Non-native Fish Removal Efforts in Grand Canyon: A Proposed Modification to Ongoing Activities

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Executive Summary

The Grand Canyon Monitoring and Research Center, at the Direction of the Glen Canyon Dam Adaptive Management Program, began implementation of non-native fish control in the Little Colorado River (LCR) inflow area of the Colorado River in January of 2003 as part of a joint federal action entitled " Proposed Experimental Flows and Removal of Non-Native Fishes". The fisheries objective of this action was to reduce the number of potential predatory and competitor fishes in habitat occupied by the federally endangered humpback chub, *Gila cypha*. The fish control effort uses electrofishing and had three primary purposes: a) determine the efficacy of this technique to reduce and control the number of non-native fishes in critical habitat for the humpback chub, b) assess native/non-native fish interaction by conducting diet and incidence of predation studies on non-native fishes (primarily rainbow and brown trout), and c) reduce the abundance of non-native fishes in the control reach as much as practicable.

The original plan was to conduct six removal trips per year from river mile 56.2 - 65.7 during 2003 and 2004. While results regarding the diet and predation studies are incomplete at this time, it is apparent that both the efficacy of this removal technique and the reductions in abundance of non-native fish have been much more successful than anticipated. This success has prompted GCMRC to examine and propose a modification to the original plan for mechanical removal. The modification would extend the original area of removal downstream to RM 72.7, adding 7 miles to the area below the LCR. Monitoring and limited electrofishing in the original removal reach would ensure that non-native fish abundance is maintained at less than 10% of the abundance observed in January 2003. Most electrofishing and removal would be focused between river mile 65.7 and 72.7 during the fifth and sixth trips in 2003 and allocated as needed during 2004 to sustain a 90% reduction in non-natives through the entire reach (RM 56.2-72.7).

Young of the year and juvenile humpback chub (HBC) entering the mainstem from the LCR almost exclusively occupy habitat downstream of the LCR. The removal area upstream is intended largely as a buffer to reduce the likelihood of immigration downstream by non-native fishes. Extending the area of removal downstream by 7 miles could more than double the area of potentially improved habitat for young HBC. Thus the strength of this experimental treatment would be greater, increasing both the likelihood that a change in HBC survival and recruitment will occur as well as increasing our ability to detect such an increase.

This proposed modification described herein has several additional advantages and could be conducted at no increased cost from the original proposal. Furthermore, GCMRC believes that it has greater probability to increase recruitment of HBC in the near term than other actions under consideration. Advantages of this modification include reducing the amount of electrofishing that adult and juvenile HBC are subjected to in the LCR inflow area, increasing the amount of hoop net sampling for juvenile HBC throughout the removal reach, reducing the amount of scientific activity in an area of the river subject to high recreational use and concentrating that effort in fewer river miles downstream, substantially reducing the amount of scientific activity in an area of high cultural significance to Native Americans

INTRODUCTION

In December 2002, U.S. Secretary of Interior Norton approved an adaptive management experiment to be conducted in Grand Canyon National Park. This experiment, recommended by the Grand Canyon Monitoring and Research Center (GCMRC), began in January 2003 and consists of elements designed to provide a better understanding of both sediment and fisheries resources. As part of the current GCMRC Adaptive Management Program, a key objective is to determine whether certain policy actions are improving humpback chub juvenile survival and recruitment. A central part of the fisheries experiment includes reducing the abundance of non-native fishes in a 9.5-mile reach of the Colorado River near the confluence of the Little Colorado River (LCR; RM 56.2-65.7). This experimental manipulation has been implemented in an attempt to better understand interactions between native and non-native fishes, particularly non-native coldwater salmonids and the federally endangered humpback chub (HBC; Coggins et al. 2003_a, *see* attachment 1, *Piscivory by Non-Native Salmonids in the Colorado River and an Evaluation of the Efficacy of Mechanical Removal of Non-Native Salmonids*).

We proposed, and have since initiated a program to reduce non-native fishes at the LCR Inflow Removal Reach (56.2 RM - 65.7 RM). This has been accomplished through the use of a series of depletion trips where non-native fishes are captured using electro-fishing methods, euthanized, and removed from Grand Canyon for use as fertilizer. In the original proposal, our study design established upstream and downstream study boundaries based on an estimated amount of time available and human effort required. We limited the extent of our removal region downstream of the LCR to between 61.5 and 65.7 RM by taking into account 1) local trout abundance, b) electrofishing efficiency, c) immigration rates, and d) fish distribution within the channel. To date, the first three of 12-depletion trips to be conducted in 2003-2004 are complete, and preliminary analyses suggest that the abundance of rainbow (RBT) and brown trout (BNT) have been reduced by greater than 80%. This rate of reduction is much greater than anticipated following the initial phase of this effort (Figure 1). Therefore, this document describes a study modification designed to increase the magnitude of the experimental treatment by expanding the removal area downstream (i.e., just above Unkar rapid at 72.7 RM). The hope is that by expanding the magnitude of the treatment, our monitoring programs will realize a greater probability of detecting a response in humpback chub population dynamics as a result of non-native removals.

Background

Predatory and competitory interactions by non-native fishes introduced into the Colorado River system are implicated in the decline and extinction of the native fishes (Minckley *et al.* 2003, Tyus and Saunders 2000). As identified in the original proposal (Attachment 1), we recommended implementing a multi-year treatment where salmonids were mechanically removed from the Colorado River near the confluence with the LCR (LCR Inflow Removal Reach; 56.2 RM - 65.7 RM). Although the actual causal mechanism responsible for the recruitment decline in HBC remains uncertain, monitoring data has suggested that an increase in trout abundance system-wide, especially in the Colorado River near the confluence of the LCR is correlated to a recent decline in HBC abundance (Coggins *et al.* 2003_b). Therefore, the primary objective of this experimental manipulation is to assess the effect that adult rainbow trout (RBT) and brown trout (BNT) have on the population dynamics of the humpback chub (HBC) population.

Young-of-year native fish spawned in the LCR are sometimes passively dispersed or hydraulically displaced into the Colorado River mainstem. The current paradigm of recruitment dynamics of the LCR HBC population suggests that some juveniles are displaced from the LCR into the mainstem Colorado River during spring runoff and late-summer freshet events (Valdez and Ryel 1995, Robinson et al 1998, Gorman and Stone 1999, Gorman and Coggins 2000). Fish remaining in the LCR potentially have much higher survival and contribute more to annual recruitment than do displaced individuals. This downstream section below the LCR confluence is considered an important region because these young developing fish are potentially vulnerable to predatory effects from salmonids. The observed pattern is that juveniles are typically found in high abundance downstream of the LCR following an elevated LCR flow, but their abundance falls quickly in the weeks and months following the freshet (Valdez and Ryel 1995, Gorman and Coggins 2000). Additionally, the abundance of juvenile HBC declines with distance downstream of the LCR. It is possible that a high proportion of these fish fall prey to non-native predators, partially explaining this pattern in abundance and implying that negative interactions between HBC and non-natives also decline with distance downstream from the LCR confluence. We therefore originally focused our efforts in the LCR Inflow Removal Reach where native and non-native interaction is thought to be most acute.

Justification Of Modification

In the original proposal we assumed that given logistical and fiscal constraints, we would only be able to effectively reduce non-native abundance in the LCR Inflow Removal Reach. However, after the first 3 Winter-depletion trips, we are now facing the situation where we have reduced non-native abundance to the point that following the first Summer Depletion Trip (July), continued extensive electrofishing within the LCR Inflow Removal Reach to remove the few remaining non-natives may be more detrimental to native fishes than interactions with the remaining non-native fishes. This notion then begs the question of deciding what should be the effective reduction level that defines the experimental treatment. However, if we knew what the level of non-native reduction that would result in increased HBC recruitment, we would not need to conduct this experiment. Faced with this circular argument and our field observations to date, we suggest that the treatment in this experiment should be the maintenance of at least a 90% reduction in non-native abundance from the level observed preceding our first Winter Depletion Trip. We further anticipate that following our first Summer Depletion Trip (July), we will have achieved this treatment level.

With this in mind, we propose that if we have achieved our target treatment level following the first Summer Depletion Trip, we expand the treatment area to a larger river reach that encompasses more area of potential interaction between HBC and non-native fish. The extent of our removal region would be increased downstream section by an additional 7 miles to Unkar Rapid. Making our total removal reach 16.5 miles in length This is important since juvenile HBC are often dispersed beyond the present downstream boundary of our removal area. It is our contention that decreasing the abundance of non-native fishes in a larger region would increase the likelihood for greater survivorship in juvenile HBC. Additionally, we suggest that the electrofishing effort be continued as originally proposed but that the focus of the depletion effort is adjusted according to changes in trout abundance. This is important for three reasons: 1) it provides for an adaptable response to demographic shifts occurring in the local fish population, 2) allows for separate contingency plans to be in place and implemented in the event of such change, and 3) because juvenile HBC are widely dispersed, a decrease in the mortality of early life stages increases the magnitude of the treatment effect for testing the Non-native Fish Predation Hypothesis.

The scientific evaluation process used for assessing treatment response consists of two forms of measurements. The first method is to assess relative abundance among trips using both electrofishing and hoop-netting data. These data allow us to compare differences in mainstem survival of young-HBC among sampling trips, as well as survival rates among years. The sampling methods used for collecting this data provide us with the means to assess local population dynamics in response to the treatment effect at a shorter time interval. This is important because there is considerable variation in survival rates for younger fish. Secondly, since the early 1990's there has been a proportional decline in HBC age-2 recruitment of 40% to 80% based on the outcome of three different stock assessment models (i.e., Supertag, annual Age-Specific Mark-Recapture (ASMR), and monthly ASMR). Therefore, assessing the biological significance of this experiment will require some time to quantitatively measure the abundance of each year class or cohort of HBC as it recruits into the adult population. In order to detect a recruitment response and reject the null hypothesis "non-native fish predation has no affect on HBC recruitment", it is thought that an increase of age-2 recruitment to the LCR HBC population of approximately 40-50% will be required. For this reason, increasing the magnitude of the treatment effect affords scientists and managers a greater likelihood that this experiment will provide an unambiguous result to use in deciding appropriate management actions.

Risks and Uncertainties

We emphasize the importance of maximizing the treatment because of the inherent risk associated with the decision making process used in interpreting the results of this experiment. A type I error is committed if the null hypothesis being tested "non-native fish predation has no effect on HBC recruitment" is rejected, when in reality the null hypothesis is true. Although, the actual management action that would be implemented remains uncertain it is conceivable that the decision making process would result in a policy action for continuation of the non-native fish removal project or increasing this effort in other regions. The result of this Type I error would be very costly and would redirect efforts from evaluating other sources of mortality that were actually responsible for the recruitment decline in HBC. Alternately, a Type II error is committed if managers were to accept the null hypothesis "non-native fish predation has no effect on HBC recruitment" when in reality it is false, and the alternate research hypothesis "non-native fish predation has an effect on HBC recruitment" was actually true. It is conceivable that the non-native fish removal project would be curtailed. Making either of these two errors has the potential of leading to the further decline or extirpation of the HBC population in Grand Canyon.

Direct Effects on Humpback Chub from Electrofishing

We estimate that the total catch of chub using electrofishing should be slightly less within the proposed removal reach versus the current LCR Inflow Removal Reach (Table 1). This result is due to the generally lower abundance of HBC as distance from the LCR increases.

Table 1. Estimated minimum, mean, and maximum anticipated catch of humpback chub per removal trip assuming 125 hours of electrofishing per trip and recent observed catch-rate.

	Tanner to Unkar Rapids Catch		LCR Inflow Removal Reach Catch	
	HBC<200	HBC>=200	HBC<200	HBC>=200
Minimum	0	0	0	0
Mean	134	0	149	6
Maximum	457	0	1114	70

Proposed Maintenance of Target Treatment Levels

In both the original proposal and this modification, we have identified a very specific removal schedule in both time and space. These schedules reflect our anticipated results of removal activities at the current time. However, our overall goal is to reduce non-native abundance within the removal reach to 10% or less of the initial abundance (i.e. the target treatment level) for the term of the experiment, while minimizing the amount of electrofishing exposure to native fishes. Therefore and assuming this proposal is approved, we will conduct depletion estimates in both the current and proposed removal reaches during the first winter trip of 2004 (January). We will then decide whether additional winter trips are necessary and within which reach(es) in order to maintain the target treatment level. Similarly, we will conduct depletion estimates in both the current and proposed removal reaches during the first summer trip of 2004 (July) to ascertain the need for subsequent summer removal trips.

SAMPLING MODIFICATION

We would propose modifying our initial scope of work based on the sampling outcome from the scheduled July-depletion trip in the LCR-inflow Reach (56.2 RM - 65.7 RM). This general area is recognized for having the highest abundance of adult and juvenile HBC in the Colorado River mainstem (Valdez and Ryel 1995, Gorman and Coggins 2000). This modification entails expanding the linear distance of the shoreline so that it encompasses a larger geographic region downstream (65.7 RM – 72.7 RM; Figures 2 & 3). Based on previous census and monitoring studies this downstream area is recognized as a dispersal corridor as well as containing near shoreline habitat that are often utilized by small sized native fish. The proposed area increase for non-native fish removal in shoreline area represents a linear distance of 22.5-km. Therefore, we suggest that the current depletion effort continue as planned in the LCR-inflow Reach for the scheduled July depletion trip; however, that an areal expansion in depletion effort be initiated in the adjoining downstream sections during the already scheduled August and September if results from the July trip suggest that the target treatment level has been achieved in the LCR Inflow Removal Reach.

As above, initiating this modification would be contingent on the results from the overall abundance estimates and differences in catch and emigration rates between this July trip and the previous Winter-depletion effort (January-March 2003). We would initiate this modification only if non-native abundance in the initial removal reach can be kept below a target value of 10% of the January 2003 abundance following the July 2003 depletion trip. We suggest that the present sampling effort continue for the next two-years and that we alternate between depletion efforts in the LCR Inflow Reach (56.2 RM - 65.7 RM) and in the new depletion reaches. The spatial distribution of the depletion effort would be contingent on the overall abundance of non-native fishes in these proposed removal areas and changes in emigration in order to achieve and maintain target value reductions of non-native fishes in all removal reaches.

AUGUST-SEPTEMBER SAMPLING SCHEDULE

Electrofishing sampling methods

Our proposed sampling design would continue to sample using electrofishing in the established control reach (56.2 RM - 65.7 RM) measuring relative abundance and marking RBT (i.e., Floy-tags, catch and release) for determining downstream emigration rates and system-wide population changes. This sampling effort would extend for a one-night time period using four electrofishing boats. The next study element would be to conduct a single-pass depletion effort in the LCR Inflow Removal Reach (56.2 RM - 65.7 RM). This would require the use of four electrofishing boats over a two-night sampling period. Following this sampling effort, we would then move downstream to the designated depletion reaches referred to as the <u>Lava Canyon-Tanner Depletion Area</u> (65.7 RM - 68.5 RM), and <u>Tanner-Unkar Depletion Area</u> (68.5 RM – 72.7 RM).

Although these newer reaches are contiguous we have separated these into two areas based on the logistical constraints of navigating rapids during the night (Fig 1). Within these two-study areas, four depletion reaches (G – I) have been established and are consistent with the naming convention used in the original proposal (Attachment A). The depletion reaches G and H represent the respective right and left shorelines from Lava Canyon (65.7 RM) to Tanner Rapid (68.5 RM). The depletion reaches I and J represent the respective right and left shorelines from Tanner Rapid (68.5 RM) to Unkar Rapid

(72.7 RM). Each of the different reaches is to be subdivided into 500-m intervals. A series of four single-pass electrofishing depletions are to be conducted in the Lava Canyon-Tanner Depletion Area. In the Tanner-Unkar Depletion Area, we intend on moving downstream and re-establishing a base camp and repeating the same effort using four single-pass electrofishing depletions.

Hoopnet Sampling Methods

Using FWS monitoring sites (Gorman and Coggins 2000), hoopnets sampling is to be continued as a method for assessing relative abundance of HBC YOY in the Colorado River mainstem. We propose to continue sampling in the LCR-inflow Reach (56.2 RM - 65.7 RM). Following this depletion effort the trip, we would move downstream to the newly establish hoopnet sampling sites at the Lava Canyon-Tanner Depletion Area (65.7 RM - 68.5 RM) and Tanner-Unkar Depletion Area (68.5 RM - 72.7 RM). Owing to estimated catch efficiency, consideration must be given to assessing whether or not continued electrofishing will have inadvertent damage to the focus species. We recommend alternating the use of hoopnets between the Lava Canyon-Tanner Depletion Area (65.7 RM - 68.5 RM), and Tanner-Unkar Depletion Area (68.5 RM – 72.7 RM) while conducting electrofishing depletion passes in the adjoining depletion area. Findings from hoop-netting effort allow us to increase the sample size, and determine local and overall response changes (relative abundance, dispersal rates, and over-wintering survival) across multiple sampling sites.

All non-native fish stomach samples will continue to be assessed for incidence of predation, and a percentage of these samples are to be evaluated for specific diet. Additionally, drift and benthic samples will continue to be collected in upstream and downstream reaches to determine how different trout species are tracking food resources relative to their availability.

PROPOSED SAMPLING SCHEDULE MODIFICATION

Day 1	Travel day
Day 2	Electrofishing relative abundance estimates for the Control Site (43 RM – 51.5 RM)
Day 3 - 4	One single-pass electrofishing depletion for the LCR-inflow Reach (56.2 RM - 65.7 RM); drift and benthic sampling at 12 sites.
Day 4, 6, & 8	Hoopnets relative abundance estimates (3, 24-h sets) for the LCR-inflow Reach (62.4 RM - 63.5 RM)
Day 5 – 8	Multiple electrofishing depletion passes (4 Nights), Lava Canyon-Tanner Reach (65.7 RM - 68.5 RM); drift and benthic sampling at 12 sites.
Day 5, 7, & 9	Hoopnets relative abundance estimates (3, 24-h sets) for the Tanner-Unkar Reach
Day 9 – 12	Multiple electrofishing depletion passes (5 Nights), Tanner-Unkar Reach (68.5 RM – 72.5 RM); drift and benthic sampling at 12 sites.
Day 10 - 12	Hoopnets relative abundance estimates (3, 24-h sets) for the Lava Canyon-Tanner Reach
Day 13	Reorganize gear, supplies and equipment.
Day 14	Technicians hike out
Day 14 - 17	Runout/takeout (Diamond Creek)

SUMMARY OF WINTER TRIP DEPLETION ACTIVITIES

Examination of the preliminary results from the January, February, and March Removal activities suggests a reduction ~87 % in RBT from the initial January abundance (6,498 fish) following the March trip (782 fish; Figure 1). Theses analyses also indicate very little change in the abundance of RBT between the end of the January trip and the beginning of the February trip (~ 61 fish). However, there was an apparent much larger change in the abundance of fish between the end of the February trip and the beginning of the March. This apparent change in abundance is not unusual even in closed system depletion efforts and could therefore be explained either by immigration into the removal reach, or fish that were previously invulnerable to the sampling gear during January and

February becoming vulnerable during March. Further sampling during the removal efforts in July should allow discrimination between these competing hypotheses. Monitoring by the Arizona Game and Fish Department during April indicates the abundance of fish in the removal reach was approximately 80% of estimates obtained the previously year. This observation adds further credibility to the notion that rapid large-scale immigration into the removal reach is not occurring.

It is our hope that this proposed modification to the existing proposal (Coggins *et al.* 2003) is acceptable and that the concerted effort identified herein be maintained in order to accomplish the stated objectives of this experiment.

LITERATURE CITED

Coggins, L., M. Yard, and C. Paukert. 2003 a. Piscivory by Non-Native Salmonids in the Colorado River and an Evaluation of the Efficacy of Mechanical Removal of Non-Native Salmonids. USGS, Grand Canyon Monitoring and Research Center, Flagstaff, AZ.

Coggins, L., C. Walters, C. Paukert, and S. Gloss. 2003 b. An overview of status and trend information for the Grand Canyon population of the humpback chub, *Gila cypha*. USGS, Grand Canyon Monitoring and Research Center, Flagstaff, AZ.

Gorman, O.T., and D.M. Stone. 1999. Ecology of spawning humpback chub, Gila cypha, in the Little Colorado River near Grand Canyon, Arizona. Environmental Biology of Fishes 55:115-133.

Gorman, O.T., and L. Coggins. 2000. Status and trends of native and non-native fishes of the Colorado River in Grand Canyon 1990-2000. Final Report, USFWS, Flagstaff, AZ.

Leslie, P.H. and D.H.S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. J. Anim. Ecol. 8:94-113.

Minckley, W.L., P.C. Marsh, J.E. Deacon, T.E. Dowling, P.W. Hedrick, W.J. Matthews, and G. Mueller. 2003. A conservation plan for native fishes of the lower Colorado River. BioScience. 53:219-234.

D.M. Stone. 1999. Ecology of Humpback Chub (Gila cypha) in the Little Colorado River, near Grand Canyon, Arizona. M.S. Thesis, Northern Arizona University, Flagstaff, AZ.

Robinson, A.T., R.W. Clarkson and R. E. Forrest. 1998. Dispersal of larval fishes in a regulated river tributary. Transactions of the American Fisheries Society 127:772-786.

Valdez, R.A. and R.J. Ryel. 1995. Life history and ecology of the humpback chub (Gila cypha) in the Colorado River, Arizona. Final Report. Contract No. 0-CS-40-09110. Salt Lake City, UT.

Tyus, H.M., and J.F. Saunders. 1996. Nonnative fishes in the upper Colorado River and a strategic plan for their control. Final Report, Upper Colorado River endangered fish recovery program. Denver: University of Colorado Center for Limnology.

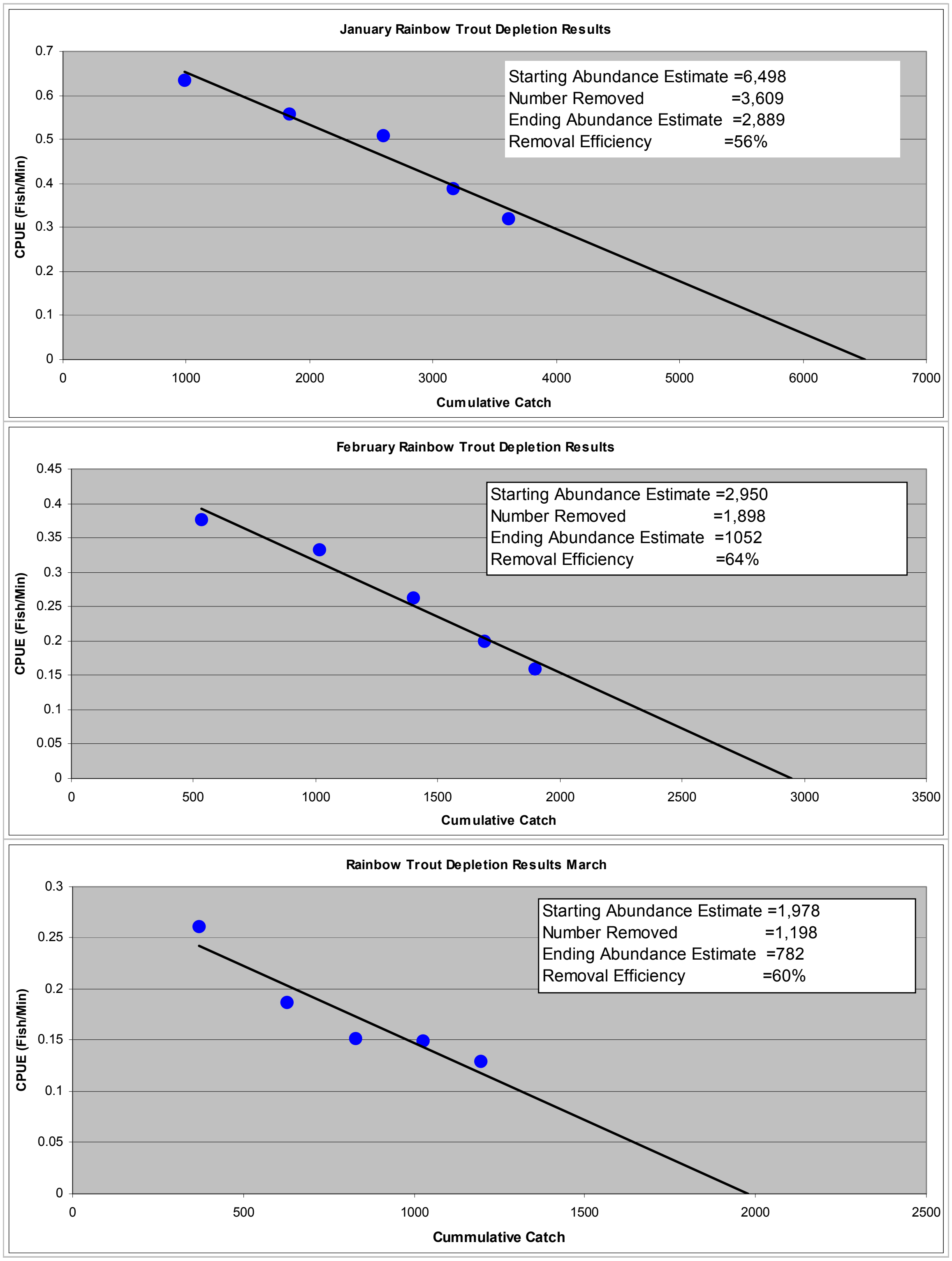

Figure 1. PRELIMINARY ANALYSES. Estimated abundance using the Leslie Method (Leslie and Davis, 1939) at the beginning and end of the three winter non-native depletion trips. The interceptions with the x-axes (cumulative catch) represents the abundance estimate at the beginning of the trips.

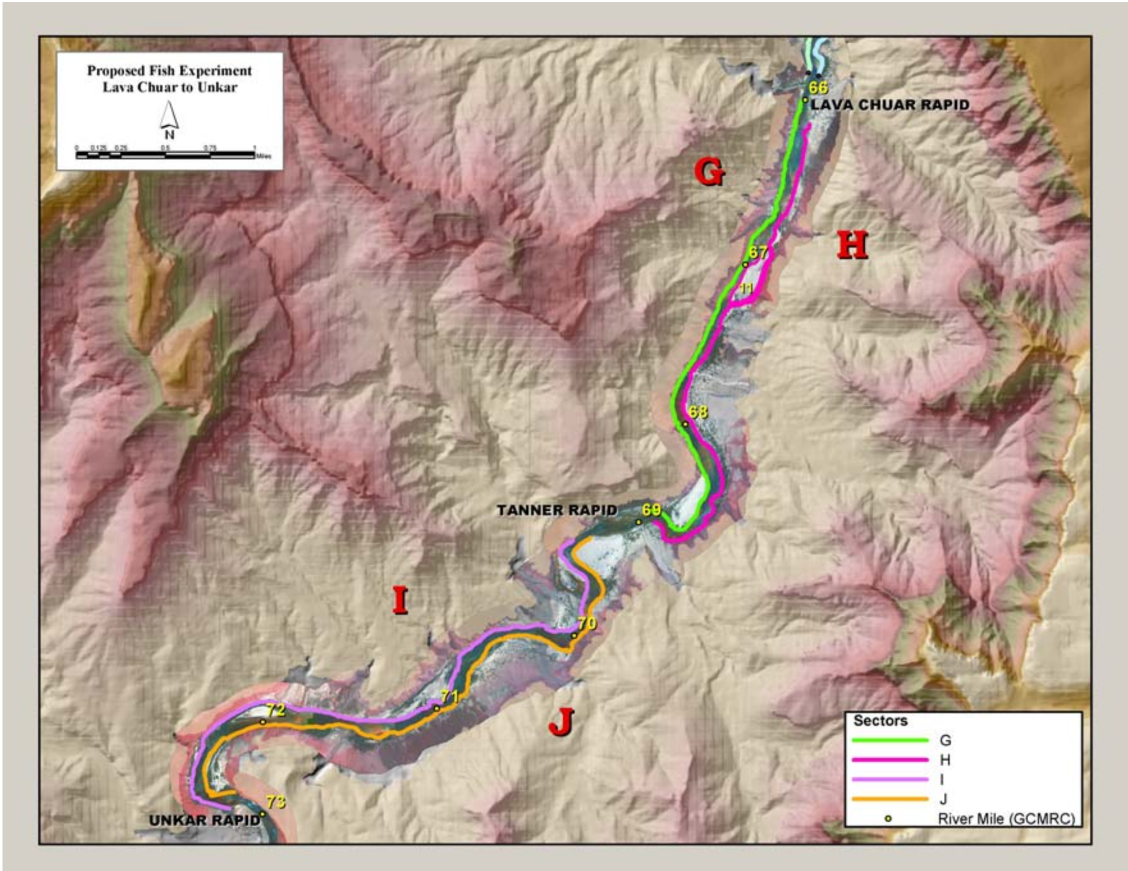

Figure 2. Map of the Colorado River depicting proposed removal reaches.

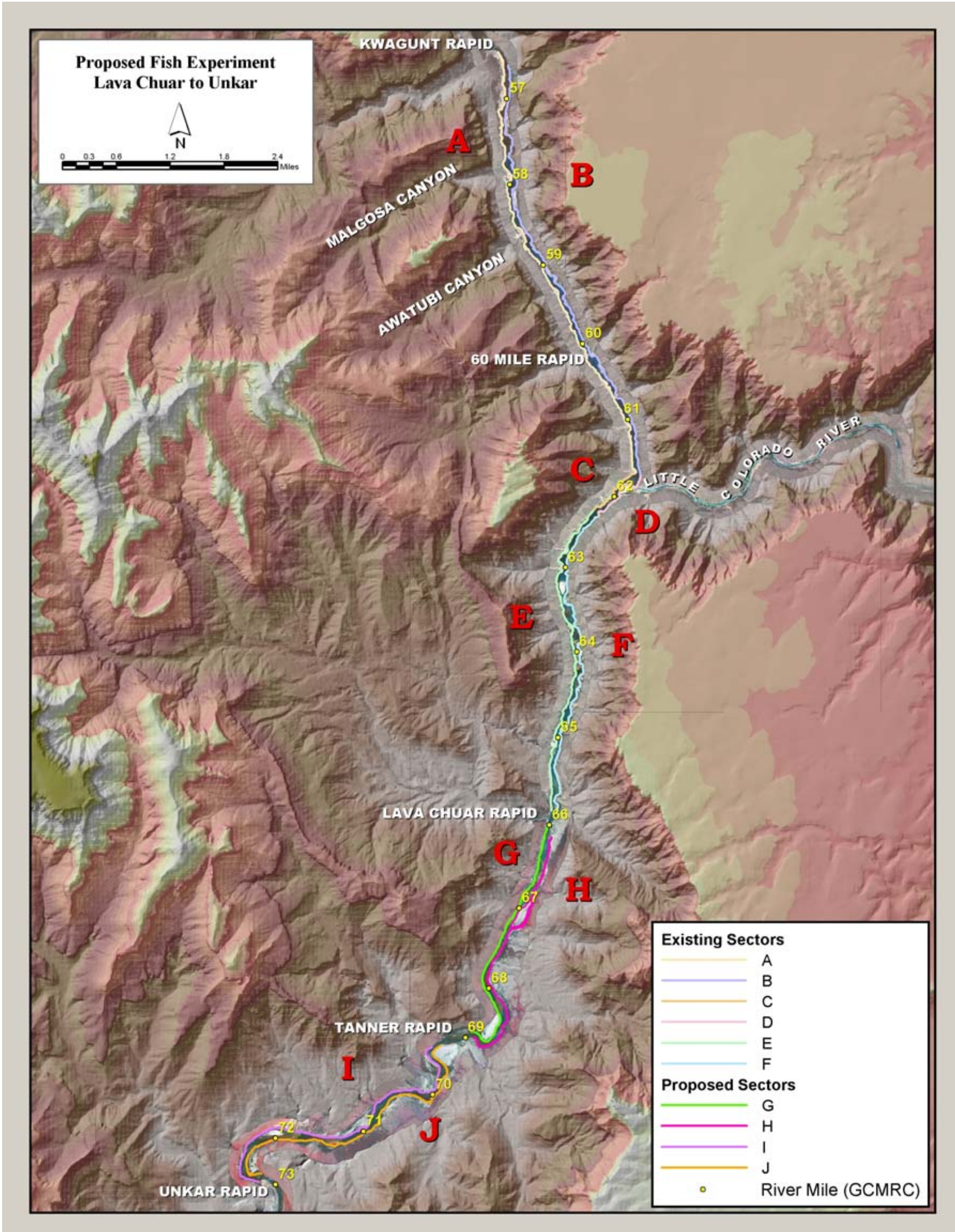

Figure 3. Map of the Colorado River depicting existing and proposed removal reaches.

Attachment 1

Piscivory by Non-Native Salmonids in the Colorado River and an Evaluation of the Efficacy of Mechanical Removal of Non-Native Salmonids

An Operational Plan

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EXECUTIVE SUMMARY

Need

The recommended flows contained within the treatment scenarios related to testing fish hypotheses center around the notion of improving future humpback chub (HBC) recruitment by reducing the number of adult rainbow trout (RBT) and brown trout (BNT) residing in the system downstream of Lee's Ferry. This study will address questions raised by the Technical Working Group (TWG) of the Glen Canyon Adaptive Management Program asking 1) whether or not reducing RBT and BNT abundance will improve HBC recruitment and a related question 2) are RBT and BNT significant predators of HBC? This study will also address a number of issues identified by the aquatic protocol evaluation panel (Anders et al. 2001). The panel had concerns with the lack of empirically established linkages between food base and fishes, and identified that a possible consequence of the recent increase in primary and secondary production may differentially benefit non-native species (competitors or predators) over native species. Secondly, the panel identified the need for establishing a better understanding of the relationship and trophic linkages between foodbase and fish. Therefore, the trout dietary analysis in this study will be integrated with other existing GCMRC long-term monitoring programs that are presently collecting or proposing to collect data specific to: 1) aquatic benthic foodbase, and 2) carbon productivity monitoring program.

Benefits

With the potential removal of non-native fishes that may prey on or compete with humpback chub, recruitment of humpback chub may increase. This study will determine if mechanical removal of salmonids is feasible in a large river ecosystem. The mechanism for possible increased humpback chub recruitment will be determined through diet analyses of salmonids. In addition, diet analyses will determine the size range of piscivorous salmonids and the relationship between prey size and predator size.

Objectives

The objectives of this study are to determine 1) the efficacy of mechanical removal of adult RBT and BNT from the LCR Inflow reach, 2) RBT and BNT predation and diet, and 3) the effect of adult RBT and BNT in the LCR inflow reach on the population dynamics of the LCR HBC population. In addition, we will continue to monitor the HBC population downstream of the LCR to determine mortality/emigration rates from the LCR reach.

Study Area

We have selected a study area in the Colorado River (56.2 RM - 65.7 RM) that encloses the majority of the geographic distribution of the Little Colorado River humpback chub population. The upstream and downstream study area endpoints are bounded by hydraulic and geomorphic controls (Kwagunt and Lava Chuar Rapid). A control reach has also been established between RM 44 and RM 52 (President Harding Rapid to Nankoweap).

Procedures

We will conduct annually, three depletion trips in January-March and three depletion trips in July-September. The annual depletion efforts will be repeated four years, for a total of 24 times, to determine how removal of fish using a series of depletion passes in a discrete area will influence the relative abundance of the remaining fish stock. The sampling efforts are scheduled to coincide with the major periods of LCR flooding events (spring runoff and monsoonal storms) that are correlated with juvenile HBC immigration to the mainstem Colorado River (Valdez and Ryel 1995). Non-native fishes will be collected, euthanized, and disposed. All native fishes will be measured, weighed, tagged, and released. Stomach contents will be collected from all non-native fish to determine incidence of predation on humpback chubs. To determine prey selection for invertebrates by salmonids, entire stomach contents from a sub-sample of non-native fish will be collected and compared with invertebrate drift samples collected during the same time as the fish collections.

Deliverables

Semi-annual reports and presentations will be given to the Adaptive Management Work Group and /or the Technical Work Group during December and June of each year of the study. At least four peer-reviewed publications in the primary literature are expected from this body of work. The anticipated submittal date for these peer-reviewed publications is 2004-2006.

INTRODUCTION

Background

Recent analyses of historical humpback chub (HBC) data suggest that the abundance of the Little Colorado River (LCR) population is in decline (Figure 1; Grand Canyon Monitoring and Research Center (GCMRC) unpublished analyses). These analyses utilized mark-recapture data in an open population model to construct estimates of the population recruitment (1989-1998 brood years) and sub-adult and adult abundance (>150 mm total length; 1991-2000). The decline in the abundance of sub-adult and adult fish appears to be the result of continued low recruitments beginning with the 1992 brood year. As these weak year classes have entered the sub-adult and adult portions of the population, the overall abundance of HBC has declined from a peak of 8,279 in 1993 to 2,515 in 2000. The overall trends in recruitment and abundance are supported by two additional analyses. First, the downward recruitment trend is supported by trends observed in the catch-rate (CPUE) of Age-1 and Age-2 HBC from hoopnet sampling in the LCR (GCMRC unpublished analyses). Second, a closed population mark-recapture experiment conducted in the LCR during the spring of 2001 indicated the population contained only 2,090 (95% C.I. 1611-2569; HBC >150 mm total length; USFWS unpublished data). Combined, these three independent analyses provide sufficient evidence to conclude that the Little Colorado River population of HBC is in decline.

Of paramount importance in conserving this population of federally endangered humpback chub is determining the factors contributing to this population decline and implementing management actions designed to minimize the effect of those factors. Although it is still unclear all of the factors that may be responsible for the recruitment decline beginning in 1992, we have identified a list of likely factors that could be acting either singly or in combination. These factors include: 1) Colorado and Little Colorado River hydrology, 2) infestation of juvenile HBC by asian tapeworm, 3) predation by or competition with warm-water native cyprinids and catastomids and non-native cyprinids and ictalurids within the LCR, and 4) predation by or competition with cold-water non-native salmonids within the Colorado River.

The body of evidence available to evaluate specific hypotheses varies among the postulated factors. For instance, beginning in August 1991 the operation of Glen Canyon Dam was changed to reflect the so-called “interim operating criteria”. This hydrology, and the subsequent Record of Decision flows that continue to present, can be generally characterized as having less severe daily flow fluctuations than the previous 28 years of load-following hydrology. Temporally, this major change in Colorado River hydrology correlates closely to the decline in HBC recruitment. Additionally, it is possible that the initial decline in HBC recruitment in 1992 was caused by the nearly continuous flooding in the LCR that occurred during summer 1992 through early winter 1993, particularly during the early summer time period when larval HBC emerge (Robinson et al. 1998). It is also possible that the high infestation rate of juvenile HBC by the introduced parasite asian tapeworm is a causative factor. HBC infected with asian tapeworm were first found during 1990, and infestation rates during 2001 have exceeded 90% (Anindo Choudury, pers. comm.). Finally, predation and competition by fishes either within the LCR or in the Colorado River may be driving the HBC recruitment trend. Although robust relative abundance data does not exist for non-native fishes within the LCR, there has been a large increase in the abundance of non-native salmonids in the Colorado River near the confluence of the LCR (LCR Inflow Reach 56.2 RM - 65.7 RM; Figure 2).

While it is difficult to determine which factor is most responsible for the HBC recruitment decline, a likely significant factor is negative interactions (predation and competition) with non-native fish. Interaction with non-native fish is implicated in the decline and extinction of native fishes throughout the Colorado River basin (Tyus and Saunders, III 2000 and references therein). Indeed, after being presented with the recent analyses describing the decline in the LCR HBC population, the Glen Canyon Dam Adaptive Management Work Group (AMWG) passed motions to begin planning and to conduct feasibility studies to reduce non-native fish abundance in the Little Colorado River and Bright Angel Creek. These first steps are commendable, however they do little to address the potential threat of predation and competition by rainbow (RBT) and brown trout (BNT) in Colorado River. To compliment these efforts, this study will be initiated to evaluate the potential effect of RBT and BNT predation on HBC recruitment and the efficacy of mechanical removal of RBT and BNT from the LCR Inflow reach.

Need

A series of experimental treatment scenarios for WY 2002-03 was developed by GCMRC in conjunction with the Adaptive Management Technical Work Group. At their April 24, 2002 meeting, the AMWG reviewed these scenarios and made their recommendation for implementing Experimental Flows and Mechanical Removal of salmonids in the LCR reach of the Colorado River Ecosystem. Secretary Norton approved the recommended experimental flows and mechanical removal in December 2002.

The recommended treatments contained within the experimental scenarios related to testing fish hypotheses center around the notion of improving future HBC recruitment by reducing the number of adult RBT and BNT residing in the system downstream of Lee's Ferry. Conceptually, this is to be accomplished in two ways. First, by reducing RBT and BNT recruitment by inflating the early life mortality rate of these fishes with highly fluctuating flows during their winter and spring spawning and rearing seasons. Second, by mechanically removing salmonids within the LCR inflow reach.

To date, a significant number of stakeholder groups have expressed concern about the winter and spring flow fluctuations called for in the experimental flows. Sport fishing interests are opposed to the fluctuating flows fearing significant negative impacts to the Lee's Ferry trout fishery. Additionally, several stakeholder groups have specifically asked: 1) whether or not reducing RBT and BNT abundance will improve HBC recruitment, and a related question 2) are RBT and BNT significant predators of HBC. This study is intended to address these questions as well as others formulated by the Technical Work Group (TWG) of the Glen Canyon Dam Adaptive Management Program. The TWG has identified a series of research information needs (RINs) specifically related to RBT and BNT predation on HBC. These include: "RIN 2.4.1-What are the most effective strategies and control methods to limit non-native fish predation and competition on native fish?; RIN 2.4.2-Determine if suppression of non-native predators and competitors increases native fish populations?; RIN 2.4.4-What are the target population levels, body size and age structure for non-native fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?; RIN 4.2.6-To what extent are RBT below the Paria River predators of native fish, primarily HBC? At what size do they become predators of native fish, especially HBC, i.e. how do the trophic interactions between RBT and native fish change with size of fish?" (GCMRC 2001). This work will attempt to answer some of these questions.

This study will also address a number of issues identified by the aquatic protocol evaluation panel (Anders et al. 2001). The panel had concerns with the lack of empirically established linkages between food base and fishes, and identified that a possible consequence of the recent increase in primary and secondary production may differentially benefit non-native species (competitors or predators) over native species. Secondly, the panel identified the need for establishing a better understanding for relationship and trophic linkages between foodbase and fish. Therefore, the trout dietary analysis in this study will be integrated with other existing GCMRC long-term monitoring programs that are the presently collecting or proposing to collect data specific to: 1) aquatic benthic foodbase, and 2) carbon productivity monitoring program.

Algae/macrophytes and invertebrates form the major components of the aquatic food base in the Colorado River ecosystem. The different macroinvertebrates consisting mostly of midge larvae (chironomids), black flies (simulids) and amphipods (Gamarus) trophically supports the trout fishery found in the Glen Canyon reach, as well as the fishery downstream of Lees Ferry. The foodbase is considered an important biotic resource because of the potential limitations, use, and availability required to support these different fish species. Research findings have revealed that a significant stair-step decrease occurs for both the composition and biomass of the major components of the foodbase (Usher and Blinn 1990, Hardwick et al. 1992, Blinn et al. 1993, Blinn et al. 1994; Shannon et al. 1994). This progressive decrease in the aquatic foodbase is related primarily to an increase in turbidity brought about from periodic tributary flows and the suspension of fines transported by higher discharges. Additionally, similar downstream patterns exist for fish distribution, compositional shifts, and a general reduction in relative abundance for certain species (Maddux et al. 1987, and Valdez and Ryel 1995). Separate studies have demonstrated a strong trophic linkage to the aquatic food base, as well as its spatial availability to fish (Shannon et al. 2001; Angradi 1994). Although, there is no direct evidence suggesting food limitations; studies measuring trophic pathways for the different biotic components have been conducted (Angradi 1994; Haden et al. 2002 In review; Shannon et al. 2001). These biotic patterns correspond to increasing distance downstream from Glen Canyon Dam.

Foraging preferences and nutritional requirements for these different fish species are not well known for this particular system (Anders *et al.* 2001). Certain observational studies (e.g., Valdez and Ryel 1995) have shown that the overall assemblage of fish use different aquatic and terrestrial invertebrates, as well as fish that are either young or small-sized (Valdez and Ryel 1995; Rowell 2001). It is ecologically recognized that most young developing fish do not survive to recruit into the reproductive population. Most of the mortality occurring to these vulnerable fish is due to predation. Therefore, small sized fish represent a proportion of the overall foodbase in this ecosystem. The physical and biotic factors that regulate their availability as a food item, as well as their survival, influence the population dynamics of these different fish species. Although predation has been documented for the different trout species (rainbow and brown trout), their apparent food habits as indicated by stomach content analysis are not conclusive. Especially, when it comes to understanding the possible trophic interactions that exist between different size-age classes and the environmental pressures associated with different population densities and variable food availability.

Our current understanding regarding benthic and drift production and fish life histories limits our ability to make these linkages between lower trophic levels and food availability for native and non-native fishes (Anders et al. 2001). Although it has been implicitly recognized that fish consume invertebrates and fish, previous research has not demonstrated food limitations to higher trophic levels (Valdez and Ryel 1995). Because the assumed trophic linkages between food base and fishes have not been empirically established, it is difficult to determine food base requirements (Anders et al. 2001). Therefore, recent increase in algae/macrophytes and invertebrates may have direct benefits to native fish. Conversely, the process of maintaining or maximizing the production of the aquatic food base may benefit solely non-native species that are possibly better competitors, and/or predators in this altered ecosystem.

OBJECTIVES

The study is motivated by the following classes of objectives: 1) Efficacy of mechanical removal of adult RBT and BNT from the LCR Inflow reach, 2) RBT and BNT predation, and 3) Effect of adult RBT and BNT in the LCR inflow reach on the population dynamics of the LCR HBC population.

Efficacy of Mechanical Removal of Adult RBT and BNT from the LCR Inflow Reach

1. Estimate abundance of adult RBT and BNT in the LCR Inflow reach prior to each removal event.

2. Estimate changes in adult RBT and BNT size composition in response to removal events.

3. Determine trout immigration rate (Seasonal and Annual) into the LCR Inflow reach between removal events.

4. Estimate gear efficiency as a function of boat type, turbidity, season, and dominant habitat type.

Rainbow and Brown Trout Diet Analysis and Predation

1. Estimate the instantaneous proportion of adult RBT and BNT residing in the LCR Inflow reach that are piscivorous.

2. Determine relationship between adult RBT and BNT total length and likelihood of piscivory.

3. Estimate the relationship between adult RBT and BNT total length and gape.

4. Estimate the relationship between adult RBT and BNT total length and prey body depth.

5. Estimate adult RBT and BNT diet composition.

Effect of Adult RBT and BNT in the LCR Inflow Reach on the Population Dynamics of the LCR HBC Population

1. Evaluate the relationship between adult RBT and BNT abundance in the LCR inflow reach and juvenile HBC survival/retention rate in the LCR inflow reach.

2. Evaluate the relationship between adult RBT and BNT abundance in the LCR inflow reach and recruitment to the LCR HBC population.

METHODS

Study 1. Procedures for the Mechanical Removal of Non-Native Salmonids from the Little Colorado River Reach of the Colorado River

Study Area and Design

Removal Reach: The LCR Inflow reach is recognized for having the highest abundance of adult and juvenile HBC in the Colorado River mainstem (Valdez and Ryel 1995). We have selected a study area (56.2 RM - 65.7 RM; Figure 3) that encloses the majority of the geographic distribution of the LCR HBC population. The study area is stratified into 6 river reaches: A-F. Reaches A and B are the right and left shore reaches from Kwagunt Rapid (RM 56.2) to Science Beach (RM 61.5). Reaches C and D are the right and left shore river reaches between RM 61.5 to RM 62.1 and include the LCR confluence and the mixing zone below the LCR. Reaches E and F are the right and left shore reaches downstream of the LCR confluence (RM 62.1 to Lava Chuar Rapid RM 65.7). We stratified the study area into these 6 reaches in order to control for the affect of the LCR discharge into the Mainstem Colorado River. Reaches A and B are unaffected by the tributary and reaches E and F are believed to be of sufficient distance downstream of the mixing zone to be affected uniformly throughout. Reaches C and D include the LCR confluence and will be differentially affected by LCR discharge throughout their lengths. Within river reaches A-B and E-F, the shoreline is divided into 500m sites. The number of sites within each river reach is as follows: A=19, B=19, E=13, and F=14 (13 shoreline sites and one island site). Reaches C and D constitute single sites. A base camp for each trip will be established at Science Beach (across from the LCR confluence).

The upstream and downstream study area endpoints are bounded by hydraulic and geomorphic control; however, they are not impermeable to system-wide fish movement (Stevens et al. 1997). For this reason, depletion efforts will be conducted that are both spatially discrete, and repeated seasonally over a period of 4 years (Table 1). We will conduct annually, three depletion trips in January-March and three depletion trips in July-September. The annual depletion efforts will be repeated four years, for a total of 24 times, to determine how removal of fish using a series of depletion passes in a discrete area will influence the relative abundance of the remaining fish stock. Since we will be unable to control for migration, recruitment and mortality occurring at a local level, comparisons among trip population estimates will be analyzed in order to evaluate if mechanical removal methods are an effective means to control for undesirable fish species. The sampling efforts are scheduled to coincide with the major periods of LCR flooding events (spring runoff and monsoonal storms) that are correlated with juvenile HBC immigration to the mainstem Colorado River (Valdez and Ryel 1995).

Control Reach: To determine if differences in fish population characteristics (e.g., relative abundance, size structure, etc.) in the experimental reach is a function of environmental influences/fluctuating flow treatments and not the mechanical removal, a control area has been selected (44 RM – 52 RM; Figure 4) and divided into 60 500 m sites occurring on both sides of the river. The 24 randomly selected sites within the control area will be sampled to estimate the relative abundance and size structure on the first night of each trip (once per trip, 6 times per year). All fish collection, handling procedures, and data recording will proceed as described below for the removal reach except no fish will be euthanized within the control reach.

Data Collection

Control Reach: Table 2 details the day specific tasks to be performed within a typical trip. On day one, sport boats will proceed ahead of the group to distinguish and mark control sites to be sampled. On night one, electrofishing within the control reach will begin. Four boats will electrofish a total of 24 sites (2 boats 7 sites each and 2 boats 5 sites each; Table 3a) to complete all data collection in the control reach. The transport boat will assist those boats sampling 7 sites with fish processing in order to speed overall sampling activities. All fish will be measured to determine relative abundance and size structure within the control reach. All fish collection, handling procedures, and data recording will proceed as described below (for the removal reach) except no fish will be euthanized within the control reach. Additionally, each captured rainbow and brown trout greater than or equal to 200 mm will be fitted with a floy tag between the dorsal fin pterygiophores near the posterior portion of the fin. The tag number and recapture status will be recorded in the two fields associated with Tag2 on the Electrofishing Depletion Data Sheets (Appendix A). All RBT and BNT fitted with a flow tag will also be given a left Pelvic Fin Clip (LP2). Finally, trout processed by the transport boat crew will be weighed in order to collect the data necessary to estimate RBT condition in the control reach. There will be no processing station; upon capture, all fish will be placed in fresh water to be worked up at the end of each sampling site. Each electrofishing boat driver/netter will be responsible for their data collection and recording on the Standardized Depletion Electrofishing Data Sheet (Appendix A). When each site is completed, all fish will be released at the upper end of the site.

Removal Reach: Following arrival at the Science Beach base camp on day two, GPS units and aerial photographs will be used to mark the boundaries of the 500m sites within reaches A-B and E-F (Figure 3). The boundaries will be marked by hanging lengths of pvc pipe wrapped with reflective tape. Each of these boundaries will also be marked with small aluminum tags inscribed with the site name immediately downstream of the boundary. Over the course of 10 nights (Days 3-12 in Table 2), all sample units within reaches A-B, E-F, and C will be electrofished 5 times. The upper ½ of reaches A-B and E-F and reach C will be electrofished on days 3,5,7,9,and 11. The lower ½ of reaches A-B and E-F will be electrofished on days 4,6,8,10, and 12. Reach D will not be electrofished unless low water conductivity and low native fish abundance can be assured. Electrofishing is not to begin earlier than dusk. The actual start time will depend on the sampling season and will be decided upon at the beginning of each trip. Electrofishing boat operators are to ensure that boats are maintained and fully operational prior to electrofishing. On each of the four (4) boats all of the necessary electrofishing equipment and supplies are to be checked prior to use. This is the responsibility of the technical electrofishing boat operator. Upon completion of nightly electrofishing, the electrofishing crews are to transport the remaining catch to the Processing Station.

Boat, Driver, and Netter Allocation within Reaches**:** A total of 4 electrofishing boats of two types each will be utilized in this study. The boat types are: 1) 15' Achilles sport boat (rubber hull) and 2) 15' Osprey sport boat (aluminum hull). Within the removal reach, a rubber boat and an aluminum boat will always be used above the LCR and 1 of each will always be used below the LCR. The 4 boat drivers will be randomly assigned to a particular reach/depletion run within each trip. The underlying purpose for the random assignment is to control for systematic bias that might exist among different electrofishing boat operators. Electrofishing boat operators are expected to sample all 10 nights without substitution or assistance from other boat operators on the trip (emergencies or illness aside). Table 3b reports boat type and boat driver assignments by depletion run for the January, February, and March trips. This design will assure that accurate assessments of reach and boat specific catch-rates are not biased by (or can be adjusted for) driver and netter affects. Sampling equipment, methods and electrical configuration used will be consistent with the established GCMRC fish handling and sampling protocols (Appendix E).

Netting is an extremely important component to the success or failure of this study; therefore this activity requires attentive behavior. However, no attempt will be made to control for variability that exists among netters. Only a single netter will be used per boat. Technical personnel that are netting are expected to rotate out every other day through the different fish electrofishing and processing activities. A personnel schedule will be posted at the science camp identifying a rotation schedule. Netters are expected to rotate between different boats, electrofishing boat operator and processing activities (refer to posted work schedule). Netters are expected to be consistent in their performance, which requires being safe, observant and coordinated. Owing to the continuous workload, if a netter becomes fatigued, alternates will replace he/she during the night. The electrofishing boat operator will make this decision. The transport-boat will be used for exchanging netting personnel rather than the electrofishing boat.

Electrofishing Power Standardization: The two boats will be outfitted with identical Coeffelt CPS mark XXII electrofishing boxes. Since the boats produce different electrical field characteristics due to different electrode configurations and therefore fishing efficiencies, the same boat will be used for each depletion run within a river reach for an entire trip. In an attempt to standardize efficiency as much as possible, the power output for each boat will be adjusted to produce on average 5,000 watts (e.g. Achilles 333 volts, 15 amps; Osprey 238 volts, 21 amps). technical boat operators will be supplied with a power curve to allow them to standardize power to 5000 watts for any ambient water conductivity (Figure 6). Power should be standardized in mid-river or a suitably deep location so that the electrical field is free of obstructions during standardizing. Power will be standardized when the CPS unit has been adjusted so that values for voltage and current (amperage) fall on the 5000 W power curve.

Fish Handling Procedures: During removal operations, qualified personnel are to identify fish to species. A fish key will be available for reference. Fish are then to be separated into two storage containers as either native- or non-native fish. Salmonids and other non-native fish (catfish, carp, fathead minnows, killifish, etc.) are to be euthanized and temporarily stored in 1/8" small mesh net. These small-meshed Net Sample Bags (30-L capacity) are to line the inside of the non-native fish storage container containing the euthanizing solution. Since there is a potential for inadvertently placing native fish in the euthanizing bath, netters are to collect no more than two fish per net sweep to avoid potential misidentification of native fish. Upon completing the designated electrofishing site the small-meshed Net Sample Bags are to be removed and transferred to the shoreline above the high water mark at designated collection points. A Data Info Card with all pertinent information will be filled out and attached to the sample bag containing euthanized fish. These data are to include: Study Reach (A, B, C, D, E, or F) and section # (1-19), date, depletion #, and total effort (seconds). In addition to the Data Info Card, a light stick will also be affixed to the bag. If an electrofishing run did not catch fish, an empty net and accompanying information will be left at the designated collection point for the fish transport boat. Additionally, if an electrofishing run did not catch fish, a depletion electrofishing data form will also be completed to record sample specific information (e.g. site, effort, depletion #, etc.). This is to be done to avoid any undue confusion regarding missed sites. The locations for these fish collection points are to be at or near the end of the electrofishing section and are to be visually apparent (i.e. light sticks visible from the river). Sample bags are to be rocked down so as to avoid scavengers (coyotes and foxes) inadvertently displacing fish carcasses. This is the responsibility of the technical electrofishing boat operator.

Non-native fish are to be euthanized using a solution super-saturated with carbon dioxide (CO_2). The solution will be prepared by dissolving 6-8 oz of sodium bisulfate ($NaHSO_4$; swimming pool acid) in approximately 12 gal of water to make a slightly acidified solution. Two pounds of sodium bicarbonate ($NaHCO_3$; Baking Soda) contained in a perforated zip lock bag will then be sunk to the bottom of the container. As the acidified water reacts with the baking soda, the solution will effervesce, driving the oxygen out of the water and causing the solution to become super-saturated with carbon dioxide. This solution should be effective for an entire night's work, but may require freshening with additional baking soda if used for multiple days.

Native fish caught during the electrofishing run are to be separated and placed in a separate container containing fresh water. Native fish will be processed and released alive in the field by qualified boat personnel. Standard fishery measurements are to be collected on all native fish encountered. To avoid recapture, fish will be transported to the upper extent of the electrofished section. Passive integrated transponders (PIT) are used as a method for mark-recapture estimates for abundance, relative year class strength, recruitment, growth and movement in the Colorado River mainstem and associated tributaries. All native fish (>120 mm) will be assessed for PIT-tags; as well as fin-clips and other associated marks being used as part of the GCMRC monitoring program. To avoid depressed oxygen levels, water needs to be periodically changed. This should occur between individual electrofishing runs. In the unlikely event of native fish mortality (e.g., endangered humpback chub), the specimen(s) will be preserved and brought back to the GCMRC for a complete analysis. Specimen(s) will be documented in the field and standard measurements (PIT-tag, TL (mm), weight (g), sex, and the presence of external parasites) will be collected. A visual inspection will be conducted to evaluate the fish for any skeletal abnormalities, or bruising and discoloration that may occur from electrofishing. A necropsy will be performed to assess for abdominal and intra-muscular injuries. The fish will be eviscerated carefully removing stomach and entire intestine for later dietary analysis.

Data Recording: Boat drivers/netters will be responsible for filling out Electrofishing Depletion Data Sheets following electrofishing each site even if the site produced no fish to record sample specific information (e.g. site, effort, depletion #, etc.; Appendix A). Data sheets are to be legible and completed for each electrofishing section. In order to expedite electrofishing effort these data sheets have been simplified to avoid redundancy in data recording. Data sheets are to remain on each of the four-electrofishing boats between runs. Upon completion of the nightly electrofishing activities, each of the electrofishing boat operators are responsible for transferring all completed data sheets to the data storage box. The following day the electrofishing boat operator/data recorder is to evaluate all recorded data sheets and identify any errors that might have occurred during the previous nights transcription. Upon validation, the data sheets are to be placed in the designated Data Storage Box for safekeeping. Any corrections made to the data sheets need to be drawn to the attention of the designated Trip Principal Investigator (PI). It is the responsibility of the trip PI to ensure that all data sheets have been properly filled out by electrofishing boat operator and processing crew.

Fish Transport: A transport boat is to collect fish at each of the designated collection points; however, because of the distance between collection points the boat operator will alternate between the upper and lower reaches while transporting fish to the Fish Processing Station. All attempts will be made to avoid undue gas consumption. The return time interval between sampled reaches is estimated at 1 to 1.5-hr. All non-native fish will be transported to Processing Station for data collection activities and processed during a single electrofishing night to avoid decomposition and loss to stomach samples. Transport boat personnel are to verify if the Data Info Card with all pertinent information has been filled out and attached to the sample bag containing euthanized fish. These data are to include: Study Reach (A, B, C, D, E, or F), site # (1-19), date, depletion #, and total effort (seconds). If data is absent this information must be acquired from the responsible electrofishing crew. Additional responsibilities include the collection of drift during nights 1 & 2. The availability of drift is to correspond with the first depletion effort. Boat operator will alternate drift sampling between upstream and downstream reaches at 12 established sites. A total of six sites, three upstream and three downstream are to be sampled per night, and then repeated at six other sites the following night. Each of the sampling locations is marked by a set of buoys that are sufficiently anchored within the mid-channel eddy complex. Buoys are to provide for a secure boat attachment and to be used as a stationary sampling platform. A total of six replicate samples are to be collected over the course of a 6-h period. This drift sampling is to coincide with the transport of euthanized fish to the Fish Processing Station. This sampling effort requires two personnel in order to deploy multiple samplers, collect and data record. Samples are to be taken to Fish Processing Station for sieving and preservation (refer to Drift Sampling). The drift effort is to be discontinued after the second night.

US Fish and Wildlife Fish Handling Directives: As a condition of the Biological Opinion (USFWS 2002) associated with mechanical removal operations issued by the US Fish and Wildlife Service, the following procedures must be followed at all times:

1. All humpback chub captured will be held separately from non-native fishes to minimize stress, predation, and injury during recovery from electrofishing. If this cannot be accomplished, the non-natives shall be sacrificed.

2. In the Control Reach, action agencies shall provide the greatest release distance between native and non-native fishes as possible.

3. All humpback chub shall be processed and released immediately after recovery in the near-shore habitat where they were collected.

4. All rainbow trout captured in hoopnets shall be checked for predation on humpback chub.

5. Placement of pit tags by field crews shall be conducted only by those individuals previously permitted by the Fish and Wildlife Service to handle and pit tag humpback chub, or those individuals who have received training by permitted individuals and 20 hours of supervised pit tagging.

Data Analysis

A variety of data analyses will be performed to address the objectives under: efficacy of mechanical removal of adult RBT and BNT from the LCR Inflow Reach. The major data analysis tasks and associated strategies include, but are not limited to, the following:

Task 1. Estimate initial abundance in each of 4 river reaches (A-B and E-F) for each trip during 2002 – 2005. We will conduct five-pass Leslie DeLury depletion estimates for each site within each reach (Van Den Avyle and Hayward 1999). The mean population estimate (number of trout per 500 m of shoreline) will be calculated for each reach and compared among reaches and years with an analysis of variance (ANOVA).

Task 2. Test whether initial abundance varies between depletion trips. The mean population estimate (number of trout per 500 m of shoreline) will be calculated for each reach from each individual site population estimate (n=13-19, depending on reach) and compared among reaches and trips with a two-way repeated measures analysis of variance (ANOVA) with reach and month as the class variables. Because each site within each reach will be sampled more than once, the population estimate from each site may not be independent of the population estimate from that same site subsequent sampling trips. Therefore, sampling site will be the repeated variable.

Task 3. Evaluate differences in efficiency among boats (rubber versus aluminum). The catchability coefficient (q) will be calculated for each 5-pass depletion estimate at each site within each reach. A three-way ANOVA with interaction terms will be used with boat type, habitat type, and river reach as main effects and q as the dependent variable. A significant ($P<0.10$) boat effect would suggest that boat type influenced catchability (assuming there were no significant interactions that included boat type).

Task 4. Evaluate differences among initial abundance among dominant shoreline habitat types. The shoreline of the entire study area will be classified into four discrete habitat types based on existing geographic information systems models. Each sampling site will be then classified as the dominant habitat type found in that site. If there is not a dominant habitat type (e.g., equal length of two habitat type within the same site), this site will be removed from further analysis. A three-way ANOVA (with interactions) will be used to compare depletion population estimates among habitat types, two river reaches (upstream of LCR and downstream of LCR), and sampling trip.

Task 5. Evaluate differences in efficiency among turbid and clear water conditions. Catchability (q) will be calculated for each depletion estimate at each site within each reach. An analysis of covariance will be used to determine if q decreased with increased turbidity, controlling for river reach. In this analysis, we hypothesize that q will increase with increased turbidity. However, q may also be affected by river reach; therefore, river reach will be used as a covariable.

Study 2. Salmonid Diet Analysis and Invertebrate Drift

There are two separate components associated with this salmonid diet/predation data collection effort; they are: Total Trout Diet Analysis and Trout Piscivory Analysis. Methods to achieve these analyses are described below.

Fish Processing and Data Collection

As described above a fish processing station will be set up at the science camp (61.4 RM). At the processing station one individual will function as field coordinator to oversee all processing activities. A four (4)-person crew will be responsible for all data collection and fish processing activities. These personnel include 1) data recorder, 2) length/weight measurements, 3) stomach evisceration/preservation, and 4) sample organizer. All processing activities will occur during night and are estimated to extend over an 8-hr period.

Data Recorder

This individual will be in charge of organizing supplies and equipment, replenishing of stock supplies, personnel scheduling, and data recording. The designated processing personnel are to assist in all aspects of these field tasks. All data will be recorded during each processing session/night. The following day the data recorder will check all recorded data sheets to identify any errors that may have occurred. Upon finalization data sheets are to be placed in safekeeping in the designated storage box. Trip leaders are responsible for examining data sheets following completion and verifying that they have been filled out properly.

Measurements: Specific measurements on all sampled fish will be recorded at the processing station. These measurements include: numeric-coded tag for stomach sample identification, species identification, total length (mm), weight (g), sex, and gape-width (mm). Information on recaptured fish such as PIT-tagged trout and fin clipped trout will also be recorded. All measurements taken will be called out to the data recorder and entered into the Fish Processing Data Sheets (Appendix B).

Stomach collection: Stomachs from all non-native fish will be collected, preserved, and stored in nalgene containers to ensure that no contents are lost. The preservative solution will consist of 95% ethanol prepared in advance. It has been estimated that 25-ml of preservative will be used for each collected stomach; however, adjustments may be made according to size and contents. A length-wise incision will be made along the foregut to ensure preservation. Each stomach will have a corresponding numeric metal-coded tag placed in the bottle with all contents. Fish will be processed sequentially and assigned to a sampling reach and section, referred to as a sampling lot. All fish collected during an electrofishing run will be collectively separated and stored using a larger plastic bag. Each plastic bag will be marked according to the designated sampling reach, site and date. Aluminum storage boxes will be used as storage containers for the different Sampling Lots. These storage boxes contain 380 nalgene containers that have been pre-filled with ETOH preservative. Each storage box will have an information sheet that identifies all Sampling Lots contained. Information will include Sampling Lot number and sampling date. These sampling lot data sheets will be stored in a designated folder in the data box. The numerical metal-coded tag assigned to each fish/stomach will allow identification back in the lab. All data recorded at the processing station for a specific fish will be linked to the stomach contents via the metal numeric-coded tag. Stomach samples used for diet analysis are to be representative of normal feeding behavior. Yet, it is conceivable that some of the fish during a depletion trip may have been exposed to multiple depletion passes before actual capture due to gear and netting efficiency. This becomes problematic since feeding behavior may be disrupted by multiple exposures to electrofishing. Therefore, stomach samples used for diet analysis are to be collected only from the first depletion pass (night 1 & 2) for a given trip. To avoid assessing digested material associated with the lower intestine, only stomach contents found in the foregut are to be used for diet analysis. Therefore to discriminate between foregut and intestine, gut contents are to be separated, stored and preserved in different nalgene containers. Intestinal tract is to be separated at junction of foregut and intestine using scissors, and then each region is to be incised lengthwise and separately placed in designated containers. Initial step requires placement of a metal numeric tag face down in bottom of 125 ml container followed by incised foregut. Secondly, the smaller intestine is also to be incised and placed in a 60 ml container and sealed. The smaller container is to be inserted into the larger 125 ml container and sealed. All containers have been pre-filled with ETOH prior to trip. The purpose for this is to maintain the association of the different stomach contents to the same numbered tag. For redundancy, processors are then to mark the outside of the larger nalgene container using the same numeric tag number. This double mark is only necessary for gut contents used for diet analysis. Alternately, the entire intestinal tract is to be used for assessing predation, therefore, fish captured during the remaining depletion passes from night 5 to 12 are to retain the entire intestinal tract. This will be incised, stored, and preserved as described above.

Fish Disposal

Fish carcasses will be temporarily stored in sealed garbage containers after each processing night. The following day fish carcasses will be mechanically ground and placed in fish disposal barrels (15 gallon). A Honda 5,000 w generator will be used to power the electric Weston grinder (Model 32, 115v, 1.5-hp). The disposal area will be located at the downstream inlet at Science Beach (61.4 RM). A sturdy aluminum table (20"x 44") and drop cloth will be used for the fish grinding and disposal process. Only personnel trained and familiar with its safe operation are to use the grinder. Ground-up carcasses will be fixed using phosphoric acid to prevent decomposition and later storage problems. These plastic containers are to be stored on a designated boat. Polyethylene tubing is to be used as a manifold to interconnect disposal barrels. Excess tubing will be extended into the river to bleed off any excess methane gas build-up. Owing to caustic nature of concentrated phosphoric acid only GCMRC will be responsible for dispensing of preservative. The disposal area will be kept clean so as to avoid undesirable health issues and attracting scavengers. Liquid Clorox bleach will be used for washing and disinfecting garbage cans and the processing area. All excess material will be collected, washed and disposed of using available brushes and bleach. Containers will be stored and transported from the Grand Canyon after each mechanical removal trip. All material produced from grinding will be delivered to the Hualapai Nation for fertilizer following the trip.

Upon trip completion the USFWS will be notified of the incidental take as specified in the research permit. Additionally, these fish will be assessed for skeletal abnormalities using radiogrammetry techniques (Sharber and Carothers 1988; Sharber et al. 1994). Specimens are to be sent to Arizona Game and Fish Department for the purpose of cataloguing and transferring such material to a proper facility for permanent collection and curatorship.

Trout diet analysis

Certain research questions exist regarding trout diet differences among species, age-size class structure and location. This type of data can be very useful in developing an energetics model. Preserved fish stomach contents will be used for this assessment using a stratified random sampling approach, whereby stomach samples are to be stratified by species (RBT and BNT), reaches (Above-LCR and Below-LCR) and length groups (< 150 mm, 151 - 200 mm, 201 - 300 mm, and > 301 mm; Table 4). Following the completion of the trip, 240 samples are to be randomly selected from the total number of samples collected during night 1 & 2, for the purpose of separating, categorizing, and enumerating identified items. These categorized items are to be desiccated for 24-h at 60°C, weighed (± 0.1 mg), ashed for 1-h at 500°C, and reweighed for ash-free standing mass determination. Digested fish and bones collected from stomach contents of non-native species will be used as voucher and diagnostic material. And where possible such material will be used for taxonomic purposes.

Laboratory Procedures: Gut contents will be analyzed from a set of sub-samples that are randomly selected and stratified by sampling locality, time and fish size (Table 4). Sample size is designated by fish TL (mm) and study reach. The diet analysis will quantify all ingested phytobenthic material, macroinvertebrates, and vertebrates using a combination of analytical methods (volumetric, weight, and numeric counts) taxonomically identified (Marrero and Lopez-Rojas 1995; Rowell 2001).

Seasonal and inter-annual differences in the availability of the aquatic food base (standing biomass and drift) are to be linked to fish feeding habits and electivity preferences. Additionally, stomach samples will be collected in the Lees Ferry Reach to assess diet. The Lees Ferry Reach is to serve as a spatial control lacking effects from the fish removal occurring downstream. The collection of these stomach samples will be coordinated with the Lees Ferry monitoring program, conducted by Arizona Game and Fish, Department.

The metal numeric-coded tags assigned to each stomach sample will be linked to the data collection effort and used for stratifying and randomizing the samples selected for diet analysis. If stomachs are observed to be empty an additional sample will be resampled from the underrepresented strata.

Sampling problems may occur. It is understood that BNT abundances are much lower than RBT in the LCR-inflow and may be underrepresented. Additionally age-class structure will be skewed toward larger fish that may have migrated into the region from the Granite Gorge.

Detailed stomach analysis will be achieved for 30 trout per length group for each reach and species; however, all collected stomachs will be analyzed for the presence or absence of fish or fish remains. Special dye markers (Alizarin red and KOH) will be used to highlight bones and cartilage contained within the gut contents. The effectiveness of the stain is rate dependent, so that at the concentrations (0.1%) used, the preserved material should be allowed to fix over a 24-hr period. Where possible, bones will be used for reconstructing and identifying prey taxa.

All collected specimens and data sheets are to be assessed for completion, accuracy, and data entry errors, and sample specimens are to be cataloged, organized and stored for later transport. All data will be entered following trips consistent with GCMRC format structures.

Data Analysis

Statistical analyses are to be performed to address the objectives under rainbow and brown trout diet analysis and predation. Based on previous research, age-0 HBC abundance will likely be higher below the LCR than above the LCR. Therefore, we hypothesize that the incidence of HBC predation will be higher below the LCR. However, other factors that may influence HBC predation may be trout species (rainbow or brown), trout length, trout and HBC abundance, and turbidity. Therefore, a logistic regression model (Agresti 1990) will be used with the dependent variable being presence or absence of HBC in a trout stomach. This model will include the variable suggested as potential factors that may influence HBC predation as listed above. Comparisons made among seasons and within years will provide information on whether or not particular cohorts are more vulnerable to predation due to differences in size, relative prey abundance or relative predator abundance.

Drift sampling

The drift sampling effort is to provide a representative sample of the available drift for foraging fish. Sampling will be conducted by the transport boat so as not to interfere with electrofishing duties. Sampling will be conducted at 12 sites (6 above the LCR and 6 below the LCR). At each of these sites, four replicate samples will be collected with a 30-cm x 120-cm width to length (1:4 ratio) and 363 µm mesh size plankton net with a current meter attached near the center of the net opening. Drift nets are to be inserted into an aluminum frame for ease of deployment. These nets will be deployed in eddies directly adjacent to the electrofishing stations using a lateral hinged boom off the sides of the boat between MT 1700 and 2200. Samples are to be collected over a 5-min period at flow velocities of 0.15-0.25 m s^{-1}. Samples will be collected 2 times (nights 1 & 2) during the non-native depletion sampling for a total of 48 samples during each trip (Table 5). Data collection will include: station location, date, time, flow velocity, depth, drift net number. In the field, drift contents are to be initially containerized using the drift collection bucket and sealed. These will be transferred to the processing station for sieving (363 µm mesh size) and preservation in 10% ethanol.

Study 3. Procedures for Estimating the Relative Abundance of Juvenile HBC in the LCR Inflow Reach

Mini-hoopnets will be used to estimate the relative abundance of humpback chub at the 30 standardized sites downstream of the LCR confluence. Data obtained during past investigations suggest that relative abundance estimated at these sites over several months (September, November, and January) may be useful in estimating the mortality/emigration rate of juvenile HBC from the LCR inflow reach (Valdez and Ryel 1995). In addition, these collections, along with incidental catch of juvenile HBC during electrofishing, will provide size structure information for juvenile HBC in the LCR inflow reach.

Study Area and Design

30 hoopnets will deployed for 3-24 hour sets on the 1st, 3rd, and 5th days of the trip. Set locations will correspond to the 30 standardized locations established by Gorman and Coggins (2000; Figure 5). Deploying nets on the 2nd, 4th, and 6th days of the trip will allow the nets to be fished during time periods when electrofishing activities are not being conducted within the sites that are occupied by the nets. The nets will be deployed between 1100 and 1300 and retrieved the following day (i.e. trip days 3, 5, and 7) during the same timeframe.

Data Collection

Results from the hoopnet sampling will be recorded on the standard netting data form (Appendix C). All captured fish will be handled and processed according to the procedures detailed in Ward 2002 (Appendix D). Upon completion of the hoopnetting activities, the boat operators are to be responsible for transferring all completed data sheets to the data storage box. Before the next netting effort is initiated, boat operator/data recorder is to evaluate all completed data sheets and identify any errors that might have occurred during the previous efforts transcription. Upon validation, the data sheets are to be placed in the designated Data Storage Box for safekeeping. Any corrections made to the data sheets need to be drawn to the attention of the designated Trip Principal Investigator (PI). It is the responsibility of the trip PI to ensure that all data sheets have been properly filled out.

SCHEDULES AND REPORTS

Semi-annual reports and presentations will be given to the AMWG and/or TWG during December and June. At least 4 publications in the primary literature are expected as a result of this work to be submitted beginning in 2004.

LITERATURE CITED

Agresti, A. 1996. An introduction to categorical data analysis. John Wiley and Sons, New York.

Anders, P., M. Bradford, P. Higgins, K. H. Nislow, C. Rabeni, and C. Tate. 2001. Protocols Evaluation programs, Final Report, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona.

Angradi, T.R. 1994. Trophic linkages in the lower Colorado River: multiple isotope evidence. J. North American Benthological Society 13:479-495.

Blinn, D. W., L. E. Stevens, and J. P. Shannon. 1993. The effects of Glen Canyon Dam on the aquatic food base in the Colorado River corridor in Grand Canyon, Arizona. Glen Canyon Environmental Studies, NPS Cooperative Agreement CA-8009-8-0002.

Blinn, D. W., L. E. Stevens, and J. P. Shannon. 1994. Interim flow effects from Glen Canyon Dam on the aquatic food base in the Colorado River corridor in Grand Canyon, Arizona. Glen Canyon Environmental Studies, NPS Cooperative Agreement CA-8024-8-0002.

GCMRC. 2001. Final draft information needs. Submitted to the Adaptive Management Work Group and the Technical Work Group of the Glen Canyon Dam Adaptive Management Program.

Gorman, O.T. and L.G. Coggins, Jr. 2000. Status and trends of native and non-native fishes of the Colorado River in Grand Canyon 1990-2000. Draft Final Report submitted to the Grand Canyon Monitoring and Research Center. U.S. Fish and Wildlife Service, Arizona Fishery Resources Office, Flagstaff.

Haden, G.A., D.W. Blinn, S.P. Shannon, and O.T. Gorman. 2002 (*In review*). Food resource limitations of the humpback chub (*Gila cypha*) and endangered cyprinid fish in the Little Colorado River, Arizona, USA.

Hardwick, G. G., D. W. Blinn, and H. D. Usher. 1992. Epiphytic diatoms on Cladophera glomerata in the Colorado River, Arizona: longitudinal and vertical distribution in a regulated river. The Southwestern Naturalist 37(2):148-156.

Maddux, H. R., D. M. Kubly, J. C. deVos, W. R. Persons, R. Staedickie, and R. L. Wright. 1987. Evaluation of varied flow regimes on aquatic resources of Glen and Grand Canyon. Arizona Game and Fish Department, Final Report.

Marrero, C., and H. Lopez-Rojas. 1995. Quantitative evaluation of the point method for fish stomach contents analysis. Journal of Fish Biology. 47:914-916.

Robinson, A.T., R.W. Clarkson and R. E. Forrest. 1998. Dispersal of larval fishes in a regulated river tributary. Transactions of the American Fisheries Society 127:772-786.

Rowell, K. 2001. Temporal and spatial snapshots of brown trout and rainbow trout pescivory and diet composition during June-December 2000 in Grand Canyon corridor of the Colorado River. GCMRC Report, Ocotber 15, 2001. 9 pp

Shannon. J.P., D.W. Blinn and L.E. Stevens. 1994. Trophic interactions and benthic animal community structure in the Colorado River, Arizona, USA. Freshwater Biology. 31:213-220.

Shannon, J.P., D.W. Blinn, G.A. Haden, E.P. Benenati, and K.P. Wilson. 2001. Food web implications of δ13C and δ15N variability over 370 km of the regulated Colorado River USA. Isotopes Environ. Health Stud., 37:179-191.

Sharber, N.G. and J.S. Black. 1999. Epilepsy as a unifying principle in electrofishing theory: A proposal. Transactions of the American Fisheries Society. 128:666-671.

Sharber, N.G. and S.W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management 14:340-346.

Sharber, N.G., S.W. Carothers, J. P. Sharber, J. C. DeVos, and D. A. House. 1994. Reducing electrofishing – induced injury in rainbow trout. North American Journal of Fisheries Management 14:340-346.

Tyus, H.M and J.F. Saunders, III. 2000. Nonnative fish control and endangered fish recovery: lessons from the Colorado River. Fisheries. 25(9): 17-24.

USFWS 2002. Biological opinion from the section 7 consultation on proposed experimental releases from Glen Canyon Dam and removal of non-native fish. US Fish and Wildlife Service, Ecological Services. Phoenix, Arizona.

Usher, H.D. and D.W. Blinn. 1990. Influence of various exposure periods on the biomass and chlorophyll a on Cladophora glomerata (Chlorophyta). J. Phycol. 26:244-249.

Valdez, R.A. and R.J. Ryel. 1995. Life history and ecology of the humpback chub (Gila cypha) in the Colorado River, Arizona. Final Report. Contract No. 0-CS-40-09110. Salt Lake City, UT

Van Den Avyle, M. J., and R. S. Hayward. 1999. Dynamics of exploited fish populations. Pages 127-192 in C. C. Kohler and W. A. Hubert, editors. Inland fisheries management in North America, second edition. American Fisheries Society, Bethesda, Maryland.

Ward, D. 2002. Sampling protocols and fish handling. Arizona Game and Fish Department, Flagstaff.

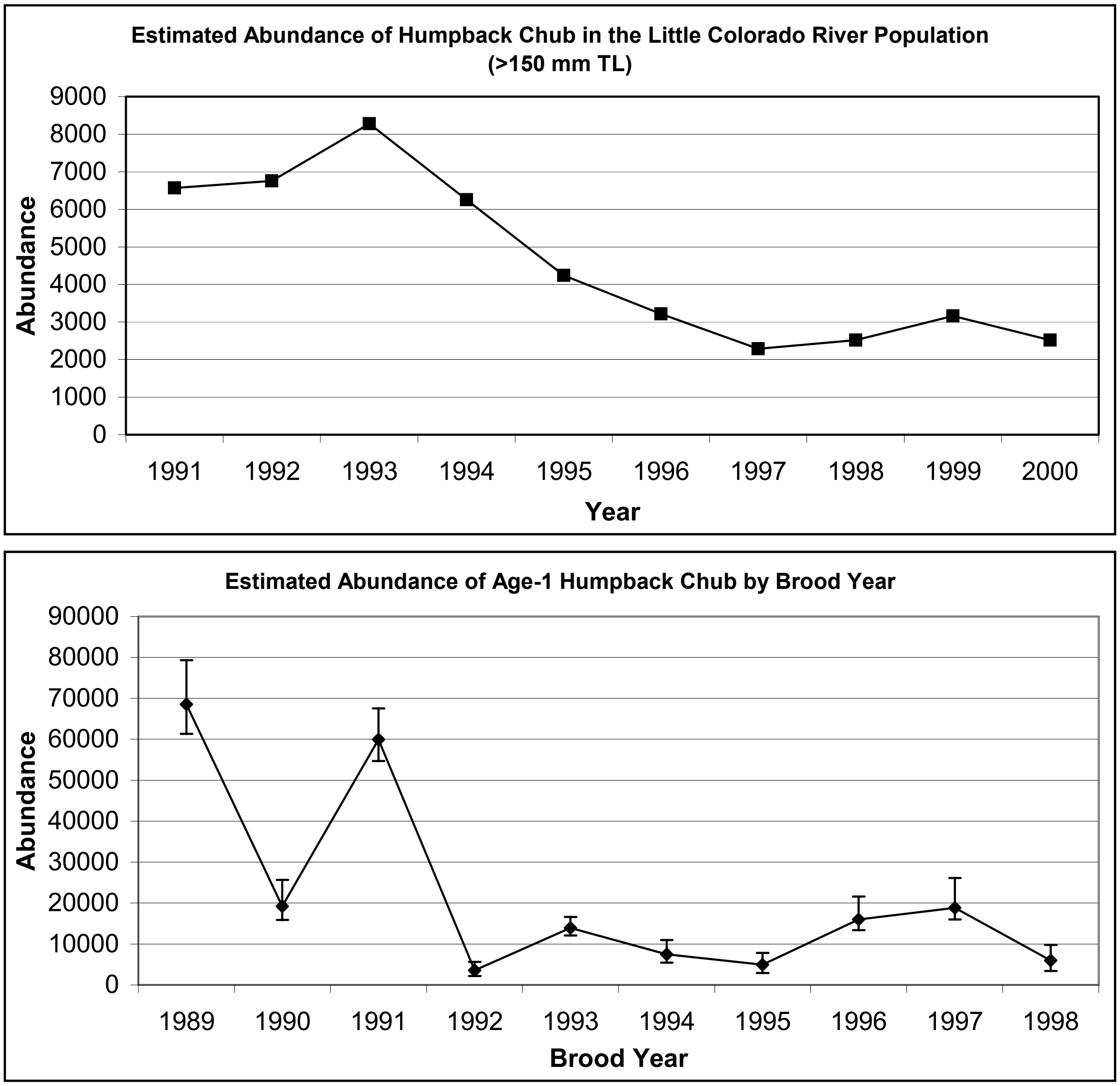

Figure 1. Estimated annual trend in population size (top panel) and recruitment (bottom panel) of the Little Colorado River population of humpback chub, Grand Canyon, Arizona.

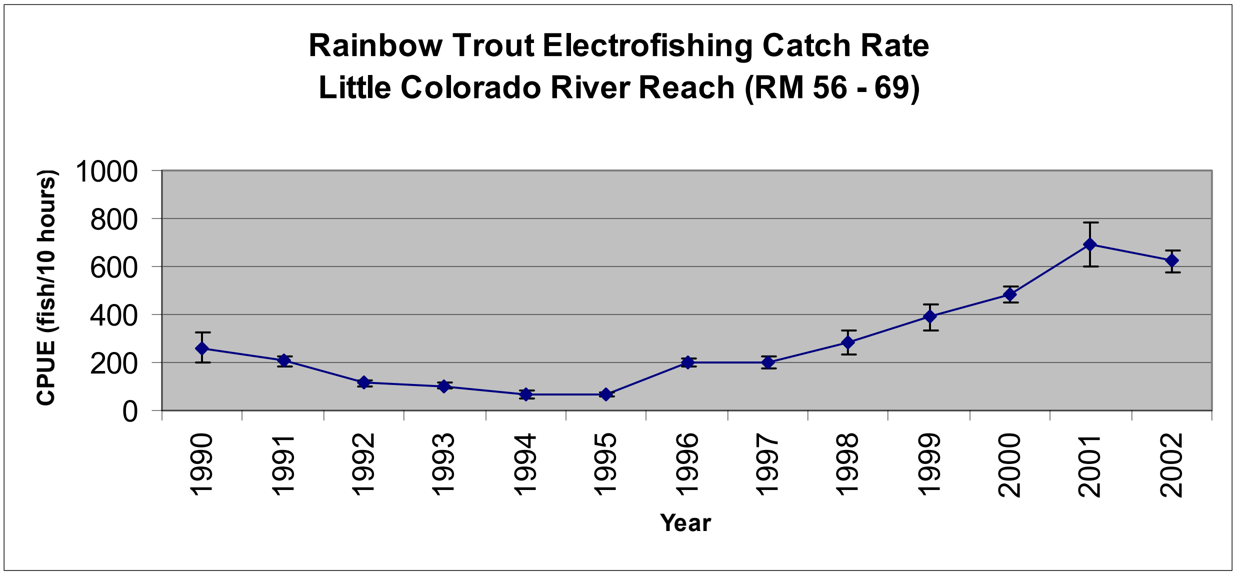

Figure 2. Relative abundance (number of fish per 10 hours of nighttime electrofishing) of rainbow trout (top panel) and brown trout (bottom panel) in the area of the Colorado River near the Little Colorado River confluence, Grand Canyon, Arizona, 1990-2002.

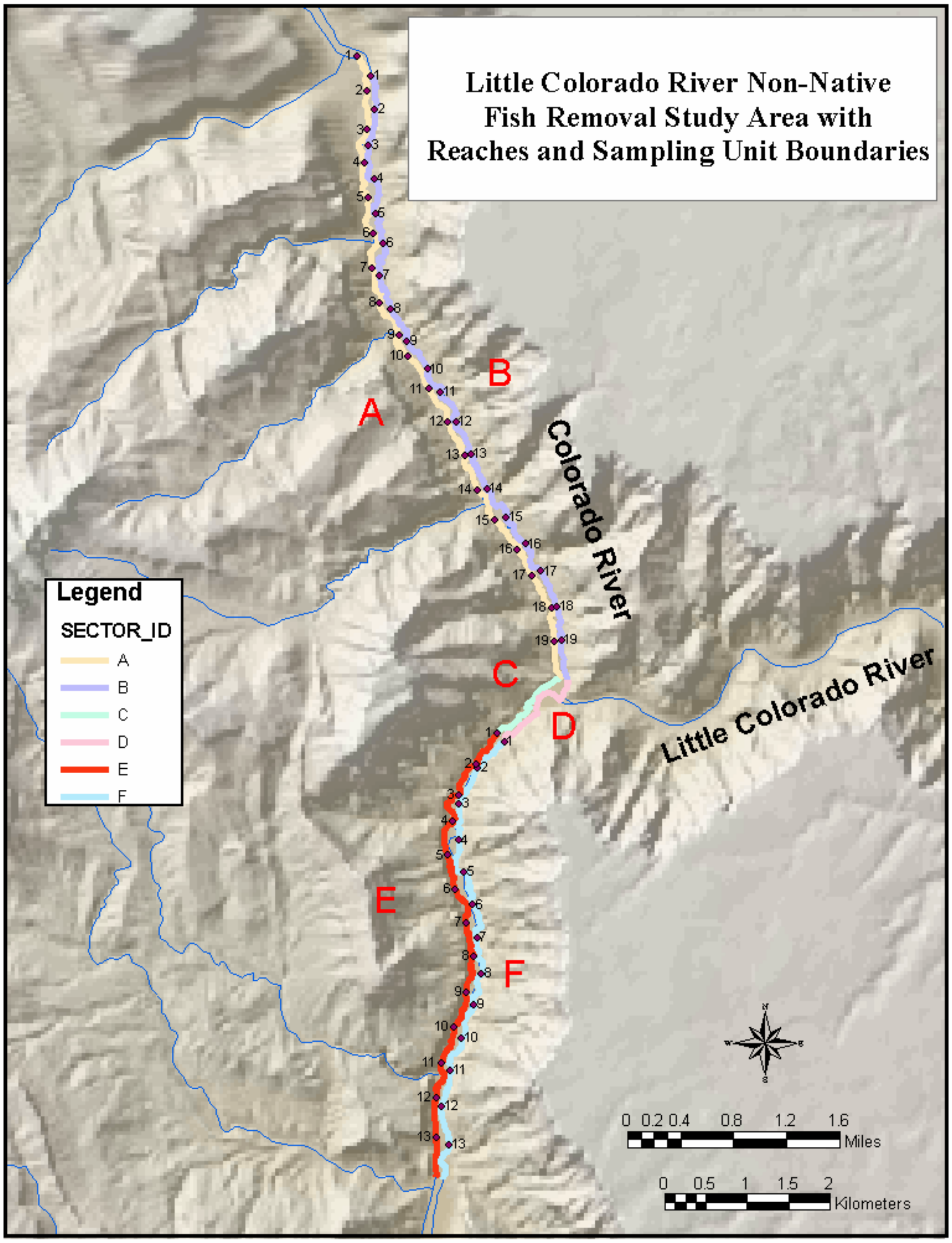

Figure 3. Proposed study area for the mechanical removal of non-native fishes in the Colorado River near the confluence of the Little Colorado River, Grand Canyon, Arizona. Six study reaches are delineated (A-F) and each sites within each reach is 500 m.

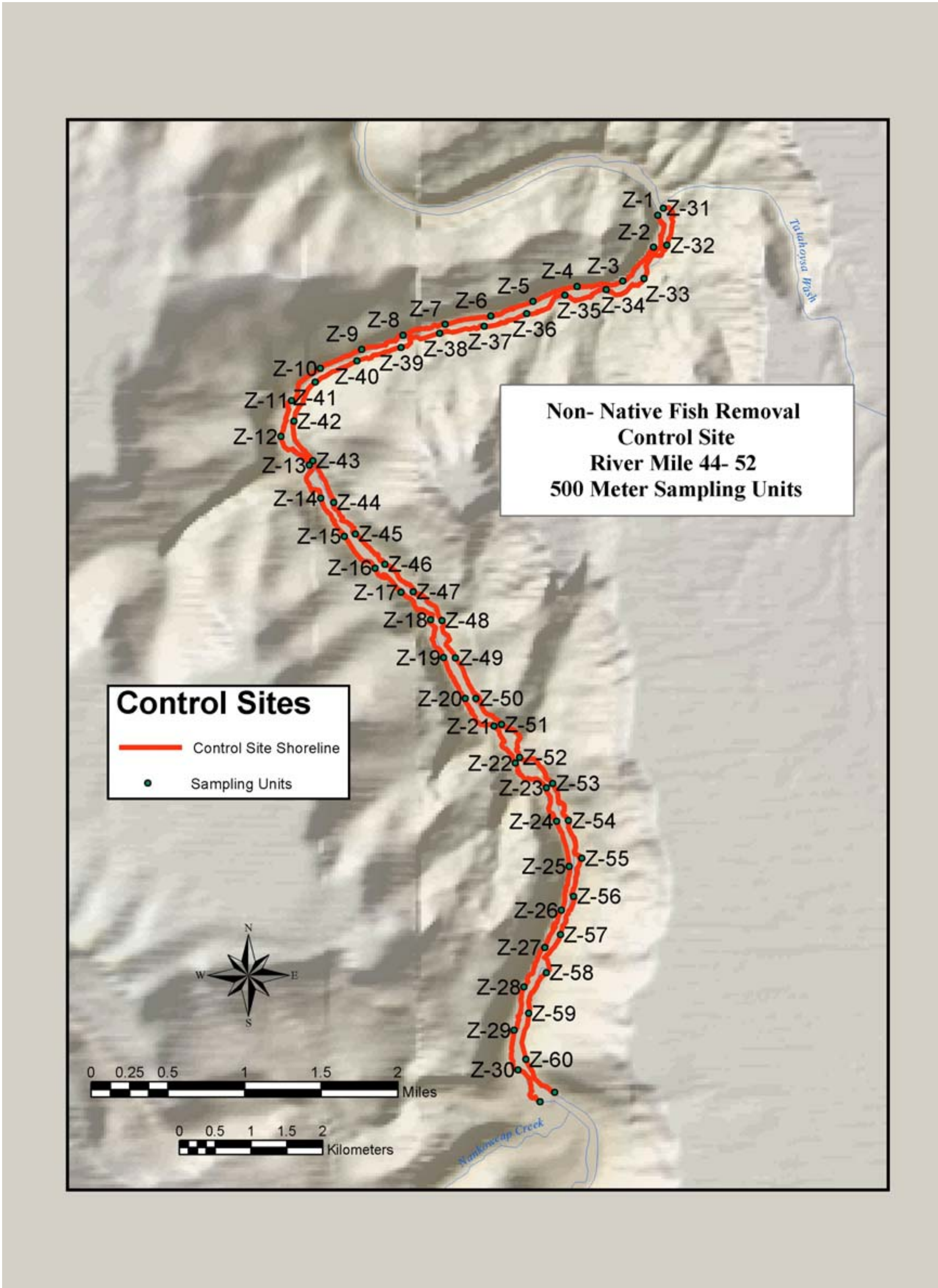

Figure 4. Proposed control area used for the mechanical removal of non-native fishes in the Colorado River, RM 44-52, Grand Canyon, Arizona. Randomly selected 500 m sites will be electrofished from this area each sampling trip; however, no fish will be removed.

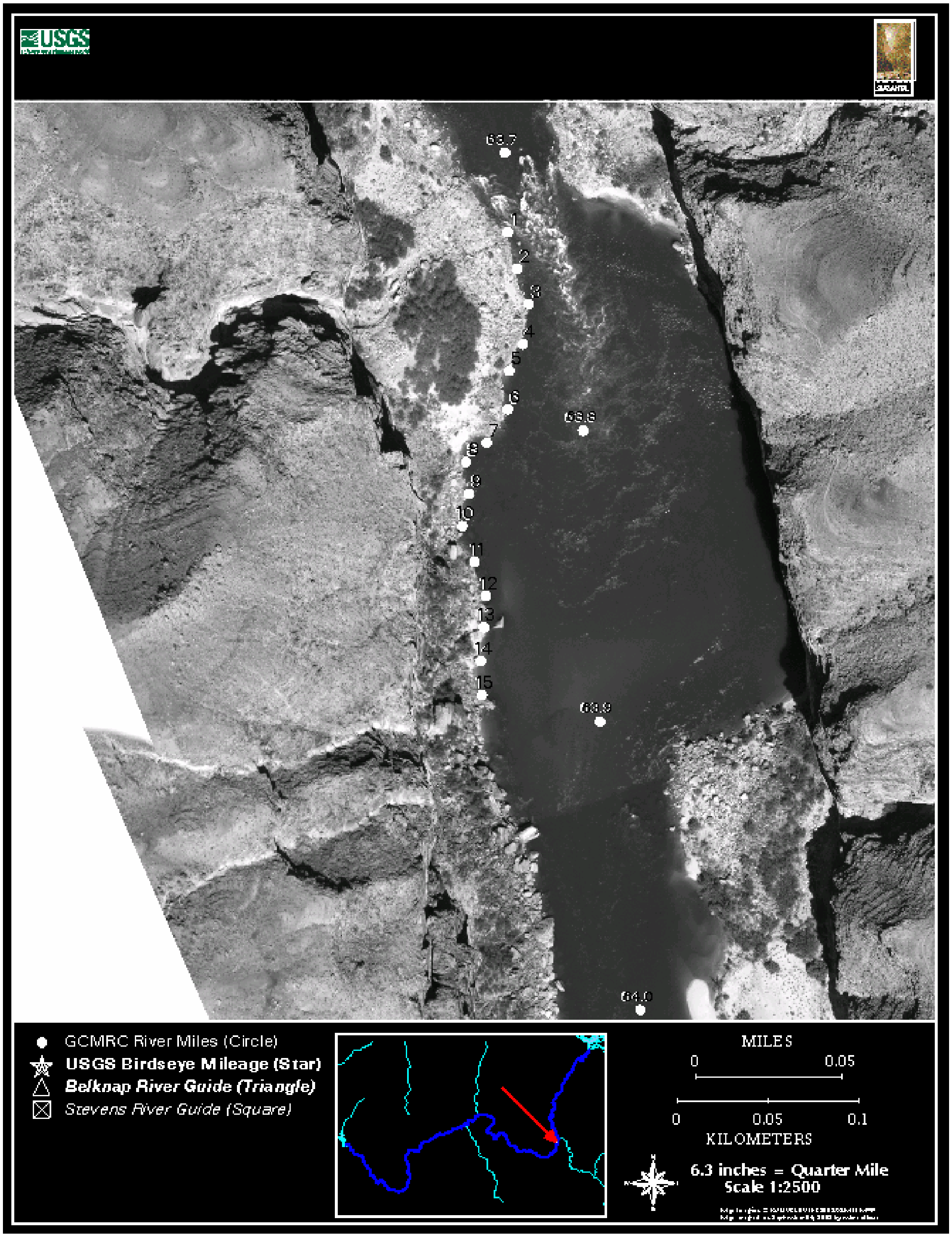

Figure 5a. Hoop-net locations (stations 1-15) for standardized humpback chub sampling in the Colorado River below the Little Colorado River confluence, Grand Canyon, Arizona.

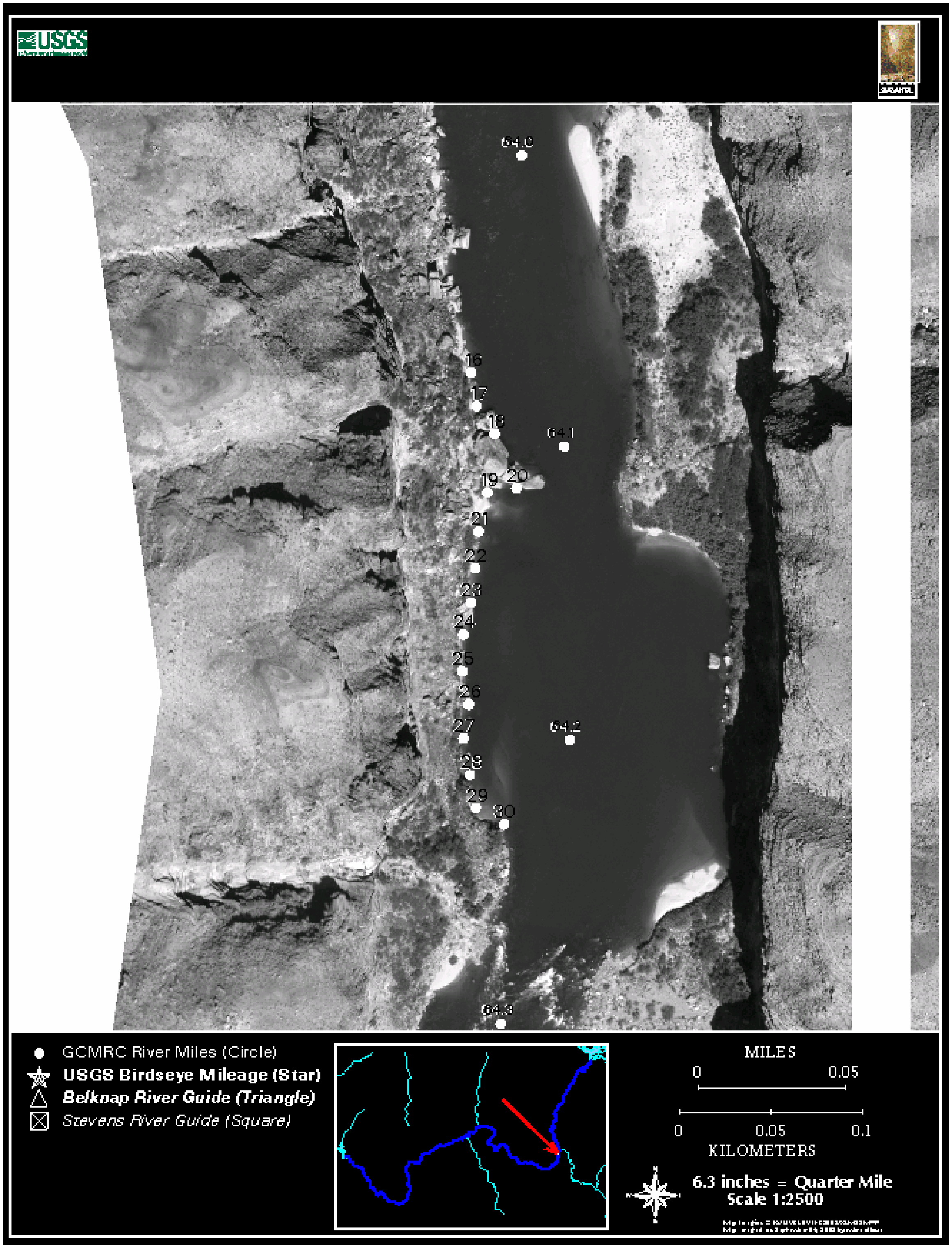

Figure 5b. Hoop-net locations (stations 16-30) for standardized humpback chub sampling in the Colorado River below the Little Colorado River confluence, Grand Canyon, Arizona.

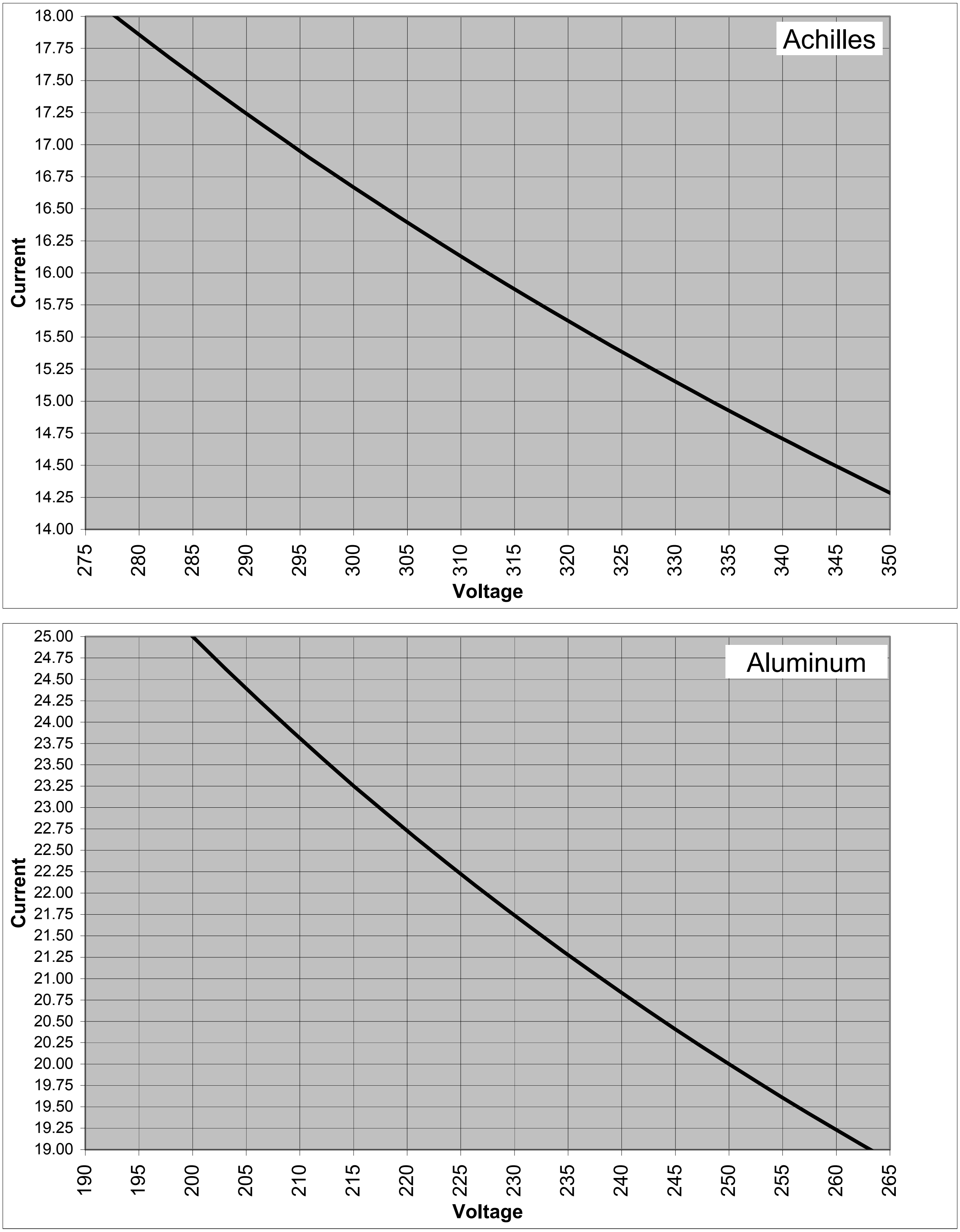

Figure 6. 5,000 watt power curves for the Achilles (top panel) and Aluminum (bottom panel) electrofishing boat. CPS settings are standardized to 5000 watts when both voltage and current values lie on the power curve.

Table 1. Summary of sampling schedule for rainbow and brown trout mechanical removal trips, 2003-2005.

Trip Type	Trip Date	FY-Year	Trip Length
Electrofishing Depletion	15 – 31 Jan	2003	17 - day
Electrofishing Depletion	12 – 28 Feb	2003	17 - day
Electrofishing Depletion	12 – 28 March	2003	17 - day
Electrofishing Depletion	1- 17 Jul	2003	17 - day
Electrofishing Depletion	1- 17 Aug	2003	17 - day
Electrofishing Depletion	1- 17 Sept	2003	17 - day
Electrofishing Depletion	3 trips Jan-Mar	2004	17 - day
Electrofishing Depletion	3 trips Jul-Sep	2004	17 - day
Electrofishing Depletion	3 trips Jan-Mar	2005	17 - day
Electrofishing Depletion	3 trips Jul-Sep	2005	17 - day
Electrofishing Depletion	3 trips Jul-Sep	2006	17 - day
Electrofishing Depletion	3 trips Jul-Sep	2006	17 - day

Table 2. Description of tasks by day for a typical trip.

Trip Day	Depletion Pass	Description of Tasks	Boat Electrofishing Locations: Boat 1	Boat 2	Boat 3	Boat 4
1	Control Reach	am: Travel from Lees Ferry to Control Reach Camp. The four electrofishing crews mark sampling unit boundaries. pm: Electrofish a total of 24 sites within the control reach to estimate CPUE for non-native fishes.	7 sites between RM 44-52	5 sites between RM 44-52	7 sites between RM 44-52	5 sites between RM 44-52
2		am: Travel from Control Reach Camp to Science Beach Camp. The four electrofishing crews deploy hoopnets at standardized locations and begin marking sampling unit boundaries within the Depletion Reach. pm: Set up camp and processing station.				
3	1	am: Complete marking sampling unit boundaries. Organize and ready all gear for depletion operations. Check and pull hoopnet sets at standardized locations. pm: Upstream crews electrofish the upper portions of reaches A and B. Downstream crews electrofish reach C and the upper portions of reaches E and F.	A1-A9	B1-B9	Reach C, E1-E6	F1-F6, F-14
4	1	am: Crews process fish carcasses from previous day. Deploy hoopnets at standardized locations. pm: Upstream crews electrofish the lower portions of reaches A and B. Downstream crews electrofish the lower portions of reaches E and F.	A10-A19	B10-B19	E7-E13	F7-F13
5	2	am: Crews process fish carcasses from previous day. Check and pull hoopnet sets at standardized locations. pm: Upstream crews electrofish the upper portions of reaches A and B. Downstream crews electrofish reach C and the upper portions of reaches E and F.	A1-A9	B1-B9	Reach C, E1-E6	F1-F6, F-14
6	2	am: Crews process fish carcasses from previous day. Deploy hoopnets at standardized locations. pm: Upstream crews electrofish the lower portions of reaches A and B. Downstream crews electrofish the lower portions of reaches E and F.	A10-A19	B10-B19	E7-E13	F7-F13
7	3	am: Crews process fish carcasses from previous day. Check and pull hoopnet sets at standardized locations. pm: Upstream crews electrofish the upper portions of reaches A and B. Downstream crews electrofish reach C and the upper portions of reaches E and F.	A1-A9	B1-B9	Reach C, E1-E6	F1-F6, F-14
8	3	am: Crews process fish carcasses from previous day. pm: Upstream crews electrofish the upper portions of reaches A and B. Downstream crews electrofish Reach C and the upper portions of reaches E and F.	A10-A19	B10-B19	E7-E13	F7-F13
9	4	am: Crews process fish carcasses from previous day. pm: Upstream crews electrofish the lower portions of reaches A and B. Downstream crews electrofish the lower portions of reaches E and F.	A1-A9	B1-B9	Reach C, E1-E6	F1-F6, F-14
10	4	am: Crews process fish carcasses from previous day. pm: Upstream crews electrofish the upper portions of reaches A and B. Downstream crews electrofish Reach C and the upper portions of reaches E and F.	A10-A19	B10-B19	E7-E13	F7-F13
11	5	am: Crews process fish carcasses from previous day. pm: Upstream crews electrofish the lower portions of reaches A and B. Downstream crews electrofish the lower portions of reaches E and F.	A1-A9	B1-B9	Reach C, E1-E6	F1-F6, F-14

Table 2 (Continued). Description of tasks by day for a typical trip.

Trip Day	Depletion Pass	Description of Tasks	Crew Electrofishing Locations: Crew 1	Crew 2	Crew 3	Crew 4
12	5	am: Crews process fish carcasses from previous day. pm: Upstream crews electrofish the upper portions of reaches A and B. Downstream crews electrofish Reach C and the upper portions of reaches E and F.	A10-A19	B10-B19	E7-E13	F7-F13
13		am: Crews process fish carcasses from previous day. All data and sample boxes inventoried and packed up for runout. Unnecessary equipment packed up for runout. Move to Tanner Beach Camp.				
14		am: Fisheries biologists and technicians hike out Tanner or Bright Angel Trail depending on conditions. Boatman begin runout				
15-17		Run out. Arrive Diamond Creek on Day 17				

Table 3a. Boat and Driver assignments for electrofishing control operations for the January-March sampling trips.

January

Boat Driver							
Dierker		Weiss		Berger		Reeder	
Boat Type	Sample Sites	Boat Type	Sample Sites	Boat Type	Sample Sites	Boat Type	Sample Sites
Achilles	Z-3	Achilles	Z-17	Aluminum	Z-31	Aluminum	Z-42
Smith-Root	Z-4	Smith-Root	Z-19	Coeffelt	Z-32	Coeffelt	Z-43
	Z-6		Z-20		Z-35		Z-56
	Z-7		Z-23		Z-36		Z-57
	Z-11		Z-27		Z-37		Z-58
	Z-13				Z-39		
	Z-14				Z-41		

February

Boat Driver							
Reeder		Dierker		Berger		Weiss	
Boat Type	Sample Sites	Boat Type	Sample Sites	Boat Type	Sample Sites	Boat Type	Sample Sites
Aluminum	Z-1	Aluminum	Z-15	Achilles	Z-31	Achilles	Z-45
Smith-Root	Z-4	Smith-Root	Z-17	Coeffelt	Z-36	Coeffelt	Z-48
	Z-6		Z-20		Z-38		Z-51
	Z-7		Z-25		Z-39		Z-55
	Z-10		Z-30		Z-40		Z-57
	Z-11				Z-43		
	Z-13				Z-44		

March

Boat Driver							
Reeder		Berger		Weiss		Dierker	
Boat Type	Sample Sites	Boat Type	Sample Sites	Boat Type	Sample Sites	Boat Type	Sample Sites
Achilles	Z-5	Achilles	Z-20	Aluminum	Z-32	Aluminum	Z-50
Smith-Root	Z-8	Smith-Root	Z-25	Coeffelt	Z-36	Coeffelt	Z-51
	Z-10		Z-26		Z-38		Z-52
	Z-11		Z-27		Z-43		Z-58
	Z-14		Z-28		Z-46		Z-60
	Z-16				Z-47		
	Z-17				Z-49		

Table 3b. Boat and Driver assignments for electrofishing removal operations by depletion pass for the January-March sampling trips.

January

	Depletion Pass [a]				
River Reach (Boat Type-Shock Box)	1	2	3	4	5
A (Rubber-Smith Root)	Dierker	Reeder	Berger	Reeder	Dierker
B (Alum- Coeffelt)	Weiss	Berger	Reeder	Dierker	Berger
E & C (Alum-Smith Root)	Reeder	Dierker	Weiss	Berger	Reeder
F (Rubber-Coeffelt)	Berger	Weiss	Dierker	Weiss	Weiss

February

	Depletion Pass [a]				
River Reach (Boat Type)	1	2	3	4	5
A (Alum-Smith Root)	Berger	Reeder	Dierker	Dierker	Dierker
B (Rubber-Coeffelt)	Dierker	Berger	Weiss	Reeder	Weiss
E & C (Rubber-Smith Root)	Weiss	Dierker	Berger	Berger	Reeder
F (Alum-Coeffelt)	Reeder	Weiss	Reeder	Weiss	Berger

March

	Depletion Pass [a]				
River Reach (Boat Type)	1	2	3	4	5
A (Rubber-Smith Root)	Dierker	Berger	Weiss	Berger	Weiss
B (Alum-Coeffelt)	Berger	Weiss	Dierker	Weiss	Dierker
E & C (Alum-Smith Root)	Weiss	Dierker	Reeder	Dierker	Berger
F (Rubber-Coeffelt)	Reeder	Reeder	Berger	Reeder	Reeder

[a] Depletion pass 1=Day 3 & 4; Depletion pass 2=Day 5 & 6; Depletion pass 3=Day 7 & 8; Depletion pass 4=Day 9 & 10; Depletion pass 5=Day 11 & 12.

Table 4. Target sample sizes and length groups for diet analysis of each species of trout in three Colorado River study areas: Lee's Ferry, above the Little Colorado River, and below the Little Colorado River, Grand Canyon, Arizona.

Length group	Lees Ferry	Above-LCR	Below-LCR
< 150 mm	30	30	30
151 - 200 mm	30	30	30
201 - 300 mm	30	30	30
>301 mm	30	30	30
TOTAL	120	120	120

Table 5. Logistics outline for invertebrate drift sampling to estimate prey availability in the Colorado River above and below the confluence with the Little Colorado River, Grand Canyon, Arizona.

	Station ID											
	Above LCR						Below LCR					
Trip Day [a]	1	2	3	4	5	6	7	8	9	10	11	12
3	4	4	4				4	4	4			
4				4	4	4				4	4	4
Total	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**

[a] Trip Days 3 and 4 correspond with the first depletion run.

APPENDIX A. ELECTROFISHING DEPLETION DATA SHEET.

Trip: GC 2002 ___ ___ Start Date: ___ ___/___ ___/___ ___ Start Time: ___ ___ ___

Station ID ___ ___ ___ Depletion Number: ___ Turbidity: ___(H/L) Boat Type_______

Volts: ___ ___ ___ AMPS: ___ ___ ______ Total Seconds: ___ ___ ___ ___ Crew:__ __,__ __

Comments:____

SP	TL	FL	WT	SEX	CON	F CLIP 1	LOT # Or BAG ID	PIT RECAP	PIT-TAG #	TAG2 RECAP	TAG2	DISP	COMMENTS

APPENDIX B. FISH PROCESSING DATA SHEET.

DEPLETION ELECTROFISHING EFFORT PROCESSING (EL) Page ___ of ___

Trip: GC 2002 ___ ___ Start Date: ___ ___/___ ___/___ ___

STATION ID ___ ___ ___ ___ DEPLETION NUMBER: ___ TOTAL SECONDS: ___ ___ ___ ___ STORE BOX # ___

Processing Comments:____

SPECIES	TL	WT	GAPE VERT	GAPE LAT	F CLIP 1	PIT RECAP	PIT-TAG #	SEX M/F	SEX COND	EMPTY (Y/N)	ISOTOPE SAMPLE (Y/N)	BOT-#	COMMENTS

APPENDIX C. STANDARD NETTING DATA SHEET.

NETTING AND TRAPPING EFFORT PAGE___of___

Gear Type:___ ___ Crew:(___ ___ ___;___ ___ ___;___ ___ ___) Clipboard:___ Ortho Cov:___ ___ ___ ___ Trip: GC 2002___ ___
Station ID:___ ___ ___ ___ River Guide:___ ___ River:___ ___ Depletion Effort:___ Water Temp:___ ___.___ Turbidity:___
Comments:___

Set #	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
Haul	___	___	___	___
Start Date	___ ___/___ ___/___ ___	___ ___/___ ___/___ ___	___ ___/___ ___/___ ___	___ ___/___ ___/___ ___
Start Time	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
End Date	___ ___/___ ___/___ ___	___ ___/___ ___/___ ___	___ ___/___ ___/___ ___	___ ___/___ ___/___ ___
End Time	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
River Mile	___ ___ ___.___	___ ___ ___.___	___ ___ ___.___	___ ___ ___.___
Side	___	___	___	___
Way Point	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
ShoreHab	___ ___	___ ___	___ ___	___ ___
HydrUnit	___ ___	___ ___	___ ___	___ ___
Substrate	___ ___	___ ___	___ ___	___ ___
Cover Type	___ ___	___ ___	___ ___	___ ___
Set Depth	___ ___.___	___ ___.___	___ ___.___	___ ___.___

Samp #	SP	TL	FL	WT	SEX	Cond	Char	Par Type	Par #	Clip 1		Clip 2		Lot# Or BAG ID	PIT RECAP	PIT-TAG #	DISP	BOT-#	Comments

Appendix D. Standardized Methods For Handling Fish In Grand Canyon Research. Adapted from Ward (2002).

General Guidelines For Handling Fish During Research

Respectful and careful treatment of fish during research is essential to the long-term success of monitoring programs. Traumatized fish can exhibit abnormal physiological, behavioral and ecological responses that defeat study purposes. Rough or improper handling of fish is a source of stress that can lead to disease and death. Delayed mortality as a result of improper handling is often not immediately seen by researchers but can occur hours or days later. This can cause misleading study results and poor public opinion resulting in loss of permits and cancellation of projects. Researchers should be sensitive to public perception and be prepared to explain sampling activities. All field personnel should be familiar with and strictly adhere to research permit guidelines and limitations. Sampling procedures should leave areas as undisturbed as possible and capture techniques should minimize injury to fish. Although specific fish handling procedures vary from one project to another all sampling should incorporate the following general guidelines:

1. Be respectful of all fish regardless of size and species
2. Minimize the time that fish are out of the water
3. Change water frequently when fish must be held for more than a few minutes or if you see fish surfacing for air. Remember that handling stress increases as water temperature increases
4. Don't put more than 8-10 fish in your workup bucket at one time. Leave the rest in a net in the river to avoid stressing fish.
5. Be aware that watch straps, lapel badges and jewelry can damage fish
6. Do not hold fish tightly around the throat and avoid touching the gills
7. Rinse all sunscreen or lotions from hands prior to handling fish
8. Always wet hands and equipment such as nets and fish boards before use. Dry hands and equipment cause damage to fish skin by removing coatings that protect fish from disease.
9. Equipment such as length boards and scales become hot in the sun and can damage fish if not wetted prior to use.

When sampling with hoop nets, shake nets when removing them from the water. Check carefully for small fish that may have become lodged between the net folds. Fish mistakenly left in nets are a large source of researcher caused mortality. Native species accidentally killed should be documented, preserved in ethanol to be deposited as voucher or teaching specimens

Protocols For Processing Fish

Native fish - Measure Total Length (TL), Fork Length (FL), and weight. Examine each fish for external parasites and sexual characteristics. Fish over 100 mm TL should be scanned for the presence of a PIT tag and any fish over 150 mm TL that do not have an existing tag should be tagged.

Nonnative fish - Measure TL of all fish and examine all salmonids for the presence of an adipose clip. Those salmonids that are adipose clipped should be examined for the presence of a pit tag.

Length Measurement

Total Length (TL) – Measure from anterior most part of the fish to the tip of the longest caudal fin ray with the lobes of the caudal fin compressed together

Fork Length (FL) – Length from the most anterior part of the fish to the tip of the median caudal fin ray.

Pit Tagging

Passive integrated transponder (PIT) tags allow long-term unique marking of individual fish. Location of PIT tag insertion varies by species.

PIT Tagging humpback chub

1. Verify that needle is sharp and clean (Biomark guidelines recommend that needles be changed every 20 fish)
2. Sterilize the needle and tag in Ethanol or Isopropyl alcohol
3. Hold the fish with the abdomen up and the tail pointing toward you
4. Insert the needle just posterior to the pelvic fin (See figure 5)
5. The insertion should be on the abdomen of the fish to the right of the mid-ventral line with the tag placed under the left pelvic girdle. The forward position of the pelvic fins on humpback chub allows the tag to be inserted higher on the abdomen than on other species.
6. The depth of penetration of the needle should be deep enough to place the tag within the body cavity and as far away for the needle hole as is feasible to prevent tag loss (preliminary data for trout suggests tag loss may be as high as 10% for tags that are injected too shallow.

(Adapted from Biomark guidelines)

PIT tagging suckers

Use the same procedures as for humpback chub with the following exception. Tags should be inserted toward the tail of the fish under the left pelvic girdle of the fish. The needle should be directed posterior so the tag is injected away from the heart and other vital organs.

Verifying Pit Tag Numbers

The error rate when transcribing and entering PIT tag numbers is very high. The following procedures help to minimize errors that occur when transcribing and entering pit tag numbers.

1. Verify that the scanner is in Scan Store mode and says “working” on the display when the trigger is pulled. If scanner is not in Scan Store mode press the menu button several times.
2. Scan the fish
3. Read and record the entire10-digit code using words instead of letters to avoid

1. Confusion of letters and numbers that sound alike.
2. Example 12A3F45E6B Read: one, two, alpha, three, fox, four, five, echo, six, bravo
3. Always cross zeros when recording PIT tag numbers. This distinguishes a zero from a “D” in the database. When recording PIT tags draw a horizontal line above any letters in the PIT tag number. This will help us distinguish letters from numbers that can often be confused (B and 8, D and 0, S and 5, etc).
4. The data recorder repeats the number back to verify that it has been recorded correctly

Clipping Fins

An adipose clip on brown trout are being used as a secondary mark for newly PIT tagged fish to evaluate tag loss. Marking fish by clipping pelvic fin allows population estimates to be made on fish too small to PIT tag effectively. All researchers must be aware of and look for all possible marks (See fin Clip codes).

1. Dorsal punch – Use caution to avoid ripping dorsal fin when removing the fin punch.
2. Pelvic fin clip – Remove a majority of the pelvic fin, but the base of the fin must remain intact so regeneration will occur
3. Adipose clip – Clip at base removing entire adipose fin.

Fin Clip Codes and Locations

RP1 = right pectoral
RP2 = right pelvic
LP1 = left pectoral
LP2 = left pelvic
ADP = adipose
UCD = upper caudal
LCD = lower caudal
DOR = dorsal
ANL = anal

Guidelines For Recording Data

1. If you don't record the data in the field, it is highly unlikely it will be reconstructed in the office. It is better to write down too much information.
2. Recording data in the field is one of the most important aspects of the research. You can only work as fast as your data taker can record legible data. If you go too fast processing fish, the data gets sloppy. If we are unable to read your handwriting the data is essentially lost. Keep an eye on your data recorder and ask if you are going too fast. Data recorders, please STOP the fish processor and tell them if they are going to fast.
3. Do not forget to write Y or N in the recap field when pit tagging or checking for a pit tag.

Guidelines For Filling Out Data Forms

Three data forms will be used to collect data related to fisheries sampling: 1) Depletion Electrofishing Effort, 2) Depletion Electrofishing Effort Processing, and 3) Netting and Trapping Effort. The Depletion Electrofishing Effort forms will be used to record electrofishing sample and fish catch specific information during both the control and removal sampling. The Depletion Electrofishing Effort Processing Form will be used to record all information about the non-native fish removed during the removal sampling. Finally, the Netting and Trapping Effort form will be used to record the data associated with mainstem hoopnetting activities downstream from the confluence of the LCR.

Depletion Electrofishing Effort Form Instructions (Control Reach)

Trip ID:	GC plus Year and Month and date trip **started** (yyyy/mm/dd); e.g. GC20030115
Start Date:	Date the electrofishing sample began (mm/dd/yy)
Start Time:	Time the electrofishing sample began; military format (hhmm)
Station ID:	Name of sampling station; e.g. Z-07
Depletion Number:	Leave blank during control section sampling.
Turbidity:	Either High (H) or low (L); see code sheet.
Boat Type:	Either Achilles (ACH) or Aluminum (ALU)
Volts:	Read off CPS unit
Amps:	Read off CPS unit
Total Seconds:	Total amount of time spent electrofishing, read off CPS Unit.
Crew:	Boatman and Crew initials (Boatman's Initials first)
Comments:	Any noteworthy issues regarding the sample.

SP:	Species of fish; see code sheet
TL:	Total Length; recorded to nearest mm for all fish captured
FL:	Fork Length; recorded to nearest mm for **native fish only**
Wt:	Weight, recorded to accuracy of scale, measure weight only **for native fish larger than 50 mm**
Sex:	Only record for fish expressing gametes. **If you do not try to determine sex, leave field blank.** If you try to determine sex but are unsuccessful, record as U. See code sheet.
Condition:	Sexual Condition. **Leave blank if you do not attempt to determine sexual condition**, otherwise use code sheet.
F Clip 1	Finclip 1. First column is recapture status of finclip (Y if fish was captured with a clip, N otherwise). Only record recapture status if you examine a fish for a clip, otherwise leave blank. **Only examine the following species for finclip recapture status: RBT, BNT, HBC; leave this field blank for all other species.** Second column is type of fin clip; leave blank if no finclip, otherwise see code sheet. **All RBT and BNT fitted with a floy tag will also be given a LEFT PELVIC CLIP (LP2).**
Lot# or Bag ID:	Pit tag Lot#; record only for fish receiving a **NEW PIT TAG.** Lot # is printed on the tape strip or bag containing the pit tags.
PIT Recap:	Recapture status of any fish containing a pit tag. **It is extremely important that this field be filled out properly.** If a fish contains a PIT Tag upon capture, this field should be “Y”. If a fish is found not to contain a PIT TAG or is injected with a new PIT Tag, this field should be “N”. **Scan all native fish >=120 mm and all BNT with an adipose clip for the presence of a PIT Tag. Inject all untagged native fish >=150 mm with a new PIT TAG. This field should be left blank for all native fish < 120 mm, all BNT without an adipose finclip, and all other fish.**
PIT-TAG #:	PIT TAG Number of all fish containing a PIT TAG upon release. Follow ***Verifying PIT TAG Numbers*** protocols as described above.
Tag2 Recap:	Recap status of other tags besides PIT TAGS. This field will be used to track the application and recapture of floy tags placed on RBT and BNT in the control reach. This field should be “Y” if a fish is captured with a floy tag. If a fish is found without a floy tag or is fitted with a floy tag, this field should be “N”. **This field should be blank for all species except RBT and BNT.**
Tag2:	Floy Tag number. Record either recaptured or new floy tag numbers in this field. Format is: USGS0001.
Disposition:	Disposition of fish after sampling. Except for accidental mortalities, this field should be “RA” in the control reach. Otherwise, see code sheet.
Comment:	Comments specific to a particular fish (e.g. Blind in left eye).

Depletion Electrofishing Effort Form Instructions (Removal Reach)

Trip ID:	GC plusYear and Month and date trip **started** (yyyy/mm/dd); e.g. GC20030115
Start Date:	Date the electrofishing sample began (mm/dd/yy)
Start Time:	Time the electrofishing sample began; military format (hhmm)
Station ID:	Name of sampling station; e.g. A-10 or F-02
Depletion Number:	Depletion Run Number (1-5).
Turbidity:	Either High (H) or low (L); see code sheet.
Boat Type:	Either Achilles (ACH) or Aluminum (ALU)
Volts:	Read off CPS unit
Amps:	Read off CPS unit
Total Seconds:	Total amount of time spent electrofishing, read off CPS Unit.
Crew:	Boatman and Crew initials (Boatman's Initials first)
Comments:	Note location where net bag containing non-native fish was left and any noteworthy issues regarding the sample.
SP:	Species of fish; see code sheet. **Should only contain native fish as all non-native fish will be processed at the processing station**
TL:	Total Length; recorded to nearest mm for all fish captured
FL:	Fork Length; recorded to nearest mm for **native fish only**
Wt:	Weight, recorded to accuracy of scale, measure weight only **for native fish larger than 50 mm**
Sex:	Only record for fish expressing gametes. **If you do not try to determine sex, leave field blank.** If you try to determine sex but are unsuccessful, record as U. See code sheet.
Condition:	Sexual Condition. **Leave blank if you do not attempt to determine sexual condition**, otherwise use code sheet.
F Clip 1	Finclip 1. First column is recapture status of finclip (Y if fish was captured with a clip, N otherwise). Only record recapture status if you examine a fish for a clip, otherwise leave blank. **Only examine the following HBC for finclip recapture status; leave this field blank for all other species.** Second column is type of fin clip; leave blank if no finclip, otherwise see code sheet.
Lot# or Bag ID:	Pit tag Lot#; record only for fish receiving a **NEW PIT TAG.** Lot # is printed on the tape strip or bag containing the pit tags.
PIT Recap:	Recapture status of any fish containing a pit tag. **It is extremely important that this field be filled out properly.** If a fish contains a PIT Tag upon capture, this field should be "Y". If a fish is found not to contain a PIT TAG or is injected with a new PIT Tag, this field should be "N". **Scan all native fish >=120 mm for the presence of a PIT Tag. Inject all untagged native fish >=150 mm with a new PIT TAG. This field should be left blank for all native fish < 120 mm and all other fish.**
PIT-TAG #:	PIT TAG Number of all fish containing a PIT TAG upon release. Follow ***Verifying PIT TAG Numbers*** protocols as described above.

Tag2 Recap:	**This field should not be needed during removal operations since non-native fish will be processed at the processing station.** Leave Blank
Tag2:	**This field should not be needed during removal operations since non-native fish will be processed at the processing station.** Leave Blank
Disposition:	Disposition of fish after sampling. **Except for accidental mortalities, this field should be "RA" in the removal reach since only native fish will be processed by electrofishing crews.** Otherwise, see code sheet.
Comment:	Comments specific to a particular fish (e.g. Blind in left eye).

Netting and Trapping Effort Data Forms (Mainstem Hoopnetting)

Gear Type:	HS (hoopnet small)
Crew:	Boatman and Crew initials (Boatman's Initials first)
Clipboard:	Leave Blank
Ortho Cov:	Leave Blank
Trip :	GC plusYear and Month and date trip **started** (yyyy/mm/dd); e.g. GC20030115
Station ID:	Refer to Map of Hoopnetting sites. Format is HS-01 through HS-30
River Guide:	Leave Blank
River:	Leave Blank
Depletion Number:	Leave Blank
Water Temp:	Leave Blank
Turbidity:	Either High (H) or low (L); see code sheet.
Set #:	Same as Station ID.
Haul:	A, B, or C. A for first set, B for second set, C for third set.
Start Date:	Date the net was set (mm/dd/yy)
Start Time:	Time the net was set; military format (hhmm)
Start Date:	Date the net was checked (mm/dd/yy)
Start Time:	Time the net was checked; military format (hhmm)
River Mile:	Leave Blank
Side:	Leave Blank
Waypoint:	Leave Blank
ShoreHab:	Shoreline Habitat; see code sheet
HydrUnit:	Hydraulic Unit; see code sheet
Substrate:	Leave Blank
Covertype:	Cover Type; see code sheet
Set Depth:	Leave Blank
SP:	Species of fish; see code sheet.
TL:	Total Length; recorded to nearest mm for all fish captured
FL:	Fork Length; recorded to nearest mm for **native fish only**
Wt:	Weight, recorded to accuracy of scale, measure weight only **for native fish larger than 50 mm**

Sex: Only record for fish expressing gametes. **If you do not try to determine sex, leave field blank.** If you try to determine sex but are unsuccessful, record as U. See code sheet.

Condition: Sexual Condition. **Leave blank if you do not attempt to determine sexual condition**, otherwise use code sheet.

Char: Sexual Characteristics. **Leave blank if you do not attempt to determine sexual condition**, otherwise use code sheet.

Par Type: Parasite Type; Leave blank if you do not examine fish for parasites, otherwise see code sheet.

Par #: Number of parasites.

F Clip 1 Finclip 1. First column is recapture status of finclip (Y if fish was captured with a clip, N otherwise). Only record recapture status if you examine a fish for a clip, otherwise leave blank. **Only examine HBC for finclip recapture status; leave this field blank for all other species.** Second column is type of fin clip; leave blank if no finclip, otherwise see code sheet.

F Clip 2 Finclip 2. First column is recapture status of finclip (Y if fish was captured with a clip, N otherwise). Only record recapture status if you examine a fish for a clip, otherwise leave blank. **Only examine HBC for finclip recapture status; leave this field blank for all other species.** Second column is type of fin clip; leave blank if no finclip, otherwise see code sheet.

Lot# or Bag ID: Pit tag Lot#; record only for fish receiving a **NEW PIT TAG.** Lot # is printed on the tape strip or bag containing the pit tags.

PIT Recap: Recapture status of any fish containing a pit tag. **It is extremely important that this field be filled out properly.** If a fish contains a PIT Tag upon capture, this field should be "Y". If a fish is found not to contain a PIT TAG or is injected with a new PIT Tag, this field should be "N". **Scan all native fish >=120 mm for the presence of a PIT Tag. Inject all untagged native fish >=150 mm with a new PIT TAG. This field should be left blank for all native fish < 120 mm and all other fish.**

PIT-TAG #: PIT TAG Number of all fish containing a PIT TAG upon release. Follow ***Verifying PIT TAG Numbers*** protocols as described above.

Disposition: Disposition of fish after sampling. See code sheet.

Bot-#: Bottle Number. If a tissue sample (e.g. a whole fish or a portion of a fish) is taken, record bottle number that contains the tissue.

Comment: Comments specific to a particular fish (e.g. Blind in left eye).

Depletion Electrofishing Effort PROCESSING Form Instructions (Removal Reach)

Trip ID: GC plusYear and Month and date trip **started** (yyyy/mm/dd); e.g. GC20030115

Start Date: Date the electrofishing sample began (mm/dd/yy), read off Data Info Card

Station ID: Name of sampling station; e.g. A-10 or F-02, read off Data Info Card

Depletion Number: Depletion Run Number (1-5), read off Data Info Card

Total Seconds:	Total amount of time spent electrofishing, read off Data Info Card.
Store Box #:	The storage box number which contains stomach samples associated with this data sheet.
Proc. Comments:	Any comments relative to all the samples processed on this sheet.
Species:	
TL	Total Length; recorded to nearest mm for all fish captured
Wt	Weight, recorded to accuracy of scale.
Gape Vert:	Gape Vertical; Gape size from lower jaw to upper jaw with mouth opened fully. Do not distort mouth past normal maximum opening to take this measurement; record to nearest mm.
Gape Lat	Gape Lateral; maximum distance between left and right maxilla. Do not distort mouth past normal maximum opening to take this measurement; record to nearest mm.
F Clip 1	Finclip 1. First column is recapture status of finclip (Y if fish was captured with a clip, N otherwise). Only record recapture status if you examine a fish for a clip, otherwise leave blank. **Only examine RBT and BNT for finclip recapture status; leave this field blank for all other species.** Second column is type of fin clip; leave blank if no finclip, otherwise see code sheet.
PIT Recap:	Recapture status of any fish containing a pit tag. **It is extremely important that this field be filled out properly.** If a fish contains a PIT Tag upon capture, this field should be "Y". If a fish is found not to contain a PIT TAG, this field should be "N". **Scan all BNT with an adipose clip for the presence of a PIT Tag. This field should be left blank for all fish except BNT with an adipose clip.**
PIT-TAG #:	PIT TAG Number of all fish containing a PIT TAG upon release. Follow ***Verifying PIT TAG Numbers*** protocols as described above.
Sex	Sex of fish as determined through dissection, see code sheet.
Sexual Condition:	Sexual condition of fish as determined through dissection, see code sheet.
Empty:	Y if stomach is empty, N otherwise.
Isotope Sample:	Y if a stable isotope is taken, N otherwise
Bottle Number:	Number of Metal tag placed in the sample bottle and written on the lid.
Comments;	Any comments specific to the fish specimen

APPENDIX. E DATA CODES

Fish species codes

Species Codes	
BBH	Black Bullhead
BGS	Bluegill
BHS	Bluehead Sucker
BKC	Black Crappie
BKT	Brook Trout
BNT	Brown Trout
CCF	Channel Catfish
CRP	Carp
CUT	Cutthroat Trout
FHM	Fathead Minnow
FMS	Flannelmouth Sucker
FRH	Flannelmouth/Razorback Hybrid
GAM	Gambusia
GSF	Green Sunfish
GSH	Golden Shiner
HBC	Humpback Chub
LMB	Largemouth Bass
NOP	Northern Pike
PKF	Plains Killifish
RBS	Razorback Sucker
RBT	Rainbow Trout
RGK	Rio Grande Killifish
RSH	Red Shiner
RTC	Roundtail Chub
SDS	Sand Shiner
SHR	Shiner
SMB	Smallmouth Bass
SPD	Speckled Dace
STB	Striped Bass
SUC	Un-identified Sucker
TFS	Threadfin Shad
UID	Un-determined Fish
UTC	Utah Chub
WAL	Walleye
YBH	Yellow Bullhead

Turbidity codes

Turbidity	
H	High secchi (< 0.5m)
L	Low secchi (> 0.5m)

Shoreline habitat codes

Shoreline Habitat	
BE	Bedrock
TD	Travertine Dams
CB	Cobble Bar
CL	Cliff
DF	Debris Fan
SB	Sand Bar
TA	Talus
BL	Boulder
LE	Ledge

Hydraulic unit codes

Hydraulic Units	
BA	Backwater
ED	Eddy (countercurrent)
RI	Riffle
RU	Run
RA	Rapid
PO	Pool (still)
RC	Return Channel
GL	Glide

Sexual condition codes

Sexual Condition	
N	Not Ripe
M	Mature, Non-Extrudable Developed Gamates
R	Ripe, Gametes Exrudable
S	Spent, Expelled Gametes
U	Undetermined

Sexual characteristics

Sexual Characteristics	
C	Color
T	Tuberculate
B	Both Colored and Tuberculate
U	Undetermined

Cover type codes

Cover Types	
V	Vegetative
B	Boulder
L	Ledge or Lateral Cover
N	None
U	Undetermined

Disposition codes

Disposition	
RA	Returned Alive
DR	Dead, Released
DP	Dead, Preserved
DS	Dead, Stomach Contents
SK	Dead, Skeletonized

Fin clip codes

Fin Clips	
(Y/N)	Recap, Fin Mark
ADP	Adipose
LP1	Left Pectoral
LP2	Left Pelvic
RP1	Right Pectoral
RP2	Right Pelvic
UCD	Upper Caudal
LCD	Lower Caudal
ANL	Anal

Parasite codes

Parasite Type	
L	Lernea
A	Asian Tapeworm
U	Undetermined
N	None

APPENDIX F. PERSONNEL FOR MECHANICAL REMOVAL OF NON-NATIVE SALMONIDS.

Trip 1 – January 15-31, 2003

HSS

1. Logistical Support Boatman	Steve Bledsoe
2. Logistical Support Boatman	Scotty Davis
3. Logistical Support Boatman	Lynn Roeder
4. Electrofishing Boatman	Brian Dierker
5. Electrofishing Boatman	Peter Weiss
6. Electrofishing Boatman	Stewart Reeder
7. Electrofishing Boatman	Brent Berger

GCMRC

8. Processing/Transport Boatman	Michael Yard (out on trip day 5)
9. Processing/Transport Boatman	Lew Coggins
10. Processors-Field-hands	Todd Tietjen
11. Processors -Field-hands	Melanie Caron
12. Netters-Field-hands	Ted Kennedy (out on trip day 5)

HSS

13. Netters-Field-hands	Alley Martinez
14. Netters-Field-hands	Courtney Giauque
15. Netters-Field-hands	Danny Martinez
16. Netters-Field-hands	Yael Bernstein
17. Processor/Logistical Support Trainee	Steve Jones
18. Netters-Field-hands	??(Volunteer)

Hualapai Nation

19. Netters-Field-hands	Aaron Mapatis