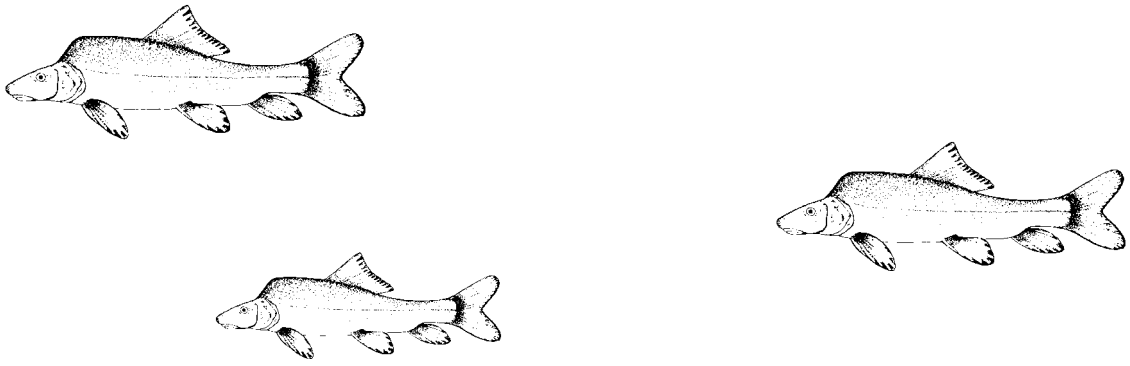
MONITORING OF RAZORBACK SUCKER STOCKED INTO THE SAN JUAN RIVER AS PART OF A FIVE-YEAR AUGMENTATION EFFORT:

1997-1999 Interim Progress Report

(Draft Final)



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EXECUTIVE SUMMARY

Razorback sucker (Xyrauchen texanus), is one of two federally-listed endangered fishes found in the San Juan River basin (Colorado pikeminnow, Ptychocheilus lucius being the other). Paucity of collections of wild fish of this species in the late 1980's and early 1990's led to the initiation of an experimental stocking program for this species in 1994. A total of 939 razorback sucker were stocked into the San Juan River as part of that study. Data collected on these experimentally-stocked fish between 1994 and 1997 indicated that a full-scale augmentation effort for razorback sucker in the San Juan River was feasible. In 1997 a FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER was developed. In September of 1997, stocking began with the goal of establishing a population of 15,900 razorback sucker in the San Juan River between Hogback Diversion, New Mexico (NM; RM 158.6) and Lake Powell (RM 0.0).

As of 31 December 1999, a total of 4,164 razorback sucker had been stocked into the San Juan River as part of the augmentation effort. This is a shortfall to date of 51,168 fish. This shortfall is mainly due to the lack of fish available to the San Juan River Recovery Implementation Program (SJRIP). Since the SJRIP had no hatchery or grow-out facilities of its own at the outset of this augmentation effort, razorback sucker had to be obtained from outside sources including the Upper Colorado River Basin Recovery Implementation Program and from Lake Mohave. To remedy the lack of hatchery and rearing facilities and help alleviate the shortfall in numbers of fish being stocked, the SJRIP obtained use of ponds (3 total) at two sites on Navajo Indian Irrigation Project (NIIP) land south of Farmington, NM in 1998 and 1999 and began stocking them with fish obtained from Lake Mohave in the Lower Colorado River Basin (LCRB). The majority of fish stocked in 1998 (90.3%) were reared in one of these ponds (Ojo Pond). In August 1999, Ojo Pond washed out due to extremely heavy rainfall. This pond was not rebuilt due to its vulnerable location. In its place the SJRIP is in the process of building a new pond on NIIP land near Farmington and assessing the feasibility of developing grow-out ponds on a parcel of private land near Bluff, Utah.

A total of 41 razorback sucker were recaptured between October 1997 and December 1999. Eighteen (0.4%) of the 4,164 fish stocked as part of the augmentation effort have been recaptured. Another 16 razorback sucker that were stocked as part of the experimental stocking study between 1994 and 1997 (and not reported upon in the final report for that study) were also recaptured. One razorback sucker that was stocked into Lake Powell in 1995 was also recaptured. An additional six razorback sucker for which no identifying PIT tag number was obtained were also recaptured during the 1997-1999 time period. Other rare species collected during razorback sucker monitoring trips in May 1998 and April 1999 included 45 stocked Colorado pikeminnow and four wild roundtail chub (Gila robusta).

The collection of habitat use data was limited to only three contacts with a single radiotelemetered fish. This fish selected for chute and shore run habitat in November 1997, riffle and sand shoal habitat during June 1998, and main channel run exclusively during September 1998. Razorback sucker were contacted at two possible preferred site in the San Juan River between October 1997 and December 1999. One was a backwater on river left at RM 77.3-77.5. The second was a possible spawning site at RM 100.2. One juvenile razorback sucker was collected upstream of the Hogback Diversion. This is the first documented movement of a stocked razorback sucker upstream past this diversion structure. Two adult razorback sucker were recaptured in Lake Powell at Piute Farms a little over one year after being stocked at Hogback Diversion, 158.6 RM upstream. As was observed during the experimental stocking study, movements of two radiotelemetered razorback sucker and seven PIT-tagged razorback sucker recaptured two or more times since stocking showed initial downstream displacements after stocking in eight fish, with six of these

eventually moving back upstream. One radiotelemetered razorback sucker was never contacted downstream of its stocking site. These nine fish were all stocked as part of the experimental stocking study (1994-1997).

Length and weight measurements on 93 fish recaptured at least once after stocking between 1994 and 1999 show that after an initial weight loss (for approximately the first 400 days) associated with stocking, razorback sucker increased steadily in both weight (WT) and total length (TL), although growth between individual fish was highly variable. By the end of the fourth year, the trend for fish stocked between 1994 and 1999 is to have increased in mean TL by approximately 25% and in mean WT by approximately 75%. Fish that were small (< 351 mm TL) at time of stocking grew almost twice as fast (mean = 0.09 mm/day in the river) as did fish that were large (> 350 mm TL) at time of stocking (mean = 0.05 mm/day in river). Fish known to be females also appeared to grow about twice as fast (0.07 mm/day in the river) as did known males (0.03 mm/day in the river). These results differed slightly from those reported in experimental stocking final report.

Although razorback sucker stocked at smaller sizes grew faster than did fish stocked at larger sizes, their recapture (and assumed survival) rates were not nearly as high. Razorback sucker that were > 350 mm TL at time of stocking composed only 423 (8.3%) of the 5,103 total fish stocked in both the experimental stocking study (n = 939 fish) and augmentation effort (n = 4,164 fish). However, they accounted for 66 (81.6%) of the 81 first-time recaptures between 1994 and 1999. Razorback sucker stocked at < 351 mm TL accounted for only 15 (18.4%) of the 81 first-time recaptures, despite composing 4,680 (91.7%) of the 5,103 razorback sucker stocked between 1994 and 1999. Using the estimated survival curve calculations from the 1997 augmentation plan, the estimated number of razorback sucker stocked between 1997 and 1999 and surviving as of 31 December 1999 is 990 fish. This is a shortfall of 14,910 fish from the estimated 15,900 target set forth in the 1997 augmentation plan.

On 16 April 1999 two ripe male and one gravid female (readily expressing eggs) razorback sucker were collected in a ten-foot-square are of the river at RM 100.2, approximately 0.3 RM downstream of the McElmo Creek confluence near Aneth, Utah (UT). This collection took place approximately 5-10 feet from the river right bank over embedded cobble substrate. These three razorback sucker were in the midst of numerous ripe adult flannelmouth sucker (Catostomus latipinnis). This collection was within a few feet of where three ripe male razorback sucker were collected and another three razorback sucker were observed in 3 May 1997. None of the fish collected from the suspected 1997 spawning aggregation were the same as those collected from the suspected 1999 spawning aggregation. In both years, fish collected from the suspected spawning aggregations came from both up- and downstream to reach the site and had originated from different stocking sites (2 in 1997, 3 in 1999). The fish from the 1997 suspected spawning aggregation originated from three different stocking dates, while those from the 1999 suspected spawning aggregation were all stocked on the same date. In both 1997 and 1999 the suspected spawning aggregations occurred on the ascending limb of the spring hydrograph. Larval razorback sucker were collected by crews from the University of New Mexico (UNM) in both 1998 (n = 2) and 1999 (n = 7) at several sites downstream of this suspected spawning area.

Field activities in 2000 will include two razorback sucker monitoring (electrofishing) trips, one in late April or early May and another in mid to late July. In addition, four adult razorback sucker (3 females, 1 male) that were implanted with radio transmitters (tags) in October 1999 will be tracked from March through May to attempt to identify spawning behavior and habitats. Up to six adult razorback sucker (> 400 mm TL) collected on the October 2000 main channel adult fish community monitoring trip will also be implanted with radio tags for a second year of tracking during spawning season (i.e. spring 2001).

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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 (NV), Utah (UT), and by the Navajo Nation.

Information on the historic distribution and abundance of the razorback sucker in the San Juan River 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 (Ryden 2000a). 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 adult 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 relatively 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, 1995, 1996, Ryden 2000b).

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 1995). 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 initiate 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).

Between March 1994 and October 1996, 939 razorback sucker were stocked into the San Juan River at four stocking sites (RM 158.6, 136.6, 117.5, and 79.6). Data gathered on these fish identified habitat types being used year-round by razorback sucker in the San Juan River, and provided information on movements, survival, growth rates, and identified a probable spawning site for razorback sucker. Based on the successes of the experimental stocking study, initiating a full-scale augmentation effort for razorback sucker in the San Juan River was deemed to be desirable. In 1997 a FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER was developed (Ryden 1997). This plan identified a target population of 15,900 razorback sucker in the San Juan River between Hogback Diversion (RM 158.6) and Lake Powell (RM 0.0). In order to meet this target population, it was estimated that 73,482 razorback sucker would have to be stocked between 1997 and 2001. To this end, stocking of razorback sucker began in September 1997. This report provides an overview on the stockings of razorback sucker that took place between 1997 and 1999 and the data subsequently collected on those fish. Although they are separate efforts, the five-year augmentation effort is an outgrowth of the experimental stocking study. Likewise, this report is a companion document to final report for the 1994-1997 experimental stocking study (Ryden 2000a). In most areas of this report, data from the experimental stocking study (1994-1997) and the five-year augmentation effort (1997-1999) are combined to strengthen data sets. If the reader should wish to read the final report for the experimental study (Ryden 2000a), it can be accessed via the internet at:

http://southwest.fws.gov/sjrip/7-Year%20Research%20Rpts/stockedrzbk.pdf

Objectives

At its inception, the objectives of the five-year augmentation plan for razorback sucker in the San Juan River were as follows:

1) Determine habitat use and needs, 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 recruit into the adult population and successfully spawn in the wild.

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

Objective 4 was dropped in 1999, because after eight years of extremely intensive fisheries collections (1991-1998), it was determined that there was not a remnant population of razorback sucker residing in the San Juan River, although a few large, old adults may still persist in the river.

Study Area

The study area for monitoring of stocked razorback sucker extends from Hogback Diversion, NM (RM 158.6), downstream to the Lake Powell interface (RM 0.0; Figure 1). For a detailed description of the geomorphic features of this study area, see the SAN JUAN RIVER STUDY AREA DESCRIPTION *in* Ryden 2000a or any of the other 7-year final research reports at the following web site:

http://southwest.fws.gov/sjrip/

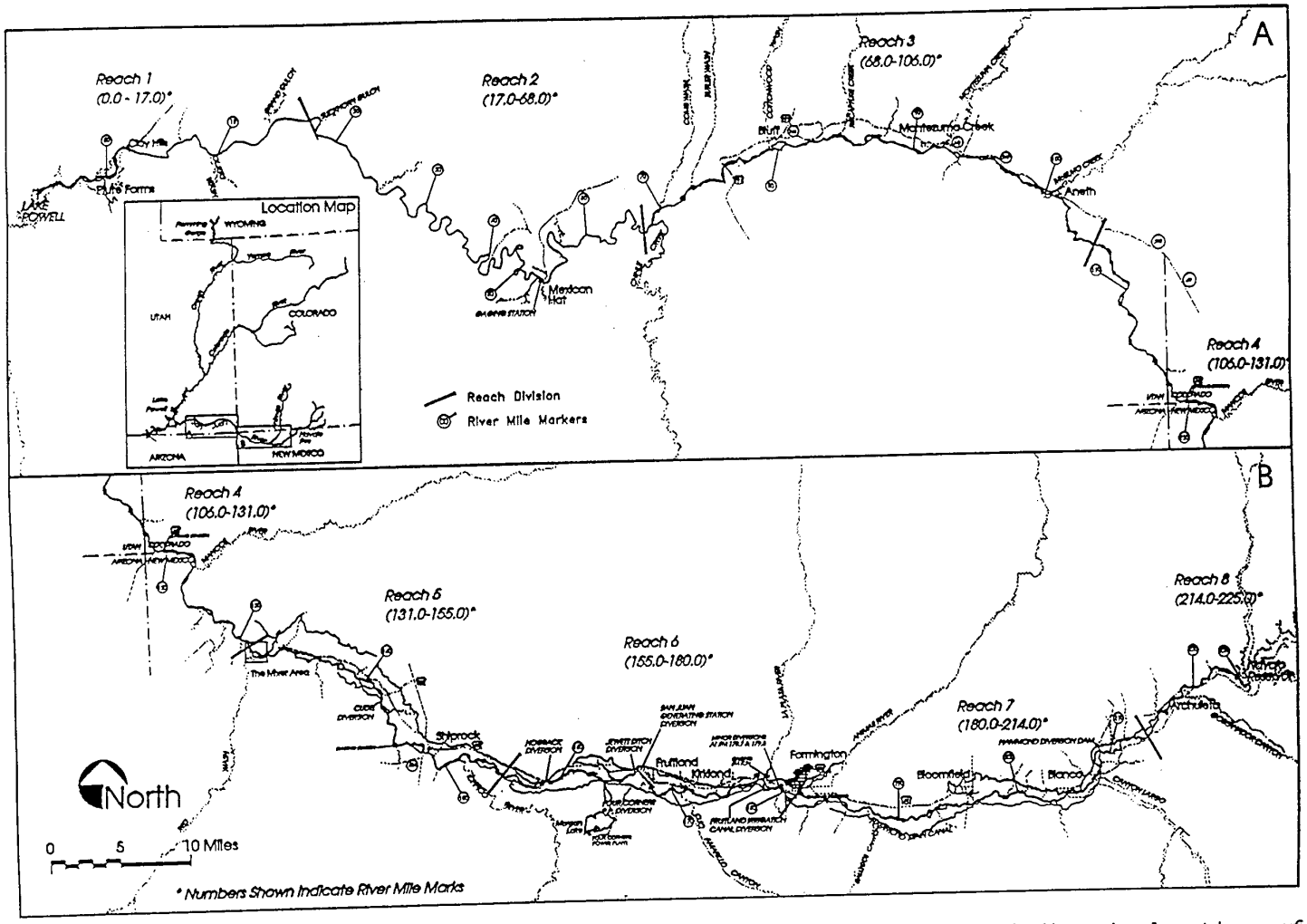

Figure 1. Map of the San Juan River between Lake Powell and Navajo Reservoir, including the locations of major towns, drainages, diversion structures, gaging stations, and river reach designations.

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

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

METHODS

Stockings of Razorback Sucker

Between 1994 and 1999, 5103 razorback sucker were stocked into the San Juan River as part of either the experimental stocking study (1994-1997) or the five-year augmentation plan (1997-1999). All 939 razorback sucker stocked into the San Juan River between 29 March 1994 and 3 October 1996 as part of the experimental stocking study were F_1 progeny of paired matings between adult razorback sucker that had been collected in the San Juan River arm of Lake Powell (SJRALP) and taken into captivity as broodstock (Table 1). See Ryden 2000a for more details on these fish.

At the beginning of the five-year augmentation plan in 1997, there were no longer any razorback sucker of SJRALP lineage available to be stocked in the San Juan River. Therefore, razorback sucker had to be obtained from other sources. Following the sequential guidelines outlined in the 1997 augmentation plan (Ryden 1997), 1,982 razorback sucker were stocked from the nearest geographic neighbor populations (i.e., the Green and Colorado river populations) and 2,182 were stocked from the razorback sucker population having the most genetic diversity (i.e., Lake Mohave; Dowling and Minckley 1994, Dowling et al. 1996a, 1996b). Table 1 summarizes the specific sources of each stocking of fish between 1994 and 1999.

All razorback sucker that were stocked were first 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.

All razorback sucker stocked between 1997 and 1999 as part of the five-year augmentation effort were stocked immediately downstream of the Hogback Diversion, NM (RM 158.6).

1994-1996

Six stockings of razorback sucker took place between 29 March 1994 and 3 October 1996 (Table 2). Another three stockings of razorback sucker occurred in Lake Powell between 8 August 1995 and 1 November 1995 (Table 2). These three stockings were not part of the experimental stocking study, but some of the fish associated with these stockings were contacted during subsequent monitoring of experimentally-stocked razorback sucker in the San Juan River. See Ryden 2000a for detailed information on fish stocked between 1994 and 1996 and monitored between 1994 and 1997.

Table 1. Lineage of and locations reared at for various groups of razorback sucker stocked into the San Juan River between 1994 and 1999.

Stocking Date	Number Of Fish Stocked	Parental Lineage	Area Where Fish Were Reared	Comments
Experimental Stocking:				
1994-1996	939	San Juan River arm of Lake Powell (parents known)	Wahweap hatchery (UDWR-Page, AZ) & Ouray hatchery (USFWS-Ouray, UT)	progeny of paired matings between wild adults; see Ryden 2000 for more detailed information
Total	939 fish stocked			
Augmentation Plan:				
09/03/97	1027	Lake Mohave (parents unknown)	Willow Beach hatchery (USFWS-Willow Beach,AZ)	collected as wild larvae from Lake Mohave
09/17/97	227	Green River X Yampa River (parents known)	Ouray hatchery (USFWS-Ouray, UT)	progeny of paired matings between wild adults
09/19/97	759	Colorado River X "Etter Pond" (parents known)	grow-out ponds in Grand Junction, CO	progeny of paired matings between wild adults
09/19/97	872	Colorado River arm of Lake Powell X "Etter" Pond (parents known)	grow-out ponds in Grand Junction, CO	progeny of paired matings between wild adults
04/22/98	57	Green River (parents unknown)	golf-course ponds in Page, AZ	progeny of stream-side spawnings of wild adults
05/28/98	67	Green River (parents unknown)	golf-course ponds in Page, AZ	progeny of stream-side spawnings of wild adults
10/14/98 and 10/15/98	1155	Lake Mohave (parents unknown)	Ojo Pond near Farmington, NM	collected as wild larvae from Lake Mohave
Total	4164 fish stocked			

Table 2. 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 December 1999. These stockings were part of an experimental stocking study (Ryden 2000a) that predated the development of the 1997 razorback sucker augmentation plan. This table is provided for information on the further monitoring of those fish only. The numbers presented here do not count toward the stocking goals set forward in the 1997 razorback sucker augmentation plan (Ryden 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)	49	27.7%
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)	1	1.5%
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)	4	1.7%
Total		939			65[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 two of these fish was recaptured during studies to monitor razorback sucker stocked in the San Juan River, one in 1996 and one in 1999. These fish were not part of the razorback sucker experimental stocking study (Ryden 2000) or the augmentation plan (Ryden 1997) and are not included in numbers discussed in the text of this report. All of these fish were PIT-tagged before release (see Table A-2, Appendix A in Ryden 2000 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 razorback sucker experimental stocking study (Ryden 2000) or the augmentation plan (Ryden 1997) and are not included in numbers discussed in the text of this report. All of these fish were PIT-tagged before release.

[c] = A total of 65 razorback sucker of known origin stocked before December 1996 had been recaptured as of 31 December 1999. Only sixty-three of these were part of the razorback sucker experimental stocking study (Ryden 2000). The other two were fish that had originally been stocked in Lake Powell at Piute Farms Marina. An additional eleven razorback sucker were recaptured for which no PIT tag numbers were obtained due to PIT tag reader failure or tag expulsion. The stocking from which these eleven fish originated is unknown. Thus, they are not included in this table. It is likely that one of these unknown-origin fish (captured 21 October 1997), given its size at recapture (216 mm TL), was from a later stocking of Lake Mohave fish (3 September 1997).

1997

There were three stockings of razorback sucker in 1997 (Table 3). The first, on 3 September 1997 consisted of 1027 fish (mean TL = 193 mm, mean WT = 76 g) that had been collected from Lake Mohave as wild larvae. These fish were reared at Willow Beach National Fish Hatchery (NFH)in AZ (Tables 1 and 3).

The second stocking, on 17 September 1997 consisted of 227 fish (mean TL = 229, mean WT = 109 g) that were F_1 progeny of paired matings between wild Green and Yampa river adults. These fish were reared at Ouray NFH until they were stocked (Tables 1 and 3).

The third stocking, on 19 September 1997 consisted of 1631 fish. Of these, 759 were F_1 progeny of paired matings between wild Colorado River and "Etter Pond" adults. "Etter Pond" is an off-channel pond approximately 20 miles upstream of Grand Junction, CO. In 1994, a population of razorback sucker was discovered in this pond. It is assumed that these fish entered this pond in either 1983 or 1984 when the Colorado River flooded the river bottom on which this pond is located. The other 872 fish were F_1 progeny of paired matings between wild Colorado River arm of Lake Powell and "Etter Pond" adults. All 1631 of these fish (mean TL = 185 mm TL, mean WT = none recorded) were reared in grow-out ponds in Grand Junction, CO (Tables 1 and 3).

1998

There were three stockings of razorback sucker in 1998 (Table 3). The first, on 22 April 1998 consisted of 57 fish (mean TL = 420 mm, mean WT = 866 g) that were progeny of streamside spawnings of wild Green River adults. These fish were reared in golf course ponds in Page, AZ (Tables 1 and 3).

The second stocking, on 28 May 1998 consisted of 67 fish (mean TL = 417 mm TL, mean WT = 874 g) that were progeny of streamside spawnings of wild Green River adults. These fish were also reared in golf course ponds in Page, AZ (Tables 1 and 3).

The third stocking, on 14 and 15 October 1998 consisted of 1155 fish (mean TL = 232 mm TL, mean WT = 112 g) that were originally collected as wild larvae from Lake Mohave in 1997. These fish were reared at Willow Beach NFH, before being transported as age-1 fish to Ojo Pond southwest of Farmington, NM in spring 1998 (Tables 1 and 3). These were the first fish to be reared in a grow-out pond owned and maintained by entities associated with the SJRIP (Table 4).

1999

No razorback sucker were stocked in 1999. Originally, the fish left in Ojo Pond from the 15 March 1998 stocking that were not collected in the October 1998 harvest and stocking effort were scheduled to be stocked in 1999. An additional 17,500 larval razorback sucker from Lake Mohave had been stocked in Ojo Pond on 3 March 1999. However, on 3 August 1999, as a consequence of numerous days of extremely heavy rains, the dike at Ojo Pond washed out, emptying the pond and washing the remaining razorback sucker down Ojo Wash. It is assumed that most of the larval razorback sucker in Ojo Pond were mortalities. It is unknown whether any of the larger fish in Ojo Pond were

Table 3. Stockings of razorback sucker in the San Juan River, 1997-1999, as part of the five-year augmentation plan for razorback sucker (Ryden 1997), and recaptures that have occurred with these fish as of 31 December 1999.

Date Stocked	Stocking Number	Number Of Fish Stocked	Mean TL(range)	Mean WT(range)	Recapture Information	
					Number of Recaptures	Percent of Total Stocked
09/03/97	1	1027	193(193-240)	76(76-175)	5	0.5%
09/17/97	2	227	229	109	1	0.4%
09/19/97	3	1631	185(104-412)	None Taken	2	0.1%
04/22/98	4	57	420(380-460)	866(612-1108)	5	8.8%
05/28/98	5	67	417(341-470)	874(547-1420)	4	6.0%
10/14-15/98	6	1155	232(185-315)	112(50-280)	1	<0.1%
Total		4164			18	

Table 4. History of fish stocked in and reared at Ojo Pond and Avocet Ponds, 1998-1999.

Date Stocked	Pond Fish Were Stocked In	Number Of Fish Stocked In Pond	Parental Lineage	Comments
1998:				
03/15/98	Ojo	8,000 (age-1)	Lake Mohave	Collected as wild larvae from Lake Mohave in 1997 and held at Willow Beach NFH; 1,155 were harvested and stocked on 14 and 15 October 1998.
1999:				
03/03/99	Ojo	17,500 (larvae)	Lake Mohave	Larvae from matings of wild Lake Mohave adults (15 females and 11 males); these fish were washed into Ojo Wash when the dike at Ojo Pond broke during heavy rains on 3 August 1999, most of these fish were likely mortalities.
03/03/99	Avocet (east cell)	17,500 (larvae)	Lake Mohave	Larvae from matings of wild Lake Mohave adults (15 females and 11 males).
05/25/99	Avocet (west cell)	30,000 (larvae)	Various (see below)	Larvae (F_2's) from crosses of 1992 F_1's (from matings of San Juan River arm of Lake Powell {SJRALP} wild adults) and 1995 F_1's (from matings of SJRALP X SJRALP, SJRALP X Colorado River {CR}, SJRALP X Colorado River arm of Lake Powell {CRALP}, and SJRALP X "Etter Pond" {EP} wild adults; 33 males and 33 females total). See below:

Number Of Fish	1992 F_1 Lineage	1995 F_1 Lineage	Family Lot	% SJRALP Lineage
3,000	SJRALP X SJRALP	SJRALP X SJRALP	9905	100
2,000	SJRALP X SJRALP	SJRALP X SJRALP	9922	100
3,000	SJRALP X SJRALP	SJRALP X SJRALP	9929	100
3,000	SJRALP X SJRALP	SJRALP X CR	9917	75
3,000	SJRALP X SJRALP	SJRALP X CR	9930	75
3,000	SJRALP X SJRALP	SJRALP X CRALP	9920	75
3,000	SJRALP X SJRALP	SJRALP X CRALP	9924	75
3,000	SJRALP X SJRALP	SJRALP X CRALP	9926	75
3,000	SJRALP X SJRALP	SJRALP X CRALP	9927	75
1,000	SJRALP X SJRALP	SJRALP X EP	9923	75
3,000	SJRALP X SJRALP	CRALP X EP	9919	50

able to negotiate the wash and reach the river (a distance of approximately six miles). There was a flow of about 30 cubic feet per second (CFS) in Ojo Wash the day after the wash-out (R. Smith pers. comm.). A crew from the Farmington Bureau of Indian Affairs Navajo Indian Irrigation Project (BIA-NIIP) office sampled Ojo Wash on 4 August, recovering approximately 200 razorback sucker larger than 200 mm TL (E. Teller pers. comm.). These fish were transported to the east cell of Avocet Ponds. By the next day, 5 August, approximately 75% of the razorback sucker recovered from Ojo Wash on 4 August and stocked in Avocet Pond had died (E. Teller pers. comm.). Subsequent electrofishing and seining (on 23 and 24 September 1999) in the mainstem San Juan River both up- and downstream of the area into which Ojo Wash empties failed to collect any razorback sucker.

Ojo And Avocet Ponds

In response to shortfalls in numbers of razorback sucker being stocked the SJRIP acquired use of three ponds on BIA-NIIP land southwest of Farmington, NM in 1998. The first, Ojo Pond was enlarged from its original size of 1.8 acres to a size of 2.4 acres and a maximum depth of six feet (Keller-Bliesner Engineering 1998). Ojo Pond was filled with water and was "online" in spring 1998. This pond was first stocked with fish on 15 March 1998 and again on 3 March 1999 (Table 4). A total of 1155 razorback sucker were harvested from this pond and stocked into the San Juan River at RM 158.6 on 14 and 15 October 1998 (Tables 3 and 4). Due to unseasonably heavy Ojo Pond washed out on 3 August 1999. This pond was not rebuilt.

The other two ponds currently being used by the SJRIP to raise razorback sucker for the five-year augmentation effort are the Avocet Ponds. These ponds are also located on BIA-NIIP land southwest of Farmington, NM, approximately 3-4 miles from Ojo Pond. These ponds were created by dividing a large existing dry basin into two smaller ponds (Keller-Bliesner Engineering 1998). The west pond is 3.34 acres with a maximum depth of six feet. The east pond is 3.52 acres, also with a maximum depth of six feet. These ponds were filled with water in fall 1998, but because they had been dry for so long, they were not considered to be "online" until spring 1999. This allowed the ponds to develop the productivity needed to support razorback sucker. East Avocet Pond was stocked with fish on 3 March 1999 (Table 4). West Avocet Pond was stocked with fish on 25 May 1999 (Table 4). Two fyke nets (one in each pond) were set for a 24-hour period in these ponds on 8-9 November 1999 to check growth of fish stocked in these ponds in spring 1999.

Monitoring Of Stocked Fish

Radio Telemetry

Two types of radio telemetry contacts were made with razorback sucker, habitat observation contacts and movement contacts. 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 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 meters upstream of the fish's most upstream location during the contact period to 100 meters downstream of the fish's most downstream location during the contact period (i.e., the "contact area"). Habitat classifications used for mapping habitat were the same as those defined by Bliesner and Lamarra (1993). 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 sucker select particular habitat types, habitat use was compared to habitat availability (Swanson et al. 1974, Johnson 1980, Osmundson et al. 1995). Selection, or lack thereof, for a particular habitat type was estimated by the average difference between the percent that 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 at 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 for the fish.

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, all years 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 interpret the relative degree of selection between selected habitats.

It was also assumed that the combination of habitats, adjacent to one another, would play a role in the fishes site selection process. 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, all years combined. The habitat richness value for each month determines the number of habitat types it is felt to be important to manage for adult razorback suckers. For example, if the mean habitat richness for all June contacts, all years combined, was 6, we assume that a block of six habitat types is therefore important in fulfilling a biological need for the fish.

The second type of radio telemetry contact, movement contacts, consisted simply of recording the radio tag number, date, and RM of contact. On occasion, more information was recorded, but this was usually not the case.

Both types of contacts were used to calculate values for total longitudinal movement, or TLM (i.e., the total number of RM moved, from the most upstream contact to the most downstream), maximum displacement, or MD (i.e., the maximum distance moved from the point of release during entire monitoring period), and final displacement, or FD (i.e., the distance from point of release to point of last contact). For fish that were tracked prior to the beginning of the augmentation effort, TLM, MD, and FD were calculated using all contacts with that fish.

Recaptures

Razorback sucker monitoring trips had the following sampling protocol. Electrofishing proceeded downstream in a continuous fashion from put-in (RM 158.6) to take-out (RM 76.4) with two electrofishing rafts. One or two netters stood on an elevated platform above the anodes and collected fish as they were drawn into the electrical field. The raft operator maneuvered the boat via oars, monitored the Variable Voltage Pulsator (VVP), and made adjustments to current, voltage, amperage, frequency, and pulse width when necessary. Rafts were oriented perpendicular to the shoreline with the anode nearest the shoreline. One raft shocked along each shoreline of the river, breaking off into large secondary channels, when they were accessible. Particular mid-channel features such as debris piles, cobble bars, and island shorelines were also shocked where they were present at the raft operators discretion.

The study area was divided into one-mile sections. Electrofishing crews began at the upstream end of each mile and collected all the fish they could net as they shocked downstream. At the end of each mile, all non-rare fish collected were enumerated by species and age class. All nonnative fish species collected during sampling were removed from the river, in support of the nonnative removal study. Common native fishes were returned alive to the river.

Captured specimens of rare native fish (razorback sucker, Colorado pikeminnow, and roundtail chub) were anesthetized using MS-222 (200 mg/L of water), weighed, measured, checked for a PIT tag, and examined for general health and reproductive status (if apparent). If no PIT tag was detected, one was implanted. River mile of capture (to the nearest 0.1 RM) was noted, if specifically known. In many electrofishing samples the crew was unaware that they had collected a rare fish 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 rare native fishes were returned alive to the river after data collection was complete.

Besides being collected on razorback sucker monitoring trips, razorback were also recaptured, incidentally, via electrofishing on main channel adult fish community monitoring trips (USFWS), and rare fish population goal sampling trips (Ecosystems Resource Institute {ERI} and Miller Ecological Consultants {MEC}), via seine on trips to monitor stocked Colorado pikeminnow (Utah Division of Wildlife Resources {UDWR}), and via trammel net during rare fish surveys in Lake Powell (U.S. Geological Survey-Biological Resources Division {USGS-BRD}).

Razorback sucker that had been recaptured two or more times since their date of stocking with at least one of those recaptures occurring after the beginning of the augmentation effort were used to calculate TLM, MD, and FD. The reason for using fish recaptured more than once was to try to examine fish that had adapted to living in the river and were displaying “natural” behaviors. Based on previous data, large initial downstream displacements observed among radiotelemetered razorback sucker after stocking were usually always followed by fish demonstrating the ability to eventually maintain their relative position in the river and even move back upriver (Ryden 2000a). Since only two data points were available for first-time recaptures, it could not be determined if these fish were still in the process of that initial downstream displacement or had already adjusted to riverine conditions.

RESULTS

Stocking Shortfalls

Between September 1997 and December 1999, a total 4164 razorback sucker were stocked into the San Juan River at RM 158.6. This equates to a shortfall of 51,168 fish over the three-year period (Table 5). In other words, to date, only 7.53% of the number of razorback sucker called for in the 1997 augmentation plan have been stocked, a 92.7% shortfall (Table 5). Including numbers of razorback sucker stocked as part of the experimental stocking study, a total of 5103 razorback sucker were stocked into the San Juan River between 29 March 1994 and 31 December 1999.

Ojo and Avocet Ponds

Currently, there are no plans to rebuild Ojo Pond. Fish in Avocet Ponds will be held until fall 2000, when they will be harvested and stocked. A fyke net set in East Avocet Pond for a 24-hour period on 8-9 November 1999 failed to collect any razorback sucker. However, a fyke net set in West Avocet Pond collected approximately 200 razorback sucker. A subsample of 33 of these fish were measured and had a mean TL of 158.6 mm (range = 135-187 mm TL). These fish had a mean TL of 25 mm when stocked in West Avocet Pond and had been in the pond for 168 days when sampled. This calculates to a mean growth rate of 0.80 mm/day (May-November). Both ponds were heavily infested with neotonic tiger salamanders (Ambystoma tigrinum) when sampled. This life stage of tiger salamander is known to be highly predaceous. However, it is unknown if the presence of large numbers of tiger salamanders represents a predation threat to larval razorback sucker being stocked into the Avocet Ponds.

Table 5. Numbers of fish projected to be stocked in the 1997 augmentation plan versus actual numbers of razorback sucker stocked into the San Juan River, 1997-1999.

Year	Number Of Fish Projected To Be Stocked	Actual Number Stocked And (Shortfall)	Percent Of Projection Actually Stocked	Percent Shortfall
1997	31,800	2,885 (28,915)	9.07%	90.93%
1998	12,720	1,279 (11,441)	10.06%	89.94%
1999	10,812	0 (10,812)	0.00%	100.00%
2000	9,286	None Yet (None)	-----	-----
2001	8,864	None Yet (None)	-----	-----
To-Date Totals 1997-1999	55,332	4,164 (51,168)	7.53%	92.47%

Monitoring Of Stocked Fish

Two razorback sucker monitoring (i.e., electrofishing) trips were conducted in 1998 and 1999, one in each year. The 1998 trip sampled RM 158.6-76.4 between 4 and 9 May 1998. It was the only trip scheduled for that year. A total of four razorback sucker were collected on that trip (Table 6). The 1999 razorback sucker monitoring trip sampled the same RM between 12 and 17 April 1999. A total of 11 razorback sucker were collected on that trip (Table 6). A second sampling trip was scheduled to be conducted in August 1999, but inordinately high flows (as high as 7,420 CFS at the Shiprock USGS gage) caused the cancellation of this trip. An additional 27 razorback sucker recaptures occurred on sampling trips for other research elements (Table 6).

Between 9 September 1997 and 31 December 1999, a total of 18 (0.4%) of the 4164 razorback sucker stocked as part of the five-year augmentation effort were recaptured (Tables 3 and 6). All 18 of these fish were first-time recaptures. In addition 16 (1.7%) of the 939 razorback sucker stocked during the experimental stocking study (and not reported in Ryden 2000a) were also recaptured (Tables 2 and 6). Of these 16, nine were first time recaptures, five were recaptured for the second time since being stocked and two were recaptured for the third time since being stocked. One of the 65 razorback sucker stocked into Lake Powell at Piute Farms (RM 0.0) on 15 August 1995 was also recaptured (Tables 2 and 6). It was a first-time recapture. An additional six razorback sucker for which no identifying PIT tag number was obtained were also recaptured between 1997 and 1999 (Table 6). The origin of these six recaptured fish (i.e., stocking date and location) was unknown.

Of the 18 recaptured known-origin razorback sucker associated the five-year augmentation effort, 15 (83.3%) were collected during various electrofishing efforts (Table 6). The other three (16.7%) were collected in trammel nets (Table 6). Of the 35 total known-origin razorback sucker collected, 31 (88.6%) were recaptured by electrofishing, 4 (11.4%) by trammel net (Table 6). For all 41 recapture events, 36 (87.8%) were recaptured via electrofishing, 4 (9.8%) using trammel nets, and one (2.4%) in a seine (Table 6).

In addition to the razorback sucker collected, 45 Colorado pikeminnow stocked by the UDWR between 1996 and 1998 were recaptured on razorback sucker monitoring trips in May 1998 and April 1999 (Table 7). One of these fish recaptured at RM 81.3 on 17 April 1999 (302 mm TL) had previously been recaptured at RM 127.0 on 30 September 1998 (299 mm TL). Likewise, four wild roundtail chub were also collected during razorback sucker monitoring trips (Table 7). One roundtail chub recaptured at RM 133.4 on 5 May 1998 (414 mm TL) was originally captured and tagged at RM 131.3 on 15 April 1996 (414 mm TL). This fish represents only the second individual roundtail chub that has been PIT-tagged and later recaptured in the mainstem San Juan River since 1991, thus displaying a long-term persistence in the river.

Habitat Use, Needs, Selection, And Richness

Radio telemetry efforts between the end of the experimental stocking study and the end of 1999 were sporadic. Tracking of razorback sucker as part of the experimental stocking study ended in July 1997 and no further radio-tracking was planned at that time. Only one razorback sucker still had an active radio transmitter (tag) at the end of the experimental stocking study

Table 6. General information on stocked razorback sucker recaptured in the San Juan River between October 1997 and December 1999 (® = a fish that has been recaptured more than once since being stocked).

Recapture Date	PIT tag number	Stock[a]	Radio Tag	Old TL(mm)	Old WT(g)	New TL(mm)	New WT(g)	Days In River	River Mile Recapture	River Mile Stocking	Sex[b]
USFWS October 1997 Main Channel Adult Fish Community Monitoring Trip (Electrofishing)											
09/29/97	511416236C	Mohave	None	193	76	193	80	26	159.0	158.6	I
10/01/97	5115611E67	Mohave	None	240	175	240	175	28	137.0	158.6	I
10/05/97	4216404436	Mohave	None	215	85	215	85	32	98.0	158.6	I
10/06/97	510D1A4408	Mohave	None	200	76	200	70	33	87.0	158.6	I
UDWR October 1997 Colorado Pikeminnow Monitoring Trip (Seining)											
10/21/97	----------[c]	Unknown	None	---	----	216	----	----	77.3	-----	I
USFWS May 1998 Razorback Sucker Monitoring Trip (Electrofishing)											
05/04/98	41281F0B44	Mohave	None	193	76	295	335	243	151.1	158.6	I
05/05/98	41277C4602	CALP/EP	None	204	----	222	120	228	134.0	158.6	I
05/07/98	1F43550544®	SJRALP	None	414	786	472	1100	1266	98.6	158.6	F
05/07/98	420F365F58	CALP/EP	None	325	----	341	580	230	98.0	158.6	I
USFWS October 1998 Main Channel Adult Fish Community Monitoring Trip (Electrofishing)											
09/30/98	1F7441614B®	SJRALP	None	390	620	474	1100	1412	122.0	117.5	F
10/01/98	7F7B126F4C[d]	Unknown	670	---	----	511	1600	----	121.0	-----	I
10/01/98	1F43670136®	SJRALP	127	418	760	493	1525	1413	119.2	117.5	I
10/03/98	7F7B121B14	Green	087	444	----	468	956	164	89.0	158.6	I
10/03/98	7F7B1A565B	Green	None	410	801	456	850	164	89.0	158.6	I
10/05/98	1F74343F7A	SJRALP	None	394	630	444	820	1417	77.5	79.6	M
10/05/98	1F41341F4D	SJRALP	None	403	640	423	700	1417	77.3	158.6	M
10/05/98	1F74335B5F	SJRALP	None	404	712	444	1050	1417	68.7	79.6	I
USFWS April 1999 Razorback Sucker Monitoring Trip (Electrofishing)											
04/12/99	1F73326C50	SJRALP	None	390	----	474	1350	1606	151.0	158.6	I
04/13/99	7F7D175C49	SJRALP	None	337	454	393	660	922	141.0	158.6	F
04/13/99	1F402E452E	SJRALP	None	388	680	440	900	1607	140.0	158.6	M
04/16/99	1F404E666D®	SJRALP	None	370	525	548	1840	1610	108.0	158.6	F
04/16/99	1F435D1C25®	SJRALP	None	422	940	509	1300	1610	100.2	117.5	M
04/16/99	1F40464E0D®	SJRALP	None	404	800	438	790	1610	100.2	158.6	M
04/16/99	1F74362314	SJRALP	None	404	670	565	1650	1610	100.2	79.6	F
04/17/99	1F40496870®	SJRALP	None	408	770	431	815	1611	95.0	136.6	M
04/17/99	1F413C7C68	SJRALP	None	393	606	527	1850	1611	91.5	79.6	F
04/17/99	51337B7079[d]	Unknown	None	---	----	440	950	----	89.8	-----	M
04/17/99	1F414E3E14	SJRALP	None	395	----	472	930	1611	86.3	79.6	M
USGS-BRD and UDWR August 1999 Lake Powell Trammel Netting											
08/17/99	7F7B1B5402	Green	None	425	894	467	1075	482	0.0	158.6	I
USFWS October 1999 Main Channel Adult Fish Community Monitoring (Electrofishing)											
09/29/99	513402471F	Mohave	None	232	112	241	110	350	107.7	158.6	I
10/01/99	7F7B107949	Green	741	434	1022	486	1450	491	88.0	158.6	F
10/01/99	7F7B177D42	GR/YR	771	229	109	357	440	744	76.4	158.6	F
10/02/99	7F7B107152	Green	761	415	836	452	980	492	59.4	158.6	M
10/03/99	7F7B1A510C	Green	841	428	1002	489	1275	529	55.3	158.6	F
USGS-BRD and UDWR October 1999 Lake Powell Trammel Netting											
10/05/99	1F75115803[e]	SJRALP	None	412	713	532	1590	1512	0.5	0.0	I
10/05/99	7F7B18014B	Green	None	445	967	490	1320	495	0.5	158.6	M
10/07/99	7F7B12155F	Green	None	432	977	459	1048	497	0.0	158.6	M
ERI and Miller Ecological October 1999 Rare Fish Population Goals Study Trip (Electrofishing)											
10/20/99	7F7B127127	Green	None	395	801	458	1008	546	104.0	158.6	I
10/20/99	----------[c]	Unknown	None	---	----	473	990	----	104.0	-----	I
10/20/99	----------[c]	Unknown	None	---	----	478	1021	----	104.0	-----	I
10/20/99	----------[c]	Unknown	None	---	----	542	1686	----	104.0	-----	I

[a] Mohave = fish harvested as wild larvae from Lake Mohave; CALP/EP = progeny of paired matings between wild adult razorback sucker from the Colorado River arm of Lake Powell and from Etter Pond near Grand Junction, CO; SJRALP = progeny of paired matings between wild adult razorback sucker from the San Juan River arm of Lake Powell; Green = progeny of streamside spawnings of wild adult Green River razorback sucker; GR/YR = progeny of paired matings between wild adult razorback sucker from the Green and Yampa rivers.

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

[c] These values were not available due to equipment failure or lack of a PIT tag reader on the trip.

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

[e] This fish was stocked by the Utah Division of Wildlife Resources (UDWR) at Piute Farms (RM 0.0) in Lake Powell on 15 August 1995. This fish was not a part of this riverine augmentation effort. It is listed here because it was collected in the same backwater (and trammel net) as a fish from our stocking effort.

Table 7. Information on other rare fish species collected from the San Juan River during razorback sucker monitoring trips in 1998 and 1999.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
Recaptured, stocked Colorado pikeminnow						
May 1998:						
05/04/98	1F5B442121	NONE	184	40	I	149.4
05/05/98	7F7D153127	NONE	173	34	I	140.0
05/05/98	7F7D180E42	NONE	154	26	I	138.0
05/05/98	7F7B110F76	NONE	187	37	I	133.0
05/05/98	7F7B016B19	NONE	185	43	I	132.0
05/05/98	7F7B03273A	NONE	182	41	I	132.0
05/05/98	7F7B0D2C24	NONE	163	30	I	131.0
05/06/98	NONE	NONE	130	15	I	128.0
05/06/98	1F74425358	NONE	150	21	I	127.0
05/06/98	1F5B7E7A0E	NONE	168	37	I	124.1
05/06/98	7F7B0D3C2B	NONE	217	83	I	123.7
05/06/98	7F7B134349	NONE	181	38	I	123.0
05/06/98	1F43566662	NONE	171	36	I	123.0
05/06/98	MORTALITY	NONE	205	60	I	122.7
05/06/98	42143B000F	NONE	176	39	I	122.0
05/06/98	NONE	NONE	---	---	I	120.0
05/06/98	1F75056C7B	NONE	204	62	I	118.0
05/07/98	1F5320036B	NONE	208	65	I	112.0
05/07/98	1F5A79721C	NONE	163	29	I	110.0
05/07/98	1F5C076717	NONE	161	29	I	110.0
05/07/98	1F5A760B06	NONE	162	31	I	110.0
05/07/98	NONE	NONE	---	---	I	110.0
05/07/98	1F5D26203E	NONE	186	44	I	109.0
05/07/98	1F5B55131E	NONE	168	65	I	107.6
05/07/98	1F6B2F4B7C	NONE	176	31	I	104.6
05/08/98	1F5B03562D	NONE	218	76	I	95.7
05/08/98	1F74730E6C	NONE	207	57	I	94.0
05/08/98	1F6B205D79	NONE	205	56	I	93.0
05/08/98	7F7D3C4C4D	NONE	151	22	I	93.0
05/08/98	7F7D090038	NONE	229	103	I	91.7
05/08/98	7F7D406402	NONE	217	79	I	91.6
05/08/98	7F7D071A71	NONE	200	55	I	91.0
05/08/98	1F46430E4A	NONE	190	45	I	91.0
05/08/98	7F7D52113F	NONE	197	60	I	90.9
05/08/98	NONE	NONE	---	---	I	89.0
05/08/98	7F7D3E7A0F	NONE	182	39	I	84.0
05/08/98	1F5B7E6B1D	NONE	250	120	I	83.6
05/09/98	7F7B0D241B	NONE	226	100	I	82.0
April 1999:						
04/12/99	1F631D2549	NONE	176	32	I	155.0
04/12/99	1F613E6C56	NONE	141	18	I	150.0
04/14/99	513A590906	NONE	168	29	I	130.7
04/15/99	51364F392A	NONE	151	13	I	117.0
04/16/99	5136501D77	NONE	163	27	I	110.0
04/17/99	5136472820	NONE	294	340	I	85.0
04/17/99	7F7B135F21®	NONE	302	272	I	81.3

® = This was a recapture of a fish that was previously captured and PIT-tagged.

Table 7, continued.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
Wild roundtail chub						
May 1998:						
05/05/98	1F6D185B01®	NONE	414	760	I	133.4
05/07/98	NONE	NONE	51	---	I	114.0
April 1999:						
04/12/99	51365B4108	NONE	346	420	I	153.0
04/12/99	223F71510A	NONE	116	13	I	147.0

® = This was a recapture of a fish that was previously captured and PIT-tagged.

(tag # 800). This tag functioned much longer than was expected. This fish (tag # 800) was tracked intermittently until September 1998 when its tag finally expired (a total of 6 more contacts). Three of the six contacts made with this fish after the experimental stocking study ended were made during trips for other research elements. Thus very little data (date and RM) were recorded for these three contacts. However, during the other three contacts, habitat use information was recorded.

The first habitat observation contact with tag # 800 occurred on 20 November 1997 at RM 143.5 for 120 minutes. During this contact, the fish was using three different habitat types: main channel run (62.5% of the time), chute (25.0%), and shoreline run (12.5%), in descending order. Habitat selection calculations revealed a 68.9% selection for chute habitat and 31.1% selection for shore run habitat, with no selection of main channel run habitat due to its relatively high availability. The habitat richness value for this habitat contact was nine. Depth at this contact location was 2.8 feet with a mean column water velocity of 4.2 feet/second (ft/sec) and a bottom velocity of 2.5 ft/sec. Water temperature at the selected locations was 4.0ºC and did not differ from the main channel temperature. Flows at Shiprock gage during the time of this contact were 1100 CFS. The substrate at this contact location was a mixed cobble and gravel substrate.

The second habitat observation contact with tag # 800 occurred on 25 June 1998 at RM 133.3 for 120 minutes. During this contact, the fish was using three different habitat types: riffle (62.5% of the time), sand shoal (23.3%), and run/riffle (14.2%), in descending order. Habitat selection calculations revealed a 72.9% selection for riffle habitat and a 27.1% selection for sand shoal habitat, with no selection of run/riffle habitat due to its relatively high availability. The habitat richness value for this particular habitat contact was five. Depth at this location was 0.8 feet with a mean column water velocity of 1.9 ft/sec and a bottom velocity of 1.4 ft/sec. Water temperature at the selected locations was 17.5ºC and did not differ from the main channel temperature. Flows at Shiprock gage during the time of this contact were 2200 CFS. The substrate at this contact location was predominately embedded cobble and sand.

The third habitat observation contact with tag # 800 occurred on 2 September 1998, again at RM 133.3, this time for 60 minutes. During this contact, the fish used only one habitat type: main channel run (100.0% of the time). Habitat selection calculations revealed a 100.0% selection for main channel run habitat. The habitat richness value for this particular habitat contact was four. Depth at this location was 2.0 feet with a mean column water velocity of 1.8 ft/sec and a bottom velocity of 1.5 ft/sec. Water temperature at the selected locations was 22.5ºC and did not differ from the main channel temperature. Flows at Shiprock gage during the time of this contact were 699 CFS. The substrate at this contact location was sand over embedded cobble.

Four additional razorback sucker were implanted with radio tags in 1998, one in May 1998 (tag # 364) and three in October 1998 (tag #'s 087, 127, and 670). These fish were PIT-tagged fish that had already been in the river for several months when they were implanted. The reason for implanting these fish was to study whether habitat use of razorback sucker that had adapted to and survived in the river over many months differed significantly from that of newly stocked razorback sucker. However high rates of apparent tag failure led to three of the four tags not being contacted after their release and the fourth (tag # 127) only being contacted once before contact was lost with it. TLM, MD, and FD were calculated for tag # 127. The radio tags being used were those left over from the experimental stocking study. This batch of radio tags had proven to be somewhat unreliable during that study as well.

Site Preference

Data for site preference among stocked razorback sucker is 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 site is a large backwater on river left at RM 38.6. The collections associated with this backwater were reported upon in Ryden 2000a. Since October 1997, there have been no further razorback sucker collections associated with this site.

The second possible preferred site is just downstream of Aneth, UT at RM 100.2 on river right. The collection of three ripe male razorback sucker and observation of three more razorback sucker that were not collected at this site was reported upon in Ryden 2000a. A fourth ripe male razorback sucker was also collected just upstream of this site on the same side of the river at RM 100.5, the confluence of McElmo Creek (Ryden 2000a). No razorback sucker were collected at this site during spring 1998 sampling (7 May 1998). However, on 16 April 1999, two ripe male razorback sucker (438 and 509 mm TL) and one gravid female razorback sucker (565 mm TL) were collected at this same site within a few feet of where the three razorback sucker were collected on 3 May 1997 (Table 6). These three razorback sucker were collected in the midst of numerous ripe (presumably spawning) flannelmouth sucker, over an embedded cobble substrate, approximately 5-10 feet from the river right bank in less than three feet of water. These three fish, all stocked on 18 November 1994 had been stocked at three different stocking sites (RM 158.6, 177.5, and 79.6).

The third possible preferred site for razorback sucker is a large backwater (side channel at higher flows) 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. Flows at Shiprock USGS gage at the time of this recapture were 1110 CFS. Although no PIT tag number was read for this fish, it is likely that this fish was a razorback sucker (Mohave stock) that had been stocked on 3 September 1997 at RM 158.6. The following year on 5 October 1998, a male razorback sucker (444 mm TL) was collected along the river left shoreline just upstream of the top of this backwater (RM 77.5) and a second male razorback sucker (423 mm TL) was collected at the mouth of the backwater (RM 77.3; Table 6). The flows at the Shiprock USGS gage at the time of this recapture were 821 CFS. A third razorback sucker was observed but not netted in the mouth of the backwater. These two male razorback sucker were originally stocked on 18 November 1994 as part of the experimental stocking study at two different stocking sites, RM 158.6 and 79.6.

There were a total of 106 razorback sucker recaptures between 1994 and 1999, including first-, second-, and third-time recaptures of known-origin razorback sucker, recaptures of unknown-origin razorback sucker (no PIT tag read), and recaptures of razorback sucker that had moved upstream from Lake Powell into the San Juan River. Of these 106 recaptures 60 (56.6%) occurred between RM 130.0 and 80.0 (Figure 2). Twenty-two of the 106 (20.8%) occurred between RM 110.0 and 100.0 (Figure 2). This is the ten-mile section of river in which the suspected spawning site at RM 100.2 occurs. Only 21 (19.8%) of the 106 recaptures occurred upstream of RM 130.0, while 25 (23.6%) of the 106 recaptures occurred downstream of RM 80.0 (Figure 2). Though not technically site preference, the large number of recaptures in this 50-RM section, centered around Aneth, UT, indicates that conditions there are very suitable for the retention and survival of stocked razorback sucker.

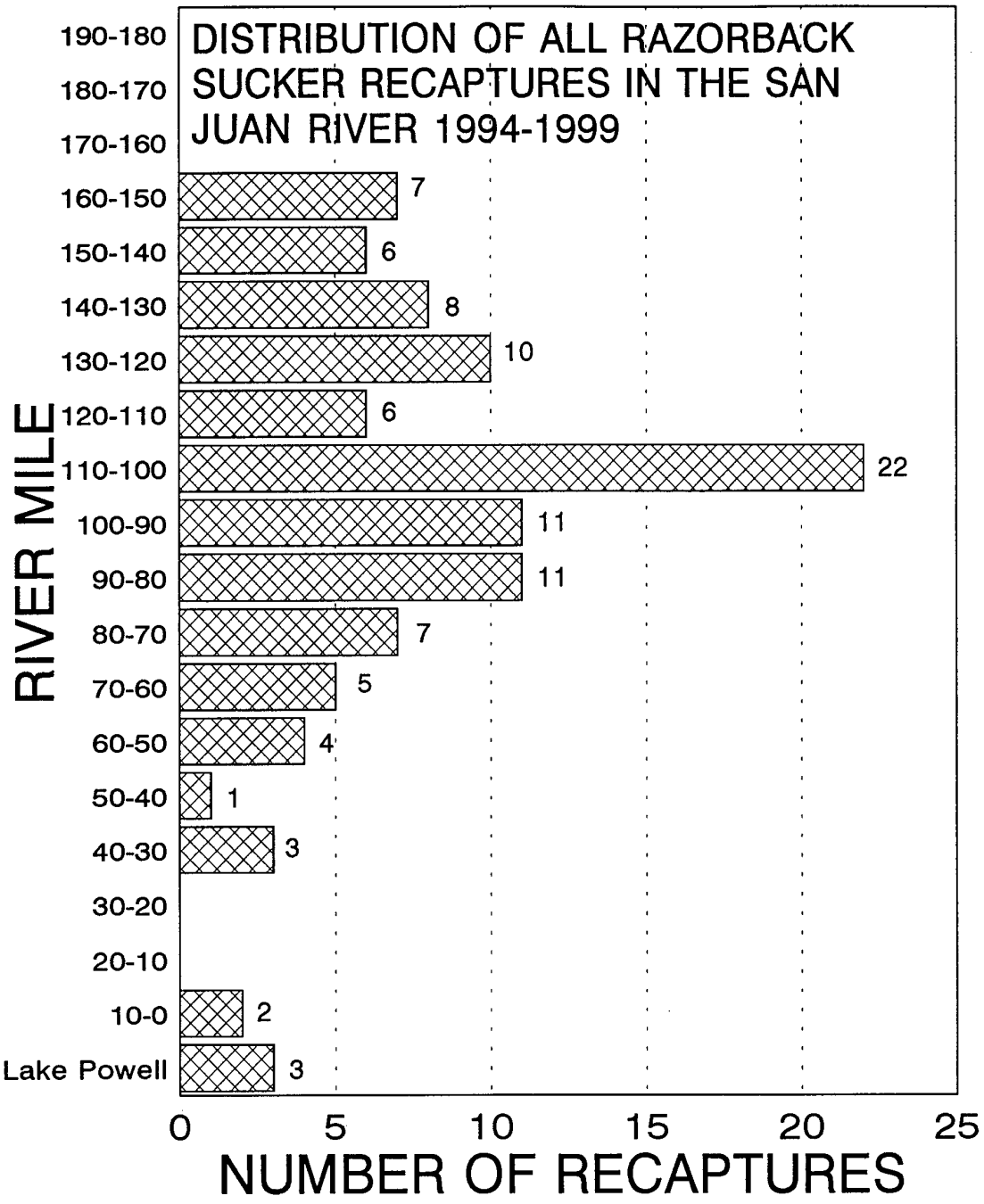

Figure 2. Longitudinal distribution of all razorback sucker recapture events (including second- and third-time recaptures) in the San Juan River between March 1994 and December 1999, by ten-RM increments. Numbers to the right of the bars represent the actual number of recapture events.

Movement Patterns

The two radio-tagged razorback sucker tracked after the end of the experimental stocking study showed very little distinctive movement (Table 8, Figure 3). Tag # 800 (sex unknown), stocked at RM 158.6 on 3 October 1996 frequented an area between RM 145.6-143.3 for several months in the summer of 1997 before moving downstream over Cudei Diversion (RM 142.0) to an area adjacent to the boat take-out at RM 133.3 (Figure 3). It remained at that location until its tag expired in the fall of 1998. Tag # 127 (sex unknown), originally stocked at RM 117.5 (with only a PIT tag) on 18 November 1994 had moved upstream to between RM 120 and RM 119.2 where it was recaptured and implanted with a radio tag on 1 October 1998. After its release at RM 119.2, it moved upstream to RM 120.3 where it was contacted once on 19 March 1999 (Figure 3). Contact was then lost with this fish. This fish was never contacted downstream of its stocking site. Movement calculations for tag #'s 800 and 127 show very small mean values for TLM, MD, and FD for these two fish (Table 8).

Details on the other three fish implanted with radio tags are as follows. The first fish, a female, had originally been stocked at RM 158.6 on 18 November 1994 and was implanted with radio tag # 364 upon its recapture on 7 May 1998 at RM 98.6. The second fish (sex unknown) was originally stocked at RM 158.6 on 3 October 1998 and was implanted with radio tag # 087 upon its recapture on 3 October 1998 at RM 89.0. No PIT tag was found in the last fish (tag # 670, sex unknown) at the time of its recapture on 1 October 1998, so its origin was unknown. This fish was implanted with a new PIT tag and radio tag # 670 before being released. None of these three fish was contacted via radio telemetry after their release.

The 41 razorback sucker recaptures between October 1997-December 1999 ranged from RM 159.0, upstream of Hogback diversion, downstream to Piute Farms (RM 0.0) in Lake Powell (Table 6). The one razorback sucker recaptured upstream of Hogback diversion was a 193 mm TL fish (Lake Mohave stock) stocked as part of the augmentation effort that had only been in the river for 26 days when recaptured (Table 6). This is the first record of a razorback sucker having moved upstream of the Hogback Diversion stocking site (RM 158.6) and traversing the diversion itself. However, it should be noted that the Hogback Diversion had largely been destroyed by river flows and had not yet been rebuilt when this upstream passage took place (pers. obs.). The other 17 razorback sucker that had been stocked as part of the augmentation effort had all moved downstream after stocking (range = 7.5-158.6 RM). Of four razorback sucker collected in trammel nets at the San Juan River-Lake Powell interface, three were razorback sucker (Green River stock) that had been stocked at RM 158.6 between 482 and 497 days earlier as part of the augmentation effort. Of these three, only two were actually in Lake Powell proper (i.e., RM 0.0 or downstream), but this does show that even some larger razorback sucker (425 and 432 mm TL at time of stocking) stocked almost 160 RM upstream will move downstream fairly quickly and into Lake Powell. The other individual collected at the San Juan River-Lake Powell interface was a fish originally stocked at Piute Farms (RM 0.0) by the UDWR on 15 August 1995. This recapture at RM 0.5 represents the second documented movement of fish stocked at Piute Farms moving upstream (albeit barely) into the San Juan River. The first, a razorback sucker stocked at RM 0.0 on 8 August 1995, was recaptured at RM 58.0 on 21 May 1996 (Ryden 2000a). The collections of two ripe male razorback sucker and one gravid female (freely expressing eggs) at RM 100.2 on 16 April 1999 represents the second time in three years that aggregations of ripe adult razorback sucker have been collected at this exact same site near Aneth, UT (Table 6).

Table 8. Total longitudinal movement, maximum displacement, and final displacement of radio-tagged razorback sucker stocked into the San Juan River as part of the experimental stocking study between 1994 and 1997 and tracked as late as 19 March 1999.

Radio Tag Number	Release RM	Sex	Number of[a] Contacts	Number of Days Contact with Fish was Maintained	Total[b] Longitudinal Movement (RM)	Maximum[c] Displacement in RM	Final[d] Displacement in RM
800	158.6	I	13	727	25.4	25.4(-)	25.4(-)
127	117.5	I	3	1582	2.8	2.8(+)	2.8(+)
Mean (for 2 fish)					14.1	14.1	14.1
Standard Deviation					16.0	16.0	16.0
Standard Error					11.3	11.3	11.3

[a] Includes stocking date as one of the contacts

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

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

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

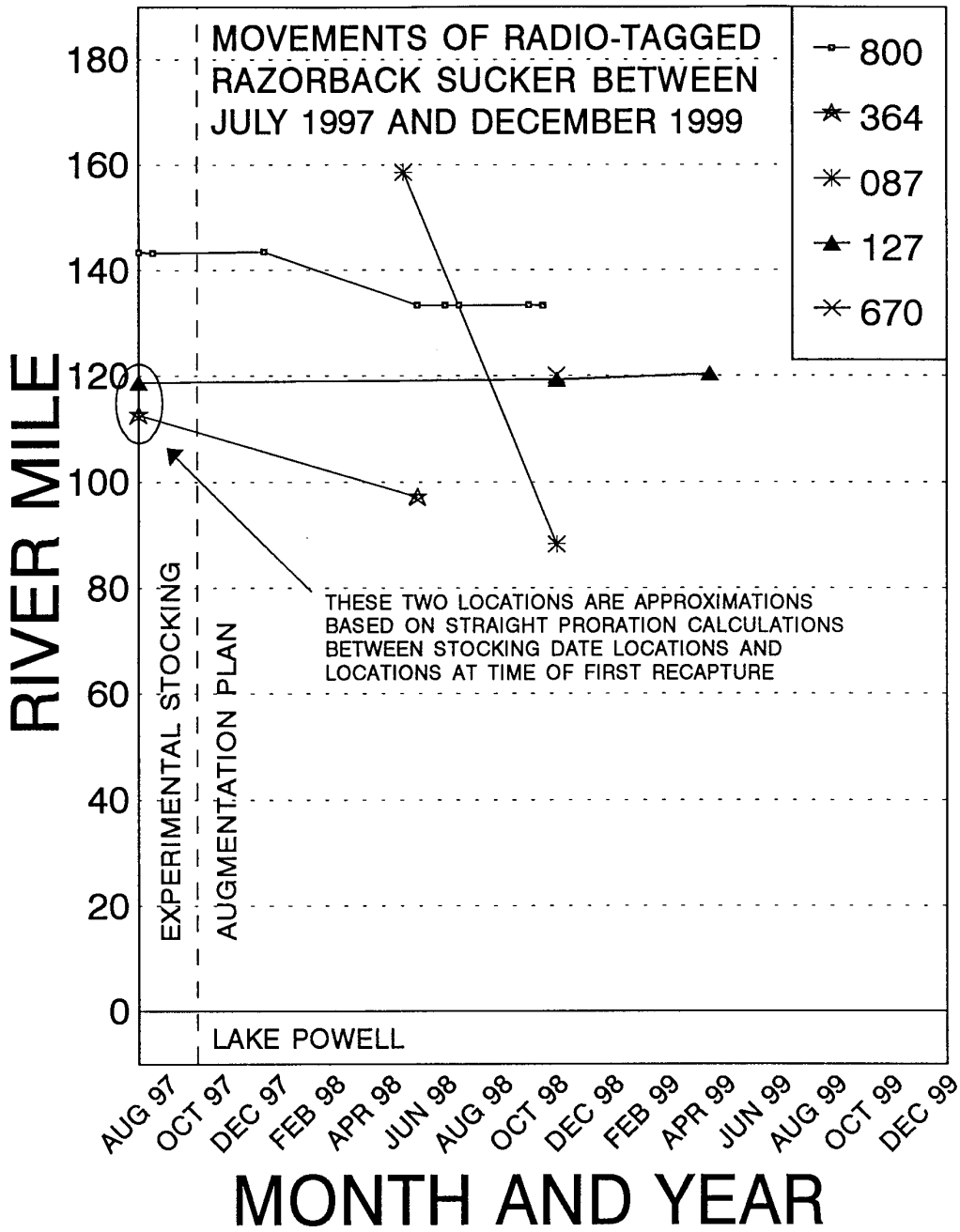

Figure 3. Movements of two radio-tagged razorback sucker (#'s 127 and 800) and three PIT-tagged razorback sucker that were implanted with radio tags after being recaptured, but never contacted after their implantation and release date (#'s 087, 364, and 670), between July 1997 and December 1999.

Seven razorback sucker stocked as part of the experimental stocking study were recaptured for either the second (n = 5) or third (n = 2) time post-stocking during the 1997-1999 time period. Movements of these seven fish consisted of a large initial downstream displacement following stocking, the fish then maintaining its relative position in the river, after which six of the seven moved upstream (Figure 4). Two of these fish, stocked at separate stocking sites in the fall of 1994, were recaptured in a suspected spawning aggregation at RM 100.2 on 16 April 1999 (Figure 4). Movement figures (TLM, MD, and FD) calculated for these seven PIT-tagged recaptures are intermediate to those presented for four groups of radiotelemetered razorback sucker during the experimental stocking study, with values being higher than two of those groups but lower than the other two (Table 9; Ryden 2000a).

DISCUSSION

Habitat Use, Needs, Selection, And Richness

Habitat use data was very sparse for the fall 1997-December 1999 period. Two of the three habitat observations with tag # 800 matched fairly well with data collected on radiotelemetered razorback sucker during the experimental stocking study, the other was somewhat contradictory. The first habitat contact on 20 November 1997 matched quite well with previous data. Tag # 800 selected for fast water habitat types 100.0% of the time, as did four fish during the experimental stocking study (Ryden 2000a), although the habitat types were different from one another (chute and shore run vs. main channel run). The habitat richness value at the November 1997 contact location was nine for tag # 800 vs. a mean of eight for the four fish during the experimental stocking study (Ryden 2000a).

The second habitat contact on 25 June 1998 did not match up with previous results nearly as well. Tag # 800 selected for a fast water habitat type (riffle) 72.9% of the time vs. a 26.0% selection of fast water habitats for 10 fish during the experimental stocking study (Ryden 2000a). Likewise tag # 800 selected for a slow water habitat type (sand shoal) 27.1% of the time vs. a 74.0% selection of slow water habitats for the ten fish from the experimental stocking study (Ryden 2000a). Neither of the individual habitat types selected by tag # 800 had ever been selected by any of the ten fish tracked in June during the experimental stocking study (Ryden 2000a). The other difference of note was the fact that in all previous June habitat observations, flooded vegetation had been heavily selected for by all 10 fish (Ryden 2000a). Tag # 800 had no flooded vegetation available to it, so used and therefore selected none. The habitat richness value at the June 1998 contact location was five for tag # 800 which was fairly comparable to the mean of six for the ten fish during the experimental stocking study (Ryden 2000a). The large differences between tag # 800's habitat selection and that of fish from the experimental stocking study may be explainable based upon the time of month in which the contacts were made. Most of the contacts with the ten fish from the experimental stocking study were made in early to mid-June, whereas the contact with tag # 800 was made on the 25th, after the flows had dropped considerably toward summer base-flows. This may have accounted for the differences observed in habitats selected.

The third habitat contact on 2 September 1998 matched almost perfectly with previous data. Tag # 800 selected for a fast water habitat type (main channel run) 100.0% of the time, as did three fish in October and four fish in November during the experimental stocking study (no September contacts were

Table 9. Total longitudinal movement, maximum displacement, and final displacement of PIT-tagged razorback sucker stocked into the San Juan River as part of the experimental stocking study between 1994 and 1997 and recaptured two or more times as of 31 December 1999.

PIT Tag Number	Release RM	Sex	Number of[a] Contacts	Number of Days Contact with Fish was Maintained	Total[b] Longitudinal Movement (RM)	Maximum[c] Displacement in RM	Final[d] Displacement in RM
1F43550544	158.6	F	3	1266	60.0	60.0(-)	60.0(-)
1F40464E0D	158.6	M	4	1610	62.8	62.8(-)	58.4(-)
1F404E666D	158.6	F	3	1610	56.1	56.1(-)	50.6(-)
1F40496870	136.6	M	4	1611	43.6	43.6(-)	41.6(-)
1F7441614B	117.5	F	3	1412	6.0	4.5(+)	4.5(+)
1F43670136	117.5	F	3	1413	18.2	16.5(-)	1.7(+)
1F435D1C25	117.5	M	3	1610	35.5	17.3(-)	17.3(-)
Mean (for 7 fish)					40.3	37.3	33.4
Standard Deviation					21.8	24.0	25.1
Standard Error					8.2	9.1	9.5

[a] Includes stocking date as one of the contacts

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

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

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

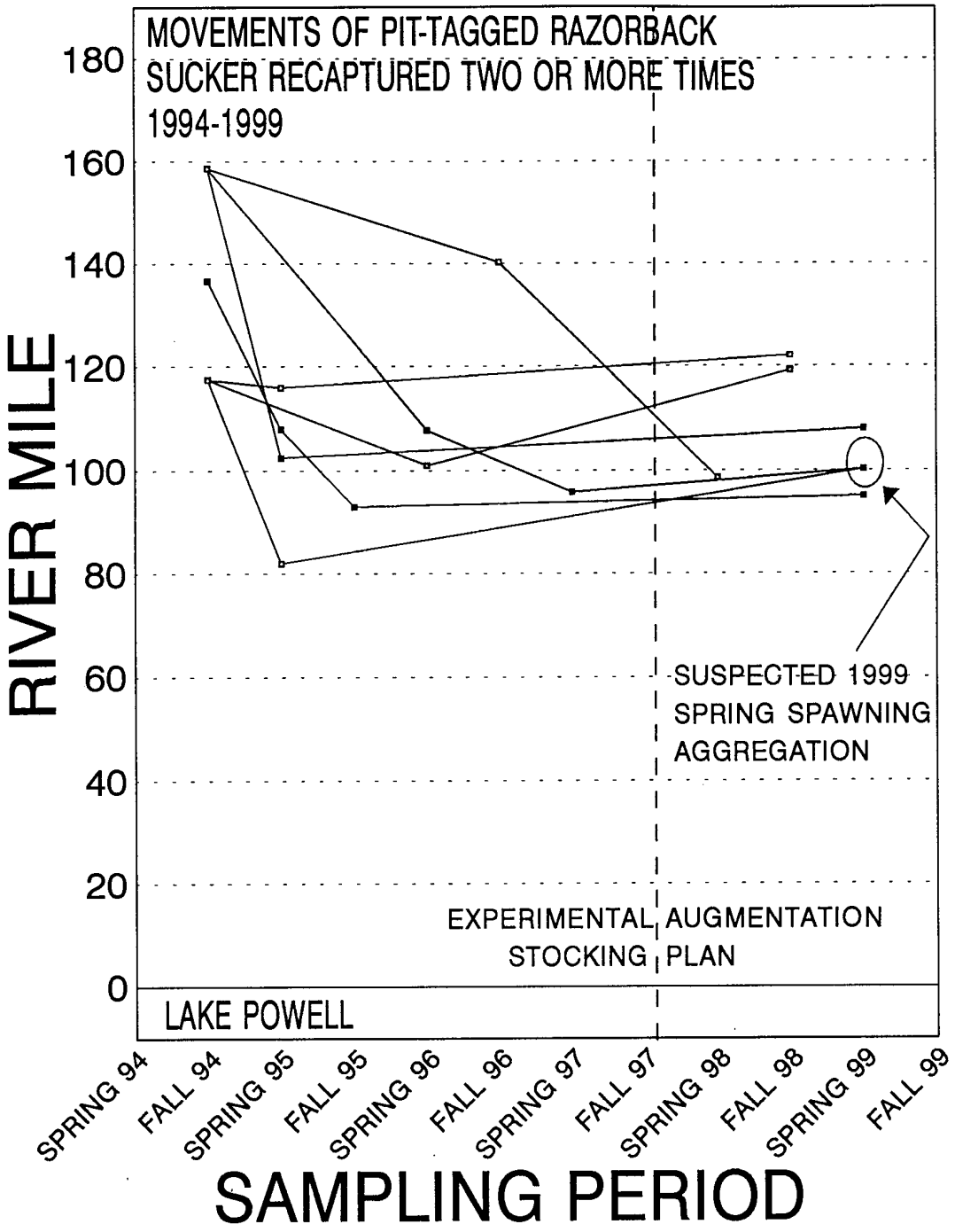

Figure 4. Movements of seven PIT-tagged razorback sucker recaptured two or more times since their stocking date, 1994-1999.

made during that study; Ryden 2000a). Five fish tracked in August during the experimental stocking study selected for both main channel runs and sand/shoal runs, thus selecting fast water habitat types 100.0% of the time as well (Ryden 2000a). The habitat richness value at the September 1998 contact location was four for tag # 800 vs. a mean of five for five fish contacted in August and a mean of four for three fish contacted in October during the experimental stocking study (Ryden 2000a).

Site Preference

Data for specific preferred sites in the San Juan River is still very sparse. Razorback sucker were collected at two of three suspected preferred sites (RM 100.2 and RM 77.5-77.3) between October 1997 and December 1999. However, no razorback sucker were recaptured during this time period at the third suspected preferred site (RM 38.6) identified in the experimental stocking study. Numbers of fish collected, even at these three are still very low and until more razorback sucker are stocked in the San Juan River and monitored, it will be very difficult to identify specific preferred sites.

However, there is a 50-RM section of the San Juan River (RM 130.0-80.0) in which more razorback sucker have been recaptured than elsewhere. It is possible that this area of the river provides more recaptures simply because this is the area where fish stop displacing downstream after stocking and have no reason to move if all of their life history requirements are being met there. However, it is intriguing that such a high percentage of recaptures is centered around the area of Aneth, UT, where the suspected spawning area is located. The only two perennial tributaries in the San Juan River downstream of Hogback Diversion, The Mancos River (RM 122.6) and McElmo Creek (RM 100.5) also enter the river in this 50-RM section.

Movement Patterns

As was seen with razorback sucker stocked as part of the experimental stocking study, most razorback sucker (17 of 18) stocked as part of the augmentation effort moved downstream after stocking, two as far as Lake Powell. It is interesting though that the only two rare fishes documented to have moved upstream past Hogback Diversion (RM 158.6) since 1991 were both small stocked fish: the 193 mm TL razorback sucker originally stocked at RM 158.6 (Table 6) and a 183 mm TL Colorado pikeminnow, probably originally stocked at Shiprock bridge (RM 147.9, date unknown) and recaptured on 31 August 1998 at RM 162.3 (Ryden 2001 In Prep.). Like the razorback sucker, it is assumed that Hogback Diversion had likely been destroyed by river flows at the time of the stocked Colorado pikeminnow's upstream passage.

The continued movement of razorback sucker into Lake Powell after stocking from as far upstream as Hogback Diversion (RM 158.6) is somewhat disconcerting. The two fish collected at Piute Farms (RM 0.0) were both large, adult fish (425 and 432 mm TL) at the time they were stocked (Table 6). Additionally both had grown (42 and 27 mm TL, respectively) between the time they were stocked and the time of their recapture, indicating feeding and good health (Table 6). It seems that despite stocking razorback sucker as far upstream in their designated Critical Habitat as possible and trying to stock larger fish (> 350 mm TL) whenever possible, the movement of a certain number of individuals downstream into Lake Powell is inevitable. However, as long as the waterfall that was present at RM 0.0 between the late 1980's and 1995

remains inundated and a population of razorback sucker remains in the San Juan River, there is both opportunity and motivation for these fish to move back upstream into the river.

The documented movement of three ripe adult fish to RM 100.2 in both 1997 and 1999 strongly suggests spawning at this site. This site is discussed in more detail in Chapter 3.

The majority of both radio- and PIT-tagged razorback sucker used to determine movement patterns (Figures 3 and 4) demonstrated largely downstream movements. Values for MD and FD indicated locations downstream of the stocking site (values with a - sign) for MD in seven of nine fish and for FD in six of nine fish (Tables 8 and 9). However, while most values represented downstream movements, MD values (with + sign) for two of nine fish and FD values (with + sign) for three of nine fish show that although downstream displacements following stocking seem to be inevitable, given time, at least some razorback sucker will move back upstream and colonize areas upstream of their stocking sites, and a few razorback sucker move upstream of these sites immediately and remain there (Tables 8 and 9, Figures 3 and 4). In addition, many stocked razorback sucker, despite initial downstream displacements, manage to remain within the river downstream of their original stocking sites and display localized upstream movements.

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 mainly from recaptured fish, but also from radiotelemetered fish that could be confirmed as being alive and moving at time of last contact. 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 five razorback sucker either stocked with a radio tag already implanted (Tag # 800) or implanted with a radio tag after being recaptured (Tag #'s 087, 127, 364, and 670), only two (tag #'s 127 and 800) were contacted after radio tag implantation and release (Figure 3). Although tag # 800 had moved downstream from its stocking site to the area of RM 133.3, it continued to make numerous localized movements during radio contacts and was therefore known to be alive at the time of last contact (30 September 1998; Figure 3). Tag # 127, although only contacted once after its release, was contacted upstream of its release site and was therefore assumed to be alive at the time of its last contact (19 March 1999; Figure 3).

The other three razorback sucker were never contacted after being implanted with radio tags and released.

PIT-Tagged Razorback Sucker

A total of 41 razorback sucker were recaptured between October 1997 and December 1999 (Table 6). Eighteen of these had been stocked as part of the augmentation effort (1997-1999) and had been in the river between 26 and 744 days at the time of their recapture (Table 6). These fish were all first-time recaptures. Another 16 were razorback sucker that had been stocked as part of the experimental stocking study (1994-1997) and had been in the river between 922 and 1,611 days at the time of their recapture (Table 6). These 16 fish included nine first-time recaptures, five fish that were recaptured for the second time since stocking (including the individual tagged with radio tag #

127), and three fish that were recaptured for the third time since stocking. One fish that had been stocked into Lake Powell by the UDWR in 1995 was also recaptured. It had been in the river for 1512 days at the time of its recapture (Table 6). The amount of time in the river for the six unknown-origin fish could not be determined.

Combined

Thirty-five individual razorback sucker of known-origin (those for which a PIT tag number was obtained) were collected between 29 September and 20 October 1999. Of these, 14 were collected during razorback sucker monitoring (electrofishing) trips (4 in 1998 and 10 in 1999), 16 during main channel adult fish community monitoring (electrofishing) trips (4 in 1997, 7 in 1998, and 5 in 1999), four during lake Powell rare fish surveys (trammel-netting) in 1999, and one during a rare fish population goal (electrofishing) trip in 1999. Seasonal breakdowns of these 35 collections show that 10 were recaptured in April (all by electrofishing), four in May (all by electrofishing), one in August (trammel net), one in September (electrofishing), and 19 in October (16 by electrofishing, and 3 by trammel net).

Five of the six unknown-origin recaptures (no PIT tag number obtained) were collected by electrofishing (1 in April and 4 in October), and the other by seine (in October). Three of these unknown-origin fish were collected on a rare fish population goal trip in October 1999, one during a razorback sucker monitoring trip in April 1999, one during an main channel adult fish community trip in October 1998 and one during a trip to monitor stocked Colorado pikeminnow in October 1997 (Table 6).

As of 31 December 1999, at least 18 (0.4%) of the 4164 razorback sucker stocked as part of the augmentation plan have been recaptured (Table 3). In addition, between 1994 and December 1999, 63 (6.7%) of the 939 razorback sucker stocked as part of the experimental stocking study have been recaptured (Table 2). These numbers may both be higher if the razorback sucker for which no PIT tag numbers were obtained were different individuals from the other recaptures. Four of the 35 recaptures of known-origin fish occurred in 1997, 11 in 1998, and 20 in 1997 (Table 6). Of these 35 fish, 15 had originally been stocked in 1994, 1 in 1995, 1 in 1996, 8 in 1997, and 10 in 1998. Stocking sites determined for these 35 known-origin fish show that 25 were originally stocked at RM 158.6, 1 at RM 136.6, 3 at RM 117.5, 5 at RM 79.6, and 1 at RM 0.0 (Table 6).

Twenty-five (71.4%) of the 35 known-origin recaptures (including the fish stocked in Lake Powell in 1995) came from groups of stocked fish that had a mean TL of 400 mm or greater at the time of stocking (Tables 2, 3, and 6). These 25 fish had a mean TL of 409.5 mm (range = 370-445 mm TL) at the time of stocking. With the exception of the very first stocking of razorback sucker in March 1994 n = 15 fish), recapture rates from stockings that had a mean TL of 400 mm or greater at time of stocking, were considerably higher than those for stockings in which the fish were smaller at time of stocking (Table 10).

The ten remaining known-origin fish (28.6% of the 35 known-origin recaptures) came from groups of stocked fish that had a mean TL of less than 400 mm at the time of stocking (Tables 2, 3, and 6). These ten fish had a mean TL of 236.8 mm (range = 193-337 mm TL) at the time of stocking. Seven (70.0%) of these ten fish were larger than the mean TL of the group of fish in which they were stocked. The three exceptions all had TL’s equal to the mean TL of the groups of fish in which they were stocked.

Table 10. Numbers and sizes of razorback sucker stocked into the San Juan River between 1994 and 1999 and recaptured, by year, as of 31 December 1999. Note: This table is for first-time recaptures only!

Date Stocked	Number Stocked	Mean TL at Stocking (in mm)	Number of recaptures						Percent Recaptured
			1994	1995	1996	1997	1998	1999	
03/30/94	15	277	0	0	0	1	0	0	6.7%
10/27/94	16	403	0	2	0	0	0	0	12.5%
11/17/94	478	190	0	3	1	0	0	0	0.8%
11/18/94	177	400	0	22	11	8	3	5	27.7%
09/27/95	16	424		0	3	0	0	0	18.8%
10/03/96	237	335			2	1	0	1	1.7%
09/03/97	1027	193				4	1	0	0.5%
09/17/97	227	229				0	0	1	0.4%
09/19/97	1631	185				0	2	0	0.1%
04/22/98	57	420					2	3	8.8%
05/28/98	67	417					0	4	6.0%
10/15/98	1155	232					0	1	<0.1%
Totals	5103		0	27	17	14	8	15	1.6%

Table 11. Numbers, by size class at time of stocking, of razorback sucker stocked into the San Juan River between 1994 and 1999 and recaptured as of 31 December 1999. Note: This table is for first-time recaptures only!

Total Length In Milli-meters	Of 5103 Stocked Fish		Of 80 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
< 51	0.0%	0	0.0%	0
51-100	<0.1%	1	0.0%	0
101-150	6.6%	339	0.0%	0
151-200	43.2%	2205	3.7%	3
201-250	35.9%	1834	8.6%	7
251-300	2.8%	144	1.2%	1
301-350	3.1%	157	4.9%	4
351-400	3.8%	195	28.4%	23
401-450	4.3%	219	53.2%	43
>450	0.2%	9	0.0%	0
Totals	100.0%	5103	100.0%	81

Razorback sucker stocked at 350 mm TL (or larger) had a much higher recapture rate than did smaller size class razorback sucker (Table 11). Razorback sucker larger than 350 mm TL at time of stocking (8.3% of the 5103 total stocked fish; n = 423 fish) accounted for 66 (81.6%) of the 80 known-origin, first-time recaptures between 1994 and 1999 (Table 11). Taken a step further, razorback sucker that were larger than 400 mm TL at time of stocking (4.5% of the 5103 total stocked fish; n = 228 fish) accounted for 43 (53.2%) of the 80 known-origin, first-time recaptures between 1994 and 1999.

Of the 35 known-origin recaptured razorback sucker, 16 (45.7%; including the Lake Powell fish) are 1992 progeny of a single paired mating (lot 2A) between San Juan River arm of Lake Powell (SJRALP) adults. Fish from this paired mating composed 33.1% of all razorback sucker stocked in the San Juan River between 1994 and 1996. However, no fish from this paired mating have been stocked since 1996 and the progeny of that paired mating now compose only 6.1% of the total of 5103 razorback sucker stocked between 1994 and 1999. Of the other 19 known-origin recaptures, nine were progeny of Green River adults (parents unknown) six were progeny of Lake Mohave adults (parents unknown), two were progeny of crosses between Colorado River and “Etter Pond” adults (parents known), one was progeny of a different paired mating between SJRALP adults (lot 2B; parents known), and one was progeny of a paired mating between adults from the Green and Yampa rivers (adults known; Tables 1 and 6; Ryden 2000a).

Using current numbers of fish stocked and the survival estimate curves presented in the five-year augmentation plan (Ryden 1997), it is estimated that of 4164 razorback sucker stocked as part of the augmentation effort, only 990 remain in the San Juan River as of 31 December 1999 (Table 12). This represents a shortfall 14,910 fish from the projected goal of 15,900 razorback sucker between RM 158.6 and 0.0 (Table 12; Ryden 1997). Though not part of the projected numbers for the augmentation plan, it is estimated that another 120 razorback sucker stocked as part of the experimental stocking study also survive in the San Juan River as of 31 December 1999 (Table 12).

Growth

Measurements of recaptured razorback sucker indicate that for up to 400 days after stocking, most fish lost weight (Figure 5). However, the percent of body weight lost by stocked fish was relatively small (Figure 6). Weight gain observed in recaptured fish after 400 days was highly variable (Figure 5), but the trend was positive (Figures 5 and 6). It was not until approximately 800 days post-stocking that recaptured razorback sucker showed large gains (> 25% of body weight at stocking) in weight (Figure 6).

Like weight, increases in TL among stocked razorback sucker were highly variable (Figure 5). Growth (increases in TL) comparisons between 10 mm TL size classes of razorback sucker showed highly variable growth among size groups with no clear patterns as fish increased in size (Table 13). However, a power regression on all recaptured fish for which lengths were taken between 1994 and 1999 (n = 94, including second- and third-time recaptures), shows a steadily increasing trend over time that is not apparent from looking at the numbers for 10 mm TL size classes alone (Figures 5 and 6).

While much less numerous (n = 16 recapture events), recaptured razorback sucker that were originally stocked at smaller sizes (< 351 mm TL) increased in TL almost twice as fast (mean of 0.09 mm TL growth per day in the river) as did recaptured fish originally stocked at larger sizes (> 350 mm TL; n = 78; mean of 0.05 mm TL growth per day in the river; Table 13). For the first time, a difference in growth rates (i.e., increase in TL) could be discerned

Table 12. Number of stocked razorback sucker projected to have survived in subsequent years, post-stocking. These numbers are based on the survivorship estimate curves used in the five-year augmentation plan (Ryden 1997). Parenthetic numbers represent the estimated survival rate from the previous year.

Stocking Year	Number Of Fish	Survival In Year... 1 (1994)	2 (1995)	3 (1996)	4 (1997)	5 (1998)	6 (1999)	7 (2000)	8 (2001)
Experimental Stockings (1994-1996)--FYI ONLY! Not Included In Augmentation Plan Projected Numbers:									
1994	686	343(.5)	206(.6)	144(.7)	115(.8)	92(.8)	78(.85)	70(.9)	63(.9)
1995	16	----	8(.5)	5(.6)	4(.7)	3(.8)	2(.8)	2(.85)	2(.9)
1996	237	----	----	119(.5)	71(.6)	50(.7)	40(.8)	32(.8)	27(.85)
Total	939	343	214	268	190	145	120	104	92
Numbers Actually Stocked For Augmentation Plan (1997-present):									
1997	2,885	----	----	----	1,443(.5)	866(.6)	606(.7)	485(.8)	388(.8)
1998	1,279	----	----	----	----	640(.5)	384(.6)	269(.7)	215(.8)
1999	0	----	----	----	----	----	----	----	----
2000	NO FISH STOCKED YET								
2001	NO FISH STOCKED YET								
Total	4,164	----	----	----	1,443	1,506	990	----	----
Numbers Projected To Be Stocked In 1997 Augmentation Plan:									
1997	31,800	----	----	----	15,900(.5)	9,540(.6)	6,678(.7)	5,342(.8)	4,274(.8)
1998	12,720	----	----	----	----	6,360(.5)	3,816(.6)	2,671(.7)	2,137(.8)
1999	10,812	----	----	----	----	----	5,406(.5)	3,244(.6)	2,271(.7)
2000	9,286	----	----	----	----	----	----	4,643(.5)	2,786(.6)
2001	8,864	----	----	----	----	----	----	----	4,432(.5)
Total	73,482				15,900	15,900	15,900	15,900	15,900
Projected Shortfall		----	----	----	14,457	14,394	14,910	None Yet	None Yet

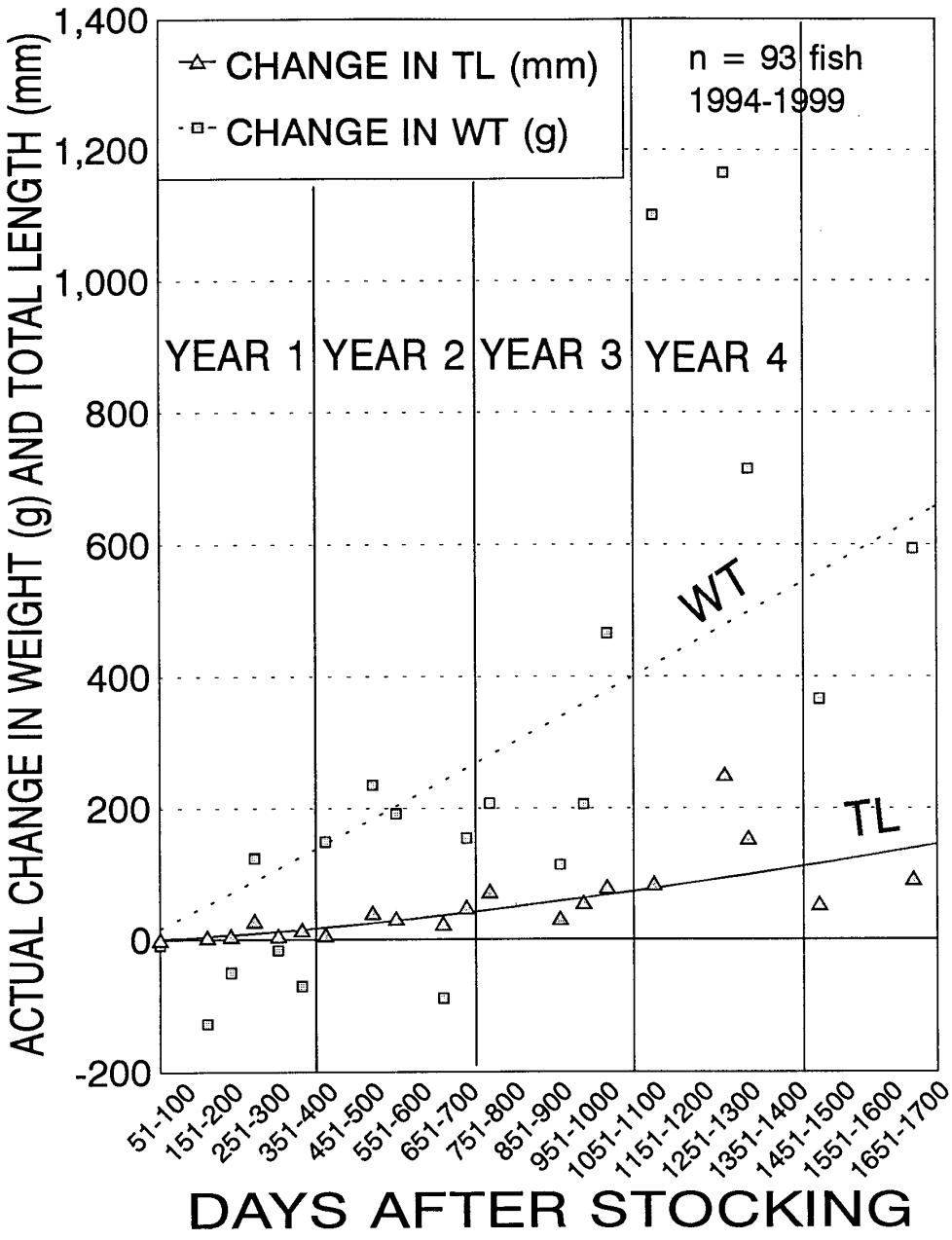

Figure 5. Growth over time of stocked razorback sucker recaptured between 1994 and 1999. Squares and triangles represent the average of actual changes in total length (TL) and weight (WT) of all razorback sucker recaptured in a given 50-day time period after stocking. The solid sloping line represents the power regression for change over time in TL values, while the dashed sloping line represents the power regression for change over time in WT values. Solid vertical lines divide days after stocking into one-year intervals.

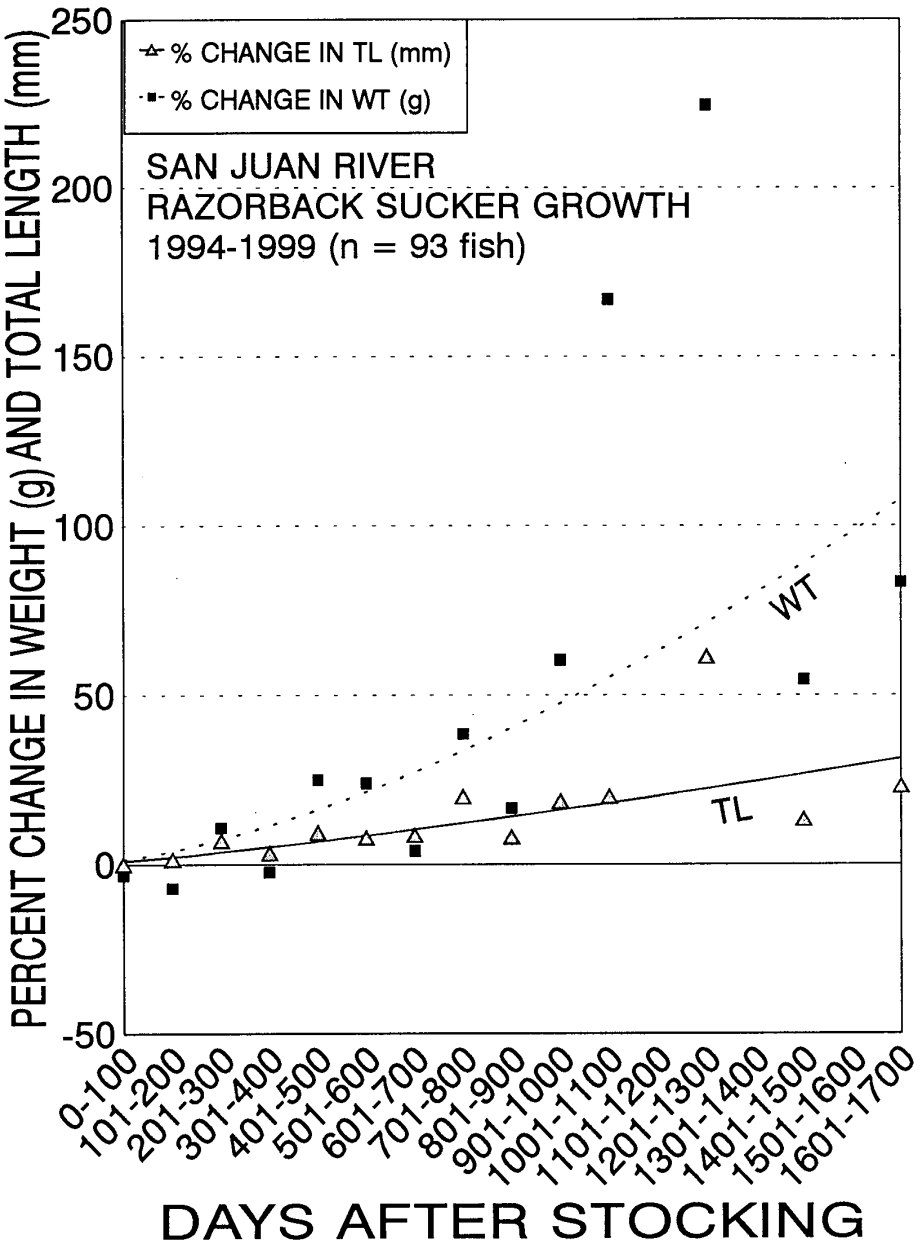

Figure 6. Percent change in total length (TL) and weight (WT) observed in razorback sucker recaptured between 1994 and 1999. Squares and triangles represent the average of percent changes in TL and WT of all razorback sucker recaptured in a given 100-day time period after stocking. The solid sloping line represents the power regression for change over time in TL values, while the dashed sloping line represents the power regression for change over time in WT values.

Table 13. Growth of razorback sucker, in millimeters per day (mm/day), observed during 94 recapture events, including multiple recaptures, 1994-1999.

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	0.10	5
221-230	0.12	2
231-240	0.02	3
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	0.07	1
331-340	0.05	1
341-350	0.04	2
351-360	0.08	1
361-370	0.04	3
371-380	0.03	2
381-390	0.03	8
391-400	0.05	11
401-410	0.05	21
411-420	0.05	15
421-430	0.04	11
431-440	0.08	2
441-450	0.07	4
>450	No Data	No Data
Small Versus Large Fish:		
<351 mm TL (range = 193-348)	0.09	16
>350 mm TL (range = 356-445)	0.05	78
Females Versus Males:		
Known Females (range = 229-442 mm TL)	0.07	19
Known Males (range = 251-445 mm TL)	0.03	40

between recaptured razorback sucker known to be females (0.07 mm TL growth per day in the river; n = 19 recapture events; TL at stocking = 229-442 mm) and recaptured razorback sucker known to be males (0.03 mm TL growth per day in the river; n = 40 recapture events; TL at stocking = 251-445 mm; Table 13).

DISCUSSION

Survival

Due to the small number of contacts, two radio-tagged razorback sucker tracked between October 1997 and December 1999 yielded little new data on habitat use or movement patterns, but both fish were known to be alive as of the last contact. The fate of three additional razorback sucker that were implanted with radio tags but never contacted after release is unknown. It is possible that these three fish were mortalities. However, the subsequent recaptures of several razorback sucker that were implanted with radio tags, never contacted after release, then later recaptured alive argues against labeling these fish as mortalities without knowing for sure (Ryden 2000a). For the present, these fish are assumed to have been implanted with radio tags that failed. The assumed failure of three implanted radio tags implanted in razorback sucker is discouraging, but certainly not unheard of.

Overall, survival of razorback sucker stocked into the San Juan River between 1994 and 1999 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 environment without being allowed to recover first, was also possibly a major factor in the failure of these stocked fish to survive. 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 a 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 main channel 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 well as getting them in the river at an age where they are likely to spawn soon after stocking.

However, despite the comparative success of razorback sucker stocked into the San Juan River versus other rivers, the fish stocked as part of the augmentation effort, though more than four times as numerous than those stocked during the experimental stocking study are being recaptured in smaller numbers than their predecessors. The likely reason for this is their relative size at time of stocking. Over six years of sampling, razorback sucker stocked at smaller sizes (< 351 mm TL) are not recaptured nearly as frequently as razorback sucker stocked at larger sizes (> 350 mm TL). 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 main channel 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 2000b). In addition, intensive seining efforts between 1994 and 1999 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 very few small size-class razorback sucker. Since razorback sucker smaller than 351 mm TL (n = 4680 fish) comprised the large majority (91.7%) of all fish stocked (n = 5103), it seems that, even given the difficulties in sampling this size-class of fish, they should have accounted for more than ten (28.6%) of the 35 known-origin recaptures between October 1997 and December 1999.

It is recommended that the SJRIP make as much of an effort as is possible to hold razorback sucker in grow-out ponds until they reach at least 350 mm TL, or more preferably 400 mm TL. Although the ultimate goal of the SJRIP is to establish self-sustaining populations of razorback sucker in the San Juan River, the immediate goal of the augmentation effort is to get a population of 15,900 adult fish into the river. It is felt that this can best be achieved by stocking larger size class fish.

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. However, this slow down in growth rate was not consistent over 10 mm TL size classes observed in our monitoring. In fact, the largest size class razorback

sucker for which growth could be determined (i.e., 431-44 mm TL and 441-450 mm TL) during our monitoring had growth rates that matched those of fish in the 321-330 mm TL and 351-360 mm TL ranges, but were still only about half of those seen in the 251-260 mm TL size class (Table 13). The likely explanation for the inconsistent values shown by some 10 mm TL size class breakdowns (Table 13) is that sample sizes for almost all size class breakdowns are very small (n = 1 for 321-330 mm TL, n = 1 for 351-360 mm TL, n = 2 for 431-440 mm TL, n = 4 for 441-450 mm TL) and thus the amount of variability between individuals in a given 10 mm size class in the river is probably not being truly reflected by the small sample size in our data set. Larger sample sizes (i.e., a minimum of 20-30 fish per 10 mm TL size class) will be needed to get a sample representative of growth in all razorback sucker in the river in a given 10 mm TL size class. In many size classes, no fish stocked in that range have been recaptured (Table 13). Only one size class in Table 13, the 401-410 mm size class, probably has enough fish sampled (n = 21 fish) to allow for a definitive growth (mm/day in river) value to be assigned to it. However, by pooling data as to small (< 351 mm TL, n = 19) versus large (> 350 mm TL, n = 78) fish it can be seen that indeed razorback sucker do grow faster at smaller sizes (Table 13). Growth curve values should become more apparent as more fish in each size class are collected in future years.

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

< Objective 3: Determine whether hatchery-reared razorback sucker will recruit into the adult population and successfully spawn in the wild

METHODS

Recaptured razorback sucker were examined to determine reproductive status and age (via PIT tag number). Those fish that were actively expressing gametes (i.e., male = 'ripe,' female = 'gravid') or had visible tuberculation present were considered to be mature, sexually active fish. Aggregations of three or more ripe adult razorback sucker during the spawning season were considered to be possible spawning aggregations, especially if both ripe male and gravid female razorback sucker were present or if a particular site was found to have aggregations of ripe/gravid adult fish in more than one year.

RESULTS

Of the 41 recapture events (including second- and third-time recaptures, unknown origin fish {no PIT tag read}, and the fish that was stocked in Lake Powell and recaptured in the San Juan River) between October 1997 and December 1999, 11 were males, 9 were females, and 21 were of indeterminate sex (Table 6). Of the 35 known-origin fish, 10 were males, 9 were females, and 16 were of indeterminate sex (Table 6). Of the nine identified females (357-565 mm TL at time of recapture), only two were obviously gravid (i.e., freely expressing eggs). Both of these gravid females were collected on 16 April 1999, one at RM 108.0 (548 mm TL), and one at RM 100.2 (565 mm TL; Table 6). None of the other seven female razorback sucker (357-527 mm TL), collected between 13 April and 3 October showed any signs of being gravid. Of the 11 known males (423-509 mm TL, including one unknown-origin fish), seven were tuberculate (431-509 mm TL), six of which were ripe (431-509 mm TL). These six ripe males were all collected between 13 and 17 April 1999, from RM 140.0-86.3 (Table 6). The one tuberculate male that was not ripe (452 mm TL) was collected on 2 October (Table 6). The other four identified males (423-490 mm TL) that were neither tuberculate or ripe were collected 2 and 5 October (Table 6).

1997

On 3 May 1997, a probable spawning aggregation of razorback sucker was identified at RM 100.2 (Ryden 2000a). This aggregation consisted of three ripe males (412-456 mm TL) that were collected in a single dip net and three additional razorback sucker that were observed but not collected all within a ten-foot-square area, in less than three feet of water, within ten feet of the river right shoreline, over a shoreline cobble shoal/run. A fourth ripe, male razorback sucker (397 mm TL) was also collected three-tenths of a mile upstream of this aggregation, also on river right a few meters downstream of the McElmo Creek confluence at RM 100.5 (Ryden 2000a). 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 (Figure 7; Ryden 2000a). A PIT tag number was not determined for one fish collected at RM 100.2, as the PIT tag reader quit working. 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 (Figure 7; Ryden 2000a). 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 (Figure 7; Ryden 2000a). The three ripe males collected at RM 100.2 were collected in a large group of ripe adult, presumably spawning, flannelmouth sucker (Ryden 2000a). 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 (Ryden 2000a).

1998

No ripe male or female razorback sucker were collected during the May 1998 razorback sucker monitoring trip. Nor were any aggregations of two or more razorback sucker identified on this trip. However, 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 (S. Platania, pers. comm.). 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.; Figure 7). 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).” Flows at the Shiprock, NM gage during this general time frame in 1998 were 1,170 on 15 April 1998; 3,500 on 1 May; 5,190 on 15 May; and 7,370 on 31 May 1998 (Ryden 2000a).

1999

On the April 1999 razorback sucker monitoring trip a total of 11 razorback sucker were collected. Of these four were females (two of which were gravid) six were males (all ripe) and one was of indeterminate sex (Table 6). On 16 April 1999 two ripe male razorback sucker (438 and 509 mm TL) and one gravid female (565 mm TL) razorback sucker were collected at RM 100.2 within a few feet of where the three razorback sucker were collected on 3 May 1997 (Table 6). These three razorback sucker were collected in the midst of numerous ripe adult, presumably spawning, flannelmouth sucker, over an embedded cobble substrate (shoreline run habitat), approximately 5-10 feet from the river right bank in about 2-3 feet of water. These three fish, all stocked on 18 November 1994 had come from three different stocking sites (RM 158.6, 177.5, and 79.6; Figure 7). Flows at the Shiprock, NM USGS gage on 1 April 1999 were 1030 CFS; 1010 CFS on 16 April; 1940 on 1 May; and 2590 on 15 May 1999. As in May 1997, the increasing flows in the river during the

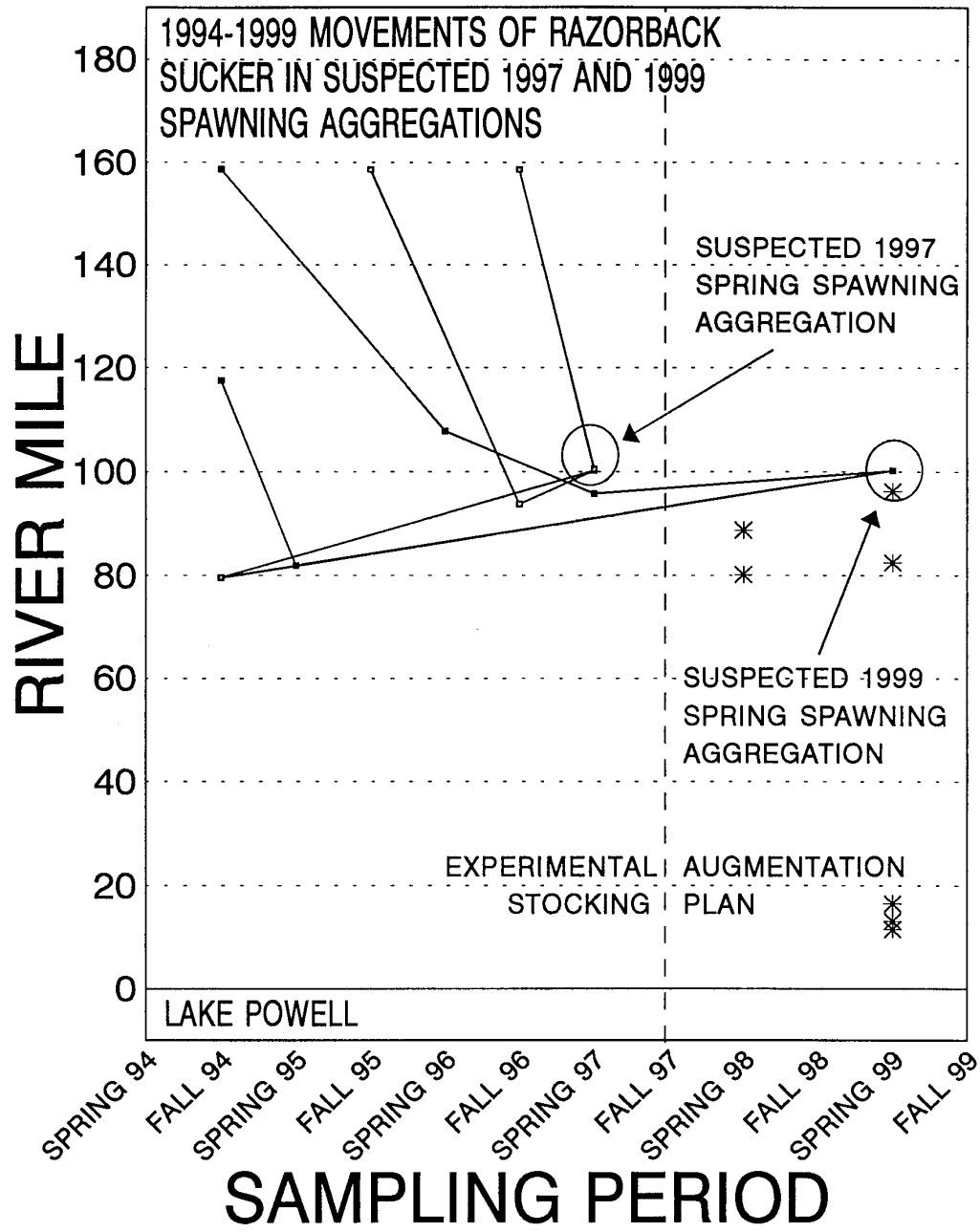

Figure 7. Evidence for suspected razorback sucker spawning activities in the San Juan River between 1997 and 1999. Solid lines represent the movements of ripe adult fish to RM 100.2 in 1997 and 1999, while asterisks represent the locations at which larval razorback sucker were collected in spring 1998 and 1999 (S. Platania pers. comm.).

general time frame in which these electrofishing collections were made, indicates 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).

In spring 1999, crews from UNM again intensively sampled (30 light-trap samples and 144 seine samples) throughout the San Juan River to try to document razorback sucker reproduction (S. Platania, pers. comm.). Between 4 May and 14 June 1999 they collected seven larval razorback sucker, with the most upstream collection being at RM 96.2 (12 May 1999) and the most downstream at RM 11.5 (14 June 1999; S. Platania, pers. comm.; Figure 7). These seven larvae ranged in size from 10.2-20.7 mm TL and in developmental stage from protolarvae to metalarvae (S. Platania, pers. comm.). Two larvae were collected in light traps on 12 May 1999, and the other five were collected via seine (S. Platania, pers. comm.). As was the case with larval razorback sucker collected in spring 1998, the seven larvae collected in spring 1999 were all collected downstream of the suspected spawning site at RM 100.2 (Figure 7).

DISCUSSION

Razorback sucker have successfully spawned in the wild in both 1998 and 1999, as is evidenced by Platania's collections of larval fish. A tentative spawning area has been identified at RM 100.2, just downstream of Aneth, Utah. Numerous pieces of evidence argue to this site being a razorback sucker spawning site. First, the collection of three ripe fish at this exact same location in both 1997 and again in 1999 points to a repeated use of this area by groups of razorback sucker over several years. The close proximity of the collected individuals, presence of other identified razorback sucker (seen but not collected), presence of large numbers of ripe adult flannelmouth sucker in both years, and collection of larval razorback sucker downstream of this site in both 1998 and 1999 strongly suggest spawning at this, and possibly other, sites in the river. The tendency of razorback sucker to aggregate with flannelmouth sucker while spawning has been documented in other UCRB rivers (e.g., Tyus and Karp 1990). This intermingling of spawning adults may lead to hybridization between these two species in the wild (e.g., Buth et al. 1987).

The collection of larval razorback sucker in May 1998 and April-June 1999 as well as the aggregations of presumably spawning razorback sucker at RM 100.2 in May 1997 and April 1999 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 96.2 are able to successfully move out of the larval drift and into low-velocity habitats before entering Lake Powell. The collection of aggregations of ripe adult or larval razorback sucker indicates that for the third consecutive year adult razorback sucker have aggregated and spawned on the ascending limb of the hydrograph.

FY-2000 FIELD ACTIVITIES

Field activities in 2000 will include two razorback sucker monitoring (electrofishing) trips, one in late April or early May and another in mid- to late July. In addition, four adult razorback sucker (3 females, 1 male) that were implanted with radio transmitters (tags) in October 1999 will be tracked from March through May to attempt to identify spawning behavior and habitats. Up to six adult razorback sucker (> 400 mm TL) collected on the October 2000 main channel adult fish community monitoring trip will also be implanted with radio tags for a second year of tracking during spawning season (i.e. spring 2001).

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