RECOVERY PROGRAM
FY 2020-2021 SCOPE OF WORK for:

Recovery Program Project Number: _128_

Abundance estimates for Colorado pikeminnow and razorback sucker in the Green River

Reclamation Agreement number: new agreement pending
Reclamation Agreement term: Oct. 1, 2018 – Sep. 30, 2023

Lead Agency: Larval Fish Laboratory (LFL)

Submitted by: Kevin Bestgen (Lead), John Hawkins, Koreen Zelasko, Gary White
Larval Fish Laboratory
Department of Fish, Wildlife, and Conservation Biology
Colorado State University
Ft. Collins, CO 80523
Phone: KRB (970) 491-1848, JAH (970) 491-2777
fax: (970) 491-5091
email: kbestgen@colostate.edu

Michael S. Partlow, Matthew J. Breen
Utah Division of Wildlife Resources
318 North Vernal Ave.
Vernal, UT 84078
Phone: (435) 781-9413
email: mpartlow@utah.gov

Christian Smith
USFWS, Green River Basin FWCO
1380 S. 2350 W.
Vernal, Utah 84078 (Jones)
Phone: (435) 789-0354
Email: christian_t_smith@fws.gov

Katherine Creighton
Utah Division of Wildlife Resources
1165 So. Hwy 191, Ste 4
Moab, UT 84532
Phone: (435) 259-3781/(435) 259-3780
Email: katherinecreighton@utah.gov

Lori Martin, Program Manager
Colorado Parks and Wildlife
711 Independent Ave.
Grand Junction, CO 81505
Office: 970-255-6186
Email: lori.martin@state.co.us

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

Expected Funding Source:
x_ Annual funds
_ Capital funds
_ Other (explain)

I. Title of Proposal: Abundance Estimates for Colorado pikeminnow and razorback sucker in the Green River Basin, Utah and Colorado

II. Relationship to RIPRAP:

See RIPRAP at http://www.coloradoriverrecovery.org/documents-publications/foundational-documents/recovery-action-plan.html

Green River Action Plan: Mainstem

V. Monitor populations and habitat and conduct research to support recovery actions (Research, monitoring, and data management).

V.C. Conduct population estimate for Colorado pikeminnow.

III. Study Background/Rationale and Hypotheses:

Background.—Abundance estimates of endangered Colorado pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus* are needed to better monitor population status and provide benchmarks against which progress toward recovery can be measured. The 2002 Recovery Goals for Colorado pikeminnow and razorback sucker establish abundance thresholds for adult and recruit sized fish that should be met before considering downlisting and delisting (USFWS 2002). The 1998 meeting of the *Interagency Standardized Monitoring Program* (*ISMP*) workgroup recommended obtaining abundance estimates for each population of endangered fish. The Genetics Management Plan identified a population (the Yampa-Green stock) of Colorado pikeminnow that inhabits the middle Green River (Middle Green River reach) from Lodore Canyon downstream to approximately the White River. The middle Green River stock includes fish in the Yampa River (Yampa River reach) and the White River (White River reach); the few fish captured in the Duchesne River are included in the middle Green River reach. The other Green River stock resides in the mainstem Green River downstream of the White River. Two reaches include the Desolation-Gray Canyon portion of the Green River (Desolation-Gray Canyon reach) and the lower Green River (lower Green River reach) from about the town of Green River, Utah, downstream to the confluence of the Colorado River. This scope of work outlines a procedure to obtain abundance estimates for juvenile (< 400 mm total length [TL]), recruit (400 to 449 mm TL) and adult (≥ 450 mm TL) Colorado pikeminnow in each of the five reaches of the Green River Basin, Colorado and Utah, as described above. From those reach estimates, an abundance estimate for each length-based life stage will be estimated for the entire Green River Basin. An additional task beginning in FY2020, is to use data collected in this sampling program to estimate abundance of razorback sucker *Xyrauchen texanus*.

Catch/effort data that describes abundance of juvenile/recruit/adult Colorado pikeminnow have been collected in the Colorado (three reaches), Green (five reaches), Yampa (three reaches), and White (two reaches) rivers from 1986 to 2000 under the auspices of the *ISMP*. Abundance estimates based on capture-recapture sampling were made from 2000-2003 in the middle Green River and from 2001 to 2003 in the lower Green River. Collectively, these data suggested increased abundance of Colorado pikeminnow in the Green River Basin until 2000 but abundance estimates indicated an apparent decline after that (Bestgen et al. 2005; 2007). Populations recovered partially in 2008 period, in response to increased survival rates and increased recruitment of young fish (Bestgen et al. 2010), but reduced capture rates from 2011-2013 (Bestgen et al. 2018) and the final analysis showed much reduced populations, a trend continued through 2018. Recovery goals (USFWS 2002) call for sampling on a three year on, two year off schedule and abundance estimates for the Green River population are due again from 2021 to 2023, with data analysis and summary in 2024; analysis of data collected from 2016-2018 is ongoing. Therefore, this proposal outlines procedures to conduct capture-recapture sampling in 2021-2023 similar to that conducted from 2000-2003, 2006-2008, 2011-2013, and 2016-2018 using uniquely marked animals so that the necessary abundance estimates can be calculated.

Parameter estimation models and assumptions.—Two general classes of models can be used to estimate abundance of animal populations in the wild and are differentiated based on assumptions about population demographics. The first class of models are closed population estimators. Closed population estimators have three main assumptions. The first is that the population is closed so that N, the true population size, is constant during the short-term annual sampling event. Geographic closure assumes that there is no immigration to or emigration from the population of interest. Demographic closure assumes no births or deaths within the sampling period. A second assumption that is often difficult to meet is that all individuals in the population have the same probability of being captured during each sampling occasion. Differences in capture probability among individuals are well-known in fish populations, often involving size related differences in susceptibility to the sampling gear. Another situation that may cause unequal probability of capture is a group of individuals that occupy a habitat type different than that used by most individuals in the population. Behavioral differences may also cause differences in capture probability among individuals. Capture probabilities may also vary among capture occasions because of changes in environmental conditions such as stream flow. A third assumption of closed abundance estimators is that previously marked animals can be reliably distinguished from unmarked animals.

The second class of models is open population estimators. Open population models are useful to estimate population abundance as well as the joint probability of survival/immigration, and births or recruitment/emigration (Burnham et al. 1987, Lebreton et al. 1992). This general model class is termed the Jolly-Seber (J-S) model (Jolly 1965, Seber 1965). Similar to closed population models, J-S population estimation models assume that tagged fish are representative of the population to which inferences are being made and that the fate of individuals is independent of each other. An assumption not common with closed abundance estimators is that fish in an identifiable class or group (e.g., adults) have the same survival and capture probabilities for each time interval. A consequence of this component in J-S population models is that all releases should be made within a short time period so that rates among individuals are the same. The J-S models do not generally require assumptions of no immigration/emigration, and no recruitment or mortality. An exception is that geographic closure is still important when population size is the parameter of interest. Although open models can estimate more and different parameters and have less restrictive underlying assumptions, abundance estimates generated from such models are often less precise than those for closed population models. Another disadvantage of abundance estimates calculated from open population models is that they are all based on model M_t, a model that allows for time varying probabilities of capture. Although time variation is likely among sampling occasions, J-S models assume no heterogeneity or behavioral response among individuals in the estimated population. Thus, abundance estimates calculated from open population models do not allow as thorough an evaluation of assumptions as do closed population models.

Robust design for capture-recapture studies.—The robust design attempts to capitalize on the strengths of closed and open population models by combining the use of each in an overall sampling and estimation program (Pollock 1982, 1990). The robust design employs sampling at two scales. Sampling occasions completed at closely spaced intervals (e.g. weeks) are used to estimate population size using closed population models. That level of sampling completed in two or more consecutive years allows for estimation of population probabilities of capture, recruitment, and annual survival rates. The robust design approach was employed by Osmundson and Burnham (1998) and Bestgen et al. (2005; 2007; 2010; 2018) to estimate abundance and survival rates of Colorado pikeminnow in the Colorado River and the Green River, respectively. This approach offers advantages of both closed and open population estimation methods if certain assumptions are met. A particular advantage is that the robust design allows evaluation of heterogeneity effects within individuals among capture occasions. We can meet the requirements of the robust study design with the approach described below.

IV. Study Goals, Objectives, End Product:

<u>Goals</u>: Obtain accurate (unbiased) and reliable (precise) estimates of adult population abundance and survival of Colorado pikeminnow and razorback sucker that occupy the Green River study area. Addition of razorback sucker is a new item explicitly recognized in this scope of work.

<u>Objectives</u>:

1. Complete a minimum of three sampling passes through the five Green River Basin reaches listed to capture sub-adult and adult Colorado pikeminnow and razorback sucker:

   a) Green River between the confluence of the White River upstream to the lower end of Whirlpool Canyon (i.e., upper Island Park), excluding Split Mountain Canyon.

   b) White River between the confluence of the Green River upstream to Taylor Draw Dam,

   c) Yampa River between Deerlodge Park and Craig, excluding Cross Mountain Canyon,

d) Green River from the White River confluence downstream to near Green River, Utah, and,

e) Green River from downstream of Green River, Utah, to the confluence with the Colorado River.

The LFL and Colorado Parks and Wildlife will attempt 3-8 sampling passes in the Yampa River, in part associated with bass and northern pike removal projects, in order to obtain a more precise and accurate Colorado pikeminnow abundance estimate.

2. Obtain highest possible rates of capture of Colorado pikeminnow and razorback sucker within concentration habitats and maximize number of individuals marked and captured on each sampling occasion.

3. Obtain estimates of probability of capture and abundance for Colorado pikeminnow in each of the five reaches and for the entire study area.

4. Obtain estimates of probability of capture and abundance for razorback sucker in each of the five reaches and for the entire study area.

End Products: The end products are abundance and survival estimates for sub-adult and adult Colorado pikeminnow and razorback sucker for each of the White, Yampa, and Green River populations. An overall estimate will also be calculated. The report for data gathered in the 2021-2023 period should be available in 2024 or early 2025.

Report Review schedule: Annual reports will be submitted each year. A final summary report for Green River Colorado pikeminnow data will be submitted to the Recovery Program Coordinator annually.

The Colorado pikeminnow analyses (including the Colorado River data analysis and the Green River data analysis and report) will include:

1. Abundance estimates for all reaches and the entire basin for all three years.
2. A summary of sampling effort and discussion of issues related to sampling efficiency.
3. A list of PIT tagged fish will be submitted to the database manager at the end of each year.
4. Depending on the wishes of the Biology Committee and the Recovery Program, other parameter estimates such as survival rates and population rates of change may be estimated.

The razorback sucker analyses (including the Green River data analysis and report) will include:

1. Abundance estimates for all reaches and the entire basin for all three years, dependent on capture rates in locations such as the White and Yampa rivers, which are typically lower, but increasing.
2. A summary of sampling effort and discussion of issues related to sampling efficiency.
3. A list of PIT tagged fish will be submitted to the database manager at the end of each year.
4. Depending on the wishes of the Biology Committee and the Recovery Program, other parameter estimates such as survival and movement rates may be estimated.

Revisions from previous SOW:

- Efforts supporting Colorado pikeminnow population estimates that were previously included in Yampa River nonnative fish SOW (125 and 98a) are now included in this SOW to ensure that work is accomplished in accordance with required parameters (timing and location) for abundance estimation.

- UDWR Vernal increased effort to include work down to Snider Bottom (~RMI 231.0), while FWS GRB FWCO changed its Desolation Canyon reach designations to allow sampling between the newly passable Tusher Diversion and Green River State Park.
- Addition of razorback sucker data collection and analyses, explicitly identified. FY 2020-2021 will be used to analyze razorback sucker data collected from 2016-2018.

V. Study Area

The Green River Basin, including Green River main stem, the lower White River, and portions of the Yampa River.

VI. Study Methods/Approach

We propose to conduct abundance estimation for sub-adult and adult life stages of Colorado pikeminnow and razorback sucker in the Green, White, and Yampa rivers as outlined in the Study Area description. Investigators will thoroughly sample habitat where Colorado pikeminnow and razorback sucker are known to congregate (concentration habitat) in each reach on three separate, consecutive occasions (passes) during springtime beginning soon after ice-off and ending prior to or during runoff. Emphasis will remain on captures of Colorado pikeminnow for this effort. Concentration habitats for pikeminnow are usually shorelines, eddies, pools, flooded tributary mouths, and backwaters. This approach will permit annual abundance estimate calculations for populations by reach and also allows for a combined estimate for the study area. This sampling program conducted over a three-year period will fulfill the requirements of the robust design and also permit calculation of survival estimates for pikeminnow and suckers in the study area.

Annual sampling to estimate Colorado pikeminnow and razorback sucker abundance.—Annual sampling will involve a minimum of three sampling occasions through the five river reaches identified above. The three sampling occasions will be conducted in spring between the time when ice off occurs and end prior to or during spring runoff before pikeminnow migration begins. Sampling will begin at the top of each major reach and proceed downstream. It is important to maximize the number of fish captured on each pass (Lebreton et al. 1992). Different gear types may be used in different sampling areas. Electrofishing will be the primary gear in main channel and small backwaters. Large backwaters and concentration areas may be sampled with a blocking trammel net and perhaps electrofishing. Gear use depends on habitat availability as well but will be applied as consistently as possible across reaches and rivers. The goal of using different gear types is to maximize capture probability on each pass.

Investigators will proceed downriver, sampling all available Colorado pikeminnow and razorback sucker concentration habitat on each pass. Information recorded at each Colorado pikeminnow and sucker capture location will be major habitat type (e.g., main channel pool, main channel eddy, backwater, flooded tributary mouth), a specific capture and release location identified by a GPS unit, and fish total length and mass. Each fish will be scanned for the presence of a PIT tag, making sure to follow standard Program protocols to ensure detection of tags with new and old frequencies. The fish will be tagged if it has not been previously marked, and the tag number recorded. The importance of back-up PIT tag scanners of both frequencies and adequate tagging supplies is critical to the success of this project. Scanning and tagging of all fish will reduce bias and result in the most accurate and precise abundance estimates possible. Tagged fish will be released in recovered condition at the point of capture.

After a single marking occasion is completed for the reach, they will proceed back to the upstream terminus and begin the second sampling occasion. A sufficient amount of time (e.g., 5-10 days) should elapse between the start of consecutive sampling occasions to allow for sufficient mixing of marked and unmarked fish. In the appropriate reaches, an *ISMP*-like sampling pass may be conducted within a primary sampling occasion to add to that data set.

Assumptions of closed population abundance estimators.—Fulfilling the assumptions underlying any abundance estimation model is a critical first step in the planning of a large field study. We have evaluated the assumptions of closed population abundance estimators in a previous study and feel confident that these assumptions can be met again (Bestgen et al. 2005; 2018). The first assumption, that of constant N during short-term annual sampling, can be assumed because the size of the study area dictates that the only point of emigration/immigration from the population of interest would be to or from the lower Green River. The likelihood of movement is much reduced at that time of year because fish occupy small and stable home ranges.

Lack of movement during that time period will also reduce movement of fish within the main study area from sampled reaches to areas that may receive little or no sampling effort such as canyons. Limiting the target group of fish to sub-adult and adult pikeminnow and limiting sampling to a relatively short time period in spring prior to migration, eliminates the possibility of additions to the population through recruitment. This fulfills the assumption of demographic closure.

The second assumption of equal probability of capture of individuals is unlikely to be met except in all but the most restricted conditions. However, techniques can be employed to reduce effects of heterogeneity among capture probabilities of individuals (e.g. size effects). Variation among capture probabilities among reaches and years can be reduced by explicitly modeling time effects. We also utilized total length as a covariate in previous analyses to account for a proportion of capture heterogeneity due to fish size differences (Bestgen et al. 2005; 2007; 2010; 2018). Previous studies presumably showed that behavior effects such as avoidance of capture gear were not generally important (Bestgen et al 2005; 2007; 2010), but declining capture rates across the entire study period, and within three-year time blocks of sampling may indicate otherwise (Bestgen et al. 2018). Colorado pikeminnow 800-mm TL or larger had very low recapture rates among years. The low number of those fish in samples suggested that bias of abundance estimates due to presumed behavior effects of those larger fish should be low. A separate study may be necessary to better understand if those behavior effects are important, or if low recapture rates of large Colorado pikeminnow are due to other factors.

Another assumption is of accurate recognition of marked and unmarked animals. To ensure that this assumption is fulfilled, investigators need to make sure tag detection equipment is in good operating order, carefully scan each fish with old and new types of tag scanners, and make sure tags are detectable prior to insertion. This requires that the tagging protocol be diligently followed.

Study duration.—The robust design requires at least two years of data collection in order for a survival estimate to be calculated, but the addition of more years will increase the number of estimates possible, and their accuracy and precision. Although survival estimation is not a main goal of this study, such estimates are useful for other purposes related to determining recovery goals and for comparison with survival rates of Colorado pikeminnow and razorback sucker in other systems or periods (Osmundson and Burnham 1998, Bestgen et al. 2005; 2007; 2010). A minimum of three years of data will also yield three separate abundance estimates for pikeminnow and razorback sucker in the study area, and will provide a consistency check for estimates among years.

Other considerations for FY 2021-2023.—This sampling design does not include higher gradient canyon reaches because pikeminnow and razorback sucker are presumed rare in those habitats during the non-spawning period (Bestgen et al. 2005; 2007; 2010; 2018). Another consideration in the decision not to intensively sample canyon reaches is the high level of logistics and effort needed to accomplish such sampling. We will use ancillary data collected in those reaches, such as was done from 2000 to 2003, 2006-2008, 2011-2013, and 2016-2018 to evaluate that this consideration still holds (Bestgen et al. 2005; 2007; 2010).

Program Mark will be used to estimate abundance and survival estimates for Colorado pikeminnow and razorback sucker in the study area. Program Mark is an omnibus data analysis program that allows exploration of a number of closed and open sampling design estimators for calculating estimates of abundance and survival. The robust design specifically incorporates closed model abundance estimation techniques, while survival is estimated from variants of the Jolly-Seber model.

VII. Task Description and Schedule (FY 2020-2024)

Because of the complexity and short duration of the sampling, and the need to use five relatively autonomous field personnel units to complete this work, we will continue to use a Standard Operating Procedure for field personnel to ensure a consistent sampling approach and timely completion of tasks. We will also have frequent conference calls with team members and field crews to discuss issues and problems. This will also provide an opportunity for each group to report on progress in completing tasks. The Larval Fish Laboratory will be responsible for routine coordination of the study. The Program Director’s office will assist in resolution of problems related to timely completion of tasks.

Task 1. (these relate mainly to activities in sampling years 2021-2023). Feb.-March. Order and prepare equipment. This task relates to objectives 1 and 2.

Task 2. April. Secure sampling location access, final equipment preparation, and crew coordination. As occurred in FY 2016-18, this related to coordination among sampling crews, a review of sampling and fish handling practices, effort allocation among trips, permit requests, and other tasks. This task relates to objectives 1, 2, and 3. Several river reaches are relatively remote or on private property and will require reconnaissance to acquire permission and find boat launch and take-out sites.

Task 3. Apr.-June. 3-pass sampling. Relates to objectives 1-3.

Task 4. Jan.-Sept. Sampling team coordination, data entry, and analysis. Relates to objectives 1-4.

Task 5. November-December. Write Recovery Program final summary report for Colorado pikeminnow data collected in each year in the 2021-2023 period, and prepare data analysis for Colorado pikeminnow analysis. Relates to objective 3. In 2024-25 this constitutes a final report summarizing all data collected in 2021-2023.

Task 6. November-December. Write Recovery Program final summary report for razorback sucker data collected in each year in the 2021-2023 period, and prepare data analysis for razorback data analysis. Relates to objective 4. In 2024-25 this constitutes a final report summarizing all data collected in 2021-2023. Funding allocated during 2020-2021 is for analysis of data collected from 2016-2018, which should be available in FY 2021.

VIII. FY-2020-2021 Work:

Deliverables, Due Dates, and Budget by Fiscal Year: For Colorado pikeminnow sampling, annual reports to Program Directors Office by November each year. Funding in FY2020-2021 includes that for razorback sucker data analysis, for fish collected in 2016-2018, which has not been previously analyzed.

In addition to annual reports, the PIs will submit a short article and photos for inclusion in the 2021 *Swimming Upstream* field report.

Budget by reach:

Larval Fish Laboratory, Yampa River sampling and data analysis

Larval Fish Laboratory: Budget includes data analysis costs for Principal Investigator. The budget presented incorporates all costs associated with the Colorado pikeminnow abundance estimation in the Yampa River, whereas in the past, some of those costs were included in Project 125 costs. Funding for FY 2018 field work for pikeminnow was shifted back to Project 125 funding in 2019 so that project can meet its goals for non-native fish control, when Colorado pikeminnow estimates are in the off year, and those arrangements will continue into the future in FY2021-2023. Funds are to be used to attempt five or six full passes for the Yampa River to improve precision of abundance estimates. Fringe benefits are 28.2% of the total amount of salaries in 2019; no future rates are available yet. LFL overhead rate is 17.5% and is charged to all items.

Travel: Travel costs for field work based on estimated per diem rates for Colorado State University for the area we are working in. Mileage is based on the standard rate for Motor Pool vehicles, which varies depending on age and size of the vehicle. We will use $ 0.50 per mile, based on 2019 rates. Meeting costs include three nights of hotel, per diem, and mileage to travel to meetings. These include costs for two people.

Personnel: Salaries include 28.2% fringe rate, an estimate for 2019, plus overhead. Overhead is calculated on all items (including salary plus fringe rate) at 17.5%, per our agreement with BOR.

Supplies: Supplies are used in the execution of field sampling. Estimated costs based on current prices procured from various online sources (local vendors for camping supplies, NRS rafting supplies, Christiansen Inc, for net supplies, Fischer Scientific for preservatives, sample jars).

Budget Summary:

FY Year	LFL (Yampa & Analysis)	CPW (Yampa)	UDWR Vernal (Green)	FWS (White)	FWS (Green)	UDWR Moab (Green)	**Total**
2020	$76,106	$0	$0	$0	$0	$0	$76,106
2021	$181,491	$43,637	$88,052	$95,087	$91,771	$127,861	$627,899
2022	$133,895	$44,217	$89,813	$92,019	$88,636	$130,418	$578,998
2023	$136,063	$44,809	$91,609	$91,129	$87,679	$133,026	$584,315
2024	$173,024	$0	$0	$0	$0	$0	$173,024
totals	**$700,579**	**$132,663**	**$269,474**	**$278,235**	**$268,086**	**$391,304**	**$2,040,342**

X. Reviewers: Dr. Richard Valdez, Dr. Paul Holden, Doug Osmundson

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