

**AUGMENTATION OF COLORADO PIKEMINNOW
IN THE SAN JUAN RIVER: 2004**

Interim Progress Report
(Final)

Submitted By:

Dale W. Ryden
Fishery Biologist

1 August 2005

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

EXECUTIVE SUMMARY

The 2003 Colorado pikeminnow augmentation plan (and its 2002 draft predecessor), called for a total of 850,000 Colorado pikeminnow to be stocked into the San Juan River by the end of 2004: 250,000 in 2002 and 300,000 each in 2003 and 2004. To date, a total of 668,570 Colorado pikeminnow have been stocked into the San Juan River: 210,418 in October 2002 (age-0 fish), 176,933 in November 2003 (age-0 and age-1 fish), 1,219 in June 2004 (age-2 fish), and 280,000 in October 2004 (age-0 fish). This constitutes a shortfall of 181,430 fish over the first three years of this eight year augmentation effort (2002-2009).

In calendar year 2004, a total of 2,649 Colorado pikeminnow (that were reported to the author) were known to have been recaptured in the San Juan River. Of these, 2 were wild-produced larval fish, 2,642 were stocked juvenile fish, and 5 were adults. These 2,649 fish were collected during sampling efforts for nine different studies. In general, age-2 Colorado pikeminnow that were stocked in October 2002 appear to have had poorer retention/survival than did their counterparts stocked in previous years (i.e., 1996, 1997, and 2003), almost from the moment of stocking. These age-2 (2002 year-class) fish were essentially absent from sub-adult and adult large-bodied fish community monitoring ("Adult Monitoring" for short) samples in the fall of 2004. The CPUE for Colorado pikeminnow on the fall 2004 Adult Monitoring trip was 1.78 fish/hr of electrofishing (n = 159 fish). This was by far the highest CPUE ever observed for Colorado pikeminnow since experimental stocking efforts for Colorado pikeminnow began in fall 1996. Length-frequency histograms of Colorado pikeminnow collected on the fall 2004 Adult Monitoring trip seem to corroborate the apparent low retention/survival rate among Colorado pikeminnow that were stocked as age-0 fish in October 2002. Only 14 (8.8%) of the 159 Colorado pikeminnow collected on this trip were fish that were stocked in October 2002. In contrast, the retention/survival rate (based on fall 2004 Adult Monitoring recaptures) among Colorado pikeminnow that were stocked as age-0 fish in November 2003 appears to have been as high as any ever observed, since stocking of age-0 Colorado pikeminnow began in the San Juan River in 1996. A total of 130 (81.8%) of the 159 Colorado pikeminnow collected on this trip were fish that were stocked in November 2003.

Growth rates observed among recaptured fish originally stocked in the fall of 1996 indicate that when age-0 Colorado pikeminnow are stocked in the fall (late October or early November) at mean sizes of 50-55 mm TL, they will reach adulthood (\geq 450 mm TL) in the fall of the year they are age-4 fish or the spring of the year they are age-5 fish. This means that, if they survive and continue to grow as predicted, age-0 Colorado pikeminnow stocked in October 2002 will begin recruiting into the adult Colorado pikeminnow population in 2006 or 2007, while those stocked in November 2003 will begin recruiting into the adult population in 2007 or 2008, and those stocked in October 2004 will begin recruiting into the adult population in 2008 or 2009. However, it should be noted that the Colorado pikeminnow being stocked in the fall at 50-55 mm TL are generally larger than (sometimes almost twice as large as) wild age-0 fish would be at that time of the year and therefore their growth will be accelerated when compared to wild-produced fish.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
TABLE OF CONTENTS	ii
LIST OF TABLES.	iii
LIST OF FIGURES	iii
INTRODUCTION.	1
Objectives.	1
METHODS	2
Fish Production And Stocking.	2
Fish Stocked In June 2004	2
Fish Stocked In October 2004.	3
2005 And Beyond	4
Monitoring Of Stocked Fish.	4
RESULTS	5
Stockings	5
Recaptures And Growth	7
Anticipated Growth Among Stocked Age-0 Colorado Pikeminnow.	11
DISCUSSION.	14
LITERATURE CITED.	16
ACKNOWLEDGEMENTS.	17

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Experimental stockings of Colorado pikeminnow in the San Juan River, 1996-2001	2
2	Stockings of Colorado pikeminnow into the San Juan River that have occurred under the auspices of the 2003 augmentation plan . .	6
3	Stockings of Colorado pikeminnow into the San Juan River, 2002-2004, versus the target number of fish specified in the 2003 Colorado pikeminnow augmentation plan.	6
4	Collections of Colorado pikeminnow that occurred in the San Juan River in 2004	8

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Colorado pikeminnow catch per unit effort (CPUE), by life stage, on fall Adult Monitoring trips, 1996-2004. Error bars represent one standard error.	9
2	Length-frequency histograms for Colorado pikeminnow recaptured during the fall 1998 and fall 2004 Adult Monitoring trips. Large numbers of age-0 Colorado pikeminnow had been stocked in the fall for two consecutive years prior to each of these Adult Monitoring trips (i.e., 1996 and 1997 versus 2002 and 2003). These are the only two Adult Monitoring trips (these trips began in 1991) during which ≥ 100 Colorado pikeminnow were recaptured.	10
3	Mean total length in mm, by month, observed among recaptured Colorado pikeminnow that were originally stocked on either 24 October 2002 (top) or 6 November 2003 (bottom). Error bars indicate minimum and maximum observed values. The dashed line indicates the expected growth trend based on observed values. . . .	12
4	Mean total length in mm, by year, observed among recaptured Colorado pikeminnow that were originally stocked on either 4 November 1996 (dashed line) or 15 August 1997 (solid line). Error bars indicate minimum and maximum observed values	13

INTRODUCTION

Colorado pikeminnow is a federally-listed endangered fish native to the San Juan River (Ryden 2003). The capture of low numbers of Colorado pikeminnow of all life stages over the past fifteen years has confirmed that a small, but reproducing population of Colorado pikeminnow is still extant in the San Juan River (e.g., Platania 1990, Ryden 2000). In 1996, experimental stocking of Colorado pikeminnow into the San Juan River was undertaken by the Utah Division of Wildlife Resources' (UDWR) Moab field station. The purpose of this effort was to evaluate dispersal and retention of stocked juvenile Colorado pikeminnow as well as determining the availability, use, and selection of habitats by early life stage Colorado pikeminnow. Between 1996 and 2000, approximately 832,000 larval and age-0 Colorado pikeminnow were stocked into the San Juan River by the UDWR (Table 1). In addition, 197 adult Colorado pikeminnow were stocked into the San Juan River, 49 in 1997 and 148 in 2001 (Table 1). To date, several hundred of those stocked juvenile and adult Colorado pikeminnow have been recaptured during either seining or electrofishing efforts. A handful of the individuals stocked in 1996 and 1997 have been documented as having recruited into the San Juan River's adult Colorado pikeminnow population (Jackson 2003, 2004). Based on data collected from these experimentally stocked fish, it is apparent that stocked, hatchery-reared, juvenile Colorado pikeminnow can survive in the San Juan River and can provide a viable method of supplementing the numbers and expanding the range of the wild San Juan River Colorado pikeminnow population.

The need for artificial propagation and augmentation of this species in the San Juan River is apparent for several reasons. Augmentation of Colorado pikeminnow would increase population numbers, provide more individuals for research purposes, add genetic diversity to the existing gene pool, and provide a riverine refugia population that would, hopefully, remain stable until further research can identify factors limiting successful recruitment of this species in the San Juan River. The San Juan River Long Range Plan identifies the need to assess the feasibility of, and then implement the augmentation of Colorado pikeminnow. In January 2003, **An Augmentation Plan For Colorado Pikeminnow In The San Juan River** (Ryden 2003) was finalized. This augmentation plan provides the necessary guidance for augmentation efforts as well as directly fulfilling objective 5.3.8.2 of the San Juan River Long Range Plan (San Juan River Recovery Implementation Program Biology Committee 1995).

The objectives of this workplan were as follows:

Objectives:

- 1.) Coordinate with Dexter National Fish Hatchery (NFH) to procure and stock fish according to guidelines set forth in **An Augmentation Plan For Colorado Pikeminnow In The San Juan River** (Ryden 2003).
- 2.) Provide a report that gathers information from various sources on fingerling production, numbers of fish stocked, subsequent recaptures during various sampling efforts (other than the intensive monitoring effort), and makes recommendations (if necessary) for modifying methods being employed for Colorado pikeminnow augmentation efforts.

Table 1. Experimental stockings of Colorado pikeminnow in the San Juan River, 1996-2001.

Date	Number Stocked	River Mile Stocked At	Mean Total Length (mm)	Range Of Total Lengths (mm)	Responsible Entity ^a
Experimental stockings of juvenile fish: 1996-2000					
11/04/1996	50,000	148.0	55	25-85	UDWR
11/04/1996	50,000	52.0	55	25-85	UDWR
08/15/1997	62,578	148.0	45	35-55	UDWR
08/15/1997	54,300	52.0	45	35-55	UDWR
07/02/1998	10,571	148.0	24	18-28	UDWR
07/07/1999	500,000	158.6	"Larvae"	Unspecified	UDWR
06/11/2000	105,000	141.9	"Larvae"	Unspecified	UDWR
Experimental stockings of adult fish: 1997 and 2001					
09/23/1997	49	180.2	644	550-753	USFWS
04/11/2001	148	180.2	540	442-641	USFWS

a: UDWR = Utah Division of Wildlife Resources - Moab Field Station, Moab, UT; USFWS = U. S. Fish and Wildlife Service - Colorado River Fishery Project, Grand Junction, CO

METHODS

All Colorado pikeminnow that were stocked by the UDWR between 1996 and 2000 (Table 1) were progeny of either the "1981 broodstock" or the "1991 broodstock" being held at Dexter NFH in Dexter, NM. These two broodstocks were identified as appropriate sources for use in augmentation efforts for Colorado pikeminnow on the San Juan River (Crist and Ryden 2003, Ryden 2003). As was stated in the 2003 Colorado pikeminnow augmentation plan (Ryden 2003), the continued use of these two broodstock lots is anticipated for the duration of the current eight-year augmentation effort (2002-2009).

Fish Production And Stocking

Fish Stocked In June 2004

On 9 June 2004, a total of 1,219 age-2 Colorado pikeminnow (mean TL = 218 mm TL; range = 144-278 mm TL) were stocked en masse at RM 180.2, just downstream of the Animas River confluence. Personnel from the J. W. Mumma Native Species Hatchery in Alamosa, CO (a.k.a. "Mumma") and from the Bureau of

Indian Affairs (BIA-NIIP) office in Farmington, NM performed the stocking of these fish. These fish had been reared at Mumma from 2002-2004. These age-2 fish were originally produced at Dexter NFH in 2002 as progeny of the "1991 broodstock" being held at Dexter NFH. The fry produced from the 2002 paired matings were transferred to Mumma from Dexter NFH in June 2002. These age-2 fish were excess fish to the Colorado pikeminnow stocking efforts that are ongoing in the Upper Colorado River Basin. This was the second year that excess fish from Mumma were made available to the San Juan River Recovery Implementation Program (SJRIP).

Fish Stocked In October 2004

Following is an excerpt from the **Colorado Pikeminnow Fingerling Production** report (Hamman and Ulibarri 2004), that describes the production of the age-0 Colorado pikeminnow stocked into the San Juan River on 21 and 28 October 2004:

Two attempts to spawn Colorado pikeminnow during May, 2004 resulted in fair to good egg production. On May 19, two Colorado pikeminnow females (1981 year-class) spawned approximately 24 hours after receiving one intraperitoneal injection of 2.0 mg carp pituitary per pound of body weight (4.4 mg/kg body weight). Females had a mean total length of 731 mm and a mean weight of 3.48 kg. Average number of eggs per female was 93,643. All swim-up fry were used for other commitments.

On May 26, a total of 29 Colorado pikeminnow females (1991 year-class) were spawned 22-24 hours after receiving one intraperitoneal injection of 2.0 mg carp pituitary per pound of body weight (4.4 mg/kg body weight). Females had a mean total length of 635 mm and a mean weight of 2.45 kg. Average number of eggs per female was 69,590.

Eggs were inventoried and placed in Heath incubators at a water temperature of 70^o F (21^o C). Eggs commenced hatching at 90 hours and were completely hatched by 140 hours. Newly hatched larvae were transferred to four fiberglass holding tanks (12.0' X 2.75' X 2.0') and held until swim-up occurred, approximately 120 hours after hatching.

Four earthen ponds, ranging in size from 0.74 to 0.88 surface acres (0.30 to 0.36 ha) were stocked with 315,000 fry. Ponds received weekly fertilizer treatments (six treatments) to promote a plankton bloom. Fry were also given a daily supplement diet of artificial feed. Fish were not moved during the grow-out period.

The young-of-the-year (YOY) Colorado pikeminnow were cultured in the four ponds for 132-145 days. Survival in the four ponds ranged from 76.6% to 97.3%. Overall survival was 88.9% for a return of 280,000 fingerlings.

Distribution was conducted on two different trips. Hauling methods consisted of two (2) double compartment fiberglass tanks and one single compartment fiberglass tank. One double compartment tank had capacities of 325 and 375 gallons (1,230 and 1,420 liters) and the other 100 gallons (376 liters) per compartment. The single compartment tank had a capacity of 300 gallons (1,136 liters).

On October 21, personnel from Dexter and BIO-WEST, transported and stocked 140,000 Colorado pikeminnow averaging 2.0 inches (50 mm) and weighing 313.5 pounds (142.2 kg) to several locations on the San Juan River. Of this number, a total of 20,000 fingerlings had been VIE marked. On October 28, personnel from Dexter transported and stocked the remaining 140,000 Colorado

pikeminnow averaging 2.0 inches (50 mm) and weighing 320 pounds (145.2 kg) to several locations on the San Juan River. All stocking efforts were coordinated with Dale Ryden of the Grand Junction CRFP Office.

On 21 and 28 October 2004, Colorado pikeminnow from Dexter NFH were loaded onto rafts and transported downstream in aerated live-wells. Fish were stocked into low-velocity habitats (mostly backwaters) throughout two river sections (each roughly ten miles long), RM 180.2-170.0 and RM 158.6-148.5. The most downstream stocking section allowed age-0 Colorado pikeminnow to be stocked downstream of all major water diversion structures, thus minimizing the potential for loss from these sources. The most upstream stocking section, while prone to loss from diversion structures (L. Renfro pers. comm.), was chosen to allow age-0 Colorado pikeminnow to be stocked as far upstream in their designated Critical Habitat (U. S. Fish and Wildlife Service 1994) range as possible. It was hoped that stocking fish 22 miles farther upstream would also increase retention, given the large-scale downstream displacements observed among age-0 Colorado pikeminnow, post-stocking, during UDWR's 1996-2000 experimental stocking efforts (Archer et al. 2000, Jackson 2001). It was also hoped that some of these age-0 Colorado pikeminnow would retain and recruit in the section of river upstream of the PNM Weir (RM 166.6) thus facilitating an expansion in range for this species in the San Juan River. It was anticipated that spreading fish to numerous low-velocity habitats would allow them to acclimate better than immediately entering main channel habitats upon stocking, thus reducing post-stocking downstream displacement. In addition, spreading young fish out into many habitats should help reduce the risk of potential predation or other catastrophic loss that may occur in any single location.

In October 2004, a total of 180,000 age-0 Colorado pikeminnow were stocked in the upper stocking section (RM 180.2-170.0) and 100,000 were stocked in the lower stocking section (RM 158.6-148.5).

2005 And Beyond

As stated above, the 2003 Colorado pikeminnow augmentation plan calls for a minimum of 300,000 age-0 Colorado pikeminnow to be stocked at roughly the same stocking locations for the next five years (i.e., through 2009).

At a meeting on 5 April 2005, the San Juan River Biology Committee decided to begin stocking a second group ($n = 3,000$) of older (age-1, ≥ 150 mm TL) Colorado pikeminnow concurrently with the annual stockings of age-0 Colorado pikeminnow that are scheduled to occur under the auspices of the 2003 Colorado pikeminnow augmentation plan. These age-1 fish (a.k.a. phase II fish) are scheduled to be produced and reared at Dexter NFH and it is anticipated that, beginning in the fall of 2006, these age-1 fish will be delivered to the San Juan River for stocking at roughly the same time as are the 300,000 age-0 fish. An addendum to the 2003 Colorado pikeminnow augmentation plan, specifying the details and rationale for this additional stocking effort is scheduled to be produced in April 2005.

Monitoring Of Stocked Fish

As was the case between 1996 and 2000 (e.g., Archer et al. 2000, Jackson 2001), there was a study implemented in 2002 to intensively monitor Colorado pikeminnow stocked as part of the eight-year augmentation effort (see Golden et al. 2004, Golden and Holden 2005). In addition, numerous Colorado

pikeminnow were collected opportunistically during sampling for other studies in 2004. Colorado pikeminnow collected during the fall sub-adult and adult large-bodied fish community monitoring study ("Adult Monitoring" for short) have been used to track catch per unit of effort (CPUE = number of fish per hour of electrofishing) of stocked Colorado pikeminnow over the last several years. This will continue throughout the current eight-year augmentation effort (2002-2009).

Recaptures of Colorado pikeminnow stocked between 1996 and 2000 were used to track long-term growth of stocked age-0 fish. Age-at-length determinations for recaptured juvenile Colorado pikeminnow were based upon growth curves presented in USFWS (2002) and upon observed lengths among known-age juvenile Colorado pikeminnow recaptured from the San Juan River between 1997 and 2005 (Ryden unpublished data).

RESULTS

Stockings

Two separate stocking efforts (one in early June and one in late October 2004) for Colorado pikeminnow occurred in 2004 under the auspices of the 2003 Colorado pikeminnow augmentation plan.

The first stocking effort occurred on 9 June 2004. On that date 1,219 age-2 Colorado pikeminnow (2002 year-class) from Mumma were stocked en masse at RM 180.2. These fish were 2002 progeny of paired matings of the "1991 broodstock" being held at Dexter NFH. The fry produced from the 2002 paired matings were transferred to Mumma Hatchery from Dexter NFH in June 2002. These age-2 fish were excess fish to the Colorado pikeminnow stocking efforts that are ongoing in the Upper Colorado River Basin. These age-2 Colorado pikeminnow had a mean TL = 218 mm TL (range = 144-278 mm TL; Table 2). These age-2 fish were all individually PIT-tagged before being released into the wild.

The second stocking effort for Colorado pikeminnow in 2004 occurred on 21 and 28 October 2004. On these two days, a total of 280,000 age-0 Colorado pikeminnow (2004 year-class) were stocked into the San Juan River. These 280,000 fish had a mean TL = 50 mm (range = 35-166 mm TL; Table 2).

On 21 October 2004, the first group of 140,000 age-0 Colorado pikeminnow (2004 year-class) from Dexter NFH was stocked into the San Juan River (Table 2). These fish were progeny of the "1991 broodstock" being held at Dexter NFH. Of these 140,000 fish, 30,000 were stocked for a study being conducted by BIO-WEST, Inc. (Golden and Holden 2005). These 30,000 fish were implanted with VIE tags prior to being stocked into acclimation holding pens. All 30,000 of the fish stocked by BIO/WEST were stocked upstream of RM 147.9. The remaining 110,000 age-0 fish stocked on 21 October 2004 were divided into two lots and stocked into two river sections, one from RM 180.2-170.0 and the other from RM 158.6-148.5 (Table 2). On 21 October 2004, a total of 80,000 age-0 Colorado pikeminnow were stocked in the upper stocking section (RM 180.2-170.0) and 60,000 were stocked in the lower stocking section (RM 158.6-148.5). These fish were stocked into numerous low velocity habitats (predominantly small backwaters) throughout each ten-mile river section. None of these fish were PIT-tagged or otherwise marked before release into the wild.

On 28 October 2004, the second group of 140,000 age-0 Colorado pikeminnow (2004 year-class) from Dexter NFH was stocked into the San Juan River (Table 2). These fish were progeny of the "1991 broodstock" being held at Dexter

NFH. The 140,000 age-0 fish stocked on 28 October 2004 were also divided into two lots and stocked into the same two river sections mentioned above (Table 2). On 28 October 2004, a total of 100,000 age-0 Colorado pikeminnow were stocked in the upper stocking section (RM 180.2-170.0) and 40,000 were stocked in the lower stocking section (RM 158.6-148.5). These fish were stocked into numerous low velocity habitats (predominantly small backwaters) throughout each ten-mile river section. None of these fish were PIT-tagged or otherwise marked before release into the wild.

Table 2. Stockings of Colorado pikeminnow into the San Juan River that have occurred under the auspices of the 2003 augmentation plan.

Date	Number Stocked	River Mile Stocked At	Mean Total Length (mm)	Range Of Total Lengths (mm)	Responsible Entity ^a
10/24/2002	210,418	180.2 & 158.6	51	32-127	USFWS
11/06/2003	155,764	180.2-170.0 & 158.6-148.5	58	38-100	USFWS
11/06/2003	20,164	188.4-180.7 & 163.7-159.2	58	38-100	BIO-WEST
11/06/2003	1,005	180.2	180	125-280	CDOW
06/09/2004	1,219	180.2	218	144-278	CDOW
10/21/2004	30,000	178.6-169.5 & 163.7-159.2	50	35-116	BIO-WEST
10/21/2004	110,000	180.2-170.0 & 158.6-148.5	50	35-116	USFWS
10/28/2004	140,000	180.2-170.0 & 158.6-148.5	50	35-116	USFWS

a: USFWS = U. S. Fish and Wildlife Service - Colorado River Fishery Project, Grand Junction, CO; BIO-WEST = BIO/WEST, Inc., Logan, UT; CDOW = Colorado Division of Wildlife, J. W. Mumma Native Species Hatchery, Alamosa, CO

Between 2002 and 2004, a total of 668,570 Colorado pikeminnow have been stocked under the auspices of the 2003 Colorado pikeminnow augmentation plan (Table 2). This constitutes a shortfall of 20,000 fish for 2004 (based on target numbers specified in the 2003 final augmentation plan; Table 3). The total shortfall for all three years combined is 181,430 fish.

Table 3. Stockings of Colorado pikeminnow into the San Juan River in 2002-2004 versus the target number of fish specified in the 2003 Colorado pikeminnow augmentation plan.

Year	Number Of Age-0 Fish Plan Calls For Annually	Number Of Age-0 Fish Actually Stocked	Shortfall (-) Or Surplus (+) For the Year
2002	250,000	210,418	(-) 39,582
2003	> 300,000	176,933	(-) 123,067
2004	> 300,000	280,000	(-) 20,000
2005-2009	> 300,000	N/A	N/A

Recaptures And Growth

Colorado pikeminnow that had been stocked as part of the augmentation effort (Table 2) were recaptured on sampling trips for nine different studies in 2004 (Table 4). A total of 2,649 YOY (age-0), juvenile (age-1 or age-2) and adult Colorado pikeminnow were collected during these studies in 2004 (Table 4). Numbers presented in Table 4 for larger juveniles (i.e., individuals with PIT tags) and adults represent first-time recaptures of unique individuals -- multiple recapture events of larger, individually identifiable fish have been eliminated from this data.

As can be seen in Table 4, Colorado pikeminnow of several different size-classes were collected throughout 2004. These included fish that were stocked as adults in April 2001 (n = 4 collections), a single individual that was likely stocked in 1996 or 1997 as an age-0 fish that had subsequently recruited into the adult population (based on growth curves in USFWS 2002), two wild-produced larvae (the first collected in the San Juan River since 2001; Brandenburg et al. 2005), and several hundred recapture events with stocked juveniles (Table 4). This represents, by far, the highest number of Colorado pikeminnow ever scientifically-documented in the San Juan River. Catch per unit effort (CPUE) for Colorado pikeminnow during the fall 2004 Adult Monitoring trip was the highest ever observed (Figure 1). However, unlike collections from other studies done earlier in the year, Colorado pikeminnow recaptured during the fall 2004 Adult Monitoring trip were heavily dominated by one year-class of fish (i.e., age-1 fish that were originally stocked on 6 November 2003).

A length-frequency histogram showed that the large majority (n = 130; 81.8%) of the 159 Colorado pikeminnow collected during the fall 2004 Adult Monitoring trip were age-1 fish that were stocked on 6 November 2003 (Figure 2). This represents a fairly stark contrast to what was seen in fall 1998 Adult Monitoring collections. In both fall 1998 and fall 2004, there had been two years of age-0 fish being stocked prior to the fall sampling trip (i.e., stockings in 1996 and 1997 versus stockings in 2002 and 2003). Also, in 1998 and 2004, the numbers of young Colorado pikeminnow were higher than anything previously documented by scientific collections in the San Juan River up to that point. In fact, these were the only two years during which ≥ 100 Colorado pikeminnow were collected on fall Adult Monitoring trips (Figure 2). However, when total lengths of Colorado Pikeminnow collected on the fall 1998 Adult Monitoring trip were plotted, they demonstrated a heavily bimodal distribution, indicating relatively good survival by both the 1996 and 1997 year-classes into the fall of 1998 (Figure 2). This was not seen in the 2004 length-frequency plots. Thus, it would appear that the Colorado pikeminnow from the 2002 stocking (2002 year-class) did not survive into the fall of 2004 (their age-2 year) in as great of numbers as was anticipated. Analysis of 1997-1998 versus 2003-2004 seining data by Golden and Holden (2005) also seems to support this conclusion.

In general, age-2 fish (i.e., from the fall 2002 stocking; Table 2) had demonstrated relatively poor retention/survival when compared to other year-classes of similarly-sized stocked Colorado pikeminnow almost from the moment of stocking (i.e., from the fall 1996, 1997, and 2003 stockings; Golden and Holden 2005, S. Ross pers. comm.). Peculiarly then, age-2 fish were collected with some regularity in the spring months (March-May) of 2004, by the UDWR in the lower San Juan River, downstream of Mexican Hat, UT (Jackson 2005, J. Jackson unpublished data). However, by the time of the fall 2004 Adult Monitoring trip, these age-2 fish were very rare, even in the lower canyon. Of the 159 Colorado pikeminnow collected during the fall 2004 Adult Monitoring trip, only 29 (18.2%) were age-2 fish (D. Ryden unpublished data). Of those 29, only 14 (8.8% of the total 159 captures) were fish that were stocked in

Table 4. Collections of Colorado pikeminnow that occurred in the San Juan River in 2004.

Study	Responsible Entity ^a	Gear Type	Time Of Year Sampled	Number Collected In 2004 ^b By Life-Stage (And Lengths in mm)
Adult Monitoring	USFWS-CRFP	Electrofishing	Fall	Juveniles = 159 (mean TL = 221 mm) (range = 130-360 mm TL)
Hogback Canal Fish Survey	UNM	Seining	Fall	Juveniles = 140 (TL = N/A)
Nonnative Fish Removal: RM 52.9-2.9	UDWR-Moab	Electrofishing	Spring & Summer	Juveniles = 180 (mean TL = 199 mm) (range = 65-296 mm TL) Adults = 1 (#) (TL = 547 mm)
Nonnative Fish Removal: RM 166.6-147.9	USFWS-NMFRO	Electrofishing	Throughout The Year	Juveniles = 97 (mean TL = 191 mm) (range = 62-397 mm TL) Adults = 1 (*) (TL = 531 mm)
Lower Animas River Sampling	BOR-Durango & Southern Ute Indian Tribe	Electrofishing	Summer	Juveniles = 5 (mean TL = 240 mm) (range = 226-250 mm TL)
PNM Fish Ladder	Navajo Nation	Selective Fish Passage Structure	April Through October	Juveniles = 2 (TL = 244 mm & 255 mm) Adults = 2 (*) (TL = 531 mm & 643 mm)
Hogback Fish Ladder Passage Study	USFWS-NMFRO	Electrofishing	Throughout The Year	Adults = 1 (*) (TL = 515 mm)
Larval Endangered Fish Surveys	UNM	Seining	Spring & Summer	Wild Larvae = 2 (TL = 14 mm & 18 mm) Juveniles = 74 (TL = N/A)
Monitoring Of Stocked Colorado Pikeminnow	BIO-WEST	Seining	Throughout The Year	Juveniles = 1,985 (mean SL = 51 mm) (range = 28-257 mm SL)

a: USFWS-CRFP = U. S. Fish and Wildlife Service - Colorado River Fishery Project, Grand Junction, CO; UNM = University of New Mexico, Museum of Southwestern Biology, Division of Fishes, Albuquerque, NM; UDWR-Moab = Utah Division of Wildlife Resources - Moab Field Station, Moab, UT; USFWS-NMFRO = U. S. Fish and Wildlife Service - New Mexico Fisheries Resource Office, Albuquerque, NM; BOR-Durango = Bureau of Reclamation, Durango CO; S. Ute Indian Tribe = Southern Ute Indian Tribe, Division of Wildlife, Ignacio, CO; Navajo Nation = Navajo Nation, Department of Game and Fish, Window Rock, AZ; BIO-WEST = BIO-WEST, Inc., Logan, UT.

b: Wild Larvae = Wild-spawned fish collected within the first few weeks after being spawned; Juveniles = Age-0, age-1, or age-2 pikeminnow that are known to have been stocked as part of the augmentation effort; Adults = Fish that were either stocked as age-0 fish, that have since recruited into adulthood (#), or fish that were stocked as adults in April 2001 (*). No wild adult Colorado pikeminnow were collected in 2004.

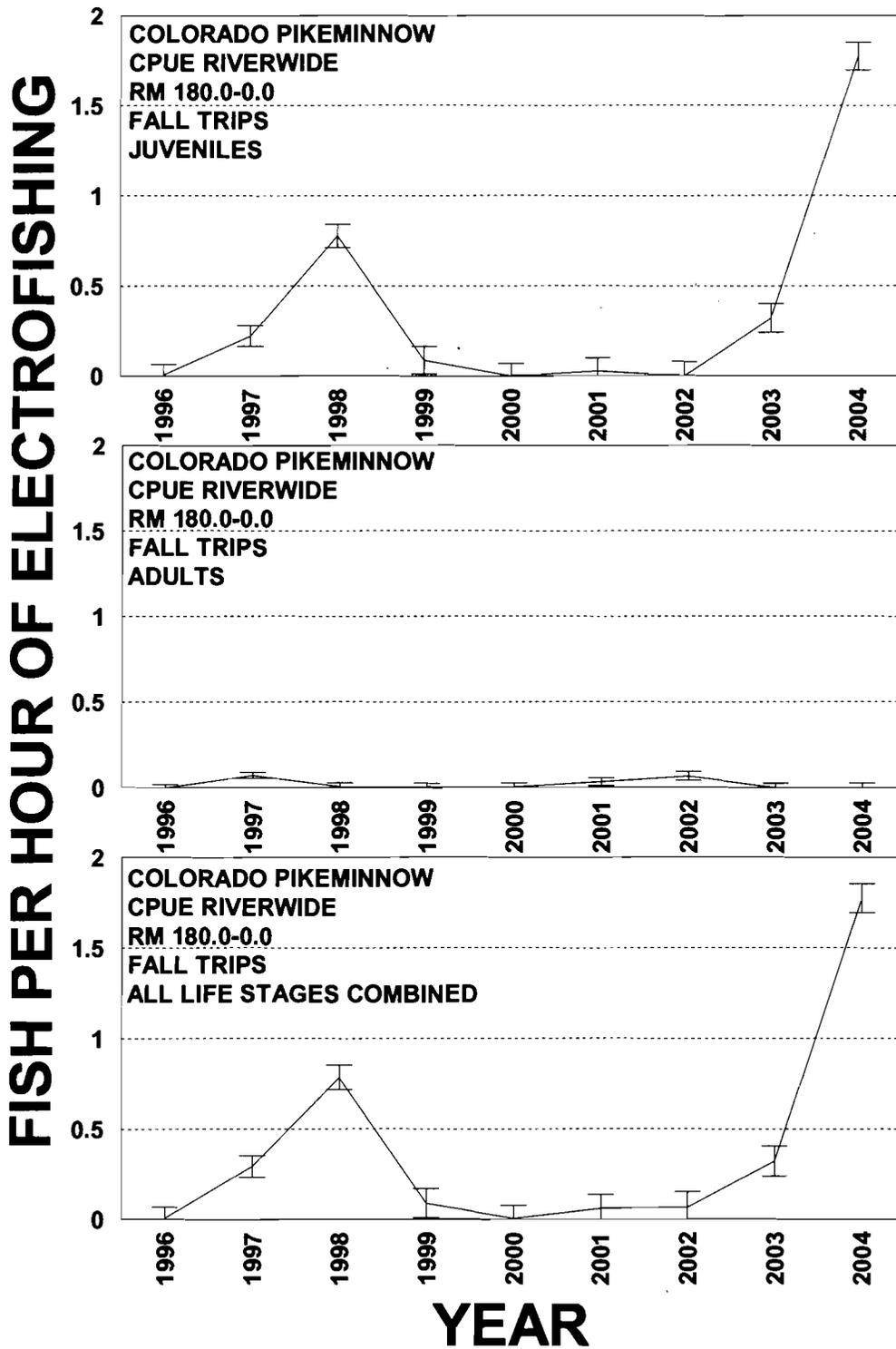


Figure 1. Colorado pikeminnow catch per unit effort (CPUE), by life stage, on fall Adult Monitoring trips, 1996-2004. Error bars represent one standard error.

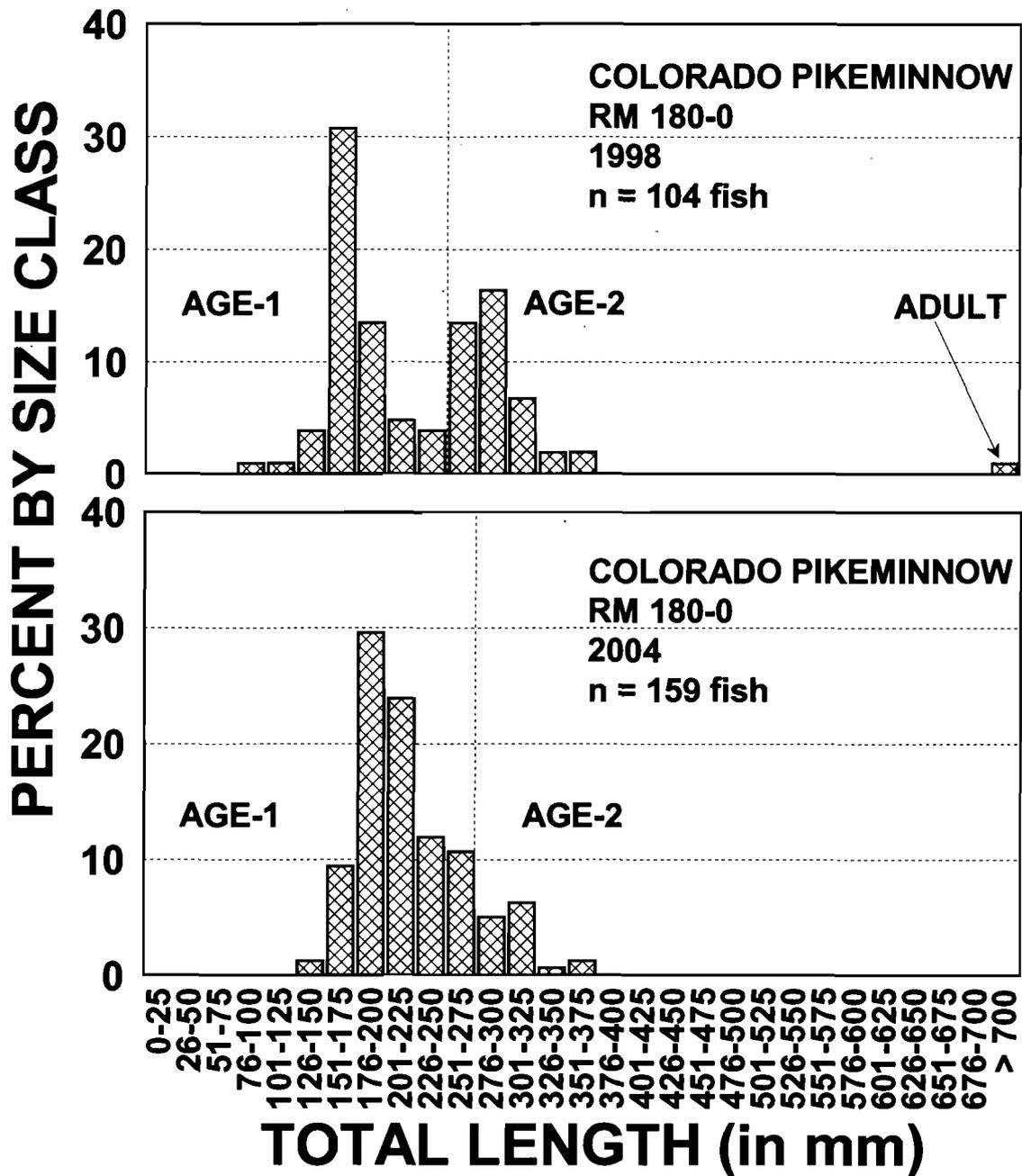


Figure 2. Length-frequency histograms for Colorado pikeminnow recaptured during the fall 1998 and fall 2004 Adult Monitoring trips. Large numbers of age-0 Colorado pikeminnow had been stocked in the fall for two consecutive years prior to each of these Adult Monitoring trips (i.e., 1996 and 1997 versus 2002 and 2003). These are the only two Adult Monitoring trips (these trips began in 1991) during which ≥ 100 Colorado pikeminnow were recaptured.

October 2002. The other 15 age-2 fish collected on the fall 2004 Adult Monitoring trip were age-2 "Mumma fish" that were relatively recently stocked (i.e., on 9 June 2004 at RM 180.2; Table 2).

Another difference between Colorado pikeminnow stocked in fall 2002 and those stocked in fall 2003 is that the fish stocked in fall 2003 were, on average, slightly larger in size when sampled as age-1 fish on the fall 2004 Adult Monitoring trip than were their counterparts sampled as age-1's on the fall 2003 Adult Monitoring trip (Figure 3). However, this observed mean size differential was not statistically significant ($p = 0.743$). The age-0 Colorado pikeminnow stocked in 2003 were slightly larger at the time of stocking than were the 2002 year-class stocked fish (2002 mean TL = 51 mm; 2003 mean TL = 58 mm TL), although the ranges of total lengths stocked were essentially the same (Table 2).

Anticipated Growth Among Stocked Age-0 Colorado Pikeminnow

The growth rate in total length, based upon recaptured Colorado pikeminnow over the last eight years that were stocked as age-0 fish (either on 4 November 1996, mean TL = 55 mm; or 15 August 1997, mean TL = 45 mm), is initially rapid from age-0 through age-2, then gradually declines as fish approach maturity (Figure 4). Length at maturity is considered to be ≥ 450 mm TL (USFWS 2002). Based on this growth curve, age-0 fish being stocked in the fall as part of the augmentation efforts, should recruit into the adult population in the summer or fall of the year that they are age-4 or age-5.

It should be noted that Colorado pikeminnow being stocked into the San Juan River in the fall of the year are typically larger than (in some cases almost twice as large as) wild fish would be at that time of year. Thus these stocked fish likely reach adulthood earlier than would wild fish.

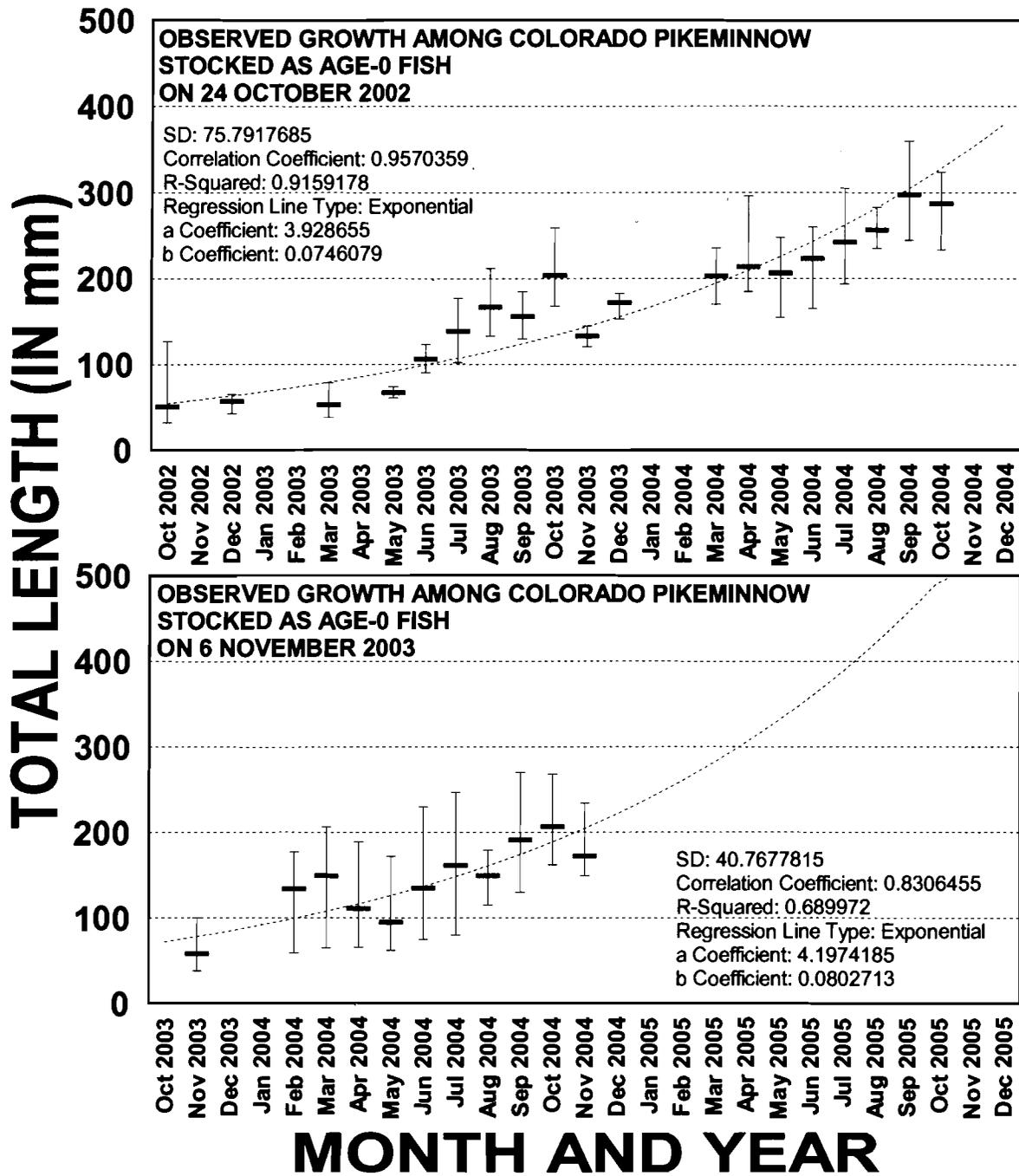


Figure 3. Mean total length in mm, by month, observed among recaptured Colorado pikeminnow that were originally stocked on either 24 October 2002 (top) or 6 November 2003 (bottom). Vertical bars indicate minimum and maximum observed values. The dashed line indicates the expected growth trend based on observed values.

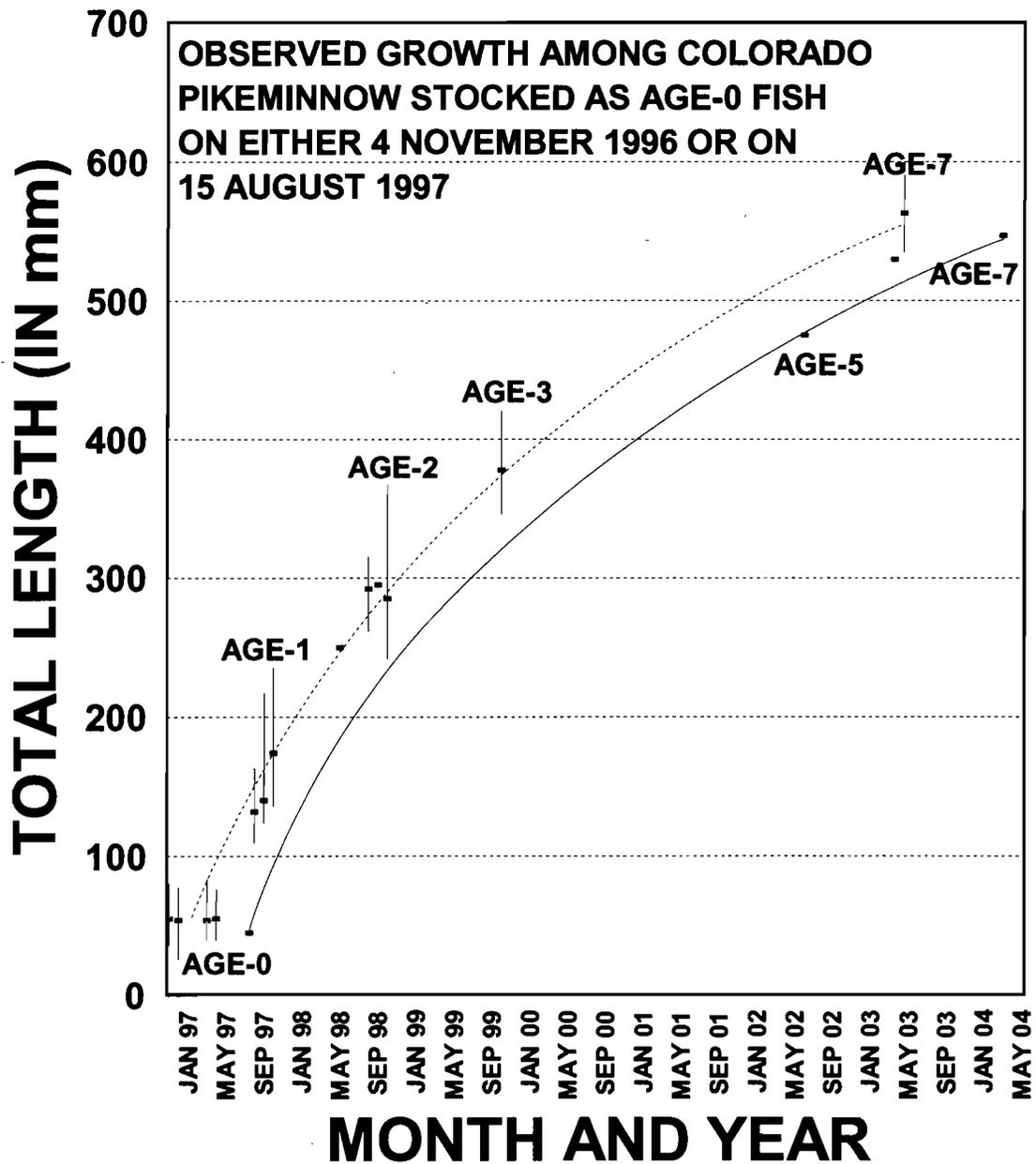


Figure 4. Mean total length in mm, by year, observed among recaptured Colorado pikeminnow that were originally stocked on either 4 November 1996 (dashed line) or 15 August 1997 (solid line). Vertical bars indicate minimum and maximum observed values.

DISCUSSION

Between 2002 and 2004, a total of 666,346 age-0 Colorado pikeminnow (from Dexter NFH) have been stocked into the San Juan River. An additional 1,005 age-1 and 1,219 age-2 Colorado pikeminnow (from the J. W. Mumma Native Species Hatchery) that were excess fish to the Colorado pikeminnow stocking efforts that are ongoing in the Upper Colorado River Basin have also been stocked into the San Juan River, in 2003 and 2004, respectively. This makes a total of 668,570 Colorado pikeminnow that have now been stocked under the auspices of the 2003 Colorado pikeminnow augmentation plan. This constitutes a shortfall of 181,430 fish (21.34%) over the first three years of the eight-year augmentation effort (2002-2009), based on the numbers specified in the 2003 augmentation plan and its 2002 draft predecessor.

While this would seem like a simple numbers production problem, it is really more complicated than that. Colorado pikeminnow are problematic to rear in captivity. This is especially true when trying to rear large numbers of Colorado pikeminnow in a passively-managed environment, such as a grow-out pond. Colorado pikeminnow (an obligate piscivore at sizes > 50 mm TL in the wild) are highly cannibalistic and unless young fish are graded almost constantly, the potential for loss due to intraspecific predation is huge. Thus rearing a minimum of 300,000 age-0 Colorado pikeminnow annually is a true challenge, even for a facility that specializes in rearing them.

Based on fall 2004 Adult Monitoring collections, it appears as if the age-0 Colorado pikeminnow that were stocked on 24 October 2002 (2002 year-class) did not survive into their age-2 year as well as had been hoped for. Based on data from numerous SJRIP studies, it would seem that the retention/survival of this group of age-0 Colorado pikeminnow was generally lower, almost from the moment of stocking, than survival of similar groups of age-0 fish stocked in 1996, 1997, and 2003 (Golden and Holden 2005, S. Ross pers. comm.). Interestingly, age-2 Colorado pikeminnow were collected by UDWR crews with some regularity in the beginning half of 2004 (March-May) in the canyon-bound sections of the San Juan River downstream of Mexican Hat (Jackson 2005). However, these collections of age-2 fish (i.e., those stocked on 24 October 2002) had dropped off considerably by late summer 2004 (J. Jackson unpublished data). The collections of age-2 Colorado pikeminnow made by the UDWR in the lower canyon in the early months of 2004 present a somewhat contradictory data set when examining survival of the 2002 year-class fish. Perhaps this data set indicates that the lower San Juan River is providing important habitats to this size/age of Colorado pikeminnow, at least in low-flow years such as 2004 (P. Holden pers. comm.).

By the time the fall 2004 Adult Monitoring trip was conducted, the large majority of the 159 Colorado pikeminnow that were recaptured were either age-1 fish from the 6 November 2003 stocking (n = 130; 81.8%) or age-2 fish that had been stocked relatively recently -- on 9 June 2004 (n = 13 fish; 8.2%). Only 14 (8.8%) of the 159 Colorado pikeminnow collections on this trip were age-2 fish that had been in the river since the fall of 2002. Two other age-2 fish recaptured on the fall 2004 Adult Monitoring trip were of unknown origin (i.e., no PIT tag number obtained due to equipment problems).

The reasons for the apparent poor survival among the 2002 year-class of Colorado pikeminnow are unknown. One possible explanation is that they were flushed from the system by the large fall storm event that occurred in the San Juan River between 7 and 14 September 2003 (immediately preceding the 2003 adult monitoring trip). This storm spike which peaked at 20,700 CFS on 10 September downstream of Bluff, UT appears to have displaced fish of all species downstream (Ryden 2004). However, other factors (e.g., poor sampling

efficiency due to high turbidity, mortality, movement into habitats where they were less prone to being collected via raft-mounted electrofishing, etc.) may also be involved.

When 2003 year-class Colorado pikeminnow were stocked on 6 November 2003, approximately 20,000 of them were acclimated in holding pens prior to their being released into the San Juan River. Within the first 36-72 hours post-stocking, crews from BIO/WEST noticed a very high mortality among fish in their holding pens (Golden and Holden 2005). Based on this, the assumption was made that survival among all of the age-0 Colorado pikeminnow stocked on 6 November 2003 would be very low. However, based on CPUE versus numbers of fish stocked, it would appear that the age-0 fish stocked on 24 October 2002 did not survive in as large of numbers as did their age-0 counterparts stocked in 1996, while the age-0 fish stocked on 6 November 2003 may actually have survived in greater numbers than did their age-0 counterparts stocked in 1997. On the fall 1998 Adult Monitoring trip, there were 216,878 stocked juvenile Colorado pikeminnow \leq age-2 available to be sampled (55.8% of what was available on the fall 2004 Adult Monitoring trip), CPUE was 0.78 fish/hour (44.1% of what it was on the fall 2004 Adult Monitoring trip), and the catch was relatively evenly split among fish from both the 1996 (i.e., age-2) and 1997 (i.e., age-1) year-classes. In contrast on the fall 2004 Adult Monitoring trip, there were 388,570 stocked juvenile Colorado pikeminnow \leq age-2 available to be sampled, CPUE was 1.78 fish/hour, and the catch was heavily dominated by fish from the 2003 (i.e., age-1) year-class. So, despite losses observed among fish being acclimated in holding pens, it would seem that survival among age-0 Colorado pikeminnow stocked in 2003 was at least as good as that previously observed among age-0 Colorado pikeminnow stocked in 1996 and 1997. An independent analysis of Colorado pikeminnow recaptured during seining efforts in 1996, 1997, 2002, and 2003 also seems to support this (S. Ross pers. comm.). This data shows almost identical retention/survival among age-0 Colorado pikeminnow stocked in 1996, 1997, and 2003 out to 9-11 months post-stocking, while those age-0 Colorado pikeminnow stocked in 2002 have markedly lower retention/survival as early as 4-5 months post-stocking when compared to 1996, 1997, and 2003 (S. Ross pers. comm.).

Based on growth rates observed among Colorado pikeminnow stocked in 1996 and 1997, the Colorado pikeminnow that were stocked as age-0 fish in 2002 should be somewhere in the 350-400 mm TL size-range in fall 2005 (i.e., age-3 fish), while the Colorado pikeminnow that were stocked as age-0 fish in 2003 should be somewhere in the 250-300 mm TL size-range in fall 2005 (i.e., age-2 fish). Those Colorado pikeminnow stocked as age-0 fish in 2004 should be somewhere in the 120-190 mm TL size-range in fall 2005 (i.e., age-1 fish). If these stocked fish continue to grow as predicted, the 2002 year-class should begin recruiting into the adult population (\geq 450 mm TL) in either 2006 or 2007, the 2003 year-class fish should begin recruiting into the adult population in either 2007 or 2008, and the 2004 year-class fish should begin recruiting into the adult population in either 2008 or 2009.

It is anticipated that CPUE for Colorado pikeminnow should be \geq 2.5 fish/hr of electrofishing during the upcoming fall 2005 Adult Monitoring trip. This is based on comparisons of the number of Colorado pikeminnow stocked in 2002-2003 versus 1996-1997 and the subsequent observed CPUE on the fall 2003 and 2004 Adult Monitoring trips versus the fall 1997 and 1998 Adult Monitoring trips.

LITERATURE CITED

- Archer, E., T. A. Crowl, and M. Trammel. 2000. Abundance of age-0 native fish species and nursery habitat quality and availability in the San Juan River, New Mexico, Colorado, and Utah. Utah State University, Logan, UT and Utah Division of Wildlife Resources, Moab, UT. Final Report to the San Juan River Recovery Implementation Program, U. S. Fish and Wildlife Service, Albuquerque, NM.
- Brandenburg, W. H., M. A. Farrington, and S. J. Gottlieb. 2005. Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2004 (Draft). University of New Mexico, Albuquerque. 92 pp.
- Crist, L. W., and D. W. Ryden. 2003. Genetics management plan for the endangered fishes of the San Juan River. U. S. Fish and Wildlife Service, Grand Junction, CO. 45 pp.
- Golden, M. E., P. B. Holden, and S. K. Dahle. 2004. Retention, growth, and habitat use of stocked Colorado pikeminnow in the San Juan River: 2002-2003 draft annual report. BIO-WEST, Inc., Logan, UT. 66 pp.
- Golden, M. E., and P. B. Holden. 2005. Retention, growth, and habitat use of stocked Colorado pikeminnow in the San Juan River: 2003-2003 draft annual report. BIO-WEST, Inc., Logan, UT. 76 pp.
- Hamman, R. L., and M. E. Ulibarri. 2004. Colorado pikeminnow fingerling production: San Juan River. 2004 SOW Completion Report. U. S. Fish and Wildlife Service, Dexter, NM. 2 pp.
- Jackson, J. A. 2001. Evaluation of stocked larval Colorado pikeminnow into the San Juan River: 2000. Utah Division of Wildlife Resources, Salt Lake City, UT. 15 pp.
- Jackson, J. A. 2003. Nonnative control in the lower San Juan River: 2002. Interim Progress Report (Draft dated 31 March 2003). Utah Division of Wildlife Resources, Moab, UT. 16 pp. + Appendix.
- Jackson, J. A. 2004. Nonnative control in the lower San Juan River: 2003. Interim Progress Report (Draft dated 31 March 2004). Utah Division of Wildlife Resources, Moab, UT. 19 pp. + Appendix.
- Jackson, J. A. 2005. Nonnative control in the lower San Juan River: 2004. Interim Progress Report. Utah Division of Wildlife Resources, Moab, UT. 28 pp.
- Platania, S. P. 1990. Biological investigation of the 1987 to 1989 New Mexico - Utah ichthyofaunal study of the San Juan River. Museum of Southwestern Biology, University of New Mexico, Albuquerque. Final Report to the New Mexico Department of Game and Fish, Santa Fe, NM and the U. S. Bureau of Reclamation, Salt Lake City, UT. 143 pp.
- Ryden, D. W. 2000. Adult fish community monitoring on the San Juan River, 1991-1997. U. S. Fish and Wildlife Service, Grand Junction, CO. 269.
- Ryden, D. W. 2003. An augmentation plan for Colorado pikeminnow in the San Juan River. U. S. Fish and Wildlife Service, Grand Junction, CO. 63 pp. + appendices.
- Ryden, D. W. 2004. Long-term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2003. Interim Progress Report (Draft). U. S. Fish and Wildlife Service, Grand Junction, CO. 67 pp. + appendices.
- San Juan River Recovery Implementation Program Biology Committee. 1995. Long Range Implementation Plan: San Juan River Recovery Implementation Plan. U. S. Fish and Wildlife Service, Albuquerque, NM. 19 pp. + appendices.

- U. S. Fish and Wildlife Service. 1994. Determination of Critical Habitat for the Colorado endangered fishes: razorback sucker, Colorado squawfish, humpback chub, and bonytail chub. Dept. of the Interior, U. S. Fish and Wildlife Service, Federal Register, 21 March 1994, 59:13374-13400.
- U. S. Fish and Wildlife Service. 2002. Colorado pikeminnow (*Ptychocheilus lucius*) Recovery Goals: amendment and supplement to the Colorado Squawfish Recovery Plan. U. S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, CO. 71 pp. + appendices.

ACKNOWLEDGEMENTS

Thanks to Steve Ross, Paul Holden, Mike Golden, and Julie Jackson for providing comments on an earlier draft of this report. Steve Ross, Mike Golden, and Julie Jackson also supplied additional data analysis that helped clarify data reporting herein.