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

2002-2003 Interim Progress Report

(Final)

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EXECUTIVE SUMMARY

The 2002-2003 time period was an interim period between the two "official" razorback sucker augmentation efforts (i.e., 1997-2001 and 2004-2011). During this interim period, a total of 1027 razorback sucker were stocked into the San Juan River, 140 in 2002 and 887 in 2003. Including these fish, a total of 7,863 razorback sucker were stocked into the San Juan River between March 1994 and October 2003.

Stocked fish were monitored via radio telemetry and electrofishing. Radiotelemetered razorback sucker remained spatially separated during presumed spawning periods in 2002 and 2003. Likewise, there were no aggregations of PIT-tagged razorback sucker identified during 2002 or 2003 razorback sucker monitoring trips. Collections of PIT-tagged fish recaptured for the third (or more) time since stocking in 2002 and 2003 indicated that during that time period, more razorback sucker were residing in the river section immediately downstream of the Hogback Diversion stocking site (i.e., RM 158.6-150.0) than in previous years, when stocked fish tended to disperse to downstream river reaches following high flow events.

In 2002, a total of seven razorback sucker were recaptured on razorback sucker monitoring trips. Another 56 were recaptured during other 2002 sampling efforts. In 2003, a total of 24 razorback sucker were recaptured on razorback sucker monitoring trips, with another 156 being recaptured during other 2003 sampling efforts. Razorback sucker CPUE increased steadily between spring 2000 and spring 2003 razorback sucker monitoring trips, reaching a high of 0.74 fish per hour of electrofishing on the spring 2003 razorback sucker monitoring trip. However, razorback sucker CPUE declined slightly between the fall 2002 and fall 2003 sub-adult and adult large-bodied fish community monitoring trips ("adult monitoring" for short). This drop in razorback sucker CPUE was likely due, at least in part, to a large, storm-induced flow spike that occurred just prior to the fall 2003 adult monitoring trip. This flow spike, which peaked at > 20,000 CFS downstream of Bluff, UT appears to have displaced fish of all species.

The majority of razorback sucker recaptured in 2002 and 2003 were fish that had been in the river $\leq$ 1200 post-stocking. This indicates that the longevity of razorback sucker in the San Juan River post-stocking is relatively short, probably less than five years on average. A few razorback sucker from the 1994-1996 stockings do still remain in the San Juan River, however, their numbers appear to be dwindling over time.

A Lincoln-Petersen population estimate for razorback sucker recaptured in 2002 estimated that there were 290 razorback sucker from RM 158.6-2.9 in the fall of 2002. A Lincoln-Petersen population estimate for razorback sucker recaptured in 2003 estimated that there were 591 razorback sucker from RM 158.6-2.9 in the fall of 2002.

Growth information obtained from recaptured razorback sucker indicated that fish stocked at < 351 mm TL grew almost twice as fast (0.09 mm per day) as did those stocked at > 350 mm TL (0.05 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.

Crews from UDWR identified a suspected spawning aggregation of razorback sucker centered around Slickhorn Rapid (RM 17.6) in the lower San Juan River on 18 April 2002. They recaptured six razorback sucker, five of which were ripe, male fish, and observed another 10 razorback sucker that they were unable to net. Of the six recaptures, only five had detectable PIT tags at the time of recapture. All but one of them had been stocked at the Hogback Diversion stocking site (one came from the Bluff stocking site), but they were all stocked on different dates. Unlike suspected razorback sucker spawning aggregations that were identified at RM 100.2 (in 1997, 1999, and 2001), the 2002 Slickhorn Rapid aggregation did not take place on the ascending limb of the spring hydrograph.

Crews from UNM collected larval razorback sucker on both 2002 (n = 812) and 2003 (n = 472). Thus, it has been verified that stocked razorback sucker have successfully spawned in each of the last six years (1998-2003). In 2002, larval razorback sucker were collected as far upstream as RM 134.5. This collection indicates the presence of an as yet unidentified razorback sucker spawning area upstream of RM 134.5, possibly in the river section immediately downstream of Hogback Diversion, where stocked are currently heavily concentrated.

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INTRODUCTION

Razorback sucker (Xyrauchen texanus), is one of three San Juan River native fish species (the Colorado pikeminnow, Ptychocheilus lucius, and the roundtail chub, Gila robusta being the other two) that have become greatly reduced in numbers and range since the turn of the century (Burdick 1992). Physical alterations of riverine habitats, water impoundment in the form of Navajo Reservoir and Lake Powell and 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).

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, scheduled to begin in 2004 and continue through 2011.

This report provides an overview of the 2002-2003 interim period between the two distinct razorback sucker augmentation efforts (i.e., 1997-2001 and 2004-2011), including information on the fish that were stocked and/or recaptured during this interim period.

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 2002. The 6-Pack Ponds were all stocked with age-1 (2001 year-class) fish, while East Avocet Pond, West Avocet Pond and Hidden Pond were stocked with larval fish (2002 year-class; Table 1) in 2002. Age-1 fish stocked into the 6-Pack Ponds in 2002 were all originally spawned at the USFWS's 24-Road Hatchery in Grand Junction, CO. The larval fish stocked into the other three ponds all came from Dexter National Fish Hatchery (NFH) in Dexter, NM.

In 2003, only five of the nine grow-out ponds were stocked. Three of the 6-Pack Ponds (# 2, # 3, and # 4) were stocked with age-1 (2002 year-class) fish from the 24-Road Hatchery (Table 1) in 2003. In 2003, Hidden Pond was drained to help clear out weeds and allow for the installation of a gravity drain and salamander fence. Salvage efforts, consisting of fyke-netting and seining, took place from 7-11 July and 4-7 August 2003. The razorback sucker salvaged during the draining of Hidden Pond were stocked into East Avocet (n = 618) and West Avocet (n = 556) ponds (Table 1). In addition East and West Avocet Pond were both stocked with age-0 (2003 year-class) fish from Dexter NFH in 2003.

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 2002, fish were harvested from grow-out ponds using fyke nets during the week of 4-8 November. In 2003, fish were harvested from grow-out ponds using fyke nets during the weeks of 14-18 April and 27-31 October. These fish 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 both 2002 and 2003, razorback sucker from two outside sources were also stocked into the San Juan River. The first outside source was 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 22 April 2002 and again on 14 April 2003. All of these fish were individually-marked with PIT tags before being released into the wild.

The second outside source was fish that were reared in aquaria, then stocked by students from Ignacio HS in Ignacio, CO as part of an I&E effort through the Colorado Division of Wildlife (CDOW) office in Grand Junction, CO. These fish were all stocked at Lion's Park near Farmington, NM (RM 178.2) on 11 April 2002 and again on 19 May 2003. All of these fish were individually-marked with PIT tags before being released into the wild.

Table 1. An overview of razorback sucker stocked into the SJRIP's grow-out ponds, 1999-2003:

Pond Name:	Years Stocked:	Total Number Of Fish Stocked In Ponds By Year:	Details About Fish Stocked Into Grow-Out Ponds:
East Avocet Pond	1999 2000 2001 2002 2003	1999 = 30,189 2000 = 20,000 2001 = 10,000 2002 = 20,000 2003 = 1,377 Total = 81,566 (6 year-classes)	Stocked with larval fish each year from 1999-2003 NOTE 1: in 1999, 189 fish that were 200-300 mm TL (i.e., 1997 year-class) were stocked into this 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
West Avocet Pond	1999 2000 2001 2002 2003	1999 = 17,500 2000 = 20,000 2001 = 10,000 2002 = 20,000 2003 = 1,315 Total = 68,815 (5 year-classes)	Stocked with larval fish each year from 1999-2003 NOTE: in 2003, 556 juvenile and adult fish salvaged from Hidden Pond were stocked into West Avocet Pond
Hidden Pond	2000 2001 2002	2000 = 60,000 2001 = 20,000 2002 = 20,000 Total = 100,000 (3 year-classes)	Stocked with larval fish each year from 2000-2002 NOTE: in 2003, Hidden Pond was drained and the fish that were salvaged were stocked in East and West Avocet Ponds
6-Pack Pond # 1	2002	2002 = 4,154 Total = 4,154 (1 year-class)	Stocked with age-1 fish (2"-6")
6-Pack Pond # 2	2002 2003	2002 = 4,154 2003 = 1,734 Total = 5,888 (2 year-classes)	Stocked with age-1 fish (2"-6") in both 2002 and 2003
6-Pack Pond # 3	2002 2003	2002 = 4,153 2003 = 1,762 Total = 5,915 (2 year-classes)	Stocked with age-1 fish (2"-6") in both 2002 and 2003
6-Pack Pond # 4	2002 2003	2002 = 4,153 2003 = 1,568 Total = 5,721 (2 year-classes)	Stocked with age-1 fish (2"-6") in both 2002 and 2003
6-Pack Pond # 5	2002	2002 = 4,452 Total = 4,452 (1 year-class)	Stocked with age-1 fish (2"-6")
6-Pack Pond # 6	2002	2002 = 5,093 Total = 5,093 (1 year-class)	Stocked with age-1 fish (2"-6")

RESULTS

In 2002, a total of 140 razorback sucker were stocked into the San Juan River (Table 2). Of the 140 razorback sucker stocked in 2002, only 25 (mean TL = 351 mm; range = 295-456 mm TL) were harvested from the SJRIP's grow-out ponds (Table 2). The reason for this was that an arctic cold front (i.e., bitter cold air temperatures) descended into the Farmington area the week harvest efforts were to take place, causing pond temperatures to drop to about 4° C. These cold temperatures precluded fish from actively moving in the grow-out ponds, thus making passive gear types (fyke nets) ineffective. A total of 102 razorback sucker (mean TL = 335 mm; range = 240-470 mm TL) from the Page golf course ponds were stocked on 22 April 2002 (Table 2). Another 13 razorback sucker (mean TL = 137 mm; range = 110-170 mm TL)from Ignacio HS were stocked on 11 April 2002 (Table 2).

In 2003, a total of 887 razorback sucker were stocked into the San Juan River (Table 2). Of the 887 razorback sucker stocked in 2003, 755 were harvested from the SJRIP's grow-out ponds, 70 (mean TL = 380 mm; range = 255-495 mm TL) from 14-18 April 2003 and another 685 (mean TL = 309 mm; range = 253-396 mm TL) from 27-31 October. A total of 121 razorback sucker (mean TL = 413 mm; range = 341-491 mm TL) from the Page golf course ponds were stocked on 14 April 2003 (Table 2). Another 11 razorback sucker (mean TL = 124 mm; range = 100-150 mm TL)from Ignacio HS were stocked on 19 May 2003 (Table 2).

Table 2. Stockings of razorback sucker into the San Juan River in 2002 and 2003 and subsequent first-time recaptures as of 31 December 2003.

Date(s) Stocked	River Mile Stocked At	Number Of Fish Stocked	Mean TL (Range) At Stocking	Number Of Individuals Recaptured	Percent Of All Fish Stocked That Have Been Recaptured
Razorback Sucker Stocked In 2002 (n = 140):					
11 April	178.2	13	137(110-170)	0	0.0%
22 April	158.6	102	335(240-470)	18	17.6%
5-6 November	158.6	25	351(295-456)	1	4.0%
Razorback Sucker Stocked In 2003 (n = 887):					
14 April	158.6	121	413(341-491)	12	9.9%
14-18 April	158.6	70	380(255-495)	10	14.3%
19 May	178.2	11	124(100-150)	0	0.0%
27-31 October	158.6	685	309(253-396)	32	4.7%

DISCUSSION

The 2002-2003 time period was an interim period between the two "official" razorback sucker augmentation efforts (1997-2001 and 2004-2011) in the San Juan River, outlined in the razorback sucker augmentation plans (Ryden 1997, 2003b). From 2002-2003 a total of 1027 razorback sucker were stocked into the San Juan River. These fish came from a number of sources including the SJRIP's grow-out ponds, the Page, AZ golf-course ponds (maintained by UDWR) and the CDOW's I&E program.

The upcoming eight-year augmentation effort for razorback sucker in the San Juan River is scheduled to begin in 2004 (Ryden 2003b). The augmentation plan for this effort calls for 11,400 age-2+ fish ($\geq$ 300 mm TL) to be stocked annually from 2004-2011. Fish from the SJRIP's grow-out ponds as well as other appropriate sources, such as those used in 2002 and 2003, will be utilized to help meet these yearly stocking goals. The SJRIP currently has 25 acres of grow-out ponds in production.

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 passively via radio telemetry and 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.

Radio Telemetry

In order for a razorback sucker to be chosen for implantation with a radio transmitter ("tag"), it must meet three criteria. First, it must have been recaptured upstream of Sand Island boat launch (RM 76.4 - near Bluff, UT). The logic behind this criterion was that radio-tagged fish often display large downstream movements immediately following radio tag implantation. Since we were trying to locate spawning areas and observe habitat use upstream of the canyon-bound reaches (RM 68.0 and downstream) of the San Juan River and since it is very hard, logistically, to track fish on a regular basis once they are downstream of Sand Island (RM 76.4), razorback sucker were not implanted with radio tags downstream of that point. Second, a recaptured razorback sucker must be 400 mm TL (or very close to that length) at the time of recapture. This criterion was used to ensure that implanted fish were mature, adult fish that might lead researchers to spawning aggregations of razorback sucker. Lastly, the fish in questions must have been in the San Juan River for at least one year before being implanted. This criterion was adopted to try to insure that we were not implanting newly-stocked (i.e., stressed and/or disoriented) fish with radio tags. This criterion would hopefully keep us from wasting time and resources on subsequent radio telemetry trips, by preventing us from observing a fish that was not acting like a "normal," wild fish and that was unlikely to be spawning during the upcoming spring.

Razorback sucker that met all three of these criteria were surgically-implanted with ATS brand radio tags on the fall 2001 and fall 2002 sub-adult and adult large-bodied fish community monitoring ("adult monitoring" for short) trips. These internally-implanted tags had a trailing antenna and a one-year (expected) life span. On the fall 2001 adult monitoring trip, five razorback sucker were implanted with radio tags. On the fall 2002 adult monitoring trip, four razorback sucker were implanted with radio tags. Even though razorback sucker don't spawn until the spring, they were implanted on the fall adult monitoring trips to allow them to heal completely before the

upcoming spawning season.

Radio telemetry trips began in late February and continued through June of each year. Trips were done every three to four weeks until or unless a suspected spawning aggregation of razorback sucker was identified. If this happened, trips were performed biweekly or even weekly.

Two types of radio telemetry contacts were made with razorback sucker, movement contacts and habitat observation contacts. Movement contacts, consisted of observing the fish for a minimum of one hour, recording the radio tag number, date, RM of contact, and general habitat types being utilized. Movement contacts were used to help pinpoint if and when radiotelemetered razorback sucker were beginning to aggregate for spawning.

The second type of radio telemetry contact, the habitat observation contact, was done only if the razorback sucker contacted were suspected to be part of a spawning aggregation. This type of contact consisted of locating a fish via radio telemetry and monitoring its movement for a minimum of one hour. During this time, the amount of time the fish spent in each habitat type and all movements made by the fish were marked on a transparent acetate sleeve laid over a hardcopy of aerial videography of the river channel that matched the flow in the river at that time. At the end of one hour, all available habitats were mapped (for the entire width of the river channel) at the fish location and from 100 meters upstream of the fish's most upstream location during the contact period to 100 meters downstream of the fish's most downstream location during the contact period (i.e., the "contact area"). Habitat classifications used for mapping were those defined by Bliesner and Lamarra (1993). Upon return from the field, the transparent sleeves were laid over a small-scale grid and relative percentages of each habitat type available to a given fish at the location area were determined.

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

Electrofishing

Razorback sucker monitoring trips had the following sampling protocol. In 2002, the razorback sucker monitoring study area consisted of RM 158.6 (Hogback Diversion) to 76.4 (Sand Island boat launch). In 2003, this study area was expanded to include the lower, canyon-bound reaches of the San Juan River (RM 158.6-2.9). This sampling was performed from mid-April to mid-May of each year.

On razorback sucker monitoring trips, electrofishing proceeded 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-mile 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 study. Common native fishes were returned alive to the river.

Captured specimens of rare native fish (razorback sucker, Colorado pikeminnow, and roundtail chub) were anesthetized using MS-222 (200 mg/L of water), weighed, measured, checked for a PIT tag, and examined for general health and reproductive status (if apparent). If no PIT tag was detected, one was implanted. River mile of capture (to the nearest 0.1 RM) was noted, if specifically known. In many electrofishing samples the crew was unaware that they had collected a rare fish until the end of the sample when fish were being sorted. In these instances, the exact collection location was impossible to determine, so the point of release was used 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 fro San Juan River studies. 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

If habitat observation contacts had been made with aggregations of spawning fish, radiotelemetry data were then analyzed to determine what particular habitat types adult razorback sucker select during spawning. To do this, habitat use was compared to habitat availability (Swanson et al. 1974, Johnson 1980, Osmundson et al. 1995). Selection, or lack thereof, for a particular habitat type was estimated by the average difference between the percent that each individual habitat type contributes to the total water area available to an individual fish (within a given contact area) and the percent frequency of use of each individual habitat type by each individual fish. If there is no selection, fish should be located in the various habitat types at the same frequency as the occurrence or availability of those habitat types. For example, if 20% of the total water area is comprised of pool habitat, one would expect 20% of the fish locations to be in pools if habitat use was random (i.e., no selection). If a fish exhibits a selection for certain habitat types (i.e., more use than availability would predict), it is assumed

that those habitat types are important in fulfilling some biological need for the fish.

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

It was also assumed that the combination of habitats, adjacent to one another, would play a role in a fishes site selection process during spawning. Habitat richness, the number of individual available habitat types observed (i.e., mapped) within each contact area during each individual fish contact, was averaged across all contacts in a given calendar month, riverwide, all years combined. The habitat richness value for each month determines the number of habitat types it is felt to be important to manage for adult razorback suckers. For example, if the mean habitat richness for all June contacts, all years combined, was six, we assume that a block of six habitat types is therefore important in fulfilling a biological need for the fish.

Generalized movement patterns were analyzed among both radiotelemetered fish and PIT-tagged fish that had been recaptured for the third (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 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 San Juan River studies 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).

Schnabel and Lincoln-Petersen (using Bailey's modification for low numbers of recaptured fish) population estimates (Van den Avyle 1993) were performed for spring razorback sucker monitoring trips and fall adult monitoring trips, for 1995-2003, to determine the size of the razorback sucker population in the common sampled area, 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., 77.6%) on fall sampling trips, which sampled from RM 158.6-2.9, 1995-2003. In other words to extrapolate the Schnabel or Lincoln-Petersen estimate to the larger area:

(population estimate value/77.6)(100)= "riverwide" estimate*

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

During both spring 2002 and spring 2003, radiotelemetered razorback sucker remained spatially separated from one another (Figure 1). Only one of these radio-telemetered fish (a 393 mm TL male when it was captured and implanted with a radio tag on 27 September 2001) was located near the known spawning area at RM 100.2 (described in Ryden 2000a, 2001) during a suspected a spawning period (i.e., on 2 May 2002; Figure 1). However, during that contact, this fish was contacted on the opposite side of the river from the previously-used spawning bar, using a swift, main-channel run habitat over a shifting sand substrate. No other razorback sucker were contacted near it or recaptured via electrofishing in the adjacent area. The previously-used spawning bar (along the river right shoreline) at RM 100.2 was completely out of the water and buried in a thick, silty mud. Likewise, no aggregations of spawning razorback sucker were identified via electrofishing collections during the razorback sucker monitoring trips in either 2002 or 2003.

However, on 18 April 2002, during a nonnative fish removal trip being conducted by the UDWR, crews collected a total of six adult razorback sucker (mean TL = 491 mm; range = 478-505 mm TL) from RM 18.0-17.5 (Jackson 2003). This is the area centered immediately around Slickhorn Rapid. Five of these six fish were ripe males, while the other one was of indeterminate sex. Another ten razorback sucker were observed, but not netted, in this same aggregation of fish (Jackson 2003). Slickhorn Rapid itself is dominated by large boulders. However, there are numerous pockets of smaller cobbles both upstream and downstream of the rapid. In fact, the most downstream cobble bar of any size in the San Juan River occurs immediately downstream of Slickhorn Rapid on river right.

Unfortunately, it was not possible to look at movement patterns of most of the six razorback sucker recaptured as part of the 18 April 2002 suspected spawning aggregation. Of these six fish, four had not been previously recaptured, prior to the 18 April 2002 recaptures, since being stocked. This means that their movements between stocking and this point in time are completely unknown (Figure 2). Likewise, another razorback sucker did not have a detectable PIT tag on 18 April 2002, so the date and RM of stocking, as well as the recapture history (if there was any), for this fish are unknown. This fish was implanted with a PIT tag before being released back into the wild. The sixth fish was recaptured only once prior to the 18 April 2002 recapture. However, with only two data points over an eight-year period post-stocking, it is hard to determine much about this fish's movement patterns (Figure 2).

Seven PIT-tagged razorback sucker were recaptured for at least the third time since stocking in 2002 and 2003 (Figure 3). Their movement patterns reveal that during that time period, the majority of these fish (n = 5, 71.4%) were remaining in or returning to the section of river upstream of RM 150.0 after stocking (Figure 3).

Recaptures of razorback sucker during 2002 razorback sucker monitoring trips ranged from RM 140.0-102.1 (Table 3). Recaptures from all 2002 sampling trips ranged from RM 164.0-7.3 (Table A-1 in Appendix A). The majority of razorback sucker recaptured during all 2002 studies occurred upstream of RM 90.0 (Figure 4), with 40.5% occurring within the first few miles downstream of the Hogback Diversion stocking site (i.e., between RM 158.6 and RM 150.0).

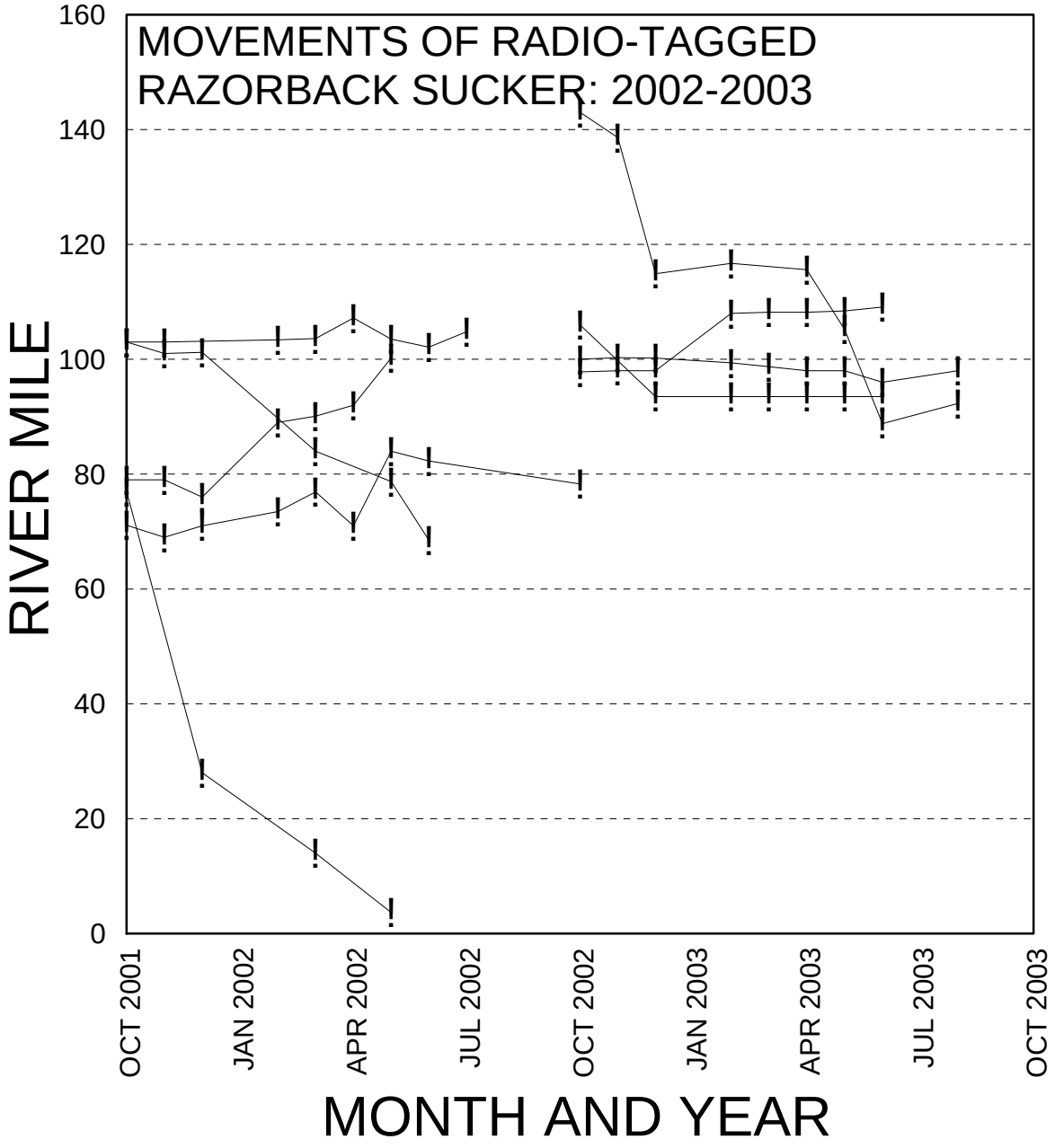

Figure 1. Observed movements of radio-tagged razorback sucker in the San Juan River in 2002 and 2003.

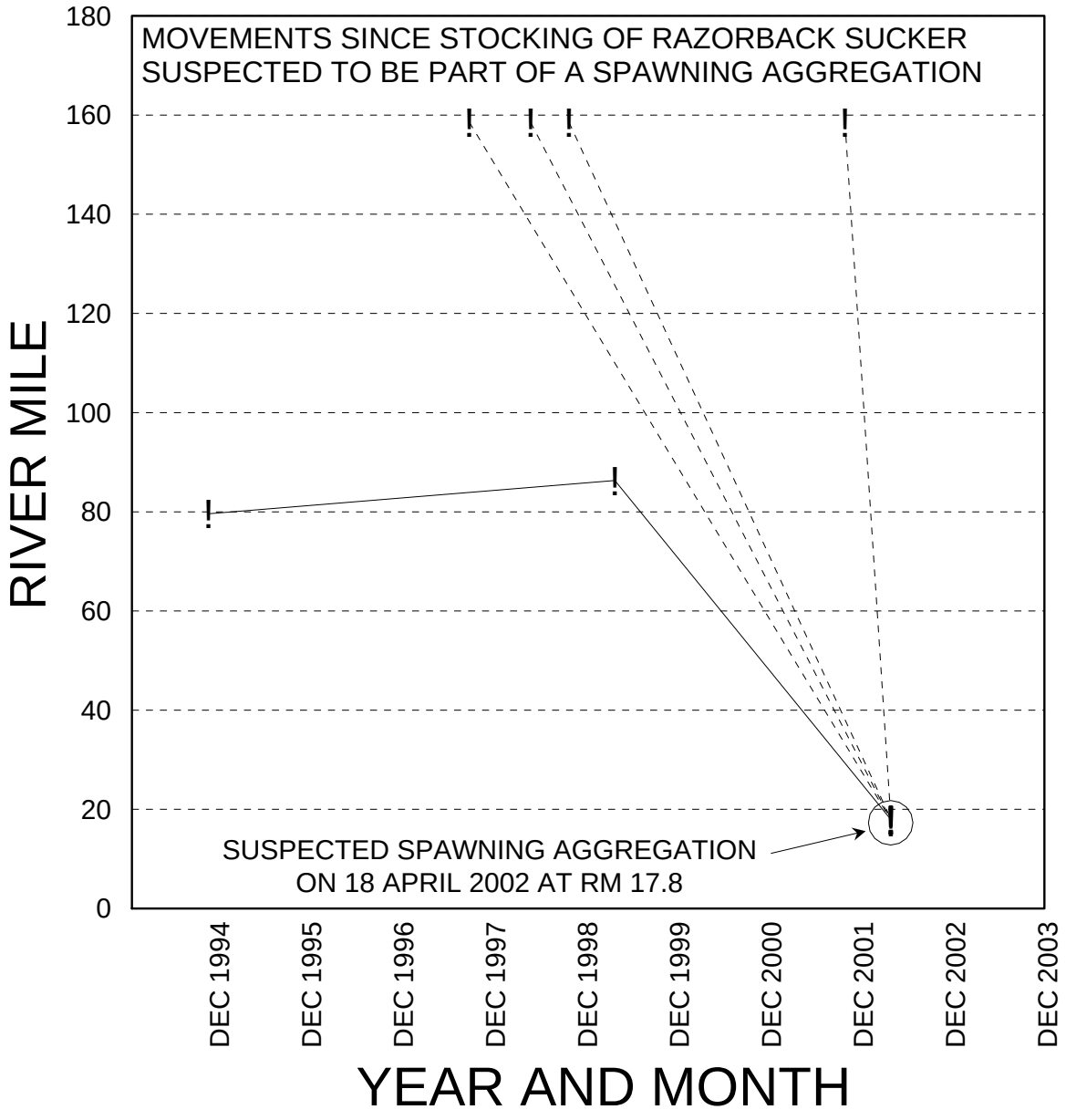

Figure 2. Stocking dates and locations and post-stocking movements of five razorback sucker that were recaptured on 18 April 2002 as part of a suspected spawning aggregation by Utah Division of Wildlife Resources field crews. Dashed lines indicate fish that had not been recaptured since stocking prior to this date.

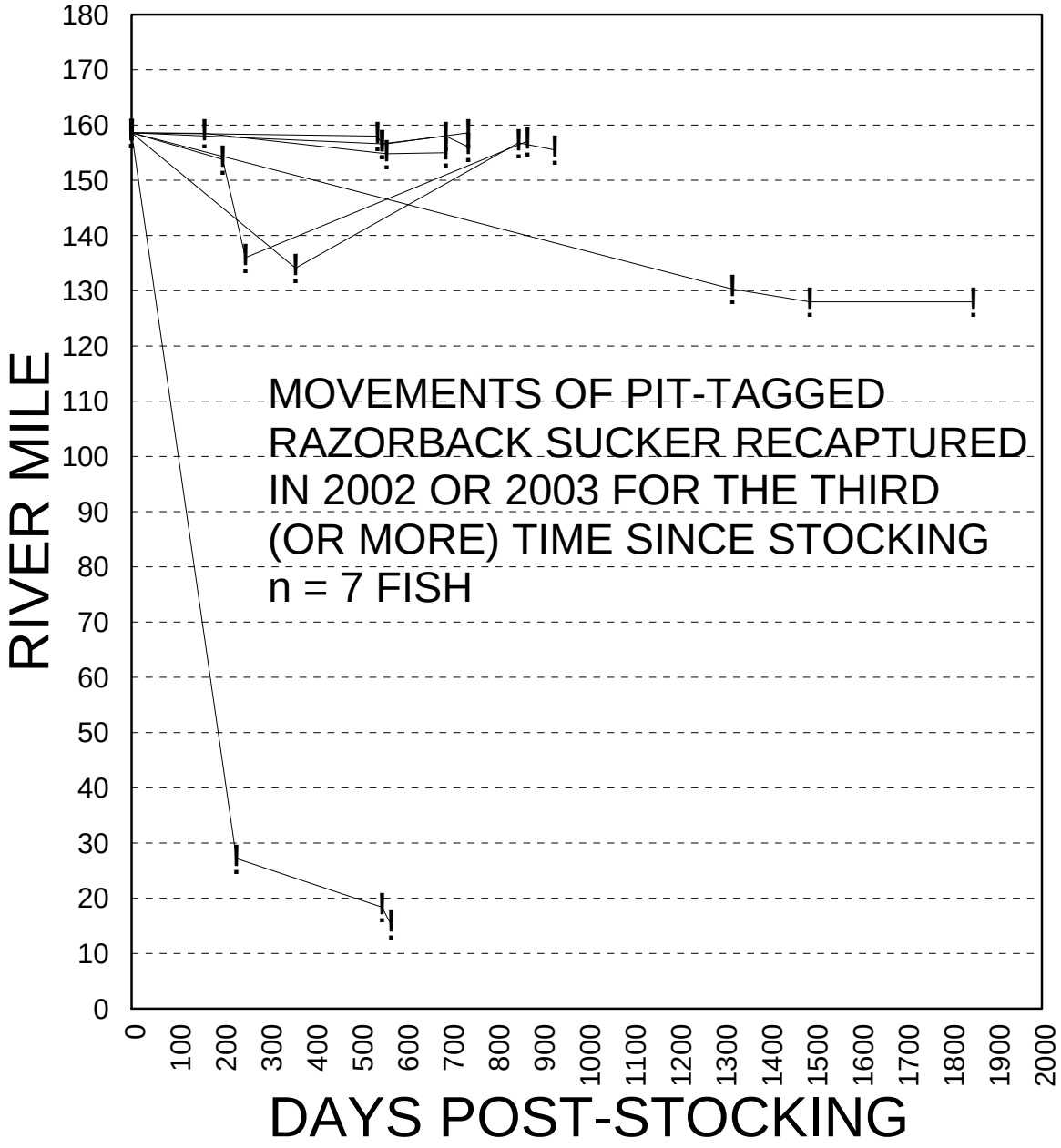

Figure 3. Movements of seven PIT-tagged razorback sucker recaptured in 2002 and 2003 for the third (or more) time since stocking.

There was also a large concentration of razorback sucker recaptures (24.3%) that occurred at or near Slickhorn Rapid (RM 17.8) in 2002 (Figure 4). This included both the suspected 2002 spawning aggregation documented by UDWR crews, as well as 8.7% of all razorback sucker recaptures that occurred during the fall 2002 adult monitoring trip.

Recaptures of razorback sucker during 2003 razorback sucker monitoring trips ranged from RM 158.2-95.1 (Table 4). Recaptures from all 2003 sampling trips ranged from RM 166.6 to (-)10.0 in Lake Powell(Table A-2 in Appendix A). As in 2002, the majority of razorback sucker recaptured during all 2003 studies occurred upstream of RM 80.0 (Figure 4), with 70.6% occurring within the first few miles downstream (RM 158.6-150.0) of Hogback Diversion.

A large, storm-induced flow spike that peaked at > 20,000 CFS downstream of Bluff, UT occurred in September 2003 (Ryden 2004). The majority of 2003 razorback sucker recaptures illustrated in Figure 4 occurred either in the spring/summer of 2003 preceding this flow spike, or late in the fall of 2003 after the flow spike but after also after the fall 2003 stockings had taken place, thus repopulating the section of the river downstream of Hogback. The longitudinal distribution of razorback sucker recaptures during the fall 2003 adult monitoring trip (which sampled almost immediately following the September 2003 storm spike) was somewhat different from other 2003 trips, in that the majority of razorback sucker recaptures (31.6%) during this trip occurred in the ten-mile river section that ends at RM 100 (Figure 4). This is very similar to the distribution pattern seen following earlier razorback sucker stockings at Hogback Diversion, when higher river flows post-stocking appeared to help distribute razorback sucker downstream in a somewhat bell-shaped curve distribution, centered around the river section ending at RM 100.0 (e.g., Ryden 2000c, 2001). However, even despite the September 2003 flow spike, there were still a good percentage of razorback sucker recaptures (21.1%) that occurred from RM 158.6-150.0 on the fall 2003 adult monitoring trip (Figure 4).

Table 3. Razorback sucker collected from the San Juan River during 2002 razorback sucker monitoring trips (n = 7).

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
04/29/2002	42421E4C1A	NONE	384	700	I	140.0	180
04/30/2002	423F7B6136	NONE	406	750	F	129.0	180
04/30/2002	423E643B63	NONE	401	775	F	130.5	182
04/30/2002	4240070D18	NONE	429	900	M	129.0	181
05/02/2002	423E5C4C46	NONE	382	600	I	110.5	182
05/02/2002	53240C4D7E	NONE	405	850	I	102.5	561
05/02/2002	1F4143510C	131	505	1475	I	102.1	2722

a: I = indeterminate; M = male; F = female

Table 4. Razorback sucker collected from the San Juan River during 2003 razorback sucker monitoring trips (n = 24).

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
04/28/2003	423F773E21	NONE	464	1300	F	158.2	544
04/28/2003	42421B2941	NONE	459	1100	F	158.2	543
04/28/2003	4242364628	NONE	443	1000	F	158.2	545
04/28/2003	423F5D406A	NONE	442	850	F	158.0	543
04/28/2003	523713037E	NONE	430	1000	F	158.0	14
04/28/2003	423E527E33	NONE	457	890	F	157.0	545
04/28/2003	423E763D46	NONE	413	900	I	157.0	543
04/28/2003	42400D333D	NONE	466	1400	F	157.0	544
04/28/2003	522A4D0929	NONE	449	1200	F	157.0	371
04/28/2003	423C7A6305	NONE	446	900	F	156.0	543
04/28/2003	423E644036	NONE	429	905	F	156.0	544
04/28/2003	423F7E7469	NONE	439	900	M	156.0	545
04/28/2003	42684B1563	NONE	414	790	M	156.0	173
04/28/2003	424217215C	NONE	482	1150	M	154.0	544
04/28/2003	523931203B	NONE	430	810	M	154.0	14
04/28/2003	423E3F2F2E	NONE	454	1150	M	149.0	545
04/29/2003	5228663833	NONE	390	-----[b]	I	139.0	15
04/29/2003	423F1A4C28	NONE	455	1000	M	136.0	546
04/29/2003	423F691523	NONE	417	690	F	136.0	546
04/30/2003	5229132259	NONE	364	780	I	126.0	373
04/30/2003	423F643C0A	NONE	440	925	F	125.9	547
04/30/2003	4269750841	NONE	458	1100	F	125.1	13
05/01/2003	52393F624A	NONE	460	-----[b]	M	110.0	17
05/02/2003	1F41386B7D	NONE	505	1450	F	95.1	3087

a: I = indeterminate; M = male; F = female

b: This value was not obtained due to equipment failure.

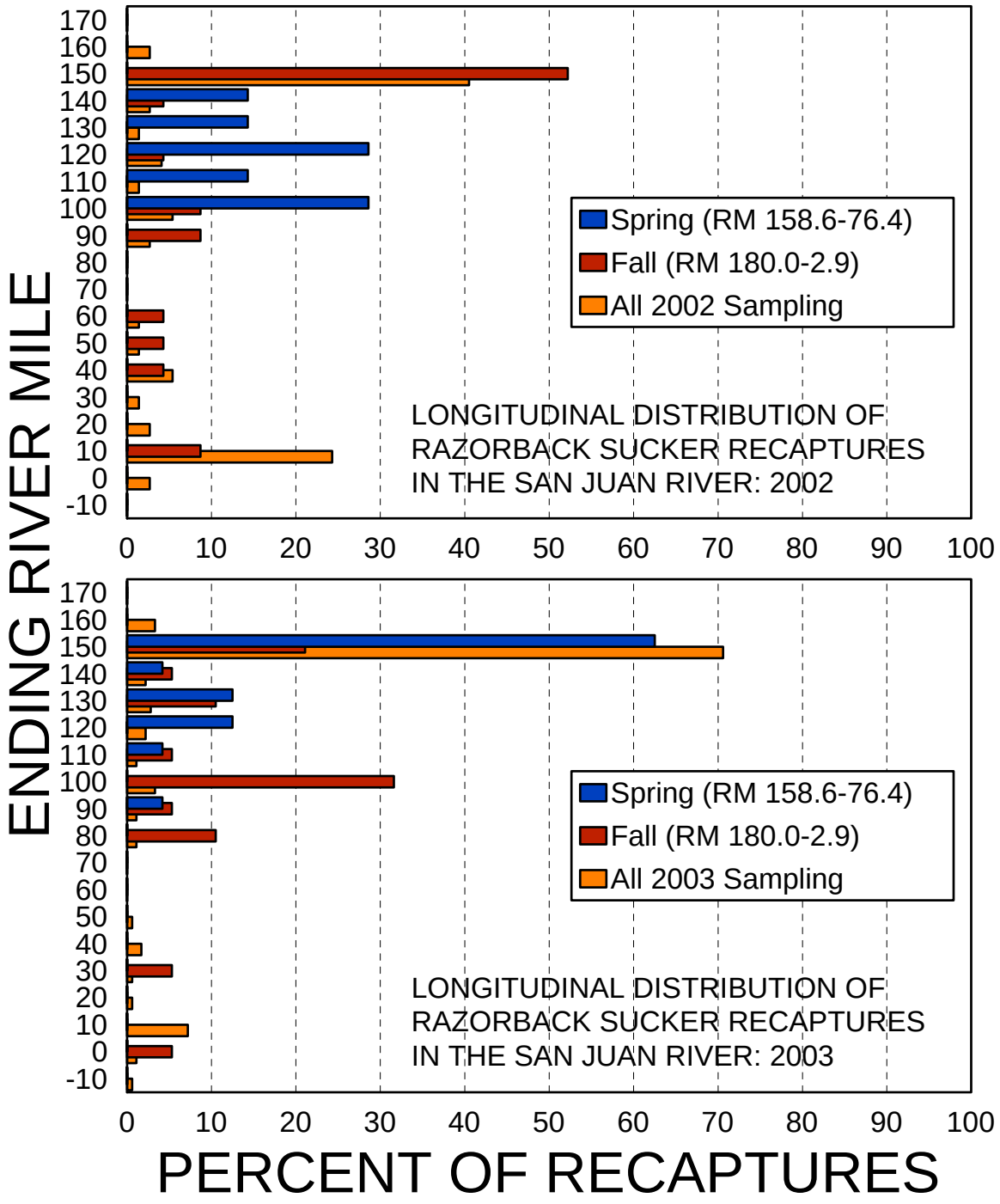

Figure 4. Longitudinal distribution of razorback sucker recaptures on 2002 and 2003 sampling trips in the San Juan River.

Objective 2b: Survival And Growth Rates

Survival

A total of seven razorback sucker were recaptured on 2002 razorback sucker monitoring trips (Table 3). An additional 56 razorback sucker were collected on sampling trips for other studies in 2002, including 23 on the fall 2002 adult monitoring trip (Table A-1 in Appendix A).

Despite the seemingly low number of razorback sucker collected during 2002 razorback sucker monitoring trips, razorback sucker catch per unit of effort in 2002 was slightly higher (0.44 fish/hr) than that observed in 2001 (0.40 fish/hr; Figure 5). 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 5). 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 2002 was consistently higher than that observed in 2001 and the highest observed to date for any trip or river section (Figure 5). While this increasing CPUE for razorback sucker is encouraging, it must be remembered that a CPUE of less than 1.0 fish/hr is still a very low value.

By far the majority of razorback sucker recaptured in 2002 (i.e., > 60%) were fish that had been stocked within the last 400 days prior to sampling (Figure 6). There were however, razorback sucker from numerous different years' stockings collected in 2002, including many (9.8% of all recaptures) from the 1994-1996 stockings (i.e., those in the river > 2200 days pot-stocking; Figure 5).

In 2003, a total of 24 razorback sucker were recaptured on razorback sucker monitoring trips (Table 4). An additional 156 razorback sucker were collected on sampling trips for other studies in 2003, including 19 on the fall 2003 adult monitoring trip (Table A-2 in Appendix A).

Razorback sucker CPUE rose again on the spring 2003 razorback sucker monitoring trip to the highest level ever observed (0.74 fish/hr; Figure 5). However, razorback sucker CPUE observed on the fall 2003 adult monitoring trip declined in comparison to the 2002 value (Figure 5). This is likely an artifact of the large storm-induced flow spike that occurred in September 2003 just prior to that trip. This storm spike peaked at > 20,000 CFS downstream of Bluff, UT. This flow spike appears to have displaced or reduced numbers of fish of all species (Ryden 2004).

As in 2002, the majority of razorback sucker recaptured in 2003 were fish that had been stocked in the recent past (i.e., within the last 800 days prior to sampling (Figure 6). However, unlike 2002, the recently-stocked razorback sucker recaptured in 2003 represented two distinct years stockings (Figure 5). While fish from numerous different years' stockings were still being collected, older fish (i.e., those that had been in the river for several years post-stocking) accounted for a much smaller percentage of the recaptures in 2003 than they did in 2002 (Figure 6). Razorback sucker from the 1994-1996 stockings composed only 2.4% of all 2003 recaptures (Figure 6).

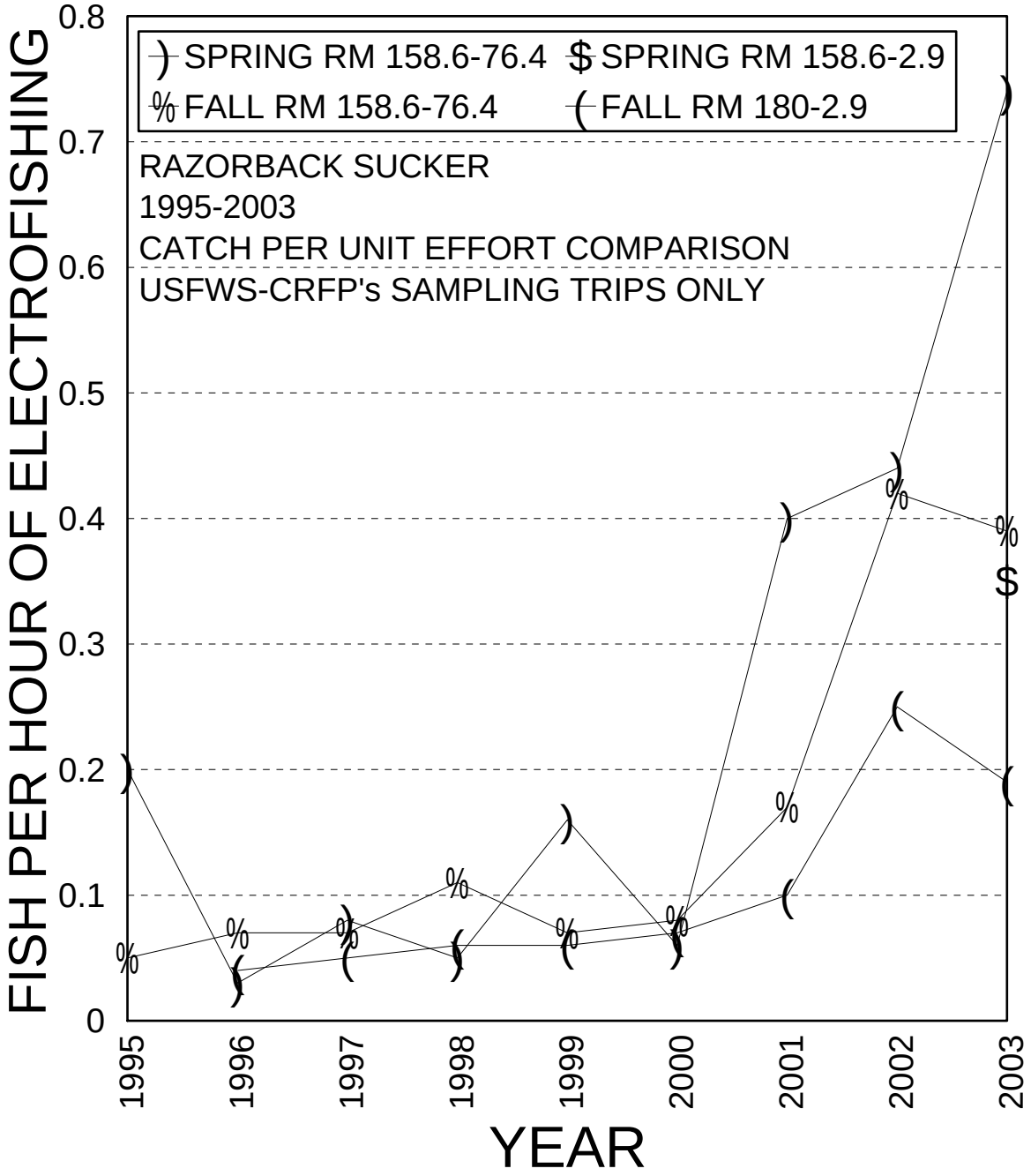

Figure 5. Razorback sucker catch per unit effort (CPUE) on spring razorback sucker monitoring trips and fall adult monitoring trips, 1995-2003.

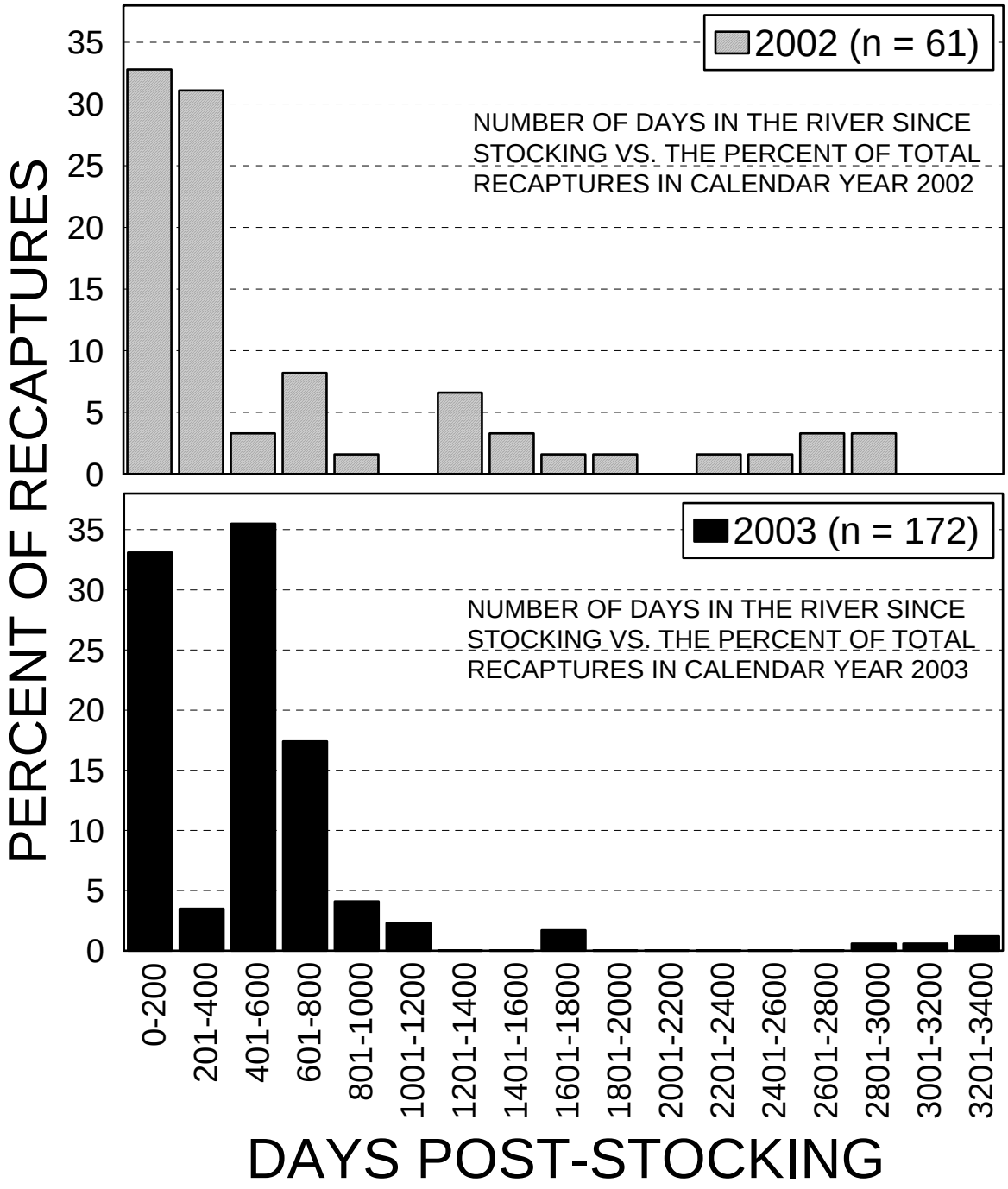

Figure 6. A measure of longevity among stocked fish in the San Juan River razorback sucker population, expressed as the number of days in the river since stocking versus the percent of total recaptures represented by recaptured fish, in 2002 (top) and 2003 (bottom). Some recaptures could not be used in this analysis due to lack of a detectable PIT tag at the time of recapture.

The Schnabel multiple census population estimate for razorback sucker recaptured in 2002 estimated that there were 402 razorback sucker (95% confidence interval {C.I.}= 243-717 fish) from RM 158.6-76.4 in the fall of 2002 (Figure 7, Table B-1 in Appendix B). This estimate, extrapolated, indicated that there were 518 razorback sucker from RM 158.6-2.9 in the fall of 2002 (Figure 7, Table B-2 in Appendix B). The Schnabel estimate for razorback sucker recaptured in 2003 estimated that there were 640 razorback sucker (95% C.I. = 400-1100 fish) from RM 158.6-76.4 in the fall of 2003 (Figure 7, Table B-1 in Appendix B). This estimate, extrapolated, indicated that there were 825 razorback sucker from RM 158.6-2.9 in the fall of 2003 (Figure 7, Table B-2 in Appendix B).

The Lincoln-Petersen population estimate for razorback sucker recaptured in 2002 estimated that there were 225 razorback sucker (95% C.I. = 68-409 fish) from RM 158.6-76.4 in the fall of 2002 (Figure 7, Table B-3 in Appendix B). This estimate, extrapolated, indicated that there were 290 razorback sucker from RM 158.6-2.9 in the fall of 2002 (Figure 7, Table B-4 in Appendix B). The Lincoln-Petersen population estimate for razorback sucker recaptured in 2003 estimated that there were 459 razorback sucker (95% C.I. = 139-834 fish) from RM 158.6-76.4 in the fall of 2002 (Figure 7, Table B-3 in Appendix B). This estimate, extrapolated, indicated that there were 591 razorback sucker from RM 158.6-2.9 in the fall of 2002 (Figure 7, Table B-4 in Appendix B).

Values for the two population estimate models do not track each other exactly. However, the pattern 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 7). Up until the spring 2000 estimate, the values provided by the Lincoln-Petersen estimate for RM 158.6-76.4 fit within the 95% C.I.'s for the corresponding Schnabel population estimate. Since that time, the Lincoln-Petersen estimate values have consistently been lower than lower C.I. interval value obtained for the Schnabel estimate. This divergence in the two estimates is likely due to the fact that the Schnabel multiple census population estimate is not really set up to compensate for mortality within a population over a long period of time, thus it is likely overestimating the number of razorback sucker present in the San Juan River over the last several (i.e., 5-7) estimate periods (Van den Avyle 1993). However, the fact that the 95% C.I.'s for the two estimates overlap for the last three estimate periods indicates that the Schnabel is probably not overestimating the razorback sucker population numbers by much. In addition, the fact that both estimates show similar increasing population trends is encouraging.

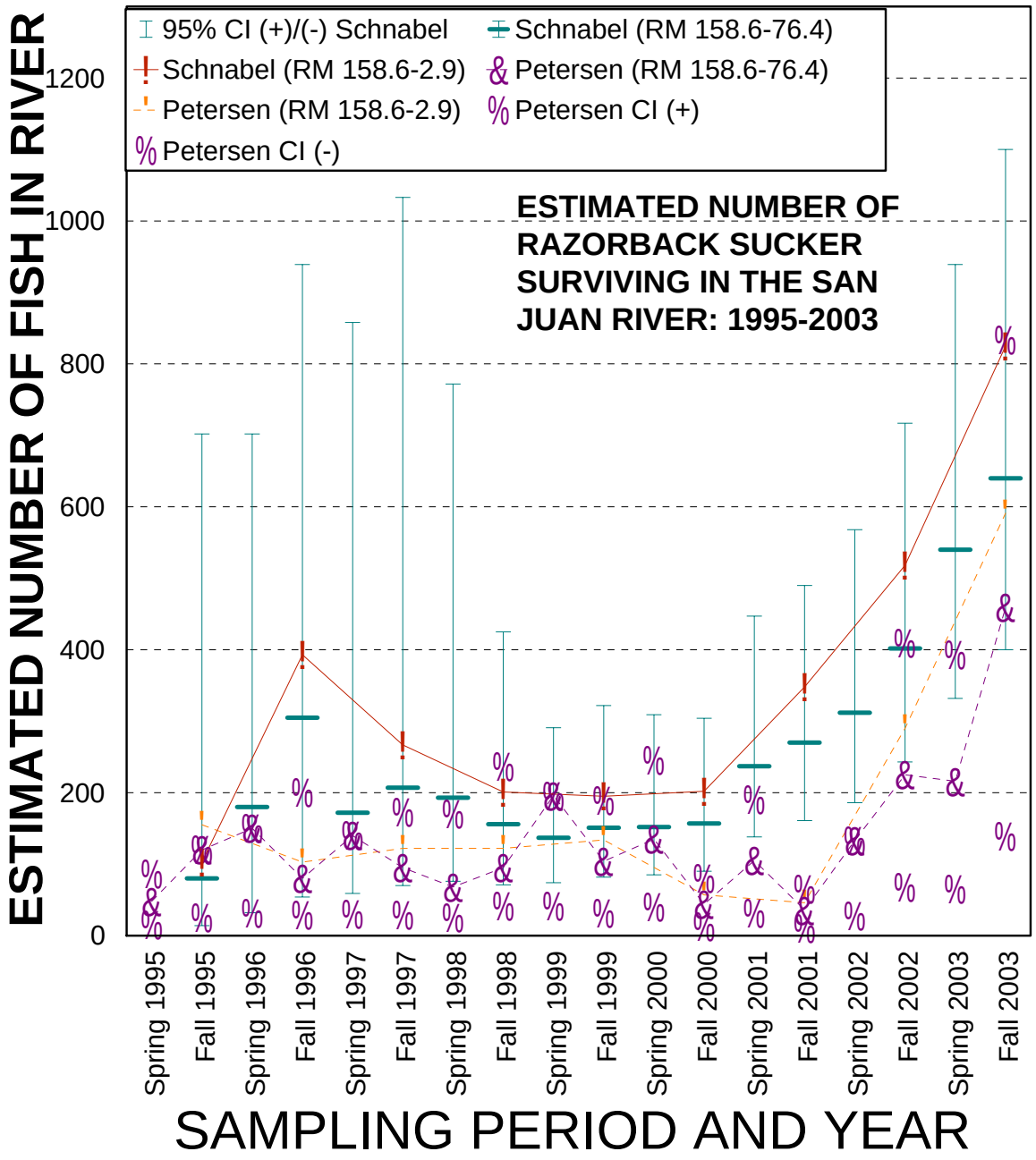

Figure 7. Schnabel and Lincoln-Petersen population estimates for the San Juan River razorback sucker population from RM 158.6-76.4 and from RM 158.6-2.9, 1995-2003. Only the estimates from RM 158.6-76.4 have associated 95% confidence intervals.

Growth

Razorback sucker have been stocked at many different size-classes and growth of these fish have varied widely (Table 5 and Figure 8). As was observed in past years, razorback sucker stocked at < 351 mm TL grew almost twice as fast (0.09 mm/day) as those stocked at > 350 mm TL (0.05 mm/day; Table 5). Known female razorback sucker (n = 59) increased in TL almost twice as fast (0.07 mm/day) as did known males (0.04 mm/day, n = 116; Table 5). The fastest growth rates were observed in fish stocked between 251 and 280 mm TL (Table 5).

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 8). After age-4, the growth curve flattens considerably and gains in TL between years become much less dramatic (Figure 8). There is a considerable range for TL values at several ages (Figure 8). This reflects the wide range of sizes among razorback sucker of the same age from different hatchery facilities used in stocking 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 26.1% and 17.3%, respectively (Figure 9). This translates into an average increase of 76 mm TL and 64 mm TL, respectively (Figure 9). By age-5 stocked razorback sucker demonstrated less than a 5.0% annual increase in mean TL between years (Figures 8 and 9). These figures are based on the observed values among 414 razorback sucker recaptured between 1995 and 2003.

Table 5. Growth of razorback sucker, in millimeters per day (mm/day), observed during 352 recapture events, including multiple recaptures, 1995-2003.

Total Length Range (in mm) Of Recaptured Fish At The Time They Were Originally Stocked	Growth (mm/day)	Range Of Growth Measurements	Number Of Recapture Events Growth Rates Are Based On (n =)
"Small" Stocked Fish Versus "Large" Stocked Fish:			
< 351 mm TL (range = 193-350 mm TL)	0.09	0.00-0.52	79
> 350 mm TL (range = 355-525 mm TL)	0.05	0.00-0.28	273
Known Females Versus Known Males:			
Females (TL range = 229-523 mm)	0.07	0.00-0.23	59
Males (TL range = 232-481 mm)	0.04	0.00-0.42	116

Table 5. Growth of razorback sucker, in millimeters per day (mm/day), observed during 352 recapture events, including multiple recaptures, 1995-2003, continued.

Total Length Range (in mm) Of Recaptured Fish At The Time They Were Originally Stocked	Growth (mm/day)	Range Of 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	0.24	0.00-0.52	7
281-290	0.04	0.00-0.23	6
291-300	0.00	0.00-0.00	5
301-310	0.00	0.00-0.02	6
311-320	0.04	0.00-0.23	13
321-330	0.05	0.00-0.13	8
331-340	0.12	0.00-0.50	8
341-350	0.06	0.00-0.12	7
351-360	0.08	0.00-0.14	8
361-370	0.07	0.00-0.20	17
371-380	0.06	0.00-0.14	27
381-390	0.05	0.00-0.17	27
391-400	0.05	0.00-0.13	30
401-410	0.05	0.00-0.28	41
411-420	0.06	0.00-0.26	25
421-430	0.03	0.00-0.12	22
431-440	0.04	0.00-0.26	13
441-450	0.03	0.00-0.15	22
> 450	0.02	0.00-0.06	41

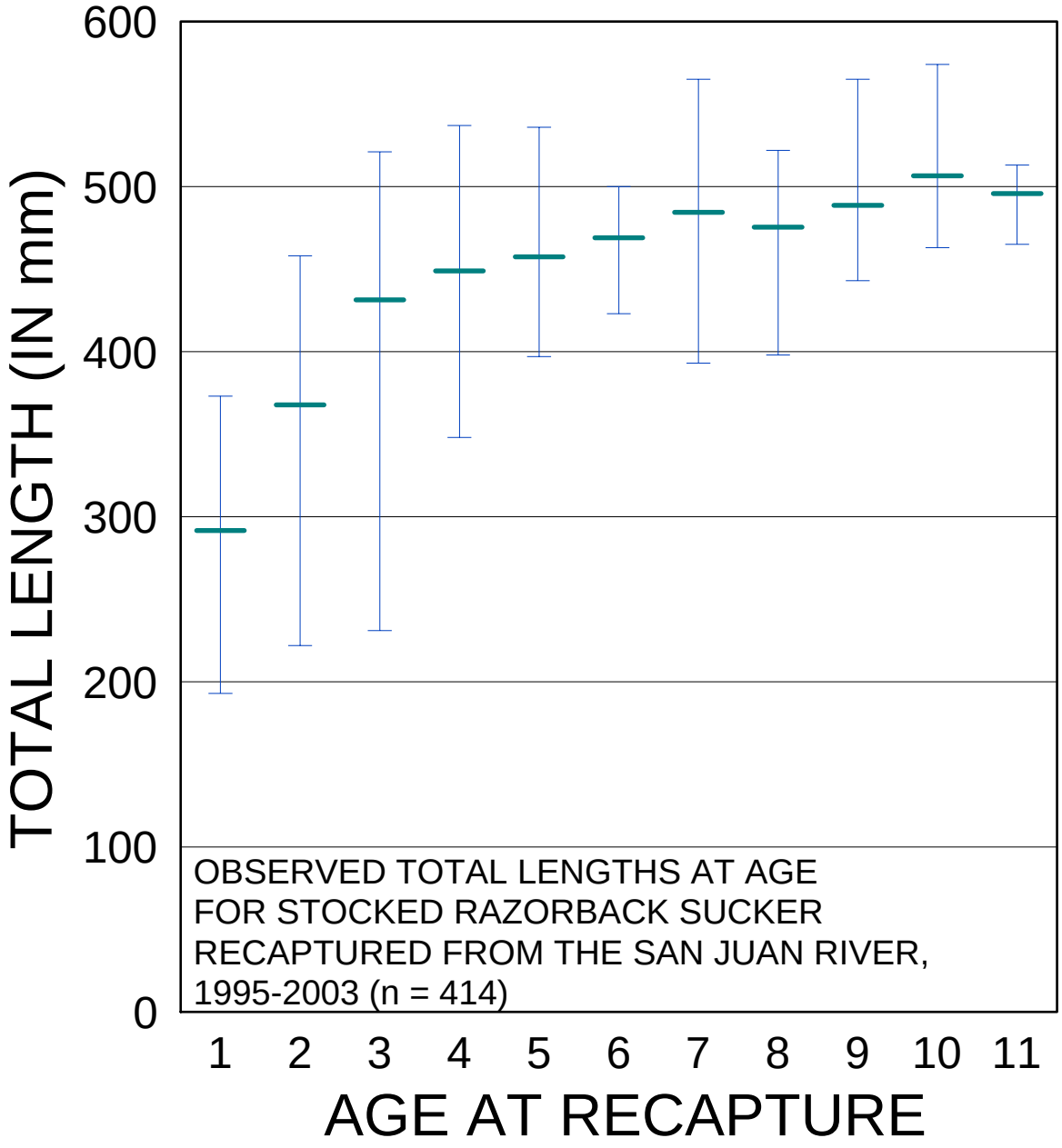

Figure 8. Total length (TL) at age observed for 414 recaptured razorback sucker in the San Juan River, 1995-2003. The dark horizontal lines represent the mean TL values, while the error bars represent the range of values observed among recaptured fish.

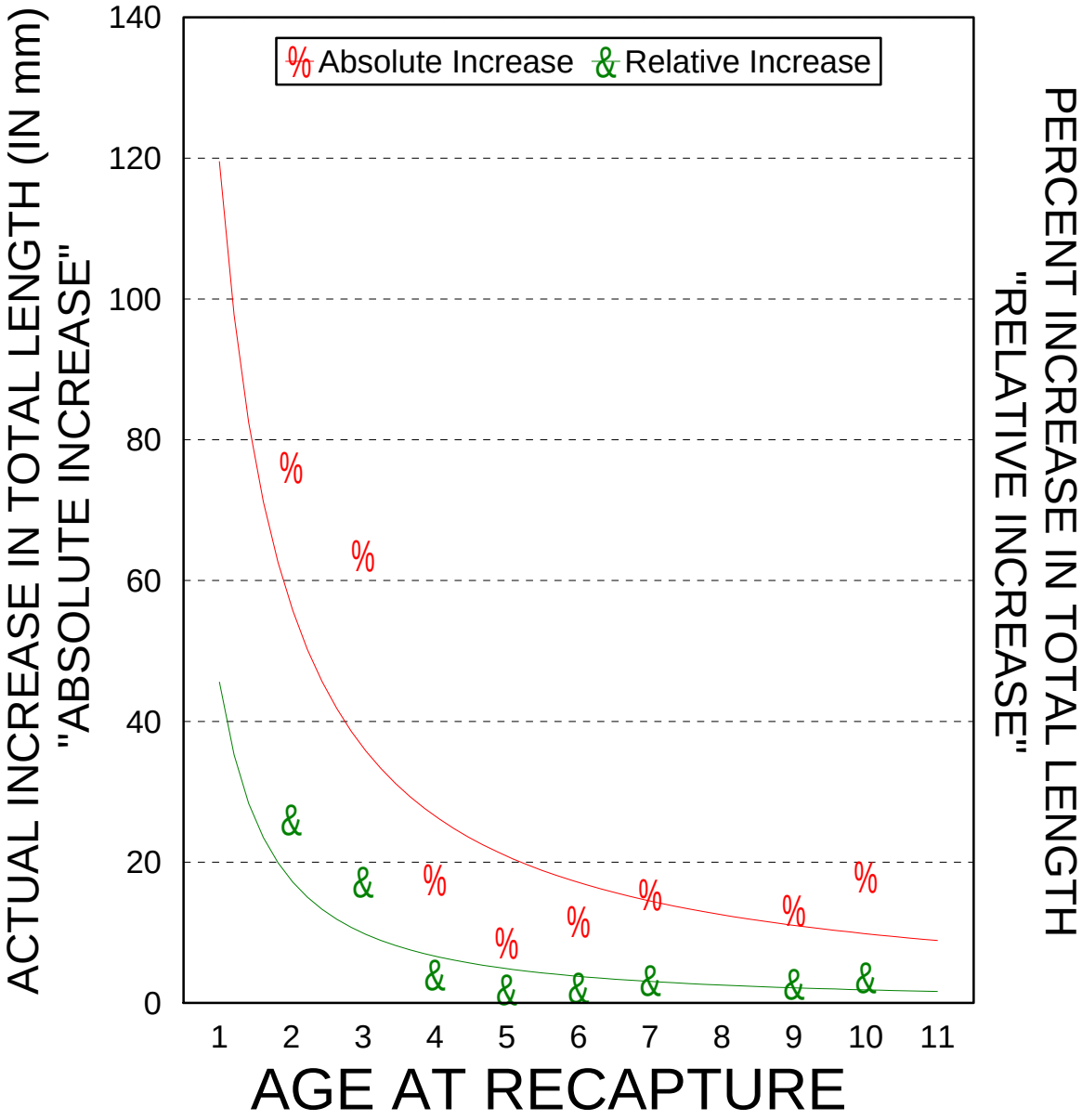

Figure 9. Absolute and relative increases in total length (TL) at age observed among 414 recaptured razorback sucker in the San Juan River, 1995-2003. NOTE: Markers at age-2 indicate the increase in TL from age-1 to age-2, those at age-3 indicate the increase in TL from age-2 to age-3 and so on.

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

In 2002, there were a total of 74 razorback sucker recaptured during all studies. Of these, 24 were males, 6 were females, and 44 were of indeterminate sex. None of the six identified females (401-574 mm TL) were ripe (i.e., freely expressing eggs) at the time of recapture. Known females were collected between 30 April and 28 September from RM 130.5-17.0. Of the 24 known males (408-516 mm TL), 18 were tuberculate (420-513 mm TL) and five of those (429-505 mm TL) were ripe (freely expressing milt). Tuberculate males were collected from 14 March to 9 October (from RM 159.0-7.3), while ripe males were collected from 18 April to 9 October (from RM 129.0-17.8).

In 2003, there were a total of 180 razorback sucker recaptured during all studies. Of these, 44 were males, 31 were females, and 105 were of indeterminate sex. None of the 31 identified females (397-551 mm TL) were ripe (i.e., freely expressing eggs) at the time of recapture. Known females were collected between 27 March and 11 November from RM 158.6-18.8. Of the 44 known males (325-500 mm TL), 34 were tuberculate (410-500 mm TL) and 18 of those (414-482 mm TL) were ripe (freely expressing milt). Tuberculate males were collected from 27 March to 11 November (from RM 166.6-15.2), while ripe males were collected from 27 March to 9 October (from RM 158.0-18.8).

2002

No spawning aggregations of razorback sucker were identified in the San Juan River during either the 2002 razorback sucker monitoring or radio-tracking trips. However, on 18 April 2002, UDWR crews encountered a large aggregation of razorback sucker centered near the rapid at Slickhorn Canyon (RM 17.6) in the lower San Juan River (Jackson 2003). Between RM 18.0 and RM 17.5, they collected five ripe male razorback sucker and another of unknown sex (Table 6; Jackson 2003, J. Jackson pers. comm.). They also observed another 10 razorback sucker, that were not netted, in this same area (Jackson 2003).

Only five of the six razorback sucker collected by UDWR had detectable PIT tags at the time of recapture (Table 6). All five of these known-origin fish came from different stocking dates and all five were different ages (Table 6, Figure 2). Only one of these five fish (PIT tag number 1F414E3E14; stocked 18 November 1994 at RM 79.6), had been recaptured previous to this encounter. It was recaptured for the first time on 17 April 1999 at RM 86.3 (472 mm TL).

As opposed to preceding years (i.e., 1997, 1999, 2001), when aggregations of razorback sucker were observed spawning near Aneth, UT (RM 100.2) on the ascending limb of the spring hydrograph (Ryden 2001, 2003a), the 2002 Slickhorn Rapid spawning aggregation occurred during a low baseflow condition. Flows at the nearest river gage (near Bluff, UT - USGS gage #09379500) were 692 CFS on 18 March 2002, 512 CFS on 31 March, 420 CFS on 18 April, 584 CFS on 30 April and 701 CFS on 18 May 2002.

The river channel at and around Slickhorn Rapid represents the first significant concentration of clean, rocky substrates in the San Juan River upstream of Lake Powell.

Table 6. Details about individual razorback sucker that were recaptured in a suspected spawning aggregation by the Utah Division of Wildlife Resources on 18 April 2002.

RM Recaptured At	PIT Tag Number	Total Length (in mm)	Weight (in g)	Sex[a]	Days Since Stocking	Date Stocked	RM Fish Was Stocked At	Year-Class & (Age At Recapture)
18.0	512A724849	480	1100	Male, tb	1282	10/14/1998	158.6	1997 (5)
17.9	1F414E3E14	487	1150	Male, tb	2708	11/18/1994	79.6	1992 (10)
17.8	1F750B7869[b]	505	1275	Male, tb	unknown	unknown	unknown	unknown
17.8	203E3F3C27	495	1125	Male, tb	1421	05/28/1998	158.6	1993 (9)
17.8	42151C0F23	500	1150	unknown	1688	09/03/1997	158.6	1996 (6)
17.5	423F635449	478	1175	Male, tb	170	10/30/2001	158.6	1999 (3)

a: tb = tuberculate

b: No PIT tag could be detected in this fish, so a previous stocking history could not be determined. A new PIT tag was implanted in this fish before it was returned to the river.

For the fifth consecutive year, crews from UNM collected larval razorback sucker 2002. A total of 812 larval razorback sucker were collected from RM 134.5-2.8 (Brandenburg et al. 2003). Larval razorback sucker were collected from 29 April through 28 June 2002 (Brandenburg et al. 2003). This was, by far, the largest number of larval razorback sucker ever scientifically documented in the San Juan River. Once again in 2002, larval razorback sucker were collected upstream of any previously-known spawning area, indicating that there must be at least one razorback sucker spawning area upstream of RM 134.5 that has not yet been located.

2003

No spawning aggregations of adult razorback sucker were identified in 2003, either by electrofishing or radio telemetry. However, successful spawning of stocked razorback sucker was confirmed when crews for UNM collected larval razorback sucker (n = 472) for the sixth consecutive year (Brandenburg et al. 2004). Larval razorback sucker were collected from RM 97.0-3.3 between 16 May and 18 June 2003 (Brandenburg et al. 2004).

DISCUSSION

Objective 2a: Spawning Season Habitat Use And Movement Patterns

Radio telemetry was largely ineffective in identifying spawning aggregations of razorback sucker in 2002 and 2003. Radio-implanted fish remained spatially separated throughout their tracking periods. Likewise, PIT-tagged razorback sucker recaptured on razorback sucker monitoring trips failed to lead researchers to spawning aggregations of fish. While this is frustrating, it is not completely unexpected. Given the very small number of razorback sucker that are currently estimated to be in the San Juan River (using the Lincoln-Petersen population estimate, 591 fish from RM 158.6-2.9 = 3.8 fish/RM), locating spawning aggregations of razorback sucker is a lot like looking for a needle in a haystack.

The razorback sucker spawning area at RM 100.2 that was used in 1997, 1999, and 2001 is now highly degraded. At lower flows it is completely out of the water and when it is inundated, it is heavily covered with silty muds. It will likely take a good high flow event to rework this area before it is again suitable for razorback sucker spawning.

Luckily, razorback sucker do still seem to be spawning in other areas of the San Juan River. Crews from UDWR identified a suspected spawning aggregation of razorback sucker at Slickhorn Rapid on 18 April 2002. In addition, continued collection of larval razorback sucker by crews from UNM (as far upstream as RM 134.5 in June 2002) proves that adult fish are still successfully spawning at some as yet unknown locations, at least one of which is upstream of RM 134.5.

In 2002 and 2003, recaptures of PIT-tagged razorback sucker were fairly heavily concentrated in the river section immediately downstream of the Hogback Diversion (i.e., RM 158.6-150.0). In preceding years, razorback sucker stocked at the Hogback Diversion stocking site (RM 158.6) tended to distribute themselves downstream in a roughly bell-shaped curve distribution centered around the RM 110-100 river section (e.g., Ryden 2000c, 2001). This was likely at least partially in response to higher flow events (i.e., runoff and storm spikes) which displaced fish to downstream areas. This may also have created a concentration of appropriately-aged fish around the Aneth, UT area that then spawned at RM 100.2. With the absence of high flow events of almost any kind in the Hogback Diversion to Shiprock section of river (RM 158.6-147.9) over the last several years, stocked, PIT-tagged razorback sucker have been remaining in this more upstream section of the San Juan River. In fact, razorback sucker have become one of the more commonly-collected fish species (via electrofishing) in the first 1-2 RM's downstream of Hogback Diversion (pers. obs.). It seems plausible then that a larger concentration of razorback sucker in this upstream section of the river may be leading to spawning occurring there. This has not yet been documented, but at least from a sheer numbers standpoint, it seems to make sense. The collection of larval razorback sucker within 15 RM's downstream of this river section also lends credence to this idea. The section of the San Juan River between Hogback Diversion and Shiprock, NM is heavily braided and complex and has plenty of clean cobble at numerous sites that appear (visually) to be appropriate for razorback sucker spawning.

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 0.74 fish/hr on the spring 2003 razorback sucker monitoring trip. All indications were that the razorback sucker CPUE value for the fall 2003 adult monitoring trip would also increase over that for the fall 2002 adult monitoring trip. However, this was not the case. The razorback sucker CPUE value on the fall 2003 adult monitoring trip actually dropped slightly, though not catastrophically when compared to the fall 2002 adult monitoring value. This drop in razorback sucker CPUE is likely tied, at least in part, to the storm-induced flow spike that occurred in September 2003, just prior to the fall 2003 adult monitoring trip. This flow spike, which peaked at > 20,000 CFS downstream of Bluff, UT, seems to have caused downstream displacement of fish of many species (Ryden 2004).

The majority of razorback sucker recaptured from the San Juan River over the last years are fish that have been in the river for ≤ 1200 days since stocking. There are still a few razorback sucker from the 1994-1996 stockings being recaptured, but their numbers are slowly dwindling. In general, it doesn’t appear that the longevity of razorback sucker stocked in the late 1990's is as good as that from the earlier stockings.

The Schnabel multiple-census population estimate indicated that there were 825 razorback sucker in the San Juan River from RM 158.6-2.9 in the fall of 2003. However, given the nature of this population estimator and its inability to deal with mortality, this estimate is probably a little high. A better (and more conservative) estimate can be obtained using the Lincoln-Petersen population estimate. This estimate indicates that there were 591 razorback sucker in the San Juan River from RM 158.6-2.9 in fall 2003. Despite the difference in numbers between the two estimates, 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.

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.

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 (mean TL = 449 mm; range = 348-537 mm TL), 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, no wild razorback sucker (other than larvae being collected by crews from UNM) are being collected in the San Juan River. However, if progeny of stocked fish successfully recruit, 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

In 2002, a suspected spawning aggregation of razorback sucker was documented in the lower San Juan River centered around Slickhorn Rapid. Known-origin adult razorback sucker associated with this suspected spawning aggregation were of many different ages and had come from different stocking locations and dates. In addition, this aggregation occurred during the third week of May. Previously-identified spawning aggregations of razorback sucker in the San Juan River had all occurred between the middle of April and the middle of May (Ryden 2000c, 2003a). In these respects (i.e., timing and make-up), this suspected spawning aggregation was very much like its predecessors, documented at RM 100.2 in 1997, 1999, and 2001 (Ryden 2000c, 2003a).

However, the 2002 suspected spawning aggregation was also different from its documented predecessors in a two respects. First, 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 at a very low base-flow condition. Second, it occurred in what would not be considered "classic" razorback sucker spawning habitat (i.e., habitat dominated by cobble or gravel substrates), such as that found in the Green River or at RM 100.2 near Aneth, UT in the San Juan River. The Slickhorn Rapid aggregation occurred in area of the river dominated by muddy shorelines, a shifting sand bottom, and a boulder-strewn rapid, with only a few small associated cobble bars. In other words, it occurred in an area that was not previously thought to be suitable razorback spawning habitat.

So, it is evident that adult razorback sucker are capable of locating one another after stocking and will aggregate to spawn in many different types of habitats throughout the San Juan River. The unfortunate part of the spawning aggregation occurring at Slickhorn Rapid is that any larval razorback sucker produced at this locale will have only a very few miles to eddy out of the drift before they enter Lake Powell and encounter the gauntlet of nonnative predators found therein.

The collection of larval razorback sucker in both 2002 and 2003 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 six consecutive years (1998-2003). The presence of larval razorback sucker as far upstream as RM 134.5 in 2002 points to an as yet unknown spawning area upstream of this location, possibly just downstream of the Hogback Diversion stocking site.

While the continued collection of razorback sucker larvae in increasing numbers is encouraging, it is somewhat disappointing that no older (i.e., age-1+) wild-produced razorback sucker have yet been collected. Until recruitment of wild-produced razorback sucker commences, establishing a self-sustaining population of razorback sucker in the San Juan River is going to be impossible.

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APPENDIX A

Summary tables for razorback sucker collected during sampling trips for studies other than the razorback sucker monitoring study in 2002 and 2003.

Table A-1. Razorback sucker collected during other studies in the San Juan River in 2002 (n = 56).

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On the fall 2002 adult monitoring trip - electrofishing (USFWS-CRFP): n = 23							
09/21/2002	1F43647A40	761	463	1160	M	106.0	2864
09/21/2002	423E640D30	800	428	700	F	100.0	326
09/21/2002	1F75165303	976	483	1200	F	98.9	2551
09/21/2002	1F743A347F	091	574	2150	F	97.8	2864
09/24/2002	7F7B106C67	NONE	468	1200	M	64.7	1580
09/25/2002	5229167B23	NONE	415	775	I	58.2	156
09/25/2002	531A7F0D1A	NONE	420	650	M	47.0	706
09/28/2002	423D082F39	NONE	530	1300	F	17.0	Unknown[b]
09/28/2002	423E5D7247	NONE	497	1150	I	14.0	332
10/07/2002	423E7E4D15	NONE	435	1150	M	158.0	341
10/07/2002	4240181B0C	NONE	435	1050	I	158.0	341
10/07/2002	423E66702C	NONE	445	1250	I	158.0	340
10/07/2002	4242335143	NONE	442	----[c]	I	158.0	342
10/07/2002	423F083F30	NONE	440	900	M	158.0	341
10/07/2002	5325750920	NONE	455	1500	I	156.0	719
10/07/2002	53257F7548	NONE	430	750	M	156.0	719
10/07/2002	52296F6261	NONE	367	590	I	156.0	168
10/07/2002	424217215C	NONE	481	1600	M	156.0	341
10/07/2002	522A505F23	NONE	337	500	I	155.0	168
10/07/2002	423E78141C	NONE	435	940	I	155.0	342
10/07/2002	423F5C3543	NONE	425	900	I	152.0	342
10/08/2002	4240191570	721	420	925	I	143.0	342
10/09/2002	416D4F3B55	NONE	468	1080	M	128.0	1846

a: I = indeterminate; M = male; F = female

b: This fish did not have a detectable PIT tag at the time of recapture, therefore the number of days it had been in the river since stocking could not be determined. A PIT tag was implanted in this fish before it was released back into the river.

c: This value was not obtained due to equipment failure

Table A-1, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On nonnative fish removal trips - electrofishing (USFWS-NMFRO): n = 12							
02/07/2002	7F7B0E0F09	NONE	430	850	I	164.0	919
04/04/2002	423F031672	NONE	479	1300	I	158.5	155
04/04/2002	423F0E6C4B	NONE	506	1350	I	158.4	155
04/04/2002	423E5F1B3F	NONE	351	510	I	158.3	156
04/04/2002	4242364628	NONE	402	790	I	157.6	156
04/04/2002	423F712672	NONE	485	1500	I	157.6	155
04/04/2002	53262F225C	NONE	331	380	I	156.4	156
06/11/2002	522A50237B	NONE	400	600	I	159.0	50
06/11/2002	423E760C18	NONE	496	1000	M	159.0	224
06/11/2002	423F6E7D60	NONE	470	1450	I	159.0	224
06/12/2002	42423D5E34	NONE	408	650	I	159.0	225
06/12/2002	531C417968	NONE	415	1000	I	159.0	601
On nonnative fish removal trips - electrofishing (UDWR-Moab): n = 21							
03/14/2002	507F727F1E	NONE	516	1500	M	18.6	1247
03/14/2002	7F7B12307C	NONE	491	1250	M	18.5	1386
03/14/2002	4240152E07	NONE	468	1200	M	12.2	135
03/15/2002	1F41612C13	NONE	513	1600	M	7.3	2361
04/18/2002	512A724849	NONE	480	1100	M	18.0	1282
04/18/2002	1F414E3E14	NONE	487	1150	M	17.9	2708
04/18/2002	42151C0F23	NONE	500	1150	I	17.8	1688
04/18/2002	203E3F3C27	NONE	495	1125	M	17.8	1421
04/18/2002	1F750B7869	NONE	505	1275	M	17.8	Unknown[b]
04/18/2002	423F635449	NONE	478	1175	M	17.5	170

a: I = indeterminate; M = male; F = female

b: This fish did not have a detectable PIT tag at the time of recapture, therefore the number of days it had been in the river since stocking could not be determined. A PIT tag was implanted in this fish before it was released back into the river.

Table A-1, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On nonnative fish removal trips - electrofishing (UDWR-Moab): continued							
04/19/2002	4240132127	NONE	490	1350	I	7.8	170
05/07/2002	5324612161	NONE	392	620	I	41.9	564
05/09/2002	423E77433E	NONE	453	900	M	18.3	191
05/09/2002	423F0F0F32	NONE	443	1100	M	18.3	190
05/20/2002	42424E135B	NONE	383	510	I	45.3	201
05/21/2002	423E793225	NONE	518	1500	I	40.6	202
05/21/2002	51337C3546	NONE	445	650	I	35.0	1314
05/22/2002	423F057A3F	NONE	470	1200	I	24.5	202
05/23/2002	4240132127®	NONE	490	1350	I	17.2	204
06/12/2002	4240072250	NONE	445	850	M	27.2	225
06/13/2002	53256E784F	NONE	452	1250	I	14.1	601

a: I = indeterminate; M = male; F = female

®: This was the second recapture of this fish in 2002. The first recapture was on 04/19/2002 at RM 7.8.

Table A-2. Razorback sucker collected during other studies in the San Juan River in 2003 (n = 156).

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On the fall 2003 adult monitoring trip - electrofishing (USFWS-CRFP): n = 19							
09/22/2003	423F0D5520	791	463	940	M	158.0	690
09/22/2003	423F031672	071	500	1400	M	155.0	691
09/22/2003	42400C0D3C	742	461	800	I	155.0	691
09/22/2003	5229107403	701	444	890	I	151.0	518
09/23/2003	423E541450	781	502	1370	F	146.0	692
09/23/2003	423F6C1E6A	711	455	850	M	137.0	693
09/23/2003	423F6C4E6D	771	495	1150	F	137.0	693
10/06/2003	5325724805	NONE	459	925	I	110.0	1083
10/06/2003	423E560E3B	NONE	475	995	F	109.9	705
10/06/2003	53254A7E7A	NONE	432	838	M	109.7	1081
10/07/2003	423C262A4F	NONE	397	700	F	107.0	706
10/07/2003	423F0F6966	NONE	493	1140	F	101.2	707
10/07/2003	1F435F1728	NONE	513	1320	F	100.0	3245
10/07/2003	423E752F7F	NONE	452	840	M	100.0	Unknown[b]
10/07/2003	42400D333D	NONE	472	1020	F	97.0	707
10/08/2003	1F74343F7A	NONE	465	980	M	85.0	3246
10/09/2003	5325740172	NONE	466	1120	M	80.1	1084
10/12/2003	4121492F55	NONE	249	125	I	35.7	Unknown[c]
10/14/2003	522A4C4A53	NONE	410	670	I	7.0	540

a: I = indeterminate; M = male; F = female

b: This fish did not have a detectable PIT tag at the time of recapture, therefore the number of days it had been in the river since stocking could not be determined. A PIT tag was implanted in this fish before it was released back into the river.

c: This juvenile fish is suspected to be a wild-spawned offspring of stocked razorback sucker.

Table A-2, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
In the PNM Fish Ladder (Navajo Nation): n = 4							
06/19/2003	423F03051B	NONE	330	709	I	166.6	597
07/19/2003	423E69336A	NONE	402	652	I	166.6	625
10/07/2003	423F0E6851	NONE	454	988	M	166.6	707
10/08/2003	423F5F1624	NONE	460	948	I	166.6	707
On nonnative fish removal trips - electrofishing (USFWS-NMFRO): n = 96							
05/07/2003	423E446022	NONE	428	900	F	158.4	553
05/07/2003	423F171D43	NONE	408	900	F	158.4	553
05/07/2003	42421C7E34	NONE	465	1100	I	158.3	Unknown[b]
05/07/2003	423F6E6558	NONE	405	600	I	157.1	553
05/07/2003	423E633457	NONE	425	1050	F	157.1	553
05/07/2003	423F0D5520	NONE	459	1150	M	156.6	554
05/07/2003	423F5D406A	NONE	443	810	F	156.5	552
05/07/2003	4240181B0C	NONE	435	840	I	156.5	553
05/07/2003	426A237242	NONE	427	840	M	156.5	20
05/07/2003	426A2B6D20	NONE	373	850	I	156.5	21
05/07/2003	53245D7146	NONE	481	1480	I	156.5	931
05/07/2003	4242324D75	NONE	453	800	I	156.3	552
05/07/2003	52283B0450	NONE	426	900	M	156.0	23
05/07/2003	423E682972	NONE	425	900	I	155.6	554
05/07/2003	423E5D0D08	NONE	443	1350	M	155.5	554
05/07/2003	42417F735D	NONE	460	1200	M	155.4	554
05/07/2003	5228404A7F	NONE	440	950	M	155.1	23
05/07/2003	532405032C	NONE	428	1100	M	155.1	931
05/08/2003	4269582672	NONE	318	450	I	158.5	24
05/08/2003	425C030138	NONE	372	870	I	158.4	22
05/08/2003	423E744C06	NONE	432	1000	I	158.3	553
05/08/2003	42696B386C	NONE	301	300	I	158.0	24
05/08/2003	423E40602E	NONE	423	1200	I	156.0	554

a: I = indeterminate; M = male; F = female

b: This fish did not have a detectable PIT tag at the time of recapture, therefore the number of days it had been in the river since stocking could not be determined. A PIT tag was implanted in this fish before it was released back into the river.

Table A-2, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On nonnative fish removal trips - electrofishing (USFWS-NMFRO): continued							
05/08/2003	423E25020E	NONE	432	990	I	155.9	555
05/08/2003	5326034D21	NONE	460	1220	I	155.9	932
05/09/2003	426926224E	NONE	328	400	I	158.5	23
05/09/2003	4240122A62	NONE	434	820	F	158.1	556
05/09/2003	4268707839	NONE	454	1250	I	157.5	23
05/09/2003	4240010F47	NONE	436	820	M	156.0	556
05/09/2003	423F7F6019	NONE	431	920	I	155.9	556
05/09/2003	52290D4047	NONE	402	680	F	155.8	382
05/09/2003	53245A7C46	NONE	449	1150	F	155.5	933
06/10/2003	423E5E570E	NONE	415	1000	I	158.4	586
06/10/2003	423F1A154A	NONE	468	1350	M	157.3	588
06/11/2003	5228752719	NONE	430	700	M	154.0	58
06/12/2003	4242473622	NONE	450	1075	I	157.1	590
06/12/2003	423F0E4F5F	NONE	413	770	M	156.5	590
06/12/2003	52392E670B	NONE	400	950	M	152.0	59
07/16/2003	5228604717	NONE	435	850	I	164.0	93
07/16/2003	423F6C1D7D	NONE	439	900	I	164.0	624
09/03/2003	423E38730A	NONE	432	920	I	158.0	673
09/03/2003	423F7E7469	NONE	440	1100	M	158.0	673
09/03/2003	423E654D5D	NONE	537	1500	I	156.2	671
09/03/2003	532405032C	NONE	433	900	M	151.4	1050
09/04/2003	522A575300	NONE	403	620	I	158.0	500
10/28/2003	425B650B18	NONE	445	1050	M	159.0	195
10/28/2003	5239306E3E	NONE	385	510	I	159.0	197
11/11/2003	423F5D406A	NONE	445	860	F	158.6	740
11/11/2003	423F035D5A	NONE	435	1600	I	158.6	740
11/11/2003	425B6A1A6D	NONE	336	-----[b]	I	158.6	14
11/11/2003	426956485C	NONE	320	295	I	158.6	12
11/11/2003	42695B6262	NONE	311	290	I	158.6	12

a: I = indeterminate; M = male; F = female
b: This value was not obtained due to equipment failure.

Table A-2, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On nonnative fish removal trips - electrofishing (USFWS-NMFRO): continued							
11/11/2003	426A261D6B	NONE	318	321	I	158.6	12
11/11/2003	423E725455	NONE	518	1410	I	157.0	740
11/11/2003	423F633E41	NONE	462	1250	I	157.0	742
11/11/2003	425B733110	NONE	295	200	I	157.0	14
11/11/2003	426A40196C	NONE	300	285	I	157.0	14
11/11/2003	42423D5E34	NONE	440	1300	M	157.0	742
11/11/2003	4269025C39	NONE	299	215	I	157.0	14
11/11/2003	423D073604	NONE	435	1500	I	156.3	Unknown[b]
11/11/2003	423E557862	NONE	510	1550	I	156.3	742
11/11/2003	42686F5C64	NONE	440	1850	I	156.3	209
11/11/2003	423F0D5520	791	463	1650	M	156.0	742
11/11/2003	42695E7955	NONE	327	310	I	156.0	12
11/11/2003	423E6F352E	NONE	448	930	I	155.0	741
11/11/2003	42694D0D54	NONE	287	225	I	154.0	14
11/11/2003	426B245C32	NONE	337	360	I	154.0	13
11/11/2003	425B744666	NONE	367	380	I	152.0	13
11/11/2003	42686E2511	NONE	338	320	I	152.0	14
11/11/2003	42693C4E34	NONE	308	250	I	152.0	12
11/12/2003	423F7E0831	NONE	467	1010	I	157.0	742
11/12/2003	425B68262B	NONE	320	260	I	157.0	15
11/12/2003	4268795611	NONE	285	165	I	157.0	15
11/12/2003	426A090E3D	NONE	316	240	I	155.0	13
11/12/2003	426B2B3208	NONE	307	240	I	154.0	14
11/12/2003	4268577300	NONE	322	320	I	152.0	15
11/12/2003	4269581102	NONE	315	250	I	151.0	13
11/12/2003	42685B592A	NONE	310	280	I	151.0	15
11/12/2003	4269044367	NONE	325	340	I	151.0	15
12/09/2003	4240033016	NONE	456	1150	M	157.0	770

a: I = indeterminate; M = male; F = female

b: This fish did not have a detectable PIT tag at the time of recapture, therefore the number of days it had been in the river since stocking could not be determined. A PIT tag was implanted in this fish before it was released back into the river.

Table A-2, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On nonnative fish removal trips - electrofishing (USFWS-NMFRO): continued							
12/09/2003	426A3B7928	NONE	286	175	I	157.0	42
12/09/2003	----------[b]	NONE	325	230	M	157.0	Unknown[b]
12/09/2003	423E454C69	NONE	444	800	I	157.0	770
12/09/2003	425B733110	NONE	295	225	I	157.0	42
12/09/2003	42694A6A5C	NONE	320	300	I	157.0	41
12/09/2003	42694D4C0E	NONE	275	200	I	157.0	42
12/09/2003	42694E4215	NONE	311	275	I	157.0	42
12/09/2003	426B3F043B	NONE	286	200	I	157.0	42
12/09/2003	42687E4733	NONE	295	225	I	157.0	40
12/09/2003	426B10597C	NONE	309	140	I	156.0	42
12/09/2003	522A215F2D	NONE	410	700	I	156.0	596
12/09/2003	522A616543	NONE	445	990	I	156.0	596
12/10/2003	426A295045	NONE	312	320	I	149.0	42
12/11/2003	425B6F7467	NONE	324	310	I	150.0	44
12/11/2003	426B360141	NONE	306	270	I	150.0	44
12/11/2003	425B687F49	NONE	281	215	I	148.6	44
On nonnative fish removal trips - electrofishing (UDWR-Moab): n = 19							
03/27/2003	5324566328	NONE	438	980	M	18.8	890
03/27/2003	7F7B10402D	NONE	551	1500	F	18.8	1764
03/27/2003	7F7B106C67	NONE	476	1100	M	18.8	1764
04/28/2003	42424F2863	NONE	497	1000	F	50.7	544
05/01/2003	423E673807	NONE	460	980	M	19.0	546
05/01/2003	4240072250	NONE	445	960	M	18.4	548
05/01/2003	51247B6557	NONE	485	1150	M	17.6	1659
05/01/2003	423F5C3654	NONE	394	770	I	12.9	547
05/21/2003	4240072250	NONE	445	1960	M	15.2	568
06/09/2003	52283A1D5F	NONE	449	870	I	47.6	413
06/10/2003	52290D016E	NONE	410	620	I	45.0	57
06/12/2003	52285E1A28	NONE	410	700	M	18.7	59

a: I = indeterminate; M = male; F = female
b: This value was not obtained due to equipment failure.

Table A-2, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On nonnative fish removal trips - electrofishing (UDWR-Moab): continued							
06/12/2003	423F7E5A02	NONE	462	1000	I	18.0	590
06/26/2003	5128465837	NONE	475	1000	I	20.2	430
06/26/2003	423F7E5A02	NONE	471	1010	I	17.8	604
07/24/2003	423F167345	NONE	410	755	I	18.5	631
07/25/2003	425863072F	NONE	274	202	I	4.8	Unknown[b]
08/07/2003	507E667172	NONE	441	890	I	11.5	472
08/19/2003	423E696E12	NONE	472	1230	I	42.5	658
On FLOY-tagging trips - electrofishing (USFWS-NMFRO): n = 16							
02/19/2003	4242312966	NONE	489	1200	I	157.8	477
02/19/2003	53245A7C46	NONE	446	950	I	156.8	854
03/04/2003	5324111728	NONE	423	1200	I	157.1	867
03/04/2003	423E78024C	NONE	459	1180	I	156.7	489
03/04/2003	522A4D342B	NONE	360	650	I	156.3	316
03/04/2003	423E78141C	NONE	418	820	I	155.7	490
03/04/2003	424004437A	NONE	425	900	I	154.6	489
05/14/2003	42301B1B41	NONE	569	2000	I	157.6	Unknown[c]
05/14/2003	423E7E4D15	NONE	435	850	M	156.9	560
05/14/2003	423F712672	NONE	498	1450	I	156.8	560
05/14/2003	423E25020E	NONE	432	850	I	156.6	561
05/14/2003	425B650B18	NONE	443	850	M	155.2	28
05/14/2003	423F633E41	NONE	462	1250	I	154.9	561
05/14/2003	423F031672	NONE	487	1400	M	154.8	560
05/14/2003	522A47736F	NONE	435	800	I	154.4	388
05/14/2003	423F5E0F2B	NONE	409	750	I	154.1	560

a: I = indeterminate; M = male; F = female

b: This juvenile fish is suspected to be a wild-spawned offspring of stocked razorback sucker.

c: This fish did not have a detectable PIT tag at the time of recapture, therefore the number of days it had been in the river since stocking could not be determined. A PIT tag was implanted in this fish before it was released back into the river.

Table A-2, continued.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Days In River Since Stocking
On trips to monitor stocked Colorado pikeminnow - seining (BIO/WEST): n = 1							
12/06/2003	Unknown[b]	NONE	253	316	I	127.6	Unknown[b]
On research trips in Lake Powell - gill-netting (UDWR - Wahweap): n = 1							
08/28/2003	1F5B36222E	NONE	500	1421	I	-10.0	2942

a: I = indeterminate; M = male; F = female

b: This value was not obtained due to the lack of a PIT tag reader on the trip.

APPENDIX B

Values obtained for the Schnabel multiple-census population estimates and Lincoln-Petersen population estimates, 1995-2003.

Table B-1. Schnabel multiple census population estimates for stocked razorback sucker (RM 158.6-76.4) on spring and fall standardized monitoring trips, 1995-2000.

Schnabel Population Estimates (RM 158.6-76.4):		
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	172	59-858
Fall 1997	207	70-1033
Spring 1998	193	76-772
Fall 1998	156	71-425
Spring 1999	137	74-291
Fall 1999	151	82-322
Spring 2000	152	85-309
Fall 2000	157	90-304
Spring 2001	237	138-447
Fall 2001	270	161-490
Spring 2002	312	186-568
Fall 2002	402	243-717
Spring 2003	540	332-939
Fall 2003	640	400-1100

Table B-2. Extrapolated riverwide (RM 158.6-2.9) population estimates for stocked razorback sucker, based on 77.6% of recaptures on 1995-2003 fall adult monitoring trips (RM 158.6-2.9) being collected in the area covered by the Schnabel population estimate (RM 158.6-76.4), above.

Trip	Extrapolated Population Estimate (RM 158.6-2.9)
Fall 1995	103
Fall 1996	393
Fall 1997	267
Fall 1998	201
Fall 1999	195
Fall 2000	202
Fall 2001	348
Fall 2002	518
Fall 2003	825

Table B-3. Lincoln-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, 1995-2003.

Lincoln-Petersen Population Estimates (RM 158.6-76.4):		
Trip	Lincoln-Petersen Population Estimate	95% Confidence Interval (C.I.)
Spring 1995	48	15-87
Fall 1995	120	25-120
Spring 1996	150	32-150
Fall 1996	80	29-200
Spring 1997	140	30-140
Fall 1997	95	29-173
Spring 1998	68	25-171
Fall 1998	95	42-237
Spring 1999	196	42-196
Fall 1999	104	32-189
Spring 2000	135	41-245
Fall 2000	44	13-80
Spring 2001	105	32-191
Fall 2001	36	11-65
Spring 2002	133	28-133
Fall 2002	225	68-409
Spring 2003	216	65-393
Fall 2003	459	139-834

Table B-4. Extrapolated riverwide (RM 158.6-2.9) population estimates for stocked razorback sucker, based on (77.6%) of recaptures on the fall 1995-2003 adult monitoring trips (RM 158.6-2.9) being collected in the area covered by the Lincoln-Petersen population estimate (RM 158.6-76.4).

Trip	Extrapolated Population Estimate (RM 158.6-2.9)
Fall 1995	155
Fall 1996	103
Fall 1997	122
Fall 1998	122
Fall 1999	134
Fall 2000	57
Fall 2001	46
Fall 2002	290
Fall 2003	591