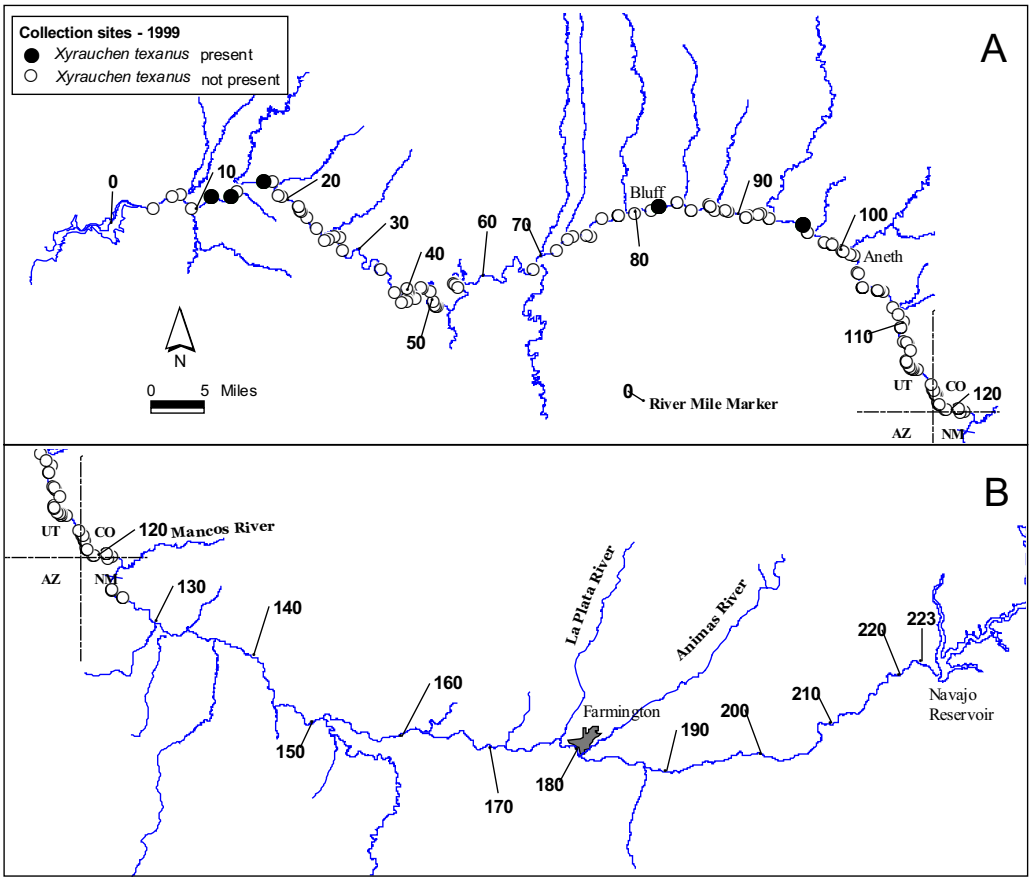
Razorback sucker larval fish survey
San Juan River

1998 and 1999

DRAFT FINAL REPORT



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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM

Razorback sucker larval fish survey in the San Juan River during 1998 and 1999

DRAFT FINAL REPORT

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submitted to:

San Juan River Biology Committee
under the direction of the
San Juan River Recovery Implementation Program

31 March 2000

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Executive Summary

The 1998 razorback sucker larval fish sampling study was modified from that previously employed to allow for collection of fish over a longer portion of the San Juan River and capture of a considerably larger number of larval fish. Starting in 1998, an inflatable raft was used to travel the river and provide the opportunity to sample habitats that were formerly either inaccessible or unobservable. The primary 1998-1999 collecting method was sampling low-velocity habitats with a fine mesh seine. This sampling technique often yielded more larval sucker at a single site than had been taken cumulatively in the 1997 light-trap samples.

There were 182 samples taken in the 1998 razorback sucker larval fish project yielding 13,608 fish representing 14 species. Included in this catch were roundtail chub (n=18), Colorado pikeminnow (n=4), and razorback sucker (n=2). This was the first record of reproduction by the cohort of razorback sucker that had been stocked in the San Juan River beginning in 1994. The two 1998 larval razorback sucker were collected at two separate localities during 21 and 22 May 1998. They were captured in low-velocity habitats located about 3.8 and 12.4 river miles upstream of Bluff, Utah.

The sampling protocol for this project did not change between 1998 and 1999 but the study area was expanded to encompass the mainstem of the San Juan River between its confluence with the Mancos River and Clay Hills, Utah. A total of 20,348 specimens representing 11 species were collected during this effort. Included in the 1999 catch were five juvenile roundtail chub and seven larval razorback sucker. The 1999 samples provided both up-and-downstream extensions of the distribution of larval razorback sucker in the San Juan River. In 1999, four larval razorback sucker were collected upstream of Bluff while three were taken downstream of Bluff. The most upstream collection of larval razorback sucker was about 19.8 river miles above Bluff which was an upstream range extension of about 7.4 miles. The three larval razorback sucker taken downstream of Bluff were collected in the downstream-most portion of the San Juan River (between river miles 10 - 20).

This study provided unequivocal documentation of reproduction in the San Juan River by members of a razorback sucker cohort that had been stocked as part of the San Juan River Recovery Implementation Program. The number of stocked razorback sucker that recruit to the adult cohort (i.e., able to reproduce) are expected to continue to increase annually as should the number and spatial distribution of collections of larval razorback sucker. Future annual studies of larval razorback sucker will provide extremely important information on the level of reproduction of this species and direction necessary to achieve recovery.

Introduction

There are few historic San Juan River records of razorback sucker despite that this is one of three endemic Colorado River basin catostomids native to the San Juan River drainage. Jordan (1891) conveyed anecdotal reports from the late 1800s of razorback sucker occurring in the Animas River as far upstream as Durango, Colorado. However, there were no specimens to substantiate this claim. The first verified records of razorback sucker in the San Juan River was in 1976 when two adult specimens were collected at an irrigation pond near Bluff, Utah (in VTN Consolidated, Inc., and Museum of Northern Arizona, 1978). A 1987 U.S. Bureau of Reclamation document (U.S. Bureau of Reclamation, 1987), citing personal communication from the Utah Division of Wildlife resources, reported the 1981-1984 spring occurrence of razorback sucker in the San Juan River arm of Lake Powell. The most recent San Juan River drainage occurrence of razorback sucker was the April 1988 collection of a single adult tuberculate male by Tom Chart (formerly of the Utah Division of Wildlife Resources) in the San Juan River near Bluff, Utah.

The extreme rarity of razorback sucker in the San Juan River drainage necessitated the experimentally stocking of a small number of individuals so that information on their habitat use, potential spawning areas, and survival and growth rates could be obtained. In 1994 personnel from the U.S. Fish and Wildlife Service's Colorado River Fishery Project (CRFP; Grand Junction, Colorado) stocked the first series of razorback sucker (n=672) in the San Juan River. Those fish, whose mean length and mass at the time of stocking were about 400 mm TL and 710 g, respectively, were released between Hogback, New Mexico and Bluff, Utah. In 1995, numerous individuals from the 1994 stocking effort were recaptured including 13 tuberculate males with six of those individuals being ripe. Four razorback sucker recaptured in 1995 were determined to be female but, unlike the males, none were sexually mature. By 1996, a total of 939 razorback sucker, all of which were progeny of paired matings between San Juan River arm of Lake Powell adults, had been stocked in the San Juan River. In their 1995 report of activities, Ryden and Pfeifer (1996) suggested that the majority of experimentally stocked 1994 San Juan River razorback sucker would achieve sexual maturity by 1996 thereby providing the potential for spawning during 1997-1998. The success of the experimental stocking study resulted in the development a full-scale augmentation program for razorback sucker in the San Juan River.

At the November 1996 San Juan River Biology Committee integration meeting, it was suggested that the Colorado pikeminnow larval fish drift study be expanded in an attempt to document spawning of razorback sucker. The MSB-NMGF larval fish drift study, which was designed to determine spawning period, identifying approximate location of spawning sites, and assess effects of annual hydrology (and temperature) on Colorado pikeminnow reproductive activities, was also successful in providing similar information for other members of the ichthyofaunal community (i.e., longnose dace and channel catfish). However, because reproduction by razorback sucker (March-May) occurred considerably earlier than Colorado pikeminnow (June-July), separate investigations of spawning periodicity and magnitude were deemed necessary for both of the aforementioned species.

The most important difference between the established Colorado pikeminnow study and proposed razorback sucker study, besides temporal, was that the razorback sucker larval fish study was attempting to provide the first documentation of reproduction by stocked members of this species in the San Juan River. Sampling for larval razorback sucker was to be conducted with no assurance that the stocked population of adult razorback sucker would spawn in this system. Conversely, previous studies demonstrated that Colorado pikeminnow reproduction had and was still occurring in the San Juan River. This certainty allowed the Colorado pikeminnow larval fish sampling efforts to be different (i.e., monitoring) than those for razorback sucker (searching).

Numerous Upper Colorado River basin researchers identified light-traps as one of the most efficient means of collecting larval razorback sucker. The 1994-1995 National Park Service - San Juan River fish investigation employed light-traps, near the San Juan River-Lake Powell confluence, as a larval fish collecting technique. That study produced an extremely large number of larval fish (ca. 25,000 per year) from a modest number of samples (n=20). Red shiner numerically dominated (>98%) the light-trap catch during both years but neither Colorado pikeminnow nor razorback sucker were collected. The success of Upper Basin researchers and potentially large number of fish that could be collected using this technique lead to the selection of light-traps as the sampling device during the first year (calendar year 1997) of San Juan River larval razorback sucker study.

Numerous locations, adjacent to U.S. Hwy 163 and Utah State Hwy 262 (which paralleled the San Juan River between Aneth and Bluff), that appeared suitable for sampling with light-traps were identified during March 1997. Light-traps were set nightly in low-velocity habitats between Aneth and Mexican Hat from late March through mid-June 1997. Traps were distributed at dusk and retrieved about four hours later with any fish taken in those samples preserved in the field. Sampling success during the 1997 razorback sucker larval fish study was quite poor. While there were over 200 light-trap sets, those sampling efforts produced only 297 fish. Of those, about 200 (66%) were larval sucker (either flannelmouth sucker or bluehead sucker). Larval razorback sucker were not present in the 1997 sampling survey.

While there were probably several variables that accounted for the poor light-trap catch rate, a principal factor was limited access to suitable habitats. Light-traps are most effective when set in habitats with little or no water velocity. Unfortunately, increased April-June flow in the San Juan River eliminated virtually all low velocity habitats identified in March 1997. Further reconnaissance from an automobile (April - May) of the snowmelt enhanced river failed to yield additional locations suitable for light-traps. One of the results of the 1997 study was the realization that being bound to specific collecting sites was an inefficient means of collecting the large number of larval fish necessary to document reproduction of a rare species.

In 1998 the razorback sucker larval fish sampling technique was modified to allow for collections over a longer portion of the San Juan River and capture of a considerably larger number of larval fish. An inflatable raft, which was used to travel the river, provided the opportunity to sample habitats that were formerly either inaccessible or unobservable under the constraints of the 1997 sampling protocol. Collecting trips were conducted at approximately bi-weekly intervals from mid-April until early-June along the river reach between Four Corners and Bluff. Both active and passive sampling techniques were employed to collect larval fish. The primary 1998 collecting method was sampling low-velocity habitats with a fine mesh seine. Light-traps were also employed in 1998 but set only when appropriate aquatic mesohabitats were located adjacent to that evenings campsite. This former technique yielded more larval sucker in a single sample than were taken cumulatively in 1997 light-trap samples.

The primary objective of this study was to determine if razorback sucker reproduction had occurred in the San Juan River and the relative level of any such effort. Additional goals were to determine the spawning periodicity of catostomids between mid-April-early June and provide comparative analysis of the reproductive effort of San Juan River catostomids. This document reports results of the 1998 and 1999 larval razorback sucker sampling effort.

Study Area

The San Juan River is a major tributary of the Colorado River and drains 99,200 km^2 in Colorado, New Mexico, Utah, and Arizona (Figure 1). From its origins in the San Juan Mountains of southwestern Colorado at elevations exceeding 4,250 m, the river flows westward for about 570 km before confluencing with the Colorado River. The major perennial tributaries to the San Juan River are (from upstream to downstream) Navajo, Piedra, Los Pinos, Animas, La Plata, and Mancos rivers, and McElmo Creek. In addition there are numerous ephemeral arroyos and washes that contribute relatively little flow annually but input large sediment loads.

Navajo Reservoir, completed in 1963, impounds and isolates the upper 124 km of the San Juan River and regulates downstream discharge. The completion of Glen Canyon Dam in 1966 and subsequent filling of Lake Powell ultimately inundated the lower 87 km of the San Juan River by the early 1980s. The San Juan River is now a 359 km lotic system bounded by two reservoirs (Navajo Reservoir near its head and Lake Powell at its mouth).

The San Juan River is canyon-bound and restricted to a single channel between its confluence with Chinle Creek (ca. 20 km downstream of Bluff, Utah) and Lake Powell. The river is predominately multi-channeled upstream of Chinle Creek with the highest density of secondary channels occurring between Bluff and the Hogback Diversion (ca. 13 km upstream of Shiprock, New Mexico). There is a general downstream decline in channel stability in the section of river between Bluff and Shiprock. Below the confluence with the Animas River near Farmington, New Mexico, the channel is less stable and more subject to floods from it largest and unregulated tributary, the Animas River. Conversely, the regulated reach of river between Farmington, New Mexico and Navajo Dam is relatively stable with few secondary channels.

From Lake Powell to Navajo Dam, the mean gradient of the San Juan River is 1.67 m/km. Examined in 30 km increments, river gradient ranges from 1.24 to 2.41 m/km but locally (i.e., <30 km reaches) can be as high as 3.5 m/km. Between Shiprock and Bluff, San Juan River substrate is primarily sand mixed among some cobble. The proportion of sand is greatest in the downstream most reaches and declines along an upstream gradient. From Farmington to Navajo Dam, the San Juan River substrate is dominated by embedded cobble. Although less embedded, cobble is also the most common substrate between Shiprock and Farmington. Except in canyon-bound reaches, the river is bordered by nonnative salt cedar (*Tamarix chinensis*) and Russian olive (*Elaeagnus angustifolia*) and native cottonwood (*Populus fremontii*) and willow (*Salix* sp.). Nonnative woody plants dominated nearly all sites and resulted in heavily stabilized banks. Cottonwood and willow accounted for less than 15% of the riparian vegetation.

The characteristic annual hydrographic pattern in the San Juan River is typical of rivers in the American Southwest with large flows during spring snowmelt, followed by low summer, autumn, and winter base flows. Summer and early autumn base flows are frequently punctuated by convective storm-induced flow spikes. Prior to closure of Navajo Dam, about 73% of the total annual San Juan River drainage discharge (based on USGS Gauge # 09379500; Bluff, Utah) occurred during spring runoff (1 March through 31 July). Median daily peak discharge during spring runoff was 10,400 cfs (range = 3,810 to 33,800 cfs). Although flows resulting from summer and autumn storms contributed a comparatively small volume to total annual discharge, the magnitude of storm-induced flows exceeded the peak snowmelt discharge about 30% of the years, occasionally exceeding 40,000 cfs (mean daily discharge). Both the magnitude and frequency of these storm induced flow spikes are greater than those recorded in the Green or Colorado rivers.

Closure of Navajo Dam altered the annual discharge pattern of the San Juan River. The natural flow of the Animas River ameliorated some aspects of regulated discharge by augmenting spring discharge. Regulation resulted in reduced magnitude and increased duration of spring runoff in wet years and substantially reduced magnitude and duration of spring flow during dry

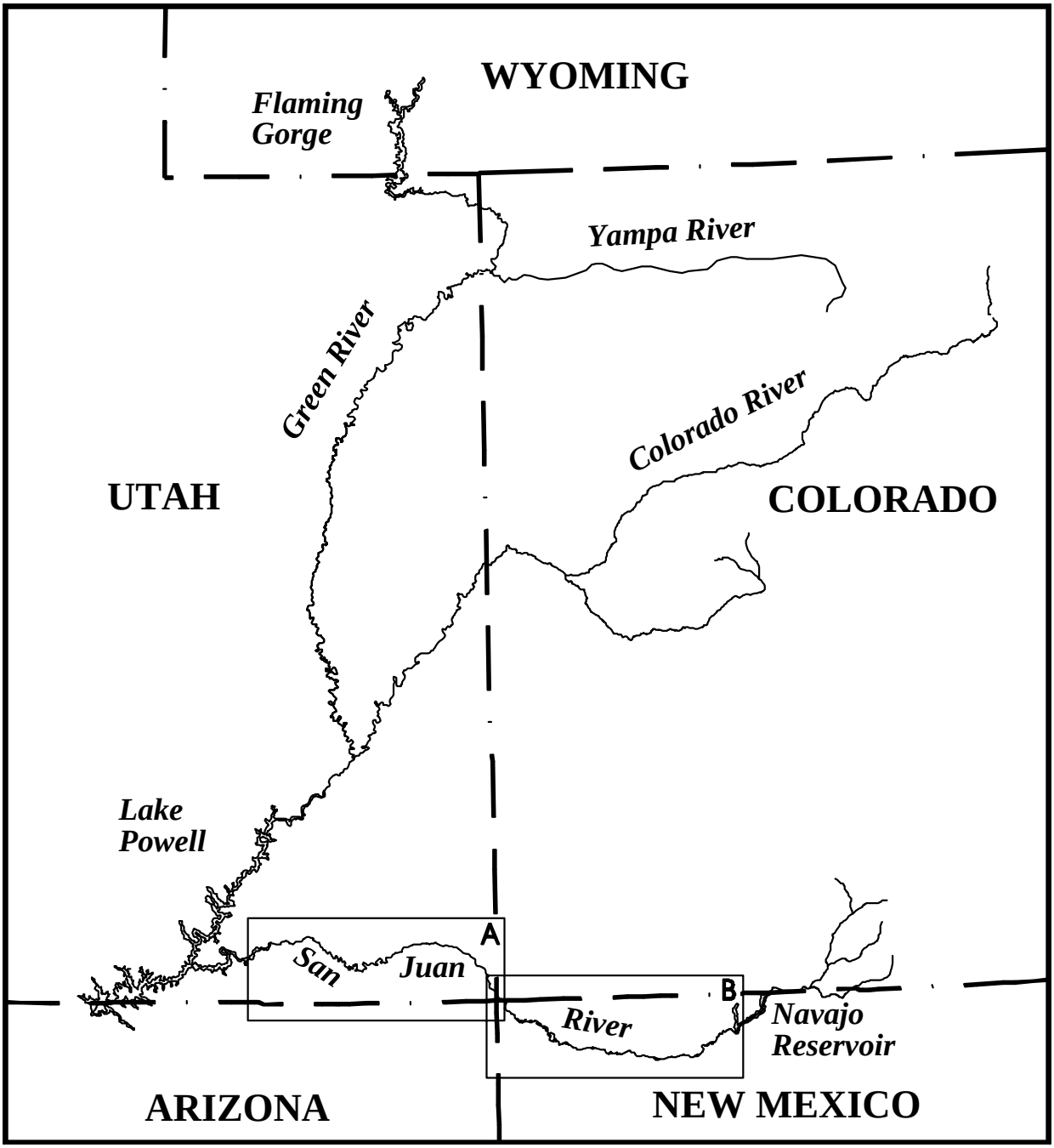


Figure 1. Location of the San Juan River within the Upper Colorado River Basin.

years. Overall, flow regulation by operation of Navajo Dam has resulted in post-dam peak spring discharge averaging about 54% of pre-dam values. Conversely, post-dam base flow increased markedly over pre-dam base flows.

Since 1992, Navajo Dam has been operated to mimic a Anatural@ San Juan River hydrograph with the volume of release during spring linked to the amount of precipitation recorded during the preceding winter. Thus in years with high spring snowmelt, reservoir releases were Alarge@ and Asmall@ in low runoff years. Base flows since 1992 were typically greater than during pre-dam years but less than those between 1964-1991.

The primary study area for most investigations conducted under the auspices of the San Juan River Seven Year Research Program, including that reported herein, were accomplished in the mainstem San Juan River and its immediate vicinity between Navajo Dam and Lake Powell. There is considerable human activity within the floodplain of the San Juan River between Shiprock and Navajo Dam. Irrigated agriculture is practiced throughout this portion of the San Juan River Valley and adjacent uplands. Much of the river valley not devoted to agriculture (crop production and grazing) consists of small communities (e.g., Blanco and Kirtland) and several larger towns (e.g., Bloomfield and Farmington).

The Animas River Valley is similarly developed. Small portions of the river valley and uplands from Shiprock to Bluff are farmed with dispersed livestock grazing as the primary land use. In the vicinity of Montezuma Creek and Aneth, petroleum extraction occurs in the floodplain and adjacent uplands. There are few human-caused modifications of the system from Bluff to Lake Powell.

A multivariate analysis of a suite of geomorphic features of the San Juan drainage was performed to segregate the river into distinct geomorphic reaches, enhance comparison between studies, and to provide a common reference for all research. This effort (Bliesner and Lamarra, 1999) resulted in the identification of eight reaches of the San Juan River between Lake Powell and Navajo Dam. A brief characterization of each reach (from downstream to upstream) follows:

Reach 1 (RM 0 to 16, Lake Powell confluence to near Slickhorn Canyon) has been greatly influenced by fluctuating reservoir levels of Lake Powell and its backwater effect. Fine sediment (sand and silt) has been deposited to a depth of about 12 m in the lowest end of this reach since the reservoir first filled in 1980. This deposition of suspended sediment into the delta-like environment of the river/reservoir transition makes it the lowest-gradient reach in the river. This portion of the river is canyon bound with an active sand bottom. Although an abundance of low-velocity habitat is present at certain flows, it is highly ephemeral, being influenced by both river flow and the elevation of Lake Powell.

Reach 2 (RM 17 to 67, near Slickhorn Canyon to confluence with Chinle Creek) is also canyon bound but is upstream of the influence of Lake Powell. The gradient in this reach is greater than in either adjacent reach and the fourth highest in the system. The channel is primarily bedrock confined and influenced by debris fans at ephemeral tributary mouths. Riffle-type habitat dominates, and the only major rapids in the San Juan River occur in this reach. Backwater abundance is low in this reach, usually occurring in association with debris fans.

Reach 3 (RM 68 to 105, Chinle Creek to Aneth, Utah) is characterized by higher sinuosity and lower gradient (second lowest) than the other reaches, a broad floodplain, multiple channels, high island count, and high percentage of sand substrate. While this reach has the second greatest density of backwater habitats after peak spring runoff, it is extremely vulnerable to change during summer and autumn storm events. After these storm events, this reach may have the second lowest density of backwaters of the eight reaches. The active channel distributes debris piles throughout the reach following spring runoff, leading to the nickname ADebris Field@.

Reach 4 (RM 107 to 130, Aneth, Utah, to below Athe Mixer@) is a transitional zone between the upper cobble substrate-dominated reaches and the lower sand substrate-dominated reaches. Sinuosity is moderate compared with other reaches, as is gradient. Island area is higher than in Reach 3 but lower than in Reach 5, and the valley is narrower than in either adjacent reach. Backwater habitats are low overall in this reach (third lowest among reaches) and there is little clean cobble.

Reach 5 (RM 131 to 154, the Mixer to just below Hogback Diversion) is predominantly multi-channeled with the largest total wetted area and greatest secondary channel area of any of the reaches. Secondary channels in this section tend to be longer and more stable (but fewer) than in Reach 3. Riparian vegetation is more dense in this reach than in lower reaches but less dense than in upper reaches. Cobble and gravel are more common in channel banks than sand, and clean cobble areas are more abundant than in lower reaches. This is the lowermost reach containing a diversion dam (Cudei). Backwaters and spawning bars in this reach are much less subject to perturbation during summer and fall storm events than are the lower reaches.

Reach 6 (RM 155 to 180, below Hogback Diversion to confluence with the Animas River) is predominately a single channel, with 50% fewer secondary channels than Reaches 3, 4, or 5. Cobble and gravel are the dominant substrata with cobble bars containing clean interstitial spaces being most abundant in this reach. There are four diversion dams that may impede fish passage in this reach. Backwater habitat abundance is low in this reach, with only Reach 2 containing fewer of these habitats. The channel has been altered by dike construction in several areas to control lateral channel movement and over-bank flow.

Reach 7 (RM 181 to 213, Animas River confluence to between Blanco and Archuleta, New Mexico) is similar to Reach 6 in terms of channel morphology. The river channel is very stable, consisting primarily of embedded cobble substrate as a result of controlled releases from Navajo Dam. In addition, much of the river bank has been stabilized and/or diked to control lateral movement of the channel and over-bank flow. Water temperature is influenced by the hypolimnetic release from Navajo Dam and is colder during the summer and warmer in the winter than that of the river below the Animas confluence.

Reach 8 (RM 213 to 224, between Blanco and Archuleta and Navajo Dam) is the most directly influenced by Navajo Dam, which is situated at its uppermost end (RM 224). This reach is primarily a single channel, with only four to eight secondary channels, depending on the flow. Cobble is the dominant substrate type, and because lateral channel movement is less confined in this reach, some loose, clean cobble sources are available from channel banks. In the upper end of the reach, just below Navajo Dam, the channel has been heavily modified by excavation of material used in dam construction. In addition, the upper 10 km of this reach above Gobernador Canyon are essentially sediment free, resulting in the clearest water of any reach. Because of Navajo Dam, this area experiences much colder summer and warmer winter water temperatures. These cool, clear water conditions have allowed development of an intensively managed blue-ribbon trout fishery to the exclusion of native species in the uppermost portion of the reach.

The sampling areas in 1998 were reaches 3 and 4 in the San Juan River. The first sampling trip was from Four Corners to Mexican Hat, Utah (Figure 2). Trips two and three (in 1998) also departed from Four Corners but terminated at Bluff, Utah. Starting with trip four in 1998, the departure point was moved upstream from Four Corners to a location about 4.9 miles upstream of the mouth of the Mancos River (RM 116) while the takeout point remained at Bluff, Utah (RM 76). The 1998 sampling effort for razorback sucker larvae in the San Juan River occurred between 17 April and 6 June 1998 over the course of six separate sampling trips. A seventh sampling effort was planned for 1998 but had to be canceled because of the presence of armed and dangerous fugitives and an intensive manhunt in the study area.

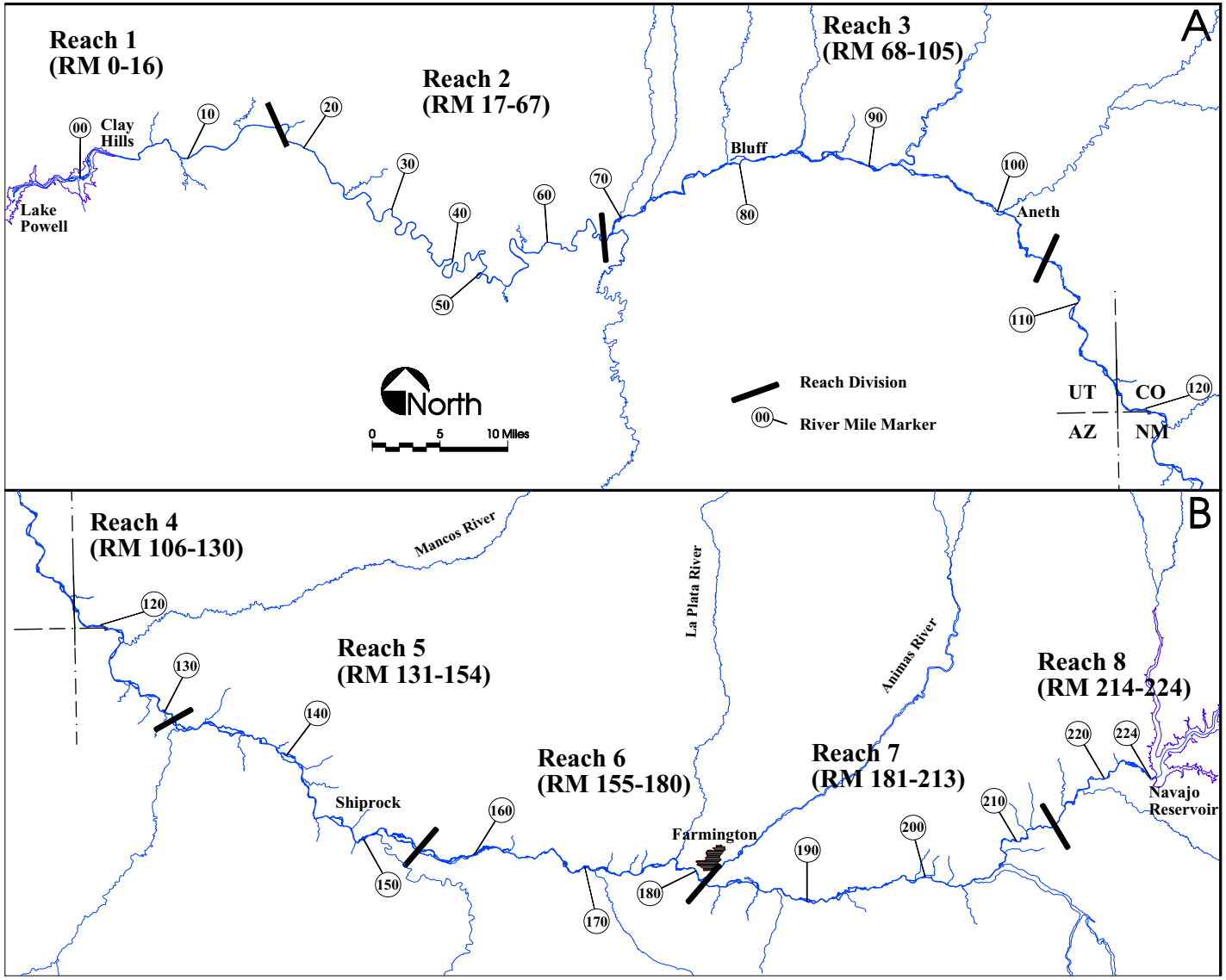


Figure 2. Map of the San Juan River study area.

In 1999, the study area was expanded downstream to Clay Hills Crossing, Utah (RM 3) thereby encompassing reaches 1 through 4. The upstream-most sampling area remained at RM 127.5 during 1999. There were seven razorback sucker larval fish collection efforts between 5 April and 14 June 1999. Four of the sampling efforts were between RM 127.5 and Bluff and three were in the lower reach. Of the three lower reach sampling efforts, one was between Bluff and Mexican Hat, and two were between Mexican Hat and Clay Hills. For presentation purposes, the 1999 data were separated into upper and lower reaches with the former including collections between RM 127.5 and Bluff and the latter containing collections from Bluff downstream to Clay Hills Crossing.

Methods

Access to the river and sampling localities was gained through the use a 16' inflatable raft that transported both personnel and collecting gear. There was not a predetermined number of samples per river mile or geomorphic reach for this study. Instead, an effort was made to collect in as many suitable larval fish habitats as possible within the river reach being sampled. Previous San Juan River investigations have clearly demonstrated that larval fish most frequently occur and are most abundant in low velocity habitats such as isolated pools, backwaters, and secondary channels.

Sampling efforts for larval fish concentrated on low velocity habitats using small mesh seines (1 m x 1 m x 0.8 mm) and light-traps. Mesohabitat type, length, maximum depth, and substrate were recorded for each sample. For seine samples, the length of each seine haul was determined in addition to the number of seine hauls per site. The aforementioned habitat conditions were recorded at light-trap sampling sites in addition to the time of placement and retrieval of the light-trap.

All retained specimens were placed in plastic bags containing a solution of 5% buffered formalin and a tag inscribed with unique alphanumeric code that was also recorded on the field data sheet. Samples were returned to the laboratory where they were sorted, specimens identified to species, enumerated, measured (minimum and maximum size [mm SL] for each species at each site), transferred to 70% ethyl alcohol, and catalogued in the Division of Fishes of the Museum of Southwestern Biology (MSB) at the University of New Mexico (UNM). Scientific and common names of fishes that are used in this report follow Robins et al. (1991) while six letter codes for species are derived from the first three letters of the genus followed by the first three letters of the species (Table 1). Common names, arranged in phylogenetic order, are presented in tables in this report.

Specimens whose species-specific identity was questionable were forwarded to Darrel E. Snyder (Larval Fish Laboratory, Colorado State University) for review. In addition, all specimens identified as razorback sucker (by MSB personnel) were sent to Darrel E. Snyder for verification. An electronic copy of the 1998 and 1999 fish collection data were submitted to Keller-Bliesner Engineering for inclusion in the San Juan River database.

This study was annually initiated prior to spring runoff and completed a few weeks before the cessation of spring runoff. Daily mean discharge during the study period was determined from U.S. Geological Survey Gauge (# 09368000) at Shiprock, New Mexico (Figures 3 and 4).

Table 1. Scientific and common names and species codes of fish collected from the San Juan River during 1998 and 1999.

Scientific Name	Common Name	Code
Order Cypriniformes		
Family Cyprinidae	carps and minnows	
Cyprinella lutrensis	red shiner	(CYPLUT)
Cyprinus carpio	common carp	(CYPCAR)
Gila robusta	roundtail chub	(GILROB)
Pimephales promelas	fathead minnow	(PIMRPO)
Ptychocheilus lucius	Colorado pikeminnow	(PTYLUC)
Rhinichthys osculus	speckled dace	(RHIOSC)
Family Catostomidae	suckers	
Catostomus commersoni	white sucker	(CATCOM)
Catostomus (Pantosteus) discobolus	bluehead sucker	(CATDIS)
Catostomus latipinnis	flannelmouth sucker	(CATLAT)
Xyrauchen texanus	razorback sucker	(XYRTEX)
Order Siluriformes		
Family Ictaluridae	bullhead catfishes	
Ictalurus punctatus	channel catfish	(ICTPUN)
Order Atheriniformes		
Family Cyprinodontidae	killifishes	
Fundulus zebrinus	plains killifish	(FUNZEB)
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish	(GAMAFF)
Order Perciformes		
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(LEPCYA)

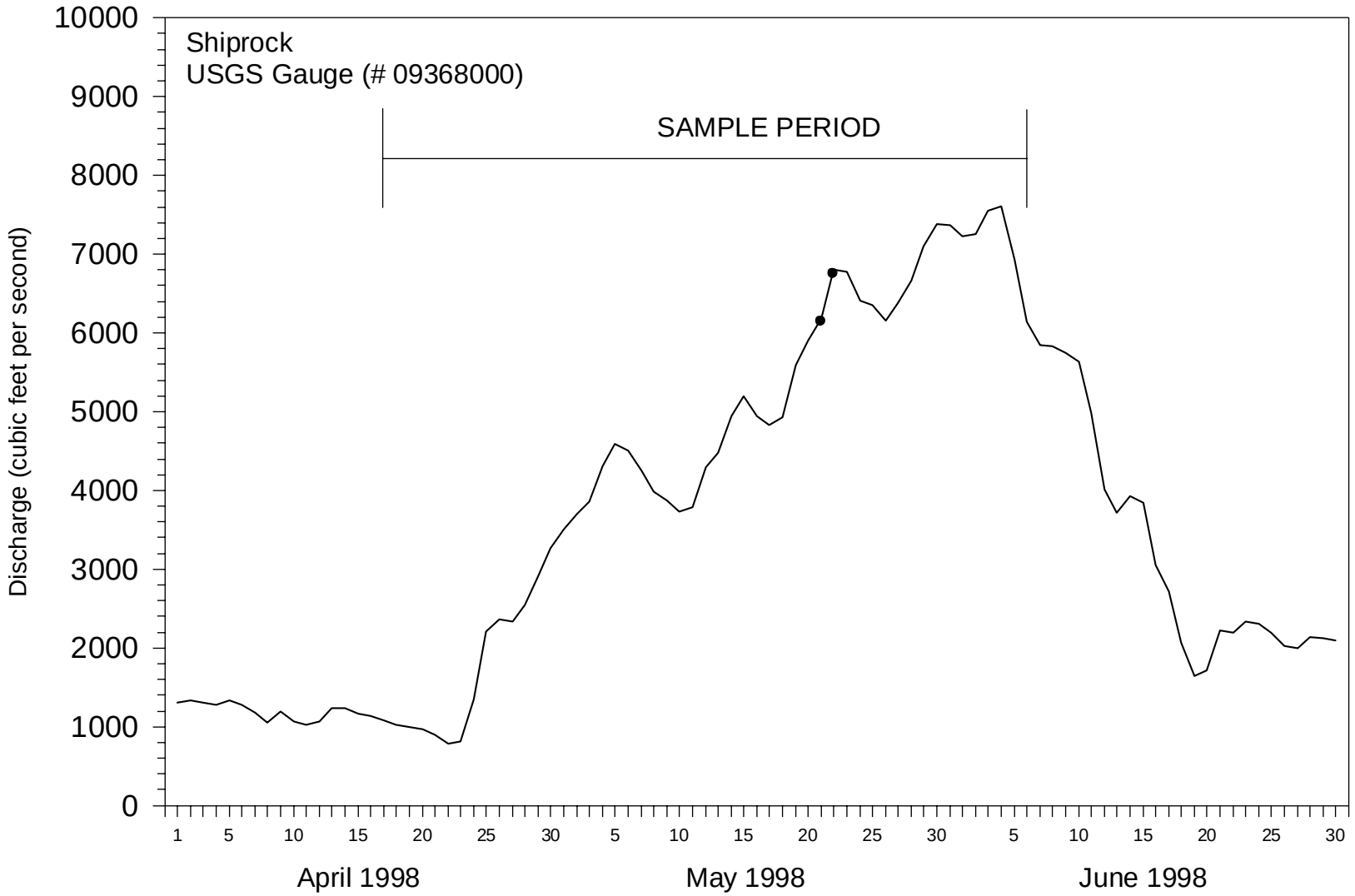


Figure 3. Hydrograph of the San Juan River at Shiprock, New Mexico during the 1998 sample period.

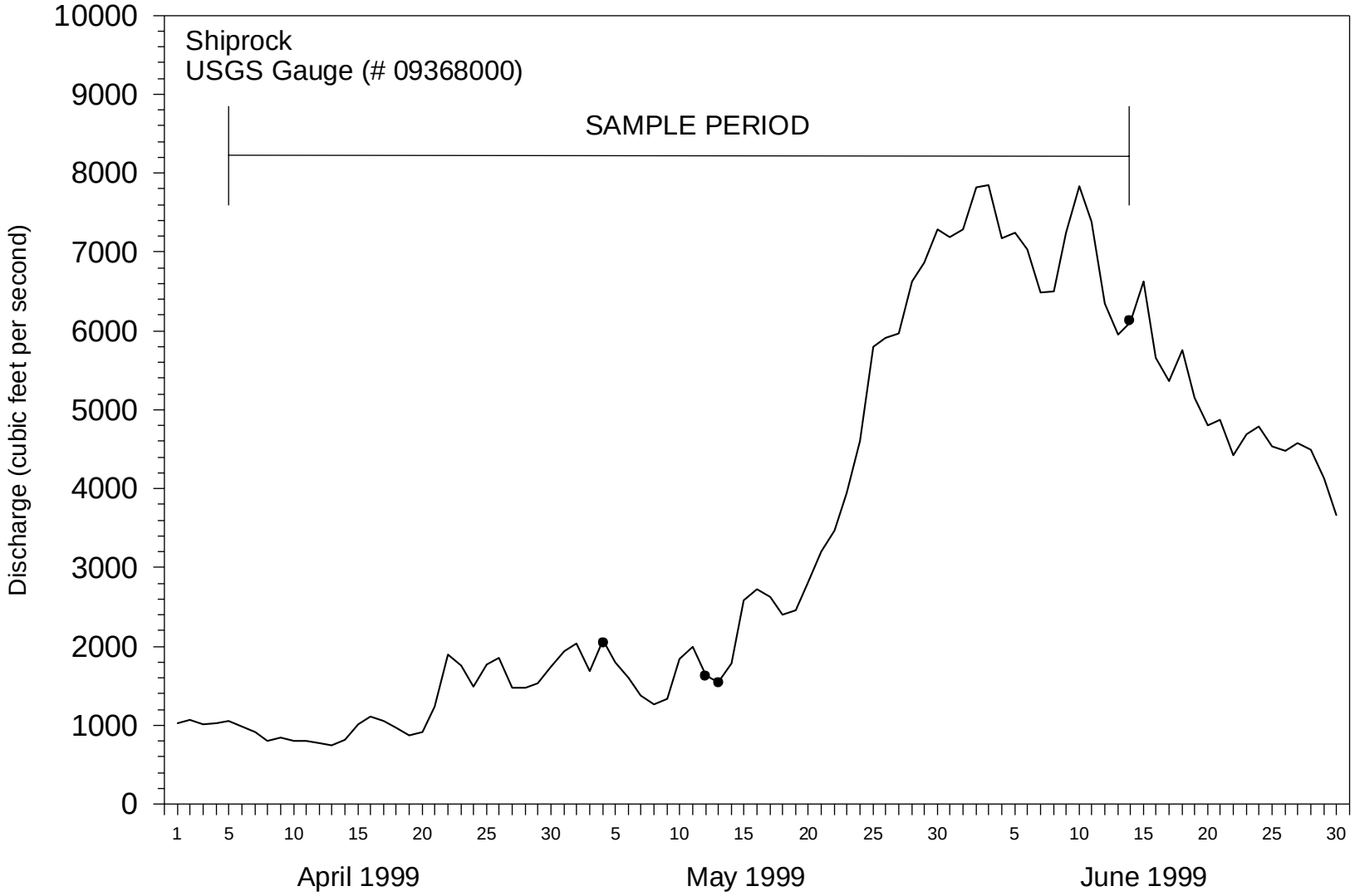


Figure 4. Hydrograph of the San Juan River at Shiprock, New Mexico during the 1999 sampling period.

Results

1998 Survey

There were 182 samples taken at over 114 sites (Figure 5) during the 1998 razorback sucker larval fish project yielding 13,608 fish representing 14 species (Table 2). All except one of the 122 seine samples made during the 17 April 1998 to 6 June 1998 duration of the study produced fish. Included in this catch were razorback sucker (n=2), roundtail chub (n=18), and Colorado pikeminnow (n=4). The 1998 catch was numerically dominated by a native sucker and nonnative cyprinid that collectively accounted for about 96% of the total catch. Over three times as many flannelmouth sucker, the most abundant fish, was taken as red shiner, the second most abundant taxon. The former species accounted for over 72% (n=9,810) of the total catch by number while red shiner was 23.88% (n=3,249) of the catch. None of the other 12 other species taken during 1998 accounted for more than 1.6% of the 1998 catch.

The 61 light-trap samples from 1998 sampling yielded three species and 721 specimens (Table 3). Almost one-third (n=20) of the 61 light-trap samples failed to yield fish. Flannelmouth sucker was the most abundant taxon taken using this sampling methodology comprising almost 90% of the catch and occurring in 29.5% of the samples. About 82% (n=590) of the light-trap catch was taken during the final sampling effort (3-6 June 1998) in which 17 light-trap collections were made. Over 100 flannelmouth sucker specimens were present in four of those 17 collections. Conversely, there were never more than 16 red shiner or bluehead sucker present in light-traps sample.

The first 1998 sampling effort yielded the fewest fish (n=123) of this survey (Table 4). Only four species were collected in the 29 samples from 17 to 20 April 1998 of which 87% were red shiner (Figure 6). The other three taxa were each represented by eight or fewer individuals. No larval sucker were collected during the first 1998 sampling effort. There was a marked increase in the number of species and fish collected during the second sampling trip, as compared with the first. The 1,526 individuals taken in the 36 samples from 29 April to 1 May 1998 were represented by 10 species, two of which were native suckers (Table 5). Single juvenile specimens of roundtail chub and Colorado pikeminnow were present in samples from the second survey. Red shiner numerically dominated the second sampling effort comprising 55.18% of the catch while flannelmouth sucker was the second most abundant taxon (n=567). None of the remaining eight species accounted for more than 4.4% of the total catch.

The third sampling effort yielded 10 species but, in contrast to the second trip, flannelmouth sucker was the most abundant species (Table 6). Red shiner was the second most abundant fish species during the third collecting effort but occurred in more samples (n=14) than flannelmouth sucker. The number of larval bluehead sucker taken from 7 to 9 May 1998 remained low (n=6) as this taxon accounted for <1% of the sucker catch. As during the second trip, a single juvenile Colorado pikeminnow was collected during this effort.

There was little difference in the total number of fish collected during the second, third, and fourth sampling trips (1,526, 1,350, 1,573). From 12 to 14 May 1998, flannelmouth sucker was again the most common fish while red shiner was the second most abundant species taken during sampling efforts (Table 7). Likewise, juvenile roundtail chub (n=3) and Colorado pikeminnow (n=2) were again present in collections made during the fourth sampling effort. Flannelmouth sucker and red shiner accounted for almost 95% of the total fourth trip sample while none the remaining seven species comprised >2.25% of the catch.

The fifth sampling effort yielded the greatest number of fish (n=6,373) during the 1998 sampling effort accounting for almost 47% of that year's catch. Flannelmouth sucker remained the most abundant species in the samples (Table 8) comprising about 84% of the total catch with red

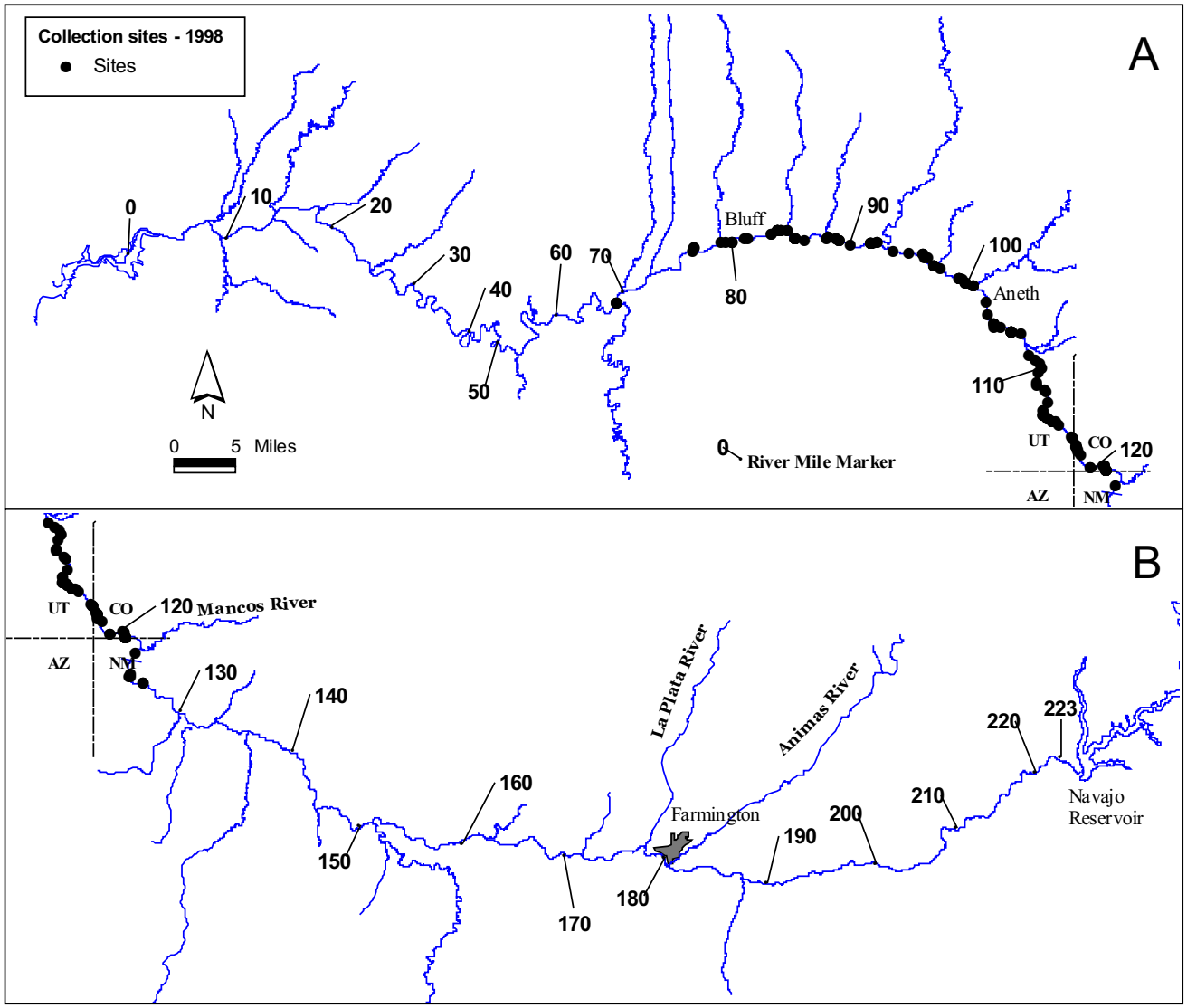


Figure 5. Distribution map of localities sampled during 1998.

Table 2. Summary of 1998 San Juan River larval razorback sucker project fish collections.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	3,249	23.88	107	58.47
common carp	I	2	0.01	1	0.55
roundtail chub	N	18	0.13	12	6.56
fathead minnow	I	210	1.54	54	29.51
Colorado pikeminnow	N	4	0.03	4	2.19
speckled dace	N	139	1.02	50	27.32
SUCKERS					
white sucker	I	1	0.01	1	0.55
flannelmouth sucker	N	9,810	72.09	103	56.28
bluehead sucker	N	147	1.08	36	19.67
razorback sucker	N	2	0.01	2	1.09
BULLHEAD CATFISHES					
channel catfish	I	2	0.01	2	1.09
KILLIFISHES					
plains killifish	I	4	0.03	4	2.19
LIVEBEARERS					
western mosquitofish	I	17	0.12	12	6.56
SUNFISHES					
green sunfish	I	3	0.02	3	1.64
TOTAL		13,608			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=183 samples.

Table 3. Summary of 1998 San Juan River larval razorback sucker project light-trap collections.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	54	7.49	10	16.39
common carp	I	–	–	–	–
roundtail chub	N	–	–	–	–
fathead minnow	I	–	–	–	–
Colorado pikeminnow	N	–	–	–	–
speckled dace	N	–	–	–	–
SUCKERS					
white sucker	I	–	–	–	–
flannelmouth sucker	N	645	89.46	18	29.51
bluehead sucker	N	22	3.05	7	11.48
razorback sucker	N	–	–	–	–
BULLHEAD CATFISHES					
channel catfish	I	–	–	–	–
KILLIFISHES					
plains killifish	I	–	–	–	–
LIVEBEARERS					
western mosquitofish	I	–	–	–	–
SUNFISHES					
green sunfish	I	–	–	–	–
TOTAL		721			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=61 samples.

Table 4. Summary of the 1st 1998 San Juan River larval razorback sucker project fish collection (17-20 April 1998; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	107	86.99	9	31.033
common carp	I	–	–	–	–
roundtail chub	N	–	–	–	–
fathead minnow	I	7	5.69	1	3.45
Colorado pikeminnow	N	–	–	–	–
speckled dace	N	8	6.50	4	13.79
SUCKERS					
white sucker	I	–	–	–	–
flannelmouth sucker	N	–	–	–	–
bluehead sucker	N	–	–	–	–
razorback sucker	N	–	–	–	–
BULLHEAD CATFISHES					
channel catfish	I	–	–	–	–
KILLIFISHES					
plains killifish	I	–	–	–	–
LIVEBEARERS					
western mosquitofish	I	–	–	–	–
SUNFISHES					
green sunfish	I	1	0.81	1	3.45
TOTAL		123			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=29 samples.

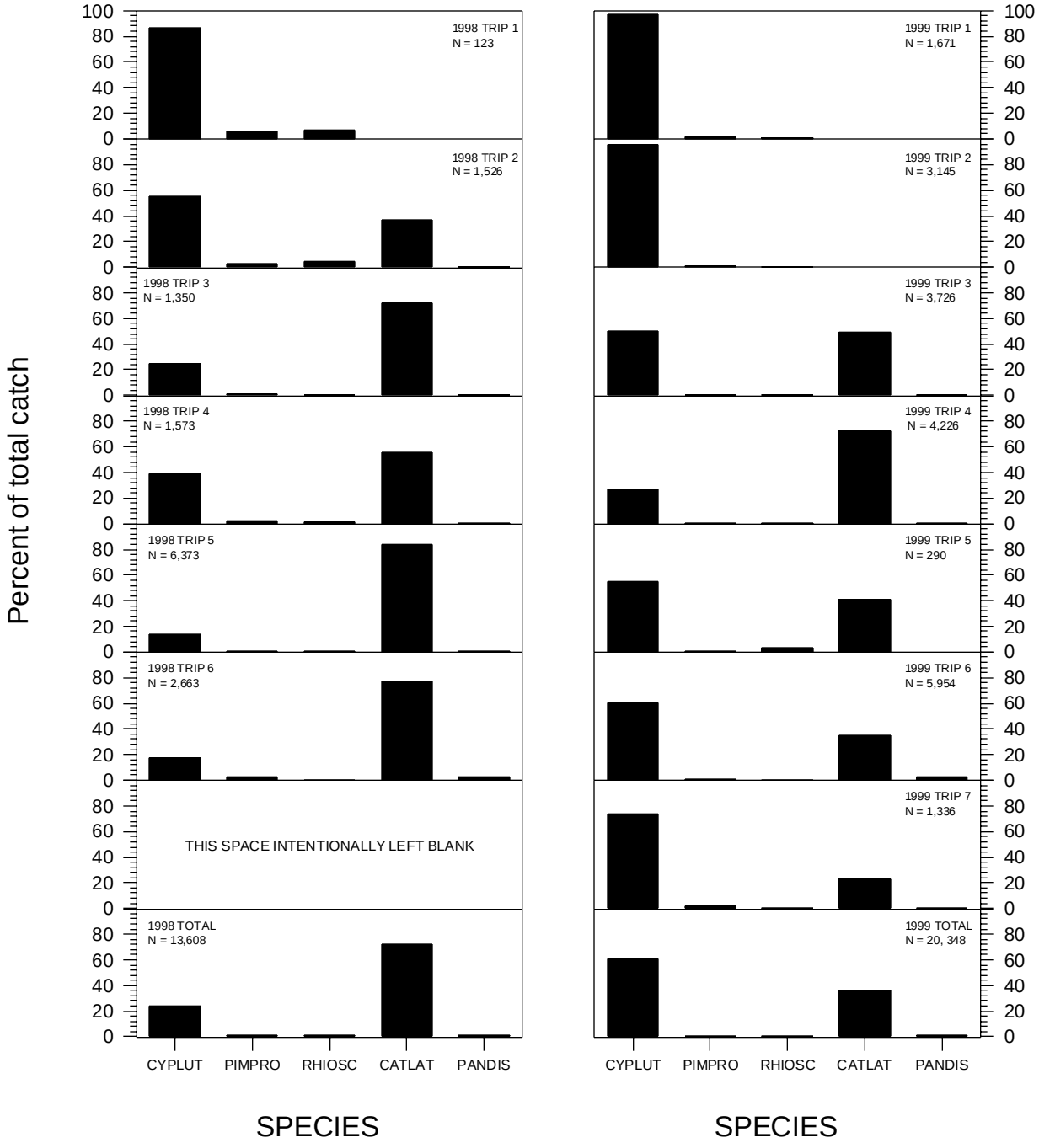


Figure 6. Ichthyofaunal composition of 1998 and 1999 sampling efforts by trip.

Table 5. Summary of 2nd 1998 San Juan River larval razorback sucker project fish collection (15-29 April - 1 May 1998; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	842	55.18	19	52.78
common carp	I	2	0.13	1	2.78
roundtail chub	N	1	0.07	1	2.78
fathead minnow	I	41	2.69	11	30.56
Colorado pikeminnow	N	1	0.07	1	2.78
speckled dace	N	67	4.39	18	50.00
SUCKERS					
white sucker	I	—	—	—	—
flannelmouth sucker	N	567	37.16	12	33.33
bluehead sucker	N	2	0.13	2	5.56
razorback sucker	N	—	—	—	—
BULLHEAD CATFISHES					
channel catfish	I	—	—	—	—
KILLIFISHES					
plains killifish	I	2	0.13	2	5.56
LIVEBEARERS					
western mosquitofish	I	1	0.07	1	2.78
SUNFISHES					
green sunfish	I	—	—	—	—
TOTAL		1,526			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=36 samples.

Table 6. Summary of 3rd 1998 San Juan River larval razorback sucker project fish collection (7-9 May 1998; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	339	25.11	14	73.68
common carp	I	—	—	—	—
roundtail chub	N	—	—	—	—
fathead minnow	I	18	1.33	6	31.58
Colorado pikeminnow	N	1	0.07	1	5.26
speckled dace	N	5	0.37	3	15.79
SUCKERS					
white sucker	I	—	—	—	—
flannelmouth sucker	N	976	72.30	11	57.89
bluehead sucker	N	6	0.44	3	15.79
razorback sucker	N	—	—	—	—
BULLHEAD CATFISHES					
channel catfish	I	1	0.07	1	5.26
KILLIFISHES					
plains killifish	I	1	0.07	1	5.26
LIVEBEARERS					
western mosquitofish	I	2	0.15	2	10.53
SUNFISHES					
green sunfish	I	1	0.07	1	5.26
TOTAL		1,350			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=19 samples.

Table 7. Summary of 4th 1998 San Juan River larval razorback sucker project fish collection (12-14 May 1998; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	615	39.10	24	77.42
common carp	I	—	—	—	—
roundtail chub	N	3	0.19	2	6.45
fathead minnow	I	35	2.23	12	38.71
Colorado pikeminnow	N	2	0.13	2	6.45
speckled dace	N	27	1.72	8	25.81
SUCKERS					
white sucker	I	—	—	—	—
flannelmouth sucker	N	874	55.56	24	77.42
bluehead sucker	N	6	0.38	4	12.90
razorback sucker	N	—	—	—	—
BULLHEAD CATFISHES					
channel catfish	I	—	—	—	—
KILLIFISHES					
plains killifish	I	—	—	—	—
LIVEBEARERS					
western mosquitofish	I	10	0.64	5	16.13
SUNFISHES					
green sunfish	I	1	0.06	1	3.23
TOTAL		1,573			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=31 samples.

Table 8. Summary of 5th 1998 San Juan River larval razorback sucker project fish collection (19-22 May 1998; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	880	13.81	25	75.76
common carp	I	–	–	–	–
roundtail chub	N	4	0.06	3	9.09
fathead minnow	I	50	0.78	14	42.42
Colorado pikeminnow	N	–	–	–	–
speckled dace	N	23	0.36	10	30.30
SUCKERS					
white sucker	I	1	0.02	1	3.03
flannelmouth sucker	N	5,347	83.90	31	93.94
bluehead sucker	N	63	0.99	9	27.27
razorback sucker	N	2	0.03	2	6.06
BULLHEAD CATFISHES					
channel catfish	I	–	–	–	–
KILLIFISHES					
plains killifish	I	–	–	–	–
LIVEBEARERS					
western mosquitofish	I	3	0.05	3	9.09
SUNFISHES					
green sunfish	I	–	–	–	–
TOTAL		6,373			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=33 samples.

shiner being the second most common species. The number of larval bluehead sucker taken during this trip had increased by over 10-fold compared with the four previous collections. Two larval razorback sucker were caught in two separate localities during the fifth 1998 sampling effort. Other noteworthy catches during this trip were juvenile roundtail chub and the only 1998 specimen of white sucker taken during this project.

The final 1998 sampling trip produced the second largest number of fish collected (n=2,663) accounting for about 20% of the total catch (Table 9). Over 76% of the catch were larval and juvenile flannelmouth sucker while 17.5% were red shiner. This sample effort yielded both the largest number of roundtail chub (n=10) and bluehead sucker (n=70) taken during 1998. As in all previous sample efforts, no species other than flannelmouth sucker and red shiner, accounted for more than 6.5% of the total catch.

Razorback sucker - 1998

Two razorback sucker were collected at two separate localities during the 1998 larval razorback sucker survey (Figure 7). Both individuals were taken during the fifth 1998 sampling effort which occurred from 19 to 22 May 1998 (Figure 8). The first larval razorback sucker was collected with a seine between 16:30 - 16:50 hr on 21 May 1998 in a 22°C backwater located about 12.2 river miles downstream of Aneth, Utah (RM 88.8; 37° 16' 21.5" N, 109° 23' 35.8" W). The backwater was about 180 m long, 2 m wide, had depth of 29 cm, a substrate comprised of mud over cobble, and exhibited virtually no flow (WHB98-143). The 4.2 m long seine haul made at head of the backwater yielded over 3,800 larval or early juvenile fish of which 3,672 were flannelmouth sucker and 23 were bluehead sucker. The larval razorback sucker was a 12.7 mm TL flexion mesolarvae (MSB 42207) distinguishable from larval bluehead sucker by its pigmentation pattern and developmental state at that length.

The second larval razorback sucker was collected in a large, murky backwater on 22 May 1998 between 11:07 - 11:29 hr about 3.8 river miles upstream of Bluff, UT (RM 80.2; 37° 16' 18.4" N, 109° 32' 37.8" W). This large backwater was about 8 m wide, over 50 m long, 27 cm deep, 19°C, and had a mud substrate (WHB98-147). Two seine hauls (total 11 m) were made near the head of the backwater producing 960 larval fish. Flannelmouth sucker was the most abundant species taken accounting for 78% (n=752) of the catch while red shiner (n=185; 19.3%) and bluehead sucker (n=14; 1.5%) were the second and third, respectively, most common fish at this site. This larval razorback sucker was a 12.1 mm TL flexion mesolarvae (MSB 42218) also distinguishable by from larval bluehead sucker by its pigmentation pattern and developmental state.

1999 Survey

The 173-1999 larval razorback sucker fish samples taken at over 75 separate localities between the confluence of the San Juan and Mancos rivers and Clay Hills, Utah (Figure 9) produced 20,348 specimens represented by 11 species (Table 10). Over 90% (n=130 of 144) of the seine samples resulted in the collection of fish. Included in the catch during the 5 April 1999 to 14 June 1999 duration of this study were five juvenile roundtail chub and seven larval razorback sucker. In contrast to the 1998 sampling effort, Colorado pikeminnow were absent from 1999 collections. Red shiner was the most abundant species in 1999 comprising 61.3% of the total catch and occurring in over 66% of the samples. Flannelmouth sucker was the second most common taxon accounting for 36.5% of the catch and occurring in 63% of the samples. Collectively these two species were 97.8% (n=19,901) of the 1999 larval razorback sucker project catch. Individually, none of the other nine species taken in 1999 even comprised 1% of the total catch.

Table 9. Summary of 6th 1998 San Juan River larval razorback sucker project fish collection (3-6 June 1998; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	466	17.50	16	45.71
common carp	I	—	—	—	—
roundtail chub	N	10	0.38	6	17.14
fathead minnow	I	59	2.22	10	28.57
Colorado pikeminnow	N	—	—	—	—
speckled dace	N	9	0.34	7	20.00
SUCKERS					
white sucker	I	—	—	—	—
flannelmouth sucker	N	2,046	76.83	25	71.43
bluehead sucker	N	70	2.63	18	51.43
razorback sucker	N	—	—	—	—
BULLHEAD CATFISHES					
channel catfish	I	1	0.04	1	2.86
KILLIFISHES					
plains killifish	I	1	0.04	1	2.86
LIVEBEARERS					
western mosquitofish	I	1	0.04	1	2.86
SUNFISHES					
green sunfish	I	—	—	—	—
TOTAL		2,663			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=35 samples.

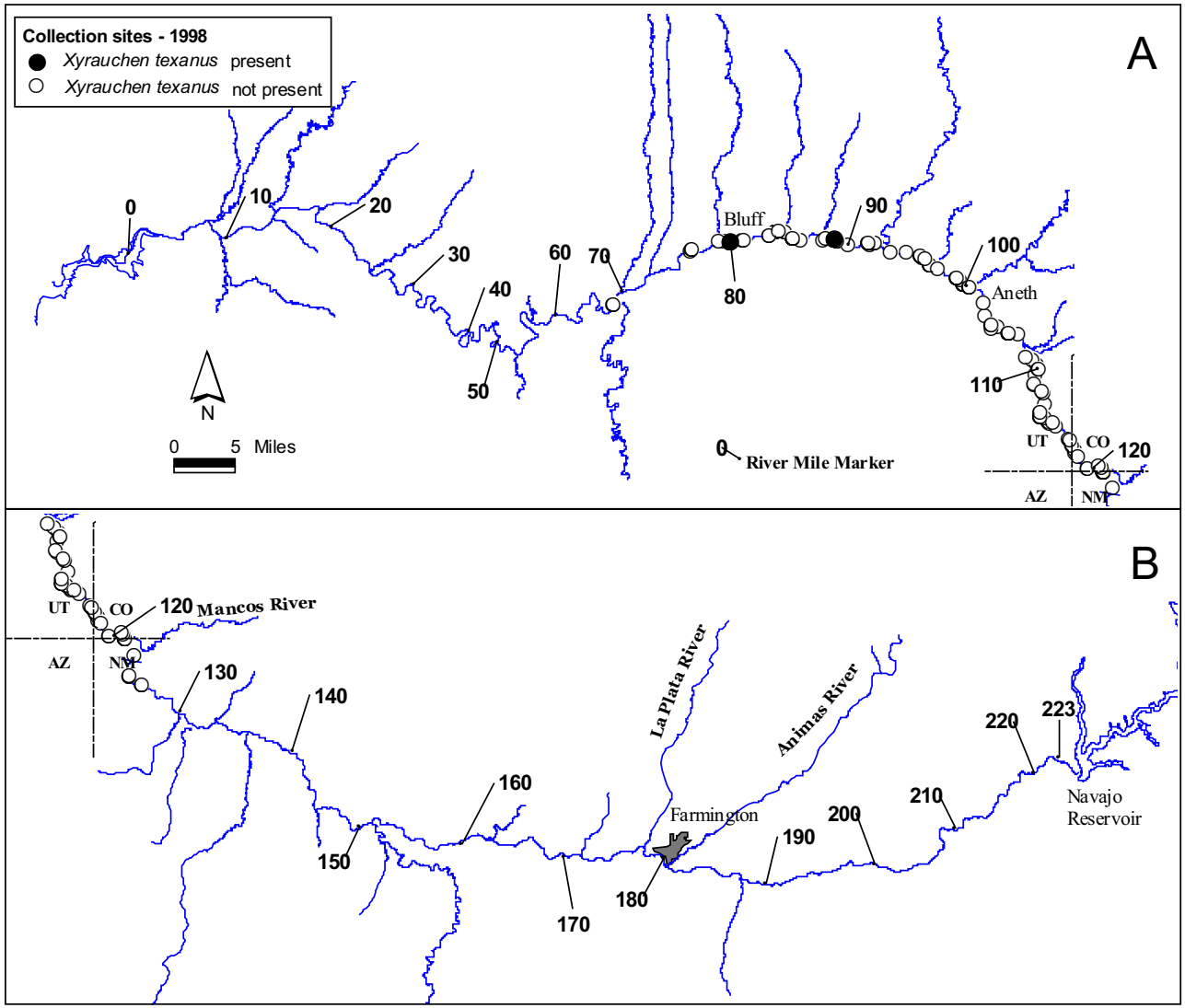
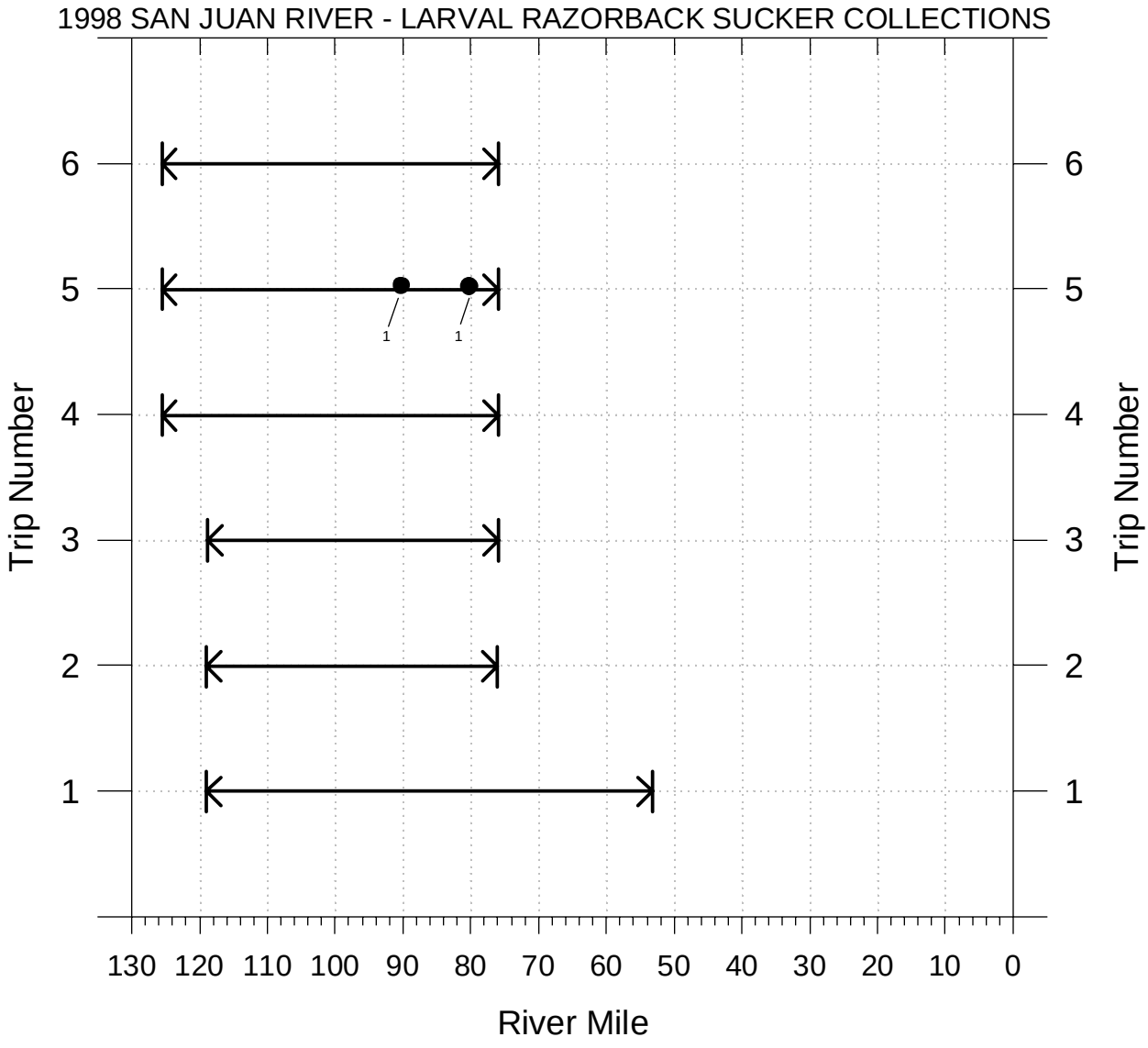


Figure 7. Distribution map of localities that yielded larval razorback sucker during 1998.



Trip Number	START DATE	END DATE
1	17 APR 98	20 APR 98
2	29 APR 98	01 MAY 98
3	07 MAY 98	09 MAY 98
4	12 MAY 98	14 MAY 98
5	19 MAY 98	22 MAY 98
6	03 JUN 98	06 JUN 98

Figure 8. Diagrammatic representation of 1998 sampling effort.

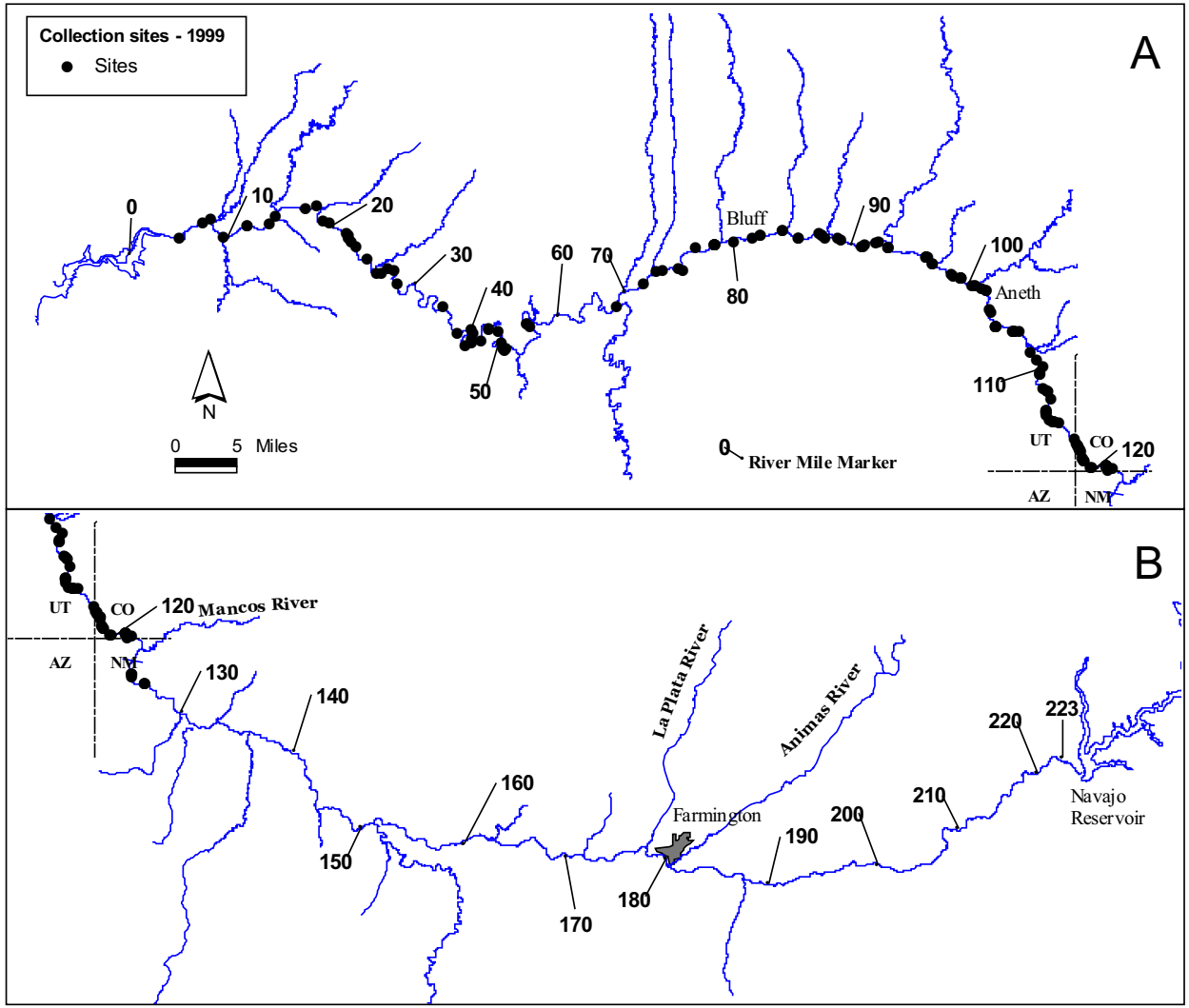


Figure 9. Distribution map of localities sampled during 1999.

Table 10. Summary of 1999 San Juan River larval razorback sucker project fish collections.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	12,469	61.28	115	66.47
common carp	I	5	0.02	5	2.89
roundtail chub	N	5	0.02	4	2.31
fathead minnow	I	163	0.80	46	26.59
speckled dace	N	60	0.29	27	15.61
SUCKERS					
flannelmouth sucker	N	7,432	36.52	109	63.01
bluehead sucker	N	197	0.97	36	20.81
razorback sucker	N	7	0.03	7	4.05
BULLHEAD CATFISHES					
channel catfish	I	4	0.02	4	2.31
KILLIFISHES					
plains killifish	I	3	0.01	3	1.73
LIVEBEARERS					
western mosquitofish	I	3	0.01	3	1.73
TOTAL		20,348			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=173 samples.

There were 29 light-traps samples in 1999, 25 (86%) of which resulted in the collection of larval fish. While only four species of fish were collected in light-traps, three of those four species were catostomids. Flannelmouth sucker was 98.8% of the light-trap catch followed by bluehead sucker, red shiner, and razorback sucker (Table 11). Only four of over 1,700 larval fish collected using this sampling methodology were nonnative (red shiner).

The majority (77%) of the total catch and sampling effort (73%) was from the upper reach of the study area (Table 12). The vast majority of those individuals were either red shiner (52.7%) or flannelmouth sucker (45.0%). All roundtail chub (n=5) and a little more than half of the razorback sucker (n=4) collected in 1999 were taken in the upper reach. Western mosquitofish was the only other species, beside roundtail chub, that was present in upper reach samples but absent from those in the lower reach. While red shiner comprised over 50% of the upper reach sample, this species accounted for about 90% of lower reach collections (Table 13). In addition, red shiner was almost ten-times more abundant than flannelmouth sucker in lower reach samples. Conversely, bluehead sucker, was seven times more abundant (based on percent of total catch) in upper than lower reach samples.

The first 1999 sampling trip was between Four Corners and Bluff in early April (5 to 7 April 1999) and yielded 1,671 fish represented by exclusively by cyprinid species (Table 14). Red shiner was the numerically dominant taxon during this first trip accounting for over 97% of the total catch. The absence of larval catostomids indicated that spawning by members of this family had not yet initiated in the San Juan River. The second 1999 sampling effort (15 to 18 April 1999) was in the reach between Mexican Hat and Clay Hills Crossing, Utah. The slightly more than twice the number of samples taken in the lower reach, as compared to the upper reach, resulted in almost twice as many fish in the lower portion of the study area. As had been observed 10 days earlier in the upper reach, red shiner numerically dominated the lower reach catch (99%) while larval catostomids were absence from the sample (Table 15).

The next sampling effort occurred in the upper reach from 2 to 5 May 1999 and resulted in the capture of numerous larval sucker (Table 16). Flannelmouth sucker comprised 49.2% of the third sample while red shiner were 50.0% of that sample. Juvenile roundtail chub (n=1), larval bluehead sucker (n=6) and larval razorback sucker (n=1) were taken for the first time in 1999 during this collection effort. The fourth sampling effort, also in the upper reach, occurred about one week after the conclusion of the previous trip. During the fourth sampling trip, flannelmouth sucker increased to over 72% of the catch but red shiner declined from 50% to 26.5% of the total catch (Table 17). Bluehead sucker (n=12) and razorback sucker (n=3) were again present in the samples however, roundtail chub was not collected.

During 1 and 2 June 1999, larval fish were sampled from the Bluff to Mexican Hat portion of the study area resulting in the collection of five species but only 290 specimens. Only nine samples were taken because few suitable larval fish habitats were present in this reach of the study area during that discharge (7,200 - 7,800 cfs). There was little difference in the ichthyofaunal composition of this reach of the river, as compared with either up or downstream segments, as red shiner and flannelmouth sucker comprised about 55% and 41% of the total catch, respectively, with most other taxa being represented by relatively few specimens (Table 18).

Red shiner and flannelmouth sucker continued to be the numerically dominant species during the 8 to 10 June 1999 upper reach sampling effort (sixth of seven 1999 trips). The 41 samples taken during this trip yielded the largest number of specimens (n=5,954) taken in 1999 (Table 19). Red shiner abundance increased to over 60% of the catch, as compared to 26.5% in mid-May, while flannelmouth sucker relative abundance declined from 72% to 35% during the same period. The sixth sampling effort produced 86.8% (n=171) of all larval bluehead sucker collected during 1999 portion of this study. Razorback sucker, which had been collected the on

Table 11. Summary of 1999 San Juan River larval razorback sucker project light-trap collections.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	4	0.23	3	10.34
common carp	I	–	–	–	–
roundtail chub	N	–	–	–	–
fathead minnow	I	–	–	–	–
speckled dace	N	–	–	–	–
SUCKERS					
flannelmouth sucker	N	1,717	98.79	25	86.21
bluehead sucker	N	15	0.86	2	24.14
razorback sucker	N	2	0.12	2	6.90
BULLHEAD CATFISHES					
channel catfish	I	–	–	–	–
KILLIFISHES					
plains killifish	I	–	–	–	–
LIVEBEARERS					
western mosquitofish	I	–	–	–	–
TOTAL		1,738			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=29 samples.

Table 12. Summary of 1999 San Juan River larval razorback sucker project fish collections in the upper portion of the study area (between Shiprock, New Mexico and Bluff, Utah).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	8,210	52.71	80	63.49
common carp	I	2	0.01	2	1.59
roundtail chub	N	5	0.03	4	3.17
fathead minnow	I	117	0.75	28	22.22
speckled dace	N	40	0.26	18	14.29
SUCKERS					
flannelmouth sucker	N	7,003	44.96	92	73.02
bluehead sucker	N	189	1.21	33	26.19
razorback sucker	N	4	0.03	4	3.17
BULLHEAD CATFISHES					
channel catfish	I	2	0.01	2	1.59
KILLIFISHES					
plains killifish	I	2	0.01	2	1.59
LIVEBEARERS					
western mosquitofish	I	3	0.02	3	2.38
TOTAL		15,577			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=126 samples.

Table 13. Summary of 1999 San Juan River larval razorback sucker project fish collections in the lower portion of the study area (between Bluff and Clay Hills Crossing, Utah).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	4,259	89.27	35	74.47
common carp	I	3	0.06	3	6.38
roundtail chub	N	—	—	—	—
fathead minnow	I	46	0.96	18	38.30
speckled dace	N	20	0.42	9	19.15
SUCKERS					
flannelmouth sucker	N	429	8.99	17	36.17
bluehead sucker	N	8	0.17	3	6.38
razorback sucker	N	3	0.06	3	6.38
BULLHEAD CATFISHES					
channel catfish	I	2	0.04	2	4.26
KILLIFISHES					
plains killifish	I	1	0.02	1	2.13
LIVEBEARERS					
western mosquitofish	I	—	—	—	—
TOTAL		4,771			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=47 samples.

Table 14. Summary of the 1st 1999 San Juan River larval razorback sucker project fish collection (5-7 April 1999; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	1,623	97.13	8	61.54
common carp	I	—	—	—	—
roundtail chub	N	3	0.18	2	15.38
fathead minnow	I	33	1.97	3	23.08
speckled dace	N	12	0.72	3	23.08
SUCKERS					
flannelmouth sucker	N	—	—	—	—
bluehead sucker	N	—	—	—	—
razorback sucker	N	—	—	—	—
BULLHEAD CATFISHES					
channel catfish	I	—	—	—	—
KILLIFISHES					
plains killifish	I	—	—	—	—
LIVEBEARERS					
western mosquitofish	I	—	—	—	—
TOTAL		1,671			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=13 samples.

Table 15. Summary of 2nd 1999 San Juan River larval razorback sucker project fish collection (15-18 April 1999; Mexican Hat to Clay Hills Crossing).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	3,114	99.01	20	71.43
common carp	I	–	–	–	–
roundtail chub	N	–	–	–	–
fathead minnow	I	21	0.67	8	28.57
speckled dace	N	9	0.29	4	14.29
SUCKERS					
flannelmouth sucker	N	–	–	–	–
bluehead sucker	N	–	–	–	–
razorback sucker	N	–	–	–	–
BULLHEAD CATFISHES					
channel catfish	I	1	0.03	1	3.57
KILLIFISHES					
plains killifish	I	–	–	–	–
LIVEBEARERS					
western mosquitofish	I	–	–	–	–
TOTAL		3,145			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=28 samples.

Table 16. Summary of 3rd 1999 San Juan River larval razorback sucker project fish collection (2-5 May 1999; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	1,861	49.95	23	57.50
common carp	I	—	—	—	—
roundtail chub	N	1	0.03	1	2.50
fathead minnow	I	11	0.30	5	12.50
speckled dace	N	9	0.24	6	15.00
SUCKERS					
flannelmouth sucker	N	1,834	49.22	26	65.00
bluehead sucker	N	6	0.16	4	10.00
razorback sucker	N	1	0.03	1	2.50
BULLHEAD CATFISHES					
channel catfish	I	1	0.03	1	2.50
KILLIFISHES					
plains killifish	I	1	0.03	1	2.50
LIVEBEARERS					
western mosquitofish	I	1	0.03	1	2.50
TOTAL		3,726			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=40 samples.

Table 17. Summary of 4th 1999 San Juan River larval razorback sucker project fish collection (11-13 May 1999; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	1,118	26.46	20	62.50
common carp	I	–	–	–	–
roundtail chub	N	–	–	–	–
fathead minnow	I	17	0.40	5	15.63
speckled dace	N	9	0.21	3	9.38
SUCKERS					
flannelmouth sucker	N	3,066	72.55	28	87.50
bluehead sucker	N	12	0.28	4	12.50
razorback sucker	N	3	0.07	3	9.38
BULLHEAD CATFISHES					
channel catfish	I	1	0.02	1	3.13
KILLIFISHES					
plains killifish	I	–	–	–	–
LIVEBEARERS					
western mosquitofish	I	–	–	–	–
TOTAL		4,226			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=32 samples.

Table 18. Summary of 5th 1999 San Juan River larval razorback sucker project fish collection (1-2 June 1999; Bluff to Mexican Hat).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	159	54.83	7	77.78
common carp	I	–	–	–	–
roundtail chub	N	–	–	–	–
fathead minnow	I	2	0.69	2	22.22
speckled dace	N	9	3.10	3	33.33
SUCKERS					
flannelmouth sucker	N	119	41.03	8	88.89
bluehead sucker	N	–	–	–	–
razorback sucker	N	–	–	–	–
BULLHEAD CATFISHES					
channel catfish	I	–	–	–	–
KILLIFISHES					
plains killifish	I	1	0.34	1	11.11
LIVEBEARERS					
western mosquitofish	I	–	–	–	–
TOTAL		290			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=9 samples.
• Indicates a values <0.00

Table 19. Summary of 6th 1999 San Juan River larval razorback sucker project fish collection (8-10 June 1999; Four Corners to Bluff).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	3,608	60.60	29	70.73
common carp	I	2	0.03	2	4.88
roundtail chub	N	1	0.02	1	2.44
fathead minnow	I	56	0.94	15	36.59
speckled dace	N	10	0.17	6	14.63
SUCKERS					
flannelmouth sucker	N	2,103	35.32	38	98.68
bluehead sucker	N	171	2.87	25	60.98
razorback sucker	N	—	—	—	—
BULLHEAD CATFISHES					
channel catfish	I	—	—	—	—
KILLIFISHES					
plains killifish	I	1	0.02	1	2.44
LIVEBEARERS					
western mosquitofish	I	2	0.03	2	4.88
TOTAL		5,954			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=41 samples.

each of the two previous upper reach sampling efforts, were not taken during the 8 to 10 June 1999 trip.

The final 1999 collecting trip occurred on 14 June along the reach between Mexican Hat and Clay Hills Crossing, Utah. Ten 10 samples were taken over the 50 river mile reach yielding eight species and 1,336 specimens (Table 20). Red shiner numerically dominated the last 1999 sample accounting for 73.8% of the total catch. All three species of native sucker were collected in this reach with flannelmouth sucker being the most abundant (n=310), followed by bluehead sucker (n=8) and razorback sucker (n=3). This was the only lower reach sample that contained razorback sucker and the second one during 1999 to produce three specimens.

Razorback sucker - 1999

A total of seven larval razorback sucker was collected in seven separate samples during 1999 (Figure 10). Four larval razorback sucker were collected upstream of Bluff and three were taken downstream of Bluff. Two of the seven razorback sucker were collected in light-traps with the remainder taken in larval fish seine (Figure 11).

The first 1999 larval razorback sucker was collected on 4 May 1999 in a backwater located about 6.1 miles upstream of Bluff, Utah (RM 82.5; 34° 16' 44.8" N, 109° 30' 16.0" W). Water temperature, at 16:05 to 16:25 hr, was about 15°C in the main river channel at the mouth of the backwater and 18.5°C near its head. The backwater was divided into two channels with the narrower segment being about 1 m in width and the primary channel about 4 m wide. Substrate was mud with some scattered instream vegetation debris present. Three seine hauls, encompassing about 22 surface m^2 of the backwater, were made at this site. The latter two seining runs were near the head of the mesohabitat and produced the majority of the catch. The collectors noted on the field data sheet that this was the most larval sucker they had seen to date (WHB99-075). There were 318 fish in this sample of which 305 (96%) were larval flannelmouth sucker and two were larval bluehead sucker. The single razorback sucker specimen collected at this site was a 11.2 mm TL, 10.7 mm SL flexion mesolarvae (MSB 44201) with a small amount of yolk remaining in the yolk-sac.

The fourth 1999 sampling trip yielded three larval razorback sucker, two of which were collected in light-traps. Light-traps (n=5) were set in a backwater 4.8 miles downstream of Aneth (RM 96.2; 37° 15' 03.4" N, 109° 15' 45.2" W) on 12 May 1999 at 19:15 hr and retrieved the following morning at 07:10 hr. The backwater was about 50 m x 4.6 m and generally shallow (ca. 13 cm) except for two small pools, about 48 cm deep, located near its mouth (n= 3 traps) and middle section (n= 2 traps). Water temperature was 22°C when the traps were set and 13°C when retrieved. Field personnel noted a high level of water visibility (ca. 38 cm) in this backwater, especially compared to other sample sites.

The contents of each trap were maintained as separate collections. Almost 73% (n=851) of the total catch in the backwater were taken in the two light-traps (WHB99-105, WHB99-106) set near the middle section of the site. Larval flannelmouth sucker, the most numerous fish in each of the five light-traps, achieved its greatest abundance in the two middle portion light-traps. Each of the two middle section traps captured one larval razorback sucker and were also the only traps at that site to capture bluehead sucker. The larval razorback sucker taken in sample WHB99-105 (MSB 44254) on 12-13 May 1999 was a 14.1 mm TL, 12.8 mm SL post-flexion mesolarvae while WHB99-106 (MSB 44257;12-13 May 1999) was a 10.2 mm TL, 9.7 mm SL flexion mesolarvae. The latter specimen was the smallest individual (length) collected during either 1998 or 1999 but not the earliest developmental stage.

The third razorback sucker collected during the fourth 1999 sampling trip (MSB 44269) was taken on 13 May 1999 in a seine collection at a site about 6.1 miles upstream of Bluff (RM 82.5;

Table 20. Summary of 7th 1999 San Juan River larval razorback sucker project fish collection (14 June 1999; Mexican Hat to Clay Hills Crossing).

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF % OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	986	73.80	8	80.00
common carp	I	3	0.22	3	30.00
roundtail chub	N	—	—	—	—
fathead minnow	I	23	1.72	8	80.00
speckled dace	N	2	0.15	2	20.00
SUCKERS					
flannelmouth sucker	N	310	23.20	9	90.00
bluehead sucker	N	8	0.60	3	30.00
razorback sucker	N	3	0.22	3	30.00
BULLHEAD CATFISHES					
channel catfish	I	1	0.07	1	10.00
KILLIFISHES					
plains killifish	I	—	—	—	—
LIVEBEARERS					
western mosquitofish	I	—	—	—	—
TOTAL		1,336			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=10 samples.

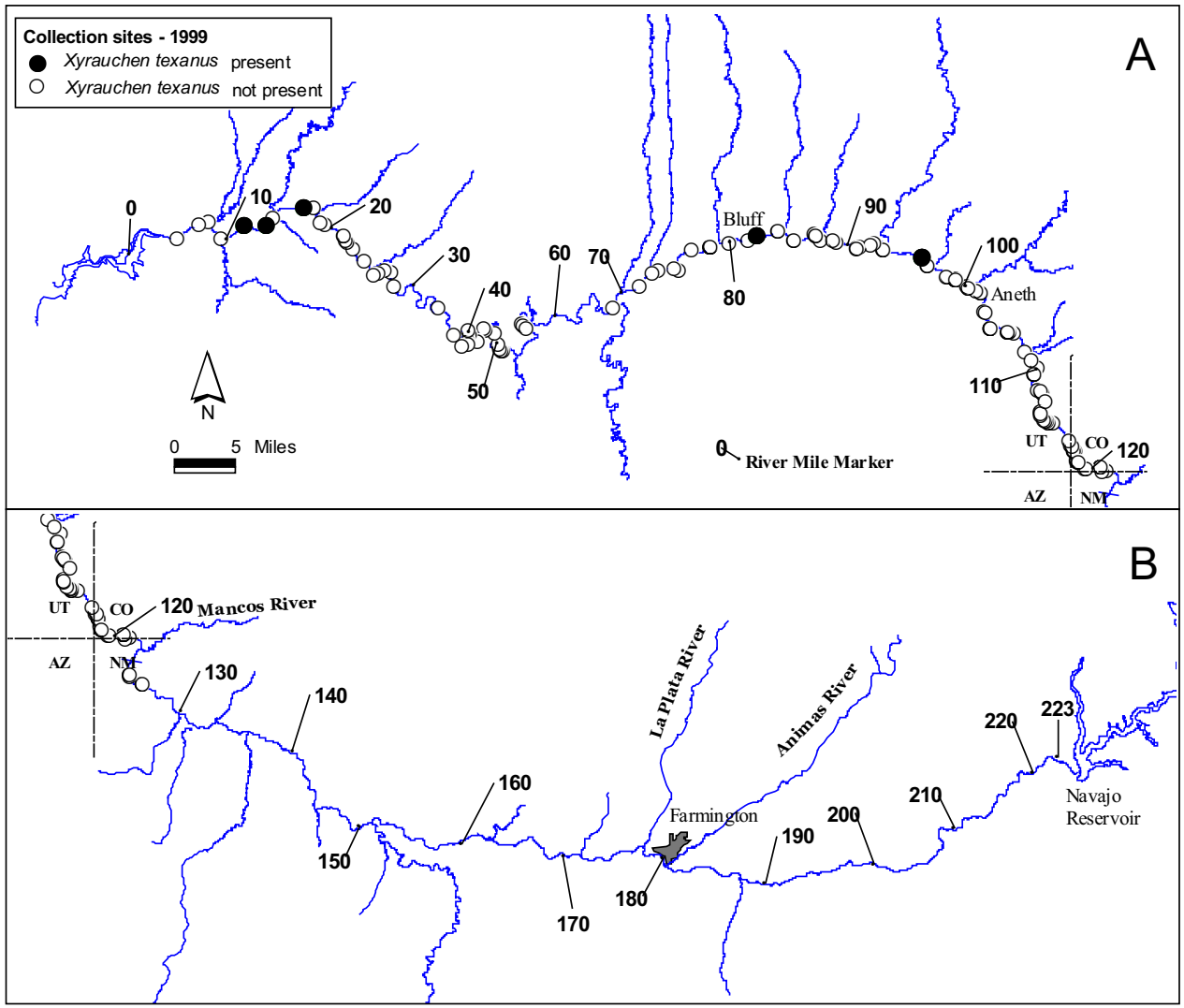
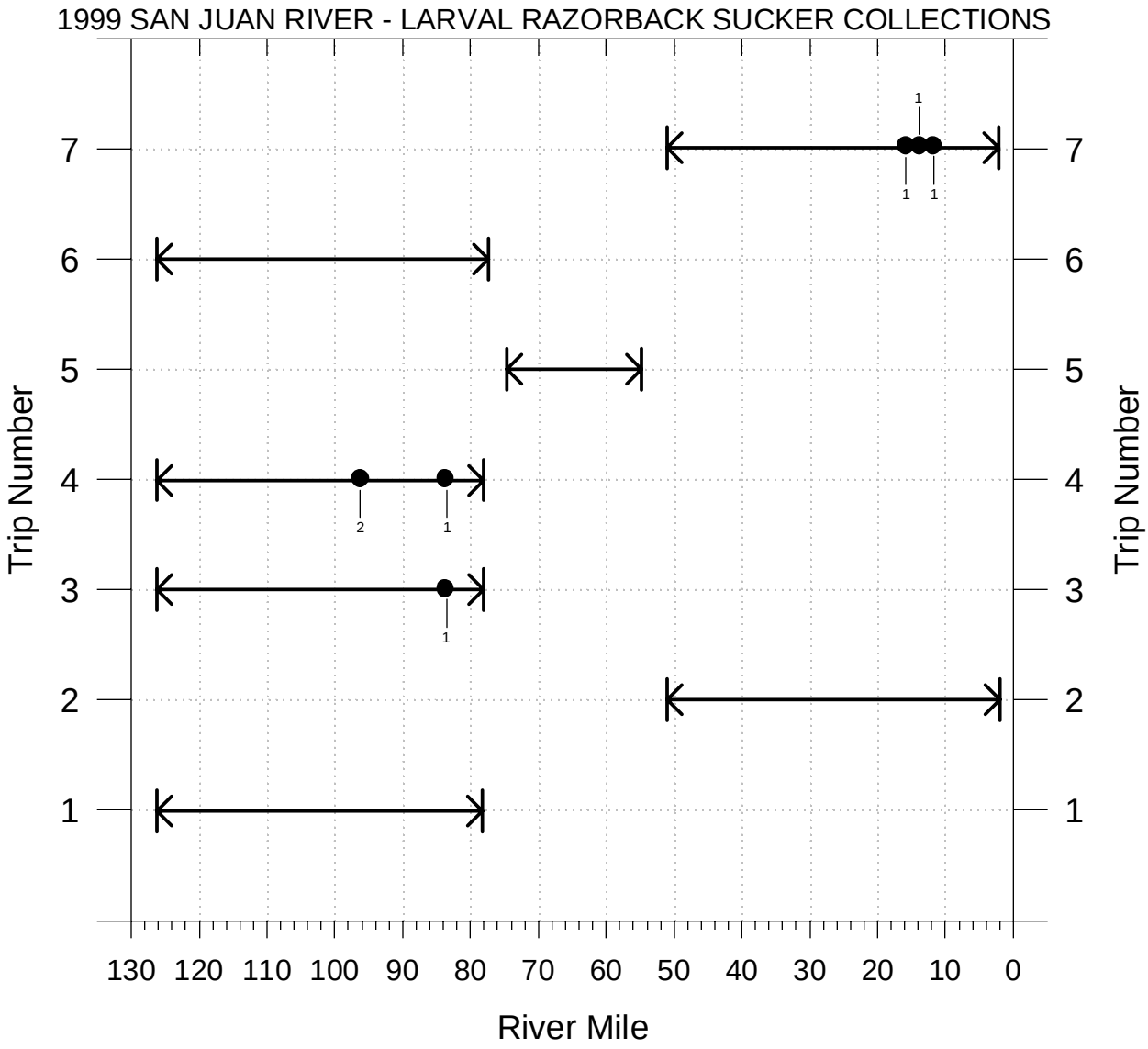


Figure 10. Distribution map of localities that yielded larval razorback sucker during 1999.



Trip Number	START DATE	END DATE
1	05 APR 99	07 APR 99
2	15 APR 99	18 APR 99
3	02 MAY 99	05 MAY 99
4	11 MAY 99	13 MAY 99
5	01 JUN 99	02 JUN 99
6	08 JUN 99	10 JUN 99
7	14 JUN 99	14 JUN 99

Figure 11. Diagrammatic representation of 1999 sampling effort.

37° 16' 44.8" N, 109° 30' 16.0" W). Fish were collected from a 15m x 4 m pool that had recently become separated from a backwater. The sample (WHB99-112) yielded 420 specimens, all of which were catostomids. Besides the single razorback sucker, the collection contained 412 larval flannelmouth sucker and seven larval bluehead sucker. The razorback sucker, a yolked 11.2 mm TL, 10.6 mm SL protolarvae, was the youngest (earliest ontogenetically) individual of this species collected.

Three razorback sucker larvae were collected in the lower reach during the final 1999 sampling trip. The three individuals were taken in three separate 14 June 1999 collections made between RM 16.5 and RM 11.5 on 14 June 1999. The most upstream site (WHB99-167; RM 16.5; 37° 19' 02.9" N, 110° 10' 19.3" W) was a large (40 m x 13 m), relatively deep (maximum depth > 2 m), backwater with shorelines that inundated extensive area of willows. This locality was about 36.5 miles downstream of Mexican Hat, Utah and under the influence of the fluctuating water levels of Lake Powell. The ichthyofaunal composition of the fish sample at this site was somewhat unusually, compared with other collections that contained razorback sucker, in that bluehead sucker were absent, flannelmouth sucker were rare, and red shiner numerically dominated (n=95%) the sample. The razorback sucker collected at this site (MSB 44421) was a 17.9 mm TL, 14.9 mm SL post-flexion mesolarvae.

The 14 June 1999 sample from RM 13.1 (WHB99-169; 37° 17' 33.5" N, 110° 13' 30.0" W) yielded only 120 fish but 74% were catostomids. As at WHB99-167, this backwater was long (50 m), wide (10 m), deep (> 2 m) and inundated large willow stands. Water visibility was relatively low (16 cm) and the majority of the fish were taken near the head of the backwater. The razorback sucker taken at this site (MSB 44428) was the largest (20.7 mm TL, 16.5 mm SL) and most developmentally advanced (metalarvae) individual collected to date.

The final 1999 larval razorback sucker collection (WHB99-170) was on 14 June 1999 in an extensive backwater located at RM 11.5 (37° 17' 53.3" N, 110° 15' 32.2" W). A total of 125 fish were collected at this site of which 62.4% (n=78) were flannelmouth sucker, five were larval bluehead sucker, and one was a post-flexion mesolarval razorback sucker (13.8 mm TL, 12.0 mm SL; MSB 44435). Maximum water depth at this site was >2 m with the majority of fish being collected near the head of this habitat in water 18-78 cm deep.

Summary

A large portion of the approximately 1,000 razorback sucker that were introduced into the San Juan River since the 1994 initiation of the experimental stocking effort are believed to have survived. If this assumption is true, than the number of stocked razorback sucker that recruit to the adult cohort (i.e., able to reproduce) should be expected to continued to increase annually. It follows that as this segment of the population increases, so should the number and spatial distribution of collections of larval razorback sucker increase.

The 1998 sampling protocol resulted in the collection of over 13,000 specimens, the majority of which were larval catostomids. This 43-fold increase in number of specimens taken in 1998 provided the opportunity to determine, with a higher degree of confidence than in 1997, if razorback sucker reproduction occurred in the San Juan River during the study period. The high number of larval fish collected in combination with the large reach of river sampled also resulted in substantially better resolution of spawning periodicity of all San Juan River catostomids. The 1998-1999 results of the larval razorback sucker study provided unequivocal documentation of reproduction in the San Juan River by members of a razorback sucker cohort which had been stocked as part of the San Juan River Recovery Implementation Program.

The initial collection of larval razorback sucker in 1998 (n=2) occurred during a single sampling effort and (19 - 22 May) with the specimens being taken and in relatively close proximity to each other (ca. 8 river miles). The effort (1998 sampling) demonstrated that targeting sampling to collect relatively large numbers of larval sucker was an effective means at acquiring information on razorback sucker reproductive efforts. Unlike the 1997 light-trap sampling project, this effort yielded a sufficient number of larval sucker so that biologically meaningful interpretation of the data could be developed.

There were two important discoveries that resulted from the 1999 larval razorback sucker study. The first was the collection of individuals (n=3) from the lower portion of the San Juan River (between RM 10 - 20). As this reach of river was not sampled for larval razorback sucker in 1998, no conclusions could be made regarding expansion of the range of this species by this ontogenetic stage. The second noteworthy find in 1999 was the collection of larval razorback sucker in a single backwater (RM 96.2) in light-traps. This sampling technique (light-trapping) has been successfully employed in the Upper Colorado River Basin as a mechanism by which larval razorback sucker can be monitored. The aforementioned San Juan River collection suggests that this passive collecting technique may, one day, be suitable for monitoring of the San Juan River population of razorback sucker.

Future annual studies of larval razorback sucker should provide extremely important information on the level of reproduction of this species and direction necessary to achieve recovery.

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Appendix 1. Summary of larval razorback sucker collected in the San Juan River.

Field Number	MSB Catalog Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
1998	**TOTAL**	**2**					
WHB98-143	42207	1	12.7	mesolarvae	21 May 1998	88.8	larval fish seine
WHB98-147	42218	1	12.1	mesolarvae	22 May 1998	80.2	larval fish seine
1999	**TOTAL**	**7**					
WHB99-075	44201	1	11.2	mesolarvae/yolk	04 May 1999	82.5	larval fish seine
WHB99-105	44254	1	14.1	mesolarvae	12-13 May 1999	96.2	light-trap
WHB99-106	44257	1	10.2	mesolarvae	12-13 May 1999	96.2	light-trap
WHB99-112	44269	1	11.2	protolarvae/yolk	13 May 1999	82.5	larval fish seine
WHB99-167	44421	1	17.9	mesolarvae	14 June 1999	16.5	larval fish seine
WHB99-169	44428	1	20.7	metalarvae	14 June 1999	13.1	larval fish seine
WHB99-170	44435	1	13.8	mesolarvae	14 June 1999	11.5	larval fish seine
TOTAL (1998-1999)		**9**					