

U.S. Department of the Interior U.S. Geological Survey

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Scientific Investigations Map 3350 Sheet 2 of 7

Sampling Assessments and Streamflow

During this study, 13 of the 15 sites were assessed under two different seasonal streamflow regimes during winter 2011–12 and summer 2012 (table 1, fig. 4); the two remaining sites (Peña Blanca and Bernalillo) were only assessed in winter 2011-12. Mesohabitats were mapped and sampled during a period of moderate streamflow between November 2011 and February 2012 and during a period of low streamflow between June and August 2012 (table 1; fig. 4). In winter 2011-12, sites were sampled generally from upstream to downstream, whereas in summer 2012, sites were sampled in an order that would ensure the Middle Rio Grande was flowing at all sites at the time of sampling. The reordered sampling during low streamflow conditions facilitated the assessment of as many sites as possible, as well as the measurement of physical properties and sampling of fish. Those sites that were at the greatest risk of drying were visited in early June 2012, and those sites that were expected to have streamflow throughout the summer were visited in August 2012. The period of comparatively low streamflows in the summer of 2012 was an opportunity to determine available habitat during a time of the year when water temperatures in the Middle Rio Grande are seasonally high and the stream channel is more accessible for sampling, thus providing more ideal conditions for the evaluation of habitat use by and distribution of fishes at low flow.



Fish Collection

Fish assemblage surveys

were done at each sampling site

(except at the Peña Blanca and

Bernalillo sites during summer

streamflows. Mesohabitat types

were subsampled (with targeted

sampling site in winter 2011–12

minimums of 20 mesohabitats per

and 30 mesohabitats per sampling

site in summer 2012) in proportion

to their relative abundance at each

reach. If three or fewer of a given

sampling site, then all mesohabitats

of that type were typically sampled.

mesohabitat type occurred in a

Fish were collected by using a

seine while wading during both

2012) at moderate and low

Mesohabitat Assessments

The approach used to assess mesohabitats in the Middle Rio Grande was modified from Parasiewicz and Dunbar (2001) (fig. 5). Mesohabitat assessments generally consist of (1) geospatial measurements to document the sampling site, (2) physical measurements of the stream properties, and (3) biological sampling at

the site. Geospatial measurements (data associated with a particular location) are made as a first step to generate maps over a range of streamflows (that is, how the various mesohabitat types change under different streamflow conditions) (Bovee and others, 1998, 2008). Geospatial and physical measurements provide a description of the ecohydraulic habitat conditions for the streamflow at the time the measurements are made. Physical measurements and biological measurements are used to determine habitat use by selected fish species.

For this study, the following mesohabitats were mapped at each study site when present: riffles, runs, pools (channel and eddy), isolated pools, forewaters, backwaters, embayments, and flats (table 2, fig. 6). Point bars and channel bars were also mapped to provide a more complete assessment of the active channel at each site. Data from two types of pools—channel and eddy were combined into a "pools" category for analysis.

Digital mapping techniques were used for all geospatial measurements. The hardware, software, and field methods that were used to accomplish the study mapping goals were selected specifically to overcome the challenges of working in a remote, arid riverine environment. A geographic information system (GIS) (Esri, 2013) and Global Positioning System (GPS) were used to create the map in the field. Location data were collected by using a Trimble DSM 232 modular receiving unit (Trimble, 2015a) with an OmniSTAR subscription (Trimble, 2015b) for real-time, subfoot accuracy observations needed for mapping. The GPS observations were directly read into a field laptop computer for onsite visualization within the GIS, and polygons were created by using location information, aerial photography, and editing tools.

Field mapping was accomplished by using a variety of approaches based on streamflow, stream depth, and streambank accessibility. Each study reach was visited twice (except for Peña Blanca and Bernalillo, which were only sampled in winter 2011–12) (table 1), corresponding to the periods of moderate and low streamflows identified

for this study. For the majority of the field mapping, the edge of the water throughout a site reach was extracted from high-resolution, remotely sensed imagery, which was used as a framework for all subsequently mapped mesohabitats within a given reach at a site. The field data collection process required two individuals working in

imagery made it possible to

generate a detailed map for each







Table 2. Description of mesohabitat types used to describe the study sites as defined by observations and physical parameters measured over the course of the study.

[Mesohabitat types and descriptions are modified from Platania (1993)]

tandem, communicating by	Mesohabitat type	Description
using a wireless connection between the GPS receiver and	Riffle	Relatively shallow and low to moderate velocity feature characterized by moderately turbulent water
of water was delineated the	Run	Relatively high velocity feature with laminar flow and a non-turbulent surface
study reach was subdivided	Pool	Feature with little or no velocity that may be deep in places
into smaller polygons, each	Channel	Type of pool where current moves in the same flow direction as the channel
representing individual	Eddy	Type of pool where current moves in the opposite direction relative to flow
mesohabitats. Individual mesohabitats were created	Isolated Pool	Type of pool that is separate from the main channel; frequently a portion of a former backwater or forewater that has become disconnected from a secondary channel
by walking boundaries of	Forewater	Slackwater feature oriented into the principal direction of flow
photointerpretation in the field.	Backwater	Slackwater feature oriented in an opposing direction to the principal flow direction
Polygons created through	Embayment	Slackwater feature located adjacent to the channel and oriented perpendicular to flow
this process were stored and attributed in an ArcGIS 10.0	Flat	Very shallow, low velocity feature typically located on the periphery of an existing point or channel bar; caused by a slight rise in stage
personal geodatabase (Esri, 2013) and stored as Microsoft	Point Bar	Crescent-shaped depositional feature located on the inside of a stream bend; typically either devoid of or containing annual vegetation
Collectively, the database	Channel Bar	Transitory parcel of land surrounded by water; typically either devoid of or containing annual vegetation
information and remotely sensed		annual vegetation

Plan view

bar

White all







Figure 5. Overview of the approach used to map mesohabitats in the Middle Rio Grande, New Mexico (modified from Parasiewicz and Dunbar, 2001).

mesohabitat. Additional details

methods are provided in Braun

and others (2015). Velocity and

depth measurements were made

FlowTracker hand-held acoustic

Doppler velocimeter attached to

a wading rod (SonTek, 2013).

Standard USGS protocols

for measuring velocity were

Turnipseed and Sauer, 2010).

followed (Rantz and others, 1982;

Additional details on the velocity

measurements are provided in

Braun and others (2015).

by wading the stream with a

on the mesohabitat data collection

upstream USGS streamflow-gaging

station (table 1). Instantaneous

discharge measurements were

Survey, 2014).

stored in NWIS (U.S. Geological

During summer 2012, stream

velocity and depth were recorded at

the centroid of each seine haul by

the crew of technicians collecting

depth, dominant substrate type and

size, and percent embeddedness

who were collecting mesohabitat

were recorded during winter

a second crew of technicians

data along randomly selected

transects within each sampled

2011–12 and summer 2012 by

fish, whereas stream velocity,

Physical Characteristics Over a Range of Streamflows

Physical characteristics

including stream velocity, depth,

and substrate type associated

with different mesohabitats

were measured over a range

of streamflows. Instantaneous

discharge measurements were

with standard USGS discharge

measurement methods (Rantz

made at most sites in accordance

and others, 1982; Turnipseed and

Sauer, 2010). At the Barelas site on

November 10, 2011, and August 11,

2012, and the Los Lunas II site on

November 15, 2011, the daily mean

discharge was obtained from the

System (NWIS) for the nearest

USGS National Water Information



Fish Assemblage Composition and Mapped Mesohabitat Features

By evaluating fish assemblage composition (that is, the number of individuals of each species collected either at a given sampling site or reach containing one or more sampling sites) over a range of streamflows during different times of the year, insights can be gained into the types of mesohabitats used by different species, including the Rio Grande silvery minnow, and how differences in the number of mapped mesohabitats and number of types of mesohabitats (depending on the amount of streamflow) correspond to changes in fish assemblages.



Fish Assemblage Composition

The average number of fish collected per site during the winter and summer sampling periods in each of the four reaches (Cochiti, Angostura, Isleta, and San Acacia) was determined by dividing the total number of fish collected per reach by the number of sites sampled per reach. The average number of fish collected decreased in the downstream direction during winter 2011–12, when the average number of fish collected was 1,394 in the Cochiti reach (based on a single sampling at the only site in the Cochiti reach, the Peña Blanca site), 154 in the Angostura reach, 97 in the Isleta reach, and 39 in the San Acacia reach (table 3). During summer 2012, the site in the Cochiti reach was not sampled, and only 3 of the 4 sites in the Angostura reach were sampled (the Bernalillo site was not sampled). In the three reaches sampled during summer 2012, substantially more fish were collected on average in each reach compared to winter 2011–12, with summer averages of 593 fish in the Angostura reach, 946 fish in the Isleta reach, and 697 fish in the San Acacia reach.

winter and summer sampling.

The sampling approach was the

same as the sampling approach

described in Moring and others

biased toward collecting fish from

shallow, low-velocity, nearshore

habitats preferred by Rio Grande

silvery minnow and similar fish;

for example, 3.0-millimeter mesh

seines were used, as opposed to

a larger mesh size, to increase

the likelihood of collecting Rio

minnow species. Additional

details on the fish assemblage

surveys are provided in Braun

and others (2015).

Grande silvery minnow and other

(2014) and was deliberately

In the three reaches sampled in both the winter and summer, the average number of species collected per sampling site was higher in summer 2012 compared to winter 2011–12. The average number of species collected per sampling site within each reach generally decreased between the upstream and downstream reaches in both winter 2011–12 (6.5, 4.4, and 2.2, respectively, in the Angostura, Isleta, and San Acacia reaches) and summer 2012 (8.0, 8.0, and 7.2, respectively, in the Angostura, Isleta, and San Acacia reaches). The Angostura reach likely maintains greater fish diversity in part because it maintains a more consistent discharge relative to the reaches downstream and does not go dry from year to year.

The relative abundance of Rio Grande silvery minnows, calculated as the number of Rio Grande silvery minnows collected at a sampling site during a sampling period (winter 2011–12 or summer 2012) divided by the total number of Rio Grande silvery minnows collected at all sampling sites during the same sampling period, was highest in

Table 3. Relative abundance of Rio Grande silvery minnows collected during sampling events in winter 2011-12 and summer 2012 on
 the Middle Rio Grande, New Mexico.

[MRGBI, Middle Rio Grande Bosque Initiative; RGSM, Rio Grande silvery minnow; CPUE, catch per unit effort; m2, square meters; ---, no data were collected during this time period]

MRGBI Reach Name	Short Name	Winter 2011–12					Summer 2012						
		Relative abun- dance of RGSM ¹ , in per- cent	CPUE for RGSM ²	Fish spe- cies rich- ness ³	Num- ber of RGSM collect- ed	Total number of fish collect- ed	Total area seined (m²)	Relative abun- dance of RGSM ¹ , in per- cent	CPUE for RGSM ²	Fish spe- cies rich- ness ³	Num- ber of RGSM collect- ed	Total number of fish collect- ed	Total area seined (m²)
Cochiti	Peña Blanca	0	0	4	0	1,394	661	—	—	—	—	—	—
stura	Bernalillo	1.23	0.38	8	2	450	531	—	—	—	_	—	_
	La Orilla	12.9	2.82	6	21	107	744	0	0	8	0	479	1,089
Addo	Barelas	7.98	1.03	5	13	23	1,259	4.55	0.08	9	1	530	1,254
	Los Padillas	4.29	1.10	7	7	34	634	0	0	7	0	770	1,185
	Los Lunas I	2.45	0.58	3	4	29	693	22.7	0.35	10	5	1,490	1,442
	Los Lunas II	0	0	1	0	1	651	18.2	0.35	9	4	817	1,155
Isleta	Abeytas	0	0	9	0	165	717	0	0	9	0	1,216	1,176
	La Joya	0.61	0.18	5	1	218	564	0	0	7	0	791	924
	Rio Salado	8.59	1.58	4	14	74	885	0	0	5	0	417	780
	Lemitar	7.98	2.46	3	13	57	529	45.5	0.88	8	10	1,729	1,142
San Acacia	Arroyo del Tajo	46.0	10.3	3	75	125	729	4.55	0.07	8	1	290	1,416
	San Pedro	3.07	0.68	2	5	6	738	4.55	0.08	7	1	269	1,314
	Bosque del Apache I	1.23	0.27	2	2	3	735	0	0	6	0	528	1,002
	Bosque del Apache II	3.68	0.82	1	6	6	735	0	0	7	0	670	1,260

0.03 in the Angostura reach. The RCPUE was substantially higher in winter 2011–12 relative to summer 2012 because not only were there far more Rio Grande silvery minnows caught in winter 2011–12 (163) than in summer 2012 (22), but the seined area tended to be higher in summer 2012 because of a change in methodology between the two sampling events (as many as 20 mesohabitats were selected for seining in winter 2011–12 as compared to 30 mesohabitats in summer 2012). The RCPUE in the Cochiti reach was 0 percent in winter 2011–12 because no Rio Grande silvery minnows were collected at the Peña Blanca site.

Among all sampling sites, the highest fish-species richness for the winter sampling period was measured at the Abeytas site (9 species); the highest fish-species richness for the summer sampling period was measured at the Los Lunas I site (10 species). The lowest fish-species richness for the winter sampling period was measured at the Los Lunas II and Bosque del Apache II sites (one species each); the lowest fishspecies richness for the summer sampling period was measured at the Rio Salado site (five species) (table 3). In all cases, the number of species collected at each sampling site in winter 2011–12 was less than (or equal to, in the case of the Los Padillas and Abeytas sites) the number of species collected at the same sampling site in summer 2012. In all cases, the total number of fish collected at each sampling site in winter 2011–12 was less than the number of fish collected at the same sampling site in summer 2012. In winter 2011–12, the most fish were collected at Peña Blanca (1,394), and the least were collected at Los Lunas II (1); whereas in summer 2012, the most fish were collected at Lemitar (1,729), and the least were collected at San Pedro (269). It stands to reason that there would be greater species richness and a larger number of fish collected in summer 2012

relative abundance of Rio Grande silvery minnows during winter 2011-12 occurred at Arroyo del Tajo (46.0 percent) followed by La Orilla (12.9 percent). Conversely, no Rio Grande silvery minnows were collected at 3 of the 15 sites sampled (Peña Blanca, Los Lunas II, and Abeytas) during winter 2011–12. The highest relative abundance of Rio Grande silvery minnows during summer 2012 occurred at Lemitar (45.5 percent) followed in succession by Los Lunas I (22.7 percent) and Los Lunas II (18.2 percent). Conversely, no Rio Grande silvery minnows were collected at 7 of the 13 sites sampled (La Orilla, Los Padillas, Abeytas, La Joya, Rio Salado, Bosque del Apache I, and Bosque del Apache II) during summer 2012.

At the mesohabitat scale, Rio Grande silvery minnows were collected in 6 of the 8 mesohabitat types mapped in this study (table 4). Rio Grande silvery minnows were collected most often in runs (101 individuals from 35 mesohabitats), followed by flats (32 individuals from 9 mesohabitats) and pools (28 individuals from 9 mesohabitats). The RCPUE by mesohabitat type was highest in pool mesohabitat types (1.44), followed by riffles (1.06) and runs (0.77).

Table 4. Rio Grande silvery minnow collection information based on mesohabitat type in the Middle Rio Grande, New Mexico, 2011–12.

[RGSM, Rio Grande silvery minnows; m², square meters; RCPUE, catch per unit effort; ---, not applicable because no RGSM were collected in these mesohabitat types]

the Isleta reach and about 5 percent in the Angostura reach. No Rio Grande silvery minnows were collected at the Peña Blanca site in the Cochiti reach during the one time it was sampled (winter 2011-12).

the San Acacia reach during

both winter 2011–12 (about

62 percent) and summer

2012 (about 54 percent).

The relative abundance of

Rio Grande silvery minnows

was higher in the Angostura

reach (about 26 percent)

in winter 2011–12 than in

the Isleta reach (about 12

was true in summer 2012, when the relative abundance

was about 41 percent in

percent), but the reverse

The catch per unit effort of Rio Grande silvery minnows (RCPUE) was calculated by dividing the number of Rio Grande silvery minnows collected at a sampling site during a sampling period (winter 2011–12 or summer 2012) by the sum of the total area seined (in square meters [m²]); the resulting quotient sites. was multiplied by 100 m² to obtain the RCPUE. The use for differences of RCPUE to standardize in sampling fish data allows for direct effort between comparisons between stream winter 2011–12 reaches or mesohabitats of and summer different sizes (Nielsen and 2012 associated Johnson, 1983). The RCPUE with differences was highest on average per in the number sampling site in the San of mesohabitats Acacia reach during both seined, relative winter 2011–12 (2.91) and abundances summer 2012 (0.20). Like of Rio Grande the relative abundance, the silvery minnows average RCPUE per site were calculated was higher in the Angostura for each of the reach (1.33) in winter sampling sites 2011–12 compared to the during both Isleta reach (0.47), but the winter 2011-12 reverse was true in summer and summer 2012, when the RCPUE was 2012 (table 3).

relative to winter 2011-12 because lower flows (and subsequently shallower mesohabitats) in summer 2012 increased the likelihood of seining success. Not only is seining easier at shallow depths (because of the potential for increased speed and mobility from the crew of technicians collecting fish), but the overall fish density for each sampling site is also higher in the summer (assuming the number of fish remains relatively consistent) because the volume of water in which the fish are confined is smaller. However, it should be noted that the fishing effort was commensurate with the number of mesohabitats sampled for fish. In most cases, the number of mesohabitats sampled for fish increased from about 20 in winter 2011–12 to about 30 in summer 2012. Fewer than 20 mesohabitats were mapped in winter 2011–12 at Bernalillo (17), La Joya (18), and Lemitar (16) (fig. 7), so the number of mesohabitats where fish were collected was less than 20 at these three To account

Mesohabitat type	Number of mesohabitats where RGSM were collected	Number of RGSM collected in each mesohabitat type	Number of seine hauls made in each mesohabitat type	Total area seined (m²)	RCPUE ¹
riffle	6	13	47	1,227	1.06
run	35	101	458	13,161	0.77
pool	9	28	97	1,941	1.44
isolated pool	2	5	52	930	0.54
forewater	0	0	10	324	
backwater	1	6	66	1,521	0.39
embayment	0	0	21	654	_
flat	9	32	237	6,185	0.52
¹ Calculated as the n	umber of RGSMs collec	ted within a given mesoh	abitat type divided by the to	tal area (in square m	neters) seined

within that mesohabitat type \times 100.

Mapped Mesohabitat Features

The total number and number of types of mesohabitats were generally larger at sampling sites during summer 2012, when streamflows were low, compared to winter 2011–12, when streamflows were moderate. During summer, streamflow also tended to decrease in the downstream direction in the study area. Decreases in streamflow in the summer compared to the winter typically led to increases in channel complexity in terms of the number of different wetted mesohabitat types present (fig. 7*A*), total number of mesohabitats present (fig. 7B), and the number of channel bars mapped (fig. 7C). Decreases in streamflow also led to reductions in wetted area at all of the sampling sites that were mapped in both winter 2011–12 and summer 2012 (fig. 7D). Summary statistics associated with winter 2011–12 are based on maps generated in November and December 2011 as well as February 2012. For sampling sites that were mapped more than once during winter 2011–12 (San Pedro and Bosque del Apache II), the data associated with sampling in February 2012 was used in the calculation of summary statistics because the data were accompanied by the collection of physical habitat and fish data, whereas no such data were collected in association for San Pedro and Bosque del Apache II from December 2011 because of inclement weather.

Decreases in streamflow between winter 2011–12 and summer 2012 also led to decreased wetted areas of mesohabitats that were mapped at each sampling site. Sampling sites in the lower part of the Angostura reach and the upper part of the Isleta reach that pass through or near the city limits of Albuquerque, N. Mex., remain perennially wet throughout the year. Six sampling sites within these reaches (La Orilla, Barelas, Los Padillas, Los Lunas I, Los Lunas II, and Abeytas) had the largest wetted area for the winter 2011–12 period, and 5 of these 6 sites had the largest wetted area for the summer 2012 period (fig. 7D). The wide channel conditions and sustained flow at the Barelas site produced the largest wetted areas (113,199 m² during winter 2011–12 and 103,094 m² during summer 2012) of all sampling sites. The greatest difference between wetted areas at a single sampling site between winter 2011–12 and summer 2012 was measured at the Abeytas site, where a difference in wetted area of 60,314 m² was measured. The smallest wetted area in winter 2011–12 was measured at the Bernalillo site (37,144 m^2), whereas the smallest wetted area in summer 2012 was measured at the Lemitar site $(13,547m^2)$.

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¹Calculated as the number of RGSMs collected at a site during a sampling period divided by total number of RGSMs collected at all sites during the same sampling period multiplied by 100. Percentages may not sum to 100 because of rounding differences.

²Calculated as the number of RGSMs collected at a site during a sampling period divided by the total area (in square meters) seined multiplied by 100.

³Total number of species collected.

Fish Assemblage Composition and Mapped Mesohabitat Features Over a Range of Streamflows in the Middle Rio Grande, New Mexico, Winter 2011–12, Summer 2012

0.14 in the Isleta reach and

By

Daniel K. Pearson, Christopher L. Braun, and J. Bruce Moring

The highest



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