Retention, Growth, and Habitat Use of Stocked Colorado Pikeminnow in the San Juan River: 2003-2004 Annual Report

JULY 2005 PR 874-2

Juvenile razorback sucker *(Xyrauchen texanus*) **and two juvenile flannelmouth sucker (***Catostomus latipinnis***) collected during Colorado pikeminnow monitoring in March 2004.**

Colorado pikeminnow (*Ptychocheilus lucius***) stocked in 2002 and recaptured at age 2 in July 2004.**

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Submitted to: San Juan River Basin Recovery Implementation Program Biology Committee

EXECUTIVE SUMMARY

The San Juan River Basin Recovery Implementation Program (SJRIP) began a multiple year augmentation program for Colorado pikeminnow (*Ptychocheilus lucius*) in 2002. The SJRIP's *Colorado Pikeminnow Augmentation Plan* (Ryden 2003a) calls for 200,000-300,000 young-of-year (YOY) Colorado pikeminnow to be stocked annually in the San Juan River with the eventual goal of developing an adult population of greater than 800 individuals. Recognizing the need for more information on the retention of stocked Colorado pikeminnow, the SJRIP funded a cooperative study to monitor the YOY Colorado pikeminnow stocked in 2002 during their first year in the river. The retention of the 2002-stocked fish appeared to be lower than anticipated. Therefore, the SJRIP funded changes in stocking protocols and experiments designed to increase the retention of YOY Colorado pikeminnow stocked in 2003. Supplemental information from SJRIP-funded research showed that the canyon section of the San Juan River below Mexican Hat, UT, appeared to be retaining the Colorado pikeminnow stocked in 2002, so three additional monitoring stations were added in the canyon. As Colorado pikeminnow exceeded 100 mm TL during early summer, seining appeared to be inefficient at capturing them. An alternative sampling technique using two 9-m-wide seines (one as a block net) was authorized for the July 2004 sampling trip.

In late November 2003 a total of 175,000 YOY Colorado pikeminnow were stocked into the San Juan River between Bloomfield and Shiprock, NM. The bulk of these fish were released in low-velocity habitats throughout two 10-mile reaches of the San Juan River above Shiprock, and some were stocked en masse at the upstream ends of these stocking reaches. An additional 20,000 were held in net pens and backwaters for 7 days after stocking in an attempt to acclimate them to river conditions before their release. This study followed the retention, growth, and survival of the Colorado pikeminnow stocked in 2003 in 10 reaches of the San Juan River from near Bloomfield, NM, to near Clay Hills Crossing, UT, and in one reach in the lower Animas River. The reaches were sampled in December 2003, March 2004, and July 2004. Supplemental information from other SJRIP-funded research and monitoring was used to provide additional spatial and temporal coverage.

Acclimation studies showed substantial mortality of YOY Colorado pikeminnow within the 36-72 hours following stocking. Despite the apparently high post-stocking mortality, monitoring efforts indicated that the YOY Colorado pikeminnow stocked in 2003 had higher initial retention and survival than the YOY Colorado pikeminnow stocked in 2002. We found higher numbers, catch-per-effort (CPE), and more samples containing YOY Colorado pikeminnow in December 2003 than in December 2002. Colorado pikeminnow showed a similar preference for backwater habitats and habitats with some type of cover in December of both years. The March and July 2004 sampling trips also showed increased numbers and CPE of Colorado pikeminnow. While we collected fewer Colorado pikeminnow in the canyon section of the river in December 2003, the highest CPE was found in the lowest part of the canyon in March 2004, indicating continued

downstream movement between December 2003 and March 2004. While the number and CPE of Colorado pikeminnow declined throughout the course of the year, in July 2004 we collected 146 age-1 Colorado pikeminnow from the 2003 stocking event; only two age-1 Colorado pikeminnow were captured in July 2003. While some of this increase is attributable to the change in our sampling technique, SJRIP fall large-bodied fish monitoring efforts collected over 120 age-1 Colorado pikeminnow in 2004 versus 32 in 2003.

The number of fish caught and CPE of Colorado pikeminnow after the 2003 stocking event was similar to or higher than those seen after the 1996, 1997, and 2002 stocking events. While initial retention appeared similar or slightly higher than 1996 and 1997, survival to age-1 appeared to be substantially higher for the Colorado pikeminnow stocked in 2003. While some of the increased retention seen after the 2003 stocking event may be attributable to changes in stocking protocols or the acclimation studies, a difference in the amount of available nursery habitat may have also played a substantial role. Continuing experimentation with different stocking procedures over a number of years may reveal what factors are most important to the retention and survival of hatchery-reared Colorado pikeminnow, which in turn could help us move closer to recovery for this species in the San Juan River.

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INTRODUCTION

In 1996 and again in 1997, approximately 100,000 young-of-year (YOY) Colorado pikeminnow (*Ptychocheilus lucius*) were stocked in the San Juan River to characterize growth and retention in the river and quantify and characterize nursery habitat used by stocked fish (Trammel and Archer 2000). This experiment showed that habitat for young Colorado pikeminnow was available and reasonably common in the San Juan River. The YOY Colorado pikeminnow stocked in 1996 and 1997 also survived for at least 2 years and grew up to 250 mm TL, and a large proportion remained in the river rather than dispersing to Lake Powell. Differences in survival and retention observed between sampling trips and years were attributed to storm events and flow patterns. Storm and runoff events tended to reduce survival and move the fish downstream. Fish in the lower river tended to be more susceptible to flow-induced changes in retention than fish in the upper river.

Based on the results and success of these experimental studies, the SJRIP drafted an Augmentation Plan for Colorado pikeminnow that calls for stocking 200,000-300,000 YOY pikeminnow annually between 2002 and 2009 (Ryden 2003a). In 2002 the Augmentation Plan began with stocking over 100,000 Colorado pikeminnow near the Animas River confluence with the San Juan River and over 100,000 Colorado pikeminnow at the Shiprock bridge in Shiprock, NM. The SJRIP funded BIO-WEST, Inc. (BIO-WEST), the New Mexico Department of Game and Fish (NMDGF), and the University of New Mexico (UNM) to follow the progress of the stocked Colorado pikeminnow seasonally through 2002-2003. The overall goal of the study was to characterize retention of stocked Colorado pikeminnow and what, if any, changes should be made to the augmentation program to increase retention. In addition, an important objective of the current augmentation program is to establish Colorado pikeminnow in the area above Shiprock, especially the area above the PNM Weir. The adult Colorado pikeminnow recovery goals (USFWS 2002) were based on the assumption that Colorado pikeminnow could be expanded into this area to utilize the abundant available forage.

Therefore, determining whether the area upstream of PNM Weir could retain stocked Colorado pikeminnow was an important objective of the Colorado pikeminnow monitoring project in 2002-2003. The 2002-2003 monitoring results showed that retention of the Colorado pikeminnow stocked in 2002 above the Hogback Diversion appeared poor. Only 12 Colorado pikeminnow were collected in approximately 14 miles of sampling between the Farmington stocking site and the Hogback Diversion in December 2002. By the March 2003 monitoring trip, only 1 Colorado pikeminnow was found in 9 miles of river sampled between the Farmington stocking site and Hogback Diversion. Below Hogback Diversion, retention seems to have been better. In December 2002, 111 Colorado pikeminnow were captured in 29 miles of river sampled between Shiprock Bridge and Sand Island, UT. In March 2003, 96 Colorado pikeminnow were collected in 29 miles of river sampled between the Shiprock Bridge and Sand Island. By July 2003 we were only able to capture two Colorado pikeminnow within the entire

study area. The total number of Colorado pikeminnow we collected and our catch per effort (CPE) appeared to be lower than that seen after the 1996 and 1997 stocking experiments conducted by the Utah Division of Wildlife Resources (UDWR), despite the fact that twice as many Colorado pikeminnow were stocked in 2002.

We proposed several explanations for the seemingly reduced retention and survival of YOY Colorado pikeminnow stocked in 2002 (Golden et al. 2004). One potential explanation was that the YOY Colorado pikeminnow had difficulty finding low-velocity habitat suitable for their survival as they dispersed from the stocking site. This could be caused by a lack of available habitat or behavioral characteristics of the fish after being introduced into a foreign environment. While Trammell and Archer (2000) found that nursery habitat was available for fish in 1996 and 1997, the amount of low-velocity habitats, specifically backwater habitat, has declined over the past few years and was at its lowest known level in fall and early winter 2002-2003 (V. Lamarra, Ecosystems Research Institute, personal communication). The changes in the San Juan River flow regime between the stocking periods is partially responsible for the decline in backwater habitat. The San Juan River, like most of the rivers in the southwest, has been in the midst of a multi-year drought, so flows were lower throughout 2002 and early 2003 than flows in 1996-1997 and 1997-1998. Nursery habitat availability in the San Juan River is dependent on flow level (Trammell 2000). The drought has apparently reduced the number of flow events required to maintain backwater habitat, so both the quality and quantity of nursery habitat available to stocked pikeminnow were probably reduced in 2002-2003.

Additionally, stocked Colorado pikeminnow may seek very specific habitats during cold winter months (Golden et al. 2004). During the December 2002 monitoring trip, Colorado pikeminnow seemed clumped in very specific habitats with near-zero velocity and debris piles (usually tree limbs) for cover. One backwater above the Four Corners Bridge contained 78% (87 of the 111) of the Colorado pikeminnow caught below Shiprock. Conversely, in March 2003 Colorado pikeminnow were distributed throughout the area below Shiprock in a variety of low-velocity habitats. Colder water temperatures may have resulted in the clumping of Colorado pikeminnow in very specific habitats that we saw during December sampling. Ross et al. (1992) and Schofield and Ross (2003) showed winter habitat shifts by two darter species were related to declines in swimming performance. Habitats with low velocity and increased cover may provide a bioenergetic refugia for Colorado pikeminnow during colder months. If backwater habitats with cover are important during this time of year, the availability of those habitats was limited in December 2002. The seemingly poor retention of Colorado pikeminnow from the 2002 stocking event, especially in the area above Hogback Diversion, led some members of the SJRIP Biology Committee to speculate that instead of stocking more fish, improving retention through new stocking techniques and habitat improvements should be investigated.

Alternative explanations for poor retention after the 2002 stocking event are that either Colorado pikeminnow stocked in 2002 were retained downstream of Bluff, UT, in areas where we did not sample or that our sampling methods were not effective during the entire monitoring period. During 2002 sampling the UDWR found several large juvenile and adult Colorado pikeminnow (potentially survivors from the 1996 or 1997 stockings) in the canyon section of the San Juan River, suggesting that Colorado pikeminnow may be using this area more than previous studies had shown (Jackson 2003). Additionally, in spring and summer 2003 both the UDWR nonnative removal sampling effort and the UNM larval fish sampling effort collected fair numbers of Colorado pikeminnow stocked in 2002 below Mexican Hat, UT, further supporting the potential importance of the canyon section of the river. Raft-mounted electrofishing also appeared to be much more efficient than seining at collecting Colorado pikeminnow once they exceeded 100 mm total length (TL).

Based on the conclusions drawn from 2002-2003 monitoring data, we added additional sampling stations below Mexican Hat, experimented with new sampling methods during July 2004 monitoring, and instituted new stocking protocols and experiments in 2003-2004. We felt one way to increase retention may be to attempt to acclimate the fish to river conditions prior to their release. Reintroduction efforts for native Colorado River fishes have had chronic problems with downstream drift of the stocked fishes (Burdick and Bonar 1997, Marsh and Langhorst 1988, Marsh and Brooks 1989, Masslich and Holden 1996, Burdick 2003). Stocking the YOY Colorado pikeminnow directly into low-velocity habitats spread throughout larger sections of river, instead of stocking them at one or two stocking sites, was approved for 2003 (Dale Ryden, USFWS, 2003 Scope of Work). Stocking the YOY Colorado pikeminnow in this manner may reduce the amount of downstream drift by eliminating the need for Colorado pikeminnow to find suitable habitat while drifting in the current. Other stocking protocol changes may also help increase the retention of stocked Colorado pikeminnow throughout the San Juan River. The December 2002 sampling trip showed that Colorado pikeminnow seem restricted to certain habitats when river temperatures were cold (Golden et al. 2003). Stocking Colorado pikeminnow when water temperatures are warmer may reduce dispersal, because YOY Colorado pikeminnow may utilize a wider variety of habitats above a certain critical temperature. This appeared to be the case in March 2003 when stocked fish were much more dispersed than during December 2002. River temperatures were generally 3-5ºC during December sampling and 7-14ºC during March sampling.

Acclimating fish to the river environment may be a useful tool in improving retention. A common suggestion for improving the retention of stocked endangered fishes in the Colorado River system has been to acclimate the fish to their new environment before releasing them (Marsh and Brooks 1989, Minckley et al. 1991, Ryden and Pfeifer 1996, Burdick 2003). During the November 2003 stocking, we attempted to acclimate 20,000 Colorado pikeminnow in low-velocity habitats throughout two of our monitoring stations. Additionally, we added woody debris (brush piles) to low-velocity habitats throughout another one of our monitoring stations.

In this report we characterize the retention and growth of YOY Colorado pikeminnow stocked into the San Juan River in November 2003 according to our findings and the findings of other SJRIP research projects conducted through October 2004. Additionally, we examine factors that may have impacted retention and growth such as river flow, storm events, habitat availability, and stocking protocols and experiments. We also compare the retention and habitat use of Colorado pikeminnow stocked in 2003 with the fish stocked in 2002, 1997, and 1996. Finally, using the available data on Colorado pikeminnow stocking success, we make suggestions for fine-tuning protocols for Colorado pikeminnow stocking events to improve survival, growth, and retention.

METHODS

Study Area

The study area for 2003-2004 was enlarged from the area studied in 2002-2003 and encompassed the San Juan River from Clay Hills Crossing, UT (RM 2.9) to near Bloomfield, NM (RM 188.4) (Figure 1). Eleven stations were utilized to represent the study area rather than the eight used in 2002-2003, two in Geormorphic Reach 6 near Farmington, two in Reaches 2 and 3, one each in Reaches 1, 4, 5, and 7, and one in the lower Animas River (Table 1). Reaches 1 and 2 were not sampled in 2002-2003. Within the geomorphic reaches the study stations above Sand Island, UT, remained the same as in 2002-2003 to allow for retention comparisons between years. We added three new stations below Sand Island: RM 40-45 just below Mexican Hat, RM 20-25 near Johns Canyon in Reach 2, and RM 8-13 near Grand Gulch in Reach 1. RM 8-13 and 20-25 were identified by Trammel and Archer (2000) as nursery areas. A relatively high number of Colorado pikeminnow stocked in 2002 were found in the RM 40-45 area during an April 2003 razorback sucker (*Xyrauchen texanus*) larval monitoring trip (H. Brandenburg, UNM, personal communication). In addition to the three new monitoring stations, we tried to sample backwater habitats throughout San Juan Canyon (RM 52.9-2.9). The Upper San Juan and APS Weir to Hogback Diversion stations were used for the acclimation experiments, and the Shiprock to Cudei station was used for the debris pile experiment.

Stocking Protocol Changes and Experiments

Stocking

On November, 6, 2003, approximately 176,900 YOY Colorado pikeminnow were stocked into the San Juan River. The fish were stocked into five main areas (Table 2). The USFWS stocked 80,000 fish directly into low-velocity habitats, such as shoals, side channels, and backwaters, in two approximately 10-mile reaches of river. The first reach extended from the confluence of the Animas River to the Hatch Trading Post and the second extended from the Hogback Diversion to

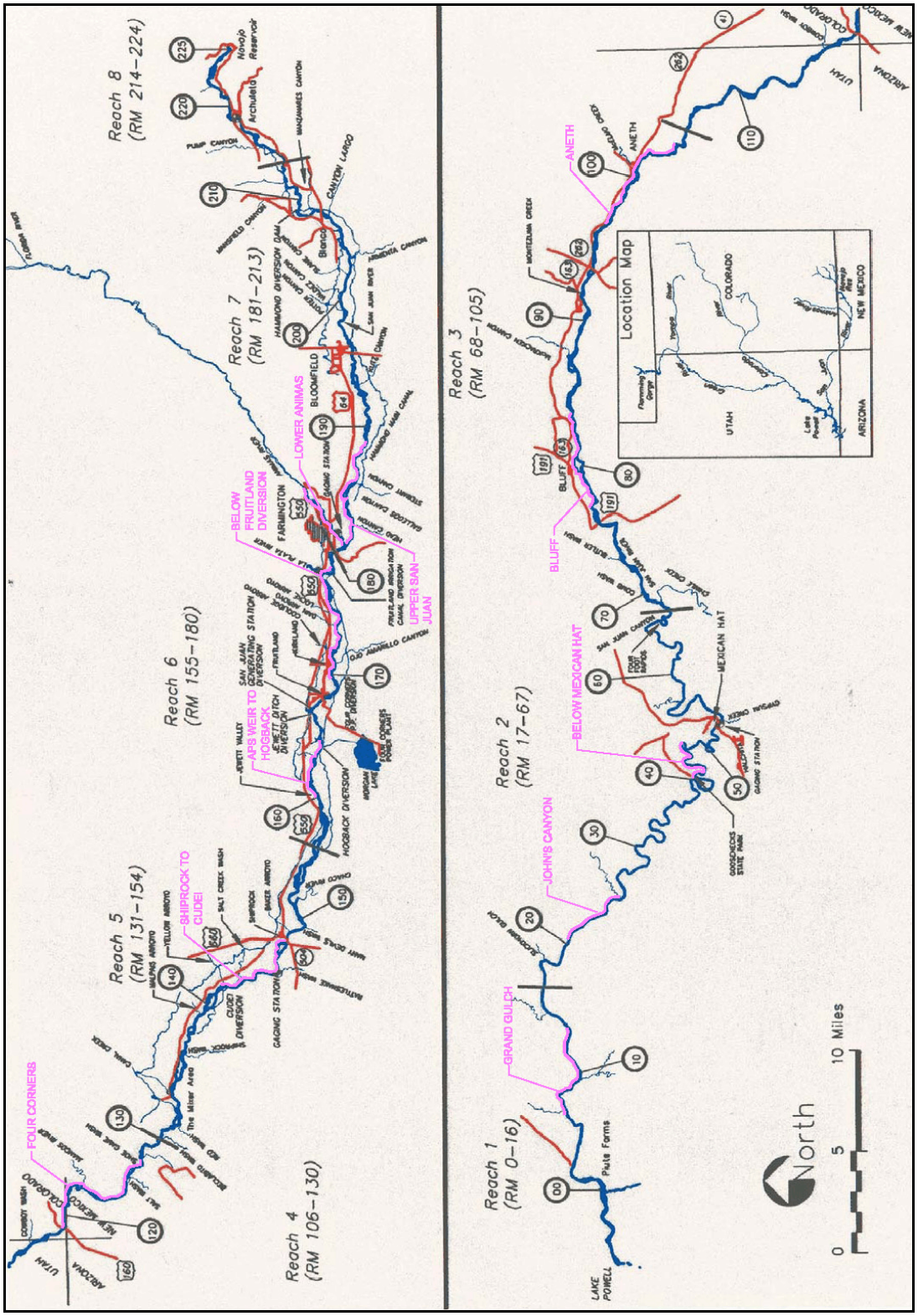

Figure 1. San Juan River New Mexico, Colorado, and Utah with the locations of the 11 sampling stations.

Table 1. Station names and corresponding river miles sampled.

STATION	RIVER MILES	Geomorphic Reach
Lower Animas	0-3.5	N/A
Upper San Juan	180.7-188.4	7
Below Fruitland Diversion	169.5-178.6	6
APS Weir to Hogback Diversion	159.2-163.7	6
Shiprock to Cudei	141.5-148.9	5
Four Corners	119.2-127.5	4
Aneth	96.4-104.1	3
Bluff	76.4-83.0	3
Below Mexican Hat	40.0-45.0	2
John's Canyon	20.0-25.0	2
Grand Gulch	8.0-13.0	1
Miscellaneous Canyon	2.9-52.9	1 and 2

Table 2. Location and number of Colorado pikeminnow stocked on November 6, 2003.

AGENCY	AREA	RIVER MILES	NUMBER OF PTYLUC[a]
BIO-WEST	Upper San Juan	180.7-188.4	10,000
USFWS	Animas River confluence	180.2	20,000
USFWS	Animas to Hatch Trading Post	180.2 - 169.5	60,000
BIO-WEST	APS Weir to Hogback Diversion	159.2-163.7	10,000
USFWS	Hogback Diversion	159.2	15,000
USFWS	Hogback Diversion to Shiprock	159.2-148.9	60,000

[a] Colorado pikeminnow.

the Shiprock Bridge. BIO-WEST stocked 20,000 fish into acclimation areas within the Upper San Juan and APS Weir to Hogback Diversion stations. Finally, the remaining fish were stocked en masse into the San Juan River near its confluence with the Animas River and immediately below Hogback Diversion.

Acclimation Studies

We conducted acclimation studies in the Upper San Juan and APS Weir to Hogback Diversion stations. After performing a reconnaissance trip through both stations on November 3, 2003, we identified six low-velocity areas within each station that we felt would be suitable for acclimation studies. On November 5, 2003, we created net pens with nets having < 3 mm mesh or enclosed the low-velocity habitat using a block net with < 3 mm mesh to prevent the escape of introduced Colorado pikeminnow and the entrance of other species.

On November 6, 2003, BIO-WEST received a subset of approximately 20,000 Colorado pikeminnow from Dexter National Fish Hatchery and Technology Center (DNFHTC). These Colorado pikeminnow were marked with a new batch mark, calcein dye, prior to delivery. The dye was supposed to distinguish Colorado pikeminnow used in the acclimation studies from the remainder of the Colorado pikeminnow stocked in 2003 during follow-up monitoring. We placed 10,000 of these dye-marked Colorado pikeminnow into acclimation areas in each station (Tables 3-4). While we were not trying to achieve certain densities within our acclimation areas, we used our best judgement to determine the number of Colorado pikeminnow that should be placed in each acclimation area by the size of the area. We monitored each area daily until 11/12/2003, at which point the block nets were removed.

Debris Pile Studies

December 2002 monitoring data indicated that the presence of cover, in the form of debris piles, may be important in retention of stocked pikeminnow during colder winter months. Therefore, we added debris piles to low-velocity habitats throughout the Shiprock to Cudei station on November 4, 2003, prior to the November 6, 2003 stocking (Table 5). We used downed tree limbs and limbs from abundant nonnative trees Russian olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix* spp.) to create debris piles in appropriate Colorado pikeminnow nursery habitats.

Monitoring

We made three sampling trips between the November 2003 YOY Colorado pikeminnow stocking trip and September 2004. The first trip was approximately was 4-5 weeks after stocking, from December 1-13, 2003. The second trip was over 4 months after stocking, from March 14-26, 2004. The third trip was conducted post-runoff and over 8 months after stocking, from July 19-31, 2004.

Table 3. Location, habitat, and method used to create each acclimation area, and the number of Colorado pikeminnow placed into each area in the Upper San Juan station.

RIVER MILE	NORTHING	EASTING	HABITAT	METHOD	NUMBER OF PTYLUC[a]
188.35	4064792	758781	Eddy	Net Pen	1,300
187.2	4065572	757250	Slackwater	Net Pen	1,300
186.65	4065277	756784	Backwater	Block net	3,000
185.75	4065277	755840	Irrigation return/Backwater	Block net	1,600
185.75	4065277	755840	Side channel	Block net	1,800
185.45	4065565	755195	Side channel	Block net	1,000

[a] Colorado pikeminnow.

Table 4. Location, habitat, and method used to create each acclimation area, and the number of Colorado pikeminnow placed into each area in the APS Weir to Hogback station.

RIVER MILE	NORTHING	EASTING	HABITAT	METHOD	NUMBER OF PTYLUC[a]
163.4	4069721	726203	Eddy/shoal	Net pens	2,400
162.25	4070217	724719	Irrigation return/Backwater	Block net	3,000
161.4	4070623	723516	Irrigation return/side	Block net	1,200
161.35	4070623	723516	Irrigation return/Backwater	Block net	1,200
161.35	4070623	723516	Eddy	Net pen	1,200
160.8	4069604	722423	Side channel	isolated	1,000

[a] Colorado pikeminnow.

Table 5. Location and habitat where debris piles where placed, as well as the number of debris piles placed at each location in the Shiprock to Cudei station in November 2003.

RIVER MILE	NORTHING	EASTING	HABITAT	NUMBER OF PILES
148.9	n/a	n/a	Side channel shoal	4
148.6	4073774	705717	Shoal	1
148.6	4073774	705717	Slackwater	2
148.2	4073987	705210	Backwater	7
148.1	4074032	705030	Backwater	2
148.1	4074032	705030	Backwater	4
146.75	4074059	702929	Slackwater shoal	5
146.5	4073928	702669	Backwater	3
145.9	4074881	702380	Side run	3
144.7	4076492	702018	Side run	5
143.4	4078498	700955	Backwater	1
143	4079230	701115	Eddy	1

During each trip, each of the 11 sampling stations were sampled for 1 day. Stations were accessed with a 14-foot or 16-foot raft. Within each station as many backwaters, shoals, and other low-velocity habitats available for young Colorado pikeminnow (Trammel and Archer 2000) were sampled as was practicable in a day. Throughout the canyon section of the river below Mexican Hat, we attempted to sample as many backwater habitats encountered between sampling stations as practicable. We used 4 m x 2 m x 3 mm and 3 m x 2 m x 3 mm double-weighted seines to sample low-velocity habitats during the December 2003 and March 2004 sampling trip. During the July 2004 sampling trip, we used two 9 m x 2 m x 6 mm double-weighted seines for sampling. One seine was held at the bottom of the habitat unit, and

we used the second seine to sample down to that seine in an attempt to block the escape of larger fish (block-seining).

We collected the following information for each sample: river mile location, GPS location (UTM), habitat type, seine type, area sampled (length and width), average depth, maximum depth, and substrate type. Water temperature was collected periodically throughout the day using a hand-held thermometer. All fish collected, except for small larvae, were identified to species and counted. At least 50 randomly selected individuals of each species were measured for standard length at each station, except for Colorado pikeminnow, all of which were measured. Native fishes were returned to the habitat alive, and nonnative fishes were retained. A separate data sheet was used for each seine haul. During the December 2003 sampling trip, we scanned every Colorado pikeminnow for the presence of the calcein dye using a SE-MARK detector device (Western Chemical, Inc.). A passive integrated transponder (PIT) tag reader was used to scan all Colorado pikeminnow over 150 mm captured during monitoring. Colorado pikeminnow larger than 150 mm (TL) without a PIT tag were marked with one.

Data on the Colorado pikeminnow stocked in 2003 were also available from other SJRIP projects. The UNM's razorback sucker and Colorado pikeminnow larval fish surveys and the SJRIP standardized fall monitoring provided additional seining information on fish stocked in 2003. University of New Mexico crews sampled from Cudei Diversion (RM 142.0) to Clay Hills Crossing (RM 3.0), and used a 1 m x 1 m x 1 mm larval seine (Sara Gottleib, UNM, personal communication). Finally, sampling was conducted from the confluence of Animas River (RM 180.2) to Clay Hills Crossing (RM 3.0) using 3 m x 2 m x 3 mm seine in September and October 2004, as part of the SJRIP standardized fall monitoring (Propst et al. 2000).

The U.S. Fish and Wildlife Service (USFWS), New Mexico Fisheries Resource Office (NMFRO), and UDWR nonnative fish species removal projects, along with SJRIP standardized fall monitoring, provided additional information via electrofishing captures of Colorado pikeminnow stocked in 2003. The NMFRO used raft-mounted electrofishing to sample two sections of river: PNM Weir to Hogback Diversion (RM 166.7-RM 159.2) and Hogback Diversion to Shiprock (RM 158.7-RM 148.9) (Jason Davis, NMFRO, personal communication). The UDWR used raft-mounted electrofishing to sample from Mexican Hat (RM 52.9) to Clay Hills Crossing (RM 2.9) several times between March and August 2004 (Julie Jackson, UDWR, personal communication). Raft-mounted electrofishing from the confluence of Animas River (RM 180.2) to Clay Hills Crossing (RM 2.9) occurred in September and October 2004, as part of the SJRIP standardized fall monitoring (Dale Ryden, USFWS, personal communication). Information from all these projects provided supplemental spatial and temporal coverage for our research effort. Data from these studies are presented to provide a more complete picture of the fate of stocked YOY Colorado pikeminnow.

As previously mentioned, YOY Colorado pikeminnow were stocked into the San Juan River in 1996, 1997, and 2002 (Trammel and Archer 2000, Golden et al. 2004). Over 200,000 fish were stocked in two groups of 100,000 near the Animas River confluence and Shiprock Bridge in 2002. Monitoring methods are described in Golden et al. 2004 and were the same as those described for the 2003 Colorado pikeminnow stocking event.

Over 100,000 fish were split into two groups and stocked near Shiprock and Mexican Hat in 1996 and 1997. Follow up monitoring was conducted by the UDWR from Shiprock (RM 148.9) to Clay Hills Crossing (RM 3.0). Methods differed from those outlined for this study. During the 1996 and 1997 monitoring, two nursery habitats were sampled every 5 miles, except in four specific 5-mile reaches, where all nursery habitats were sampled. Trammel and Archer (2000) outline the details of this monitoring protocol. Despite the differences in collection methods and locations, we use data collected on retention from these two historical stockings, as well as the 2002 stocking, as a baseline to compare with the information we collected on the YOY Colorado pikeminnow stocked in November 2003.

Data Analysis

We attempted to analyze the data collected by BIO-WEST statistically. Originally, we had planned to use a nested ANOVA with Tukey's Honestly Significant Difference multiple comparison test to examine differences in CPE for YOY Colorado pikeminnow (and other species) between trips, between stations within trips, and within stations between trips. However, as with the monitoring data collected after the 2002 stocking, the numbers, catch rate, and CPE data for Colorado pikeminnow and other native fish species did not fit the normal distribution. We attempted multiple transformations, but none was able to conform the data to the normal distribution. Neither could Colorado pikeminnow catch rate and CPE from backwater habitats be transformed to fit the normal distribution. Additionally, we attempted to compare Colorado pikeminnow catch rate and CPE between trips within years, between trips, and between years within trips by using the total catch rate or CPE for each reach during each trip as the sample unit. Only catch rate data from the follow-up monitoring to the 2003 stocking were able to approximate the normal distribution, using the natural log of the catch rate plus 1. Therefore, we statistically compared the catch rate between December 2003, March 2004, and July 2004 sampling trips using a nested ANOVA with Tukey's Honestly Significant Difference multiple comparison test

As explained in more detail in Golden et al. (2004), the large number of zero values in the data was responsible for the lack of normality. The large number of zeros also prevents meaningful analyses using non-parametric statistics. One alternative way to view that data is through a type of survivorship curve. Since we have emigration and mortality between each of our sampling trips, the curve we generate is more of a survivorship/retention curve for Colorado pikeminnow stocked in 1996, 1997, 2002, and 2003. We scaled the number of Colorado pikeminnow stocked

each year to 100,000, as well as using the same scaling factor to transform the catch rate of Colorado pikeminnow during each follow-up trip. These data were then log transformed and plotted to provide an idea of any differences in survivorship and retention between years. We are currently seeking other alternative ways to statistically analyze the data, but for this report we provide mainly descriptive measures of CPE to examine differences in CPE between trips, between reaches within trips, and within reaches between trips. While the mean is not necessarily a good summary statistic for the resulting distribution, we have provided the average catch rate and CPE along with the standard error, to provide some idea of central tendency and variation. Additionally, we provide information on the total number of fish caught and the total effort expended.

We also examined habitat use by the stocked Colorado pikeminnow. We used Mann Whitney U tests with Bonferroni-adjusted probabilities to compare the average CPE of stocked Colorado pikeminnow collected in side channels versus main channels within each trip. We used Chi-Square Goodness-of-Fit tests to determine whether stocked Colorado pikeminnow used specific habitats more than would be expected from the distribution of samples taken. We also employed paired t-tests with Bonferroni-adjusted probabilities to compare depth of all samples versus the depth of samples containing Colorado pikeminnow.

We also included information on stocked Colorado pikeminnow captured from the UNM spring-summer larval sampling, nonnative species removal efforts by NMFRO and UDWR, and September-October standardized monitoring to provide a complete first-year picture of the fate of the stocked fish. Since all of these projects differed in collection methods and objectives, we presented the data graphically but did not attempt statistical comparisons.

We were unable to combine the multiple data sets from the 1996 and 1997 collections into a data set that could be statistically compared with our monitoring data from the 2002 and 2003 stocking events. We have provided descriptive comparisons of total CPE and CPE in backwater habitats between the 2003, 2002, 1997, and 1996 stocking events.

RESULTS

Discharge

The Colorado pikeminnow stocked in 2003 were exposed to the conditions of the 2004 water year (Figure 2). As with 2003, 2004 had relatively low flows. Similar to 2003, flows during fall and winter of 2004 were low and constant. No major flow spikes occurred between the November 2003 stocking event and the December 2003 monitoring trip. Flows in July and August 2004 were also low and constant, similar to 2003. While 2004 was characterized by low spring runoff, fairly low winter and summer flows, and a storm-induced flow spike in September

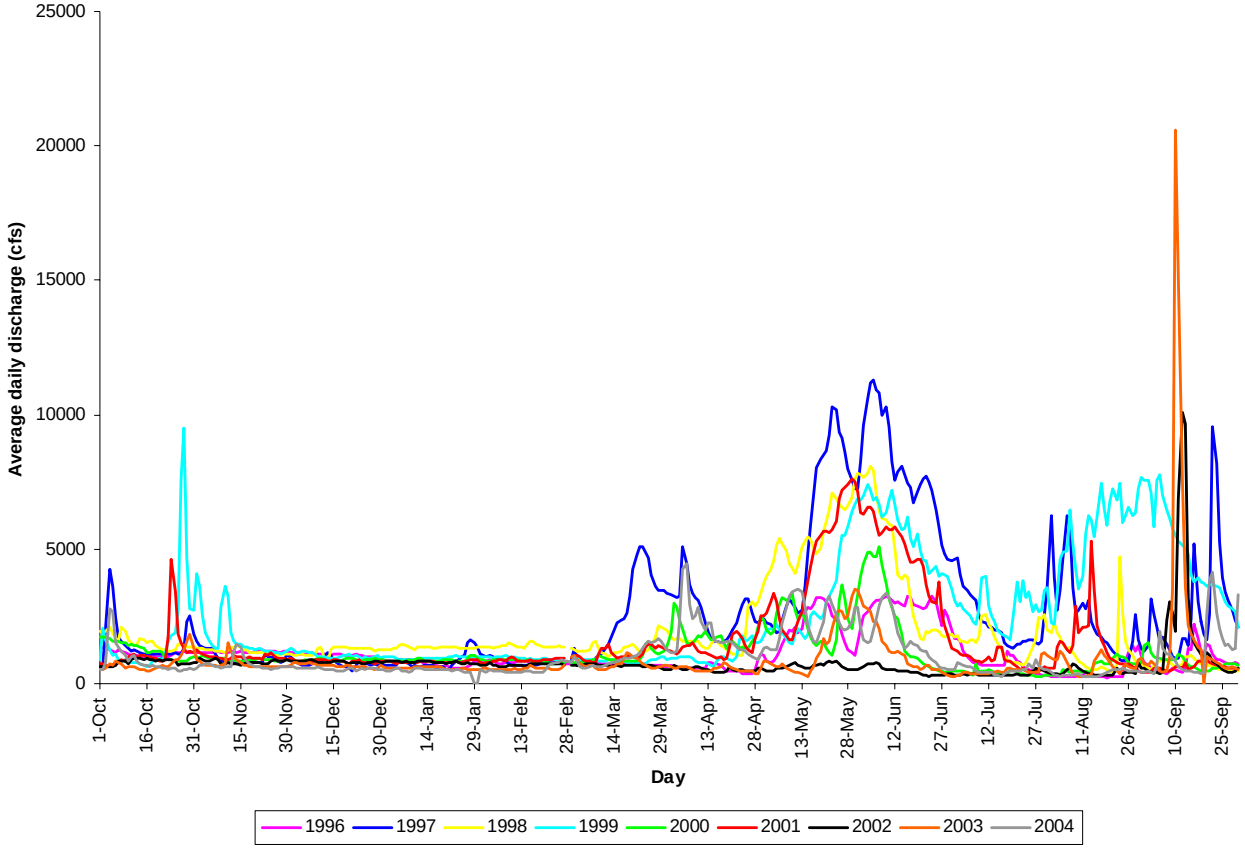

Figure 2. Average daily discharge for the San Juan River near Bluff, Utah (USGS gage 09379500), for water years 1997-2004 (water year is October 1- September 30).

2004, there were several differences between flows in 2003 and 2004. In 2004 there were multiple small peaks during an extended spring runoff that lasted from mid March to mid June 2004. Conversely, 2003 had a small, short-duration spring runoff. The early runoff peak in March 2004 occurred while we were on our March sampling trip and could have impacted the results of that trip. The extended runoff could have redistributed fish during our March 2004 sampling trip and between this trip and our July 2004 sampling trip. Similar to 2003, 2004 had a monsoon flow spike in September, but the spike in 2003 was five times larger than the spike in 2004.

Flows in 1997 and 1998 provided water conditions for fish stocked in 1996 and 1997, respectively (Figure 3). Compared to 2003 and 2004, these years had substantially higher spring runoff, higher summer flows, and more summer spike flows.

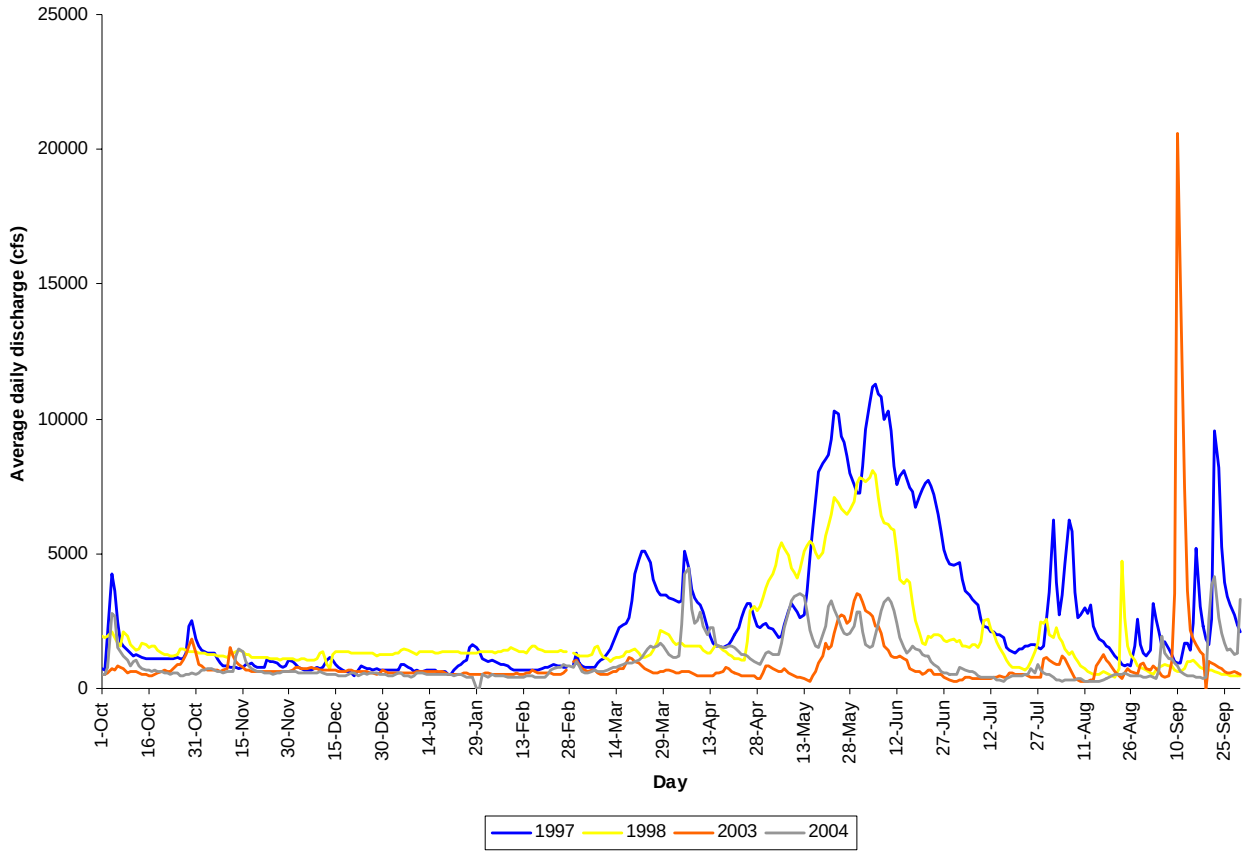

Figure 3. Average daily discharge for the San Juan River near Bluff, Utah (USGS gage 09379500), for water years 1997, 1998, 2003, and 2004 (a water year is October 1-September 30).

Temperature

Average water temperature during the week that fish were stocked in 2003 varied from 5-9 ºC near Farmington and 7-10°C near Shiprock (Figures 4-5). During the December 2003 sampling trip, average daily temperature varied between 1-4.5°C near Farmington and 1.5-5°C near Shiprock. Average daily water temperatures during the March 2004 sampling trip were 9.5 - 13°C near Farmington and 10-14°C near Shiprock. Finally, average temperatures during the July 2004 sampling trip varied from 19-22°C near Farmington and 22-25°C near Shiprock.

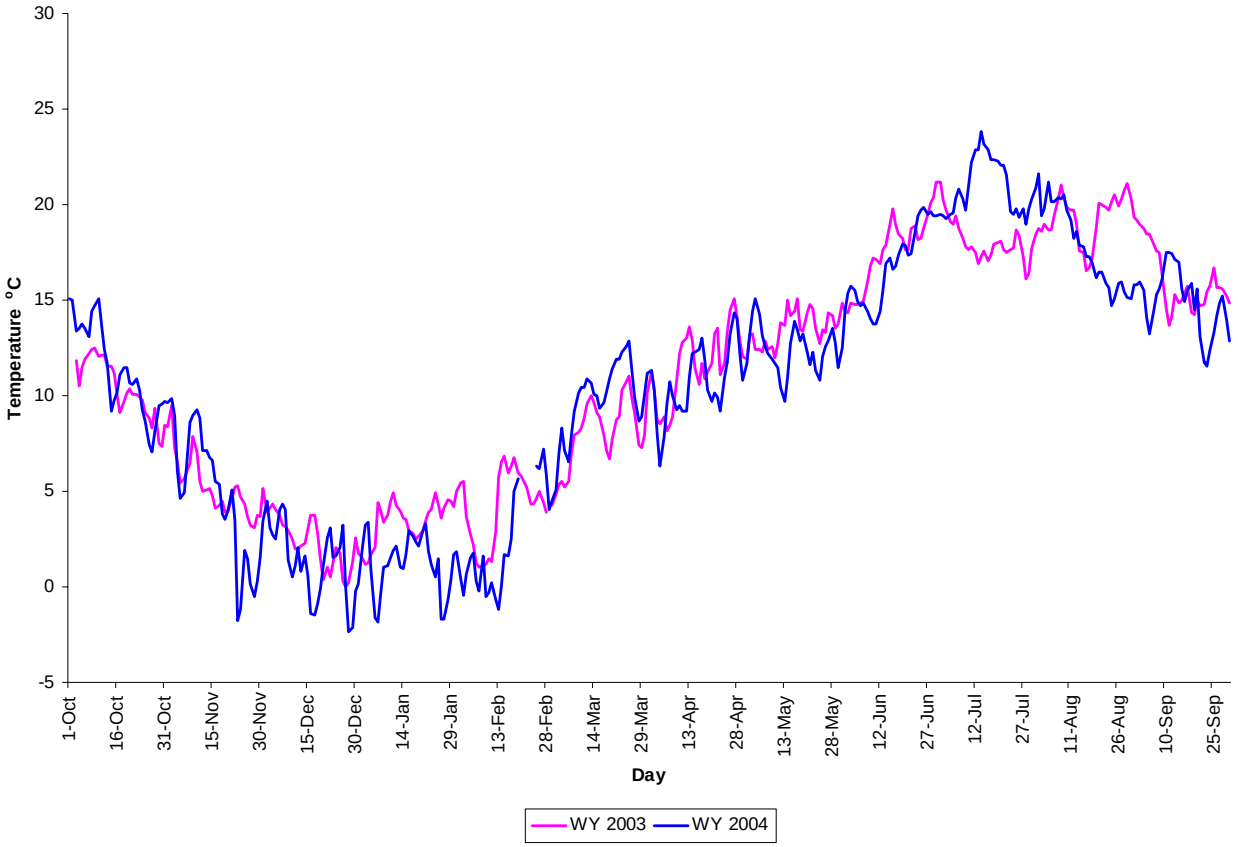

Figure 4. Average daily water temperatures near Farmington, New Mexico, from October 1, 2003, to September 30, 2004 (Keller-Bliesner Engineering data).

Average water temperatures in the first week following the 2003 stocking event were generally a couple of degrees cooler than temperatures following the 2002 stocking event. This was caused in large part by the 2-week difference in stocking time. Average temperatures from mid October to mid November were similar in 2002 and 2003. However, temperatures from mid November 2003 to February 2004 were generally several degrees cooler than temperatures during a similar time period after the 2002 stocking event. July and August 2003 appeared to have slightly higher average water temperatures than July and August 2004. The remainder of 2003-2004 had average water temperatures similar to 2002-2003.

The only continuous temperature data available from the main stem of the San Juan River during the 1996 and 1997 stocking period were from near Archuleta, NM. Releases from Navajo Dam maintain fairly consistent temperatures in this area, so temperature comparisons from this area would probably provide little information on the magnitude of temperature differences in downstream areas between years.

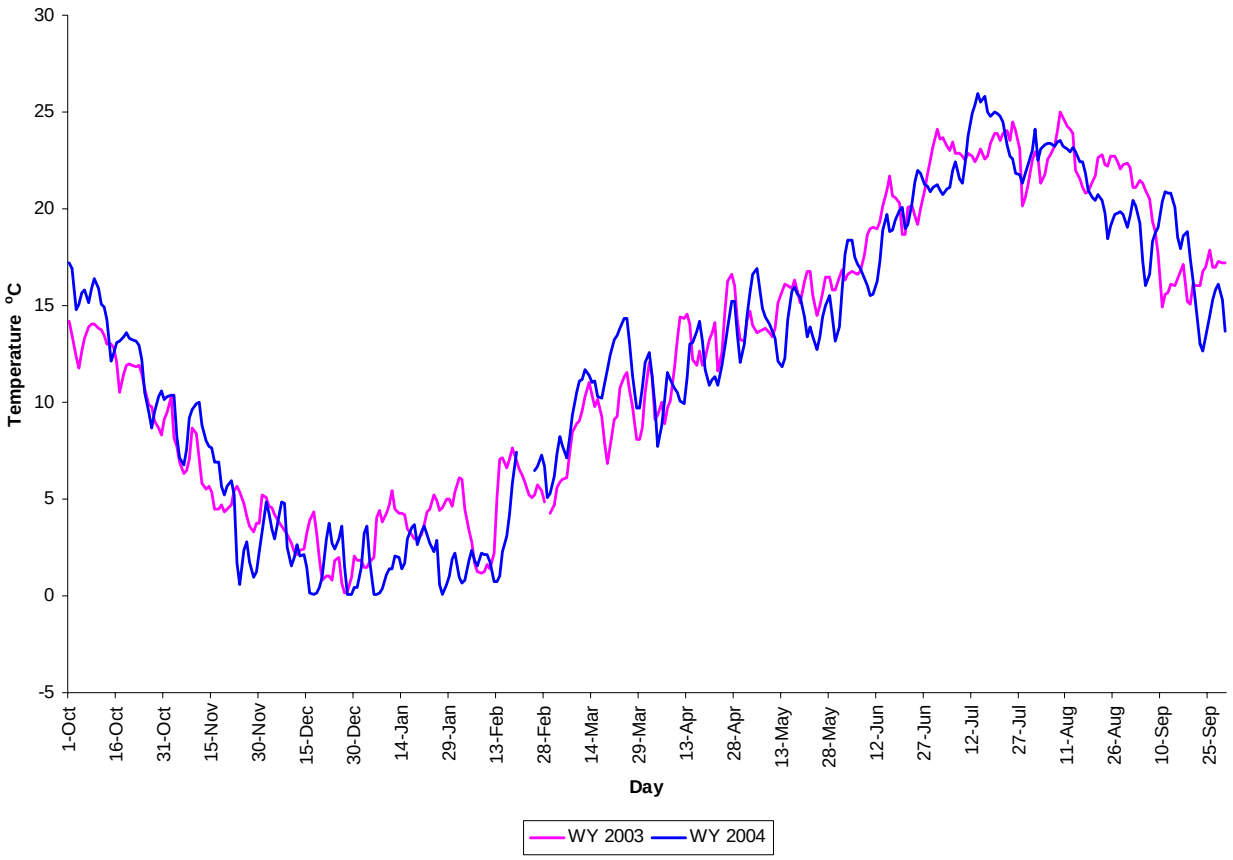

Figure 5. Average daily water temperatures near Shiprock, New Mexico, from October 1, 2003, to September 30, 2004 (Keller-Bliesner Engineering data).

Acclimation Studies

We placed Colorado pikeminnow into the APS Weir to Hogback Diversion station acclimation areas between 10:00 and 13:00 MST, and into the Upper San Juan station acclimation areas between 14:30 and 18:00 MST on November 6, 2003. When we floated the Upper San Juan station between 07:00 and 12:00 MST on November 7, 2003, we found that most of our acclimation areas seemed to be in place, and the fish seemed to be in good health. However, when we floated the APS Weir to Hogback Diversion station from 13:00 to 17:00 MST, we found many Colorado pikeminnow dead or under severe stress. Signs of stress included gulping at the surface, loss of equilibrium, and a red coloration, especially on the chest. Many of the dead Colorado pikeminnow had a large red dot in the middle of the ventral surface between the pectoral fins.

We returned to one of the acclimation areas in the Upper San Juan station that evening and still saw no sign of stress or mortality at that site. When we returned to the Upper San Juan station the next morning, we saw similar mortality and stress occurring throughout the acclimation areas in that station (Figure 6). Several of the acclimation areas in the Upper San Juan station had breached overnight on November 7, 2003, so it is more difficult to quantify the number of mortalities versus the number of escapees in that area. The bulk of the stress and mortality appeared to occur over the first 72 hours at both stations. Many of the mortalities retrieved after November 9, 2003, showed evidence of some decomposition, indicating they may have been mortalities from the first 72 hours that we did not find.

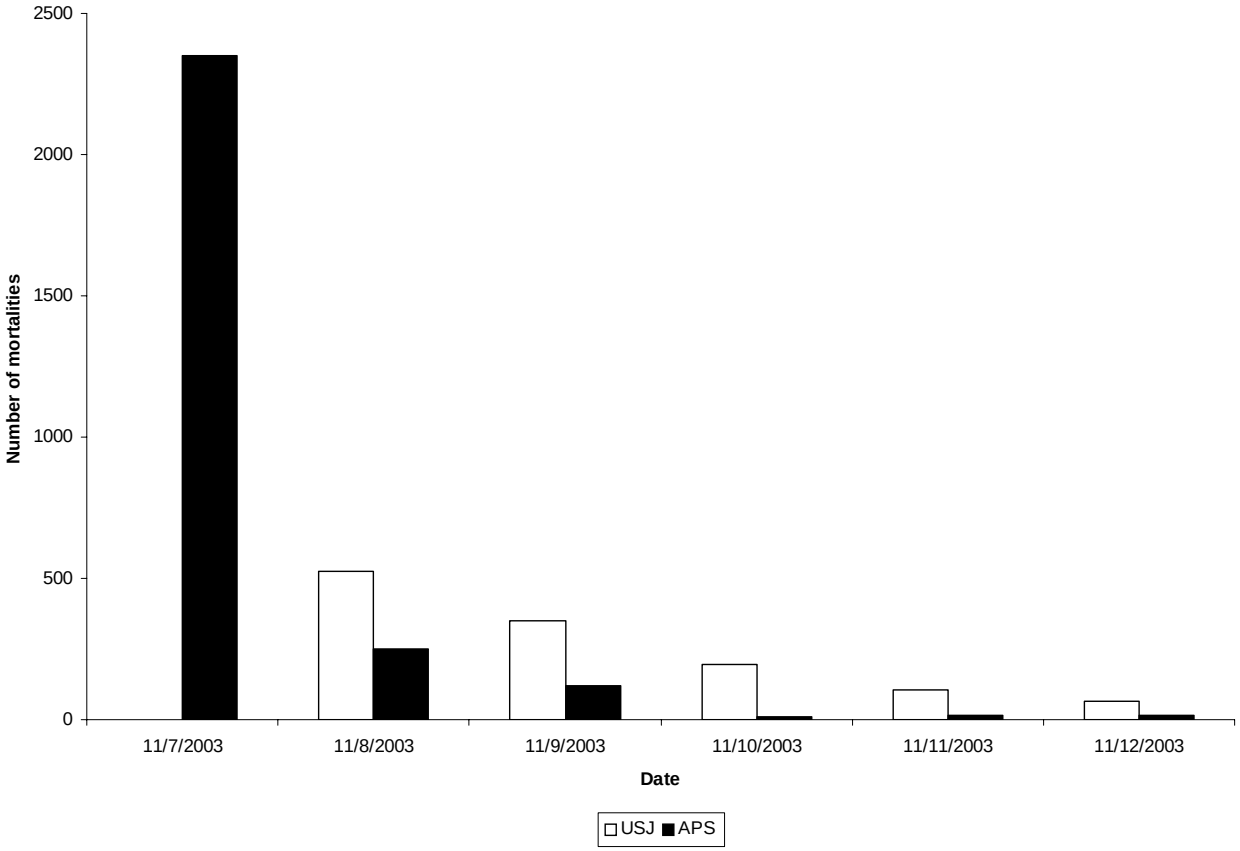

Figure 6. Number of Colorado pikeminnow mortalities observed during the acclimation experiments in November 2003. USJ = Upper San Juan station and APS = APS Weir to Hogback Diversion station.

When we released the stocked Colorado pikeminnow from acclimation areas on November 12, 2003, we made an estimate of how many Colorado pikeminnow were released alive. At best, we estimate that we released around 2,200 Colorado pikeminnow from the Upper San Juan station acclimation areas and 3,200 Colorado pikeminnow from the APS Weir to Hogback Diversion station acclimation areas (Figure 7). We preserved 50-100 mortalities on dry ice and sent them to DNFHTC for necropsy. The fish appeared to have died as a result of hemorrhaging of multiple internal organs. Such hemorrhaging is symptomatic of acute stress.

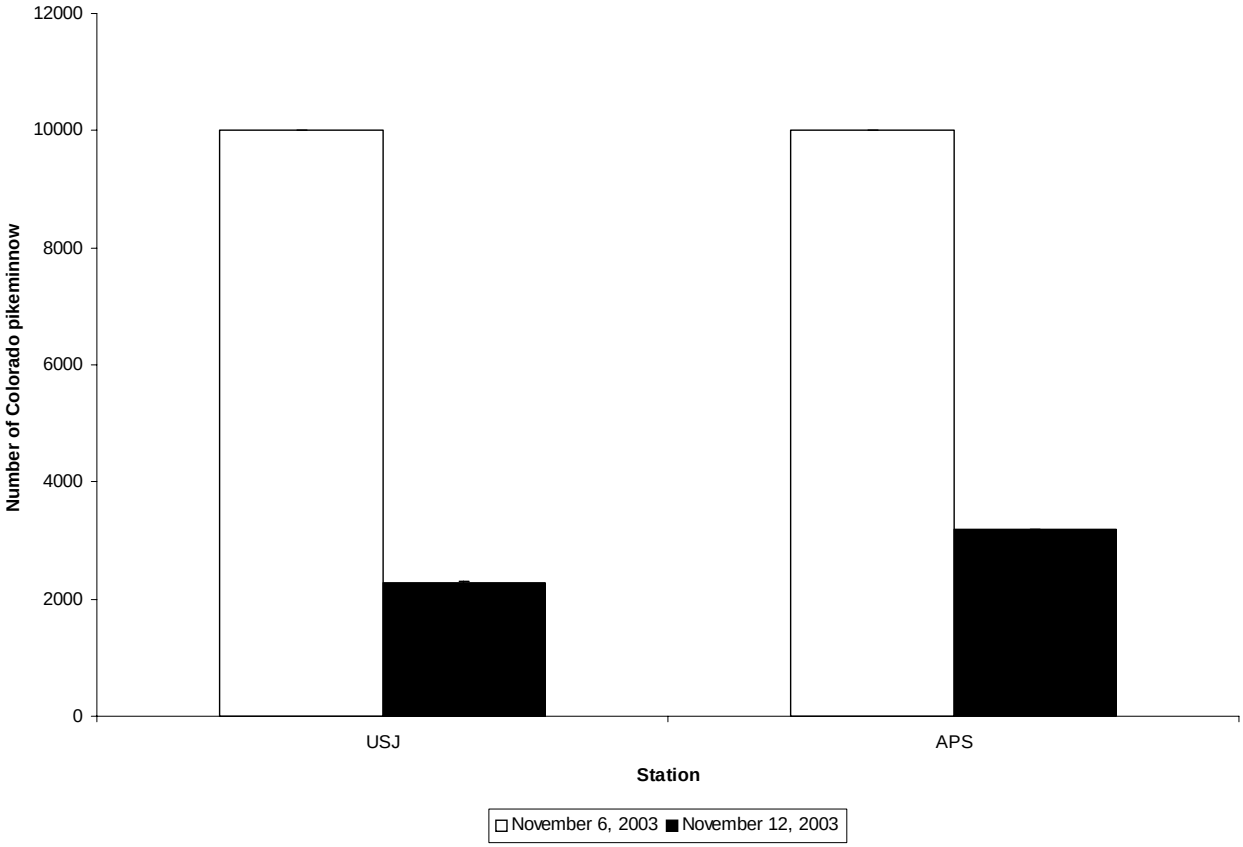

Figure 7. Number of Colorado pikeminnow stocked into acclimation areas on November 6, 2003, and the maximum estimated number released alive on November 12, 2003.

During our December 2003 sampling trip we examined all YOY Colorado pikeminnow for the presence of the calcein dye, but we did not find any fish with the mark. In one side channel in the APS Weir to Hogback Diversion station, we were certain that some of our recaptures were acclimated fish. We preserved one of these fish on dry ice and sent it to DNFHTC for further analysis. They found that the dye could be seen under laboratory conditions, but it could not be seen under field conditions. Therefore, we could not differentiate the acclimated fish from the general population of stocked fish.

Brush Pile Studies

Flows dropped nearly 100 cfs at the USGS gage near Shiprock between November 4, 2003, when debris piles were placed, and November 6, 2003, when Colorado pikeminnow were stocked (Figure 8). The week following debris pile placement, flows increased to 200 cfs higher than the flows at which debris piles were placed. However, the flows declined rapidly, and the flows encountered during the December 2003 monitoring trip flows were still 100 cfs below the flows at which brush piles were placed in November 2003. While the variation level of these flows appears small, they appeared to have a large impact on the debris piles themselves and the quality of the habitats where we placed debris piles. During our December 2003 monitoring trip, we found that several of our debris piles were gone or covered with silt, and several others were either out of the water or the habitats they were placed in were now extremely shallow (Figure 9).

Retention of Colorado Pikeminnow Stocked in 2003

BIO-WEST Collections

We collected 289 of the 2003 stocked Colorado pikeminnow in December 2003, approximately 4-5 weeks after 175,000 were stocked (Table 6). The majority of these fish were collected in the two stations above the Hogback Diversion in the Below Fruitland Diversion and APS Weir to Hogback Diversion stations, as well as in the Four Corners and Bluff stations. The Below Fruitland Diversion station was one of the areas where fish were stocked, and acclimation experiments were conducted in the APS Weir to Hogback Diversion station. No Colorado pikeminnow were captured in the Lower Animas station or the Upper San Juan station, despite the fact that Colorado pikeminnow were acclimated in the Upper San Juan station. Few of the 2003 stocked Colorado pikeminnow were collected in the canyon section of the river below Mexican Hat.

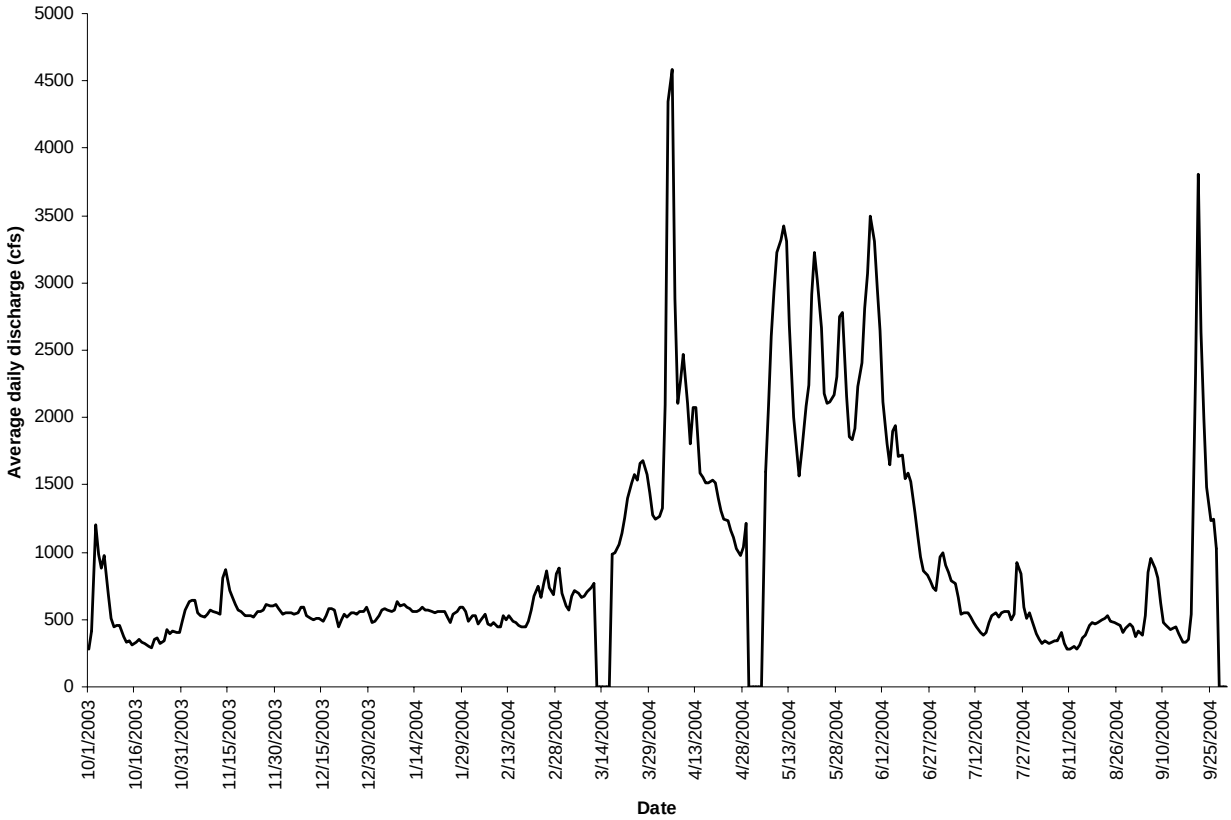

Figure 8. Average daily discharge for the San Juan River near Shiprock, New Mexico (USGS gage 09368000), for water year 2004 (a water year is October 1-September 30).

Figure 9. Backwater area with added brush piles on (a) November 4, 2003, and (b) December 5, 2003.

Table 6. Number of samples, area sampled, and Colorado pikeminnow from the 2002 and 2003 stocking events collected in each station by seining in December 2003.

STATION	SEINE HAULS	AREA SAMPLED (m^2)	2003 STOCKED PTYLUC[a]	2002 STOCKED PTYLUC
Lower Animas	32	1,100.22	0	0
Upper San Juan	54	1,986.04	0	0
Below Fruitland Diversion	61	2,195.59	59	0
APS Weir to Hogback Diversion	56	2,011.92	45	0
Shiprock to Cudei	54	1,632.77	16	0
Four Corners	38	1,343.96	78	4
Aneth	43	1,325.00	14	0
Bluff	43	1,211.10	50	0
Below Mexican Hat	27	756.15	1	1[b]
John's Canyon	21	310.75	6	0
Grand Gulch	43	929.00	11	0
Miscellaneous Canyon	17	294.90	4	0
Total	489	15,097.40	289	5

[a] Colorado pikeminnow
[b] This fish was from Mumma Fish Hatchery and was stocked at the Animas confluence on November 6, 2003.

Surprisingly, we collected higher numbers (413) of the 2003 stocked Colorado pikeminnow during our March 2004 sampling trip, but we also expended more effort in terms of both the number of samples and the area sampled (Table 7). Numbers decreased from December 2003 in areas above the Hogback Diversion, but they generally stayed the same or increased below the Hogback Diversion. Highest numbers were collected below RM 13.0 in the lower section of the canyon.

Table 7. Number of samples, area sampled, and Colorado pikeminnow from the 2002 and 2003 stocking events collected in each station by seining in March 2004.

STATION	SEINE HAULS	AREA SAMPLED (m^2)	2003 STOCKED PTYLUC[a]	2002 STOCKED PTYLUC
Lower Animas	32	789.36	0	0
Upper San Juan	48	1,928.23	0	0
Below Fruitland Diversion	52	2,058.17	31	0
APS Weir to Hogback Diversion	54	2,166.08	6	0
Shiprock to Cudei	83	2,486.18	20	0
Four Corners	70	3,493.33	63	0
Aneth	64	2,689.85	32	0
Bluff	83	3,009.52	67	0
Below Mexican Hat	48	1,783.26	13	0
John's Canyon	42	1,652.58	33	0
Grand Gulch	46	2,431.85	78	7
Miscellaneous Canyon	44	1,522.05	70	2
Total	666	26,010.46	413	9

[a] Colorado pikeminnow.

Overall, we collected fewer Colorado pikeminnow during our July 2004 sampling trip (Table 8) than during March sampling. We did maintain a similar or higher number of Colorado pikeminnow at the APS Weir to Hogback Diversion and Shiprock to Cudei stations. We also collected our first Colorado pikeminnow in the Upper San Juan station. While the area sampled increased during the July trip, the number of samples decreased. Using larger seines to block seine during this sampling trip is the reason sampling area increased.

Table 8. Number of samples, area sampled, and Colorado pikeminnow from the 2002 and 2003 stocking events collected in each station by seining in July 2004.

STATION	SEINE HAULS	AREA SAMPLED (m2)	2003 STOCKED PTYLUC[a]	2002 STOCKED PTYLUC
Lower Animas	16	2,485.60	0	0
Upper San Juan	34	6,064.10	2	1 (1)[b]
Below Fruitland Diversion	25	5,319.61	16	2 (2)[b]
APS Weir to Hogback Diversion	25	7,420.90	19	0
Shiprock to Cudei	31	7,129.50	29	3 (3)[b]
Four Corners	23	4,115.10	21	1
Aneth	29	5,910.40	2	0
Bluff	27	6,297.70	17	2
Below Mexican Hat	30	6,024.00	6	2
John's Canyon	31	3,655.60	2	1
Grand Gulch	33	4,823.00	27	1
Miscellaneous Canyon	25	3,009.55	5	0
Total	329	62,255.06	146	13 (6)[b]

[a] Colorado pikeminnow.
[b] Number in parentheses represent fish stocked from Mumma Fish Hatchery at the Animas confluence on June 9, 2004.

In addition to YOY Colorado pikeminnow stocked in 2003, we also collected some larger Colorado pikeminnow that were survivors from the YOY Colorado pikeminnow stocked in 2002 and Colorado pikeminnow from Mumma Fish Hatchery that were stocked near the Animas River confluence on November 6, 2003 (age-1) and June 9, 2004 (age-2).

Since effort varied in both the number of samples and area sampled between the sampling trips, the CPE statistic is probably a more useful way of evaluating differences between stations within trips and between trips. As outlined in the methods section, the number of samples without Colorado pikeminnow prevents meaningful statistical analysis of the data. Therefore, we provide commentary on visual trends of the average number of Colorado pikeminnow captured per m^2.

Once the total number of Colorado pikeminnow were scaled for sampling effort, we found that the Below Fruitland Diversion and Four Corners stations had the highest CPE (Figure 10). Other than the Below Mexican Hat station, which had a very low CPE, most other stations had a similar CPE in December 2003. In March 2004 the canyon sections of the river had a higher CPE than most of the upstream stations, showing a continual shift downstream beginning when the fish were stocked through March 2004. In fact, the Grand Gulch station had the highest average CPE of all stations in March 2004. Additionally, the high average CPE of the canyon samples collected outside our stations was predominantly from Colorado pikeminnow collected between the bottom of the Grand Gulch station and Clay Hills Crossing. By July 2004 CPE of Colorado pikeminnow was considerably lower, but it was fairly consistent at all the stations.

Using larger seines in July 2004 substantially elevated the amount of area sampled during that time. However, we do not think that increasing the amount of habitat sampled also increased the number of Colorado pikeminnow collected. Instead, we believe that Colorado pikeminnow were prevented from escaping by the larger seines. If this were the case, then sampling the extra area would cause a decrease in the Colorado pikeminnow CPE during the July 2004 sampling trip that was not related to the number of Colorado pikeminnow present. To alleviate this potential bias, we also calculated the number of Colorado pikeminnow per sample (Figure 11). Examining the number of Colorado pikeminnow collected per seine haul shows trends similar to the CPE data in December 2003 and March 2004. However, the catch rate for Colorado pikeminnow in July 2004 did not decrease dramatically from the March 2004 catch rate. Catch rate actually increased between March and July 2004 at all stations upstream from Aneth.

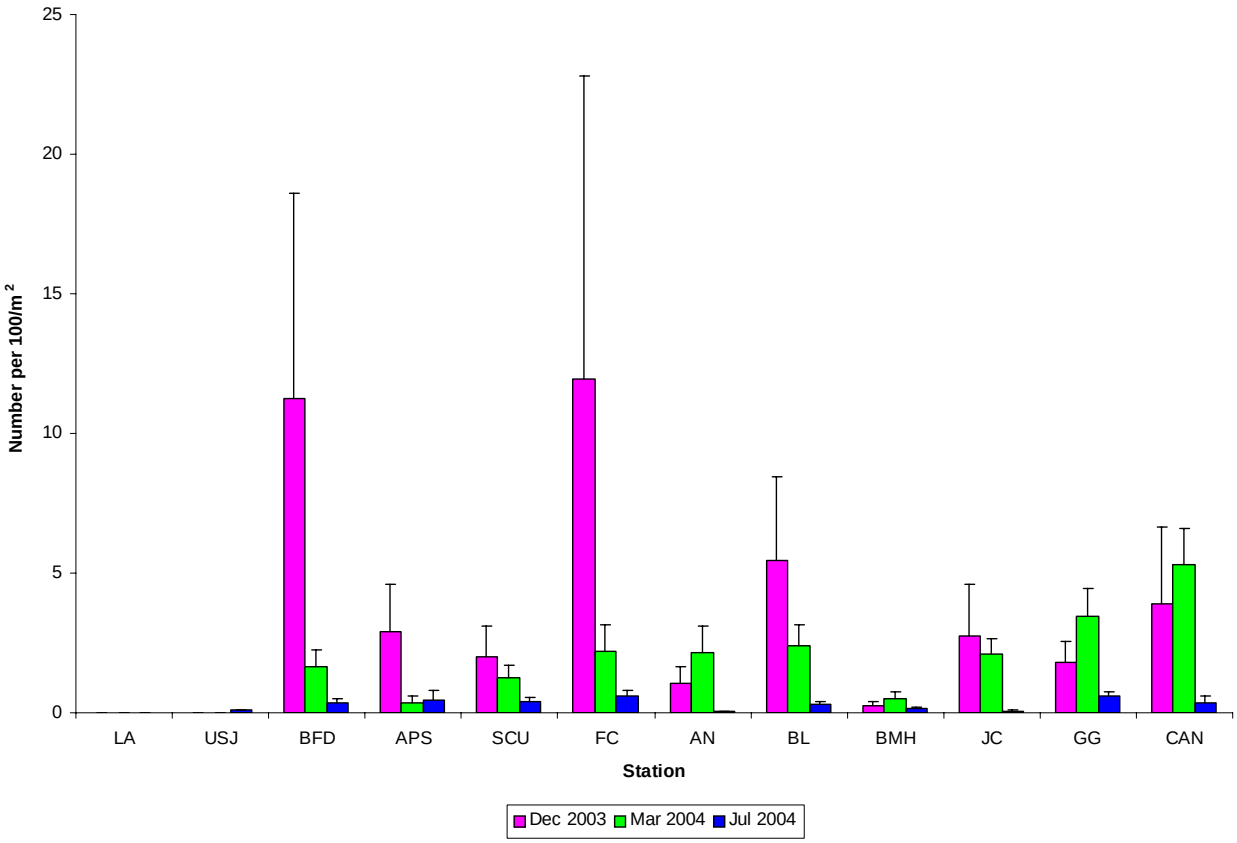

Figure 10. Number of Colorado pikeminnow collected per 100 m^2 at each station in December 2003, March 2004, and July 2004. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback Diversion, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon. Error bars represent +/- 1 standard error.

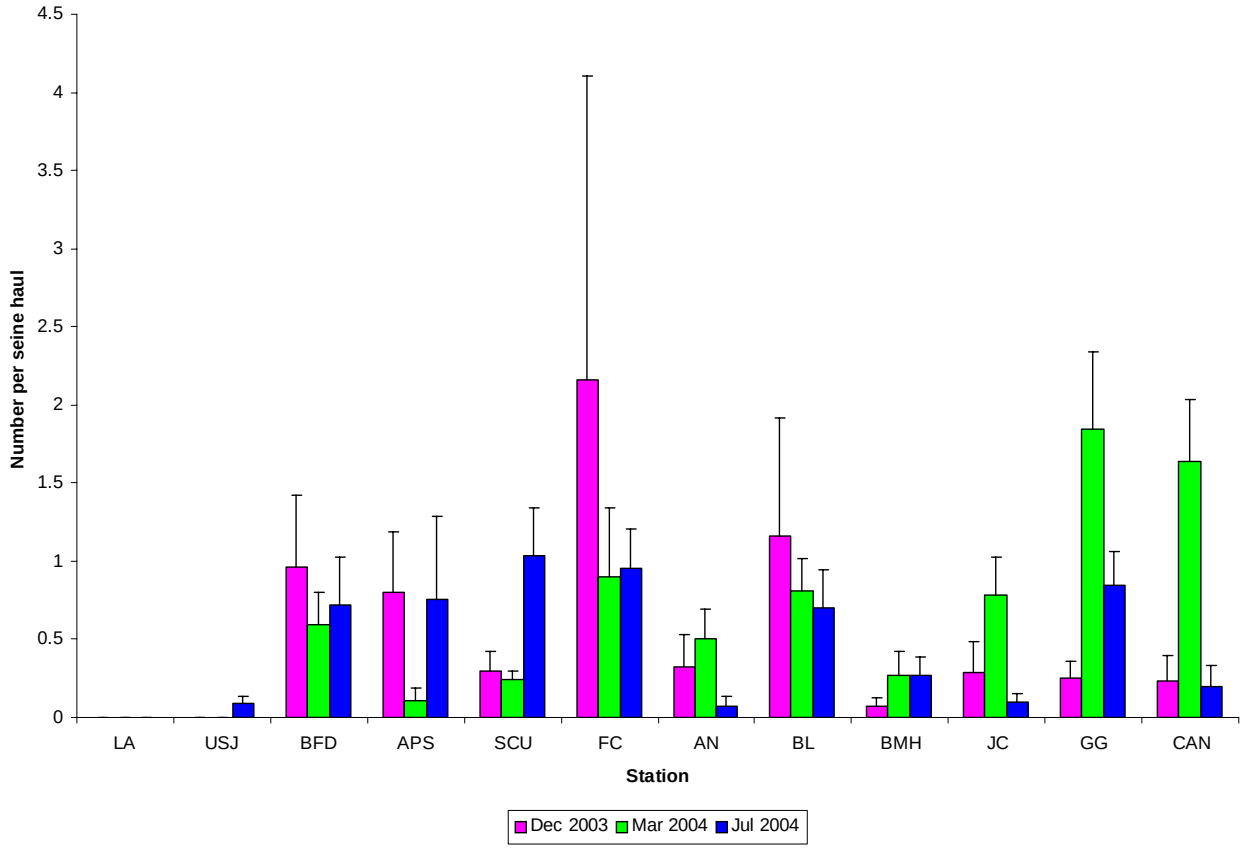

Figure 11. Number of Colorado pikeminnow collected per seine haul at each station in December 2003, March 2004, and July 2004. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback Diversion, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon. Error bars represent +/- 1 standard error.

When we calculated the total Colorado pikeminnow CPE and catch rate for each sampling trip after the 2003 stocking event, we found little difference between the December 2003 and March 2004 collections (Figures 12-13). We did find a large drop in total Colorado pikeminnow CPE between March 2004 and July 2004. While the catch rate for Colorado pikeminnow showed a slight increase between the December 2003 and March 2004 sampling trips and a small decline between the March 2004 sampling trip and the July 2004 sampling trip, the differences were not significant.

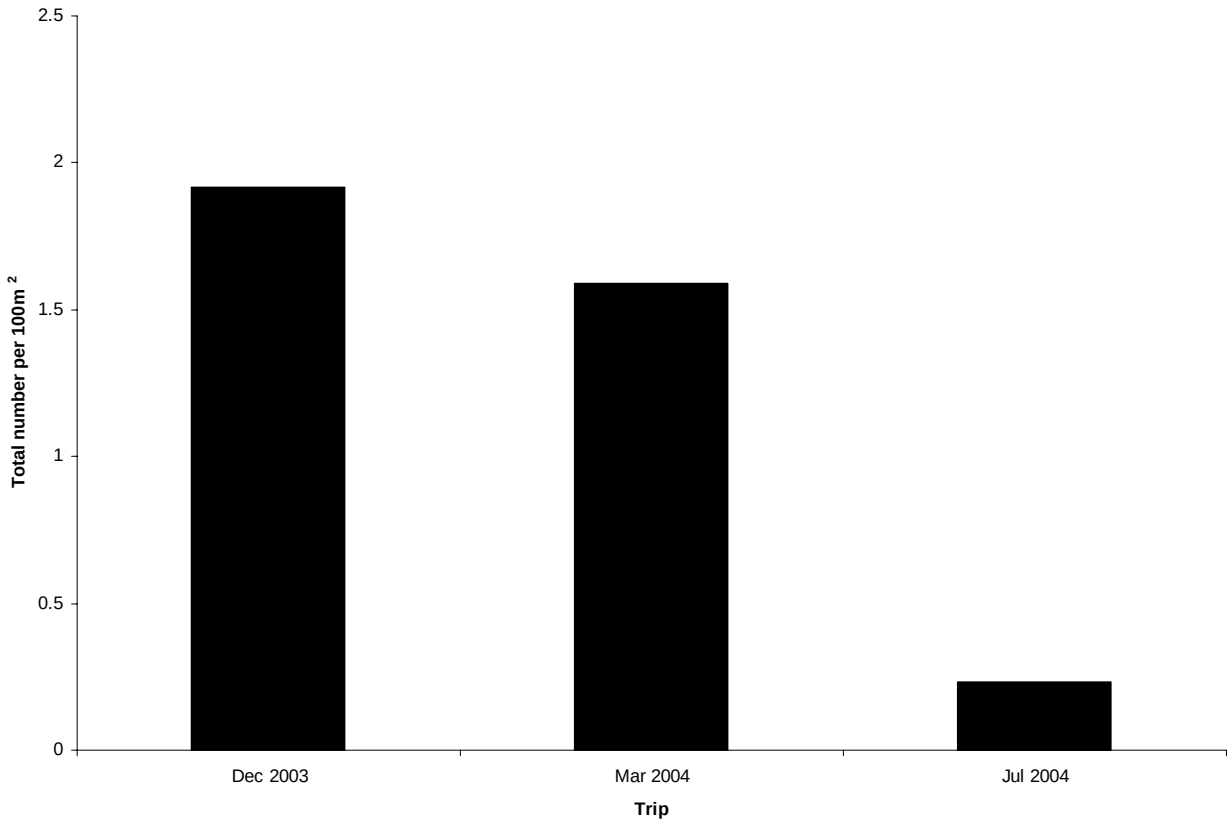

Figure 12. Total catch per effort (total number per 100 m^2) of Colorado pikeminnow collected in December 2003, March 2004, and July 2004.

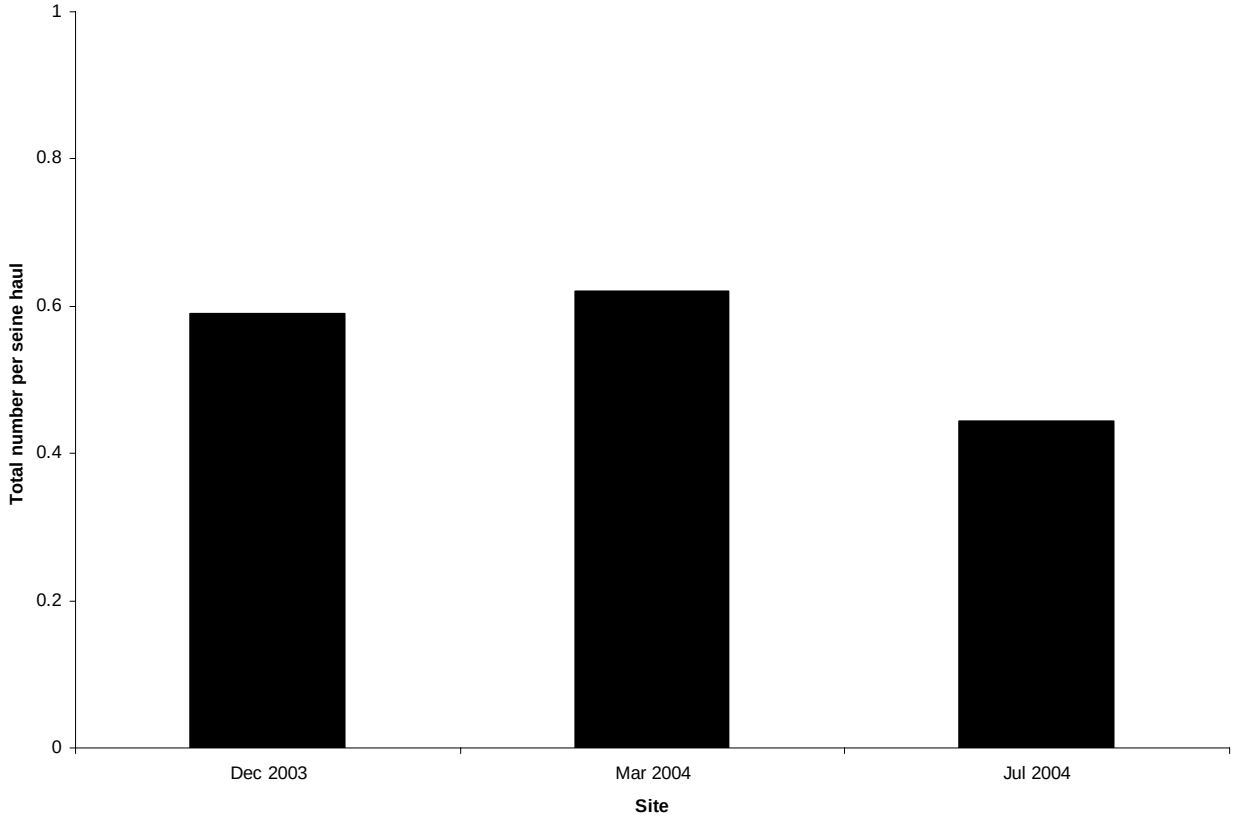

Figure 13. Total catch rate (total number per seine haul) of Colorado pikeminnow collected in December 2003, March 2004, and July 2004.

Other SJRIP Cooperator Collections

Colorado pikeminnow stocked in 2002 and 2003 continued to be collected by other researchers on the San Juan River in 2004 (Figure 14). During UNM larval fish sampling efforts, Colorado pikeminnow stocked in 2003 were collected throughout the canyon area from RM 54.2 to RM 13.9 in April and May 2004. As the Colorado pikeminnow stocked in 2003 grew, larval seines were much less efficient at catching them. No Colorado pikeminnow were collected by UNM personnel from June through August 2004, but they did collect one Colorado pikeminnow stocked in 2003 in September 2004.

During UDWR nonnative removal efforts from RM 52.9 to RM 2.9, Colorado pikeminnow stocked in 2003 were collected in March through August 2004. Numbers were relatively low and consistent, with a slight increase in August 2004. During NMFRO nonnative removal efforts between PNM Weir and Hogback Diversion and between Hogback Diversion and Shiprock, Colorado

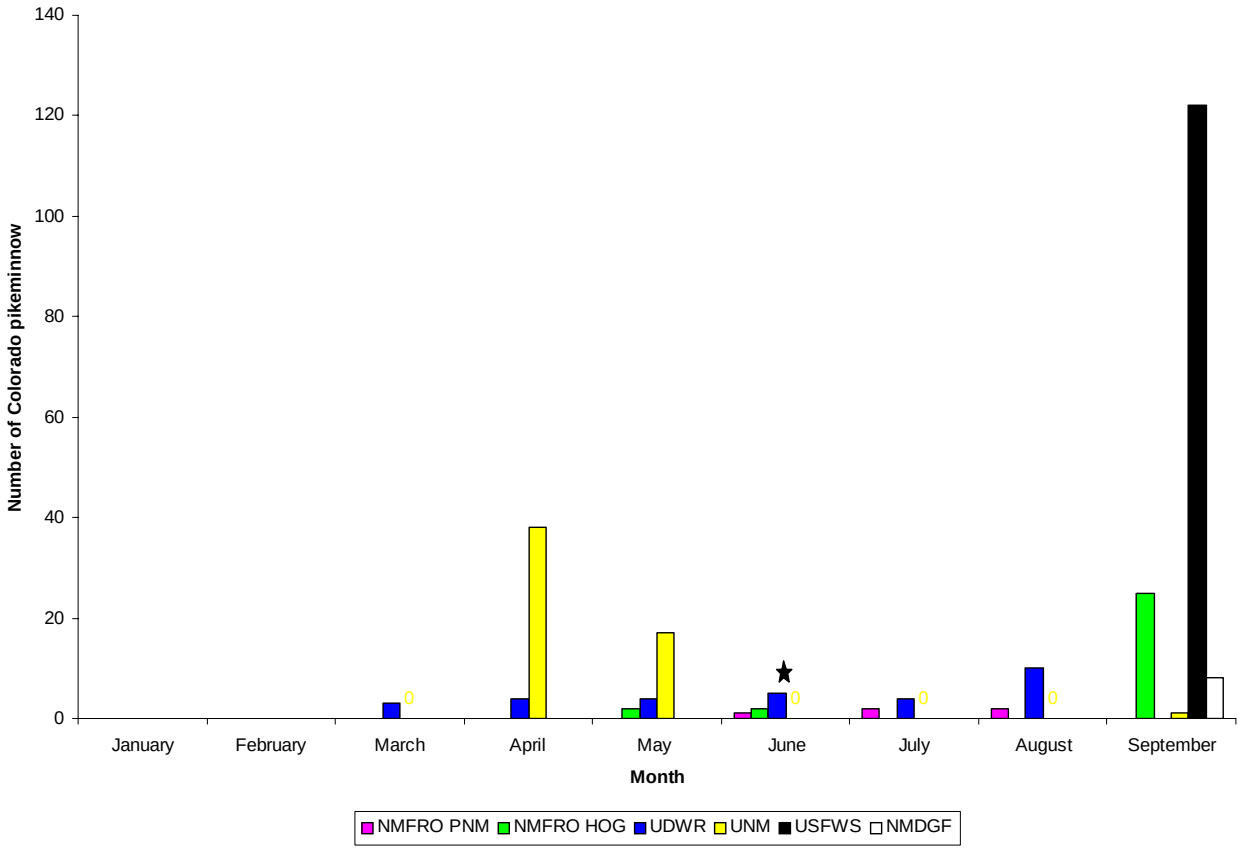

Figure 14. Number of 2003 stocked Colorado pikeminnow collected by other SJRIP cooperators in 2004. Star indicates the combined results of two collections in that month.

pikeminnow stocked in 2003 were also collected. They found low, but consistent numbers in both areas sampled through August 2004. However, in September 2004 they saw a substantial increase in the number of Colorado pikeminnow stocked in 2003 that were collected from PNM Weir to Hogback Diversion.

Finally, during the annual fall monitoring trip, the NMDGF collected eight Colorado pikeminnow stocked in 2003 using seines, and the USFWS collected 122-138 Colorado pikeminnow stocked in 2003 using raft-mounted electrofishing. The length frequency distribution for Colorado pikeminnow collected in 2004 fall monitoring efforts did not show a clear break between age-1 (2003 stocking) and age-2 (2002 stocking) fish. Using 205 mm standard length (SL) as the break results in 122 age-1 Colorado pikeminnow, and using 230 mm SL as the break results in 138 age-1 Colorado pikeminnow. We used the more conservative number (122) in Figure 14.

Additionally, age-2 Colorado pikeminnow from the 2002 stocking and the Colorado pikeminnow from Mumma Fish Hatchery were collected by other researchers in 2004 (Figure 15). In the canyon section of the river, the UDWR collected over 20 of the Colorado pikeminnow stocked in 2002 on all of their nonnative removal trips between March through June 2004, peaking on the April 2004 trip with a catch of 37. After this, numbers fell considerably and were down to four by August 2004. From PNM Weir to Shiprock, NMFRO personnel found low but consistent numbers of Colorado pikeminnow stocked in 2002, except in June 2004, when numbers jumped to 33. The majority of these fish were age-2 Colorado pikeminnow from Mumma Fish Hatchery that were stocked at the Animas River confluence on June 9, 2004. The NMGFD did not catch any age-2 Colorado pikeminnow using seines during annual fall monitoring. The USFWS collected between 20-38 age-2 Colorado pikeminnow, depending on the length at which we divide the two year classes. Twelve of the age-2 Colorado pikeminnow were fish from Mumma Fish Hatchery that had been stocked on June 9, 2004, near the Animas River confluence (Dale Ryden, USFWS, personal communication).

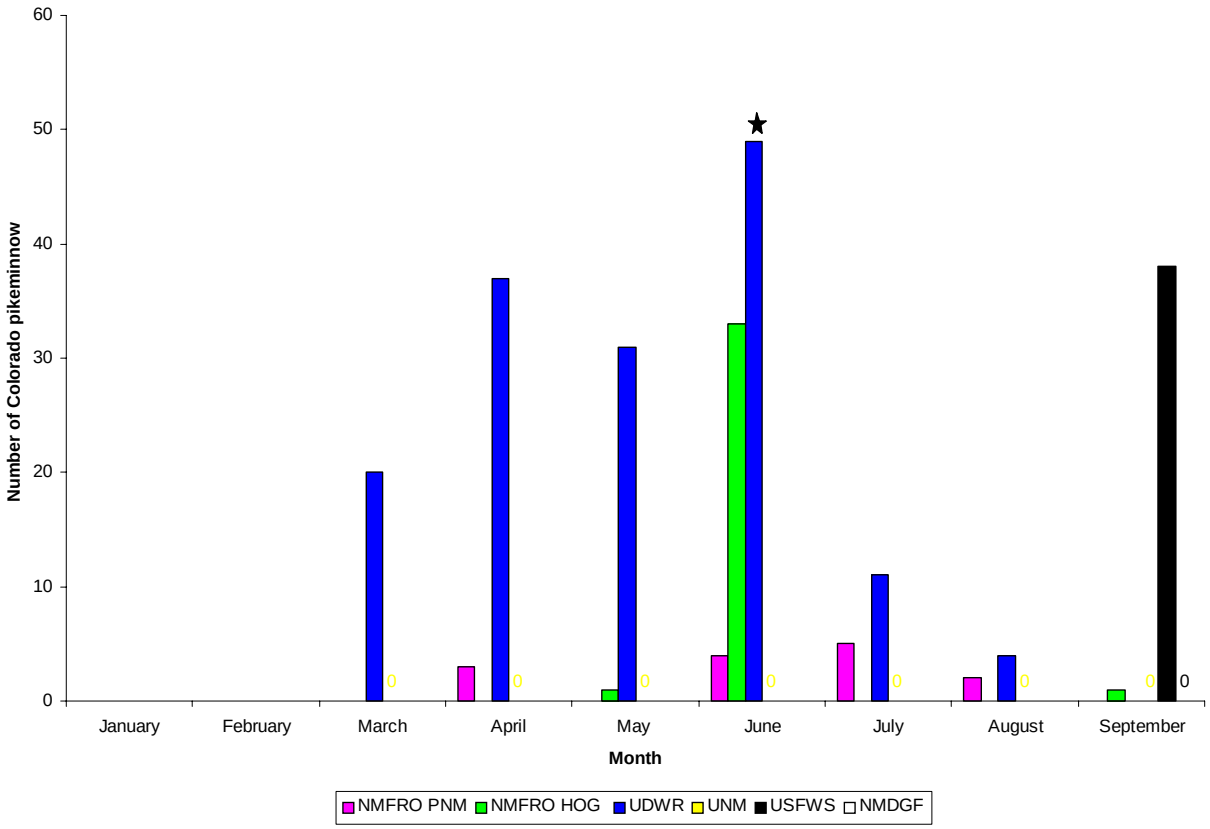

Figure 15. Number of 2002 stocked Colorado pikeminnow and fish from Mumma Hatchery stocked in November 2003 and June 2004 collected by other SJRIP cooperators in 2004. Star indicates the combined results of two collections in that month.

Comparison with Colorado Pikeminnow Stocked in 2002

We collected nearly double the numbers of YOY Colorado pikeminnow from the Upper San Juan to Bluff stations in December 2003 and March 2004 as we did in December 2002 and March 2003 (Table 9). In July 2004 we collected over 100 age-1 Colorado pikeminnow from the 2003 stocking event between the Upper San Juan and Bluff stations, while in July 2003 we only collected two age-1 Colorado pikeminnow from the 2002 stocking event. During 2004 SJRIP annual fall monitoring, eight age-1 Colorado pikeminnow were collected by seining and over 120 were collected by electrofishing. No Colorado pikeminnow stocked in 2002 were collected by seining, and four times fewer age-1 Colorado pikeminnow were collected by electrofishing during 2003 fall monitoring.

Table 9. Number of stocked YOY Colorado pikeminnow collected at similar times after the 2002 and 2003 stocking events.

TIME	2002 - 2003	2003 - 2004
December	123	289 (262) [a]
March	117	413 (219) [a]
July	2	146 (106) [a]
Fall seining	0	8
Fall monitoring	32	122-138 [b]

[a] Number in parentheses is the number collected in the eight stations sampled in both years.

[b] The length frequency distribution for Colorado pikeminnow collected in the 2004 fall monitoring did not show a clear break between age-1 (2003 stocking) and age-2(2002 stocking) fish. Using 205 mm SL as the break results in 122 age-1 Colorado pikeminnow, and using 230 mm SL as the break results in 138 age-1 Colorado pikeminnow.

We found that average CPE of YOY Colorado pikeminnow in December 2003 was 2.5-3 fold higher in the Below Fruitland Diversion and Four Corners stations than during December 2002. Average CPE in the Bluff station was over 40 times higher in December 2003 than in December 2002. Average CPE in the APS Weir to Hogback Diversion station increased from 0 in December 2002 to 2.9 in December 2003. The Shiprock to Cudei and Aneth stations had slightly lower average CPE in December 2003 versus December 2002 (Figure 16).

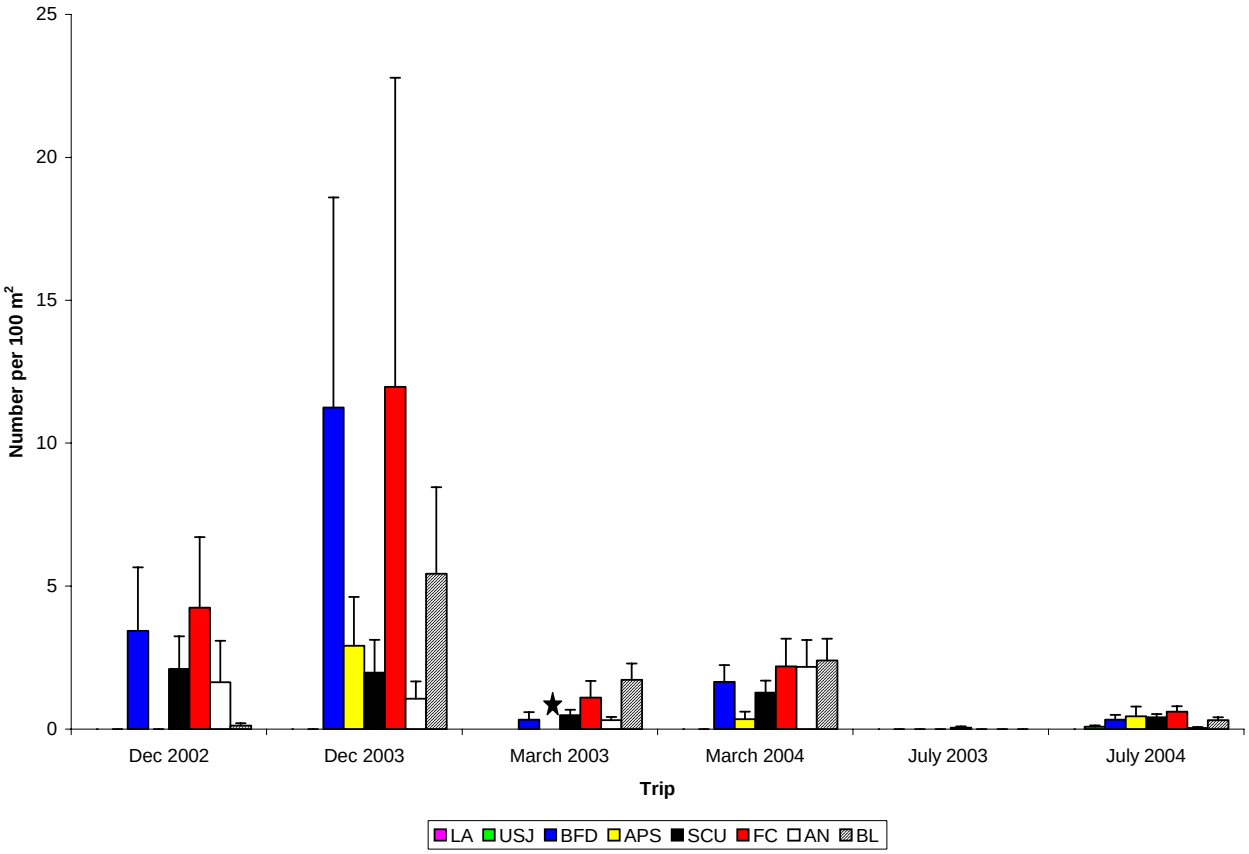

Figure 16. Average catch per effort (number per 100 m^2) of Colorado pikeminnow collected from the Upper San Juan station to Bluff stations after the 2002 and 2003 stocking events. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudie, FC = Four Corners, AN = Aneth, and BL = Bluff. Error bars represent +/-1 standard error.

The trend toward increased average CPE continued in both March and July 2004. In March 2004 the average CPE was anywhere from 1.4 to 7 times higher than in March 2003. Additionally, in July 2004 we collected age-1 Colorado pikeminnow at every station except for the Lower Animas station. In July 2003 we only collected age-1 Colorado pikeminnow in the Shiprock to Cudei station.

The average CPE for each sampling trip, combining all stations, was higher for all trips following the 2003 stocking event compared with trips following the 2002 stocking event (Figure 17). Comparing the stations that were sampled in both years, average CPE for Colorado pikeminnow in December and March after the 2003 stocking event was more than twice that found in December and March after the 2002 stocking event. The average CPE for Colorado

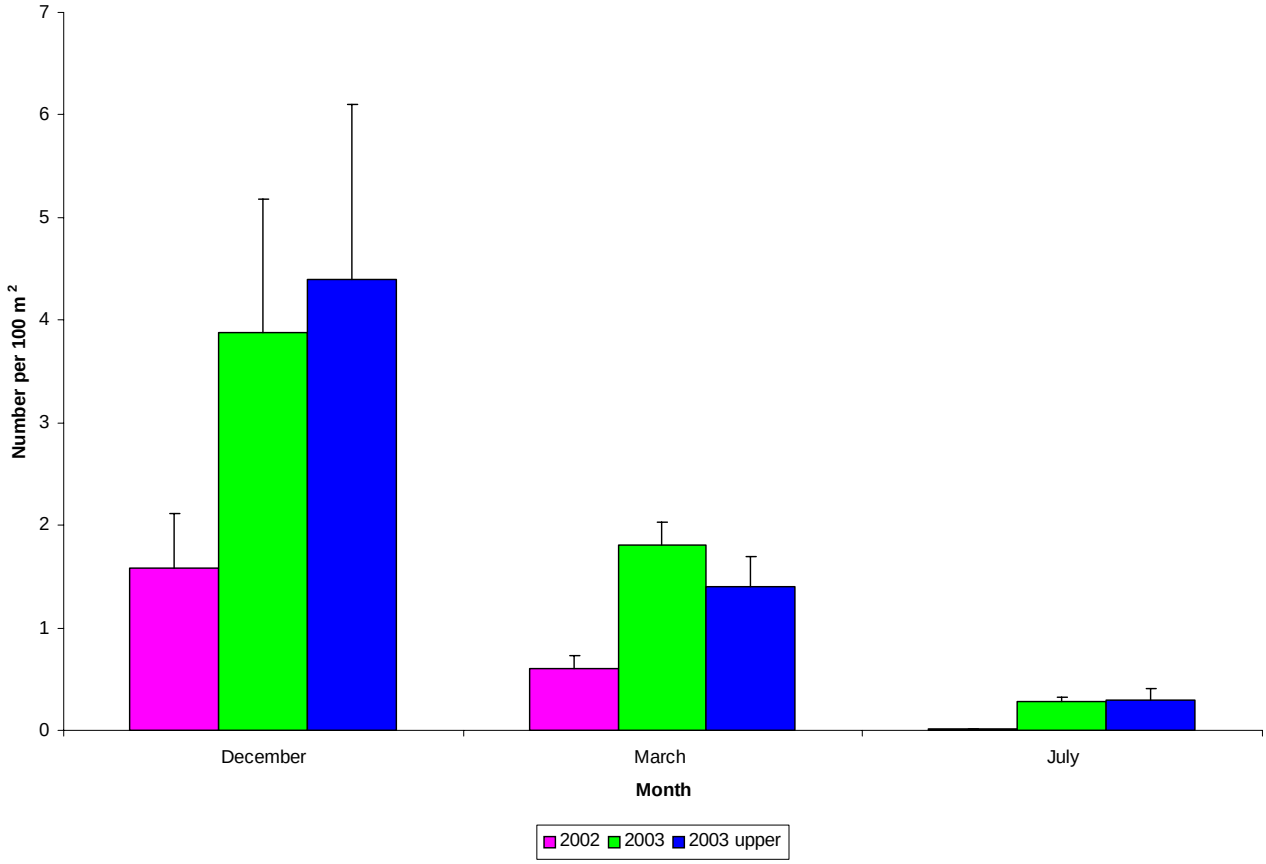

Figure 17. Average catch per effort (number per 100 m^2) of Colorado pikeminnow collected at all stations combined during each sampling trip after the 2002 and 2003 stocking events. 2003 upper = combined CPE for the Upper San Juan to Bluff stations after the 2003 stocking event. Error bars represent +/-1 standard error.

pikeminnow in July 2004 was over 35 times the average CPE for Colorado pikeminnow in July 2003. The total CPE per trip for all stations sampled in both years combined also showed a 1.5- to 2-fold increase in December 2003 and March 2004 over December 2002 and March 2003 (Figure 18). Total CPE in July 2004 was over 25 times higher than total CPE in July 2003.

We found that the majority of samples collected after the 2002 stocking event did not contain Colorado pikeminnow. Another indication of differences in the retention and survival of YOY Colorado pikeminnow between the 2002 stocking and the 2003 stocking, efforts might be the number of samples where Colorado pikeminnow were collected. Examining the stations sampled in both years, we found that Colorado pikeminnow were collected in 11%, 5%, and 24% more samples in the December, March, and July collections, respectively, following the 2003 stocking event (Table 10).

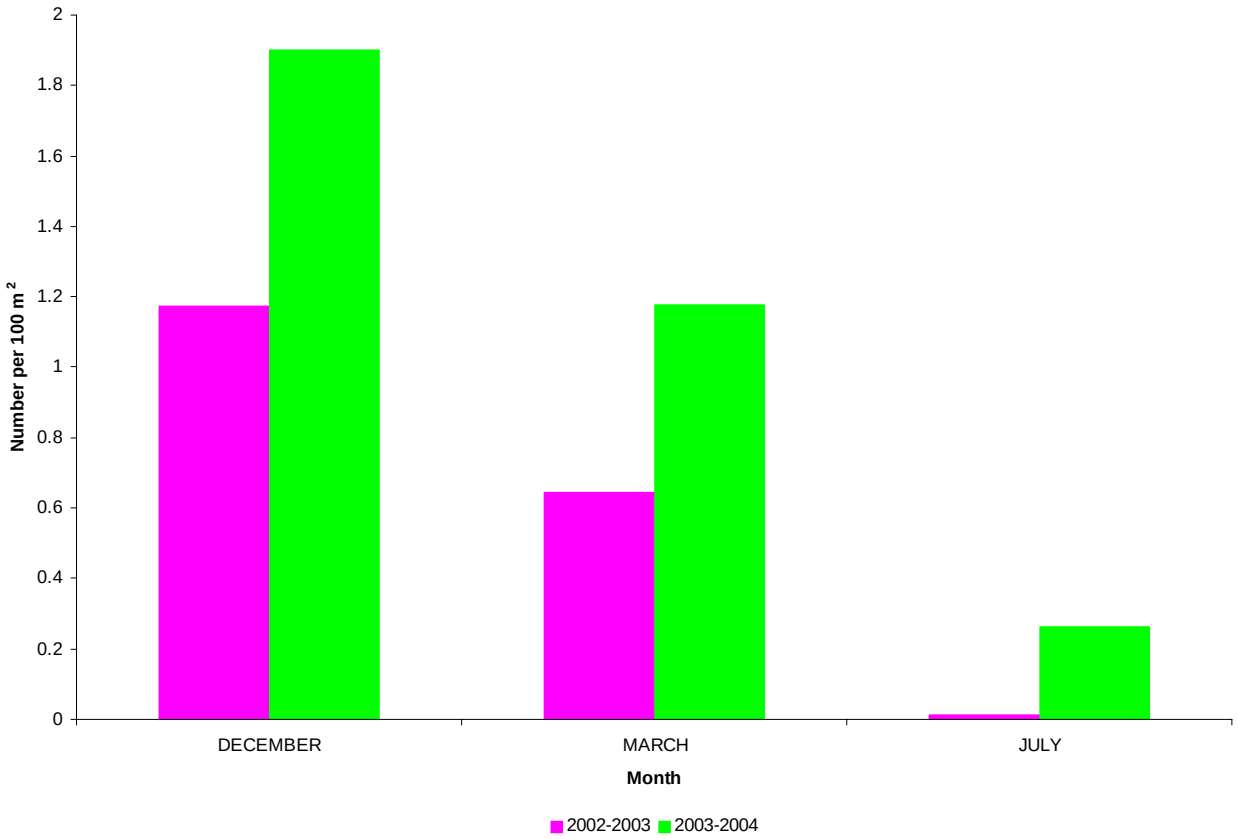

Figure 18. Total catch per effort (number per 100 m^2) for Colorado pikeminnow collected at all stations sampled in both years (Upper San Juan to Bluff) combined during each sampling trip after the 2002 and 2003 stocking events.

Growth of Colorado Pikeminnow Stocked in 2003

BIO-WEST

Average standard length of Colorado pikeminnow did not change between the December 2003 sampling trip and the March 2004 sampling trip range (December average standard length = 43 mm, range 28 mm - 81 mm; March average standard length 43 mm, range 33 mm - 79 mm), and we did not see a shift in the length frequency distribution (Figure 19). Colorado pikeminnow grew to an average standard length of 107 mm (range 64 mm - 158 mm), which was a significant increase ($p < 0.001$, after Bonferroni correction).

Table 10. Number of samples where Colorado pikeminnow were present or absent, along with the percent of samples containing Colorado pikeminnow.

TRIP	2002			2003		
	PRESENT	ABSENT	PERCENT	PRESENT	ABSENT	PERCENT
December	17	347	4.7	60 (46) [a]	429 (335) [a]	12.3 (16.4) [a]
March	53	359	12.9	149 (88) [a]	517 (398) [a]	22.4 (18.1) [a]
July	1	453	0.2	79 (52) [a]	250 (158) [a]	24.0 (24.8) [a]

[a] Number in parentheses represents data from the Upper San Juan to Bluff stations after the 2003 stocking.

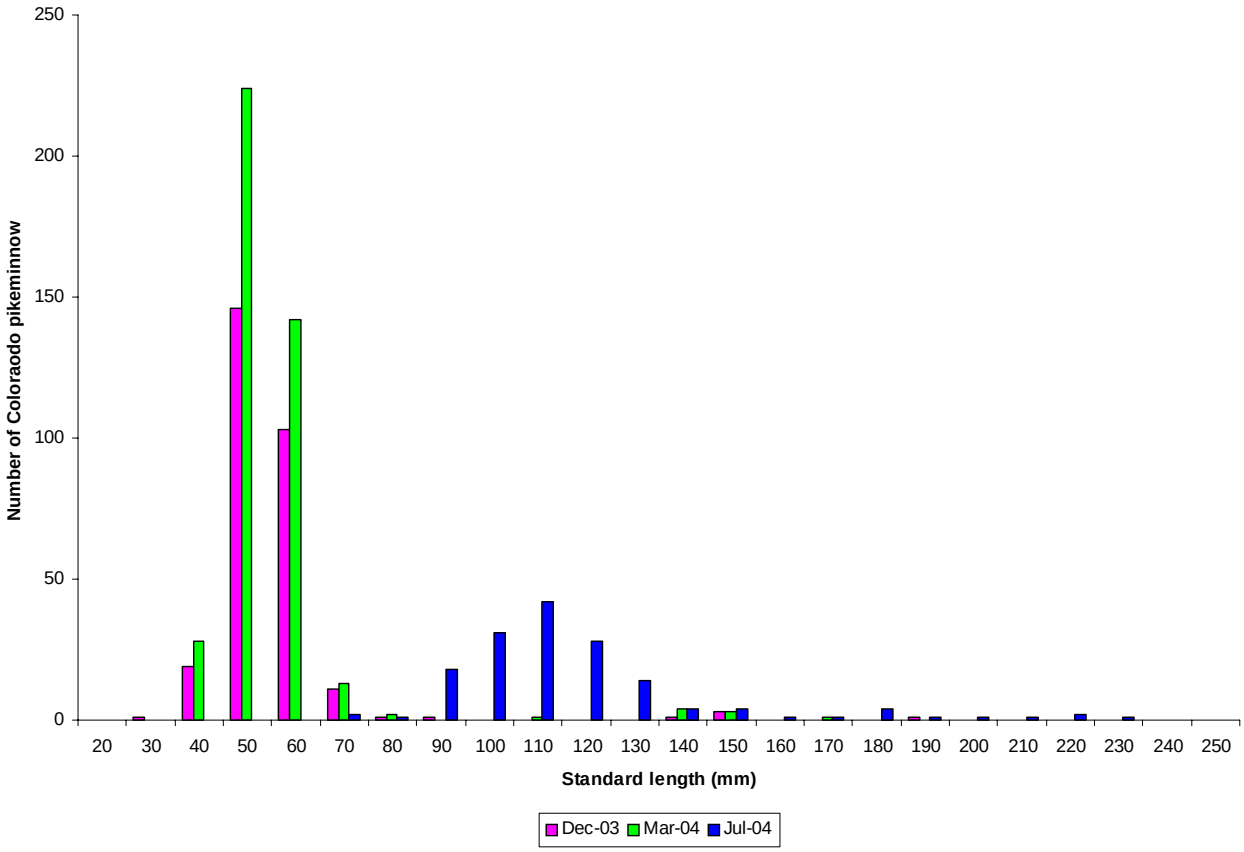

Figure 19. Length frequency distribution of Colorado pikeminnow collected in December 2003, March 2004, and July 2004.

SJRIP Cooperators

The UDWR and NMFRO nonnative removal efforts portray the continued growth of Colorado pikeminnow from June to September 2004 (Figure 20). Age-1 Colorado pikeminnow from the 2003 stocking event were approximately 80 mm SL in June 2004 and grew to between 140-160 mm SL by September 2004. In June through August 2004, two distinct size classes were visible. The age-2 year class reached 210-220 mm SL by August, but they seemed to disappear from the catch in September 2004.

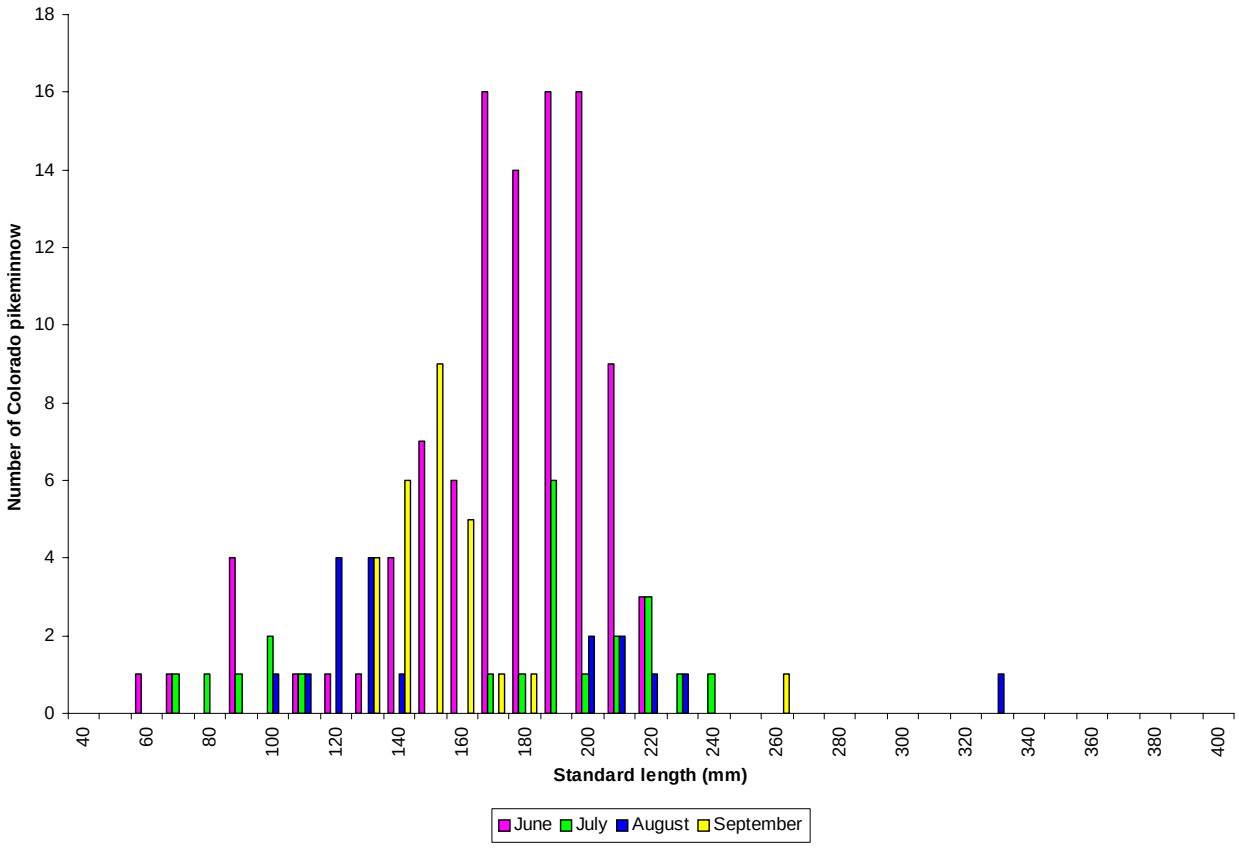

Figure 20. Length frequency distribution of age-1 and age-2 Colorado pikeminnow collected during nonnative removal efforts by the Utah Division of Wildlife resources and U.S. Fish and Wildlife Service, New Mexico Fisheries Resource Office from June to September 2004.

The SJRIP annual fall monitoring shows that while the age-2 fish did not disappear entirely, their numbers were much lower than the age-1 fish stocked in 2003 (Figure 21). Age-1 Colorado pikeminnow had grown to an average size of 162 mm SL (using fish smaller than 205 mm SL) by late September/early October 2004. Finding the division between the age-1 and age-2 Colorado pikeminnow collected during 2004 fall monitoring was difficult because of the variable numbers of fish collected between 205-230 mm. Clearly, there is a distinct break in the histogram at 230 mm, but the fish ranging 205-230 mm are probably a mixture of both year classes rather than solely age-1 fish.

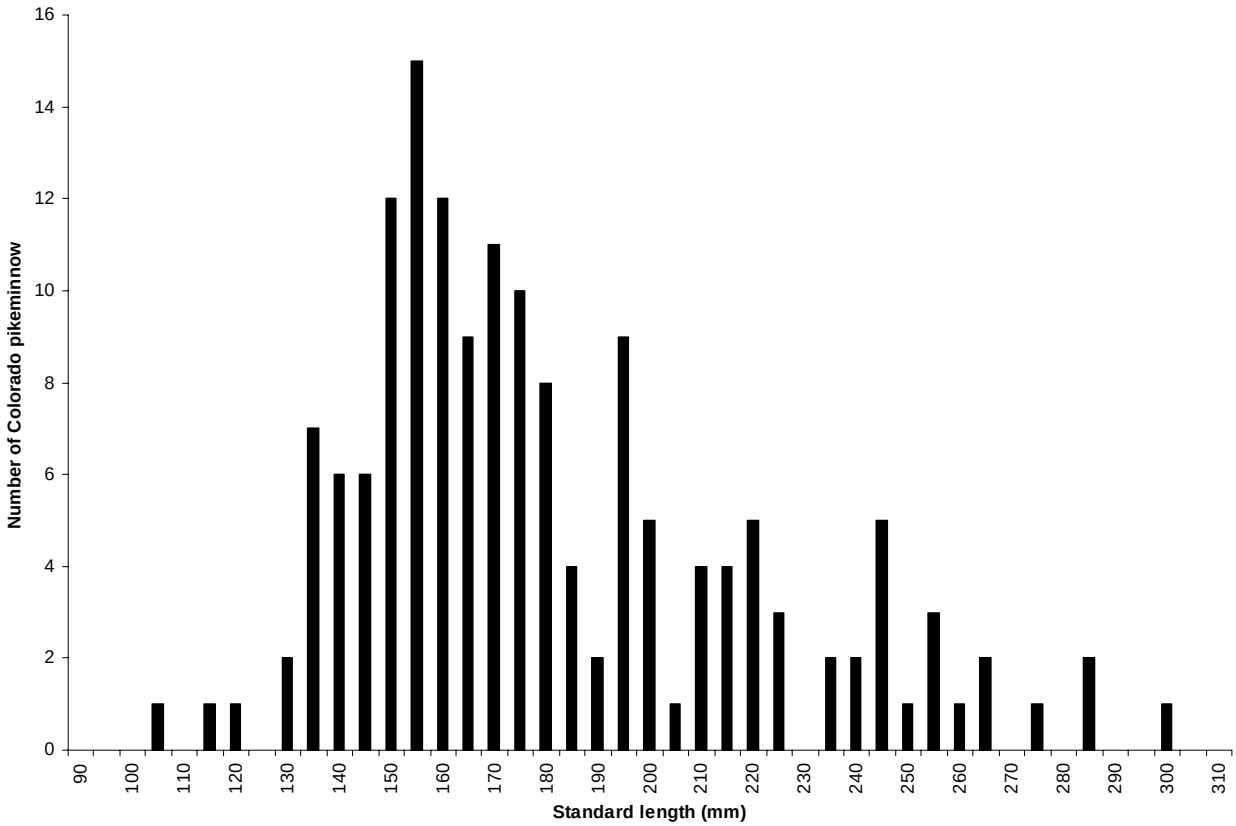

Figure 21. Length frequency distribution of age-1 and age-2 Colorado pikeminnow collected during San Juan River Recovery Implementation Program fall monitoring in late September and early October 2004.

Comparison with Colorado Pikeminnow Stocked in 2002

The YOY Colorado pikeminnow stocked in 2003 were 6 mm larger than the YOY Colorado pikeminnow stocked in 2002 (Figure 22) (t-test, $p < 0.05$). No difference in average size was seen between December and March of either year, but average standard length of Colorado pikeminnow collected in March 2004 was significantly larger than fish collected in March 2003 (6 mm, $p < 0.05$). We only collected two Colorado pikeminnow in July 2003, so size comparisons of Colorado pikeminnow collected in July 2003 versus July 2004 would not be meaningful. Average total length of age-1 Colorado pikeminnow collected during SJRIP annual fall monitoring was not significantly different between 2003 and 2004.

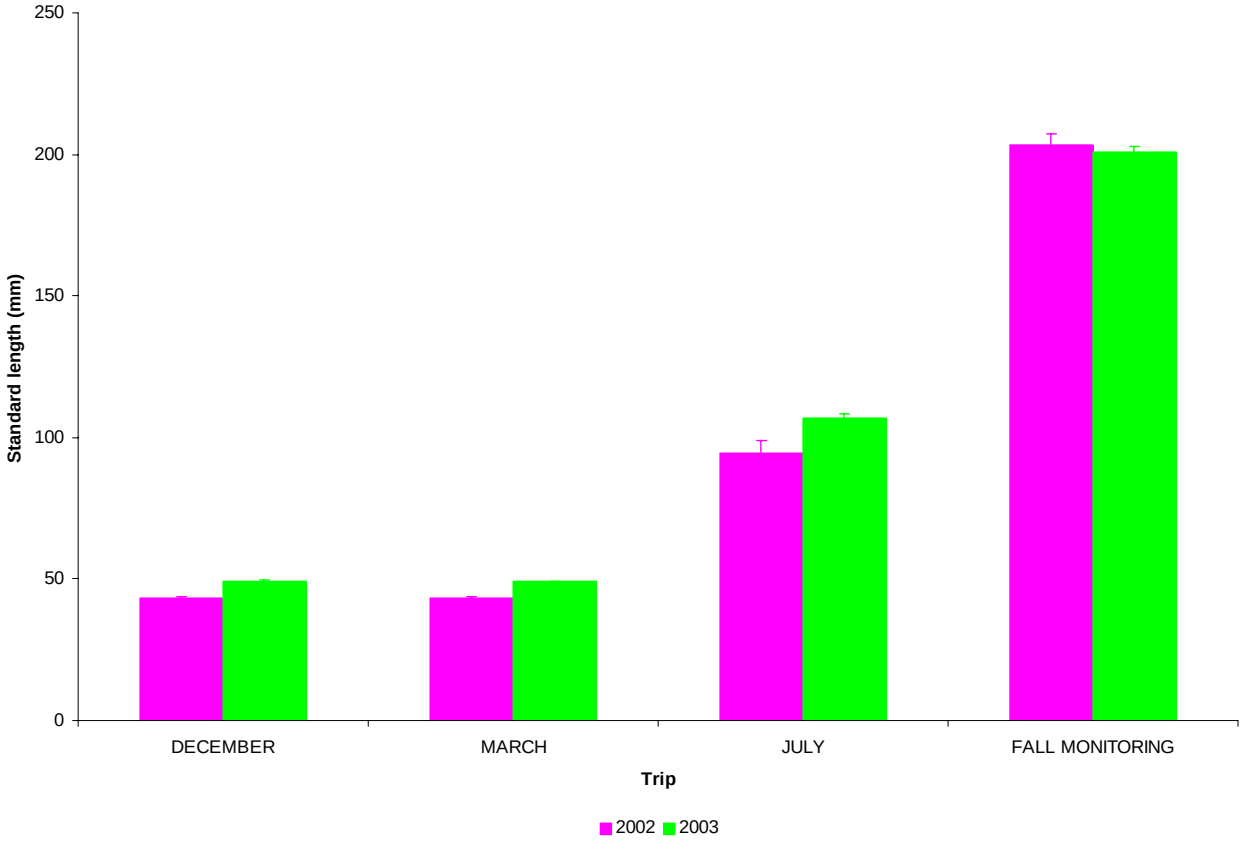

Figure 22. Average standard length of YOY and age-1 Colorado pikeminnow collected in BIO-WEST follow-up monitoring and average total length of age-1 Colorado pikeminnow collected during the annual fall monitoring after the 2002 and 2003 stocking events. Error bars represent +/- 1 standard error.

Habitat Use of Colorado Pikeminnow Stocked in 2003

While much of the previous monitoring for young Colorado pikeminnow in the San Juan River focused on side channels and backwaters (Propst and Hobbes 1999, Trammel and Archer 2000), we attempted to sample a diversity of low-velocity habitats (Golden et al. 2004). We found no difference in the average CPE for Colorado pikeminnow between main channel and side channel habitats during any of our sampling trips after the 2003 stocking event. A higher percentage of collections were made in side channel habitats during the December 2003 sampling trip than during the March or July 2004 sampling trips (Figure 23). We do not think that this was representative of the availability of side channel habitats during the three trips. Age-1 Colorado pikeminnow seemed to be most abundant in main channel shoals and slackwaters in July 2004, so our sampling concentrated in those areas. In March 2004 flows were elevated, and many side channels had higher-velocity habitats than in December 2004. Additionally, the higher flows created more main channel backwater habitat to sample in the mouths of side canyons and side channels.

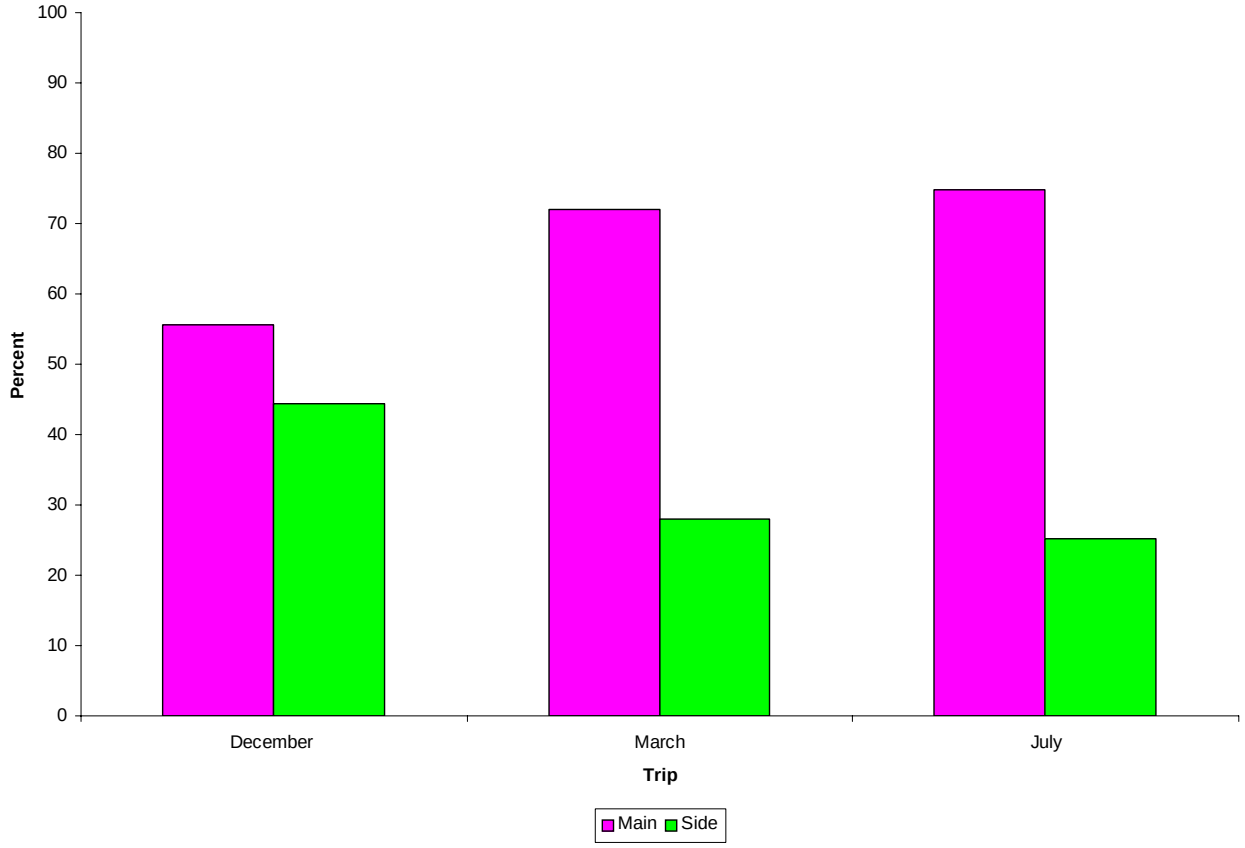

Figure 23. The proportion of side channel versus main channel habitats sampled during each trip.

Colorado pikeminnow seemed to have an affinity for low-velocity habitats with cover in December 2003; the majority of this cover was small woody debris and overhanging vegetation. Nearly 80% of the samples that contained Colorado pikeminnow had some type of cover. Over 50% of the samples that contained Colorado pikeminnow were from backwaters, slackwaters, pools, and eddies. Young of year Colorado pikeminnow were found more often than expected in backwater- , pool-, and debris-type habitats, and found less often than expected in run-type habitats (Table 11) (Chi-square, $p < 0.001$). Within individual habitat types Colorado pikeminnow were found more often than expected in backwaters, debris piles, eddies with debris piles, and pools (Chi-square, $p < 0.001$). Shore runs and runs had fewer samples containing Colorado pikeminnow than were expected.

Table 11. Total number of samples and number of samples containing Colorado pikeminnow in general habitat categories during the December 2003sampling trip.

HABITAT	TOTAL SAMPLES IN HABITAT	TOTAL SAMPLES WITH PTYLUC[a]
Backwater	64 (13.1)[b]	15 (25.0)[b]
Debris	84 (17.2)[b]	16 (26.7)[b]
Eddy	28 (5.7)[b]	2 (3.3)[b]
Embayment	7 (1.4)[b]	0 (0)[b]
Pool	33 (6.8)[b]	9 (15)[b]
Riffle	1 (0.2)[b]	0 (0)[b]
Run	212 (43.5)[b]	11 (18.3)[b]
Shoal	21 (4.3)[b]	2 (3.3)[b]
Side Channel Mouth	6 (1.2)[b]	2 (3.3)[b]
Slackwater	29 (6.0)[b]	3 (5.0)[b]
Unknown	2 (.4)[b]	0 (0)[b]

[a] Colorado pikeminnow.
[b] Number in parentheses is the percentage of samples in that habitat.

In March 2004 Colorado pikeminnow were found more often than expected in backwater- and embayment-type habitats and less often than expected in run- and debris-type habitats (Table 12) (Chi-square, $p < 0.001$). Within individual habitat types Colorado pikeminnow were found more often than expected in backwaters, backwaters with debris piles, and embayments, and less often than expected in runs, shore runs, and debris piles (Chi-square, $p < 0.001$). While debris-type habitats seemed to be less important in March 2004, 46% of the samples that contained Colorado pikeminnow had some type of cover associated with them. The majority of this cover was small, woody debris and overhanging vegetation.

Table 12. Total number of samples and number of samples containing Colorado pikeminnow in general habitat categories during the March 2004 sampling trip.

HABITAT	TOTAL SAMPLES IN HABITAT	TOTAL SAMPLES WITH PTYLUC[a]
Backwater	220 (33.0)[a]	78 (52.3)[a]
Debris	39 (5.9)[a]	5 (3.4)[a]
Eddy	23 (3.5)[a]	4 (2.7)[a]
Embayment	24 (3.6)[a]	9 (6.0)[a]
Pool	6 (0.9)[a]	1 (0.7)[a]
Riffle	2 (0.3)[a]	0 (0)[a]
Run	275 (41.3)[a]	38 (25.5)[a]
Shoal	16 (2.4)[a]	2 (1.3)[a]
Side Channel Mouth	8 (1.2)[a]	1 (0.7)[a]
Slackwater	53 (8.0)[a]	11 (7.4)[a]

[a] Number in parentheses is the percentage of samples in that habitat.

As age-1 fish in July 2004, Colorado pikeminnow were found more often in backwater-, shoal-, and slackwater-type habitats than expected and less often than expected in run-type habitats (Table 13) (Chi-square, $p < 0.005$). Within individual habitat types Colorado pikeminnow were found more often than expected in backwaters, shoal runs, and slackwater runs, and less often than expected in shore runs (Chi-square, $p < 0.008$). Backwaters were important again in July, but only in the larger backwaters created in the canyon section of the San Juan River. Over 80% of the backwaters containing Colorado pikeminnow were found in the canyon section of the river. Above Sand Island, shoals and slackwaters seemed to be much more important. Cover did not appear to be as important for Colorado pikeminnow in July 2004. We did not sample any debris piles, but only 35% of the samples containing Colorado pikeminnow were associated with cover. The majority of this cover was large boulder and bedrock outcrops, versus woody debris and overhanging vegetation.

Table 13. Total number of samples and number of samples containing Colorado pikeminnow in general habitat categories during the July 2004 sampling trip.

HABITAT	TOTAL SAMPLES IN HABITAT	TOTAL SAMPLES WITH PTYLUC[a]
Backwater	43 (13.1)[b]	17 (21.5)[b]
Eddy	9 (2.7)[b]	2 (2.5)[b]
Embayment	5 (1.5)[b]	0 (0)[b]
Pool	4 (1.2)[b]	1 (1.3)[b]
Riffle	2 (.6)[b]	0 (0)[b]
Run	123 (37.4)[b]	13 (16.5)[b]
Shoal	102 (31.0)[b]	29 (36.7)[b]
Side Channel Mouth	1 (0.3)[b]	0 (0)[b]
Slackwater	40 (12.2)[b]	17 (21.5)[b]

[a] Colorado pikeminnow.
[b] Number in parentheses is the percentage of samples in that habitat.

We found no differences between the mean average depth or mean maximum depth of samples with Colorado pikeminnow compared with all samples collected during all three sampling trips following the 2003 stocking event (Figures 24-25). Samples with and without Colorado pikeminnow had significantly greater average and maximum depth in July 2004 versus December 2003 and March 2004 (ANOVA with Tukey's Honestly Significant Difference multiple comparison test, $p < 0.001$).

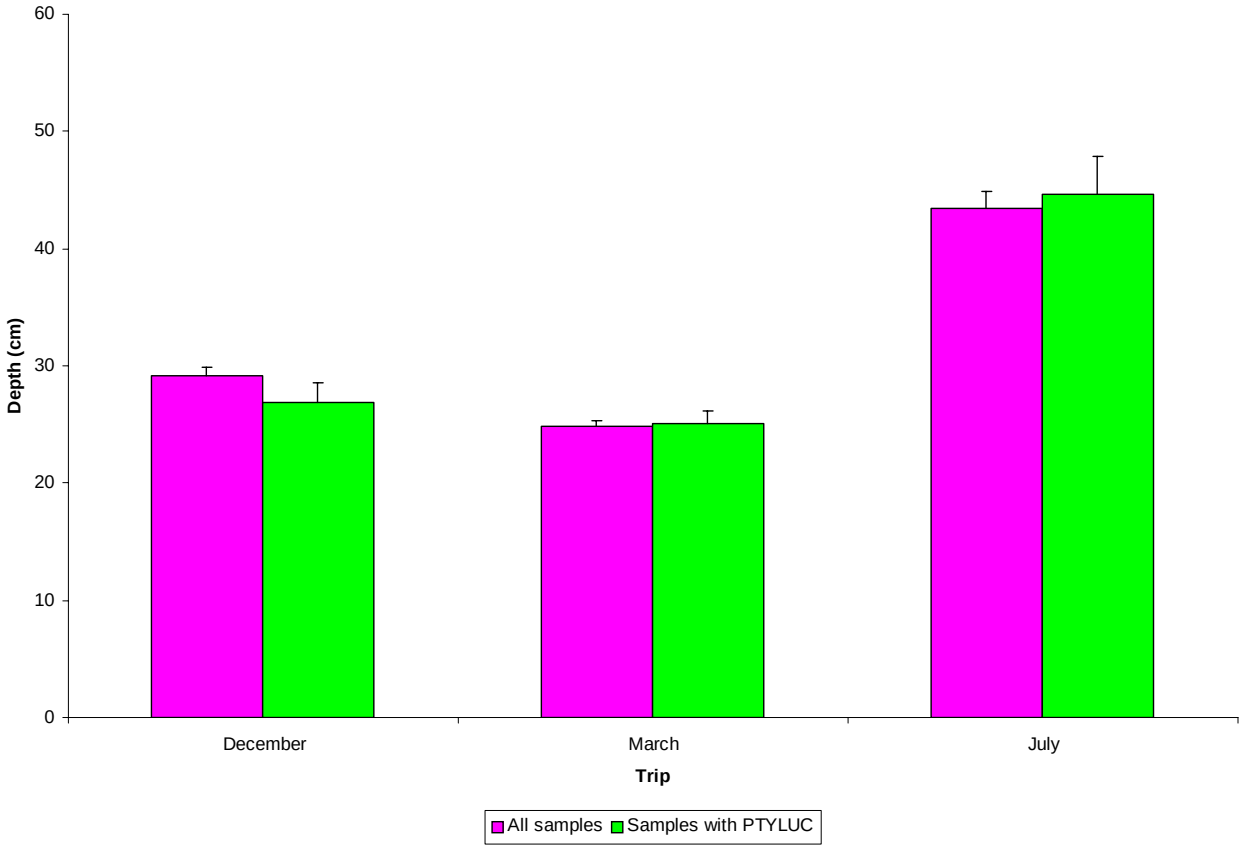

Figure 24. Mean average depth of all samples and samples with Colorado pikeminnow in sampling trips after the 2003 stocking event. PTYLUC = Colorado pikeminnow. Error bars represent +/- 1 standard error.

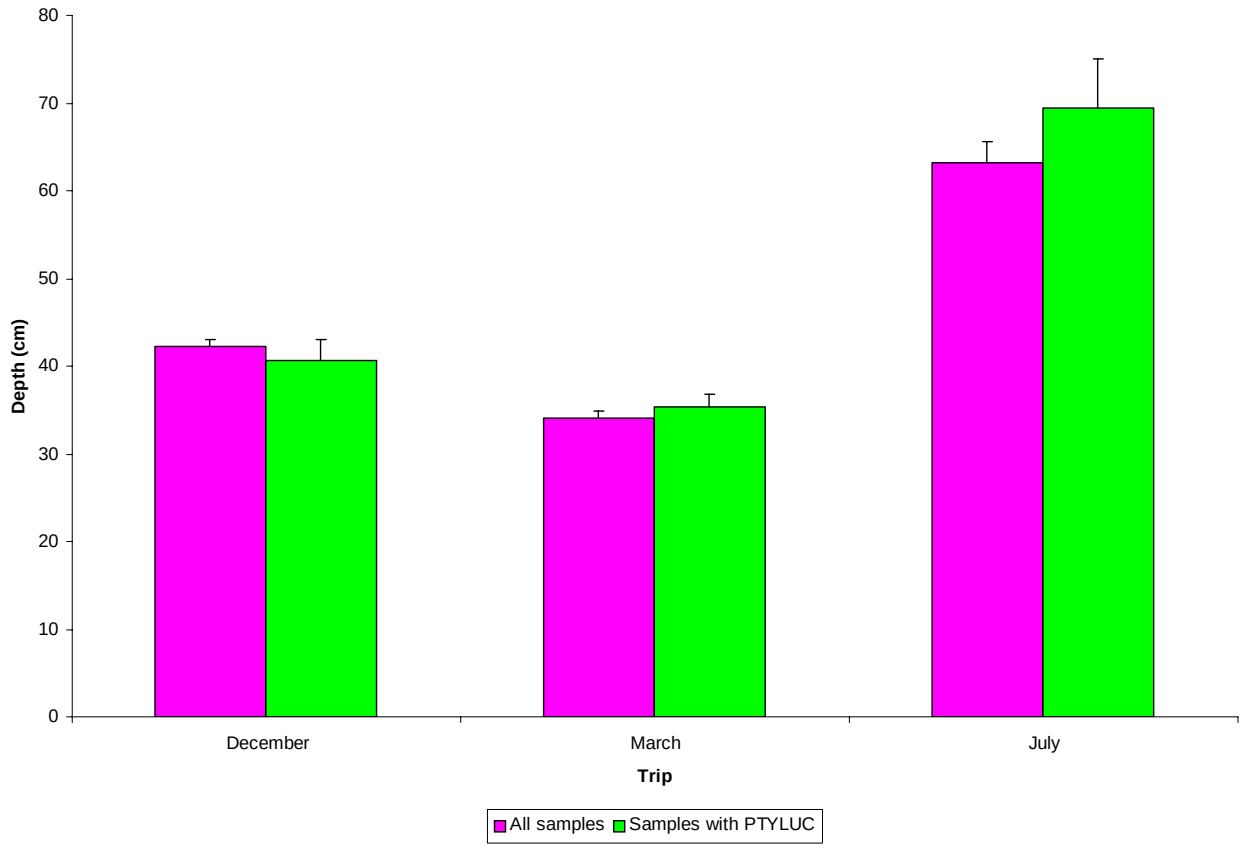

Figure 25. Mean maximum depth of all samples and samples with Colorado pikeminnow in sampling trips after the 2003 stocking event. PTYLUC = Colorado pikeminnow. Error bars represent +/- 1 standard error.

Comparison with Colorado Pikeminnow Stocked in 2002

Backwater habitats appeared to be important for stocked YOY Colorado pikeminnow after both the 2002 and 2003 stocking events. Therefore, the availability and characteristics of backwaters sampled between the two years may have impacted the CPE and retention of YOY Colorado pikeminnow. Since the number of samples we collected varied between trips, we felt that the proportion of samples collected in backwaters would be a better measure of the availability of backwaters between sampling trips (Figure 26). In March and July 2004, we sampled proportionately more backwaters from the Upper San Juan to Bluff stations than during any other sampling trip, indicating that more backwaters were probably available to sample during those two sampling trips.

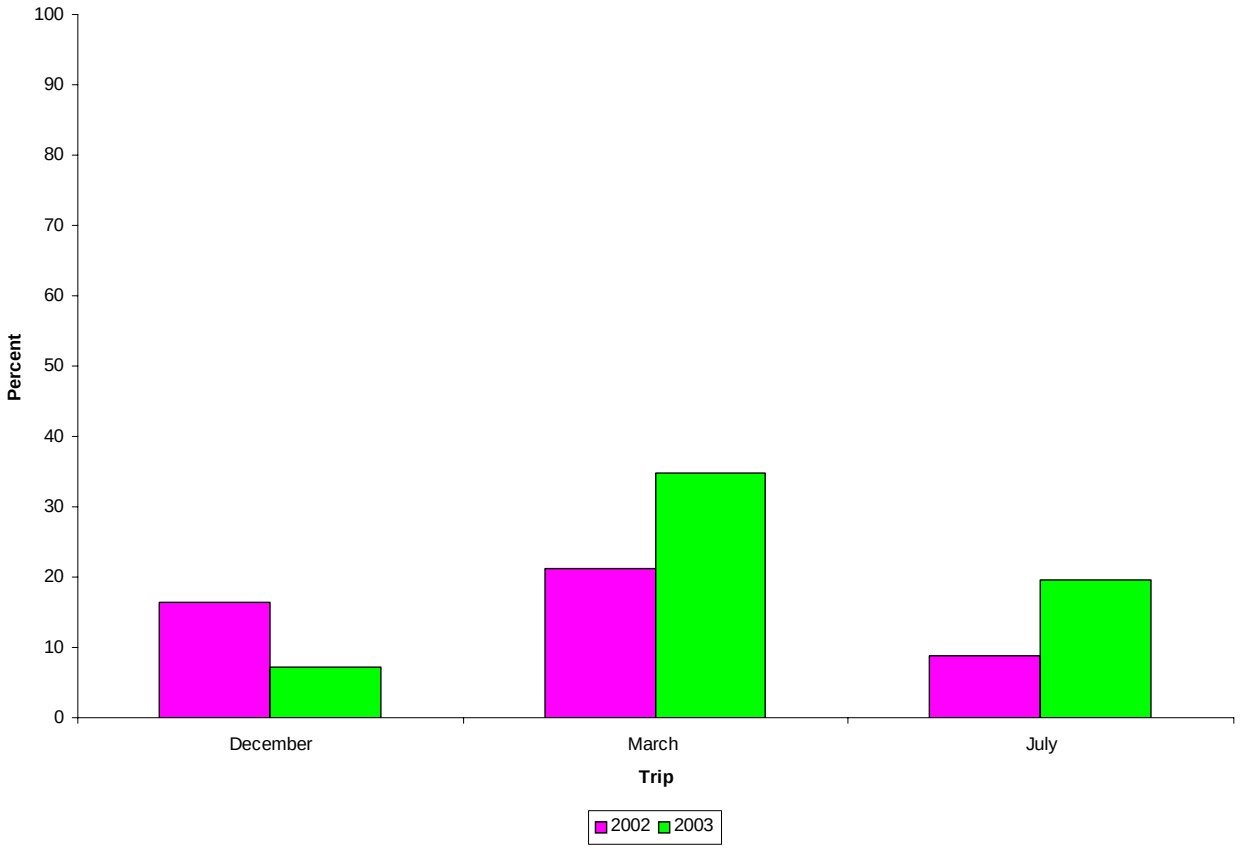

Figure 26. Proportion of all samples that were collected in backwaters from the Upper San Juan to Bluff stations during each sampling trip following the 2002 and 2003 stocking events.

The amount and proportion of backwater area sampled provides additional evidence that more backwaters were probably available during March and July 2004 (Figures 27-28). Previously we showed that the average CPE for 2003 stocked Colorado pikeminnow appeared to be higher than the average CPE for 2002 stocked Colorado pikeminnow (Figure 17). The increased proportion and area of backwater habitat sampled in March and July 2004 may have influenced the number of Colorado pikeminnow collected. In other words, if we sampled more preferred habitat in 2003 we may have increased the number of Colorado pikeminnow we collected without a real increase in the number available to be captured. However, we found that average CPE of Colorado pikeminnow in backwaters was also higher after the 2003 stocking event (Figure 29), especially in December 2003 at the eight stations we sampled during both years.

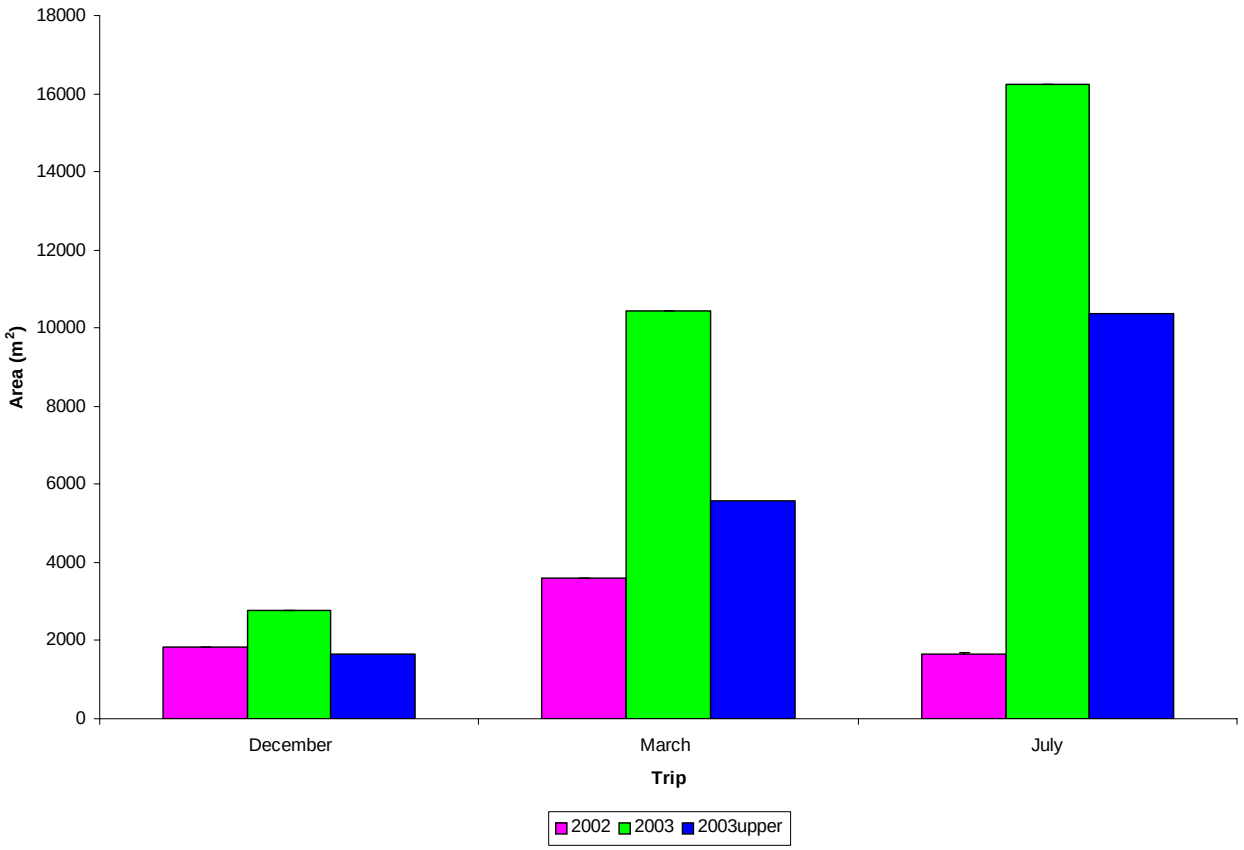

Figure 27. Total backwater area sampled during each sampling trip following the 2002 and 2003 stocking events. 2003 upper = total backwater areas from the Upper San Juan to Bluff stations after the 2003 stocking event.

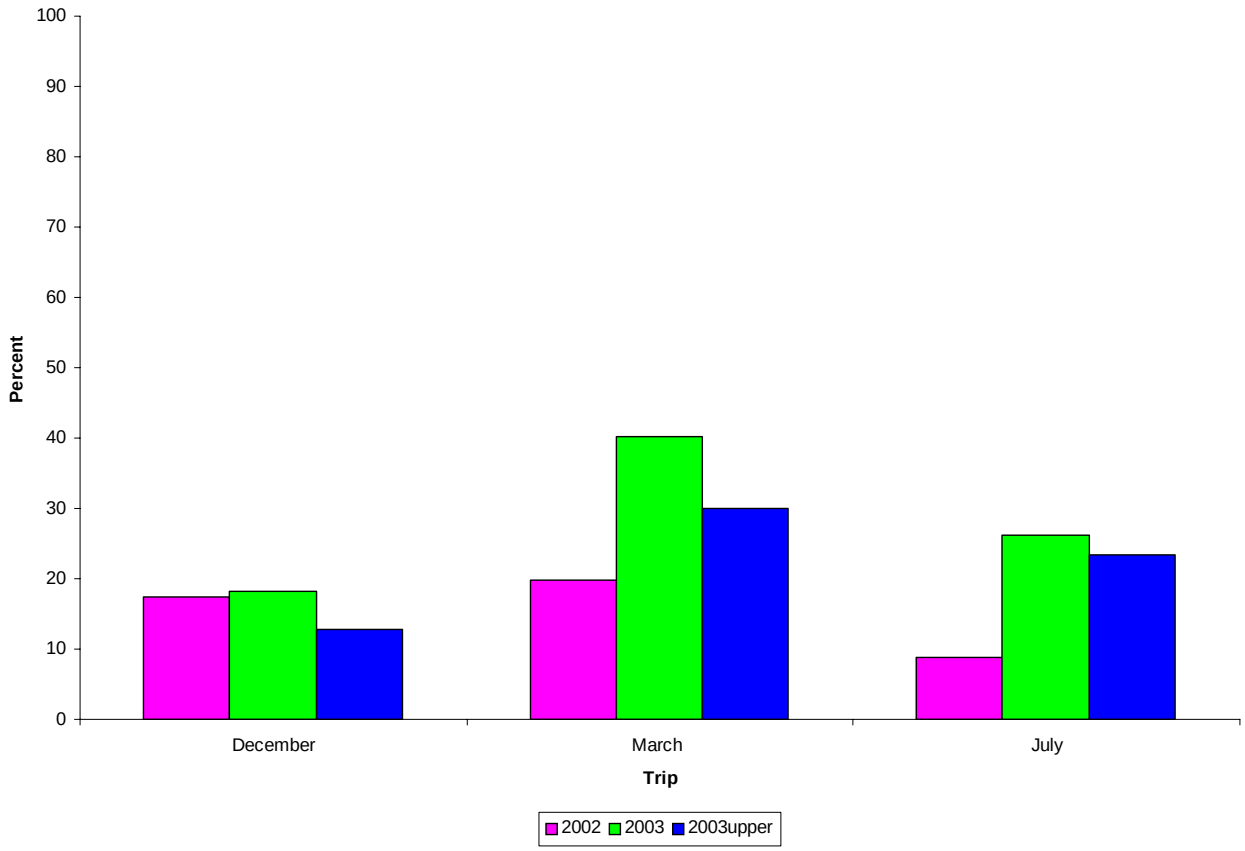

Figure 28. Proportion of total area sampled that was backwater area during each sampling trip following the 2002 and 2003 stocking events. 2003 upper = proportion of area from the Upper San Juan to Bluff stations after the 2003 stocking event.

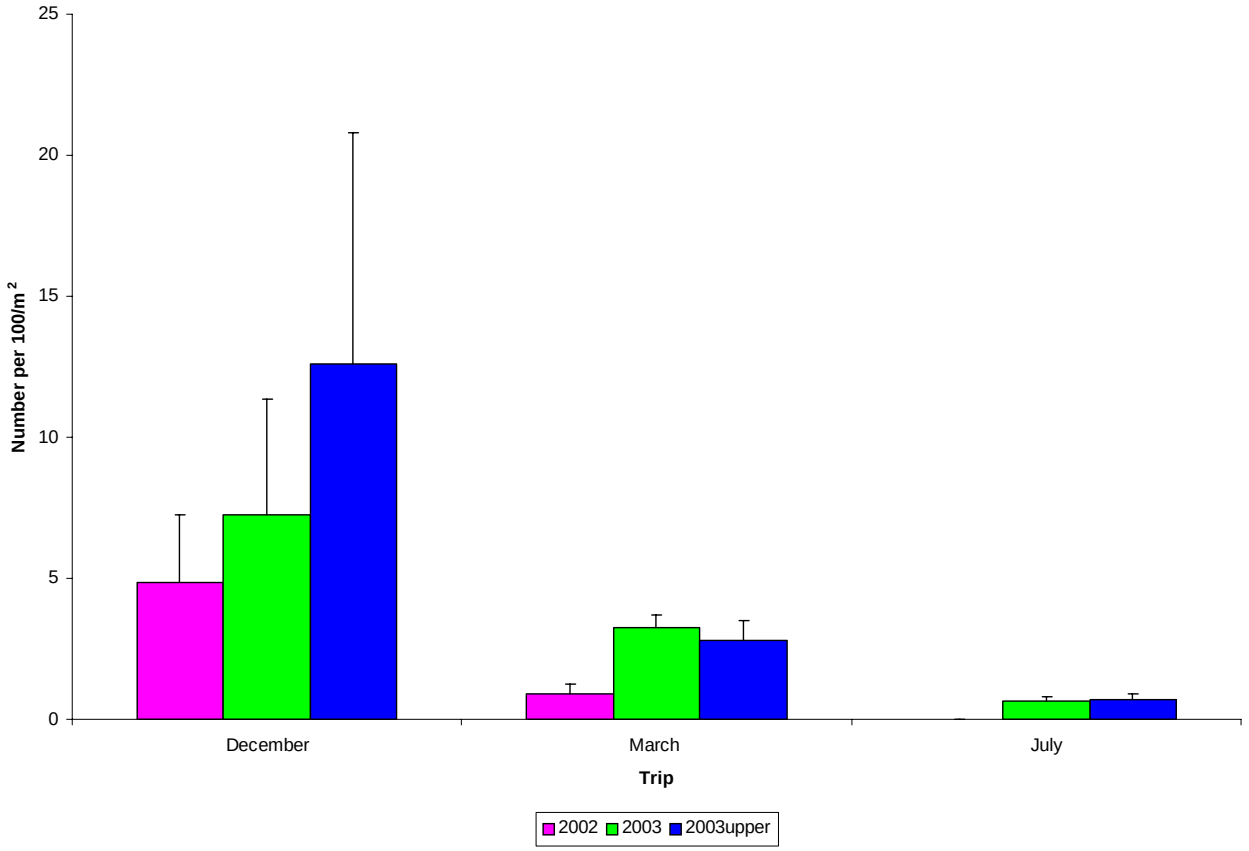

Figure 29. Average catch per effort (number per 100m^2) for Colorado pikeminnow collected in backwater habitats during each sampling trip following the 2002 and 2003 stocking events. 2003 upper = combined CPE for the upper San Juan to Bluff stations after the 2003 stocking event. Error bars represent +/- 1 standard error.

The increased frequency and area of backwaters may have been responsible for the increased average CPE in March and July 2004, but we saw a higher average CPE in December 2003 with no increase in the frequency or area of backwaters. Perhaps the quality of backwaters varied between years and influenced Colorado pikeminnow CPE. We examined maximum and average depth differences in backwaters between years as an index of backwater quality. July 2004 had significantly higher mean average and mean maximum depths for samples that contained Colorado pikeminnow than all other sampling trips except for December 2002 (Figure 30) (ANOVA with Tukey's Honestly Significant Difference multiple comparison test, $p < 0.01$). July 2003 was not included in measurements of samples containing Colorado pikeminnow because only one sample contained Colorado pikeminnow.

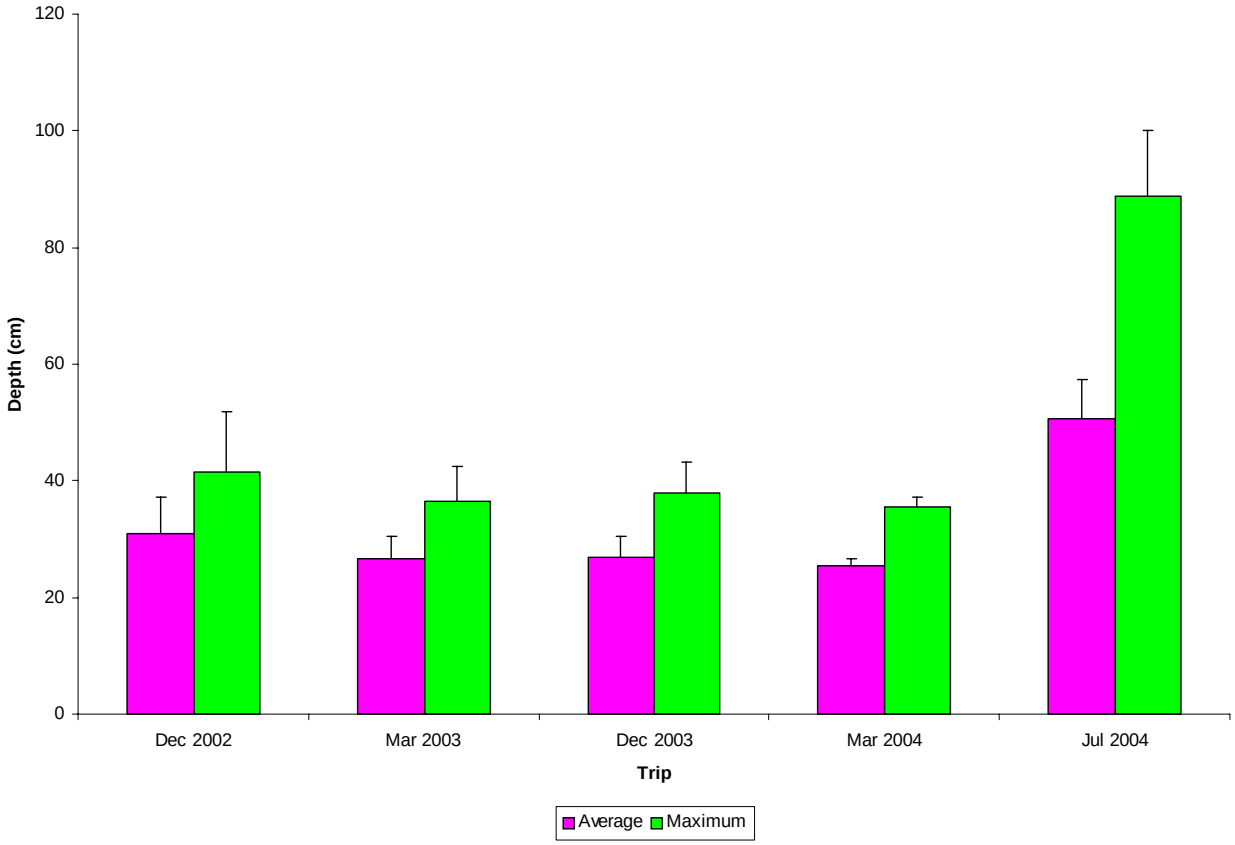

Figure 30. Mean average and maximum depths of samples containing Colorado pikeminnow collected in backwater habitats. Error bars represent +/- 1 standard error.

Mean maximum depth of samples containing Colorado pikeminnow was also significantly greater in July 2004 than all other sampling trips ($p < 0.01$).

Mean maximum depths of all backwater samples was significantly greater than all other sampling trips (Figure 31) ($p < 0.01$). Mean maximum depth of backwater samples in July 2004 was significantly greater than those collected in March 2003 ($p < 0.05$). Mean average depth of all backwater samples containing Colorado pikeminnow collected in July 2004 was also significantly greater than all sampling trips except for July 2003 ($p < 0.01$). Additionally, mean average depth of backwater samples containing Colorado pikeminnow collected in July 2003 was significantly greater than March 2003 and March 2004 ($p < 0.05$).

In July 2004 mean average and maximum depths of backwater samples where Colorado pikeminnow were collected were significantly higher than in backwater samples where Colorado pikeminnow were not collected (t-test, $p \leq 0.05$ after Bonferroni adjustment).

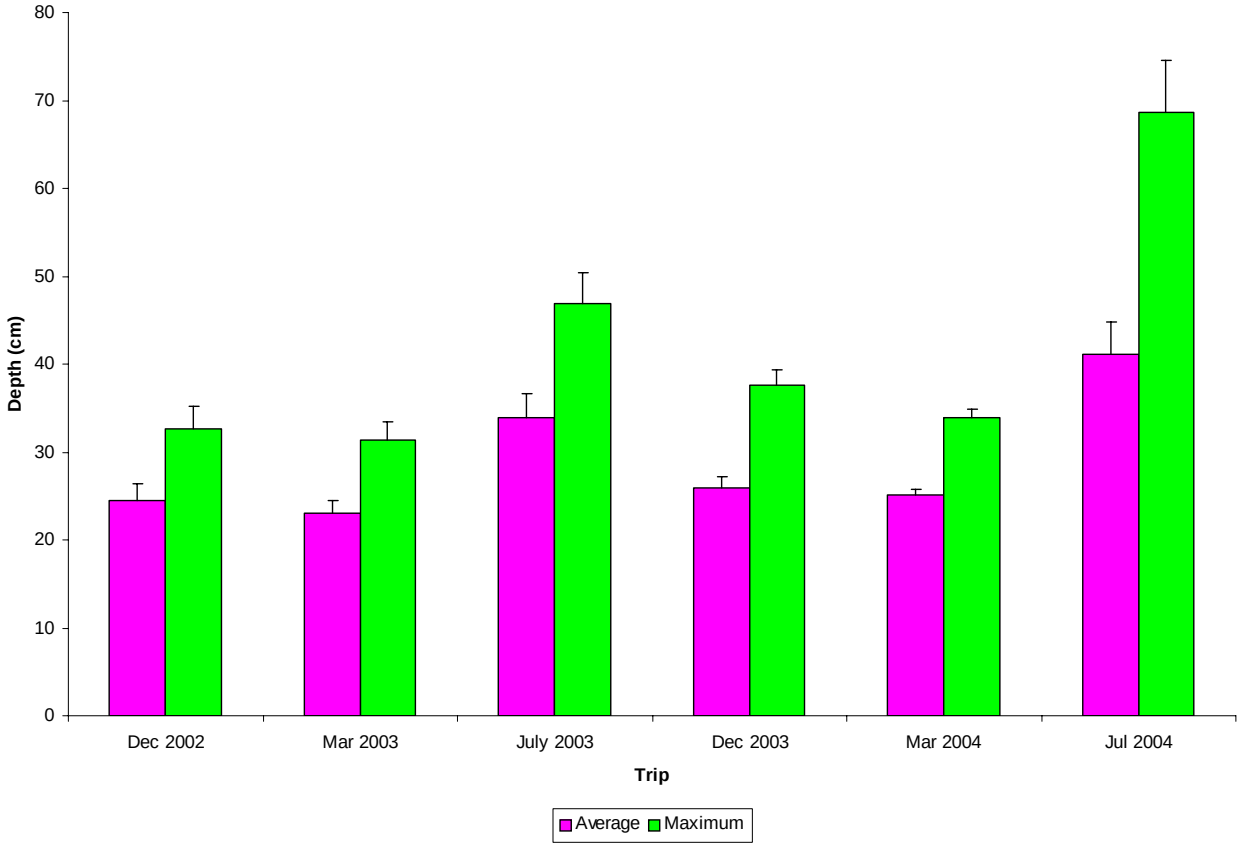

Figure 31. Mean average and maximum depths of all samples collected in all backwater habitats. Error bars represent +/- 1 standard error.

Comparisons with Historical Data

While nearly twice as many Colorado pikeminnow were stocked in 2002 as in 1996 and 1997, only 1.5-1.8 times the total number were stocked in 2003 (Table 14). In 2002 fewer Colorado pikeminnow were collected during all of our sampling trips than were collected at similar times after the 1996 and 1997 stocking events. During monitoring trips after the 2003 stocking event, we collected numbers of Colorado pikeminnow similar to or higher than those collected during sampling trips conducted at similar times after YOY Colorado pikeminnow were stocked in 1996, 1997, and 2002. Electrofishing efforts during the 2003 SJRIP fall monitoring trip collected 32 age-1 Colorado pikeminnow from the 2002 stocking event, which was similar to the number collected after the 1996 stocking event and less than that collected after the 1997 stocking event. Conversely, over 120 age-1 Colorado pikeminnow from the 2003 stocking event were collected during the 2004 fall monitoring trip.

Table 14. Total number of YOY Colorado pikeminnow stocked in 1996, 1997, 2002, and 2003, along with the area sampled and number of Colorado pikeminnow collected in follow-up monitoring for approximately 1 year after stocking.

	1996		1997		2002		2003	
TIME	AREA (m^2)	NUMBERS	AREA (m^2)	NUMBERS	AREA (m^2)	NUMBERS	AREA (m^2)	NUMBERS
At stocking	n/a	100,000	n/a	117,000	n/a	210,000	n/a	176,000
1 month after stocking	15,939	376	6,858	212	10,483	123	15,097	289
4-5 months after stocking	13,221	198	8,606	74	18,079	117	26,010	413
9-11 months after stocking	8,742	8	7,694	11	19,166	2	62,255	146
Fall monitoring	n/a	35	n/a	55	n/a	32	n/a	122

We also constructed a survivorship/retention curve as an alternative way to view the number of Colorado pikeminnow collected (Figure 32). The curve shows that while the initial retention/survival of Colorado pikeminnow stocked in 2003 did not appear much better than for Colorado pikeminnow stocked in 2002, long-term survival and retention over the first year was much more similar to 1996 and 1997. In fact, only the Colorado pikeminnow stocked in 2002 seemed to show any difference in survival/retention over the first year. Colorado pikeminnow stocked in 2002 seemed to have a lower survival/retention than the other 3 years.

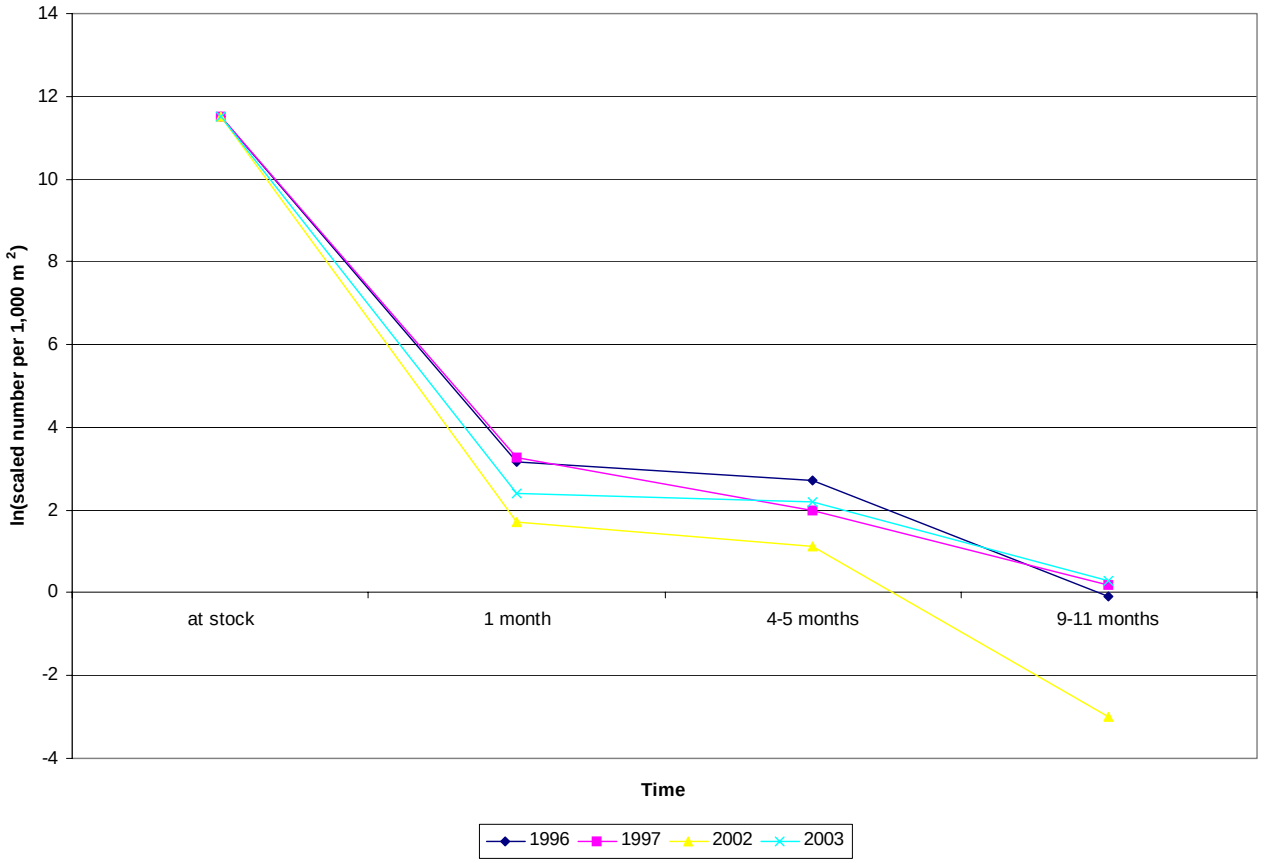

Figure 32. Survivorship/retention curve for Colorado pikeminnow stocked in 1996, 1997, 2002, and 2003.

In addition to the age-1 fish collected in fall monitoring, some of the stocked fish have been recaptured as age-2 fish during annual fall monitoring collections. The number of age-2 fish from the 2002 stocking event collected during 2004 fall monitoring was in between the numbers collected two years after the 1996 and 1997 stocking events. Twelve age-2 Colorado pikeminnow from Mumma Fish Hatchery that were stocked near the Animas confluence on June 9, 2004, were also collected during 2004 fall electrofishing (Table 15).

Table 15. Number of Colorado pikeminnow stocked in 1996, 1997, 2002, and 2003 recaptured as age-1 and age-2 fish in SJRIP fall large-bodied fish monitoring.

AGE CLASS	1996	1997	2002	2003
Age-1	35	55	32	122-138
Age-2	40	4	9-25	n/a

We compared the total CPE (total number/100 m^2) of stocked Colorado pikeminnow found at similar time periods after being stocked in 1996, 1997, 2002, and 2003 (Figure 33). As we saw for the total number of Colorado pikeminnow collected, Colorado pikeminnow CPE 1-month after the 1996, 1997, and 2003 stocking events was similar. The CPE 1 month after the 2002 stocking event was considerably lower than for the other 3 years. By 4-5 months after stocking, CPE remained higher in 1996 and 2003 than in 1997 and 2002. By 9-11 months after stocking, Colorado pikeminnow CPE had declined substantially in all years, but it was highest after the 2003 stocking event. The CPE 9-11 months after stocking may not be very comparable because of the differences in sampling protocol. We used 9-m wide seines in July 2004, which increased the area sampled dramatically. Therefore, although we collected 14 times the number of Colorado pikeminnow 9-11 months after the 2003 stocking event than 9-11 months after any of the other stocking events, the CPE was not even double the 1997 CPE for the same time period.

We have used a different sampling methodology to monitor YOY Colorado pikeminnow stocked in 2002 and 2003 than was used in 1996 and 1997 (Trammel and Archer 2000). We sampled all available low-velocity habitats within our sample reaches (66 miles of the San Juan River over a total 185 miles), along with 3.5 miles of the lower Animas River, and we occasional sampled throughout the canyon. Trammel and Archer (2000) collected samples over almost 140 miles of river, sampling backwater and slackwater habitats exclusively. They sampled two backwaters every 5 miles. Additionally, they had four 5-mile nursery habitat areas where they sampled every backwater. These differences in methodology resulted in different amounts of backwater and habitat being sampled during 2002 and 2003 versus 1996 and 1997.

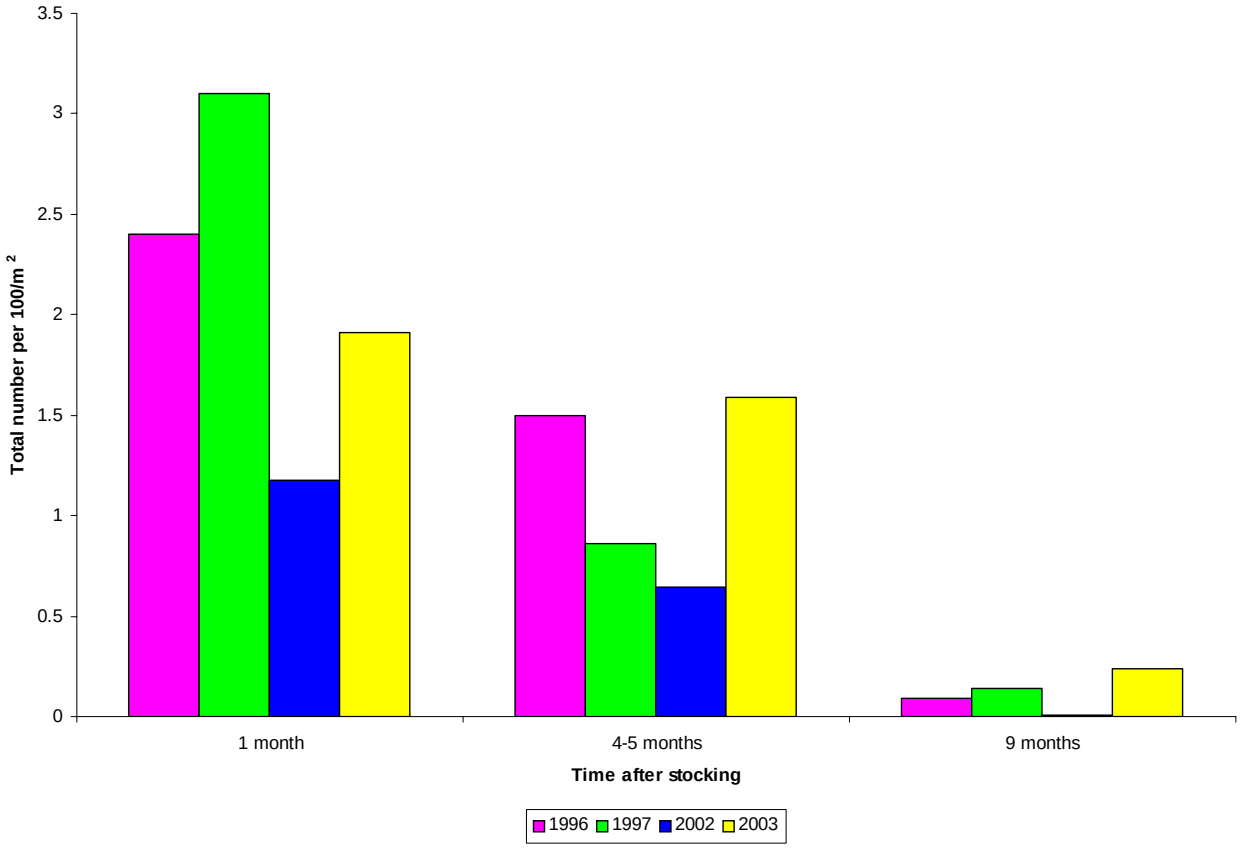

Figure 33. Total catch per effort (total number per total 100 m^2) for Colorado pikeminnow at similar times after the 1996, 1997, 2002, and 2003 stocking events.

In an attempt to make our data more comparable with theirs (Trammel and Archer 2000), we generated the CPE from just backwater-type habitats that were sampled during our monitoring trips to compare with the CPE of YOY Colorado pikeminnow collected in 1996 and 1997 (Figure 34). The 2002 and 2003 CPE in preferred habitats for YOY Colorado pikeminnow 1 month after stocking was over double that of 1996 and nearly double that of 1997. By 4-5 months after the 2002 stocking event, the Colorado pikeminnow CPE from preferred habitats was similar to the CPE for Colorado pikeminnow seen 4-5 months after stocking in 1997 and lower than the CPE for Colorado pikeminnow seen 4-5 months after stocking in 1996. Conversely, the CPE from preferred habitats 4-5 months after the 2003 stocking event was triple that of 1997 and 2002 and double that of 1996. As with the CPE from all habitats for 2002 and 2003, a large decline in the CPE from preferred habitats occurred between 4-5 months after stocking and 9-11 months after stocking. However, CPE from preferred habitat 9-11 months after the 2003 stocking event was five times higher than 1996 and more than four times higher than 1997. No Colorado pikeminnow were collected in preferred habitats 9-11 months after the 2002 stocking event.

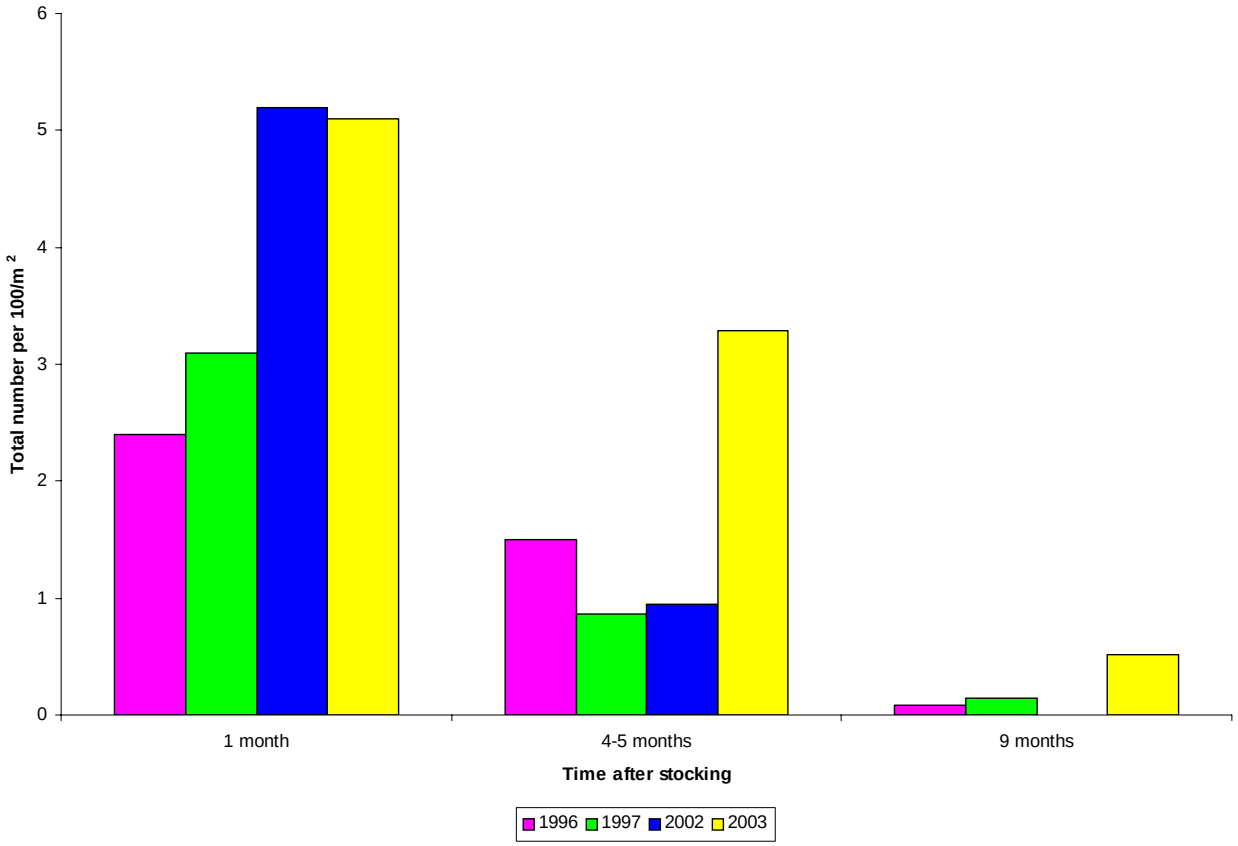

Figure 34. Total catch per event (total number per total 100 m2) for Colorado pikeminnow in backwater habitats at similar times after the 1996, 1997, 2002, and 2003 stocking events.

Additional Fish Information

As with the Colorado pikeminnow data, we were unable to conform data for any other species to the normal distribution. Since the mean is not a good summary statistic, we calculated the total CPE for native fish species other than Colorado pikeminnow. We collected four native fish species other than Colorado pikeminnow in monitoring following the 2003 stocking event: flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), speckled dace (*Rhinichthys osculus*), and razorback sucker. Flannelmouth sucker was the most abundant and most ubiquitous native fish during all of our sampling trips (Figure 35). We did not collect flannelmouth sucker in the Shiprock to Cudei, Four Corners, or Bluff stations in December 2003, but flannelmouth sucker was present at all other stations in every trip. Flannelmouth sucker was most abundant in stations upstream from the Hogback Diversion.

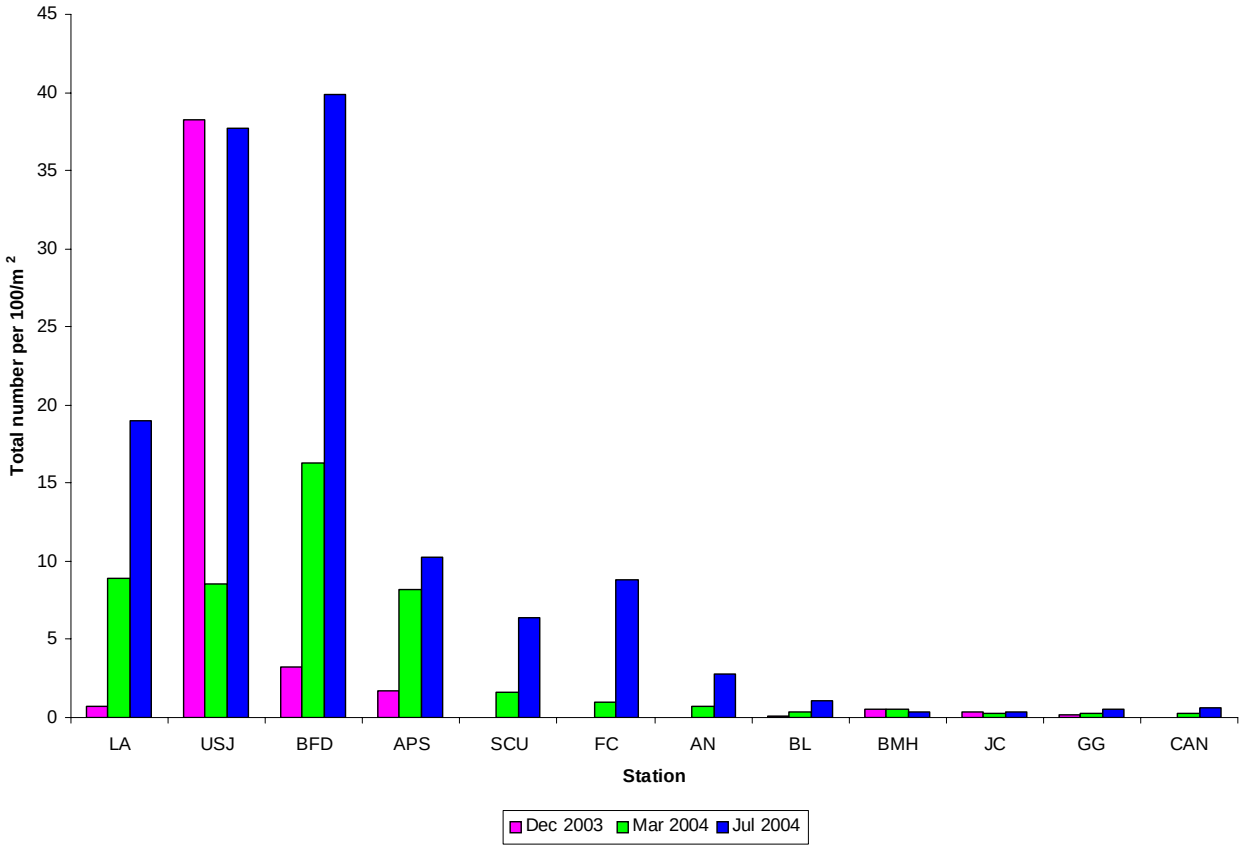

Figure 35. Total catch per effort (total number per total 100 m^2) for flannelmouth sucker during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.

Bluehead sucker was also most abundant above the Hogback Diversion during all sampling trips following the 2003 stocking event (Figure 36). We collected few bluehead sucker below the Four Corners station. Most of the bluehead sucker collected below this were YOY fish collected on the July 2004 sampling trip. Speckled dace also appeared to be most abundant above the Hogback Diversion (Figure 37). However, a large number of YOY fish were found in the Four Corners station in July 2004. This group of YOY speckled dace appeared to persist downstream to the Bluff station.

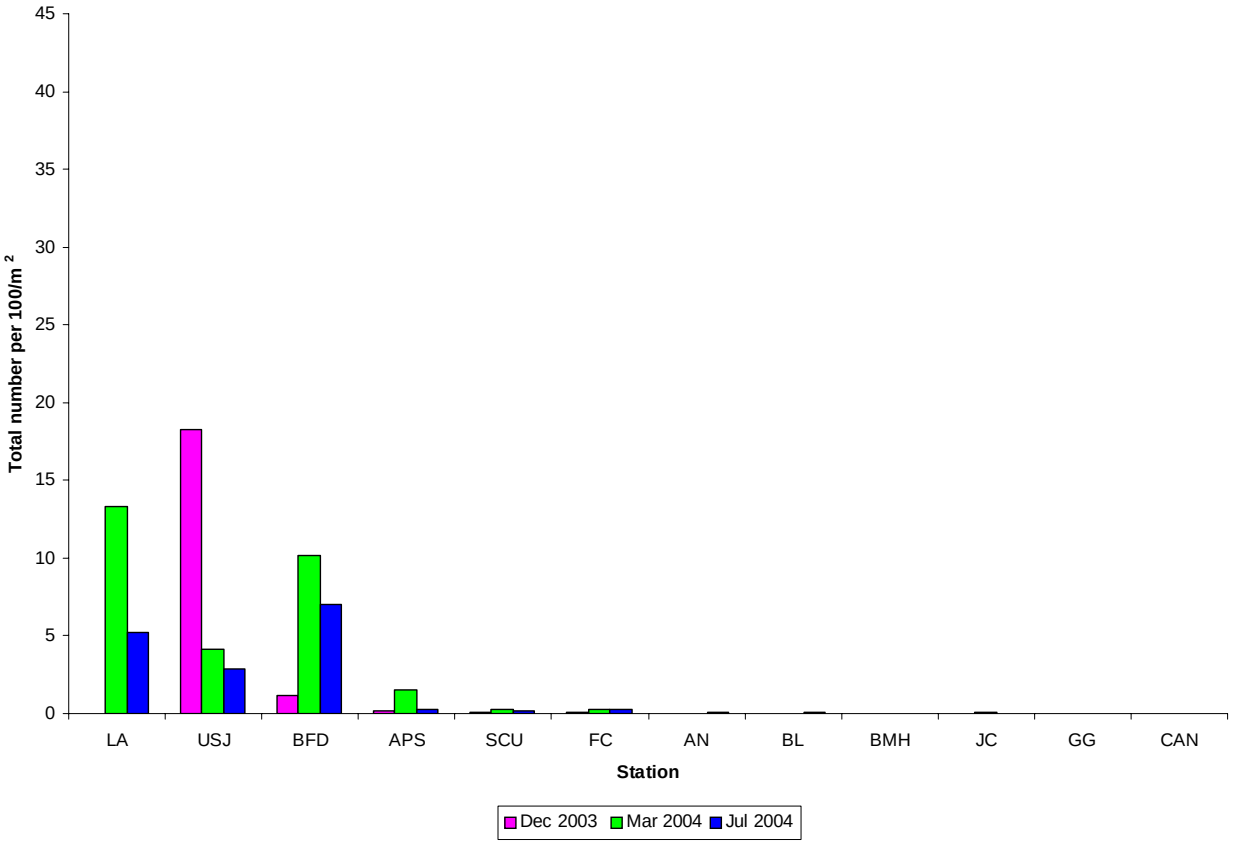

Figure 36. Total catch per effort (total number per total 100 m^2) for bluehead sucker during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.

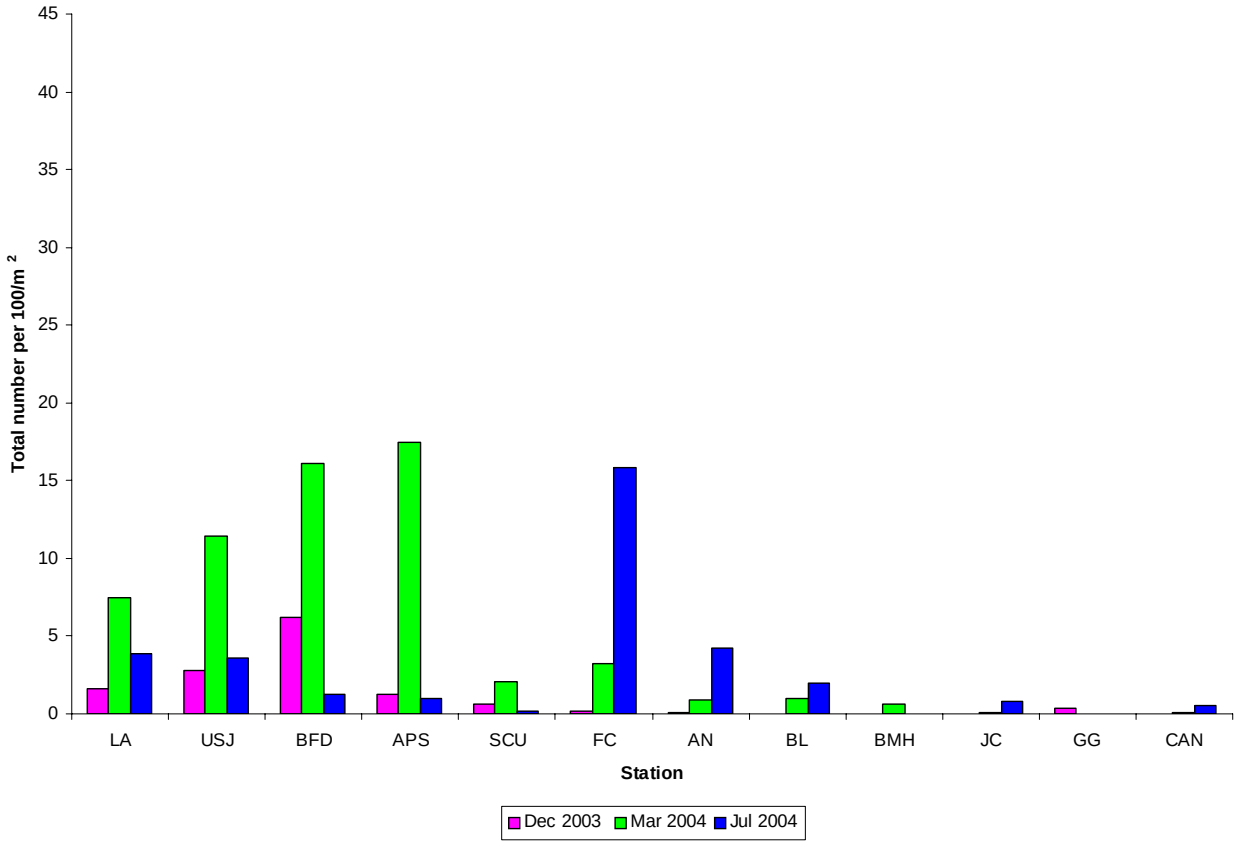

Figure 37. Total catch per effort (total number per total 100 m^2) for speckled dace during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.

We collected a total of nine razorback sucker (including potential hybrids) in sampling following the 2003 Colorado pikeminnow stocking event (Figure 38). Three of these fish were larger than 290 mm SL and were PIT tagged. We collected all three of these larger, stocked razorback sucker in July 2004. One was collected just below the APS Weir (RM 163.5), and the other two were collected in the Grand Gulch station (RM 11.6 and 12.5). The remaining six fish were juveniles collected in the canyon section of the river. In March 2004 we collected one juvenile razorback sucker (94 mm SL) in a backwater near RM 11.4 at the Grand Gulch station. We also captured what we thought was a razorback X flannelmouth hybrid (95 mm SL) in an embayment near Slickhorn Canyon (RM 17.5). In July 2004 we collected a YOY razorback sucker (64 mm SL) in an isolated pool at RM 37.4 and two YOY razorback sucker (54 mm and 68 mm SL) and one possible razorback X flannelmouth hybrid (62 mm SL) in a backwater near RM 12.5 in the Grand Gulch station.

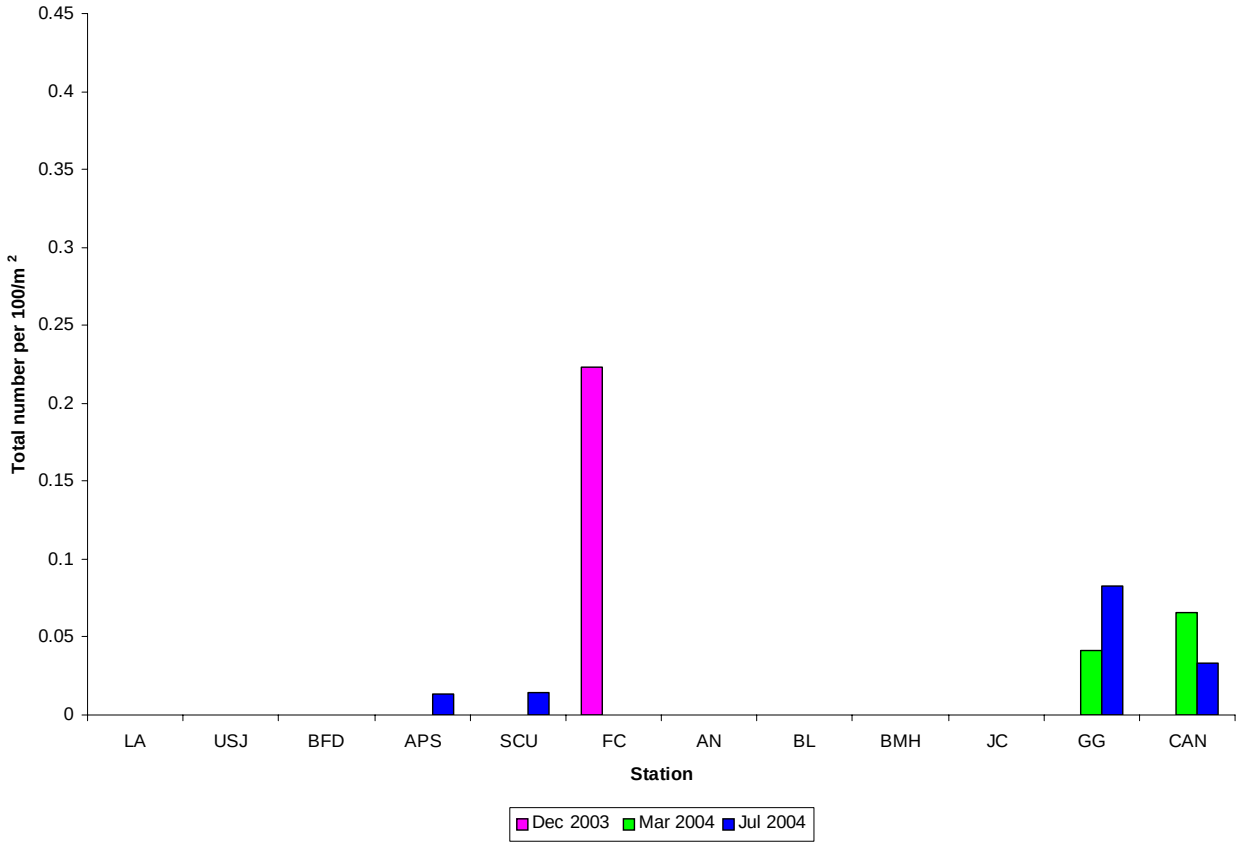

Figure 38. Total catch per effort (total number per total 100 m^2) for razorback sucker during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.

Red shiner (*Cyprinella lutrensis*) and fathead minnow (*Pimephales promelas*) were the most abundant nonnative fishes we collected in sampling trips after the 2003 stocking event (Figures 39-40). We collected very few red shiner in stations above the APS Weir. Red shiner was most abundant in the APS Weir to Hogback Diversion, Shiprock to Cudei, Four Corners, Aneth, and Bluff stations. Red shiner abundance was lower in the downstream stations within the canyon. The decreased red shiner CPE in July 2003 is probably the result of switching to the 9-m wide seines that had a larger mesh size (6 mm versus 3 mm). Small and YOY red shiner could pass through this mesh. Fathead minnow were collected in all stations on at least one sampling trip following the 2003 stocking. This species seemed to be most abundant in the same stations as red shiner. The decrease in fathead minnow CPE observed in July 2004 is probably attributable

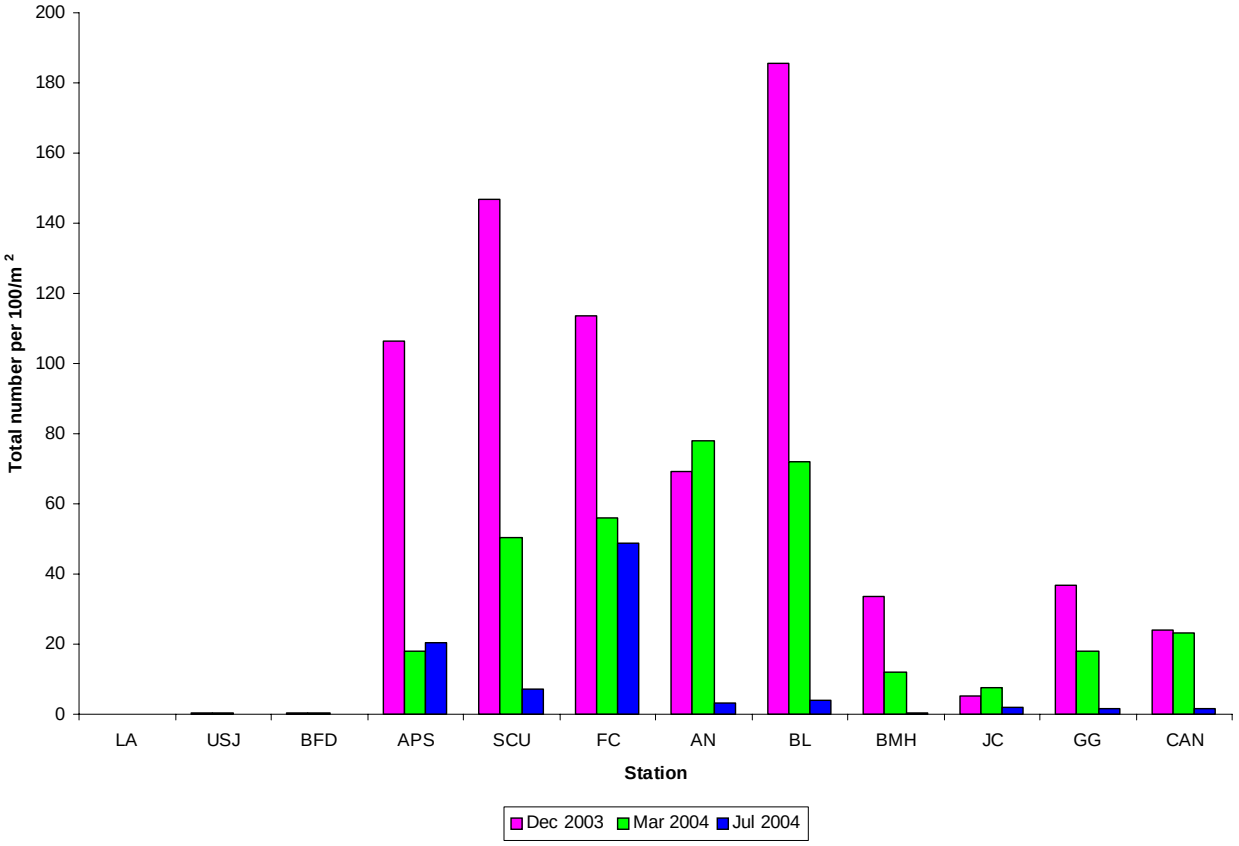

Figure 39. **Total catch per effort (total number per total 100 m^2) for red shiner during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.**

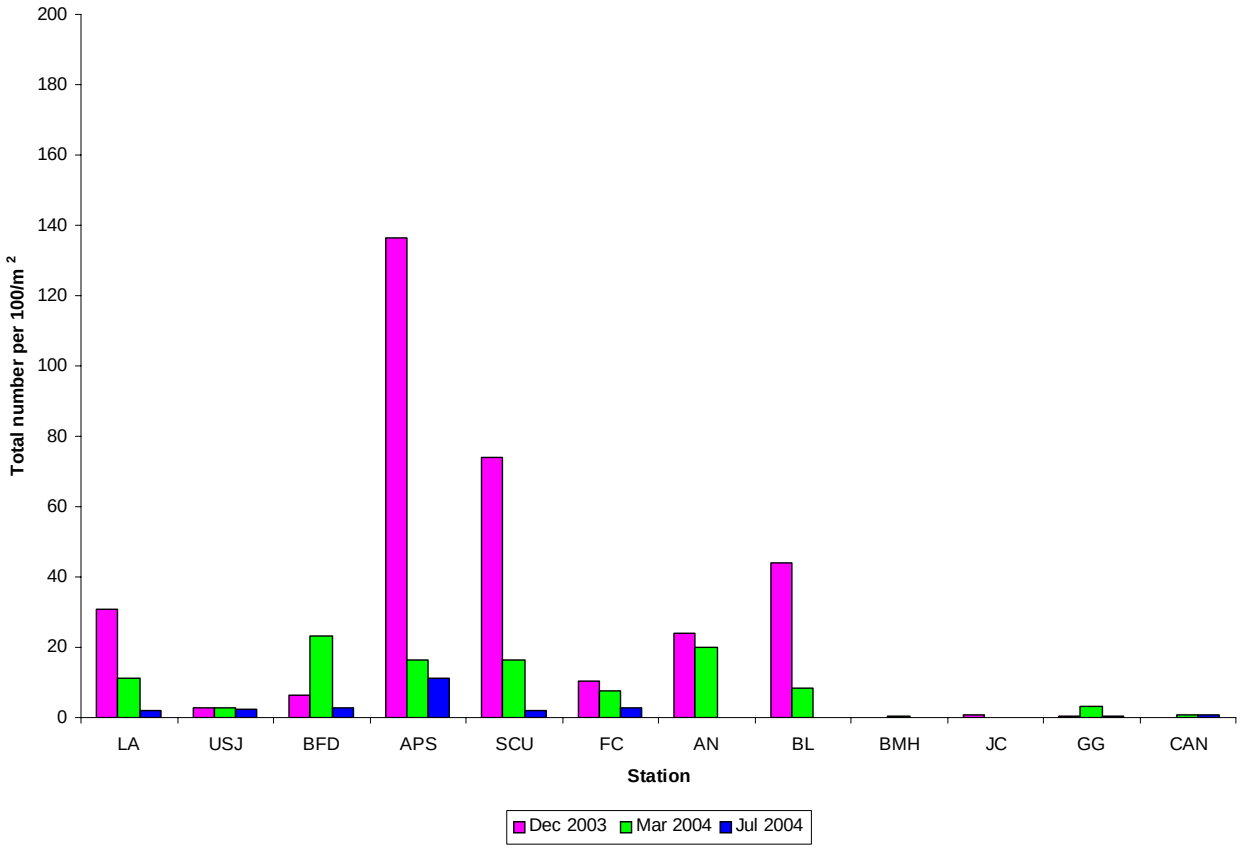

Figure 40. Total catch per effort (total number per total 100 m^2) for fathead minnow during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.

to the larger mesh size of seines used during that sampling trip, too. We found two channel catfish (*Ictalurus punctatus*) in the Lower Animas station in July 2004 (Figure 41). Otherwise, did not collect channel catfish above the APS Weir. Channel catfish appeared to be most abundant from the Aneth station downstream to Clay Hills Crossing.

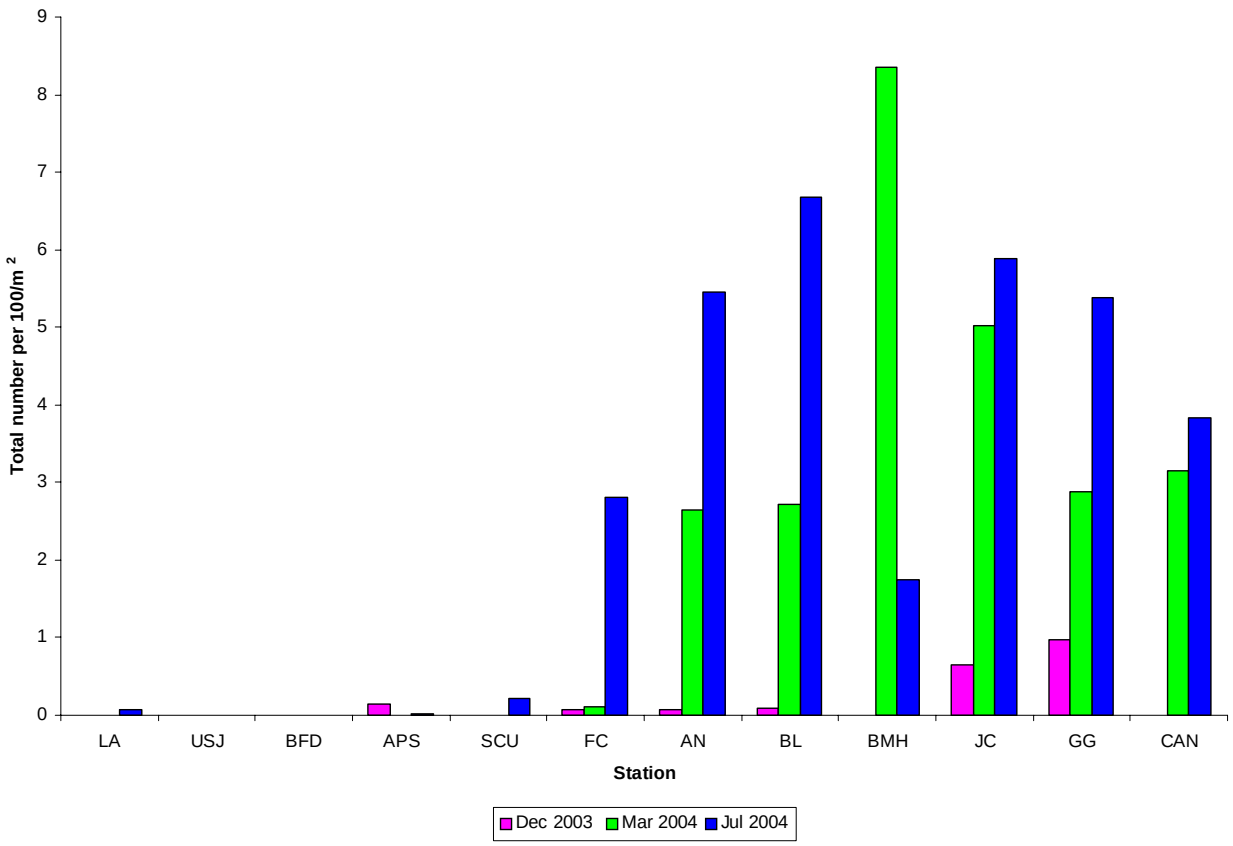

Figure 41. Total catch per effort (total number per total 100 m^2) for channel catfish during the December 2003, March 2004, and July 2004 sampling trips. LA = Lower Animas, BFD = Below Fruitland Diversion, APS = APS Weir to Hogback, SCU = Shiprock to Cudei, FC = Four Corners, AN = Aneth, BL = Bluff, BMH = Below Mexican Hat, JC = John's Canyon, GG = Grand Gulch, CAN = Miscellaneous Canyon.

In addition to red shiner, fathead minnow, and channel catfish, we collected nine other nonnative fish species, including western mosquitofish (*Gambusia affinis*), common carp (*Cyprinus carpio*), white sucker (*Catostomus commersoni*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), black bullhead (*Ameiurus melas*), plains killifish (*Fundulus zebrinus*), and brown trout (*Salmo trutta*). The CPE for these fishes was generally low and sporadic (Figure 42). Increased CPE at the Shiprock to Cudei and Bluff stations in December was caused by increased numbers of western mosquitofish. Increased CPE in July 2004 was caused by high numbers of YOY largemouth bass and common carp.

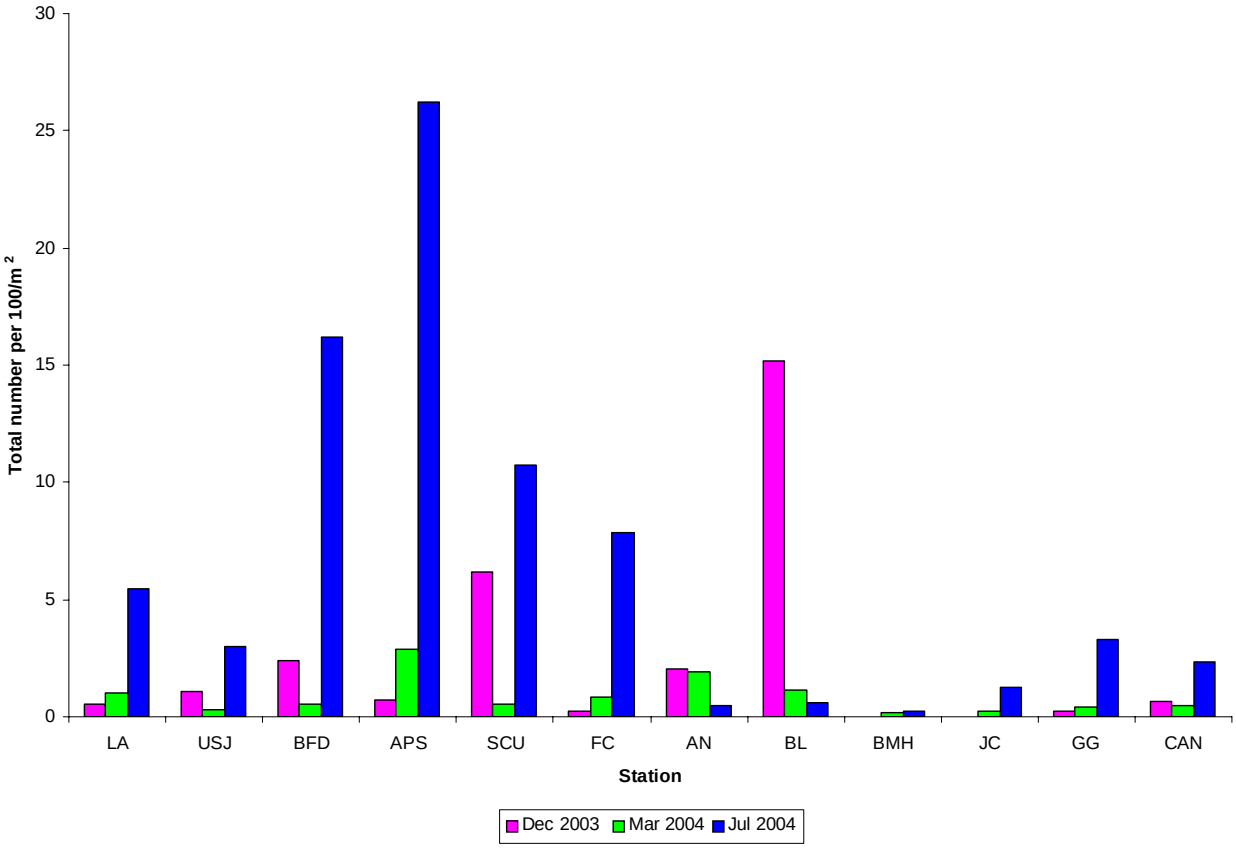

Figure 42. Total catch per effort (total number per total 100 m^2) for other nonnative fishes during the December 2003, March 2004, and July 2004 sampling trips.

DISCUSSION

Retention and Survival of Stocked Colorado Pikeminnow

We found that the retention of the YOY Colorado pikeminnow stocked in 2003 appeared to be greater than that of the Colorado pikeminnow stocked in 2002. We found higher total numbers, average CPE, total CPE, and CPE from backwaters of Colorado pikeminnow in sampling following the 2003 stocking event versus sampling following the 2002 stocking event. We also found that Colorado pikeminnow were present in a higher proportion of the samples collected after the 2003 stocking event. Unfortunately, we are unable to attach statistical significance to any of these numbers. However, average CPE of Colorado pikeminnow collected at stations sampled in both years was nearly three times higher in December and March following the 2003

stocking event. More importantly, in July 2004 average CPE of Colorado pikeminnow collected at stations sampled in both years was over 40 times higher than in July 2003.

Initial retention of the Colorado pikeminnow stocked in 2003 appeared similar to the retention of fish stocked in 1996 and 1997, despite the fact that 50,000-75,000 more fish were stocked in 2003. However, by March 2004, number and CPE of Colorado pikeminnow collected in 2003 appeared to be higher than that collected after the 1997 stocking event and equal to that collected after the 1996 stocking event, which was probably the best of the previous three stocking events in terms of survival. Survival to age-1 after the 2003 stocking event appeared to be higher than for any previous year. The number of age-1 Colorado pikeminnow collected during 2004 annual fall monitoring was two to four times that seen following the prior three YOY Colorado pikeminnow stocking events.

Part of the July 2004 increase in Colorado pikeminnow number and CPE probably resulted from using a new sampling method. Block seining with 9-m-wide seines seemed to be much more effective for collecting age-1 Colorado pikeminnow than seining with 4-m-wide seines and without a block seine. We collected 40 age-1 Colorado pikeminnow during sampling between Mexican Hat and Clay Hills Crossing in July 2004. The UDWR sampled this same river reach using raft-mounted electrofishing 2 weeks before and 2 weeks after our July 2004 sampling trip, collecting four age-1 and ten age-1 Colorado pikeminnow, respectively. Raft-mounted electrofishing appears to be more effective at collecting age-1 and age-2 Colorado pikeminnow than seining without a block seine. During 2004 SJRIP fall monitoring, eight age-1 Colorado pikeminnow were collected by seining, while over 120 were collected by electrofishing. Since we seemed to collect higher numbers of age-1 Colorado pikeminnow by block seining than the UDWR did by electrofishing, we feel that block seining with 9-m-wide seines is considerably more effective than using 4-m-wide seines without a block seine.

We also increased the number of stations sampled after the 2003 stocking event, which was partially responsible for the increase in the number of Colorado pikeminnow collected. In 2004 we sampled three new 5-mile stations, along with the backwater habitats between them, in the 50-mile, canyon-bound section of river between Mexican Hat and Clay Hills Crossing. We found that within 1 month following stocking, Colorado pikeminnow were present in the furthest downstream station (Grand Gulch). By March 2004 47% of the Colorado pikeminnow we collected were found in the canyon section of the river below Mexican Hat. In July 2004 27% of the age-1 Colorado pikeminnow we collected were found in the canyon section of river. Additionally, the majority of the Colorado pikeminnow captured from the 2002 stocking event and all YOY and juvenile razorback sucker we collected in March and July 2004 were found in the canyon section of the river. The canyon section seems to be important for the endangered fish species of the San Juan River, at least under current flow conditions.

While changes in sampling protocol and the addition of new sampling stations in the canyon were responsible for part of the increase in numbers of Colorado pikeminnow, it appears that overall retention/survival was higher for Colorado pikeminnow stocked in 2003. Numbers of and CPE for Colorado pikeminnow in sampling trips after the 2003 stocking event were higher than after the 2002 stocking event, even when we excluded samples collected in the canyon section of the river and focused on the stations that were sampled in both years. We collected higher numbers of fish and had increased CPE during monitoring following the 2003 stocking event, despite the fact that almost 20% less Colorado pikeminnow were stocked in 2003. The USFWS and BIO-WEST received 35,000 fewer YOY Colorado pikeminnow in 2003 than in 2002. These numbers were further reduced when 14,000-15,000 Colorado pikeminnow died during the acclimation experiments. The 2- to 50-fold increase we saw in the number of YOY Colorado pikeminnow collected after the 2003 stocking event at stations sampled in both years, despite a 20% reduction in the number of stocked fish, indicates that retention and/or survival of Colorado pikeminnow was higher after the 2003 stocking event than after the 2002 stocking event.

While the results of our monitoring indicate retention appeared higher after the 2003 stocking event compared with the 2002 stocking event, the initial retention of the 2003 stocked Colorado pikeminnow did not appear to be much better than retention after the 1996 and 1997 stocking events. The number and CPE of Colorado pikeminnow collected 1 month and 4-5 months after the 2003 stocking event did not appear to be higher than the number and CPE of Colorado pikeminnow found at similar times after the 1996 and 1997 stocking events. Conversely, the survival to age-1 of Colorado pikeminnow stocked in 2003 appeared to be better than survival of Colorado pikeminnow stocked in 1996 and 1997. We collected over 14 times the number of Colorado pikeminnow 9-11 months after the 2003 stocking event than were collected 9-11 months after the 1996 and 1997 stocking events. Again, this comparison is tainted by the use of different sampling methods, but during the annual large-bodied fish monitoring two to four times the number of age-1 Colorado pikeminnow were collected by electrofishing in 2004 as were collected in 1997, 1998, and 2003 following the 1996, 1997, and 2002 stocking events.

Given the numbers of age-1 Colorado pikeminnow collected in July 2004 and during annual fall monitoring in 2004, it seems clear that Colorado pikeminnow from the 2003 stocking event remained in the river and/or survived to age-1 at a higher rate than fish from the 2002 stocking event. However, it remains unclear why greater numbers Colorado pikeminnow stocked in 2002 persisted to age-1. Changes in stocking protocol may have decreased the amount of initial drift, resulting in higher retention. In 2002 YOY Colorado pikeminnow were stocked en masse less than 2 miles upstream from the Below Fruitland Diversion station. In 2003 the USFWS stocked YOY Colorado pikeminnow directly into low-velocity habitats throughout this station. On the initial monitoring trip following the 2003 stocking event, average CPE in the Below Fruitland Diversion station was almost four times higher than found during the initial monitoring trip following the 2002 stocking event. The increase in average CPE at this station was maintained through the March and July 2004 sampling trips.

The USFWS also stocked fish directly into low-velocity habitats in the 10 miles of river immediately upstream from the Shiprock to Cudei station. We did not see an increase in the average CPE of Colorado pikeminnow in this station during the initial sampling trip after the 2003 stocking event. Whether this lack of increase was caused by increased retention in the Hogback to Shiprock reach, where the fish were stocked, is unknown. However, during nonnative removal efforts from Hogback to Shiprock, NMFRO collected fewer Colorado pikeminnow from the 2003 stocking event than they did sampling in an upstream area (PNM Weir to Hogback Diversion) where stocking did not take place. Finding fewer age-1 Colorado pikeminnow from the 2003 stocking event from Hogback to Shiprock in summer 2004 may indicate that at least long-term retention did not appear higher in the Hogback to Shiprock reach.

The results of the acclimation experiments are also unclear. Unfortunately, the majority of our acclimated fish died, and those that were released may have been less fit than the Colorado pikeminnow from the larger stocking event. Follow-up experiments attempting to mimic the factors affecting the acclimated fish prior to the 2003 stocking event have been unable to duplicate the mortality (Holden and Golden 2005), which makes it difficult to elucidate the cause of the stress and mortality we saw in November 2003. As of November 2004 the only factor that has not been duplicated in field and laboratory experiments was marking the fish with calcein, while they underwent the same harvest and stocking treatment as in November 2003. The marking process was simulated for field experiments conducted in November 2004, but the fish were not actually marked.

Not only is the use of calcein dye suspect in the mortality of acclimated fish, the dye turned out to be a poor field mark, too. We did not see the calcein mark on any of the fish we collected in December 2003, despite collecting Colorado pikeminnow from some of the same sites where acclimation experiments took place. Since we could not see the mark, we were unable to differentiate between the retention of acclimated fish and fish from the larger stocking event. We performed acclimation experiments in two of our monitoring stations, so we did collect information on the number and CPE of Colorado pikeminnow found in areas where acclimation experiments were conducted. We did not find any Colorado pikeminnow in the Upper San Juan station until July 2004, when we collected two age-1 Colorado pikeminnow from the 2003 stocking event. At age-1 it is reasonable to expect that these fish may have swum upstream from other areas. For all intents and purposes, it appears that there was no retention of acclimated fish in the Upper San Juan station.

Conversely, after the 2003 stocking event we saw higher numbers and CPE of Colorado pikeminnow during all three sampling trips in the APS Weir to Hogback Diversion station, compared with monitoring conducted after the 2002 stocking event. We did not collect any Colorado pikeminnow in the APS Weir to Hogback Diversion station after the 2002 stocking event, but we collected Colorado pikeminnow in this station during every sampling trip after the 2003 stocking event. While we can not definitively say that any of the fish we collected were from our acclimation experiments, 65% of the Colorado pikeminnow we collected in the APS

Weir to Hogback Diversion station in December 2003 were from a large side channel/backwater where we acclimated fish. The entrance to the side channel remained dry between the acclimation experiment and the December 2003 sampling trip, and the exit was less than 6 cm deep. We felt that it would have been difficult for any of the Colorado pikeminnow from the larger stocking event to get into this side channel and assumed that the Colorado pikeminnow collected here during the December 2003 monitoring trip were fish from our acclimation experiments.

To further muddle the influence that the changes in stocking protocol and acclimation experiments may have had on the retention and survival of the Colorado pikeminnow stocked in 2003, we also found increases in the initial number of CPE of Colorado pikeminnow at downstream stations that were sampled in both years. Average CPE at the most downstream station sampled in both years (Bluff) was 50 times higher in December 2003 than December 2002. We found Colorado pikeminnow as far downstream as RM 8.0 during the December 2003 monitoring trip, indicating that some fish had drifted a considerable distance. The goal of the stocking protocol and acclimation experiments was to reduce the amount of initial drift downstream after stocking. It is possible that the majority of the Colorado pikeminnow found in downstream areas were fishes stocked en masse at the Animas confluence and Hogback Diversion, but since these fishes were not marked we can not be sure. Therefore, while the increase in numbers and CPE found in the Below Fruitland Diversion and APS Weir to Hogback Diversion stations may be some evidence that the changes in stocking protocol and acclimation experiments were somewhat successful, the higher numbers and CPE of Colorado pikeminnow at downstream stations indicate that many of the stocked fish still drifted.

The fact that retention increased across all stations may indicate that habitat or environmental conditions were different after the 2003 stocking event. Discharge was relatively low and constant in the month following both the 2002 and 2003 stocking events. Water temperatures were slightly lower in the first month after the 2003 stocking event, which we feel would reduce rather than increase retention. The flow and temperature conditions appeared the same or slightly worse in the first month following the 2003 stocking event compared with the first month following the 2002 stocking event. The Colorado pikeminnow stocked in 2003 appeared slightly larger (6 mm) than the Colorado pikeminnow stocked in 2002, but growth throughout the remainder of the year appeared similar to growth seen after the 2002 stocking event. The similar growth is another indication that environmental conditions were relatively similar between the two years.

Colorado pikeminnow YOY have been shown to prefer low-velocity habitats such as secondary channels and backwaters (Tyus and Haines 1991, Propst and Hobbes 1999, Chart and Lentsch 2000). Golden et al. (2004) postulated that the poor retention of Colorado pikeminnow stocked in 2002 was related to a decline in backwater area and quality noted by Bliesner and Lamarra (2003). Therefore, an increase in the availability of backwater habitat after the 2003 stocking event could have resulted in increased retention of stocked YOY Colorado pikeminnow. We

found that we sampled a lower proportion of backwater habitats and less backwater area in December 2003 than in December 2002 and, since we try to sample as much low-velocity habitat as possible, we feel that this is an indication of the availability of backwater habitat. So it does not appear as though habitat or environmental conditions were any better in the first month following the 2003 stocking event than the first month following the 2002 stocking event. The lack of increased habitat or better environmental conditions provided some evidence that initial increased retention may be at least partially attributable to stocking protocol changes. As a caveat to this, we felt that better low-velocity habitat was available in December 2003 than in December 2002 based on our visual observations, but the data we collected do not provide evidence of this.

Flows were substantially higher in March 2004 than March 2003. These higher flows inundated the mouths of many side channels and side canyons, which increased the amount and proportion of available backwater habitat we were able to sample. Flows above 1,000 cfs were maintained for almost 3 months in spring 2004. Conversely, flows above 1,000 cfs were maintained for less than 1 month in spring 2003. We found that we were able to sample a higher proportion of backwater and a larger amount of backwater area in March 2004 than during any other sampling trip. We found that the increase in the percent and area of backwater area appeared to carry over into the July 2004 sampling trip, even though flows were similar to those seen in December 2003. However, backwater habitats appeared to be less important for age-1 Colorado pikeminnow in July 2004 than during the December 2003 and March 2004 sampling trips, especially in stations upstream from the canyon-bound section of river below Mexican Hat.

Backwaters probably remained important for several months after our March 2004 sampling trips. During UNM larval fish sampling in April and May 2004, Colorado pikeminnow stocked in 2003 were collected in backwaters, indicating the continued importance of these habitats through early June. The creation and maintenance of backwater habitats are partially dependent on the ability of the flow regime of a given year to clean and maintain side channel and backwater habitats. The extended flows above 1,000 cfs may have helped clear some side channel and backwater mouths that had been previously sealed off from sediment build up during low flows in 2002 and 2003. The large, monsoon-induced spate event in September 2003 may have also helped to open some side channel and backwater mouths that had been previously sealed off by sediment that accumulated during low flows. Increased habitat availability from March to June 2004 may have allowed for more YOY Colorado pikeminnow to survive to age-1.

Additional Fish Information

Information collected in 2003-2004 supports data collected in 2002-2003 and in other SJRIP-funded research (Propst and Hobbes 1999, Propst et al. 2003, Ryden 2003b). We found that native fish numbers were generally higher in the area upstream of Hogback Diversion. Flannelmouth sucker and speckled dace appeared to be more abundant and were distributed further downstream than bluehead sucker, although we did collect bluehead sucker in the canyon section of the river in March 2004. Additionally, we collected a juvenile razorback sucker in March 2004 and several YOY razorback sucker in July 2004, indicating that some of the larval razorback sucker spawned from stocked fish are persisting to larger YOY and potentially age-1 fish. All of these razorback sucker were collected in the canyon section of the river, reinforcing its importance for endangered fishes.

As in 2002 the small-bodied, nonnative fish community was comprised primarily of red shiner and fathead minnow. We also found that YOY largemouth bass and common carp were fairly common in summer 2004. Nonnative fishes were significantly less abundant above the PNM Weir, but their numbers were variable in areas downstream.

CONCLUSIONS AND RECOMMENDATIONS

We think the YOY Colorado pikeminnow stocked in 2003 had higher initial retention and survival to age-1 than Colorado pikeminnow stocked in 2002. Additionally, the fish stocked in 2003 appeared to have a higher survival rate to age-1 than YOY Colorado pikeminnow stocked in 1996 and 1997. Tag failure and stress-induced mortality of 75% of the acclimated Colorado pikeminnow make it nearly impossible to speculate on any benefits of acclimating fish prior to their release. Ascertaining the influence of the changes in stocking protocol was also difficult, because more preferred habitat appeared to be available during spring and early summer 2004. However, habitat and environmental conditions appeared similar in the first month following stocking in both 2002 and 2003, which may provide evidence that the change in stocking protocols, and possibly the acclimation experiments, did assist Colorado pikeminnow in surviving and retaining during the first few weeks following stocking.

The results of July 2004 sampling and 2004 fall monitoring showed that regular seining with 4-m-wide seines is not effective at collecting age-1 and age-2 Colorado pikeminnow. Additionally, we found that the canyon section of the river, particularly the lower portion, appears to be very important for the two endangered fish species of the San Juan River. We feel that repeating the new stocking protocols with all stocked fish, attempting acclimation experiments with new handling protocols and different tagging methods, attempting to manipulate habitats, and stocking over multiple years during a suite of environmental conditions should help maximize retention and survival, bringing the SJRIP closer to reaching recovery goals. We also feel that further investigation of the importance of the lower San Juan River

above Lake Powell will provide valuable information on this area's use by and importance to endangered fishes.

(1) Continue monitoring efforts in 2004-2005. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

We feel that the current study, in conjunction with other research and monitoring activities, has provided valuable information on the patterns of retention and growth of Colorado pikeminnow stocked in 2002 and 2003. More YOY Colorado pikeminnow will be stocked in 2004 and 2005. Continuing to study the retention, growth, and survival of stocked Colorado pikeminnow exposed to different environmental conditions and stocking protocols should help elucidate the most effective methods to achieve maximum retention and survival of stocked Colorado pikeminnow. Additionally, determining how many Colorado pikeminnow are surviving to age-1 and age-2 provides valuable information on whether the directives of the Augmentation Plan will meet the Recovery Goals for Colorado pikeminnow in the San Juan River.

(2) Discontinue sampling at the Lower Animas and Upper San Juan stations. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

We have not collected any Colorado pikeminnow stocked as YOY fish in 2002 or 2003 in the Lower Animas station. We did not collect any YOY Colorado pikeminnow in the Upper San Juan station after the 2002 stocking event and only collected two age-1 Colorado pikeminnow from the 2003 stocking event at this station in July 2004. None of the YOY Colorado pikeminnow from the 2003 stocking event were collected in the Upper San Juan station in December 2003 or March 2004, despite the fact that approximately 2,000 fish were released in this station following acclimation for 7 days. Both of these stations have a paucity of low-velocity habitat and seem unlikely to support large numbers of YOY Colorado pikeminnow. These stations may become more important in the future as the stocked Colorado pikeminnow grow into adults, but for the present we recommend discontinuing the monitoring at these stations.

(3) Investigate the importance of the areas between Clay Hills Crossing and Lake Powell. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

Our data indicated fish stocked in 2002 and 2003 continued to move downstream for at least 4-5 months following stocking. Data collected after the 2003 stocking event showed large numbers of YOY Colorado pikeminnow below Slickhorn Rapid and continued use of the lower canyon after stocked Colorado pikeminnow have reached age-1 and age-2. Water levels on Lake Powell have dropped considerably during the past 3 years, creating over 25 miles of riverine habitat below Clay Hills Crossing. This habitat is separated from upstream areas by a waterfall that was nearly 3 m high in summer 2003 (Julie Jackson, UDWR, personal communication). Stocked Colorado pikeminnow that drift over the waterfall will not be able to get back upstream, but they

may be able to persist in the riverine habitat below the waterfall. The 14 miles upstream from Clay Hills Crossing appear to be important habitat for both Colorado pikeminnow and razorback sucker. The habitat between Clay Hills Crossing and Lake Powell may also be important at the current lake level. To determine the number of stocked Colorado pikeminnow transported and persisting below the waterfall, we recommend extending the canyon portion to the confluence of the San Juan River with Lake Powell for sampling after the 2004 stocking event.

(4) Continue to experiment with new methods during the July sampling trip. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

Golden et al. (2004) felt that once Colorado pikeminnow exceeded 100 mm they became much less susceptible to capture by seining. Raft-mounted electrofishing conducted during other SJRIP-sponsored projects indicated that more Colorado pikeminnow were present than we were able to collect by seining after the 2002 stocking event. Additionally, block seining in July 2004 appeared to be equally or more effective than raft-mounted electrofishing. We had planned to implement "shock and block" tactics using electrofishing and large seines, but equipment malfunctions prevented these trials. Therefore, along with the continued use of block seining, we recommend trials using and shock and block tactics with a backpack electrofishing unit and large seines in July 2005, if time and water conditions are amenable.

(5) Continue new stocking protocols with the addition of new handling protocols for Colorado pikeminnow stocked in 2004. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

While we cannot prove that the new stocking protocols increased the retention and survival of Colorado pikeminnow stocked in 2003, there is some evidence that the new protocols contributed to increased retention. We also saw a large amount of YOY Colorado pikeminnow mortality during the 2003 acclimation experiments. Field and laboratory experiments have been unable to duplicate that mortality, but it appears that a large amount of handling over a short period of time, combined with the added stress of the calcein dye, may have been responsible (Holden and Golden 2005). If the high frequency of handling over a short time period was responsible for the mortality we observed, then all Colorado pikeminnow stocked in 2003, and possibly in 1996, 1997, and 2002, experienced a higher rate of post-stocking mortality than was necessary. Therefore, to increase retention and survival of fish stocked in 2004, we recommend instituting new handling protocols that extend the harvest period to reduce handling and stress frequency the week prior to stocking. We also recommend continuing to stock all YOY Colorado pikeminnow directly into low-velocity habitats in 2004.

(6) Re-attempt acclimation experiments with Visible Implant Elastomer (VIE)-tagged Colorado pikeminnow. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

We do not know whether site acclimation improved retention of fish stocked in 2003 because of the high mortality of acclimated fish along with the calcein dye failure. After the 2002 stocking event, we asserted that acclimating YOY Colorado pikeminnow may increase retention (Golden et al. 2004). We still assert this and recommend trying to acclimate a subset of 20,000 YOY Colorado pikeminnow in 2004-2005. To avoid the mortality and tag failure problems seen in 2003, we recommend using the new handling protocols and VIE tags, instead of calcein dye, to mark these fish.

(7) Re-attempt debris pile experiments. (*Note: This recommendation was approved in the 2005 Scope of Work.*)

We experimented with placing debris piles in low-velocity habitats in the Shiprock to Cudei station after the 2003 stocking event. We found no increase in the initial retention of Colorado pikeminnow in this station after the 2003 stocking event. However, a reduction in flows immediately following debris placements rendered many of the debris piles useless for Colorado pikeminnow. In December 2003, as in December 2002, we found that cover was important for YOY Colorado pikeminnow in low-velocity habitats. We recommend manipulating existing habitat to make it more suitable for stocked Colorado pikeminnow immediately after stocking in 2004-2005.

(8) Attempt stocking at warmer water temperatures.

The December 2002 and 2003 sampling trips showed that Colorado pikeminnow seem restricted to certain habitats when river temperatures are cold. Stocking Colorado pikeminnow when water temperatures are warmer may reduce dispersal, because YOY Colorado pikeminnow may utilize a wider variety of habitats above a certain critical temperature. This appeared to be the case in March 2003 when stocked fish were much more dispersed than during December 2002. River temperatures were generally 3-5˚C during the December sampling and 7-14˚C during the March trip. The 1997 stocking event occurred in August when river temperatures were warmer, versus November and October in 1996 and 2002. Of the three YOY Colorado pikeminnow stocking events prior to 2003, the largest number of age-1 Colorado pikeminnow were found during standardized fall monitoring in 1998, despite apparent increased downstream dispersal caused by numerous flow spikes. While we don't know whether the earlier stocking time in 1997 contributed to better long-term survival that year, we recommend experimenting with different stocking times to determine which may be best for maximizing retention.

ACKNOWLEDGMENTS

This project was funded by the SJRIP, the National Park Service, and the State of Utah, and was a cooperative effort between BIO-WEST, the NMDGF, the UDWR, and the UNM's Museum of Southwestern Biology, Division of Fishes. Sampling was conducted jointly between these three groups.

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Lee Renfro (UNM),
Tim Ricks (BIO-WEST),
Ryan Smith (UDWR),
Justin Tabor (UDWR),
Melissa Trammell (National Park Service),
Steve Trujillo (UDWR), and
Katie Webster (UDWR).

Collection permits were provided by the Navajo Nation, NMDGF, UDWR, and USFWS. The U. S. Bureau of Indian Affairs, especially Ernie Teller, provided an immense amount of logistical support. Steve Ross (UNM) provided comments that greatly improved this report. Sara Gottleib (UNM), Julie Jackson (UDWR), Jason Davis (NMFRO), Dale Ryden (USFWS, Grand Junction, Colorado), and Marvin Harris (Keller-Bliesner Engineering) all responded patiently to our repeated data requests. Susan Durham, (Utah State University [USU], Department of Biology), Ron Ryel (USU, Department of Forest, Range, and Wildlife Sciences) and Ann Kitchen (USU, Department of Forest, Range, and Wildlife Sciences) provided statistical advice. Finally, Joel Foutz and Buck and Ginger Wheeler provided repeated access to the river through their property. Thanks to all.

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