Nonnative and Rare Fish Monitoring in the Lower San Juan River 2018

Draft Report

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EXECUTIVE SUMMARY

Nonnative control for Channel Catfish occurred in the lower canyon of the San Juan River for 14 consecutive years. The last nonnative removal pass occurred in the spring of 2015. Since 2015, sampling has only occurred upstream of the lower canyon. In the spring of 2018, we wanted to sample in the lower canyon to assess any changes that have occurred during the three-year hiatus. In particular, we wanted to 1) compare catch per unit effort (CPUE) of Channel Catfish, Razorback Sucker, and Colorado Pikeminnow during the removal years (2003-2015) to the post removal period (2018); 2) compare size structure of Channel Catfish between removal and post removal; 3) compare Channel Catfish population estimates between removal and post removal; 4) compare capture probabilities (as a surrogate of survival) of Razorback Sucker and Colorado Pikeminnow held in salted vs unsalted water during handling to determine if salted water increased survival.

Three passes occurred in the spring of 2018 (March and April) using raft mounted electrofishing. The work took place between Mexican Hat and Clay Hills, Utah on the San Juan River.

The mean Channel Catfish (all size classes) CPUE in 2018 in the lower San Juan River was 50 fish/hr. Adult Channel Catfish (300 + mm) CPUE of 25 fish/hr in 2018 was the highest CPUE calculated in the lower San Juan River. Colorado Pikeminnow CPUE of 0.69 fish/hr has remained stable since 2013. Razorback Sucker CPUE of 1.77 fish/hr in 2018 was also the highest calculated in the lower San Juan River.

Mean size (total length) of Channel Catfish in 2018 was 316 mm and the second highest calculated in the lower canyon of the San Juan River. Mean total length prior to 2018 was stable around 265 mm except for 2008 (324 mm), which was the largest mean length recorded in the lower canyon.

Abundance estimates for Channel Catfish have remained stable since the inception of the nonnative fish removal project. The estimates have consistently remained close to 20,000 Channel Catfish.

There was no difference in capture probabilities for Colorado Pikeminnow and Razorback Sucker held in salted water compared to fish held in river water. Also capture probabilities increased as fish length increased for both Colorado Pikeminnow and Razorback Sucker.
INTRODUCTION

Native fishes in the Southwestern United States have been negatively impacted by extensive water development, anthropogenic alteration of habitats, and the spread of nonnative fishes (Minckley and Marsh 2009). The establishment of nonnative species occurred via the intentional planting of desired sport fishes and through illegal stockings. The widespread distribution of nonnative species has led to the homogenization of fish communities throughout the Southwest and elsewhere and potentially affects the persistence and structure of native fish communities (Rahel 2002). Within the Upper Colorado River Basin (i.e. Colorado, Green, and San Juan Rivers), increases in the abundance of nonnative fishes coupled with habitat changes have led to reductions in abundance and range contractions of many native fishes. Subsequently, four native species including the Colorado Pikeminnow, Razorback Sucker, Humpback Chub (*Gila cypha*), and Bonytail (*Gila elegans*) have been listed as endangered and are fully protected under the Endangered Species Act. Competitive and predatory interactions between native and nonnative fishes have been identified as potential factors limiting recovery of these species, and managers within the Upper Colorado River Endangered Fish Recovery Program and the San Juan River Recovery Implementation Program have established removal projects to control nonnative fishes (Mueller 2005).

The lower San Juan River in southeastern Utah contains remnant populations of Colorado Pikeminnow and Razorback Sucker (Ryden 2000, Davis et al. 2010). These populations are recruitment limited and augmentation activities were instituted in 1994 to re-establish populations (Ryden 2003). Since the threat of nonnative fishes exists and there was concern that striped bass and other Lake Powell fishes may colonize and establish reproducing populations within the Lower San Juan River (Gustaveson et al. 1984), the Utah Division of Wildlife Resources Moab Field Station (UDWRMFS) initiated the mechanical removal of nonnative fishes in the lower San Juan River from Mexican Hat, Utah to the Clay Hills Crossing beginning in 2002.

Since the initiation of the mechanical removal of nonnative fishes, conditions in the San Juan River have changed. A drought has persisted since 2002 reducing the elevation of Lake Powell. In addition, the San Juan River channel has shifted and now has a waterfall that prohibits upstream movement of fishes. Lower reservoir levels coupled with the waterfall have kept Lake Powell fishes from colonizing the San Juan River. Channel Catfish are now the most abundant nonnative fish in the San Juan River and have been the main target of recent removal efforts.

In 2015, nonnative removal work ceased in the lower canyon due to our effort shifting to the reach between Montezuma Creek and Mexican Hat. Monitoring and nonnative removal continued between Montezuma Creek and Mexican Hat in 2016 and 2017 with an experimental design to test the effectiveness of nonnative removal, but not in the reach below Mexican Hat. In 2018 and 2019, the nonnative fish removal project will assist the Kansas State University Channel Catfish diet study during the summer months. Since work has not occurred in the lower canyon for three years, the UDWRMFS wanted to move some effort back down into the lower canyon during spring of 2018 to assess any changes that have occurred during the three-year hiatus.
Specifically, the objectives of this study include: (1) Compare Channel Catfish, Razorback Sucker, and Colorado Pikeminnow catch per unit effort (CPUE) in 2015 to the post removal period (2018-2019). (2) Compare size structure of Channel Catfish between removal and post removal. (3) Compare Channel Catfish, Razorback Sucker, and Colorado Pikeminnow population estimates (pre and post removal). (4) Compare recapture probabilities of Razorback Sucker and Colorado Pikeminnow using salted vs unsalted water during handling.

METHODS

Study Area

The study area includes the lower canyon reach of the San Juan River from Mexican Hat (RM 52.8) to Clay Hills (RM 2.9), Utah (Figure 1). The river from RM 52.8 to RM 16.0 is primarily canyon bound with a bedrock substrate and dominated by riffle and run habitats. The lower stretch of the canyon has an active alluvial bed from RM 16.0 to Clay Hills (RM 2.9). The study area of river has been identified as nursery habitat for native and endangered fishes (Archer et al. 2000).

Sampling

Sampling occurred via two raft mounted electrofishing boats in a downstream fashion with one boat on each shoreline. Each boat had one netter and one rower. Three five-day passes with six people were completed in March and April. Each electrofishing boat was outfitted with an ETS electrofishing system. Voltage for the ETS system was typically set between 300 and 400 depending on specific conductivity measurements. Individual sampling units consisted of approximately three-mile segments of shoreline fished by each electrofishing raft. The range of sample units per trip was between 13-20.

All nonnative fish were identified to species, enumerated, measured to the nearest mm for total length and released back into the river. All Channel Catfish, >130mm total length, also received an individually numbered T-bar floy tag and were scanned for a PIT tag. If a PIT tag was not present, one was inserted and then the fish was returned to the river on all trips.

All endangered fish were enumerated, measured to the nearest mm for total and standard length, weighed to the nearest gram, and scanned for a PIT tag. If a PIT tag was not present, one was inserted. All threatened and endangered fish collected were returned to the river at the location in which they were caught. Catch rates (CPUE) for all fish were calculated as number of fish caught per hour.

A closed population mark and recapture estimate was generated for Channel Catfish using Program MARK. We also calculated confidence intervals around the estimate, the coefficient of variation, and the probability of capture.
Turbidity (Secchi disk depth, mm), water temperature, and conductivity were measured once a day; additional daily measurements were taken if an obvious change in flow or turbidity was observed. River discharge was determined from the USGS gage # 09379500 near Mexican Hat, Utah.

Data Analysis

This project focused on evaluating temporal changes of CPUE, size structure, and population size of the fish communities in the section of the San Juan River between Mexican Hat and Clay Hills, UT during and after nonnative removal ceased. I also evaluated the effects of using salted water on capture/handling stress of Colorado Pikeminnow and Razorback Sucker. First, I tested for significant changes in the temporal variability of CPUE in Channel Catfish, Colorado Pikeminnow, and Razorback Sucker. Second, I tested for significant changes in the temporal variability of the size structure of Channel Catfish. Third, I tested for significant changes in the temporal variability of population sizes of Channel Catfish. Finally, I tested the effect of capture/handling on Colorado Pikeminnow and Razorback Sucker using an experiment comparing recapture probabilities (surrogate for mortality) of both species with a treatment of salted (0.6% NaCl) water and a control of unsalted (river) water in the live wells (Carneiro and Urbinati 2001). All analyses were done using RStudio (RStudio 2015) and significance was tested to $p \leq 0.05$ for objectives 1, 2, and 3. Akaike information criteria (AIC) was used for model selection for objective 4 (Akaike 1974). The boat that used the salted water was chosen randomly a priori using a random number generator.

For all analyses, I used nonnative removal data from March and April 2006-2018. I also only used Channel Catfish > 130 mm in all analyses.

RESULTS

Temporal variation in CPUE of Channel Catfish, Colorado Pikeminnow, and Razorback Sucker

Mean CPUE was calculated for each year (2006-2018), species (Channel Catfish, Colorado Pikeminnow, and Razorback Sucker), and tested for changes in trends. I used a nonparametric Kruskal Wallis test to determine significant differences in CPUE of all species and all years. When the overall test was significant, a post hoc Dunn’s test with Bonferroni correction was used to compare differences with 2018.

Colorado Pikeminnow CPUE varied significantly over time ($\chi^2=496.86$, df=10, $p<0.001$). Several years (2009, 2010, 2011, and 2012) were significantly different from 2018 (Figure 2). A majority of the years demonstrated no variation in CPUE for Colorado Pikeminnow (Figure 2). Razorback Sucker CPUE varied significantly between years ($\chi^2=189.93$, df=10, $p<0.001$). Catch rates for Razorback Sucker in 2018 were significantly higher than all years, but 2015 (Figure 3). Channel Catfish CPUE also varied between years ($\chi^2=203.02$, df=9, $p<0.001$). Catch rates in 2018 were the second highest observed after 2014 (Figure 4). I then separated them out by size class (subjuvenile (sj): 130-199 mm, juvenile (j): 200-299 mm, and adult (a): 300+ mm) and tested for differences between each size and year. All three size classes varied significantly over time (sj: $\chi^2=375.92$, df=9, $p<0.001$; j: $\chi^2=236.09$, df=9, $p<0.001$; a: $\chi^2=387.16$, df=9,
Subjuvenile Channel Catfish catch rates in 2018 were significantly lower than all years except 2008 and 2009 (Figure 5). Juvenile Channel Catfish catch rates in 2018 were significantly higher than 2007-2009, and 2012, but were significantly lower 2013 and 2014 (Figure 5). Adult Channel Catfish CPUE in 2018 was significantly higher than all years (Figure 5).

Temporal variation in size structure of Channel Catfish

The objective was to test if mean total length of Channel Catfish in 2018 (after nonnative removal ceased) significantly differed from previous years (during nonnative removal). I calculated mean total length of Channel Catfish for each year (2007-2018) then tested for significant differences between years using a nonparametric Kruskal Wallis test. When the overall test was significant, a post hoc Dunn’s test with Bonferroni correction was used to compare differences with 2018.

Mean total length varied significantly between years ($\chi^2=6871.38, \text{df}=9, p=<0.001$). Mean total length of Channel Catfish in 2018 was significantly higher than all years except 2008 (Figure 5). Mean total length was lowest in 2012 (Figure 6).

Temporal variation in population size of Channel Catfish

I analyzed Channel Catfish population size differences by comparing population size and their associated 95% confidence intervals between all years (2003-2018). There were several years that were significantly different from one another (i.e. 2014 vs. 2018), but the general trend of all years is stable around 20,000 Channel Catfish (Figure 7).

Effects of salt water on the stress of Colorado Pikeminnow and Razorback Sucker during capture/handling

I used a generalized linear model to test if capture probabilities of fish held in salted water were higher than the capture probabilities of fish held in river water. I used total length and treatment as fixed factors and their interaction was included in the model and used AIC to select the best model. I chose the models with $\Delta \text{AIC}_c$ values below 2 (Burnham and Anderson 2004, Burnham et al 2011). Total length and the additive model of total length and treatment were the two models that had $\Delta \text{AIC}_c$ values $\leq 2$ and explained 84% and 86% of the variability for Colorado Pikeminnow and Razorback Sucker, respectively (Tables 1 and 2). There were no significant differences in capture probabilities of fish held in salted vs not salt water for both species (Figures 8 and 9). Also recapture probabilities increased as fish got larger for both species (Figures 10 and 11).

DISCUSSION

Temporal variation in CPUE of Channel Catfish, Colorado Pikeminnow, and Razorback Sucker

Catch per unit effort is a standard metric used by fisheries professionals to compare temporal and spatial trends in the relative abundance of fish populations (Ney 1999). Channel Catfish CPUE
gradually increased from 2010 to 2014 while nonnative removal was occurring. While nonnative removal was efficient at removing larger, adult (300+ mm) size Channel Catfish, an increasing juvenile (200-299 mm) population fueled this increase in relative abundance. Then in 2015 juvenile catch rates decreased and sub-juvenile (61-199 mm) catch rates increased. We shifted nonnative removal’s effort out of the lower canyon in 2016-2017 and no work was done in this reach for two years. That two year hiatus allowed the abundant smaller size classes of Channel Catfish to recruit into adult fish hence the high number adults sampled in 2018 (Figure 5).

Colorado Pikeminnow catch rates have remained relatively stable since 2013. There was a large peak in 2009, but that was due sampling after a stocking event happened in the spring. After that incident, Colorado Pikeminnow were stocked in the fall and at a much smaller size (YOY). The stability in relative abundance could be result of multiple issues including carrying capacity, low survival, or immigration. Colorado Pikeminnow are a long-lived, r-selected species with high fecundity (≤ 100,000 eggs). Since they are long-lived, reproduction does not need to occur every year, but 400,000 young of the year are stocked every fall. A majority of these fish do not survive, but stocking this amount every year could result in reaching carrying capacity. Immigration could be an issue because there is no way to assess if the Colorado Pikeminnow that are stocked every year remain in the river or if a majority of them emigrate downstream below the Piute Farms waterfall. Survival could also be an issue in the San Juan River. Clark et al (2018) reported that survival of Colorado Pikeminnow ages 1-3 is extremely low and capture/handling associated with sampling could be the contributor. After the results of this study were published fewer sampling trips are occurring (Channel Catfish removal is not occurring) and Colorado Pikeminnow ages 1-3 are not being handled. This reduction in capture/handling will likely result in increased survival of Colorado Pikeminnow.

Razorback Sucker CPUE has remained relatively stable until recently. The recent increase in relative abundance of Razorback Suckers could be a result of multiple issues including emigration and stocking. Razorback Sucker are stocked in the San Juan River on a yearly basis. Approximately 170,000 Razorback Sucker have been stocked in the San Juan River since augmentation began in 1994 (Furr 2019). If the recent increase in CPUE was a result of stocking, I would have expected the increase to occur much earlier (early 2000’s). Emigration from below the waterfall could also have resulted in the recent relative abundance increase. Beginning in 2016, work below the Piute Farms waterfall on the San Juan has resulted in the transfer of 407 individual Razorback suckers above the waterfall into the San Juan River (STReaMS 2019). During the field work for this study 25 of the 174 Razorback Suckers captured were transferred from below the waterfall.

Temporal variation in size structure of Channel Catfish

A common occurrence in exploited fish populations is a reduction in overall size of the population. Past research within the Powder River drainage in Wyoming indicated that population structure and abundance of Channel Catfish changed considerably as adult exploitation rates increased (Gerhardt and Hubert 1991). Gerhardt and Hubert (1991) reported that an annual exploitation rate of 22% would result in a 75% reduction in overall abundance of catfish ≥ 300 mm TL, and cause a substantial shift towards smaller individuals. Similar shifts in
yield and size structure have been observed in sport and commercial fisheries as the rate of exploitation increased (Bennett 1971, McHugh 1984, Pitlo 1997).

In the San Juan River, shifts in lengths of Channel Catfish were observed in upstream reaches (Davis 2005) and on a river-wide scale (Ryden 2005) after the initiation of nonnative fish removal. Specifically in the lower canyon mean total length of Channel Catfish was reduced after nonnative fish removal was initiated (Hines 2015). Nonnative removal ceased in the lower canyon in 2015 and since then mean length of Channel Catfish has increased ~50mm (Figure 6). This increase in mean total length will likely continue until the population hits its carrying capacity and stabilizes. Larger Channel Catfish will be more abundant and could negatively impact the fish community.

Temporal variation in population size of Channel Catfish

Abundance estimates for Channel Catfish have remained relatively constant since the inception of the nonnative removal project in 2002. The most probable cause of this population stability is low exploitation rates, especially in the smaller size classes of Channel Catfish. Exploitation rates are typically < 20 % for most size classes of Channel Catfish in the lower San Juan River (Hines 2014, 2015). Pennock et al (2018) reported that the exploitation rates of nonnative removal in the San Juan River are not enough to see declines in abundance estimates.

Several factors likely contribute to the low exploitation rates; sampling methods and turbidity. Electrofishing is the primary method used to remove Channel Catfish in the San Juan River and it inherently has biases toward sampling larger fishes (Dolan and Miranda 2003). High turbidity is another factor that can contribute to the low exploitation rates (Lyon et al 2014). The San Juan River is subject to high turbidity during spring runoff and summer monsoonal events, typically when sampling occurs. Visibility can range from 5 mm to 50 mm when turbidity is high. The combination of low visibility and biased sampling are the likely two main causes of the low exploitation rates.

Effects of salt water on the stress of Colorado Pikeminnow and Razorback Sucker during capture/handling

Stress associated with capture and handling is a commonly documented response in the fisheries field (Clark et al 2018, Gharacheh 2018, Martins et al 2018). Mucous production and cortisol levels typically increase, which eventually could lead to delayed mortality (Tacchi et al 2015, Sadoul and Geffroy 2019). The use of salt in live wells is a documented practice in recovery water to reduce stress in teleosts (Barton and Zitzow 1995, Tsuzuki et al 2001, Tacchi et al 2015). Clark et al 2018 concluded that young Colorado Pikeminnow (ages 1-3) had extremely high mortality rates and one factor that is likely contributing to low survival was capture and handling during fieldwork. In response to the work done by Clark et al 2018, I wanted to test if salted water would reduce handling and capture stress (i.e. increased recapture rates).

Although recapture rates of fish, (both species) held in salted water were higher than recapture rates of fish held in river water, they were not significantly higher. Several factors can lead to this relationship being non-significant including water temperatures and number of recaptures.
This study was done in the spring when water temperatures ranged from 7.4-13.6 °C, which is relatively low for the San Juan River. When temperatures are lower, stress is typically lower on fish because there is more available oxygen (Matthews and Berg 1997). If this study was done during the summer, when water temperatures are relatively higher, then a significant relationship between salted water and recapture rates may occur because of the increased stress of the control water. Recapture rates were low due to the study only being done during one sampling season. Originally, the study was proposed for two years, but was not funded for the second year. Since there is one year of data, I am only relying on recaptures between trips and incidental antenna detections. If a second trip was done I would have likely had more recaptures and would have narrowed the confidence intervals of the recapture rates.

CONCLUSIONS AND RECOMMENDATIONS

- The CPUE of Channel Catfish in 2018 increased since 2015. Adult CPUE tripled from 8.5 fish/hr to 25.5 fish/hr. Smaller sub-juvenile fish CPUE significantly dropped from 14 fish/hr in 2015 to 1 fish/hr in 2018. The increase in adult CPUE and drop in of sub-juvenile CPUE is likely the result of Channel Catfish not being removed in this section of river since 2015. The sub-juvenile Channel Catfish in 2015-2017 filled the empty niche of adult Channel Catfish, which was created during nonnative removal efforts. Electrofishing is biased towards larger individual fish, so by eliminating electrofishing in this section this allowed the smaller fish to recruit to adult sized Channel Catfish.
- Catch rates of Colorado Pikeminnow have remained stabled in the lower canyon of the San Juan River.
- Catch rates of Razorback Sucker have almost doubled since 2015. This increase is most likely due to the transfer of fish from below the Piute Farms waterfall to above. In 2018, 15% of the Razorback Suckers captured were transferred from below the waterfall.
- Mean total length of Channel Catfish has increased by 48 mm since nonnative removal ceased in the lower San Juan River in 2015.
- Although there is considerable variation, abundance estimates of Channel Catfish in the lower San Juan River have remained relatively stable since removal began in 2002. Estimates of Channel Catfish abundance were relatively imprecise (indicated by large confidence intervals) from 2003 to 2006, but have improved in recent years with the notable exception of 2012.
- Results from the salt study suggest that using salt in live wells may have no effect on recapture rates of endangered fish. The findings showed that using salt in live wells had no effect on recapture rates of Colorado Pikeminnow and Razorback Sucker. Caveat: this study was done in the spring when water temperatures were quite low. In the future we should think of doing this study again in the summer when water temperature and stress levels are higher. That would allow the results to be more meaningful.
LITERATURE CITED


Table 1. General linear models of recapture rates of Colorado Pikeminnow held in salted (treatment) vs un-salted water. Treatment and total length (TL) were the fixed factors in the model. Models are ranked by Akaike’s information criterion (AICc).

<table>
<thead>
<tr>
<th>Models</th>
<th>K</th>
<th>AICc</th>
<th>Delta_AICc</th>
<th>AICcWt</th>
<th>Cum.Wt</th>
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<tr>
<td>Treatment+TL</td>
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<td>74.46866</td>
<td>1.150922</td>
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<td>Treatment*TL</td>
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<td>26.149458</td>
<td>0.0000011</td>
<td>1</td>
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</tbody>
</table>

Table 2. General linear models of recapture rates of Razorback Sucker held in salted (treatment) vs un-salted water. Treatment and total length (TL) were the fixed factors in the model. Models are ranked by Akaike’s information criterion (AICc).

<table>
<thead>
<tr>
<th>Models</th>
<th>K</th>
<th>AICc</th>
<th>Delta_AICc</th>
<th>AICcWt</th>
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<td>0.00098883</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 1. Map of the San Juan River from Mexican Hat to Clay Hills, UT.
Figure 2. Mean electrofishing catch-per-unit-effort of Colorado Pikeminnow in the lower San Juan River by year. Error bars represent 95% confidence intervals.

Figure 3. Mean electrofishing catch-per-unit-effort of Razorback Sucker in the lower San Juan River by year. Error bars represent 95% confidence intervals.
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Figure 11. Recapture rates of Colorado Pikeminnow by size (total length (mm)). Shaded area represents the 95% confidence intervals.