COLORADO RIVER RECOVERY PROGRAM Project No.: 22i
FY-2000 PROPOSED SCOPE OF WORK

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Date submitted: 21 April 2000

Category:	Expected Funding Source:
X Ongoing project	x Annual funds
_ Ongoing-revised project	_ Capital funds
_ Requested new project	_ Other (explain)
_ Unsolicited proposal	

I. Title of Proposal:

Abundance Estimates for Colorado pikeminnow in the Middle Green River /Yampa River System

II. Relationship to RIPRAP:

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

V.B. Conduct research to acquire needed life history information.

V.B.1. Identify significant deficiencies in life history information and needed research (will come partially from IMOs).

V.B.2. Conduct appropriate studies to provide needed life history information.

III. Study Background/Rationale and Hypotheses:

Background.—Abundance estimates of endangered Colorado pikeminnow *Ptychocheilus lucius* are needed to better monitor population status and provide benchmarks against which progress toward recovery can be measured. 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 from Lodore Canyon downstream to approximately the White River. The Yampa-Green stock includes fish in all tributaries including the Yampa, White, and Duchesne rivers. This scope of work outlines a procedure to obtain an abundance estimate for the Yampa-Green stock of sub-adult and adult (fish $\geq$ 250 mm Total length) Colorado pikeminnow.

Data that describes abundance of sub-adult /adult Colorado pikeminnow have been collected in the Colorado (three reaches), Green (five reaches), Yampa (three reaches), and White (two reaches) rivers since 1986 under the auspices of the *ISMP*. These data suggest increased abundance of Colorado pikeminnow throughout the upper Colorado River Basin. However, the veracity of these catch-effort trends relative to absolute population abundance is unknown.

Therefore, we propose to conduct capture-recapture sampling 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. 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. For example, a fish that has been repeatedly captured by electrofishing may tend to avoid capture if the fish can detect the presence of a boat and move away from it. 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 are 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) to estimate abundance and survival rate of Colorado pikeminnow in the Colorado River. 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:

Goals

Obtain an accurate (unbiased) and reliable (precise) estimate of the adult population abundance and survival of Colorado pikeminnow that occupy the middle Green River study area.

Objectives

1. Complete three sampling passes through the three reaches listed to capture sub-adult and adult Colorado pikeminnow:

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

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

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

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

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

4. Evaluate abundance of Colorado pikeminnow in canyon reaches relative to other more intensively sampled reaches (FY 2001).
5. Design a procedure for monitoring population abundance, survival, and recruitment, using data collected during the study (FY2002).

End Product:

The end products are abundance and survival estimates for sub-adult and adult Colorado pikeminnow for each of the White, Yampa, and Green River populations. An overall estimate will also be calculated.

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1. Abundance estimate for second year
2. Summary of second year results.
3. A list of PIT tagged fish will be submitted to the database manager at the end of each year.

V. Study Area

The primary study sites will include the Green River from Rainbow Park to the White River confluence and the major tributaries of the Green River including the Yampa River from Craig to Deerlodge Park, the White River from Taylor Draw Dam to the Green River confluence, and the Duchesne River from Randlett to the Green River confluence. Because capture data indicate that Yampa Canyon, Lodore Canyon, Whirlpool Canyon, and Split Mountain Canyon generally contain fewer Colorado pikeminnow than the alluvial reaches, canyons will not be sampled in the first year. The Vernal Field Station of the US Fish and Wildlife Service will be responsible for sampling the White River, Utah Division of Wildlife Resources will be responsible for sampling the Green River, and Colorado State University will be responsible for sampling the Yampa River upstream of Dinosaur National Monument (Table 1).

VI. Study Methods/Approach

We propose to conduct abundance estimation for sub-adult and adult life stages of Colorado pikeminnow in the Green, White, and Yampa rivers as outlined in the Study Area description. Investigators will thoroughly sample habitat where Colorado pikeminnow are known to congregate (concentration habitat) in each reach on three separate, consecutive occasions (passes) during springtime beginning just after ice-off and ending prior to or during runoff. Concentration habitats are usually 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 permit calculation of survival estimates for pikeminnow in the study area.

Annual sampling to estimate pikeminnow abundance.—Annual sampling will involve a minimum of three sampling occasions through the portions of each of the three 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 used in different sampling areas. Electrofishing will be the primary gear in main channel and small backwaters. Large backwaters and concentration areas will 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.

Most sampling effort will occur in concentration habitat, which should provide the highest capture rates for pikeminnow while minimizing the time required to complete a single pass Concentration habitat will be sampled with electrofishing gear, trammel and fyke nets, or some combination of each. Because it is important to achieve the highest capture probability possible in concentration habitat, where feasible, these areas will be enclosed with capture nets to prevent escape of fish and sampled until investigators are confident that most Colorado pikeminnow have been captured. The importance of making repeated sampling efforts in large off-channel habitat was illustrated in the Yampa River in spring 1999 (J. Hawkins, unpublished data). There, a large flooded wash was blocked with a trammel net and three successive "scare and snare" efforts were made. Successive efforts yielded five, eight, and one pikeminnow, which demonstrated how few fish would have been captured with only a single sampling effort. In smaller backwaters, suitable effort may simply be a thorough electrofishing effort without a blocking net.

Investigators will proceed downriver, sampling all available pikeminnow concentration habitat on each pass. Information recorded at each pikeminnow 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. 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 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 the investigator completes a single marking occasion for the reach, they will proceed back to the upstream terminus and begin the second sampling occasion. A sufficient amount of time (e.g., 7-10 days) should elapse between the start of consecutive sampling occasions to allow for sufficient mixing of marked and unmarked fish. In the appropriate reaches, *ISMP* may be used in an evaluation of fish habitat use patterns (described below in the Study Design Refinements section).

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 and feel confident that these assumptions can be met. The first assumption, that of constant N, 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, this is not problematic because there are closed abundance estimation models to detect and explicitly model recapture data that have heterogeneity, behavioral, and time varying probabilities of capture (White et al. 1982). These models require that a minimum of three sampling occasions be completed.

An assumption particularly relevant to this study is that animals mix freely between concentration habitat and adjoining areas between sampling occasions. There is evidence that mixing of pikeminnow does occur between concentration areas and other habitat types among sampling occasions in the Colorado River (Osmundson and Burnham 1998). They presumed high probabilities of capture within concentration habitat on a single sampling occasion, but low probabilities of capture between occasions. The logical explanation for that capture pattern is that many fish moved into and out of concentration habitat between sampling occasions. Lack of mixing of animals would result in a biased abundance estimate, and one for fish that occur only in the concentration habitat that we intend to sample. Therefore, we will also use intensive sampling conducted at a smaller spatial scale to assess the degree to which fish move among concentration habitat and adjoining habitat types among occasions (see pilot study description below).

The third assumption of recognition of marked and unmarked animals should be easy to fulfill because individual fish are marked with unique PIT tags. 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 in other systems such as the Colorado River (Osmundson and Burnham 1998). A minimum of three years of data will also yield three separate abundance estimates for pikeminnow in the study area, and will provide a consistency check for estimates among years. Because it is likely that environmental conditions will vary among years, and because first year logistics and sampling considerations are complex in a large study such as this, three years should be the minimum duration for this study.

Study design refinements.—At least two main pieces of information will guide study design refinements prior to initiating sampling in spring 2000. The first is an analysis of *ISMP* data collected from 1991 to 1997 that is being conducted by the LFL. That analysis will provide some expectations for probabilities of capture during the sampling season and will also provide information on the level of effort necessary to capture a certain number of fish. Published habitat use and telemetry data will also be used to examine the degree of site specific fidelity of individual fish. This may be useful to estimate the likelihood of variation in capture probabilities and potential sampling bias if only a subset of habitat within each reach is sampled. A second piece of information that will help guide sampling design considerations is a pilot sampling program conducted at the beginning of the main spring sampling effort. Such an effort will involve a relatively short 32-km (20-mile) river reach where intensive shoreline and congregation habitat sampling would occur. This will be done by Utah DWR in the Green River. Partitioning captures by habitat type will allow comparative abundance estimates to be calculated. An important finding of the pilot study would be estimates of the most cost-effective techniques for sampling. More importantly, analysis of data collected over three passes in one intensively sampled reach will be useful to assess the assumption of mixing among marked and unmarked fish. Collection of fish size and associated habitat information would also be used to evaluate whether differential habitat use by a portion of the population may bias abundance estimates.

Other considerations for FY 2001 and 2002.—This sampling design does not include canyon reaches because fish are presumed less abundant in those habitats during the non-spawning period. Another consideration in the decision not to intensively sample canyon reaches is the high level of logistics and effort needed to accomplish such sampling. However, in 2001 and 2002, it will be useful to determine the relative abundance of fish in unsampled canyon reaches or other areas by lower intensity sampling in the second season. We offer two preliminary options for obtaining information on abundance of Colorado pikeminnow in canyon reaches but will wait on final design considerations until the second year after we have more information. One means to sample the canyon reaches would be to conduct raft electrofishing or trammel-netting in eddies in the late-summer or autumn after the second year of abundance estimation sampling (e.g., September 2001 and 2002). Two rafts would move simultaneously down canyon reaches, sampling all available habitat. Comparison of ratios of marked to unmarked fish in canyon reaches obtained in this one-pass sampling effort with other reaches would yield information on rates of fish movement among the reaches. An alternative would be to sample reaches of the Green and Yampa rivers in Echo Park with appropriate gear and attempt three-pass sampling in that reach. This approach would yield more quantifiable information than that obtained for a single pass through all canyon reaches but would be for a more restricted reach. Such sampling should be conducted in the second and third years of the study because investigators would have a higher probability of capturing some of the fish tagged in the previous year. Ratios of marked to unmarked fish will be useful to determine the geographic areas for which inferences about abundance estimates are valid.

Use of existing data gathered in *ISMP* or use of Colorado pikeminnow captures and releases in different studies that are collected coincident with abundance estimation sampling will be evaluated. The *ISMP* data are likely useful for study design considerations and planning. Additional capture or recapture data collected during other studies but in the same time period as abundance estimation sampling may be usefully incorporated into occasion specific captures and releases and used in abundance estimation.

Program Mark will be used to estimate abundance and survival estimates for Colorado pikeminnow 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. We have consulted with Dr. Ken Burnham, Colorado State University, during preparation of this proposal. We will likewise incorporate his expertise, as well as that of other experienced field biologists, during interim data collection phases of this study and during final data analysis.

VII. Task Description and Schedule (FY-2001)

Because of the complexity and short duration of the sampling design, and the need to use three relatively autonomous 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 Program Coordinator for Monitoring or the Program Director will also participate in conference calls. The Larval Fish Laboratory will be responsible for routine coordination of the study. The Program Directors office will assist in resolution of problems related to timely completion of tasks.

Task 1. Feb.-March. Order and prepare equipment. This task relates to objectives 1 and 2.

Task 2. April. Scout locations, final equipment preparation. 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. Conduct canyon sampling in late-summer or autumn. Up to two passes will be completed by raft electrofishing in Yampa, Whirlpool, Split Mountain, and Lodore canyons. Relates to objective 5.

Task 5. Jan.-Sept. Sampling team coordination, data entry, and analysis. Relates to objectives 1-4.

Task 6. December. Write Recovery Program annual summary report. Relates to objectives 3, 4 and 5.

Task Description and Schedule (FY-2002)

Task 1. Feb.-March. Literature research, order and prepare equipment, develop standard protocol for field crews.

Task 2. April. Scout locations, final equipment preparation.

Task 3. Apr.-June. 3-pass sampling.

Task 4. September. Sample appropriate canyon reaches to evaluate fish movement.

Task 5. Jan.-Sept. Sampling team coordination, data entry, and analysis.

Task 6. December. Write Recovery Program annual summary report.

VIII. FY-2001 Work

- Deliverables/Due Dates

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- Budget by Task:

Task	Colorado	Utah	FWS	LFL	Total
Tasks 1, 2, & 3	0	31,200	31,200	31,200	93,600
Task 4	0	7,500	7,500	7,500	22,500
Task 5	0	2,100	2,100	14,500	18,700
Task 6	0	2,100	2,100	4,200	8,400
					143,200

Capital Expenses: Utah has indicated a need for a new boat motor for $5,000.

FY 2001 budget total $148,200

FY-2002 etc. (for multi-year study)

- Budget Estimate: $150,000

IX. Budget Summary

FY-2000	$165,000
FY-2001	$148,200
FY-2002	$150,000

Total: $465,000

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

XI. References

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Table 1. River reaches that will be sampled for the abundance estimate of the Green/ Yampa stock of Colorado pikeminnow and the agency responsible for sampling each reach.

River	**Location Bounds**	**River Miles**	**Total Miles**	**Agency Responsible**
Green	Lodore and Whirlpool Canyons	244 - 214	30	none
Green	Rainbow & Island Parks	214 - 208	6	UWR
Green	Split Mountain Canyon	208 - 199	9	none
Green	Split Mountain take-out - White River Confluence	199 - 126	73	UWR
White	Taylor Draw Dam - Green River Confluence	104 - 0	104	FWS
Yampa	Fuhr Gulch - Deerlodge Park	117 - 46	71	CSU
Yampa	Yampa Canyon	46-0	46	none
Duchesne	Randlett- Green River Confluence	14 - 0	14	none,* Pending Access