AUGMENTATION AND MONITORING OF THE SAN JUAN RIVER RAZORBACK SUCKER POPULATION:

2004 Interim Progress Report

(Final)

Submitted By:

Dale W. Ryden

1 August 2005

U.S. Fish and Wildlife Service
Colorado River Fishery Project
764 Horizon Drive, Building B
Grand Junction, Colorado 81506-3946

EXECUTIVE SUMMARY

In 2004, a total of 2,989 razorback sucker were stocked into the San Juan River. Stocked fish were monitored via raft-mounted electrofishing. Recaptured razorback sucker remained spatially separated during presumed spawning periods in 2004, with the exception of one ripe male and one ripe female that were collected within ten feet of one another at RM 154.27 on 26 April 2004. Collections of PIT-tagged fish recaptured for the second (or more) time since stocking in 2004 indicated that greater than 50% of the San Juan River razorback sucker population is currently residing within 10 RM's up- or downstream of the Hogback Diversion stocking site (i.e., RM 158.6-150.0). Apparently, the lack of high spring flows over the last several years has failed to disperse stocked fish into downstream river reaches as has been the case in past years following high spring flow events.

In 2004, a total of 62 razorback sucker were recaptured on the April 26-30, 2004 razorback sucker monitoring trip. Another 117 razorback sucker were recaptured during the fall 2004 ***Sub-Adult And Adult Large-Bodied Fish Community Monitoring*** trip (called Adult Monitoring for short). Razorback sucker CPUE increased markedly between the spring 2000 and spring 2004 razorback sucker monitoring trips, reaching a high of 1.54 fish per hour of electrofishing on the spring 2004 razorback sucker monitoring trip (from RM 158.6-76.4).

The majority of razorback sucker recaptured in 2004 were fish that had been in the river $\leq$ 1200 days post-stocking. This indicates that the longevity of razorback sucker in the San Juan River post-stocking is relatively short, probably around four years on average. Apparently, very few razorback sucker from the 1994-1996 stockings remain in the San Juan River.

A Petersen population estimate for razorback sucker recaptured in 2004 estimated that there were 936 razorback sucker from RM 158.6-76.4 in the spring of 2004. A Schnabel multiple-census estimate for these same RM's in the fall of 2004 estimated that there were 1,063 razorback sucker (95% C.I. = 594-2,166 fish) from RM 158.6-76.4. This estimate extrapolated to a "riverwide" (i.e., RM 158.6-2.9) value, estimates a total of 1,215 razorback sucker in the river in the fall of 2004.

Growth information obtained from recaptured razorback sucker indicated that fish stocked at < 351 mm TL grew almost twice as fast (0.11 mm per day) as did those stocked at > 350 mm TL (0.06 mm per day). Likewise, known female razorback sucker grew almost twice as fast (0.07 mm per day) as did known males (0.04 mm per day). The fastest average growth rates, post-stocking, occurred among razorback sucker that were stocked at 251-280 mm TL. Growth curves developed for razorback sucker show that between age-0 and age-4 razorback sucker stocked into the San Juan River grow rapidly, reaching a mean TL of 449 mm (range = 348-537 mm TL) by age-4. After age-4, the growth curve flattens considerably and gains in TL between years become much less dramatic.

A single suspected razorback sucker spawning aggregation was identified in 2004. This aggregation consisted of one ripe male (455 mm TL, 950g) and one ripe female (497 mm TL, 1390 g) collected at RM 154.27 on 26 April 2004. Both fish were freely expressing gametes when they were collected over a shallow cobble-gravel bar, amid numerous ripe, presumably spawning flannelmouth sucker. Both fish originally been stocked at the Hogback Diversion stocking site, but in different years, and the female fish was a year older than the male. This suspected spawning aggregation did not take place on the ascending limb of the spring hydrograph, but rather occurred during a trough between two distinct flow peaks on what was otherwise a relatively low-volume discharge spring hydrograph.

Crews from UNM collected larval razorback sucker again in 2004. Thus, it has been verified that stocked razorback sucker have successfully spawned in each of the last seven years (1998-2004). In 2004, a handful of wild-produced age-0 (n = 3) and age-1+ juvenile (n = 4) razorback sucker were collected by crews from BIO-WEST and the Utah Division of Wildlife Resources. The collection of age-1+ juvenile fish indicates that some small percentage of wild-produced larvae are surviving into subsequent years. Whether or not these fish will survive to recruit into adulthood remains to be seen.

TABLE OF CONTENTS

EXECUTIVE SUMMARY i
TABLE OF CONTENTS iii
LIST OF TABLES. iv
LIST OF FIGURES iv
LIST OF TABLES IN APPENDICES. v
INTRODUCTION. 1
Objectives. 3
Study Area. 3
CHAPTER 1: OBTAIN, REAR, HARVEST, AND STOCK RAZORBACK SUCKER. 4
METHODS 4
RESULTS 7
DISCUSSION. 7
CHAPTER 2: MONITORING OF STOCKED RAZORBACK SUCKER 9
METHODS 9
Field Sampling. 9
Electrofishing. 9
Data Analysis 10
Objective 2a: Spawning Season Habitat Use And Movement Patterns 10
Objective 2b: Survival And Growth Rates 11
Survival. 11
Growth. 12
Objective 2c: Determine Whether Hatchery-Reared Razorback Sucker Will Recruit Into The Adult Population And Successfully Spawn In The Wild. . . . 12
RESULTS 13
Objective 2a: Spawning Season Habitat Use And Movement Patterns 13
Objective 2b: Survival And Growth Rates 19
Survival. 19
Growth. 21
Objective 2c: Determine Whether Hatchery-Reared Razorback Sucker Will Recruit Into The Adult Population And Successfully Spawn In The Wild 28
2004 Spawning Aggregation 28
DISCUSSION. 30
Objective 2a: Spawning Season Habitat Use And Movement Patterns 30
Objective 2b: Survival And Growth Rates 30
Survival. 30
Growth. 32
Objective 2c: Determine Whether Hatchery-Reared Razorback Sucker Will Recruit Into The Adult Population And Successfully Spawn In The Wild 32
LITERATURE CITED. 34
APPENDIX A (Population Estimate Values) 37
APPENDIX B (A Map Of The Suspected Spawning Area At RM 154.27). 40

LIST OF TABLES

Table		Page
1	An overview of razorback sucker stocked into the SJRIP's grow-out ponds, 1999-2004.	5
2	Stockings of razorback sucker into the San Juan River in 2004.	7
3	Razorback sucker collected from the San Juan River during the April 26-30, 2004 razorback sucker monitoring trips (n = 62)	16
4	Growth of razorback sucker, in millimeters per day (mm/day), observed during 430 recapture events, including multiple recaptures, 1995-2004.	24

LIST OF FIGURES

Figure		Page
1	Stocking dates and locations and post-stocking movements of two razorback sucker that were recaptured on 26 April 2004 as part of a suspected spawning aggregation at RM 154.27	14
2	Movements of four PIT-tagged razorback sucker recaptured in 2004 for the second (or more) time since stocking.	15
3	Longitudinal distribution of razorback sucker recaptures during the April 26-30, 2004 razorback sucker monitoring trip (solid black bars) and the fall 2004 Adult Monitoring trip (cross-hatched bars) in the San Juan River.	18
4	Razorback sucker catch per unit effort (CPUE) on spring razorback sucker monitoring trips and fall Adult Monitoring trips, 1995-2004. Error bars represent one standard error. Error bars are not presented for the other CPUE trend lines as they are all essentially subsets of the RM 180.0-2.9 data set and in order to avoid unnecessarily cluttering the graph	20
5	A measure of longevity among stocked fish in the San Juan River razorback sucker population, expressed as the number of days in the river since stocking versus the percent of total recaptures represented by recaptured fish, in 2002 (top), 2003 (middle), and 2004 (bottom). Some recaptures could not be used in this analysis due to lack of a detectable PIT tag at the time of recapture.	22
6	Schnabel and Petersen population estimates for the San Juan River razorback sucker population from RM 158.6-76.4 and from RM 158.6-2.9, 1995-2004. Only the Schnabel multiple-census estimate from RM 158.6-76.4 has associated 95% confidence intervals displayed.	23

LIST OF FIGURES

Figure		Page
7	Total length (TL) at age observed for 568 recaptured razorback sucker in the San Juan River, 1995-2004. The solid circles represent the mean observed TL values for each age-class at time of recapture. Error bars represent the range of values observed among known-age, recaptured fish in each age-class. The dark upward-sloping line represents the expected length-at-age, based on observed values. The solid black columns at the bottom represent the sample sizes upon which length-at-age values for each age-class were based	26
8	Absolute and relative increases in total length (TL) at age observed among 568 recaptured razorback sucker in the San Juan River, 1995-2004. NOTE: Markers at age-2 indicate the increase in TL from age-1 to age-2, those at age-3 indicate the increase in TL from age-2 to age-3 and so on	27

LIST OF TABLES IN APPENDICES

Table		Page
A-1	Petersen population estimates (using Bailey's modification) for stocked razorback sucker (RM 158.6-76.4) on spring razorback sucker monitoring trips and fall adult monitoring trips, 1995-2004	38
A-2	Extrapolated "riverwide" (i.e., RM 158.6-2.9) population estimates for stocked razorback sucker, based on 87.5% of recaptures on the fall 1995-2004 Adult Monitoring trips (RM 158.6-2.9) being collected in the area covered by the Petersen population estimate (i.e., 158.6-76.4)	38
A-3	Schnabel multiple-census population estimates for stocked razorback sucker (RM 158.6-76.4) on spring razorback sucker monitoring trips and fall Adult Monitoring trips, 1995-2004. . .	39
A-4	Extrapolated "riverwide" (RM 158.6-2.9) population estimates for stocked razorbacks sucker, based on 87.5% of recaptures on 1995-2004 fall Adult Monitoring trips (RM 158.6-2.9) being collected in the area covered by the Schnabel multiple-census population estimate (RM 158.6-76.4).	39

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 their associated effects on flow and thermal regimes, introduction of non-native fish 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 (CA), 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 about 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, in the vicinity of Piute Farms Marina, RM 0.0 (Platania 1990). In 1988 one adult razorback sucker was captured and released in the San Juan River near Bluff, UT, close to the 1976 capture site (Platania 1990). This is the only scientifically-documented collection of a wild 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 populations of endangered razorback sucker in appropriate historic habitat, if necessary (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 San Juan River 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 Farmington, NM and Lake Powell in UT (i.e., the area designated as Critical Habitat for razorback sucker; Maddux et al. 1993, USFWS 1994).

Between March 1994 and October 1996, 940 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, the initiation of a full-scale augmentation effort for razorback sucker in the San Juan River was deemed to be desirable by the SJRIP Biology Committee (BC).

In 1997 a FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER was completed (Ryden 1997). The 1997 razorback sucker augmentation 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. Between September 1997 and November 2001, a total of 5,896 razorback sucker were stocked into the San Juan River, with all stockings occurring at RM 158.6. This represented a 92.0% shortfall (n = of 67,586 fish) compared to the target stocking numbers specified in the 1997 augmentation plan.

Despite this large shortfall, numerous encouraging observations were made among the relatively few fish that were stocked. To begin with, the recapture (i.e., survival) rate among razorback sucker stocked at $\geq$ 300 TL was better than expected (Ryden 2001). Second, aggregations of suspected spawning adults were collected in 1997, 1999, and 2001 at RM 100.2 just downstream of Aneth, UT (Ryden 2001, 2003a). And third, crews from the University of New Mexico (UNM) have collected larval razorback sucker in every year since 1998 (Brandenburg 2000, Brandenburg et al. 2001, 2002, 2003, 2004, 2005).

Based on these observations, the SJRIP-BC decided to extend the augmentation effort for razorback sucker. AN AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER: AN ADDENDUM TO THE FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER (Ryden 1997) was completed in February 2003 (Ryden 2003b). This addendum outlines an additional eight-year augmentation period for razorback sucker. This eight-year augmentation period was scheduled to begin in 2004 and continue through 2011.

However, because of several mitigating circumstances (detailed in Ryden 2005a), the timeline for beginning this eight-year augmentation effort has been pushed back to at least 2006. Therefore, the razorback sucker stocking and augmentation efforts that occurred from 2002-2004 were considered to be an interim effort, separate from these two distinct razorback sucker augmentation

efforts. This report provides an overview of the 2004 interim razorback sucker augmentation efforts, including information on the fish that were stocked and/or recaptured during that calendar year.

Objectives

The 2002-2003 razorback sucker augmentation effort had the following objectives:

1) Obtain, rear, harvest, and stock razorback sucker to fulfill tasks and objectives outlined in the current version of the razorback sucker augmentation plan

2) Monitor stocked razorback sucker in the wild for various parameters, including:
   a) Spawning season habitat use and movement patterns
   b) Survival and growth rates
   c) Determine whether hatchery-reared razorback sucker will recruit into the adult population and successfully spawn in the wild

Study Area

The study area for monitoring of stocked razorback sucker extends from Hogback Diversion in NM (RM 158.6), downstream to Clay Hills boat launch (RM 2.9). 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/

CHAPTER 1: OBTAIN, REAR, HARVEST, AND STOCK RAZORBACK SUCKER

Objective 1: Obtain, rear, harvest, and stock razorback sucker to fulfill tasks and objectives outlined in the current version of the razorback sucker augmentation plan

METHODS

All nine grow-out ponds were stocked with fish in 2004 (Table 1). All six of the 6-Pack ponds were stocked on 27 May 2004 with larval (2004 year-class) fish with 27,240 larvae per pond (Table 1). The fish stocked into the 6-Pack ponds were a mixture of 22 separate family lots from the 24-Road Hatchery in Grand Junction, CO.

Hidden Pond was also stocked with larval (2004 year-class) fish from these same 22 mixed family lots on 27 May 2004. However, it was stocked with 97,160 larvae. The reason for the difference in numbers of fish stocked between the 6-Pack ponds and Hidden Pond was because Hidden Pond had no other year-classes of fish present in it at the time it was stocked in May 2004 (Table 1). Hidden Pond had been completely drained in August 2003 (it was re-filled during the early spring of 2004), at which time it was retrofitted with a gravity drain and a salamander fence. In contrast, all of the 6-Pack ponds had at least one other year-class of fish in them at the time the 27 May 2004 stockings of larvae occurred.

West Avocet Pond was stocked on 12 April 2004 with 1,698 age-1 (2003 year-class) fish (Table 1). These fish were a mixture of 20 family lots from the 24-Road Hatchery in Grand Junction, CO. Then, in the first week of May 2004, Ray Smith of the Farmington Bureau of Indian Affairs office noticed numerous razorback sucker in West Avocet Pond that were exhibiting signs of stress (i.e., gulping air at the ponds surface, crowding around the water inlet pipe), as well as a few mortalities. Water quality measurements showed very low dissolved oxygen levels in the pond due to a massive aquatic vegetation die-off (there are some indications that this may have been caused by the introduction of a chemical substance, possibly a pesticide or fertilizer, into the pond) and a distinctive red sheen in the water (a zooplankton bloom of some kind). Salvage efforts performed during the week of 8-13 May, collected approximately 550 live fish (range = 75-432 mm TL) that were transferred into adjacent East Avocet Pond (Table 1). Several hundred (> 400) more carcasses were retrieved from West Avocet Pond, but the exact number of fish lost during this incident is unknown. West Avocet Pond was completely drained during the salvage effort and continues to remain dry. Plans are underway to scrape and reshape the bottom of West Avocet Pond and retrofit the pond with a gravity drain structure.

A total of 22,697 razorback sucker were stocked into East Avocet Pond over the course of three separate stockings in 2004 (Table 1). The first stocking, on 12 April 2004, consisted of 1,697 age-1 (2003 year-class) fish from 24-Road Hatchery in Grand Junction, CO. These fish came from the same mixture of the 20 family lots that were stocked into West Avocet Pond on that same date. The second stocking occurred on 8-13 May 2004, when approximately 550 fish (range = 75-432 mm TL) salvaged from West Avocet Pond were transferred into East Avocet Pond. The last stocking occurred on 27 May 2004

Table 1. An overview of razorback sucker stocked into the SJRIP's grow-out ponds, 1999-2004.

Pond Name:	Years Stocked:	Total Number Of Fish Stocked In Ponds By Calendar Year:	Details About Fish Stocked Into Grow-Out Ponds:
East Avocet Pond	1999 2000 2001 2002 2003 2004	1999 = 30,189 2000 = 20,000 2001 = 10,000 2002 = 20,000 2003 = 1,377 2004 = 22,697 Total = 104,263 (7 year-classes)	Stocked with larval fish each year from 1999-2004 NOTE 1: In 1999, 189 fish that were 200-300 mm TL (i.e., 1997 year-class) were stocked into East Avocet Pond. These were survivors of the August 1999 wash-out of Ojo Pond. NOTE 2: In 2003, 618 juvenile and adult fish salvaged from Hidden Pond were stocked into East Avocet Pond. NOTE 3: In 2004, 550 fish (75-432 mm TL) salvaged from West Avocet Pond were stocked into East Avocet Pond.
West Avocet Pond	1999 2000 2001 2002 2003 2004 ---------	1999 = 17,500 2000 = 20,000 2001 = 10,000 2002 = 20,000 2003 = 1,315 2004 = 1,698 Total = 70,513 (5 year-classes) ----------	Stocked with larval fish each year from 1999-2003 NOTE 1: In 2003, 556 juvenile and adult fish salvaged from Hidden Pond were stocked into West Avocet Pond. NOTE 2: A fish kill occurred in this pond in early May 2004. The pond was completely drained and all surviving fish were transferred to East Avocet Pond.
Hidden Pond	2000 2001 2002 --------- 2004	2000 = 60,000 2001 = 20,000 2002 = 20,000 Total = 100,000 (3 year-classes) ---------- 2004 = 97,160 Total = 97,160 (1 year-class)	Stocked with larval fish each year from 2000-2002 and again in 2004 NOTE 1: In 2003, Hidden Pond was drained and the fish that were salvaged were stocked into East and West Avocet ponds. NOTE 2: Hidden Pond was refilled in the early spring of 2004 and was restocked with larval fish in 2004. This pond now has only one year-class of fish in it.
6-Pack Pond # 1	2002 2004	2002 = 4,154 2004 = 27,240 Total = 31,394 (2 year-classes)	Stocked with age-1 fish (2"-6") in 2002. Stocked with larval fish in 2004.
6-Pack Pond # 2	2002 2003 2004	2002 = 4,154 2003 = 1,734 2004 = 27,240 Total = 33,128 (3 year-classes)	Stocked with age-1 fish (2"-6") in both 2002 and 2003. Stocked with larval fish in 2004.

Table 1. Continued.

Pond Name:	Years Stocked:	Total Number Of Fish Stocked In Ponds By Calendar Year:	Details About Fish Stocked Into Grow-Out Ponds:
6-Pack Pond # 3	2002 2003 2004	2002 = 4,153 2003 = 1,762 2004 = 27,240 Total = 33,155 (3 year-classes)	Stocked with age-1 fish (2”-6”) in both 2002 and 2003. Stocked with larval fish in 2004.
6-Pack Pond # 4	2002 2003 2004	2002 = 4,153 2003 = 1,568 2004 = 27,240 Total = 32,961 (3 year-classes)	Stocked with age-1 fish (2”-6”) in both 2002 and 2003. Stocked with larval fish in 2004.
6-Pack Pond # 5	2002 2004	2002 = 4,452 2004 = 27,240 Total = 31,692 (2 year-classes)	Stocked with age-1 fish (2”-6”) in 2002. Stocked with larval fish in 2004.
6-Pack Pond # 6	2002 2004	2002 = 5,093 2004 = 27,240 Total = 32,333 (2 year-classes)	Stocked with age-1 fish (2”-6”) in 2002. Stocked with larval fish in 2004.

and consisted of 20,450 age-0 (2004 year-class) fish from the 24-Road Hatchery. These age-0 fish were from the same 22 mixed family lots that were stocked into all of the 6-Pack ponds and into Hidden Pond on this date.

Razorback sucker were passively-managed from the time they were stocked into grow-out ponds until harvest efforts occurred. Fish fed on a natural diet found in the ponds. No supplemental feeding occurred. Personnel from the Bureau of Indian Affairs (BIA-NIIP) office in Farmington, NM managed water levels in the ponds and checked pond water quality. In 2004, fish were harvested from grow-out ponds using fyke nets during three separate weeks (April 12-16, July 12-16, and August 23-27). Fish harvested during these weeks were all stocked immediately downstream of the Hogback Diversion (RM 158.6). All of these fish were individually-marked with PIT tags before being released into the wild.

In 2004, razorback sucker from one outside source were also stocked into the San Juan River. These were fish being reared by the Utah Division of Wildlife Resources’ (UDWR) Wahweap Hatchery in golf course ponds in Page, AZ. These fish were cooperatively monitored, harvested, and stocked by students from Page High School (HS) as part of an information and education (I&E) effort. These fish were all stocked immediately downstream of the Hogback Diversion (RM 158.6) on 26 April 2004. All of these fish were individually-marked with PIT tags before being released into the wild.

RESULTS

In 2004, a total of 2,989 razorback sucker (mean TL = 353 mm; range = 225-559 mm TL) were stocked into the San Juan River (Table 2). Of these 2,989 stocked fish, 2,678 (mean TL = 352 mm; range = 235-540 mm TL) were harvested from the SJRIP's grow-out ponds (Table 2). The other 311 razorback sucker (mean TL = 366 mm; range = 225-559 mm TL) were from the Page golf course ponds (Table 2). This was by far the largest number of razorback sucker stocked in any single year since augmentation efforts for this species began in 1994.

Table 2. Stockings of razorback sucker into the San Juan River in 2004.

Date(s) Stocked	River Mile Stocked At	Number Of Fish Stocked	Mean TL (and TL Range) At Time Of Stocking
Razorback Sucker Stocked In 2004 (n = 2,989):			
12-16 April	158.6	969	326 (280-480)
26 April	158.6	311	366 (225-559)
12-16 July	158.6	983	379 (295-540)
23-27 August	158.6	726	350 (235-510)

DISCUSSION

The 2,989 razorback sucker stocked into the San Juan River in 2004 was by far the largest number of this species to be stocked in any single year since razorback sucker augmentation efforts began in the San Juan River in 1994. This is encouraging. However, it also somewhat sobering in that the target stocking numbers specified in AN AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER: AN ADDENDUM TO THE FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER (Ryden 1997) (Ryden 2003b) indicates that we should be stocking 11,400 razorback sucker annually. Therefore, even though we had the best year to date for stocking razorback sucker, there was still had a shortfall of 8,411 stocked fish (or 73.78%) in 2004.

The "official" eight-year augmentation effort for razorback sucker (as specified in Ryden 2003b) was scheduled to begin in 2004 and continue through 2011. However, due to numerous setbacks in the razorback sucker augmentation program, the timetable for "starting the clock" on this eight-year augmentation period has been pushed back to at least 2006 and possibly even 2007 (Ryden 2005a). These setbacks include 1) West Avocet Pond is currently out of production; 2) There is currently no written pond management plan that can be followed to help maximize production and growth in the existing grow-out ponds; 3) There is currently an (assumed) heavy loss of stocked larvae each year to predation by tiger salamanders; 4) There is currently not a

trained, "on-the-ground" pond manager to implement the strategies that will be laid out in the pond management plan, to maintain and monitor ponds on a daily basis, and to respond to biological emergencies and/or pond security issues; 5) As was proven by the fish kill in West Avocet Pond, there is a need for all grow-out ponds to have security fences to prevent illegal access that could lead to catastrophic loss of fish populations in the ponds, due to dumping, poisoning or other unforeseen circumstances. Each of these factors is currently in the process of being addressed by the SJRIP-BC. However, until each of these factors has been addressed and rectified, it will be difficult to expect to meet the annual stocking goal of 11,400 fish annually. And, in all honesty, there could be further unforeseen issues that arise in future years that could also hinder meeting these stocking goals.

Therefore, 2004 was another in a series of interim years between the first augmentation effort (1997-2001) that took place under the auspices of the FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER (Ryden 1997) and the upcoming eight-year augmentation effort that will be governed by the two razorback sucker augmentation plan addendums (Ryden 2003b, 2005a).

The annual contribution of fish that are reared at the Page Golf Course ponds by UDWR-Wahweap has been a boon to the San Juan River razorback sucker augmentation effort. This cooperative effort should continue to be fostered by the SJRIP.

CHAPTER 2: MONITORING OF STOCKED RAZORBACK SUCKER

Objective 2: Monitor stocked razorback sucker in the wild for various parameters, including:
- a) Spawning season habitat use and movement patterns
- b) Survival and growth rates
- c) Determine whether hatchery-reared razorback sucker will recruit into the adult population and successfully spawn in the wild

METHODS

Field Sampling

Monitoring of stocked razorback sucker was done actively via raft-borne electrofishing. In addition, recaptures of razorback sucker from other San Juan River studies were used to help strengthen the razorback sucker monitoring data set for purposes of data analysis. Thanks go to those researchers that forwarded their data to me and gave their permission for its inclusion in these analyses.

Electrofishing

The study area for razorback sucker monitoring started at RM 158.6 (Hogback Diversion) and continued downstream to RM 2.9 (Clay Hills boat landing). Razorback sucker monitoring was performed during the week of April 26-30, 2004. Crews from the USFWS's Colorado River Fishery Project (CRFP) office in Grand Junction, CO performed razorback sucker monitoring in the upstream section of the San Juan River (> RM 53.0). Crews from the UDWR's Moab, UT field station (supervised by Julie Jackson) performed razorback sucker monitoring in the downstream section of the San Juan River (RM 52.9-2.9), while they were engaged in their regularly-scheduled nonnative fish removal trip. This was done to avoid redundant sampling and to eliminate excess stress on the fish in this section of the river that would have been caused by sampling in consecutive weeks.

The April 26-30, 2004 razorback sucker monitoring trip was intentionally performed in close temporal proximity to several 2004 razorback sucker stocking dates (it actually began on the day that the razorback sucker from UDWR-Wahweap were stocked; Table 2). This was done to try to obtain more information on the short-term, post-stocking dispersal patterns among recently-stocked fish.

During razorback sucker monitoring trips, the following sampling protocol was used. Electrofishing proceeds downstream in a continuous fashion from put-in to take-out with two electrofishing rafts. One netter 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 operator's discretion.

The study area was divided into two-RM sections. Electrofishing crews began at the upstream end of section and collected all the fish they could net as they shocked downstream. At the end of each section, 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 efforts. Common native fishes were returned alive to the river. One RM was skipped between each two-RM electrofishing section (i.e., sampling crews shocked two out of every three RM's), so that sampling methodology would provide data that was comparable to that collected on the fall ***Sub-Adult And Adult Large-Bodied Fish Community Monitoring*** trip (i.e., "Adult Monitoring" for short).

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 in lieu of the actual capture RM. All rare native fishes were returned alive to the river after data collection was complete.

Razorback sucker were also recaptured, incidentally, via electrofishing, seining, and trammel-netting during sampling trips for other SJRIP-approved studies and monitoring efforts. If these capture data were forwarded to us, we used them to help support and strengthen our razorback sucker data sets, especially for determining growth.

Razorback sucker that had been recaptured two or more times since their date of stocking were used to examine movement patterns. 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 followed by fish demonstrating the ability to maintain their relative position in the river with many even moving 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.

Data Analysis

Objective 2a: Spawning Season Habitat Use And Movement Patterns

Generalized movement patterns were analyzed among PIT-tagged fish that had been recaptured for the second (or more) time since stocking. These general movements were used to examine short-term dispersal of stocked fish, as well as long-term movements that might reveal preferred areas or sections of the river. Longitudinal distribution of all razorback sucker recaptured in a given year was also examined to examine the within-year distribution of the razorback sucker population in the San Juan River.

Objective 2b: Survival And Growth Rates

Survival

Catch per unit effort (CPUE = number of fish per hour {hr} of electrofishing) can give an indirect indication of population size (i.e., the greater the CPUE, the greater the relative population size). By tracking the CPUE trend over time, it should be possible to determine whether the razorback sucker population is increasing or decreasing in number. If this metric is increasing over time, it is indicative of one of two possibilities. First, either stocked fish are surviving post-stocking and the population is growing based on multiple year-classes of fish. The other possibility is that stocked fish are not surviving and increasingly larger numbers young fish are being stocked each year, thus making the likelihood of recapturing a newly-stocked fish more and more likely.

In order to determine whether an increasing CPUE is indicative of a multiple year-class population or not, an attempt was made to examine how long fish from the various stockings since 1994 were remaining in the San Juan River razorback sucker population. This was done by examining the number of days a recaptured fish had been in the river since stocking versus the percent of total recaptures represented by that fish. Using this metric, it was possible to determine what percentage of the San Juan River razorback sucker population within a given year was composed of older versus more recently-stocked fish. To make this particular data set more robust, recaptures of razorback sucker from all SJRIP studies for which I had data in a given year were used. A few recaptures could not be used in this analysis due to lack of a detectable PIT tag at the time of recapture.

This analysis (days post-stocking versus percent of total recaptures) was used in lieu of a length-frequency histogram analysis of the San Juan River razorback sucker population for a couple of reasons. First, we know that there is essentially no wild razorback sucker population in the San Juan River. Because of this, the current razorback sucker population is based exclusively around larger ($\geq$ 300 mm TL), stocked fish or their age-0 offspring. Until these age-0 fish begin to recruit into the juvenile and sub-adult age classes, measuring the health of this population based on size-structure will essentially be useless. Thus, the closest thing to a measure of population health and viability we currently have is going to be the occurrence and longevity of stocked adult fish and the presence/absence and relative abundance of their larval offspring (being monitored by a separate study element).

Petersen and Schnabel population estimates (using Bailey's modification for low numbers of recaptured fish; Van den Avyle 1993) were performed for spring razorback sucker monitoring trips and fall Adult Monitoring trips, for 1995-2004, to determine the size of the razorback sucker population in the common sampled area of the San Juan River, i.e., RM 158.6-76.4. Population estimate values were then extrapolated to "riverwide" (RM 158.6-2.9) estimates based on the population estimate value versus the mean percentage of total razorback sucker recaptures that occurred in the common sampled area (RM 158.8-76.4)of the San Juan River (i.e., 87.5%) on fall sampling trips, which sampled from RM 158.6-2.9, 1995-2004. In other words to extrapolate the Petersen or Schnabel estimate to the larger area:

(population estimate value/87.5)(100) = the "riverwide" estimate*

Razorback sucker recapture data collected on two consecutive USFWS-CRFP monitoring trips (occurring approximately six calendar months apart) were used to generate numbers for Petersen estimates. In contrast, razorback sucker recapture data collected on four consecutive USFWS-CRFP monitoring trips (a time period spanning approximately 18 calendar months) were used to generate numbers for the Schnabel multiple-census population estimates. This way of generating numbers for the Schnabel multiple-census estimate was slightly different than in past years, when recapture data from eight consecutive USFWS-CRFP monitoring trips were used (a time period spanning approximately 42 calendar months). Reducing the recapture data being utilized down to just four consecutive monitoring trips for the Schnabel multiple-census population estimate helped keep down the amount of over-estimation inherent in this model, due to its lack of ability to deal with losses in the population due to mortality. Using the four-trip method changed (i.e., lowered) some previously-generated Schnabel point estimate values. It also reduced the number of available recapture events in any given estimate, which caused increases in many of the associated 95% confidence intervals. Overall though, this method generated a much more realistic Schnabel estimate value, and it made estimate values generated by the two population estimate models (Petersen and Schnabel) track much better with one another.

Growth

Growth was determined from measurements of recaptured fish. Growth rate trends for recaptured fish stocked in distinct 10-mm total length (TL) size-class groupings were compared. Mean TL (and range) was determined for age at recapture and used to plot a growth curve for TL at age. Absolute and relative increases in TL (Van den Avyle 1993) were determined for distinct one-year growth periods.

Objective 2c: Determine Whether Hatchery-Reared Razorback Sucker Will Recruit Into The Adult Population And Successfully Spawn In The Wild

Recaptured razorback sucker were examined to determine reproductive status and age (via PIT tag number). Those fish that were freely expressing gametes (i.e., were ripe) or had visible tuberculation present were considered to be mature, sexually active fish. Aggregations of three or more ripe, adult male razorback sucker during the spawning season were considered to be suspected spawning aggregations. Aggregations of two or more razorback sucker were considered to be likely spawning aggregations, if both ripe male and ripe female fish were documented as being present.

Suspected spawning areas were identified as those areas at which aggregations of ripe, adult razorback sucker were observed. Likely spawning areas were identified as those areas at which aggregations of ripe, adult razorback sucker were observed in more than one calendar year.

RESULTS

Objective 2a: Spawning Season Habitat Use And Movement Patterns

Recaptured razorback sucker were spatially separated from one another, for the most part, during the April 26-30, 2004 razorback sucker monitoring trip. Habitat types from which razorback sucker were recaptured during the April 26-30, 2004 monitoring trip varied from low- to zero-velocity shoreline pools and slackwaters in simpler areas of the river channel, to low-velocity slackwater/eddy zones at the downstream tips of islands where the secondary and main channel reunited, to higher velocity shallow cobble riffles and cobble shoals ($\leq$ 2 ft. deep) -- especially in and around island complexes (pers. obs.). Substrate types over which razorback sucker were collected also varied, from silt (in the lower velocity shoreline habitats), to sand (at the downstream ends of islands), to cobbles and gravels (in the higher velocity riffle habitats).

There was only one collection of two or more razorback sucker that were in close proximity to one another on the April 2004 monitoring trip. On 26 April 2004, two adult razorback sucker were collected at RM 154.27 on river left over a cobble bar (containing "small cobbles to pea-sized gravel"; pers. obs.) at the very upstream end of a secondary channel. One of these fish was a ripe, tuberculate male (TL = 455 mm, WT = 950 g) and the other was a ripe female (TL = 497 mm, 1390 g). Both fish were freely expressing gametes. These two fish were collected within ten feet of one another and both were collected in the midst of numerous flannelmouth sucker that were in spawning condition. Time of collection was approximately 5:30 PM and water temperature at the site was 17°C at the time of collection. Recapture histories for both of these fish indicated that both fish were originally stocked just downstream of Hogback Diversion (RM 158.6) and seem to have remained in this same general river section over the last several years (Figure 1). This was the second recapture since stocking for both of these fish.

Of the 62 razorback sucker recaptured on the April 26-30, 2004 monitoring trip, 57 were first-time recaptures. Another 4 had been recaptured twice since stocking. One did not have a detectable PIT tag at the time of recapture, so its post-stocking movements could not be determined. One of the four fish that was recaptured for the second time in 2004 (PIT tag # 423E541450) had had a radio tag (# 40.781) surgically implanted into it on 23 September 2003. It had had only one radio telemetry contact made with it (on 10 March 2004 at RM 147.2) before the radio tag apparently failed (there was no signal being emitted by the radio tag when this fish was recaptured on 27 April 2004). Movement patterns of the four fish that were collected or contacted for the second (or more) time since stocking in 2004, revealed that three out of four of these fish had remained upstream of Shiprock, NM (RM 147.9), within just a few RM's of their original stocking location (Figure 2).

Recaptures of razorback sucker during the April 26-30, 2004 razorback sucker monitoring trip (n = 62) ranged from RM 157.1-17.0 (Table 3). Recaptures of razorback sucker from the fall 2004 Adult Monitoring trip (n = 117) ranged from RM 160.0-2.9 (Figure 3; Ryden 2005b In Prep.). The large majority (161 {89.9%} of 179) of razorback sucker recaptured during these two monitoring trips were collected upstream of RM 80.0 (Figure 3). In fact, over half (97 {54.2%} of 179) of all razorback sucker recaptured during these two trips were collected within ten miles up- or downstream of the Hogback Diversion stocking site (RM 158.6; Figure 3).

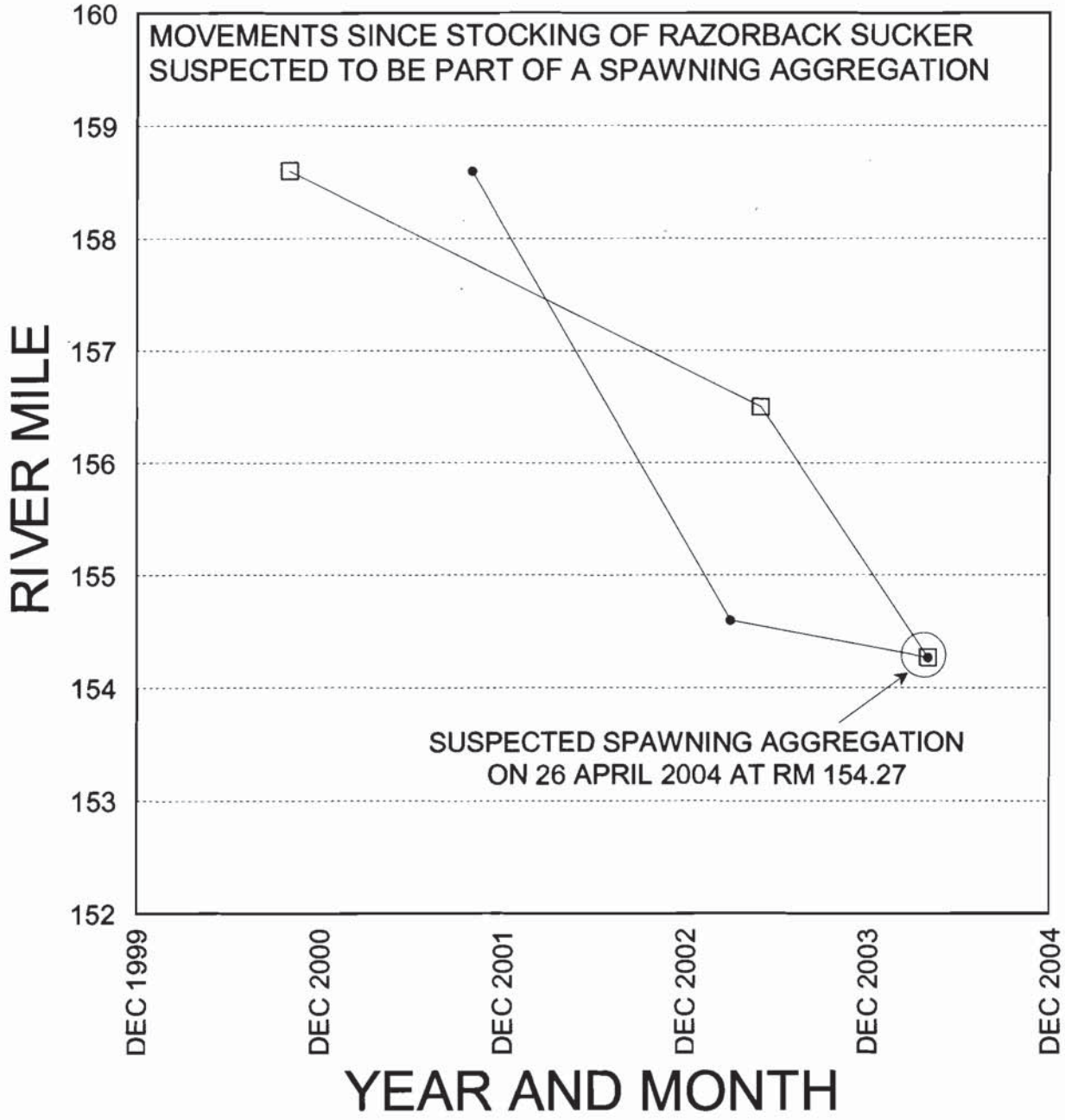


Figure 1. Stocking dates and locations and post-stocking movements of two razorback sucker that were recaptured on 26 April 2004 as part of a suspected spawning aggregation at RM 154.27.

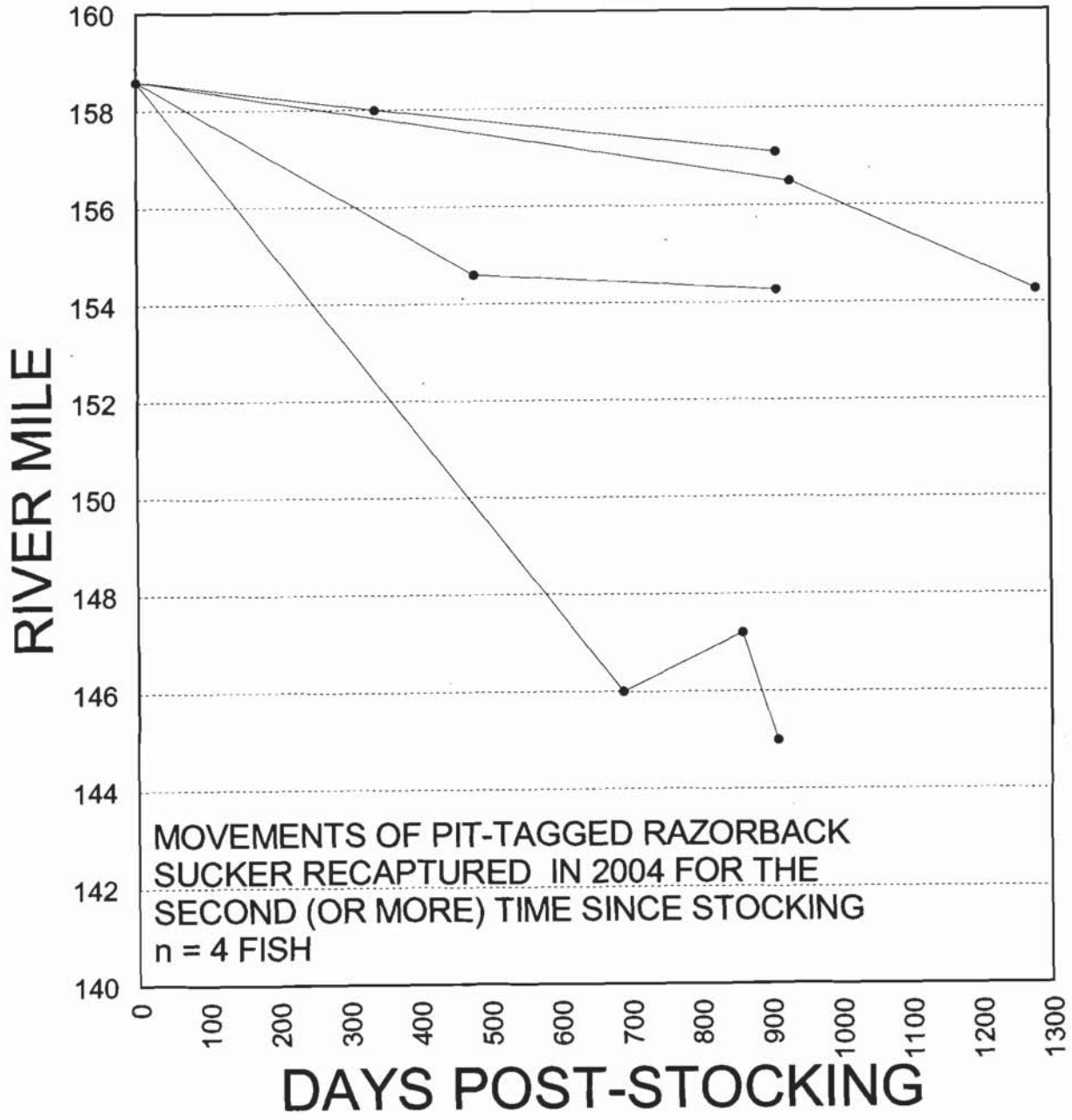


Figure 2. Movements of four PIT-tagged razorback sucker recaptured in 2004 for the second (or more) time since stocking.

Table 3. Razorback sucker collected from the San Juan River during the April 26-30, 2004 razorback sucker monitoring trip (n = 62).

Date Of Capture	PIT Tag Number	Radio Tag Frequency	Total Length (mm)	Weight (g)	Sex[a]	Actual Recapture RM (Or Ending RM Of Sample)	Days In The River Since Stocking
04/26/2004	441D530E11	NONE	377	520	I	(157.1)	0
04/26/2004	4417096354	NONE	371	500	I	(157.1)	0
04/26/2004	4417233825	NONE	348	440	I	(157.1)	0
04/26/2004	44172E2937	NONE	341	400	I	(157.1)	0
04/26/2004	44172E621F	NONE	375	520	I	(157.1)	UNKNOWN
04/26/2004	441A734755	NONE	367	510	I	(157.1)	0
04/26/2004	441C783267	NONE	476	1200	I	(157.1)	0
04/26/2004	441D067A1A	NONE	332	400	I	(157.1)	0
04/26/2004	441D407141	NONE	354	400	I	(157.1)	0
04/26/2004	4416781603	NONE	350	450	I	(157.1)	0
04/26/2004	441F010373	NONE	366	460	I	(157.1)	0
04/26/2004	4420796C1F	NONE	354	480	I	(157.1)	UNKNOWN
04/26/2004	4421164460	NONE	336	490	I	(157.1)	0
04/26/2004	4421193B07	NONE	464	1000	I	(157.1)	0
04/26/2004	52283A5C05	NONE	354	510	I	(157.1)	UNKNOWN
04/26/2004	52283C6F04	NONE	345	500	I	(157.1)	0
04/26/2004	5229721B23	NONE	369	600	I	(157.1)	0
04/26/2004	532750503A	NONE	336	390	I	(157.1)	UNKNOWN[b]
04/26/2004	NONE	NONE	436	950	I	(157.1)	UNKNOWN[c]
04/26/2004	423F083F30	NONE	446	1000	I	(157.1)	908
04/26/2004	4240105835	NONE	452	900	I	(157.1)	909
04/26/2004	4269617C3F	NONE	320	295	I	(157.1)	12
04/26/2004	424218610D	NONE	427	800	I	(157.1)	908
04/26/2004	424004437A	NONE	455	950	M	154.27	908[d]
04/26/2004	53245D7146	NONE	497	1390	F	154.27	1286[d]
04/26/2004	441A6E562B	NONE	298	300	I	(154.2)	0
04/26/2004	423F5B7248	NONE	445	820	I	(154.2)	908
04/26/2004	52282F2510	NONE	417	780	I	(154.2)	UNKNOWN
04/27/2004	44167D0572	NONE	367	500	I	(151.0)	1
04/27/2004	441E6D444E	NONE	371	520	I	(151.0)	UNKNOWN
04/27/2004	52291E4D27	NONE	360	470	I	(148.0)	1
04/27/2004	5229105523	NONE	380	480	I	(148.0)	1

a: F = Female; M = Male; I = Indeterminate

b: This fish had no detectable PIT tag at the time of recapture. A new PIT tag was implanted in this fish before it was returned to the river.

c: This fish had no detectable PIT tag at the time of recapture. However, before it could be implanted with a new PIT tag, it was accidentally dropped back into the river.

d: These two fish were part of a suspected spawning aggregation. Both fish were ripe (freely expressing gametes) when collected. These two fish were within ten feet of one another over a cobble/gravel bar.

Table 3. Continued.

Date Of Capture	PIT Tag Number	Radio Tag Frequency	Total Length (mm)	Weight (g)	Sex[a]	Actual Recapture RM (Or Ending RM Of Sample)	Days In The River Since Stocking
04/27/2004	5228452762	NONE	336	470	I	(148.0)	UNKNOWN
04/27/2004	423E746677	NONE	424	730	I	(148.0)	909
04/27/2004	4415023300	NONE	323	340	I	(148.0)	1
04/27/2004	423F6F4361	NONE	445	950	F	(148.0)	908
04/27/2004	4420773462	NONE	344	360	I	(148.0)	1
04/27/2004	423E541450	40.781	485	1100	F	(145.0)	909
04/27/2004	426B340708	NONE	314	280	I	(145.0)	14
04/27/2004	423E63127A	NONE	424	950	M	(142.0)	908
04/27/2004	522A604477	NONE	416	890	M	(139.0)	736
04/28/2004	441B121F12	NONE	424	1125	M	(136.0)	2
04/28/2004	42423D1211	NONE	439	1090	M	(133.0)	911
04/28/2004	42696F7752	NONE	333	450	I	(130.0)	13
04/29/2004	426A183935	NONE	321	275	I	(121.0)	14
02/29/2004	7F7B11307E	NONE	446	850	M	119.1	3
04/29/2004	426A3E7E3D	NONE	345	410	I	(115.0)	14
04/29/2004	42696E2575	NONE	320	295	I	(112.0)	15
04/29/2004	425C237B59	NONE	347	350	I	(109.0)	16
04/30/2004	426A2E4921	NONE	318	320	I	107.8	16
04/30/2004	4268777123	NONE	303	296	I	(106.0)	185
04/30/2004	42697F304A	NONE	352	410	I	(97.0)	17
04/30/2004	426A1B3E4B	NONE	310	280	I	(97.0)	15
04/26/2004	425C2A7C17	NONE	285	230	I	50.0	UNKNOWN
04/26/2004	42421B7D5C	NONE	455	375	I	(49.0)	908
04/28/2004	42694C4B17	NONE	330	263	I	27.0	14
04/28/2004	42693E1B6D	NONE	331	265	I	(25.0)	14
04/28/2004	4268472A0E	NONE	332	265	I	(22.5)	14
04/28/2004	42697B3272	NONE	307	243	I	22.2	13
04/28/2004	522A20623B	NONE	186	148	I	21.9	N/A[b]
04/29/2004	4269634B28	NONE	332	283	I	18.5	16
04/29/2004	4269031C54	NONE	305	232	I	(17.0)	14

a: F = Female; M = Male; I = Indeterminate

b: N/A = Not Applicable: This was a wild-produced, juvenile fish. Based on its size it was likely an early age-2 fish (i.e., 2002 year-class). It was almost certainly the progeny of stocked razorback sucker that had reproduced in the San Juan River. This fish was implanted with a new PIT tag before being returned to the river.

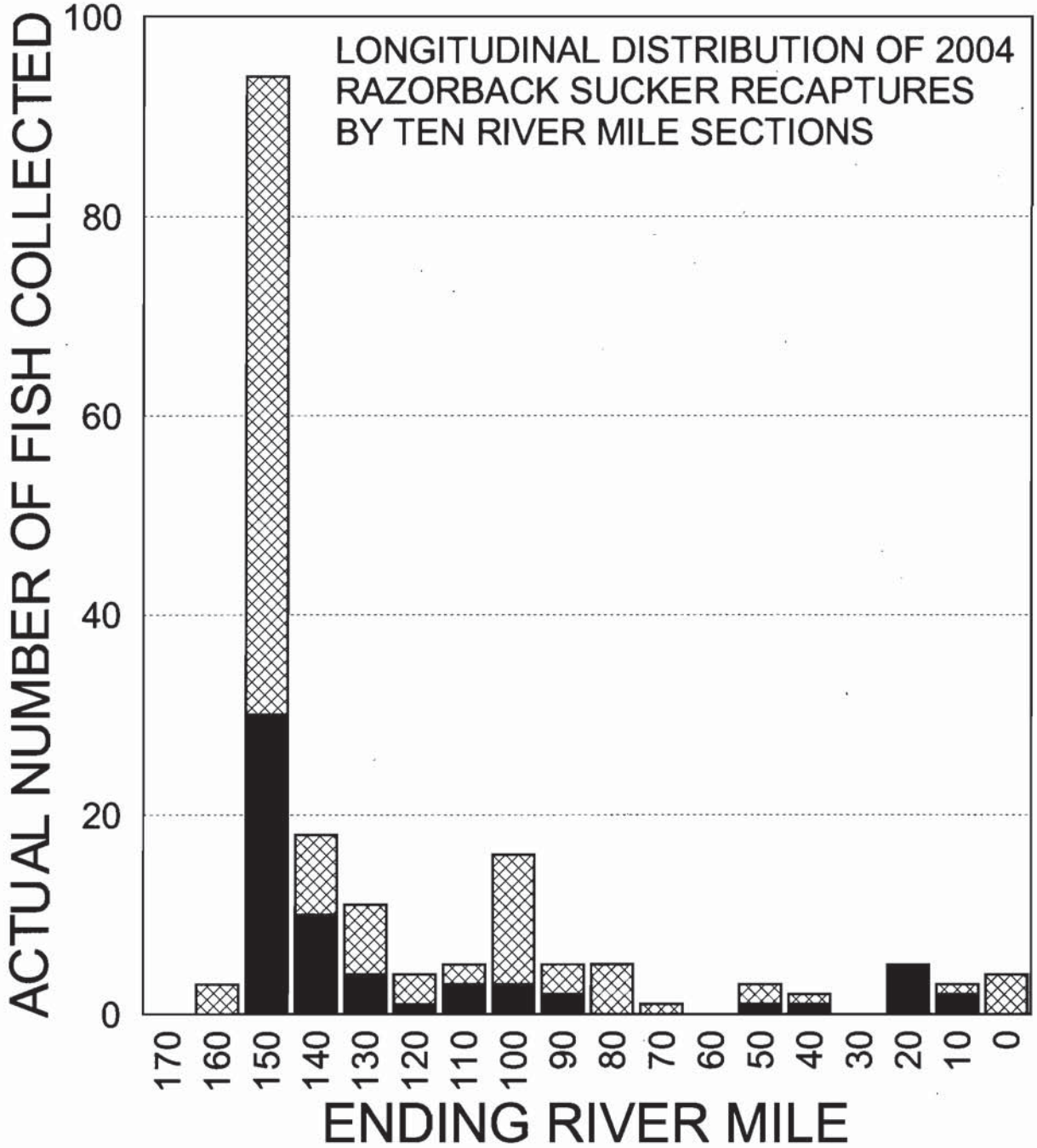


Figure 3. Longitudinal distribution of razorback sucker recaptures during the April 26-30, 2004 razorback sucker monitoring trip (solid black bars) and the fall 2004 Adult Monitoring trip (cross-hatched bars) in the San Juan River.

Of the 62 razorback sucker collected on the April 26-30, 2004 monitoring trip, original stocking information could not be located for nine fish (as indicated by an "UNKNOWN" in the 'Days In The River...' column in Table 3). In addition, one of the razorback sucker collected by the UDWR-Moab crews was a wild-produced juvenile fish (186 mm TL) that did not have a PIT tag when it was recaptured at RM 21.9 on 28 April 2004 (Table 3). That left 52 for which the original stocking information was available. Of those 52 fish, 38 (73.1%) had been in the river for $\leq$ 17 days at the time of recapture. These recent recaptures occurred from RM 157.1, downstream to RM 17.0 (Table 3). Fish stocked by UDWR-Wahweap at RM 158.6 on 26 April 2004 were collected as far downstream as RM 119.1 (a downstream displacement of 39.5 RM's), only three days post-stocking (this fish was 446 mm TL). Likewise, razorback sucker stocked at RM 158.6 during the week of 12-16 April, 2004 were collected as far downstream as RM 17.0 (a downstream displacement of 141.6 RM's), only 14 days post-stocking (this fish was 305 mm TL). Thus, it appears that recently-stocked razorback sucker, even ones stocked at $\geq$ 300 mm TL, can have large initial downstream displacements, some as high as 10.1-13.2 RM's per day, within the first couple of weeks post-stocking.

Objective 2b: Survival And Growth Rates

Survival

A total of 62 razorback sucker were recaptured on the April 26-30, 2004 razorback sucker monitoring trip (Table 3). Another 117 razorback sucker were collected on the fall 2004 Adult Monitoring trip (Ryden 2005b In Prep.). CPUE for razorback sucker on both of these 2004 monitoring trips was the highest ever scientifically observed for this species in the San Juan River (Figure 4). CPUE on the April 26-30,2004 razorback sucker monitoring trip was 0.76 fish/hr of electrofishing from RM 158.6-2.9. This value was over twice as high as on the April 2003 razorback sucker monitoring trip. CPUE on the fall 2004 Adult Monitoring trip was 1.44 fish/hr of electrofishing from RM 180.0-2.9. This value was over five times higher than any previously observed value on an Adult Monitoring trip. Values for the common sampled area of the river (RM 158.6-76.4) on both trips showed similar increases between 2003 and 2004 (Figure 4). Generally speaking, up through 2002, CPUE for razorback sucker on spring razorback sucker monitoring trips has been higher than that observed on fall Adult Monitoring trips (Figure 4). The reason for this is that razorback sucker tend to occupy the river from RM 158.6-76.4 in higher numbers than are found in either the upstream (RM 166.6-158.6) or downstream (RM 76.4-2.9) river sections. Thus, when these two river sections are added in, the CPUE for the entire trip tends to be lower. However, no matter which sections of river were examined, CPUE for razorback sucker in 2004 was consistently higher than that observed in any river section in any given year.

On the April 26-30, 2004 razorback sucker monitoring trip, 56 fish with known stocking dates were recaptured (of 62 total recaptures). These 56 fish came from six different stocking events (ranging from 18 October 2000 to 26 April 2004) and these fish had been in the river from 0-736 days post-stocking. On the fall 2004 Adult Monitoring trip, 107 fish with known stocking dates were recaptured (of 117 total recaptures). These 107 fish came from nine different stocking events (ranging from 18 November 1994 to 25 August 2004) and these fish had been in the river from 25-3,609 days post-stocking. By far the large majority of razorback sucker (133 {81.6%} out of the 163 fish with known stocking dates) recaptured on either the April 26-30,

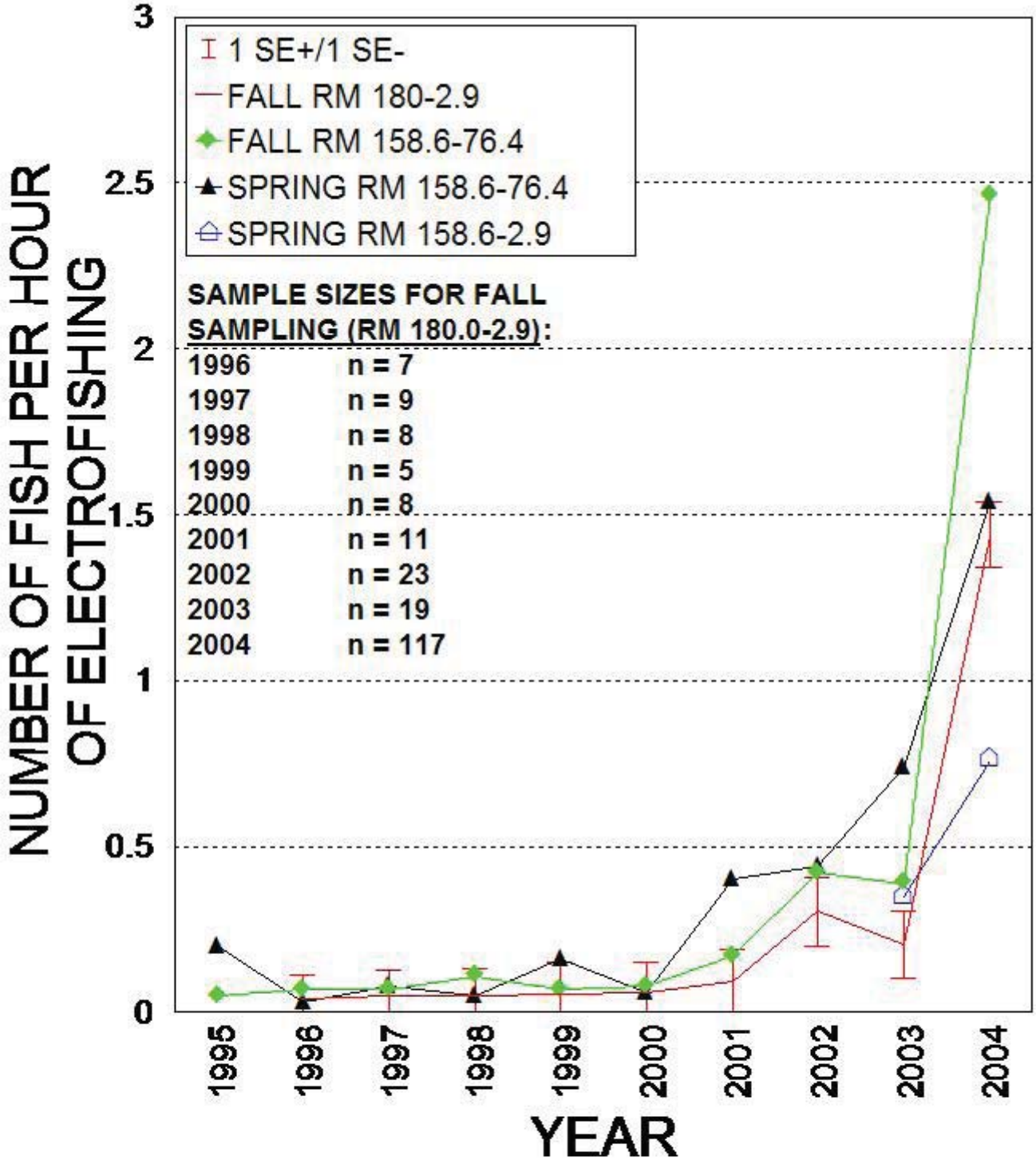


Figure 4. Razorback sucker catch per unit effort (CPUE) on spring razorback sucker monitoring trips and fall Adult Monitoring trips, 1995-2004. Error bars represent one standard error. Error Bars are not presented for the other CPUE trend lines as they are all essentially subsets of the RM 180.0-2.9 data set and in order to avoid unnecessarily cluttering the graph.

2004 razorback sucker monitoring trip or the fall 2004 Adult Monitoring trip were fish that had been stocked within the last 200 days prior to sampling (Table 3, Figure 5; Ryden 2005b In Prep.).

As was the case in 2002 and 2003, the majority of razorback sucker recaptured in 2004 were fish that had been stocked in the relatively recent past (Figure 5). However, unlike 2002, there were very few individual razorback sucker collected in 2003 and 2004 that had been resident in the San Juan River for > 1200 days post-stocking (n = 5 fish in 2004; Figure 5). While fish from numerous different stocking events continued to be recaptured on both USFWS-CRFP 2004 monitoring trips, all but one of these fish had been stocked within the last four calendar years. This trend away from the apparent long-term recapture/retention of older stocked razorback sucker (i.e., those that have been in the river > 1200 days post-stocking) is somewhat disconcerting.

The recent increases in razorback sucker CPUE and population estimates are due primarily to recaptures of recently-stocked fish. Stocked razorback sucker may not be surviving or remaining in the San Juan River in any appreciable numbers past about four years post-stocking.

The Petersen population estimate for razorback sucker recaptured in the spring of 2004 was 936 fish (95% C.I. = 442-2,161) from RM 158.6-76.4 (Figure 6, Table A-1 in Appendix A). The Schnabel estimate for razorback sucker recaptured in the fall of 2004 was 1,063 fish (95% C.I. = 594-2,166 fish) from RM 158.6-76.4 (Figure 6, Table A-3 in Appendix A). The Schnabel estimate, extrapolated, was 1,215 razorback sucker from RM 158.6-2.9 in the fall of 2004 (Figure 6, Table A-4 in Appendix A).

The values for the two population estimate models tracked each other very closely (though not exactly) up through the spring 2004 sampling period. The patterns shown by both population estimates indicates that numbers of razorback sucker in the San Juan River have risen markedly and steadily since fall 2000 (Figure 6). With the exception of the time period from fall 1998 to fall 2000, the values provided by the Petersen estimate for RM 158.6-76.4 fit within the 95% C.I.'s for the corresponding Schnabel population estimate and with the exception of the spring 2004 estimate, the population point estimate numbers being generated by both models are very close to the same. The fact that both estimates show similar increasing population trends is encouraging. However, given the large confidence intervals around the point estimates, there really isn't much statistical (or perhaps biological) significance to the population estimate data yet. This data, at present, essentially represents an increasing trend with a large amount of associated variation. Additionally, in light of the long-term retention data (Figure 5), which shows the San Juan River razorback sucker population being made up mostly of recently-stocked fish, one wonders what the population estimates would look like in five years if stocking of this species were discontinued today.

Growth

Razorback sucker have been stocked at many different size-classes and growth of these fish have varied widely (Table 4 and Figure 7). As was observed in past years, razorback sucker stocked at < 351 mm TL grew almost twice as fast (0.11 mm/day) as those stocked at > 350 mm TL (0.06 mm/day; Table 4). Known female razorback sucker (n = 63) increased in TL almost twice as fast (0.07 mm/day) as did known males (0.04 mm/day, n = 128; Table 4). The fastest growth rates were observed in fish stocked between 251 and 280 mm TL (Table 4).

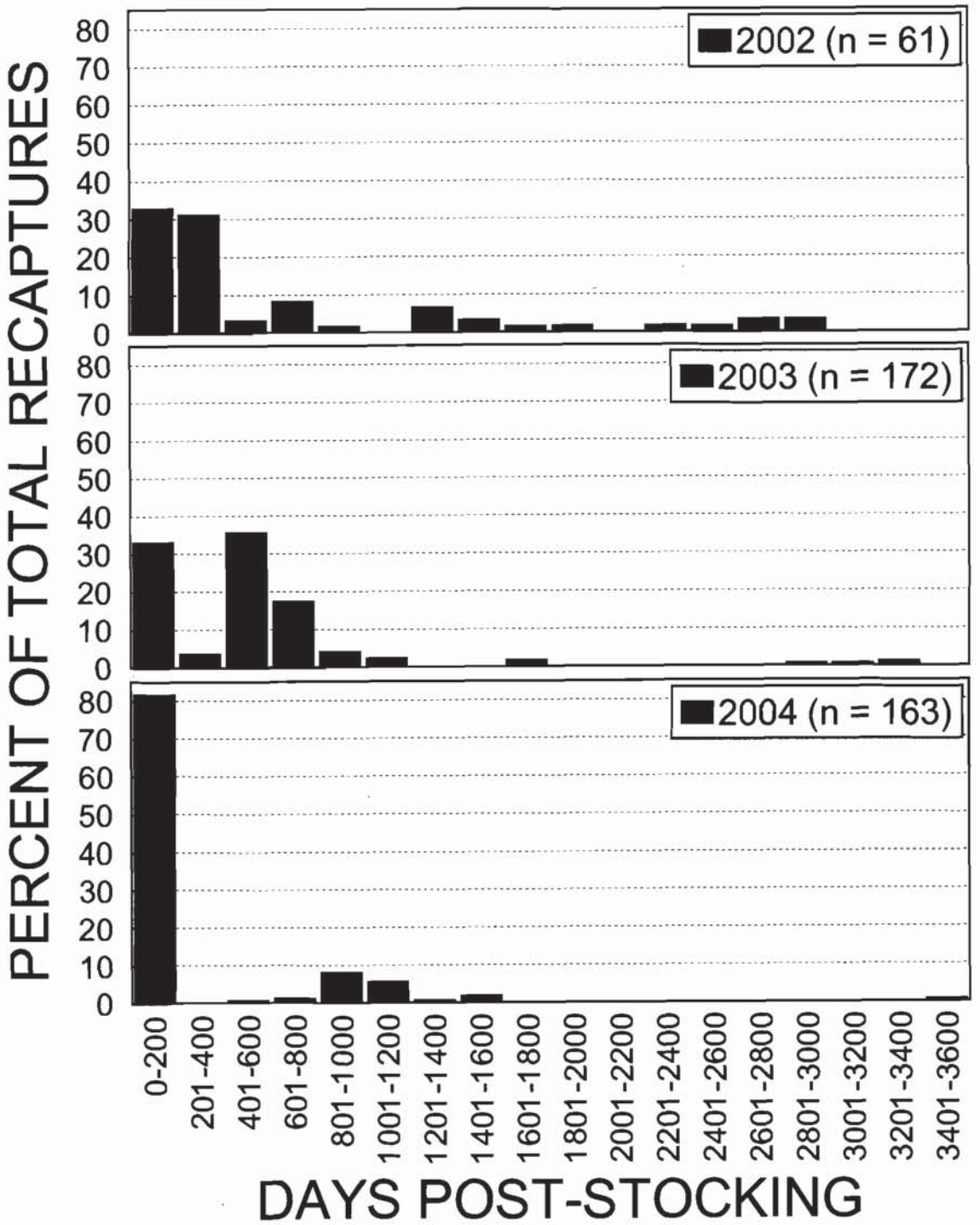


Figure 5. A measure of longevity among stocked fish in the San Juan River razorback sucker population, expressed as the number of days in the river since stocking versus the percent of total recaptures represented by recaptured fish, in 2002 (top), 2003 (middle), and 2004 (bottom). Some recaptures could not be used in this analysis due to lack of a detectable PIT tag at the time of recapture.

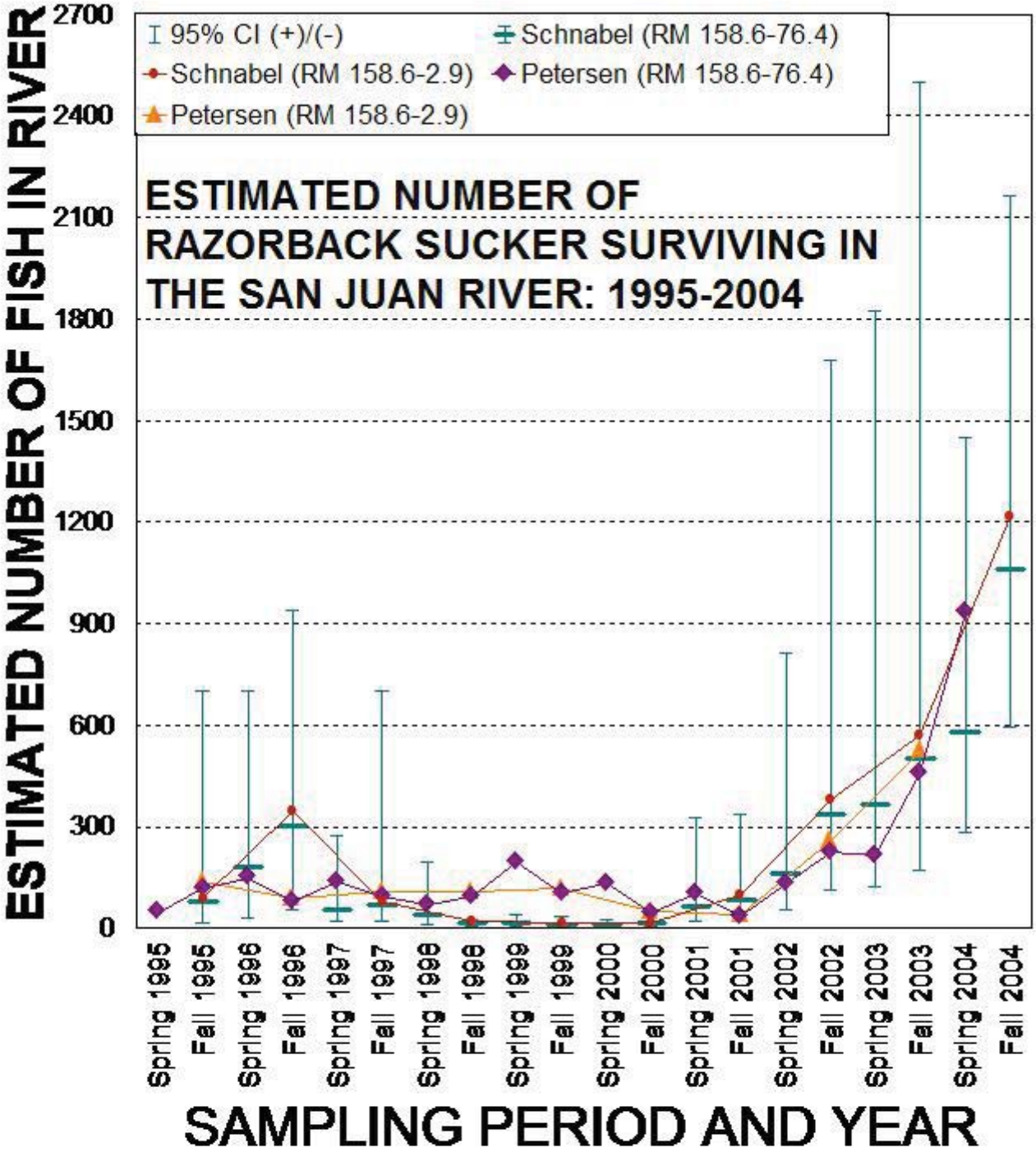


Figure 6. Schnabel and Petersen population estimates for the San Juan River razorback sucker population from RM 158.6-76.4 and from RM 158.6-2.9, 1995-2004. Only the Schnabel multiple-census estimate from RM 158.6-76.4 has associated 95% confidence intervals displayed.

Table 4. Growth of razorback sucker, in millimeters per day (mm/day), observed during 430 recapture events, including multiple recaptures, 1995-2004.

Total Length Range (in mm) Of Recaptured Fish At The Time They Were Originally Stocked	Mean Growth (mm/day)	Range Of Observed Growth Measurements	Number Of Recapture Events Growth Rates Are Based On (n =)
By 10-mm TL Size-Classes:			
< 221	0.11	0.00-0.42	6
221-230	0.12	0.07-0.17	2
231-240	0.15	0.00-0.42	7
241-250	No Data	No Data	No Data
251-260	0.20	0.20-0.20	2
261-270	0.24	0.22-0.25	2
271-280	0.23	0.00-0.52	8
281-290	0.06	0.00-0.23	7
291-300	0.03	0.00-0.16	7
301-310	0.02	0.00-0.14	7
311-320	0.08	0.00-0.35	16
321-330	0.04	0.00-0.13	9
331-340	0.14	0.00-0.50	13
341-350	0.15	0.00-0.34	12
351-360	0.14	0.00-0.41	20
361-370	0.09	0.00-0.23	22
371-380	0.07	0.00-0.33	35
381-390	0.06	0.00-0.21	32
391-400	0.08	0.00-0.32	37
401-410	0.06	0.00-0.28	45
411-420	0.07	0.00-0.26	28
421-430	0.05	0.00-0.25	26
431-440	0.05	0.00-0.26	16
441-450	0.03	0.00-0.15	25
> 450	0.02	0.00-0.08	46

Table 4. Continued.

Total Length Range (in mm) Of Recaptured Fish At The Time They Were Originally Stocked	Mean Growth In mm/Day	Range Of Observed Growth Measurements	Number Of Recapture Events Growth Rates Are Based On (n =)
"Small" Stocked Fish Versus "Large" Stocked Fish:			
"Small" (< 351 mm TL) (range = 193-350 mm TL)	0.11	0.00-0.52	98
"Large" (> 350 mm TL) (range = 353-540 mm TL)	0.06	0.00-0.41	331
Known Females Versus Known Males:			
Females (TL range = 229-523 mm)	0.07	0.00-0.23	63
Males (TL range = 232-481 mm)	0.04	0.00-0.42	128

Growth curves developed for razorback sucker show that between age-0 and age-4 razorback sucker grow rapidly reaching a mean TL of 449 mm (range = 348-537 mm TL) by age-4 (Figure 7). After age-4, the growth curve flattens considerably and gains in TL between years become much less dramatic (Figure 7). There is a considerable range for TL values at several ages (Figure 7). This reflects the wide range of sizes among razorback sucker of the same age from different hatchery facilities and grow-out ponds used in augmentation efforts. The largest gains in TL relative to the fish's body size occur from age-1 to age-2 and from age-2 to age-3, when razorback sucker increase in TL by 30.1% and 13.1%, respectively (Figure 8). This translates into an average increase of 85 mm TL and 48 mm TL, respectively (Figure 8). By age-5 stocked razorback sucker demonstrated less than a 5.0% observed annual increase in mean TL between years (Figures 7 and 8). These figures are based on the observed values among 568 razorback sucker recaptured between 1995 and 2004.

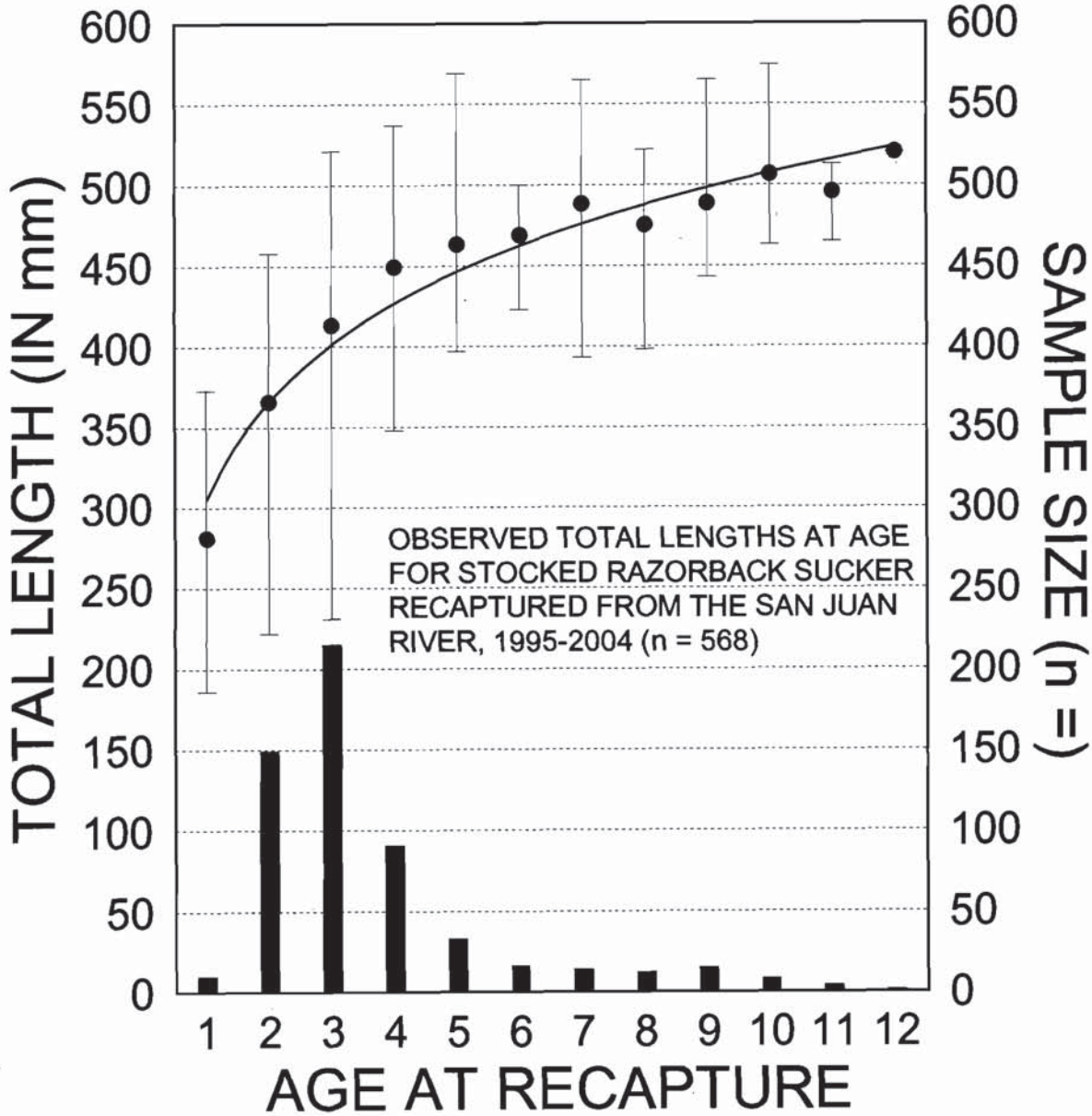


Figure 7. Total length (TL) at age observed for 568 recaptured razorback sucker in the San Juan River, 1995-2004. The solid circles represent the mean observed TL values for each age-class at time of recapture. Error bars represent the range of values observed among known-age, recaptured fish in each age-class. The dark upward-sloping line represents the expected length-at-age, based on observed values. The solid, black columns at the bottom represent the sample sizes upon which length-at-age values for each age-class were based.

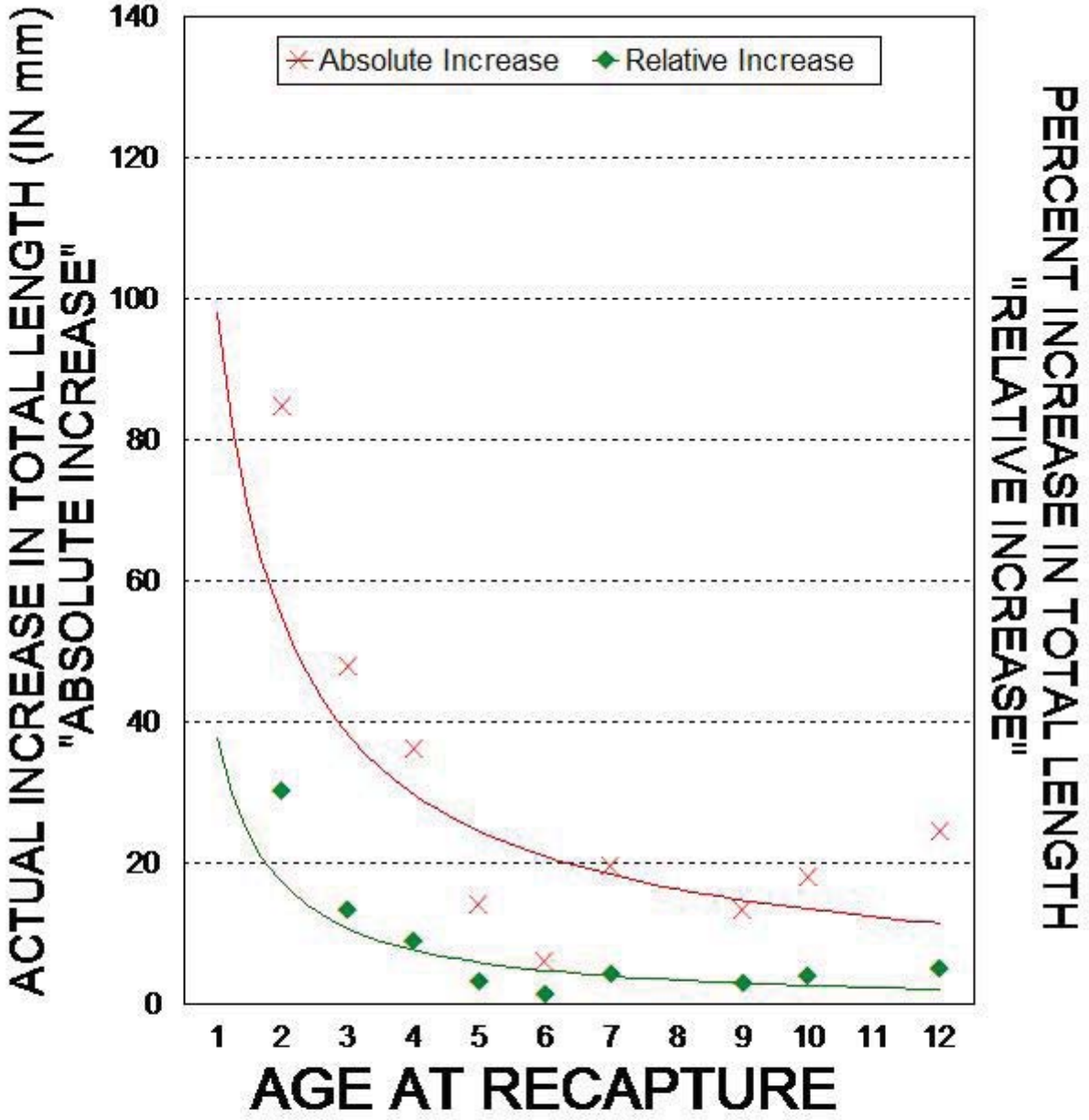


Figure 8. Absolute and relative increases in total length (TL) at age observed among 568 recaptured razorback sucker in the San Juan River, 1995-2004. NOTE: Markers at age-2 indicate the increase in TL from age-1 to age-2, those at age-3 indicate the increase in TL from age-2 to age-3 and so on.

Objective 2c: Determine Whether Hatchery-Reared Razorback Sucker Will Recruit Into The Adult Population And Successfully Spawn In The Wild

A total of 179 razorback sucker recaptured during the April 26-30, 2004 razorback sucker monitoring trip (n = 62) and the fall 2004 Adult Monitoring trip (n = 117). Of these 179 recaptures, 22 were known male fish, four were known female fish, and 153 were of indeterminate sex. Only one of the four identified females (445-520 mm TL) was ripe (i.e., freely expressing eggs) at the time of recapture. This ripe female was 497 mm TL and was collected at RM 154.27 on 26 April 2004. Known females were collected between 26 April and 5 October from RM 154.27-101.0. All 22 of the known males were tuberculate (382-569 mm TL) and 11 of those (416-458 mm TL) were ripe (i.e., freely expressing milt). Tuberculate males were collected from 26 April to 8 October from RM 154.27-72.0. Likewise, ripe males were also collected from 26 April to 8 October from RM 154.27-72.0.

2004 Spawning Aggregation

A single suspected spawning aggregation of razorback sucker was identified in the San Juan River during 2004 (see Appendix B for map plate). On 26 April 2004 two ripe adult razorback sucker were collected at RM 154.27 on river left (Table 3). One was a female (497 mm TL, 1390 g) and the other was a male (455 mm TL, 950 g). Both fish were freely expressing gametes (i.e., ripe) at the time of collection. The collection of an adult female razorback sucker that is freely expressing gametes is very rare in the San Juan River and is usually indicative that spawning is taking place at the time and site of collection, thus the labeling of this site as a suspected spawning location. These two fish were collected less than ten feet apart from one another in the midst of numerous ripe, presumably-spawning flannelmouth sucker over a shallow cobble bar (< 2 feet deep) at the upstream mouth of a long secondary channel. The water temperature was 17°C at the site at the time of collection (i.e., ~5:30 PM). Substrate at the site ranged from small cobbles to pea-sized gravel.

These two fish had been stocked on two different stocking dates, the female having been stocked on 18 October 2000 at RM 158.6, and the male having been stocked on 31 October 2001 at RM 158.6. The female had been in the river for 1286 days post-stocking, while the male had been in the river for 908 days post-stocking. As has been observed in past years, fish from temporally-separated stockings appear to have located one another and suitable habitat for spawning (e.g., Ryden 2004).

In contrast to past years, the 2004 spawning aggregation did not take place on the ascending limb of the 2004 spring hydrograph. Rather, it occurred at almost the bottom of a trough between two distinct peaks of a relatively low-volume spring hydrograph. The first peak occurred on 5 April 2004 when flows in the river reached 4,760 CFS (as measured at the Shiprock USGS gage, # 09368000). Flows then dipped to a low trough of 949 CFS on 27 April 2004 (the spawning aggregation was documented the day before this low flow). Then flows rose again to 3,560 CFS on 11 May 2004. With one exception (i.e., the spring 2002 razorback sucker spawning aggregation at Slickhorn Rapid, which occurred at a base flow; Ryden 2004) razorback sucker spawning aggregations that were documented in past years (i.e., 1997, 1999, 2001) have occurred on a distinctly ascending limb of the spring hydrograph.

For the seventh consecutive year, crews from UNM collected larval razorback sucker 2004. A total of 41 larval razorback sucker were collected in 2004 from 130.1-8.1 between 15 May and 15 June (Brandenburg et al. 2005).

Unfortunately, this was a ten-fold decrease when compared to the number of larval razorback sucker that were collected in the San Juan River in 2003 (n = 472; Brandenburg et al. 2005). In addition to their larval collections, crews from UNM collected a single wild-produced juvenile razorback sucker (probably an age-1 fish = 124 mm TL) in 2004 at RM 70.0 (Brandenburg et al. 2005).

Sampling crews for other study elements also collected putatively wild-produced juvenile razorback sucker in 2004. UDWR-Moab collected four wild-produced juvenile razorback sucker (120-280 mm TL, all lacking PIT tags at the time of capture) in 2004 (Jackson 2005). Crews from BIO-WEST collected four putatively wild-produced razorback sucker (94, 64, 54, and 68 mm SL; collected at RM's 11.4, 37.4, 12.5, and 12.5, respectively) and two putative razorback sucker X flannelmouth sucker hybrids (95 and 62 mm SL; collected at RM's 17.5 and 12.5, respectively) during their March and July 2004 sampling trips in the lower canyon-bound sections of the San Juan River (Golden and Holden 2005).

The collection of larval razorback sucker for the seventh consecutive year, coupled with the apparent upswing in the number of young, untagged razorback sucker and razorback sucker X flannelmouth sucker hybrids indicates that spawning is continuing annually among stocked razorback sucker in the San Juan River. Recruitment, at least a limited amount of recruitment, through age-1 or age-2 is also occurring. Whether or not these smaller fish will survive to recruit into adulthood remains to be seen, however.

DISCUSSION

Objective 2a: Spawning Season Habitat Use And Movement Patterns

During the 26-30 April 2004 razorback sucker monitoring trip and the fall 2004 Adult Monitoring trip, most razorback sucker remained spatially separated from one another. Only one aggregation of two or more fish was documented by USFWS-CRFP crews in 2004. A suspected spawning aggregation containing one ripe adult female fish and ripe adult male fish was documented at RM 154.27 on 26 April 2004. This was labeled as a suspected spawning aggregation because of the presence of the ripe (i.e., freely expressing eggs) female fish. Collections of ripe female fish are very rare in the San Juan River and are usually indicative of spawning at or very near the site of the fish's collection. The collection of these two ripe adults over a clean cobble-gravel bar and being in the presence of large number of ripe (apparently spawning) flannelmouth sucker also argues for this being a spawning aggregation.

Most of the razorback sucker collected during our 2004 collections were first-time recaptures. In some ways, this seems very logical, since more razorback sucker were stocked in 2004 (n = 2,989) than had been stocked in any previous year. However, given the large number of razorback sucker that had been stocked in the previous ten years (n = 7,863 fish stocked from 1994-2003), it would seem as if a somewhat higher percentage of razorback sucker with two or more recaptures could be expected. One thing is certain however, the razorback sucker population between the Hogback Diversion stocking site (RM 158.6) and the town of Shiprock, NM is getting relatively large. Of the 179 razorback sucker collected on the two USFWS-CRFP sampling trips in 2004, over half (n = 97, or 54.2%) were collected within the first ten RM's up- or downstream of the Hogback Diversion stocking site (RM 158.6).

The large number of razorback sucker upstream of Shiprock, NM would seem to be a logical source for spawning groups which are producing the larval razorback sucker that crews from UNM have been collecting upstream of the previously-identified razorback sucker spawning area just downstream of Aneth, UT (i.e., at RM 100.2) over the last several years. One such spawning aggregation was indeed identified in 2004 at RM 154.27.

Given the "stacking up" of stocked razorback sucker that has been occurring just downstream of the Hogback Diversion stocking site over the past several low-flow years, it will be interesting to see whether or not these fish will redistribute themselves into downstream sections of the San Juan River, or whether they will remain in this upstream section of the San Juan River after the anticipated high spring 2005 runoff.

Objective 2b: Survival And Growth Rates

Survival

Between 1996 and 200, CPUE for razorback sucker in electrofishing collections remained low (< 0.2 fish/hr). Then, beginning in spring 2001, razorback sucker CPUE rose steadily, until it reached a high of 1.54 fish/hr on the spring 2004 razorback sucker monitoring trip (from RM 158.6-76.4) a two-fold increase over the 2003 CPUE value for this same section of river. On

the fall 2004 Adult Monitoring trip in this same river section razorback sucker CPUE rose to 2.46 fish/hr (from RM 158.6-76.4), a six-fold increase over the 2003 CPUE value for this same section of river.

In 2004, the large majority (81.6%) of razorback sucker recaptured from the San Juan River had been in the river < 201 days post-stocking. While this again seems to intuitively make sense, given the large number of razorback sucker (n = 2,989) that were stocked in 2004, the general lack of older fish (i.e., those that had been in the river > 1600 days post-stocking) is worrisome. These older fish were also not seen during 2003 collections. For the last two years especially, it appears as if the San Juan River razorback sucker population is composed mainly of fish that are less than four years old. There does not seem to be a large presence of fish that were stocked in the mid- to late 1990's still residing in the San Juan River. It will be important to track the length of time individual fish continue to reside in the San Juan River over the next several years. If older fish are indeed being lost from the San Juan River razorback sucker population (whether via emigration to Lake Powell or mortality) at around age-4 it may affect stocking strategies for the upcoming eight-year stocking effort (Ryden 2003b).

On the other hand, if older fish are indeed moving out of the San Juan River razorback sucker population, it makes it all the more remarkable that we have observed the spawning successes that we have among stocked razorback sucker over the last seven years. If stocked fish must get acclimated to the river, find appropriate spawning habitat and others of its own species and successfully reproduce all within the span of their first four years in the river, it means that the razorback sucker is truly an adaptable fish. Especially, given that only 10,852 razorback sucker have been stocked over the last 11 years (1994-2004) and that there are certainly many less than that (i.e., several hundred) surviving in the river at any given time.

As was stated earlier, since recapture data being used to generate the Schnabel multiple-census population estimate has been limited to a four consecutive trip time window, it now tracks much better with estimates being obtained by the Petersen population estimate (which uses data from two consecutive trips, but recapture data from only a single trip -- i.e., the second of these two consecutive trips). The Schnabel multiple-census population estimate indicated that there were 1,215 razorback sucker in the San Juan River from RM 158.6-2.9 (1,063 from RM's 158.6-76.4) in the fall of 2004. This same Schnabel multiple-census population estimate indicated that there were 571 razorback sucker in the San Juan River from RM 158.6-2.9 (500 from RM's 158.6-76.4) in fall 2003. Thus the san Juan River population essentially doubled between 2003 and 2004, with the stocking of the 2,989 fish during 2004. This fits in well with the idea that the San Juan River razorback sucker population is composed heavily of younger ($\leq$ 4 years old) fish.

The Petersen population estimate for RM's 158.6-76.4 indicated that there were 936 razorback sucker in the San Juan River in the spring of 2004. It is worth noting however, that the first sampling pass for this spring 2004 estimate (i.e., the April 26-30 razorback sucker monitoring trip) took place very soon after relatively heavy spring 2004 stockings of razorback sucker. Thus in 2004, the fall estimate is probably a better indicator of the actual number of razorback sucker surviving in the river. In either case, it appears that close to 1,000 razorback sucker (and possibly as many as 1,200) were resident in the San Juan River in the fall of 2004. Despite the differences in actual point estimate numbers between the two population estimate models, they both show the same general trend in the San Juan River razorback sucker population. This trend indicates that since fall 2000, the San Juan River razorback sucker population has been on the rise. However, since the San Juan

River razorback sucker population appears to be composed of mostly younger fish, point estimates obtained via population estimates may depend heavily upon the number of fish being stocked annually.

The population estimate data corresponds well with the CPUE data from electrofishing collections. Between the two, they indicate that the razorback sucker population in the San Juan River is increasing, but that increase is composed largely of younger, more recently-stocked fish, that are inhabiting the river in increasing numbers upstream of Shiprock, NM. Given this data, the issue of trying to increase longer-term survival/retention among stocked adult razorback sucker may become critical. The idea of the razorback sucker augmentation program was to establish a long-term, self-sustaining population in the San Juan River. If stocked fish are only remaining in the population for about four years and recruitment of wild-produced fish remains low (as has been the case so far), the San Juan River razorback sucker population may not survive at a sustainable level for very long once artificial augmentation efforts cease. Luckily, we have at least eight to ten more years (given the upcoming eight-year augmentation effort specified in Ryden 2003b) to try to remedy the long-term retention problem.

Growth

The faster growth rates observed in razorback sucker stocked at < 351 mm TL were expected. Most species of fish exhibit a period of rapid growth early in life and a subsequent period of more gradual increases as they mature (Van den Avyle 1993). As in previous years, known female razorback sucker once again increased in TL faster than did known males, post-stocking. In general, stocked razorback sucker in the San Juan River grow rapidly until they reach about age-4, at which time growth slows considerably. However, fairly large absolute increases in TL (i.e., almost 18 mm annually) were still observed in some stocked fish as late as age-10.

The growth curve developed for stocked razorback sucker acts as a tool to judge the relative age of untagged razorback sucker. Currently, very few wild-produced razorback sucker (other than larvae being collected by crews from UNM) are being collected in the San Juan River. However, when wild-produced progeny of stocked fish successfully are collected, this growth curve will provide a tool to make an educated guess as to their age.

Objective 2c: Determine Whether Hatchery-Reared Razorback Sucker Will Recruit Into The Adult Population And Successfully Spawn In The Wild

On 26 April 2004, a suspected spawning aggregation of razorback sucker was documented at RM 154.27. The two known-origin adult razorback sucker (one male and one female, both ripe) associated with this suspected spawning aggregation were different ages and had come from different stocking dates, although both had been stocked at RM 158.6. This aggregation occurred during the fourth week of April. Previously-identified spawning aggregations of razorback sucker in the San Juan River had all occurred between the middle of April and the third week of May (Ryden 2000c, 2003a, 2004). In addition, this group of spawning razorback sucker were collected over a substrate of clean cobbles and gravels. In these respects (i.e., timing, make-up, and substrate), this suspected spawning aggregation was very much like many of its predecessors, documented at RM 100.2 in 1997, 1999, 2001, and 2002 (Ryden 2000c, 2003a, 2004).

However, the 2004 suspected spawning aggregation was also different from most of its documented predecessors in one respect. This aggregation of fish did not occur on the ascending limb of the spring hydrograph as did preceding aggregations of suspected spawning fish. Rather, it occurred during a low-flow trough between two distinct peaks in what was otherwise a relatively low-volume spring hydrograph. In this respect, this spawning aggregation was more like the razorback sucker spawning aggregation documented at Slickhorn Rapid (RM 17.6) on 18 April 2002 which occurred at essentially a base-flow condition (Jackson 2003, Ryden 2004).

So, it is evident that adult razorback sucker continue to locate one another after stocking and will aggregate to spawn in many different types of habitats, and apparently at many different flow conditions as well, throughout the San Juan River.

The collection of larval razorback sucker in 2004 continues to attest to the successful spawning of stocked razorback sucker in the San Juan River. Documented reproduction by stocked fish has now occurred for seven consecutive years (1998-2004). The documenting of a razorback sucker spawning site at RM 154.27 finally answers some of the questions about previous year's collections of larval razorback sucker that were occurring upstream (e.g., at RM 134.5 in 2002) of the Aneth, UT spawning site (RM 100.2), which up until 2004 was the most upstream documented razorback sucker spawning site in the San Juan River. It appears that stocked razorback sucker are spawning within just a few miles downstream of the Hogback Diversion spawning site (RM 158.6).

In 2004, a handful of wild-produced juvenile razorback sucker were collected in the San Juan River. This is an encouraging sign. It is hoped that as numbers of stocked adult fish in the river increase, collections of age-1+ fish will increase correspondingly in coming years. For it is only through successful reproduction and the subsequent survival and recruitment of these wild-produced juvenile fish that a self-sustaining population of razorback sucker can become established in the San Juan River.

LITERATURE CITED

Brandenburg, W. H. 2000. Razorback sucker larval fish survey: San Juan River 1998 and 1999. Division of Fishes, Museum of Southwestern Biology, University of New Mexico, Albuquerque. 46 pp.

Brandenburg, W. H., M. A. Farrington, and S. J. Gottlieb. 2001. Razorback sucker larval fish survey: San Juan River 2000. Division of Fishes, Museum of Southwestern Biology, University of New Mexico, Albuquerque. 34 pp.

Brandenburg, W. H., M. A. Farrington, and S. J. Gottlieb. 2002. Razorback sucker larval fish survey: San Juan River 2001. Division of Fishes, Museum of Southwestern Biology, University of New Mexico, Albuquerque. 34 pp.

Brandenburg, W. H., M. A. Farrington, and S. J. Gottlieb. 2003. Razorback sucker larval fish survey in the San Juan River during 2002. Division of Fishes, Museum of Southwestern Biology, University of New Mexico, Albuquerque. 48 pp.

Brandenburg, W. H., M. A. Farrington, and S. J. Gottlieb. 2004. Razorback sucker larval fish survey in the San Juan River during 2003 (Draft Report). Division of Fishes, Museum of Southwestern Biology, University of New Mexico, Albuquerque. 55 pp.

Brandenburg, W. H., M. A. Farrington, and S. J. Gottlieb. 2005. Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2004 (Draft Report). Division of Fishes, Museum of Southwestern Biology, University of New Mexico, Albuquerque. 92 pp.

Brooks, J. E., L. Crist, L. A. Ahlm, R. Bliesner, M. J. Buntjer, W. P. Goettlicher, K. Lashmett, W. J. Miller, D. L. Propst, and D. W. Ryden. 1993. San Juan River Seven Year Research Program: Summary Report 1992. San Juan River Recovery Implementation Program, Dexter, NM. 20 pp.

Buntjer, M. J., T. Chart, and L. Lentsch. 1993. Early life history investigations. Utah Division of Wildlife Resources , Salt Lake City, UT. 35 pp.

Buntjer, M. J., T. Chart, and L. Lentsch. 1994. Early life history fishery survey of the San Juan River, New Mexico and Utah. Utah Division of Wildlife Resources , Salt Lake City, UT. 48 pp.

Burdick, B. D. 1992. A plan to evaluate stocking to augment or restore razorback sucker in the Upper Colorado River. U.S. Fish and Wildlife Service, Grand Junction, CO. 56 pp.

Gido, K. B., and D. L. Propst. 1994. San Juan River secondary channel community studies permanent study sites: 1993 Annual Report (Final). New Mexico Department of Game and Fish, Santa Fe, NM. 42 pp.

Golden, M. E., and P. B. Holden. 2005. Retention, growth, and habitat use of stocked Colorado pikeminnow in the San Juan River: 2003-2004 Draft Annual Report. BIO-WEST, Inc., Logan, UT. 76 pp.

Jackson, J. A. 2003. Nonnative control in the lower San Juan River: 2002. Utah Division of Wildlife Resources, Moab, UT. 16 pp. + appendix.

Jackson, J. A. 2005. Nonnative control in the lower San Juan River: 2004. Utah Division of Wildlife Resources, Moab, UT. 28 pp.

Jordan, D. S. 1891. Report of the explorations in Colorado and Utah during the summer of 1889, with an account of the fish found in each of the river basins examined. Bulletin of the U.S. Fish Commission. Volume IX:1-40.

Koster, W. J. 1960. Ptychocheilus lucius (Cyprinidae) in the San Juan River, New Mexico. Southwestern Naturalist 5:174-175.

Lashmett, K. 1993. Fishery survey of the lower San Juan River and the upper Arm of Lake Powell (RM 4.0-[-]11.0) 1991/92 - Annual Report. Bureau of Reclamation, Durango, CO. 29 pp.

Lashmett, K. 1994. Fishery survey of the lower San Juan River and the upper Arm of Lake Powell (RM 4.0-[-]0.8) 1993 - Annual Report. Bureau of Reclamation, Durango, CO. 11 pp. + Appendix.

Maddux, R. H., L. A. Fitzpatrick, and W. A. Noonan. 1993. Colorado River endangered fishes Critical Habitat: Draft Biological Support Document and appendices. U.S. Fish and Wildlife Service, Salt Lake City, UT. 222 pp. + appendices.

Minckley, W. L., P. C. Marsh, J. E. Brooks, J. E. Johnson, and B. L. Jensen. 1991. Management toward recovery of the razorback sucker. Pages 303-357 in W. L. Minckley and J. E. Deacon, editors. Battle against extinction. University of Arizona Press, Tucson, AZ. 517 pp.

Olson, H. F. 1962. State-wide rough fish control: Rehabilitation of the San Juan River. Job Completion Report for Job Number C-16-4, Federal Aid Project F-19-D-4, New Mexico Dept. of Game and Fish, Santa Fe, NM. 6 pp.

Platania, S. P. 1990. Biological summary of the 1987-1989 New Mexico-Utah ichthyofaunal study of the San Juan River. Report to the New Mexico Dept. of Game and Fish, Santa Fe, NM, and the U.S. Bureau of Reclamation, Salt Lake City, UT. 143 pp.

Ryden, D. W. 1997. Five-year augmentation plan for razorback sucker in the San Juan River. U.S. Fish and Wildlife Service, Grand Junction, CO. 27 pp.

Ryden, D. W. 2000a. Monitoring of experimentally stocked razorback sucker in the San Juan River: March 1994 through October 1997. U.S. Fish and Wildlife Service, Grand Junction, CO. 132 pp.

Ryden, D. W. 2000b. Adult fish community monitoring on the San Juan River, 1991-1997. U.S. Fish and Wildlife Service, Grand Junction, CO. 269 pp.

Ryden, D. W. 2000c. 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). U.S. Fish and Wildlife Service, Grand Junction, CO. 49 pp.

Ryden, D. W. 2001. Monitoring of razorback sucker stocked into the San Juan River as part of a five-year augmentation effort: 2000 Interim Progress Report (Final). U.S. Fish and Wildlife Service, Grand Junction, CO. 83 pp.

Ryden, D. W. 2003a. Long-term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 1999-2001 Integration Report. U.S. Fish and Wildlife Service, Grand Junction, CO. 127 pp. + Appendices.

Ryden, D. W. 2003b. An augmentation plan for razorback sucker in the San Juan River: An addendum to the five-year augmentation plan for razorback sucker in the San Juan River (Ryden 1997). U.S. Fish and Wildlife Service, Grand Junction, CO. 32 pp.

Ryden, D. W. 2004. Augmentation and monitoring of the San Juan River razorback sucker population: 2002-2003 Interim Progress Report (Final). U.S. Fish and Wildlife Service, Grand Junction, CO. 54 pp.

Ryden, D. W. 2005a. An augmentation plan for razorback sucker in the San Juan River. Addendum # 2: Justification for changing the beginning date of the eight-year stocking period (Final). U.S. Fish and Wildlife Service, Grand Junction, CO. 4 pp.

Ryden, D. W. 2005b In Prep. Long-term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2004 Interim Progress Report. U.S. Fish and Wildlife Service, Grand Junction, CO.

Ryden, D. W, and F. K. Pfeifer. 1993. Adult fish collections on the San Juan River (1991-1992): Annual Progress Report. U.S. Fish and Wildlife Service, Grand Junction, CO. 69 pp.

Ryden, D. W., and F. K. Pfeifer. 1994a. An experimental stocking plan for razorback sucker in the San Juan River. U.S. Fish and Wildlife Service, Grand Junction, CO. 26 pp.

Ryden, D. W., and F. K. Pfeifer. 1994b. Adult fish community monitoring on the San Juan River: 1993 Annual Progress Report. U.S. Fish and Wildlife Service, Grand Junction, CO. 84 pp.

Ryden, D. W., and F. K. Pfeifer. 1995. Adult fish community monitoring on the San Juan River: 1994 Annual Progress Report. U.S. Fish and Wildlife Service, Grand Junction, CO. 94 pp.

Ryden, D. W., and F. K. Pfeifer. 1996. Adult fish community monitoring on the San Juan River: 1995 Annual Progress Report. U.S. Fish and Wildlife Service, Grand Junction, CO. 46 pp. + appendices.

San Juan River Recovery Implementation Program Biology Committee. 1995. San Juan River Basin Recovery Implementation Program: Program Document. U.S. Fish and Wildlife Service, Albuquerque, NM. 56 pp.

U.S. Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants: the razorback sucker (Xyrauchen texanus) determined to be an endangered species. Dept. of the Interior, U.S. Fish and Wildlife Service, Federal register, 23 October 1991, 56:54957-54967.

U.S. Fish and Wildlife Service. 1994. Determination of critical habitat for the Colorado River endangered fishes; razorback sucker, Colorado pikeminnow, humpback chub, and bonytail chub. Dept. of the Interior, U.S. Fish and Wildlife Service, Federal Register, 21 March 1994, 59:13374-13400.

Van den Avyle, M. J. 1993. Dynamics of exploited fish populations. Pages 105-135 in C. C. Kohler and W. A. Hubert (eds.). Inland fisheries management in North America. American Fisheries Society, Bethesda, MD. 594 pp.

VTN Consolidated, Inc. and Museum of Northern Arizona. 1978. Fish, wildlife and habitat assessment; San Juan River, New Mexico and Utah. Gallup-Navajo Indian Water Supply Project. VTN Consolidated, Inc., Irvine, CA. 241 pp.

APPENDIX A

Point estimates generated for the Petersen population estimate and the Schnabel multiple-census population estimate, 1995-2004.

Table A-1. Petersen population estimates (using Bailey's modification) for stocked razorback sucker (RM 158.6-76.4) on spring razorback sucker monitoring trips and fall Adult Monitoring trips, 1995-2004.

Petersen Population Estimates (RM 158.6-76.4):	
USFWS-CRFP Monitoring Trip	Petersen Population Estimate
Spring 1995	48
Fall 1995	120
Spring 1996	150
Fall 1996	80
Spring 1997	140
Fall 1997	95
Spring 1998	68
Fall 1998	95
Spring 1999	196
Fall 1999	104
Spring 2000	135
Fall 2000	44
Spring 2001	105
Fall 2001	36
Spring 2002	133
Fall 2002	225
Spring 2003	216
Fall 2003	459
Spring 2004	936

Table A-2. Extrapolated "riverwide" (i.e., RM 158.6-2.9) population estimates for stocked razorback sucker, based on 87.5% of recaptures on the fall 1995-2004 Adult Monitoring trips (RM 158.6-2.9) being collected in the area covered by the Petersen population estimate (i.e., 158.6-76.4).

USFWS-CRFP Monitoring Trip	Extrapolated Population Estimate (for RM 158.6-2.9)
Fall 1995	137
Fall 1996	91
Fall 1997	109
Fall 1998	109
Fall 1999	119
Fall 2000	50
Fall 2001	41
Fall 2002	257
Fall 2003	524

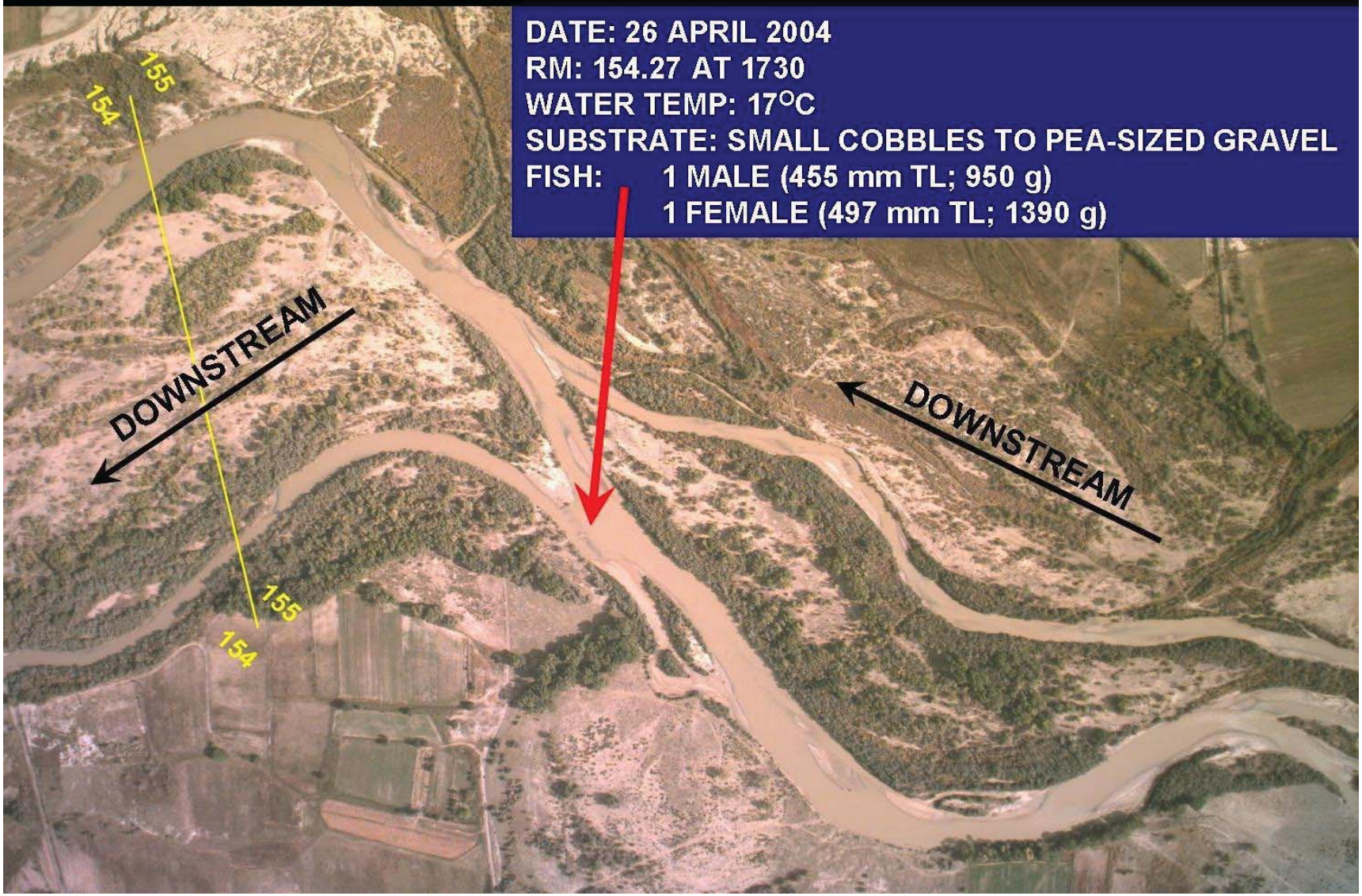
Table A-3. Schnabel multiple-census population estimates for stocked razorback sucker (RM 158.6-76.4) on spring razorback sucker monitoring trips and fall Adult Monitoring trips, 1995-2004.

Schnabel Multiple-Census Population Estimates (RM 158.6-76.4):		
USFWS-CRFP Monitoring Trip	Schnabel Population Estimate	95% Confidence Interval (C.I.)
Fall 1995	80	14-702
Spring 1996	180	32-702
Fall 1996	305	54-939
Spring 1997	54	19-272
Fall 1997	70	19-700
Spring 1998	39	13-195
Fall 1998	18	6-27
Spring 1999	17	8-41
Fall 1999	14	7-34
Spring 2000	11	5-28
Fall 2000	15	7-40
Spring 2001	66	22-328
Fall 2001	85	33-338
Spring 2002	162	55-812
Fall 2002	335	114-1,676
Spring 2003	365	124-1,823
Fall 2003	500	170-2,501
Spring 2004	579	282-1,449
Fall 2004	1,063	594-2,166

Table A-4. Extrapolated "riverwide" (RM 158.6-2.9) population estimates for stocked razorbacks sucker, based on 87.5% of recaptures on 1995-2004 fall Adult Monitoring trips (RM 158.6-2.9) being collected in the area covered by the Schnabel multiple-census population estimate (RM 158.6-76.4).

USFWS-CRFP Monitoring Trip	Extrapolated Population Estimate (for RM 158.6-2.9)
Fall 1995	91
Fall 1996	349
Fall 1997	80
Fall 1998	21
Fall 1999	16
Fall 2000	17
Fall 2001	97
Fall 2002	383
Fall 2003	571
Fall 2004	1,215

APPENDIX B

A map of the suspected razorback spawning bar at RM 154.27.

RAZORBACK SUCKER SPAWNING SITE?