MONITORING OF EXPERIMENTALLY STOCKED RAZORBACK SUCKER IN THE SAN JUAN RIVER: MARCH 1994 THROUGH OCTOBER 1997

Final Report

January 31, 2000

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EXECUTIVE SUMMARY

Intensive fisheries collections completed between 1987 and 1993 failed to collect any wild razorback sucker, of any life stage, from the riverine portion of the San Juan River. Due to this lack of collections, 939 hatchery-reared razorback sucker were stocked into the San Juan River at four separate stocking sites (RM 158.6, 136.6, 117.5, and 79.6) between 29 March 1994 and 3 October 1996. The purpose of these stockings were to facilitate the collection of basic life history information on this species in the San Juan River, and to evaluate the efficacy of stocking razorback sucker into the San Juan River as a means of reintroducing this species to its historically-occupied habitats in this river system.

Of the 939 stocked razorback sucker, 57 were surgically-implanted with radio transmitters. Radio telemetry contacts made with these fish demonstrated that stocked razorback sucker show seasonal differences in habitat selection. During winter months (i.e., December through February) radiotelemetered razorback sucker selected habitat-rich areas of the river, using edge pool habitats during very cold periods and venturing into main channel runs for very short (i.e., several minute) periods during the warmest parts of the day (water temperatures > 3.0ºC). During pre-runoff periods (March and April), stocked razorback sucker selected numerous low and faster velocity habitats, again in habitat-rich areas of the river. March and April were two of only three months (June being the other) during which radiotelemetered razorback sucker selected habitats that were warmer than the adjacent main channel. On both the ascending and descending limbs of the hydrograph (May and July) radiotelemetered razorback sucker selected only two habitat types eddies and main channel runs. During runoff periods (June) razorback sucker selected numerous slow and fast water habitats (much like in March and April), with the most selected for habitat being inundated vegetation. June was the only month inundated vegetation was an available habitat type. Habitat richness of areas of the river being utilized by razorback sucker in June and July was less than that seen between December and May. This trend towards using more simplified areas of the river continued into the summer and fall base-flow months (August through October). During these base-flow months radiotelemetered razorback sucker selected only fast water run habitats and stayed active around the clock, probably feeding. Then as water temperatures started to drop again in November, razorback sucker selected habitat-rich areas of the river again, but did not abandon their active use of main channel runs until colder December temperatures set in.

There is some evidence that may point to three sites in the San Juan River being preferred by stocked razorback sucker. The first possible preferred site is a large backwater on river left at RM 38.6. In two different years, three individual razorback sucker (two males and one of indeterminate sex) were collected in the backwater itself, as well as just up- and downstream of the backwater's mouth. The second possible preferred site is on river right just downstream of the McElmo Creek confluence (RM 100.2) where three ripe male razorback sucker were collected and three other razorback sucker were observed but not collected on 3 May 1997. A fourth ripe

male razorback sucker was collected at RM 100.5 on the same side of the river. The third potential preferred site is the debouchment of a side channel (mouth of a backwater at low flows) at RM 77.3. Over the space of two years, two adult male and one immature razorback sucker have been collected near or at the debouchment of this secondary and another observed, but not collected. These three areas of the San Juan River are the only three areas where more than one razorback sucker has been collected.

Movement patterns of stocked razorback sucker indicate that these fish experience large downstream displacements within the first few weeks after stocking. After this initial downstream displacement, stocked razorback sucker hold their relative position in the river, even during high flow events, and many make upstream movements (some quite long) after several months in the river.

As of October 1997, at least 54 (5.8%) of the 939 stocked razorback sucker had been recaptured and verified to be alive. This number may be as high as 59 (6.3% of stocked fish) if five razorback sucker for which no PIT tag number was obtained are different individuals from the other 54 recaptures. Razorback sucker stocked at larger sizes (> 350 mm TL) accounted for 49 (90.7%) of the 54 known-origin recaptures, even though fish of this size class composed only 31.7% of the original 939 stocked fish. Even larger razorback sucker (> 400 mm TL at time of stocking) were even more successful, accounting for 32 (59.2) of the 54 known-origin recaptures while composing only 13.7% of the original 939 stocked fish. Evidence of predation on native flannelmouth suckers by channel catfish, striped bass, and walleye in the San Juan River coupled with a channel catfish bite mark observed across the dorsal keel of a recaptured razorback sucker (408 mm TL) would seem to indicate that stocking razorback sucker at 400 mm TL or greater will increase their chances for survival.

Growth information obtained from recaptures indicates that for up to 400 days after stocking, razorback sucker lost weight and increased in total length little, if at all. It was not until approximately 800 days post-stocking that recaptured razorback sucker showed large gains in weight. While they accounted for very few recaptures, smaller size class razorback sucker (< 350 mm TL at time of stocking) grew over three times faster (0.10 mm per day) than did larger size class (> 350 mm TL at time of stocking) razorback sucker (0.03 mm per day). Virtually no difference in growth rates between male and female fish could be determined from our recaptures.

Hatchery-reared razorback sucker aggregated and appeared to be spawning just downstream of McElmo Creek (at RM 100.2), near Aneth, Utah in May 1997. In addition, two larval razorback sucker (12.7 and 12.1 mm TL) were collected on 21 and 22 May 1998 downstream of this suspected spawning site (at RM 88.8 and 80.2, respectively), proving that stocked razorback sucker did spawn successfully in the spring of 1998.

No wild razorback sucker were collected in the San Juan River during this study. It did not appear that stocked razorback sucker were in any way useful in leading researchers to any old, wild remnant populations of razorback sucker left in the San Juan River.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES IN APPENDICES

INTRODUCTION

Razorback sucker (Xyrauchen texanus), is one of three San Juan River native fish species (the Colorado pikeminnow, Ptychocheilus lucius, and the roundtail chub, Gila robusta being the other two) that have become greatly reduced in numbers and range since the turn of the century (Burdick 1992). Physical alterations of riverine habitats, water impoundment in the form of Navajo Reservoir and Lake Powell, and associated effects on flow and thermal regimes, introduction of non-native species, and contaminants have probably all contributed to the decline of these native species (Platania 1990, Brooks et al. 1993, Ryden and Pfeifer 1994a). Extremely small numbers of wild razorback sucker and the apparent long-term lack of recruitment led to this fish being listed as endangered under the Endangered Species Act on 22 November 1991 (U.S. Fish and Wildlife Service {USFWS} 1991). The razorback sucker is also currently protected by state laws in Arizona (AZ), California, Colorado (CO), Nevada, Utah (UT), and by the Navajo Nation.

Information on the historic distribution and abundance of the razorback sucker in the San Juan Basin is sparse. Until the late 1980's the number of fishery surveys conducted in the San Juan River was relatively small compared to the rest of the Colorado River basin. This is probably because much of the San Juan River is canyon-bound in it's lower stretches and a large percentage of the river runs through Indian reservation land (Maddux et al. 1993). Anecdotal accounts of "humpies" from the Animas River near Durango (Jordan 1891), and the San Juan River near Farmington (Koster 1960) indicated the presence of razorback sucker in these areas. However, these accounts were not verified by scientific collections. Pre-impoundment rotenone applications in the Navajo Dam area in 1962 killed fish downriver to Farmington, New Mexico (NM). However, no razorback sucker were documented among the fish killed (Olson 1962). The first scientifically-documented record of razorback sucker from the San Juan River basin was in 1976 when two adults were seined from a pond near Bluff, UT at approximately river mile (RM) 81 (VTN Consolidated, Inc. and Museum of Northern Arizona 1978, Platania 1990, Minckley et al. 1991). According to local residents, a second pond adjacent to the one where these two fish were caught was drained just weeks before leaving approximately 100-250 razorback sucker stranded, resulting in their death. These two ponds communicated with the river via a canal that allowed fish movement to and from the river, but only when the headgates were open (VTN Consolidated, Inc. and Museum of Northern Arizona 1978, Platania 1990, Minckley et al. 1991). Between 1987 and 1989 sixteen adult razorback sucker were collected from the San Juan River arm of Lake Powell, near Piute Farms Marina, RM 0.0 (Platania 1990). In 1988 one razorback sucker was captured and released near Bluff, UT, close to the 1976 capture site (Platania 1990). This is the only verifiable capture of a razorback sucker from the mainstem San Juan River.

No scientifically-documented, wild razorback sucker have been collected from the San Juan River in either CO or NM. Neither have spawning or recruitment of this species been documented in the San Juan River, prior to 1998. However, the recent presence of a few large adult fish near Bluff, UT suggests that there may have been a remnant population of old razorback sucker remaining in the San Juan River as late as 1988. Extensive electrofishing surveys from 1991 to 1997 failed to collect any wild razorback sucker from the mainstem San Juan River (Ryden and Pfeifer 1993, 1994b, 1995a, 1996a, Ryden 2000).

One of the two goals of the San Juan River Recovery Implementation Program (SJRIP) is to protect and recover endangered fishes in the San Juan

River Basin, including Colorado pikeminnow and razorback sucker, with the ultimate goal of promoting self-sustaining populations of razorback sucker and Colorado pikeminnow (SJRIP 1995a). This includes reestablishing, if necessary, populations of endangered razorback sucker in appropriate historic habitat (Ryden 1997). Due to the paucity of historic and recent collections of this species, including the failure to collect any wild razorback sucker during three years (1991-1993) of intensive studies on all life stages of the fish community (Buntjer et al. 1993, 1994, Lashmett 1993, 1994, Ryden and Pfeifer 1993, 1994b, Gido and Propst 1994) the San Juan River Biology Committee identified the necessity to begin an experimental stocking program for razorback sucker in the San Juan River (Ryden and Pfeifer 1994a). Experimental stocking was implemented to provide needed insight about recovery potential and habitat suitability for the razorback sucker in the San Juan River between Lake Powell and Farmington, NM (designated as Critical Habitat for razorback sucker; Maddux et al. 1993, USFWS 1994).

Objectives

The objectives of the experimental stocking study for razorback sucker in the San Juan River were as follows:

1) Determine habitat use, needs, and selection, site preference, and movement patterns of hatchery-reared razorback sucker in the wild.

2) Determine survival rates and growth rates of hatchery-reared, known-age razorback sucker in the wild.

3) Determine whether hatchery-reared razorback sucker will exhibit spawning behavior in the wild.

4) Determine if hatchery-reared razorback sucker can lead researchers to their wild counterparts.

This report represents a summary of data collected on razorback sucker that were stocked as part of the experimental stocking study (i.e., 1994-1996) and examines this data under items one through four above. Although the experimental stocking study, in essence, ended in December 1996, this report summarizes data collected on razorback sucker stocked as part of this study through October 1997 (the end of the seven-year research period). Based on the results obtained from this experimental stocking study through 1996, a more formal, five-year augmentation plan for razorback sucker was developed and implemented in 1997 (Ryden 1997). Razorback sucker stocked as part of that five-year augmentation effort are not included in this report.

SAN JUAN RIVER STUDY AREA DESCRIPTION

The San Juan River is a major tributary of the Colorado River and drains 99,200 km^2 in Colorado, Utah, Arizona, and New Mexico (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 to the Colorado River. The major perennial tributaries to the San Juan River are the Navajo, Piedra, Los Pinos, Animas, La Plata, and Mancos rivers, and McElmo Creek. In addition there are numerous ephemeral arroyos and washes contributing little total flow but large sediment loads.

Navajo Reservoir, completed in 1963, impounds the San Juan River, isolating the upper 124 km of river and partially regulating downstream flows. The completion of Glen Canyon Dam and subsequent filling of Lake Powell in the early 1980's inundated the lower 87 km of the river, leaving about 359 km of river between the two reservoirs.

From Navajo Dam to Lake Powell, the mean gradient of the San Juan River is 1.67 m/km. Locally, the gradient can be as high as 3.5 m/km, but taken in 30 km increments, the range is from 1.24 to 2.41 m/km. Between the confluence of the San Juan River with Lake Powell and the confluence with Chinle Creek about 20 km downstream of Bluff, UT, the river is canyon-bound and restricted to a single channel. Upstream of Chinle Creek the river is multi-channeled to varying degrees with the highest density of secondary channels occurring between the Hogback Diversion about 13 km east of Shiprock and Bluff, Utah. The reach of river between Navajo Dam and Farmington, NM is relatively stable with predominantly embedded cobble substrate and few secondary channels. Below the confluence with the Animas River, the channel is less stable and more subject to floods from the unregulated Animas River. Between Farmington and Shiprock cobble substrate still dominates, although it is less embedded. Between Shiprock and Bluff the cobble substrate becomes mixed with sand to an increasing degree with distance downstream, resulting in decreasing channel stability.

Except in canyon-bound reaches, nonnative woody plants--salt cedar (*Tamarix chinensis*) and Russian olive (*Elaeagnus angustifolia*) dominate the river’s borders, with native cottonwoods (*Populus fremontii* and *P. angustifolia*) and willows (*Salix amygdaloides* and *S. exiqua*) accounting for less than 15% of the riparian vegetation. With the advent of higher flows in the 1990's there appears to be generation of new stands of cottonwood and willow taking place, although it is still too early to tell if this will represent a significant, let alone permanent, improvement.

Discharge of the San Juan River is typical of rivers in the American Southwest. The characteristic annual pattern is one of large flows during spring snowmelt, followed by low summer, autumn, and winter base flows. Base flows are frequently punctuated by convective storm-induced flow spikes during summer and early autumn. Prior to closure of Navajo Dam about 73% of the total annual discharge (based on USGS Bluff, UT gage) of the drainage occurred during spring runoff (1 March through 31 July). The median daily peak discharge during spring runoff was 10,400 cubic feet per second ({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 in the basin, the magnitude of storm-induced flows exceeded the peak snowmelt

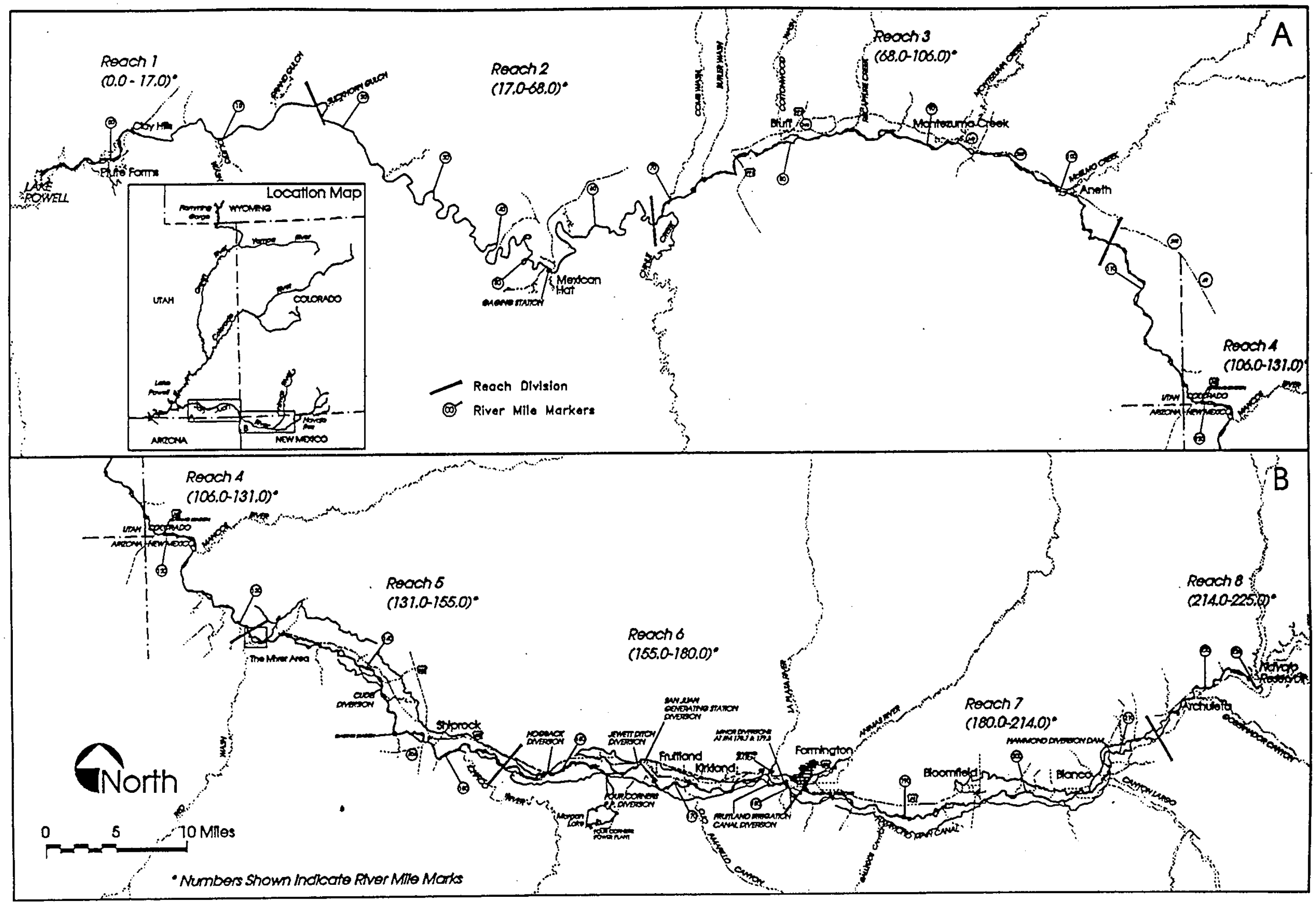

Figure 1. Map of the San Juan River between Lake Powell and Navajo Reservoir, including the locations of major towns, drainages, diversion structures, gaging stations, and river reach designations.

discharge about 30% of the years, occasionally exceeding 40,000 CFS (mean daily discharge). Both magnitude and frequency of these storm-induced flow spikes are greater than those seen in the Green or Colorado rivers.

Closure of Navajo Dam altered the annual discharge pattern of the San Juan River. The natural flows of the Animas River ameliorated some aspects of regulated discharge by augmenting spring discharge. However, regulation resulted in reduced magnitude and increased duration spring runoff in wet years and seriously reduced magnitude and duration spring flows during dry years. Overall, flow regulation via operation of Navajo Dam has resulted in post-dam peak spring discharge averaging about 54% of pre-dam values. After dam closure, base flows were increased substantially over pre-dam base flows.

Since 1992, Navajo Dam has been operated to mimic a “natural” hydrograph with the volume of release during spring linked to the amount of precipitation during the preceding winter. Thus in years with high spring snowmelt, reservoir releases were “large” and “small” in low runoff years. Base flows since 1992 were typically greater than during pre-dam years but less than post-dam years.

The primary study area for most studies conducted under the auspices of the San Juan River Seven Year Research Program, including the razorback sucker monitoring study, was the mainstem San Juan River and its immediate vicinity between Navajo Dam and Lake Powell. Between Navajo Dam and Shiprock there is considerable human activity within the floodplain of the San Juan River. Irrigated agriculture is practiced throughout this portion of the valley and much of the immediate uplands. Much of the river valley that is 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 valley of the Animas River, the San Juan's largest tributary in the study area, is similarly developed. Downstream of Shiprock to Bluff small portions of the river valley (and uplands) are farmed, however, dispersed livestock grazing is the primary land use. In the vicinity of Montezuma Creek and Aneth, petroleum extraction occurs within the floodplain and the adjacent uplands. Between Bluff and the confluence with Lake Powell, there are few human-caused modifications of the system.

Razorback Sucker Monitoring Study Area

To enhance comparisons among studies and to provide a common reference for all research, a multivariate analysis of a variety of geomorphic features of the San Juan River drainage was performed to segregate the river into distinct geomorphic reaches. This effort (Bliesner and Lamarra 2000) identified eight geomorphic reaches between Navajo Dam and Lake Powell. However, as is typical of tailwaters below large dams in the Upper Colorado River Basin (UCRB), the river immediately downstream of Navajo Dam (i.e., Reaches 7 and 8) is too clear and cold to support populations of endangered fish (Holden and Wick 1982, Marsh 1985, Bestgen and Williams 1994). These cold waters extend some 44 miles downstream to Farmington, NM. The study area for monitoring experimentally-stocked razorback sucker starts at Hogback Diversion (RM 158.6) in Reach 6 and ends at Clay Hills Landing (RM 2.9) in Reach 1, just upstream of Lake Powell. The boundaries were chosen because Hogback Diversion is the upstream limit of designated Critical Habitat for the razorback sucker in the San Juan River (Maddux et al. 1993, USFWS 1994), while Clay Hills is the last boat take-out in the San Juan River upstream of the waterfall that is present at certain lake levels at RM 0.0. Critical Habitat for razorback sucker actually extends into Lake Powell to Neskahai Canyon, but sampling the lake by electrofishing is impractical. Reaches 1-6 encompass the entirety of the experimental stocking study area. Within the study area are four experimental stocking sites. The four stocking sites are at RM 79.6, 117.5, 136.6, and 158.6. Following is a brief description of each geomorphic reach within the razorback sucker monitoring study area. For a more detailed description of the geomorphology and hydrology of the San Juan River see Bliesner and Lamarra (1993-1996).

Reach 6 (RM 180.0 to 155.0, Animas River confluence to below Hogback Diversion, NM) is predominately a single channel, with 50% fewer secondary channels than Reaches 3, 4, or 5. Cobble and gravel substrates dominate, and cobble bars with clean interstitial space are more abundant in this reach than in any other. Backwater habitat abundance is low in this reach, with only Reach 2 having less. The channel has been altered by dike construction in several areas to control lateral channel movement and over-bank flow.

Several instream diversion structures, located between Navajo Dam and the Colorado state line, may be impediments to fish passage (Figure 1). Of these diversion structures, the majority (four major and three minor) are located in Reach 6, but are upstream of this study area. The four major diversion structures are Fruitland Diversion at RM 178.5, San Juan Generating Station Diversion at RM 166.6, Four Corners Generating Station Diversion at RM 163.3, and Hogback Diversion at RM 158.6. Three minor diversion structures are located at RM 179.3, 178.7, and 166.4.

The Hogback Diversion stocking site is located at RM 158.6. This site was added to the three original three stocking sites (see below) in November 1994. Before November 1994, all razorback sucker stocked into the San Juan River were stocked at the three stocking sites farther downstream. However, based on results obtained from earlier stockings (i.e., between 29 March 1994 and 27 October 1994), all razorback sucker stocked in 1995 and 1996 were stocked at the Hogback Diversion site.

Reach 5 (RM 155.0 to 131.0, just below Hogback Diversion to the “Mixer”, New Mexico) is predominantly multi-channeled with the largest total wetted area (TWA) and largest secondary channel area of any of the reaches. Secondary channels tend to be longer and more stable than in Reach 3 but fewer in number overall. 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 an instream diversion structure (Cudei Diversion), at RM 142.0. Backwaters and spawning bars in this reach are much less subject to perturbation during summer and fall storm events than the lower reaches.

In this section of the river (i.e., the border of Reaches 4 and 5) is an area of the river known as the "Mixer." The Mixer extends from RM 133.4 to RM 129.8. The river channel in these 3.6 miles has been relatively stable over the historic record with little variation in the degree of channel braiding. However, certain areas are locally dynamic. The habitat is complex with numerous channels always present. The locally dynamic areas contribute to this complexity.

The Mixer stocking site is located at RM 136.6. This site was chosen because it has a relatively large amount of clean cobble and gravel substrates that should support large standing crops of algae and invertebrates which compose the diet of juvenile and adult razorback sucker. In addition, this area of the river is an important reach of river for Colorado pikeminnow and was chosen because it provided the best chance of observing possible interactions between these two rare fish species.

Reach 4 (RM 131.0 to 106.0, below the Mixer to Aneth {New Mexico, Colorado, and Utah}) is a transitional reach between the upper cobble-dominated reaches and the lower sand-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 habitat abundance is low overall in this reach (third lowest among reaches) and there is little clean cobble. The Four Corners, or Upper UT, site is located at RM 117.6. This site was chosen due to its high degree of channel braiding. It is also an intermediate location between the Bluff and Mixer sites.

Reach 3 (RM 106.0 to 68.0, Aneth to Chinle Creek confluence {UT}) 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. This reach has the second highest density of backwater habitats after spring peak flows, but is extremely vulnerable to change during summer and autumn storm events, after which this reach may have the second lowest density of backwaters. Following spring runoff, debris piles are deposited throughout the active channel in this reach, leading to the nickname “The Debris Fields”. The Bluff, UT stocking site is located at RM 79.6. This site was chosen because it represents the site of the only documented razorback sucker capture in the mainstem San Juan River (Platania 1990, Platania et al. 1991).

Reach 2 (RM 68.0 to 17.0, Chinle Creek confluence to near Slickhorn Canyon {UT}) is also canyon bound but is located above the influence of Lake Powell. The gradient in this reach is higher than in either adjacent reach and the fourth highest in the system. The channel is primarily bedrock confined and is influenced by debris fans at ephemeral tributary mouths. Riffle-type habitat dominates, and the major rapids in the San Juan River occur in this reach. Backwater abundance is low in this reach, occurring mostly in association with the debris fans.

Reach 1 (RM 17.0 to 0.0, near Slickhorn Canyon to Piute Farms Marina in Lake Powell {UT}) has been heavily influenced by the 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 the reach since the reservoir first filled in 1980. This deposition of suspended sediment into the delta-like environment of the river/reservoir transition has created the lowest-gradient reach in the river. This reach is canyon bound with an active sand substrate. Although there is an abundance of low velocity habitat at certain flows, it is highly ephemeral, being influenced by both river flow and the elevation of Lake Powell.

As Lake Powell filled to capacity, approximately 14 RM of the lower San Juan River was inundated. During this time, fish could travel freely between Lake Powell and riverine habitats (Platania et al. 1991, Ryden and Ahlm 1996). In the late 1980's the water level in Lake Powell receded, leaving the lower 14 miles of river to wander through immense sediment deposits just upstream of the lake. The accumulated sediments greatly decreased the gradient of this reach of the San Juan River. The sediment accumulation also caused the river channel to shift from its historic bed and flow over a sandstone outcrop as it entered Lake Powell, creating a waterfall ($\geq$ 10 meters [m] high at some lake levels) that was impassable by fish. This feature was present for about six years. In spring 1995, lake levels rose high enough to inundate the waterfall, once again allowing unimpeded movement of fish species between Lake Powell and the San Juan River.

CHAPTER 1: HABITAT USE, NEEDS, AND SELECTION, SITE PREFERENCE, AND MOVEMENT PATTERNS

- Objective 1: Determine habitat use, needs, and selection, site preference and movement patterns of hatchery-reared razorback sucker in the wild.

METHODS

Stockings of Razorback Sucker

All razorback sucker stocked in the San Juan River between 29 March 1994 and 3 October 1996 as part of this experimental stocking study were F_1 progeny of adult razorback sucker that had been collected in the San Juan River arm of Lake Powell and taken into captivity as broodstock. These adult razorback sucker were spawned in paired matings at U.S. Fish and Wildlife Service's (Service) Ouray National Fish Hatchery (NFH) in Ouray, UT in 1992. The F_1 razorback sucker stocked in the San Juan River were "excess fish" obtained from the Recovery Implementation Program for the Endangered Fish Species of the Upper Colorado River Basin (UCRB-RIP). These excess fish were produced above and beyond refugia and stocking needs of the UCRB-RIP or were culled from lots of refugia fish as fish in these lots grew and numbers in each lot were reduced. These fish were scheduled for disposal if a suitable purpose could not be found for them.

All razorback sucker that were to be stocked (whether implanted with a radio transmitter or not) were implanted with BioSonics brand Passive Integrated Transponder (PIT) tags. These passive tags require a PIT tag reader. This reader emits a signal from a hand-held wand which strikes the tag and reflects back a unique ten digit alpha-numeric code. Since these tags are passive, they never expire and can be read for the life of the fish. All stocked razorback sucker were individually measured to the nearest millimeter (mm) for total length (TL), weighed to the nearest 5 grams (g), and had sex noted (if apparent) before stocking. In 1994, all radio-tagged fish also had scales samples taken and had five-mm muscle plugs taken for baseline contaminants analysis.

Razorback sucker that were implanted with radio transmitters (tags) were first anesthetized using 200 milligrams/Liter (4 g/gallon) of tricaine methanesulfonate (MS-222; following Tyus and McAda 1984), then implanted with an AVM brand radio tag with varying lifespans (see each group of stocked fish for specifics). After being sutured up, razorback sucker implanted with radio tags were given an injection of the antibiotic Gentocin (0.5 milliliters/2 kilograms of body weight {WT}; M. Baker, pers. comm.). Fish were then returned to the ponds to recover.

Razorback sucker were transported from hatchery facilities (Wahweap or Ouray) to stocking sites using stocking trucks equipped with 250-gallon aerated stock tanks. Upon arrival at stocking sites, razorback sucker were placed in habitats with the lowest possible water velocities, usually shallow side channels or backwaters.

1994

Two stockings of razorback sucker took place in 1994 (Table 1), one in the spring (March) and one in the fall (October and November). Razorback sucker experimentally stocked in 1994 were reared at the Utah Division of Wildlife Resources' (UDWR) Wahweap Warmwater Fish Hatchery (Wahweap), near Page, AZ. These razorback sucker were excess fish from lots of razorback sucker held at Ouray NFH. None of these razorback sucker were PIT-tagged prior to leaving Ouray NFH. On 12 June 1992, approximately 17,200 larval razorback sucker were transferred from Ouray NFH to Colorado State University (CSU) to be used in experiments. On 22 December 1992, the 3,779 surviving razorback sucker were transferred from CSU to Wahweap by Service and UDWR personnel. These fish unfortunately did not fare well during transport and by 13 July 1993, only 15 of the fish from the CSU experimental group were left. At this point the CSU fish were placed in a pond with 690 razorback sucker (all from one family lot, i.e., lot 2A) that had been transferred from Ouray NFH to Wahweap on 21 April 1993. Again, none of these razorback sucker had been PIT-tagged prior to leaving Ouray NFH. Thus, after mixing groups of fish, the exact lineage of any given fish was not able to be determined. However, by knowing the number of fish from each family lot that were originally transferred from Ouray NFH, we were able to ascertain that at least 97% of all fish being reared at Wahweap in 1994 were from a single family lot (lot 2A).

On 29 and 30 March 1994, 15 of these fish that had been surgically-implanted with six-month lifespan AVM brand radio tags (WT = 5 g) were stocked at three stocking sites (RM 79.6, 117.5, and 136.6), five per site (Table 1). These fish had a mean TL of 277 mm and an mean WT of 260 g.

The fall 1994 stocking of razorback sucker was actually a group of three stockings. The first of these fall stockings took place on 27 October 1994 (Table 1). On this date 16 razorback sucker that had been surgically-implanted with two-year lifespan AVM brand radio tags (WT = 12 g) were stocked into the San Juan River, in even numbers, at three stocking sites (RM 79.6, 117.5, and 136.6). These fish had a mean TL of 403 mm, and a mean WT of 718 g (Table 1). These fish were also from the group of razorback sucker being reared at Wahweap. In the 1994 Annual Progress Report (Ryden and Pfeifer 1995b), these 16 fish were erroneously reported as being part of the 177 fish from Wahweap that were stocked on 18 November 1994. This was not the case.

The second stocking in the fall of 1994 took place on 16 and 17 November 1994, and consisted of 478 PIT-tagged fish from Ouray NFH (Table 1). These fish were stocked in equal numbers at all four stocking sites (RM 79.6, 117.5, 136.6, and 158.6). The majority of these fish from Ouray NFH were from different family lots than those held at Wahweap and were stocked not only to help obtain data for this study, but also to dampen any possible negative genetic effects that may have arisen in the future from using the large number of fish from the Wahweap lot (known to be dominated by a single family lot). These fish had a mean TL of 190 mm and a mean WT of 89 g.

The third stocking in the fall of 1994 took place on 18 November 1994, and consisted of 177 PIT-tagged razorback sucker from Wahweap (Table 1). These fish, like the 478 fish from Ouray, were also stocked in roughly equal

Table 1. Experimental stockings of razorback sucker in the San Juan River and the San Juan River Arm of Lake Powell, 1994-1996, and recaptures that have occurred with these fish as of 31 October 1997.

Date Stocked	Stocking Number	Number of Fish Stocked	Mean TL(range)	Mean WT(range)	Recapture Information: Number of Recaptures	Recapture Information: Percent of Total Stocked
03/29-30/94	1	15	277(251-316)	260(169-396)	1	6.7%
10/27/94	2	16	403(384-435)	718(580-1018)	2	12.5%
11/16-17/94	3	478	190(100-374)	89(8-512)	4	0.8%
11/18/94	4	177	400(330-446)	715(480-990)	41	23.2%
08/08/95	5	65[a]	405(348-428)	716(452-874)	1	1.5%
08/15/95	6	65[a]	409(369-437)	727(526-871)	0	0.0%
09/27/95	7	16	424(397-482)	794(627-1194)	3	18.8%
11/01/95	8	34[b]	446(419-495)	964(760-1240)	0	0.0%
10/03/96	9	237	335(204-434)	437(90-950)	3	1.3%
Total		939			55[c]	

[a] = The Utah Division of Wildlife Resources stocked 130 razorback sucker, 65 each on 8 August and 15 August 1995, into Lake Powell at Piute Farms (San Juan RM 0.0). They are included here because one of these fish was recaptured at RM 58.0 on 21 May 1996. These fish were not part of the experimental stocking study and are not included in numbers discussed for this study. All of these fish were PIT-tagged before release (see Table A-2 in Appendix A for a list of the PIT tag numbers).

[b] = The Bureau of Reclamation (Cathy Karp, Denver, CO) and U. S. Geological Survey (Gordon Mueller, Denver, CO) stocked 34 sonic-tagged razorback sucker into Lake Powell on 1 November 1995. Sixteen were stocked at Neskahi Wash (approximately 29 RM below Piute Farms -- RM 0.0) and 18 at Zahn Bay (approximately 10.2 RM below Piute Farms -- RM 0.0). These fish are included here because at least five of them were known to have moved upstream into the lower portion of the San Juan River. None were recaptured during electrofishing, seining, or trammel-netting efforts in the San Juan River. These fish were not part of the experimental stocking study and are not included in numbers discussed for this study. All of these fish were PIT-tagged before release.

[c] = A total of 55 razorback sucker of known origin have been recaptured. Only fifty-four of these were part of the experimental stocking study. An additional five razorback sucker were recaptured for which no PIT tag numbers were obtained due to PIT tag reader failure. The stocking from which these five originated is unknown. Thus they are not included in this table.

numbers at all four stocking sites. These fish had a mean TL of 400 mm and a mean WT of 715 g. PIT-tagged razorback sucker were stocked to help facilitate the collection of data on post-stocking dispersal, age and growth of hatchery-reared fish in the wild, and contaminants in the San Juan River.

1995

On 27 September 1995, 16 razorback sucker (mean TL = 424 mm, mean WT = 794 g) that had been surgically-implanted with two-year lifespan AVM brand radio tags (WT = 12 g) were stocked at the Hogback (RM 158.6) stocking site (Table 1). These fish were stocked to supplement the dwindling numbers of radio-implanted from the fall 1994 stocking and facilitate the collection of winter habitat use data. All of these fish were from the group being reared at Wahweap.

Because of space limitations and costs associated with rearing, the UDWR was unable to retain all of the razorback sucker remaining at Wahweap in 1995. Thus, 130 razorback sucker were stocked into the San Juan River Arm of Lake Powell at Piute Farms Marina (San Juan RM 0.0) in two separate stockings on 8 (mean TL = 405 mm, mean WT = 716 g) and 15 (mean TL = 409 mm, mean WT = 727 g) August 1995, 65 fish each day (Table 1). All of these fish were PIT-tagged before being stocked. These fish were not part of the experimental stocking study, however, they are mentioned here because one of them was recaptured during our monitoring efforts (RM 58.0, 21 May 1996).

In addition to the 130 razorback sucker stocked into the San Juan River Arm of Lake Powell by the UDWR, the Bureau of Reclamation and U.S. Geological Survey (Denver offices) stocked 34 sonic-tagged razorback sucker (mean TL = 446 mm, mean WT = 964g) into the San Juan River Arm of Lake Powell on 1 November 1995 (Table 1). These fish all came from the group of fish being held at Wahweap. All of these 34 razorback sucker were PIT-tagged before their release. Again these fish were not part of the experimental stocking study, but are mentioned here because at least five of them were known to have moved upstream (at least as far as RM 15.0) into the lower portion of the San Juan River in 1996.

1996

On 3 October 1996, 237 razorback sucker (mean TL = 335 mm, mean WT = 437 g) were stocked at the Hogback stocking site (RM 158.6; Table 1). Ten of these fish had been surgically-implanted with AVM brand radio tags (WT = 12 g). All of these fish were from the group of fish being reared at Wahweap. There were no other stockings of razorback sucker in 1996, either in the San Juan River itself or in the San Juan River Arm of Lake Powell.

Monitoring Of Stocked Fish

Monitoring of experimentally stocked razorback sucker consisted of radiotelemetry observations and information gained when razorback sucker were recaptured by electrofishing, trammel netting, or seining. Radiotelemetry of stocked razorback sucker was done largely during razorback sucker radio telemetry trips throughout the year, although radio contacts with fish were obtained during research trips for some other studies as well (i.e., winter habitat use by Colorado pikeminnow (radio telemetry). Recaptured razorback sucker were mostly contacted during trips for other studies (i.e., adult fish community monitoring, mechanical removal of nonnative fishes, Lake Powell razorback sucker studies, and secondary channel fish community monitoring).

Radio Telemetry

During razorback sucker monitoring trips, two types of radio telemetry contacts were made with razorback sucker, habitat observation contacts and movement contacts. Habitat observation contacts were made during razorback sucker radio telemetry trips and whenever else possible. Habitat observation contacts consisted of locating a fish via radio telemetry and monitoring its movement for a minimum of one hour. During this time, the amount of time the fish spent in each utilized habitat type and all movements made by the fish were marked on a transparent acetate sleeve laid over a hardcopy of aerial videography of the river channel that matched the flow in the river at that time. At the end of one hour, all available habitats were mapped (for the entire width of the river channel) at the fish location and from 100 yards upstream of the fish's most upstream location during the contact period to 100 yards downstream of the fish's most downstream location during the contact period (e.g., Figure 2). Habitat classifications used for mapping habitat (Table 2) were the same as those defined by Bliesner and Lamarra (1993) and used during Colorado pikeminnow habitat use studies (Miller 1994, 1995). Upon return from the field, the transparent sleeves were laid over a small-scale grid to determine the relative percentages of each habitat type available to a given fish at the location area.

Habitat and water quality data were also collected at the habitat observation locations. Habitat data recorded included depth, velocity, substrate, water clarity, cover type, and distance from fish location to cover. Water quality parameters recorded were main channel (MC) and habitat temperatures, dissolved oxygen (DO), conductivity, pH, and salinity. At the end of a habitat observation an attempt was made to recapture the radiotelemetered fish by trammel netting or seining to obtain growth and associated fish community information. This sampling also helped determine if the fish in question demonstrated an avoidance behavior and was, therefore, alive.

To determine if adult razorback suckers select particular habitat types, habitat use was compared to habitat availability (Swanson et al. 1974, Johnson 1980, Osmundson et al. 1995). Preference, or lack thereof, for a particular habitat type was estimated by the average difference between the percent that

Table 2. Habitat classifications used for mapping during razorback sucker habitat observations. Habitat classifications follow the system developed by Bliesner and Lamarra (1993).

Habitat number	Habitat type name	Type of habitat (Slow/Slack water = S, Fast water = F)
1	Backwater	S
2	Backwater pool	S
3	Pool	S
4	Debris pool	S
5	Rootwad pool	S
6	Eddy	S
7	Edge pool	S
8a	Sand shoal	S
8b	Cobble shoal	S
9a	Sand shoal/run	F
9b	Cobble shoal/run	F
10	Run	F
11	Scour run	F
12	Shore run	F
13	Undercut run	F
14	Run/riffle	F
15	Riffle	F
16	Riffle eddy	S
17	Shore riffle	F
18	Riffle/chute	F
19	Chute	F
20	Slackwater	S
21	Isolated pool	S
22	Embayment	S
24	Overhanging vegetation	neither
25	Cobble Bar	neither
26	Rootwad Pile	S (if inundated)
27	Abandoned channel (dry)	neither
28	Sand Bar	neither
29	Tributary	S or F depending on flow
30	Shoal/riffle	F
31	Island	neither
32	Rapid	F
33	Irrigation return	S or F depending on flow
34	Inundated vegetation	S
35	Pocket water	S
36	Boulders	neither
37	Water fall	F or neither

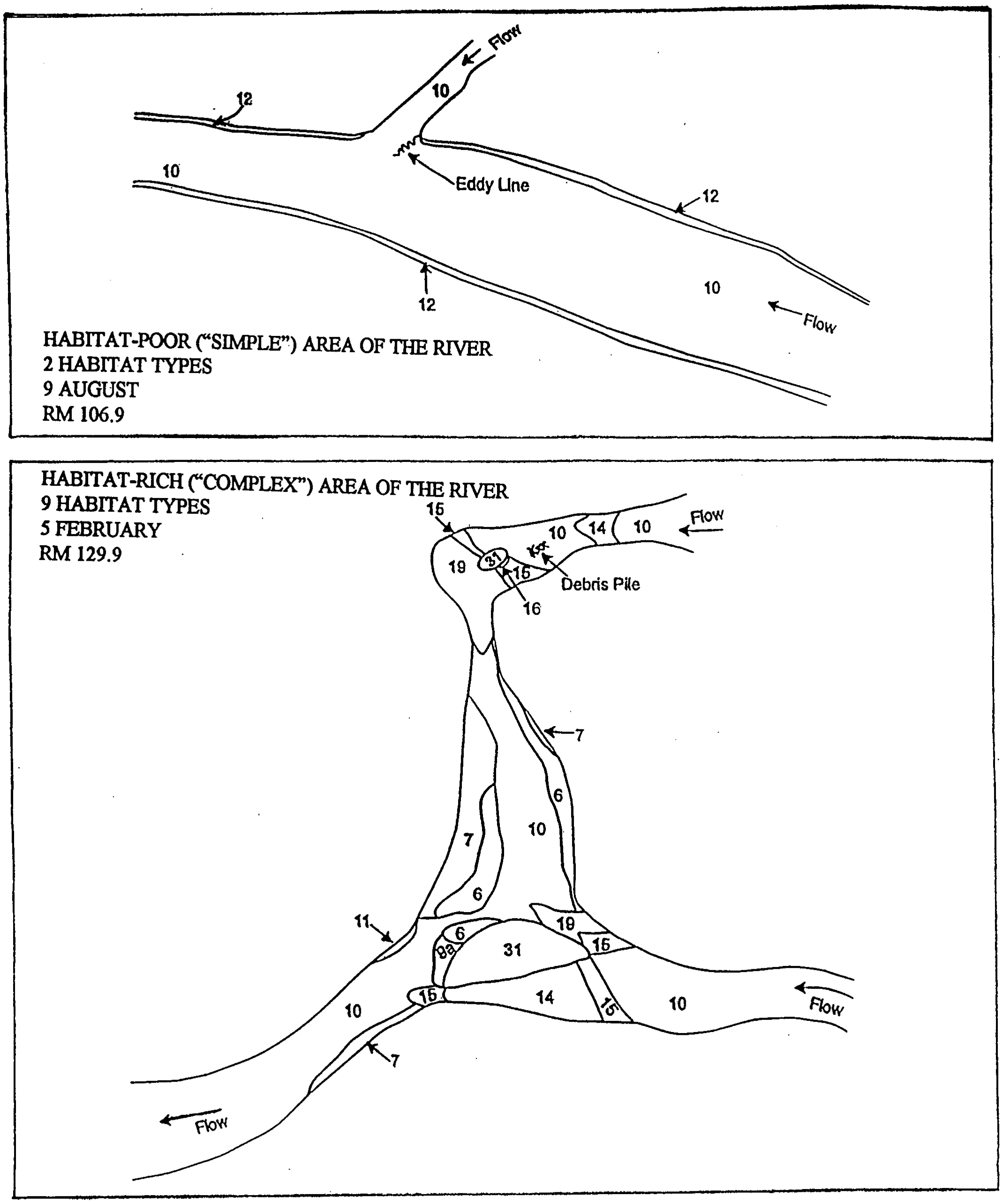

Figure 2. Actual habitat maps from two different razorback sucker radiotelemetry contacts showing the difference between a habitat-poor (i.e., "simple") area of the river with few available habitat types (top) versus a habitat-rich (i.e., "complex") area of the river with numerous available habitat types (bottom). See Table 2 for habitat classifications.

each individual habitat type contributes to the total water area available to an individual fish (within a given contact area) and the percent frequency of use of each individual habitat type by each individual fish. If there is no selection, fish should be located in the various habitat types in the same frequency as the occurrence or availability of those habitat types. For example, if 20% of the total water area is comprised of pool habitat, one would expect 20% of the fish locations to be in pools if habitat use was random, i.e., no selection. If the fish exhibit a selection for certain habitat types, i.e., more use than availability would predict, we assume that those habitat types are important in fulfilling some biological need. Maximizing the quantity and quality of such habitats is viewed as benefitting the fish and is therefore a goal of flow management.

To determine habitat selection, relative percentages for every individual habitat type available to a given fish at each individual fish location were determined. Relative percentages of time that fish spent using each habitat type during the radiotelemetry contact were also determined. Percent availability of each individual habitat type within a given contact area was subtracted from the percent use of that habitat type by that fish. Differences between the two percentages were then averaged across all fish in a given calendar month, riverwide, 1994-1997 combined. This follows the 'aggregate percent method' (Swanson et al. 1974) that greatly reduces biases associated with unequal numbers of contacts among sampled fish. In addition, analyses involving a limited number of fish observations are greatly enhanced if observations made during many months (i.e., a given calendar month over many years) can be pooled to increase sample size (Osmundson et al. 1995). This mean difference between percent use and percent availability, called the "weight value", was then used as a measure of the degree of selection for each individual habitat type. Those habitat types with positive weight values (>0) were considered to be selected for; the higher the value, the more selected for. Negative weight values were interpreted simply as a lack of selection for a specific habitat type rather than an active avoidance of it (Osmundson et al. 1995). After weight values were determined, negative weight values were dropped from further analysis and all positive weight values for a given month were ranked in descending order to determine the relative importance of selected habitats within a given month. All positive weight values within a given month were then converted to a scale of 100% to make it easier to view the relative degree of selection between selected habitats.

Also it was assumed that the combination of habitats, adjacent to one another, would also play a role in the fishes site selection process. Therefore, after determining selected habitats, habitat richness was used to determine the specific blocks of habitats that might be selected. Habitat richness, the number of individual available habitat types observed (i.e., mapped) within each contact area during each individual fish contact, was averaged across all contacts in a given calendar month, riverwide, 1994-1997 combined. The habitat richness value for each month or season determines the number of habitat types to manage for in our habitat recommendations for adult razorback suckers. For example, the mean habitat richness for all June contacts, 1994-1996, was 6. Thus, we assume that a block of six habitat types is therefore important in fulfilling a biological need for these fish. Main channel runs were not included in habitat blocks since they were ubiquitous, the dominant habitat type in all razorback sucker contacts, and were utilized, though not necessarily selected by radio-tagged razorback suckers, during most months. A Krukal-Wallis nonparametric test was used to test if monthly changes in habitat richness were statistically significant. Since habitat richness was a set, quantifiable value for each fish location (i.e., not a sample value such as catch rate), the alpha value for determining significance between comparisons was set at $p < 0.05$. If significant differences were detected, a two-sample Kolmogorov-Smirnov (K-S) test was performed to identify significant differences in pairwise monthly comparisons.

During the winters of 1995-1996 and 1996-1997, the Bureau of Reclamation (USBR) made two separate winter low-flow test releases from Navajo Reservoir. These low-flow tests consisted of reducing winter reservoir releases from the normal operating range of 500-600 CFS to 250 CFS. The first low-flow test release occurred between 14 and 27 January 1996. This short-duration test release was designed to identify potential problems that would arise in the river (e.g., fish or invertebrate kills) or with its many users (e.g., municipal water uses, power plant diversions, effects on the Navajo Dam tailwater trout fishery) at low flows. However, it was generally agreed among biologists that little if any biological response would be observed among endangered fish species related to such a short duration low-flow test.

Since no catastrophic effects were observed during the January 1996 two-week test flow, a second low-flow test release was performed between 4 November 1996 and 2 March 1997. The basic objective of this low-flow test was to determine the effect of reduced flows on endangered fish species, their habitat, and other river resources from Navajo Dam downstream to Lake Powell (USBR 1998). Flows less than 250 CFS occurred naturally in the San Juan River before the construction of Navajo Reservoir. In addition, computer modeling has shown that sufficient water can be stored in Navajo Reservoir to make spring releases critical to San Juan River endangered fishes by implementing winter flows of 250 CFS from Navajo Reservoir in low precipitation years and under future water development scenarios. Radio tracking was performed during both winter low-flow tests to observe the effects of reduced flows on razorback sucker habitat use and selection.

The second type of radio telemetry contact was a movement contact. These contacts consisted of simply determining the exact RM at which the radio-telemetered fish was located and marking it on a set of river maps or a data sheet. In some cases more information was obtained if time allowed. These radio telemetry contacts were made during trips for other research studies and were used to determine gross movement patterns only.

Both types of radio telemetry contacts together were used to determine total longitudinal movement, or TLM (total number of RM moved, from the most upstream contact to the most downstream), maximum displacement, or MD (maximum distance moved from the point of release during entire monitoring period), and final displacement, or FD (distance from point of release to point of last contact).

Radio telemetry was used exclusively in determining habitat use, needs and selection of hatchery-reared razorback sucker in the wild. Radio telemetry was used in tandem with recapture information in determining site preference and movement patterns of hatchery-reared razorback sucker in the wild.

Recaptures

Razorback sucker were recaptured via electrofishing on both adult fish community monitoring trips, trips to mechanically remove nonnative fish species, and secondary channel fish community monitoring trips. Razorback sucker that were recaptured while electrofishing were scanned for a PIT tag, weighed, measured, and examined for general health and reproductive status (if apparent). River mile of capture (to the nearest 0.1 RM) was noted, if specifically known. In many electrofishing samples (usually one RM in length) the crew was unaware that they had collected a razorback sucker until the end of the sample when fish were being sorted. In these instances, the exact collection location was impossible to determine, so the point of release was used to determine displacements from point of stocking.

All but three razorback sucker recaptured by electrofishing were returned alive to the river after data collection was complete. On the October 1995 adult fish community monitoring trip, three razorback sucker were harvested to allow a whole-body contaminants analysis to be performed.

See Ryden (2000) for a complete synopsis of dates and RM’s sampled on adult fish community monitoring trips, Buntjer and Brooks (1996) and Brooks et al. (2000) for a synopsis of dates and RM’s sampled on mechanical removal trips, and Propst and Hobbes (2000) for a synopsis of dates and RM’s sampled on secondary channel fish community monitoring trips.

Trammel-netting and seining were done on an opportunistic basis on all razorback sucker radio telemetry trips. In addition, razorback sucker were recaptured via trammel net on a razorback sucker “hunt” trip by the National Park Service and U.S. Geological Survey’s Biological Resources Division in Lake Powell. On razorback sucker monitoring trips, trammel nets were used to block the mouths of secondary channels and backwaters while a seine or second trammel net was dragged from the top of the habitat towards the set net. Seines were used in small, shallow embayments and backwaters where a crew could begin at the mouth of the habitat and seine its entire length and width. All fish collected in trammel nets and seines were enumerated and returned alive to the river. All trammel nets used were 150-feet long and had one-inch mesh. Seines were approximately 12-feet (four-meters) long and had ½-inch mesh.

RESULTS

A total of 54 stocked razorback sucker of known origin (i.e., those for which PIT tag numbers were obtained at time of recapture) were recaptured between 3 March 1995 and 5 October 1997 (Table 3). Of these 54 fish, eight were radio-tagged and 46 were PIT-tagged. Another razorback sucker, stocked by the UDWR into Lake Powell in August 1995, was recaptured at RM 58.0 on 21 May 1996, bringing the total number of individual known-origin razorback sucker recaptured to 55. This fish was not stocked as part of the experimental stocking study, but is included here because it was collected in the San Juan River. Five of the known-origin, experimentally stocked, razorback sucker (three with radio tags and two with PIT tags) were recaptured

Table 3. General information on recaptured razorback sucker that were stocked into the San Juan River between 29 March 1994 and 3 October 1996.

Recapture Date	PIT tag number	Radio Tag	Old		New		Days In River	River Mile		Sex[a]
			TL(mm)	WT(g)	TL(mm)	WT(g)		Recapture	Stocking	
03/09/95	1F685A1C03	None	223	----[b]	231	130	113	94.2	158.6	I
03/16/95	1F43686353	475	427	930	427	803	140	-8.5[c]	79.6	M
04/24/95	Unknown	None	---	----	405	720	----	134.7	Unknown	I
04/24/95	Unknown	None	---	----	424	345	----	134.1	Unknown	I
04/25/95	Unknown	None	---	----	405	700	----	141-140	Unknown	I
04/27/95	1F41483B1D	460	411	707	412	650	182	129.3	117.5	M
05/08/95	7F7D177124	None	341	----	356	450	173	158.6-158	158.6	I
05/08/95	1F404F4A08	None	388	630	388	630	171	156.5	158.6	M
05/09/95	1F40735A54	None	420	----	420	750	172	137.2	158.6	I
05/10/95	7F7D164D53	None	240	----	244	120	175	129.9	136.6	I
05/10/95	1F41401050	None	415	910	427	800	175	127-126	136.6	M
05/11/95	1F43596560	None	388	----	388	600	174	124-123	136.6	M
05/11/95	1F733D0031	None	372	----	376	525	174	124-123	136.6	M
05/11/95	1F402D165E	None	404	----	404	750	174	123-122	158.6	M
05/11/95	1F7441614B	None	390	620	390	510	174	117-116	117.5	F
05/12/95	1F4040075A	None	442	990	442	950	175	110.7	136.6	F
05/12/95	1F40496870	None	408	770	408	720	175	109-108[d]	136.6	M
05/12/95	1F404E666D	None	370	525	372	600	175	102.5	158.6	F
05/13/95	1F41405A06	None	408	----	419	750	176	93.9	117.5	F
05/13/95	1F40326B04	None	364	----	364	635	176	87.6	158.6	I
05/13/95	1F742E4D72	None	408	----	411	765	176	87.3	117.5	I
05/14/95	1F435D1C25	None	422	940	422	850	177	83-82	117.5	M
05/15/95	1F43686353®	475	427	930	427	790	200	72.1	79.6	M
05/15/95	1F41505779	None	414	----	414	675	178	63-62	136.6	M
05/16/95	1F732D724F	None	420	870	424	790	179	54.1	136.6	M
08/01/95	1F435F6B54	None	378	----	387	520	256	38.6	117.5	I
08/01/95	1F733C7240	None	417	820	417	665	256	38.1	79.6	M
10/03/95	1F41394126	None	403	710	442	870	319	151-150	158.6	I
10/05/95	1F733C535F	None	404	780	427	625	321	135-134	136.6	I
10/06/95	1F733C783A	None	428	812	439	800	322	120-119.2	136.6	M
10/07/95	1F731C2E24	None	404	740	411	510	323	114-113	158.6	M
10/09/95	1F40496870®	None	408	770	408	585	325	94-93	136.6	M
04/15/96	1F41386B7D	None	407	740	433	970	514	132.1	79.6	F
04/17/96	1F7328172F	None	427	812	456	970	516	128.3	136.6	F
05/14/96	7F7D177851	None	356	----	397	720	543	143.0	136.6	I
05/14/96	1F413C3034	None	418	----	433	940	543	140.5	158.6	I
05/17/96	1F40464E0D	None	404	800	420	910	546	107.8	158.6	M
05/17/96	1F43670136	None	418	760	450	980	546	101.0	117.5	F
05/19/96	1F435C784A	None	399	----	417	675	548	83.9	158.6	M
05/20/96	1F403B7C6A	None	396	638	412	780	549	69.9	117.5	I
05/20/96	1F7509154E	301	415	750	423	850	236	67.9	158.6	I
05/20/96	1F403E2E35[e]	None	---	----	462	1060	----	66.6	-----	M
05/21/96	1F402F0B67	None	417	778	456	900	287	58.0	0.0[f]	I

[a] I = Indeterminate, M = Male, F = Female

[b] These values were not available due to equipment failure

[c] This fish was stocked at RM 79.6 (27 October 1994), recaptured in Lake Powell on 16 March 1995 (RM -8.5), transported back to original stocking site and later recaptured during electrofishing at RM 72.1 (15 May 1995).

[d] This fish was recaptured twice in 1995 (12 May and 9 October 1995). Upon its second recapture, a bite mark was noted on its back straddling the dorsal keel that was not present earlier in the year.

® These collections are recaptures of previously captured and tagged fish.

[e] No PIT tag could be detected in this fish at the time of recapture. However, the size, appearance, and general health of this fish were indicative of a stocked fish. This fish was implanted with the PIT tag listed here before being released.

[f] This fish was stocked by the Utah Division of Wildlife Resources (UDWR) at Piute Farms (RM 0.0) in Lake Powell on 8 August 1995. This fish was not part of the experimental stocking study.

Table 3, continued.

Recapture Date	PIT tag number	Radio Tag	Old		New		Days In River	River Mile		Sex
			TL(mm)	WT(g)	TL(mm)	WT(g)		Recapture	Stocking	
10/16/96	7F7D164F11	475	403	731	403	731	13	150.0	158.6	M
10/18/96	1F43550544	None	414	786	463	940	700	140.2	158.6	I
10/20/96	7F7D163271	None	348	440	348	390	17	114.2	158.6	I
10/21/96	1F743A347F	None	406	----	460	890	703	103.5	136.6	I
10/21/96	1F43650D2C	None	405	700	453	900	703	103.8	79.6	I
10/22/96	1F5B684A54	101	428	859	430	960	391	93.8	158.6	M
10/22/96	1F587A6725	500	426	778	439	975	391	92.9	158.6	F
10/24/96	1F743D4B65	None	418	800	481	890	706	70.1	79.6	F
05/02/97	1F404D755F	None	382	558	434	1150	896	122.0	136.6	F
05/03/97	1F74333B7F	None	404	688	442	800	897	105.3	136.6	M
05/03/97	7F7D17641A	176	397	680	397	692	212	100.5	158.6	M
05/03/97	Unknown	None	---	----	456	750	----	100.2	-----	M
05/03/97	1F5B684A54®	101	428	859	452	770	603	100.2	158.6	M
05/03/97	1F4031135D	None	383	650	412	650	897	100.2	79.6	M
05/04/97	1F40464E0D®	None	404	800	434	850	898	95.8	158.6	M
05/05/97	1F435A6262	None	396	700	420	660	899	80.3	79.6	M
05/05/97	1F731B4112	None	392	682	410	650	899	75.5	79.6	M
08/12/97	1F73402806	None	392	660	472	1125	998	42.9	79.6	M
08/12/97	7F7D173B24	499	251	185	502	1350	1232	38.7	79.6	M
10/02/97	7F7D173B24®	499	251	185	502	1300	1283	130.8	79.6	M
10/04/97	1F7435F728	None	442	----	471	1000	1051	107.7	136.6	I
10/05/97	1F4132402E	None	396	660	536	1760	1052	100.0	136.6	I

twice, bringing the number of recapture events with known-origin fish to 60 recaptures, including the Lake Powell fish (Table 3).

An additional five razorback sucker of unknown origin (those for which no PIT tag reading was obtained at the time of recapture) were also recaptured. A PIT tag number could not be obtained for four of these five unknown-origin fish due to equipment (i.e., PIT tag reader) failure. The fifth unknown-origin razorback sucker was scanned with a PIT tag reader that was working, but no tag was detected. This fish had apparently expelled its PIT tag or been implanted with a defective PIT tag. Thus, the number of individual, recaptured razorback sucker may have actually been as high as 60, and the number of razorback sucker recapture events as high as 65.

River miles of razorback sucker recaptures ranged from RM 158.0 (just downstream of Hogback Diversion, NM) to RM (-)8.5 (near Copper Canyon in the San Juan River Arm of Lake Powell, UT). Of the 65 razorback sucker recapture events, one was collected by seine during a razorback sucker radio-tracking trip (9 March 1995), one by trammel net in Lake Powell (16 March 1995), four by electrofishing during a single channel catfish removal trip (24-27 April 1995), and 59 by electrofishing during nine adult fish community monitoring trips (8 May 1995-5 October 1997). From these numbers, it appears that electrofishing is the most efficient methodology for monitoring experimentally stocked razorback sucker. It is also apparent that a certain number of stocked razorback sucker, at least those that are stocked as far downstream as Bluff, UT, are moving downstream into Lake Powell.

Habitat Use, Needs, and Selection

Between 29 March 1994 and 24 July 1997, a total of 183 contacts were made with radiotelemetered razorback sucker. Of these 183 radio contacts, 79 were used to determine habitat use, needs, selection, and richness. Habitat use and selection by radio-tagged razorback sucker varied among months, but generally occurred in habitat-rich areas of the river. Habitat use breakdowns for radiotelemetered razorback sucker by season are as follows:

Pre-Runoff And Ascending Limb Of Hydrograph (March, April, And May)

During pre-runoff periods (March and April), radio-tagged razorback sucker used a variety of low-velocity habitat types (pools, eddies, shoals, and backwaters), mixed with a few fast-water habitats (Table 3). These habitats were located along the river’s margins, with the pools and eddies often being located on the inside curve of large bends in the river channel. Main channel runs, although used by radiotelemetered fish in both months, were not a habitat type that was selected for in either month.

During March, radiotelemetered razorback sucker selected four separate habitat types, three of which were slow or slackwater habitat types (Table 3). The most important (i.e., the most selected) low-velocity habitat during March contacts was pool, followed by eddy then by edge pool. Sand shoal/run (a fast water habitat type) was actually the second most selected for habitat type during March contacts. Mean habitat richness at March fish locations was seven habitats (Table 4, Figure 3). Mean water depth at fish locations during March was 2.7 ft. (range = 1.4-4.1 ft.; Figure 4). March was one of only three months (April and June being the other two) in which the mean habitat temperature at razorback sucker locations was warmer than adjacent main channel habitats (Figure 5). Mean habitat temperature at radiotelemetry locations in March was 10.9°C (range = 6.0-13.0°C), while the mean main channel temperature at contact locations in March was 9.8°C (range = 6.0-13.0°C). Mean bottom velocity at March radiotelemetry locations was 1.5 ft. per second (ft/sec; range = 0.9-1.9 ft/sec), while the mean column velocity at these same locations was 1.7 ft/sec (range = 0.05-2.5 ft/sec; Figure 6).

During April, radiotelemetered razorback sucker selected for five separate habitat types, three of which were slow or slackwater habitats (Table 4). The most selected low-velocity habitat during March contacts was sand shoal, followed by backwater, and pool. April was the only month in which either sand shoal or backwater were selected habitat types. Higher velocity shoreline runs and sand shoal/runs were also selected habitat types in April, though to a much lesser degree than were the low-velocity habitat types (Table 4). Mean habitat richness at April fish locations was seven habitats (Table 4, Figure 3). Mean water depth at fish locations during April was 2.3 ft. (range = 0.5-5.5 ft.; Figure 4). April was the second of only three months (March and June being the other two) in which the mean habitat temperature at razorback sucker locations was warmer than adjacent main channel habitats (Figure 5). Mean habitat temperature at radiotelemetry locations in April was 13.0°C (range = 8.0-18.5°C), while the mean main channel temperature at contact locations in April was 12.0°C (range = 8.0-14.0°C). Mean bottom velocity at April radiotelemetry locations was 0.6 ft/sec (range = 0.1-1.6 ft/sec), while the mean column velocity at these same locations was 1.0 ft/sec (range = 0.1-3.0 ft/sec; Figure 6).

On 11 April 1995, the only overnight radio telemetry contact (1,060 minutes {17.7 hours}) during our study was done on a razorback sucker (tag number 325) at RM 40.2. During this contact, the fish remained midchannel, in a main channel run, moving up- and downstream (as well as up and down in the water column) in a roughly oval pattern approximately 100 yards in length for the entire contact. The water temperature was 10.0°C and the flows in the river, as recorded on the USGS gage at RM 53.0 (Mexican Hat, UT) were 3,600 CFS. This indicates that activity (probably related to feeding) was continuing around the clock. Initially, this contact would seem to contradict the habitat selection values presented in Table 4 for April contacts. However, when figuring the habitat selection values for this contact by itself, the large amount of main channel run present at this contact location yields a very low selection value for main channel run habitat. Then when averaged with all other April contacts, selection for main channel runs disappears completely. This particular fish is a perfect example of how figuring habitat selection by this methodology keeps a single fish (even if it is tracked for a much longer time period than all other fish in given month) from biasing habitat selection values.

Habitat selection for May showed a strong selection for eddies associated with the inside of large bends in the river channel (Table 4). Main channel runs adjacent to these eddies were also used, with radiotelemetered razorback

Table 4. Mean habitat selection and mean habitat richness values, by month, calculated for radio-tagged razorback sucker in the San Juan River, 1994-1997. Mean habitat selection values for each calendar month have been converted to a 100 percent scale to make them easier to compare between months.

	Selection By Month										
Habitat Type	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Oct.	Nov.
FAST WATER HABITAT TYPES:											
Run	74		28			3	14	25	15	100	100
Shore Run			2		12						
Sand Shoal/Run				30	9		12		85		
SLOW/SLACKWATER HABITAT TYPES:											
Edge Pool	26	100	44	4			24				
Eddy			26	26		97		75			
Pool				40	21		22				
Backwater					23						
Sand Shoal					35						
Inundated Vegetation							28				
Mean Habitat Richness	7	6	8	7	7	8	6	6	5	4	8
Number of fish[a] contacts were made with (n =)	5	4	4	14	12	4	10	4	5	3	4

[a] = This row represents the number of individual razorback sucker with which habitat observation contacts were made in any given calendar month. Habitat observation contacts were often made with an individual fish more than once in the same calendar month.

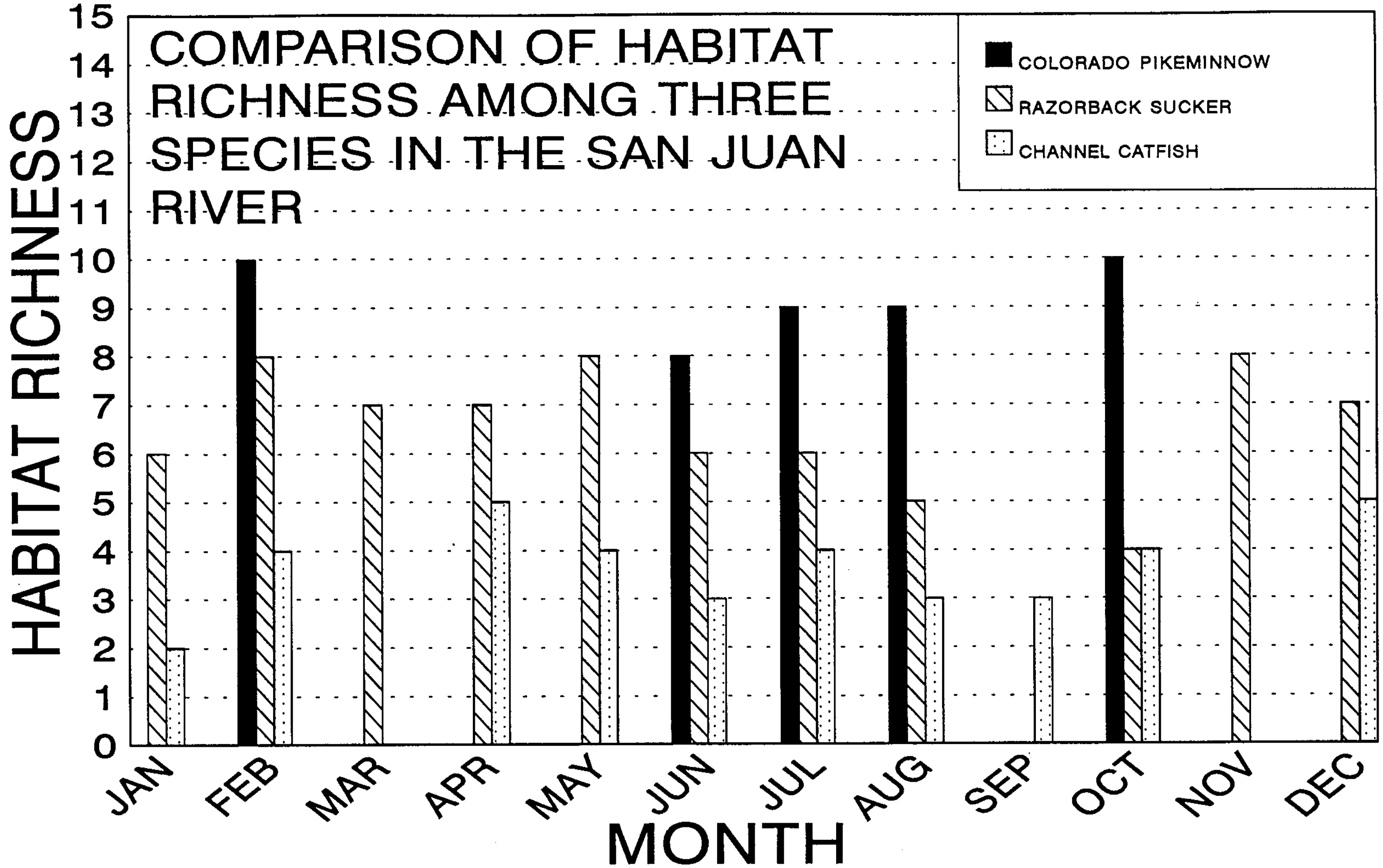

Figure 3. A comparison, by calendar month, of mean habitat richness values obtained for radiotelemetered razorback sucker, Colorado pikeminnow, and channel catfish in the San Juan River, 1992-1997. Numbers for Colorado pikeminnow are from Miller (1999), while those for channel catfish are from Buntjer (1999).

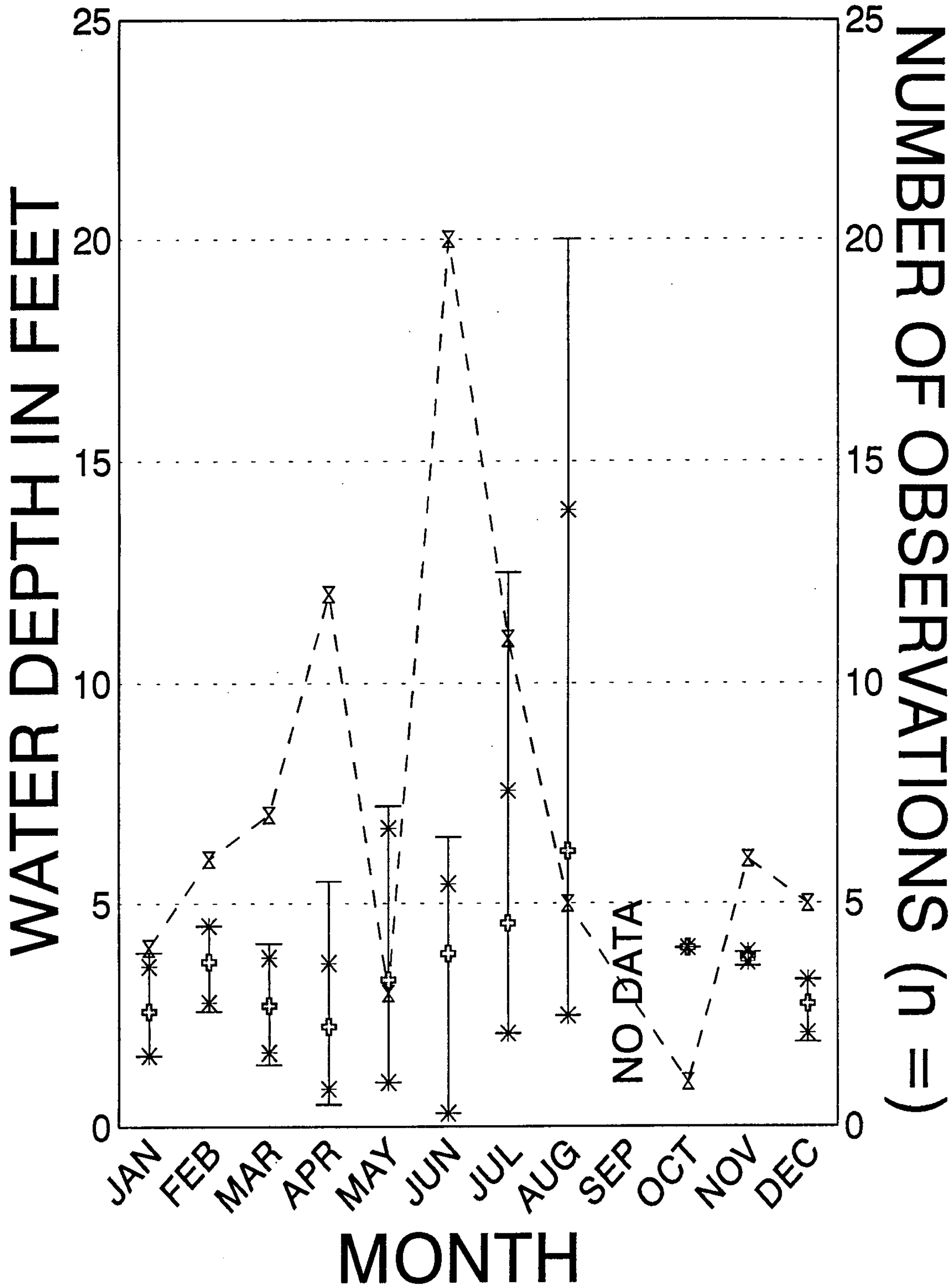

Figure 4. Mean water depth in feet, by month, at razorback sucker radiotelemetry locations. Crosses represent the mean water depth for a given month, error bars represent the range of values for a given month, and asterisks represent the standard deviation values for a given month. Hourglass symbols connected by the dashed line represent the number of individual observations for a given month.

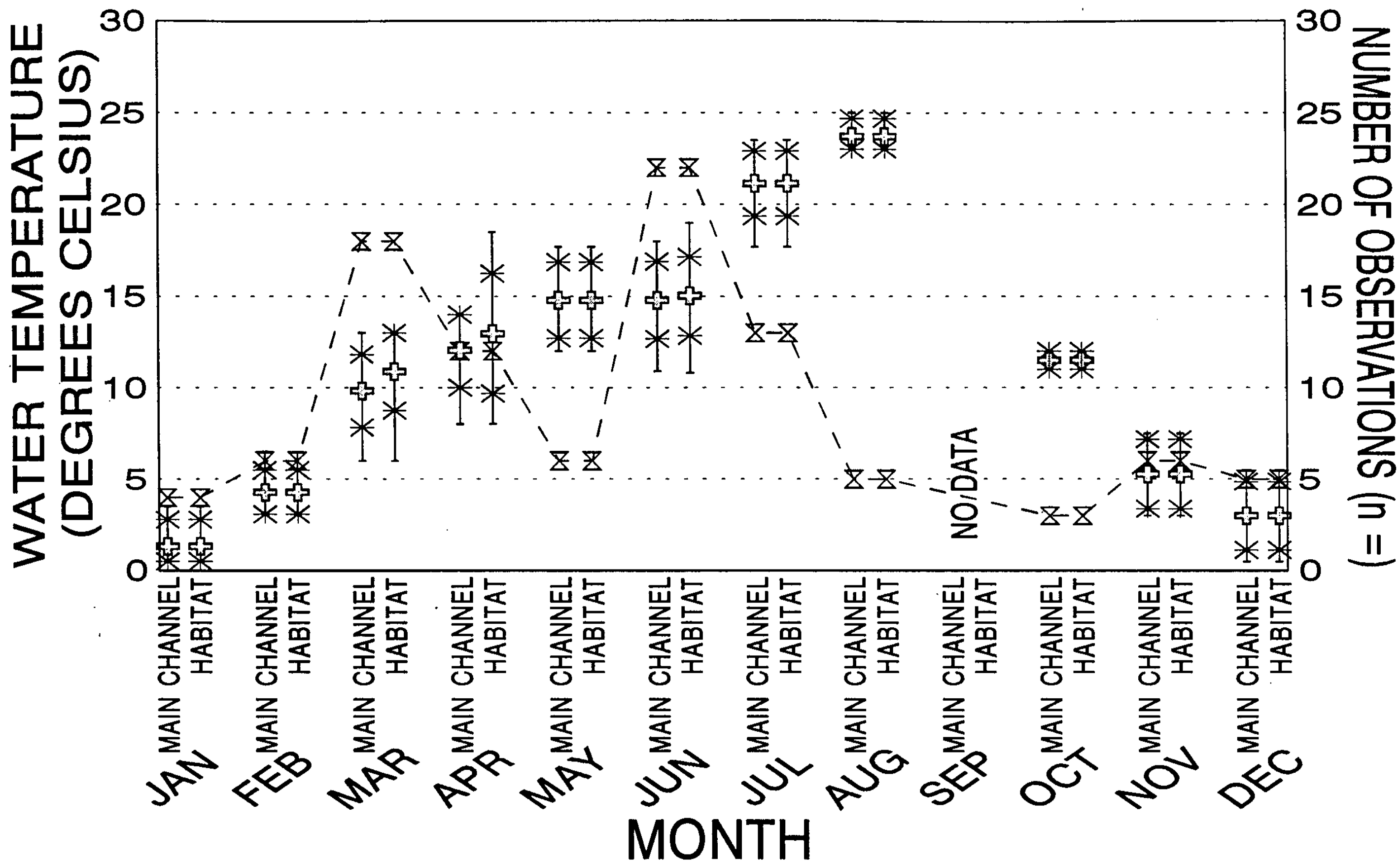

Figure 5. Mean water temperature (in degrees Celsius), by month, for radiotelemetered razorback sucker, in both the habitat being selected by the fish and in the adjacent main channel. Crosses represent the mean water temperature for a given month, error bars represent the range of values for a given month, and asterisks represent the standard deviation values for a given month. Hourglass symbols connected by the dashed line represent the number of individual observations for a given month.

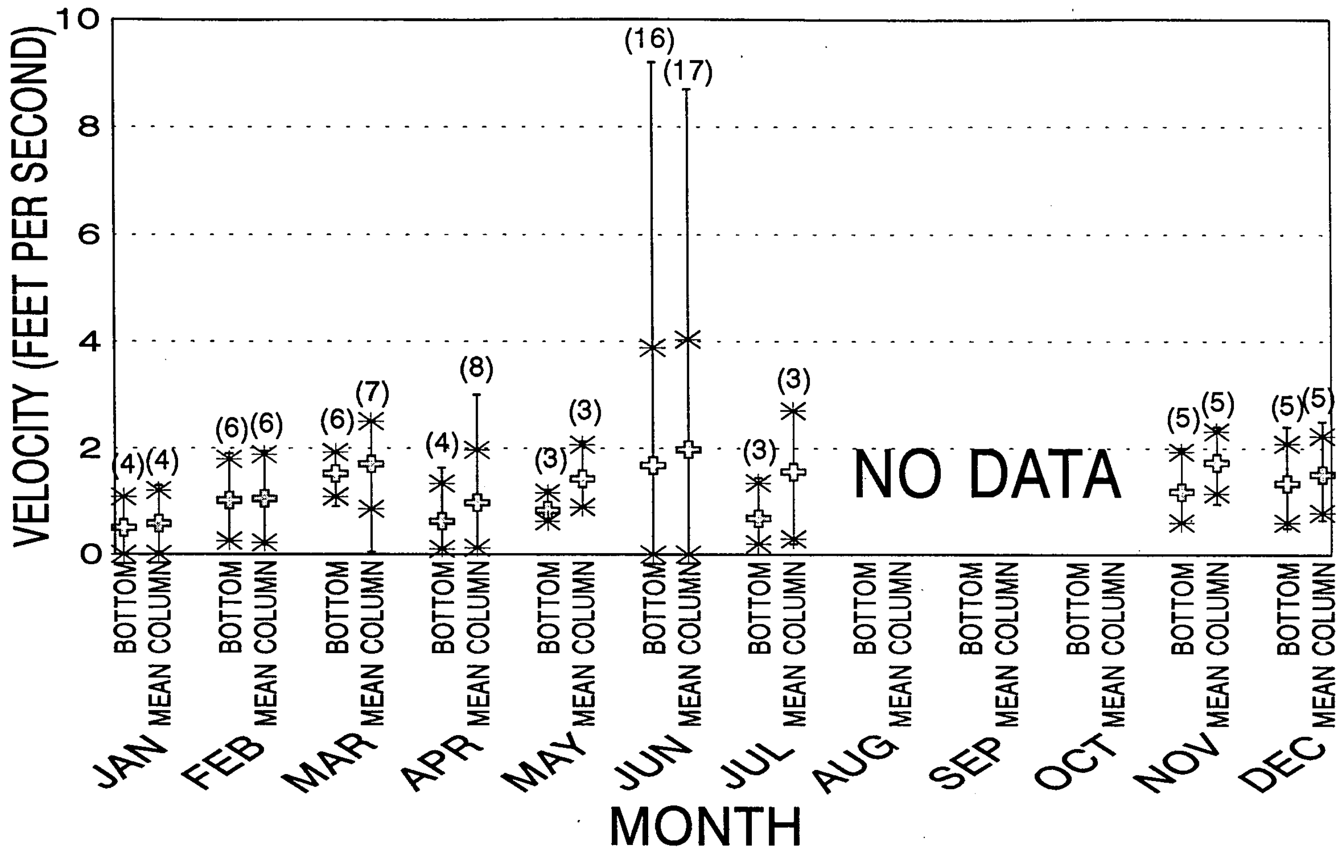

Figure 6. Mean water velocities (in feet per second), both bottom velocities and mean water column velocities, by month, for razorback sucker in selected habitats as determined by radiotelemetry. Crosses represent the mean velocity for a given month, error bars represent the range of values for a given month, and asterisks represent the standard deviation values for a given month. Parenthetic numbers represent the number of individual observations for a given month.

sucker demonstrating a slight selection for these runs. These were the only two habitat types selected for by radiotelemetered razorback sucker. Mean habitat richness at May fish locations was eight habitats (Table 4, Figure 3).

Until May 1997, habitat use by stocked radiotelemetered razorback sucker appeared to be related to resting or feeding. However, during May 1997 electrofishing surveys, nine adult razorback sucker were recaptured. Eight of these were ripe male fish. All eight male fish were captured in aggregations of ripe, presumably spawning, flannelmouth sucker, over midchannel cobble riffles and run/riffles, or along the river's margins over cobble shoal/runs. No velocities were recorded at these locations, but collection locations were all less than three feet in depth. These collections appeared to be tied to sexually mature male razorback sucker exhibiting spawning behavior on the ascending limb of the hydrograph, as was seen in other Upper Colorado River Basin rivers (Tyus 1987, Tyus and Karp 1989, USFWS 1998). Although habitat selection can not be inferred from electrofishing collections, the recapture of these eight male razorback sucker provide circumstantial evidence that suggests a shift in habitat use, if not selection, during spawning periods for individual razorback sucker that have reached maturity.

Mean water depth at fish locations during May was 3.3 ft. (range = 1.0-7.2 ft.; Figure 4). Mean habitat temperature at razorback sucker locations in May was exactly the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in May was 14.8°C (range = 12.0-17.7°C). Mean bottom velocity at April radiotelemetry locations was 0.8 ft/sec (range = 0.6-1.2 ft/sec), while the mean column velocity at these same locations was 1.4 ft/sec (range = 0.9-2.1 ft/sec; Figure 6).

Runoff, Descending Limb Of The Hydrograph, And Post-Runoff (June and July)

Habitat selection during the runoff period (June) was dominated by inundated vegetation (Table 4). June was the only month in which this habitat type was available to razorback sucker. Two other low-velocity habitats, edge pools and pools, were also selected. Higher velocity sand shoal/runs and main channel runs were also selected, but to lesser degrees than low-velocity habitat types. All habitats used, even the main channel runs, were near shore (i.e., not midchannel) habitats. During June runoff (high-flow) periods radio-tagged razorback sucker moved to the river's margins and utilized habitat-rich, low-velocity areas. The reasons for this were probably to avoid high, turbulent main channel flows during runoff as well as for foraging. The mean habitat richness value at June fish locations was six habitats (Table 4, Figure 3). This high habitat richness value for June may be due to the fact that as flows increase and inundate more areas, the margins of the river channel become increasingly complex, rather than actual habitat selection by radiotelemetered razorback sucker. Mean water depth at fish locations during June was 3.9 ft. (range = 0.3-6.5 ft.; Figure 4). June was the last of three months (March and April being the other two) in which the mean habitat temperature at razorback sucker locations was warmer than adjacent main channel habitats (Figure 5). Mean habitat temperature at radiotelemetry locations in June was 15.0°C (range = 10.8-19.0°C), while the mean main channel temperature at contact locations in April was 114.8°C (range = 10.9-

18.0°C). Mean bottom velocity at June radiotelemetry locations was 1.7 ft/sec (range = 0.0-9.2 ft/sec), while the mean column velocity at these same locations was 2.0 ft/sec (range = 0.0-8.7 ft/sec; Figure 6).

In July (the descending limb of the hydrograph to post-runoff), as flows decreased, habitat use for radio-tagged razorback sucker greatly resembled use in May (ascending limb of the hydrograph), with eddies being the dominant selected habitat type and main channel runs being the only other selected habitat type (Table 4). July was the last month until December that low-velocity habitats were selected for by radiotelemetered razorback sucker. The mean habitat richness value for July was six habitats (Table 4, Figure 3). Mean water depth at fish locations during July was 4.6 ft. (range = 2.1-12.5 ft.; Figure 4). Mean habitat temperature at razorback sucker locations in July was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in July was 21.1°C (range = 17.7-23.5°C). Mean bottom velocity at July radiotelemetry locations was 0.7 ft/sec (range = 0.2-1.4 ft/sec), while the mean column velocity at these same locations was 1.6 ft/sec (range = 0.2-2.7 ft/sec; Figure 6).

Post-Runoff Summer/Fall Base-Flow Period (August Through October)

Habitat use and selection during this time of the year differed greatly from that seen in preceding periods. As flows receded to the summer/fall base-flow period (August through October), midchannel, main channel fast water habitats (i.e., main channel runs and sand shoal runs) were the only selected habitat types (Table 4). This selection of midchannel, main channel, fast water habitat types, as well as the fact that radiotelemetered razorback sucker remained active throughout the day, probably indicates a period of almost around-the-clock, active feeding. No low-velocity habitat types were selected during the summer/fall base-flow period.

In addition, the summer/fall base-flow period was the time period when habitat richness of areas used by razorback sucker was most reduced (i.e., fish were using less habitat-rich or simplified areas of the river). These low habitat richness values were probably, once again, as much a factor of what habitat were available in the river at low flows as actual habitat selection by radiotelemetered razorback sucker. When flows drop to a base-flow condition, many features that help form low-velocity habitats at higher flows (e.g., secondary channels, mouths of seasonal washes, and debris and rootwad piles) become isolated and dry as the remaining water is funneled into a more simplified channel. The only time this is not the case during the summer/fall base-flow period is when rain storms cause very short-duration (and often quite dramatic) flow spikes. However, these flow spikes are usually very short (i.e., several hours to a few days) in duration, making other habitats available to fishes for only a short amount of time. Unfortunately, because of the short duration and random nature of these “storm spikes,” no contacts were made with radiotelemetered razorback sucker during any of these events. Thus, it is not known whether these storm spikes cause a shift in habitat use by razorback sucker or not.

During August, radiotelemetered razorback sucker utilized two fast water habitat types, runs, and sand shoal/runs (Table 4). The mean habitat richness value for August was five habitats (Table 4, Figure 3). Mean water depth at fish locations during August was 6.2 ft. (range = 2.5-20.0 ft.; Figure 4). These water depth numbers for August include a single contact with a radiotelemetered fish (tag number 025) that was utilizing a very deep water (i.e., 20.0 ft. deep) main channel run habitat at RM 23.0 on 2 August 1995. This particular habitat depth number is probably somewhat skewed to a deeper number than is really representative, since there are not many places in the entire San Juan River, even during high flows, that are 20-ft. deep, let alone during August base-flows. Mean habitat temperature at razorback sucker locations in August was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in August was 23.7°C (range = 23.0-25.0°C). No velocities were recorded for August radiotelemetry contacts.

In contrast to habitat use and selection observed among radiotelemetered razorback sucker, a single PIT-tagged razorback sucker was recaptured, via electrofishing, in August 1995 at RM 38.6, in a large, deep (>6 feet) backwater on river left. Again it must be stated that habitat use or selection cannot be inferred from electrofishing data. However, this fish was collected in the only backwater of this size available between Mexican Hat, UT and Lake Powell. In addition, it was collected approximately 30 yards upstream from the mouth of the backwater, probably indicating that it was in the backwater before the electrofishing raft entered it. How long this fish had, or continued to, occupy this backwater after its release is unknown. So, it is not known whether backwaters, where they are present at razorback sucker locations, are a habitat that this species would select for. On this same day, a second PIT-tagged razorback sucker was collected in a main channel run on river left, indicating that not all razorback sucker in the immediate area of this backwater were using it.

No radiotelemetry contacts were made with razorback sucker during September. However, given the great similarities between August and October data for radiotelemetered fish, it is assumed for the sake of this report that September habitat selection, habitat richness values, depths, and temperatures were very similar to those obtained for August and October.

During October, radiotelemetered razorback sucker used (and thus selected for) only one habitat type, main channel run (Table 4). The mean habitat richness value for October was four habitats, the lowest value for the entire year (Table 4, Figure 3). Mean water depth at fish locations during October was 4.0 ft. (Figure 4). Mean habitat temperature at razorback sucker locations in October was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in October was 11.5°C (range = 11.0-12.0°C). No velocities were recorded for October radiotelemetry contacts.

Fall/Winter Transition Period (November)

In November, as was the case with October contacts, midchannel main channel runs were the only used and selected habitat (Table 4). The one difference between the two months was that the mean habitat richness value at November contact locations was once again high, being eight habitats, as opposed to four habitats in October (Table 4, Figure 3). Mean water depth at fish locations during November was 3.8 ft. (range = 3.6-3.9 ft.; Figure 4). Mean habitat temperature at razorback sucker locations in November was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in November was 5.3°C (range = 3.0-7.5°C). Mean bottom velocity at November radiotelemetry locations was 1.2 ft/sec (range = 0.6-2.0 ft/sec), while the mean column velocity at these same locations was 1.7 ft/sec (range = 1.0-2.4 ft/sec; Figure 6).

Winter Base-Flow Period (December Through February)

During December, only two habitat types were selected for, main channel runs and edge pools (Table 4). Main channel runs were selected for more in the early part of December when daytime water temperatures regularly topped 3.0°C. Radiotelemetered fish remained active in the main channel during warmer parts of the day, but used edge pools during the early morning and late afternoon as temperatures cooled. Later in the month as colder air temperatures prevailed, radiotelemetered fish selected for edge pools and became much more sedentary. The mean habitat richness value for December contacts was seven habitats (Table 4, Figure 3). Mean water depth at fish locations during December was 2.8 ft. (range = 1.9-3.3 ft.; Figure 4). Mean habitat temperature at razorback sucker locations in December was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in December was 3.0°C (range = 0.5-5.5°C). Mean bottom velocity at December radiotelemetry locations was 1.3 ft/sec (range = 0.5-2.4 ft/sec), while the mean column velocity at these same locations was 1.5 ft/sec (range = 0.7-2.5 ft/sec; Figure 6).

During January, consistently the coldest month of the year during our studies, radiotelemetered razorback sucker selected only one habitat type, edge pools (Table 4). During January contacts, razorback sucker were very sedentary, with the most active making only short (i.e., several minute) forays into main channel runs during the very warmest parts of the day (i.e., above 3.0°C, before returning to shoreline edge pools. On colder days (i.e., those days where temperatures did not get above 3.0°C), radiotelemetered fish hardly moved at all. The mean habitat richness value for January contacts was six habitats (Table 4, Figure 3). Mean water depth at fish locations during January was 2.6 ft. (range = 1.6-3.9 ft.; Figure 4). Mean habitat temperature at razorback sucker locations in January was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in January was 1.3°C (range = 0.5-3.5°C). Mean bottom velocity at January radiotelemetry locations was 0.5 ft/sec (range = 0.0-1.1 ft/sec), while the mean column velocity at these same locations was 0.6 ft/sec (range = 0.05-1.3 ft/sec; Figure 6).

As water temperatures began to warm up again in February, radiotelemetered razorback sucker once again began to become fairly active. During February, razorback sucker selected for four different habitats, only two of which were low-velocity habitat types. The most selected habitat type was still edge pool, followed by main channel run, eddy, and shore run (Table 4). The mean habitat richness value for February was eight habitats (Table 4, Figure 3). Mean water depth at fish locations during February was 3.7 ft.

(range = 2.6-4.5 ft.; Figure 4). Mean habitat temperature at razorback sucker locations in February was the same as that of adjacent main channel habitats (Figure 5). Mean habitat and main channel temperature at radiotelemetry locations in February was 4.3ºC (range = 3.0-6.5ºC). Mean bottom velocity at February radiotelemetry locations was 1.0 ft/sec (range = 0.3-1.9 ft/sec), while the mean column velocity at these same locations was 1.0 ft/sec (range = 0.2-2.0 ft/sec; Figure 6).

A Kruskal-Wallis test indicated that there were significant differences in habitat richness values between months (test statistic = 19.682, p = 0.032). A K-S test revealed that in sequential comparisons, there were no significant differences (p > 0.05 in all cases) in habitat richness from one month to the next. In monthly pairwise comparisons, the only significant difference between habitat richness values was in February versus October (p = 0.025). All other K-S values showed no significant differences in monthly pairwise comparisons (p > 0.05).

Site Preference

Data for site preference are sparse. Groupings of razorback sucker sampled at three locations in the San Juan River may indicate preference for a specific site in the river. The first possible evidence for a preferred site is centered around a large backwater on river left at RM 38.6. On 1 August 1995, a 387 mm TL razorback sucker of indeterminate sex was electrofished from this backwater, approximately 50 ft. upstream of its mouth. Water depth at this recapture location was 3.0 ft. deep, with a silt substrate. A second razorback sucker (a 417 mm TL male) was collected along the shoreline on the river left at RM 38.1 just minutes later. A third razorback sucker (a 502 mm TL male) was collected from the river left shoreline at RM 38.7, just upstream of the mouth of the backwater on 12 August 1997.

The second possible preferred site is just downstream of Aneth, UT at RM 100.2 on river right. On 3 May 1997, one ripe male razorback sucker (397 mm TL) was collected within a few yards downstream of the McElmo Creek confluence (RM 100.5), on river right. Approximately three-tenths of a mile downstream (at RM 100.2), three more ripe male razorback sucker (412, 452, and 456 mm TL) were captured in a single dip net full of fish over a shoreline cobble shoal/run. In addition, three other razorback sucker were observed, but not captured, in this same aggregation of fish.

The last possible preferred site for razorback sucker is a large backwater on river left just upstream of Sand Island boat launch at RM 77.3. On 21 October 1997, an immature razorback sucker (216 mm TL) was seined from this backwater by a crew from UDWR. This fish was a razorback sucker that had been stocked on 3 September 1997 at RM 158.6, and was not a part of this study. The following year on 5 October 1998, one male razorback sucker (444 mm TL) was collected along the river left shoreline just upstream of the mouth of this backwater. In addition, another male razorback sucker (423 mm TL) was collected at the mouth of the backwater and a third razorback sucker was observed but not netted (unpublished data). These two male razorback sucker were originally stocked as part of the experimental stocking study, but are not included in any other analyses in this report as they were not recaptured previous to the end of this study (i.e., 1997).

Movement Patterns

Stocked razorback sucker displayed large initial downstream displacements shortly after being stocked. Among the 15 radiotelemetered fish stocked in March 1994, one (tag number 599) stocked at RM 117.5 was contacted 5.5 RM downstream of the stocking site in 17 days (Figure 7). This fish was contacted several more times at this same location on later dates. Two other radiotelemetered fish from the March 1994 stocking (tag numbers 739 and 448; both stocked at RM 136.6) were contacted 19.9 and 33.8 RM downstream, respectively, of their stocking site within 47 days after stocking (Figure 7). Tag number 739 was contacted 0.2 RM upstream 12 days later, while tag number 448 has not been contacted since that date. No short-term contacts were made with radiotelemetered fish stocked in the fall of 1994 (Figure 8).

Of the 16 fish stocked in September 1995 (at RM 158.6), three (tag numbers 350, 490, and 500) were contacted on 8 October 1995. All three had moved over 50 RM downstream from the stocking site (56.7, 57.5, and 54.7 RM, respectively) in only eleven days (Figure 9). When contacted 52 days later, tag number 500 had moved upstream 8.0 RM. Neither of the other two fish has been contacted since.

Of the ten radiotelemetered fish stocked in October 1996 (at RM 158.6), one (tag number 475) was recaptured 8.6 RM downstream 13 days after stocking, but had moved upstream 2.2 RM when contacted 28 days later (Figure 10). Another (tag number 311) was contacted 90.5 RM downstream 21 days after stocking. This fish has not been contacted since that date. In addition, a PIT-tagged fish stocked at RM 158.6 in October 1996 was recaptured 17 days later 44.4 RM downstream of the stocking site (Table 3).

Mean FD values for all four groups of radiotelemetered razorback sucker were less than both mean TLM and mean MD values (Tables 5-8).

Razorback sucker stocked in the spring had smaller MD values than those stocked in the fall, despite being smaller fish and having to deal with high spring flows relatively soon after stocking. The mean MD for smaller radiotelemetered razorback sucker (mean TL at stocking = 277 mm) stocked in the spring of 1994 was 13.2 RM (based on 15 fish), while the mean MD for larger radiotelemetered razorback sucker (mean TL at stocking = 410 mm) stocked in the fall was 50.5 RM (based on 23 fish). The majority of razorback sucker tracked during runoff events, despite their size at stocking, did not show any great downstream displacements coinciding with high flow events (Figures 7-10). On the contrary, these fish more often than not held their relative position in the river during the runoff periods in which they were tracked. In addition, the mean MD value for recaptured PIT-tagged razorback sucker (all of which were stocked in the fall) was 30.4 RM (based on 46 fish; mean TL at stocking = 393 mm). For all fish from fall stockings (n = 69; mean TL at stocking = 399 mm), whether radiotelemetered or PIT-tagged, for which a MD could be determined, the mean MD was 37.1 RM.

Movements varied between groups of razorback sucker stocked at different stocking sites. Overall, MD for PIT-tagged fish recaptured between 1995 and 1997 ranged from 52.5 RM upstream to 82.5 RM downstream of the original

Table 5. Total longitudinal movement, maximum displacement, and final displacement of radiotelemetered razorback sucker stocked in the San Juan River, 29 and 30 March 1994.

MARCH 1994 STOCKING Tag Number	Release RM	Number of Contacts	Number of Days Contact with Fish was Maintained	Total[a] Longitudinal Movement (RM)	Maximum[b] Displacement in RM	Final[c] Displacement in RM
428	136.6	8	132	22.1	22.1(-)	22.1(-)
448	136.6	2	45	33.8	33.8(-)	33.8(-)
539	136.6	7	132	22.1	22.1(-)	22.1(-)
739	136.6	6	70	19.9	19.9(-)	19.7(-)
819	136.6	4	83	16.8	16.8(-)	16.8(-)
406	117.5	3	133	10.7	10.6(-)	10.6(-)
439	117.5	6	84	0.2	0.2(-)	0.0
519	117.5	5	84	3.8	3.8(-)	3.8(-)
599	117.5	8	133	5.5	5.5(-)	5.5(-)
639	117.5	2	16	0.1	0.1(+)	0.1(+)
398	79.6	8	85	1.1	1.1(-)	0.6(-)
418	79.6	6	132	2.4	2.4(-)	1.8(-)
499	79.6	3	1283	92.1	51.2(+)	51.2(+)
748	79.6	7	85	3.0	3.0(-)	2.9(-)
808	79.6	8	125	5.7	5.7(-)	5.7(-)
Mean				16.0	13.2	13.1
Standard Deviation				23.4	14.6	14.7
Standard Error				6.0	3.8	3.8

[a] Total number of river miles moved, from the most upstream contact to the most downstream.

[b] Maximum distance moved from point of release during entire monitoring period, (+) represents upstream movement, (-) represents downstream movement.

[c] Distance from point of release to point of last contact, (+) represents upstream movement, (-) represents downstream movement.

Table 6. Total longitudinal movement, maximum displacement, and final displacement of radiotelemetered razorback sucker stocked in the San Juan River, 27 October 1994.

OCTOBER 1994 STOCKING Tag Number	Release RM	Number of Contacts	Number of Days Contact with Fish was Maintained	Total[a] Longitudinal Movement (RM)	Maximum[b] Displacement in RM	Final[c] Displacement in RM
126	136.6	3	46	0.9	0.9(-)	0.9(-)
225	136.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
375	136.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
525	136.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
576	136.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
826	136.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
025	117.5	4	279	94.5	94.5(-)	94.5(-)
176	117.5	3	179	107.5	107.5(-)	107.5(-)
460	117.5	3	182	13.1	11.8(+)	11.8(+)
726	117.5	4	265	72.5	72.5(-)	58.7(-)
276	79.6	3	243	20.3	20.3(-)	20.3(-)
325	79.6	5	243	39.4	39.4(-)	39.3(-)
475	79.6	4	200	88.1	88.1(-)	7.5(-)[d]
739	79.6	2	134	9.1	9.1(-)	9.1(-)
775	79.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
926	79.6	1	1	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
Mean				49.5	49.3	38.8
Standard Deviation				41.4	41.5	39.7
Standard Error				13.8	13.8	13.2

[a] Total number of river miles moved, from the most upstream contact to the most downstream.

[b] Maximum distance moved from point of release during entire monitoring period, (+) represents upstream movement, (-) represents downstream movement.

[c] Distance from point of release to point of last contact, (+) represents upstream movement, (-) represents downstream movement.

[d] This fish was captured in Lake Powell on 16 March 1995, transported upstream to Bluff, Utah (RM 79.6), and placed back in the river. It was recaptured at RM 72.1 during an electrofishing trip (15 May 1995).

Table 7. Total longitudinal movement, maximum displacement, and final displacement of radiotelemetered razorback sucker stocked in the San Juan River, 27 September 1995.

SEPTEMBER 1995 STOCKING Tag Number	Release RM	Number of Contacts	Number of Days Contact with Fish was Maintained	Total[a] Longitudinal Movement (RM)	Maximum[b] Displacement in RM	Final[c] Displacement in RM
051	158.6	1	1	-------------NOT	APPLICABLE	-------------
101	158.6	3	584	64.8	64.8(-)	58.4(-)
141	158.6	1	1	-------------NOT	APPLICABLE	-------------
199	158.6	1	1	-------------NOT	APPLICABLE	-------------
250	158.6	1	1	-------------NOT	APPLICABLE	-------------
276	158.6	1	1	-------------NOT	APPLICABLE	-------------
301	158.6	2	236	90.7	90.7(-)	90.7(-)
351	158.6	2	11	56.7	56.7(-)	56.7(-)
400	158.6	1	1	-------------NOT	APPLICABLE	-------------
425	158.6	1	1	-------------NOT	APPLICABLE	-------------
490	158.6	2	11	57.5	57.5(-)	57.5(-)
500	158.6	7	391	65.7	65.7(-)	65.7(-)
625	158.6	6	169	70.2	70.2(-)	70.1(-)
676	158.6	1	1	-------------NOT	APPLICABLE	-------------
875	158.6	7	231	63.6	63.6(-)	29.3(-)
976	158.6	1	1	-------------NOT	APPLICABLE	-------------
Mean				67.0	67.0	66.5
Standard Deviation				11.4	11.4	13.0
Standard Error				4.3	4.3	5.3

[a] Total number of river miles moved, from the most upstream contact to the most downstream.

[b] Maximum distance moved from point of release during entire monitoring period, (+) represents upstream movement, (-) represents downstream movement.

[c] Distance from point of release to point of last contact, (+) represents upstream movement, (-) represents downstream movement.

Table 8. Total longitudinal movement, maximum displacement, and final displacement of radiotelemetered razorback sucker stocked in the San Juan River, 3 October 1996.

OCTOBER 1996 STOCKING Tag Number	Release RM	Number of Contacts	Number of Days Contact with Fish was Maintained	Total[a] Longitudinal Movement (RM)	Maximum[b] Displacement in RM	Final[c] Displacement in RM
176	158.6	16	294	60.2	60.2(-)	60.0(-)
258	158.6	4	293	9.8	9.8(-)	9.8(-)
311	158.6	2	21	90.5	90.5(-)	90.5(-)
325	158.6	1	1	NOT APPLICABLE		
437	158.6	1	1	NOT APPLICABLE		
451	158.6	9	294	41.7	41.7(-)	41.6(-)
475	158.6	11	293	21.0	21.0(-)	20.9(-)
551	158.6	1	1	NOT APPLICABLE		
800	158.6	8	413	15.3	15.3(-)	15.1(-)
841	158.6	7	160	10.6	10.6(-)	6.0(-)
Mean				35.6	35.6	34.8
Standard Deviation				30.5	30.5	31.1
Standard Error				11.5	11.5	11.7

[a] Total number of river miles moved, from the most upstream contact to the most downstream.

[b] Maximum distance moved from point of release during entire monitoring period, (+) represents upstream movement, (-) represents downstream movement.

[c] Distance from point of release to point of last contact, (+) represents upstream movement, (-) represents downstream movement.

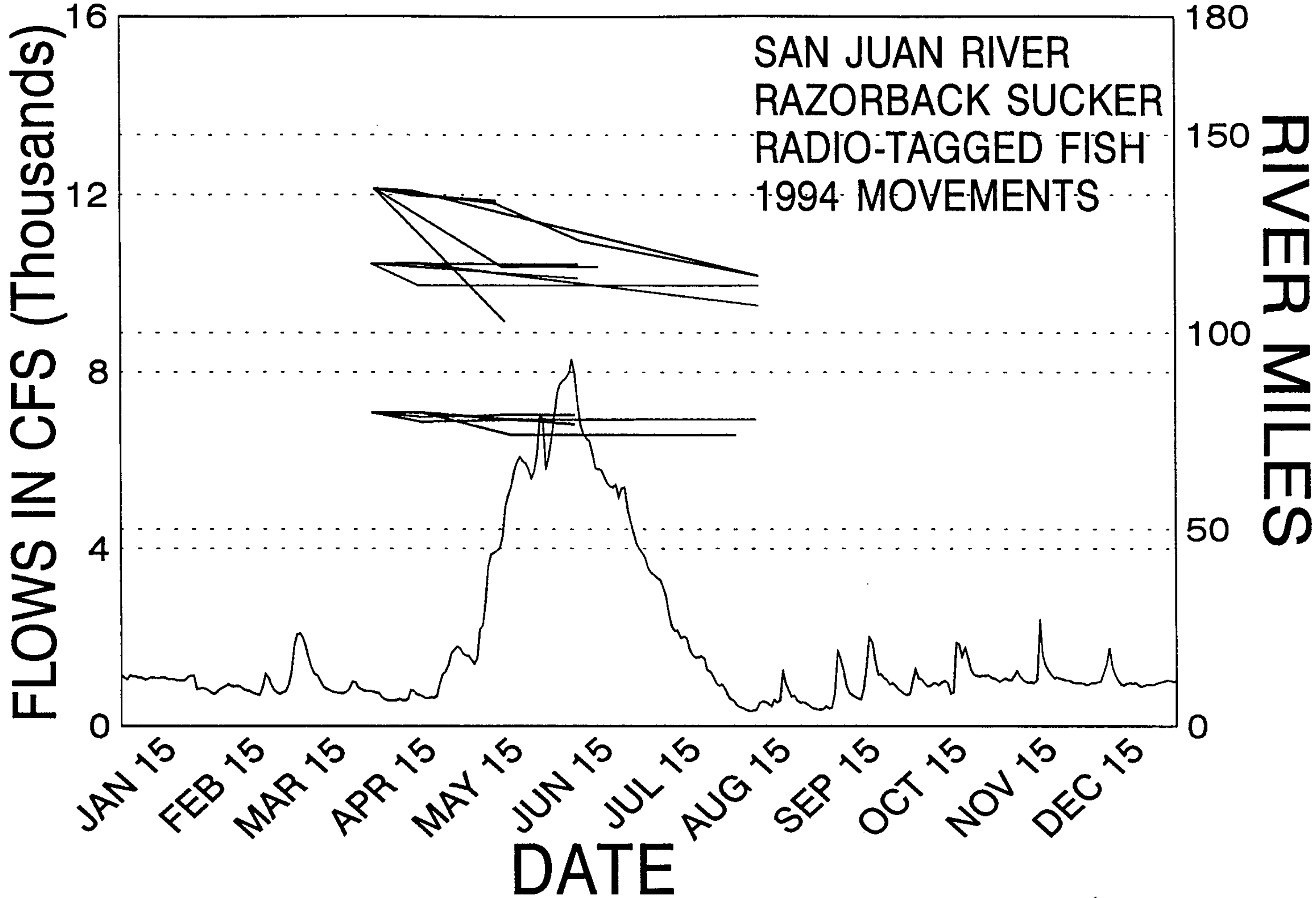

Figure 7. Movements of radiotelemetered razorback sucker that were stocked on 29 and 30 March 1994 (at RM 136.6, 117.5, and 79.6), plotted against the 1994 hydrograph. Lines may represent the movements of more than one fish.

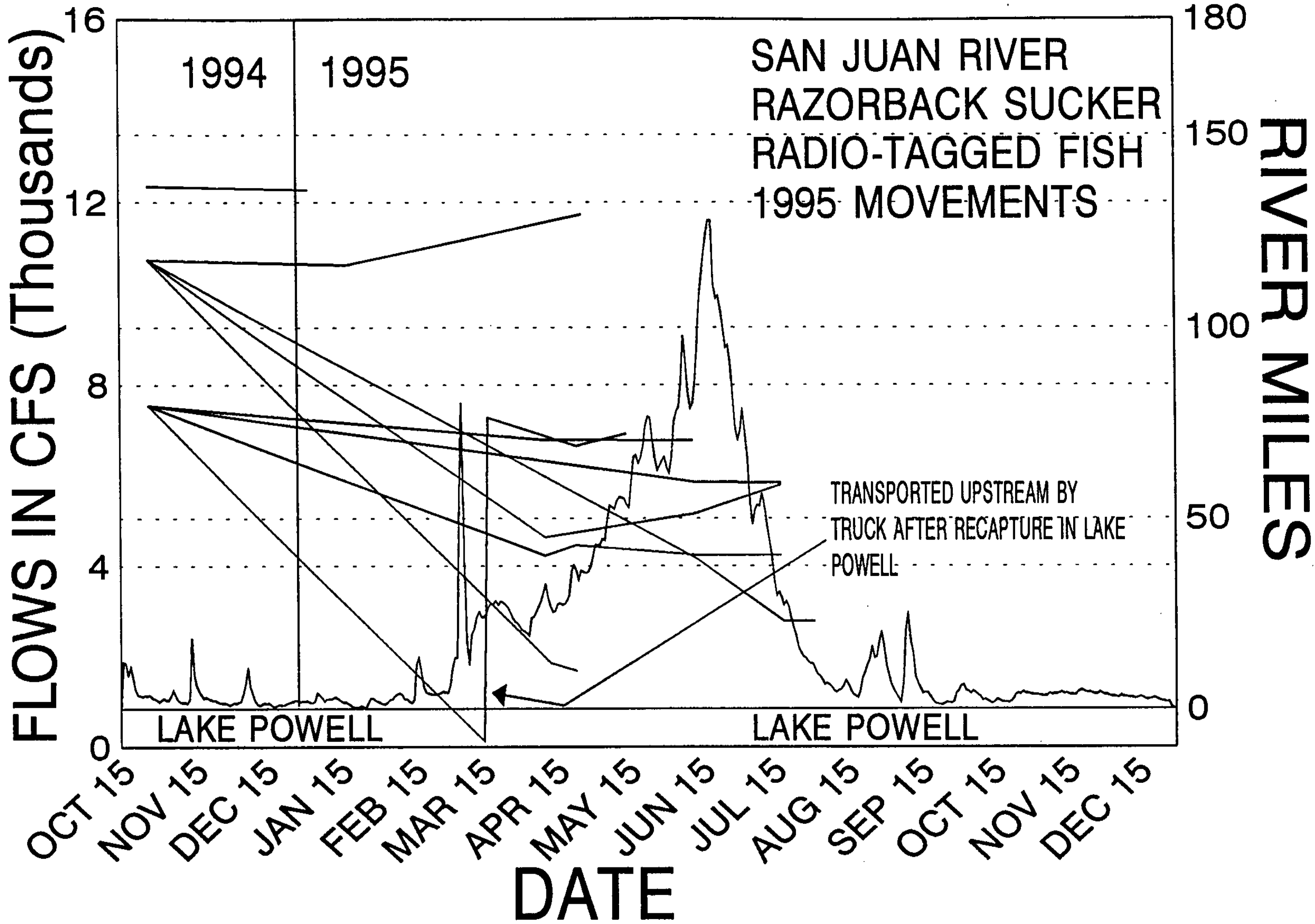

Figure 8. Movements of radiotelemetered razorback sucker that were stocked on 27 October 1994 (at RM 136.6, 117.5, and 79.6), plotted against the 15 October 1994 through 31 December 1995 hydrograph. Lines may represent the movements of more than one fish.

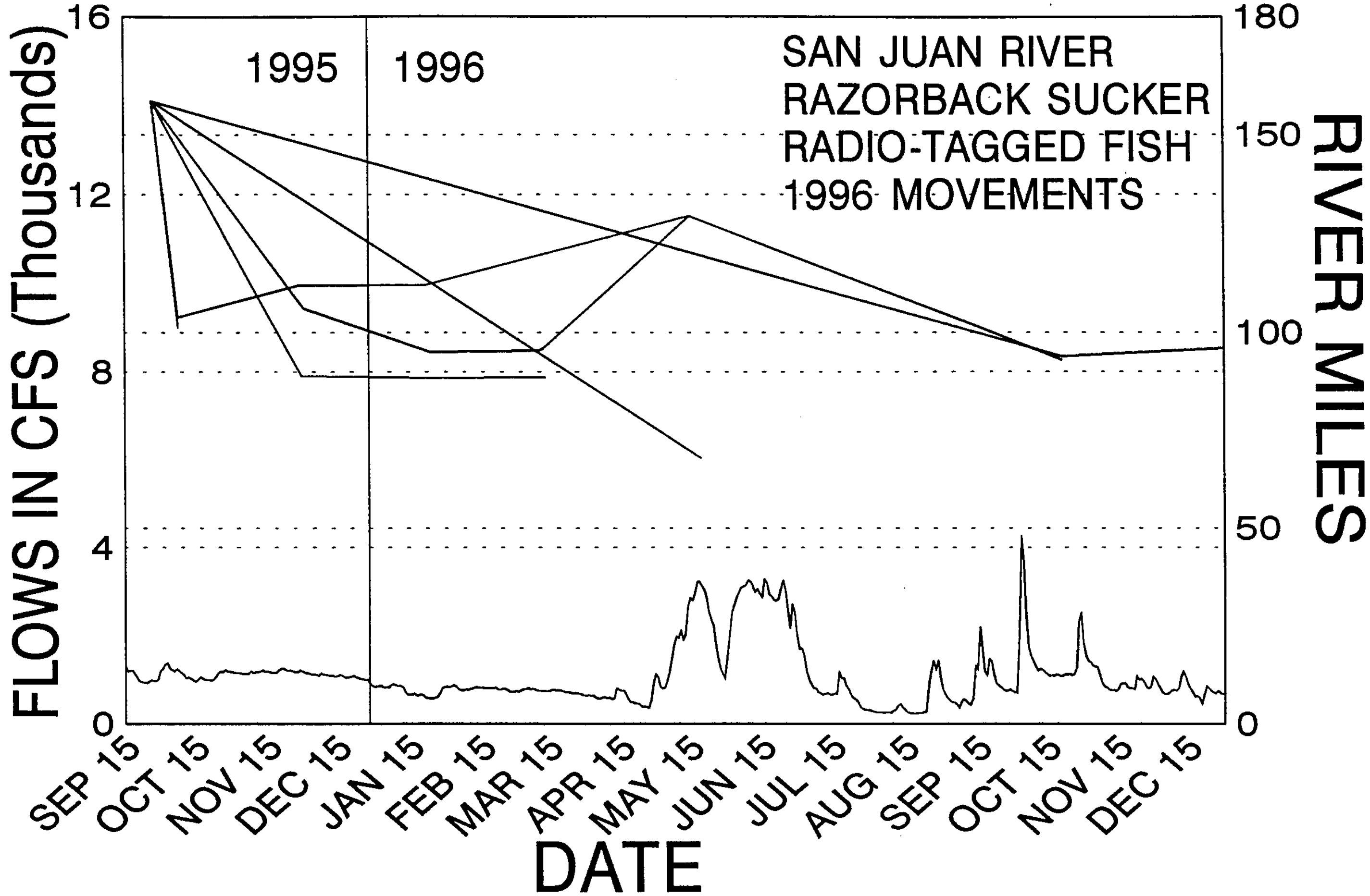

Figure 9. Movements of radiotelemetered razorback sucker that were stocked on 27 September 1995 (at RM 158.6), plotted against the 15 September 1995 through 31 December 1996 hydrograph. Lines may represent the movements of more than one fish.

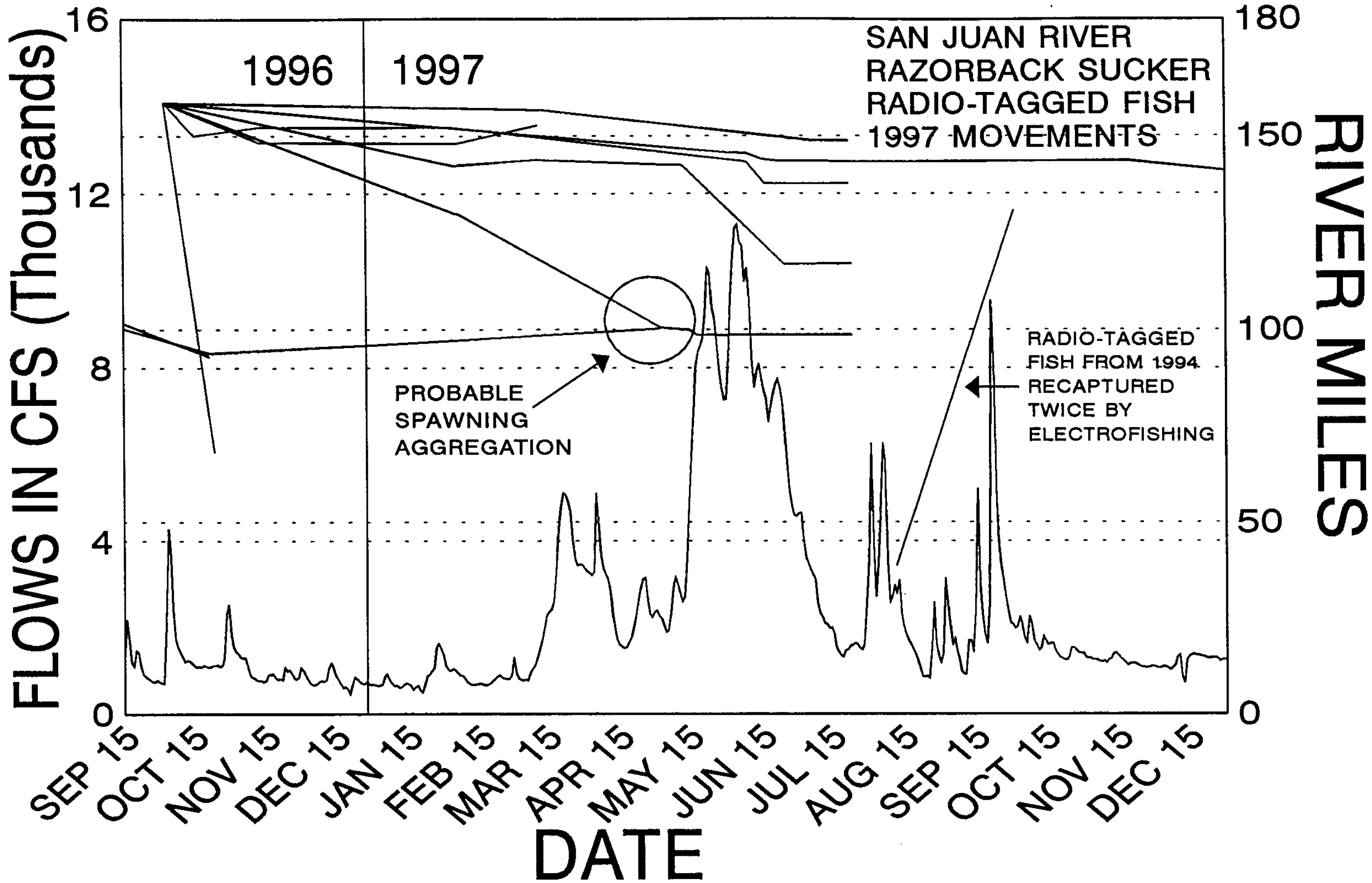

Figure 10. Movements of radiotelemetered razorback sucker that were stocked on 3 October 1996 (at RM 158.6), plotted against the 15 September 1996 through 31 December 1997 hydrograph. Also included are the movements of two radiotelemetered fish from the 27 September 1995 stocking that still had active tags, and two electrofishing recaptures of a radio-implanted razorback sucker (tag was expired at the time of both recaptures) from the 29 and 30 March 1994 stocking. Lines may represent the movements of more than one fish.

stocking sites. Among recaptured, known origin, PIT-tagged razorback sucker, the fish stocked at RM 158.6 demonstrated the greatest MD (mean = 37.5 RM; n = 14 fish), followed by the fish stocked at RM 117.5 (mean MD = 33.4 RM; n = 7 fish), RM 136.6 (mean MD = 26.5 RM; n = 17 fish), and RM 79.6 (mean MD = 23.7 RM; n = 8 fish) sites.

Total longitudinal movements of radiotelemetered razorback sucker tracked between 1994 and 1997 ranged from 0.1-107.5 RM while MD ranged from 51.2-107.5 RM downstream of the original stocking sites (Tables 5-8). Between 1994 and 1997, radio-implanted razorback sucker stocked at RM 158.6 had the greatest TLM and MD (mean TLM = 51.3 RM; mean MD = 51.3 RM; n = 14 fish), followed by fish stocked at RM 117.5 (mean TLM = 34.2 RM; mean MD = 34.1 RM; n = 9 fish), RM 79.6 (mean TLM = 29.0; mean MD = 24.4; n = 9 fish), and RM 136.6 (mean TLM = 19.3 RM; mean MD = 19.3 RM; n = 6 fish).

For both radiotelemetered and PIT-tagged fish combined, MD were greatest for fish stocked at RM 158.6 (mean MD = 44.4 RM; n = 28), followed by fish stocked at RM 117.5 (mean MD = 33.8 RM; n = 16), RM 136.6 (mean MD = 24.6 RM; n = 24.6), and RM 79.6 (mean MD = 24.1 RM; n = 17).

When comparing movement patterns displayed by razorback sucker implanted with only PIT tags versus those implanted with both PIT and radio tags, it was found that recaptured, PIT-tagged fish had smaller mean MD values (mean MD = 30.4 RM; n = 46 fish) than did observed radiotelemetered razorback sucker (mean MD = 35.8 RM; n = 38 fish). However, when tested using a T-test, it was found that the difference in the two MD values was not significantly different (P = 0.37; 95% Confidence Interval {CI}).

There were also differences between movements displayed for razorback sucker of different size classes. Among recaptured PIT-tagged razorback sucker, four young juveniles were recaptured. The mean MD for these four young juveniles was 29.0 RM. A total of 42 subadult/adult PIT-tagged razorback sucker were recaptured during that same time. The mean MD for these 42 fish was 30.5 RM.

Among radiotelemetered razorback sucker, the mean MD for young juvenile razorback sucker razorback sucker was 13.2 RM (n = 15), while the mean MD for subadult/adult radiotelemetered razorback sucker was 50.5 RM (n = 23 fish). For both radiotelemetered and PIT-tagged razorback sucker combined, the mean MD for young juveniles was 16.5 RM (n = 19), while the mean MD for subadult/adults was 37.6 RM. A T-test performed on these values revealed that during this study, based on MD values, young age class razorback sucker moved significantly less post-stocking than did subadult/adult razorback sucker (P = 0.00; 95% CI).

Migratory behavior has been displayed by stocked razorback sucker with downstream movements of up to 92.1 RM (mean 33.7 RM, n = 51) and upstream movements of up to 90.7 RM (mean 30.3 RM, n = 9). The longest upstream movement was displayed by an individual that was 251 mm TL at time of stocking. This fish originally stocked at RM 79.6 on 29 March 1994, was recaptured at RM 38.7 on 12 August 1997. It was recaptured again on 2 October 1997 at RM 130.8, an upstream movement of 92.1 RM in 51 days (Table 3; Figure 10).

In the spring of 1997, several razorback sucker moved to the area of the San Juan River just downstream of Aneth, Utah (see Objective 3), presumably to spawn. On 3 May 1997, one ripe male razorback sucker was recaptured at RM 100.5 and three other ripe male razorback sucker were recaptured at RM 100.2 in a single dip net full of fish. Another three razorback sucker were seen at

RM 100.2 within several feet of where the three males were netted, but could not be collected. The male razorback sucker recaptured at RM 100.5 had been stocked at RM 158.6 on 3 October 1996. This radio-tagged individual (number 176), had been contacted as late as 6 February 1997 at RM 129.9. Of the other three razorback sucker recaptured at RM 100.2, one (radio tag number 101) had been stocked at RM 158.6 on 27 September 1997 and recaptured via electrofishing at RM 93.8 on 22 October 1996, before this collection. Another PIT-tagged male had been stocked at RM 79.6 on 18 November 1994. Unfortunately, due to a PIT tag reader failure, no PIT tag number was obtained for the fourth fish. However, from the three fish for which identity was ascertained, it appears that stocked razorback sucker had come from both up- and downstream to this particular area, presumably to spawn. The presence of the other three observed razorback sucker in such close proximity to the individuals recaptured at RM 100.2 lends credence to this idea. Thus, it appears that in addition to making long movements at other times of the year, stocked razorback sucker will also migrate to spawn.

The movement of stocked fish into Lake Powell was confirmed when a single razorback sucker stocked at RM 79.6 on 29 March 1994 was recaptured (via trammel net) approximately 8.5 miles into Lake Powell on 16 March 1995 (Table 3, Figure 8). It was transported back to its original stocking site (RM 79.6) and re-released into the river on 18 March 1995. This fish was contacted again on 24 April (at RM 69.0) and 15 May 1995 (at RM 72.1), but contact was lost with it after that date, so its movements during the high water period of 1995 are unknown.

Several razorback sucker were also documented to have moved upstream from Lake Powell into the San Juan River as well. On 21 May 1996 a male razorback sucker (456 mm TL) was recaptured at RM 58.0, via electrofishing (Table 3). This fish had been stocked 287 days earlier, on 8 August 1995 at Piute Farms Marina (RM 0.0) in Lake Powell. In addition, five sonic-tagged fish originally stocked in Lake Powell (at Zahn Bay [approximate RM - 10.2] or Neskahai Wash [approximate RM -29.0]) on 1 November 1995 were contacted in the lower San Juan River upstream of Grand Gulch (RM 14.5) in May and June 1996 (G. Mueller pers. comm.), with at least one sonic-tagged razorback sucker moving as far upstream as RM 20.9 (on 20 June 1996), 0.7 RM upstream of Government Rapid (unpublished data).

Stocked razorback sucker showed little to no downstream displacement associated with high flow events. In 1994, despite a peak spring flow of around 283 cubic meters per second (m^3/sec), or 10,000 cubic feet per second (CFS) six, small razorback sucker (251-301 mm TL) managed to maintain their position fairly high up in the river (Figure 7; Ryden and Pfeifer 1995b). In 1995, fish stocked in the fall of 1994, with one exception (# 460), demonstrated large initial downstream displacements after stocking but little, if any downstream displacement in association with a spring peak flow of approximately 339 m^3/sec (12,000 CFS; Figure 8; Ryden and Pfeifer 1996b). In 1996, high flows were almost non-existent in the San Juan River (Figure 9). Flows in 1996 peaked at just above 119 m^3/sec (4,200 CFS), and at least two radiotelemetered razorback sucker had moved upstream while another had ceased to move downstream by the time “peak” flows occurred (Figure 9). Movements of radiotelemetered razorback sucker in 1997 again mirrored those seen in 1994 and 1995 with radiotelemetered fish maintaining their relative position in the river during peak flows of almost 311 m^3/sec (11,000 CFS; Figure 10).

DISCUSSION

Habitat Use, Needs, and Selection

The information gained from the stocked razorback sucker has shown that the San Juan River can provide habitat for subadult and adult life stages and that habitats used are not always the most abundant habitat types in the river. In fact, those habitat types that were actively selected by stocked razorback sucker were often some of the least abundant in the river, especially during colder months of the year and during periods of high flow. In addition, contacts with radiotelemetered razorback sucker showed that like Colorado pikeminnow, low-velocity habitats and habitat-rich areas of the river are important to razorback sucker. Shifts in habitat richness values at razorback sucker locations between calendar months, while not statistically significant, do appear to have some biological significance. At present, there appear to be no limiting habitats for subadult and adult razorback sucker in the San Juan River, at least at the small population sizes that now exist in the San Juan River. As augmentation of this species continues and (hopefully) numbers of this species in the river increase, limiting habitats (if they exist) may become apparent in the future.

Mean depths at radiotelemetry locations generally between 2.0 and 4.0 ft. deep (Figure 4). Two contacts during July and August with a fish at RM 23.0 (tag number 025) represent the only two contacts, during high flows or otherwise, where radiotelemetered razorback sucker used habitats deeper than 7.2 ft. deep. This particular fish was located in an unusually deep area of the San Juan River, and contact depths were 12.5 ft. deep in July and 20.0 ft. deep in August. This skewed the mean depths for July and August to 4.6 and 6.2 feet deep. While this was not particularly representative of the habitat depths utilized by the other radiotelemetered razorback sucker, one must wonder if more deep water areas such as that at RM 23.0 were available in the San Juan River, would razorback sucker utilize them more frequently?

Temperatures of selected habitats were the same as that of adjacent main channel habitats in all but three months. Two of the months (March and April) in which radiotelemetered razorback sucker selected habitats warmer than main channel habitats were during the period of time in which razorback sucker are known to spawn. It is likely that razorback sucker seek warmer habitats at this time of the year in order to prepare for spawning activities.

In all months in which bottom and mean column velocity were recorded at razorback sucker radiotelemetry locations, bottom velocity was always slower than mean column velocity. However, mean velocities (both bottom and mean column) in all months for which they were recorded were less than 2.0 ft/sec, indicating that most radiotelemetered razorback sucker tended to use low-velocity habitats throughout the majority of the year (Figure 6). In addition, slower bottom velocities would provide an area near the river bed where razorback sucker can swim and feed in less turbulent water than that above them. Overall, mean velocities (both bottom and mean column) of utilized habitats remained low (< 2.0 ft/sec) throughout the year, although during high flows (June), certain individual razorback sucker demonstrated the ability to utilize very high velocity (over 8.0 ft/sec) main channel run habitat.

Between January and July, razorback sucker use (i.e., select for) slow/slackwater habitats far more than fast water habitats (Figure 11). During the period of August through December, this trend is almost completely reversed, with no documented use of slow/slackwater habitats by radiotelemetered razorback sucker in August, October, or November. Throughout the majority of the year, razorback sucker select habitat-rich areas of the San Juan River, although not as habitat-rich as those that were selected by radiotelemetered wild Colorado pikeminnow for months in which they were tracked (Figure 3; Miller 1999). In all months except October, radio-telemetered razorback sucker utilized areas of the San Juan River that were more habitat-rich than those used by radiotelemetered wild channel catfish (Figure 3; Buntjer 1999). The drop in habitat richness values for radiotelemetered razorback sucker correlates strongly with a drop in the amount of time spent by these fish in low-velocity habitats (Table 4, Figure 3). In other words, in summer and fall when water temperatures are warm, radiotelemetered razorback sucker use more fast water habitat types, and are found in areas of the river which are less habitat-rich. In winter and spring (colder water months), they seek areas of greater habitat richness and make greater use of low-velocity habitats.

During pre-runoff (March and April) razorback sucker use a number slow and fast water habitats. The mean water temperature for March and April habitats (i.e., warmer than the main channel) indicates that razorback sucker are probably building up heat units in preparation for spawning. During the ascending limb of the hydrograph (May) and the descending limb of the hydrograph (July) razorback sucker select eddies almost exclusively, while a number of low-velocity habitats (edge pool, pool, and inundated vegetation) along the river’s margins were selected for during high flows. The selection of inundated vegetation, a "classic" razorback sucker behavior in the Upper Basin, was conspicuously evident in that this was the most selected habitat type among radiotelemetered razorback sucker during June high flows. June was the only month in which inundated vegetation was available to razorback sucker during our observations. The use of these low-velocity habitats is likely associated with avoiding high velocity, turbulent main channel flows, as well as feeding in the productive areas being inundated along the river’s margins as flows increase.

As flows decrease to summer and fall base-flows razorback sucker move to less habitat-rich areas of the river and into the main channel runs to feed almost round the clock. Velocities in the main channel runs during these base-flow months are comparatively low, thus allowing razorback sucker to feed while not fighting high velocities. Available habitat richness in the San Juan River is also lowest during these base-flow periods, forcing razorback sucker into less habitat-rich areas.

In November, even though radiotelemetered razorback sucker were still selecting exclusively main channel runs, they were moving to more habitat-rich areas of the river. The most probable explanation for this is that November represents the last month of the calendar year before main channel water temperatures begin to drop substantially, and winter-like conditions begin to influence razorback sucker habitat use. So, razorback sucker are still in the main channel runs feeding, but are starting to move to areas of the river that will provide them the types of low-velocity habitats and habitat richness that they will need during the winter months.

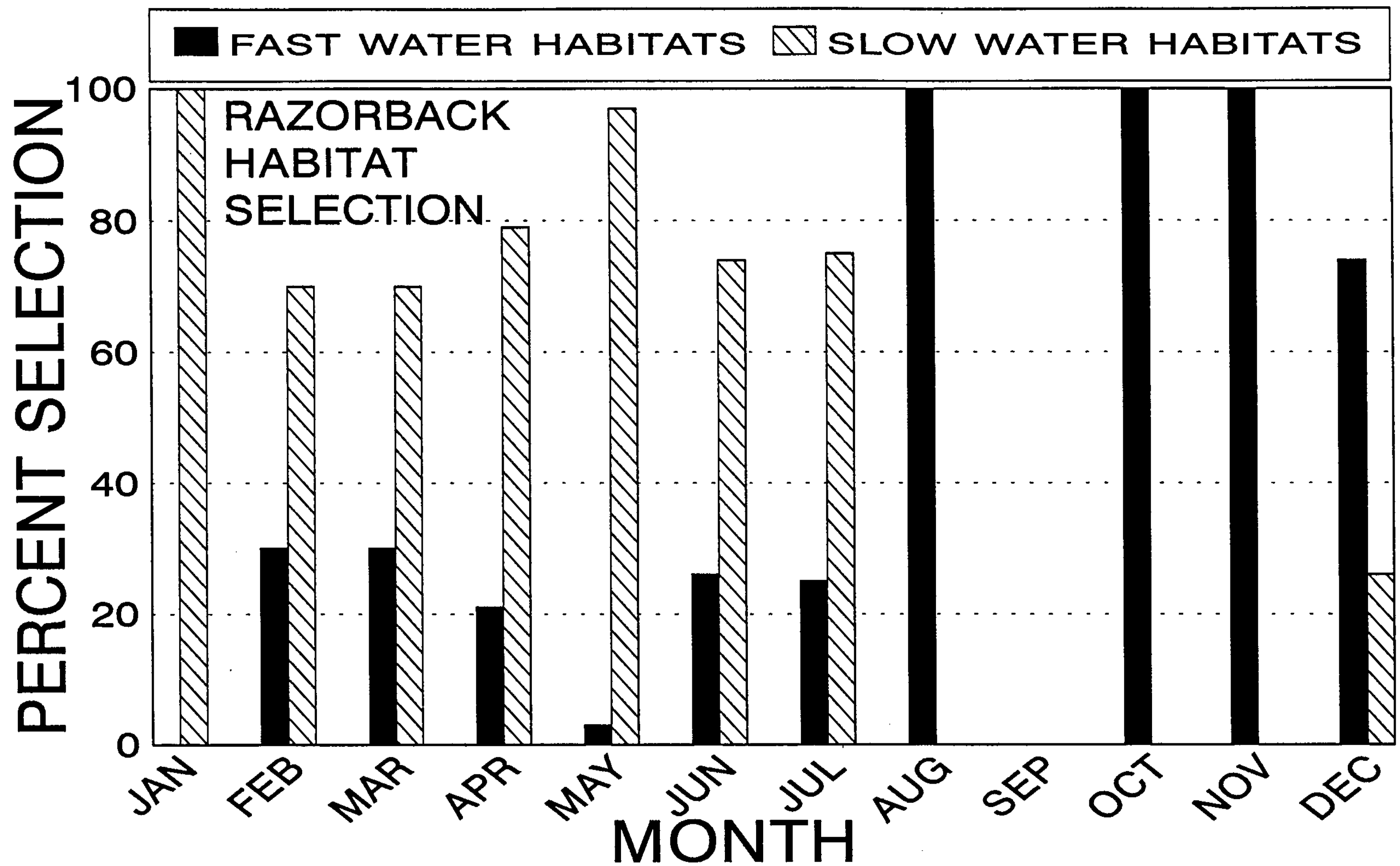

Figure 11. A comparison, by calendar month, of razorback sucker habitat selection by generalized habitat type (i.e., fast water or slow/slackwater).

During winter base-flow months, edge pools were the most-selected habitat (in fact the only selected habitat in January), although eddies and main channel runs were also used. Edge pools are a vitally important habitat type to razorback sucker during winter low-flow periods, regardless of flows from Navajo Reservoir. Because of high flows in the Animas River throughout the winter of 1996-1997, flows in the San Juan River downstream of the Animas River confluence more closely resembled a "normal" winter base flow period than they did during the January 1996 250-CFS research flow. January 1996 was the only time a true "low-flow" was seen in the San Juan River downriver of the Animas River confluence during this study. Regardless, no dramatic changes in habitat use were observed between the two 250-CFS "low-flow" periods during January 1996 and winter 1996-1997. Radio-tagged razorback sucker showed little to no response to the two-week, 250-CFS releases from Navajo Reservoir in January 1996. So, at least for limited amounts of time, very low winter flows have no observable detrimental effect on larger size-class razorback sucker.

Although very few habitat types were selected during the winter, habitat richness at razorback sucker locations was relatively high, indicating the use of complex areas of the river. During December's radio telemetry contacts, use of main channel runs during the warmest periods of the day was possibly due to feeding behavior. Slight weight increases of a few recaptured razorback sucker between fall 1994 and spring 1995 seem to indicate some wintertime feeding. As the weather continues to cool into January, feeding behavior would, presumably, tail off to a minimum. The exclusive use of edge pool habitats in January radio contacts (consistently the coldest month of the year during this study) seems to support the idea that there was little or no activity (and probably no feeding) occurring during the coldest parts of the winter. Data collected in January 1996 and the winter of 1996-1997 appear to indicate that there may be a threshold temperature between 0.0 and 3.0^{o}C that determines the shift in razorback sucker habitat use from main channel runs to lower velocity edge pools (December, January, and February) and eddies (February). It also appears that turbidity may play an important role in habitat selection, because radiotelemetered razorback sucker used deeper habitats when the water was clear, probably for cover.

Comparison With Habitat Use In Other Upper Colorado River Basin Rivers

Comparing habitat selection of stocked razorback sucker in the San Juan River with data from wild fish in previous studies on other UCRB rivers is complicated by several factors. First, previous UCRB studies tended to concentrate on a specific functional period (i.e., spawning, "overwintering"), often several months long, then combined habitat use data across all months instead of presenting by-month values. Second, data are presented as habitat use and not habitat selection. Third, the San Juan River is in many ways a very unique river when compared to other UCRB rivers. The San Juan River is, physically, a much smaller river than other UCRB rivers in which populations of razorback sucker are found. The San Juan River is generally less wide, shallower, and steeper than other UCRB rivers. The San Juan River has a relatively small number of backwaters compared to the Colorado and Green rivers. The San Juan River does not form flooded bottomland areas or have gravel pits along its length that are subject to seasonal flooding as do other UCRB rivers. In addition, the San Juan River is less prone to winter icing events than river farther north such as the Green and Yampa. Lastly, the habitat designations used in other studies, while close to the same, are not always completely reflective of, or interchangeable with, our habitat designations.

Following are descriptions, by river and study, of razorback sucker habitat use from other area of the Colorado River Basin. Comparisons are made where this information is applicable to this study. Only information on riverine habitat use is included.

Year-Round--The “15-mile reach” and “18-mile reach” of the Colorado River near Grand Junction, CO (Osmundson and Kaeding 1989, Osmundson et al. 1995): In March, razorback sucker used mostly pools and eddies (70% of the time, combined), followed by runs (20%), and backwaters (10%). Mean depth at contact locations in March was 6.1 ft. Mean column velocities recorded at razorback sucker locations in the Colorado River by Osmundson and Kaeding (1989) tended to be slow (i.e., < 0.96ft/sec) in all months, and were always less than 2.0 ft/sec with exception of a small percentage of contacts in May. In April, razorback sucker again used mostly pools (66.7%), followed by runs (16.7%), and backwaters (16.7%). Mean depth at April contact locations was 6.2 ft. In May, razorback sucker used runs and backwaters equally (45.5% each), followed by “shoreline” habitats (9.09%). Mean habitat depth was 3.0 ft. in May. May was the first of only three consecutive month in which these “shoreline” habitats were used. In June, gravel pits (43%) and backwaters (28.5%) were the most widely used habitats (71.5%), followed by pools and eddies combined (21.4%) and shoreline habitats (7.14%). This is the only month in which gravel pits were available to, and used by, razorback sucker during these studies. Mean water depth at June locations was 3.3 ft. During July, razorback sucker used backwaters most often (35.7%), followed by runs and riffles combined (35.7%), pools (21.4%) and shoreline habitats (7.14%). July was the only month that riffles were a used habitat and the last month that shoreline habitats would be used. Mean habitat depth in July was 4.1 ft. During August, only two habitat types were used, pools (66.7%) and runs (33.3%). Mean habitat depth in August was 5.4 ft. In September, runs accounted for fully 75.0% of the habitats used, followed by pools and eddies combined (25.0%). September mean habitat depth was 5.5 ft. Like August, only two habitats were used in October, runs (57.1%) and pool (42.9%). Mean habitat depth was 5.5 ft. in October. In November, the only habitat used was pools (100.0%). Mean habitat depth in November was 6.4 ft. In December razorback sucker used mostly pools and eddies combined (83.3%) followed by runs (16.7%). Mean water depth in December was 7.2 ft. Like December, in January pools and eddies combined were used much more (81.8%) than runs (18.2%). Mean water depth in January was 6.4 ft. Lastly, in February, pools and eddies combined and runs were used equally (50.0% each). Mean water depth in February was 6.8 ft.

During these studies, razorback sucker displayed many differences in habitat use, like utilizing backwaters and flooded gravel pits (not found on the San Juan River) and using numerous low-velocity habitats during the summer and fall base-flow periods. However, the use of mostly runs in September and the use of mostly low-velocity habitats during the cold months of December and January are very much like the behaviors displayed by San Juan River razorback sucker. In general, water velocities at contact locations in both the

Colorado and San Juan rivers were low year-round (mean column < 2.0 ft/sec). Not surprisingly, mean habitat depth year-round tended to be deeper on the Colorado than on the San Juan River. Interestingly though, mean habitat depth at razorback sucker locations in the Colorado River was shallowest in May-July. Mean habitat depth during these same months in the San Juan River were among the deepest observed. Osmundson and Kaeding (1989) stated that razorback sucker displayed a strong preference for deep water sites, particularly sites $\geq$ 6.0 ft. deep. Low-velocity habitats deeper than 6.0 ft. are scarce in the San Juan River, especially during summer to winter base-flow periods.

January to March--Colorado River, 4.8 miles downstream of Hoover Dam, AZ-NV (Mueller 1989): Between 28 January and 11 March 1984, spawning razorback sucker were observed in riverine habitat. Habitat was a main channel-backwater interface at the mouth of a dry wash. Substrate was scoured sands and gravels. Habitat depths at this site ranged from 3.9-6.6 ft. and velocities ("nose velocities" = 100 mm above substrate) ranged from 0.0-1.2 ft/sec.

May--Lower Yampa River, just upstream of confluence with the Green River, CO (McAda and Wydoski 1980): In May 1975, spawning razorback sucker were collected over predominately cobble substrates. The depth at these collection sites ranged from 2.3-3.3 ft., temperatures ranged from 7-16°C, and velocities ranged from 2.9-3.1 ft/sec. Five razorback sucker were monitored via sonic telemetry in May 1975. The first was usually always found in quiet water near shore, but was twice detected in relatively swift, shallow water on the outer edge of a gravel bar at the confluence of the Green and Yampa rivers, similar to the nearby spawning areas. This site was shallow (about 1 ft. deep), and water velocity varied from 1.4-2.6 ft/sec. The other four fish were always contacted in quiet water habitats.

Spring to July--Green and Duchesne rivers, UT (Tyus 1987): Ripe razorback sucker in main channel habitats were usually collected over coarse sand substrates, but occasionally over near gravel and cobble bars between 10 May and 14 June in 1984 and 1986. Temperatures at these collection sites ranged from 10-18°C. Ripe razorback sucker were also collected in flooded bottomland habitat in the Green River between 18 and 28 May 1986 over sand and silt substrates. The temperatures at these collection sites ranged from 17-19°C.

Outside of the spawning season, radiotelemetered fish occupied habitats with a mean monthly depth of 4.9 ft. and mean velocity of 1.0 ft/sec in 1980 (n = 1) and a mean monthly depth of 4.3 ft. and mean velocity of 1.3 ft/sec in 1985 (n = 5). These habitats had a range of depths from 2.0-11.2 ft. deep. These telemetered fish usually occupied near shore runs in the spring and midchannel sand bars in summer (all radiotelemetered fish were located over these midchannel features in July). Midchannel bars were made of coarse shifting sands and were usually less than 6.5 ft. deep, with mean velocities of 1.6 ft/sec.

Like Green River razorback sucker, San Juan River fish used some near shore runs in the spring. However, San Juan River razorback sucker apparently also used much more low-velocity habitat than did Green River fish during this time of the year. Likewise, the use of midchannel bars is consistent with the use of main channel run habitats by San Juan River razorback sucker in August through October, but not in July. As was seen with razorback sucker in the Colorado River, Green River razorback sucker tended to occupy deeper habitats, overall than did San Juan River fish.

April to June--Green and Yampa rivers, CO and UT (Tyus and Karp 1990): Ripe razorback sucker, collected between 20 April and 14 June over seven separate years (between 1981 and 1989) were usually captured in runs associated with cobble, gravel and sand substrates. Mean depth of these bars was 2.0 ft. and mean water velocity was 2.4 ft/sec. Spawning took place on the ascending limb of the hydrograph at mean temperatures of 13.8ºC (range = 10.5-16.0ºC) in the Yampa and 14.1ºC (range = 9.0-17.0ºC) in the Green River. Ripe female fish were collected over an average of 27 days (range = 24-28 days) and ripe males over 34 days (range = 26-41 days).

Habitat use data from the Green and Yampa rivers concentrates heavily on large spawning adults (as does that of Mueller {1989}). Unfortunately, the razorback sucker used in the San Juan River did not begin to show spawning-like behaviors until 1997, the very last year of this study (see Chapter 3 for results). As was detailed in the result of this study, there is apparently a shift in habitat use during the pre-runoff and runoff period when razorback sucker mature and start to demonstrate spawning behavior. Consequently the Green River data, while quite good, is not directly comparable to the large majority of habitat selection data presented here.

Late July to August--Green River in Canyonlands National Park, UT (Foster and Mueller 1999): Razorback sucker were stocked in the Green River and tracked during late July and August 1998. About half (52%) of the contacts with radiotelemetered fish during this study occurred in main channel habitats, with the others occurring in “near shore” habitats (37%) and “eddy pools” (11%).

These data are somewhat in contrast to San Juan River razorback sucker that selected midchannel main channel habitats 100% of the time in August.

Winter--Green River below Flaming Gorge Dam, UT (Valdez and Masslich 1989, Valdez 1994): Wild razorback sucker were tagged and tracked in the Green River during “overwintering periods” (October to March) between 1986 and 1988. Mean depth at Green River razorback sucker locations was 2.0 ft. and mean velocity was 1.1 ft/sec or less. Green River razorback sucker used low-velocity slow runs, slackwaters (essentially the same habitat as edge pool in this study), and eddies throughout overwintering periods. Additionally, the majority of Green River razorback sucker made only localized movements, remaining in one to three-mile river reaches.

This data, probably more than any other data set on wild razorback sucker in the UCRB matches nicely with observations made for San Juan River razorback sucker. The major differences in these two data sets would be the presence of large amounts of ice cover present throughout the Green River studies (almost completely absent in the San Juan River) and the fact that San Juan River razorback sucker wintertime movements were even more localized than those of Green River fish.

Site Preference

While the three razorback sucker recaptures at or near RM 38.6 did not occur in close proximity (i.e., within several ft. or yards) to each other, it is intriguing that they all occurred very close to what is a fairly distinctive geomorphic feature for this particular section of the river.

Backwaters, especially large, permanent backwaters are all but non-existent in the canyon-bound reaches of the river downstream of RM 68.0.

It is assumed that the aggregation of ripe razorback sucker at RM 100.2 indicates a spawning aggregation (see Chapter 3). Only further monitoring will tell whether this particular site is preferred and will be used again in future spawning efforts. This is the first documented aggregation of razorback sucker in spawning condition ever in the San Juan River.

Although razorback sucker collected in and near the backwater/secondary channel at RM 77.3 were collected after the data collection period for the razorback sucker experimental stocking study was over and are not included in any other analyses for this report, they are included in this section, because they have direct bearing on this objective. Like the backwater at RM 38.6, the backwater/secondary channel at RM 77.3 is a large, feature that retains water in it during all but the lowest flows.

To date, these are the only three sites in the San Juan River that have been documented to be used either by numerous razorback sucker at the same time, or by different individuals over time. Only further monitoring will be able to prove or disprove if these particular sites are indeed preferred sites for razorback sucker.

Movement Patterns

Mean FD values for all groups of radiotelemetered razorback sucker were less than both mean TLM and mean MD, indicating that stocked razorback sucker experience an initial period of downstream displacement lasting several weeks to several months. This same phenomenon was observed among newly-stocked razorback sucker in other studies as well (Hendrickson 1993, Burdick and Bonar 1997, Foster and Mueller 1999). After initial downstream displacements, followed by a period of stocked razorback sucker maintaining their relative position in the river, several radiotelemetered razorback sucker have made upstream movements. Several PIT-tagged razorback sucker have also made upstream movements after initially being recaptured downstream of their original stocking location. Coupled with the relatively short distance movements made by the razorback sucker (tag number 475) captured in Lake Powell after it was restocked in the river, it appears that after an initial adjustment period, stocked razorback sucker can maintain their position in the river, even the lower canyon-bound sections, during high water events without being swept into Lake Powell, and can and do move freely throughout the San Juan River. It appears that post-stocking displacements of razorback sucker, despite their size at stocking or the season in which they are stocked (spring or fall), are due as much or more to acclimation to a riverine environment as to displacement by flows.

While razorback sucker stocked at RM 79.6 and 136.6 have the smaller displacement values than fish stocked at the other sites, the documented movement of the razorback sucker stocked at RM 79.6 into Lake Powell shows that the individuals from stocking sites farther downstream that have very large downstream displacements stand a greater chance of leaving the river altogether. Thus, even though the MD values for fish stocked at RM 158.6 are largest (larger than RM 79.6 by 20.3 RM), it would still appear wisest to stock fish at this most upstream site, giving stocked razorback sucker the maximum amount of river (79.0 more RM upstream of Lake Powell than at RM 79.6) in which to disperse and adapt.

A concern when assessing behavior, habitat use, and other factors by observing hatchery-reared, radio-implanted fish is that their behaviors may not necessarily be representative of the other stocked fish. It was assumed at the beginning of the experimental stocking study that radio-implanted fish would have larger downstream movements than PIT-tagged fish. The reason for this assumption was that surgical implantation of radio tags tends to be a very traumatic process for fish, much more so than the simple insertion of a PIT tag. In addition, fish that were implanted with a radio transmitter were also implanted with a PIT tag as well. Thus, these fish were initially much more traumatized than were fish that were only PIT-tagged. As it turned out, even though the MD values for PIT-tagged razorback sucker were lower than those for radio-tagged fish, the difference was not statistically significant. Thus, at least in this one aspect, the behaviors displayed by radiotelemetered razorback sucker appear to be representative of all stocked razorback sucker.

Another concern when initiating a stocking program for any fish species is what size of fish to stock. As has been demonstrated through other studies, stocking razorback sucker that are too young and physically very small has been unsuccessful (see Objective 2). Likewise, stocking razorback sucker that are too old and domesticated to pond or hatchery settings is also unsuccessful. During experimental stocking of razorback sucker in the San Juan River, two very distinct size classes of razorback sucker were stocked, young juveniles (i.e., those that were < 351mm TL) and large subadult/adult fish (i.e., those > 350 mm TL). For both radiotelemetered and PIT-tagged razorback sucker combined, based on MD values, young age class razorback sucker (n = 19) moved significantly less post-stocking than did subadult/adult razorback sucker (n = 65; P = 0.00; 95% CI).

A basic assumption among researchers is that wild razorback sucker are able to perform in natural conditions better than hatchery-reared razorback sucker. Assuming this is so, the long-distance upstream movement made by a hatchery-reared razorback sucker (radio tag number 499; Table 3, Figure 10) lends credence to the idea that wild razorback sucker occupying the San Juan River in Utah (both historically and recently) could, and probably did, enter the mainstem San Juan and Animas Rivers in Colorado and New Mexico as is related in various anecdotal reports (Jordan 1891, Koster 1960; L. Ahlm pers. comm. in Ryden 1997).

Other upstream movements observed during our study, while not as long, are equally important in addressing issues facing future reintroduction efforts for razorback sucker in the San Juan River. At the beginning of this experimental stocking study, it was feared that once stocked razorback sucker moved downstream as far as RM 68 (i.e., where the river becomes canyon-bound for its duration) that they would be swept into Lake Powell. The documented movement of a stocked fish into Lake Powell proves that at least some of the razorback sucker stocked in downstream locations, such as RM 79.6, are going to move into Lake Powell, especially during high flow events. However, movements of several razorback sucker that were not directly associated with our study prove that even if stocked razorback sucker do move into Lake Powell, they can move back upstream into the San Juan River, if the waterfall at RM 0.0 is not present. Given these observed upstream movements by stocked fish, the documented occurrences of wild razorback sucker at Piute Farms Marina (RM 0.0) in 1987 and 1988 (Platania 1990, Platania et al. 1991), and the general lack of wild razorback sucker captures in the San Juan River between 1987 and 1993, one wonders if the razorback sucker (a 571 mm TL ripe, male) collected near Bluff, UT on 25 April 1988 (Platania 1990, Platania et al. 1991) was an individual that had moved upstream from the Piute Farms area of Lake Powell.

CONCLUSIONS/MANAGEMENT IMPLICATIONS

< Study Objective met? Yes

< Habitats being actively selected for by radiotelemetered razorback sucker are some of the more rare habitat types (percentage-wise) in the San Juan River (i.e., edge pools, eddies, pools, backwaters)
  < However, at present, there appear to be no limiting habitat types for stocked subadult and adult razorback sucker in the San Juan River, at least at the low numbers present in the river

< General characteristics of selected habitats
  < Mean depths at radiotelemetry locations were between 2.0 and 4.0 ft (0.6-1.2 m deep)
  < Temperatures at radiotelemetry locations were same as in adjacent main channel in eight of eleven months fish were tracked
    < March and April (i.e., pre-spawning) habitats were warmer than adjacent main channel
  < Mean velocities (bottom and mean column) were less than 2.0 ft/sec (0.6 m/sec)

< Between January and July radiotelemetered razorback sucker selected slow/slackwater habitat in habitat-rich areas of the San Juan River

< Between August and October radiotelemetered razorback sucker selected mid-channel, main channel runs in areas of the San Juan River with relatively low habitat richness

< November was a transition month with radiotelemetered razorback sucker still selecting main channel runs, but moving to more habitat-rich areas of the river

< There appears to be a threshold temperature between 0.0° and 3.0°C that determines the shift in razorback sucker habitat use from main channel runs to lower velocity habitats (i.e., edge pools and eddies)

< During radiotelemetry contacts where turbidity was low razorback sucker used deeper habitats, probably as cover

< Three possible preferred sites have been identified at RM 100.2, 77.3, and 38.6

< Stocked razorback sucker experience an initial period of downstream displacement lasting several weeks to several months after stocking

- After initial displacements, stocked razorback sucker are able to maintain their relative position in the river even during high flow events

- Razorback sucker stocked at RM 136.6 and 79.6 had the smallest maximum displacement (MD) values

- At least some of the razorback sucker stocked as far downstream as the Bluff stocking site are moving downstream into Lake Powell
  - Recaptured and sonic-tagged razorback sucker prove that these fish will also move upstream from Lake Powell to the San Juan River

- Behaviors displayed by radiotelemetered razorback sucker appear to be representative of all stocked razorback sucker

- Young juvenile razorback sucker (< 351 mm TL) moved significantly less post-stocking than did subadult/adult (> 350 mm TL) razorback sucker

- Upstream movements made by stocked razorback sucker lend credence to the anecdotal reports of wild razorback sucker in the San Juan and Animas river in New Mexico, despite the lack of historic collections

CHAPTER 2: SURVIVAL AND GROWTH OF STOCKED RAZORBACK SUCKER

< Objective 2: Determine survival rates and growth rates of hatchery-reared, known-age razorback sucker in the wild

METHODS

Survival of stocked razorback sucker was determined from radiotelemetered fish that could be confirmed as being alive and moving at time of last contact and by recaptured fish. In order to be considered alive, a radiotelemetered fish must have been contacted upstream of the last contact, be observed actively moving against the current during a contact, or (if sedentary) be disturbed and actively move from its position in the river at the end of a contact period. Growth was determined from measurements of recaptured fish.

RESULTS

Survival

Radio-Tagged Razorback Sucker

Of the 57 radiotelemetered razorback sucker stocked during this study, only two (3.5%) were confirmed to be mortalities (Tables 9-12). On 15 June 1994, one mortality was confirmed when a six-month lifespan radio tag (number 739) was recovered at RM 116.7 (Table 9). This particular fish had been stocked at RM 136.6 on 30 March 1994 (TL = 289 mm). After an initial downstream displacement of 19.9 miles (to RM 116.7 on 13 May), this fish was contacted at RM 116.9 on 25 May, having moved upstream 0.2 RM. The next contact with this fish was on 15 June 1994 when the tag was recovered on land in a coyote (Canis latrans) scat near the river's edge. It is assumed that the coyote scavenged the dead fish from the river's edge and consumed the carcass and tag. The second mortality was confirmed on 12 June 1995 when a 24-month lifespan radio tag (again, ironically, numbered 739) was recovered at RM 70.4 (Table 10). This fish was stocked at RM 79.6 on 27 October 1994 (TL = 388 mm). It was verified as being alive and actively moving as late as 10 April 1995 at RM 70.5. However, the tag was recovered at RM 70.4, on land under a large rock near the river, on 12 June 1995, in a wood rat (Neotoma spp.) nest. This fish may have been in poor health and moved into shallow water where it was actively captured or scavenged by an animal (e.g., raccoon {Procyon lotor}, coyote, wood rat, or bird). The radio tag was then apparently drug under the rock by the wood rat, exclusive of the fish's carcass.

Table 9. General information on radiotelemetered razorback sucker stocked at three stocking sites in the San Juan River, 29 and 30 March 1994.

Sex[a]	Total Length (mm)	Standard Length (mm)	Weight (g)	Radio Tag	PIT Tag	Stocking Site (RM)	Date of last contact	River Mile (RM) at last contact	Disposition at time of last contact[b]
I	282	229	270	428	7F7D1E093D	136.6	08/09/94	114.5	Alive
I	289	241	282	448	7F7D1D7872	136.6	05/14/94	102.8	Unknown
I	301	247	302	539	7F7D225F0E	136.6	08/09/94	114.5	Alive
I	289	240	290	739	7F7D22532E	136.6	06/08/94	116.9	Mortality
I	269	221	230	819	7F7D1E3662	136.6	06/21/94	119.8	Unknown
I	269	225	229	406	7F7D170C67	117.5	08/09/94	106.9	Alive
I	239	197	169	439	7F7D1D4E7D	117.5	06/21/94	117.5	Alive
I	316	265	396	519	7F7D173C48	117.5	06/21/94	113.7	Alive
I	252	218	200	599	7F7D224E24	117.5	08/09/94	112.0	Mortality or Expelled
I	274	225	241	639	7F7D1B6654	117.5	04/14/94	117.6	Alive
I	276	230	244	398	7F7D224A51	79.6	06/22/94	79.0	Alive
I	256	212	210	418	7F7D17484E	79.6	08/08/94	77.9	Alive
M	251	210	186	499	7F7D173B24	79.6	10/02/97	130.8	Alive
I	289	240	304	748	7F7D171A43	79.6	06/22/94	76.7	Alive
I	306	255	345	808	7F7D22491A	79.6	08/01/94	73.9	Mortality or Expelled

[a] M = Male, F = Female, I = Indeterminate

[b] Alive = confirmed alive at last contact; Unknown = a positive disposition of the fish was not determined at time of last contact; Mortality = known to be a dead fish; Expelled = tag not moving, may have been expelled by the fish, tag was not recovered and fish has not been recaptured, fish may or may not be alive

Table 10. General information on radiotelemetered razorback sucker stocked at three stocking sites in the San Juan River, 27 October 1994.

Sex[a]	Total Length (mm)	Standard Length (mm)	Weight (g)	Radio Tag	PIT Tag	Stocking Site (RM)	Date of last contact	River Mile (RM) at last contact	Disposition at time of last contact[b]
M	398	330	690	126	1F40454517	136.6	01/03/95	135.7	Alive
I	386	323	598	225	1F41513F10	136.6	10/27/94	136.6	No Contact
I	419	355	816	375	1F40756C40	136.6	10/27/94	136.6	No Contact
M	435	365	1018	525	1F43631724	136.6	10/27/94	136.6	No Contact
M	401	340	702	576	1F1E385437	136.6	10/27/94	136.6	No Contact
I	427	360	736	826	1F4366191F	136.6	10/27/94	136.6	No Contact
M	384	325	647	025	1F1E2E5F36	117.5	08/02/95	23.0	Alive
M	394	330	674	176	1F1F561458	117.5	04/24/95	10.0	Alive
M	412	347	650	460	1F41483B1D	117.5	04/27/95	129.3	Alive
M	388	328	698	726	1F733E4868	117.5	07/19/95	58.8	Alive
I	405	338	670	276	1F73381A1C	79.6	07/19/95	59.3	Alive
I	424	355	818	325	1F40374129	79.6	07/19/95	40.3	Alive
M	419	350	790	475	1F43686353	79.6	05/15/95	72.1	Alive
I	388	325	664	739	1F43632219	79.6	04/10/95	70.5	Mortality
I	386	325	580	775	1F404C4A0B	79.6	10/27/94	79.6	No Contact
I	384	325	660	926	1F1E300C07	79.6	10/27/94	79.6	No Contact

[a] M = Male, F = Female, I = Indeterminate

[b] Alive = confirmed alive at last contact; No contact = has not been contacted since date of stocking; Mortality = known to be a dead fish

Table 11. General information on radiotelemetered razorback sucker stocked at the Hogback Diversion stocking site, San Juan River, 27 September 1995.

Sex[a]	Total Length (mm)	Standard Length (mm)	Weight (g)	Radio Tag	PIT Tag	Stocking Site (RM)	Date of last contact	River Mile (RM) at last contact	Disposition at time of last contact[b]
I	411	353	741	051	1F412E4230	158.6	09/27/95	158.6	No Contact
M	428	360	859	101	1F5B684A54	158.6	05/03/97	100.2	Alive
M	415	345	699	141	1F1F707A58	158.6	09/27/95	158.6	No Contact
I	432	360	875	199	1F5B747C16	158.6	09/27/95	158.6	No Contact
I	417	350	758	250	1F64712656	158.6	09/27/95	158.6	No Contact
I	424	355	758	276	1F40195E2A	158.6	09/27/95	158.6	No Contact
I	415	345	750	301	1F7509154E	158.6	05/20/96	67.9	Alive
M	431	360	847	351	1F41612C13	158.6	10/08/95	101.9	Alive
M	425	355	822	400	1F40026639	158.6	09/27/95	158.6	No Contact
I	415	345	627	425	1F6B1D0E4B	158.6	09/27/95	158.6	No Contact
I	424	360	729	490	1F587A7D0F	158.6	10/08/95	101.1	Alive
I	426	355	778	500	1F587A6725	158.6	10/22/96	92.9	Alive
I	421	355	843	625	1F43670433	158.6	03/14/96	88.5	Alive
I	482	405	1194	676	1F463E213C	158.6	09/27/95	158.6	No Contact
M	397	330	647	875	1F6B1E0D4B	158.6	05/15/96	129.3	Alive
I	415	355	770	976	1F75165303	158.6	09/27/95	158.6	No Contact

[a] M = Male, F = Female, I = Indeterminate

[b] No contact = has not been contacted since date of stocking; Alive = confirmed alive at last contact

Table 12. General information on radiotelemetered razorback sucker stocked at the Hogback Diversion stocking site, San Juan River, 3 October 1996.

Sex[a]	Total Length (mm)	Standard Length (mm)	Weight (g)	Radio Tag	PIT Tag	Stocking Site (RM)	Date of last contact	River Mile (RM) at last contact	Disposition at time of last contact[b]
M	397	335	692	176	7F7D17641A	158.6	07/24/97	98.6	Alive
F	412	349	721	258	7F7D181039	158.6	07/23/97	148.8	Alive
M	434	368	862	311	7F7D165E75	158.6	10/24/96	68.1	Alive
M	395	333	625	325	7F7D161F4C	158.6	10/03/96	158.6	No Contact
I	426	365	950	437	7F7B104932	158.6	10/03/96	158.6	No Contact
I	429	363	826	451	7F7D164920	158.6	07/24/97	117.0	Alive
M	403	337	731	475	7F7D164F11	158.6	07/23/97	137.7	Alive
F	415	353	733	551	7F7D176C68	158.6	10/03/96	158.6	No Contact
I	415	358	764	800	7F7D176C1E	158.6	11/20/97	143.5	Alive
F	389	326	595	841	7F7D161E67	158.6	03/12/97	152.6	Alive

[a] M = Male, F = Female, I = Indeterminate

[b] Alive = confirmed alive at last contact; No contact = has not been contacted since date of stocking

Two additional radiotelemetered fish (3.5%) may have either been mortalities or may have expelled their radio tags (Table 9). The first (tag number 808, six-month lifespan) was stocked at RM 79.6 on 29 March 1994 (TL = 306 mm). This fish was contacted and confirmed to be alive at RM 79.6 on 15 April. It was contacted twice during the runoff period, both times at RM 73.9. On 6 June the signal from this tag was located near the river left shoreline in a low-velocity area, and the fish may have indeed been dead or the tag expelled at this time. On 1 August, the final contact with this tag, it was in the exact same area as the contact on 6 June. However, receding flows had left this area approximately two feet from the river left shoreline in about six inches of very clear water. Attempts to recover this tag were unsuccessful. The muffled signal from the tag, even very close to its source indicated that it was buried, probably fairly deep in the sand substrate. The second fish that was a possible mortality (tag number 599) was stocked at RM 117.5 on 29 March 1994 (TL = 252 mm). It was contacted at RM 112.0 on 14 April and ascertained to be alive and moving. However, subsequent contacts (on 14 May, 8 June, and 9 August 1994) failed to show any movements by this tag. Throughout these last three contacts the tag was located in a large swift rapid, behind the same rock. Unfortunately efforts to recover the tag failed due to the depth and swiftness of the water.

PIT-Tagged Razorback Sucker

One PIT-tagged razorback sucker (408 mm TL) recaptured near Montezuma Creek, UT in October 1995 had what appeared to be a large bite mark (scarred over), approximately 130 mm wide, on both sides of its back, straddling the dorsal keel. Several researchers present agreed that this appeared to be a bite scar from a channel catfish mouth. This fish had been previously captured in May 1995 and had shown no evidence of a bite mark or similar wound at that time. The fish had not grown since the May capture (Table 3), so the approximate size of the bite mark was probably very close to the size of the original wound and not an artifact of being stretched through growth of the fish's skin.

Combined

Fifty-four individual razorback sucker of known-origin (those for which a PIT tag number was obtained) were collected between 9 March 1995 and 5 October 1997. Of these, 49 were collected during adult fish community monitoring (electrofishing) trips (31 in May, 4 in August, and 14 in October), two on channel catfish removal (electrofishing) trips, one during a radio-tracking trip (by seine), and one during Lake Powell razorback sucker surveys (trammel-netting). Seasonal breakdowns of these collections show that two were recaptured in March (one by trammel net, one by seine), three in April (all by electrofishing), 31 in May (all by electrofishing), four in August (all by electrofishing), and 14 in October (all by electrofishing).

All five of the unknown-origin recaptures (no PIT tag number obtained) were collected by electrofishing. Three of these were collected on a channel catfish removal trip in April and two on May adult fish community trips. The five known-origin fish that were recaptured a second time were all collected via electrofishing on adult fish community monitoring trips, three on May trips and two on October trips.

As of October 1997, at least 54 (5.8%) of the 939 razorback sucker stocked as part of the experimental stocking study have been recaptured. This number may be as high as 59 (6.3%) if the five razorback sucker for which no PIT tag number was obtained were different individuals from the other 54 recaptures. Twenty-seven of the recaptures of known-origin fish (i.e., those for which a PIT tag number was obtained) occurred in 1995, 17 in 1996 and 10 in 1997. Of these, 48 had originally been stocked in 1994, three in 1995 and three in 1996. Stocking sites determined for these 54 known-origin fish show that 19 were originally stocked at RM 158.6, 17 at RM 136.6, 8 at RM 117.5, and 10 at RM 79.6 (Figure 12). This represents at least a 4.5% recapture rate for fish stocked at RM 158.6, 9.7% for fish stocked at RM 136.6, 4.6% for fish stocked at RM 117.5, and 5.8% for fish stocked at RM 79.6. However, given the large downstream displacements observed in newly stocked razorback sucker (Figures 7-10), as well as the very different survival ratios between small and large fish, the particular stocking location seems to have less to do with survival after stocking than does a fish’s size at the time of stocking. Fifty of the 54 razorback sucker recaptures of known-origin were fish that had been reared at Wahweap. The other four known-origin recaptured razorback sucker were fish that had been reared at Ouray. Five individuals (all reared at Wahweap) have been recaptured twice. Of the 54 known-origin recaptures, 41 (75.9%) came from a single stocking (stocking number 4 in Table 1) on 18 November 1994, a 23.2% recapture rate for razorback sucker from this particular stocking.

Between 1995 and 1997, PIT-tagged razorback sucker, which are harder to monitor for survival than radiotelemetered fish, had a recapture rate of 5.2% (46 of 882 fish). This rate may be as high as 4.8% if the five unknown-origin fish captured between 1995 and 1997 were different individuals from the other recaptured razorback sucker. This recapture rate indicates a fairly high survival rate among PIT-tagged fish. Radiotelemetered fish had a much higher recapture rate, 14.0% (8 of 57 fish), and radiotelemetry contacts at time of last contact indicate that these survival rates for radiotelemetered fish are probably higher than 14.0%.

Forty-six (85.2%) of the 54 known-origin recaptures came from groups of stocked fish that had a mean TL of 400 mm or greater at the time of stocking (i.e., from stocking numbers 2, 4, and 7 in Table 1). These 46 fish had a mean TL of 405 mm (range = 364-442 mm TL) at the time of stocking. In addition, the razorback sucker stocked into Lake Powell on 8 August 1995 (417 mm TL) and recaptured at RM 58.0 on 21 May 1996 came from a group of fish (stocking number 5 in Table 1) that was greater than 400 mm TL at the time of stocking. Recapture rates for fish from stocking numbers 2 (12.5%), 4 (23.2%), and 7 (18.8%), all stockings in which the mean TL of stocked fish was 400 mm or greater, were considerably higher than those for stockings numbers 1 (6.7%), 3 (0.8%), and 9 (1.3%; Table 1).

The eight remaining known-origin fish (14.8% of the 54 known-origin recaptures) came from groups of stocked fish that had a mean TL of less than 400 mm at the time of stocking (i.e., from stocking numbers 1, 3, and 9 in Table 1). These eight fish had a mean TL of 320 mm (range = 223-403 mm TL) at the time of stocking. Seven of these eight fish were larger than the mean TL

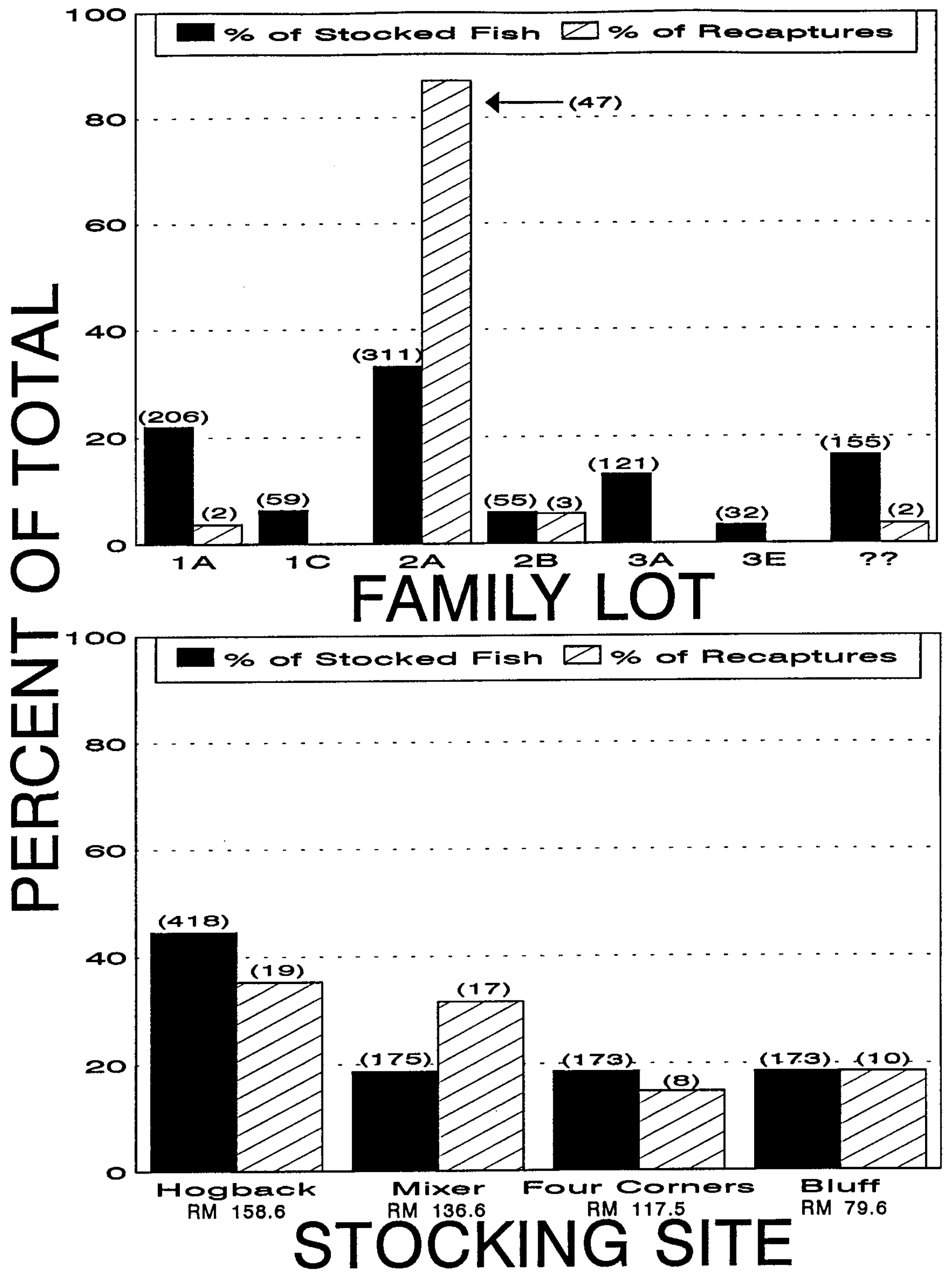

Figure 12. Percentages of the 939 stocked razorback sucker and the 54 known-origin recaptures represented by each individual family lot (top) and the groups of fish stocked at each of the four stocking sites (bottom). Parenthetic numbers represent the actual numbers of individual fish for each column. Summary information for each family lot can be found in Table 13.

for the group of fish in which they were stocked. The one exception (251 mm TL at the time of its stocking) was the smallest of the fifteen fish stocked on 29 and 30 March 1994.

Of the 54 known-origin recaptured razorback sucker, 47 (87.0%) are progeny of a single paired mating, family lot 2A (Figure 12). Fish from this family lot comprised 33.1% of all razorback sucker stocked in the San Juan River between 1994 and 1996 (Table 13). Of the other six known-origin recaptures, two (3.7%) were family lot 1A, three (5.6%) from family lot 2B, and two (3.7%) from undetermined family lots. The two fish from undetermined family lots were among many fish that were PIT-tagged when family lots were being held in separate tanks in the hatchery and subsequently expelled their PIT tag after fish from all family lots were placed together in a common holding pond at Ouray. The fact that these fish lost their PIT tags after this mixing of family lots occurred made it impossible to determine the family lot from which they originated. These fish were implanted with another PIT tag before their release into the wild.

It appears that in the San Juan River, razorback sucker stocked at 350 mm TL (or larger) survive better (based on recapture data) than smaller size class razorback sucker (Table 14). Razorback sucker larger than 350 mm TL at time of stocking (31.7% of the 939 stocked fish; n = 298) accounted for 49 (90.7%) of the 54 known-origin recaptures. Taken a step further, razorback sucker that were larger than 400 mm TL at time of stocking (13.7% of the 939 stocked fish; n = 129) accounted for 32 (59.2%) of the 54 known-origin recaptures.

Growth

Measurements of recaptured razorback sucker indicate that for up to 400 days after stocking, most fish lost weight (Figure 13). However, the percent of body weight lost by stocked fish was relatively small (Figure 14). Weight gain observed in recaptured fish after 400 days was highly variable (Figure 13), but the trend was positive (Figure 14). It was not until approximately 800 days post-stocking that recaptured razorback sucker showed large gains in weight (Figures 13 and 14).

Like weight, marked increases in TL among stocked razorback sucker were not apparent until sometime after 400 days post-stocking (Figures 13 and 14). Seventeen individual razorback sucker (348-442 mm TL at time of stocking) recaptured from 13-325 days after stocking had not increased in TL at all. Overall, growth among stocked razorback sucker appears to be highly variable. In the most dramatic example, a recaptured male razorback sucker, stocked in March 1994 and recaptured in August and again in October 1997 had doubled in length, from 251 to 502 mm TL (a 100% increase; 0.20 mm TL growth per day in the river), and had increased in weight, from 185 to 1300 grams (a 703% increase), in weight in 1283 days (Table 3, Figures 13 and 14). Growth rates for two other razorback sucker, stocked on 18 November 1994 and recaptured one day apart in October 1997, were less dramatic, but still very different from one another. The first had increased in length, from 442 to 471 mm TL (a 7% increase), in 1051 days in the river. No weight was taken for this fish at stocking due to equipment failure, so weight comparisons could not be done. The second had increased in length, from 396 to 536 mm TL (a 35% increase),

Table 13. Information on 1992 paired matings between adult razorback sucker collected from Piute Farms Marina in the San Juan River Arm of Lake Powell. All 939 razorback sucker stocked into the San Juan River between 1994 and 1996 were progeny of these 1992 paired matings.

PIT Tag Number		Family Lot	Number of Progeny From Each Family Lot Stocked Between 1994 and 1996	Mean Total Length (mm) of Fish at Stocking
Female	Male			
7F7F187B63	7F7D055802	1A	206	232
7F7F187B63	7F7E605000	1B	0	
7F7F187B63	7F7F365964	1C	59	304
7F7F187B63	7F7F365C29	1D	0	
7F7F187B63	7F7F366926	1E	0	
7F7F19036C	7F7D055802	2A	311	339
7F7F19036C	7F7E605000	2B	55	332
7F7F36275F	7F7D055802	3A	121	257
7F7F36275F	7F7E605000	3B	0	
7F7F36275F	7F7F366926	3E	32	331
7F7E36634D	7F7F366926	4E	0	
Unknown	Unknown	??	155	176

Table 14. Breakdowns, by size-class, of the 939 razorback sucker stocked into the San Juan River between 1994 and 1996.

Total Length In Milli-meters	Of 939 Stocked Fish		Of 54 Known-Origin Recaptures	
	Percent of Total Represented By This Size-Class	Total Number Stocked	Percent of Total Represented By This Size-Class	Total Number Caught
< 50	0.0%	0	0.0%	0
51-100	0.1%	1	0.0%	0
101-150	13.4%	126	0.0%	0
151-200	18.4%	173	0.0%	0
201-250	14.0%	131	3.7%	2
251-300	7.9%	74	1.9%	1
301-350	14.5%	136	3.7%	2
351-400	18.0%	169	31.5%	17
401-450	13.6%	128	59.2%	32
>451	0.1%	1	0.0%	0
Totals	100.0%	939	100.0%	54

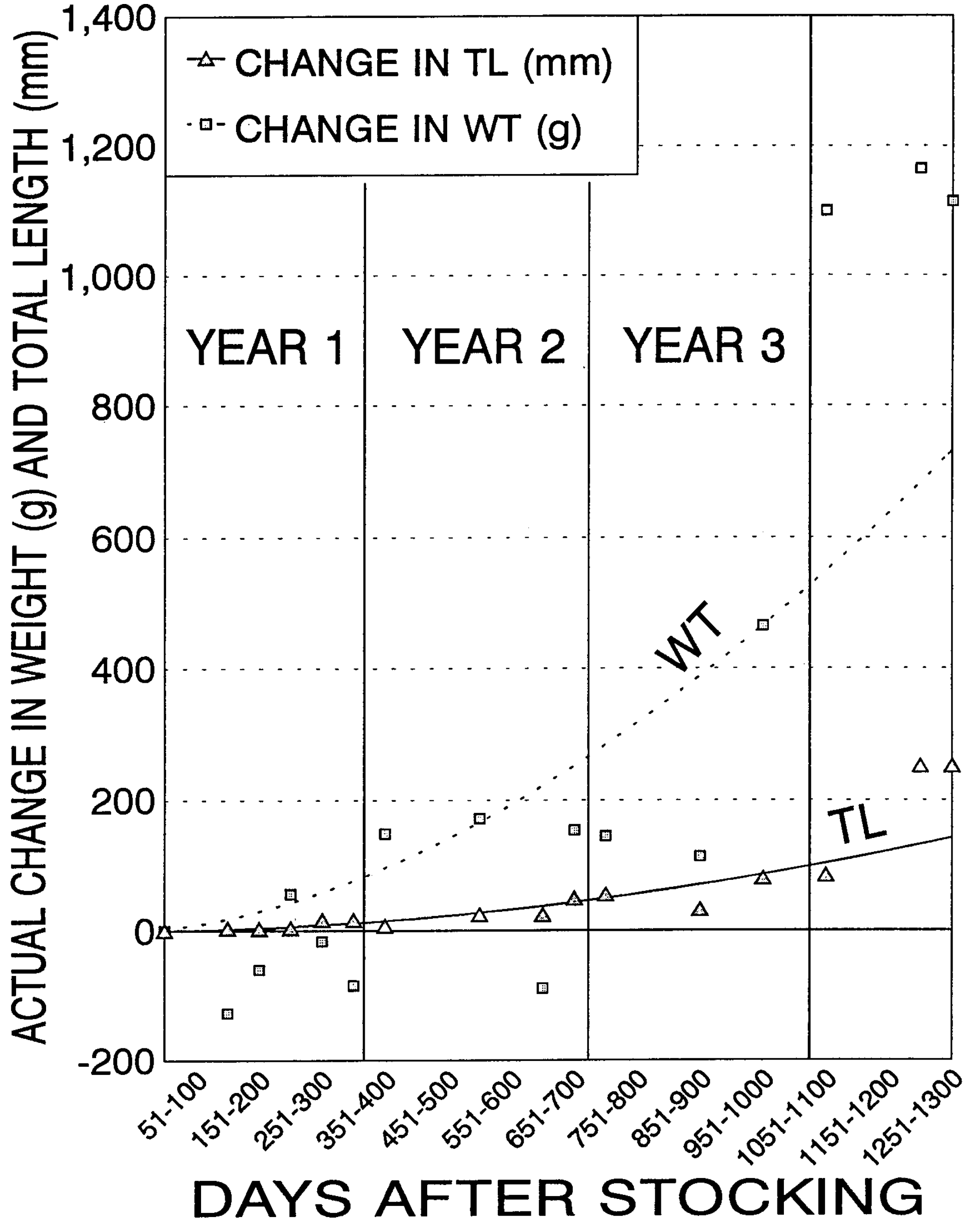

Figure 13. Growth over time of stocked razorback sucker recaptured between 1995 and 1997. Squares and triangles represent the average change in total length and weight of all razorback sucker recaptured in a given 50-day time period after stocking. The solid sloping line represents the power regression for change over time in total length values, while the dashed sloping line represents the power regression for change over time in weight values. Solid vertical lines divide days after stocking into one-year intervals.

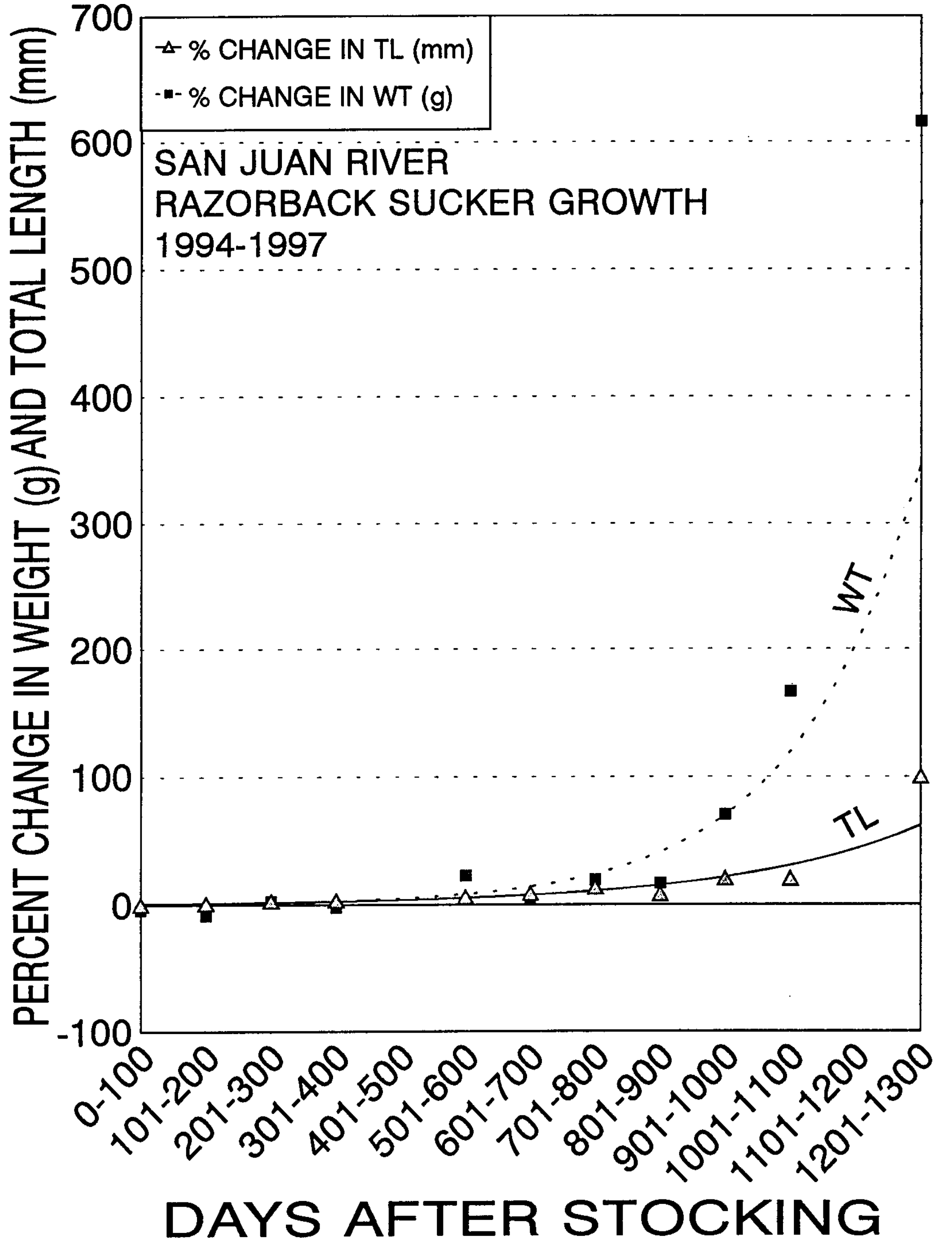

Figure 14. Percent change in total length (TL) and weight (WT) observed in razorback sucker recaptured between 1995 and 1997. The solid sloping line represents the trend over time for change in TL values, while the dashed sloping line represents the trend over time for change in WT values.

and had increased in weight from 660 to 1760 grams (a 167% increase), in 1052 days in the river (Table 3, Figures 13 and 14).

While much less numerous (n = 6 recapture events), recaptured razorback sucker that were originally stocked at smaller sizes (< 351 mm TL) increased in TL over three times faster (mean of 0.10 mm TL growth per day in the river) than did recaptured fish originally stocked at larger sizes (> 350 mm TL; n = 54; mean of 0.03 mm TL growth per day in the river; Table 15). Virtually no difference in growth rates (i.e., increase in TL) could be discerned between recaptured razorback sucker known to be females (0.04 mm TL growth per day in the river; n = 10 recapture events; mean TL at stocking = 409 mm) and recaptured razorback sucker known to be males (0.03 mm TL growth per day in the river; n = 30 recapture events; mean TL at stocking = 396 mm; Table 14).

Growth information from 23 individual razorback sucker stocked in the fall (27 September or later) of one year and recaptured the subsequent spring indicate that these fish are feeding and growing during the winter months. Of these 23 individuals 11 (47.8%) had shown at least some overwinter growth (Table 16). Overwinter growth among these 11 fish ranged from 1-15 mm TL (113-236 days between fall and spring captures). The other 12 fish had not grown over the winter (171-212 days between fall and spring captures).

Razorback sucker that had grown between time of stocking and time of recapture had smaller MD values (mean MD = 33.7 RM; range = 58.0 RM upstream to 90.7 RM downstream from their original stocking site; based on 41 fish) than did fish that had not grown (mean MD = 38.1 RM; range = 1.5 to 88.1 RM downstream from their original stocking site; based on 16 fish). In addition, between 1995 and 1997, only eight individual razorback sucker (including the individual originally stocked at RM 0.0 in Lake Powell) were collected upstream of their original stocking site (range MD = 0.7-58.0 RM [mean = 28.2 RM]). All eight of these fish were fish that had grown since being stocked (range = 1-251 mm TL growth [mean = 57 mm TL growth]; range = 182-1283 days post-stocking [mean = 686 days]). Six of these eight individuals were PIT-tagged fish and two were radio-tagged fish.

DISCUSSION

Survival

Determining survival of stocked fish after release is problematic. The single greatest complicating factor is the relatively small number of fish stocked (939) between 1994 and 1996, making it fairly difficult to recapture stocked fish, despite intensive efforts to do so. However, having fish that are equipped with radio tags makes it easier to track the movements and survival ratios of those particular fish (Tables 9-12).

Tag numbers 808 and 599 cannot be positively labeled as mortalities. Numerous razorback sucker that were initially implanted with radio tags at the Wahweap facility expelled them within a few days to several weeks and lived (Appendix B). This is not an uncommon phenomenon. Research on other fish species has shown that up to 59% of radio tags were lost or expelled when implanted in rainbow trout (_Onchorynchus_ _mykiss_), up to 71.4% in channel catfish, and in shortnose sturgeon (_Acipenser_ _brevirostrum_) and Atlantic

Table 15. Growth of razorback sucker, in millimeters per day (mm/day), observed during 60 recapture events, including second time recaptures.

Total Length Range (In Millimeters) Of Recaptured Fish At Time Of Stocking	Growth (mm/day)	Number Of Recapture Events Growth Rates Are Based On (n =)
By 10-mm TL Size Classes:		
<221	No Data	No Data
221-230	0.07	1
231-240	0.02	1
241-250	No Data	No Data
251-260	0.20	2
261-270	No Data	No Data
271-280	No Data	No Data
281-290	No Data	No Data
291-300	No Data	No Data
301-310	No Data	No Data
311-320	No Data	No Data
321-330	No Data	No Data
331-340	No Data	No Data
341-350	0.04	2
351-360	0.08	1
361-370	0.01	2
371-380	0.03	2
381-390	0.02	5
391-400	0.05	7
401-410	0.04	15
411-420	0.04	12
421-430	0.02	8
431-440	No Data	No Data
441-450	0.01	2
>450	No Data	No Data
Small Versus Large Fish:		
<351	0.10	6
>350	0.03	54
Females Versus Males:		
Known Females	0.04	10
Known Males	0.03	30

Table 16. Recaptured razorback sucker for which growth information for a specific overwintering period could be determined.

PIT Tag Number	Stocking Date	Recapture Date	Change In Total Length (in mm)	Number Of Days Between Captures
1F685A1C03	11/16/94	03/09/95	8	113
1F41483B1D	10/27/94	04/27/95	1	182
7F7D177124	11/16/94	05/08/95	15	173
1F404F4A08	11/18/94	05/08/95	0	171
1F40735A54	11/18/94	05/09/95	0	172
7F7D164D53	11/16/94	05/10/95	4	175
1F41401050	11/18/94	05/10/95	12	175
1F43596560	11/18/94	05/11/95	0	174
1F733D0031	11/18/94	05/11/95	4	174
1F402D165E	11/18/94	05/11/95	0	174
1F7441614B	11/18/94	05/11/95	0	174
1F4040075A	11/18/94	05/12/95	0	175
1F40496870	11/18/94	05/12/95	0	175
1F404E666D	11/18/94	05/12/95	2	175
1F41405A06	11/18/94	05/13/95	11	176
1F40326B04	11/18/94	05/13/95	0	176
1F742E4D72	11/18/94	05/13/95	3	176
1F435D1C25	11/18/94	05/14/95	0	177
1F43686353	10/27/94	05/15/95	0	200
1F41505779	11/18/94	05/15/95	0	178
1F732D724F	11/18/94	05/16/95	4	179
1F7509154E	09/27/95	05/20/96	8	236
7F7D17641A	10/03/96	05/03/97	0	212

sturgeon (A. oxyrhynchus) 18.0% of tags were expelled (Summerfelt and Mosier 1984, Chisholm and Hubert 1985, Kynard and Kieffer 1992). In channel catfish, larger tags (2.0% of body weight) were expelled at a higher rate (88.8%) than smaller tags (1.0% of body weight), which had an expulsion rate of 52.9% (Summerfelt and Mosier 1984). It was also noted that implanted fish may rub strongly against substrates to help relieve the irritation and discomfort caused by sutures and healing incision wounds (Kynard and Kieffer 1992). This same behavior of rubbing newly-implanted sutures against the substrate and the concrete of the "kettle" (water drainage) area was observed in razorback sucker being held at Wahweap for recovery after surgery (Appendix B). It is also conspicuous that three of the four razorback sucker that were either confirmed mortalities or suspected mortalities/expelled tags were among the smallest of radio-implanted razorback sucker, stocked in March 1994. Tag weight for these 15 radio-implanted fish averaged 1.9% of body weight. For the other groups of implanted razorback sucker, tags averaged 1.7% of body weight for the 16 fish stocked on 27 October 1994, 1.5% of body weight for the 16 fish stocked 27 September 1995, and 1.6% of body weight for the ten fish stocked 3 October 1996.

Electrofishing appears to be the most efficient method for monitoring experimentally-stocked razorback sucker. Further, spring (March through May) sampling trips have, thus far, been the most successful at recapturing stocked razorback sucker.

Survival of experimentally-stocked razorback sucker in the San Juan River appears to be quite good compared to other stocking efforts attempted in the Lower Colorado River Basin (LCRB) and the Gunnison and Colorado Rivers. Stocking of small size-class (range = 45-168 mm SL) razorback sucker in the LCRB in the presence of ictalurid predators (i.e., flathead catfish [Pylodictis olivaris] and channel catfish) was unsuccessful (Marsh and Brooks 1989). Marsh and Brooks (1989) stated that the loss of stocked razorback sucker to predation lessened when average size of stocked fish was increased from 68 mm SL to 113 mm SL. In addition, Marsh and Brooks (1989) theorized that stocking razorback sucker in the range of 300 mm may enhance post-stocking survival. Conversely, adult razorback sucker collected from "Etter Pond" (near DeBeque, CO) and stocked into the Gunnison and Colorado Rivers upstream of Grand Junction, CO in 1994 and 1995 demonstrated poor survival with mortality rates being as high as 85% in the Colorado and 88% in Gunnison River (Burdick and Bonar 1997). High degrees of body fat in stocked fish were documented, indicating that the Etter Pond razorback sucker were in good condition at the time of radio tag implantation and stocking. Burdick and Bonar (1997) speculated that the reasons for poor survival of these adults may have been due to inability to cope with the riverine environment (i.e., currents, turbidity, and fluctuating flows), or being unable to learn to use natural food items, thus leading to eventual starvation. These older fish (possibly as old as 11-12 years old at the time of stocking) may simply have been too domesticated to their artificial pond environment to be able to survive in a riverine environment, a situation known as domestication selection (Burdick 1992, Ryden and Pfeifer 1994a). However, the additional stress associated with radio tag implantation and immediate stocking in a riverine without being allowed to recover first, was undoubtedly also a major factor in the failure of these stocked fish. Razorback sucker stocked into the San Juan River between 1994 and 1996 were apparently still young enough to not be domesticated, but large enough, in most cases, to avoid predation by channel catfish and other predators (i.e., walleye and striped bass). While the bite mark observed on a recaptured, PIT-tagged razorback sucker is by no means conclusive proof of nonnative fish predation, this observation combined with the numerous flannelmouth sucker (Catostomus latipinnis), some as large as 300 mm SL (Brooks et al. 2000), taken from the digestive tracts of walleye (Stizostedion vitreum), striped bass (Morone saxitilis), and channel catfish on the August and October 1995 adult fish community monitoring trips suggests that nonnative predators may have a major impact on native fishes of 410 mm TL or less. Stocking fish at 410 mm TL or greater appears to get fish past the predation threshold (as discussed earlier), as well as getting them in the river at an age where they are likely to spawn soon after stocking (see Objective 3).

Some of the difference observed between recaptures of various size-class razorback sucker after stocking can almost certainly be placed on the tendency (i.e., bias) of electrofishing to collect larger size class fish. However, between 1991 and 1997 adult fish community monitoring (electrofishing) was very successful in collecting smaller size-class ($\leq$ 351 mm TL) flannelmouth sucker, bluehead sucker, and channel catfish as well as numerous adult speckled dace and red shiner, which reach a maximum of about 150 mm TL as adults (e.g. Ryden and Pfeifer 1993, 1994b, 1995a, 1996a, Ryden 2000). In addition, intensive seining efforts between 1994 and 1997 by the New Mexico Department of Game and Fish and the Utah Division of Wildlife Resources, and sporadic seining, trammel-netting, and hoop-netting efforts by other agencies resulted in the collection of only a single small size-class (231 mm TL) razorback sucker on 9 March 1995 (Table 2). Since razorback sucker smaller than 351 mm TL (n = 641 fish) comprised the large majority (68.3%) of fish stocked, it seems that, even given the difficulties in sampling this size-class of fish, they should have accounted for more than five (9.3%) of the 54 known-origin recaptures.

Growth

The initial weight loss after stocking is indicative of stocked fish becoming conditioned to swim in river currents and learning to forage on and compete for natural food items in a turbid river (i.e., conditions that don't exist in calm, clear, highly-productive grow-out ponds).

The faster growth rates observed in small size-class razorback sucker (< 351 mm TL) were to be expected, as most fish generally have a period of rapid growth early in life and a subsequent period of more gradual increase as they mature (Van Den Avyle 1993). Minckley (1983) indicated that, based on size-frequency distributions of wild-caught fish, growth among "adult" razorback sucker (370-740 mm TL) in Lake Mohave averaged only about 5 mm per year.

One piece of information gained during this study that was somewhat unexpected was the fact that razorback sucker in the San Juan River appear to be growing during the winter. During most winters, water clarity increases, resulting in blooms of algae (e.g., Cladophora spp.). These large standing crops of algae likely provide good forage for razorback sucker during the winter. Contacts made with radiotelemetered razorback sucker during January 1996 and the winter of 1996-1997 indicate that, at all but the coldest temperatures, razorback sucker spend at least part of the day in main channel runs and are assumed to be feeding (see Objective 1). Based on radio telemetry observations, there appears to be a threshold water temperature somewhere between 0.0 and 3.0°C at which razorback sucker become completely sedentary (i.e., spend all their time in low-velocity habitats, moving little if at all) and probably cease feeding. However, in order to sustain water temperatures of 3.0°C and less (water temperatures that appear to preclude feeding), sustained daytime air temperatures of 3.0°C or less must be present. These types of sustained low air temperatures are seen only for short periods of time each winter in the San Juan River basin within our study area. Thus, it would appear that during the majority of most winters, razorback sucker have the potential to feed and grow in the San Juan River.

Razorback sucker reared in warmer climate grow-out ponds, such as those at Wahweap, grew larger over the short-term (2-4 years) than did razorback sucker held in colder-water rearing facilities (i.e., Ouray NFH). This combination of being able to rear fish large enough to be past the predation threshold at any early age while still allowing the fish to be stocked before they become domestically selected is important. Placing young razorback sucker that are to be used in future stocking efforts into warmer grow-out pond environments whenever possible appears to be advantageous.

Stocked razorback sucker that adapted well to riverine conditions (foraging, dealing with turbulent river currents, turbidity, competition and predation pressures, etc.) grew faster and maintained their relative position in the river (or even moved upstream) better than those that didn't.

CONCLUSIONS/MANAGEMENT IMPLICATIONS

< Study Objective met? Yes

< Two confirmed mortalities among radiotelemetered razorback sucker

< Bite mark from a channel catfish present on the dorsal keel of a 408 mm TL razorback sucker

< Electrofishing appears to be the most efficient method for monitoring experimentally-stocked razorback sucker

< As of October 1997, at least 54 (5.8%) of the 939 stocked razorback sucker have been recaptured
    < Number of recaptures may be as high as 59 (6.3%) if razorback sucker for which no PIT tag number was determined are included

< Forty-six (85.2%) of the 54 known-origin recaptures were from groups of fish that had a mean TL of 400 mm or greater at the time of stocking

< Of the 54 known-origin recaptures, 47 (87.0%) were progeny of a single family lot
    < This family lot comprised 33.1% of all stocked fish

- For the first 400 days post-stocking stocked razorback sucker tend to lose weight
    - Fish are learning to survive and forage in the river

- After 400 days post-stocking, weight gain in stocked razorback sucker is highly variable, but the trend is positive

- Small size-class razorback sucker (<351 mm TL) grew over three times faster than did razorback sucker stocked at larger size-classes (>350 mm TL)
    - Small fish of almost every species grow fast when they are young, with growth slowing as they get older

- Virtually no difference was discerned in growth rates between stocked male and female razorback sucker

- Stocked razorback sucker are feeding and growing over the winter
    - There appears to be a threshold temperature somewhere between 0.0 and 3.0°C at which razorback sucker become completely sedentary and cease to feed during the winter

- Razorback sucker that had grown between time of stocking and time of recapture maintained their relative position in the river (or even moved upstream) better than those that hadn't

- Stocking razorback sucker at sizes of approximately 400 mm appears to get fish past the predation threshold and place fish in the river at an age where they are not yet domesticated and will likely spawn soon after stocking

CHAPTER 3: WILL HATCHERY-REARED RAZORBACK SUCKER SPAWN IN THE WILD?

- Objective 3: Determine whether hatchery-reared razorback sucker will exhibit spawning behavior in the wild

METHODS

Radiotelemetry and recaptures were examined to see if aggregations of stocked razorback sucker could by identified during potential spawning periods (i.e., February through May). Recaptured razorback sucker were examined to determine reproductive status and age. Those fish that were actively expressing gametes or had visible tuberculation present were considered to be mature, sexually active fish.

RESULTS

Of the 65 recapture events (including second recaptures and the fish that was stocked in Lake Powell and recaptured in the San Juan River) during our study, 32 were males, 10 were females, and 23 were of indeterminate sex. None of the 10 identified females (372-481 mm TL), collected between 15 April and 24 October, were obviously gravid (i.e., in spawning condition). The 32 tuberculate male razorback sucker (376-502 mm TL) were collected between 16 March and 22 October, while the 15 individual males (376-502 mm TL) which were ripe (i.e., freely expressing milt) were collected between 16 March and 2 October.

Of the 51 recapture events with razorback sucker prior to May 1997, nine were females (none of which were visibly gravid or expressing eggs), 21 were tuberculate males (with seven being ripe), and 21 were of indeterminate sex. During May 1997 electrofishing surveys, nine adult razorback sucker were collected (two of which were second time recaptures; Table 3). Eight of these were ripe male fish (397-456 mm TL, 650-850 g; Table 3). The ninth fish, a female (434 mm TL, 1150 g), collected at RM 122.0 on 2 May 1997, did not appear to be in spawning condition (Table 3). Seven of the eight male razorback sucker collected were ripe (i.e., freely expressing milt). All eight male razorback sucker were captured in aggregations of ripe, presumably spawning, flannelmouth sucker, over midchannel cobble riffles and run/riffles, or along the river’s margins over cobble shoal/runs. On 3 May 1997, one male razorback sucker (397 mm TL, 692 g) was collected within a few yards downstream of the McElmo Creek confluence (RM 100.5), near Aneth, UT, on river right by one of two electrofishing rafts working in tandem. Approximately three-tenths of a mile downstream of this location (RM 100.2), again on river right, three more ripe male razorback sucker (412-456 mm TL, 650-770 g) were captured in a single dip net full of fish over a shoreline cobble shoal/run by the other electrofishing raft. Three other razorback sucker were observed but not captured in this same aggregation of fish. Of the four male razorback sucker that were recaptured at RM 100.5 and 100.2, three had originally been stocked at either Hogback Diversion (RM 158.6) or Bluff, UT (RM 79.6), and had converged near Aneth presumably to spawn. A PIT tag number was not determined for the fourth fish, as the PIT tag reader quit working after reading the PIT tag for the third fish. Therefore a stocking location for the last fish could not be determined. The ripe male razorback sucker that was recaptured at RM 100.5 was a radio-tagged fish that had been located at RM 129.9 in February 1997. One of the three males captured at RM 100.2 was also a radio-tagged fish that was last contacted at RM 93.8 on 22 October 1996. Flows were increasing in the river during the time these electrofishing collections were made, indicating that these razorback sucker were spawning on the ascending limb of the hydrograph as is seen in other Upper Colorado River Basin (UCRB) rivers (Tyus 1987, Tyus and Karp 1989, USFWS 1998). Flows at the Shiprock, NM USGS gage on 15 April 1997 were 1,390; 1,770 on 3 May; 5,580 on 15 May; and 8,050 on 31 May 1997.

Based on the observations of suspected spawning razorback sucker in May 1997, crews from the University of New Mexico (UNM) began intensive monitoring efforts (light-trapping and seining for larval fishes) throughout the San Juan River in the spring of 1998 to try to document razorback sucker reproduction. On 21 and 22 May 1998, two larval razorback sucker (flexion mesolarvae = 12.7 mm TL and 12.1 mm TL, respectively) were collected in seines from backwaters between Montezuma Creek and Bluff, UT (RM 88.8 and 80.2, respectively; S. Platania pers. comm.). Platania stated that the "mesohabitat location where these fish were collected indicate that they were no longer true components of the drift (i.e., these specimens had the ability to move out of the flow)."

DISCUSSION

The first piece of evidence for hatchery-reared razorback sucker demonstrating spawning behavior in the wild was collected in May 1997. Prior to May 1997, no obvious spawning behavior had been demonstrated by stocked fish in the wild. All behaviors observed via radio telemetry up to that time appeared to be related to either feeding or resting. Also, no aggregations of either radiotelemetered or PIT-tagged adult razorback sucker larger than two fish were evident prior to this time (groups of 4-5 radiotelemetered juvenile razorback sucker had aggregated for several days to several weeks post-stocking in March and April 1994). The May 1997 collection of four ripe razorback sucker and observation of three other fish in such a small area points strongly to a spawning aggregation. However, the failure to collect a gravid female razorback sucker in this aggregation may raise the question as to whether or not this was a viable razorback sucker spawning aggregation or if ripe male razorback sucker were just being attracted by the presence of numerous ripe flannelmouth sucker. In May 1997, all ripe razorback sucker were collected in aggregations of ripe flannelmouth sucker. This tendency to aggregate with flannelmouth sucker while spawning has been documented in other UCRB rivers (e.g., Tyus and Karp 1990) and leads to hybridization between these two species in the wild (e.g., Buth et al. 1987, Ryden 1997, Ryden 2000).

The collection of two larval razorback sucker in May 1998 represent the first ever records of reproduction by razorback sucker in the San Juan River drainage, and prove that stocked razorback sucker are able to locate one another, locate suitable habitats, and successfully spawn in the San Juan River. In addition, larval razorback sucker spawned at some point upstream of RM 88.8 are able to successfully move out of the larval drift and into low-velocity habitats before entering the canyon-bound reaches of the San Juan River (i.e., downstream of RM 68.0) where suitable nursery habitat is scarce. The relative size of these larval razorback sucker indicates that they were probably spawned near the beginning of May (no formula for the back-calculation of razorback sucker spawning dates has been developed yet), indicating that for the second consecutive year adult razorback sucker aggregated and spawned on the ascending limb of the hydrograph. Flows at the Shiprock, NM gage during this general 1998 time frame were 1,170 on 15 April 1998; 3,500 on 1 May; 5,190 on 15 May; and 7,370 on 31 May 1998.

CONCLUSIONS/MANAGEMENT IMPLICATIONS

< Study Objective met? Yes

< Prior to 1997 no aggregations larger than two razorback sucker observed

< In May 1997 a spawning aggregation was observed at RM 100.2

< In May 1998, the collection of two larval razorback sucker at RM 88.8 and 80.2 by crews from the University of New Mexico prove that successful reproductive efforts are taking place in the San Juan River

CHAPTER 4: CAN HATCHERY-REARED RAZORBACK SUCKER LEAD RESEARCHERS TO THEIR WILD COUNTERPARTS?

< Objective 4: Determine if hatchery-reared razorback sucker can lead researchers to their wild counterparts

METHODS

All razorback sucker collected during the seven-year research period were scanned to detect the presence of a PIT tag. All fish bearing PIT tags were known to be stocked fish. It was assumed given the dearth of wild razorback sucker in previous collections that any wild razorback sucker still remaining in the San Juan River would be old, large adult fish. These older wild razorback sucker tend to be large fish (i.e., over 500 mm TL) that are usually scarred, blind in or both eyes, and have split or broken fins. Therefore, if a razorback sucker was collected and no PIT tag could be collected, the size and general health of the fish were observed to make a judgement call as to whether or not the fish was a wild fish.

RESULTS

All razorback sucker that have been collected from the mainstem San Juan River during the 1990's have been fish that were stocked into the river as part of various studies from 1994 to present. The one possible exception was the capture of a razorback sucker at RM 66.6 on 20 May 1996. This fish was scanned for a PIT tag upon capture and none could be found. The PIT tag reader was tested with another PIT tag and was found to be working properly. The size (462 mm TL), appearance (i.e., no visible scarring or parasites), and general health (i.e., no split fins or blind eyes) of this fish were indicative of a recently-stocked fish. It is likely that this fish had expelled its PIT tag or was originally implanted with a defective PIT tag. In any case, this fish was recorded as being a stocked fish and implanted with a new PIT tag before it was returned to the river (Table 2).

On 21 and 22 May 1998, two larval razorback sucker (12.7 mm TL and 12.1 mm TL, respectively) were collected from backwaters at RM 88.8 and 80.2, respectively, between Montezuma Creek and Bluff, UT (S. Platania pers. comm.).

DISCUSSION

The last, and in fact only, scientifically-documented collection of a wild razorback sucker in the mainstem San Juan River occurred on 25 April 1988, near Bluff, UT (Platania 1990, Platania et al. 1991). Extensive electrofishing and seining efforts in the mainstem San Juan River between 1991 and 1997 failed to collect any wild razorback sucker of any life stage. Additionally, the last wild razorback sucker to be collected from the San Juan

River Arm of Lake Powell were collected in the late 1980's. Sporadic electrofishing, seining, and trammel-netting efforts conducted in the San Juan River Arm of Lake Powell throughout the 1990's collected only a single razorback sucker, on 16 March 1995. This razorback sucker had been stocked at Bluff, UT (RM 79.6) on 27 October 1994 as a part of our study (Table 3). It is assumed that there is no extant wild razorback sucker population remaining in the San Juan River. However, stocked razorback sucker that have survived and now occupy the San Juan River are functionally acting as a wild razorback sucker population. All razorback sucker stocked as part of this and future stocking efforts will be considered to be, and protected as, wild fish.

The two larval razorback sucker collected in May 1998 were progeny of stocked razorback sucker. However, the fact that they were spawned in the San Juan River would make them wild fish. Likewise, any razorback sucker that are spawned in the San Juan River and recruit into adulthood will also be, functionally if not genetically, wild fish.

CONCLUSIONS/MANAGEMENT IMPLICATIONS

< Study Objective met? Yes

< No wild fish were collected during this or concurrent studies
  - < The lack of collections likely indicates that there is no longer an extant population of wild razorback sucker in the San Juan River

< Any razorback sucker spawned in the San Juan River that recruits into adulthood will be a wild fish, despite its parents being hatchery-reared

RECOMMENDATIONS

The following conclusions and recommendations were developed as a result of the data collected as part of this experimental stocking study. These recommendations were incorporated in the Five-Year Augmentation Plan For Razorback Sucker in the San Juan River (Ryden 1997).

1) Stocking in the spring versus stocking in the fall. This item presents somewhat of a quandary. Based on post-stocking displacement data alone, it appears that the best time to stock hatchery-reared razorback sucker is in the spring (i.e., late March or early April). Radiotelemetered razorback sucker stocked in the spring of 1994 had smaller downstream displacements than did fish stocked in the fall of 1994, 1995, or 1996. Once initial downstream displacements associated with stocking took place, stocked, hatchery-reared razorback sucker demonstrated the ability to maintain their relative position in the river during high water periods, even in the lower, canyon-bound reaches of the river. Also, stocking in the spring allows fish to adapt to their new environment before their first winter season and frees up hatchery facilities and grow-out ponds for use in raising new batches of young fish to be stocked. These new batches of young fish are usually obtained between March and May as larvae are collected from the wild or produced in hatcheries.

The disadvantage of stocking fish in the spring is that fish have less time to grow before being stocked. Based on our recapture percentages, stocked razorback sucker survive better when stocked at larger sizes (i.e., > 350 mm TL). The problem is that the number of fish that can be held and reared at any facility is limited. This number becomes even more reduced as fish in those facilities grow to larger sizes. Thus, if fish are held until fall and reared to larger sizes, there is less room for new fish for following years to be held and reared. However, given the observed differences in recapture rates between large and small size-class fish, it may be just as wise to stock fewer large size class fish in the fall that have a better chance of survival than more small size-class fish in the spring even though they move less post-stocking.

Both spring and fall stocking appear to have advantages. The best of both worlds would be to stock large size-class fish in the spring of the year. However, this would require holding fish in rearing facilities for an even longer period of time (i.e., overwinter). In reality the decision of whether to stock fish in the spring or fall will likely have to be a yearly decision based on available hatchery and grow-out pond space, the number of razorback sucker currently being reared in those facilities, and the amount of fish the SJRIP is able to obtain for future stocking efforts that have to be accommodated at these same facilities.

2) Stock as far upstream as possible. Hatchery-reared razorback sucker should be stocked as far upstream as is feasible, due to large initial downstream displacements. The farthest upstream location in the San Juan River where interaction with other razorback sucker could occur if a fish did not displace downstream at all after stocking is probably Hogback Diversion (RM 158.6). Upstream of this point, numerous instream diversion structures would isolate groups of stocked fish from one another. In addition, Hogback

Diversion is the upstream limit of Critical Habitat for razorback sucker in the San Juan River. In addition, stocking fish as far downstream as Bluff, UT will result in the movement of some of these fish downstream into Lake Powell.

3) Keep the waterfall inundated. Some movement of stocked fish into Lake Powell appears inevitable if razorback sucker continue to be stocked as far downstream as Bluff, UT. This was evidenced by the March 1995 capture of a radiotelemetered razorback sucker (# 475) in a trammel net sample in Lake Powell. Several wild adult razorback sucker have been collected from Lake Powell at Piute Farms Marina just below the waterfall at RM 0.0 (present from approximately 1987 to 1995). In fact, the adult razorback sucker collected near Bluff, UT in 1988 may have been an individual that had moved upstream from San Juan River Arm of Lake Powell before the formation of the waterfall. At least one PIT-tagged razorback sucker stocked into Lake Powell in August 1995 and five sonic-tagged razorback sucker stocked into Lake Powell in November 1995 have moved into the lower reaches of the San Juan River since the waterfall's inundation. Couple this with the 92.1 RM upstream movement of a PIT-tagged razorback sucker between 12 August and 2 October 1997, and it appears that even stocked razorback sucker have the ability to regularly move between Lake Powell and the San Juan River. Thus even if razorback sucker move downstream into Lake Powell initially after stocking, there is a chance that these fish (as well as any wild fish that may still inhabit the San Juan River Arm of Lake Powell) may return to the San Juan River if the waterfall at RM 0.0 is not present.

It is important to note here that the waterfall at RM 0.0 is not a natural feature. It was formed by the filling to capacity (early 1980's) and subsequent drop in lake level (ca. 1987) of Lake Powell. During the filling of Lake Powell, huge sediment deposits (approximately 60 ft. deep in some places) were laid down in the lower 14 RM of the San Juan River (Ryden and Ahlm 1996). The drop in lake level caused the river to cut a new course through the sediment accumulation and flow over a sandstone outcrop creating the waterfall (> 10 m at some flows). Due to its very nature, the presence and or absence of the waterfall cannot truly be managed for in a selective manner and, thus, used to reliably deter the upstream movement of lacustrine predatory fishes. Thus, the greatest benefit to both wild and stocked razorback sucker entering or already present in the San Juan River arm of Lake Powell can be achieved by keeping the waterfall inundated, allowing free access to the San Juan River.

4) Stock large size-class fish, and maintain a mechanical removal program for nonnative predators. Since the waterfall at RM 0.0 was inundated by rising levels in Lake Powell in spring 1995, predatory lacustrine fish species (striped bass and walleye) have invaded the river from Lake Powell and added an additional predation pressure on top of the large numbers of channel catfish already present in the river. Stomach samples from these three species documented predation on native flannelmouth sucker (the most abundant native fish in the San Juan River) up to 300 mm SL by nonnative channel catfish, striped bass, and walleye (Ryden 2000). This evidence combined with the presence of a large (130 mm wide) bite mark across the dorsal keel of a stocked razorback sucker (408 mm TL) suggest that in order to avoid loss of stocked fish to predation, stocked razorback sucker should be greater than 410

mm TL. Also, mechanical control of nonnative predatory fish species may be necessary to insure success of an augmentation effort.

In addition, razorback sucker that were stocked at larger size-classes (> 350 mm) have a much higher recapture rate than do smaller fish.

5) Stock fish no later than three years of age. While small size-class razorback sucker are known to be lost to predation and other causes, old razorback sucker appear to become domesticated to conditions present at hatcheries and ponds and are unable to adapt to riverine conditions when held too long.

RELATIONSHIP TO RECOVERY PROGRAM

One of the two purposes of the SJRIP is to protect and recover endangered fishes in the San Juan River basin, including Colorado pikeminnow and razorback sucker. Item 3.2.2.2.b under RESEARCH AND RECOVERY ELEMENTS AND RECOVERY PROGRAM IMPLEMENTATION in the SJRIP Program Document specifies evaluating the need to augment wild populations of razorback sucker and augmenting if deemed necessary, desirable, and likely to improve the status of this species (San Juan River Recovery Implementation Program Biology Committee 1995a). Item 5.3.8 in the SJRIP Long Range Plan (LRP) identifies determining the need for and implementing, if necessary, an augmentation program to recover endangered razorback sucker in appropriate historic habitat (San Juan River Recovery Implementation Program Biology Committee 1995b). In addition, items 5.2.5 in the SJRIP LRP identifies the need to determine and monitor habitat use of endangered (and other) fishes, and item 5.2.6 in the LRP states the need to identify limiting habitats for endangered fishes. Due to the paucity of historic and recent collections of razorback sucker, including the failure to collect any wild razorback sucker during the three years (1991-1993) of intensive studies on all life stages, the San Juan River Biology Committee identified the necessity to begin an experimental stocking program for razorback sucker in the San Juan River (Ryden and Pfeifer 1994a). The experimental stocking program was designed to facilitate study of this species in the wild and evaluate the efficacy of initiating a full-scale augmentation program for razorback sucker in the San Juan River. All stocked razorback sucker are afforded the same protection as wild razorback sucker under the Endangered Species Act.

ACKNOWLEDGEMENTS

The author would like to thank the numerous individuals and agencies without whose help this study could not have been accomplished:

Bureau of Indian Affairs (Farmington, NM)–Bob Krakow, Ernie Teller, Ray Smith, Paul Thompson, Calvin Jim, Emmett Johnson, Janice Biggs, and Libby Mitchell. Thanks for all the extra radio-tracking you did for us, as well as the innumerable shuttles to Clay Hills (and other places)!

Miller Ecological Consultants, Inc. (Fort Collins, CO)–Jeff Hogle, Bill Miller, and Charlie Morris.

National Park Service (Page, AZ and Denver, CO)–Susan Dodson and Rick Wydoski (and Dick Wydoski for relaying information).

New Mexico Dept. of Game and Fish (Santa Fe and Navajo Dam, NM)--Bob Larson, Santiago (Jimmy) Misquez, and Tom Sansom.

University of New Mexico (Albuquerque, NM)–Greg Lein

U.S. Fish and Wildlife Service (Albuquerque, NM)–Jim Brooks, Mike Buntjer, Chris Hoagstrom, Julie Jackson, Jude Smith, and Barry Wiley.

U.S. Fish and Wildlife Service (Grand Junction, CO)–Mike Baker, Bruce Bonar, Joe Flair, Terry Ireland, Meredee Lloyd, Frank Pfeifer, Mike Montagne, Toby Mourning, Doug Osmundson, Terry Ireland, Matt Toner.

U.S. Fish and Wildlife Service (Pinetop, AZ)–Beth McCasland and Jerry Landye.

Utah Division of Wildlife Resources (Wahweap)–George Blommer, Wayne Gustaveson, Craig Schaugaard, and numerous seasonal employees.

Volunteer–Chris Flann

Thanks as well to all the individuals who participated in adult fish community monitoring trips, channel catfish removal trips, secondary channels fish community monitoring trips, and the National Park Service's Lake Powell razorback sucker sampling. Those studies accounted for many of the razorback sucker recaptures detailed in this report.

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APPENDIX A

PIT tag numbers and stocking information for razorback sucker stocked into the San Juan River by the U.S. Fish and Wildlife Service between 29 March 1994 and 3 October 1996, and into the San Juan River Arm of Lake Powell by the Utah Division of Wildlife Resources on 8 and 15 August 1995.

Table A-1. Stocking information for the 939 fish stocked between 29 March 1994 and 3 October 1996 as part of the experimental stocking study for razorback sucker in the San Juan River.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F1E2E5F36	10/27/94	117.5	384	2A
1F1E300C07	10/27/94	79.6	384	2A
1F1E385437	10/27/94	136.6	401	2A
1F1F561458	10/27/94	117.5	394	2A
1F1F707A58	09/27/95	158.6	415	2A
1F40026639	09/27/95	158.6	425	2A
1F40195E2A	09/27/95	158.6	424	2A
1F402D076D	11/18/94	117.5	398	2A
1F402D1064	11/18/94	136.6	393	2A
1F402D165E	11/18/94	158.6	404	2A
1F402D797B	11/18/94	117.5	407	2A
1F402E145F	11/18/94	158.6	420	2A
1F402E4330	11/18/94	136.6	373	2A
1F402E452E	11/18/94	158.6	388	2A
1F4030155C	11/18/94	79.6	360	2A
1F40301B56	11/18/94	79.6	403	2A
1F4030373A	11/18/94	136.6	395	2A
1F4031135D	11/18/94	79.6	383	2A
1F40326A05	11/18/94	136.6	417	2A
1F40326B04	11/18/94	158.6	364	2A
1F4033610D	11/18/94	136.6	390	2A
1F40340D60	11/18/94	79.6	418	2A
1F40346409	11/18/94	117.5	399	2A
1F40355517	11/18/94	79.6	385	2A
1F40374129	11/18/94	79.6	424	2A
1F40387D6C	11/18/94	117.5	407	2A
1F40395414	11/18/94	136.6	430	2A
1F403B7C6A	11/18/94	117.5	396	2A
1F403C570E	11/18/94	136.6	384	2A
1F4040075A	11/18/94	136.6	442	2A
1F40416977	11/18/94	117.5	385	2A
1F40422D32	11/18/94	79.6	386	2A
1F40432B33	11/18/94	158.6	404	2A
1F40440855	11/18/94	117.5	385	2A
1F40445D00	11/18/94	136.6	379	2A
1F40447964	11/18/94	79.6	402	2A
1F40453923	11/18/94	158.6	375	2A
1F40454517	11/18/94	136.6	398	2A
1F40464714	11/18/94	158.6	408	2A
1F40464E0D	11/18/94	158.6	404	2A
1F40472337	11/18/94	117.5	404	2A
1F40476575	11/18/94	158.6	402	2A
1F40496870	11/18/94	136.6	408	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F404B4B0B	11/18/94	117.5	417	2A
1F404C4A0B	10/27/94	79.6	386	2A
1F404D755F	11/18/94	136.6	382	2A
1F404E646F	11/18/94	158.6	412	2A
1F404E666D	11/18/94	158.6	370	2A
1F404F3D15	11/18/94	117.5	358	2A
1F404F4A08	11/18/94	158.6	388	2A
1F4052143B	11/18/94	158.6	427	2A
1F40735A54	11/18/94	158.6	420	2A
1F40742706	11/18/94	79.6	404	2A
1F40756448	11/18/94	117.5	406	2A
1F40756C40	10/27/94	136.6	419	2A
1F40775852	11/18/94	136.6	414	2A
1F40776C3E	11/18/94	117.5	420	2A
1F40785F4A	11/18/94	79.6	410	2A
1F40793870	11/18/94	79.6	388	2A
1F407B0224	11/18/94	117.5	402	2A
1F41180F7A	10/03/96	158.6	368	??
1F412A2D49	11/18/94	117.5	412	2A
1F412A482E	11/18/94	158.6	392	2A
1F412B1362	11/18/94	117.5	446	2A
1F412E4230	09/27/95	158.6	411	2A
1F412E5022	11/18/94	158.6	398	2A
1F4132402E	11/18/94	136.6	396	2A
1F41334627	11/18/94	136.6	398	2A
1F41341F4D	11/18/94	158.6	403	2A
1F4134412B	11/18/94	117.5	410	2A
1F41361A50	11/18/94	136.6	395	2A
1F41373732	11/18/94	136.6	330	2A
1F41386B7D	11/18/94	79.6	407	2A
1F41394126	11/18/94	158.6	403	2A
1F413B7471	11/18/94	79.6	423	2A
1F413C0C58	11/18/94	117.5	422	2A
1F413C3034	11/18/94	158.6	418	2A
1F413C4321	11/18/94	117.5	408	2A
1F413C7C68	11/18/94	79.6	393	2A
1F413F164B	11/18/94	79.6	412	2A
1F41401050	11/18/94	136.6	415	2A
1F41405A06	11/18/94	117.5	408	2A
1F41406D73	11/18/94	117.5	418	2A
1F4143510C	11/18/94	136.6	422	2A
1F41437964	11/18/94	79.6	374	2A
1F41451C3F	11/18/94	136.6	420	2A
1F41453724	11/18/94	158.6	356	2A
1F41455F7C	11/18/94	117.5	418	2A
1F4146005A	11/18/94	136.6	400	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F41461D3D	11/18/94	158.6	404	2A
1F41473623	11/18/94	136.6	370	2A
1F41482038	11/18/94	158.6	367	2A
1F41483B1D	10/27/94	117.5	411	2A
1F41495F78	11/18/94	158.6	383	2A
1F414E0C46	11/18/94	79.6	385	2A
1F414E3E14	11/18/94	79.6	395	2A
1F414E537F	11/18/94	117.5	418	2A
1F414F460B	11/18/94	158.6	390	2A
1F414F557C	11/18/94	136.6	420	2A
1F41505779	11/18/94	136.6	414	2A
1F41513F10	10/27/94	136.6	386	2A
1F41612C13	09/27/95	158.6	431	2A
1F43550544	11/18/94	158.6	414	2A
1F43552524	11/18/94	79.6	414	2A
1F4359192C	11/18/94	136.6	404	2A
1F43591E27	11/18/94	136.6	365	2A
1F43596560	11/18/94	136.6	338	2A
1F43597253	11/18/94	158.6	395	2A
1F435A6262	11/18/94	79.6	396	2A
1F435C784A	11/18/94	158.6	399	2A
1F435D1C25	11/18/94	117.5	422	2A
1F435F053A	11/17/94	158.6	147	??
1F435F1728	11/18/94	136.6	442	2A
1F435F625D	11/18/94	158.6	404	2A
1F435F6B54	11/18/94	117.5	378	2A
1F43602A14	11/18/94	79.6	398	2A
1F43605C62	11/18/94	79.6	408	2A
1F4361437A	11/18/94	158.6	407	2A
1F43623507	11/18/94	117.5	373	2A
1F43631724	10/27/94	136.6	435	2A
1F43632219	10/27/94	79.6	388	2A
1F43633803	11/18/94	79.6	383	2A
1F43634972	11/18/94	117.5	423	2A
1F43644D6D	11/18/94	117.5	414	2A
1F43647A40	11/18/94	158.6	378	2A
1F43650D2C	11/18/94	79.6	405	2A
1F4366191F	10/27/94	136.6	427	2A
1F43670136	11/18/94	117.5	418	2A
1F43670433	09/27/95	158.6	421	2A
1F43683105	11/18/94	136.6	407	2A
1F43686353	10/27/94	79.6	415	2A
1F4368684E	11/18/94	79.6	388	2A
1F43686B4B	11/18/94	158.6	390	2A
1F43690134	11/18/94	79.6	404	2A
1F463E213C	09/27/95	158.6	482	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F564C6C53	11/16/94	117.5	190	??
1F587A6725	09/27/95	158.6	426	2A
1F587A7D0F	09/27/95	158.6	424	2A
1F59480838	11/16/94	117.5	141	2A
1F5B684A54	09/27/95	158.6	428	2A
1F5B747C16	09/27/95	158.6	432	2A
1F5E1F4C18	10/03/96	158.6	314	2A
1F5E275E7E	11/17/94	158.6	190	??
1F5E787E0D	11/16/94	117.5	117	??
1F60081366	11/17/94	158.6	153	??
1F600C2E47	10/03/96	158.6	320	2A
1F60146508	11/16/94	79.6	160	??
1F60465F5C	11/16/94	136.6	134	2A
1F604C466F	11/16/94	117.5	164	??
1F60536D41	11/16/94	136.6	200	??
1F60555953	11/16/94	136.6	170	??
1F60583D6C	11/17/94	158.6	176	??
1F60590B1D	11/16/94	136.6	133	2A
1F6060336E	11/16/94	79.6	218	??
1F60606041	11/17/94	158.6	117	2A
1F6062207F	11/17/94	158.6	126	??
1F60632777	11/16/94	117.5	118	2A
1F60722D62	11/16/94	136.6	180	??
1F61025D21	11/17/94	158.6	178	??
1F6110650B	11/16/94	117.5	102	2A
1F6112432B	11/17/94	158.6	123	??
1F61186602	11/16/94	117.5	183	??
1F6120025E	11/16/94	79.6	137	??
1F61265802	11/16/94	117.5	137	??
1F612C6D67	11/17/94	158.6	122	2A
1F61311A35	11/16/94	79.6	131	2A
1F613A5472	11/17/94	158.6	174	??
1F614C2410	11/16/94	117.5	109	??
1F614C2A0A	11/17/94	158.6	225	??
1F61541715	11/16/94	136.6	162	??
1F61546943	11/16/94	79.6	106	??
1F61583573	11/16/94	117.5	188	??
1F615C0420	11/17/94	158.6	200	??
1F615D4E55	10/03/96	158.6	313	2A
1F61677C1D	11/16/94	136.6	190	??
1F61774346	11/16/94	136.6	188	??
1F61777712	11/16/94	79.6	137	??
1F61794C3B	11/16/94	79.6	217	??
1F62012E50	11/16/94	136.6	121	??
1F62053F3B	11/17/94	158.6	184	??
1F62094333	11/16/94	79.6	111	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F620F747C	11/16/94	117.5	118	??
1F6211707E	11/16/94	117.5	177	??
1F62156604	11/16/94	117.5	132	??
1F62244219	11/17/94	158.6	109	2A
1F624A4372	11/16/94	136.6	114	2A
1F62537E2E	11/16/94	79.6	108	??
1F62557733	11/17/94	158.6	202	??
1F62593D69	11/16/94	117.5	158	??
1F625B5A4A	10/03/96	158.6	342	2A
1F626B365E	11/16/94	79.6	102	??
1F62713D51	11/16/94	117.5	110	??
1F6274513A	11/16/94	136.6	150	2A
1F62770B7D	11/16/94	79.6	140	2A
1F62782A5D	11/16/94	136.6	193	??
1F62796620	11/16/94	136.6	179	??
1F627A6E17	11/16/94	117.5	109	2A
1F627B4341	11/16/94	117.5	212	??
1F627C6A19	11/17/94	158.6	117	2A
1F627D641E	11/16/94	136.6	147	2A
1F627E275A	11/16/94	117.5	121	??
1F627F166A	11/16/94	136.6	177	??
1F63032853	11/16/94	117.5	201	??
1F63044139	11/17/94	158.6	132	2A
1F63046317	11/16/94	117.5	173	??
1F63060B6D	11/16/94	117.5	186	??
1F6309195C	11/16/94	79.6	116	??
1F6309482D	11/17/94	158.6	112	2A
1F630D6F02	11/16/94	136.6	100	2A
1F630E2B45	11/16/94	136.6	108	2A
1F63176D7A	11/16/94	117.5	188	??
1F63195B0A	11/16/94	136.6	178	??
1F6319776E	11/16/94	79.6	160	??
1F631C4022	11/16/94	79.6	146	??
1F631C7B67	11/16/94	136.6	188	??
1F631D045D	11/16/94	136.6	123	2A
1F631F0B54	11/16/94	136.6	194	??
1F632F7956	11/16/94	136.6	130	??
1F63337C4F	11/16/94	117.5	148	??
1F633A7F45	11/16/94	117.5	117	2A
1F63500F1F	11/16/94	136.6	241	??
1F63565B4D	11/17/94	158.6	130	2A
1F63592104	11/16/94	136.6	128	2A
1F635C170B	11/17/94	158.6	176	??
1F635C346E	11/17/94	158.6	192	??
1F63623666	11/16/94	136.6	115	2A
1F63656E2B	11/16/94	79.6	185	??

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F6366090F	11/16/94	117.5	121	2A
1F636A3460	11/16/94	117.5	173	??
1F63767810	11/17/94	158.6	188	??
1F63781D69	11/17/94	158.6	140	??
1F63784A3C	11/16/94	136.6	128	2A
1F637C334F	11/17/94	158.6	176	??
1F637E2957	11/16/94	79.6	138	??
1F63A73321	11/16/94	117.5	195	??
1F640A0C67	11/16/94	79.6	133	??
1F640D0A66	10/03/96	158.6	316	2A
1F64162641	11/17/94	158.6	190	??
1F6419657F	11/16/94	117.5	130	2A
1F641A0063	11/17/94	158.6	140	??
1F64345D6C	11/16/94	136.6	195	??
1F643E1C23	11/16/94	136.6	110	??
1F64437F3B	11/16/94	79.6	122	2A
1F64506449	11/16/94	79.6	156	??
1F6451624A	11/16/94	136.6	123	2A
1F64544465	11/16/94	136.6	135	2A
1F64572105	11/16/94	136.6	112	??
1F64644752	11/16/94	79.6	116	2A
1F64672A6C	11/17/94	158.6	222	??
1F646B563C	10/03/96	158.6	332	2A
1F646D1000	11/16/94	79.6	218	??
1F6471216B	11/16/94	136.6	190	??
1F647B4240	11/16/94	79.6	147	??
1F647E4F30	11/17/94	158.6	192	??
1F647F4638	11/16/94	79.6	106	2A
1F65012457	11/17/94	158.6	158	??
1F65104A22	11/16/94	117.5	130	??
1F651C431D	11/17/94	158.6	131	2A
1F65226872	11/17/94	158.6	118	2A
1F65271243	11/17/94	158.6	124	2A
1F652C2927	11/16/94	117.5	137	2A
1F65306F5D	11/17/94	158.6	117	??
1F6534192F	11/16/94	79.6	184	??
1F65347355	11/17/94	158.6	194	??
1F654E1717	11/17/94	158.6	196	??
1F655B3F62	10/03/96	158.6	305	2A
1F655E603E	11/16/94	79.6	179	??
1F65621109	11/16/94	136.6	101	2A
1F65622A70	11/16/94	117.5	122	??
1F6568672D	11/16/94	79.6	144	??
1F656B2170	11/17/94	158.6	158	??
1F6577592C	11/16/94	136.6	130	2A
1F65780A7A	11/16/94	117.5	115	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F657D512E	11/16/94	117.5	116	2A
1F66023841	11/16/94	79.6	177	??
1F66252333	11/16/94	117.5	131	??
1F662B557B	11/16/94	136.6	208	??
1F662E6667	11/16/94	117.5	177	??
1F6633596F	11/16/94	79.6	107	2A
1F66340542	11/17/94	158.6	187	??
1F66351531	11/16/94	117.5	188	??
1F663C5966	11/16/94	79.6	130	2A
1F663D2E10	11/16/94	79.6	180	??
1F663D5F5F	11/16/94	136.6	118	??
1F66406556	11/16/94	136.6	114	2A
1F664C4C63	11/16/94	117.5	204	??
1F66565451	11/17/94	158.6	204	??
1F665B6E32	11/16/94	79.6	152	??
1F66680112	11/16/94	136.6	183	??
1F666A6928	11/16/94	79.6	124	??
1F671D401D	11/16/94	79.6	113	??
1F672C5C72	11/16/94	117.5	180	??
1F673A1D23	11/17/94	158.6	113	2A
1F67405E5C	11/16/94	79.6	213	??
1F681D025A	11/16/94	117.5	133	??
1F681D3527	11/16/94	117.5	128	??
1F68224116	11/17/94	158.6	175	??
1F68227F58	11/16/94	117.5	206	??
1F6825391B	11/17/94	158.6	135	??
1F682A0F40	11/16/94	136.6	110	??
1F682A4807	10/03/96	158.6	317	2A
1F682F705A	10/03/96	158.6	340	2A
1F684B7935	11/16/94	79.6	129	2A
1F684F6545	11/16/94	136.6	111	??
1F68514E5A	11/17/94	158.6	114	2A
1F6853574F	11/16/94	136.6	137	2A
1F68595848	11/16/94	117.5	132	??
1F685A1C03	11/17/94	158.6	223	??
1F6864791C	11/16/94	136.6	188	??
1F6866444F	11/16/94	117.5	217	??
1F68665241	11/16/94	117.5	114	2A
1F6866593A	11/16/94	117.5	174	??
1F6B1D0E4B	09/27/95	158.6	415	2A
1F6B1E0D4B	09/27/95	158.6	397	2A
1F6CFE5303	10/03/96	158.6	346	??
1F6E1C2631	11/17/94	158.6	118	2A
1F6E1C5B7C	11/16/94	79.6	112	2A
1F6E2B5573	11/16/94	136.6	193	??
1F6E2C7E49	11/16/94	136.6	140	??

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F6E301330	11/17/94	158.6	148	??
1F6E30447F	11/16/94	79.6	187	??
1F717E2C46	11/16/94	136.6	116	2A
1F717E541E	11/16/94	117.5	130	2A
1F72014826	11/16/94	136.6	207	??
1F720F2040	11/17/94	158.6	120	2A
1F720F2739	11/17/94	158.6	209	??
1F72121647	11/16/94	136.6	203	??
1F72157367	11/16/94	79.6	145	??
1F73115409	11/16/94	136.6	205	??
1F731B371C	11/18/94	158.6	400	2A
1F731B4112	11/18/94	79.6	392	2A
1F731C2E24	11/18/94	158.6	404	2A
1F731D420F	11/18/94	79.6	357	2A
1F731D7160	11/18/94	117.5	374	2A
1F731F6E61	11/18/94	117.5	397	2A
1F7320400E	11/18/94	79.6	402	2A
1F73221438	11/18/94	79.6	408	2A
1F7323212A	11/18/94	79.6	394	2A
1F7323400B	11/18/94	136.6	380	2A
1F7328172F	11/18/94	136.6	427	2A
1F73282224	11/18/94	117.5	395	2A
1F732B063D	11/18/94	117.5	435	2A
1F732C5B67	11/18/94	158.6	388	2A
1F732C5C5C	11/18/94	79.6	398	2A
1F732D0E33	11/18/94	158.6	424	2A
1F732D4001	11/18/94	117.5	411	2A
1F732D724F	11/18/94	136.6	420	2A
1F7330506E	11/18/94	136.6	396	2A
1F7331201D	11/18/94	158.6	388	2A
1F73326C50	11/18/94	158.6	390	2A
1F73326E4E	11/18/94	117.5	426	2A
1F73334477	11/18/94	158.6	390	2A
1F73334F6C	11/18/94	79.6	393	2A
1F73361622	11/18/94	158.6	380	2A
1F73372E09	11/18/94	136.6	423	2A
1F73381A1C	11/18/94	79.6	405	2A
1F73385165	11/18/94	158.6	404	2A
1F73386353	11/18/94	158.6	393	2A
1F73386F47	11/18/94	158.6	435	2A
1F733B250E	11/18/94	117.5	404	2A
1F733C535F	11/18/94	136.6	404	2A
1F733C585A	11/18/94	158.6	395	2A
1F733C7240	11/18/94	79.6	417	2A
1F733C783A	11/18/94	136.6	428	2A
1F733D0031	11/18/94	136.6	372	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F733D674A	11/18/94	117.5	404	2A
1F733E3000	11/18/94	79.6	395	2A
1F733E4868	10/27/94	117.5	388	2A
1F733E7838	11/18/94	158.6	420	2A
1F733F3B74	11/18/94	158.6	393	2A
1F73402806	11/18/94	79.6	392	2A
1F742E4D72	11/18/94	117.5	408	2A
1F74312616	11/18/94	136.6	380	2A
1F74321823	11/18/94	136.6	420	2A
1F74326556	11/18/94	79.6	400	2A
1F74327447	11/18/94	79.6	380	2A
1F74333B7F	11/18/94	136.6	404	2A
1F74335B5F	11/18/94	79.6	404	2A
1F74343F7A	11/18/94	79.6	394	2A
1F74345366	11/18/94	136.6	407	2A
1F74351028	11/18/94	117.5	433	2A
1F74361D1A	11/18/94	117.5	390	2A
1F74362314	11/18/94	79.6	404	2A
1F74373006	11/18/94	79.6	377	2A
1F74391321	11/18/94	158.6	406	2A
1F74395361	11/17/94	158.6	179	??
1F743A347F	11/18/94	136.6	406	2A
1F743A6D46	11/18/94	117.5	420	2A
1F743D161A	11/18/94	117.5	393	2A
1F743D4B65	11/18/94	79.6	418	2A
1F743D763A	11/18/94	117.5	364	2A
1F743E042B	11/18/94	136.6	420	2A
1F743E2708	11/18/94	136.6	413	2A
1F743E2F00	11/18/94	158.6	404	2A
1F743F210D	11/18/94	117.5	393	2A
1F7441614B	11/18/94	117.5	390	2A
1F74421714	11/18/94	136.6	430	2A
1F74712656	09/27/95	158.6	417	2A
1F7509154E	09/27/95	158.6	415	2A
1F75165303	09/27/95	158.6	415	2A
1F770D2439	11/17/94	158.6	128	??
1F77103C1E	10/03/96	158.6	351	2A
1F77117F5A	11/17/94	158.6	190	??
1F7715765F	11/16/94	136.6	168	??
1F77164311	11/16/94	117.5	174	??
2007327235	11/16/94	117.5	121	2A
2007333F67	11/16/94	117.5	121	2A
2007335D49	11/16/94	117.5	163	??
200737465C	11/16/94	79.6	106	??
2007405445	10/03/96	158.6	336	2A
2007432274	11/17/94	158.6	104	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
2007467C17	11/16/94	79.6	160	??
2007493759	11/17/94	158.6	204	??
2007495D33	11/16/94	117.5	106	??
20074B2F5F	11/16/94	79.6	170	??
20074B513D	11/17/94	158.6	138	??
20074C3459	11/17/94	158.6	104	??
20074C4D40	11/16/94	79.6	190	??
20074E6328	11/17/94	158.6	118	2A
2007501475	11/17/94	158.6	180	??
2007506029	11/16/94	136.6	192	??
2007511771	11/17/94	158.6	192	??
2007526522	11/16/94	136.6	183	??
7F7B023E0D	10/03/96	158.6	333	3A
7F7B0F1B05	11/16/94	79.6	184	3A
7F7B104932	10/03/96	158.6	426	2A
7F7B10607E	10/03/96	158.6	353	2A
7F7B107310	10/03/96	158.6	326	3A
7F7B107434	11/16/94	136.6	215	3A
7F7B107464	10/03/96	158.6	326	2A
7F7B107A51	11/16/94	79.6	227	3A
7F7B107E6D	11/16/94	136.6	122	3A
7F7B107F62	11/17/94	158.6	190	3A
7F7B110221	11/16/94	117.5	341	3A
7F7B110C71	10/03/96	158.6	303	3A
7F7B111359	11/17/94	158.6	217	3A
7F7B11196C	11/16/94	136.6	156	3A
7F7B112101	10/03/96	158.6	300	3A
7F7B112A36	11/16/94	136.6	224	3A
7F7B113277	10/03/96	158.6	396	2A
7F7B11376D	11/16/94	136.6	160	3A
7F7B113E18	11/16/94	79.6	190	3A
7F7B114507	11/16/94	79.6	181	3A
7F7B11467D	11/17/94	158.6	350	3A
7F7B11732B	11/16/94	136.6	220	3A
7F7B117470	11/17/94	158.6	205	3A
7F7B117C30	11/16/94	79.6	207	3A
7F7B121A4C	11/16/94	117.5	355	3A
7F7B123F24	10/03/96	158.6	304	3A
7F7B124445	10/03/96	158.6	384	2A
7F7B124609	11/16/94	136.6	216	3A
7F7B13015C	10/03/96	158.6	330	3A
7F7B134B45	11/17/94	158.6	142	3A
7F7B135017	11/17/94	158.6	212	3A
7F7B135435	10/03/96	158.6	322	3A
7F7B137C04	10/03/96	158.6	343	2A
7F7B176876	10/03/96	158.6	385	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7B177076	10/03/96	158.6	342	2A
7F7B177140	10/03/96	158.6	373	2A
7F7B180139	10/03/96	158.6	346	2A
7F7B180319	10/03/96	158.6	370	2A
7F7B180938	10/03/96	158.6	316	3A
7F7B191400	10/03/96	158.6	348	??
7F7B194562	11/16/94	79.6	191	3A
7F7B19504F	11/17/94	158.6	222	3A
7F7B195D51	10/03/96	158.6	215	3A
7F7B1A3A0C	11/16/94	136.6	204	3A
7F7B1A3C34	10/03/96	158.6	356	2A
7F7B1A3E50	11/16/94	117.5	353	3A
7F7B1A4A1E	11/16/94	136.6	244	3A
7F7B1A4C2C	11/16/94	117.5	223	??
7F7B1A525B	10/03/96	158.6	356	2A
7F7B1A6245	10/03/96	158.6	357	3A
7F7B1A644E	10/03/96	158.6	302	3A
7F7B1A7946	10/03/96	158.6	318	3A
7F7B1B007E	10/03/96	158.6	349	2A
7F7B1B057F	11/17/94	158.6	224	3A
7F7B1B0713	10/03/96	158.6	357	3A
7F7B1B0A5E	10/03/96	158.6	374	2A
7F7B1B160E	11/16/94	136.6	194	3A
7F7B1B1720	10/03/96	158.6	308	3A
7F7B1B1A23	10/03/96	158.6	322	3A
7F7B1B2201	11/16/94	79.6	226	3A
7F7B1B4D27	11/17/94	158.6	169	3A
7F7B1B5218	10/03/96	158.6	382	2A
7F7B1B5237	10/03/96	158.6	356	2A
7F7B1B5D47	11/16/94	79.6	195	3A
7F7B1B604F	11/16/94	117.5	238	3A
7F7B1B714D	10/03/96	158.6	314	3A
7F7D026279	10/03/96	158.6	311	1A
7F7D0A2858	10/03/96	158.6	310	1A
7F7D0B6720	11/16/94	117.5	204	1A
7F7D0C117C	11/16/94	136.6	227	1A
7F7D0C3630	11/16/94	117.5	234	1A
7F7D0C3E39	11/16/94	136.6	234	1A
7F7D0D6F54	11/16/94	79.6	365	1A
7F7D0D7A0B	11/16/94	136.6	182	1A
7F7D0F1F75	11/16/94	79.6	220	1A
7F7D0F2265	11/16/94	136.6	165	3A
7F7D0F2430	11/16/94	117.5	126	1A
7F7D0F293E	11/16/94	117.5	190	3A
7F7D0F323C	11/16/94	79.6	195	1A
7F7D0F3361	10/03/96	158.6	330	1A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D0F345F	11/16/94	117.5	195	1A
7F7D0F381C	11/17/94	158.6	158	1A
7F7D0F3859	11/17/94	158.6	183	1A
7F7D0F3A1F	11/16/94	79.6	202	1A
7F7D0F3B01	10/03/96	158.6	363	1A
7F7D0F3B36	10/03/96	158.6	342	1C
7F7D0F3C21	11/16/94	136.6	374	1A
7F7D0F3D76	10/03/96	158.6	353	1A
7F7D0F617A	11/16/94	117.5	204	1A
7F7D0F6570	11/16/94	79.6	272	1A
7F7D0F6571	11/16/94	136.6	270	1A
7F7D0F673A	11/16/94	79.6	295	1A
7F7D0F685E	11/16/94	79.6	120	1A
7F7D0F6F2F	11/16/94	117.5	178	1A
7F7D0F7122	11/17/94	158.6	200	1A
7F7D0F7275	11/16/94	79.6	165	1A
7F7D0F7412	11/16/94	136.6	247	1A
7F7D0F7524	10/03/96	158.6	362	1C
7F7D0F763A	10/03/96	158.6	401	1C
7F7D0F7A0E	11/16/94	117.5	253	1A
7F7D100E2A	11/16/94	136.6	209	1A
7F7D100F3D	11/17/94	158.6	325	1A
7F7D101056	10/03/96	158.6	340	1A
7F7D10114B	11/16/94	136.6	205	3A
7F7D101503	11/16/94	117.5	202	1A
7F7D112431	11/16/94	136.6	205	1A
7F7D127307	11/16/94	79.6	240	1A
7F7D13091A	11/16/94	79.6	194	3A
7F7D130B22	11/16/94	117.5	293	3E
7F7D132E2B	11/16/94	79.6	277	1A
7F7D133703	11/16/94	136.6	147	1A
7F7D135141	11/16/94	79.6	153	??
7F7D137C57	10/03/96	158.6	371	3E
7F7D152A4E	11/17/94	158.6	203	1C
7F7D154961	11/17/94	158.6	330	1C
7F7D16194D	10/03/96	158.6	329	2B
7F7D161957	10/03/96	158.6	328	2B
7F7D161A00	11/16/94	79.6	263	1A
7F7D161A27	11/16/94	79.6	242	1A
7F7D161A36	10/03/96	158.6	318	2A
7F7D161A57	11/17/94	158.6	204	1A
7F7D161A66	10/03/96	158.6	316	3E
7F7D161C39	11/17/94	158.6	229	1A
7F7D161C45	10/03/96	158.6	386	2B
7F7D161C48	10/03/96	158.6	403	1C
7F7D161C51	11/16/94	117.5	180	1A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D161C75	11/17/94	158.6	188	1A
7F7D161E01	11/16/94	136.6	152	1A
7F7D161E02	11/17/94	158.6	188	1A
7F7D161E67	10/03/96	158.6	389	1A
7F7D161E72	10/03/96	158.6	285	3E
7F7D161F06	11/16/94	117.5	155	1A
7F7D161F23	10/03/96	158.6	353	2B
7F7D161F25	11/16/94	79.6	184	1A
7F7D161F2C	10/03/96	158.6	314	3E
7F7D161F38	11/16/94	136.6	318	3E
7F7D161F4C	10/03/96	158.6	395	3E
7F7D161F50	11/16/94	117.5	191	1A
7F7D161F57	10/03/96	158.6	204	2B
7F7D162002	10/03/96	158.6	380	3E
7F7D162003	11/16/94	117.5	238	1A
7F7D16200F	10/03/96	158.6	420	3E
7F7D162013	11/16/94	136.6	274	1A
7F7D162655	10/03/96	158.6	301	3E
7F7D162759	11/16/94	136.6	212	1A
7F7D16275E	11/16/94	117.5	238	1A
7F7D162830	11/16/94	117.5	207	1A
7F7D162A34	11/16/94	79.6	254	1A
7F7D162C06	10/03/96	158.6	355	1C
7F7D162D0E	11/16/94	117.5	341	1C
7F7D162E30	10/03/96	158.6	412	1C
7F7D163121	11/16/94	79.6	321	1C
7F7D16340E	10/03/96	158.6	370	1C
7F7D16352E	10/03/96	158.6	372	1C
7F7D16367C	11/16/94	117.5	192	1C
7F7D163F39	10/03/96	158.6	235	1A
7F7D163F3A	11/17/94	158.6	213	1A
7F7D163F5E	10/03/96	158.6	284	1A
7F7D164010	11/16/94	117.5	231	1A
7F7D16405E	11/16/94	136.6	172	1A
7F7D164109	10/03/96	158.6	348	2B
7F7D16417B	11/16/94	79.6	163	1A
7F7D164219	11/16/94	117.5	224	1A
7F7D16421B	10/03/96	158.6	326	3E
7F7D164276	11/16/94	79.6	282	1A
7F7D16443F	11/16/94	79.6	344	2B
7F7D164545	11/16/94	136.6	204	1A
7F7D164558	10/03/96	158.6	333	2B
7F7D16467E	11/16/94	79.6	165	1A
7F7D164759	11/16/94	117.5	200	1A
7F7D164815	11/16/94	79.6	176	1A
7F7D164823	10/03/96	158.6	341	2B

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D164920	10/03/96	158.6	429	1A
7F7D164945	10/03/96	158.6	302	1A
7F7D164A66	11/17/94	158.6	138	1A
7F7D164D1F	11/17/94	158.6	232	1A
7F7D164D25	10/03/96	158.6	340	2B
7F7D164D33	10/03/96	158.6	337	1A
7F7D164D34	11/16/94	79.6	218	1A
7F7D164D53	11/16/94	136.6	240	1A
7F7D164E02	11/16/94	117.5	192	1A
7F7D164E46	11/16/94	136.6	257	1A
7F7D164F11	10/03/96	158.6	403	2B
7F7D164F53	11/16/94	79.6	152	1A
7F7D165028	11/17/94	158.6	194	1A
7F7D165047	10/03/96	158.6	345	1A
7F7D16506C	11/16/94	79.6	262	1A
7F7D16507C	11/16/94	117.5	202	2B
7F7D16513E	11/16/94	136.6	205	1A
7F7D165261	11/16/94	136.6	209	1A
7F7D165A63	11/16/94	136.6	236	1A
7F7D165A6D	11/17/94	158.6	158	3A
7F7D165B33	11/16/94	117.5	248	1A
7F7D165C3D	11/16/94	79.6	160	1A
7F7D165C5A	10/03/96	158.6	304	3E
7F7D165D6B	10/03/96	158.6	339	1A
7F7D165E20	11/16/94	117.5	141	1A
7F7D165E6C	10/03/96	158.6	368	2B
7F7D165E75	10/03/96	158.6	434	2B
7F7D166017	10/03/96	158.6	330	2B
7F7D166060	11/16/94	117.5	338	2B
7F7D166105	10/03/96	158.6	286	3E
7F7D166106	10/03/96	158.6	311	2B
7F7D16610A	11/16/94	136.6	269	1A
7F7D16613F	11/17/94	158.6	200	1A
7F7D16617F	11/16/94	117.5	192	1A
7F7D166219	11/16/94	117.5	182	1A
7F7D166251	10/03/96	158.6	339	3E
7F7D16627C	11/16/94	79.6	242	1A
7F7D166374	11/17/94	158.6	150	1A
7F7D170A45	11/17/94	158.6	204	1A
7F7D170B50	10/03/96	158.6	354	3A
7F7D170C01	11/16/94	117.5	244	1A
7F7D170C37	10/03/96	158.6	361	3E
7F7D170C67	03/29/94	117.5	269	2A
7F7D170D68	11/17/94	158.6	170	1A
7F7D170F46	11/16/94	136.6	182	1C
7F7D171149	11/16/94	117.5	232	1A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D171178	11/17/94	158.6	185	3A
7F7D171259	11/16/94	117.5	168	1A
7F7D171315	11/16/94	79.6	223	1A
7F7D17136B	11/17/94	158.6	194	1A
7F7D171371	11/16/94	117.5	188	1C
7F7D171439	11/16/94	136.6	365	3E
7F7D171467	11/16/94	136.6	230	1A
7F7D171522	10/03/96	158.6	327	3A
7F7D171566	11/17/94	158.6	162	3A
7F7D171604	11/16/94	117.5	117	1A
7F7D17165A	11/16/94	136.6	185	1A
7F7D171679	11/16/94	136.6	214	1A
7F7D17172B	10/03/96	158.6	365	1C
7F7D171774	10/03/96	158.6	276	3E
7F7D171829	11/16/94	117.5	233	1A
7F7D171924	11/16/94	79.6	204	3A
7F7D171937	10/03/96	158.6	335	3A
7F7D17193A	11/16/94	136.6	157	1A
7F7D17194B	10/03/96	158.6	304	3E
7F7D171957	11/17/94	158.6	241	1A
7F7D171972	10/03/96	158.6	275	1A
7F7D171A11	11/16/94	79.6	190	1A
7F7D171A34	10/03/96	158.6	297	3A
7F7D171A36	10/03/96	158.6	319	3E
7F7D171A43	03/29/94	79.6	289	2A
7F7D171A4E	10/03/96	158.6	242	3A
7F7D171A79	11/17/94	158.6	219	1C
7F7D171B0C	11/16/94	136.6	193	3A
7F7D171B21	10/03/96	158.6	336	2B
7F7D171B26	11/16/94	117.5	204	1A
7F7D171B32	11/16/94	117.5	167	1A
7F7D171B5B	10/03/96	158.6	330	1C
7F7D171B76	11/16/94	117.5	212	3A
7F7D171D7C	10/03/96	158.6	337	1C
7F7D171E01	11/17/94	158.6	172	3A
7F7D171E24	11/16/94	136.6	333	2B
7F7D171E4A	10/03/96	158.6	281	3E
7F7D171F36	11/17/94	158.6	218	3A
7F7D171F40	10/03/96	158.6	291	3A
7F7D171F4E	10/03/96	158.6	270	2B
7F7D171F7F	11/17/94	158.6	240	1A
7F7D1710OB	10/03/96	158.6	333	2B
7F7D172017	11/16/94	117.5	133	3A
7F7D172023	11/16/94	117.5	297	1A
7F7D172104	11/16/94	117.5	220	1A
7F7D172105	11/16/94	79.6	197	1A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D172114	11/16/94	136.6	247	1A
7F7D172128	11/16/94	117.5	212	3A
7F7D17221D	10/03/96	158.6	393	3A
7F7D17221E	11/16/94	79.6	333	3A
7F7D172233	10/03/96	158.6	366	3A
7F7D172259	10/03/96	158.6	279	1C
7F7D17225D	11/16/94	79.6	171	1A
7F7D17240B	11/16/94	79.6	236	1A
7F7D172436	11/16/94	136.6	242	1C
7F7D17245D	11/16/94	117.5	169	3A
7F7D172479	10/03/96	158.6	373	3A
7F7D172523	10/03/96	158.6	360	3A
7F7D17252E	11/16/94	79.6	143	1A
7F7D172579	11/16/94	136.6	223	1A
7F7D172623	11/16/94	136.6	218	1A
7F7D17266A	11/16/94	136.6	222	3A
7F7D172704	11/16/94	117.5	218	1A
7F7D17274C	10/03/96	158.6	296	3A
7F7D17277D	10/03/96	158.6	362	2B
7F7D172806	11/16/94	136.6	240	1C
7F7D172825	10/03/96	158.6	358	1C
7F7D172862	10/03/96	158.6	327	3A
7F7D17287A	10/03/96	158.6	281	1A
7F7D17290A	10/03/96	158.6	318	1A
7F7D17296C	11/16/94	79.6	277	1A
7F7D172B71	10/03/96	158.6	330	1C
7F7D172C0C	10/03/96	158.6	387	1A
7F7D173B24	03/29/94	79.6	251	2A
7F7D173B45	03/30/94	136.6	301	2A
7F7D173C48	03/29/94	117.5	316	2A
7F7D173F04	03/30/94	136.6	269	2A
7F7D17484E	03/29/94	79.6	256	2A
7F7D17562F	10/03/96	158.6	342	3A
7F7D175662	11/16/94	79.6	166	1A
7F7D17571A	11/17/94	158.6	218	3A
7F7D17571D	10/03/96	158.6	329	2B
7F7D175756	11/17/94	158.6	158	3A
7F7D175811	10/03/96	158.6	274	3A
7F7D17582B	11/17/94	158.6	238	1A
7F7D175855	10/03/96	158.6	378	3A
7F7D17587B	10/03/96	158.6	354	3A
7F7D175913	10/03/96	158.6	347	2B
7F7D175930	11/16/94	136.6	277	1A
7F7D175937	11/16/94	117.5	241	1A
7F7D175953	11/16/94	79.6	325	1A
7F7D17597B	10/03/96	158.6	277	1A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D175A01	11/17/94	158.6	150	1A
7F7D175A52	10/03/96	158.6	359	1A
7F7D175B09	11/16/94	136.6	160	1A
7F7D175B4E	10/03/96	158.6	355	2B
7F7D175B7A	10/03/96	158.6	347	1C
7F7D175C0A	11/17/94	158.6	194	3A
7F7D175C42	11/16/94	136.6	160	1A
7F7D175C47	10/03/96	158.6	362	2B
7F7D175C49	10/03/96	158.6	337	2B
7F7D175C67	11/16/94	136.6	198	3A
7F7D175D1F	10/03/96	158.6	315	3A
7F7D175D3B	10/03/96	158.6	346	3A
7F7D175E4E	11/16/94	117.5	173	3A
7F7D175E51	11/17/94	158.6	158	1A
7F7D175E73	10/03/96	158.6	313	??
7F7D175F04	11/17/94	158.6	231	1A
7F7D175F33	11/17/94	158.6	193	1A
7F7D175F3F	10/03/96	158.6	351	??
7F7D175F6C	11/16/94	117.5	190	3A
7F7D176031	10/03/96	158.6	390	3E
7F7D176068	10/03/96	158.6	330	1C
7F7D17606A	10/03/96	158.6	372	2B
7F7D17606E	10/03/96	158.6	371	2B
7F7D176139	10/03/96	158.6	290	3A
7F7D17613D	11/16/94	117.5	143	2B
7F7D17614C	10/03/96	158.6	321	2B
7F7D176167	10/03/96	158.6	295	3A
7F7D176232	10/03/96	158.6	297	1A
7F7D176251	10/03/96	158.6	301	1C
7F7D176262	11/17/94	158.6	182	3A
7F7D176276	11/16/94	79.6	182	1C
7F7D176327	11/16/94	79.6	223	1C
7F7D176358	10/03/96	158.6	319	3E
7F7D17636E	10/03/96	158.6	293	3A
7F7D176371	10/03/96	158.6	325	2B
7F7D17640B	11/16/94	136.6	134	1A
7F7D176412	10/03/96	158.6	355	2B
7F7D17641A	10/03/96	158.6	397	2B
7F7D17641F	10/03/96	158.6	318	3A
7F7D176427	11/17/94	158.6	315	3E
7F7D17646A	10/03/96	158.6	323	3A
7F7D176473	11/17/94	158.6	195	3A
7F7D17650F	10/03/96	158.6	310	1A
7F7D176520	10/03/96	158.6	333	1A
7F7D176603	10/03/96	158.6	326	1A
7F7D176655	11/17/94	158.6	180	3A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D17676A	11/16/94	79.6	220	1A
7F7D176808	11/16/94	136.6	220	1A
7F7D17681D	11/17/94	158.6	122	1A
7F7D176844	11/16/94	117.5	120	1A
7F7D17690B	10/03/96	158.6	330	1C
7F7D17690C	10/03/96	158.6	386	2B
7F7D176954	11/17/94	158.6	350	2B
7F7D17695A	10/03/96	158.6	350	1A
7F7D17696A	11/17/94	158.6	204	3A
7F7D176973	11/17/94	158.6	211	1A
7F7D17697F	10/03/96	158.6	308	??
7F7D176A03	11/16/94	79.6	218	3A
7F7D176A1B	11/16/94	117.5	173	1A
7F7D176A1F	10/03/96	158.6	384	2B
7F7D176A2E	11/16/94	136.6	166	1A
7F7D176A31	11/16/94	136.6	196	1A
7F7D176A54	11/16/94	79.6	207	3A
7F7D176A5C	10/03/96	158.6	299	1A
7F7D176B2F	11/16/94	136.6	250	1A
7F7D176B78	10/03/96	158.6	282	3A
7F7D176B7F	10/03/96	158.6	320	3A
7F7D176C0F	10/03/96	158.6	332	2B
7F7D176C1E	10/03/96	158.6	415	3E
7F7D176C20	10/03/96	158.6	333	1C
7F7D176C65	11/16/94	79.6	277	1A
7F7D176C67	11/17/94	158.6	175	1C
7F7D176C68	10/03/96	158.6	415	2B
7F7D176C6E	11/16/94	79.6	122	1A
7F7D176D12	11/16/94	117.5	134	1A
7F7D176D16	10/03/96	158.6	331	3A
7F7D176D4D	10/03/96	158.6	304	3A
7F7D176E03	10/03/96	158.6	357	3A
7F7D176E5D	10/03/96	158.6	297	1A
7F7D176E63	11/16/94	79.6	194	1A
7F7D176F45	10/03/96	158.6	330	1A
7F7D176F59	10/03/96	158.6	282	2B
7F7D176F5E	10/03/96	158.6	333	1C
7F7D177029	10/03/96	158.6	350	2B
7F7D177045	11/16/94	136.6	261	1C
7F7D177078	11/16/94	117.5	188	3A
7F7D177105	10/03/96	158.6	399	1C
7F7D177124	11/17/94	158.6	341	1C
7F7D177132	11/16/94	117.5	176	1A
7F7D177179	10/03/96	158.6	322	3A
7F7D177217	11/16/94	79.6	203	3A
7F7D177262	10/03/96	158.6	288	1A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D177307	11/17/94	158.6	218	3A
7F7D17735E	10/03/96	158.6	244	2B
7F7D177361	10/03/96	158.6	322	??
7F7D177453	11/16/94	136.6	258	1C
7F7D17746D	10/03/96	158.6	315	3A
7F7D177514	11/17/94	158.6	276	??
7F7D177523	10/03/96	158.6	374	1C
7F7D177533	11/16/94	117.5	277	1A
7F7D177557	11/17/94	158.6	193	2B
7F7D177559	10/03/96	158.6	344	1C
7F7D17755D	11/16/94	79.6	209	1A
7F7D177562	10/03/96	158.6	335	1A
7F7D177569	11/16/94	117.5	196	1A
7F7D17762A	10/03/96	158.6	386	2B
7F7D177655	10/03/96	158.6	357	1C
7F7D177709	11/16/94	79.6	138	1A
7F7D17773E	10/03/96	158.6	306	2B
7F7D17773F	11/16/94	79.6	247	1A
7F7D177743	11/16/94	79.6	172	1A
7F7D17774A	10/03/96	158.6	274	1A
7F7D177819	10/03/96	158.6	255	1A
7F7D177829	10/03/96	158.6	378	2B
7F7D17782A	10/03/96	158.6	325	1C
7F7D177851	11/16/94	136.6	356	2B
7F7D177861	11/16/94	136.6	175	1C
7F7D177867	10/03/96	158.6	382	2B
7F7D177869	11/16/94	117.5	198	2B
7F7D17786C	10/03/96	158.6	313	3A
7F7D17787E	10/03/96	158.6	334	2B
7F7D17791A	10/03/96	158.6	351	1A
7F7D177923	11/16/94	117.5	191	1A
7F7D177924	10/03/96	158.6	308	2B
7F7D177928	11/16/94	79.6	187	1A
7F7D17792B	10/03/96	158.6	306	3A
7F7D17796B	10/03/96	158.6	363	1C
7F7D177A01	11/16/94	117.5	160	1A
7F7D177A45	11/16/94	79.6	237	1A
7F7D177A56	11/16/94	79.6	172	??
7F7D177C03	11/16/94	79.6	187	1A
7F7D177C3B	10/03/96	158.6	380	1A
7F7D177C60	11/16/94	117.5	220	1C
7F7D177E1F	11/16/94	117.5	298	1C
7F7D177F1A	11/17/94	158.6	234	1A
7F7D177F1B	11/16/94	136.6	263	1C
7F7D180062	10/03/96	158.6	335	1C
7F7D180113	10/03/96	158.6	375	1C

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D180427	11/16/94	136.6	234	1A
7F7D180659	11/16/94	79.6	194	1A
7F7D180723	11/16/94	117.5	145	1C
7F7D180903	10/03/96	158.6	405	1C
7F7D180A3A	10/03/96	158.6	323	2B
7F7D180D46	10/03/96	158.6	257	1C
7F7D181039	10/03/96	158.6	412	1C
7F7D18107B	11/16/94	117.5	218	1A
7F7D181134	10/03/96	158.6	290	3E
7F7D181174	10/03/96	158.6	372	3E
7F7D181256	11/16/94	136.6	199	1A
7F7D181266	11/17/94	158.6	266	1C
7F7D181513	10/03/96	158.6	351	1C
7F7D181634	11/16/94	117.5	252	1A
7F7D181702	10/03/96	158.6	374	1C
7F7D181772	11/16/94	117.5	283	1A
7F7D181922	10/03/96	158.6	373	1C
7F7D18266C	10/03/96	158.6	290	1C
7F7D183F2D	11/16/94	136.6	186	1C
7F7D184031	10/03/96	158.6	308	2B
7F7D184067	10/03/96	158.6	365	3E
7F7D1A2A2D	11/17/94	158.6	152	3A
7F7D1A2B48	11/16/94	136.6	208	1A
7F7D1A2B50	10/03/96	158.6	393	1A
7F7D1A2C32	10/03/96	158.6	284	3E
7F7D1A2C59	11/16/94	79.6	290	1A
7F7D1A2D48	11/16/94	79.6	169	1A
7F7D1A2E04	11/16/94	79.6	157	3A
7F7D1A2E2E	11/16/94	117.5	236	1A
7F7D1A3064	11/16/94	79.6	258	1A
7F7D1A417A	10/03/96	158.6	325	3A
7F7D1A462F	11/16/94	79.6	207	1A
7F7D1A4774	10/03/96	158.6	282	1A
7F7D1A477A	10/03/96	158.6	320	3A
7F7D1A4936	11/16/94	79.6	287	1A
7F7D1A4A09	11/16/94	79.6	278	1A
7F7D1A4A1B	10/03/96	158.6	346	3A
7F7D1A4D36	11/16/94	136.6	193	3A
7F7D1A4D77	11/17/94	158.6	360	3E
7F7D1B6654	03/29/94	117.5	274	2A
7F7D1C1402	11/16/94	79.6	209	1A
7F7D1C1604	10/03/96	158.6	289	3E
7F7D1C164B	10/03/96	158.6	302	1A
7F7D1C2874	11/16/94	136.6	232	1A
7F7D1C2B54	10/03/96	158.6	343	3A
7F7D1D4E7D	03/29/94	117.5	239	2A

Table A-1, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
7F7D1D7872	03/30/94	136.6	289	2A
7F7D1E093D	03/30/94	136.6	282	2A
7F7D222501	10/03/96	158.6	360	??
7F7D22270C	10/03/96	158.6	331	3A
7F7D22270D	11/16/94	79.6	171	1A
7F7D222A2F	11/16/94	79.6	163	1C
7F7D22306E	10/03/96	158.6	304	1A
7F7D223073	11/16/94	79.6	360	1A
7F7D223A48	11/16/94	79.6	228	3A
7F7D22491A	03/29/94	79.6	306	2A
7F7D224A51	03/29/94	79.6	276	2A
7F7D224E24	03/29/94	117.5	252	2A
7F7D22532E	03/30/94	136.6	289	2A
7F7D225979	11/16/94	79.6	197	1A
7F7D226066	11/16/94	136.6	244	1A
7F7D226B0C	11/16/94	136.6	211	1A
7F7D226B3E	10/03/96	158.6	368	2B
7F7D226B53	11/16/94	79.6	241	1A
7F7D226B5A	10/03/96	158.6	363	2B
7F7D226C2D	10/03/96	158.6	303	3E
7F7D78367E	10/03/96	158.6	282	3A
7F7F5F5901	10/03/96	158.6	323	3E

Table A-2. Stocking information for the 130 razorback sucker stocked into Lake Powell at Piute Farms Marina (RM 0.0) on 8 and 15 August 1995 by the Utah Division of Wildlife Resources. These fish were not part of the experimental stocking study for razorback sucker in the San Juan River, but are included here because one of them was recaptured during our study.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F3F181872	08/08/95	0.0	408	2A
1F3F192069	08/15/95	0.0	406	2A
1F3F1F2E55	08/15/95	0.0	390	2A
1F40002001	08/08/95	0.0	414	2A
1F40016739	08/08/95	0.0	414	2A
1F40017828	08/15/95	0.0	387	2A
1F400A0B0C	08/08/95	0.0	408	2A
1F400B7422	08/15/95	0.0	415	2A
1F400D2173	08/15/95	0.0	406	2A
1F400F533F	08/08/95	0.0	406	2A
1F40171674	08/15/95	0.0	389	2A
1F4019691F	08/08/95	0.0	420	2A
1F401B1E68	08/15/95	0.0	413	2A
1F401E057E	08/08/95	0.0	402	2A
1F40206F12	08/15/95	0.0	434	2A
1F402A5B1C	08/08/95	0.0	423	2A
1F402C1164	08/15/95	0.0	426	2A
1F402F0B67	08/08/95	0.0	417	2A
1F40412739	08/08/95	0.0	414	2A
1F4101732C	08/08/95	0.0	411	2A
1F41062278	08/15/95	0.0	385	2A
1F41074950	08/08/95	0.0	412	2A
1F410F2869	08/15/95	0.0	385	2A
1F4111355A	08/08/95	0.0	401	2A
1F4112711D	08/15/95	0.0	437	2A
1F41175D2C	08/15/95	0.0	401	2A
1F41185335	08/08/95	0.0	410	2A
1F411B3A4B	08/08/95	0.0	420	2A
1F411E6220	08/08/95	0.0	417	2A
1F41705E52	08/08/95	0.0	413	2A
1F41724A64	08/08/95	0.0	397	2A
1F41774663	08/08/95	0.0	418	2A
1F41794562	08/08/95	0.0	382	2A
1F42362841	08/15/95	0.0	423	2A
1F462A5918	08/08/95	0.0	401	2A
1F4636095C	08/08/95	0.0	374	2A
1F46445502	08/15/95	0.0	369	2A
1F4648272C	08/15/95	0.0	426	2A
1F53231556	08/08/95	0.0	425	2A
1F53240466	08/15/95	0.0	408	2A

Table A-2, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F5A74741F	08/08/95	0.0	410	2A
1F5A74771C	08/15/95	0.0	416	2A
1F5A751D75	08/15/95	0.0	397	2A
1F5A7B4844	08/15/95	0.0	412	2A
1F5A7D0C7E	08/08/95	0.0	411	2A
1F5B007115	08/15/95	0.0	410	2A
1F5B025C28	08/08/95	0.0	400	2A
1F5B050B76	08/15/95	0.0	421	2A
1F5B07522D	08/08/95	0.0	402	2A
1F5B08116D	08/08/95	0.0	370	2A
1F5B08324C	08/08/95	0.0	427	2A
1F5B0E0177	08/08/95	0.0	422	2A
1F5B0E0C6C	08/08/95	0.0	411	2A
1F5B0F2255	08/08/95	0.0	392	2A
1F5B0F3740	08/08/95	0.0	410	2A
1F5B143042	08/08/95	0.0	405	2A
1F5B1E5C0C	08/08/95	0.0	418	2A
1F5B1E5F09	08/08/95	0.0	383	2A
1F5B1F5C0B	08/08/95	0.0	402	2A
1F5B215C09	08/15/95	0.0	403	2A
1F5B2E3424	08/08/95	0.0	417	2A
1F5B306F67	08/08/95	0.0	421	2A
1F5B316E67	08/08/95	0.0	418	2A
1F5B32272D	08/08/95	0.0	431	2A
1F5B330C47	08/08/95	0.0	409	2A
1F5B36222E	08/08/95	0.0	394	2A
1F5B39400D	08/15/95	0.0	412	2A
1F5B3A3A12	08/08/95	0.0	385	2A
1F5B3A4903	08/15/95	0.0	396	2A
1F5B3B113A	08/15/95	0.0	396	2A
1F5B3B1F2C	08/08/95	0.0	416	2A
1F5B3E3D0B	08/15/95	0.0	414	2A
1F5B3F4205	08/08/95	0.0	386	2A
1F5B3F6A5D	08/15/95	0.0	419	2A
1F5B407F47	08/15/95	0.0	388	2A
1F5B4B4675	08/08/95	0.0	413	2A
1F5B792B62	08/15/95	0.0	414	2A
1F5B7B117A	08/08/95	0.0	396	2A
1F5C0A1962	08/15/95	0.0	410	2A
1F5C0B0773	08/15/95	0.0	386	2A
1F5C0B4931	08/15/95	0.0	409	2A
1F5C0C3445	08/15/95	0.0	419	2A
1F5C0D7503	08/15/95	0.0	407	2A
1F5C0F6511	08/15/95	0.0	429	2A
1F5C153D33	08/15/95	0.0	378	2A
1F5C1D3236	08/15/95	0.0	412	2A

Table A-2, continued.

PIT Tag Number	Date Of Stocking	River Mile Of Stocking	Total Length In Millimeters	Family Lot
1F5D01681B	08/08/95	0.0	348	2A
1F5D52161C	08/08/95	0.0	370	2A
1F6B1D1544	08/15/95	0.0	420	2A
1F6B1D7069	08/15/95	0.0	411	2A
1F6B267C54	08/15/95	0.0	374	2A
1F6B2B7356	08/15/95	0.0	405	2A
1F6B2B7A51	08/15/95	0.0	428	2A
1F6B2C7555	08/08/95	0.0	414	2A
1F6B317A4B	08/08/95	0.0	415	2A
1F6B34350D	08/15/95	0.0	419	2A
1F6B34744E	08/15/95	0.0	399	2A
1F6B38744A	08/15/95	0.0	405	2A
1F6B393607	08/08/95	0.0	401	2A
1F6B3A201C	08/15/95	0.0	420	2A
1F6B3E0533	08/15/95	0.0	397	2A
1F6B410A2B	08/15/95	0.0	417	2A
1F6B415E57	08/15/95	0.0	422	2A
1F6B443C76	08/15/95	0.0	415	2A
1F6B48327C	08/15/95	0.0	399	2A
1F6C2C5A6F	08/15/95	0.0	399	2A
1F6C307A4B	08/08/95	0.0	397	2A
1F6D062A44	08/08/95	0.0	406	2A
1F6D0C5F09	08/08/95	0.0	405	2A
1F6D0F3431	08/08/95	0.0	368	2A
1F6D110D56	08/08/95	0.0	391	2A
1F6D112340	08/08/95	0.0	420	2A
1F6D171A43	08/15/95	0.0	413	2A
1F6D172934	08/15/95	0.0	389	2A
1F6D6A7713	08/15/95	0.0	423	2A
1F6E677A12	08/08/95	0.0	392	2A
1F7471106C	08/15/95	0.0	412	2A
1F74712F4D	08/15/95	0.0	412	2A
1F74725427	08/15/95	0.0	432	2A
1F747A3142	08/15/95	0.0	432	2A
1F747A591A	08/08/95	0.0	422	2A
1F747A5F14	08/15/95	0.0	418	2A
1F747B2C46	08/15/95	0.0	415	2A
1F747F3F2F	08/08/95	0.0	407	2A
1F75036C7D	08/08/95	0.0	395	2A
1F7508075D	08/15/95	0.0	427	2A
1F75093033	08/08/95	0.0	428	2A
1F75115803	08/15/95	0.0	412	2A
1F75137663	08/15/95	0.0	412	2A
1F7A31191D	08/08/95	0.0	402	2A

APPENDIX B

Summary information on mortalities, radio tag expulsion, and radio tag retention among surgically-implanted razorback sucker being held in hatchery ponds for recovery after surgery.

The following tables are a summary of information on mortalities and tag expulsion in razorback sucker (Xyrauchen texanus) held in hatchery ponds (for varying lengths of time) for recovery after surgery. These fish were surgically implanted with AVM radio transmitters (tags) as part of the experimental stocking effort in the San Juan River between 1994 and 1997. All radio-implanted fish were obtained from stocks being reared in "grow-out" ponds at the Utah Division of Wildlife Resources' (UDWR) Wahweap Warmwater Fish Hatchery near Page, Arizona. Immediately after surgery, implanted fish were returned to a pond exclusive of any other fish, to recover. Visual numerical counts were made by daily UDWR hatchery staff and mortalities were collected and recorded. At a later date, fish were recovered from the ponds using seines and transported to the San Juan River, there to be stocked at one of the four stocking sites. While recovering fish from the ponds before stocking, I found what I consider to be a rather high percentage of implanted fish that had either died after surgery, or had expelled their radio tags but still survived. This led to the necessity of having to re-implant radio tags in either the same or a different razorback sucker before stocking.

Fish that had expelled their radio tags and survived had completely, or almost completely, healed incision scars. This information, along with updates forwarded to myself by the UDWR hatchery staff about visual numerical counts made of implanted fish leads me to believe that almost immediately after being returned to the pond post-surgery, implanted fish would proceed to the concrete-lined end of the holding pond near the "kettle" (the area where the pond is drained through a control gate), and rub their sutures against the concrete. This would either lead to the fish rubbing the sutures open and expelling the tag, or to the fish developing a "blown stomach" (i.e., literally rubbing the stomach completely open and expelling its own innards) and dying. Most of the mortalities that were recovered (some mortalities were scavenged from the ponds by animals during the night and only their tags were recovered) had blown stomachs. Approximately half of the recovered radio tags from mortalities and/or expulsions were recovered in the kettle area. Also, numerous razorback sucker that had retained their radio tags had several missing sutures in the incision area. In all cases, visual numerical counts of implanted fish verified that mortalities ceased and numbers of surviving fish held stable after approximately one week post-surgery.

As the experimental stocking project progressed, the decision was made to hold implanted fish in the ponds for a longer period of time following surgery. This was done to allow implanted fish more time to completely recover following surgery and to insure that their sutures were completely healed before stocking.

Following is a summary of the four initial radio implantation efforts from 1994 to 1996. This information represents only the initial group of fish implanted on any given date (i.e., no second time or follow-up surgeries included) and is not representative of the final number or sizes of the radio-tagged fish that were eventually stocked (i.e., those reported upon in the body of this report). This is strictly secondary information obtained during the experimental stocking study and thus has had no particular analysis performed upon it. This information is presented here only to document that getting hatchery-reared razorback sucker to retain surgically-implanted radio tags in a concrete-lined pond environment is problematic. This was true regardless of the size of the fish at the time of surgery, tag to body weight ratio, whether or not an anesthetic (MS-222) was used during surgery, whether or not an antibiotic (Gentocin) was given post-surgery, or the length of time fish were allowed to recover in ponds post-surgery.

Table B-1. Summary of information for 15 razorback sucker implanted with radio tags on 22 March 1994.

Surgery Date:	22 March 1994
Pond temperature (degrees Celsius):	23.5
Number of fish implanted:	15
Mean TL (in mm) of fish:	274
Mean WT (in g) of fish:	256
Tag dry weight (g):	5
Tag's mean % of fish body WT:	2.07
Number surgeries MS-222 used in:	0
Number of fish given Gentocin (antibiotic) following surgery:	15
Number of mortalities within 6 days:	5 (33.3%)
Mean TL (mm) of mortalities at surgery:	276
Mean WT (g) of mortalities at surgery:	264
Tag's mean % of mortalities body WT:	1.97
Number surgeries MS-222 was used in:	0
Number of eventual mortalities given Gentocin (antibiotic) following surgery:	5
Number of surviving fish that expelled transmitters within 6 days:	0 (0.0%)
Mean TL (in mm) of fish that expelled radio tags:	No Data
Mean WT (in g) of fish that expelled radio tags:	No Data
Tag's mean % of expulsions body WT:	No Data
Number surgeries MS-222 used in:	No Data
Number of fish given Gentocin (antibiotic) following surgery:	No Data
Number of surviving fish that retained transmitters within 6 days:	10 (66.7%)
Mean TL (in mm) of survivors:	273
Mean WT (in g) of survivors:	252
Tag's mean % of survivors body WT	2.12
Number surgeries MS-222 used in:	0
Number of fish given Gentocin (antibiotic) following surgery:	10

Table B-2. Summary of information for 15 razorback sucker implanted with radio tags on 7 September 1994.

Surgery Date:	7 September 1994
Pond temperature (degrees Celsius):	27.0
Number of fish implanted:	15
Mean TL (in mm) of fish:	395
Mean WT (in g) of fish:	673
Tag dry weight (g):	12
Tag's mean % of fish body WT:	1.80
Number surgeries MS-222 used in:	15
Number of fish given Gentocin (antibiotic) following surgery:	7
Number of mortalities within 50 days:	6 (40.0%)
Mean TL (mm) of mortalities at surgery:	395
Mean WT (g) of mortalities at surgery:	658
Tag's mean % of mortalities body WT:	1.86
Number surgeries MS-222 was used in:	6
Number of eventual mortalities given Gentocin (antibiotic) following surgery:	4
Number of surviving fish that expelled transmitters within 50 days:	2 (13.3%)
Mean TL (in mm) of fish that expelled radio tags:	393
Mean WT (in g) of fish that expelled radio tags:	681
Tag's mean % of expulsions body WT:	1.77%
Number surgeries MS-222 used in:	2
Number of fish given Gentocin (antibiotic) following surgery:	0
Number of surviving fish that retained transmitters within 50 days:	7 (46.7%)
Mean TL (in mm) of survivors:	395
Mean WT (in g) of survivors:	684
Tag's mean % of survivors body WT	1.77
Number surgeries MS-222 used in:	7
Number of fish given Gentocin (antibiotic) following surgery:	3

Table B-3. Summary of information for 19 razorback sucker implanted with radio tags on 7 July 1995.

Surgery Date:	7 July 1995
Pond temperature (degrees Celsius):	NOT TAKEN
Number of fish implanted:	19
Mean TL (in mm) of fish:	420
Mean WT (in g) of fish:	788
Tag dry weight (g):	12
Tag's mean % of fish body WT:	1.55
Number surgeries MS-222 used in:	19
Number of fish given Gentocin (antibiotic) following surgery:	0
Number of mortalities within 43 days:	4 (21.0%)
Mean TL (mm) of mortalities at surgery:	409
Mean WT (g) of mortalities at surgery:	766
Tag's mean % of mortalities body WT:	1.58
Number surgeries MS-222 was used in:	4
Number of eventual mortalities given Gentocin (antibiotic) following surgery:	0
Number of surviving fish that expelled transmitters within 43 days:	3 (15.8%)
Mean TL (in mm) of fish that expelled radio tags:	413
Mean WT (in g) of fish that expelled radio tags:	771
Tag's mean % of expulsions body WT:	1.58
Number surgeries MS-222 used in:	3
Number of fish given Gentocin (antibiotic) following surgery:	0
Number of surviving fish that retained transmitters within 43 days:	12 (63.2%)
Mean TL (in mm) of survivors:	425
Mean WT (in g) of survivors:	800
Tag's mean % of survivors body WT	1.54
Number surgeries MS-222 used in:	12
Number of fish given Gentocin (antibiotic) following surgery:	0

Table B-4. Summary of information for 10 razorback sucker implanted with radio tags on 26 August 1996.

Surgery Date:	26 August 1996
Pond temperature (degrees Celsius):	NOT TAKEN
Number of fish implanted:	10
Mean TL (in mm) of fish:	404
Mean WT (in g) of fish:	706
Tag dry weight (g):	12
Tag's mean % of fish body WT:	1.72
Number surgeries MS-222 used in:	10
Number of fish given Gentocin (antibiotic) following surgery:	0
Number of mortalities within 37 days:	3 (30.0%)
Mean TL (mm) of mortalities at surgery:	397
Mean WT (g) of mortalities at surgery:	700
Tag's mean % of mortalities body WT:	1.73
Number surgeries MS-222 was used in:	3
Number of eventual mortalities given Gentocin (antibiotic) following surgery:	0
Number of surviving fish that expelled transmitters within 37 days:	0 (0.0%)
Mean TL (in mm) of fish that expelled radio tags:	No Data
Mean WT (in g) of fish that expelled radio tags:	No Data
Tag's mean % of expulsions body WT:	No Data
Number surgeries MS-222 used in:	No Data
Number of fish given Gentocin (antibiotic) following surgery:	No Data
Number of surviving fish that retained transmitters within 37 days:	7 (70.0%)
Mean TL (in mm) of survivors:	406
Mean WT (in g) of survivors:	708
Tag's mean % of survivors body WT	1.71
Number surgeries MS-222 used in:	7
Number of fish given Gentocin (antibiotic) following surgery:	0

Table B-5. Summary of information for 59 total razorback sucker initially implanted with radio tags from 1994 to 1996.

Total number of fish:	59
Total number of mortalities within a mean of 34 days of surgery:	18 (30.5%)
Total number of surviving fish that expelled transmitters but survived within a mean of 34 days of surgery:	5 (8.5%)
Total number of surviving fish that retained transmitters within a mean of 34 days after surgery	36 (61.0%)

APPENDIX C

Similarity comparisons for radio telemetry contacts having the same habitat richness values.

INTRODUCTION

The tables in this Appendix were generated in response to a comment from Peer review Panel member Dr. David Galat on an earlier draft of this report. Their purpose is to analyze the similarity between razorback sucker contact locations with the same habitat richness value. Dr. Galat’s question was are two contact locations with the same habitat richness values truly the same? Because this particular question does not relate directly to any specific study objective and because of the lateness of this analysis in the report development process, this analysis is included here as an appendix rather than in the body of the report.

METHODS

Radio telemetry contacts were partitioned by habitat richness values, 2-11. All 2's were compared, pairwise, to all other 2's, all 3's, pairwise, to all other 3's, and so on. Comparisons were based on the difference between the observed percentages of all individual habitat types at two contact locations (quantified on the habitat maps during radio tracking) tested against a hypothetical mean of 0.00. The hypothetical mean is the value that would be obtained if the two contact locations being compared possessed identical types and quantities (percentages) of habitats. Bonferroni-adjusted, nonparametric, T-tests were performed on given pairs of contact locations to determine if they were statistically similar or different. Since the percentage of each habitat type was a known, quantified value at each contact location, the significance level (p-value) was set at $p = 0.05$. Values less than this indicated that the two contact locations were statistically different, while values above this indicated that the two contact locations were statistically similar. Multiple contacts with fish at the same contact location on a given tracking trip (usually one week long) were not included in this analysis. Values of $p = 1.000$ (with no t-statistic given) indicate that both fish in this comparison were using the same contact location, thus the types and percentages of available habitats were identical for both fish at that point in time.

RESULTS

As can be seen on Table C-1, when more than 4 habitats were present at contact locations, the percentage of contact locations that were statistically similar dropped dramatically. This can be explained by the fact that many contact locations with more than 4 habitats had widely varying types (and relative percentages) of habitats. In many comparisons, contact locations with 5 or more habitats had only one habitat type (main channel run, habitat #10 in Table 2) in common. In addition, the relative percentages of the available habitats, even if they were common to both contact locations, tended to vary widely, often by ten percent or more. However, the percent of contact locations that were statistically similar did not drop linearly as habitat richness value increased. At habitat richness values of 2 and 3, 100.0% of the T-test comparisons were statistically similar. At a habitat richness value of 4, 70.0% were similar. For higher habitat richness values, 10.6% were similar at a habitat richness value of 5, 18.2% were similar at a habitat richness value of 6, 9.9% at 7, 15.4% at 8, 16.7% at 9, and 0.0% at 10. Only one contact location had a habitat richness value of 11, so no comparisons could be made with it.

DISCUSSION

As shown by paired T-tests, quite a high percentage of contact locations with habitat richness values of 5 or greater were statistically dissimilar (Table C-1). This indicates that there is, apparently, not a set combination, or block, of habitat types (or percentages thereof) that are specifically selected for by razorback sucker. The selection of a certain habitat type (or types) at given times of the year appears to be more of a driving factor in habitat use than a particular combination of habitats. In other words, razorback sucker select the habitat(s) they want or need to use and the presence of other unused habitats at that location is likely due to the hydrologic conditions that make the selected habitat(s) available. However, the use of areas of the river that have high habitat richness values throughout most of the year indicates that, like Colorado pikeminnow, razorback sucker need areas with relatively high habitat richness values in order to provide the habitats that they select for, especially in months when they have as many as five selected habitats (i.e., April and June; Table 4).

Table C-1. Pairwise comparisons (Bonferroni-adjusted T-tests) of similarity between contact locations of radiotelemetered razorback sucker having the same habitat richness values ($p < 0.05$ = * = statistically significant relationship {i.e., contact locations are statistically different}). Values of p = 1.000 (with no t-statistic given) indicate that both fish were using the same contact location (i.e., percentages of available habitats were identical for both fish).

Habitat Richness Value = 2

	Aug
Apr	t=1.655 p=0.110

(1 of 1 comparisons {100.0%} statistically similar)

Habitat Richness Value = 3

	Jun	Oct
Oct	t=1.951 p=0.062	
Dec	t=2.019 p=0.054	t=1.599 p=0.122

(3 of 3 comparisons {100.0%} statistically similar)

Habitat Richness Value = 4

	Apr	Jun	Jul	Aug
Jun	t=1.798 p=0.084			
Jul	t=1.766 p=0.090	t=1.963 p=0.061		
Aug	t=2.177 p=0.039*	t=1.854 p=0.076	t=1.851 p=0.076	
Oct	t=2.034 p=0.053	t=2.235 p=0.035*	t=2.238 p=0.034*	t=1.871 p=0.073

(7 of 10 comparisons {70.0%} statistically similar)

Table C-1, continued.

Habitat Richness Value = 5	Jan	Mar	Mar	Mar	Mar	Jun	Jun	Jun	Jul	Aug	Oct
Mar	t=2.929 p=0.007*										
Mar	t=2.929 p=0.007*	p=1.000									
Mar	t=2.929 p=0.007*	p=1.000	p=1.000								
Mar	t=2.929 p=0.007*	p=1.000	p=1.000	p=1.000							
Jun	t=2.413 p=0.023*	t=2.621 p=0.015*	t=2.621 p=0.015*	t=2.621 p=0.015*	t=2.621 p=0.015*						
Jun	t=2.578 p=0.016*	t=2.619 p=0.015*	t=2.619 p=0.015*	t=2.619 p=0.015*	t=2.619 P=0.015*	t=2.231 p=0.035*					
Jun	t=2.352 p=0.027*	t=2.523 p=0.018*	t=2.523 p=0.018*	t=2.523 p=0.018*	t=2.523 p=0.018*	t=2.280 p=0.031*	t=2.199 p=0.037*				
Jul	t=2.902 p=0.008*	t=2.731 p=0.011*	t=2.731 p=0.011*	t=2.731 p=0.011*	t=2.731 p=0.011*	t=2.766 p=0.011*	t=2.360 p=0.026*	t=2.609 p=0.015*			
Aug	t=3.437 p=0.002*	t=2.281 p=0.031*	t=2.281 p=0.031*	t=2.281 p=0.031*	t=2.281 p=0.031*	t=2.810 p=0.009*	t=2.829 p=0.009*	t=2.766 p=0.011*	t=2.126 p=0.044*		
Oct	t=2.492 p=0.020*	t=2.605 p=0.015*	t=2.605 p=0.015*	t=2.605 p=0.015*	t=2.605 p=0.015*	t=2.298 p=0.030*	t=2.160 p=0.041*	t=2.194 p=0.038*	t=2.548 p=0.017*	t=2.686 p=0.013*	
Dec	t=2.371 p=0.026	t=2.610 p=0.015*	t=2.610 p=0.015*	t=2.610 p=0.015*	t=2.610 p=0.015*	t=2.301 p=0.030*	t=2.012 p=0.055	t=2.083 p=0.048*	t=2.331 p=0.028*	t=2.644 p=0.014*	t=2.689 p=0.013*

(7 of 66 comparisons {10.6%} statistically similar)

Table C-1, continued.

Habitat Richness Value = 6	Jan	Mar	Mar	Apr	Apr	Apr	May	Jun	Jun	Jul
Mar	t=2.582 p=0.016*									
Mar	t=2.586 p=0.017*	t=2.345 p=0.027*								
Apr	t=2.097 p=0.046*	t=2.297 p=0.030*	t=2.405 p=0.024*							
Apr	t=3.417 p=0.002*	t=2.527 p=0.018*	t=2.880 p=0.008*	t=2.309 p=0.030*						
Apr	t=2.591 p=0.016*	t=2.511 p=0.019*	t=2.338 p=0.028*	t=2.113 P=0.045*	t=2.750 p=0.011*					
May	t=2.517 p=0.019*	t=2.274 p=0.032*	t=2.103 p=0.046*	t=1.863 p=0.074	t=2.480 p=0.020*	t=1.982 p=0.059				
Jun	t=2.442 p=0.022*	t=2.592 p=0.016*	t=2.551 p=0.017*	t=2.711 p=0.012*	t=2.615 p=0.015*	t=2.214 p=0.036*	t=2.015 p=0.055			
Jun	t=1.976 p=0.059	t=2.066 p=0.049*	t=2.122 p=0.044*	t=2.153 p=0.041*	t=2.012 p=0.055	t=1.983 p=0.059	t=1.907 p=0.068	t=2.017 p=0.055		
Jul	t=2.953 p=0.007*	t=2.773 p=0.010*	t=2.885 p=0.008*	t=2.673 p=0.013*	t=2.227 p=0.035*	t=2.417 p=0.023*	t=2.117 p=0.044*	t=2.585 p=0.016*	t=2.089 p=0.047*	
Jul	t=2.433 p=0.022*	t=2.581 p=0.016*	t=2.554 p=0.017*	t=2.891 p=0.008*	t=1.966 p=0.061	t=2.339 p=0.028*	t=2.022 p=0.054	t=2.675 p=0.013*	t=2.417 p=0.023*	t=2.585 p=0.016*

(10 of 55 comparisons {18.2%} statistically similar)

Table C-1, continued.

Habitat Richness Value = 7	Feb	Feb	Mar	Mar	Mar	Mar	Mar	Apr	Jun	Aug	Aug	Nov	Dec
Feb	t=1.877 p=0.072												
Mar	t=2.192 p=0.038*	t=2.837 p=0.009*											
Mar	t=2.192 p=0.038*	t=2.837 p=0.009*	p=1.000										
Mar	t=2.192 p=0.038*	t=2.837 p=0.009*	p=1.000	p=1.000									
Mar	t=2.192 p=0.038*	t=2.837 p=0.009*	p=1.000	P=1.000	p=1.000								
Mar	t=2.423 p=0.023*	t=3.164 p=0.004*	t=2.883 p=0.008*	t=2.883 p=0.008*	t=2.883 p=0.008*	t=2.883 p=0.008*							
Apr	t=2.319 p=0.029*	t=3.168 p=0.004*	t=3.011 p=0.006*	t=3.011 p=0.006*	t=3.011 p=0.006*	t=3.011 p=0.006*	t=2.789 p=0.010*						
Jun	t=3.088 p=0.005*	t=3.320 p=0.003*	t=2.369 p=0.026*	t=2.369 p=0.026*	t=2.369 p=0.026*	t=2.369 p=0.026*	t=3.296 p=0.003*	t=2.414 p=0.023*					
Aug	t=1.878 p=0.072	t=2.151 p=0.041*	t=3.038 p=0.006*	t=3.038 p=0.006*	t=3.038 p=0.006*	t=3.038 p=0.006*	t=2.518 p=0.019*	t=2.982 p=0.006*	t=2.468 p=0.021*				
Aug	t=1.878 p=0.072	t=2.151 p=0.041*	t=3.038 p=0.006*	t=3.038 p=0.006*	t=3.038 p=0.006*	t=3.038 p=0.006*	p=2.518 p=0.019*	t=2.982 p=0.006*	t=2.468 p=0.021*	p=1.000			
Nov	t=2.155 p=0.041*	t=2.625 p=0.015*	t=2.973 p=0.006*	t=2.973 p=0.006*	t=2.973 p=0.006*	t=2.973 p=0.006*	t=2.652 p=0.014*	t=2.612 p=0.015*	t=3.278 p=0.003*	t=2.264 p=0.032*	t=2.264 p=0.032*		
Dec	t=2.471 p=0.021*	t=3.496 p=0.002*	t=2.983 p=0.006*	t=2.983 p=0.006*	t=2.983 p=0.006*	t=2.983 p=0.006*	t=2.353 p=0.027*	t=2.933 p=0.007*	t=3.271 p=0.003*	t=2.609 p=0.015*	t=2.609 p=0.015*	t=3.420 p=0.002*	
Dec	t=2.471 p=0.021*	t=3.496 p=0.002*	t=2.983 p=0.006*	t=2.983 p=0.006*	t=2.983 p=0.006*	t=2.983 p=0.006*	t=2.353 p=0.027*	t=2.933 p=0.007*	t=3.271 p=0.003*	t=2.609 p=0.015*	t=2.609 p=0.015*	t=3.420 p=0.002*	p=1.000

(9 of 91 comparisons (9.9%) statistically similar)

Table C-1, continued.

Habitat Richness Value = 8

	Jan	Mar	Mar	Mar	Apr	Apr	Apr	Apr	Apr	Jun	Nov	Dec
Mar	t=2.535 p=0.018*											
Mar	t=2.535 p=0.018*	p=1.000										
Mar	t=2.535 p=0.018*	p=1.000	p=1.000									
Apr	t=2.241 p=0.034*	t=2.974 p=0.006*	t=2.974 p=0.006*	t=2.974 p=0.006*								
Apr	t=2.241 p=0.034*	t=2.974 p=0.006*	t=2.974 p=0.006*	t=2.974 P=0.006*	p=1.000							
Apr	t=2.530 p=0.018*	t=2.602 p=0.015*	t=2.602 p=0.015*	t=2.602 p=0.015*	t=2.222 p=0.036*	t=2.222 p=0.036*						
Apr	t=2.062 p=0.050	t=2.550 p=0.017*	t=2.550 p=0.017*	t=2.550 p=0.017*	t=2.533 p=0.018*	t=2.533 p=0.018*	t=1.978 p=0.059					
Apr	t=2.062 p=0.050	t=2.550 p=0.017*	t=2.550 p=0.017*	t=2.550 p=0.017*	t=2.533 p=0.018*	t=2.533 p=0.018*	t=1.978 p=0.059	p=1.000				
Jun	t=2.442 p=0.022*	t=2.599 p=0.015*	t=2.599 p=0.015*	t=2.599 p=0.015*	t=3.024 p=0.006*	t=3.024 p=0.006*	t=2.286 p=0.031*	t=2.538 p=0.018*	t=2.538 p=0.018*			
Nov	t=2.923 p=0.007*	t=2.744 p=0.011*	t=2.744 p=0.011*	t=2.744 p=0.011*	t=2.232 p=0.035*	t=2.232 p=0.035*	p=3.008 p=0.006*	t=2.062 p=0.050	t=2.062 p=0.050	t=2.575 p=0.016*		
Dec	t=2.792 p=0.010*	t=2.340 p=0.028*	t=2.340 p=0.028*	t=2.340 p=0.028*	t=2.156 p=0.041*	t=2.156 p=0.041*	t=2.622 p=0.015*	t=2.085 p=0.047*	t=2.085 p=0.047*	t=2.222 p=0.036*	t=2.346 p=0.027*	
Dec	t=2.792 p=0.010*	t=2.340 p=0.028*	t=2.340 p=0.028*	t=2.340 p=0.028*	t=2.156 p=0.041*	t=2.156 p=0.041*	t=2.622 p=0.015*	t=2.085 p=0.047*	t=2.085 p=0.047*	t=2.222 p=0.036*	t=2.346 p=0.027*	p=1.000

(12 of 78 comparisons (15.4%) statistically similar)

Table C-1, continued

Habitat Richness Value = 9

	Feb	May	Jun
May	t=3.212 p=0.004*		
Jun	t=2.660 p=0.013*	t=3.098 p=0.005*	
Dec	t=2.240 p=0.034*	t=2.242 p=0.034*	t=1.971 p=0.060

(1 of 6 comparisons {16.7%} statistically similar)

Habitat Richness Value = 10

	Feb	Mar
Mar	t=2.121 p=0.044*	
Apr	t=2.470 p=0.021*	t=2.971 p=0.006*

(0 of 3 comparisons {0.0%} statistically similar)

Habitat Richness Value = 11

--Only one contact location with 11 habitats; no comparisons were possible