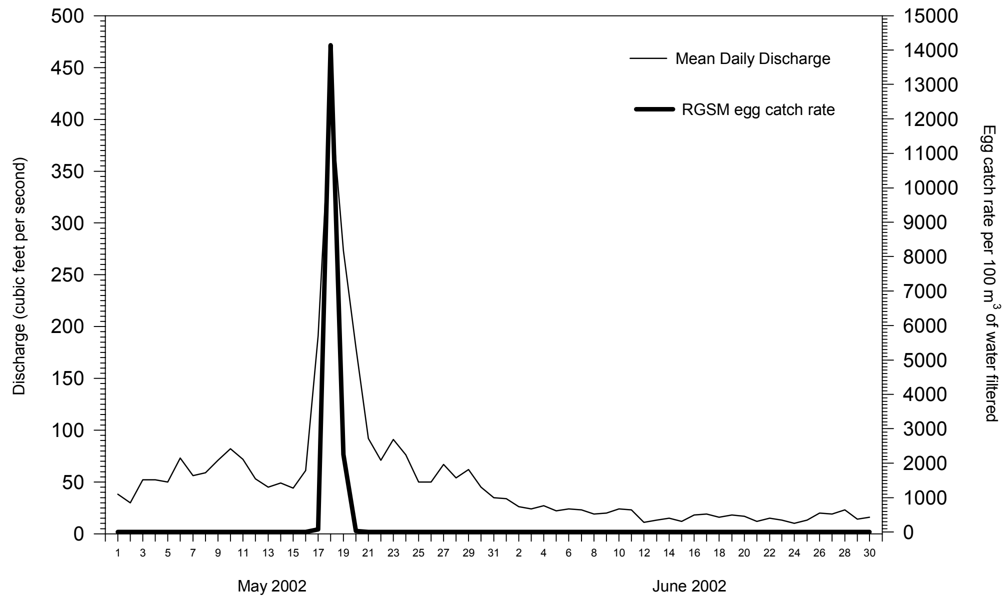
SPAWNING PERIODICITY OF RIO GRANDE SILVERY MINNOW, *HYBOGNATHUS AMARUS*, DURING 2002

Final Report



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American Southwest Ichthyological Research Foundation

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EXECUTIVE SUMMARY

Spawning of Rio Grande silvery minnow and other members of its reproductive guild (broadcast spawners with semibuoyant eggs) appears to be triggered by specific environmental cues. These fishes exhibited a strong positive correlation between flow and spawning. In 1999, 2001, and 2002 the peak spawning event by Rio Grande silvery minnow occurred soon after the initiation of spring snowmelt runoff (during the first two-three weeks of May). Egg catch rates in the Rio Grande and Pecos River appear most closely correlated with increased flow as opposed to absolute water volume.

Discharge in the Rio Grande during 2002 was extremely low due to a severe drought which resulted in a lack of snowmelt runoff and reduced storage of water in upstream reservoirs. Flow in the Rio Grande at San Marcial Railroad Bridge Crossing generally remained <600 cfs from well before the end of previous irrigation season (1 November 2001) throughout the 2002 calendar year. Base flow in the Rio Grande at San Marcial during April and most of May 2002 was, with the exception of the artificial flow spike, between 50-100 cfs.

The artificial flow spike that was released to stimulate spawning by Rio Grande silvery minnow was initiated at Cochiti Dam on 13 May 2002 and continued for three days. The flow spike arrived at San Acacia Diversion Dam on 16 May 2002 and peaked on 17 May 2002 (mean daily discharge 768 cfs). The flow spike to travel from San Acacia to San Marcial in one day as mean daily discharge at the latter locality rose from 61 cfs (16 May 2002) to 191 cfs on 17 May 2002. The peak in discharge, though markedly reduced in volume, arrived at San Marcial (421 cfs) one day after being recorded at San Acacia Diversion Dam .

The first Rio Grande silvery minnow eggs collected during the 2002 sampling period occurred on 7 May 2002 with 35 eggs taken for a cumulative daily catch rate of about 4.5 eggs/100 m^3 of water sampled. By 18:00 h on 17 May 2002, the rising water level associated with the artificial flow spike was apparent and egg catch rate increased to 14.1 eggs/100 m^3 of water sampled. During the next two hours (20:00-22:00 h), egg catch rate increased 10-fold (160.7 eggs/100 m^3) and from 22:00-24:00 it increased an additional seven-fold (1,122.7 eggs/100 m^3). The rate of egg collection at the study site rose steadily throughout the morning of 18 May 2002 as did flow. This pattern was also documented in 1999 and 2001.

At about 0600 h on 18 May 2002, egg catch rate surpassed 10,000 eggs/100 m^3 and at 0900 h had reached 20,000 eggs/100 m^3. The highest catch rates during this study were obtained in the samples taken between 16:00 and 18:30 on 18 May 2002. During that period Rio Grande silvery minnow eggs were taken at rates of 56,500, 48,500, and 96,500 per 100 m^3. By late afternoon on 19 May 2002, catch rate declined to about 150 eggs/100 m^3 while the late evening sample of 20 May 2002 (1730-1930 h) yielded a catch rate of 1.6 eggs/100 m^3 and was the last to produce eggs.

There were 134 samples taken that were dedicated exclusively to providing Rio Grande silvery minnow eggs for propagation efforts. The number of eggs retained from those samples was estimated conservatively to be 922,000. The vast majority of those eggs (85%, n=784,000) were collected between 0800-1700 h on 18 May 2002.

Catch rate of Rio Grande silvery minnow eggs was notably higher in 2002 than in 2001. It is important to note, however, that this increased catch rate does not necessarily imply more eggs were produced in 2002 than in 2001. Catch rate is dependent on both the number of eggs present in the water column at the time of sampling and the total volume of water in the river channel. Peak egg collections in 2002 occurred during daily flows that ranged from 200-500 cfs while peak collections in 2001 occurred during flows that ranged between 500-800 cfs. This difference in flow would be expected to result in a higher catch rate in 2002 than in 2001 although the magnitude of the difference would be difficult to predict.

INTRODUCTION

The reach of the Rio Grande between Cochiti Dam and Elephant Butte Reservoir (Middle Rio Grande) has been greatly modified over the last 50 years (Lagasse, 1985). Historically, this section of the river gradually meandered through a wide floodplain in a vegetated valley. Extensive braiding of the river as it flowed over the shifting sand substrate was common and flow was generally perennial except during times of severe or extended drought (Scurlock, 1998). The Middle Rio Grande was relatively shallow throughout most of the year because of regionally low precipitation levels (Gold and Dennis, 1985) but was subjected to periods of high discharge. Flow was generally greatest during the annual spring snow melt runoff (April-June), however intense localized summer rainstorms (monsoonal events) often caused severe flooding and were important in maintaining perennial flow. Historically, the Middle Rio Grande possessed all of the characteristics distinctive of a Great Plains aquatic ecosystem.

The historical Middle Rio Grande fish fauna was also reflective of a Great Plains River. At least five cyprinid species that can be characterized as Great Plains river fishes formerly occurred in the Middle Rio Grande (Platania and Altenbach, 1998). Of the aforementioned species, speckled chub, *Macrhybopsis aestivalis*, Rio Grande shiner, *Notropis jemezanus*, and Rio Grande bluntnose shiner, *Notropis simus simus,* have been extirpated from the Middle Rio Grande. A fourth species, phantom shiner, *Notropis orca*, is extinct (Bestgen and Platania, 1990). Rio Grande silvery minnow, *Hybognathus amarus*, is the only extant member of the Great Plains River cyprinid fish fauna (Bestgen and Platania, 1991; Platania, 1991) and is federally listed as endangered (U. S. Department of the Interior, 1994).

This group of cyprinids shared several life-history characteristics. All were small (generally <100 mm TL), short-lived (2-5 years), fishes that occupied mainstem habitats. Four of the species are characterized as omnivorous while Rio Grande silvery minnow is herbivorous and feeds on epipsammonic algae. In addition to these shared traits, all five species were members of a reproductive guild of fishes that are pelagic spawners laying semibuoyant eggs.

Reproduction in fish in this guild is characterized by the production of non-adhesive eggs that, upon expulsion, swell rapidly with water and become nearly neutrally buoyant. Upon release the eggs are about 1.6 mm in diameter but quickly expand (ca. 3.0 mm) and remain suspended in the water column during development. Egg hatching time is temperature dependent, but rapid, occurring in 24-48 hours. Recently hatched larval fish remain a component of the drift until development of the gas bladder. This physiological development corresponds with a shift in swimming behavior as larvae actively seek low-velocity habitats.

The 3-5 days necessary for newly spawned Rio Grande silvery minnow to attain the developmental stage necessary to control horizontal movements and freely disperse allows for considerable downstream displacement of eggs and larvae in the Middle Rio Grande. As has been well documented for other aquatic organisms, it is necessary for at least some portion of the drifting propagules to settle in appropriate low-velocity habitats or move upstream to maintain viable populations (Speirs and Gurney, 2001). Downstream transport distance of the progeny of Rio Grande silvery minnow is dependent on a variety of factors including flow magnitude and duration, water temperature, and channel morphology. Historically, there were no permanent barriers to upstream dispersal of fishes in the Middle Rio Grande. There are currently three instream diversion structures between Cochiti Dam and Elephant Butte Reservoir that are barriers to upstream movement of fishes and fragment the once continuous range of the only remaining member of this reproductive guild. While there is the possibility of upstream fish movement through Isleta Diversion Dam when the diversion gates remain elevated for extensive periods (primarily during non-irrigation season:

November through February), cold water temperatures and reduced fish activity likely preclude this from being a viable mechanism to reconnect downstream and upstream populations.

The early life history of Rio Grande silvery minnow has been extensively studied (Platania, 1995; Platania and Altenbach, 1996, 1998). These investigations revealed that silvery minnow is also member of a unique reproductive guild of Rio Grande basin Plains Stream cyprinids. The studies also demonstrated that spawning by Rio Grande silvery minnow is associated with high-flow events such as spring run-off or summer rainstorms.

Systematic monitoring of the reproductive output of Rio Grande silvery minnow at several sites in the Middle Rio Grande was first conducted in 1999 (Platania and Dudley, 2002a). That monitoring involved collecting and quantifying catch rate of Rio Grande silvery minnow eggs at several Middle Rio Grande sites during the relatively short spawning period of this species. Limited Rio Grande silvery minnow egg collecting efforts were also conducted at selected sites in the Middle Rio Grande (Platania and Hoagstrom, 1996; Smith and Hoagstrom, 1997) and in the Low Flow Conveyance Channel (Smith and Hoagstrom, 1997; Smith, 1998, 1999) between 1996-1999. These latter samples provide information on the magnitude of reproduction during certain times and for specific sites. However, consistent monitoring throughout the spawning season produces the most reliable measure of the duration and magnitude of Rio Grande silvery minnow reproductive output.

Population monitoring studies of Rio Grande silvery minnow have recorded an annual decline in the number and catch rate of this species since 1996 (Dudley and Platania, 1999, 2000, 2001, 2002). Currently over 90% of the catch of Rio Grande silvery minnow is in the San Acacia Reach of the Middle Rio Grande (Dudley and Platania, 2001, 2002). Multi-agency efforts in areas of habitat improvement, research, and propagation are underway in an attempt to increase population size and distribution with the ultimate goal being recovery of this species.

Institutional background and considerations

Monitoring the reproductive effort of Rio Grande silvery minnow was identified as a requirement of the 29 June 2001 Programmatic Biological Opinion of the Effects of Actions Associated with the U. S. Bureau of Reclamation's, U. S. Army Corps of Engineers', and Non-Federal Entities Discretionary Actions related to Water Management on the Middle Rio Grande, New Mexico as authored by the U. S. Fish and Wildlife Service. This work was part of an ongoing effort to document changes in the distribution and abundance of the federally endangered Rio Grande silvery minnow. This research effort provided an assessment of the reproductive output (eggs) for Rio Grande silvery minnow within the Middle Rio Grande and specifically addressed the task: "Evaluate the status and trend of the Rio Grande silvery minnow" as identified by the Middle Rio Grande Endangered Species Collaborative Program (ESA Workgroup).

The Rio Grande silvery minnow Recovery Plan (U. S. Fish and Wildlife Service, 1999) also outlined research objectives (2.2. Determine spawning periodicity of silvery minnow under multiple flow regimes; 2.2.1. Determine environmental factors that cue spawning in silvery minnow) that were addressed through this research. This investigation provided an assessment of the relative magnitude of the Rio Grande silvery minnow spawning effort and yielded information useful for resource management decisions in the Middle Rio Grande. This project was also a central component of the Rio Grande silvery minnow propagation and genetics research efforts, both requirements of the 29 June 2001 Programmatic Biological Opinion (see "Project Objectives" 2 and 3).

During early 2002, ESA Workgroup members and silvery minnow researchers met on several occasions and discussed Rio Grande flow issues and the impacts of the 2002 hydrological conditions on Rio Grande silvery minnow. A crucial meeting component was to discuss and coordinate research activities and follow the adaptive management doctrine adopted by the ESA Workgroup to modify projects as necessary to accommodate changing environmental conditions. The dismal 2002 snow pack in the headwaters of the Rio Grande meant that there would not be a natural spring flow spike in 2002 in the Middle Rio Grande and, therefore, it was unlikely that there would be a spring spawn by silvery minnow. Personnel from ESA Workgroup agencies decided to create an artificial flow spike during mid-May 2002, using reservoir storage, to initiate a spawn by silvery minnow. This document includes the results of the spawn of Rio Grande silvery minnow during that artificial flow spike.

STUDY AREA

The reproductive effort of Rio Grande silvery minnow has, in the past, been sporadically determined at selected collecting localities in the Angostura and Isleta reaches. The original 2002 sample locations included stations on the Rio Grande in the Angostura Reach (n=1) about 4 miles downstream of the NM State Highway 44 (=U. S. Hwy 550) Bridge Crossing at Bernalillo (RM 200.0) and in the Isleta Reach (n=2) at the U. S. Hwy 60 Bridge Crossing at Bernardo (RM 130.6) and 0.6 miles upstream of San Acacia Diversion Dam (RM 116.8). However, given the lack of a spring runoff and necessity of scheduling of an artificial flow spike, sampling duties and locations for the 2002 version of the project were modified, in consultation with agency researchers, following the adaptive management protocol of the ESA Workgroup.

The New Mexico Fishery Resources Office (NMFRO) of the U. S. Fish and Wildlife Service assumed sampling responsibility for eggs in the Angostura Reach of the Rio Grande. They selected the NM State Highway 44 (=U.S. Hwy 550) Bridge Crossing (=Bernalillo Bridge; RM 203.8) as a sampling site because of the presence of an extensive dataset of annual egg collecting data (at that site) during 1999 and 2001. Collection of those 2002 data were also important to NMFRO for comparative purposes with the data they were acquiring, under a separate project, on entrainment of Rio Grande silvery minnow propagules in canals. The NMFRO also conducted abbreviated sampling in the Rio Grande (in Albuquerque) for silvery minnow eggs at the Paseo del Norte Bridge Crossing (RM 191.2) and Rio Bravo Boulevard Bridge Crossing (NM State Hwy 500; RM 178.3).

Sampling in the Isleta Reach was markedly restructured due to the extremely low flow conditions in the Rio Grande during 2002. Most of the water in the Rio Grande was diverted at Isleta Diversion Dam with return flows to the river occurring at a point immediately upstream of San Acacia Diversion Dam. Flow at San Acacia Diversion Dam during spring 2002 was extremely low, generally being <150 cfs. The Middle Rio Grande Conservancy District (MRGCD), in an effort to maximize the volume of flow spike water reaching the San Acacia Reach and in cooperation with federal resource agencies, was to use their network of canals to transport a large portion of the May artificial flow spike and return it to the Rio Grande near San Acacia Diversion Dam. Given these scenarios, sampling at the most downstream site in the Isleta Reach was (RM 116.8) was eliminated due to a lack of water and collecting efforts where the U. S. Hwy 60 Bridge crossed the Rio Grande (just east of Bernardo; RM 130.6) were significantly curtailed. The New Mexico Department of Game and Fish (NMGF), in cooperation with the U. S. Fish and Wildlife Service's Ecological Service Division conducted cursory sampling at the U. S. Hwy 60 Bridge site during the May spike release.

The San Acacia Reach of the Middle Rio Grande is about 56 miles (91 km) long extending from the apron of San Acacia Diversion Dam to the head of Elephant Butte Reservoir. Sections of this reach are characterized by a wide river channel, meandering flow, sand substrate, high suspended sediment load, and broad variety of aquatic mesohabitats. Conversely, some segments in this reach are relatively narrow and result in increased water velocity and decreased habitat heterogeneity. The 12 mile (19 km) reach of the Rio Grande downstream of San Marcial Railroad bridge crossing is confined to a channel that is about 50 m wide. Substrate in this segment of the river is predominately sand but braiding of the channel is uncommon except under conditions of relatively low flow.

There was a severe drought in the Rio Grande basin during 2002 which resulted, in part, in very low runoff during Rio Grande silvery minnow spawning season. The poor 2002 hydrologic conditions were principal in the decision to generate an artificial flow spike through a controlled release of reservoir storage water in an effort to initiate spawning of Rio Grande silvery minnow. This decision resulted in slight modification of the original 2002 study to ensure the continual monitoring of the reproductive output of Rio Grande silvery minnow in the Middle Rio Grande and secure the largest number of eggs for the propagation facilities. Given downstream drift of eggs, the location of collecting activities was selected so as to maximize the potential number of eggs collected and rescue eggs destined to drift into Elephant Butte Reservoir where, if hatched, larvae would be subjected to a wide array of nonnative predators. The Rio Grande silvery minnow egg collecting site was located about 10 miles (16 km) downstream of the San Marcial Railroad bridge crossing at River Mile 58.8 (3716150 Northing; 307846 Easting, Zone 13). This site was located near the downstream-most point in the San Acacia Reach (Figure 1). In addition to easy accessibility and favorable river conditions, (i.e., wide river channel, current being carried through a single river channel, gently sloped banks, moderate gradient) the only means of vehicle access to this site was gated and could be secured.

MATERIALS AND METHODS

The egg collecting device, developed specifically for the collection of large numbers of live and undamaged semibuoyant fish eggs (Moore Egg Collector; MEC), was the only sampling apparatus used in this project (Altenbach et al., 2000). Numerous modifications made to the collecting gear since the original publication detailing the construction and operation of the MEC (Altenbach et al., 2000) that have resulted in increased effectiveness and efficiency of the MEC (i.e., greater catch rate per sampling period). Catch rate of Rio Grande silvery minnow eggs in the Middle Rio Grande was determined following the sampling protocol described in Altenbach et al. (2000). A mechanical flowmeter was attached to the MEC so that volume of water filtered could be calculated and catch rate per unit of water determined. Catch-per-unit-effort (CPUE) of drifting eggs was calculated as the total number of eggs collected · volume of water sampled^{-1} · 100 (i.e., N [eggs] · m^3 water^{-1} · 100).

Rio Grande silvery minnow egg sampling was conducted daily from 1 May-30 June 2002. Previous studies (Platania and Dudley 2002a, 2002b) documented May and June as primary period of silvery minnow reproductive activity. A normal sampling regime was comprised of three daily efforts (morning, noon, and evening), each of two-hour duration. Two MEC's were generally operated (non-peak spawning) so as to increase the volume of water sampled per unit time. During the period that the principal Rio Grande silvery minnow spawning effort occurred (17-19 May 2002), quantitative egg sampling was conducted almost continuously with a single flowmeter equipped MEC. Research personnel were constantly present at the sampling site from 30 April through 1 July 2002.

Volumetric determination of the number of Rio Grande silvery minnow eggs collected, as employed in 2001, lacked the rigor necessary for effective evaluation of the relative level of spawning by this species. Minor changes in the 2002 sampling protocol were instituted to increase the amount and utility of the information acquired from this research activity. The result was that the two principal objectives of this project, determining the reproductive output of Rio Grande silvery minnow and obtaining eggs for use in Rio Grande silvery minnow propagation activities, were accomplished through slightly different sampling protocols.

In 2002, a single MEC was dedicated for determining the number of eggs being collected. The daily quantitative sampling undertaken to determine the relative reproductive effort of Rio Grande silvery minnow was generally accomplished by a single researcher using one or two MEC's equipped (always) with mechanical flow meters. On most occasions, collected eggs could be easily

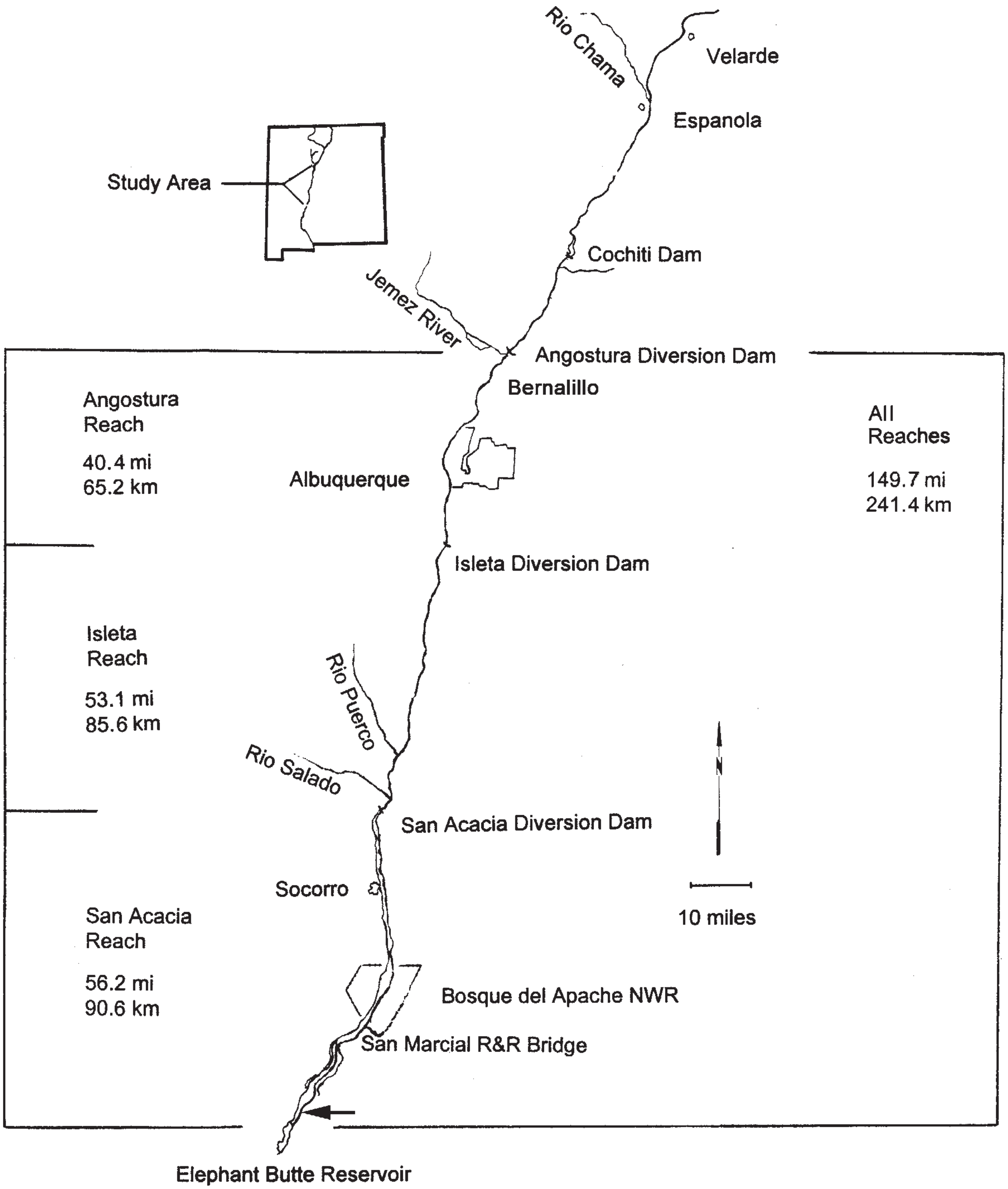


Figure 1. Map of the Middle Rio Grande, New Mexico. The arrow indicates the 2002 Rio Grande silvery minnow spawning periodicity sampling site in the San Acacia Reach (RM 58.8).

counted and retained for the propagation program (i.e., catch of <500 eggs per hour). However, enumeration of eggs during peak spawning was not possible and it was during that period that an accurate determination of the egg/volume of water sampled catch rate was essential. Under those circumstances (peak spawn), eggs were retained and preserved in a solution of 5% buffered formalin for subsequent enumeration in the laboratory.

Conversely, the collection of eggs for use in propagation activities was coordinated by the U.S. Fish and Wildlife Service and involved the participation of numerous individuals (and several agencies) during the short duration of the peak spawning event. The purpose of that effort was the capture of as many Rio Grande silvery minnow propagules as possible. Participating individuals also employed MEC's to acquire eggs from the river, however, those units were not equipped with mechanical flow meters. As the number of eggs collected from the hatchery-bound samples would not be enumerated, little value would have been gained from the time consumptive activities involved in the process required to determine volume of water filtered. Eliminating this aspect of the sampling allowed individuals to spend more time in the water which resulted in a greater number of eggs collected for propagation. Data obtained from the non-quantified egg samples included date, time, and duration of the individual sampling effort as well as the collector's name and agency. (Again, it should be noted that at least one flow meter-equipped MEC was always operating during these periods thereby providing a quantification of Rio Grande silvery minnow reproductive effort).

During the peak spawning period, eggs for propagation activities were placed in a small plastic bag containing river water and a tag inscribed with a unique alpha-numeric code. At the end of the sample period, the plastic bag containing Rio Grande silvery minnow eggs was carried to shore, filled with oxygen, and sealed. The bag was then placed in a large volume ice chest that contained a small amount of ice to maintain the samples at temperatures of about 20 °C. Personnel from U.S. Fish and Wildlife Service assumed responsibility for transporting ice chests containing Rio Grande silvery minnow eggs from the study site to the Albuquerque Aquarium (BioPark) and Dexter National Fish Hatchery and Technology Center during 17-19 May 2002. Those eggs were used to assist in augmentation programs already established for recovery of Rio Grande silvery minnow. A subset of live eggs collected was also provided to Dr. Thomas F. Turner (UNM-MSB) for a study on aspects of the population/conservation genetics of Rio Grande silvery minnow.

Water temperature was recorded by two temperature logging devices deployed at the study site on 30 April 2002 and programmed to record hourly water temperatures. The second temperature logger was redundant and deployed to compensate in the case of the potential loss of data due to electronic failure in the primary unit. Hourly water temperature data from the primary temperature logger were synthesized and are presented in this report as mean, minimum, and maximum daily water temperatures. Mean daily discharge data for this study were acquired from the U.S. Geological Survey river gauge at the San Marcial Railroad Bridge crossing of the Rio Grande (gauge # 08358400) and are presented in cubic feet per second (cfs).

Reporting of research activities (qualitative results) of the Rio Grande silvery minnow reproductive effort monitoring study was accomplished by posting a summary of daily activity on the U. S. Bureau of Reclamation maintained "*Rio Grande silvery minnow Spawning Periodicity Study 2002*" world-wide-web page (URL: http://msb-fish.unm.edu/rgsm2002/Egg_Salvage/index.html). An e-mail list-serve was established through this web site as a means of keeping those individuals interested in the project informed of river conditions, project updates, and putative silvery minnow spawning period. This outlet provided an extremely effective means of communication, information dissemination, and public outreach. The web page contained a brief summary of the project scope, goals, and schedule of activities, photographs of the sampling site and sampling efforts, a 7.5' USGS topographic map indicating the collection locality, and served as an archive of e-mail correspondence. Finally, the spawning periodicity study web page contained links that allowed the reader to obtain

USGS flow data at San Marcial Railroad Bridge Crossing, New Mexico site, "pdf" (portable document format) copies of the 1999 and 2001 reports on spawning periodicity of Rio Grande silvery minnow, and access to the 2002 Rio Grande silvery minnow population monitoring research page.

Estimation of the number of eggs retained for propagation activities

In 2002, a non-volumetric and very conservative mechanism of estimating the number of Rio Grande silvery minnow eggs retained for rearing efforts during peak spawning events was devised. Catch rate data from the flowmeter equipped sampling device was reanalyzed to generate a catch per unit time (minute) instead of catch per volume of water filtered and thereby provide an estimate of eggs retained for propagation. Details of the procedure undertaken to achieve those values follow.

The peak spawning event was divided into one-hour periods from 1600 h on 17 May until 1600 h on 19 May 2002. Egg collection data acquired from the quantified sampling effort during that time were recalculated as necessary and assigned to the appropriate time-bin. The volume of water filtered in a given sample (known variable) was divided by the duration of the sample (noted on data-sheets) to produce the volume of water sampled per unit of time (m^3 per min). The new variable (m^3/min) was multiplied by the volumetric catch rate (a known value from the enumerated sample) assigned to that one-hour period. The product (=catch rate/min for that specific one-hour period) generated was a new value (constant) used to estimate the number of eggs retained for propagation.

Individual (non-quantitative) samples in the propagation program that were obtained during the peak spawning period were also assigned to the aforementioned one-hour sampling time-bins. The "per minute" catch rate data for specific hourly sampling periods was multiplied by the number of minutes for the individual (non-quantitative) sample to yield a number of eggs taken in that effort.

This estimate is conservative because the value employed for time sampled (in the quantified sample) in the initial series of calculations is consistently an over estimate as it represents the duration of the sampling period, not the actual number of minutes that the device was collecting eggs. A hypothetical example for the sampling period of 1000 h to 1100 h (18 May 2002) is presented below where the sample time was designated as 60 minutes when the actual duration of sampling (MEC in the water) was in reality 45 minutes. The volumetric catch rate for that sample (which does not incorporate time in the determination) was 200 eggs/m^3 and 600 m^3 of water was filtered (both of these values would have been obtained from the flowmeter).

Sample time for the non-quantified sample (collection of live eggs for propagation facilities) during the 1000 h to 1100 h period on 18 May 2002 will be designated as 30 minutes. The two separate adjusted constants and resulting estimates of live eggs retained in the sample would be:

Original time sampled during quantitative sampling ***was 60*** *minutes then:*

Volumetric rate of water sampled	= 10 m^3/min
Actual egg catch rate	= 200 eggs/m^3
10:00-11:00 catch rate constant (18 May 2002):	
200 eggs/m^3 * 10 m^3/min	= 2,000 eggs/min
30 min of live catch sampling	
30 min * 2,000 eggs/min	= 60,000 eggs

Original time sampled during quantitative sampling ***actually 45*** *minutes then:*

Volumetric rate of water sampled	= 13.3 m^3/min
Actual egg catch rate	= 200 eggs/m^3
10:00-11:00 catch rate constant (18 May 2002):	
200 eggs/m^3 * 13.3 m^3/min	= 2,660 eggs/min
30 min of live catch sampling	
30 min * 2,660 eggs/min	= 79,980 eggs

The conservative values derived from these calculations are important because they provide an estimate, albeit low, of the number of Rio Grande silvery minnow eggs that were collected during the peak 2002 spawning effort for the rearing project. Despite any shortcomings of the method, it is more reliable than that of volumetric determination as it is based on a large and well quantified sample allowing variables to be adjusted as necessary. Efforts to determine an accurate, prompt, and nondestructive means of enumerating live eggs in the field should continue to be investigated.

RESULTS

Hydrology during 2002 and the artificial flow spike

Flow in the Rio Grande during 2002 was extremely low due to a severe drought which resulted in a lack of snowmelt runoff and reduced storage of water in upstream reservoirs (Figure 2). Discharge in the Rio Grande at San Marcial Railroad Bridge Crossing (USGS Gauge 08358400) generally remained <600 cfs from well before the end of previous irrigation season (1 November 2001) throughout the calendar year. Base flow in the Rio Grande at San Marcial during April and most of May 2002 was, with the exception of the artificial flow spike, between 50-100 cfs. Isolated summer monsoons provided brief and minimal relief to the drought..

The artificial flow spike that was released to stimulate spawning by Rio Grande silvery minnow was initiated at Cochiti Dam on 13 May 2002 and continued for three days (Figure 3). An 420 cfs increase in mean daily discharge at Cochiti Dam between 12-13 May 2002 (950 to 1,370 cfs) marked the initiation of this short duration flow spike. Discharge at the dam peaked at 1,650 cfs on 14 May and declined to 1,270 cfs on 15 May before returning to a base-flow of about 1,000 cfs on 16 May 2002. All except about 50-100 cfs of the baseflow from Cochiti Dam was diverted for irrigation prior to arriving at the San Acacia Reach of the Rio Grande.

The flow spike arrived at San Acacia Diversion Dam on 16 May 2002 (mean daily discharge 628 cfs) and peaked on 17 May 2002 (mean daily discharge 768 cfs), three days after peaking at Cochiti Dam (Figure 4). Discharge at San Acacia Diversion Dam dropped rapidly on 18 May and was back to pre-flow spike levels by 20 May 2002. It required only one day for the flow spike to travel from San Acacia to San Marcial as mean daily discharge at the latter locality rose from 61 cfs (16 May 2002) to 191 cfs on 17 May 2002 (Figure 5). The peak in discharge, though markedly reduced in volume, arrived at San Marcial (421 cfs) one day after being recorded at San Acacia Diversion Dam .

Rio Grande silvery minnow egg collections

Angostura Reach and Isleta Reach Sites

The NMFRO sampled for Rio Grande silvery minnow eggs every day throughout May 2002 at the Bernalillo Bridge (RM 203.8). Approximately 18,000 m^3 of water was filtered at this site during the 31 samples taken in May 2002 but no Rio Grande silvery minnow eggs were ever collected. Conversely, the egg sampling efforts of the NMFRO on 14-17 May 2002 at the Paseo del Norte Bridge (RM 191.2) and Rio Bravo Boulevard Bridge (178.3) yielded a total of 320 eggs in six samples. On 15 May 2002, 34 eggs were collected at the Paseo del Norte Bridge Site at a catch rate of 3.4 eggs/100 m^3 of water sampled while later that same day 181 eggs were collected at the Rio Bravo Bridge at a catch rate of 97.8 eggs/100 m^3 of water sampled. The following day the catch rate at the Paseo del Norte Bridge site was 3.6 eggs/100 m^3 of water sampled (n=12) and 68.2 eggs/100 m^3 of water sampled (n=93) at the Rio Bravo Bridge. The last sample at the Paseo del Norte Bridge (17 May 2002) did not produce any Rio Grande silvery minnow eggs, while sampling at the Rio Bravo Bridge was discontinued after 16 May 2002.

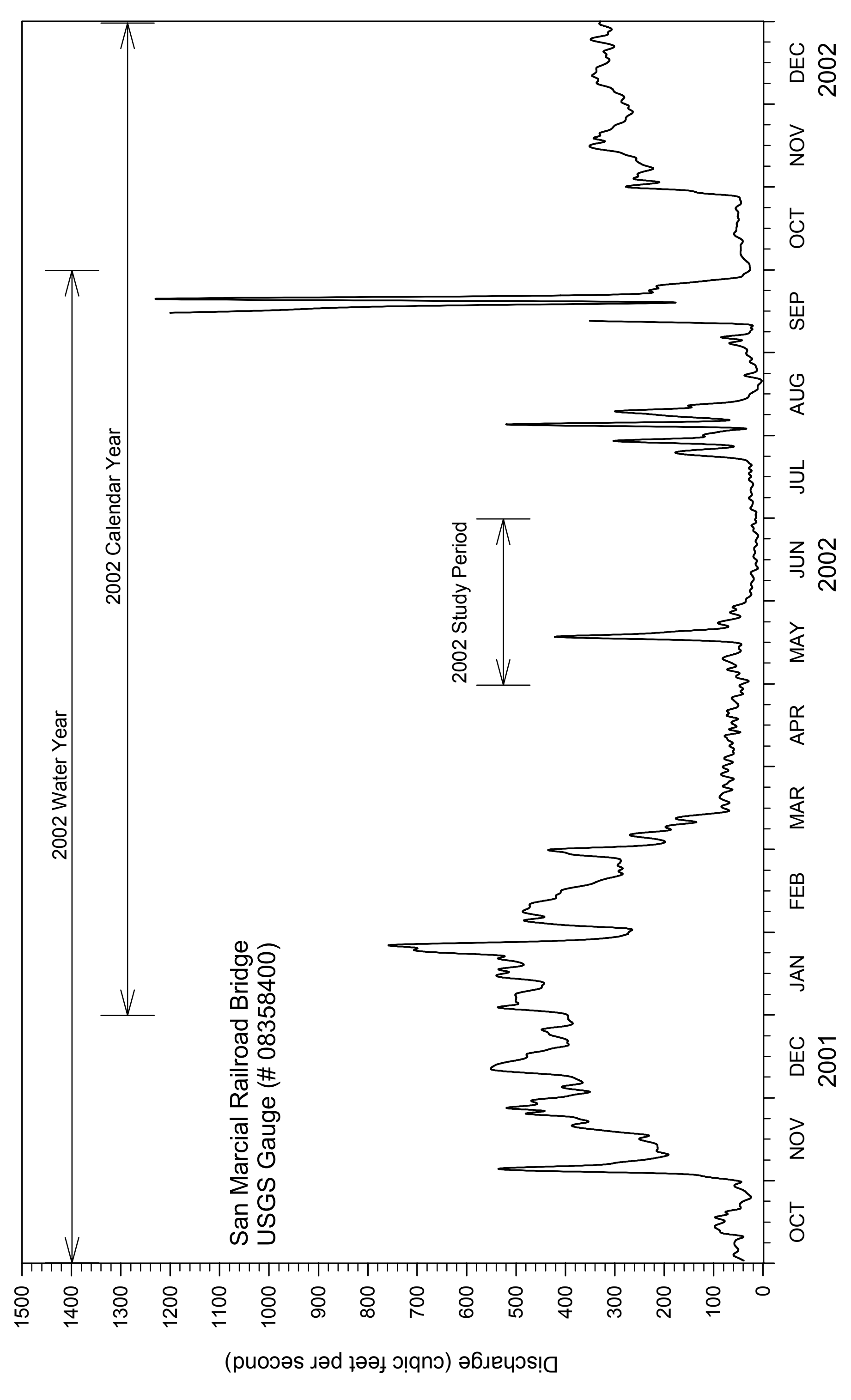


Figure 2. Hydrograph of the Rio Grande, New Mexico, at the San Marcial Railroad Crossing before and during the 2002 study period.

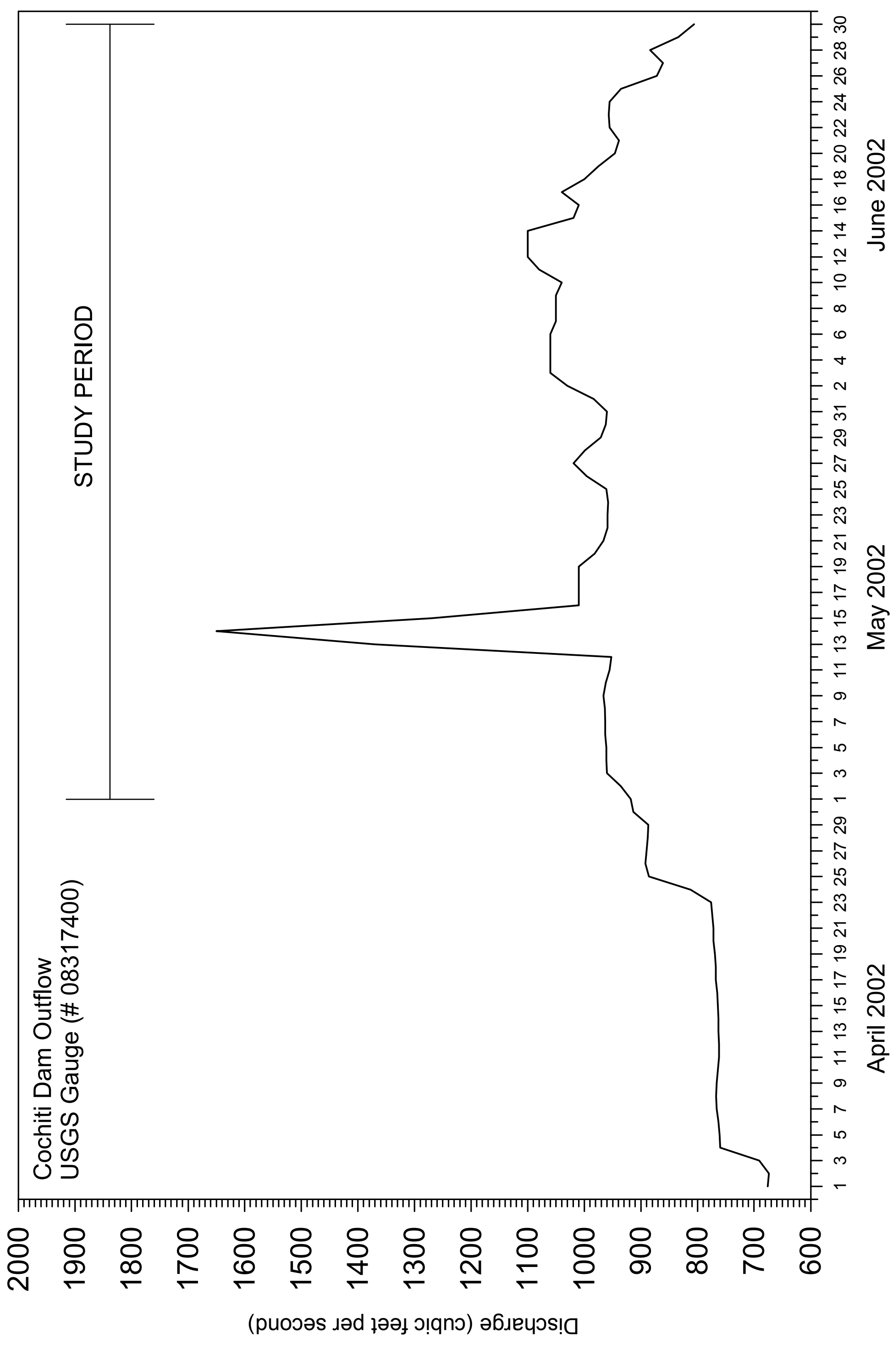


Figure 3. Hydrograph of the Rio Grande, New Mexico, at Cochiti Dam during the 2002 study period.

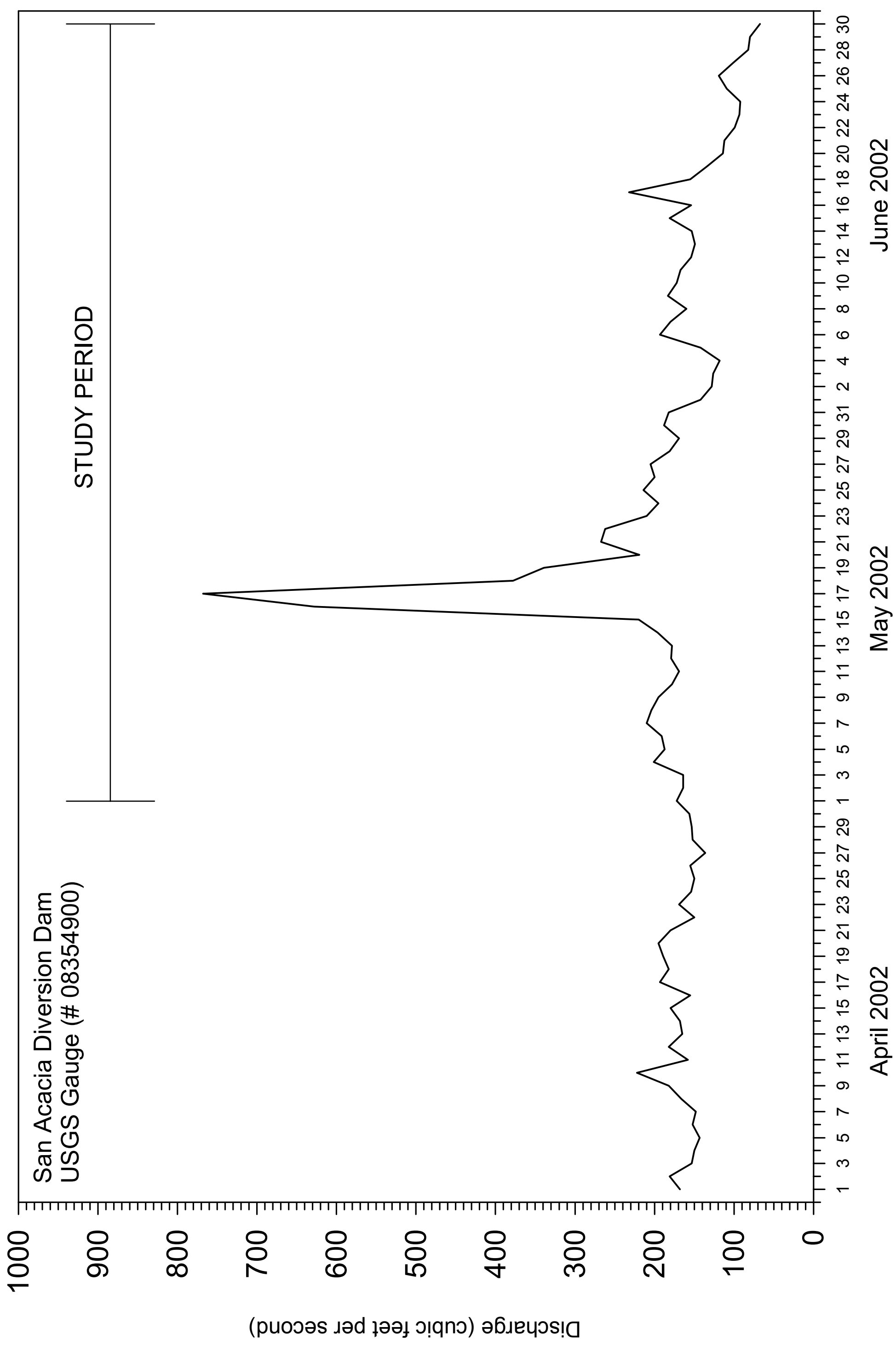


Figure 4. Hydrograph of the Rio Grande, New Mexico, at San Acacia Diversion Dam during the 2002 study period.

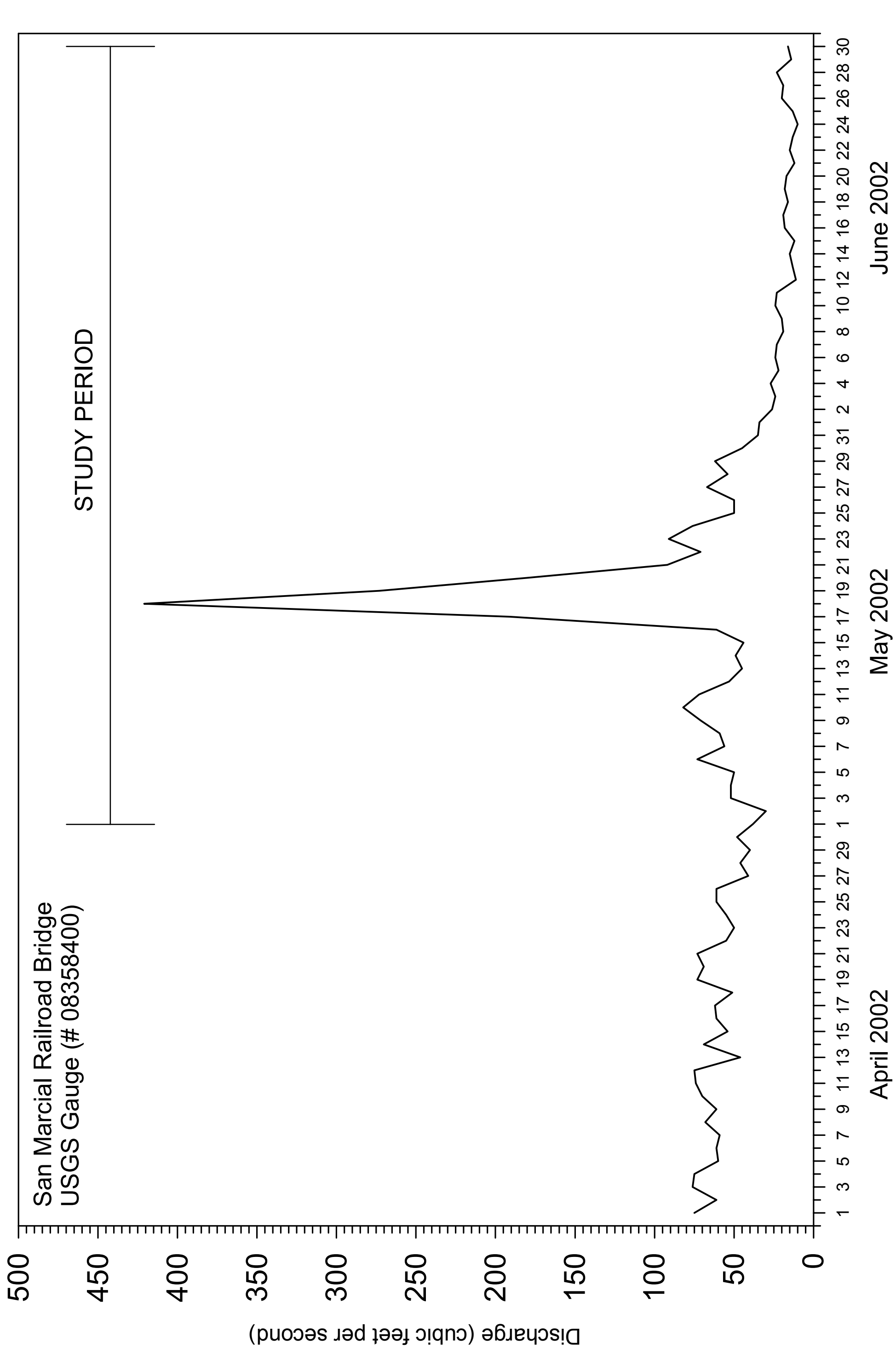


Figure 5. Hydrograph of the Rio Grande, New Mexico, at San Marical Railroad Bridge Crossing during the 2002 study period.

The site of the U. S. Highway 60 Bridge Crossing on the Rio Grande, just west of Bernardo (RM 130.6), was sampled several times during May 2002 but apparently produced eggs on only one occasion. On 17 May 2002, the river was sampled from 1200-1315 h with multiple MEC's (Field Number DLP-4875 = David L. Propst). One of the two sampling devices had a flowmeter and filtration of about 268 m^3 of water was recorded. There was no indication of the number or deposition of the Rio Grande silvery minnow eggs taken in that sampling effort. Repeated efforts to locate additional collection records for that site during May 2002 have, to date, been unsuccessful.

San Acacia Reach Site

The first Rio Grande silvery minnow eggs collected during the 2002 sampling period occurred on 7 May 2002 with propagules being taken in each of the three daily samples. A total of 35 eggs were taken with a cumulative daily catch rate of about 4.5 eggs/100 m^3 of water sampled. Four days later, a second (markedly smaller) catch of eggs occurred with specimens again taken in each of the three daily samples. The four eggs from the 11 May 2002 sample resulted in a cumulative daily catch rate of about 0.6 eggs/100 m^3 of water sampled. No additional Rio Grande silvery minnow eggs were collected until the arrival of the artificial flow spike.

On 17 May 2002, between 1200-1800 h there were four sampling efforts each resulting in the collection of at least one Rio Grande silvery minnow egg. These four sampling efforts occurred immediately prior to the arrival of the flow spike at the San Acacia reach sampling site. By 18:00 h, the rising water level was apparent and egg catch rate increased from <1 to 14.1 eggs/100 m^3 of water sampled. During the next two hours (20:00-22:00 h), egg catch rate increased 10-fold (160.7 eggs/100 m^3) and from 22:00-24:00 it increased an additional seven-fold (1,122.7 eggs/100 m^3). The rate of egg collection rose steadily throughout the morning of 18 May 2002 as did flow at the study site (Figure 6). This pattern was also documented in 2001 (Figure 7) and in 1999 (Figures 8 and 9).

At about 0600 h on 18 May 2002, egg catch rate had surpassed 10,000 eggs/100 m^3 and at 0900 h it had reached 20,000 eggs/100 m^3 of water sampled. The egg catch rate fluctuated between 20,000-28,000 eggs/100 m^3 during sampling conducted from 1500-1600 h. The highest catch rates recorded during this study were obtained in the three samples taken between 16:00 and 18:30 on 18 May 2002. During that period incredibly high egg catch rates of 56,500, 48,500, and 96,500 eggs/100 m^3 were obtained from the single flowmeter equipped egg collection device that was in operation. Catch rate of the next 18 May 2002 sampling effort (1900 h) had declined markedly from that of the previous samples and, as indicated by a notation in the 1900 h sample field notes, was quite apparent to the operator of the egg catcher long before any analysis of the raw data had been performed.

The catch rate of the two samples taken between 1900-2200 h on 18 May 2002 were the last during this study to be >10,000 eggs/100 m^3 of water sampled. By 02:00 early in the morning of 19 May 2002, the Rio Grande silvery minnow egg catch rate had declined to about 6,450 eggs/100 m^3. There was a 3.5 hour hiatus between sampling events with the next collection, initiated at 05:30 (19 May 2002), producing an egg catch rate of about 2,000 eggs/100 m^3. By 15:30 h, the decline in catch rate continued to be documented (825 eggs/100 m^3) with the final 19 May 2002 collecting effort (1600-1800 h) yielding 150 eggs/100 m^3 of water sampled (Figure 10).

On 20 May 2002, the small number of eggs being taken and the immense number that had been provided to the propagation facilities during the previous 48 hours, allowed the protocol for egg collecting to return to three samples per day. Rio Grande silvery minnow eggs were collected during each of those 20 May 2002 efforts with an early morning collection (06:00-08:00) resulting in a catch rate (147 eggs/100 m^3) which was very similar to that obtained during the previous evening. An obvious decline in catch during the latter portion of the 0600-0800 h sample prompted egg collecting to be reinitiated at 09:00-11:00. The 23 eggs/100 m^3 taken in the 09:00-11:00 sampling

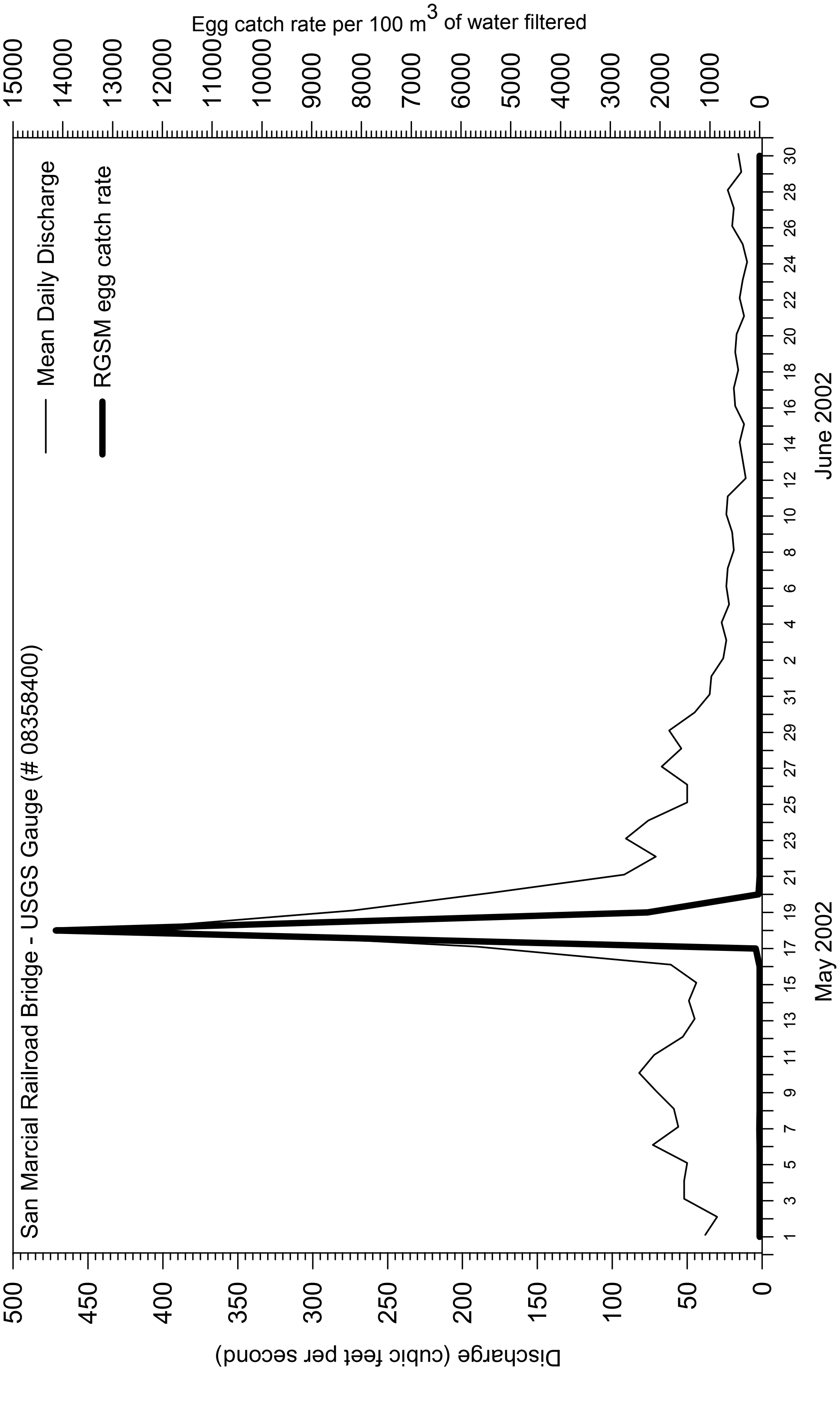


Figure 6. Rio Grande silvery minnow catch rates (CPUE) during the 2002 study period compared with mean daily discharge at San Marcial.

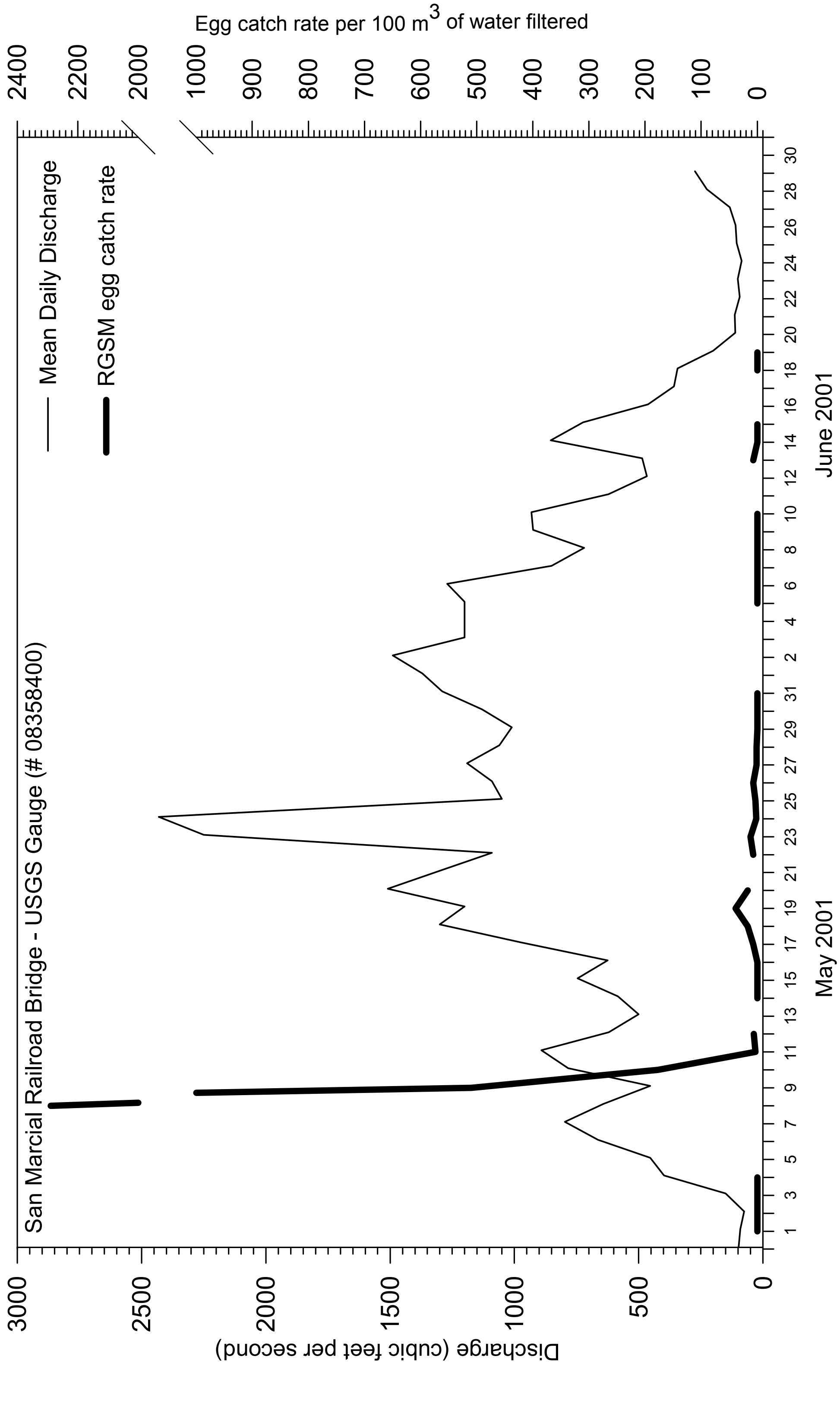


Figure 7. Rio Grande silvery minnow catch rates (CPUE) during the 2001 study period compared with mean daily discharge at San Marcial.

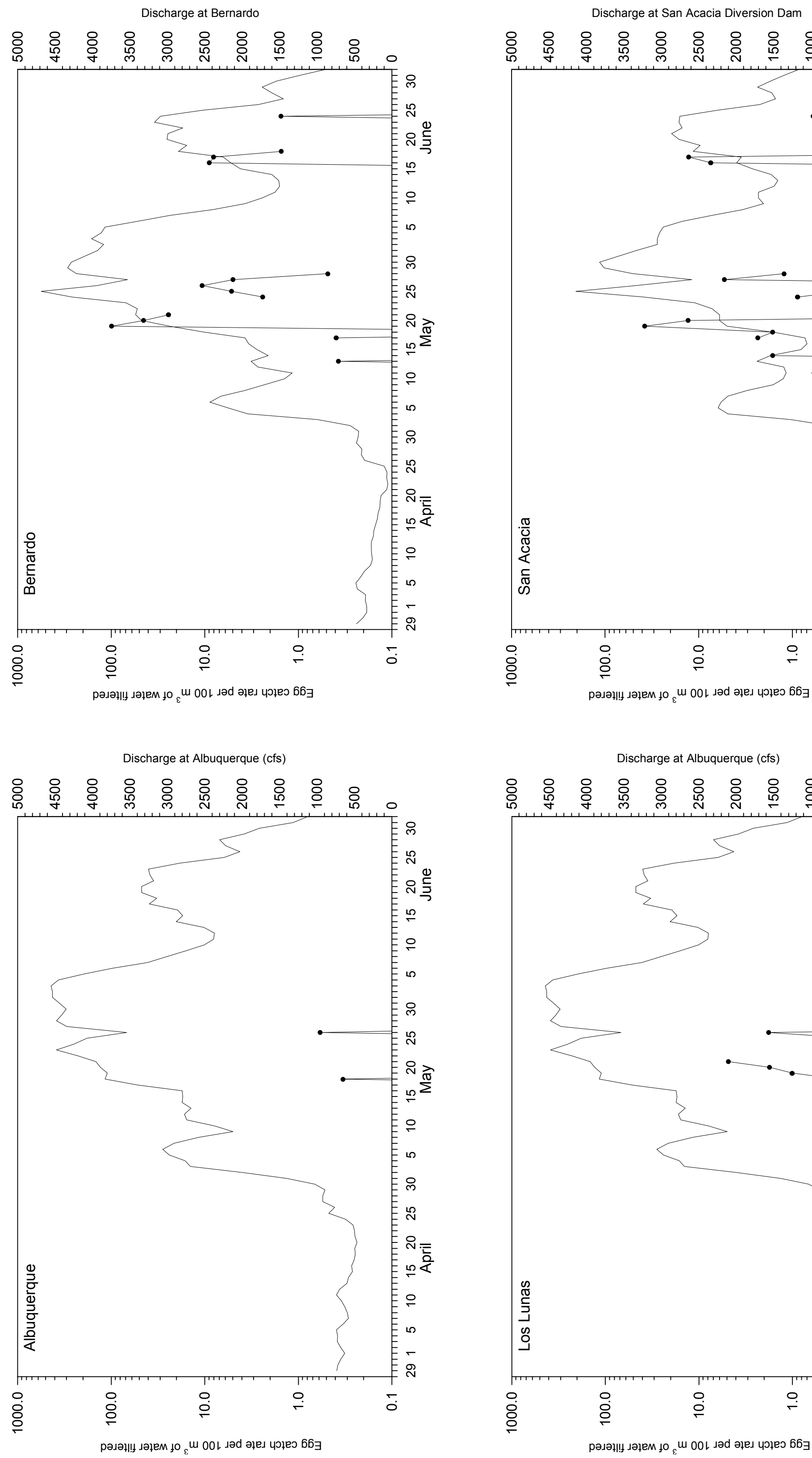


Figure 8. Rio Grande silvery minnow egg CPUE compared with mean daily discharge for the 1999 study period at Albuquerque, Los Lunas, Bernardo, and San Acacia sampling localities. Note that the catch rate (Y) axis is logarithmic.

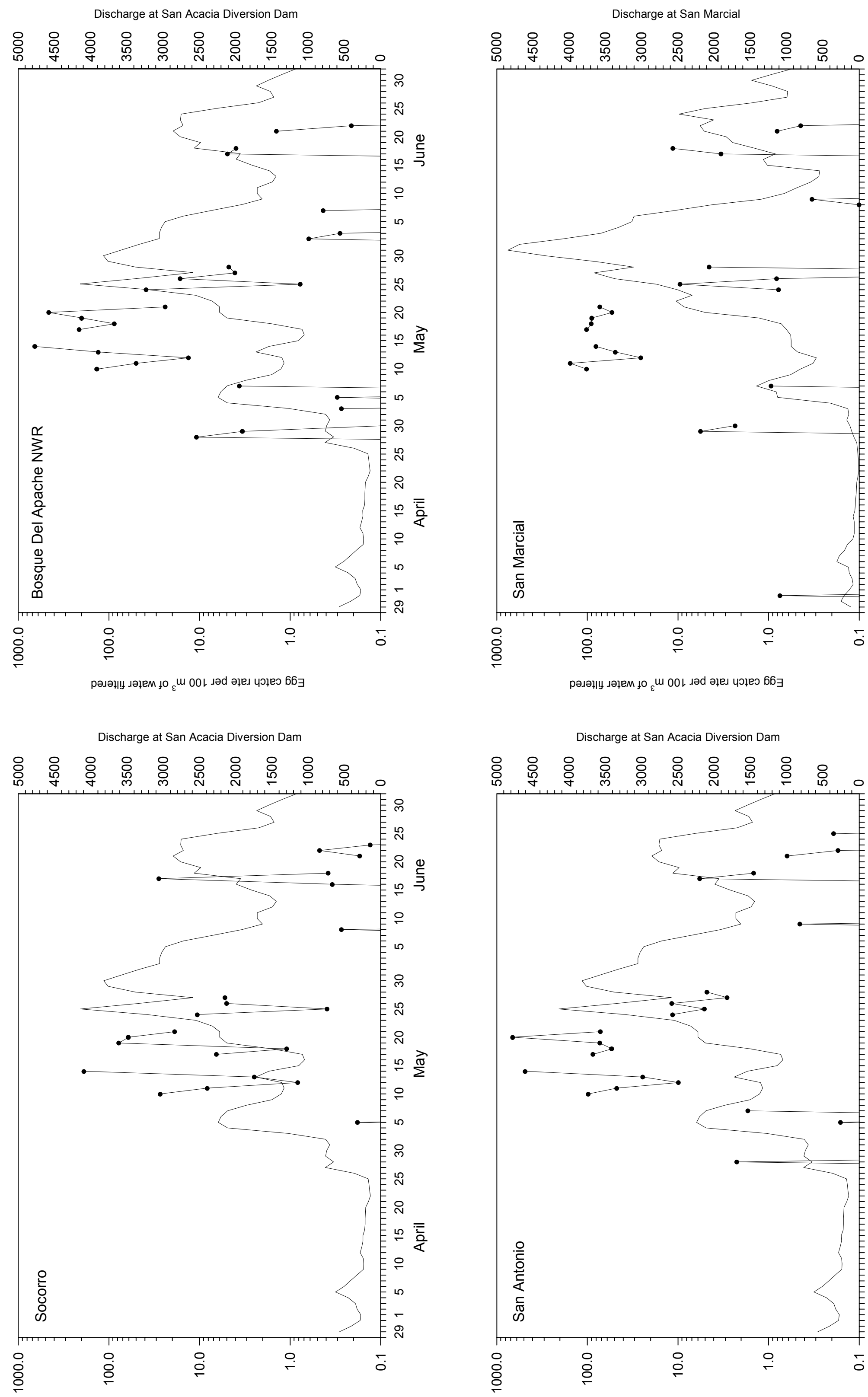


Figure 9. Rio Grande silvery minnow egg CPUE compared with mean daily discharge for the 1999 study period at Socorro, San Antonio Bosque del Apache NWR, and San Marcial sampling localities. Note that the catch rate (Y) axis is logarithmic.

effort served to document the near cessation of Rio Grande silvery minnow spawning associated with the flow spike. The final sample of 20 May 2002 (1730-1930 h) yielded a catch rate of 1.6 eggs/100 m^3 and was the last sample of this study to produce eggs.

There were 108 sampling efforts recorded following the cessation of reproductive activities of Rio Grande silvery minnow associated with the flow spike. During that 41-day period, only about 6,000 m^3 of water was filtered at the study site. Extremely low discharge in the Rio Grande from the end of May throughout June severely limited the volume of water that could be sampled. The relatively low volume of water sampled over that period does not alter the results of the data which indicated an absence of Rio Grande silvery minnow reproductive activity in the vicinity of the San Acacia Reach study site during that period.

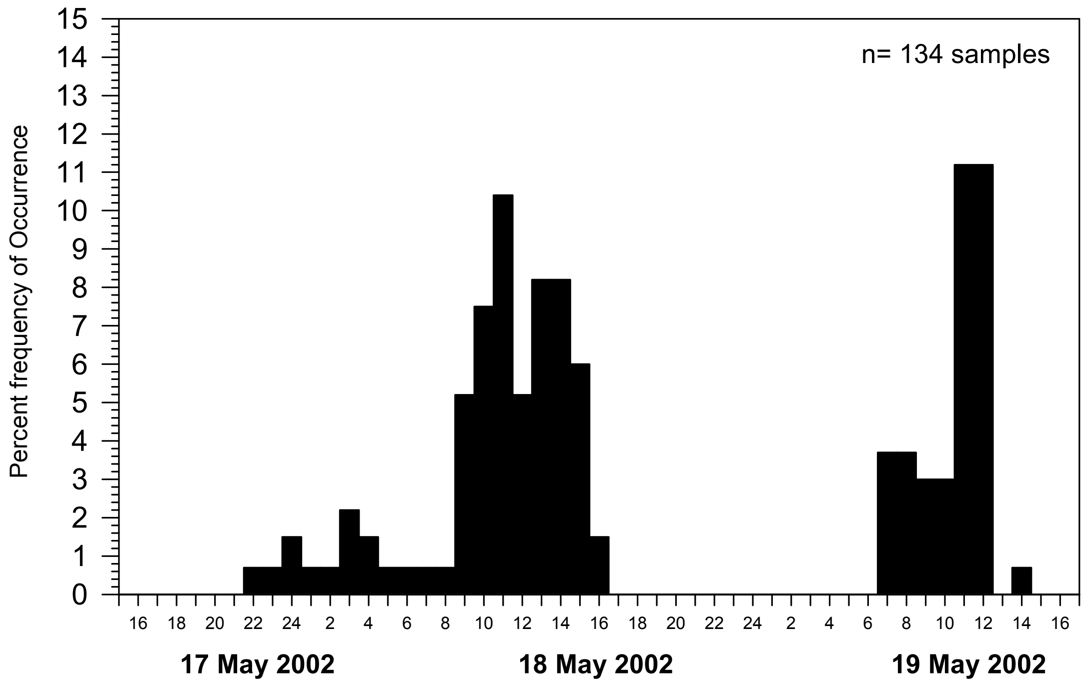
Water temperature

Mean daily water temperature increased rapidly in May 2002 rising almost 10°C between the beginning (16°C) and end (26°C) of the month. During the duration of the flow spike, mean daily water temperature at the site remained a relatively constant 21°C but dropped about 2°C on 22 May 2002 at the cessation of the flow spike. From 22-30 May 2002, the steady increase in water temperature at the study site (18°C to 26°C) corresponded with declining discharge (ca. 70 cfs to 50 cfs). Mean daily water temperature at the San Acacia Reach study site during June 2002 fluctuated between 21°C and 27°C while mean daily discharge generally remained <30 cfs (Figure 11).

More important and informative than the mean daily water temperatures at the study site were maximum daily water temperatures. Maximum daily water temperatures remained between 21-27°C prior to and during the flow spike but began to increase almost immediately after the cessation of the manipulated discharge. Water temperatures in excess of 30°C were recorded at the study site on 146 occasions and 29 dates in May and June with the maximum single water temperature of 36.3°C occurring at 1630 h on 23 June 2002 (Figure 12). All of these values were achieved subsequent to the flow spike. During approximately half (47%) of those 146 occasions, water temperature was in excess of 32°C. The majority (84%) of the high water temperatures occurred in June with at least one hourly water temperature >30°C recorded continuously from 11 June through the end of the project. Water temperatures in excess of 30°C occurred during all except five days in June 2002. Conversely, there were only three days and 14 measures during May 2002 during which water temperature was >30°C

Estimate of the number of eggs retained for propagation activities

There were 134 samples taken between 2200 h on 17 May 2002 and 1500 h on 19 May 2002 that were dedicated exclusively to providing Rio Grande silvery minnow eggs for propagation efforts. The number of eggs retained, as determined using the procedures and calculations detailed in the Materials and Methods section of this report, was estimated conservatively to be 922,000. The vast majority of those eggs (85%, n=784,000) were collected between 0800-1700 h on 18 May 2002. That aforementioned nine-hour period coincided with the time during which the largest number of samples were taken (n=71; 53%). While there were 49 live egg samples acquired during the following day (19 May 2002), they accounted for only 10% of the total live egg catch (n=92,000). Egg capture rates peaked, as determined through quantitative sampling with a flowmeter equipped egg catcher, from 1500-1800 h on 18 May 2002. Unfortunately, the peak occurred after the sampling crew dedicated to the collection of eggs for propagation had left the site for the day. No accounting was made regarding the disposition of individual live egg collections as that portion of the project was under the jurisdiction of the New Mexico branch of the U.S. Fish and Wildlife Service's Ecological Services Division.



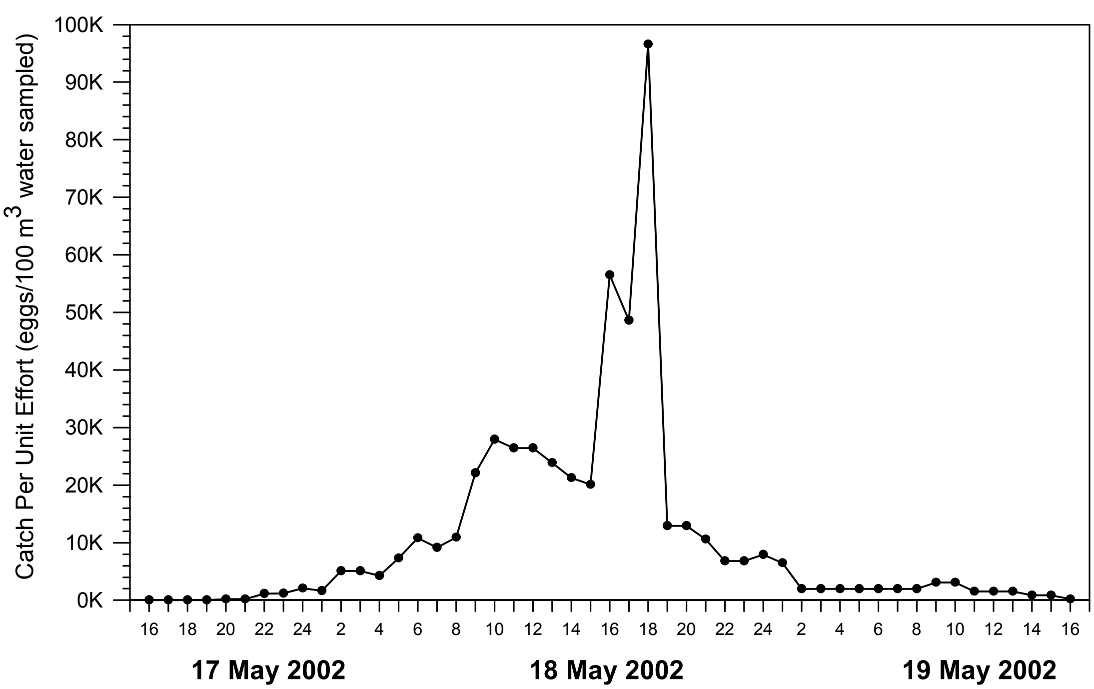


Figure 10. Upper Graph: Distribution of sampling effort for collection of eggs for propagation.
Lower Graph: Hourly egg catch rate during Rio Grande silvery minnow spawning peak.

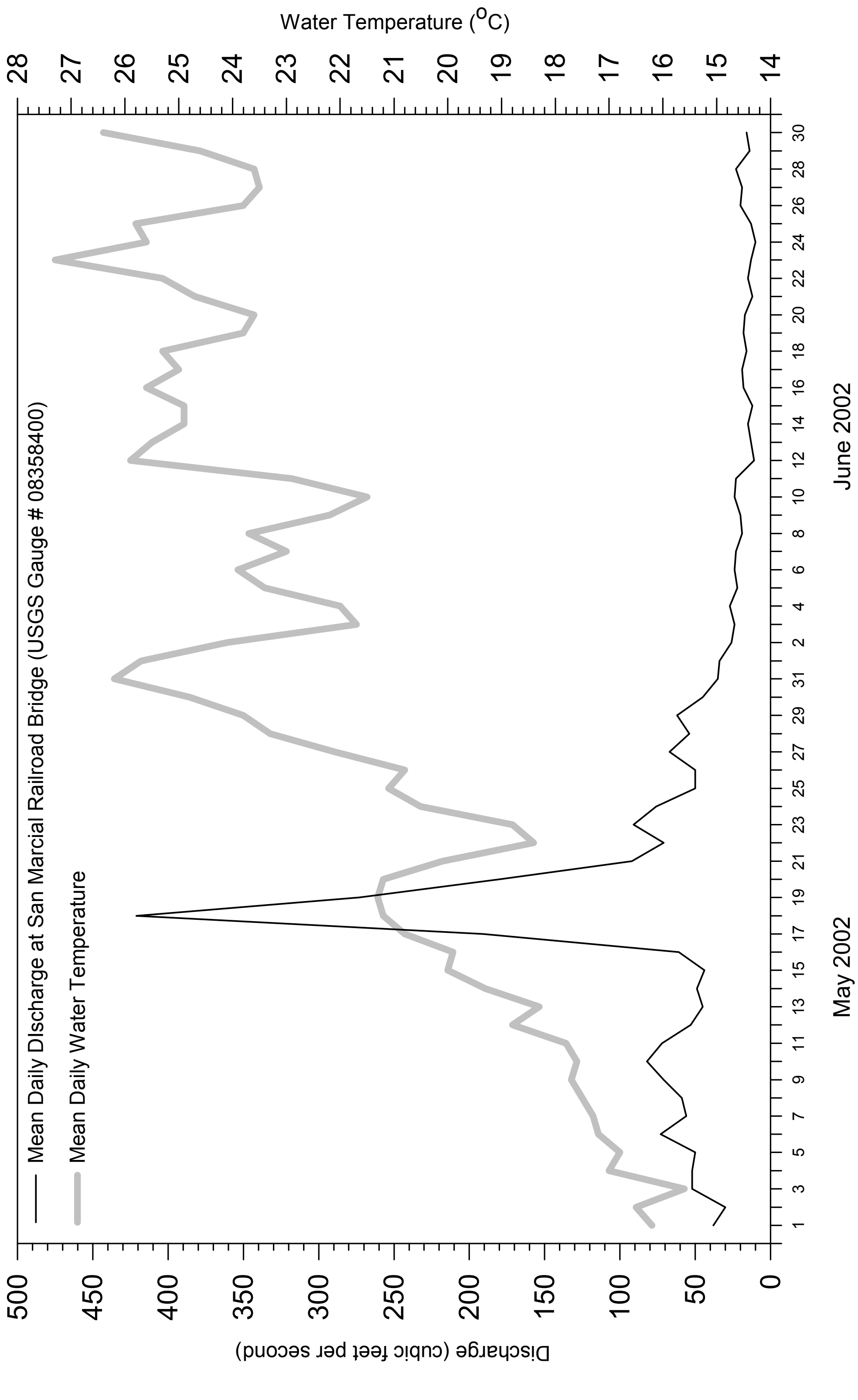


Figure 11. Mean daily discharge (at San Marcial) compared with mean daily water temperature during the 2002 study period.

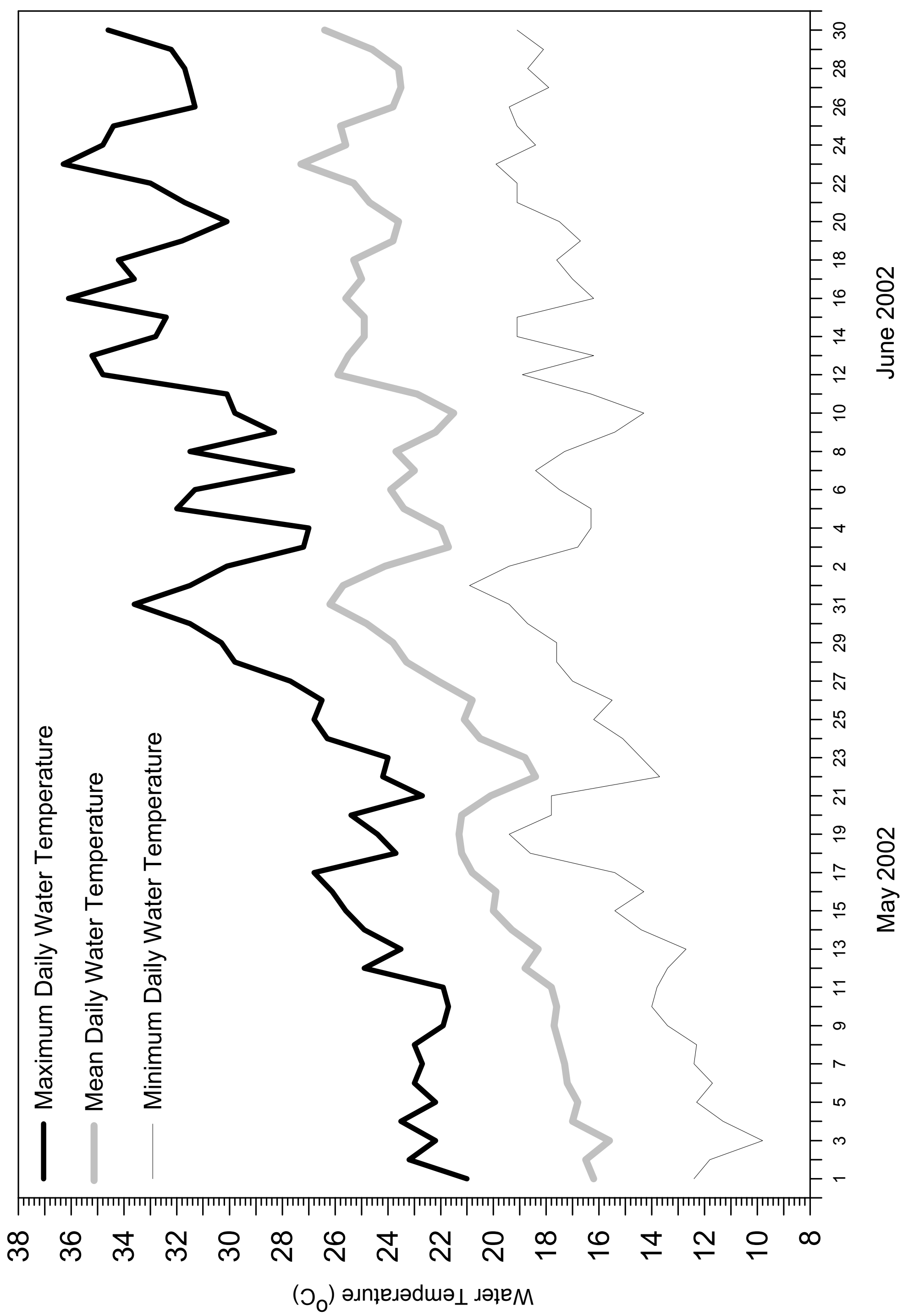


Figure 12. Maximum, mean, and minimum daily water temperatures at the San Acacia Reach study site during the 2002 study period.

DISCUSSION

As rivers have become increasingly fragmented, an important factor limiting the recolonization of upstream reaches is the downstream transport of reproductive products below barriers or displacement into highly degraded downstream riverine habitats and reservoirs. The potential negative impacts of dam-related modifications of flow and habitat on Great Plains stream cyprinids that employ drifting eggs and larvae as an early life history strategy have been well documented (Stanford and Ward, 1979; Cross et al., 1983; Cross et al. 1985, Cross and Moss, 1987; Winston et al., 1991; Luttrell et al., 1999). In the Middle Rio Grande, many of the eggs and larvae of the federally endangered Rio Grande silvery minnow are rapidly displaced downstream of diversion dams and into Elephant Butte Reservoir. The loss of this reproductive effort from upstream sources is one factor that has led to the currently imperiled state of this species. Reducing the rate of downstream transport, allowing upstream passage, and salvaging eggs destined for Elephant Butte Reservoir are all options that will, to some degree, improve the current status of Rio Grande silvery minnow.

Since Rio Grande silvery minnow is the only extant species of the previously discussed reproductive guild in the Middle Rio Grande, the species-specific identification of any semibuoyant egg collected during this study is unambiguous. The only other eggs that we have captured in the Middle Rio Grande during this and previous investigations that look (to the untrained individual) remotely similar to those of Rio Grande silvery minnow are the eggs of common carp, *Cyprinus carpio*. Fortunately, there are numerous differences between the eggs of these two species that aid in identification. As the eggs of common carp are adhesive, there are usually small pieces of particulate matter attached to the chorion. Additionally, common carp eggs are smaller and more opaque than Rio Grande silvery minnow eggs, and the eyes of carp embryo become pigmented very early in development. Conversely, the egg of Rio Grande silvery minnow is clear, nonadhesive, smooth, large, and the embryo lacks discernible pigment.

Spawning of Rio Grande silvery minnow and other members in its reproductive guild (Platania and Altenbach, 1998) appear to be triggered by specific environmental cues. These fishes exhibited a strong positive correlation between flow and spawning. In 1999, 2001, and 2002 the peak spawning event by Rio Grande silvery minnow occurred soon after the initiation of spring snowmelt runoff (during the first two weeks of May). Egg catch rates in the Pecos River and Rio Grande appear most closely correlated with increased flow and not absolute water volume. This relationship has been observed throughout the Middle Pecos River from early-May until late-September. Spawning was closely correlated to sharp increases in flow from local rainstorms and egg catch rates would drop as soon as flows began to drop. This sequential pattern (increased flow, increased spawning, decreased flow, decreased spawning) occurred throughout the summer in the Pecos River, NM. By late-September, the association between spawning and flow was minimal, indicating the end of the reproductive season for the five members of the reproductive guild that occupy the Pecos River.

Population monitoring efforts produced reproductively capable Rio Grande silvery minnow (both genders) from late-March until late-July during 2002. Morphological features indicative of reproductive development in female Rio Grande silvery minnow (i.e., distended abdomens indicating maturation of eggs) first apparent in 2002 during February population monitoring efforts. Gonadal maturation appeared to proceed rapidly and coincide with the notably warmer water temperatures recorded in March 2002. In late July 2002, gravid female silvery minnow were collected from several sites in the San Acacia Reach including localities immediately downstream of San Acacia Diversion Dam. On 23 July 2002, mean daily discharge at San Acacia Diversion Dam rose from ca. 250 to 700 cfs as a result of localized rainstorms. Spawning by Rio Grande silvery minnow in response to this increase in discharge was documented from 24-26 July 2002 by the collection of eggs in the San Acacia Reach of the river by U. S. Fish and Wildlife personnel (Jude R. Smith, NMES, pers. comm.). While quantitative data of the magnitude of the late-July 2002 spawning event are not available, the spawn was of sufficient magnitude for biologists in the field for non-egg related research activities to detect the presence of Rio Grande silvery minnow eggs in the river.

An incidence of summer spawning by Rio Grande silvery minnow was also documented during late June in 1996. Discharge in the Rio Grande in 1996, as in 2002, was low throughout the spring and lacked the high and sustained discharge typical at that time of the year for the Middle Rio Grande. Rainstorms in the Middle Rio Grande Valley on 26 June 1996 resulted in increased flow in the river and localized flash-flood events. Heavy rainfall in the Rio Puerco-Rio Salado basin resulted in a flash flood on 28 June 96 and mean daily discharge recording of 5,500 cfs at San Acacia Diversion Dam on that date. These storms triggered spawning by Rio Grande silvery minnow and eggs were collected at all sites sampled (during population monitoring efforts) on 28 June 1996 between Albuquerque and Socorro. Again, quantified data on the magnitude of reproductive effort for that spawning event were not obtained. However, notes were recorded regarding the sampling methodology, duration of sampling, and number of eggs taken. The crude collecting technique (larval fish seine), short sampling duration (1-5 minutes per sample), and relatively large number of eggs per sample (up to 60) suggest a large magnitude spawning event by Rio Grande silvery minnow. Low flows occasionally augmented by rain events in 1996 probably resulted in some additional level of spawning throughout the summer.

It is possible that during periods of low spring discharge (e.g., 1996 and 2002), a large proportion of the Rio Grande silvery minnow population do not spawn during spring but rather retain eggs until flow increases later in the year. The presence of appropriate environmental cues (i.e., increased discharge) are an overriding factor in determining timing of Rio Grande silvery minnow spawn. The ecological implications are for retaining eggs into the summer are unclear. Spawning during summer would result in a contracted growing season, compared with spring spawning, for larval and juvenile Rio Grande silvery minnow. Reduced growth could have negative implications for survival into and through the winter because of host of different factors (e.g., competition, predation, disease etc.). The biotic environment would be different in summer as compared to spring because the majority of other fish taxa present in the Middle Rio Grande would have already reproduced potentially leaving Rio Grande silvery minnow at a competitive disadvantage. (Rio Grande silvery minnow are one of the earliest fish to reproduce. Only white sucker spawns earlier in the calendar year [consistently] than Rio Grande silvery minnow).

Catch rate of Rio Grande silvery minnow eggs was notably higher in 2002 than in 2001. It is important to note, however, that this increased catch rate does not necessarily imply more eggs were produced in 2002 than in 2001. Catch rate is dependent on both the number of eggs present in the water column at the time of sampling and the total volume of water in the river channel. As a hypothetical example, if an equal number of eggs were produced during both 1,000 cfs and 2,000 cfs flow events, catch rates from the former samples would be expected to about double those of the latter event. If flow was constant during the two hypothetical spawning events it would be possible, after performing simply arithmatic conversions, to compare catch rates of Rio Grande silvery minnow eggs between different years with a high degree of confidence. However, the rapidly fluctuating nature of flow spikes is such that direct annual comparisons would be more subject to error. As a general comparison, peak egg collections in 2002 occurred during daily flows that ranged from about 200-500 cfs while collections in 2001 occurred during flows that ranged from about 500-800 cfs. This difference in flow would be expected to result in a higher catch rate in 2002 than in 2001 although the magnitude of the difference would be difficult to predict.

Although low flow in the river channel during spawning are primarily responsible for the elevated 2002 Rio Grande silvery minnow catch rates, it still appears that large numbers of Rio Grande silvery minnow eggs were spawned during the May flow spike. Despite the large production of Rio Grande silvery minnow eggs in 2002, recruitment of young into the population was, based on population monitoring data, apparently very low. One hypothesis that may explain why so few young Rio Grande silvery minnow survived is the harsh river conditions following the artificial spawning spike may have been unsuitable for their growth and development. Unlike a natural spring runoff that can last several weeks, the engineered spring spawning spike occurred over only days and hydraulically resembled a rain event (i.e., rapid increase in flow followed by rapid decrease in flow). The increase in discharge was large enough magnitude and sufficient timing that it resulted in a strong spawning response by Rio Grande silvery minnow. However, the elevated flows that resulted in the production of large numbers of Rio Grande silvery minnow eggs quickly subsided to extremely low flows.

Flow at the San Acacia Reach sampling locality had declined to <100 cfs within several days of the May spawning event and were about 50 cfs less than a week following this reproductive effort. Following the recession of flow, mean water temperatures rose rapidly from about 20°C to over 25°C in less than one week. Also, maximum daily water temperatures increased from about 24°C to over 33°C within the two weeks following peak spawning. High water temperatures are known to decrease spawning success of Rio Grande silvery minnow and may inhibit development of larvae as well (Platania, 2000). In addition to elevated water temperatures, low flow also resulted in the confinement of both the river and its fishes to a much smaller area than would normally be available. These conditions resulted in increased competition or predation for newly spawned Rio Grande silvery minnow. This is in stark contrast to high spring runoff years when elevated and sustained flows result in the creation of numerous nursery habitats over of several weeks, cooler water temperatures, and allow YOY Rio Grande silvery minnow increased access to resources and cover.

Downstream displacement of drifting fish eggs and larvae in aquatic ecosystems poses a unique problem for resource managers. While the most simple solution would appear to be collecting eggs from downstream localities and transporting them to rearing facilities, this method has only short term significance. Additionally, the capture of eggs using current techniques and levels of effort will result in the collection of only a minuscule fraction of the total reproductive effort that is destined for Elephant Butte Reservoir. The ability to efficiently sample even 1% of the entire volume of water that carries these reproductive propagules downstream requires a monumental effort. The low flow in May 2002 and the subsequent collecting efforts that resulted meant that a larger portion of the river was sampled during that Rio Grande silvery minnow egg collecting effort than had ever previously occurred. Even with all of the personnel present during 17-19 May under the 2002 flow scenario, considerably <1% of the cross-sectional instantaneous river discharge was sampled. Between 30-40 egg collectors (and people) would have been required to have achieved that level in 2002.

Future efforts should also focus on reducing the deleterious effects that changes in river connectivity, flow patterns, and habitat heterogeneity have on the downstream displacement of Rio Grande silvery minnow eggs and larvae. Eliminating diversion structures as barriers would allow upstream passage of individuals to reaches from which they were displaced. Repopulating upstream reaches of the Middle Rio Grande through natural recolonization would greatly aid in the recovery of this species. Efforts to improve degraded riverine habitats could include returning the flow regime to a more historical pattern (i.e., allowing passage of large flow events) and removing or relocating structures that inhibit the lateral movement of the Rio Grande (e.g., jetty-jacks, levees, and water conveyance ditches). The long-term recovery of Rio Grande silvery minnow will depend on taking management actions that attempt to restore the natural processes of this river.

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APPENDIX I:

Rio Grande silvery minnow spawning periodicity study 2002

World-Wide-Web pages

URL: http://msb-fish.unm.edu/rgsm2002/Egg_Salvage/index.html

Rio Grande Silvery Minnow Spawning Periodicity Study 2002

and Egg Salvage Site

This project has ended for the 2002 season.

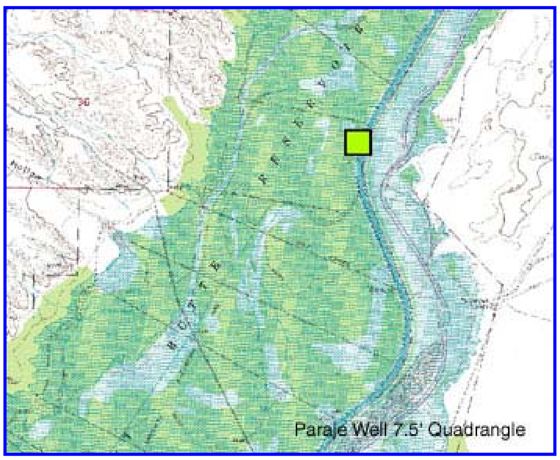

Photo of the site on 18 May 2002

Locality Description
click on map to enlarge

Socorro County, Rio Grande, ca. 18 miles downstream of the southern end of the Bosque del Apache National Wildlife Refuge. *Site is at approximately the same location as the Upper Corral Site.*
SAN ACACIA REACH
River Mile 58.8

Rio Grande silvery minnow, *Hybognathus amarus*, is a member of a reproductive guild (group) of fishes characterized by pelagic-broadcast spawning and the production of semibuoyant eggs. Spawning by members of this reproductive guild is associated with high-flow events such as spring run-off or summer rainstorms. Upon release, eggs are about 1.6 mm diameter but quickly swell (ca. 3.0 mm) and remain suspended in the water column during development (see drawings and photos). Egg hatching time is temperature dependent but rapid occurring in 24-48 hours. Recently hatched larval fish remain a component of the drift until development of the gas bladder. This physiological development corresponded with a shift in swimming behavior as larvae actively seek low-velocity habitats.

The 3-5 days necessary for propagules to attain the developmental stage that allows them to freely disperse permits time for considerable downstream dispersal of eggs and larvae in the Middle Rio Grande. It is necessary for at least some portion of the displaced fish to move upstream to maintain those populations. Historically, there were no permanent barriers to upstream dispersal of fishes in the Middle Rio Grande. There are currently three instream diversion structures between Cochiti Dam and Elephant Butte Reservoir are barriers to upstream movement of fishes and fragment the once continuous range of the only remaining Middle Rio Grande (NM) member of this reproductive guild.

Currently over 90% of the catch of Rio Grande silvery is in the San Acacia Reach of the Middle Rio Grande. Multi-agency efforts in areas of habitat improvement, research, and propagation are underway in an attempt to increase population size and distribution with the ultimate goal being recovery of this species.

This study was designed to acquire information on the timing, duration, and magnitude of spawning by Rio Grande silvery minnow. Previous efforts

indicated that Rio Grande silvery minnow spawning occurs over a relatively short period during spring run-off. This information will be useful in assessing progress of efforts towards recovery of this endangered fish. Additional goals of this study were to acquire Rio Grande silvery minnow eggs for rearing and use in propagation efforts and provide eggs for genetic analysis.

Reports from Previous Project Years

Spawning Periodicity of Rio Grande silvery minnow during 2001
Final Report by Steven P. Platania and Robert K. Dudley

Spatial Spawning Periodicity of Rio Grande silvery minnow during 1999
Final Report by Steven P. Platania and Robert K. Dudley

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...or check below for daily updates

Egg-collecting in the river

Egg-collecting in the LFCC

Click Here for More Photos

2002 Rio Grande silvery minnow Egg Salvage Project

Daily Updates - Current Flow Conditions at San Marcial gauge

April

30	Site setup day - no eggs were collected in four hours of active sampling.

May

1	No Rio Grande silvery minnow eggs at Upper Corral Site. Caught a few common carp eggs. Also sampled near San Acacia Diversion Dam - no eggs collected.
2	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
3	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
4	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
5	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
6	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
7	First catch of Rio Grande silvery minnow eggs in the river - about 75 total were collected.
8	No Rio Grande silvery minnow eggs were collected during a full day of (intensive) sampling.
9	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
10	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
11	Collected a cumulative total of 9 RGSM eggs during today's sampling effort
12	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
13	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
14	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
15	No Rio Grande silvery minnow eggs were collected during a full day of sampling. River has not yet risen from Cochiti release.
16	No Rio Grande silvery minnow eggs were collected during a full day of sampling. Reports have come in of eggs being collected upstream of the site. Discharge increase expected to reach the site late Friday (17 May) evening.
17	The first eggs arrived around 2:00 p.m.
18	Hundreds of thousands of eggs were collected.
19	Tens of thousands of eggs were collected.
20	Hundreds of eggs were collected.
21	A few Rio Grande silvery minnow eggs were collected during a full day of sampling.
22	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
23	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
24	No Rio Grande silvery minnow eggs were collected during a full day of sampling. Water levels have returned to pre-Cochiti release levels.
25	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
26	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
27	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
28	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
29	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
30	No Rio Grande silvery minnow eggs were collected during a full day of sampling.
31	No Rio Grande silvery minnow eggs were collected during a full day of sampling.

June

1 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
2 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
3 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
4 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
5 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
6 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
7 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
8 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
9 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
10 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
11 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
12 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
13 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
14 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
15 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
16 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
17 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
18 No Rio Grande silvery minnow eggs were collected during a full day of sampling. We are waiting to see if the increase in flow that resulted from the rainstorm on Friday, 14 June will reach the site. Flow increased to approximately 300 cfs over San Acacia on Monday, 17 June.
19 No Rio Grande silvery minnow eggs were collected during a full day of sampling. Still waiting to see if the river level will rise.
20 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
21 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
22 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
23 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
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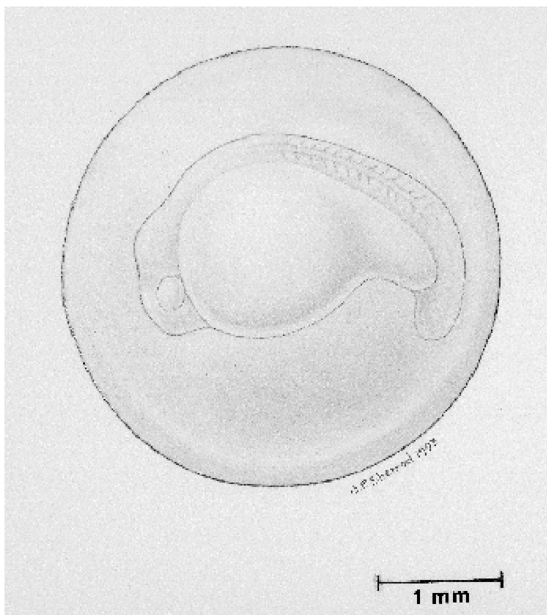
28 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
29 No Rio Grande silvery minnow eggs were collected during a full day of sampling.
30 No Rio Grande silvery minnow eggs were collected during a full day of sampling.

Rio Grande Silvery Minnow Spawning Periodicity Study 2002

Images

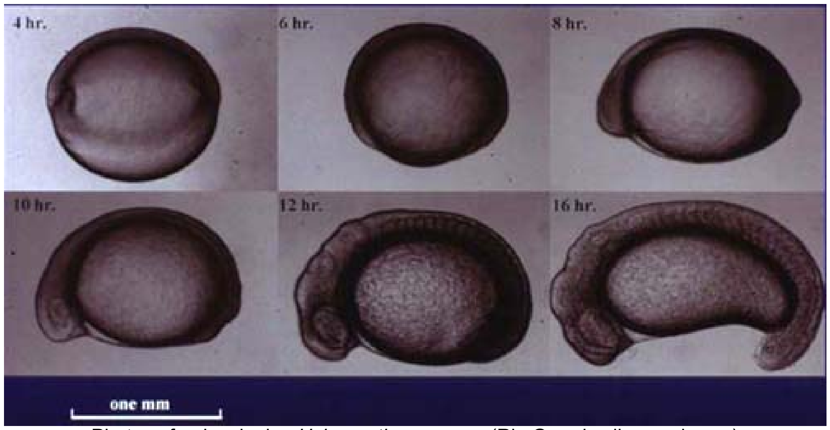
Back to Main Site Page

The following set of drawings and photos illustrates the development of plains minnow (*Hybognathus placitus*) embryo in an egg, time-series photos of the development of a Rio Grande silvery minnow (*Hybognathus amarus*) embryo, a schematic of the device used to collect eggs in the river, and photos of eggs in the collector from the 2001 collecting season.

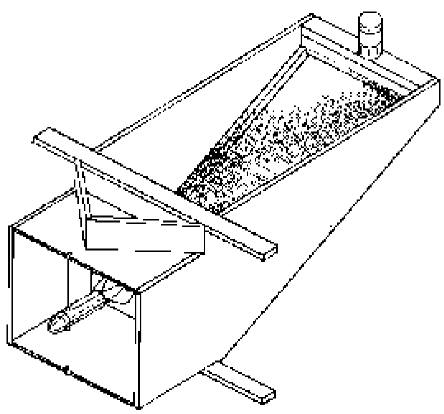


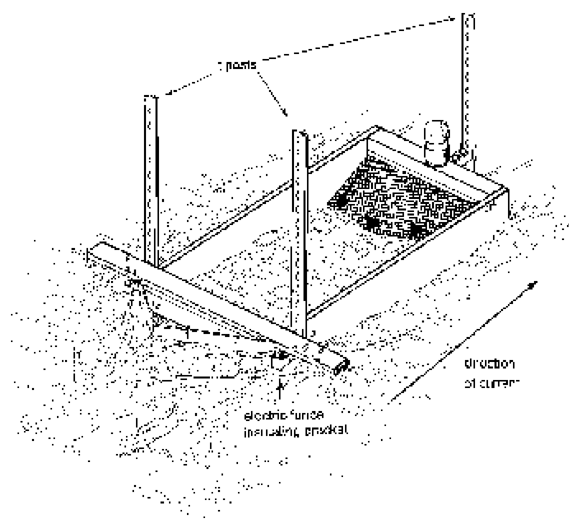
Hybognathus placitus (plains minnow) egg - drawing by J.P. Sherrod

2002 Rio Grande silvery minnow Egg Salvage Project Photos



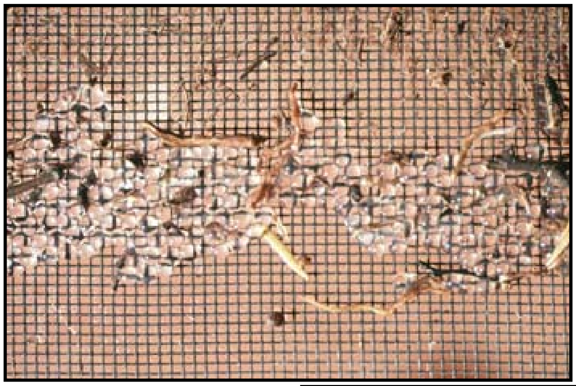
Photos of a developing *Hybognathus amarus* (Rio Grande silvery minnow)
embryo (outer shell of egg not visible) under high-powered microscope
photos by R.K. Dudley





Moore Egg Collector - Drawings by J.P. Sherrod

2002 Rio Grande silvery minnow Egg Salvage Project Photos

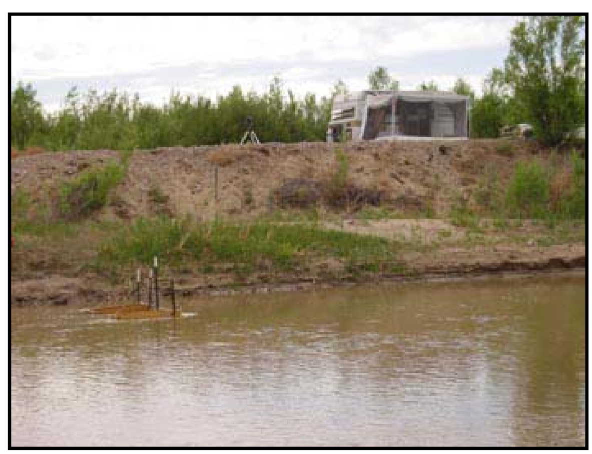


Eggs in the Moore Egg Collector (file photos - 2001 season)

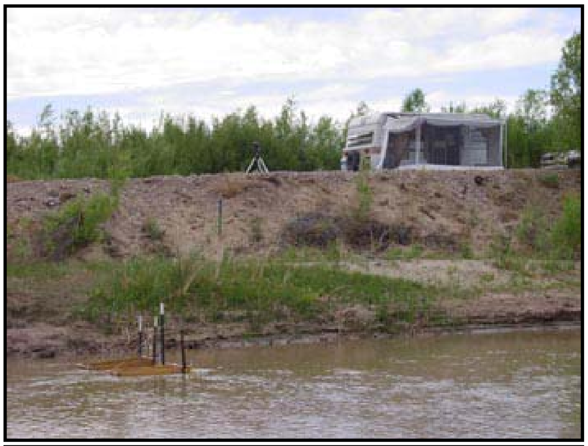
Photos from 18 May 2002
(hundreds of thousands of eggs collected)

2002 Rio Grande silvery minnow Egg Salvage Project Photos

Photos from 16 May 2002



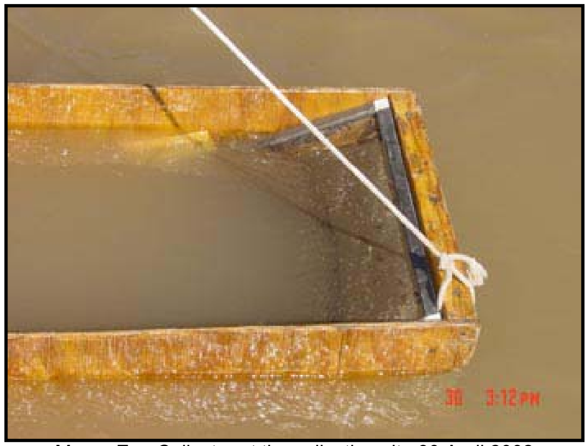
2002 Rio Grande silvery minnow Egg Salvage Project Photos



These photos were taken on site setup day - 30 April 2002

http://www.uc.usbr.gov/progact/rg/rgsm2002/Egg_Salvage/photos.html (5 of 9) [1/21/2003 8:47:22 AM]

2002 Rio Grande silvery minnow Egg Salvage Project Photos



Moore Egg Collector at the collection site 30 April 2002

Trailer (operations base) at the site

Looking upstream towards the trailer

2002 Rio Grande silvery minnow Egg Salvage Project Photos

Looking downstream from the site

Looking upstream from the site

Thermograph

Setting up the thermograph to take hourly river temperature readings

Photos from the [2001 collecting season]

2002 Rio Grande silvery minnow Egg Salvage Project Photos

Egg-collecting effort in the Rio Grande 22 May 2001

Egg-collecting in the LFCC 22 May 2001

2002 Rio Grande silvery minnow Egg Salvage Project Photos