Project Title

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

Bureau of Reclamation Agreement Number:
R17AC00039

Reclamation Agreement Term
Oct. 1, 2021 – Dec. 30, 2023

Note: Recovery Program FY23 scopes of work are drafted in May 2022. They often are revised before final Program approval and may subsequently be revised again in response to changing Program needs. Program participants also recognize the need and allow for some flexibility in scopes of work to accommodate new information and changing hydrological conditions.

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Category:
x Ongoing project
__ Ongoing-revised project
__ Requested new project
__ Unsolicited proposal

Expected Funding Source:
_X_ Annual funds
__ Capital funds
__ Other *[explain]*

Relationship to LRP:

Study Background/Rationale and Hypotheses:

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).

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.

Study Goals, Objectives, End Product(s):

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

Study Area:

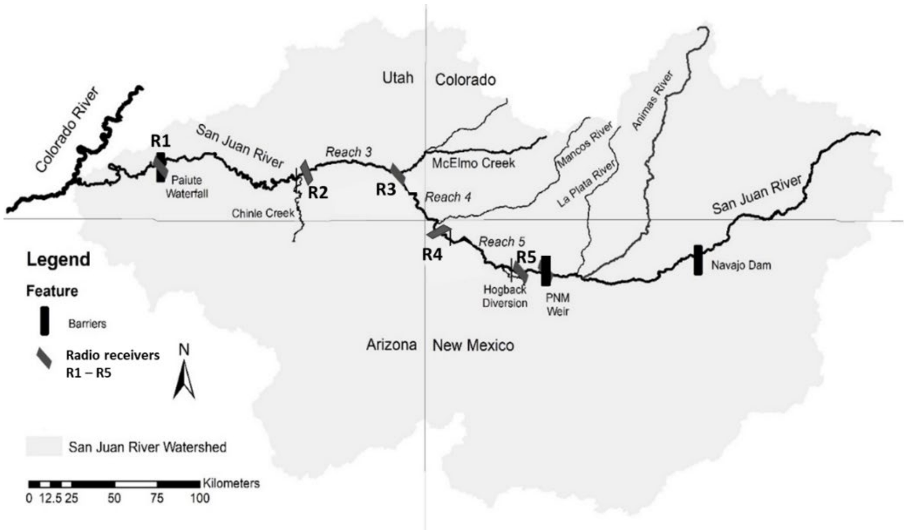

Figure 1, Map of San Juan River and location of radio receivers and study reaches.

Methods/Approach:

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) as not to influence the behavior of the fish. 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 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).

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 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 (note, an additional stationary receiver was placed at Mexican Hat to determine if fish move downstream of that location). 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.

Task Description, Deliverables and Schedule:

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												

Budget Summary:

FY Year	*KSU*
2023	$105,010
Total	$105,010

Reviewers:

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