Dispersal, behavior and habitat use of stocked age-1 and established age-2 and age-3 Colorado Pikeminnow in the San Juan River

Proposed Scope of Work for FY 2022 and 2023 (Revised)

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Objectives

1) Evaluate the behavior and habitat use of recently stocked age-1 Colorado pikeminnow
2) Evaluate the movement and habitat use of age-2 and age-3 Colorado pikeminnow
3) Facilitate transport of Razorback Sucker above PNM weir and evaluate movements upstream

Background

Low survival rates of hatchery reared fish are common due to the stark differences between hatchery and natural environments (Araki and Schmid 2010). One approach to quantify the success of a stocking program for threatened or endangered fishes is the use of telemetry. Telemetry studies can provide information on the migration and distribution of released individuals in relation to stocking locations and habitat availability within natural stream systems (Li et al. 2021). These studies can also be used to test rearing and stocking strategies, such as conditioning or release methods. Understanding how environmental and hatchery conditions affect persistence of stocked individuals could improve the conservation efficiency of hatchery augmentations.

Individuals from the natural population of Colorado Pikeminnow *Ptychocheilus lucius* (CPM) in the San Juan River were last observed in the late 1990s. This population consisted of a few large adults and a limited number of larvae. Since the presumed extirpation of this population, a stocking program was established and is likely maintaining the current population of CPM in the San Juan River. However, it is not clear if that population can maintain itself through natural recruitment to reproductive adults. In 2021, larger age-1 pikeminnow will be stocked in the system so surveys will be able to measure natural reproduction via abundance of age-0 fish. In Task 1 of this scope of work (SOW), we propose to use radio telemetry to evaluate the dispersal, behavior and habitat use of these stocked age-1 fish. Ideally, we would also like to evaluate potential hatchery practices that could be implemented in the future (e.g., flow- or prey-conditioning). In Task 2 of the proposal, we propose to simultaneously use radio telemetry to track the movement, behavior and habitat use of age-2 and age-3 CPM that have been in the system for a minimum of 1 year. There appears to be a recruitment bottleneck for these juvenile CPM (Franssen et al. 2007, Clark et al. 2018), thus habitat use of this vulnerable stage might provide information on factors limiting survival, such as dispersal below the Piute Farms waterfall (Ryden and Ahlm 1996), entrainment in water diversions, or overlap with piscivorous nonnative Channel Catfish (Hedden et al. 2021). Moreover, current plans to evaluate CPM stocking efforts rely on subsequent recaptures or detections by active sampling or remote PIT antennas, and may take several years before enough data will likely be collected prior to evaluation. Using radio telemetry to assess the fate of these individuals should provide for a quicker assessment of the altered management strategy.

There are a number of previous studies that used radio telemetry to track the movement and identify habitat use of CPM, all of which focused on adult fish. McAda and Kaeding (1991) found that spawning movements of adult CPM averaged 23 km in the upper Colorado River. Trammell et al. (1993) found highly variable movement of CPM stocked in Kenny Reservoir on

the White River; some fish moved upstream, some downstream through the dam and others remained in the reservoir. In the San Juan River, Ryden and Ahlm (1996) found that adult CPM were generally sedentary but moved a short distance (5 km) upstream from the mouth of the Mancos to a putative spawning area (i.e., the "mixer"). Miller and Ptacek (2000) reported adult habitat use of seven radio tagged fish from the natural population and seven hatchery-reared fish. Fish primarily used run and eddy habitats and moved to specific habitats during spawning. They also tracked hatchery-reared adult fish, but the majority moved downstream and it was speculated they might have been in poor condition. This study provides a framework from which to compare habitat use and availability of younger fish that are currently in the system.

Durst and Franssen (2014) used PIT tag recaptures to quantify movements of age-1 and age-2 CPM at relatively course scales. Their findings indicated fish made long-distance upstream movements from spring to summer while moving back downstream over winter. Seasonal movements may be associated with maximizing growth along longitudinal and seasonal temperature regimes. Finally, Cathcart et al. (2019) noted use of tributaries by PIT-tagged CPM, with adults more likely to be found at the confluence with Chaco Wash, near Shiprock, NM and sub-adults at the confluence with McElmo Creek, near Aneth, UT. However, there is a clear knowledge gap in finer scale habitat use and movement patterns of juvenile CPM (i.e., age-2 and age-3 fish), which also coincides with relatively low survival of these age classes (Clark et al. 2018).

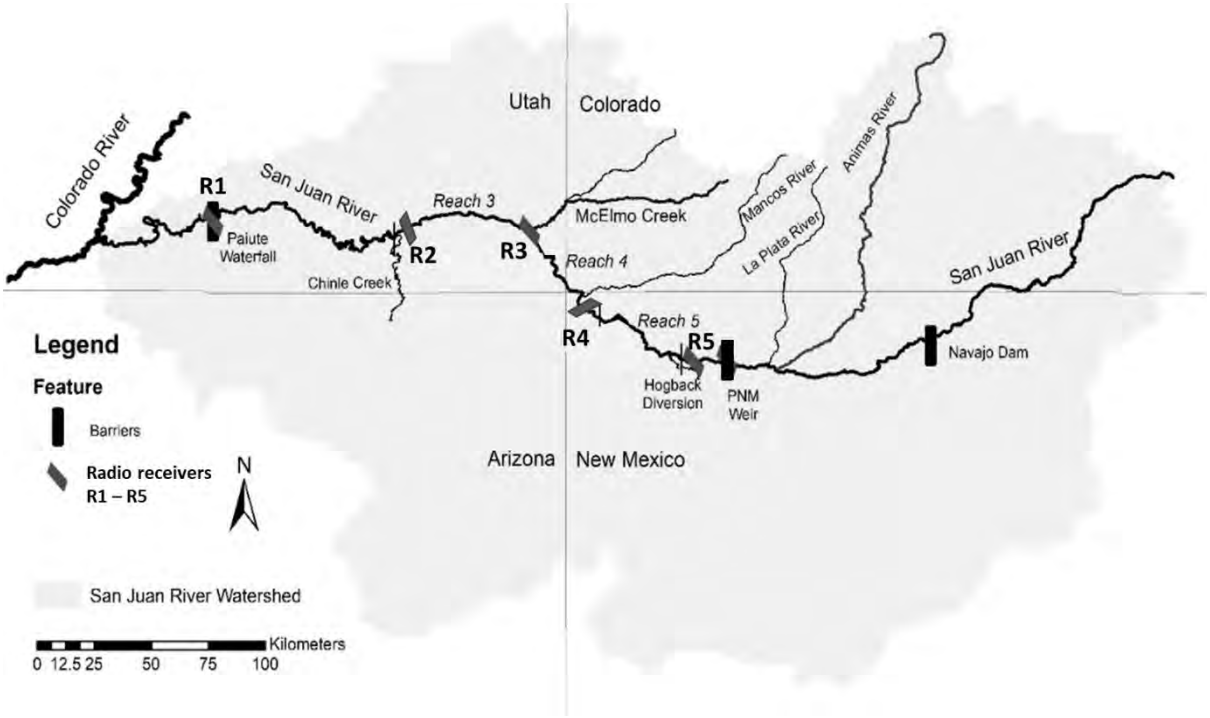

Figure 1, Map of San Juan River and location of radio receivers and study reaches.

Telemetry studies have been used to evaluate the dispersal and success of stocking hatchery-reared native fishes (e.g., Li et al. 2021). The proposed study will not only evaluate the immediate response of fish stocked in the river, but will quantify dispersal and habitat

preferences of sub-adult fish, which is lacking in the literature. For example, we can assess the use of different geomorphic reaches, secondary channels, cover and tributaries and their confluences. Such information may also increase our understanding of the importance of natural and reconstructed habitats to these life-stages (e.g., secondary channels). This project will leverage existing telemetry equipment and expertise at the Fish Ecology Lab at Kansas State University, where we are currently monitoring habitat use and dispersal of Razorback Sucker *Xyrauchen texanus* and Flannelmouth Sucker *Catostomus latipinnis* in the San Juan River. Specifically, we have installed stationary radio antenna receiver arrays at several locations along the river to delineate key transition points (Figure 1). These receiver arrays will help track long-distance dispersal of tagged fish and help focus our efforts on small-scale habitat use by stream reaches. This array will also be able to inform us where fish are likely residing among river reaches, increasing our ability to focus efforts to increase the frequency of reencountered individuals.

Task 1: Evaluate the behavior and habitat use of stocked age-1 Colorado Pikeminnow

Evaluating the success of stocking age-1 CPM is potentially critical to the recovery of this species. It is likely that fish coming from a hatchery setting will be disoriented after transportation and stocking. This project will quantify dispersal and habitat use of stocked fish to help understand if these fish are able to rapidly adapt to life in the river. We suggest that half of the tagged fish should undergo some type of hatchery enrichment (e.g., flow-conditioning) or be stocked at different locations that vary in habitat complexity to help optimize future stockings. However, we are not proposing specifics of potential experiments here, as those will likely need to be determined by the Biology Committee but will likely have limited impact to our proposed work on the ground.

Tagging - Age-1 CPM will be surgically implanted with small radio transmitters (ATS model F1530; 1.7 g, ~ 90 day battery life) at the Southwestern Native Aquatic Resource Recovery Center (SNARRC) at least one week prior to stocking in the San Juan River to assure survival and tag retention prior to stocking. Transmitters will not exceed 5% of the body weight of fish (Cooke et al. 2021) and our experience tracking fishes on the San Juan River suggest we will be able to locate individuals within a 10 m radius or smaller through triangulation. Transmitters will be placed in 25 fish/year and stocked at a location to be determined by the SJRBRIP. The number of fish able to be tagged is limited by the number of frequencies that can efficiently be monitored in the field (i.e., coded tags are too large for these size of fish). Timing of stocking is to be determined, but we expect stocking to occur in late summer or early fall. For the purposes of this proposal, we will assume stocking occurs in early September, but we should be able to complete the proposed work any time fish are stocked. Transmitters will use an external, whip antenna rather than an internal coil antenna to maximize detection range, which might be important if fish move into secondary channels.

Passive tracking - Stationary radio receivers will be setup near each of the reach breaks for passive detection (Figure 1). An additional stationary antenna will be placed at the Piute Farms Waterfall to capture any movement downstream of that barrier. Each stationary receiver has two Yagi antennas pointed up and down stream so that direction and time of movement can be

determined. Receivers scan through tag frequencies and pause when a fish is detected to scan through each antenna in turn. Stationary antennas will be equipped with rechargeable batteries and a solar panel for power and checked monthly. An additional two stationary radio receivers will be placed 2 km up- and downstream of the stocking location(s) and maintained for approximately 2 months to capture short term dispersal away from the stocking location(s).

Active tracking – For the first 4 days following stocking, daily rafting trips to locate fish will be made through the ~ 4 km reach (depending on access) surrounding the stocking location(s) to identify the precise location of stocked fish. Surveys might be modified if fish are found to move outside of the 4 km stocking reach (based on stationary antennas). For example, surveys might be longer distances and at lower frequencies if fish are found to move substantial distances downstream. Rafting trips will be conducted weekly following the first week (e.g., through September) and then monthly in October and November. Coordinates of fish will be recorded and their locations marked on aerial photographs in case it is necessary to return to evaluate habitat.

Habitat use - We will classify habitat at the location of fish occurrences at multiple spatial scales. At the finest scale, we will use the meso-habitat classification based on Miller and Ptacek (2000) and revised by Bliesner et al. (2009; Figure 2). Additionally, depth, substrate and

Habitat Features	
HABITAT	**DEFINITION**
1 Backwater	Typically a body of water off-channel in an abandoned secondary mouth, behind a bar or in a bank indention, water depth from <10 cm to >1.5 m, no perceptible flow, substrate typically silt or sand and silt. Little or no mixing of backwater and channel water.
3 Pool	Area within channel where flow not perceptible or barely so; water depth usually ≥ 30 cm; substrate silt, sand, or silt over gravel, cobble, or rubble.
6 Eddy	Same as pool, except water flow is evident (but slow) and direction typically opposite that of channel or circular.
8A Sand Shoal	Generally shallow (≤25 cm) areas with laminar flow (very slow to slow velocity: ≤5 cm/sec) over sand substrate
8B Cobble Shoal	Same as 8A except over cobble substrate
10 Run	Typically moderate or rapid velocity water 10-30 cm/sec with little or no surface disturbance. Depths usually 10-74 cm but may exceed 75 cm. Substrate usually sand but may be silt in slow velocity runs and gravel or cobble in rapid velocity runs.
15 Riffle	Area within channel where gradient is moderate (5 cm/m), water velocity usually moderate to rapid (10 to 31 cm/sec), and water surface disturbed. Substrate usually cobble and rubble and portions of rocks may be exposed. Depths vary from <5 to 50 cm, rarely greater.
19 Chute	Rapid velocity (⩾30 cm/sec) portion of channel (often near center) where gradient ⩾10 cm/m. Channel profile often U- or V-shaped. Depth typically ⩾30 cm. Substrate large cobble or rubble and often embedded.
20 Slackwater	Low velocity habitat usually along inside margin of river bends, shoreline invaginations, or immediately downstream of debris piles, bars or other in-stream features, but deeper than shoals (>25 cm).
21 Isolated Pool	Small body of water in a depression, old backwater, or side channel, not connected to the channel as a result of receding flows.
22 Embayment	Open shoreline depression similar to a backwater but that faces upstream. Typically at the top end of abandoned secondary channels or bars.
32 Rapid	Deep, high gradient, high velocity areas often with standing waves
35 Pocket water	Low velocity water similar to slack water, but in boulder fields. These usually occur in channel margins in the canyon reaches.
41 Plunge	The transition area below a riffle or chute where the channel deepens into a run with transition from high to low velocity.

Figure 2 Habitat classifications for the San Juan River recommended by Bliesner et al. (2009).

velocity will be recorded at the approximate point locations of fish occurrences. We also will quantify habitat at a 1-km reach scale to quantify channel complexity in the area in which the fish occurs. Measures such as channel braiding (island counts), sinuosity, mesohabitat diversity and large wood will be quantified for those 1-km reaches based on field surveys and aerial images of the river. Finally, we will look at the coarse distribution of fish at the scale of geomorphic reaches to identify affiliations to specific reaches within the river. Hall et al. (2018) provide an example of a large-scale based method of measuring habitat complexity that considers side channels, braids and wood jams that is useful in predicting salmonid recruitment and productivity.

Habitat availability – To quantify the selectivity or preference for specific habitats, we propose to quantify habitat availability to compare with habitat use based on locations of tagged fish. To optimize the time in the field, we propose a random sampling of points to identify availability. We will randomly select 200 points within each geomorphic reach using the 'spsurvey' package in R (Kincaid and Olsen 2011, Kegerries et al. 2020). At each random point (i.e., the equivalent to a random fish in the river), meso-habitat and 1-km reach habitat will be quantified to obtain a distribution of availability that can be compared to use by tagged fish.

Data analysis – Descriptive data will summarize dispersal distances and rates of movement of stocked fish. We will also quantify variation in dispersal among individuals. Habitat use will also be quantified for located individuals as well as identified on annual aerial photographs. Differences in dispersal between experimental treatments will be evaluated as needed. We will use the FishTracker tool in ArcMap to estimate home ranges and core use areas. This tool performs kernel density estimation using detection locations while accounting for transit times and hard boundaries (e.g., river banks). The 'adehabitat' package will be used to quantify habitat selection based on use and availability (Calenge 2006). We will also explore new statistical packages in R that are available to quantify movement and tracking of animals (Joo et al. 2020).

Task 2: Evaluate the movement and habitat use of age-2 and age-3 Colorado Pikeminnow

Capturing habitat use and dispersal of age-2 and age-3 CPM will provide basic information on the ecology of these sub-adult fish that has not previously been reported. We propose similar methods as in Task 1, but will capture 25-30 fish per year using electrofishing in late winter or early spring (around March) and use tags with longer battery life (ATS F1570; 3.1 g, ~ 250 day battery life). Sampling will occur between Hogback diversion and Sand Island within geomorphic reaches 3, 4 and 5. Prior to each trip, data from stationary radio receivers will be downloaded to help focus efforts on particular geomorphic reaches. We will use both passive and active tracking; including monthly floats of the river to monitor locations and habitat use of these fish. Because there appears to be a bottleneck in recruitment for these age classes (Clark et al. 2018), we will do more extensive habitat use surveys for these fish. Specifically, we will monitor diel movement of at least 6 fish, ideally spread out among the three geomorphic reaches (3, 4 and 5), during each monthly survey. A camp will be established near each target fish. The target fish will be located and observed for one hour to identify behavior or movement. One-hour observations will be made at a minimum of every 6 hours to understand diel change in location.

Tracking will be from shore or wading (e.g., Miller and Ptacek 2000) centered around dusk, dawn, mid-day and mid-night.

Task 3: Facilitated passage of Razorback above PNM weir

Due to COVID restrictions in spring 2020, Kansas State University was unable to conduct the first year of a telemetry study evaluating the translocation of Razorback Sucker above PNM weir. Translocations were successful in spring 2021 and provided information on habitat use and potential spawning locations above PNM weir. The San Juan River Basin Recovery Implementation Program Biology Committee indicated a desire to add this task to the current SOW to obtain a second year of data from the PNM weir to validate results from 2021. Similar methods will be used as described in the approved SOW "Facilitated fish passage for enhancing populations of endangered fishes in the San Juan River" (see https://www.fws.gov/southwest/sjrip/pdf/2021WorkPlan.pdf). Funds are requested to purchase 40 coded radio transmitters, personnel, and travel expenses.

Contingencies

High mortality of age-1 Colorado Pikeminnow **–** By tagging age-1 fish in the hatchery, we will be able to hold and observe tagged fish. This should minimize tagging mortality. If we notice high mortality of radio-tagged fish after stocking (tags have a mortality switch), we will work with the Program researchers to identify potential issues. For example, we might hold fish in mesh cages to identify if there is initial mortality following stocking. This could be done with radio tagged and control fish.

Ability to capture age-2 and age-3 Colorado Pikeminnow **–** We expect to capture enough (25-30) age-2 and age-3 CPM to implant radio transmitters. If abundances are low, we will work with other efforts (e.g., sampling for age-1 Razorback Sucker) to increase our chances of capturing enough individuals to complete this work.

Yearly Timeline

Task	Mar (22)	Apr (22)	May (22)	Jun (22)	Jul (22)	Aug (22)	Sep (22)	Oct (22)	Mar (23)	Apr (23)	May (23)	Jun (23)	Jul (23)	Aug (23)	Sep (23)	Oct (23)
Capture and tag age-2+ fish	**X**								**X**							
Track age-2+fish		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Tag age-1 CPM in SNARRC							**X**								**X**	
Track age-1 fish							**X**	**X**							**X**	**X**
Maintain remote radio antenna	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
PNM razorback translocation	**X**	**X**	**X**	**X**												

Deliverables

Annual reports will be produced for each field season (February – November) and completed by February the following year; prior to SJRBIP Biology Committee Meeting. A final report and data sets summarizing result of the study will be provided to the SJRBIP within 90 days after the completion of the project.

Budget

Period: October 1, 2021 to September 30, 2023

Category	Item	FY22	FY23	Total
Salaries				
Project PI: Advise student and coordinate graduate project	Dr. Keith Gido	$ 12,250	$ 12,618	$ 24,868
Graduate Student		$ 28,106	$ 28,949	$ 57,055
Undergraduate Student		$ 12,000	$ 6,180	$ 18,180
Fringe benefits				
Project PI	30.00%	$ 3,675	$ 3,785	$ 7,460
Graduate Student	10.00%	$ 2,811	$ 2,895	$ 5,706
Undergraduate Student	1.00%	$ 130	$ 134	$ 264
Travel				
Travel: PI, graduate student and undergraduate student for field sampling	Field per diem ($20/person/day)	$ 3,640	$ 3,080	$ 6,720
	Lodging-Bluff, UT or Farmington, NM ($105/day)	$ 3,570	$ 2,100	$ 5,670
	Vehicle mileage (mile; 2000 miles round trip Manhattan, KS to Bluff, UT and travel to field sites x 5 trips)	$ 11,600	$ 11,600	$ 23,200
Travel: Durango, CO for San Juan Researchers meeting (2 people)	Per diem ($46/person/day)	$ 184	$ 184	$ 368
	Lodging-Durango, CO	$ 525	$ 525	$ 1,050
	Airfare (Manhattan, KS to Durango, CO)	$ 1,000	$ 1,000	$ 2,000
Supplies				
Field Sampling Gear	Radio transmitters (F1555 @ $150.10 each)	$ 7,505	$ 7,505	$ 15,010
	Coded Radio transmitters (F1225C @ $270.75 each)	$ 10,830	$ -	$ 10,830
	Satellite Phone (Iridium 9555) charge ($100/month)	$ 1,200	$ 1,200	$ 2,400
	Reconfigure existing ATS receivers to read non-coded tags ($300/receiver)	$ 3,000	$ -	$ 3,000
	Misc field gear	$ 500	$ 500	$ 1,000
	Surgery equipment	$ 200	$ 200	$ 400
Graduate Student Tuition and Fees-Spring	KSU Tuition and Fees for Graduate student course work (no overhead)	$ 7,889	$ 8,126	$ 16,015
	Total Task 1	$ 110,615	$ 90,580	$ 201,195
	F&A	$ 17,977	$ 14,430	$ 32,407
	Incl KSU 17.5%	$ 128,592	$ 105,010	$ 233,602

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Appendix I. Comments (regular font) and responses (bold font) to technical review of SOW *NEW – 4 Dispersal, behavior and habitat use of stocked age-1 and established age-2 and age-3 Colorado Pikeminnow in the San Juan River*. PIs K.B. Gido, Kansas State University and C.A. Pennock, Utah State University

How can the technical aspects of this SOW be improved?

Crockett (CPW): Hard to predict if enough data will be generated to be meaningful, especially for the older fish. Extrapolating habitat preference from at least 6 fish, as proposed, seems like a stretch. The question of where stocked fish go and whether they stay in the system is more likely to be answered successfully.

We agree this might be a limitation if there is variable behaviors within the population. It is logistically difficult to "camp" on a large number of individuals to obtain diel patterns of movement and habitat use. We are assuming that 6 fish each month will be representative of the population and will evaluate differences among individuals to test the validity of that assumption.

Keith (TNC): Please provide more information on radio tag size relative to fish size, detection range, and spatial accuracy of detection. This will help determine the likelihood of success and any potential issues with study design (e.g., ability to accurately determine habitat use and movement). Describe how habitat quantification at a 1-km reach scale will be sufficient to determine habitat characteristics used by fish.

We added "Transmitters will not exceed 5% of the body weight of fish (Cooke et al. 2021) and our experience tracking fishes on the San Juan River suggest we will be able to locate individuals within a 10 m radius or smaller through triangulation."

The 1-km reach will only be used to estimate habitat complexity and is intended to complement the mesohabitat scale measures of habitat use described in previous studies of pikeminnow. Thus, the 1-km reach will provide another scale at which to assess habitat use.

Larrick (UMUT): No suggestions.

Mazzone (Jicarilla Apache Nation): No Comment

McKinstry (BOR):This proposal is well written and well supported with logic and literature. I'm not sure we get much from looking at age 1 fish, but…it is worth a try. Young fish are destined to die. 98+% of them will die within the first year. It is once they get to age 2, or better yet 3, where they seem to provide some better information. But, I don't want to get in the way of gaining information that might be useful, so forget this comment if it isn't supported by the whole group. I would also think about doing older fish that are captured—i.e., have some larger coded tags available. Also, have some coded tags available for fish that are captured at the waterfall and moved upstream. Can the radio receivers be programmed to detect both coded and non-coded fish? If not, we should have two receivers at each location so we can also pick up any coded fish (RBS will still have active tags in 2022, or for CPM that are larger that can take coded tags).

Unfortunately, ATS receivers need to be either coded or non-coded. We have receivers we can use for non-coded fish when actively tracking, but our stationary antennas are limited to non-coded fish for this proposal. We are open to a discussion on how to gain additional information as long as we are on

the river tracking fish. It is also possible to maintain some coded and some non-coded receivers simultaneously.

Miller (Southern Ute Indian Tribe): The proposed SOW relies on rafts and fixed location receivers to detect implanted fish. I recommend the addition of occasional aerial surveys to establish fish locations prior to the raft surveys. In previous work on the San Juan and Yampa rivers, we used aerial surveys to locate fish at the start of each observation week. This provides the ground teams the ability to determine where fish encounters are likely. A raft survey may not detect fish depending on time of day, fish position in the river, and raft position. This is especially true for areas with multiple channels. The large number of tagged fish in an advantage in providing more data but also complicates the detection ability if fish are not sedentary. Late fall telemetry in the Yampa showed that the youngest, smallest fish had the highest mobility of all the tagged fish in the study.

Aerial surveys would be a great way to narrow the focus of ground telemetry. We would be happy to work with NMGF if there are funds available to support flights. Alternatively, we have modified the SOW to include the use of stationary receivers located at the junction of each geomorphic reach to identify if fish have moved outside of each reach. We can check those receivers prior to each trip to at least get a coarse location (geomorphic reach) where fish occur.

The proposal should include more detail on how long the observers will spend at each fish location. Since it seems that the monthly floats will not include repeated passes, there should be a predetermined time set for each fish contact. An interval of one or two hours may be appropriate to determine fish behavior and movement at each contact location.

We modified the SOW as follows: "A camp will be established near each target fish. The target fish will be located and observed for one hour to identify behavior or movement. One-hour observations will be made at a minimum of every 6 hours to understand diel change in location. Tracking will be from shore or wading (e.g.,.Miller and Ptacek 2000) centered around dusk, dawn, mid-day and mid-night."

The deliverables should include transfer of the data sets to the Program in addition to the annual reports.

We added this to the deliverables.

Schleicher (USFWS R6): Line 118: Stocking of CPM has been in October or November based on when the last monitoring is done.

This is good to know. As stated in the SOW, we will work around the stocking schedule determined by the Program.

SOW New-1 and New-4 appear to have a fair amount of overlap (including PIs) looking at habitat usage of younger Pikeminnow. Would combining these two SOW's be better for both? Both take place during cooler weather months, both can utilize PIT tag information while one will rely more on radio tags.

Good idea. We will certainly work together when possible and have added this to the contingency planning.

Warren (Peer Reviewer): Overall, the SOW is well conceived, and I really have no substantive comments for improvement.

I am concerned about sample size proposed (n=25 for both tasks). It's a big river! The fact that the fish will be double tagged (pit and radio) helps relieve my concern to some extent. I recognize the radio frequency constraints and the logistics of tracking more fish.

This is a good point and we are aware of this limitation. As mentioned above (Crockett comment), we will carefully consider how much heterogeneity exists in movement and behavior within the population.

Figure 1 caption indicates the map shows locations of radio antennas, but the legend indicates slash symbols are locations of pit antennas. Please clarify (I suspect the radio antennas are at the pit tag antenna location?).

Sorry about this error. The map was updated and receiver locations were labeled for clarity.

Zeigler (NMDGF): Line 33: The switch to stocking age-1 instead of age-0 Colorado Pikeminnow was not because of concerns with Channel Catfish. The switch to stocking age-1 fish was to facilitate the ability to differentiate between wild and stocked fish

Change was made in the revised SOW.

Line 121: Can additional stationary receivers be set up at Reach 1 and at the waterfall? A major question we still have is how many fish move over the waterfall and into the lower river/Lake Powell. This will not directly answer that question, but it could provide some meaningful information.

This is a good point. We added a receiver at the waterfall. There is one at that location being used for the current razorback sucker work. That receiver can be modified to detect non-coded tags. As mentioned above (McKinstry comment), we are open to a discussion on how to balance the needs of different study objectives but there would be no problem having a receiver at the waterfall.

Line 150: Habitat Availability. Will this be determined from annual aerial photos or will this be measured on the ground? Some habitats may be difficult to classify using aerial photos and habitat availability will change with differences in discharge. How will these issues be addressed? I think Vince Lamarra use to identify habitats while floating the river when that work was still ongoing. This could easily be accomplished as people float and locate fish.

Yes, our plan was to identify habitat availability on the ground at randomly selected points within each geomorphic reach during each fish survey. Availability will be measured each month, so we can evaluate how that changes with discharge, assuming we have variable discharge among surveys.

Line 167: Can these capture efforts be combined with sampling for age-1 Razorback Sucker (SOW21-19b)? This would decrease electrofishing passes in the river. However, multiple passes may be required to locate enough fish to reach the targeted sample size.

Yes, we will definitely coordinate with other capture efforts to minimize the number of electrofishing passes. This was also discussed during the BC meeting in early May.

PO:

Figure 1 states that it shows radio receivers, but those features do not appear to be shown on the map and it would help to show the locations of these receivers. Or clarify that these are located at reach transition as stated later in the SOW.

Figure was updated per comment by Warren.

It would be useful if the PIs could provide contingency plans in the case of high mortality rates of tagged age-1 Colorado Pikeminnow.

We do not expect there to be high mortality. However, we have added a "Contingencies" section to the revised SOW to address this and other issues. If there is high mortality, we would first test if this was due to radio tagging. If not, this would be important information for the Program when evaluating the stocking effort.

What is this SOW's contribution to recovery?

Crockett (CPW): Obviously important to know more about what these stocked fish are doing.

Keith (TNC): Will provide valuable information to help guide adaptive management decisions related to stocking size and location, as well as provide important baseline data on age-specific habitat use and movement by CPM in the San Juan.

Larrick (UMUT): Evaluation of behavior and habitat use of age 1,2,3 CO Pikeminnow will help understand dispersal, behavior and habitat use to better support recruitment of a sustaining population.

Mazzone (Jicarilla Apache Nation): It seems this project is especially relevant given our current/long-term stocking efforts, and glaring recruitment bottleneck. Potential projects to further the Programs understanding of critical early life stages of Colorado Pikeminnow have been tossed around the BC for a while and this scope really gets us closer to filling a critical data gap.

McKinstry (BOR): Learning as much as we can about the life history of these species is critical. We really do not know that much about the endangered fish, especially as it relates to their use of the SJR. Learning more about fate of CPM post release, or post recruitment to juvenile (for wild spawned fish) could yield some information on what needs to be done to retain and recruit more of these fish and size classes. Habitat use would be good to know as we move forward with more habitat projects.

Miller (Southern Ute Indian Tribe): The proposed SOW is one of the few focused on Colorado Pikeminnow and may provide information critical to understanding how Age 1, 2 and 3 fish use the San Juan River.

Schleicher (USFWS R6): Knowledge of where stocked CPM go after being stocked is crucial towards recovery. If fish vacate the river then we as a program will need to look at alternative stocking methods or creating a way for these fish to stay in the river.

Warren (Peer Reviewer): The Program has long discussed the need to know what CPM do after stocking in terms of movement and habitat use. There is some data, but this SOW should really provide some granular and reach scale data. Likewise, the tracking of larger fish will provide a picture of habitat use and movement at the stage where CPM seem to hit a bottle neck with a higher degree of granularity than the small bodied sampling or adult sampling. I support this SOW.

Zeigler (NMDGF): This is a well-designed study that aims to identify the habits of stocked age-1 and age 2-3 Colorado Pikeminnow in the San Juan River. Tracking of stocked age-1 Colorado Pikeminnow should provide some information on immediate movements and retention of fish near the stocking locating. Stationary antennas should also give an estimate on immediate long-term dispersal, although I think it would be beneficial to have antennas located at Reach 1 and at the waterfall. However, I do not think that this project will provide much more information than Demographic monitoring. Ultimately what the Program cares about is long- term survival of those stocked age-1 fish. Tracking of age-2 and age-3 fish should provide information on habitat requirements and movements which could help to identify missing habitat requirements and could provide valuable guidance for habitat restoration efforts.

PO: The SJRIP would benefit from continued work focused on identified juvenile bottlenecks for stocked Colorado pikeminnow. Fine scale movement and habitat use data on ages of fish that have shown low survival in the San Juan River may provide the information we need to improve the recruitment of these stocked fish to subsequent adult life-stages.