Project Title
Identification of Razorback Sucker spawning areas in the upper San Juan River using mobile PIT tag antennas

Bureau of Reclamation Agreement Number:
[if applicable & known]

Reclamation Agreement Term
[if applicable & known, e.g., Oct. 1, 2018 – Sep. 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.

Lead Agency:
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Category:
__ Ongoing project
X Ongoing-revised project
__ Requested new project
__ Unsolicited proposal

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

Relationship to LRP:

Specific Actions in the Long-Range Plan relate to Task 4.1.2.1 (Conduct larval fish sampling to determine if reproduction is occurring, locate spawning and nursery areas, and to gauge the extent of annual reproduction) and Task 4.4.1.1 (Document and quantify reproduction, survival, and recruitment; USFWS 2016).

Study Background/Rationale and Hypotheses:

Razorback Sucker *Xyrauchen texanus* are endemic to the Colorado River Basin including the San Juan River drainage. Human development and modification to hydrologic regime of western rivers resulted in extirpation of Razorback Sucker in the San Juan River and general decline throughout their historically occupied range (USFWS 2002). Currently, Razorback Suckers are federally endangered and protected under the Endangered Species Act of 1973. In 2021, the USFWS proposed reclassification of Razorback Sucker from endangered to threatened (USDOI 2021).

Augmentation efforts led by the San Juan River Basin Recovery and Implementation Program (SJRIP) resulted in the re-establishment of a Razorback Sucker population within the San Juan River. This population, which is currently estimated at 2,461–3,210 adult individuals (Schleicher et al. 2019), is entirely supported through annual stocking of large (>300 mm TL) hatchery-reared fish despite documentation of reproduction by this species since 1998 and with rare incidence of recruitment (Zeigler and Wick 2019). Razorback Suckers are known to make long distance movements and upstream spawning migrations (Tyus and Karp 1990; Pennock et al. 2020b), yet discrete spawning locations in the San Juan River have not been verified. In the Green River, UT, Razorback Suckers exhibit annual spawning site fidelity (Webber and Beers 2014). Knowledge of spawning locations is invaluable for informing management decisions related to promotion of successful Razorback Sucker reproduction and subsequent recruitment, both of which are paramount for recovery. Acquiring this information would allow direct measurement of reproductive effort, documentation of interannual variation in spawning, identification of flow requirements for inundation of spawning habitat, and evaluation of habitat requirements for spawning fish including any deficits that may exist in the San Juan River. Lastly, because Razorback Sucker recruitment is lacking in the San Juan River, documentation of spawning locations allows mitigation of larval downstream transport through informed development of low-to-zero velocity habitats near identified spawning locations to increase retention and ontogenetic development.

Spawning of Razorback Sucker is associated with the ascending limb of the spring hydrograph, peak spring discharge, and warming river temperatures. Adults congregate in riffles with cobble, gravel, and sand substrates typically in depths less than one meter (USFWS 2002). In the San Juan River, Razorback Suckers exhibit an extended spawning season from March to June or July, depending on temperature and discharge conditions, with peak spawning period typically occurring in the last 2 weeks of April and first week of May (Clark Barkalow et al. 2021). In the San Juan River, spawning by Razorback Sucker was first documented in 1998 and successful spawning has occurred in each of the last 23 years (1998 – 2020; Farrington et al. 2019, Farrington et al. 2022). In recent years, larval Razorback Suckers have been progressively documented further upstream and in 2020 were documented as far upstream as RM 184.3 near Bloomfield, NM (Farrington et al. 2022).

In the San Juan River, large-bodied adult fishes are often sampled using raft-mounted electrofishing (Schleicher et al. 2019; Clark et al. 2018). Although electrofishing is an effective technique for capturing and studying adult fishes, electric currents may be lethal to fish embryos (Muth and Ruppert 1997; Bohl et al. 2010; Simpson et al. 2018), so attempts to document spawning aggregates of endangered fishes using this technique should be avoided. Passive integrated transponder (PIT) tag interrogation is a non-invasive method for detecting endangered fishes and is widely used in studies on long-lived fishes including Razorback Suckers. Most, if not all, Razorback Suckers in the San Juan River originated from hatcheries and have been implanted with PIT tags prior to being stocked in the San Juan River. Recent research in the San Juan River has used both stationary, passive integrated antenna (PIA), and mobile (Passive Integrate Transponder Portable Antenna SystemS [PITPASS]; Stout et al. 2019, 2020) PIT tag antennas to non-invasively monitor endangered fishes (Durst and Franssen, 2014; Stout et al. 2019; Pennock et al. 2020a; Pennock et al. 2020b).

Although stationary PIT tag antennas are valuable for tracking fish movement past discrete locations (e.g., PNM weir) and may allude to timing of spawning migrations, they are unable to indicate the ultimate destination or verify spawning. Floating PIT tag antennas, like PITPASS are an innovative technology (Stout et al. 2019, 2020, Zentner et al. 2021) recently used in the San Juan River and can detect adult fishes at similar rates to electrofishing (McKinstry and MacKinnon 2011). With PITPASS, PIT tags can be detected at depths up to 1.0 m (Biomark) or discharge up to 999 cfs (28.3 m^3/s) in the San Juan River (Stout et al. 2019). Unlike a stationary PIA, PITPASS can detect tagged fish longitudinally across a reach of river and does not require fish swim past a set point. Further, longitudinal PITPASS surveys can be repeated in an area in short succession to build a history of detection events and interpret fish movements. Due to the high number of PIT tagged endangered fishes in the San Juan River (STReamS 03/22/2021), PITPASS may be a valuable tool for detecting congregations of fishes like those that may be present in spawning aggregates. A similar floating PIT tag antenna system has been developed for use in trout streams of Colorado (Richer et al. 2017) and has shown high detection efficiency, with greater numbers of fish detected with multiple passes.

Razorback Suckers have been spawning continuously in the San Juan River since 1998 and spawning aggregates have been observed (Ryden 2004), yet discrete spawning areas, like those documented in other locations in the Upper Colorado River basin (Bestgen et al. 2011, 2012) have yet to be verified in the San Juan River. Detection of spawning locations in the San Juan River facilitates management decisions related to spawning by endangered fishes and recruitment of larvae to later age classes. Identification of spawning areas allows SJRIP to ensure fish can bypass potential spawning migrations barriers (USFWS 2016; Task 4.4.3.1), enable creation of spawning habitat if needed (USFWS 2016; Task 4.3.1.2) and perhaps most importantly, dictate the placement and operation of nursery habitat for the promotion of recruitment to later life stages (USFWS 2016; Task 4.4.3.1).The San Juan River is characterized by rapid rate of larval drift terminating in Lake Powell (Dudley and Platania 2000), steep gradient relative to other rivers of the upper Colorado River basin (Holden 1999), and lack of large permanent nursery habitats like those present in other rivers where Razorback Suckers exist (Modde 1996; Bestgen et al. 2011; Bestgen et al. 2012). The San Juan River habitat workshop identified a lack of persistent low velocity habitat as a likely bottleneck to Razorback Sucker recruitment and project rankings indicated a high prioritization of nursery habitat creation, like that of lateral canyons and persistent secondary channel backwaters. By identifying spawning locations, constructed nursery habitats can be more ideally located and operated to best entrain larvae to promote recruitment to later age classes.

Study Goals, Objectives, End Product(s):

This scope of work is year-2 of a two-year project investigating the efficacy of using PITPASS to detect Razorback Sucker spawning areas.

Specific objectives are to:

1. Identify Razorback Sucker spawning locations using floating inflatable PIT tag antennas (Biomark; 2022 and 2023).
2. Characterize habitat of identified spawning locations (2022 and 2023).

3. Validate utility of PITPASS technology for detection of spawning aggregates (2022 and 2023).
4. Confirm spawning locations (year-2) to evaluate spawning site fidelity (2023).
5. Confirm spawning by Razorback Suckers (year-2) by using drift net samples placed immediately upstream and downstream of identified spawning areas (2023).

Study Area:

The study area is a 28.9 river-mile reach of the San Juan River between RM 188.3 (Sun Ray Park and Casino) and RM 159.4 (Buck Wheeler Farm; Figure 1). In 2020, yolked Razorback Sucker larvae were detected at RM 184.3 near Sun Ray Casino, Bloomfield, NM, the furthest upstream detection to date. Because the larvae were in the earliest stage of their development it is assumed that a spawning location was nearby. Additional early developmental stages of Razorback Suckers (protolarvae and flexion-mesolarvae) were collected downstream to RM 161.2, supporting the hypothesis that a spawning area is present in this river reach. The proposed study area was chosen primarily because the short river sections allow the segments to be sampled in a single day, successive detection passes may be repeated to ensure adequate data collection, and a high number of adult Razorback Suckers have been documented in this stretch (Schleicher et al. 2018).

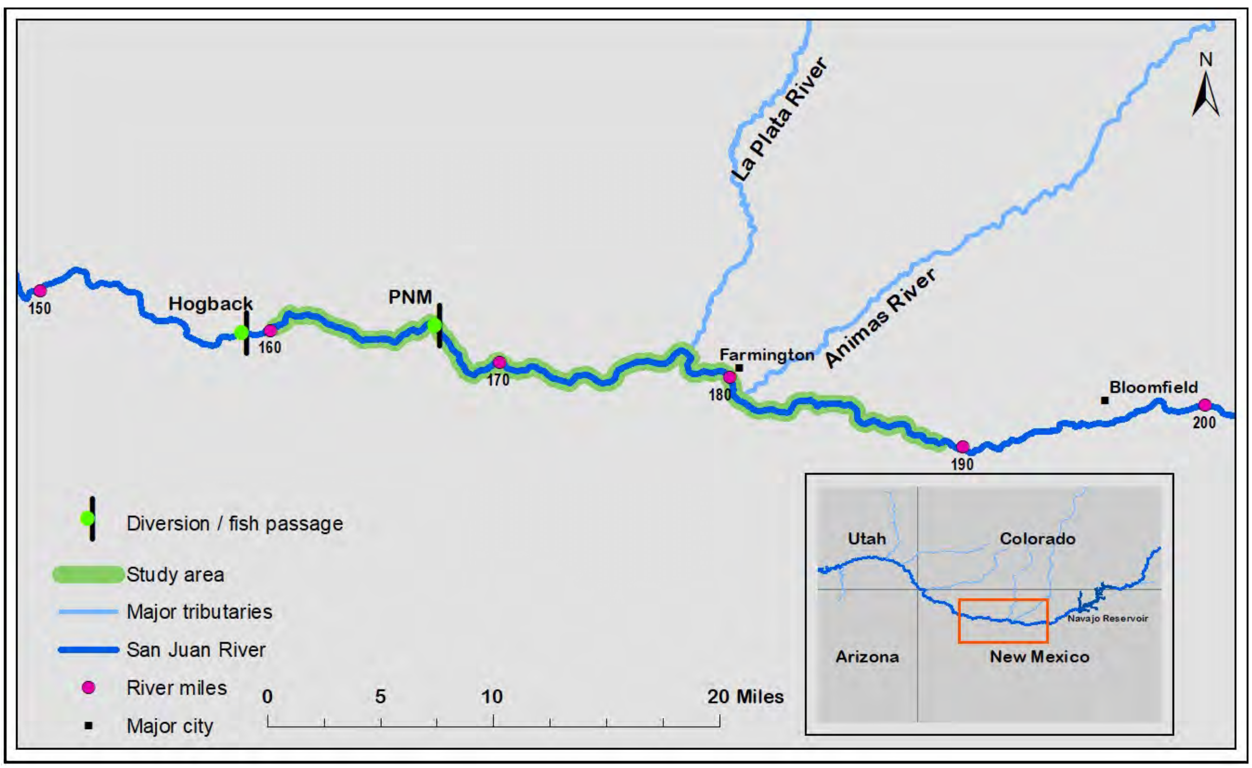

Figure 1. Proposed study area for detection of Razorback Sucker spawning locations using PITPASS.

Study Methods/Approach:

Detection passes will be repeated in the same section of river (RM 188.3–159.4) that was sampled in 2022 to confirm spawning sites and examine spawning-site fidelity (i.e., the same individuals being contacted in both years). Repeated detection passes will be performed in the study area over a three-week period from the last two weeks of April (beginning April 17) to the first week of May (Table 1.). These weeks have been identified as periods of high Razorback Sucker spawning activity (Farrington et al. 2019; Clark Barkalow et al. 2021) and coincide with previous detections of early-development Razorback Suckers in the study area (Farrington et al. 2022). Additionally, because this period is typically either before or at the very beginning of spring runoff, flows are generally below the 999 cfs threshold identified by Stout et al (2019). Because Razorback Suckers typically spawn at depths less than 1.0 m (USFWS 2002), increased flow should not result in decreased detection efficiency. However, if San Juan River flow projections indicate high discharge in the spawning period, the sampling period can be adjusted to occur prior to spring runoff.

Table 1. Proposed timeline for Razorback Sucker Spawning location identification in 2023.

Year	Dates	Location	Action
2023	April 17– 21	RM 188.3 – 159.4	PITPASS Survey (n=4)
2023	April 24 – 27	RM 188.3 – 159.4	PITPASS Survey (n=4)
2023	April 24 – 27	Spawning areas in study area	Drift nets
2023	May 1 – 4	RM 188.3 – 159.4	PITPASS Survey (n=4)

Two catarafts, equipped with Biomark Inflatable Antenna System (PITPASS), including two floating antennas (each 3 m x 1.2 m) and an integrated GPS and data recording system, will be used to detect PIT tags. One cataraft will work river right (RR) and one will sample on river left (RL). Each cataraft will have a PIT tag detection range of 6.1 m x 1.2 m to a depth up to 1.0 m and detection of unique tags is possible in milliseconds (Biomark). Catarafts will simultaneously drift near-shore at a 45° angle, each cataraft will drift on a designated side of the river (RR or RL). Because previously identified spawning bars in the upper section of the San Juan River have occurred at the upstream “nose” of an island (Bliesner and Lamarra 2007), when islands are encountered at least one cataraft will focus detection effort on this feature. Upon detection of a PIT tag, the data recording system automatically records latitude and longitude with relatively high degree of accuracy (~6 m, the total combined length of the antennas; Biomark; Stout et al. 2019). Riverine habitat will be recorded at each detection and will be based on observations made from the drifting raft. Instream habitat measurements will be made at high frequency detection locations following peak spawning to prevent disruption of potential spawning activity and will be obtained at the same river stage at which Razorback Suckers were detected. Substrate will be characterized using a Wentworth scale (Wentworth 1922). Depth to embeddedness will be measured using techniques identified by Bliesner and Lamarra (2003), and velocity will be measured using a Marsh-McBirney flo-mate 2000. Additionally, at each site maximum and minimum depth (m) and water quality parameters (instantaneous temperature, dissolved oxygen, conductivity, and pH) will be recorded.

In 2019, aerial imagery was obtained for the San Juan River when water turbidity was extremely low (Lamarra and Lamarra 2020). Aerial imagery will be evaluated prior to performing detection passes in the river to *a priori* identify cobble bars that might be candidate spawning areas (Figure 2). These cobble bars will be recorded on the river map to ensure they are monitored by PITPASS. Data will be analyzed at the completion of a detection pass (daily). Though PITPASS is valuable for detecting congregations of fish over a broad longitudinal area, because it detects PIT tags from a single moment in space, it will not be able to capture the full extent of habitat use by Razorback Suckers over a 24 h period. Therefore, after analysis of detection pass data and identification of an area of high fish density, PIA(s) (“wagon-wheel”) will be deployed to detect Razorback Suckers in suspected spawning areas over a longer period (up to one week). Temperature loggers (HOBO tidbit) will be placed simultaneously with PIAs in suspected spawning areas.

Figure 2. Example of 2019 aerial imagery showing submerged cobble.

Drift nets will be deployed for a minimum of four hours at night (Carter and Reader 2000; Reeves and Galat 2000; Lechner et al. 2016) at suspected spawning sites, identified in the previous week's sampling, to confirm spawning by Razorback Suckers. Drift nets will be composed of conical plankton nets with a 0.5 m diameter mouth connected to rectangular metal frames (35 x 48 cm) with 6 cm metal rings welded to the corners to allow nets to be attached to steel fence-posts placed in canals. Drift nets will be 4 m long with 560 µm mesh and will be equipped with removable collection buckets that collected drift from the water column, including larval fish. Drift netting will occur over four-nights between April 24, 2023 and April 27, 2023 at one suspected spawning site per night. At each suspected spawning site, two drift nets will be deployed about 50 m upstream of the suspected spawning area and two will be deployed immediately downstream of the spawning area. Collection of gametes (eggs), embryos, and recently hatched larvae will be compared between upstream and downstream collections to confirm presence of the spawning area. Drift will be preserved in a 95% solution of ethanol and brought back to the laboratory for sorting and identification. Larvae will be identified to species whereas eggs and embryos will be identified to family. All egg and embryo samples will be maintained in a 95% solution of ethanol and samples will be submitted to Southwestern Native Aquatic Resources and Recovery Center for genetic analyses.

As an alternative method to drift netting, Surber samplers have been used to collect catostomid eggs, gametes, and larvae to confirm spawning areas (Mueller 1989; Hamel et al. 1997). However, this collection method has not previously been used to sample spawning areas in the San Juan River. Collection of eggs, gametes, and larvae was not previously proposed for the year-1 effort (2022 field season), so this technique will be tested in 2022. If proven to be an effective sampling method, Surber samplers will be used instead of drift nets because they allow targeted sampling on the suspected spawning bar itself and eliminate the need for overnight sampling that is required for drift nets. If Surber samplers are used, discrete samples will be made downstream and upstream of the suspected spawning bar, as well as in any visible spawning depressions.

Because the Public Service Company of New Mexico (PNM) fish passage facility is included in the lower portion of the study area there will be a record of fish detected below and successfully passed upstream of the diversion into the upstream study area. Detections at PNM will be used to evaluate the ability of successive PITPASS surveys to detect known live fish within the study area. To evaluate fish leaving the study area, we will deploy PIAs at the mouth of Animas River confluence in areas where fish would likely be detected (e.g., eddy near the thalweg).

At end of the 3-week detection period, fish detections from PITPASS will be compiled and “ghost tags” removed following methods outlined in Stout et al. (2019). A heat map of Razorback Sucker density will be created by overlaying frequency of occurrence on the spatial extant of the study area. A Moran’s I test (Muska et al. 2018) will be performed to test for spatial autocorrelation (i.e., are spatial patterns significant or random) to determine significance of fish patterns. Further, a Getis-Ord Gi* (pronounced G-i-star) test will be performed to identify statistically significant hot spots (Martling et al. 2020) of PIT tag detections. Spawning areas will be determined as areas with the highest frequencies of PIT tag detections, a significant Moran’s I index and a significant Getis-Ord test statistic. Detections of PIT tags of PIAs will be examined to evaluate the number of individual fishes visiting a spawning location over a 24-hour period to determine size of spawning population of fish at each location. Pending a sufficient number of PIT tag detections, an estimate of the spawning population will be computed (Cathcart et al. 2018).

Task Description, Deliverables and Schedule:

Task	Schedule
Presentation at Biology Committee meeting	February 2024
Draft final report produced	31 March 2024
Final Report	30 June 2024
Transmit electronic copy of data to SJRBRIP	30 June 2024
Peer-reviewed manuscript production	Summer 2024
Swimming upstream article	2024

Budget Summary:

FY	*ASIR*	*NMDGF*
2023	$78,521.58	$22,174.93
Total	$78,521.58	$22,174.93

Reviewers:

References:

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