Evaluation of age-0 versus age-1+ Colorado pikeminnow stocking

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ABSTRACT

In an effort to recover populations of the endangered Colorado pikeminnow (*Ptychocheilus lucius*) in the San Juan River, the San Juan River Basin Recovery Implementation Program (Program) has been stocking two different age classes under a formal augmentation plan since 2006. The Program's goal is to annually stock 300,000 and 3,000 age-0 and age-1+ Colorado pikeminnow, respectively. During monitoring and management activities, Colorado pikeminnow stocked in the two different age classes are recaptured in the San Juan River allowing for the calculation of return rates. I used these return rates to conduct a cost-benefit analysis of stocking Colorado pikeminnow in these two different size classes. Age-1+ Colorado pikeminnow are over 30-times more expensive to propagate, rear, transport, and stock compared to age-0 pikeminnow. However, although age-1+ Colorado pikeminnow have higher relative return rates, 15-times more age-0 pikeminnow are recaptured in the San Juan River at least one-year post-stocking. This analysis appears to suggest that stocking age-0 Colorado pikeminnow is a more cost effective way to reestablish populations of this endangered species in the San Juan River.

INTRODUCTION

The San Juan River Basin Recovery Implementation Program (Program) has been stocking age-0 Colorado pikeminnow (*Ptychocheilus lucius*) in the San Juan River under a formal augmentation plan since 2003 (Ryden 2003). The Program started stocking age-1+ pikeminnow in 2006 primarily because of higher post-stocking survival and retention rates previously observed in larger fish (Ryden 2005). The stocking goals currently call for 300,000 age-0 and 3,000 age-1+ Colorado pikeminnow to be annually stocked in the San Juan River (Ryden 2003, Ryden 2005). In addition to the stocking called for in the formal augmentation plans, the Program opportunistically stocked numerous Colorado pikeminnow as they became available through a variety of sources (mostly age-2+; Ryden 2008). To date the Program has not assessed the cost-benefits of stocking age-0 versus age-1+ Colorado pikeminnow. However, recent monitoring

efforts have provided capture information for pikeminnow stocked in various size classes that can be used to assess return rates. In this document I will detail the process I used to conduct a cost-benefit analysis using these return rates and costs associated with rearing and stocking these fish. For the purpose of this analysis, I will refer to those fish stocked at age-0 and subsequent recaptures of fish stocked as age-0 as *age-0*; and those fish stocked as age-1 or older and the subsequent recapture of fish stocked as age-1 or older as *age-1+*.

Age-1+ Colorado pikeminnow were implanted with a PIT (passive integrated transponder) tag prior to stocking in the San Juan River but age-0 fish were too small to be implanted with a PIT tag. The Program recaptured stocked pikeminnow in the San Juan River during electrofishing activities to remove nonnative fish species and monitor the San Juan River fish community. Recaptured fish were weighed, measured, and scanned for PIT tags; PIT tags were implanted in fish that did not have a PIT tag. Pikeminnow that were captured without a PIT tag were thought to be fish stocked as age-0 because insufficient Colorado pikeminnow reproduction was detected in the San Juan River to assume that these fish were produced in the wild (Brandenburg and Farrington 2009). Because age-0 fish did not receive a PIT tag until they were recaptured, there was no record of their stocking event and their encounter history was incomplete. I assigned these individuals an age and year-class based on the date and their size at first recapture in order to complete their encounter history and assign them to a stocking event without a corresponding stocking record (Table 1; Ryden personal communication – email 27 October 2009). Every recapture and stocking record was entered into an integrated PIT tag database that contained records from the Program's monitoring, research, non-native fish removal, and stocking activities. The integrated PIT tag database was used to determine encounter histories for all stocked fish in order to calculate return rate for a given stocking year and other demographic parameters.

COLORADO PIKEMINNOW STOCKING

The Program stocked 1,758,440 age-0 Colorado pikeminnow from 2002 to 2007 and 27,571 age-1+ pikeminnow between 2003 and 2008 (Ryden 2008). Due to errors in the PIT tag records of 474 age-1+ fish, the stocking records of these fish were eliminated from the PIT tag database and my analysis of age-1+ pikeminnow was based on 27,097 age-1+ fish with complete stocking

records. Dexter National Fish Hatchery and Technology Center estimated that costs to propagate, grow, and transport 50 mm total length (TL) age-0 Colorado pikeminnow were $0.25/fish and costs to propagate, grow, PIT tag, and transport 150 mm TL age-1+ Colorado pikeminnow were $8.50/fish (Knight personal communication – email 23 October 2009). These costs do not reflect the cost of the PIT tags that were implanted prior to stocking age-1+ or after the recapture of age-0 pikeminnow. The Program provides hatcheries and researchers on the San Juan River with PIT tags at a cost of $3 per tag (McKinstry personal communication – email 15 December 2009). Although some age-1+ Colorado pikeminnow opportunistically stocked into the San Juan River since 2002 were as old as age-5, for the purposes of this analysis all age-1+ fish were assumed to have the same production costs (an underestimate of the true cost of producing fish in older age classes). The total estimated stocking costs (excluding PIT tags) for the 27,097 age-1+ pikeminnow from 2003 to 2008 was $230,324 and $439,610 for the 1,758,440 age-0 pikeminnow stocked from 2007 to 2007.

COLORADO PIKEMINNOW RECAPTURES

I used the PIT tag database to determine the number of unique Colorado pikeminnow that were captured each year (Table 2 and 3). I did not count multiple recaptures of the same individual within one year. Because age-0 and age-1+ pikeminnow are stocked at different ages, age-0 and age-1+ fish recaptured at the same age have spent different amounts of time in the San Juan River. In order to make a relative comparison of the return rates for age-0 and age-1+ pikeminnow, I based the cost-benefit analysis on the number of unique fish recaptured by year after at least one-year post-stocking. The one-year post-stocking time period does not necessarily represent the return rate of fish that have been in the San Juan River for 365 days, but fish that have survived at least one overwinter period. This analysis does includes fish that were recaptured multiple years after they were stocked, so the encounter history of some fish have gaps in years when they were not detected. Thus a fish stocked any time during a year and recaptured at any time during the next year or any subsequent year would have survived at least one-year post-stocking for the purposes of this analysis.

Between 2003 and 2008 the Program recaptured 2,418 age-0 Colorado pikeminnow (return rate = 0.14%). One age-0 fish was captured in the same year it was stocked, 1,476 fish were captured

one year post-stocking, 910 were captured two years post-stocking, and 103 fish were captured three years post-stocking (Table 2). Some pikeminnow were recaptured in more than one year. Because almost all Colorado pikeminnow stocked as age-0 fish were recaptured at least one-year post-stocking (2,417 unique fish from 2003 to 2008), the at least one-year post-stocking return rate was the same as the overall return rate (0.14%).

The Program recaptured 938 age-1+ Colorado pikeminnow between 2003 and 2008 (return rate = 3.46%). The majority of these 938 fish were recaptured in the same year that they were stocked (83%; 791 individuals). Only 150 pikeminnow were captured one-year post-stocking and 7 were captured two-years post-stocking (Table 3). Some fish were recaptured in more than one year. The Program thus recaptured 157 unique age-1+ Colorado pikeminnow at least one-year post-stocking between 2003 and 2008. Because most age-1+ pikeminnow were only recaptured in the year that they were stocked, the one-year post-stocking return rate for age-1+ fish was 0.58%; almost 6-times lower than the overall return rate.

I considered recaptures of age-0 and age-1+ Colorado pikeminnow in terms of the total cost of stocking fish plus the cost of the $3 PIT tag implanted in fish for each age class. Note that only those age-0 fish that were recaptured were implanted with a PIT tag and all age-1+ stocked into the San Juan River were implanted with a PIT tag. PIT tag costs were an additional $7,254 and $81,291 for age-0 and age-1+ Colorado pikeminnow, respectively. To calculate the cost per recapture I divided the total production cost of fish stocked in each age class plus the total cost of implanted PIT tags by the number of unique age-0 and age-1+ fish recaptured at least one-year post-stocking. The cost per individual recaptured at least one-year post-stocking was $184.88 and $1984.81 for age-0 and age-1+ Colorado pikeminnow, respectively.

CONCLUSIONS

From 2003 to 2008, after at least one-year post-stocking, the cost of recaptured age-1+ Colorado pikeminnow was over 10-times more expensive than recaptured age-0 pikeminnow. Because 83% of age-1+ pikeminnow were recaptured only in the same year that they were stocked, the one-year post-stocking return rate of age-1+ fish was only 4-time greater than age-0 fish. The Program started stocking age-1+ pikeminnow in 2006 because of the anticipated greater retention

and survival of these fish (Ryden 2005). Although this appears to be true, the high cost of producing age-1+ fish is not off-set by much greater recapture rates compared to age-0 fish. This analysis did not consider the cost of monitoring, research, and management activities that lead to these recaptures. However, any costs associated with recapture effort should be the same for fish stocked as age-0 or age-1+ since the probability of detecting fish of equal size should be the same. The Program could reduce the overall stocking cost per recaptured individual by increasing the return rate of these fish. Nevertheless, increasing effort in activities that increase recapture rates would also incur additional costs to the Program that should be considered before any adjustments to annual work plans are made.

For the six years considered in this analysis, the Program stocked 1,758,440 age-0 Colorado pikeminnow compared to only 27,097 age-1+ pikeminnow. Because so many more age-0 pikeminnow were stocked and so many more age-0 fish were recaptured after one-year post-stocking, increasing efforts in stocking age-0 fish may result in greater populations of stocked pikeminnow in the San Juan River. Had the cost of stocking age-1+ fish from 2003 to 2008 ($230,324) gone entirely to stocking age-0 fish, an additional 921,298 age-0 fish could have been stocked in the San Juan River. Based on return rates observed between 2003 and 2008, this additional age-0 stocking could have resulted in recaptures of 1,290 additional age-0 individual pikeminnow at least one-year post-stocking compared to the 157 age 1+ fish that were recaptured. Because this analysis appears to indicate that larger numbers of age-0 pikeminnow are retained in the San Juan following one-year post-stocking, the Program should consider discontinuing the stocking age-1+ Colorado pikeminnow in favor of age-0 fish.

I based this cost-benefit analysis on the return rates of stocked juvenile Colorado pikeminnow. Ideally, an analysis such as this should be based on stocked fish that have begun reproducing; however, pikeminnow are infrequently captured 3-4 years post-stocking (Ryden 2009) and pikeminnow reproduction is rarely detected (Brandenburg and Farrington 2009). For the stocking program to ultimately be successful, stocked fish need to survive and eventually reproduce in the San Juan River. Because Colorado pikeminnow are only rarely found in reproducing size classes and reproduction is not regularly detected, the use of survival and reproduction cannot be used evaluate the success of the stocking program. Since the total

pikeminnow population in the San Juan River is presumably stocked fish, an estimate of abundance of Colorado pikeminnow could also be used to conduct this analysis, but the Program is not currently conducting Colorado pikeminnow population estimates. The Program should evaluate methods to retain more Colorado pikeminnow within the San Juan River so they will recruit into the adult population and eventually reproduce. In the meantime, using methods such as recapture rates to evaluate the stocking program can inform augmentation plans that will hopefully lead to a self-sustaining population of Colorado pikeminnow in the San Juan River.

TABLES AND FIGURES

Table 1. Age matrix for untagged Colorado pikeminnow based on size and date of capture. Fish over 400mm TL without a PIT tag could not be reliably aged.

	Month of capture											
Size at capture (TL)	Jan	Feb	Mar	April	May	June	Jul	Aug	Sept	Oct	Nov	Dec
< 100mm	Age-0											
100-190mm	Age-1											
191-240mm	Age-2								Age-1			
241-300mm	Age-2											
301-350mm	Age-3								Age-2			
351-400mm	Age-3											

Table 2. Age-0 Colorado pikeminnow stocked and captured by year. The number stocked by year is taken from Ryden (2008). The total number captured may differ from the sum of the number of individuals captured by year because of individuals that were recaptured in more than one year (e.g. there were 17 pikeminnow in the 2006 year-class that were initially captured in 2007 that were recaptured in 2008).

Year stocked	Year class	Number stocked	Total captured	Individuals captured by year					
				2003	2004	2005	2006	2007	2008
2002	2002	210,418	211	73	132	11	0	1	0
2003	2003	175,928	446	-	190	233	33	2	0
2004	2004	280,000	341	-	-	155	183	22	5
2005	2005	302,270	547	-	-	-	393	138	37
2006	2006	313,854	477	-	-	-	-	270	224
2007	2007	475,970	396	-	-	-	-	1	395

Table 3. Age-1+ Colorado pikeminnow stocked and recaptured by year. Some individuals were recaptured in different years at multiples ages so the sum of individuals captured by year exceeds the total number captured.

Year stocked	Year class	Number stocked	Total captured	Individuals captured by year					
				2003	2004	2005	2006	2007	2008
2003	2002	1002	3	3	0	0	0	0	0
2004	2002	1217	79	-	66	13	1	0	0
2005	2003	3619	56	-	-	54	2	0	0
	2004	500	33	-	-	30	3	0	0
2006	2001	1980	243	-	-	-	235	9	0
	2003	279	0	-	-	-	0	0	0
	2004	7202	56	-	-	-	49	7	0
	2005	3200	51	-	-	-	10	37	6
2007	2006	3250	214	-	-	-	-	141	79
2008	2006	4848	203	-	-	-	-	-	203

LITERATURE CITED

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