

# San Juan River Demographic Monitoring 2019

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## Study Schedule: 2019 – 2024

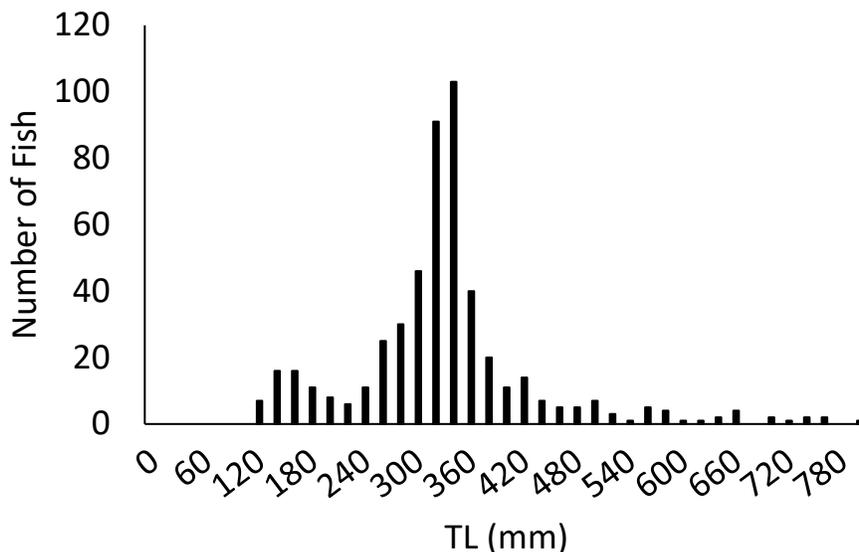
Sampling will occur in Fiscal Year (FY) 19 – 21. No sampling will occur for Demographic Monitoring in FY22-23, however fall Adult Monitoring may resume. For reporting in FY19 and FY20, estimate of age-specific capture probabilities per pass and age-specific abundance will be provided as per the Scope of Work. In FY21, a larger overall report will be generated in a more formal format that will include more in depth discussion and an additional estimate of age-specific survival for Colorado Pikeminnow and Razorback Sucker.

## Accomplishment of FY2019

### Colorado Pikeminnow

Sampling occurred from 26 August through 5 October. We completed three passes in the middle section of the San Juan River from Shiprock Bridge (river mile (RMI) 147.9) to Sand Island boat launch (RMI 76.5). Trip 1 took place from 26 August and ended 30 August. Trip 2 took place from 17 September and ended 21 September. The final trip, trip 3, took place from 1 October and ended 5 October.

There were 501 capture events of 430 individual Colorado Pikeminnow over the three trips. These fish ranged from 105 mm in total length (TL) to 786 mm TL (Figure 1), and weighed from 7 to 4700g. Captures spanned the entire length of the sampling area, from RMI 147.9 to 76.5. Of the 501 capture events, 493 were fish large enough to PIT tag (i.e. greater than 130mm TL). The largest peak for size of Colorado Pikeminnow was between 320 and 359mm TL (Figure 1).



*Figure 1. Length frequency histogram for Colorado Pikeminnow, 20mm TL denominations*

Of the 501 capture events for Colorado Pikeminnow 166 of these were from trip 1, 104 were from trip 2, and 231 from trip 3. Trip 1 had 166 captures of 151 individual Colorado Pikeminnow. Within trip recaptures of fish totaled twelve that were captured twice and one fish that was captured four times.

There were 113 fish that were tagged on this trip, meaning this was the first encounter of this fish, they ranged from 105mm TL to 572mm TL.

On trip 2, 102 individual fish were captured of the 104 capture events. Only two fish had a single within trip recapture. There were 73 fish of the 102 individuals that did not have a PIT tag present when captured, these fish ranged from 138mm TL to 498mm TL. One of the fish that was captured twice during trip 2 was originally tagged during trip 1. Two fish were captured twice during trip 1 that were captured once during trip 2, one was tagged on trip 1 the other was tagged prior to demographic monitoring. There were four fish that were originally tagged during trip 1 that were recaptured during trip 2, and one fish that was a recapture during trip 1 and 2.

On trip 3, 208 individual fish were captured of the 231 capture events. There were four fish that were captured three times during trip three and fifteen fish that were captured twice during trip 3. A total of 131 fish were tagged on trip 3 ranging in size from 123mm TL to 515mm TL. Of the four fish that were captured three times during trip 3, one was captured during trip one but was tagged prior to demographic monitoring, the other three were tagged during trip three and captured two more times. Of the fifteen fish that were captured twice on trip 3, there was one fish that was also captured four times on trip one, six fish that were tagged on trip 3 and captured again, and nine fish that were captured sometime prior to demographic monitoring. In addition, there was one fish that was captured once during all three trips, nine fish that were captured once during both trip 2 and 3, and eleven fish that were captured in trip 1 and trip 3.

*Table 1. Captures of individual Colorado Pikeminnow (CPM) and Razorback Sucker (RBS) for each trip and recapture combination. \*Number of fish is included in individual trip totals (i.e. Trip 1, Trip 2, or Trip 3)*

	Trip 1	Trip2	Trip 3	Trip 1&2	Trip 1&3	Trip 2&3	All Trips
CPM	151	102	208	7*	13*	9*	1*
RBS	333	395	740	30*	57*	79*	6*

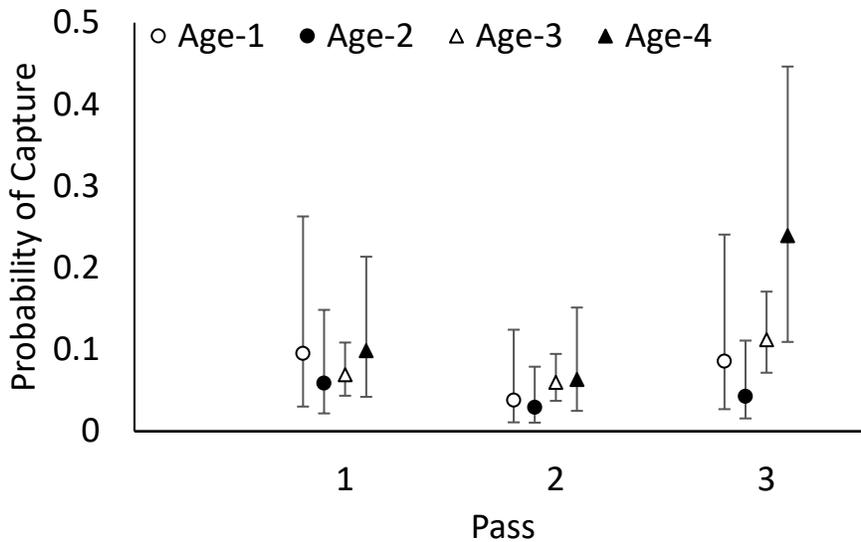
Three parameters were proposed to be estimated for this project using program MARK (White 2019): age-specific capture probabilities (per pass), age-specific survival (annual), and age-specific abundance (annual). However, age-specific survival cannot be estimated until after the third year of data collection due to limitations of the Robust Design. Here, we estimated the other parameters using Huggins' P and C closed captured model which allows for the use of individual covariates, however, we did not include them here in order to simplify modeling. Age classes were designated by total length of fish, age-1 100-199 mm TL, age-2 200-299 mm TL, age-3 300-399 mm TL, and age-4+ 400+ mm TL because previous length-age estimating tools did not perform well (i.e., Ryden 2006). We assessed three different model structures and ranked them using AIC (Akaike 1973): M(0) where there is no variation in probabilities of capture (p) or recaptures (c) over time, M(t) where there is variation in p and c among passes, and M(b) where there is no variation over time but there is a behavioral effect where (p) is not equal to (c). Based

on AIC selection, by far the best model was M(t) and therefore we report estimates from that model below (Table 2).

*Table 2. Results from AIC rankings for all ages of Colorado Pikeminnow combined.*

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance	-2log(L)
{Mt}	-2167.74	0	1	1	16	35.9063	-2200.18
{Mb}	-2140.06	27.6878	0	0	10	75.8537	-2160.23
{M0}	-2131.69	36.0576	0	0	5	94.351	-2141.73

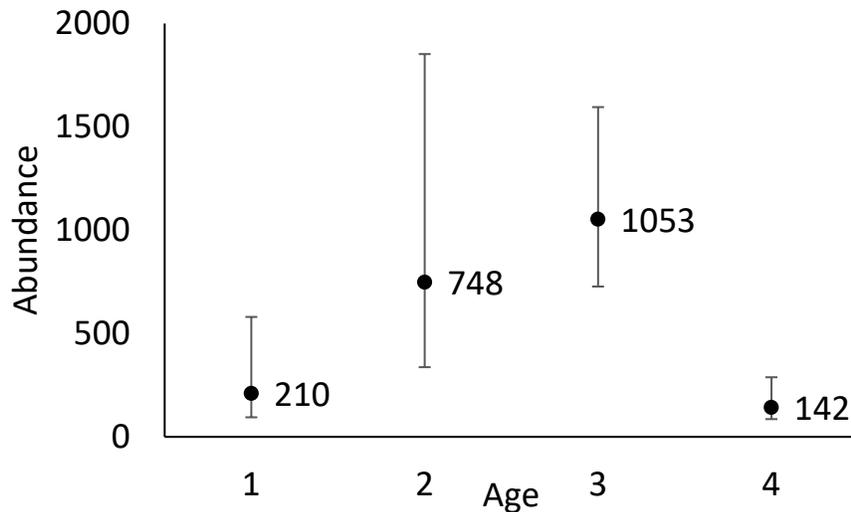
Age specific capture probabilities for Colorado Pikeminnow showed no statistical difference between passes within any of the age classes based on overlapping 95% confidence intervals. Estimates for age-1 fish ranged from 0.04 to 0.10 between passes with upper and lower 95% confidence intervals from 0.01 to 0.26. Age-2 estimates ranged from 0.03 to 0.06 with upper and lower 95% confidence intervals from 0.01 to 0.15. Age-3 estimates ranged from 0.06 to 0.11 with 95% confidence intervals from 0.04 to 0.17. Age-4+ estimates ranged from 0.06 to 0.24 with 95% confidence intervals from 0.02 to 0.45 (Figure 2). Raw values can be found in Appendix I.



*Figure 2. Age specific capture probabilities per pass for Colorado Pikeminnow captured in 2019. Error bars represent upper and lower 95% confidence intervals.*

Age specific abundances estimates were also calculated using program MARK using Huggins P and C closed capture model. Abundance estimate for age-1 fish was 210 fish in the study area with 95% confidence intervals from 95 to 580 fish. Age-2 estimate came out to 748 fish with 95% confidence intervals between 337 and 1852 fish. Age-3 estimate was 1053 fish with 95% confidence intervals

ranging from 727 to 1595. Finally, age-4+ fish had an estimate of 142 fish with 95% confidence intervals between 86 and 288 individuals (Figure 3). Raw values can be found in Appendix I.

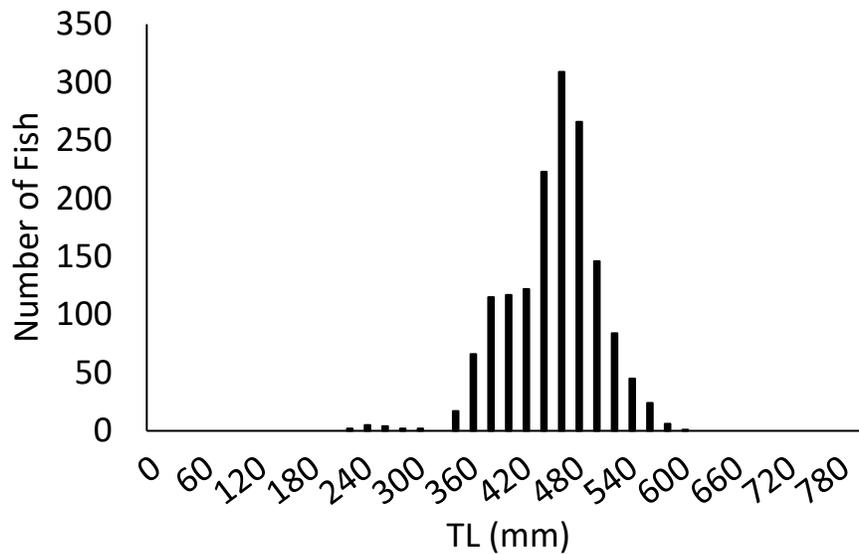


*Figure 3. Age specific abundance estimates for Colorado Pikeminnow between San Juan River miles 147.9 to 76.0. Confidence intervals are 95%.*

### Razorback Sucker

There were 1550 capture events of 1290 individual Razorback Sucker over the three trips. These fish ranged from 200 mm in total length (TL) to 585 mm TL (Figure 4), and weights from 68 to 1900 g. A noticeable peak in the length frequency histogram formed around the size class of 460 to 479mm TL. Captures spanned the entire length of the sampling area, from RMI 147.9 to 76.0. Of the 1550 capture events, 53 of these were fish that did not have a PIT tag present upon capture, three of which escaped prior to being tagged.

A point of interest was the capture of 15 fish under 300mm TL, which is the minimum length of stocked Razorback Sucker (Figure 4). These fish ranged in size from 155mm TL to 290mm TL. Captures of these fish spanned the entire length of the sampling area from the first mile sampled to the very last mile sampled. Of the fifteen fish under 300mm TL, two fish were recaptures. The first was a recapture without information on the tagging event. The other was a capture of a fish that was tagged in the spring during the Age-1 Razorback Sucker sampling trip. This fish was captured twice during the fall within two miles of where it was tagged in the spring.



*Figure 4. Length frequency histogram for Razorback Sucker captured, 20 mm TL denominations*

Trip 1 had 338 captures of 333 individual Razorback Suckers, five fish had a within trip recapture. Of the 333 individuals, 15 fish were not tagged upon capture, 13 of which received a PIT tag prior to release, two fish were able to escape prior to receiving a tag. Fish total length ranged from 210mm to 560mm on this trip.

Trip 2 had 404 captures of 395 individual fish, one fish was captured three times during trip 2, and seven fish were captured twice during this trip. Of the 395 individuals captured on trip 2, 36 were recaptures from trip 1, and 20 individuals did not have a PIT tag prior to being captured. All fish that did not have a PIT tag prior to being captured were implanted with one before being released. Fish ranged in size from 235mm to 585mm total length.

Trip 3 had 808 captures of 740 individual fish, three fish were captured three times, one of these three fish was captured on trip one, another one of the fish was captured on trip two, and the third was only captured on trip 3. There were 63 fish that had one within trip capture, eight of these fish were recaptures from trip 1, four fish were recaptures from trip 2, and one of the fish from trip two had a within trip recapture from trip 2. A total of 675 fish were captured only once during trip 3, of those, 47 were recaptures from trip 1, with one being captured twice during trip 1. An additional 74 fish were recaptures from trip 2, one of which was captured twice during trip 2 while another was captured three times during trip 2. Six fish were captured during all three trips with one of the six being captured twice during trip 2.

Age class specific capture probabilities were calculated for each pass using program MARK and running closed capture Huggins' p and c model. Similar to Colorado Pikeminnow, the M(t) model was by far the most supported and we present estimates from that model (Table 3). Capture probabilities were similar between all three passes for juvenile Razorback Suckers (<400 mmTL), as well as passes one and two, the only significant difference observed was for adult age class ( $\geq 400$  mmTL) fish in pass three which

was significantly higher than any other capture probability based on confidence intervals that do not overlap (Figure 5).

Table 3. Results from AIC rankings for all life stages of Razorback Sucker combined

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance	-2log(L)
{Mt}	-11093.78	0	1	1	8	20.8386	-11109.817
{Mb}	-10955.756	138.0243	0	0	4	166.8894	-10963.766
{M0}	-10841.965	251.8152	0	0	3	282.685	-10847.971

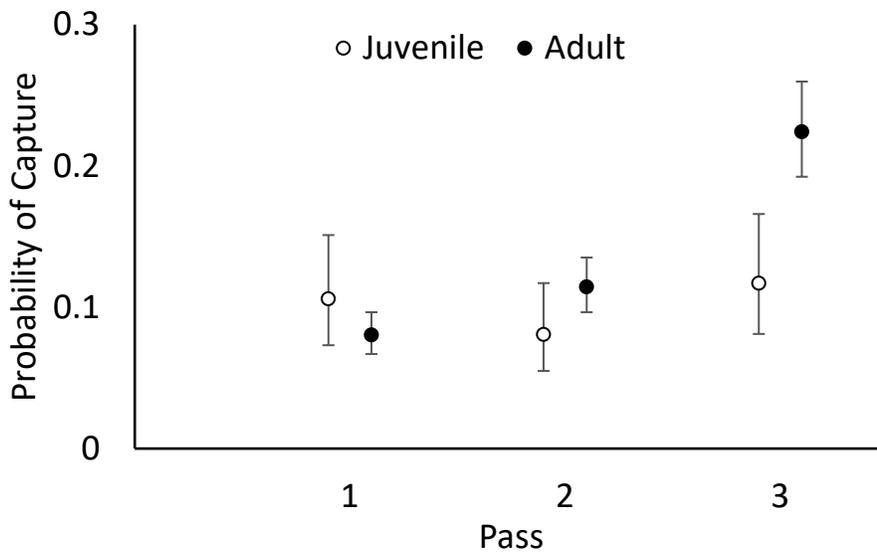
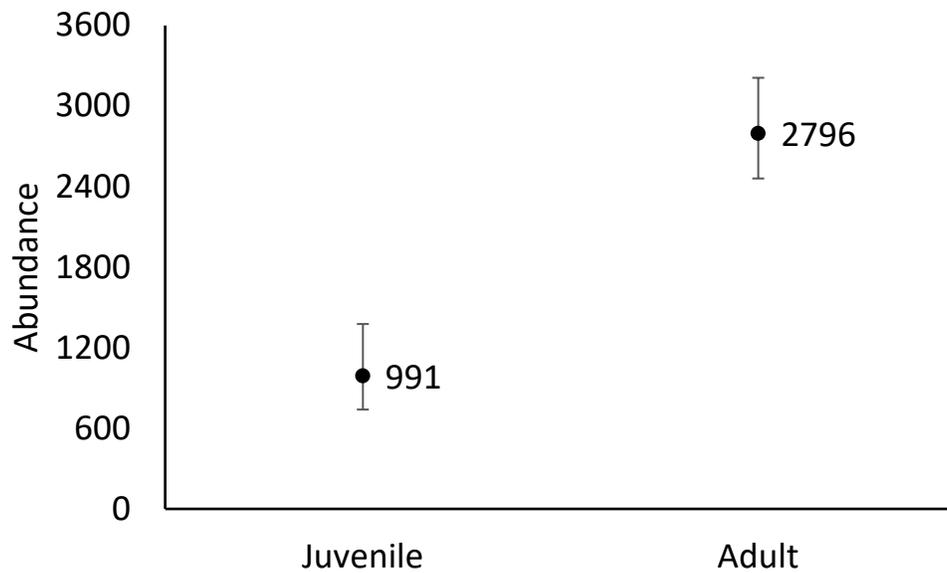


Figure 5. Age class specific capture probabilities for three sampling passes on the San Juan River between river miles 147.9 and 76.0. Age classes are separated into juvenile and adult age class. Confidence intervals are 95%.

Juvenile and adult Razorback Sucker abundance estimates were calculated using program MARK. Juvenile abundance was 991 individuals with upper and lower 95% confidence intervals of 1377 and 740 individuals respectively. Adult abundance was 2796 individuals with upper and lower 95% confidence intervals ranging from 3210 to 2461 individuals respectively (Figure 6).



*Figure 6. Age class specific abundance estimates for Razorback Sucker between San Juan River miles 147.9 to 76.0. Confidence intervals are 95%.*

## Additional observations

In addition to Colorado Pikeminnow and Razorback Suckers, two more species were captured. A single Roundtail Chub was captured during trip 1 at RMI 124. This fish had a total length of 200mm and weight 68g, there was also no PIT tag present upon capture but received one prior to being released. There were 29 individual Flannelmouth Sucker x Razorback Sucker hybrids as well captured between the three passes. They ranged from 163 to 540mm TL, from 42 to 1400g in weight, and a PIT tag was inserted if one was not preset prior to release. Fish were determined as hybrid based on assessment of physical attributes at time of capture. Two of these fish were recaptured from other projects prior to Demographic Monitoring, and two fish were captured on multiple Demographic Monitoring trips, Trip 1 and Trip 2, and another on Trip 2 and Trip 3.

## Recommendations

We recommend to continue with Demographic Monitoring in FY20 and FY21 as planned. Continue to use sampling methods as described in the original SOW to allow for comparative analyses from year to year. We also recommend continuing to sample hybrids and other rare fish other than the two targeted species (i.e. Colorado Pikeminnow and Razorback Sucker).

## Literature Cited

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. Pages 267–281 in B.N. Petrov and F. Csáki, editors. Proceedings of the Second International Symposium on Information Theory. Akadémiai Kiadó, Budapest, Hungary.

Ryden, D.W. 2006. Augmentation of Colorado Pikeminnow in the San Juan River: 2005. U.S. Fish and Wildlife Service Colorado River Fisheries Project. Grand Junction, CO. 20 pp.

White, G.C. 2019. Program MARK: Mark and Recapture Parameter Estimation.

## Appendix I

Output for Figure 2. Capture probabilities per pass for Colorado Pikeminnow with 95% Confidence Intervals

Pass	Age	Label	Estimate	SE	LCI	UCI
1	1	p	0.095421	0.053661	0.030246	0.262954
2	1	p	0.038168	0.023874	0.010971	0.124314
3	1	p	0.085879	0.048717	0.027084	0.240727
1	2	p	0.058831	0.029004	0.021899	0.148584
2	2	p	0.029416	0.015165	0.010587	0.079053
3	2	p	0.042786	0.021461	0.015753	0.11098
1	3	p	0.0693	0.016212	0.043516	0.108628
2	3	p	0.059807	0.014266	0.037247	0.094688
3	3	p	0.11202	0.024923	0.071667	0.170911
1	4	p	0.098546	0.041267	0.042129	0.21366
2	4	p	0.063351	0.029377	0.02499	0.151453
3	4	p	0.239325	0.087391	0.109363	0.446333

Output for Figure 3. Age specific abundance estimates for Colorado Pikeminnow between San Juan River miles 147.9 to 76.0. Confidence intervals are 95%.

Age	Estimate	SE	LCI	UCI	CV
1	210	109.1157	94.65314	580.3271	0.519599
2	748	352.1259	337.2113	1852.096	0.470756
3	1053	215.8191	727.3171	1595.421	0.204956
4	142	47.32444	85.92705	288.4386	0.333271

Output for Figure 5. Age class specific capture probabilities for Razorback Sucker with 95% Confidence Intervals.

Pass	Index	Label	Estimate	SE	LCI	UCI
1	Juvenile	p	0.1059468	0.0196573	0.07313	0.15109
2	Juvenile	p	0.0807213	0.015611	0.054944	0.117093
3	Juvenile	p	0.1170459	0.0214299	0.081127	0.165995
1	Adult	p	0.0804674	0.0075158	0.066913	0.096483
2	Adult	p	0.1144426	0.0098478	0.096512	0.135206
3	Adult	p	0.2242359	0.0171866	0.192352	0.259705



## Response to Comments

### Tom Wesche comments:

Does this include fish > 500 mm? If so, should designate as >=Age 4

Changed to age-4+ as it encompasses anything larger than age 3

This range is incorrect given estimate of 142.

Fixed

What size classes for adults? >400 mm?

Correct, incorporated into the text for clarity

### New Mexico Department Game and Fish comments:

The report should be reformatted to include an Introduction, Methods, Results, and Discussion section. If you plan to include this information in a final report at the end of the three years, this should be stated. At a minimum, a Methods section should be included to describe the sampling methods and study area.

The format for this report replicates the “Monitoring the Colorado pikeminnow population estimate in the mainstem Colorado River via periodic population estimates” (Project 127) in the upper basin. Demographic Monitoring itself is based off of Project 127 as will the reporting format. Information about greater detail placed in the final report has been included.

A comparison of CPUE from the first pass of this study to single pass CPUE from previous Adult Monitoring data should be provided for RBS and CPM. This would provide a good comparison between 2020 data and previous years.

Demographic Monitoring is a three pass project with four shocking rafts completing a single pass. These passes are preformed intermittently from late August to the beginning of October. Sampling of similar river miles for Adult Monitoring takes place in the latter half of September with only two shocking rafts. To pull a single pass from Demographic Monitoring and only use the “downstream boats” for the 2<sup>nd</sup> pass would still not be a similar comparison as only endangered fish are being netted. During Adult Monitoring all fish are netted which would create differences in catch rates and probability of being netted. If there can be some use for a comparison in future reports, then we can included them in the 2<sup>nd</sup> year’s report or even in the final report after the third year.

I would add ticks on both axes on this graph and others. Displaying this graph as a stacked bar graph with tagged/untagged fish would also be helpful.

This graph displays fish captures, not necessarily individual fish, there are multiple recaptures of fish, fish that are tagged and then recaptured on later trips that would convolute any stacked bar graph. Tick marks are kept off as to not make the graph any busier than it needs to be.

The four paragraphs above this table could all be combined into this table.

Multiple tables were made for the narrative portion. These go into greater detail than the generalized Table 1 at the bottom.

[program MARK] Cite

Included

How were these breaks determined?

Switched terminology to “designated” as these age classes were arbitrarily assigned loosely based on age at length from past adult monitoring.

Introduce Akaike’s information criterion and cite

Included

Provide this information in a table

Included

Can a graph/breakdown be provided of fish captured by age/year class?

Unsure as to what information would be gained given that estimates are later produced for fish based on adult and juvenile.

Please provide more information on these fish. Where were they captured? Were any recaptures from previous tagging efforts? What was the size distribution of these fish?

Information added

This could all go into a table.

Multiple tables were created for this detailed of a narrative. Addition of those tables would not fit neatly into this report.

Please provide this information in a table

Included

How was this determined? Please state methods used to determine hybrid status. Were all “hybrids” implanted with a PIT tag?

Information included

**Scott Durst comments:**

For both Colorado Pikeminnow and Razorback Sucker it might be worth comparing the length frequency from Demographic Monitoring to Adult Monitoring in the same reach. I think that might be a good way to highlight that big cohort of CPM 300-350 mm. I don't think a cohort that big (proportionally) has ever been documented and it would be good to draw attention to that finding.

I was trying to stick with reporting on what was in the SOW for the FY19. If comparisons to Adult Monitoring are wanted, then we can include that in the report for FY20 and the final report in FY21. I have my concerns on how numbers can be misinterpreted between the two projects given one is targeting only endangered fish and the other is catching anything and everything in the river.

What do you think of a table showing the number of fish that each possible encounter history to summarize this? Seems like it might be a simple presentation of that data.

Multiple tables were made for the narrative portion. These go into greater detail than the generalized Table 1 at the bottom.

You did this independently for each age? Maybe it's worth showing the model result table? It'd be an opportunity to say that you present the parameter estimates for the Mt model since it was the only one that was supported (I assume that was the case).

Table with results has been included

Same comment as pikeminnow about summarizing this with the number of fish that each unique encounter history.

Multiple tables were created for this detailed of a narrative. Addition of those tables would not fit neatly into this report.

Model results table?

Included

Maybe say how you're evaluating this.

Changed to include that confidence intervals did not overlap

Is it part of the normal protocol to collect a fin clip from these fish? Do you think that might be worthwhile?

It is not normal protocol to collect fin clips from suspected hybrid native sucker X Razorback Sucker. A number of questions could be potentially answered, or partially answered. A few of those questions could be: At what rate is hybridizing happening; is this a product of a few successful spawns; are hybrids spawning with pure Flannelmouth or Razorback Suckers? This would be more a question for the BC and would more than likely be a stand-alone SOW that would take fin clips in from multiple projects.

Why are there two sets of upper and lower confidence intervals? Some look like they don't overlap the mean estimate.

Fixed