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 558.0 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	13

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5

02 February 2012 **RKD12-015** River Mile: 161.4

UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas

M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 512.8 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	198
76	*Hybognathus amarus**	50
81	*Carpiodes carpio*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 50
age-2:

Rio Grande silvery minnow Population Monitoring

February 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

02 February 2012 **RKD12-014** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome

M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 536.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	69
76	*Hybognathus amarus**	5
212	*Gambusia affinis*	32

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 5

age-2:

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

02 February 2012 **RKD12-013** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 494.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	298
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	1
212	*Gambusia affinis*	11
294	*Pomoxis annularis*	2

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 3

age-2:

Rio Grande silvery minnow Population Monitoring
February 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8
02 February 2012 **RKD12-012** River Mile: 130.6
UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas
M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 498.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	78
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	6
212	*Gambusia affinis*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9
02 February 2012 **RKD12-011** River Mile: 127.0
UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas
M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 529.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	497
76	*Hybognathus amarus**	4
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	6
294	*Pomoxis annularis*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 4
age-2:

Rio Grande silvery minnow Population Monitoring

February 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia — Site Number: 9.5
01 February 2012 — **RKD12-010** — River Mile: 116.8
UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya
M.A.Farrington, W.H.Brandenburg, J.L.Hester — Effort: 517.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	11
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	5
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 2
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly below San Acacia Diversion Dam, San Acacia. — Site Number: 10
01 February 2012 — **RKD12-009** — River Mile: 116.2
UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia
M.A.Farrington, W.H.Brandenburg, J.L.Hester — Effort: 567.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	2
76	*Hybognathus amarus**	7
76	*Platygobio gracilis*	15
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 7
age-2:

Rio Grande silvery minnow Population Monitoring
February 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11
01 February 2012 **RKD12-008** River Mile: 114.6
UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar
M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 563.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	20
76	*Hybognathus amarus**	7
76	*Platygobio gracilis*	15
212	*Gambusia affinis*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 7
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. Site Number: 12 River Mile: 99.5
01 February 2012 **RKD12-007**
UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas
M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 565.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	52
76	*Hybognathus amarus**	6
76	*Platygobio gracilis*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 6
age-2:

Rio Grande silvery minnow Population Monitoring

February 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13

01 February 2012 **RKD12-006** River Mile: 91.7

UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio

M.A.Farrington, W.H.Brandenburg, J.L.Hester Effort: 575.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	9
76	*Hybognathus amarus**	23

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 23

age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14

01 February 2012 **RKD12-005** River Mile: 87.1

UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio

R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 595.8 sq. m

FAMILY		N
76	*Hybognathus amarus**	18

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 18

age-2:

Rio Grande silvery minnow Population Monitoring
February 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
01 February 2012 **RKD12-004** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 545.0 sq. m

FAMILY		N
76	*Hybognathus amarus**	20

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 20
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
01 February 2012 **RKD12-003** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
R.K.Dudley, R.C.Keller, S.A.Zipper Effort: 498.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	31
76	*Hybognathus amarus**	7
93	*Ictalurus punctatus*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 7
age-2:

Rio Grande silvery minnow Population Monitoring

February 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing — Site Number: 17

01 February 2012 — **RKD12-002** — River Mile: 60.5

UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well

R.K.Dudley, R.C.Keller, S.A.Zipper — Effort: 548.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	14
76	*Hybognathus amarus**	29
76	*Pimephales promelas*	2
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 29

age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18

01 February 2012 — **RKD12-001** — River Mile: 58.8

UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well

R.K.Dudley, R.C.Keller, S.A.Zipper — Effort: 494.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	9
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	20
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	20

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 20

age-2:

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0
05 April 2012 **RKD12-038** River Mile: 209.7
UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo
W.H.Brandenburg, J.L.Hester, A.L.Barkalow Effort: 478.3 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	2
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	4
76	*Rhinichthys cataractae*	1
81	*Catostomus commersonii*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1
05 April 2012 **RKD12-039** River Mile: 203.8
UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo
W.H.Brandenburg, J.L.Hester, A.L.Barkalow Effort: 546.9 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	107
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	18
76	*Rhinichthys cataractae*	5
81	*Catostomus commersonii*	8

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho.

Site Number: 2

River Mile: 200.0

05 April 2012 **RKD12-040**

UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo

W.H.Brandenburg, J.L.Hester, A.L.Barkalow

Effort: 394.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	254
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	13
76	*Platygobio gracilis*	18
81	*Catostomus commersonii*	35
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	2
294	*Lepomis macrochirus*	2
295	*Perca flavescens*	1

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 3

age-2:

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

05 April 2012 **RKD12-037** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

W.H.Brandenburg, J.L.Hester, A.L.Barkalow Effort: 469.4 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	86
76	*Hybognathus amarus**	5
76	*Pimephales promelas*	13
76	*Platygobio gracilis*	13
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 5

age-2:

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4
River Mile: 178.3
05 April 2012 **RKD12-036**
UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West
W.H.Brandenburg, J.L.Hester, A.L.Barkalow Effort: 448.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	41
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	4
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	4
294	*Lepomis macrochirus*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5
04 April 2012 **RKD12-035** River Mile: 161.4
UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas
W.H.Brandenburg, A.L.Barkalow, S.J.Sasek Effort: 501.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	78
76	*Hybognathus amarus**	11
76	*Pimephales promelas*	2
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	6

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 11
age-2:

Rio Grande silvery minnow Population Monitoring
April 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6
04 April 2012 **RKD12-034** River Mile: 151.5
UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome
W.H.Brandenburg, A.L.Barkalow, S.J.Sasek Effort: 402.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	504
76	*Cyprinus carpio*	5
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	9
81	*Carpiodes carpio*	6
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	13

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 3
age-2:

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7
04 April 2012 **RKD12-033** River Mile: 143.2
UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita
W.H.Brandenburg, A.L.Barkalow, S.J.Sasek Effort: 390.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	98
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	1
212	*Gambusia affinis*	14

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring
April 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8

04 April 2012 **RKD12-032** River Mile: 130.6

UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas

W.H.Brandenburg, A.L.Barkalow, S.J.Sasek Effort: 353.9 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	335
76	*Cyprinus carpio*	3
76	*Pimephales promelas*	4
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	21

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9

04 April 2012 **RKD12-031** River Mile: 127.0

UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas

W.H.Brandenburg, A.L.Barkalow, S.J.Sasek Effort: 350.9 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	195
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	1
81	*Carpiodes carpio*	5
93	*Ictalurus punctatus*	5

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 1

age-2:

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia — Site Number: 9.5

05 April 2012 — **RKD12-030** — River Mile: 116.8

UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya

R.K.Dudley, M.A.Farrington, S.J.Sasek — Effort: 490.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	85
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	12
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	3

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, directly below San Acacia Diversion Dam, San Acacia. — Site Number: 10

05 April 2012 — **RKD12-029** — River Mile: 116.2

UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia

R.K.Dudley, M.A.Farrington, S.J.Sasek — Effort: 467.5 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	8
76	*Cyprinella lutrensis*	20
76	*Cyprinus carpio*	1
76	*Platygobio gracilis*	10
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	1

Rio Grande silvery minnow Population Monitoring
April 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

05 April 2012 **RKD12-028** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar

R.K.Dudley, M.A.Farrington, S.J.Sasek Effort: 521.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	55
76	*Hybognathus amarus**	26
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	7
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	8

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 26
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. Site Number: 12 River Mile: 99.5

05 April 2012 **RKD12-027**

UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas

R.K.Dudley, M.A.Farrington, S.J.Sasek Effort: 413.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	46

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13
05 April 2012 **RKD12-026** River Mile: 91.7
UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio
R.K.Dudley, M.A.Farrington, S.J.Sasek Effort: 440.3 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	3
81	*Carpiodes carpio*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14
04 April 2012 **RKD12-025** River Mile: 87.1
UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio
R.K.Dudley, M.A.Farrington, J.L.Hester Effort: 355.7 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	2
76	*Hybognathus amarus**	3
93	*Ictalurus punctatus*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 3
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
04 April 2012 **RKD12-024** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
R.K.Dudley, M.A.Farrington, J.L.Hester Effort: 291.0 sq. m

FAMILY		**N**
76	*Cyprinus carpio*	1

Rio Grande silvery minnow Population Monitoring
April 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
04 April 2012 **RKD12-023** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
R.K.Dudley, M.A.Farrington, J.L.Hester Effort: 407.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	9
76	*Platygobio gracilis*	1
93	*Ictalurus punctatus*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing Site Number: 17
04 April 2012 **RKD12-022** River Mile: 60.5
UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well
R.K.Dudley, M.A.Farrington, J.L.Hester Effort: 417.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	106
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	7
76	*Pimephales promelas*	9
76	*Pimephales vigilax*	1
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	17

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 7
age-2:

Rio Grande silvery minnow Population Monitoring

April 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing   Site Number: 18

04 April 2012   **RKD12-021**   River Mile: 58.8

UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well

R.K.Dudley, M.A.Farrington, J.L.Hester   Effort: 508.4 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	47
76	*Hybognathus amarus**	2
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	15

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 2

age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0

02 May 2012 **RKD12-058** River Mile: 209.7

UTM Easting: 363811 UTM Northing: 3916006 Zone: Quad: San Felipe Pueblo

R.K. Dudley, M.A. Farrington, A.M. Snyder, L.M. Strickland Effort: 529.7 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	42
76	*Pimephales promelas*	2
76	*Rhinichthys cataractae*	7
81	*Catostomus commersonii*	4
212	*Gambusia affinis*	1

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1

02 May 2012 **RKD12-059** River Mile: 203.8

UTM Easting: 358543 UTM Northing: 3909722 Zone: Quad: Bernalillo

R.K. Dudley, M.A. Farrington, A.M. Snyder, L.M. Strickland Effort: 604.8 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	176
76	*Platygobio gracilis*	8
76	*Rhinichthys cataractae*	1
81	*Catostomus commersonii*	9

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho. Site Number: 2

River Mile: 200.0

02 May 2012 **RKD12-060**

UTM Easting: 354772 UTM Northing: 3905355 Zone: Quad: Bernalillo

R.K. Dudley, M.A. Farrington, A.M. Snyder, L.M. Strickland Effort: 474.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	90
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	17
76	*Rhinichthys cataractae*	12
81	*Catostomus commersonii*	30
212	*Gambusia affinis*	3

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

02 May 2012 **RKD12-057** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: Quad: Albuquerque West

R.K. Dudley, M.A. Farrington, A.M. Snyder, L.M. Strickland Effort: 446.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	47
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	26
81	*Catostomus commersonii*	11
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	8

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 2
age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4 River Mile: 178.3

02 May 2012 **RKD12-056**

UTM Easting: 347554 UTM Northing: 3877163 Zone: Quad: Albuquerque West

R.K. Dudley, M.A. Farrington, A.M. Snyder, L.M. Strickland Effort: 527.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	34
76	*Platygobio gracilis*	4
212	*Gambusia affinis*	4

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5

03 May 2012 **RKD12-055** River Mile: 161.4

UTM Easting: 342898 UTM Northing: 3852531 Zone: Quad: Los Lunas

M.A. Farrington, S.A. Zipper, S.J. Sasek Effort: 499.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	194
76	*Hybognathus amarus**	4
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	4

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 4
age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

03 May 2012 **RKD12-054** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: Quad: Tome

M.A. Farrington, S.A. Zipper, S.J. Sasek Effort: 463.5 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	499
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	7
76	*Pimephales promelas*	10
81	*Carpiodes carpio*	78
212	*Gambusia affinis*	26

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 7
age-2:

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

03 May 2012 **RKD12-053** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: Quad: Veguita

M.A. Farrington, S.A. Zipper, S.J. Sasek Effort: 420.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	978
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	5
81	*Carpiodes carpio*	2
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	12

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 2
age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8

03 May 2012 **RKD12-052** River Mile: 130.6

UTM Easting: 334604 UTM Northing: 3809726 Zone: Quad: Abeytas

M.A. Farrington, S.A. Zipper, S.J. Sasek Effort: 406.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	948
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	19
212	*Gambusia affinis*	30
294	*Pomoxis annularis*	2

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9

03 May 2012 **RKD12-051** River Mile: 127.0

UTM Easting: 331094 UTM Northing: 3805229 Zone: Quad: Abeytas

M.A. Farrington, S.A. Zipper, S.J. Sasek Effort: 491.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	1032
76	*Hybognathus amarus**	3
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	7
212	*Gambusia affinis*	16

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 3

age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia — Site Number: 9.5

02 May 2012 — **RKD12-050** — River Mile: 116.8

UTM Easting: 327902 UTM Northing: 3792603 Zone: Quad: La Joya

W.H. Brandenburg, S.A. Zipper, S.J. Sasek — Effort: 510.6 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	120
76	*Pimephales promelas*	55
76	*Platygobio gracilis*	16
81	*Catostomus commersonii*	17
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	14

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, directly below San Acacia Diversion Dam, San Acacia. — Site Number: 10

02 May 2012 — **RKD12-049** — River Mile: 116.2

UTM Easting: 326162 UTM Northing: 3791977 Zone: Quad: San Acacia

W.H. Brandenburg, S.A. Zipper, S.J. Sasek — Effort: 563.2 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	21
76	*Hybognathus amarus**	71
76	*Platygobio gracilis*	46
81	*Catostomus commersonii*	1
81	*Ictiobus bubalus*	1
212	*Gambusia affinis*	8

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 71

age-2:

Rio Grande silvery minnow Population Monitoring
May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

02 May 2012 **RKD12-048** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: Quad: Lemitar

W.H. Brandenburg, S.A. Zipper, S.J. Sasek Effort: 495.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	109
76	*Hybognathus amarus**	8
76	*Platygobio gracilis*	17
81	*Catostomus commersonii*	1
93	*Ictalurus furcatus*	2
93	*Ictalurus punctatus*	2

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 8

age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro.

Site Number: 12
River Mile: 99.5

02 May 2012 **RKD12-047**

UTM Easting: 327097 UTM Northing: 3771043 Zone: Quad: Loma de las Canas

W.H. Brandenburg, S.A. Zipper, S.J. Sasek

Effort: 537.5 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	293
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	1
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	15
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	10

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 2

age-2:

Rio Grande silvery minnow Population Monitoring
May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13
02 May 2012 **RKD12-046** River Mile: 91.7
UTM Easting: 328140 UTM Northing: 3761283 Zone: Quad: San Antonio
W.H. Brandenburg, S.A. Zipper, S.J. Sasek Effort: 503.3 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	58
76	*Hybognathus amarus**	2
76	*Platygobio gracilis*	3
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 2
age-2:

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14
01 May 2012 **RKD12-045** River Mile: 87.1
UTM Easting: 328914 UTM Northing: 3754471 Zone: Quad: San Antonio
R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 512.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	16
76	*Cyprinus carpio*	1
76	*Platygobio gracilis*	2
93	*Ictalurus furcatus*	1

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15

01 May 2012 **RKD12-044** River Mile: 79.1

UTM Easting: 327055 UTM Northing: 3740839 Zone: Quad: San Antonio SE

R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 475.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	12
76	*Hybognathus amarus**	3
81	*Carpiodes carpio*	1
212	*Gambusia affinis*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 3
age-2:

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16

01 May 2012 **RKD12-043** River Mile: 68.6

UTM Easting: 315284 UTM Northing: 3728347 Zone: Quad: San Marcial

R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 382.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	132
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	3
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 3
age-2:

Rio Grande silvery minnow Population Monitoring

May 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing — Site Number: 17

01 May 2012 — **RKD12-042** — River Mile: 60.5

UTM Easting: 309487 UTM Northing: 3718178 Zone: Quad: Paraje Well

R.K. Dudley, W.H. Brandenburg, S.J. Sasek — Effort: 538.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	57
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	5

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18

01 May 2012 — **RKD12-041** — River Mile: 58.8

UTM Easting: 307846 UTM Northing: 3716150 Zone: Quad: Paraje Well

R.K. Dudley, W.H. Brandenburg, S.J. Sasek — Effort: 520.2 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	32
76	*Platygobio gracilis*	1

Rio Grande silvery minnow Population Monitoring

June 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0

05 June 2012 **RKD12-078** River Mile: 209.7

UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo

R.K.Dudley, W.H.Brandenburg, J.L.Hester Effort: 519.6 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	74
76	*Pimephales promelas*	1
76	*Rhinichthys cataractae*	42
81	*Catostomus commersonii*	196
212	*Gambusia affinis*	1
294	*Lepomis cyanellus*	2

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1

05 June 2012 **RKD12-079** River Mile: 203.8

UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo

R.K.Dudley, W.H.Brandenburg, J.L.Hester Effort: 554.1 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	64
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	15
76	*Rhinichthys cataractae*	3
81	*Catostomus commersonii*	42

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 1

age-2:

Rio Grande silvery minnow Population Monitoring

June 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho.

Site Number: 2
River Mile: 200.0

05 June 2012 **RKD12-080**

UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo

R.K.Dudley, W.H.Brandenburg, J.L.Hester

Effort: 463.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	52
76	*Pimephales promelas*	6
76	*Platygobio gracilis*	2
76	*Rhinichthys cataractae*	1
81	*Carpiodes carpio*	16
81	*Catostomus commersonii*	62
93	*Ameiurus natalis*	1
212	*Gambusia affinis*	2
294	*Pomoxis annularis*	1
295	*Perca flavescens*	11

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

05 June 2012 **RKD12-077** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

R.K.Dudley, W.H.Brandenburg, J.L.Hester Effort: 517.8 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	23
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	22
81	*Carpiodes carpio*	99
81	*Catostomus commersonii*	6
212	*Gambusia affinis*	3
295	*Sander vitreus*	1

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 1

age-2:

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4
River Mile: 178.3
05 June 2012 **RKD12-076**
UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West
R.K.Dudley, W.H.Brandenburg, J.L.Hester Effort: 572.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	21
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	25
76	*Rhinichthys cataractae*	1
81	*Carpiodes carpio*	19
81	*Catostomus commersonii*	3
212	*Gambusia affinis*	74

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5
05 June 2012 **RKD12-075** River Mile: 161.4
UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas
M.A.Farrington, S.A.Zipper, S.J.Sasek Effort: 499.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	246
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	1
81	*Carpiodes carpio*	14
212	*Gambusia affinis*	11

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring

June 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

05 June 2012 **RKD12-074** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome

M.A.Farrington, S.A.Zipper, S.J.Sasek Effort: 536.5 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	224
76	*Pimephales promelas*	2
81	*Carpiodes carpio*	9
212	*Gambusia affinis*	2

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

05 June 2012 **RKD12-073** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

M.A.Farrington, S.A.Zipper, S.J.Sasek Effort: 427.4 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	631
76	*Pimephales promelas*	11
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	5
212	*Gambusia affinis*	7

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8
05 June 2012 **RKD12-072** River Mile: 130.6
UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas
M.A.Farrington, S.A.Zipper, S.J.Sasek Effort: 428.2 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	683
76	*Cyprinus carpio*	1
81	*Carpiodes carpio*	1
212	*Gambusia affinis*	23

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9
05 June 2012 **RKD12-071** River Mile: 127.0
UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas
M.A.Farrington, S.A.Zipper, S.J.Sasek Effort: 511.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	438
76	*Pimephales promelas*	7
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	5
212	*Gambusia affinis*	106

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia — Site Number: 9.5
04 June 2012 — **RKD12-070** — River Mile: 116.8
UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya
M.A.Farrington, S.A.Zipper, J.L.Hester — Effort: 347.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	48
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	181
81	*Carpiodes carpio*	6
81	*Catostomus commersonii*	5
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	6
295	*Sander vitreus*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly below San Acacia Diversion Dam, San Acacia. — Site Number: 10
04 June 2012 — **RKD12-069** — River Mile: 116.2
UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia
M.A.Farrington, S.A.Zipper, J.L.Hester — Effort: 339.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	88
76	*Cyprinus carpio*	3
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	131
81	*Catostomus commersonii*	11
212	*Gambusia affinis*	11

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring

June 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

04 June 2012 **RKD12-068** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar

M.A.Farrington, S.A.Zipper, J.L.Hester Effort: 450.5 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	46
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	4
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	79
81	*Carpiodes carpio*	43
212	*Gambusia affinis*	6

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 4
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. Site Number: 12 River Mile: 99.5

04 June 2012 **RKD12-067**

UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas

M.A.Farrington, S.A.Zipper, J.L.Hester Effort: 436.7 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	89
76	*Cyprinus carpio*	3
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	10
81	*Catostomus commersonii*	4
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	3

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13

04 June 2012 **RKD12-066** River Mile: 91.7

UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio

M.A.Farrington, S.A.Zipper, J.L.Hester Effort: 431.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	50
76	*Platygobio gracilis*	8
81	*Carpiodes carpio*	34
81	*Catostomus commersonii*	3
212	*Gambusia affinis*	52

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14

04 June 2012 **RKD12-065** River Mile: 87.1

UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio

R.K.Dudley, W.H.Brandenburg, S.J.Sasek Effort: 549.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	6
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	61
81	*Catostomus commersonii*	1
81	*Ictiobus bubalus*	1

*** *Hybognathus amarus* by age class:**

age-0: 1

age-1: 1

age-2:

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
04 June 2012 **RKD12-064** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
R.K.Dudley, W.H.Brandenburg, S.J.Sasek Effort: 442.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	2
76	*Hybognathus amarus**	12
76	*Pimephales promelas*	7
76	*Platygobio gracilis*	14
81	*Carpiodes carpio*	14

*** *Hybognathus amarus* by age class:**

age-0: 6
age-1: 6
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
04 June 2012 **RKD12-063** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
R.K.Dudley, W.H.Brandenburg, S.J.Sasek Effort: 477.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	13
76	*Cyprinus carpio*	6
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	7
81	*Carpiodes carpio*	8
81	*Ictiobus bubalus*	4
294	*Micropterus salmoides*	1

*** *Hybognathus amarus* by age class:**

age-0: 1
age-1:
age-2:

Rio Grande silvery minnow Population Monitoring
June 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing — Site Number: 17
04 June 2012 — **RKD12-062** — River Mile: 60.5
UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well
R.K.Dudley, W.H.Brandenburg, S.J.Sasek — Effort: 480.7 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	56
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	9
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	1
93	*Ictalurus furcatus*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	4

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18
04 June 2012 — **RKD12-061** — River Mile: 58.8
UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well
R.K.Dudley, W.H.Brandenburg, S.J.Sasek — Effort: 473.4 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	13
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0

11 July 2012 **RKD12-098** River Mile: 209.7

UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo

R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 451.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	62
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	2
76	*Rhinichthys cataractae*	42
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	75
212	*Gambusia affinis*	68
294	*Lepomis cyanellus*	2
294	*Micropterus salmoides*	3
294	*Pomoxis annularis*	2

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 1

age-2:

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1

11 July 2012 **RKD12-099** River Mile: 203.8

UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo

R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 559.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	84
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	45
76	*Rhinichthys cataractae*	32
81	*Carpiodes carpio*	2
81	*Catostomus commersonii*	88
93	*Ameiurus natalis*	2
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	35

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 2

age-2:

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho.

Site Number: 2
River Mile: 200.0

11 July 2012 **RKD12-100**

UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo

R.K. Dudley, W.H. Brandenburg, S.J. Sasek

Effort: 605.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	254
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	22
76	*Platygobio gracilis*	50
76	*Rhinichthys cataractae*	10
81	*Carpiodes carpio*	2
81	*Catostomus commersonii*	58
93	*Ameiurus natalis*	9
93	*Ictalurus punctatus*	7
212	*Gambusia affinis*	15
295	*Perca flavescens*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring

July 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

11 July 2012 **Rkd12-097** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 475.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	45
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	61
76	*Platygobio gracilis*	24
81	*Carpiodes carpio*	9
81	*Catostomus commersonii*	11
93	*Ameiurus natalis*	2
93	*Ictalurus punctatus*	101
212	*Gambusia affinis*	7
294	*Lepomis cyanellus*	3
294	*Micropterus salmoides*	2
295	*Sander vitreus*	1

Rio Grande silvery minnow Population Monitoring

July 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4

River Mile: 178.3

11 July 2012 **RKD12-096**

UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West

R.K. Dudley, W.H. Brandenburg, S.J. Sasek Effort: 592.2 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	100
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	37
76	*Platygobio gracilis*	8
81	*Carpiodes carpio*	32
81	*Catostomus commersonii*	8
93	*Ameiurus melas*	1
93	*Ameiurus natalis*	11
93	*Ictalurus punctatus*	108
212	*Gambusia affinis*	43

*** *Hybognathus amarus* by age class:**

age-0: 1

age-1:

age-2:

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5

11 July 2012 **RKD12-095** River Mile: 161.4

UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas

M.A. Farrington, J.L. Hester, S.A. Zipper Effort: 447.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	284
76	*Cyprinus carpio*	2
76	*Pimephales promelas*	17
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	68
93	*Ictalurus punctatus*	44
212	*Gambusia affinis*	8

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

11 July 2012 **RKD12-094** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome

M.A. Farrington, J.L. Hester, S.A. Zipper Effort: 354.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	658
76	*Pimephales promelas*	4
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	8
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	6
212	*Gambusia affinis*	78
294	*Pomoxis annularis*	1

Rio Grande silvery minnow Population Monitoring

July 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

11 July 2012 **RKD12-093** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

M.A. Farrington, J.L. Hester, S.A. Zipper Effort: 349.2 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	746
76	*Pimephales promelas*	11
81	*Carpiodes carpio*	5
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	96

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8

11 July 2012 **RKD12-092** River Mile: 130.6

UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas

M.A. Farrington, J.L. Hester, S.A. Zipper Effort: 424.9 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	225
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	7
81	*Carpiodes carpio*	11
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	470

*** *Hybognathus amarus* by age class:**

age-0:

age-1:

age-2: 1

Rio Grande silvery minnow Population Monitoring

July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9

11 July 2012 **RKD12-091** River Mile: 127.0

UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas

M.A. Farrington, J.L. Hester, S.A. Zipper Effort: 378.2 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	403
76	*Hybognathus amarus**	1
81	*Carpiodes carpio*	8
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	214

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 1

age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia Site Number: 9.5

10 July 2012 **RKD12-090** River Mile: 116.8

UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya

M.A. Farrington, J.L. Hester, A.L. Barkalow Effort: 250.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	121
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	61
81	*Carpiodes carpio*	5
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	21
212	*Gambusia affinis*	14

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, directly below San Acacia Diversion Dam, San Acacia. Site Number: 10

10 July 2012 **RKD12-089** River Mile: 116.2

UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia

M.A. Farrington, J.L. Hester, A.L. Barkalow Effort: 344.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	256
76	*Cyprinus carpio*	6
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	3
76	*Platygobio gracilis*	473
76	*Rhinichthys cataractae*	1
81	*Carpiodes carpio*	2
81	*Ictiobus bubalus*	1
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	165
93	*Pylodictis olivaris*	1
212	*Gambusia affinis*	24

*** *Hybognathus amarus* by age class:**

age-0:
age-1:
age-2: 1

Rio Grande silvery minnow Population Monitoring

July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

10 July 2012 **RKD12-088** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar

M.A. Farrington, J.L. Hester, A.L. Barkalow Effort: 352.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	562
76	*Cyprinus carpio*	6
76	*Pimephales promelas*	12
76	*Platygobio gracilis*	258
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	109
212	*Gambusia affinis*	10

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Site Number: 12

Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. River Mile: 99.5

10 July 2012 **RKD12-087**

UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas

M.A. Farrington, J.L. Hester, A.L. Barkalow Effort: 430.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	540
76	*Cyprinus carpio*	59
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	4
81	*Carpiodes carpio*	5
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	15
212	*Gambusia affinis*	35

Rio Grande silvery minnow Population Monitoring

July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13
10 July 2012 **RKD12-086** River Mile: 91.7
UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio
M.A. Farrington, J.L. Hester, A.L. Barkalow Effort: 518.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	1
76	*Hybognathus amarus**	2
81	*Carpiodes carpio*	2
212	*Gambusia affinis*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 2
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14
10 July 2012 **RKD12-085** River Mile: 87.1
UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio
R.K. Dudley, W.H. Brandenburg, S.A. Zipper Effort: 520.6 sq. m

FAMILY		N
76	*Cyprinus carpio*	8
81	*Carpiodes carpio*	1

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
10 July 2012 **RKD12-084** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
R.K. Dudley, W.H. Brandenburg, S.A. Zipper Effort: 572.4 sq. m

FAMILY		N
93	*Ictalurus punctatus*	11
212	*Gambusia affinis*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
10 July 2012 **RKD12-083** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
R.K. Dudley, W.H. Brandenburg, S.A. Zipper Effort: 530.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	335
76	*Cyprinus carpio*	49
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	4
81	*Catostomus commersonii*	2
81	*Ictiobus bubalus*	1
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	36
294	*Micropterus salmoides*	3

*** *Hybognathus amarus* by age class:**

age-0: 1
age-1:
age-2:

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing — Site Number: 17

10 July 2012 — **RKD12-082** — River Mile: 60.5

UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well

R.K. Dudley, W.H. Brandenburg, S.A. Zipper — Effort: 454.2 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	2
76	*Cyprinella lutrensis*	189
76	*Cyprinus carpio*	55
76	*Hybognathus amarus**	13
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	17
81	*Carpiodes carpio*	16
81	*Ictiobus bubalus*	2
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	48

*** *Hybognathus amarus* by age class:**

age-0: 6

age-1: 7

age-2:

Rio Grande silvery minnow Population Monitoring
July 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18

10 July 2012 — **RKD12-081** — River Mile: 58.8

UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well

R.K. Dudley, W.H. Brandenburg, S.A. Zipper — Effort: 505.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	178
76	*Cyprinus carpio*	36
76	*Pimephales promelas*	5
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	1
81	*Ictiobus bubalus*	2
212	*Gambusia affinis*	6

Rio Grande silvery minnow Population Monitoring

August 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0

02 August 2012 **RKD12-118** River Mile: 209.7

UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo

W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: 468.1 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	66
76	*Cyprinus carpio*	10
76	*Pimephales promelas*	8
76	*Platygobio gracilis*	5
76	*Rhinichthys cataractae*	38
81	*Catostomus commersonii*	9
93	*Ameiurus natalis*	1
212	*Gambusia affinis*	116

Rio Grande silvery minnow Population Monitoring
August 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1

02 August 2012 **RKD12-119** River Mile: 203.8

UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo

W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: 440.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	81
76	*Hybognathus amarus**	6
76	*Pimephales promelas*	7
76	*Platygobio gracilis*	62
76	*Rhinichthys cataractae*	3
81	*Catostomus commersonii*	51
93	*Ameiurus natalis*	2
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	16

*** *Hybognathus amarus* by age class:**

age-0: 2

age-1: 4

age-2:

Rio Grande silvery minnow Population Monitoring

August 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho.

Site Number: 2

River Mile: 200.0

02 August 2012 **RKD12-120**

UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo

W.H.Brandenburg, J.L.Hester, S.A.Sasek

Effort: 540.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	44
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	15
76	*Platygobio gracilis*	19
81	*Catostomus commersonii*	20
93	*Ameiurus natalis*	3
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	52
295	*Sander vitreus*	1

*** *Hybognathus amarus* by age class:**

age-0: 2

age-1:

age-2:

Rio Grande silvery minnow Population Monitoring
August 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

02 August 2012 **RKD12-117** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: 514.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	23
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	28
76	*Platygobio gracilis*	6
81	*Carpiodes carpio*	16
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	8
212	*Gambusia affinis*	39
294	*Micropterus salmoides*	1

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4

River Mile: 178.3

02 August 2012 **RKD12-116**

UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West

W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: 515.2 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	32
76	*Pimephales promelas*	7
81	*Carpiodes carpio*	3
93	*Ictalurus punctatus*	14
212	*Gambusia affinis*	38

Rio Grande silvery minnow Population Monitoring
August 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5
02 August 2012 **RKD12-115** River Mile: 161.4
UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas
R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: sq. m

FAMILY		N
	Site Not Sampled (Site Dry)	

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6
02 August 2012 **RKD12-114** River Mile: 151.5
UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome
R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 382.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	201
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	15
81	*Carpiodes carpio*	152
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	152

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

Rio Grande silvery minnow Population Monitoring
August 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

02 August 2012 **RKD12-113** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 425.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	858
76	*Pimephales promelas*	28
81	*Carpiodes carpio*	29
93	*Ictalurus punctatus*	7
212	*Gambusia affinis*	282

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8

02 August 2012 **RKD12-112** River Mile: 130.6

UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas

R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 402.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	657
76	*Pimephales promelas*	2
81	*Carpiodes carpio*	8
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	243

Rio Grande silvery minnow Population Monitoring

August 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9

02 August 2012 **RKD12-111** River Mile: 127.0

UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas

R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 489.1 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	260
76	*Cyprinus carpio*	6
76	*Pimephales promelas*	23
81	*Carpiodes carpio*	13
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	65

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia Site Number: 9.5

01 August 2012 **RKD12-110** River Mile: 116.8

UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya

R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 446.0 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	21
76	*Pimephales promelas*	2
76	*Platygobio gracilis*	5
93	*Ictalurus punctatus*	10
212	*Gambusia affinis*	40

Rio Grande silvery minnow Population Monitoring
August 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly below San Acacia Diversion Dam, San Acacia. Site Number: 10
01 August 2012 **RKD12-109** River Mile: 116.2
UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia
R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 437.0 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	4
76	*Cyprinella lutrensis*	159
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	142
76	*Rhinichthys cataractae*	3
81	*Ictiobus bubalus*	5
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	24
212	*Gambusia affinis*	2

*** *Hybognathus amarus* by age class:**

age-0:
age-1: 1
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11
01 August 2012 **RKD12-108** River Mile: 114.6
UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar
R.K.Dudley, S.A.Zipper, K.R.Naegele Effort: 515.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	117
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	8
76	*Platygobio gracilis*	11
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	15
212	*Gambusia affinis*	2

Rio Grande silvery minnow Population Monitoring

August 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro.

Site Number: 12

River Mile: 99.5

01 August 2012 **RKD12-107**

UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas

R.K.Dudley, S.A.Zipper, K.R.Naegele

Effort: 419.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	15
76	*Hybognathus amarus**	1
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	1
81	*Ictiobus bubalus*	1
212	*Gambusia affinis*	1

*** *Hybognathus amarus* by age class:**

age-0: 1
age-1:
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing.

Site Number: 13

01 August 2012 **RKD12-106**

River Mile: 91.7

UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio

R.K.Dudley, S.A.Zipper, K.R.Naegele

Effort: sq. m

FAMILY		N
	Site Not Sampled (Site Dry)	

Rio Grande silvery minnow Population Monitoring

August 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14
01 August 2012 **RKD12-105** River Mile: 87.1
UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio
W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: sq. m

FAMILY		N
	Site Not Sampled (Site Dry)	

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
01 August 2012 **RKD12-104** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: 33.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	1
76	*Cyprinus carpio*	14
81	*Carpiodes carpio*	5
212	*Gambusia affinis*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
01 August 2012 **RKD12-103** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
W.H.Brandenburg, J.L.Hester, S.A.Sasek Effort: 437.2 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	116
76	*Cyprinus carpio*	2
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	28

Rio Grande silvery minnow Population Monitoring

August 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing — Site Number: 17
01 August 2012 — **RKD12-102** — River Mile: 60.5
UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well
W.H.Brandenburg, J.L.Hester, S.A.Sasek — Effort: 478.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	230
76	*Hybognathus amarus**	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	6
81	*Carpiodes carpio*	3
93	*Ictalurus punctatus*	11
212	*Gambusia affinis*	52

*** *Hybognathus amarus* by age class:**

age-0: 1
age-1:
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18
01 August 2012 — **RKD12-101** — River Mile: 58.8
UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well
W.H.Brandenburg, J.L.Hester, S.A.Sasek — Effort: 470.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	132
76	*Cyprinus carpio*	2
93	*Ictalurus punctatus*	10
212	*Gambusia affinis*	5

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0
07 September 2012 **RKD12-138** River Mile: 209.7
UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo
R.K.Dudley, S.A.Sasek, K.R.Naegle Effort: 486.4 sq. m

FAMILY		N
69	*Dorosoma cepedianum*	1
76	*Cyprinella lutrensis*	207
76	*Cyprinus carpio*	3
76	*Pimephales promelas*	37
76	*Platygobio gracilis*	46
76	*Rhinichthys cataractae*	6
81	*Catostomus commersonii*	6
212	*Gambusia affinis*	71
294	*Micropterus salmoides*	1

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage
Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1
07 September 2012 **RKD12-139** River Mile: 203.8
UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo
R.K.Dudley, S.A.Sasek, K.R.Naegle Effort: 496.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	150
76	*Pimephales promelas*	20
76	*Platygobio gracilis*	207
76	*Rhinichthys cataractae*	13
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	11
212	*Gambusia affinis*	45

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho.

Site Number: 2
River Mile: 200.0

07 September 2012 **RKD12-140**

UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo

R.K.Dudley, S.A.Sasek, K.R.Naegle

Effort: 430.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	24
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	6
76	*Platygobio gracilis*	55
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	7
93	*Ictalurus punctatus*	5
212	*Gambusia affinis*	33

*** *Hybognathus amarus* by age class:**

age-0: 1

age-1:

age-2: 1

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque. Site Number: 3

06 September 2012 **RKD12-137** River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

W.H.Brandenburg, S.A.Sasek, K.R. Naegle Effort: 497.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	44
76	*Cyprinus carpio*	2
76	*Pimephales promelas*	9
76	*Platygobio gracilis*	12
81	*Carpiodes carpio*	16
93	*Ictalurus punctatus*	29
212	*Gambusia affinis*	29

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4

River Mile: 178.3

06 September 2012 **RKD12-136**

UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West

W.H.Brandenburg, S.A.Sasek, K.R. Naegle Effort: 513.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	53
76	*Cyprinus carpio*	1
76	*Hybognathus amarus**	2
76	*Pimephales promelas*	10
76	*Platygobio gracilis*	11
81	*Carpiodes carpio*	24
93	*Ameiurus melas*	2
93	*Ictalurus punctatus*	23
212	*Gambusia affinis*	157
295	*Sander vitreus*	1

*** *Hybognathus amarus* by age class:**

age-0:

age-1: 1

age-2: 1

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5

06 September 2012 **RKD12-135** River Mile: 161.4

UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas

W.H.Brandenburg, S.A.Sasek, K.R. Naegle Effort: sq. m

FAMILY		N
	Site Not Sampled (Site Dry)	

Rio Grande silvery minnow Population Monitoring
September 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

06 September 2012 **RKD12-134** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome

W.H.Brandenburg, S.A.Sasek, K.R. Naegle Effort: 389.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	230
76	*Pimephales promelas*	29
76	*Platygobio gracilis*	1
81	*Carpiodes carpio*	19
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	149

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

05 September 2012 **RKD12-133** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 429.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	875
76	*Pimephales promelas*	17
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	628

Rio Grande silvery minnow Population Monitoring
September 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8
05 September 2012 **RKD12-132** River Mile: 130.6
UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 406.0 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	1762
76	*Pimephales promelas*	38
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	1007

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9
05 September 2012 **RKD12-131** River Mile: 127.0
UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 488.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	459
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	9
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	463

Rio Grande silvery minnow Population Monitoring
September 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia — Site Number: 9.5
05 September 2012 — **RKD12-130** — River Mile: 116.8
UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle — Effort: 426.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	20
76	*Platygobio gracilis*	3
212	*Gambusia affinis*	108

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly below San Acacia Diversion Dam, San Acacia. — Site Number: 10
05 September 2012 — **RKD12-129** — River Mile: 116.2
UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle — Effort: 468.5 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	448
76	*Cyprinus carpio*	10
76	*Pimephales promelas*	7
76	*Platygobio gracilis*	24
81	*Carpiodes carpio*	4
81	*Ictiobus bubalus*	2
93	*Ictalurus punctatus*	10
212	*Gambusia affinis*	26

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

05 September 2012 **RKD12-128** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar

R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 614.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	342
76	*Cyprinus carpio*	3
76	*Pimephales promelas*	6
76	*Platygobio gracilis*	2
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	95

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Site Number: 12

Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. River Mile: 99.5

04 September 2012 **RKD12-127**

UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas

R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 538.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	18
76	*Cyprinus carpio*	1
212	*Gambusia affinis*	6

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13
04 September 2012 **RKD12-126** River Mile: 91.7
UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: sq. m

FAMILY	**N**
Site Not Sampled (Site Dry)	

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14
04 September 2012 **RKD12-125** River Mile: 87.1
UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: sq. m

FAMILY	**N**
Site Not Sampled (Site Dry)	

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
04 September 2012 **RKD12-124** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: sq. m

FAMILY	**N**
Site Not Sampled (Site Dry)	

Rio Grande silvery minnow Population Monitoring
September 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
04 September 2012 **RKD12-123** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 510.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	86
76	*Cyprinus carpio*	2
76	*Hybognathus amarus**	1
93	*Ictalurus punctatus*	3
212	*Gambusia affinis*	7

*** *Hybognathus amarus* by age class:**

age-0: 1
age-1:
age-2:

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing Site Number: 17
04 September 2012 **RKD12-122** River Mile: 60.5
UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well
R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle Effort: 420.6 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	350
76	*Cyprinus carpio*	3
76	*Pimephales promelas*	1
93	*Ictalurus punctatus*	20
212	*Gambusia affinis*	68

Rio Grande silvery minnow Population Monitoring

September 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18

04 September 2012 — **RKD12-121** — River Mile: 58.8

UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well

R.K.Dudley, W.H.Brandenburg, S.A.Sasek, K.R.Naegle — Effort: 493.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	346
76	*Platygobio gracilis*	2
93	*Ictalurus punctatus*	29
212	*Gambusia affinis*	172

Rio Grande silvery minnow Population Monitoring

October 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, directly below Angostura Diversion Dam, Algodones. Site Number: 0

04 October 2012 **RKD12-158** River Mile: 209.7

UTM Easting: 363811 UTM Northing: 3916006 Zone: 13 Quad: San Felipe Pueblo

R.K. Dudley, K.R. Naegele Effort: 545.4 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	113
76	*Pimephales promelas*	26
76	*Platygobio gracilis*	28
76	*Rhinichthys cataractae*	13
81	*Catostomus commersonii*	4
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	10
294	*Micropterus salmoides*	1
295	*Sander vitreus*	1

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, at US HWY 550 (formerly NM State HWY 44) bridge crossing, Bernalillo. Site Number: 1

04 October 2012 **RKD12-159** River Mile: 203.8

UTM Easting: 358543 UTM Northing: 3909722 Zone: 13 Quad: Bernalillo

R.K. Dudley, K.R. Naegele Effort: 578.1 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	47
76	*Platygobio gracilis*	647
76	*Rhinichthys cataractae*	14
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	4
212	*Gambusia affinis*	22

Rio Grande silvery minnow Population Monitoring

October 2012

NEW MEXICO: SANDOVAL Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles downstream of US HWY 550 (formerly NM State HWY 44) bridge crossing, at Rio Rancho Wastewater Treatment Plant, Rio Rancho.

Site Number: 2

River Mile: 200.0

04 October 2012 **RKD12-160**

UTM Easting: 354772 UTM Northing: 3905355 Zone: 13 Quad: Bernalillo

R.K. Dudley, K.R. Naegele

Effort: 582.6 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	71
76	*Pimephales promelas*	5
76	*Platygobio gracilis*	44
76	*Rhinichthys cataractae*	1
81	*Catostomus commersonii*	13
93	*Ameiurus natalis*	1
93	*Ictalurus punctatus*	34
212	*Gambusia affinis*	48

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage

Rio Grande, at Central Avenue bridge crossing (US HWY 66), Albuquerque.

Site Number: 3

04 October 2012 **RKD12-157**

River Mile: 183.4

UTM Easting: 346840 UTM Northing: 3884094 Zone: 13 Quad: Albuquerque West

R.K. Dudley, K.R. Naegele

Effort: 528.9 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	95
76	*Pimephales promelas*	14
76	*Platygobio gracilis*	13
81	*Carpiodes carpio*	1
81	*Catostomus commersonii*	1
93	*Ictalurus punctatus*	89
212	*Gambusia affinis*	40

Rio Grande silvery minnow Population Monitoring
October 2012

NEW MEXICO: BERNALILLO Co., RIO GRANDE Drainage
Rio Grande, at Rio Bravo Blvd. Bridge crossing (NM State HWY 500) crossing, Albuquerque. Site Number: 4
River Mile: 178.3
03 October 2012 **RKD12-156**
UTM Easting: 347554 UTM Northing: 3877163 Zone: 13 Quad: Albuquerque West
R.K. Dudley, M.A. Farrington, J.L. Hester Effort: 490.9 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	88
76	*Pimephales promelas*	12
76	*Platygobio gracilis*	2
81	*Carpiodes carpio*	12
93	*Ictalurus punctatus*	27
212	*Gambusia affinis*	33

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage
Rio Grande, at Los Lunas Bridge crossing (NM State HWY 49), Los Lunas. Site Number: 5
03 October 2012 **RKD12-155** River Mile: 161.4
UTM Easting: 342898 UTM Northing: 3852531 Zone: 13 Quad: Los Lunas
R.K. Dudley, M.A. Farrington, J.L. Hester Effort: sq. m

FAMILY		N
	Site Not Sampled (Site Dry)	

Rio Grande silvery minnow Population Monitoring

October 2012

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 1.0 miles upstream of NM State HWY 309/6 bridge crossing, Belen. Site Number: 6

03 October 2012 **RKD12-154** River Mile: 151.5

UTM Easting: 339972 UTM Northing: 3837061 Zone: 13 Quad: Tome

R.K. Dudley, M.A. Farrington, J.L. Hester Effort: 314.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	994
76	*Cyprinus carpio*	82
76	*Pimephales promelas*	77
81	*Carpiodes carpio*	59
93	*Ictalurus punctatus*	21
212	*Gambusia affinis*	428

NEW MEXICO: VALENCIA Co., RIO GRANDE Drainage

Rio Grande, ca. 2.2 miles upstream of NM State HWY 346 bridge crossing, Jarales. Site Number: 7

03 October 2012 **RKD12-153** River Mile: 143.2

UTM Easting: 338136 UTM Northing: 3827329 Zone: 13 Quad: Veguita

R.K. Dudley, M.A. Farrington, J.L. Hester Effort: 481.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	983
76	*Pimephales promelas*	2
212	*Gambusia affinis*	111

Rio Grande silvery minnow Population Monitoring
October 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at US HWY 60 bridge crossing, Bernardo. Site Number: 8
03 October 2012 **RKD12-152** River Mile: 130.6
UTM Easting: 334604 UTM Northing: 3809726 Zone: 13 Quad: Abeytas
R.K. Dudley, M.A. Farrington, J.L. Hester Effort: 388.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	1581
76	*Pimephales promelas*	13
212	*Gambusia affinis*	251

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 3.5 miles downstream of the US HWY 60 bridge crossing, Bernardo. Site Number: 9
03 October 2012 **RKD12-151** River Mile: 127.0
UTM Easting: 331094 UTM Northing: 3805229 Zone: 13 Quad: Abeytas
R.K. Dudley, M.A. Farrington, J.L. Hester Effort: 452.8 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	624
76	*Pimephales promelas*	3
212	*Gambusia affinis*	258

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 0.6 miles upstream of San Acacia Diversion Dam, San Acacia Site Number: 9.5
02 October 2012 **RKD12-150** River Mile: 116.8
UTM Easting: 327902 UTM Northing: 3792603 Zone: 13 Quad: La Joya
R.K. Dudley, J.H. Hester, K.R. Naegele Effort: 543.3 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	29
76	*Platygobio gracilis*	7
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	1

Rio Grande silvery minnow Population Monitoring

October 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, directly below San Acacia Diversion Dam, San Acacia. Site Number: 10

02 October 2012 **RKD12-149** River Mile: 116.2

UTM Easting: 326162 UTM Northing: 3791977 Zone: 13 Quad: San Acacia

R.K. Dudley, J.H. Hester, K.R. Naegele Effort: 446.4 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	327
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	14
81	*Carpiodes carpio*	1
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	1

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia. Site Number: 11

02 October 2012 **RKD12-148** River Mile: 114.6

UTM Easting: 325263 UTM Northing: 3790442 Zone: 13 Quad: Lemitar

R.K. Dudley, J.H. Hester, K.R. Naegele Effort: 503.7 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	85
76	*Cyprinus carpio*	1
76	*Pimephales promelas*	1
76	*Platygobio gracilis*	22
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	10

Rio Grande silvery minnow Population Monitoring

October 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, east of Socorro, 0.5 miles upstream of Socorro Low Flow Conveyance Channel bridge and east just upstream of Socorro Wastewater Treatment Plant, Socorro. Site Number: 12 River Mile: 99.5

02 October 2012 **RKD12-147**

UTM Easting: 327097 UTM Northing: 3771043 Zone: 13 Quad: Loma de las Canas

R.K. Dudley, J.H. Hester, K.R. Naegele Effort: sq. m

FAMILY	**N**
Site Not Sampled (Site Dry)	

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 4.0 miles upstream of U.S. 380 bridge crossing. Site Number: 13

02 October 2012 **RKD12-146** River Mile: 91.7

UTM Easting: 328140 UTM Northing: 3761283 Zone: 13 Quad: San Antonio

R.K. Dudley, J.H. Hester, K.R. Naegele Effort: sq. m

FAMILY	**N**
Site Not Sampled (Site Dry)	

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, at US HWY 380 bridge crossing, San Antonio. Site Number: 14

01 October 2012 **RKD12-145** River Mile: 87.1

UTM Easting: 328914 UTM Northing: 3754471 Zone: 13 Quad: San Antonio

R.K. Dudley, J.H. Hester, K.R. Naegele Effort: sq. m

FAMILY	**N**
Site Not Sampled (Site Dry)	

Rio Grande silvery minnow Population Monitoring
October 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, directly east of Bosque del Apache National Wildlife Refuge Headquarters. Site Number: 15
01 October 2012 **RKD12-144** River Mile: 79.1
UTM Easting: 327055 UTM Northing: 3740839 Zone: 13 Quad: San Antonio SE
R.K. Dudley, J.H. Hester, K.R. Naegele Effort: sq. m

FAMILY		**N**
	Site Not Sampled (Site Dry)	

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, at San Marcial Railroad Bridge, San Marcial. Site Number: 16
01 October 2012 **RKD12-143** River Mile: 68.6
UTM Easting: 315284 UTM Northing: 3728347 Zone: 13 Quad: San Marcial
R.K. Dudley, J.H. Hester, K.R. Naegele Effort: 545.0 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	67

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage
Rio Grande, ca. 8 miles downstream of the San Marcial railroad bridge crossing Site Number: 17
01 October 2012 **RKD12-142** River Mile: 60.5
UTM Easting: 309487 UTM Northing: 3718178 Zone: 13 Quad: Paraje Well
R.K. Dudley, J.H. Hester, K.R. Naegele Effort: 491.4 sq. m

FAMILY		**N**
76	*Cyprinella lutrensis*	130
76	*Platygobio gracilis*	4
93	*Ictalurus punctatus*	2
212	*Gambusia affinis*	16

Rio Grande silvery minnow Population Monitoring

October 2012

NEW MEXICO: SOCORRO Co., RIO GRANDE Drainage

Rio Grande, ca. 10 mi downstream of the San Marcial railroad bridge crossing — Site Number: 18

01 October 2012 — **RKD12-141** — River Mile: 58.8

UTM Easting: 307846 UTM Northing: 3716150 Zone: 13 Quad: Paraje Well

R.K. Dudley, J.H. Hester, K.R. Naegele — Effort: 487.1 sq. m

FAMILY		N
76	*Cyprinella lutrensis*	38
93	*Ictalurus punctatus*	1
212	*Gambusia affinis*	8