Habitat Assessment for Rio Grande Silvery Minnow (*Hybognathus amarus*) in the Cochiti Reach, at Peña Blanca, New Mexico

FINAL REPORT

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EXECUTIVE SUMMARY

A small-scale habitat assessment for Rio Grande silvery minnow (RGSM) was conducted in the Cochiti Reach at Peña Blanca, New Mexico to characterize habitat, document the status of RGSM, and provide recommendations regarding future management. Surveys were conducted during fall (November 2006), winter (February 2007), and spring (April 2007). Habitat characterization included transect and fish community data analysis from Peña Blanca, a hydrograph exceedence probability comparison of three U.S. Geological Survey (USGS) gauges (from 1975-2006), and a Geographical Information System (GIS) analysis of active channel changes (from 1992 and 2006) within the Cochiti Reach.

Channel morphology, velocities, and substrate were similar between Peña Blanca and previously surveyed sites above Cochiti Lake. Runs and pools were the most common mesohabitat type available at the Peña Blanca site. Substrate was sand and gravel. Velocities at Peña Blanca ranged from 0.0 to 5.5 ft/sec. Mean velocity was 2.25 ft/sec (± 0.04 SE). Cochiti Reach had higher average discharge than Isleta and San Acacia reaches, and less hydrographic diversity. No RGSM were collected and the site was primarily dominated by non-native fish species. Fish communities were different between Peña Blanca and downstream sites (Isleta and San Acacia reaches). Downstream sites displayed higher occurrences of slackwater areas, mesohabitats more often utilized by RGSM. Active channel GIS analysis indicated a continued trend in channel narrowing and incision within Cochiti Reach.

The absence of low-velocity habitats and lower habitat diversities is indicative of the Cochiti Reach channel no longer experiencing historic levels of meandering, braiding, and overbank flooding from natural variations and sediment supply. Benefits of the Peña Blanca site for supporting RGSM are continuous flow and location (e.g., adjacent to and upstream of remaining population). However, at this time, establishing a self-sustaining population of RGSM through augmentation efforts at this time would be problematic in the Cochiti Reach because environmental constraints (such as habitat fragmentation and channel dynamics) that continue to persist.

A variety of management actions could improve the viability of Cochiti Reach for RGSM habitat. Recommendations include surveying Peña Blanca during summer months, characterizing additional sites for habitat / fish community analysis within the Cochiti Reach, reconnecting Cochiti and Angostura reaches via fish passage at Angostura Diversion Dam, and developing an open communication network with neighboring Pueblos to maximize the benefits of their projects on the native fish community.

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INTRODUCTION

The Rio Grande begins in the San Juan Mountains of southern Colorado and flows south for approximately 1,900 mi (3,000 km) through New Mexico and Texas. The river forms the international boundary with Mexico and ultimately reaches the Gulf of Mexico.

The Rio Grande was influenced by human activities prior to European colonization, but most large-scale changes occurred within the last 78 years (Ortiz 2000). Cochiti Dam (Figure 1) was constructed for flood and sediment control on the mainstem of the Middle Rio Grande (MRG) in 1975 and is operated by the U.S. Army Corps of Engineers. Significant geomorphic changes have occurred downstream since the construction of Cochiti Dam including channel degradation, narrowing and straightening of the channel, and a coarsening of bed sediment within the active wetted perimeter of the channel (MEI 2002; USBR 2004). Upon dam completion, flows became highly regulated, sediment became trapped upstream of the dam, and the river channel became degraded and armored (MEI 2002; USBR 2004). Although some of these changes began prior to dam construction due to upstream reclamation efforts and channelization, changes were exacerbated after dam construction was completed (Ortiz 2000; Baird and Sanchez 1997). Similar to many dams around the world, Cochiti was an engineering success; however, the reservoir impoundment contributed in various ways to the decline of native aquatic organisms (Luttrell et al. 1999). One species directly affected by Cochiti Dam and the modified control of the MRG is the federally endangered Rio Grande silvery minnow *(RGSM, Hybognathus amarus*).

Rio Grande silvery minnow

Historically, RGSM occupied close to 4,000 river km within the Rio Grande Basin stretching from northern New Mexico to the Gulf of Mexico. Rio Grande silvery minnow was among the most abundant and widespread Rio Grande fish species. Rio Grande silvery minnow currently occupy only 7% of their historical range, from below Cochiti Dam to Elephant Butte Reservoir in New Mexico (Bestgen and Platania 1991; USFWS 2007). Factors contributing to the decline of RGSM include modified stream discharge, altered sediment loads, channel desiccation, habitat fragmentation, channelization, competition and predation by nonnative species, and water quality degradation (Remshardt 2006; USFWS 2007).

Research concerning the federally endangered RGSM has been conducted primarily by U.S. Fish & Wildlife Service (USFWS), American Southwestern Ichthyological Researchers, LLC, and University of New Mexico. Studies outlined in Table 1 relate specifically to this project in that they used similar habitat characterization and methodology. These studies are important because they provide insight not only into the biology of RGSM, but also to habitat preference and associations.

Platania (1993) studied habitat preference at eight sites within the current RGSM range, concentrating on the Isleta and San Acacia reaches. Platania (1993) incorporated visual mesohabitat type, substrate identification, water column measurements (depth and velocity), and transect measurements. While the study identified 17 mesohabitat types, most RGSM were found to occupy slackwater habitats such as pools and embayments. Rio Grande silvery minnow were collected with some regularity from Bernalillo downstream, but RGSM were rare in Angostura Reach (Platania 1993).

Watts et al. (2002) conducted a habitat study and found RGSM primarily in habitats associated with debris and shoreline areas in the Angostura and Isleta reaches. While RGSM were most often found in shoreline and debris habitats during winter and fall, they were found to move into open water habitats (such as runs and pools) during spring (Dudley and Platania 1997; Remshardt and Tashjian 2003; Watts et al. 2002). Rio Grande silvery minnow were commonly found in depths < 0.50 meters (m), velocities < 0.40 meters/second (m/sec), and silt substrate, most frequently utilizing debris piles, pool, and backwater mesohabitats (Dudley and Platania 1997; USFWS 2007). Habitat preferences varied by size class, smaller RGSM individuals (60 mm standard length (SL) or less) utilized relatively shallow and slow waters while larger RGSM (> 60 mm SL) often utilized a wider range of depths and mean velocities (Dudley and Platania 1997, Remshardt and Tashjian 2003).

Since RGSM currently occupy only about 7% of its historical range, determining and understanding habitat availability within the current range is imperative for conservation. After Cochiti Dam was constructed, lateral channel mobility of the Cochiti reach decreased, and sinuosity decreased (Richard 2001). From 1985 to 1992 the Cochiti reach active channel width narrowed an estimated 12 % (Richard 2001).

According to the RGSM Recovery Plan (USFWS, 2007), multiple populations of RGSM must be established outside of the MRG. In response to this criterion, Buntjer and Remshardt (2005) conducted RGSM surveys and habitat assessments in the Rio Chama and Rio Grande above Cochiti Lake. The intent was to determine the presence of RGSM above Cochiti Lake and to evaluate the areas suitability as a potential reintroduction site. Surveys found these areas unsuitable for RGSM due primarily to relatively high (≥ 2.5 ft/sec) water velocities, unsuitable substrate, and relatively short reach length.

To supplement populations of RGSM in the MRG, an experimental augmentation and monitoring project was initiated in 2002 by USFWS. Augmentation was initially focused in the Angostura Reach, but now includes the Isleta and San Acacia reaches with positive results (Remshardt 2006). Successful augmentation led to the evaluation of other areas as potential reintroduction sites for recovery (Remshardt and Kitcheyan, 2005).

Rio Grande silvery minnow are abundant in Isleta and San Acacia reaches (Remshardt and Tashjian 2003), but frequent surface flow intermittence during summer months reduces larval fish survival and recruitment on an annual basis. Cochiti and Angostura reaches may be valuable to recovery efforts because they are relatively free of intermittency.

Uncertainty remains whether the Cochiti reach provides the geomorphic and biological requirements necessary to sustain the life cycle of the RGSM. There have been no documented collections in Cochiti Reach since 1999, but it is possible that RGSM may still persist, albeit in low numbers (Remshardt and Kitcheyan 2005). Rio Grande silvery minnow surveys and habitat assessments in the Cochiti Reach would provide information necessary to determine presence and feasibility of releasing RGSM in this reach (Remshardt and Kitcheyan 2005).

Project objectives

Objectives of this project were to:

- Assess active river channel changes over time to relate to the presence/absence of RGSM in Cochiti Reach.
- Determine habitat suitability for RGSM within the Cochiti Reach.
- Provide recommendations regarding future augmentation implementations of RGSM within the Cochiti Reach.

METHODS

Study Site

The MRG is defined as the stretch of river between Cochiti Dam and Elephant Butte Reservoir in New Mexico (Figure 1). The MRG is separated into four sections or "reaches". They include Cochiti (22.9 mi or 36.85 km), Angostura (40.4 mi or 65.02 km), Isleta (53.1 mi or 85.46 km), and San Acacia reaches (57.2 mi or 92.05 km). Within the Cochiti Reach, we were limited to 1 site located between southern boundary of Cochiti Pueblo and northern boundary of Santo Domingo Pueblo. This site, known as Peña Blanca, is approximately 1.5 mi (2.41 km) in length (Figure 2). This site is representative of conditions throughout Cochiti Reach.

River Channel Characterization

We compared macro-habitat at Peña Blanca by analyzing previously available active channel width data within the Cochiti Reach and post-dam hydrograph records (1975-2006). Richard (2001) reported the "active channel" as the area between the abandoned floodplain surfaces that is un-vegetated and has a significant probability of inundation during the year. Active channel data was obtained from Richard (2001) and Bureau of Reclamation, Denver office (2006). ArcGIS was then used to analyze these data sets.

To characterize point-in-time hydrological conditions, transects were placed at the top (1), middle (2), and bottom (3) of the site (Figure 3). At each transect, a tag line was placed perpendicular to channel direction. Depth (ft) and velocity (ft/sec) measurements were recorded at 4-ft intervals. Depth at each point was recorded using a wading rod in engineer's increments (tenths of feet) and current velocity was measured using a Marsh-McBirney flow meter at 0.6 of water column for depths $\leq$ 2 ft. (Thevenet and Stantzer, 1999). For depths $\geq$ 2 ft., velocity was measured at 0.2 and 0.8 of the water column and then averaged to obtain mean velocity. Transect data were translated into velocity and depth profiles to determine a measure of volumetric availability of velocities at a given flow range and differences in channel depths.

Habitat Characterization

Mesohabitat characterization surveys were conducted in 2006 and 2007. We sampled on 20 November 2006 (fall), 21 February 2007 (winter), 20 April 2007 (spring) to assess variations in seasons and flow regimes (low [< 100 cfs], moderate [100 to 800 cfs], and high [> 800 cfs]) (Table 2).

United States Geological Survey (USGS) stream gauge *USGS 08317400 Rio Grande below Cochiti Dam* was used to acquire average daily discharge for each sampling period. Physical water chemistry was recorded using a YSI™ 556 instrument at the start and completion of each field-sampling period and included the following measurements: dissolved oxygen (mg/l), pH, salinity (ppt), total dissolved solids (g/L), and temperature (ºC) (Table 3). Depth and velocity measurements were collected similar to previously described methods.

Mesohabitat surveys (coinciding with fish survey seine hauls) were conducted based on features categorized by Hoagstrom and Tashjian (2001) (Appendix A). The presence or absence of algae on substrate, aerial overhang, and debris on substrate were recorded. Type of riverbed surface, cohesion, and fluvial patterns were also recorded.

Fish community

Fish surveys coincided with mesohabitat characterization surveys. On 20 November, 2006, each seine haul was marked with GPS waypoints (Figure 3). During subsequent survey periods (21 February and 20 April 2007), the same GPS locations were re-located to the best of our ability in an attempt to provide consistency among seine hauls during the low (< 100 cfs), moderate (100 to 800 cfs), and high (> 800 cfs) flow regimes. A total of 40 seine hauls were conducted throughout the entire length of the site using a seine [2.74 m x 1.83 m x 3.18 mm mesh with a double lead-weighted (every 0.15m) drag line]. Sampling area was calculated by multiplying seine width by seine haul length. Initial seine haul locations were discretionary, but attempts were made to survey all available habitats within the Peña Blanca site including habitats known to be favorable to RGSM. To supplement seining data, a Smith-Root backpack electrofisher (Type 12 model, settings = J-5, 300 amps) was used to sample deep/fast habitats. All fish were identified to species, enumerated, and released.

Relative abundance was calculated as the number of individuals of a species divided by the total number of all fish collected. Percent occurrence was calculated as the number of seine hauls a species was collected in divided by the total number of all seine hauls. Catch rates were calculated by dividing the total number of fish for a specific sampling day by the total seine haul area for that sampling day, then multiplied by one hundred (# fish / 100 m^2). Graphical illustrations of catch rates were provided for 13 species, taxa representing the most abundant species present in recent Middle Rio Grande collections (Dudley and Platania 2007). Related fish taxa codes are located in Appendix B.

Data Analysis

Habitat characterization consisted of examining Geographical Information System (GIS) data from the Cochiti Reach. Using Arc Map (GIS), the 1992 and 2006 data sets were overlaid and transposed onto aerial photography (obtained from USFWS Region 2 office) images taken in January 2006 of Cochiti Reach. After completing the overlay analysis, sums of each area's changes were compared in the attribute table of each layer. A percentage change for the reach was then computed from the differences in sums between the 1992 and 2006 layers.

Hydrograph analysis of the Peña Blanca site included obtaining mean daily flow numbers (1975-2006) from three USGS gauging stations; USGS 08317400 Rio Grande below Cochiti Dam, New Mexico; USGS 08330000 Rio Grande at Albuquerque, New Mexico; and USGS 08354900 Rio Grande Floodway at San Acacia, New Mexico. The hydrograph was analyzed to examine similarities and differences among three USGS gauging stations. An exceedence probability curve was generated for each of the three gauge sites. Gauge data (1975-2006) were plotted with mean daily flow (exceedence probability, y-axis) versus discharge (cfs, x-axis). The exceedence probability was the percent of time when flow was greater than the associated value.

Fish community data from Peña Blanca was compared to three downstream sites [La Orilla (LO), Los Lunas (LL), and Bosque del Apache (BDA)] (Remshardt and Tashjian 2003) using a non-metric multidimensional scaling (NMDS) analysis. A main fish species matrix was created, which the NMDS analysis was solely based upon. A secondary matrix containing categorical and quantitative environmental variables (i.e., site, season, channel type, habitat type, surface type, bed type, and cohesion type) was used to evaluate patterns associated with fish communities. While ordination results were 3-dimensional, visual results were plotted as a 2-dimensional graph comparing all fish communities among the days surveyed. The NMDS was run using PC-ORD, statistical software for multivariate analysis of ecological data (McCune and Mefford 1999).

RESULTS

River Channel Characterization

The active channel width analysis included the entire Cochiti reach, however only the Peña Blanca site is shown in detail (Figure 4). Analysis from the combined river channel data sets indicated an 8.24% area (m^2) reduction between 1992 and 2006 (Figure 4). GIS analysis showed a narrowing in area and channel incision between 1992 and 2006.

Flows varied in the downstream San Acacia reach compared to the Cochiti and Albuquerque gauges (Figure 5). Discharge data from 1975-2006 indicated exceedence probabilities were similar at and above 1,000 cfs. Conversely, below 1000 cfs, exceedence probabilities were lower in the San Acacia reach at similar flows. Flows associated with the Peña Blanca site (Cochiti gauge) indicated that 40% of the time flows exceeded 1,000cfs. Velocities recorded from transects at Peña Blanca ranged from 0.0 to 5.5 ft/sec (Figure 6). Mean velocity was 2.25 ft/sec (± 0.04 SE). Transect depth profiles indicated a shift in channel depth from the east-side channel to the west side channel for transects 1 and 3 (Figure 7 and 8). Depth profiles were more single threaded in the spring-concentrated flow (April 2006), but also showed a shift in riverbed depths among seasons.

Habitat Characterization

Water quality measurements for all four sampling periods are described in Table 3. During all sampling periods, the most observed habitats at Peña Blanca were runs and pools (Figure 9). While additional habitat types such as riffles and embayments were observed, runs were the most dominant. Of the 14 mesohabitat types we monitored for, only 7 were observed Peña Blanca. Substrate was dominantly loose, consisting of sand (58.2%) and gravel (19.5%). An expansive 300 m X 100 m backwater was observed on river left during all sampling periods. Four side-channels were observed below transect 2 but water availability was dependent on season and discharge (cfs). On 20 November 2006, we observed flow within a side channel located below transect 2. However, on 21 February 2007 the same side channel was dry with a few isolated pools. Shoreline vegetation at Peña Blanca was littered primarily by invasive species such as Russian olive (*Eleagnus angustifolia*) and salt cedar (*Tamarisk sp*.).

Fish Community

Non-native fish were the dominate species at Peña Blanca (Table 4). No RGSM were collected during any sampling occasion. No fish were collected during the fish surveys conducted on February 21, 2007; area sampled was 1140.67 m²; average discharge was 789 cfs. A total of 53 individuals were collected on 28 February 2007; area sampled was 849.85 m²; average discharge was 719 cfs. A total of 15 individuals were collected on 20 April 2007; area sampled was 1675.05 m²; average discharge was 1,129 cfs. Among the six species collected (Table 4), the only native species found was longnose dace (*Rhinichthys cataractae*). The most abundant species were western mosquitofish (*Gambusia affinis*) and white sucker (*Catostomus commersoni*). Catch rates for Peña Blanca (Figures 10-12) were highest in November and February when discharge averages were lower (1,129 and 789 cfs). The NMDS ordination (Figure 13) suggests the fish community at the Peña Blanca site were different than those in sites of the lower reaches. Fish communities at LL and BDA were distributed along axis 2 and 3, indicating variability in community structure and habitat diversity. Results from NMDS ordination indicate fish communities in the downstream sites have more favorable habitat associated with RGSM, including silt substrate and braided channel type.

DISCUSSION

In river systems, variation in flows often creates habitat complexity; therefore variation in flows is important in the development of dynamic habitat. Cochiti Dam is a pass-through reservoir, except when operated for flood control. This results in peak flow and sediment reduction, an important factor in sculpting dynamic RGSM habitat. Richard (2001) concluded that since the completion of Cochiti Dam, the river channel in the Cochiti Reach has evolved towards a more stable channel configuration. This study (data spanning 1975 to 1992) concluded the Rio Grande adjusted (i.e., a historically meandering and braided active channel transformed) into a more stable, single channel configuration.

Cochiti Reach appears to be following a trend of active channel narrowing with high velocities > 1 ft/sec. Velocities at Peña Blanca ranged from 0 to 5.5 ft/sec, but with limited slackwater habitats for RGSM. Velocities and substrates at sites above Cochiti Lake were similar to Peña Blanca (Buntjer and Remshardt 2005). As discharges increased at both sites, width/depth ratios decreased, suggesting channelization (Figure 14). However, wetted width ratios at Peña Blanca were higher than sites above Cochiti Lake (Figure 15). Remshardt and Tashjian (2003) characterized velocity patterns at three sites (LL, LO, and BDA) as slack water (0 – 0.5 ft/sec), medium (0.5 to 1.5ft/sec), fast (1.5 to 3.5 ft/sec), x-fast (> 3.28 ft/sec) (Figure 16). Among the four velocity patterns, slack water was most often reported at the LL site (Figure 17) while fast velocities were highest at the LO and Peña Blanca sites. Among the four sites, Peña Blanca displayed the most occurrences of high velocities (> 1.5 ft/sec) (Figure 16). Whereas, low velocities were most often displayed at the downstream sites (i.e., LL and BDA) corresponding to favorable RGSM mesohabitats. Rio Grande silvery minnow were most abundant (86.5%) in areas with little or no water velocity (< 0.3 ft/sec), found occasionally (11.0%) in areas of moderate velocity (0.4 ft/sec to 1.0 ft/sec), and rarely found (0.8%) in habitats with water velocities > 1.3 ft/sec (Dudley and Platania 1997; USFWS 2007).

The absence of several mesohabitat types, specifically low-velocity habitat indicates that habitat diversity is limited at Peña Blanca. It can be hypothesized that much of the Cochiti Reach channel lacks adequate low flow habitats, no longer experiences historic levels of meandering, braiding, and overbank flooding due to the absence of flow variations and sediment supply. Fish require ecological conditions similar to what was historically present to support self-sustaining populations (Polivka, 1999; Hoagstrom, 2003).

Runs were the most common mesohabitat type available at Peña Blanca. Dudley and Platania (1997) found that pools are among the most frequently used habitats (30% of the time), while runs (often the most abundant mesohabitat type) are usually avoided by RGSM, utilized only 1.3% of the time. In comparison to downstream sites, mesohabitats available at Peña Blanca would not be preferred by RGSM. Rio Grande silvery minnow were found in Isleta and San Acacia reaches where there is higher habitat diversity with pools and embayments, including features such as low-velocity shorelines and debris piles (Table 5; Remshardt and Tashjian, 2003). Prior to reservoir construction, the Cochiti Reach would have resembled downstream areas of the Rio Grande, which historically consisted of a braided channel with sand substrates. The Cochiti Reach (including Peña Blanca) has become a single-threaded channel with high incision rates due to sediment retention by Cochiti Dam and other upstream reservoirs contributing to the loss of RGSM habitat formation and sustainability (Ortiz 2000; Baird 2001; USFWS 2007).

The fish community at Peña Blanca reflects an area for cold-water fish associated with gravel-bottom substrates. The absence of RGSM at Pena Blanca does not rule out the fact that they are absent from the site, let alone the entire Cochiti Reach. Nevertheless, the population in this reach, if still present, is at such low levels that they are functionally absent. Egg monitoring activities at Angostura diversion dam since 2002 have failed to document RGSM spawning activity in Cochiti Reach (NMFWCO, unpublished data).

A self-sustaining population of RGSM would likely not persist in the Cochiti Reach because the environmental constraints that caused the initial decline are still present (i.e.

habitat conditions, habitat fragmentation, channel dynamics). The most common mesohabitat types found at Peña Blanca were deep, swift runs, which are not generally preferred by RGSM. Dudley and Platania (1997) found pools are among the most frequently used habitats (30% of the time), while runs are usually avoided by RGSM, utilized only 1.3% of the time. Additionally, the absence of low velocity habitats for larvae and young-of-the-year, and the relative short reach length limit the ability of RGSM to successfully complete its life cycle.

The benefits of the Peña Blanca site for supporting RGSM would be continuous flow and location. Rio Grande silvery minnow in the upper areas of the Cochiti Reach might alleviate the negative effects caused by intermittency, which remains a serious dilemma in the Isleta and San Acacia reaches. Rio Grande silvery minnow are pelagic spawners, site location is important for this species reproductive ecology. The presence of potential spawners upstream could add to the stability of the current population. While releases from Cochiti Dam likely decrease water temperatures from those observed upstream (i.e., Otowi Bridge) there is no reason to believe that adult RGSM could not survive or over-winter in these lower water temperatures. Results from population surveys below Angostura Diversion Dam, which were comparable due to similar discharge, substrate, and habitat availability, reveal the presence of RGSM suggesting similar habitat conditions (Dudley and Platania 2007).

An experimental, small-scale, augmentation project targeted for the Peña Blanca site could provide management flexibility for RGSM, but should only be considered if there was an excess or “surplus” of RGSM. Suitable habitat may be present for adult silvery minnow, since adult RGSM occupy a variety of other habitats such as runs (USFWS 2007).

RECOMMENDATIONS

A variety of management actions could improve the viability of Cochiti Reach as RGSM habitat. Regardless of any management decision, we must take into account that the land base encompassing the Cochiti Reach is primarily tribal owned. Efforts must be fully supported by our Pueblo partners to enhance the aquatic ecosystem in the Cochiti Reach. Specific recommendations include:

- Characterize habitat at Peña Blanca during summer months to determine variations among all four seasons. Sampling techniques might be modified (raft electro-fishing) to accommodate higher flows.

- Reconnect Cochiti and Angostura reaches via fish passage at Angostura Diversion Dam.

- Develop an open communication network with neighboring Pueblos concerning their stream restoration efforts and work cooperatively to determine the effects of their projects on the fish community.

- Characterize additional sites for habitat / fish community to encompass the entire Cochiti Reach.

- Reintroduction is not currently recommended based on this research and other current information. If fish passage is constructed and proven to be beneficial, further management actions including augmentation could be considered.

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Watts, H. E., C.W. Hoagstrom, and J.R. Smith. 2002. Observations on habitat associated with Rio Grande Silvery Minnow (*Hybognathus amarus*), U.S. Fish and Wildlife Service, New Mexico Fishery Resources Office, Albuquerque. Report submitted to U.S. Army Corps of Engineers, Albuquerque District. 18 pp.

Table 1. Summaries of selected RGSM studies conducted on the Middle Rio Grande, New Mexico.

SOURCE / REFERENCE	TIME / PERIOD	LOCATION / REACH	STUDY DESCRIPTION
Remshardt and Tashjian 2003	2002-2004	Angostura, Isleta, and San Acacia	Determined habitat preference of RGSM in relation to fluvial geomorphology and flow regime
Watts et al. 2002	1998-2001	Angostura and Isleta	Determined RGSM distribution, abundance, co-occurrence of fish species, qualitatively described mesohabitat, and quantitatively characterized RGSM habitat associations in Angostura and Isleta reaches
Dudley and Platania 1997	1994-1996	Angostura and San Acacia	Characterized habitat use of RGSM in two sites; determined by measurements of depth, velocity, and substrate
Platania 1993	1993	Cochiti	Documented community composition of Rio Grande fish fauna within the Cochiti reach of the Rio Grande
Buntjer and Remshardt 2005	2004	Rio Grande and Rio Chama above Cochiti	Habitat assessment of areas above Cochiti Reservoir describing mesohabitat and velocity

Table 2. Field sampling dates conducted at Peña Blanca, Middle Rio Grande, New Mexico.

DATE	TYPE OF SURVEY	MEAN DAILY DISCHARGE (CFS)
November 20, 2006	Habitat assessment and fish survey	1, 162
February 21, 2007	Habitat assessment and fish survey	789
February 28, 2007	Fish survey (Electrofishing)	719
April 20, 2007	Habitat assessment and fish survey	1,129

Table 3. Mean daily water quality measurements (± std) Peña Blanca, Middle Rio Grande, New Mexico.

SAMPLING DATE	20 NOV 2006	21 FEB 2007	28 FEB 2007	20 APR 2007
Physical water chemistry				
Temperature (°C)	8.62 (0.95)	5.48 (2.50)	5.58 (2.52)	11.08 (0.00)
Dissolved Oxygen (%)	119.85 (9.97)	116.60 (2.32)	88.90 (4.10)	117.50 (0.00)
Dissolved Oxygen (mg/L)	13.95 (0.82)	14.61 (2.13)	11.16 (0.18)	12.92 (0.00)
Specific Conductivity (uS/cm)	251.50 (0.71)	285.50 (3.54)	275.00 (1.41)	23.00 (0.00)
Total Dissolved Solids (g/L)	0.164 (0.00)	0.186 (0.00)	0.179 (0.00)	0.155 (0.00)
Salinity (ppt)	0.12 (0.00)	0.14 (0.00)	0.13 (0.00)	0.11 (0.00)
pH	7.67 (1.24)	8.56 (0.50)	8.49 (0.27)	7.68 (0.00)
Mean daily discharge (cfs)	1,162	789	719	1,129

Table 4. Fish survey results conducted at Peña Blanca, Middle Rio Grande, New Mexico. Species name, status (N=native, I=introduced or non-native), numbers (N), relative abundance, percentage occurrence, and habitat associations in seine haul collections from three habitat survey days combined.

SPECIES	Status	N	Relative Abundance	Percent Occurrence	Observed Habitat
Longnose dace *(Rhinichthys cataractae)*	N	3	0.03	0.68	Riffle
White sucker *(Catostomus commersoni)*	I	32	0.28	2.05	Pool, Run, Backwater
Black bullhead *(Ameiurus melas)*	I	1	0.01	0.68	Pool
Western mosquitofish *(Gambusia affinis)*	I	75	0.65	2.05	Pool, Backwater
Largemouth bass *(Micropterus salmoides)*	I	2	0.02	1.36	Pool, Isolated pool
Brown trout *(Salmo trutta)*	I	2	0.02	0.68	Riffle, run
TOTAL		115			

Table 5. Habitat feature types (%) recorded during habitat surveys among all four sites(Peña Blanca [PB], La Orilla [LO], Los Lunas [LL], and Arroyo del Tajo [ADT]. **Feature labeled 'Other' includes dynamic features types (dune crest plunge, embayment fence, confluence pool, by-pass channel, divergence run, forewater, and isolated pool) not typically observed in substantial percentages at any of the four sites.

	SITES			
HABITAT FEATURES	PB	LO	LL	ADT
Lateral plunge	1.0	1.1	1.0	1.2
Riffle	2.0	2.8	1.5	2.5
Pool	30.0	10.9	12.5	7.5
Run	59.0	67.7	62.3	63.7
Lateral embayment	2.0	3.1	10.0	7.5
Mid-channel embayment	2.0	6.0	4.5	3.1
Backwater	3.0	1.1	5.5	8.1
Other **	1.0	6.9	2.5	6.2

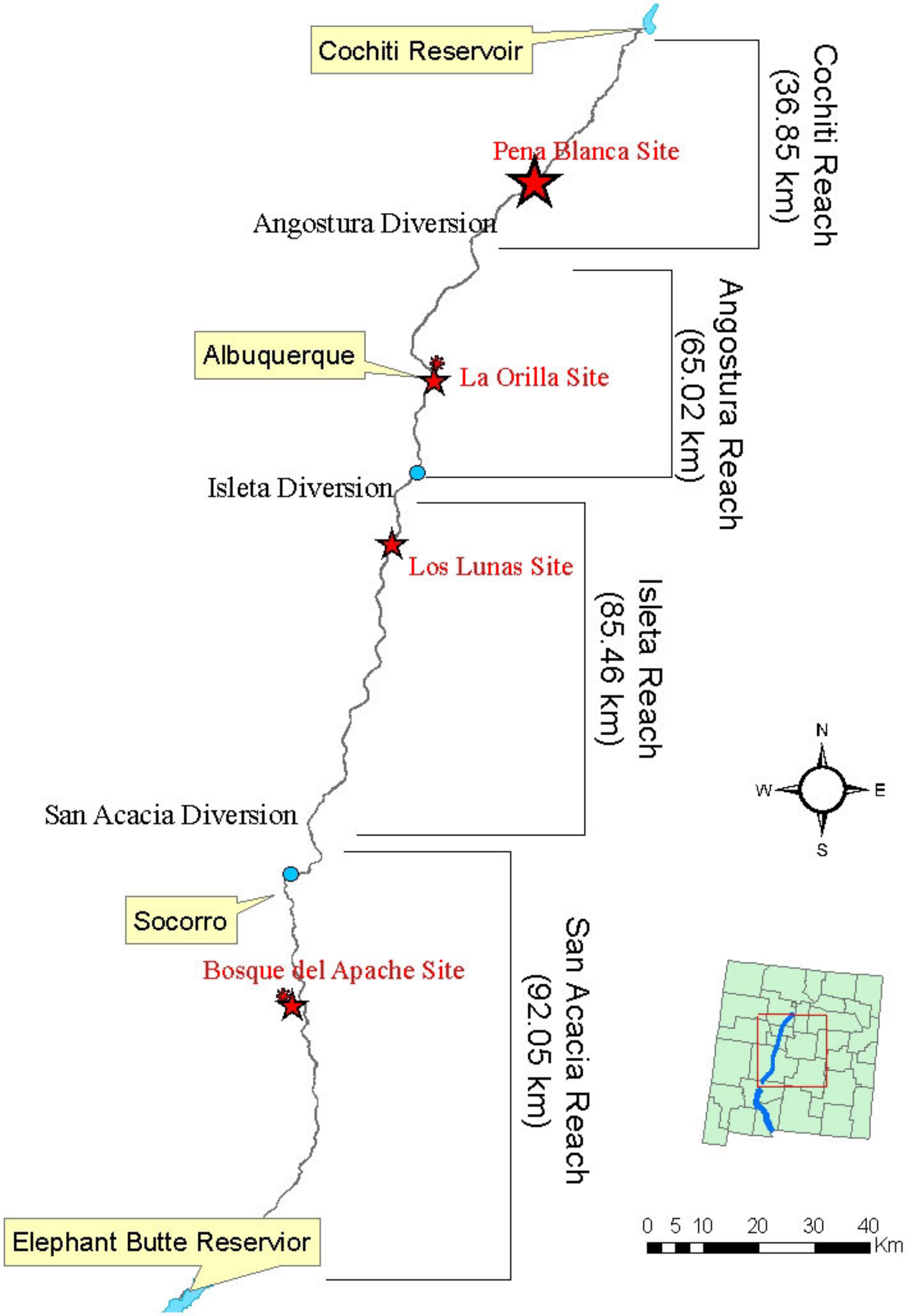


Figure 1. Map of the Middle Rio Grande Valley in New Mexico illustrating four reaches and dam diversions.

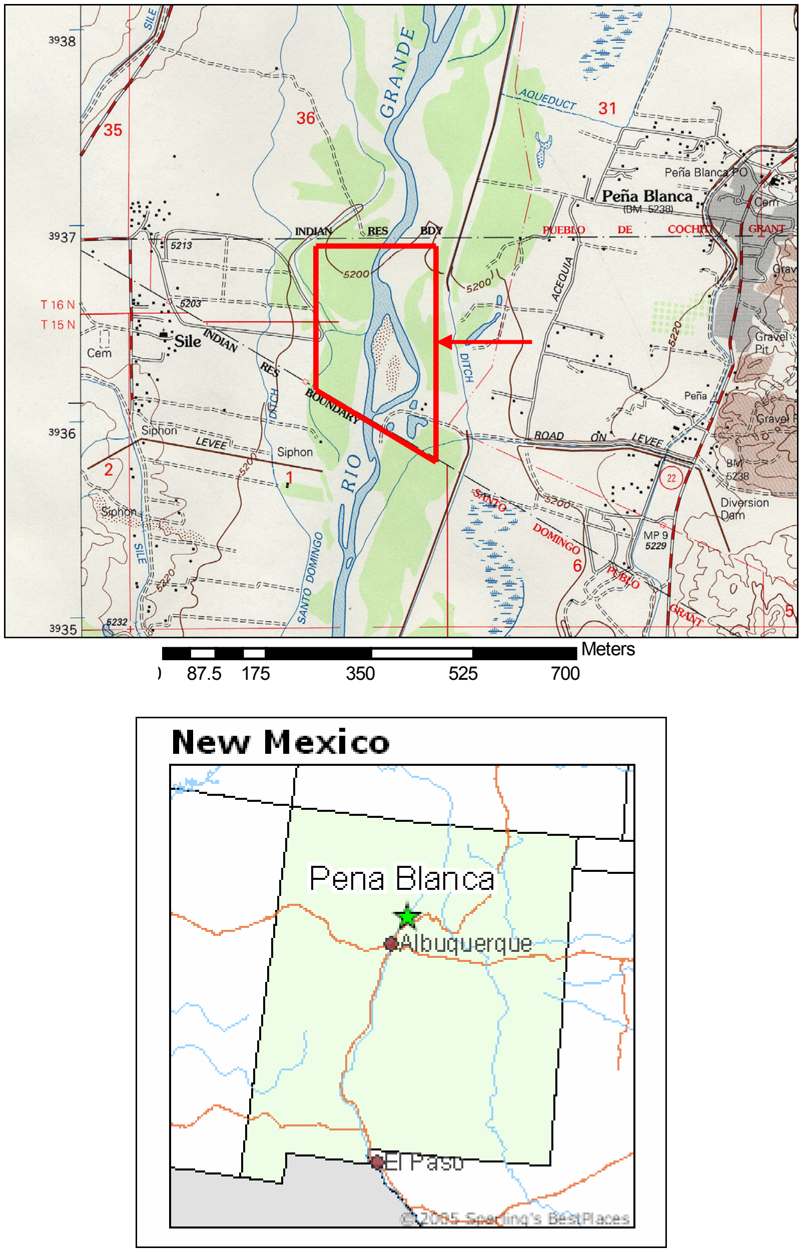


Figure 2. Peña Blanca site, Middle Rio Grande, New Mexico (site outlined on top map).

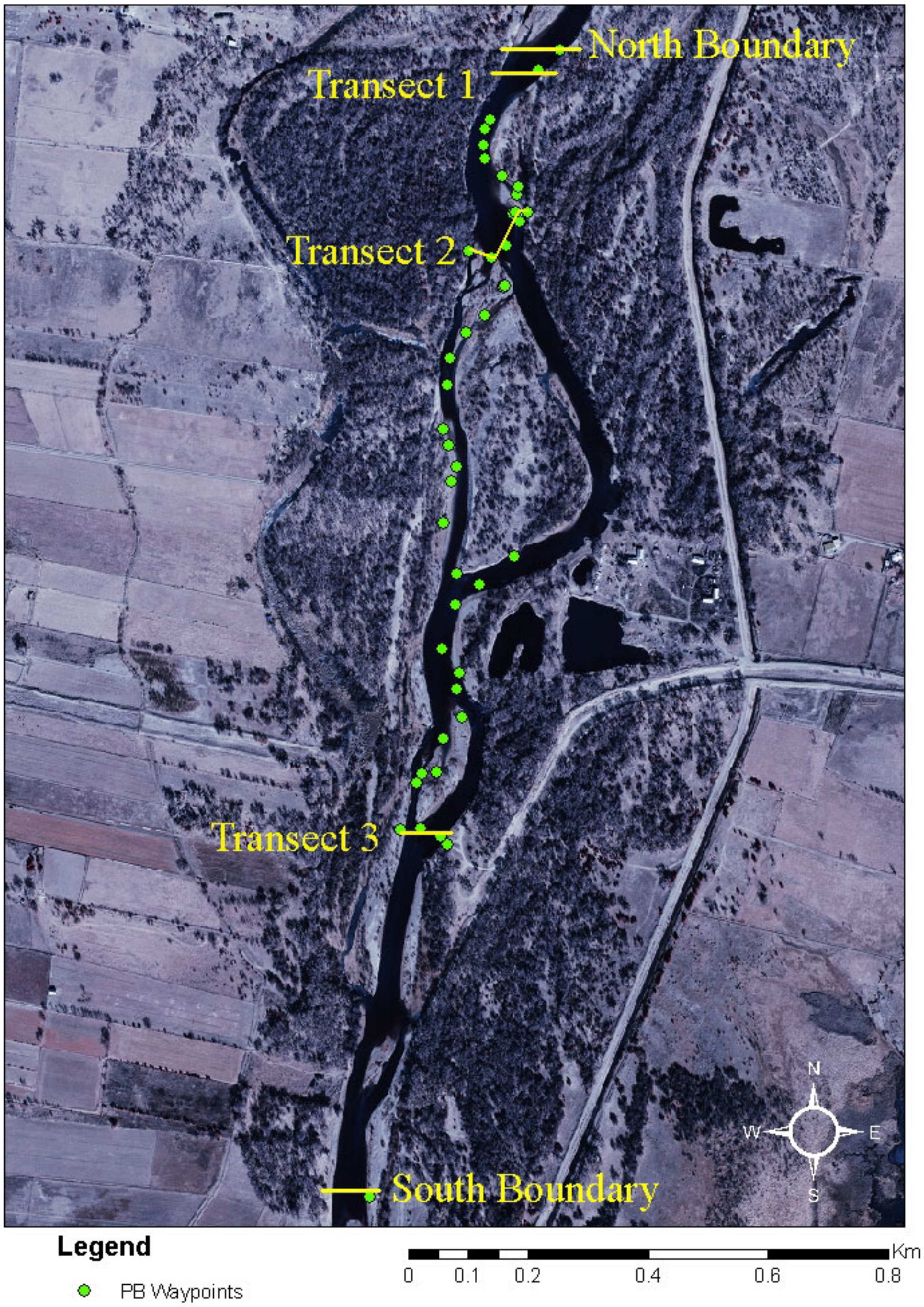


Figure 3. Seine haul and transect locations within the Peña Blanca site, Middle Rio Grande, New Mexico. Both seine haul and transect locations were re-visited during the three habitat characterization dates. Electrofishing sites were discretionary, but were conducted in areas similar to the habitat characterization sites.

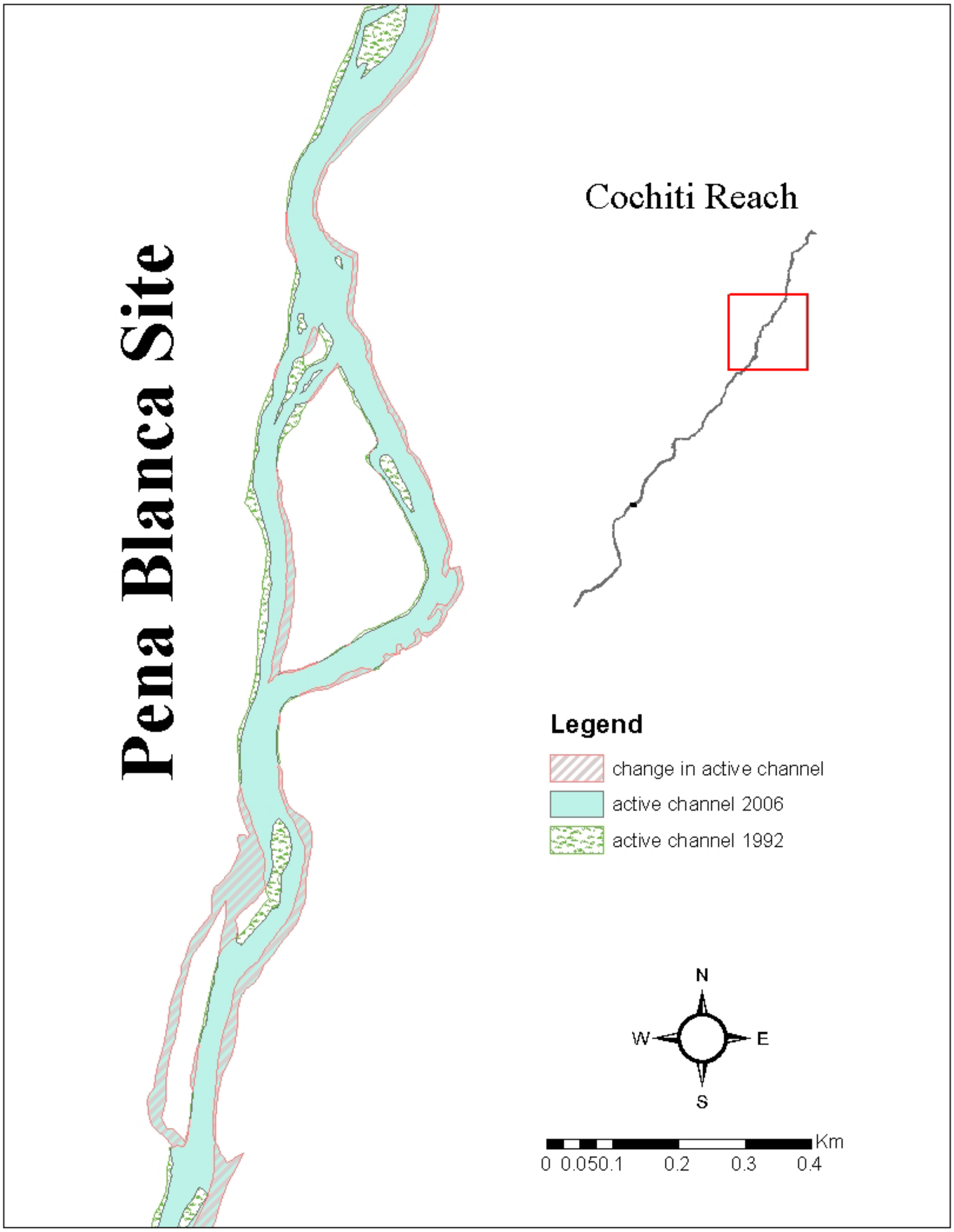


Figure 4. Illustration of GIS overlay of Cochiti Reach to determine the change in active channel (site illustrated is Peña Blanca).

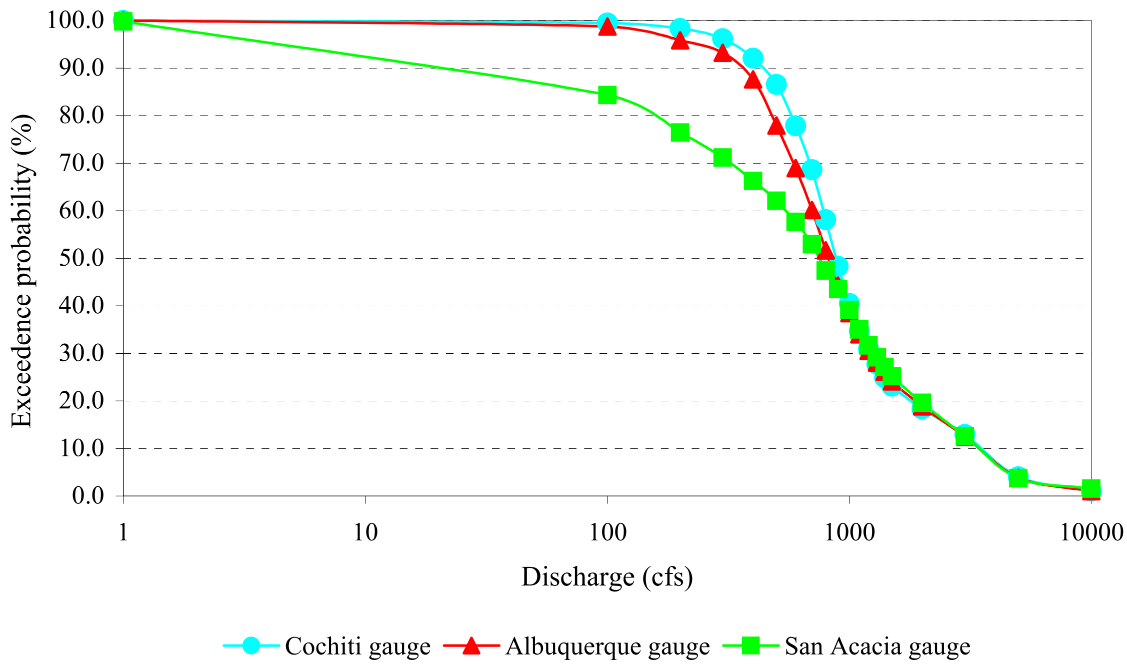


Figure 5. Exceedence curve illustrating historical mean daily flow regimes (1975-2006) among three USGS gauges, Cochiti, Albuquerque, and San Acacia, Middle Rio Grande, New Mexico. Discharge data were plotted on a logarithmic scale.

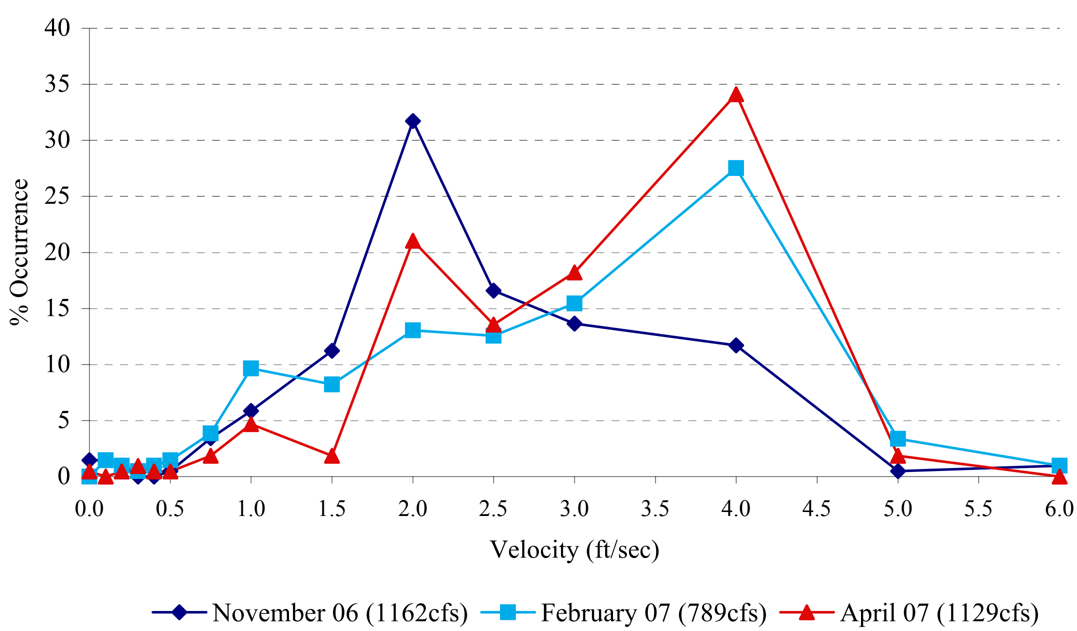


Figure 6. Transect velocity profile of the Peña Blanca site for three sampling dates.

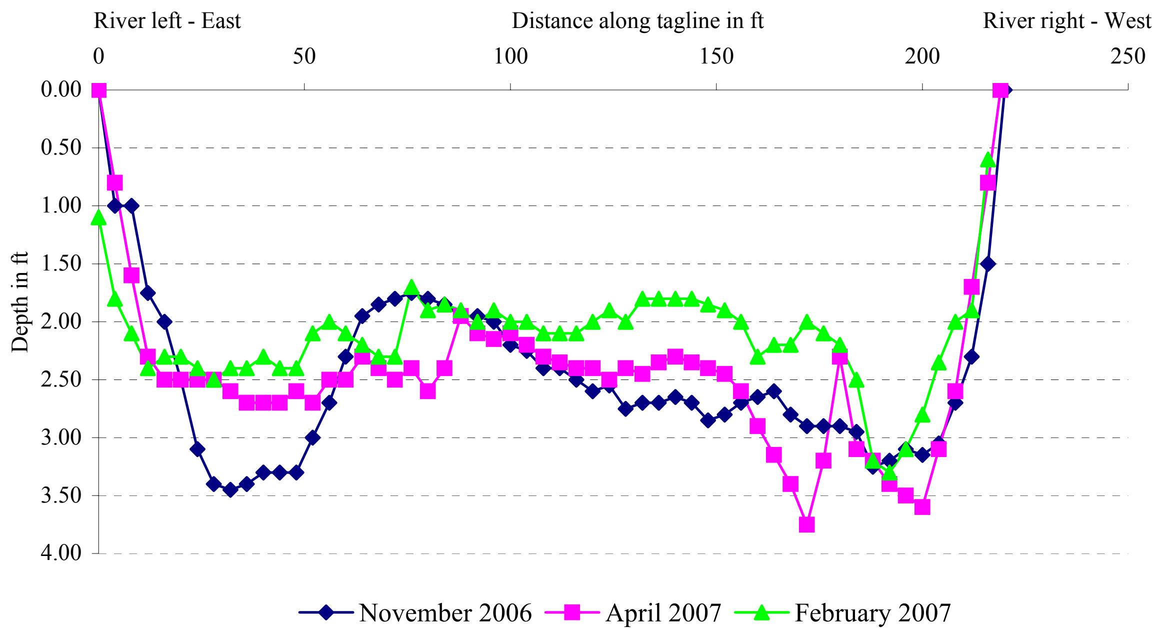


Figure 7. Depth profiles for transect 1 at Peña Blanca during November 2006, February 2007, and April 2007 sampling days.

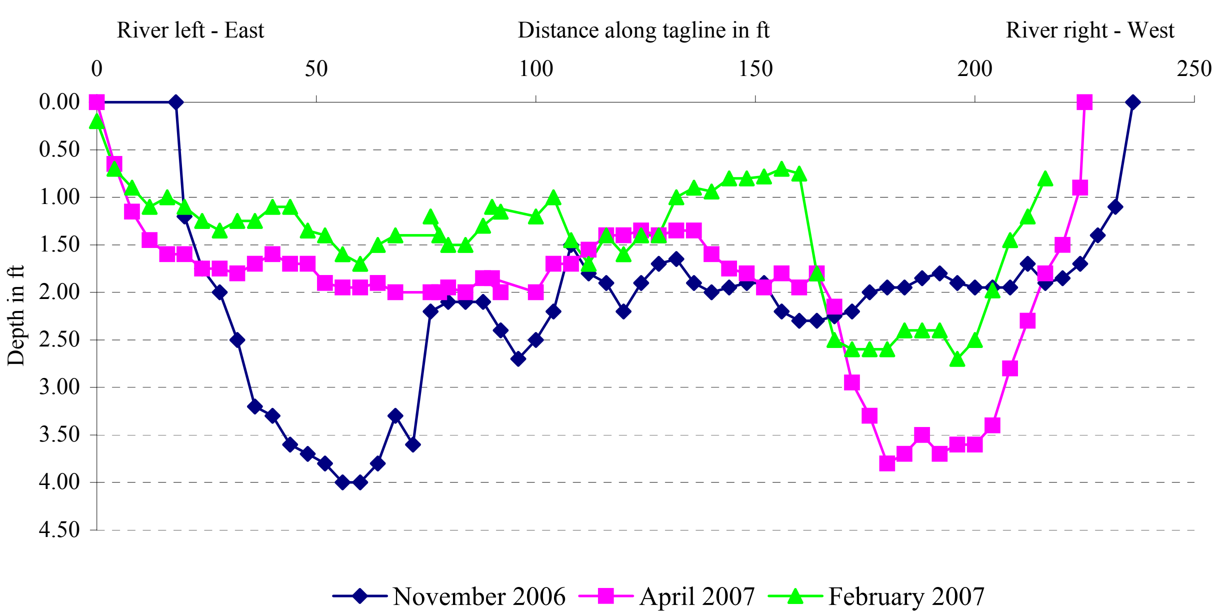


Figure 8. Depth profiles for transect 3 at Peña Blanca during November 2006, February 2007, and April 2007 sampling days.

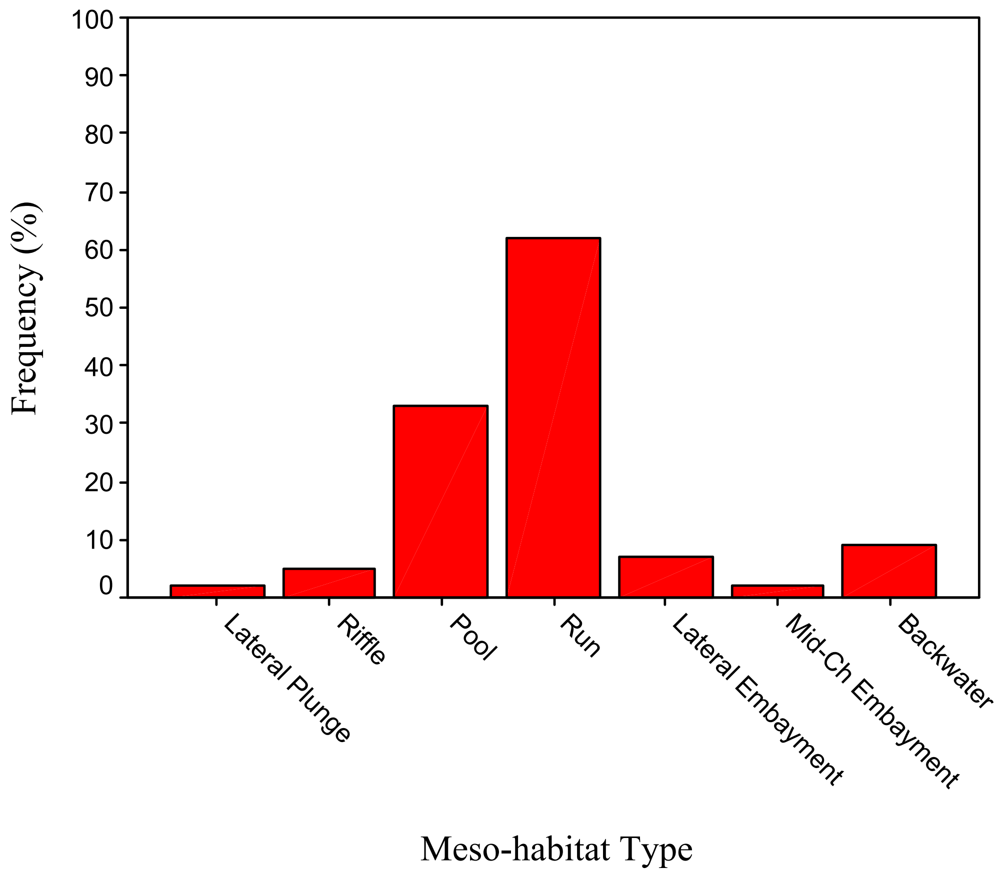


Figure 9. Frequency (%) of mesohabitat types identified at Peña Blanca, Middle Rio Grande, New Mexico, during 20 November 2006, 21 February 2007, and 20 April 2007.

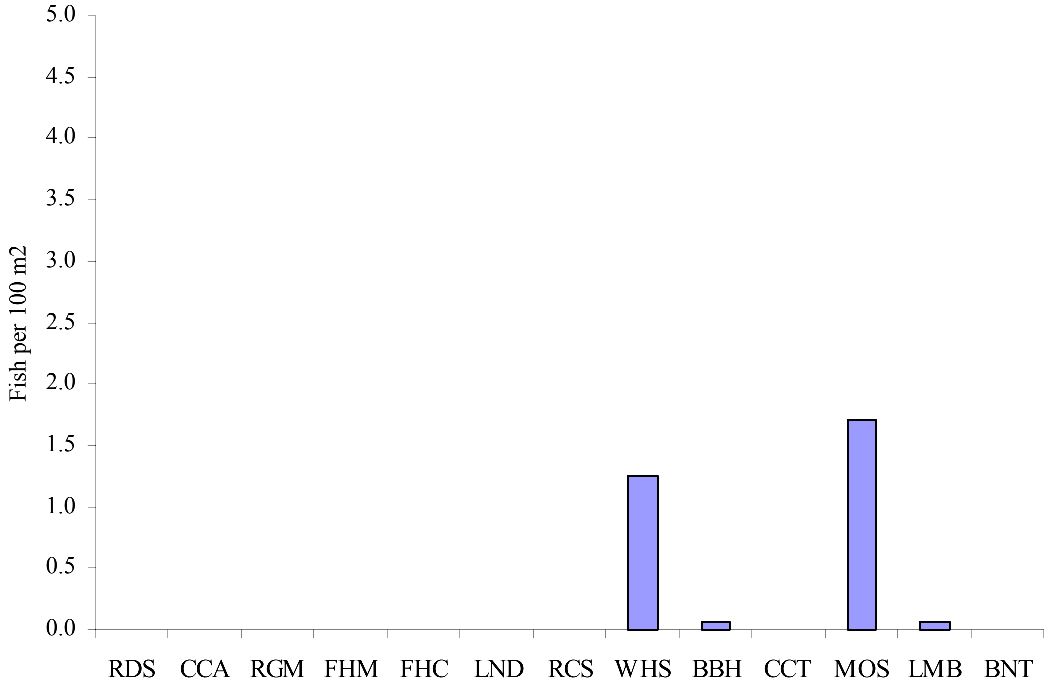


Figure 10. Fish species catch per unit effort (CPUE) for Peña Blanca during the November 2006 sampling period. See Appendix B for species codes.

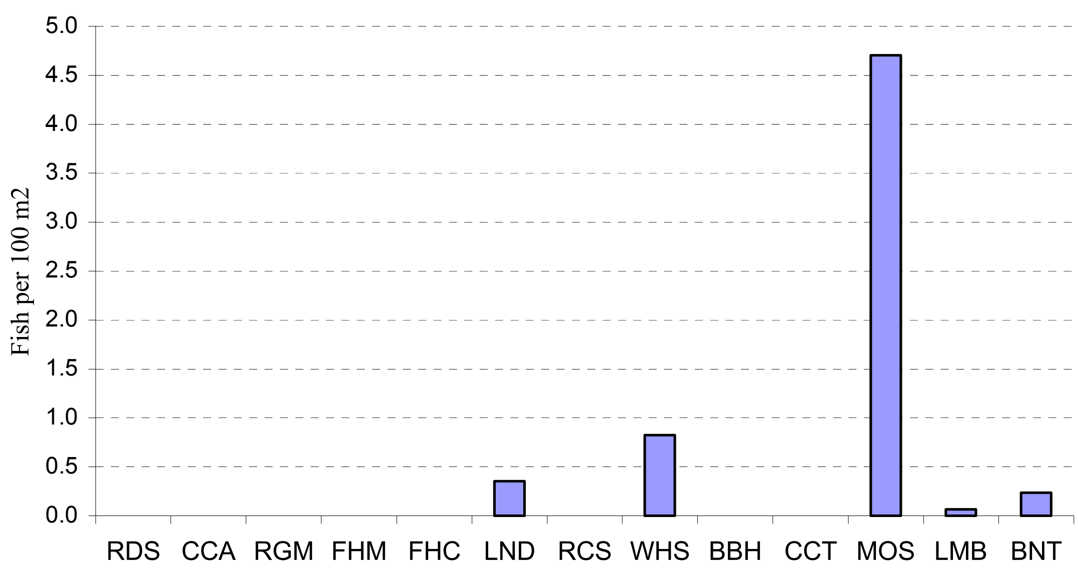


Figure 11. Fish species catch per unit effort (CPUE) for Peña Blanca during the February 28, 2007 sampling period. See Appendix B for species codes.

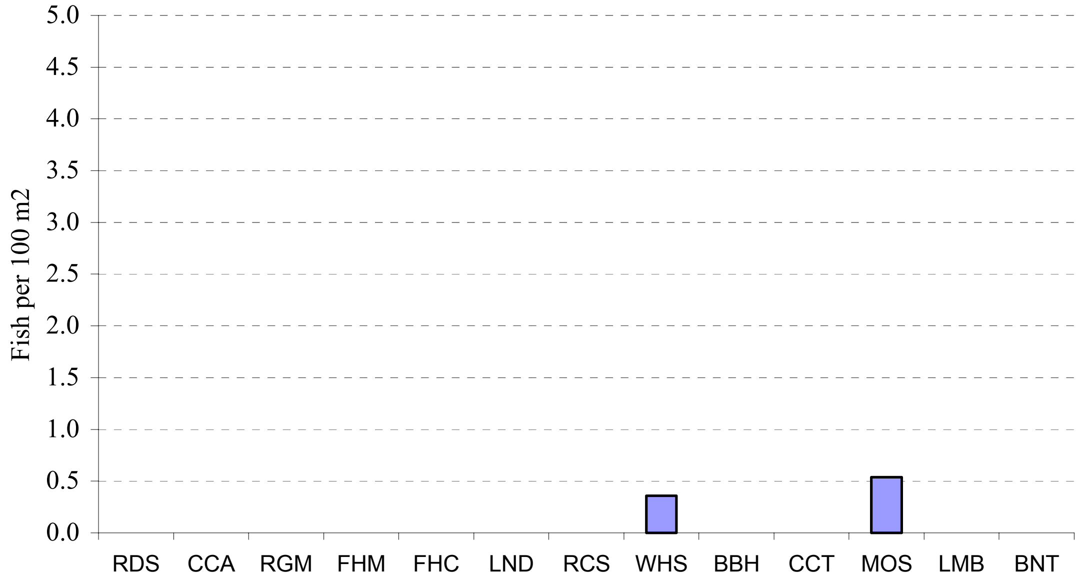


Figure 12. Fish species catch per unit effort (CPUE) for Peña Blanca during the April 2007 sampling period. See Appendix B for species codes.

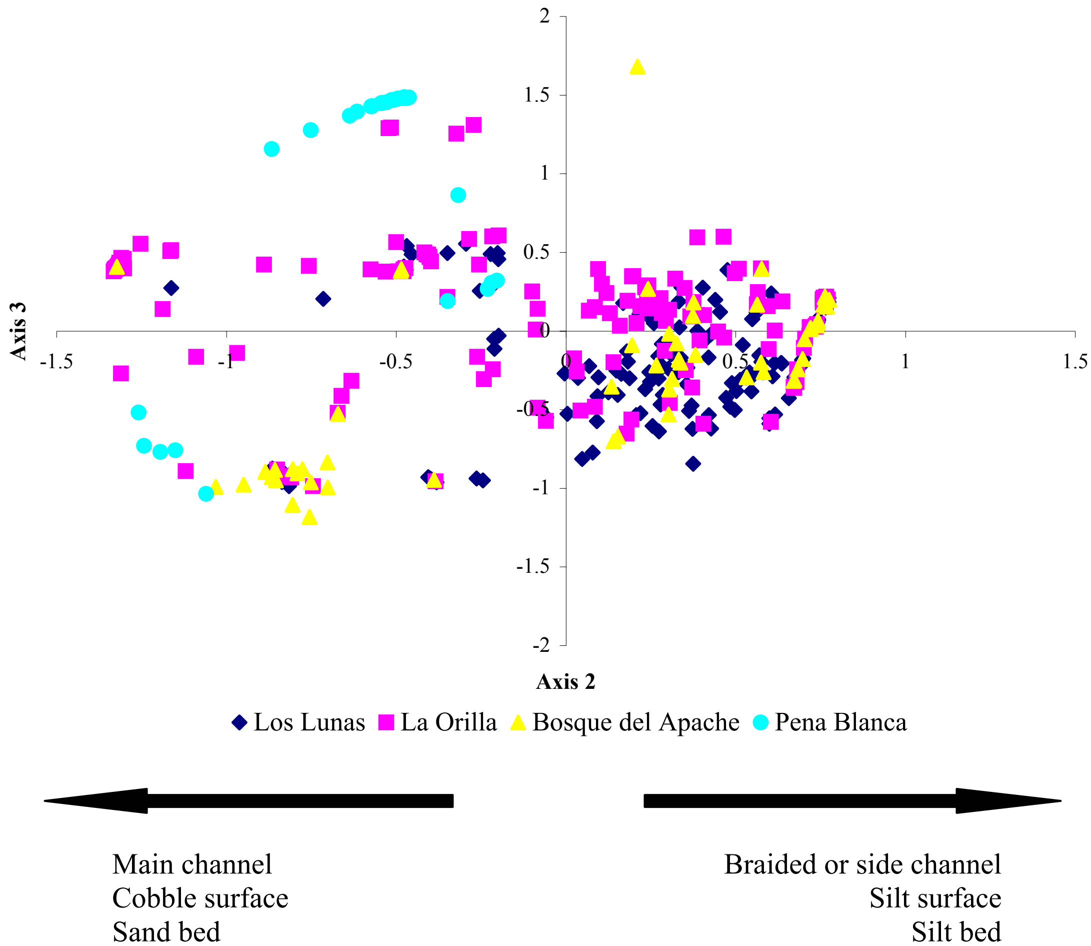


Figure 13. Axes 2 and 3 from non-metric multidimensional scaling (NMDS) ordination results among four sites on the Middle Rio Grande, New Mexico. NMDS analysis compares fish communities among four sites, identifying patterns with variables such as channel type, surface type, and bed type. Arrows point towards the direction of increased values for dominant environmental variables.

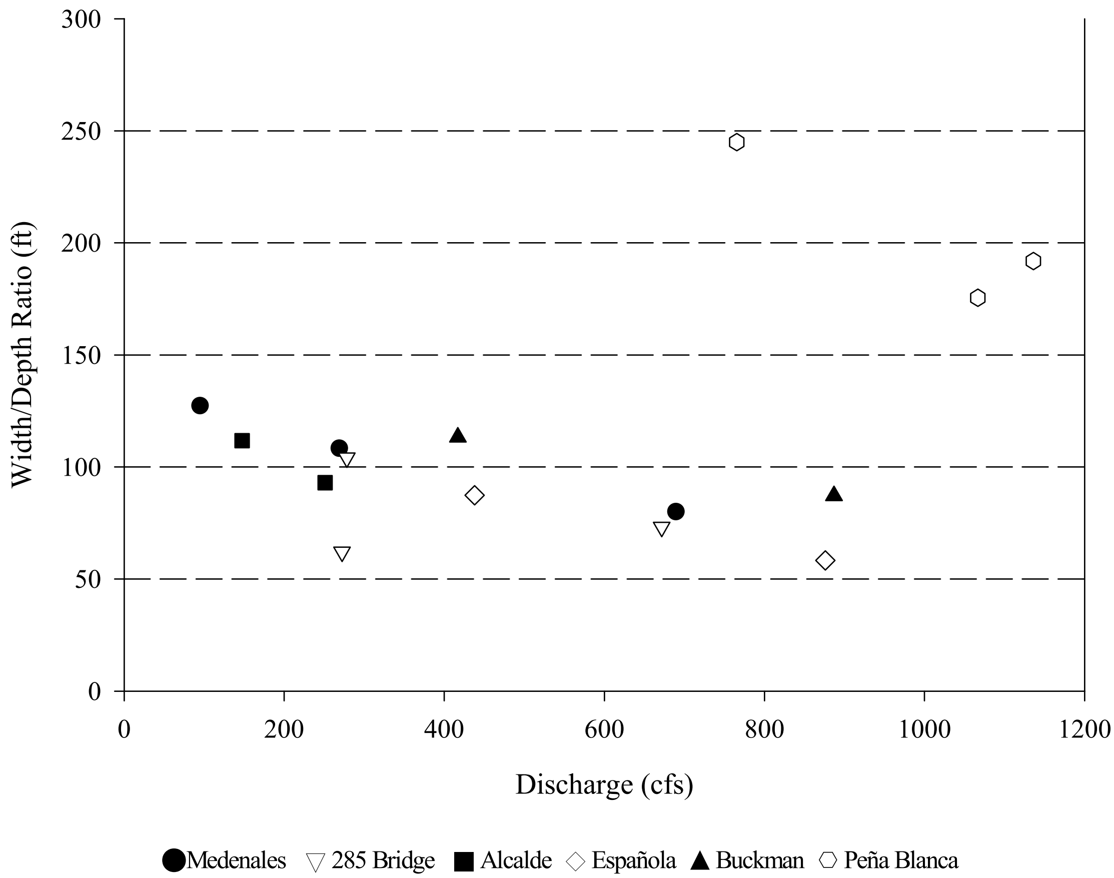


Figure 14. Width/depth ratio (ft) versus discharge (cfs) for sites surveyed above Cochiti Lake and Peña Blanca sites. Data from Buntjer and Remshardt 2005. Fish surveys and habitat assessment in the Rio Chama and Rio Grande Upstream of Cochiti Lake.

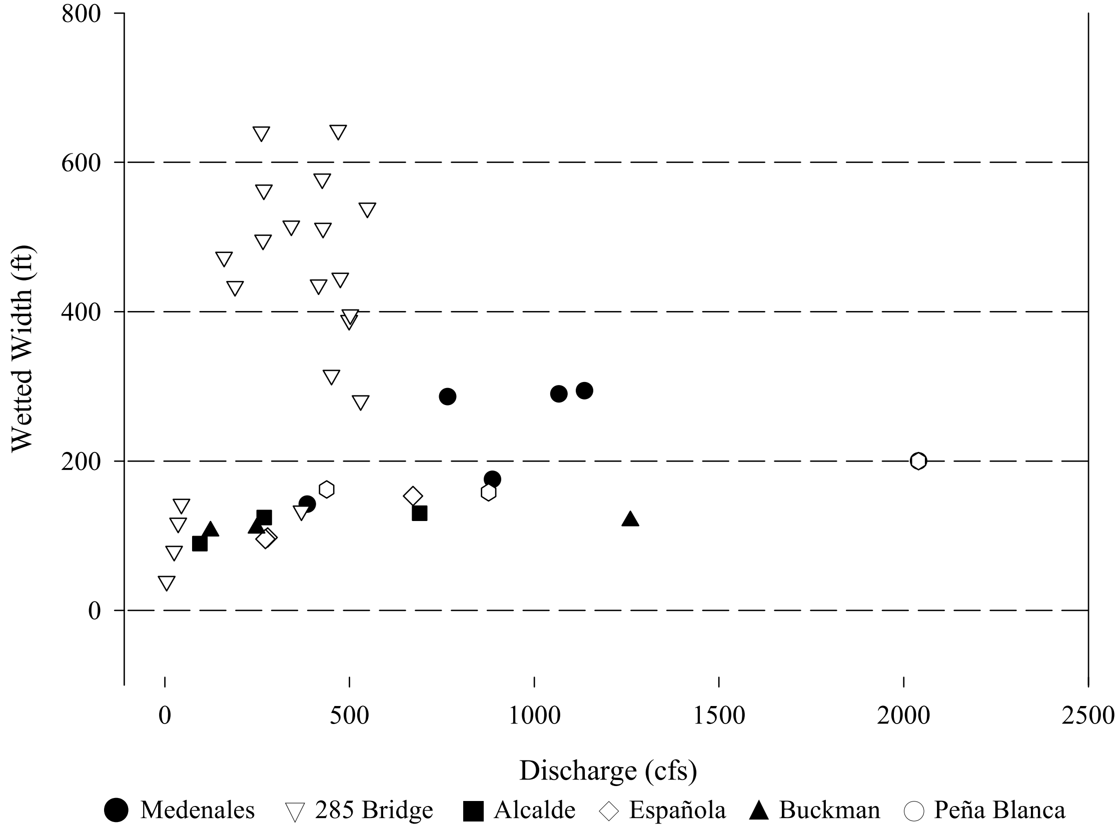
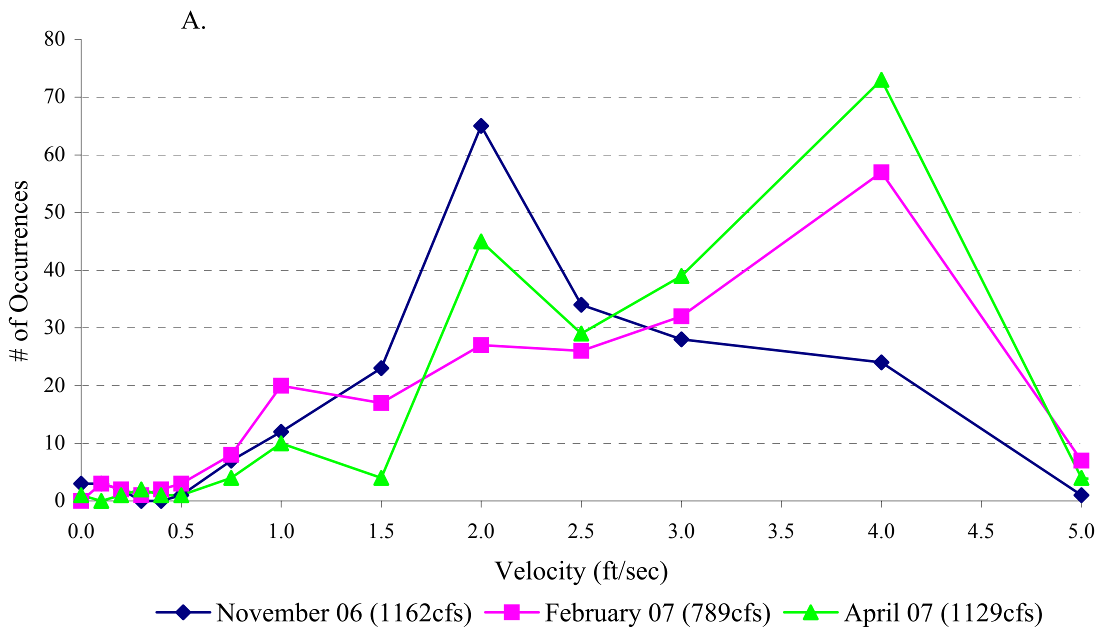


Figure 15. Wetted width (ft) versus discharge (cfs) for sites surveyed above Cochiti Lake and the Peña Blanca site. Data from Buntjer and Remshardt 2005. Fish surveys and habitat assessment in the Rio Chama and Rio Grande Upstream of Cochiti Lake.



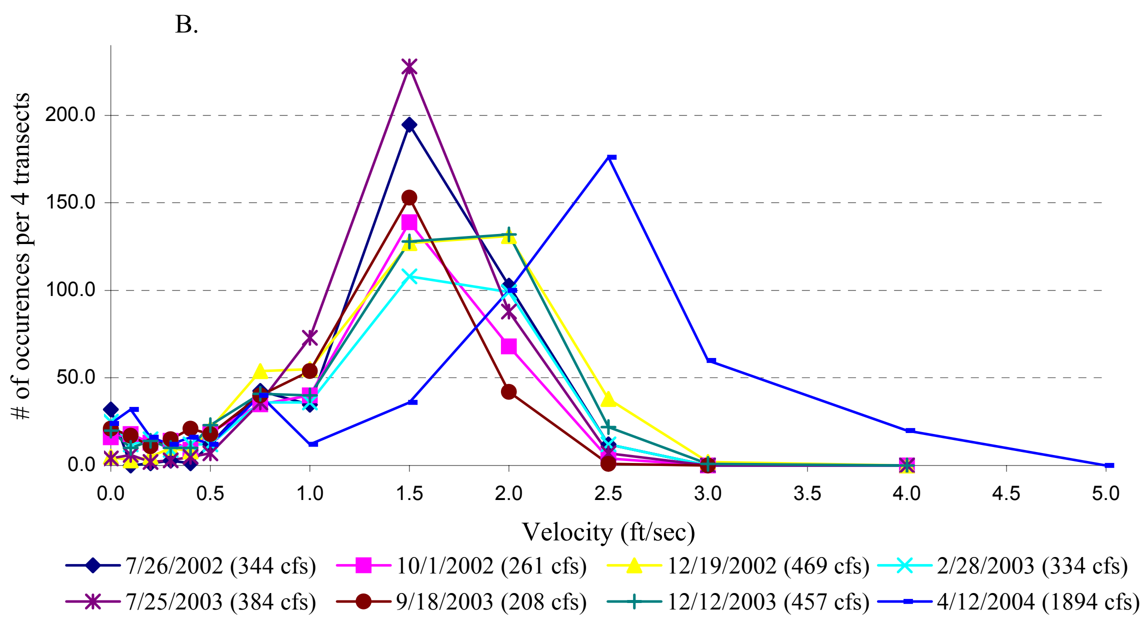
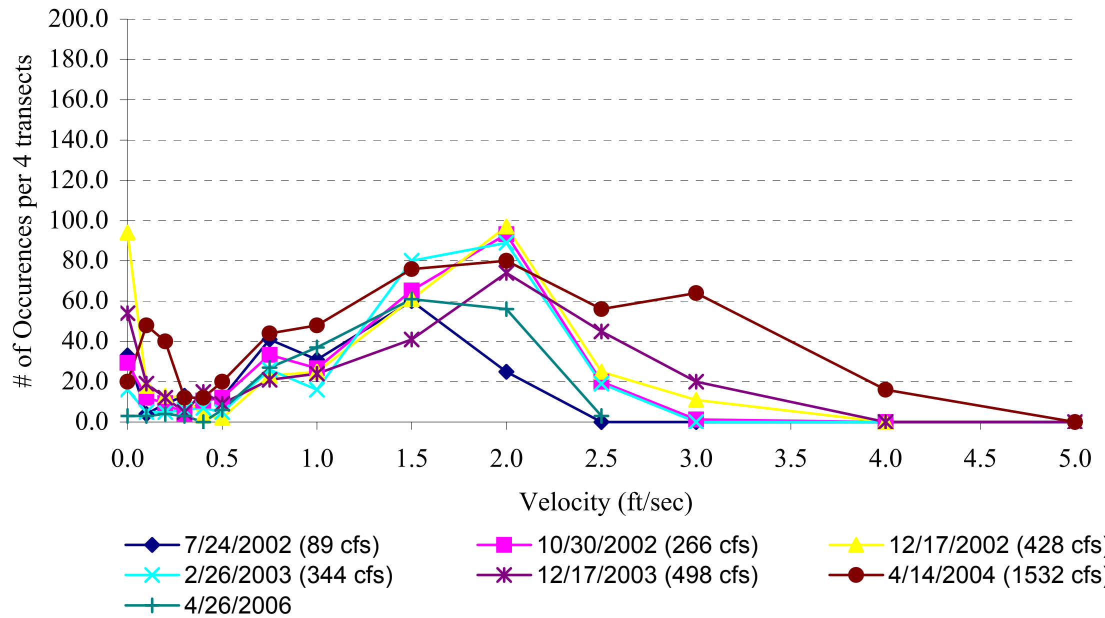


Figure 16. Transect velocity profiles of RGSM habitat sites, including Peña Blanca (A) (Cochiti-Angostura reach), La Orilla (B) (Albuquerque reach), Los Lunas (C) (Isleta reach), and Bosque del Apache (D) (San Acacia reach). Data from Remshardt and Tashjian, 2003. Habitat preference of Rio Grande silvery minnow in relation to fluvial geomorphology, and flow regime, Middle Rio Grande Valley; Interim Report.

C.



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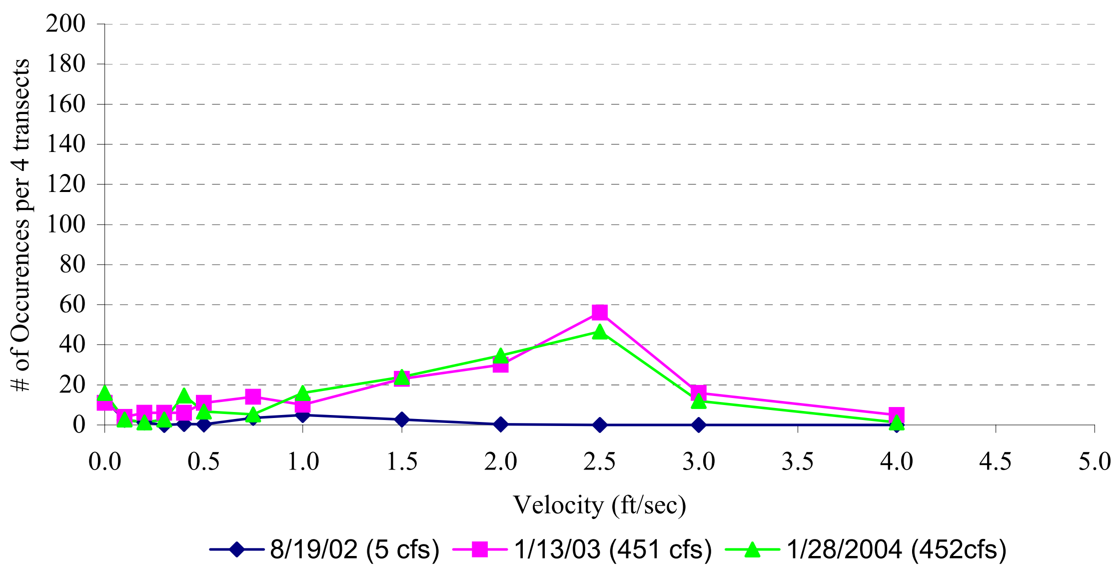

Figure 16. (Continued…)

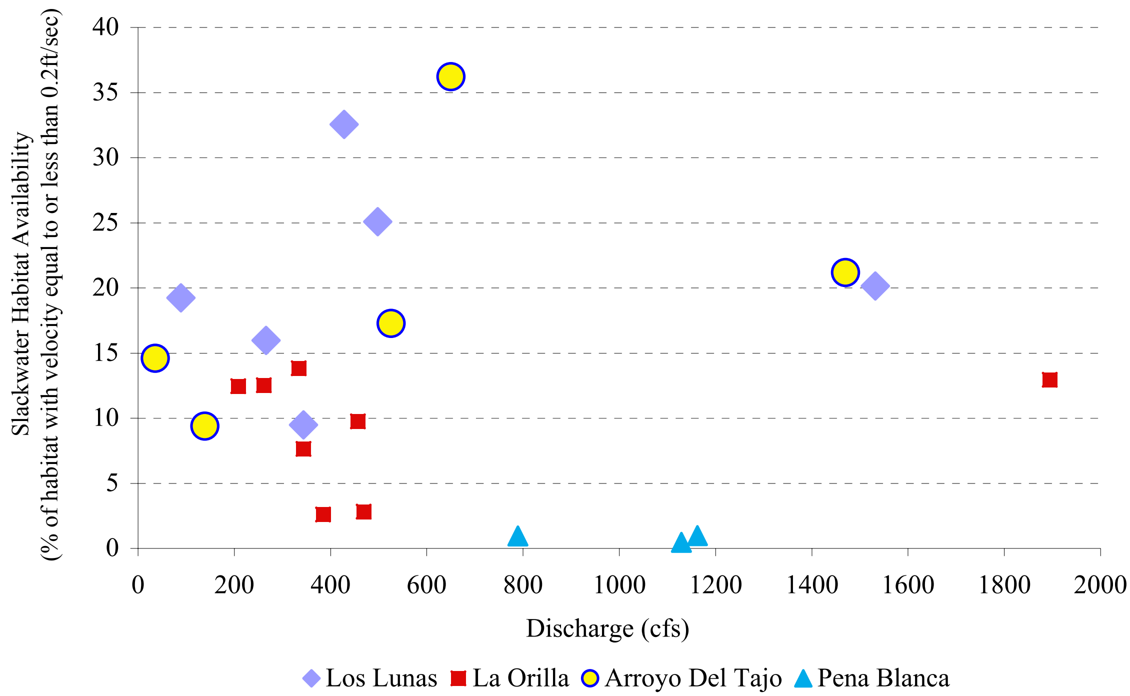

Figure 17. Discharge vs. slackwater habitat availability data (% of habitat with velocity equal to or less than 0.2 ft/sec) from 2002-2004 of MRG habitat sites. Data from Tashjian and Massong, 2006. The Implications of Recent Floodplain Evolution on Habitat within the Middle Rio Grande, NM. Joint 8th Federal Interagency Sedimentation Conference and 3rd Federal Interagency Hydrologic Modeling Conference, Reno, NV.

Appendix A. Mesohabitat and feature definitions used for seine haul descriptions

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Run – Fluvial habitat with direction of flow generally parallel with the adjacent shore. Dominant mesohabitat with average depths and velocities.

Divergence Run- Fluvial habitat with direction of flow split by features such as submerged debris or islands.

Riffle – Fluvial habitat with flow direction generally parallel with the adjacent shore, shallow and with higher gradient than adjacent habitats.

Dune Crest Plunge- A turbulent pool created by water spilling over the downstream end of a feature such as riffle, dune, or debris pile.

Lateral Plunge- A turbulent pool created by water spilling over the side of a feature such as riffle, dune, or debris pile, creating perpendicular flow.

Bank – Flowing habitat along a submerged feature similar to shoreline that is parallel to flow.

Confluence – Turbulent pool created at the junction of two flowing channels.

Pool – Fluvial habitat with direction generally parallel to adjacent shore, deeper and slower than adjacent habitats.

Confluence Pool- Pool habitat created at the downstream end of two or more channels or flow patterns converging into one mesohabitat.

Bypass Channel- Habitat formed perpendicular to banks, similar to run habitat but generally slower and shallower. May be in conjunction with multi-threaded channel.

Backwater – Non-fluvial habitat found at downstream end of abandoned channels.

Forewater – Non-fluvial habitat found at abandoned inlets of high flow channels.

Embayment Fence- Transitional habitat between fluvial and non-fluvial habitats with minimal velocities, perpendicular to adjacent river bank.

Lateral Embayment- Non-fluvial habitats with, perpendicular to shorelines.

Mid-channel Embayment- Transitional habitat between fluvial and non-fluvial habitats with minimal velocities found in main channel, typically found at downstream ends of islands, sandbars.

Isolated Pool – An abandoned, off-channel, remnant pool sometimes fed by subsurface seepage

Appendix B. Fish species corresponding to code references. Data from Dudley and Platania, 2007. Summary of Rio Grande silvery minnow Population Monitoring Program Results, American Southwest Ichthyological Researchers, L.L.C.

Table 1. Scientific and common names and species codes of fish collected in the Middle Rio Grande during the 1999-2006 Rio Grande silvery minnow population monitoring program.

Scientific Name	Common Name	Code
Order Clupeiformes		
Family Clupeidae	herrings	
Dorosoma cepedianum	gizzard shad	(GZS)
Order Cypriniformes		
Family Cyprinidae	carps and minnows	
Cyprinella lutrensis	red shiner [1]	(RDS)
Cyprinus carpio	common carp [1]	(CCA)
Gila pandora	Rio Grande chub	(RGC)
Hybognathus amarus	Rio Grande silvery minnow [1]	(RGM)
Pimephales promelas	fathead minnow [1]	(FHM)
Pimephales vigilax	bullhead minnow	(BHM)
Platygobio gracilis	flathead chub [1]	(FHC)
Rhinichthys cataractae	longnose dace [1]	(LND)
Family Catostomidae	suckers	
Carpiodes carpio	river carpsucker [1]	(RCS)
Catostomus commersonii	white sucker [1]	(WHS)
Ictiobus bubalus	smallmouth buffalo	(SMB)
Order Siluriformes		
Family Ictaluridae	North American catfishes	
Ameiurus melas	black bullhead	(BBH)
Ameiurus natalis	yellow bullhead	(YBH)
Ictalurus punctatus	channel catfish [1]	(CCT)
Pylodictis olivaris	flathead catfish	(FCT)
Order Salmoniformes		
Family Salmonidae	trouts and salmons	
Salmo trutta	brown trout	(BNT)
Order Cyprinodontiformes		
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish [1]	(MOS)

[1] focal taxa represent the most abundant species present in recent Middle Rio Grande collections and species illustrated in monthly plots of data.

Appendix B (continued). Fish species corresponding to code references. Data from Dudley and Platania, 2007. Summary of Rio Grande silvery minnow Population Monitoring Program Results, American Southwest Ichthyological Researchers, L.L.C.

Summary of Rio Grande silvery minnow Population Monitoring Program Results
American Southwest Ichthyological Researchers, L.L.C.

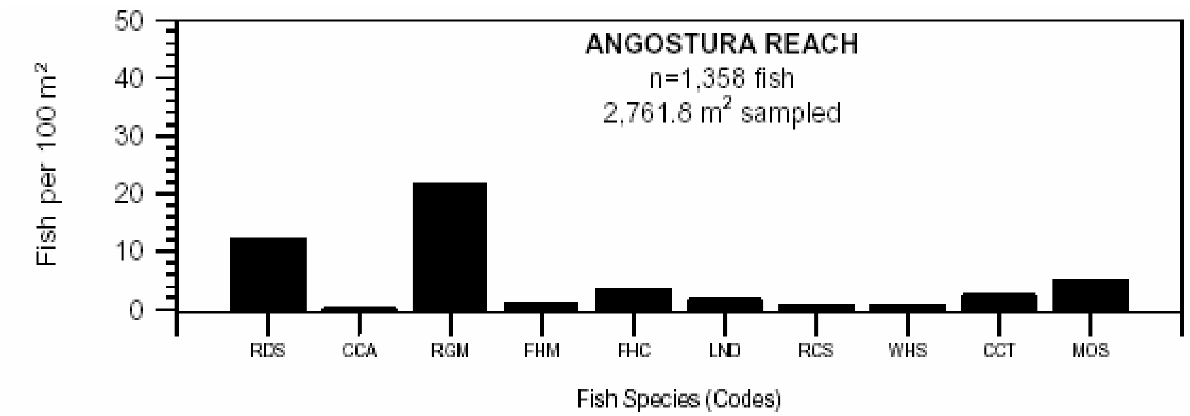
Sample Period: February 2007
12 March 2007

Table 1. Scientific and common names and species codes of fish collected in the Middle Rio Grande during the 1999-2006 Rio Grande silvery minnow population monitoring program (continued).

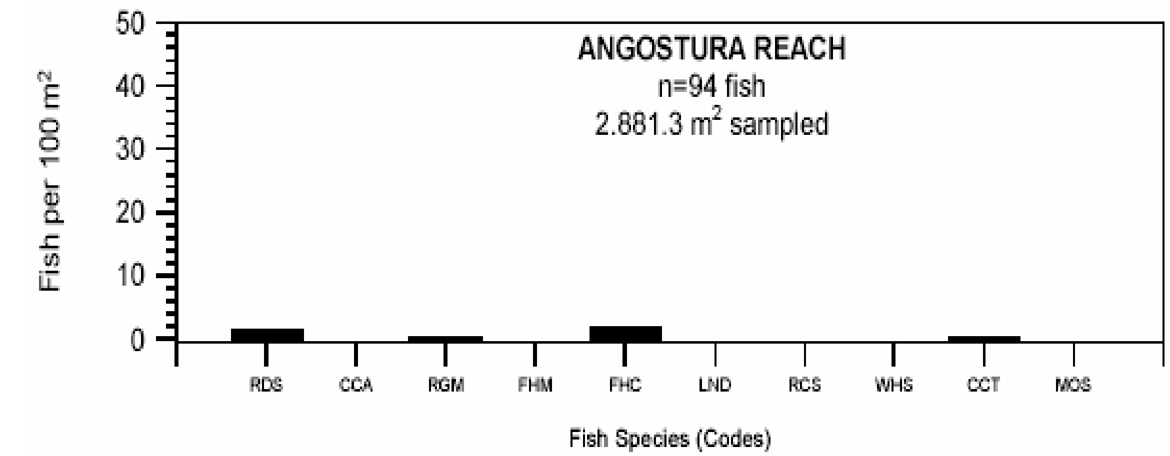
Scientific Name	Common Name	Code
Order Perciformes		
Family Percichthyidae	temperate basses	
Morone chrysops	white bass	(WHB)
Order Perciformes		
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(GNS)
Lepomis macrochirus	bluegill	(BGL)
Micropterus salmoides	largemouth bass	(LMB)
Pomoxis annularis	white crappie	(WCR)
Pomoxis nigromaculatus	black crappie	(BCR)
Family Percidae	perches	
Perca flavescens	yellow perch	(YWP)
Sander vitreus	walleye	(WLE)

Appendix C. Catch rates, for the 10 focal species, during October 2007 at Angostura reach (5 sites). Data from Dudley and Platania, 2007a-c. Summary of Rio Grande silvery minnow Population Monitoring Program Results, American Southwest Ichthyological Researchers, L.L.C.

OCTOBER 2007



FEBRUARY 2007



APRIL 2007