Proposed

Two-Year Science Plan
for
Experimental Flow Treatments and Mechanical Removal Activities in WY's 2002-2004

PREPARED BY THE GRAND CANYON MONITORING AND RESEARCH CENTER

for
Glen Canyon Adaptive Management Program
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Proposed GCMRC Science Plan for Experimental Flow Treatments and Mechanical Removal Activities for WY 2002-2004

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Two-Year Science Plan for Experimental Flow Treatments and Mechanical Removal Activities in WY's 2002-2004

Introduction

This plan describes a conceptual framework, which identifies priority project areas for research and monitoring related to experimental flows and mechanical removal of non-naive fishes. It is not intended to provide highly detailed methodologies for accomplishing the research and monitoring. The plan assumes that normal core monitoring activities conducted by GCMRC as part of the Glen Canyon AMP will be completed and indeed may provide much of the necessary information to evaluate the effectiveness of the treatment scenarios.

In response to a motion passed by the Adaptive Management Work Group at their January 2002 meeting a series of treatment scenarios for WY2002-03 was developed by the Grand Canyon Monitoring and Research Center in conjunction with the Technical Work Group (GCMRC, 2002). At their April 24, 2002, meeting, the Adaptive Management Work Group 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. The Bureau of Reclamation has forwarded the AMWG recommendation to the Secretary of the Interior via the Assistant Secretary for Water and Science. The Secretary's decision on that recommendation is expected during summer of 2002.

The treatments recommended by GCMRC and adopted by the AMWG for WY 2002 – 2004 are intended to: (1) decrease downstream export of tributary input sediment from Marble Canyon, (2) increase retention of sediment through Beach/Habitat-Building Flows (BHBF), (3) improve survival and recruitment of HBC by reducing competition and predation from non-native fish (primarily rainbow trout) and (4) improve and maintain habitat for young native fish.

Within the recommended experimental flow scenario for WY 2002 – 2003 GCMRC is recommending a series of treatments, depending on the timing of and whether or not one gets significant sediment inputs, that combine low flows to reduce sediment export, BHBFs to enhance sediment storage, and high fluctuating flows to disadvantage non-native fish. This latter flow pattern will potentially improve the growth of salmonids by reducing density in the Lees Ferry reach and reduce predation or competition by rainbow and brown trout on the endangered humpback chub in the LCR reach. Integrated science studies are also being designed to document relationships between terrestrial sand-bar dynamics and vegetation and impacts to cultural and recreational resources within Grand Canyon.

In addition, GCMRC has provided a first draft of a larger set of experimental flows that can serve as a starting point for working with the Science Advisors, the TWG, and other stakeholders to develop a longer term program of experimental flows. This long term implementation plan was part of the AMWG motion passed April 24, 2002.

The implementation of treatment activities could begin as early as September, 2002. GCMRC is undertaking preliminary work necessary to enable effective implementation of proposed treatments pending their approval by the Secretary. An essential element of that preparation is the development of a Science Plan which will identify necessary research and monitoring activities needed to evaluate the effects of proposed treatment actions. This document represents the proposed Science Plan and is intended to form the basis for implementation of the plan by the GCMRC. The Science Plan links the hypotheses to be tested with project descriptions which are in turn related to Goals and Management Objectives for the AMP.

Background

A detailed description of the experimental flow recommendations made to the Secretary and the rationale for those recommendations is contained in Version 4.0 of a document entitled "Treatment Scenarios for Water Year 2002-2003" developed by GCMRC in consultation with the TWG and presented to the AMWG on April 24, 2002. The general working hypotheses which resulted in the preferred treatment scenario recommendation from the AMWG are as follows:

Fine Sediment (Mass Balance and Bar Dynamics) - Monitoring data indicate that tributary inputs of sand do not accumulate within the river channel over multi-year periods as predicted by the final EIS, and that such inputs are transported out of the Colorado River Ecosystem within less than one year under most ROD operations (Rubin et al., 2002; Rubin and Topping, 2001; Topping et al., 2000a; 2000b). On the basis of results from the summer 2000 flow experiment, as well as historical sediment-transport data, new inputs of sand should be retained more effectively within main channel storage sites during extended periods of dam releases at or below about 10,000 cfs (Rubin et al., 2002; Rubin and Topping, 2001; Topping et al., 2000a; 2000b). If such operations promote retention of sand (and finer sediment as well), then implementation of a BHBF following such periods should greatly increase the effectiveness of such flows in restoring and maintaining terrestrial sand bars and related resources.

More efficient retention of fine sediment and silt prior to BHBFs is hypothesized to result in more rapid rates of sand bar deposition, as well as sand bars with finer grain-size distributions. Finer-textured sand bars may be less prone to rapid erosion following bar building, as well as retain a higher level of nutrients contributed to the main channel by tributaries. Such improved bar characteristics may enhance the longevity of recreational camping areas, and improve chances for on-going in-situ preservation of cultural sites. Enhanced conservation of tributary sediment inputs in the channel should result in elevated suspended-sediment concentrations during BHBFs, leading to rapid depositional rates during sandbar building. Elevated rates of sandbar deposition should reduce the required duration for BHBFs, and hence will limit spill volumes. If sand bar deposition is significantly enhanced by implementing BHBFs when the ecosystem's sediment supply is greatly enriched (resulting in sustainability of finer, more stable bars), then perhaps the frequency for making such releases is simply linked to timing of tributary inputs, rather than strictly basin hydrology.

Coarse Sediment (Inputs and Impacts) – Ongoing debris flows from drainages tributary to the Colorado River ecosystem continue depositing coarse sediment into the main channel. The direct and indirect impacts and influences on the ecosystem continue to be monitored annual with respect to aggradation of rapids and debris fans, as well as impacts to terrestrial and aquatic habitats. Experimental high flows, such as BHBFs, provide opportunities to document the degree to which these coarse-sediment deposits can be reworked by operations from Glen Canyon Dam. Limited studies of debris fan and rapid reworking are proposed in this science plan for the first, and possible the second years of experimental flows in WY 2002-04.

Native and Non-Native Fish - The Little Colorado River (LCR) population of humpback chub (HBC) has not demonstrated a positive response to the mainstem flow regimes under ROD operations. In contrast, the population of rainbow trout in Lees Ferry and the populations of rainbow and brown trout in the mainstem below the Paria River appear to have shown a positive response as reflected in increased abundance. Within the ROD, there is a need to implement experimental flows, which may improve survival and recruitment of HBC. The LCR population of HBC is comprised of fish resident in the LCR and in the mainstem near the LCR confluence. Therefore flows, which affect changes in HBC status in the mainstem, may positively influence the overall LCR HBC population.

Recent analyses of historical humpback chub (HBC) data suggest that the abundance of the Little Colorado River (LCR) population of HBC is in decline; 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 (1989-1997 brood years) and sub-adult and adult abundance (>150 mm total length; 1991-1999). 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 8,517 in 1993 to 3,388 in 1999. 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 *in prep*.). 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 ROD 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 the summer of 1992, 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 RM 56.6-68.3; Gorman and Coggins, 2000).

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. Finally, it is plausible that the predation/competition hypothesis could overwhelm any benefits derived from management flow prescriptions intended to provide beneficial habitat conditions.

GCMRC believes the benefits to native fish will accrue indirectly through a reduction in predation/competition by non-native fish, primarily salmonids in the LCR reach. The model developed by Dave Speas and Carl Walters provides support for high fluctuating flows to reduce the number of RBT by interfering with and disrupting spawning activity and/or reducing the recruitment of young fish. This model and data pertaining to the impacts of fluctuating flows are most relevant to the Lees Ferry reach where targeted reduction in trout numbers is also thought to be desirable. Unpublished and published (Maddux et al. 1987; McKinney et al., 1999) data from AGFD and GCMRC indicate that spawning is most frequent in January to March. In addition the amount of recruitment in the Lees Ferry rainbow trout population is most strongly correlated with fluctuating flows in this same period and the range of those fluctuating flows. The correlations are negative which means the lowest recruitment corresponds to fluctuating flows in these months. Similarly, the greater the degree of daily fluctuation, the lower the recruitment. It is reasonable to assume that these relationships are similar in the LCR reach although timing of spawning could be different. A separate document containing data regarding the recent decline in the growth of rainbow trout in the Lees Ferry reach of the river is included as Appendix 1.

Initial flow experiments to modify habitat have not shown a strong response in increased HBC abundance. This could be due to a number of factors including both the power of the experiment, the ability of monitoring programs to detect a change, and the short time since the most recent experiment, termed the Low Summer Steady Flow (LSSF), has been conducted. Another possibility is that non-native and native fish interactions (i.e., predation and competition) are over-riding any potential positive effects from flows that improve habitat conditions. The treatments described here are intended to test this possibility and produce a measurable affect on non-native fish and hence on non-native and native fish interactions. The hope is that this will result in a positive effect on HBC and lead to the designing of experimental flows or other management actions that also can improve habitat for native fish, including HBC that will address Goal 2 of the AMP strategic plan.

Proposed Treatment Scenarios (#1 and #2)

This scenario provides for experimental flows aimed at both conserving sediment and benefiting native fishes. Treatments will be conducted during both WY's 2003 and 2004. Through August 2002 the dam follows normal ROD operations. Following significant[1] sediment inputs in the September - December 2002 period, and beginning as early as September 1, 2002, the dam would release alternative 2-week periods of constant 8,000 cfs and fluctuating 6,500 cfs to 9,000 cfs until January 2003. In January 2003 a BHBF[2] of limited duration is conducted. This is followed by high experimental fluctuating flows with a daily range of 5,000 cfs to 20,000 cfs for the main portion of the non-native spawning and emergent/juvenile season (January through March). From April – September 2003 operations would follow monthly volumes under the ROD. Concurrent with the experimental flow treatment, mechanical removal of rainbow and brown trout in the LCR reach (described below) would be implemented. This overall treatment (flows and mechanical removal) has the most potential to result in measurable responses, which improve the Lees Ferry trout fishery, reduce non-native predation/competition on native fish in the LCR reach, enhance native fish habitat, and increase sediment retention in the CRE.

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[1] These are defined as inputs from the Paria River of at least 500,000 metric tons of sediment after July 1. Continuation of the Scenario 1 experiment past October 31 would be dependent on cumulative total Paria River sand inputs of at least 1.4 million metric tons. Implementation of a January BHBF would require retention of at least 1,000,000 (+/- 20 percent, for measurement uncertainty) metric tons of sand in the reach above the Little Colorado River. For purposes of the BHBF triggering decision, the start point for estimating total accumulated sand storage in Marble Canyon shall be September 1st.

[2] In every scenario where a BHBF is proposed to be released in 2003 or 2004, the BHBF should have a magnitude of at least 10,000 cfs above peak power-plant discharge or higher, depending on lake elevation.

The flow treatment 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. Conceptually, this is to be accomplished primarily by reducing RBT and BNT recruitment by increasing the early life mortality rate of these fishes with highly fluctuating flows during their winter and spring spawning and rearing seasons. The other experimental treatment calls for the reduction of adult RBT and BNT abundance in the Colorado River mainstem (MCR) near the confluence of the Little Colorado River (LCR) via electrofishing and mechanical removal.

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 sampling reach (56.2 RM - 65.7 RM) that encloses the majority of this population (see attached map). The proposed sampling effort will be uniformly distributed within this reach. The upstream and downstream endpoints are bounded by hydraulic and geomorphic control; however, it is not impermeable to system-wide fish movement (Stevens et al. 1997). We are proposing to conduct annually, three depletion trips in January-March and three depletion trips in July-September. The effort would also yield information regarding abundance of YOY HBC during this period and be complimentary to existing monitoring efforts.

Specific Proposed Action

The action proposed is an integrated ecosystem treatment that combines experimental flows to conserve sediment and improve native fish habitat with flows intended primarily to disadvantage non-native salmonid fishes in the CRE. The latter flow treatment is coupled with the mechanical removal of salmonids to reduce likely competition with and predation on native fish-particularly Humpback chub. Because this is an integrated ecosystem treatment aimed at learning more about conserving several key resources it involves tradeoffs when compared to a treatment which might optimize for a single resource, e.g. sediment.

Experimental Treatment Scenarios Project Overview

The Science Plan is intended to describe the suite of additional research and monitoring activities thought to be desirable, feasible, and necessary to interpret and understand the effects of the foregoing treatment scenarios on key resources in the CRE over an approximate two year period beginning in September (mechanical removal) or September (sediment flows) 2002. The projects identified below are in addition to or represent an expansion of on-going research and monitoring activities already approved in GCMRC's FY02 and FY03 Work Plans. As such, these activities will require additional funding to complete. GCMRC is proposing to complete the following projects through increased activities of existing contractors and cooperators as well as through engagement of additional on-site contractors. Projects have been grouped to correspond with the elements of the annual treatment scenario as follows:

1. Primary Sediment Components (September through December flows)
1. Secondary Sediment Components (BHBF contingent upon minimum sand inputs and accumulation within Marble Canyon, river miles 1-61)
2. Post-BHBF Components (January to April fluctuating flows)
3. Non-Flow Components (mechanical removal of non-native fishes, primarily salmonids)

The experimental flows and mechanical removal treatments described above and in more detail in other documents are intended to be the first treatments in a longer series of management actions implemented experimentally. Many of the treatments and ultimately the overall multi-year experiment have hypotheses associated with their possible effects. In some cases these hypotheses may be testable almost immediately. However, in other cases, and particularly with regard to biological responses, testing these hypotheses may take several years owing to life cycles of fishes involved, sampling strategies, etc. Finally, some projects undertaken may only result in descriptive data which are not useful in the statistical sense of testing hypotheses but may yield valuable information regarding ecosystem responses.

The implementation of research and monitoring activities associated with the Experimental Treatment Scenarios over the next two years will represent a substantial undertaking by GCMRC, its cooperators and contractors. A summary of individual projects and their association with AMP goals and management objectives, as well as the projected cost of each project is provided in Table 1. The final column in this table ranks projects relative to GCMRC's perception of their importance in providing information critical to making management recommendations by AMWG. A synopsis of the hypotheses to be considered by each project is provided in Table 2. More detailed individual project descriptions are found in the following section of the science plan.

;UMMARY

8/9/2002

Prog Mgr	FY-02	FY-03	FY-04	TOTAL	AMP GOAL	AMP MO's	Funding Priority
:lis	123,000	376,000	376,000	875,000	Goal 8	MO's 8.1-8.6	High
:lis	20,000	840,000	680,000	1,540,000	Goal 8	MO's 8.1-8.6	High
ılston	0	80,000	80,000	160,000	Goal 6	MO 6.4	Low
oss	115,500	100,000	100,000	315,500	Goal 1	MO 1.1, 1.2	Medium
oss	10,000	125,000	125,000	260,000	Goal 2	MO 2.2	High
:lis	0	71,000	49,000	120,000	Goal 8	MO's 8.1-8.6	Medium
:lis	0	65,000	65,000	130,000	Goal 8	MO's 8.1-8.6	Medium
oss		10,000	10,000	20,000	Goal 5	MO 5.1	High
oss	0	50,000	50,000	100,000	Goal 1	MO 1.1,1.2	Medium
oss	0	50,000	50,000	100,000	Goal 7	MO 7.1,7.2	Low
oss	0	10,000	10,000	20,000	Goal 7	MO 7.1,7.2	Low
oss	0	10,000	10,000	20,000	Goal 7	MO 7.1,7.2	Low
loss	72,500	168,800	168,800	410,100	Goal 4	MO 4.1	High
loss	0	100,000	100,000	200,000	Goal	MO 4.1	Medium
loss	0	200,000	200,000	400,000	Goal 4	MO 4.1	Low
loss	20,000	95,000	95,000	210,000	Goal 1	MO 1.1, 1.2	Medium
loss	191,000	648,500	610,000	1,449,500	Goals 2 & 4	MO 2.7, 4.2	High
loss	0	50,000	50,000	100,000	Goal 7	MO 7.1,7.2	Low
loss	118,000	161,500	123,000	402,500	Goal 2	MO 2.7	High
loss	49,000	58,000	58,000	165,000	Goal 2	MO 2.7	High
oulam	0	0	0	0	Goal 11	MO 11.1, 11.2	
ambert	0	35,000	35,000	70,000	Goal 11	MO 11.1, 11.2	High
oulam/Melis	0	0	0	0	Goal 11	MO 11.1, 11.2	
ambert	0	250,000	250,000	500,000	Goal 11	MO 11.2	High
ambert	0	20,000	20,000	40,000	Goal 9	MO 9.1	Medium
almer	0	0	0	0	Goal 10	MO 10.1	
ambert	0	25,000	25,000	50,000	Goal 9	MO 9.3	Medium
ambert	0	20,000	20,000	40,000	Goal 9	MO 9.2	Low
	10,000	43,500	40,000	93,500			
	2,500	21,000	21,000	44,500			
	0	535,000	145,000	680,000			
	137,190	0	0	137,190			
	868,690	4,218,300	3,565,800	8,653,790			
	508,000			508,000			
	360,690	4,218,300	3,565,800	8,144,790			

Table 2. Proposed Research and monitoring Projects, Hypotheses, Estimated Cost, and Funding Priority

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
Fine Sediment Balance Parts A & B	H_o - Sand-transport and silt-transport rates, are not significantly different under stable flows of 8,000 cfs versus low fluctuating flows ranging between 6,500 cfs and 9,000 cfs. H_o - Paria River sand inputs during July and August 2002, are not subject to high transport rates through Marble Canyon (significant export) under scheduled power-plant operations. H_o - Paria River silt/clay inputs during July and August 2002, are not subject to high transport rates through Marble Canyon (significant export) under scheduled power-plant operations. H_o - Paria River sand inputs during September through December 2002, are not subject to high transport rates through Marble Canyon (significant export) under experimental low-flow operations. H_o - Paria River silt/clay inputs during September through December 2002, are not subject to high transport rates through Marble Canyon (significant export) under experimental low-flow operations H_o - Paria River sand inputs during July through December 2003, are not sufficiently accumulated within Marble Canyon eddies to meet the December triggering criteria for implementation of a January BHBF. H_o - Paria River silt/clay inputs during July through December 2003, are not significantly accumulated within Marble Canyon eddies and will not contribute substantially to bar restoration even if a January BHBF is implemented.	$ 875,000 Total for Parts A, B, C, D	High
Fine Sediment Balance Part C	H_o - With respect to its grain size and concentration, the sand supply within Marble Canyon is not significantly depleted during the BHBF. H_o - With respect to concentration, the silt/clay supply within Marble Canyon is not significantly depleted during the BHBF.		High
Fine Sediment Balance Part D	H_o - With respect to concentration, the sand-transport rates are not decreased following the BHBF. H_o - With respect to concentration, the silt/clay-transport rates are not decreased following the BHBF.		High

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
Fine Integrated Sediment Team (FIST) - Parts A and B	H_o - Fine-Sediment storage above 8,000 cfs is not decreased during low stable or low fluctuating flows (either 8,000 cfs constant releases or 6,500 to 9,000 cfs fluctuations). H_o - Fine-Sediment storage below 8,000 cfs is not increased during low stable or low fluctuating flows (either 8,000 cfs constant releases or 6,500 to 9,000 cfs fluctuations). H_o - Fine-Sediment storage between 5,000 and 31,500 cfs is not increased during normal ROD operations in combination with peak power-plant releases that follow Paria River sediment inputs from July through October. H_o - Fine-Sediment storage below 8,000 cfs is not decreased during normal ROD operations in combination with peak power-plant releases that follow Paria River sediment inputs from July through October.	1,540,000 Total for Parts A, B, C, D	High
Fine Integrated Sediment Team (FIST) – Part C	H_o - Fine-Sediment storage above 8,000 cfs within Marble Canyon is not increased compared with conditions measured following the 1996 flood experiment. H_o - Fine-Sediment storage below 8,000 cfs is not decreased compared with conditions measured following the 1996 flood experiment. H_o - Fine-Sediment deposits above 8,000 cfs in Marble Canyon do not have finer grain-size distributions (with respect to sand-sizes) when compared with sand bars deposited by the 1996 controlled flood experiment. H_o - Fine-Sediment deposits above 8,000 cfs in Marble Canyon do not have higher contents of silt/clay when compared with sand bars deposited by the 1996 controlled flood experiment H_o - Fine-Sediment storage between 8,000 and 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 controlled flood experiment and one summer of ROD fluctuations. H_o - considered Fine-Sediment storage above 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 controlled flood experiment and one summer of ROD fluctuations. H_o - considered Fine-Sediment grain size of channel-bed material below 8,000 cfs is not coarser than conditions measured in January, immediately following the BHBF test.		High

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
	H_0 - considered Fine-Sediment grain size of sand bar deposits above 8,000 cfs <u>is not</u> coarser than conditions measured in January, immediately following the BHBF test. H_0 - considered Total fine-sediment storage within Marble Canyon study sites is not less than conditions measured immediately following the BHBF test. H_0 - considered Total fine-sediment storage above 25,000 cfs stage elevation within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test. H_0 - considered Total fine-sediment storage within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test. H_0 - considered Fine-sediment deposits created by the experimental BHBF do not possess cohesive properties similar to pre-dam deposits. H_0 - considered Fine-sediment deposits created by the experimental BHBF do not possess cohesive properties similar to prior post-dam deposits. H_0 - considered Fine-sediment deposits created by the experimental BHBF are not significantly reworked by wind. H_0 - considered Fine-sediment deposited by the experimental BHBF are not transported by aeolian processes to areas where recent gully erosion has exposed cultural sites. NOTE: Also see Socio-Cultural Studies, Part A below.		
Fine Integrated Sediment Team (FIST) – Part D	H_0 - Fine-Sediment storage between 8,000 and 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 controlled flood experiment and one summer of ROD fluctuations. H_0 - Fine-Sediment storage above 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the1996 controlled flood experiment and one summer of ROD fluctuations. H_0 - Fine-Sediment grain size of channel-bed material below 8,000 cfs is not coarser than conditions measured in January, immediately following the BHBF test. H_0 - Fine-Sediment grain size of sand bar deposits above 8,000 cfs is not coarser than conditions measured in January, immediately following the BHBF test.		High

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
	H_0 - Total fine-sediment storage within Marble Canyon study sites is not less than conditions measured immediately following the BHBF test H_0 - Total fine-sediment storage above 25,000 cfs stage elevation within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test. H_0 - Total fine-sediment storage within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test. H_0 - Down-ramping rates of 2,500 cfs per hour do not result in increased seepage erosion rates in newly created sand bars when compared with down-ramping rates of 1,500 cfs per hour.		
Fine-Sediment Dynamics and Terrestrial Vegetation Responses	H_0 - Sand bar volume change above 25,000 cfs will not be affected by vegetation cover. H_0 - Sandbar grain size following a controlled flood will be heterogeneously distributed and have no effect on seedling establishment. H_0 - Vegetation cover has no effect on seedling emergence or diversity.	160,000	Low
State of Primary Productivity, Carbon Flux and Alteration of Food Base	H_0 - Primary production as measured by algal biomass before and after low fall flows will not differ in the Glen Canyon reach H_0 - Dissolved and particulate organic drift will not increase in the CRE H_0 - NZMS density in the Glen Canyon reach will not change as a result of LFF.	315,500	Medium
Near Shore Temperature and Habitat Use Monitoring During Low Steady Flows	H_0 - There is no difference in near-shore habitat for steady 8,000 cfs releases and low fluctuations (6,500 to 9,000 cfs) in terms of temperatures, velocities, turbidity, and nutrients. (The strength of this hypothesis increases with concurrent collection of fish information.) H_0 - There is no difference between the alternative flow sequences of the fall flow period with respect to juvenile fish behavior. H_0 - There is no difference between the alternative flow sequences of the fall flow period for native and non-native fish abundance in near-shore areas.	260,000	Hi9gh

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
Sediment-Transport Modeling Measurements	H_o - Sand-Bar depositional rates within study eddies are invariant throughout the duration or the BHBF and do not verify model-simulations relative to suspended-sediment concentrations and grain-size conditions measured during the high flow. H_o - Evolution of fine-sediment supply with respect to concentration and grain size do not verify 1-Dimensional sand routing model simulations. H_o - Rapid sand-bar failures do not occur during the 2.5-day long BHBF.	120,000	Medium
Coarse-Sediment Monitoring (Inputs, Impacts and Reworking)	H_o - Coarse-grained sediments recently deposited on debris fans and within rapids are not significantly reworked during the rising limb of the BHBF, as previously measured during the 1996 flood experiment (41,000 cfs versus 45,000 cfs peak discharges). H_o - Boulders transported from newly aggraded debris fans at 41,000 cfs are not deposited within pools immediately below debris fans and constricted rapids. H_o - Fine gravel-sized sediment from newly aggraded debris fans at 41,000 cfs are not redistributed to downstream channel elements.	130,000	Medium
Kanab Ambersnail Population	H_o - KAS density in habitat below BHBF flows will not change as a result of the BHBF flows. H_o - Available KAS habitat will not change as a result of BHBF flows. H_o - Pre-BHBF population estimates will not differ from estimates derived during routine monitoring in the fall.	20,000	High
Foodbase Impacts of BHBF Flows in Glen Canyon Reach	H_o – The phyto-benthic community will not change in response to the BHBF flows.	100,000	Medium
Water Quality, Hydrology in Glen Canyon Forebay	H_0 - The water quality (temperature, nutrients, and biological components) of reservoir releases during the BHBF will not differ significantly from normal operational patterns. H_0 - Current reservoir volumes do not have an effect on the upstream or vertical extent of the withdrawal plume in the reservoir compared to that seen in 1996. H_0 - The BHBF will not have an effect on the routing of inflow currents compared to other winter periods. H_0 - The withdrawal plume can be adequately predicted by the CE-QUAL-W2 reservoir model in its current configuration.	100,000	Low

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
Water Quality Monitoring of Jet Tubes	H_o – The water quality (temperature, nutrients, and biological components) of jet tube releases during the BHBF will not differ significantly from penstock release water quality.	20,000	Low
Mixing Zone and Monitoring of Downstream Water Quality	Lees Ferry H_o - Recruitment of YOY rainbow trout in the Lees Ferry reach is not different than during MLFF years H_o - Growth and condition of rainbow trout in the Lees Ferry reach is not different than during MLFF years H_o - CPUE of all size classes of rainbow trout in the Lees Ferry reach is not different than MLFF years. Downstream H_o - Recruitment of YOY RBT and BNT is not different than during previous two MLFF years H_o - CPUE for RBT and BNT of all size classes is not different from preceding two MLFF years H_o - CPUE for RBT and BNT of all size classes is not different in areas subject to mechanical removal of salmonids	20,000	Low
Monitoring of Rainbow Trout Adult Stranding & Mortality	H_o – No difference in the abundance of stranded adult rainbow trout in selected areas of the Lees Ferry reach will occur between the low fall flows (Nov-Dec) and fluctuating flows from Jan-March.	410,100	High
Distribution of Spawning Redds for Rainbow Trout in the Lees Ferry Reach.	H_o - Location of spawning redds does not change in relation to season or dam releases. H_o - Distribution and abundance of spawning redds is unaffected by the presence of fine sediment on the channel bottom.	200,000	Medium
Determination of the Mechanism Accounting for Reduced Recruitment During Fluctuating Flows in the Lees Ferry Reach.	H_o - No difference in abundance of YOY RBT results from presence or absence of adult RBT. H_o - No seasonal difference exists between survival of YOY RBT H_o - No difference in survival of YOY RBT occurs between fish with access to fluctuating flow regime versus fish restricted below 5-8,000cfs.	400,000	Medium
Food Base Impacts of Fluctuating Flows	H_o – The phyto-benthic community will not change in response to the BHBF flows.	210,000	Low

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
Mechanical Removal of Non-Native Fishes (Primarily Salmonids) from the Colorado River Near the Confluence with the Little Colorado River	H_o - Mechanical removal of RBT and BNT using electrofishing methods is an effective method of reducing adult RBT and BNT abundance in the LCR Inflow reach. H_o - Abundance of adult RBT and BNT in the LCR Inflow reach prior to each removal event is similar. H_o - No changes occur in adult RBT and BNT size composition in response to removal events. H_o - Trout immigration (Seasonal and Annual) into the LCR Inflow reach between removal events is undetectable.	1,449,500	High
Water Quality Impacts of Trout Removal	H_o – BOD does not differ in regard to proximity to non-native fish carcass disposal areas	100,000	Low
Rainbow Trout Diet Analysis at the LCR Confluence and in Glen Canyon Reach	H_o: There are no seasonal differences in trout diet use. H_o: There are no spatial (upstream versus downstream) differences in trout diet use. H_o: There are no size-class differences in trout diet use. H_o: Determine if differences in feeding patterns are related to flow characteristics.	402,500	High
Incidence of Predation on Humpback Chub by Rainbow and Brown Trout at the Confluence of the Little Colorado River, Grand Canyon	H_o - There is no incidence of predation by RBT and BNT on HBC in the LCR reach. H_o - Incidence of predation is unrelated to size-class and other meristic characteristics (e.g., gape-width, body-depth, length) of both the predator and prey. H_o - The incidence of predation by RBT and BNT does not changes(±) in response to predator abundance. H_o - Particular cohorts are more vulnerable to predation due to differences in size, relative prey abundance or relative predator abundance.	165,000	High
Monitoring for Effects of the Test Flow at Archaeological Site	H_o - There are no significant changes in the condition of the archaeological sites as a result of the high flows. H_o -There are no significant changes in the condition of the archaeological sites as a result of the fluctuating flows.	0	
Monitoring of Sediment De3position in Arroyos	H_o - There are no significant changes in sediment deposition or erosion at the study arroyo sites as a result of the high flows. H_o - There are no significant changes in sediment deposition or erosion at the study arroyo sites as a result of the fluctuating flows.	70,000	High

PROJECT NAME	HYPOTHESES TESTED/CONSIDERED	PROJECT COST	PRIORITY
Monitoring of Aeolian Sediment Transport at Archaeological Sites	H_o - There are no significant changes in aeolian sediment deposition at the study sites as a result of the high flows. H_o - There are no significant changes in aeolian deposition at the study sites following the fluctuating flows.	0	
Monitoring of Traditional Tribal Resources	H_o - There are no significant changes in the condition of tribal traditional resources as a result of the high flows. H_o - There are no significant changes in the condition of tribal traditional resources as a result of the fluctuating flows.	500,000	High
Economic Impacts to Whitewater & Angler Concessionaires & Private Boaters and Anglers	H_o - Economic impacts to whitewater and angling concessionaires will not differ significantly from economic impacts under normal daily operations. H_o - Economic impacts to private whitewater boaters and anglers will not differ significantly from economic impacts under normal daily operations.	40,000	Medium
Economic Impacts to Power Customers	H_o - Economic impacts to power customers will not differ significantly from economic impacts under normal daily operations.	0	
Changes in Campable Beach Areas	H_o - Campable beach areas during the proposed experiment will not differ significantly from campable beach areas under normal daily operations.	50,000	Medium
Recreational Safety Study	H_o - Whitewater and angler safety during the high flows and fluctuating flows will not significantly differ from safety during normal daily flows.	40,000	Low

Project Descriptions

I. **PRIMARY SEDIMENT COMPONENTS** (Low Flows)
(September through December of 2002, and July through December 2003, low flow period in 2002 for Treatment #1, with Treatment #2 focused on peak power-plant tests in 2003)

Project 1. Fine-Sediment Mass Balance, Parts A and B

Treatment #1 - Sediment mass balance to ascertain triggering for low fall flows.

Part A. - July through October 2002 - Commence with annually scheduled daily sediment-transport sampling along main channel and monitoring of tributary inputs, July 1st through October 15th. Costs are currently covered by core monitoring for cableway sampling, but an additional amount will be required to expand use of instrumentation along four main channel locations to provide high-resolution, continuous sediment-transport data for improving mass-balance estimates. Comparison of sediment-transport rates under stable versus low fluctuating flows shall begin with two weeks of constant 8,000 cfs releases on September 1, 2002, if Paria inputs have already reached 500,000 metric tons, or immediately following this level of sand input should it occur after September 1st. Alternating two-week periods of stable versus low, fluctuating flows shall be released through at least October to evaluate which of these two operations conserve the most sand and silt/clay. The additional intensive sediment monitoring work that may be required after October 15, 2002, is proposed through modifications of existing agreements with USGS, plus 2 new procurements in summer/fall 2002.

Part B - November through December 2002 - On the basis of sediment-transport measurements made in September and October (assuming that the sediment supply of the channel has been significantly enriched, see above), sediment scientists shall recommend which of the two low-flow operations should be continued from November through December 2002, to conserve the greatest volume of the Paria River inputs. This recommendation shall be made on the basis of whether or not daily transport rates for sand and silt are significantly different (outside of the range of measurement uncertainty) for the two test-flow operations.

December 2002 – If during December, sediment-transport data indicate (within known levels of measurement uncertainty) that sufficient sand has accumulated within Marble Canyon, then a recommendation shall be made to decision makers to implement testing of the BHBF in early January 2003.

Methods – Please refer to currently funded USGS work plan on file at the GCMRC.

<u>Null Hypothesis Related to Sand and Finer-Transport Rates:</u>
(Dam Operations and Export of Paria River fine-Sediment Inputs)

<u>Hypotheses to be tested/considered:</u>

H_o - Sand-transport and silt-transport rates, are not significantly different under stable flows of 8,000 cfs versus low fluctuating flows ranging between 6,500 cfs and 9,000 cfs.

Regarding Treatment #2 (Peak power-plant releases in response to Paria River sand inputs instead of low flows). The mass-balance project would follow the same protocol during July through December 2003, except that the measurements would be made for mostly normal ROD operations, with perhaps one to several peak power-plant releases made in response to significant sand inputs from the Paria River between July and November. A decision point would still occur in December 2003, on the basis of whether or not sufficient sand accumulation had occurred within Marble Canyon over the course of the sediment-input season. If the threshold of sand accumulation is met, then a BHBF would be released in early January 2004.

<u>Null Hypotheses Relating to Mass Balance Parts A & B:</u>
(Accumulation of Paria River fine-Sediment Inputs)

Treatment #1, High Fluctuations in July & August, Low Flows in September through December (either stable at 8,000 cfs or fluctuations from 6,500 to 9,000 cfs)

<u>Hypotheses to be tested/considered:</u>

H_o - Paria River sand inputs during July and August 2002, **are not** subject to high transport rates through Marble Canyon (significant export) under scheduled power-plant operations.

H_o - Paria River silt/clay inputs during July and August 2002, are not subject to high transport rates through Marble Canyon (significant export) under scheduled power-plant operations.

H_o - Paria River sand inputs during September through December 2002, are not subject to high transport rates through Marble Canyon (significant export) under experimental low-flow operations.

H_o - Paria River silt/clay inputs during September through December 2002, are not subject to high transport rates through Marble Canyon (significant export) under experimental low-flow operations.

Treatment #2 - Normal Scheduled Fluctuations in July through December 2003, along with one to several peak power-plant releases that coincide or closely follow significant Paria River sediment inputs.

Additional Mass-Balance Hypotheses to be tested/considered:

H_0 - Paria River sand inputs during July through December 2003, are not sufficiently accumulated within Marble Canyon eddies to meet the December triggering criteria for implementation of a January BHBF.

H_0 - Paria River silt/clay inputs during July through December 2003, are not significantly accumulated within Marble Canyon eddies and will not contribute substantially to bar restoration even if a January BHBF is implemented.

Notes:

1) Assuming that significant Paria River sand inputs have occurred and that the low-flow testing has been conducted, reach-integrated fieldwork shall be conducted by the FIST (Fine Integrated Sediment Team, composed of researchers from USGS, Utah State University and Northern Arizona University, (see below for details) in early to mid-December, regardless of whether the BHBF threshold is met or not. These December measurements will still provide extremely valuable data as to how Paria River sediment inputs were distributed and stored in the main channel throughout Marble Canyon (upper versus lower reaches of this critical management reach). These field measurements will be made primarily within existing study reaches in Marble Canyon, and exclusively in reaches upstream of Phantom Ranch (river mile 87).

2) Comparison of the sand conservation achieved by Treatments #1 and #2 assume that similar minimum volumes of sand are input from the Paria River during the '02 versus '03 sediment season. There is a high likelihood that this assumption will be violated during the next two years, making direct comparison of these two treatments impossible.

3) Experimental testing of BHBF in January requires a minimum accumulation of 1,000,000 metric tons (+/- 20 percent) within Marble Canyon. Similar sand volumes input by the Paria River during January through July 2003, may result in testing of BHBF immediately (see alternative described with the GCMRC Treatment Scenarios document).

4) Cooperating sediment scientists have recommended that the period for determining accumulation of sand in Marble Canyon, relative to BHBF triggering threshold, begin on September 1, 2002.

Project 2. FIST - Parts A and B - Fine Integrated Sediment Team
(Pre-BHBF Sampling to measure and estimate bar shape, grain-size distributions and volumes)

Part A. - October 2002 - Intensive, repeat measurements of selected sand-bars and camping area assessments (44 sites using standardized sand-storage change-detection protocols between Lees Ferry and Diamond Creek. This work is mostly funded as part of FY2002 CORE monitoring.

Part B. - December 2002 - Field measurements shall be collected within a subset of 5 FIST reaches (reaches 2-6) during December 2002, regardless of whether the BHBF test is implemented to identify where sediment inputs have been stored within Marble Canyon. These field measurements will be repeated again in January 2003, if the BHBF test occurs.

Aerial Photography - shall be flown in December 2002, and again in January 2003, within reaches 1-11, in the event that the BHBF test is implemented.

Daily Oblique Photography - of FIST long-term sandbars shall occur regardless of whether the BHBF test is implemented. These daily photographic data will be collected as a means of documenting bar conditions prior to implementation of the January to April fluctuating-flow treatment.

All of the Part B work proposed above shall be accomplished through modifications of existing agreements with USGS, NAU, USU.

Methods – Please refer to currently funded FIST work plan on file at the GCMRC.

Null Hypotheses Relating to FIST Part A and B:

Treatment #1, Response of Sand-Storage Conditions within Marble Canyon Under Low-Flows during September through December.

Hypotheses to be tested/considered:

H_o - Fine-Sediment storage above 8,000 cfs is not decreased during low stable or low fluctuating flows (either 8,000 cfs constant releases or 6,500 to 9,000 cfs fluctuations).

H_o - Fine-Sediment storage below 8,000 cfs is not increased during low stable or low fluctuating flows (either 8,000 cfs constant releases or 6,500 to 9,000 cfs fluctuations).

Treatment #2, Response of Sand-Storage Conditions within Marble Canyon Under ROD fluctuations + Peak Power-Plant Releases coincident with Paria River Floods

H_o - Fine-Sediment storage between 5,000 and 31,500 cfs is not increased during normal ROD operations in combination with peak power-plant releases that follow Paria River sediment inputs from July through October.

H_o - Fine-Sediment storage below 8,000 cfs is not decreased during normal ROD operations in combination with peak power-plant releases that follow Paria River sediment inputs from July through October.

Project 3. Fine-Sediment Dynamics and Terrestrial Vegetation Responses

Sediment dynamics, riparian community development and disturbance by flooding are tightly linked in southwestern river systems. The amount and kind of vegetation along a riparian zone can affect sediment scour and deposition dynamics by changing velocities along a scour zone. In turn, sediment availability and grain size, and vegetation densities affect recruitment, mortality and associated biodiversity within a riparian community. Sediment volumes and grain-size, beach area and vegetated area are included in management objectives and goals for the adaptive management program. Understanding how vegetation cover affects sediment dynamics during a controlled flood and subsequent riparian community development following disturbance is an important variable associated with management strategies for sediment conservation and habitat diversity.

Project Objectives

1. To determine the effect of vegetation cover on sand bar volume and grain-size changes at stage levels above 25,000 cfs following a controlled flood of up to 41,000 cfs.
2. To determine the effect of vegetation cover and substrate grain-size on seedling emergence, abundance and diversity by stage elevation above 25,000 cfs following a controlled flood.

Hypotheses to be tested/considered:

4. Sand bar volume change above 25,000 cfs will not be affected by vegetation cover.
5. Sandbar grain size following a controlled flood will be heterogeneously distributed and have no effect on seedling establishment.
6. Vegetation cover has no effect on seedling emergence or diversity.

Methods

Methods for vegetation cover consist of establishing transects with point counts at specific stage elevations. Methods follow current monitoring methods for vegetation dynamics in Kearsley et al., (2001). Transects running perpendicular to the river's edge would be established within FIST monitoring reaches were where sandbar volumes and grain-size values are measured. For each FIST monitoring reach, 10 transects will be established. The location of these transects will be randomized in a manner similar to those used by Kearsley et al. (2001). Because we want to know how stage elevation interacts with substrate and cover, point counts well be made at stage elevations of 25, 35, and 45K cfs along the transect line. These represent stages within camping beach areas and the upper limit of the proposed controlled flood. Point counts will be made by using four $1m^2$ and two-1X2 m^2. The second plot size is slightly different from the current monitoring design. It will be used to compare if values for cover and diversity differ with plot shape for each stage elevation. Plot shape has been shown to affect diversity values for other vegetation communities. Data from this portion of the effort will feedback into monitoring design. The plots will be collected along each of the stage elevation zones with the 1X2 m^2 plots sandwiched between the $1m^2$ plots. Data from all plots would be averaged to represent cover at each zone. At each stage elevation, sediment samples will be collected for seed bank grow-out information. A suggested reaches would be in the Eminence, and in the Kwagunt monitoring reaches, where mesquite and acacia become more prominent and in lower Grand Canyon, in 206-209 mi reach. These sites should be visited in September/October, January, March, and May each year that experimental flows include a disturbance above 25,000 cfs.
Some vegetation dynamics transects and plots are within the current FIST monitoring reaches, but they are not in sufficient quantity to address the objectives of this project, hence the need for additional transects. These data will supplement canyon-wide monitoring, at a local scale (see Kearsley et al. 2001).

Project 4. State of Primary Productivity, Carbon Flux and Alteration of Food Base

Evaluating the net productivity of the river is important to understanding potential impacts on the food base, particularly as it pertains to the Lees Ferry trout fishery. There is also potential for interaction between warming temperatures during this period and increases in abundance of the NZMS. This project will access and monitor the rate of primary productivity in the Glen Canyon reach as well as the rate of downstream export of organic carbon (drift and dissolved). An effort will also be made to examine changes in the composition and abundance of the invertebrate community, including the NZMS.

Assessment:

Algal and macroinvertebrate biomass (g/m2 AFDM) and density estimates will be determined at the sites corresponding to the 2000 LSSF for comparison. Riffles/cobble habitats will be assessed at each site. Sampling will be conducted along three transects, perpendicular to the shoreline, 30 m apart (n=6). Stage/discharge estimates from the GUI Model will be used to determine stage of collections, targeting < 5K cfs to reduce flow influence on cobble/riffle collections. Samples will be processed live within 48 h and sorted into five biotic categories: C. glomerata, Oscillatoria spp., detritus, miscellaneous algae and macrophytes, and macroinvertebrates which will also be numerated into Gammarus lacustris, chironomid larvae, simuliid larvae, and miscellaneous invertebrates. Distribution, density, size class and biomass of the New Zealand Mud Snail will be documented as a separate biotic category. Miscellaneous invertebrates will include lumbriculids, tubificids, physids, trichopterans, terrestrial insects and unidentifiable animals. Detritus is composed of both autochthonous (algal/bryophyte/macrophyte fragments) and allochthonous (tributary upland and riparian vegetation flotsum. Each biotic category will be oven-dried at 60°C and weighed to determine dry weight biomass. Samples will then be ashed (500°C for 1 h), and reweighed for ash-free dry mass estimates. Preservatives alter biomass estimates and accurate mass is required for building energetic models. Substratum type, microhabitat conditions, Secchi depth, water velocity, depth, date, site, and time of day will be recorded at each sample site. Depth integrated light intensity data loggers will be deployed at each of the five sites.

Collection Dates: Mid-September, Late October, Early January

Data Analysis: These estimates will be compared past to past data collected during 1991-2001 for differences between sites, within sites and collection dates using multivariate analysis including, MANOVA and community analysis with Non Dimensional Multi-Scaling and Principal Components Analysis. Predictor variables include all abiotic data while response variables will include biomass and density biotic categories.

Organic drift (DOC, FPOM and CPOM) will be estimated at the sites corresponding to the 2000 LSSF for comparison. Protocols will the same as used by Benenati et al. (2001), Shannon et al. (1996), Blinn et al. (1999). Dissolved Organic Carbon (DOC) Samples (50 ml; n=3) will be collected at each site with a Millipore Swinex® system filtered through a glass fiber filter (Whatman® GF/A) and preserved with sulfuric acid (pH<2). Three 250 µml aliquots will be injected into a Rosemount/Dohrmann DC-180 from each sample or until the standard deviation is < 10%.

Coarse Particulate Organic Matter (CPOM). Nearshore surface drift samples (0- 0.5 m deep) will be collected at each site for CPOM during each collection trip (n=3). Collections will be taken in triplicate between 1000 h and 1500 h at each site to establish the affects of discharge on drift. Collections will be made with a circular tow net (48 cm diameter opening with 500 µm mesh) held in place behind a moored pontoon raft or secured to the river bank. Samples will be sorted and processed live for biota as outlined for the phyto-benthic collections above. Current velocity will be measured with a Marsh-McBirney electronic flow meter and collection duration will be measured for volumetric calculations (mass/m3/s). Fine Particulate Organic Matter (FPOM drift will be collected at the same time and with the same general protocol as CPOM (n = 3). The net has a 30 cm diameter opening with 0.5 µm mesh. Samples will be preserved in 70% EtOH and sorted in the lab with a dissecting scope into the following categories: Copepoda

(Calanoida, Cyclopoida, Harpacticoida), Cladocera, Ostracoda, and miscellaneous zooplankton, which include small chironomids, Gammarus lacustris, planaria, hydra, etc. Large samples will be split with either 1 ml, 5 ml or 10 ml sub-samples sorted from a 100 ml dilution. Zooplankton densities of each category, general condition, reproductive status and presence of nauplii will be recorded. Samples will be processed for dry mass estimates and converted to ash-free dry mass using regression equations (Shannon et al. 1996). The remaining organic material will be filtered through a 1 mm sieve to remove CPOM and then filtered onto a glass fiber filter (Whatman® GF/A) with a Millipore Swinex® system. Filters will be dried at 60°C and combusted for 1 h at 500° C. Water volume collected will be calculated using a Marsh-McBireny electronic current meter and mass will be converted to mass/m3/s.

Collection Dates: Mid-September -late October.

Data Analysis: These estimates will be compared to past to data collected during 1991-2001 for differences between sites, within sites and collection dates using multivariate analysis including, MANOVA and community analysis with Non Dimensional Multi-Scaling and Principal Components Analysis. Predictor variables include all abiotic data while response variables will include biomass and density biotic categories.

Hypotheses to be tested/considered:

H_0 : Primary production as measured by algal biomass before and after low fall flows will not differ in the Glen Canyon reach

H_0 : Dissolved and particulate organic drift will not increase in the CRE

H_0 : NZMS density in the Glen Canyon reach will not change as a result of LFF.

Project 5. Near Shore Temperature and Habitat Use Monitoring During Low Steady Flows

The purpose of near shore temperature monitoring is to detect any near shore warming resulting from low steady flows. The approach will be to monitor the same sites as were monitored during the Low Summer Steady Flows of 2000, allowing for replication and thus a stronger correlation between steady flows and near shore warming. It will also enable the determination of seasonal effects, comparing 2000 summer measurements with 2002 fall measurements. The anticipated benefit will be to establish whether fall steady flows are potentially beneficial to native fish species by warming near shore habitat.

Methods will be similar to those used during the Low Summer Steady Flows of 2000; three separate thermistor strings will be extended perpendicular to a particular shore, with the thermistors measuring near surface temperatures at measured bottom depths. Air temperature will also be collected continuously at each site. Specific backwater sites near the LCR confluence will be monitored for fish use and abundance during alternating fall flow sequences to examine trends in use and abundance. These sites will also be measured with respect to habitat quality-depth, velocity, turbidity, etc.

***Hypotheses to be tested/considered*:**

H_0: There is no difference in near-shore habitat for steady 8,000 cfs releases and low fluctuations (6,500 to 9,000 cfs) in terms of temperatures, velocities, turbidity, and nutrients. (The strength of this hypothesis increases with concurrent collection of fish information.)

H_o: There is no difference between the alternative flow sequences of the fall flow period with respect to juvenile fish behavior.

H_o: There is no difference between the alternative flow sequences of the fall flow period for native and non-native fish abundance in near-shore areas.

II. SECONDARY SEDIMENT COMPONENTS *(Beach/Habitat-Building Flows)*

Project 1. Part C - Continuation of Mass Balance for Fine Sediment

Part C. - Continuation of intensive daily sediment-transport sampling along main channel and monitoring of tributary inputs. Sediment-transport monitoring sites include: Paria River near Lees Ferry, Paria River at Highway 89 bridge, Little Colorado River near Cameron, 30-Mile, 60-Mile, Grand Canyon near Phantom Ranch and Colorado River above the confluence with Diamond Creek. During the BHBF, the network of suspended-sediment measurements will be expanded to include data collection at the Lees Ferry cableway as well. During the high flow, several measurements per day will be made at each of the main channel stations using conventional sampling protocols, while alternative technologies, such as LISST (*Laser In-Situ Scattering and Tranmissometry*)shall be used to collect data once every 15-minutes to an hour. This work is contingent upon the BHBF test being implemented, and is proposed through modifications of existing agreements with USGS.

Null Hypotheses Relating to Mass Balance Part C
(Response of Fine-Sediment Supply in Marble Canyon to BHBF)

Treatment #1 and Treatment #2 are the same relative the BHBF of similar magnitude and duration released in January (41,000 to 45,000 cfs for 2.5 days)

Hypotheses to be tested/considered:

H_0 - With respect to its grain size and concentration, the sand supply within Marble Canyon is not significantly depleted during the BHBF.

H_0 - With respect to concentration, the silt/clay supply within Marble Canyon is not significantly depleted during the BHBF.

Project 6. Sediment-Transport Modeling Measurements (Wiele et al.)

Intensive, repeat measurements of selected channel elements at 1-2 sites within Marble Canyon. Work is proposed through modifications of existing agreements with USGS, Johns Hopkins University, USU and possibly -- GCMRC staff, as well as FIST team members. The resources required to accomplish the FIST pre- versus post-BHBF monitoring, plus the proposed timing of the BHBF, currently make implementation of this research element uncertain.
Note: This BHBF research element is contingent upon availability of personnel, equipment and funding resources, and requires additional planning and coordination between GCMRC and its physical-science cooperators.

Methods – Please refer to currently funded USGS work plan on file at the GCMRC.

Null Hypotheses Relating to Sediment Modeling
(Response of Sand-Bar Depositional Rates in Marble Canyon to BHBF)

Treatment #1 and Treatment #2 are the same relative the BHBF of similar magnitude and duration released in January (41, 000 to 45,000 cfs for 2.5 days)

Hypotheses to be tested/considered:

H_0 - Sand-Bar depositional rates within study eddies are invariant throughout the duration or the BHBF and do not verify model-simulations relative to suspended-sediment concentrations and grain-size conditions measured during the high flow.

H_0 - Evolution of fine-sediment supply with respect to concentration and grain size do not verify 1-Dimensional sand routing model simulations.

H_0 - Rapid sand-bar failures do not occur during the 2.5-day long BHBF.

Project 7. Coarse-Sediment Monitoring (Inputs, Impacts and Reworking)

Intensive monitoring of recently aggraded debris-fan deposits is proposed by the USGS just prior to, during and immediately following the January BHBF, at river mile 67 (Comanche Rapid) and 93 (Granite Falls Rapid). This work shall only occur if the BHBF is scheduled for implementation, and is proposed through modification of an existing agreement with the Water Resources Discipline of the USGS. The project requires some additional remote-sensing support for the study sites that can be completed as part of the FIST photogrammetry overflights.

Methods – Please refer to currently funded USGS work plan on file at the GCMRC.

Null Hypotheses Relating to Reworking on Newly Aggraded Debris Fans and Rapids
(Response of Recently Deposited Coarse Sediments at Comanche and Granite Falls Rapids)

Treatment #1 and Treatment #2 are the same relative the BHBF of similar magnitude and duration released in January (41,000 to 45,000 cfs for 2.5 days)

Hypotheses to be tested/considered:

H_0 - Coarse-grained sediments recently deposited on debris fans and within rapids are not significantly reworked during the rising limb of the BHBF, as previously measured during the 1996 flood experiment (41,000 cfs versus 45,000 cfs peak discharges).

H_0 - Boulders transported from newly aggraded debris fans at 41,000 cfs are not deposited within pools immediately below debris fans and constricted rapids.

H_0 - Fine gravel-sized sediment from newly aggraded debris fans at 41,000 cfs are not redistributed to downstream channel elements.

Project 8. Kanab Ambersnail Compliance Monitoring

Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. While the taxonomic ranking of this taxon is currently unresolved, it represents a taxon that is endemic to Vasey's Paradise. The snail and its habitat is a unique ecosystem determined to be of concern by stakeholders. The site is also a traditional cultural resource to all Native American stakeholders. The abundance and distribution of the snail and the quality of its habitat is influenced by operations of Glen Canyon Dam, as well as by springs located at Vasey's Paradise. Monitoring of quality, area and distribution occurs on a more detailed scale due to the limited nature of the habitat and surveys for animals are limited to snails. These surveys occur more than once per year. The relationships between operations from Glen Canyon Dam, habitat quality and its use by Kanab ambersnail at Vasey's Paradise are a management concern. Monitoring data on these ecosystem elements provide information on the effectiveness of the primary experimental flow treatment (Secretary's 1996 Record of Decision) relative to stated resource management objectives.

Monitoring of Kanab ambersnail densities, size classes and utilized habitat: (1) allows managers to assess the status of this endangered species; (2) provides data that allows identification and interpretation of linkages between physical and biological variables within the Colorado River ecosystem; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the population dynamics and habitat interactions of this species.

Kanab ambersnail is a federally listed endangered species occurring in one location in Grand Canyon: Vasey's Paradise. While the taxonomic ranking of this taxon is currently unresolved, it represents a taxon that is endemic to Vasey's Paradise. The snail and its habitat is a unique ecosystem determined to be of concern by stakeholders. The site is also a traditional cultural resource to all Native American stakeholders. Monitoring of habitatquality, area and distribution occurs on a more detailed scale due to the limited nature of the habitat and surveys for animals are limited to snails. These surveys occur more than once per year. The relationships between operations from Glen Canyon Dam, habitat quality and its use by Kanab ambersnail at Vasey's Paradise are a management concern. Monitoring data on these ecosystem elements provide information on the effectiveness of the primary experimental flow treatment (Secretary's 1996 Record of Decision) relative to stated resource management objectives.

Monitoring of Kanab ambersnail densities, size classes and utilized habitat: (1) allows managers to assess the status of this endangered species; (2) provides data that allows identification and interpretation of linkages between physical and biological variables within the Colorado River ecosystem; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the population dynamics and habitat interactions of this species.

Objectives: To determine the abundance of Kanab ambersnails that inhabit the Vasey's Paradise Springs vegetation and to determine how snail densities change relative to the BHBF flows and available habitat, as habitat is influenced by operations and discharge from the spring. Monitoring of Kanab ambersnail densities, size classes and utilized habitat: (1) allows managers to assess the status of this endangered species; (2) provides data that allows identification and interpretation of linkages between physical and biological variables within the Colorado River ecosystem; (3) provides data on the effect of periodic management of sediment through high flows under the Record of Decision on the population dynamics and habitat interactions of this species.

These data will be related to available habitat changes relative to BHBF operations of Glen Canyon Dam and life history requirement of the species of concern. Kanab ambersnail monitoring data will be collected using primarily field-based survey methods for snail densities and available habitat. Habitat will be measured when possible using remotely sensed methods to minimize impact to the site. Available habitat values are used for biological opinion consultation associated with special high releases (e.g., BHBF).

The work associated with before and after estimates of snail numbers and available habitat will also afford an opportunity to add additional knowledge to the program regarding overwinter mortality of KAS which is usually high based on routine monitoring. Specifically the project will allow quaintification of the number of KAS and available habitat up to 41,000 cfs or perhaps 45,000cfs in year 2. The project will also quantify available and lost habitat as well as conduct error test on selected habtat patches.

Hypotheses to be tested/considered:

H_o: KAS density in habitat below BHBF flows will not change as a result of the BHBF flows.

H_o: Available KAS habitat will not change as a result of BHBF flows

H_o: Pre-BHBF population estimates will not differ from estimates derived during routine monitoring in the fall.

Project 9. Food Base Impacts of BHBF Flows in Glen Canyon Reach

Continuation of Project 4 described above.

Hypothesis to be considered:

H_o: The phyto-benthic community will not change in response to the BHBF flows.

Assessment:

Algal and macroinvertebrate biomass (g/m2 AFDM) and density estimates will be determined at the five sites corresponding to the 2000 LSSF for comparison (Shannon et al. 2002). Riffles/cobble habitats will be assessed at each site. Sampling will be conducted along three transects, perpendicular to the shoreline, 30 m apart (n=6). Stage/discharge estimates from the GUI Model will be used to determine stage of collections, targeting < 5K cfs to reduce flow influence on cobble/riffle collections. Samples will be processed live within 48 h and sorted into five biotic categories: C. glomerata, Oscillatoria spp., detritus, miscellaneous algae and macrophytes, and macroinvertebrates which will also be numerated into Gammarus lacustris, chironomid larvae, simuliid larvae, and miscellaneous invertebrates. Distribution, density, size class and biomass of the New Zealand Mud Snail will be documented as a separate biotic category. Miscellaneous invertebrates will include lumbriculids, tubificids, physids, trichopterans, terrestrial insects and unidentifiable animals. Detritus is composed of both autochthonous (algal/bryophyte/macrophyte fragments) and allochthonous (tributary upland and riparian vegetation flotsum. Each biotic category will be oven-dried at 60°C and weighed to determine dry weight biomass. Samples will then be ashed (500°C for 1 h), and reweighed for ash-free dry mass estimates. Preservatives alter biomass estimates and accurate mass is required for building energetic models. Substratum type, microhabitat conditions, Secchi depth, water velocity, depth, date, site, and time of day will be recorded at each sample site. Depth integrated light intensity data loggers will be deployed at each of the five sites.

Collection Dates: Early March, Early June.

Data Analysis: These estimates will be compared past to past data collected during 1991-2001 for differences between sites, within sites and collection dates using multivariate analysis including, MANOVA and community analysis with Non Dimensional Multi-Scaling and Principal Components Analysis. Predictor variables include all abiotic data while response variables will include biomass and density biotic categories.

Project 10. Water Quality, Hydrology in Glen Canyon Forebay

Lake Powell surface elevations have declined during the past five years. Current projections forecast the reservoir surface elevation at 3633 ft AMSL by the end of Water Year 2002. This represents storage of 15.1 MAF, 58 % of reservoir capacity. The reservoir will continue to be drawn down a low point of 3615 ft AMSL, (13.2 MAF, 50 of capacity) by the end of March 2003. This level is slightly higher than that of 3612 ft reached on February 1993. These represent the lowest reservoir levels since the low level of 3591 ft of April 1973. Because of the reduced storage in the reservoir, the effects of the operation of alternate release structures during a BHBF will be more pronounced than those seen during the BHBF of 1996.

Projected low flows in Autumn 2002 are expected to result in less variation to reservoir and release water quality than under normal operations due to the reduction in daily fluctuations and total discharge for this period. However, the projected BHBF may cause significant changes to both the quality of the water in the forebay of Lake Powell and the quality of water released downstream.

The primary objective of this study is to determine the effects of a sharp increase in reservoir releases, from combined penstock and river outlet works structures, on reservoir release water quality, reservoir stratification, and the fate of winter inflow currents. A secondary objective is to determine the vertical and upstream extent of the withdrawal plume with acoustic Doppler velocity measurements.

Hypotheses to be tested/considered:

H_0: The water quality (temperature, nutrients, and biological components) of reservoir releases during the BHBF will not differ significantly from normal operational patterns.

H_0: Current reservoir volumes do not have an effect on the upstream or vertical extent of the withdrawal plume in the reservoir compared to that seen in 1996.

H_0: The BHBF will not have an effect on the routing of inflow currents compared to other winter periods.

H_0: The withdrawal plume can be adequately predicted by the CE-QUAL-W2 reservoir model in its current configuration.

Project 11. Water Quality Monitoring of Jet Tubes

When releases exceed power-plant capacity, use of the river outlet works (or jet tubes) is required. These structures are located 30 meters below the elevation of the penstocks, and hence, pull from significantly deeper, colder, less oxygenated, more saline and nutrient-rich water of the reservoir. During the 1996 experimental flow, the releases from the jet tubes were not directly measured and therefore the exact quality of this water could not be easily tracked, predicted or evaluated for impact to downstream water quality, though its signature was detectable and pronounced.

Hypotheses to be tested/considered:

H_0: The water quality (temperature, nutrients, and biological components) of jet tube releases during the BHBF will not differ significantly from penstock release water quality.

Project 12. Mixing Zone and Monitoring of Downstream Water Quality

When the jet tubes are used, their discharge shoots downstream and over the power-plant effluent. The monitor located in the river beneath the jet tube ports can only reliably measure an unknown mix of effluents dominated by the power-plant during jet tube operation. Any in-stream measurements must be located downstream below the zone of mixing to reflect total discharge during this time. Mixing of these waters has not been tracked, but probably does not occur for a kilometer or more downstream. It is important to be able to identify initial water quality conditions from the dam. This can be calculated from known discharge from ports in combination with data from the continuous monitors within the dam (assuming a jet tube monitor described above is in place). However, it is important to understand the length of the zone of mixing to determine when a consistent and fully mixed water quality is available to the downstream food-base community.

III. POST-BHBF COMPONENTS *(January through April fluctuating flows)*

This aspect of the treatment is intended primarily to disadvantage non-native salmonids in the CRE, both above and below the Paria River. In the Lees Ferry reach there exists an overabundance of rainbow trout (see trout discussion paper, Appendix 1), thus reducing the population numbers through decreased recruitment should result in improved growth and condition of remaining trout. Downstream of Lees Ferry trout represent an unwanted non-native competitor and potential predator in consistent with AMP management goals. Reducing non-natives is thought to be desirable to improve the biological environment of the critical habitat for humpback chub.

However, this aspect of the treatment scenario for WY 2003 and 2004 also has potential to yield information relative to the rate of sediment loss and beach erosion compared to post 1996 BHBF conditions and ROD operations over the past 5-7 years.

Much of the potential impact of fluctuating flows on salmonid recruitment and abundance will be obtained through routine on-going monitoring, which includes four regularly scheduled electrofishing efforts each year in the Lees Ferry reach where CPUE, length frequency, recruitment of YOY fish, condition factor, and spawning condition are all measured or estimated. The AGFD and GCMRC have over 12 years of data against which to compare results following implementation of fluctuating flows. Examples of this kind of data can be found in the attached trout discussion paper.

Downstream monitoring includes two regularly scheduled electrofishing trips which also provide similar (although less comprehensive sampling coverage) data for salmonids and other non-native fishes. Comparison of sampling locations within and outside of the mechanical removal reach around the LCR should enable detection of differences due to effects of mechanical removal versus fluctuating flows.

Hypotheses to be tested/considered include:

Lees Ferry

H_0: Recruitment of YOY rainbow trout in the Lees Ferry reach is not different than during MLFF years

H_0: Growth and condition of rainbow trout in the Lees Ferry reach is not different than during MLFF years

H_0: CPUE of all size classes of rainbow trout in the Lees Ferry reach is not different than MLFF years.

Downstream

H_0: Recruitment of YOY RBT and BNT is not different than during previous two MLFF years

H_0: CPUE for RBT and BNT of all size classes is not different from preceding two MLFF years

H_0: CPUE for RBT and BNT of all size classes is not different in areas subject to mechanical removal of salmonids

Project 13. Monitoring of Rainbow Trout Adult Stranding and Mortality

A significant concern to the angling and guiding community who utilize the Lees Ferry fishery is the notion that the January–March fluctuating flows may impose substantial mortality on the spawning (adult) portion of the RBT population in the Lees Ferry reach. During the 1990-1991 research flows, the Arizona Game and Fish Department documented so called stranding pools in the Lees Ferry reach. These pools were locations that tended to capture adult rainbow trout following flow reductions and impose varying degrees of mortality due to reduced water quality and dewatering. The January-March fluctuating flows **could** be designed to minimize stranding, as the purpose of the fluctuating flows is to impact recruitment for the 2003 and 2004 year class of RBT rather than adult abundance. Precise upramp and downramp rates as well as the degree of daily fluctuation remain unresolved at this writing. However, it is likely that some stranding will still occur and the locations of known stranding pools will be periodically monitored to evaluate mortality due to stranding. We will estimate the daily number of adult fish stranded in known stranding pool locations in the Lees Ferry reach and the mortality rate of fish in known stranding pools in the Lees Ferry reach. If fluctuations are to be done every day of the week, surveys will need to be conducted during nighttime hours. If fluctuations are limited to Monday-Saturday, surveys can be conducted during daylight hours on Sundays.

Hypotheses to be tested/considered:

H_0: No difference in the abundance of stranded adult rainbow trout in selected areas of the Lees Ferry reach will occur between the low fall flows (Nov-Dec) and fluctuating flows from Jan-March.

Project 14. Distribution of spawning redds for rainbow trout in the Lees Ferry reach (contractor to be determined)

This project would map, using snorkeling and/or SCUBA observations, the elevational and longitudinal distribution of spawning redds in the Lees Ferry reach using transect corresponding to the snorkeling surveys conducted during routine monitoring. Transect would be mapped once per month from November through May. Observations of redd location would be related to flow regime to see whether fluctuating flows induced spawning at higher elevations (>cfs flow rates). Additional transects in selected reaches below the Paria will be mapped in an effort to determine whether sediment inputs and deposition/retention in the channel affects the distribution or abundance of salmonid spawning redds.

Hypothesis to be considered:

H_0: Location of spawning redds does not change in relation to season or dam releases.

H_0: Distribution and abundance of spawning redds is unaffected by the presence of fine sediment on the channel bottom.

Project 15. Determination of the mechanism accounting for reduced recruitment during fluctuating flows in the Lees Ferry reach. (contractor to be determined)

This project would attempt to gather information pertaining to the causal mechanism for reduced recruitment (if any) of rainbow trout in the Lees Ferry reach during periods of fluctuating flows from Jan-March. A series of replicated enclosure experiments containing various numbers and densities and combinations of adult and YOY/juvenile RBT would be established at selected locations. Enclosures would be preceded upstream by debris fences. Enclosures would be placed perpendicular to shore and extend from elevations corresponding to flow rates of 25,000 cfs to < 5,000 cfs. Enclosures would be stocked with captured wild rainbow trout using electrofishing and monitored during the period November to May. Visual estimates of changes in abundance of stocked fish would be used to infer possible mechanisms accounting for changes in density of different size classes of fish. Changes would be related to observed distributions in collections associated with routine monitoring.

Hypotheses to be tested/considered:

H_0: No difference in abundance of YOY RBT results from presence or absence of adult RBT.

H_0: No seasonal difference exists between survival of YOY RBT

H_0: No difference in survival of YOY RBT occurs between fish with access to fluctuating flow regime versus fish restricted below 5-8,000cfs.

Project 16. Food Base Impacts of Fluctuating Flows

Algal and macroinvertebrate biomass (g/m2 AFDM) and density estimates will be determined at the sites corresponding to the 2000 LSSF for comparison. Riffles/cobble habitats will be assessed at each site.

Sampling will be conducted along three transects, perpendicular to the shoreline, 30 m apart (n=6). Stage/discharge estimates from the GUI Model will be used to determine stage of collections, targeting < 5K cfs to reduce flow influence on cobble/riffle collections Samples will be processed live within 48 h and sorted into five biotic categories: C. glomerata, Oscillatoria spp., detritus, miscellaneous algae and macrophytes, and macroinvertebrates which will also be numerated into Gammarus lacustris, chironomid larvae, simuliid larvae, and miscellaneous invertebrates. Distribution, density, size class and biomass of the New Zealand Mud Snail will be documented as a separate biotic category. Miscellaneous invertebrates will include lumbriculids, tubificids, physids, trichopterans, terrestrial insects and unidentifiable animals. Detritus is composed of both autochthonous (algal/bryophyte/macrophyte fragments) and allochthonous (tributary upland and riparian vegetation flotsum. Each biotic category will be oven-dried at 60°C and weighed to determine dry weight biomass. Samples will then be ashed (500°C for 1 h), and reweighed for ash-free dry mass estimates.

Preservatives alter biomass estimates and accurate mass is required for building energetic models. Substratum type, microhabitat conditions, Secchi depth, water velocity, depth, date, site, and time of day will be recorded at each sample site. Depth integrated light intensity data loggers will be deployed at each of the five sites.

Collection Dates: Early March, Early June.

Data Analysis: These estimates will be compared past to past data collected during 1991-2001 for differences between sites, within sites and collection dates using multivariate analysis including, MANOVA and community analysis with Non Dimensional Multi-Scaling and Principal Components Analysis. Predictor variables include all abiotic data while response variables will include biomass and density biotic categories.

Hypothesis to be tested/considered:

H_0: The phyto-benthic community will not change in response to the BHBF flows.

Project 1. Part D - Ongoing Mass Balance of Sediment Transport (Post-BHBF)

Part D. - Continued daily sediment-transport sampling at the four primary main channel stations (30-Mile, 60-Mile, 87-Mile and 226-Mile), as well as flood-event monitoring of tributary inputs at existing stations on the Paria and Little Colorado Rivers. Conventional and alternative methods for sampling suspended-sediment transport shall be used during this period and into summer 2003, following termination of the fluctuating–flow treatment. This work is beyond the normal scope of annual monitoring and is proposed through modifications of existing agreements with the USGS.

Null Hypotheses Relating to Mass Balance Part D
(Post-BHBF Suspended-Sediment Transport Rates)

Treatment #1 and Treatment #2 are the same relative the BHBF of similar magnitude and duration released in January (41, 000 for 2-3 days)

Hypotheses to be tested/considered:

H_0 - With respect to concentration, the sand-transport rates **are not** decreased following the BHBF.

H_0 - With respect to concentration, the silt/clay-transport rates **are not** decreased following the BHBF.

Project 2. Part C - FIST
(Post-BHBF sampling to measure and estimate bar shape, grain-size distributions and volumes within integrated monitoring reaches, as well as at selected sites where cultural resource preservation within sand deposits is of critical concern.)

Part C. – January and March 2003 - Field measurements shall be collected within a subset of 5 FIST reaches during January and March 2003, contingent upon whether or not the BHBF test is implemented. Studies of aeolian transport of sand shall also occur on a March 2003, river trip, if the BHBF is implemented, so as to better document the fate of wind-reworked sand bars in the proximity of recently eroded cultural sites. Additional fieldwork related to the fate of sand bars in the vicinity of cultural resources shall be undertaken within Part D of the FIST (see below).

Aerial Photography - shall be flown in January 2002.

Daily Oblique Photography - of FIST long-term sandbars shall continue regardless of whether the BHBF test is implemented. These daily photographic data will be collected as a means of documenting bar conditions prior to implementation of the January to April fluctuating-flow treatment.

Null Hypotheses Relating to FIST Part C

Treatment #1 and Treatment #2 are Assumed to have the Same Magnitude and Duration of BHBF and Similar Antecedent Fine-Sediment Supply Conditions
(Response of Sand-Storage Conditions within Marble Canyon in Response to BHBF)

Hypotheses to be tested/considered:

H_0 - Fine-Sediment storage above 8,000 cfs within Marble Canyon is not increased compared with conditions measured following the 1996 flood experiment.

H_0 - Fine-Sediment storage below 8,000 cfs is not decreased compared with conditions measured following the 1996 flood experiment.

H_0 - Fine-Sediment deposits above 8,000 cfs in Marble Canyon do not have finer grain-size distributions (with respect to sand-sizes) when compared with sand bars deposited by the 1996 controlled flood experiment.

H_0 - Fine-Sediment deposits above 8,000 cfs in Marble Canyon do not have higher contents of silt/clay when compared with sand bars deposited by the 1996 controlled flood experiment.

H_0 - Fine-Sediment storage between 8,000 and 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 controlled flood experiment and one summer of ROD fluctuations.

H_0 - Fine-Sediment storage above 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 ontrolled flood experiment and one summer of ROD fluctuations.

H_0 - Fine-Sediment grain size of channel-bed material below 8,000 cfs **is not** coarser than conditions measured in January, immediately following the BHBF test.

H_0 - Fine-Sediment grain size of sand bar deposits above 8,000 cfs is not coarser than conditions measured in January, immediately following the BHBF test.

H_0 - Total fine-sediment storage within Marble Canyon study sites is not less than conditions measured immediately following the BHBF test.

H_0- Total fine-sediment storage above 25,000 cfs stage elevation within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test.

H_0 - Total fine-sediment storage within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test.

H_0- Fine-sediment deposits created by the experimental BHBF do not possess cohesive properties similar to pre-dam deposits.

H_0 - Fine-sediment deposits created by the experimental BHBF do not possess cohesive properties similar to prior post-dam deposits.

H_0 - Fine-sediment deposits created by the experimental BHBF are not significantly reworked by wind.

H_0 - Fine-sediment deposited by the experimental BHBF are not transported by aeolian processes to areas where recent gully erosion has exposed cultural sites.

All of the Part C, work proposed above shall be accomplished through modifications of existing agreements with USGS, NAU, USU.

IV. <u>NON-FLOW TREATMENT</u> *(Mechanical Removal of Salmonids)*

Project 17. Mechanical Removal of Non-Native Fishes (Primarily Salmonids) from the Colorado River Near the Confluence with the Little Colorado River

While it is difficult to determine which factor is most responsible for the HBC recruitment decline documented in recent years, 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. This project is the initiation of a multi-objective study 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.

The LCR Inflow reach is recognized for having the highest abundance of adult and juvenile HBC in the Colorado River mainstem. We have selected a sampling reach (56.2 RM - 65.7 RM) that encloses the majority of this population. (See map, Appendix 2.) The proposed sampling effort will be uniformly distributed within this reach. The upstream and downstream endpoints are bounded by hydraulic and geomorphic control; however, it is not impermeable to system-wide fish movement. For this reason, we are proposing to conduct a depletion effort that is both spatially discrete, and repeated seasonally over a period of 4 years. We are proposing to conduct annually, three depletion trips in January-March and three depletion trips in July-September. The sampling efforts are scheduled to precede the major periods of LCR flooding events (spring runoff and monsoonal storms) that are correlated with juvenile HBC immigration to the mainstem

Colorado River. Due to the logistical obstacles associated with beginning this program, only 1 trip will be conducted during 2002 (September). All captured species and individuals not native to the CRE will be removed and destroyed during the mechanical removal sampling process.

Hypotheses to be tested/considered:

H_o: Mechanical removal of RBT and BNT using electrofishing methods is an effective method of reducing adult RBT and BNT abundance in the LCR Inflow reach.

H_o: Abundance of adult RBT and BNT in the LCR Inflow reach prior to each removal event is similar.

H_o: No changes occur in adult RBT and BNT size composition in response to removal events.

H_o: Trout immigration (Seasonal and Annual) into the LCR Inflow reach between removal events is undetectable.

Methods

A series of five, single-pass depletion efforts will be conducted in fishable habitat using four electrofishing boats that concurrently sample the river on opposing sides. Two boats will sample upstream of the LCR confluence and two downstream. Sampling equipment, methods and electrical configuration used will be consistent with the established GCMRC fish handling and sampling protocols. The sampling time required to complete each single depletion pass has been estimated at 2 days, with an initial estimated catch of approximately 1500 fish for the first depletion pass. Using a depletion method, the catch-rates of single depletions passes are regressed against the cumulative catch for the trip to determine an initial population estimate. This depletion effort 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 designated 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 and trip catchability coefficients (Q) are to be analyzed in order to evaluate if mechanical removal methods are an effective means to control for undesirable fish species. Additionally, electrofishing catch-rate will be used to measure juvenile HBC relative abundance.

Hoop-net sampling: In conjunction with trout depletion efforts, an estimate of juvenile HBC relative abundance (CPUE) will be determined using a combination of gear types (electrofishing and hoop-nets). Owing to the established NPS non-motor season (16 September to 15 December; NPS 2001) additional electrofishing sampling is unrealistic. For this reason, a total of 30 hoop-nets (24"x 36") will be fished for a 4-day period at pre-established transects that are presently used as part of the long-term monitoring program, and checked at 24-hr intervals (Gorman and Coggins 2000). In addition to this annual netting effort (mid-September and January depletion trips), USFWS has proposed

(VanHaverbeke 2002) to resample these same transects using hoop-nets on an annual basis during November. This supplemental netting effort will provide an additional CPUE datum to determine relative abundance of this vulnerable size-class during a period of motor use restrictions and will comply with NPS regulations. Following Valdez and Ryel (1995), these CPUE data will be used to construct survival/retention rates of juvenile HBC in the LCR Inflow reach.

Data Analysis

During the course of this study, long term monitoring activities will continue to track the recruitment of HBC into the LCR population. Specifically, program SUPERTAG will be updated annually to produce continuing estimates of annual recruitment and abundance. Long term monitoring data will also be used to estimate: instantaneous abundance of HBC >150 mm total length residing in the LCR during the spring spawning season; abundance of age-1 fish (recruitment) residing in the LCR during the fall; and survival/retention rate of juvenile HBC within the LCR Inflow reach. With these data sets in hand, we will eventually be able to examine the relationship between adult RBT and BNT abundance in the LCR Inflow reach and survival/retention rates of juvenile HBC in the LCR Inflow reach. We will also have the ability to examine the relationship between adult RBT and BNT abundance in the LCR Inflow reach and concurrent brood year specific recruitment to the LCR HBC population.

Project 18. Water Quality Impacts of Trout Removal.

The effects of releasing up to several tons of trout refuse may place a significant biological oxygen demand on the receiving waters of the Colorado River. This could produce a profusion of bacteriological activity with unknown environmental consequences. To assess possible effects to water quality, general equations could be applied, or in-stream BOD experiments could be performed for greater accuracy. While the aerated conditions dominate in the riverine environment with abundant rapids as in Grand Canyon, there is little or no data available on the bacterial composition or concentrations in the canyon. A precise disposal method or location has yet to be identified for non-native fish carcasses.

Hypothesis to be tested/considered

H_o: Water quality does not differ in regard to proximity to non-native fish carcass disposal areas

Project 19. Rainbow Trout Diet Analysis at the LCR Confluence and in Glen Canyon Reach

Predation by non-native fishes is considered to be one of the most likely hypotheses explaining HBC recruitment trend. In the last eight years, trout have responded positively at a system-wide scale to modifications in flow operations at Glen Canyon dam. Trout abundance levels have had a 2.5 to 8 fold increase system-wide. Additionally, the phytobenthic community has corresponded similarly to these flow modifications.

We have proposed a multi-year study to evaluate the potential effect of rainbow trout (RBT) and brown trout (BNT) predation on HBC recruitment. Concerns exist regarding how rainbow trout (RBT) will respond to a set of prescribed manipulations consisting of experimental flows (system-wide effect) and mechanical removal (localized effect) during a multi-year experiment. Proposed high flow fluctuations scheduled between January-March and are timed to disadvantage RBT spawning activities as well as destabilize near shoreline habitat for emergent fry. The underlying purpose of these flows is intended to target recruitment mechanisms for this non-native species. These fluctuating flows may influence the phytobenthic community by changing the standing biomass, community composition, production (primary and secondary), and drift characteristics

A popular RBT fishery located in a 25-km tail-water section of Glen Canyon has responded to modified operations at Glen Canyon. Although, this local population demonstrates high abundance, recent trends have indicated shifts in reduced angling catch rates and reduced condition that are perhaps in response to population dynamics and carrying capacity constraints in the system. Concerns have arisen regarding issues of trout response (i.e., habitat partitioning, cannibalism, dispersal) to changes in food base composition and availability owing to changes in flow operations. The primary questions of this project are: 1) Are there spatial (upstream versus downstream) and seasonal (winter versus summer) differences in trout diet? 2) Does trout diet vary in response to changes in seasonal flow patterns at Glen Canyon Dam? 3) Does trout diet vary in response to changes in trout abundance? The scope of work specific to the trout diet analysis will require an integrated approach by combining activities with other studies collecting information. The objectives listed below are specific to addressing the dietary use patterns of RBT. Other species are unlikely to occur in large numbers in electro-fishing samples (exception may be carp). However all species collected will be sampled for diet analysis in relation to their prevalence in samples.

Hypotheses to be tested/considered:

H_0: There are no seasonal differences in trout diet use.

H_0: There are no spatial (upstream versus downstream) differences in trout diet use.

H_0: There are no size-class differences in trout diet use.

H_0: Determine if differences in feeding patterns are related to flow characteristics.

Sampling Method: The scheduling of data collection activities for assessing differences in dietary use patterns is to be coordinated with ongoing monitoring and research efforts. These include quarterly sampling in the Lees Ferry/Glen Canyon Section, and biannual sampling in the Little Colorado River reach, and downstream regions of Grand Canyon. Electrofishing will be the primary mode of capture.

Dietary Analysis: Gut contents are to be analyzed from a set of sub-samples that are randomly selected and stratified by fish size. The dietary analysis is to quantify ingested phytobenthic and macroinvertebrates using a combination of analytical methods (volumetric, weight, and numeric counts) taxonomically identified. 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 **all trout** collected from the LCR inflow, are to be assessed for the presence or absence of fish in the gut. Dietary analysis is problematic, owing to differential rates of digestion and the difficulties associated with recognizing and identifying accurately specific items from partially digested material. To evaluate for fish presence/absence and distinguishing taxonomic characteristics of macroinvertebrates a series of voucher specimens will be developed from previously assessed samples, as well as accumulating from the gross field assessment a comparative library of anatomical characters and traits. 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.

Project 20. Incidence of Predation on Humpback Chub by Rainbow and Brown Trout at the Confluence of the Little Colorado River, Grand Canyon

Predation by non-native fishes is considered to be one of the most likely hypotheses explaining HBC recruitment trend. Additionally, it is one of the more testable hypotheses. There are two hydrological time periods (Spring and Summer monsoons) that increase the frequency of YOY fish dispersed into the LCR. Displaced YOY originate from different brood years owing to the timing of the hydrological displacement periods. Therefore, size and abundance of this potential prey will vary because of differences in life history schedule. The variation in abundance and size should influence prey vulnerability levels. The primary questions of this scope of work are: 1) Do trout prey on HBC? 2) If predation occurs, does the incidence of predation change (±) in response to changes in predator or prey abundance?

We are proposing to conduct annually, three depletion trips in January-March and three depletion trips in June-September. The sampling efforts are scheduled to coincide with seasonal HBC-YOY dispersal from the LCR to the Colorado River Mainstem (August-September), followed again by early winter sampling. The scope of work specific to the stomach analysis will be an integrated effort with other studies collecting information on sampling efficacy, trout and HBC abundance, immigration rates, and diet analysis. The objectives listed below are specific to addressing the incidence of predation.

<u>Hypotheses to be tested/considered:</u>

H_o: There is no incidence of predation by RBT and BNT on HBC in the LCR reach.

H_o: Incidence of predation is unrelated to size-class and other meristic characteristics (e.g., gape-width, body-depth, length) of both the predator and prey.

H_o: The incidence of predation by RBT and BNT does not changes(±) in response to predator abundance.

H_o: Particular cohorts are more vulnerable to predation due to differences in size, relative prey abundance or relative predator abundance.

Design and Analysis: Owing to the passive dispersal of young-of-year HBC the availability of this prey to trout is disproportionately distributed in the downstream reach. For comparative purposes the trout population ($\mu_1 = \mu_2$) in the upper extent will serve as the spatio/temporal control. Comparisons in the incidence of predation will be made between the two separate trout populations to compare predation response relative to differences in prey availability. Comparisons between years will provide an understanding of how incidence of predation changes as a function of changes in trout abundance owing to multiple years of depletion (μ_{2a} μ_{2b} . μ_{2c} μ_{2d}). 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.

The stomachs are scheduled to be collected annually during the March and September trips when there is a high likelihood that HBC have been dispersed into the Colorado River mainstem. For all captured trout, stomach samples will be collected and analyzed for the presence or absence of fish or fish remains. Special dye markers will be used with preservatives to discriminate for bones and cartilage contained in the gut contents. Where possible, bones will be used for reconstructing and identifying prey taxa. Samples are to be assessed in the laboratory and not the field location.

Project 1. Part E - Ongoing Sediment Mass Balance (Fluctuating Flow Treatment)

Part E. – Continuation of intensive suspended-sediment measurements during fluctuating flows treatment and afterwards through June 2003. This component of intensive daily monitoring would conclude the sediment portion of Treatment #1, and would immediately precede implementation of Treatment #2.

Null Hypotheses Relating to Mass Balance Part E
(Post-BHBF Suspended-Sediment Transport Rates under Non-ROD Fluctuating-Flows)

Treatment #1 and Treatment #2 are the same relative the fluctuating-flow treatment

Hypotheses to be tested/considered:

H_0 - With respect to concentration, the sand-transport rates are not increased during Non-ROD fluctuations relative to ROD operations following the 1996 BHBF.

H_0 - With respect to concentration, the silt/clay-transport rates are not increased during Non-ROD fluctuations relative to ROD operations following the 1996 BHBF.

Project 2. Part D - FIST
(Post-Fluctuating Flows, sampling to measure and estimate bar shape, grain-size distributions and volumes)

Part D. - May 2003 - Field measurements shall be collected within a subset of all 11 FIST reaches during May 2003, contingent upon whether or not the BHBF test is implemented.

Aerial Photography - shall be flown in May 2003 (this system-wide photography is part of core monitoring and is included in the FY03 work plan). Additional aerial photography and related photogrammetry shall also be flown within each of the 11 FIST reaches. This additional component of the May 2003 over-flight is not part of the FY 2003 annual remote-sensing protocol, and would not be flown until May 2004 under normal FIST monitoring.

Daily Oblique Photography - of FIST long-term sandbars shall continue regardless of whether the BHBF test is implemented. These daily photographic data will be continued as a means of documenting bar conditions following implementation of the January to April fluctuating-flow treatment.

All of the Part D, work proposed above shall be accomplished through modifications of existing agreements with USGS, NAU, USU. Following, are tentative FIST trip schedules required to support Treatments #1 and #2.

Null Hypotheses Relating to FIST Part D

Treatment #1 and Treatment #2 are Assumed to have the Same Magnitude and Duration of BHBF and Similar Antecendent Fine-Sediment Supply Conditions
(Response of Sand-Storage Conditions within Marble Canyon in Response to Non-ROD Fluctuating Flows during winter/spring)

Hypotheses to be tested/considered:

H_0 - Fine-Sediment storage between 8,000 and 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 controlled flood experiment and one summer of ROD fluctuations.

H_0 - Fine-Sediment storage above 25,000 cfs within Marble Canyon is not decreased below conditions measured in September 1996, following the 1996 ontrolled flood experiment and one summer of ROD fluctuations.

H_0 - Fine-Sediment grain size of channel-bed material below 8,000 cfs is not coarser than conditions measured in January, immediately following the BHBF test.

H_0 - Fine-Sediment grain size of sand bar deposits above 8,000 cfs is not coarser than conditions measured in January, immediately following the BHBF test.

H_0 - Total fine-sediment storage within Marble Canyon study sites is not less than conditions measured immediately following the BHBF test

H_0 - Total fine-sediment storage above 25,000 cfs stage elevation within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test.

H_0 - Total fine-sediment storage within Upper Marble Canyon study sites is not greater than conditions measured immediately prior to the BHBF test.

H_0 - Down-ramping rates of 2,500 cfs per hour do not result in increased seepage erosion rates in newly created sand bars when compared with down-ramping rates of 1,500 cfs per hour.

Socio-Cultural Studies

A) Archaeological Studies:

Project 21. Monitoring for Effects of the Test Flows at Archaeological Sites

These monitoring efforts are currently on-going by the NPS under a cultural resource program administered by Reclamation to record change at archaeological sites. These activities will encompass assessments of the test flow affects on archaeological sites during scheduled monitoring trips. Regular monitoring trips will be scheduled to allow assessments of site conditions prior to and after the proposed high flow and after the fluctuating flows. Trip schedules to be determined by the NPS and Reclamation.

Hypotheses to be tested/considered:

H_0: There are no significant changes in the condition of the archaeological sites as a result of the high flows.

H_0: There are no significant changes in the condition of the archaeological sites as a result of the fluctuating flows.

Project 22. Monitoring of Sediment Deposition in Arroyos

This project will monitor the deposition of high flow (BHBF) sediments in arroyos mouths at or near archaeological sites. Sediment deposition in arroyos has the potential to reduce gully erosion through archaeological sites. Locations will be selected from FIST reaches where a comprehensive study has been proposed to record deposition of sediment at sand bars and recreational camping beaches. As feasible, selection criteria will include geomorphic data obtained in earlier work that studied erosion/deposition and geomorphic settings. Study locations will be monitored for the amount and type of sediment deposited (e.g., grain size), and the retention of sediments deposited from the high flows and the possible loss of sediments from erosion. To the extent possible, study sites will be tied to arroyo locations studied in 1996 under that experimental flow. Study location data will be collected prior to and following the high flows and following the fluctuating flows to determine the retention of the arroyo deposits. Where feasible, monitoring data will be integrated with the proposed aeolian sediment transport study described below.

Hypotheses to be tested/considered:

H_0: There are no significant changes in sediment deposition or erosion at the study arroyo sites as a result of the high flows.

H_0: There are no significant changes in sediment deposition or erosion at the study arroyo sites as a result of the fluctuating flows.

Project 23. Monitoring of Aeolian Sediment Transport at Archaeological sites.

This project will assess, quantify, and monitor aeolian sediments that are derived from BHBF deposits in selected archaeological locations. The study will investigate transport characteristics of the sediments, including their condition and the rates of change. Monitoring will occur prior to and after the proposed BHBF and following the fluctuating flows. Stage elevation of study locations relative to aeolian transport and the depositional source (e.g. aeolian or fluvial) of sediments will be studied. This project will coordinate with Project 22 (described above) to investigate aeolian deposits in arroyos at or near archaeological sites, as these are locations where aeolian and fluvial deposits are likely to occur. Study personnel will include geologists and geoarchaeologists.

Hypotheses to be tested/considered:

H_0: There are no significant changes in aeolian sediment deposition at the study sites as a result of the high flows.

H_0: There are no significant changes in aeolian deposition at the study sites following the fluctuating flows.

B) Tribal Resource Studies

Project 24. Monitoring of Traditional Tribal Resources.

Tribal stakeholders are currently monitoring traditional resources under a cultural resource program administered by Reclamation. Their monitoring activities will be expanded under the proposed experimental flow project. These activities will monitor and assess traditional tribal resources relative to the proposed experiment. Monitoring and assessment specifics will be developed by each tribe within the framework of the experiment. Tribal monitoring will be conducted prior to and after the proposed BHBF and following the fluctuating flows. Tribal groups will assess and report on the effects of the test flow on their traditional resources.

Hypotheses to be tested/considered:

H_0: There are no significant changes in the condition of tribal traditional resources as a result of the high flows.

H_0: There are no significant changes in the condition of tribal traditional resources as a result of the fluctuating flows.

C) Economic Studies

Project 25. Economic Impacts to Whitewater and Angler Concessionaires and Private Boaters and Anglers.

The proposed hydrograph may have economic impacts to recreationalists. The high flow periods may affect fishing opportunities in the Lees Ferry reach, and other recreationalists and create economic impacts to fishermen, river runners, and guides. This study will investigate the affects of the experiment on these groups relative to the proposed high flow and the subsequent fluctuation flows.

Using existing records supplemented with direct interview, compare and contrast the number of guided fishing trips during the proposed project with comparable previous periods to study the economic impacts to angling within the area of the Dam to Lees Ferry and below in the Colorado River. Possible sources of impact due to flows include changes in the frequency of guided trips, numbers of fishermen, and possible motor and equipment damage due to flows. Using this information, develop estimates of the economic impacts to commercial fishing guides and the local community.

Impacts to whitewater boating within the Lees Ferry reach (day use boating) and downstream (multi-day) will be studied to determine the economic impacts to these groups. Areas of possible economic impacts include adjusted boating schedules due to the proposed flows and incidences of motor, equipment and raft damage due to flows. In addition, economic impacts to rafting operations launching at Diamond Creek (on the Hualapai Reservation at River Mile 226) may be affected. Where possible and feasible, similar data may be obtained through direct interview. Using available data and direct interviews estimate economic impacts to these groups.

Hypotheses to be tested/considered:

H_0: Economic impacts to whitewater and angling concessionaires will not differ significantly from economic impacts under normal daily operations.
H_0: Economic impacts to private whitewater boaters and anglers will not differ significantly from economic impacts under normal daily operations.

Project 26. Economic Impacts to Power Customers

This project will investigate the economic impacts of the experimental flow project to power marketers and customers. The project will be conducted by

WAPA and project methodology will be comparable to the economic impacts study conducted for the LSSF project.

Hypotheses to be tested/considered:

H_0: Economic impacts to power customers will not differ significantly from economic impacts under normal daily operations.

D) Recreational Use Studies

Project 27. Changes in Campable Beach Areas.

The availability of camping beaches is of concern to recreationalists within the Grand Canyon. This study proposes to use aerial data collected during pre-experiment and post experiment to determine the change in camping beach area at selected beaches. Specific study areas will include: 1) sediment deposition relative to camping beaches during each stage of the experiment; 2) sediment deposition at camping beaches in critical reaches; 3) sediment retention at camping beaches; and 4) differences in sediment retention at camping beaches, based on grain size. Following these experimental flows, these data will be analyzed and evaluated against campable areas known to exist under normal (ROD) operations. The on-going efforts of the Adopt-A-Beach project of the Grand Canyon River Guides will be coordinated with this effort to monitor the affects of the experiment on the camping beaches.

Hypotheses to be tested/considered:

H_0: Campable beach areas during the proposed experiment will not differ significantly from campable beach areas under normal daily operations.

Project 28. Recreational Safety Study

The purpose of this study is to determine the risks and potential impacts to whitewater boaters and anglers during the experimental project compared to normal daily flows. Study questions include impacts due to rapid changes in flows and ramping rates on and in the river and at camping beaches as well as possible impacts due to high flow releases.

Hypotheses to be tested/considered:

H_0: Whitewater and angler safety during the high flows and fluctuating flows will not significantly differ from safety during normal daily flows.

Relationship of Proposed Projects to Existing Monitoring Programs

Core monitoring efforts conducted by GCMRC have become increasingly robust over recent years for some resources. These monitoring efforts will provide much of the data necessary to evaluate effects of the experimental treatment flows and mechanical removal activities. For example, although the principal fisheries treatment is to reduce non-native salmonids in the LCR reach of the CRE, the anticipated consequence of this treatment is an increase in recruitment rate of HBC as non-natives are reduced.

Hypothesis to be considered

H_0: Humpback chub in the LCR population will show no change in recruitment as non-native fish abundance declines

Data will be gathered to test this hypothesis through the routine monitoring programs in place. Tables illustrating the kind and timing of information from fisheries sampling that will be available to the AMP program from core monitoring are provided in Appendix 3. Similar tables may be developed for other resources.

A brief summary of the core monitoring program for fisheries in the CRE is as follows:

Lees Ferry Trout
4 annual monitoring trips to estimate electrofishing CPUE, abundance, size distribution, and PSD.

Downstream Non-native Fish **(primarily Salmonids and Carp)**
2 annual monitoring trips to estimate electrofishing CPUE, abundance, size distribution, and condition. Detect presence and distribution of all non-native species.

LCR Humpback chub
4 annual trips to estimate spring and fall abundance, spring spawning abundance, fall recruitment form previous year class, open population model to estimate recruitment and abundance using 1989-present PIT tag database.

LCR Flannelmouth Sucker
Open population model to estimate trends in recruitment and abundance using 1989-present PIT tag database.

Downstream Native Fish Monitoring
2 annual trips to estimate relative abundance (CPUE), size distribution, condition (HBC, FMS, BHS). Look for HBC recruitment (changes in size distribution and mark rate).

Note: The following additional sections will be added to this science plan document.

REMOTELY SENSED DATA COLLECTION (AERIAL PHOTOGRAPHY AND TOPOGRAPHIC CHANNEL MAPPING)

1. Photogrammetrically derived topography data within FIST reaches in December 2002, January 2003, May 2003 (Treatment #1), and December 2003, January 2004 and May 2004 (Treatment #2)
2. Multi-beam hydrography within the first five FIST reaches in Marble Canyon in December 2002, and January 2003.
3. Multi-beam hydrography within all 11 FIST reaches in May 2003 (Treatment #1), with elements of 4 and 5 repeated in support of Treatment #2 in 2003 and 2004

Survey Support

1. Installation and removal of photogrammetric panels within FIST reaches in December 2002, and January and May 2003
2. GCMRC assistance in terrestrial survey elements related to FIST activities in December 2002, and January and May 2003

Logistics

Logistical costs support the Treatment #1 and Treatment #2 Experimental Scenarios, and not components of the studies that are already scheduled under CORE monitoring.

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APPENDICES

APPENDIX 1

Discussion Paper
(April 4, 2002)

Lees Ferry Trout Fishery Status and Trends

Prepared jointly by GCMRC and AGFD

Introduction

There has been considerable interest and discussion regarding the current status and trends in the Lees Ferry trout population and particularly the sport fishery associated with the population. The Grand Canyon Monitoring and Research Center (GCMRC) stimulated much of this discussion by advancing the proposition that predatory and competitive interactions between rainbow trout and brown trout in the Colorado River ecosystem (CRE) near the confluence of the Colorado River and the Little Colorado River may be contributing to the observed decline of humpback chub. GCMRC has suggested that until the population of salmonids in the CRE below the Paria River is reduced in number, any effort to benefit the humpback chub through improving habitat conditions, may be overwhelmed by the potential predatory-prey and competitive interactions with non-native fish. In addition, in 2000, GCMRC raised questions about the size of the Lees Ferry rainbow trout population (256,000 age II^{+}) and suggested that those densities of fish could not be sustained in the Lees Ferry reach and provide the quality fishery called for by the Arizona Game and Fish Department and incorporated into the goals of the Glen Canyon Dam Adaptive Management Program.

In response to declining humpback chub population trends, GCMRC is recommending testing a period of fluctuating flows to disadvantage trout spawning and recruitment. The GCMRC is proposing testing fluctuating flows during a short period of the year (Jan-March). The experimental design calls for repeating this treatment for two consecutive years. The goals of the treatment differ in different parts of the CRE. In the CRE below the Paria River, the goal is to reduce the number of trout which may be acting as predators/competitors on the native humpback chub population. In the Lees Ferry reach, the goal is to reduce the density of trout in order to increase growth and average fish size and to improve the overall quality of the fishery.

The purpose of this document is to facilitate a discussion over the conflicting views regarding the effect the proposed treatment may have on the Lees Ferry trout fishery. To that end, Section 1 of this document provides data that depict some key characteristics of the trout population in recent years. Section 2 provides some plausible explanations for the trends shown in the different data sets. We anticipate additional explanations to be developed as we continue discussions with the Lees Ferry trout guides, the Arizona Game and Fish Department, the TWG, and outside scientists and the public. Section 3 presents a discussion of what we currently consider to be the most plausible explanations.

Section 1 – Data

Figure 1 depicts the catch rate, an index of abundance, of rainbow trout in the Lees Ferry reach using electrofishing methods spanning the time period 1991 – March 2002. The data displayed in this figure indicate that the catch rate increased significantly since the 1991-93 period. This increase appears to have started about 1993 and since 1997 the abundance of rainbow trout appears stable or slightly declining. While the samples collected in March 2002 with the Coffelt boat indicate a possible decline in catch rate since 2001, these data are inconclusive at this time (Figure 1A) and only represent a single month of sampling for 2002.

Figure 2 presents data that shows that since 1990 there has been a decreasing proportion of larger fish in the population (i.e. decrease in proportional stock density, PSD). Thus, of all fish in the population 12 inches and larger (305 mm), only 5% are 16 inches and larger (406 mm).

Figure 3 depicts the average relative condition factor (1991-2001), which is a measure of the plumpness of the fish based on the relationship between a fish's length and its weight.

Figure 4 presents data that shows the angling catch rate has essentially mirrored the electrofishing catch-rate increase beginning in 1991. However since 1998, the angling catch rate has exhibited a more precipitous decline than the electrofishing catch rate, which may be oscillating.

Figure 5 displays data that depicts the size distribution of rainbow trout captured using electrofishing methods during March and April 2000-2002. Notice that these sampling events illustrate that the population contains a very high proportion of fish in the smallest size classes.

We have one piece of observational data that needs to be considered. Beginning in early fall 2001, the Lees Ferry trout guides reported catch rates began to decline significantly, indicating to them a decrease in population abundance. This decline in catch-rate is further-supported by AGFD creel survey data (Figure 6).

Figure 7 shows the relationship between fish density as reflected by mean annual electrofishing catch per minute and the amount of available habitat as reflected by mean annual streamflow.

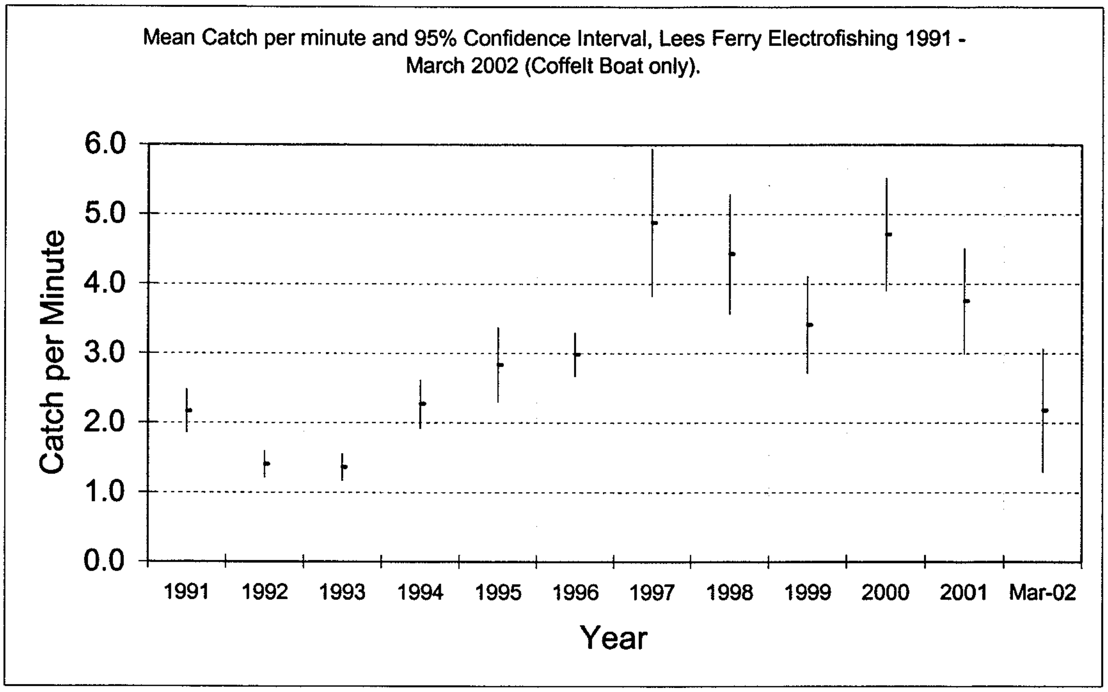


Figure 1. Mean catch per effort for RBT caught in Glen Canyon reach using electrofishing since 1991. Catch rates increased until 1997 and have been stable or slightly decreasing since then.

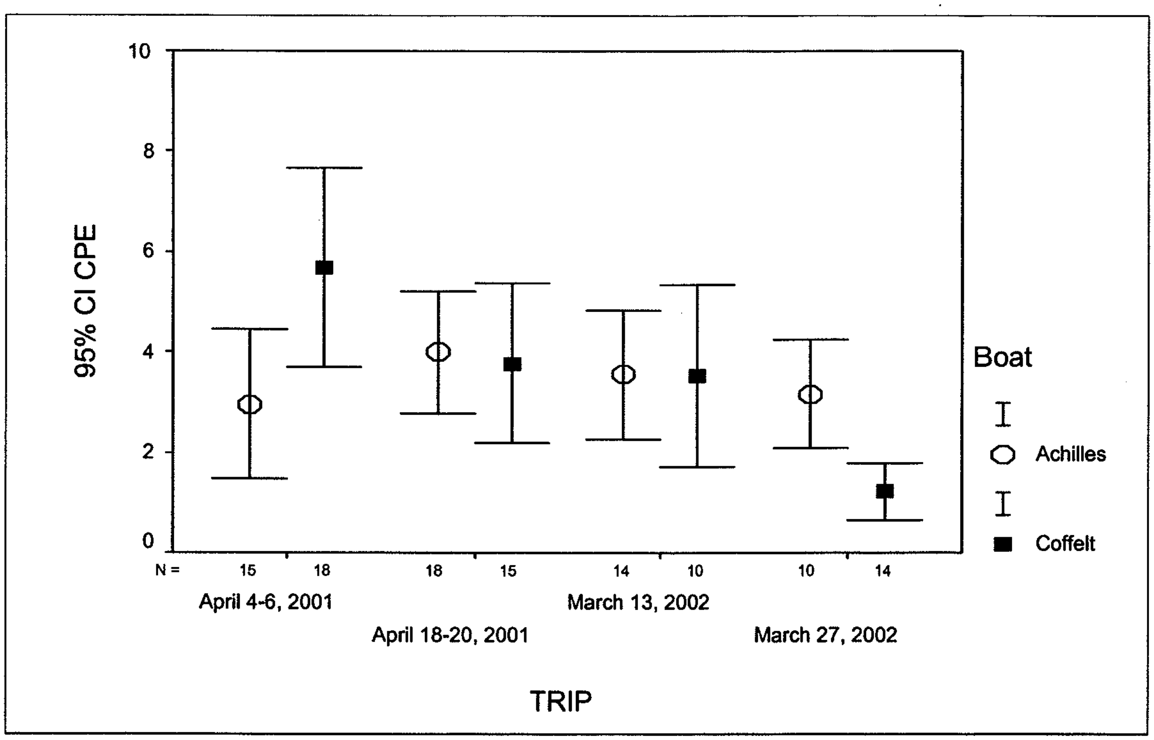


Figure 1A. Comparison of electrofishing catch rates for two types of electrofishing boats used at Lees Ferry. The Coffelt boat (C) is the boat used over the long term at Lees Ferry. The Achilles boat (A) is the boat used in downstream trout sampling and the proposed boat of choice for future Lees Ferry sampling following several years of paired comparisons to demonstrate that switching to this boat won't produce an anomaly in the time series data.

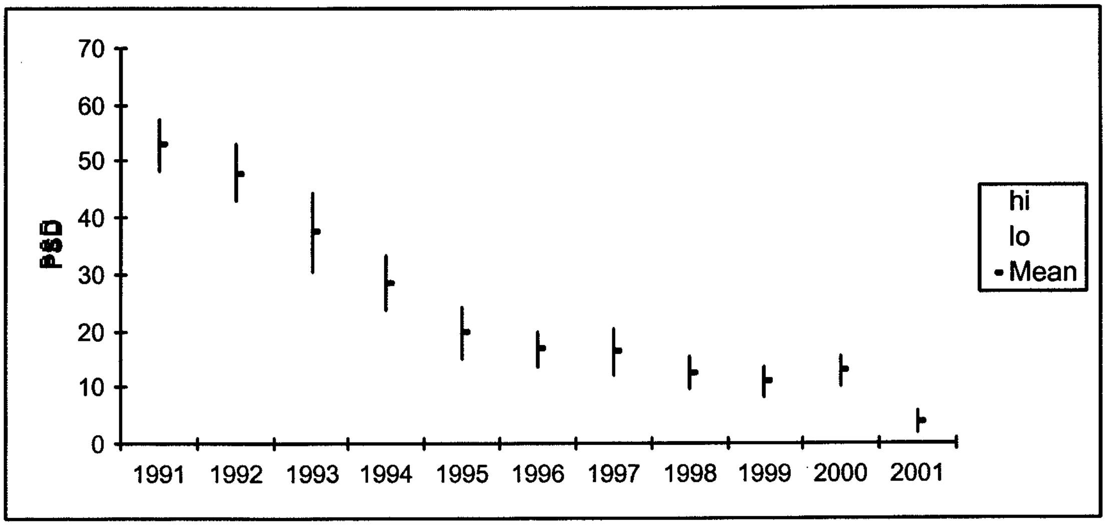


Figure 2. Proportional Stock Density (PSD), i.e. the proportion of fish 16 inches and larger contained within the population of fish 12 inches and larger, PSD = (abundance ≥ 16 inches)/(abundance ≥ 12 inches).

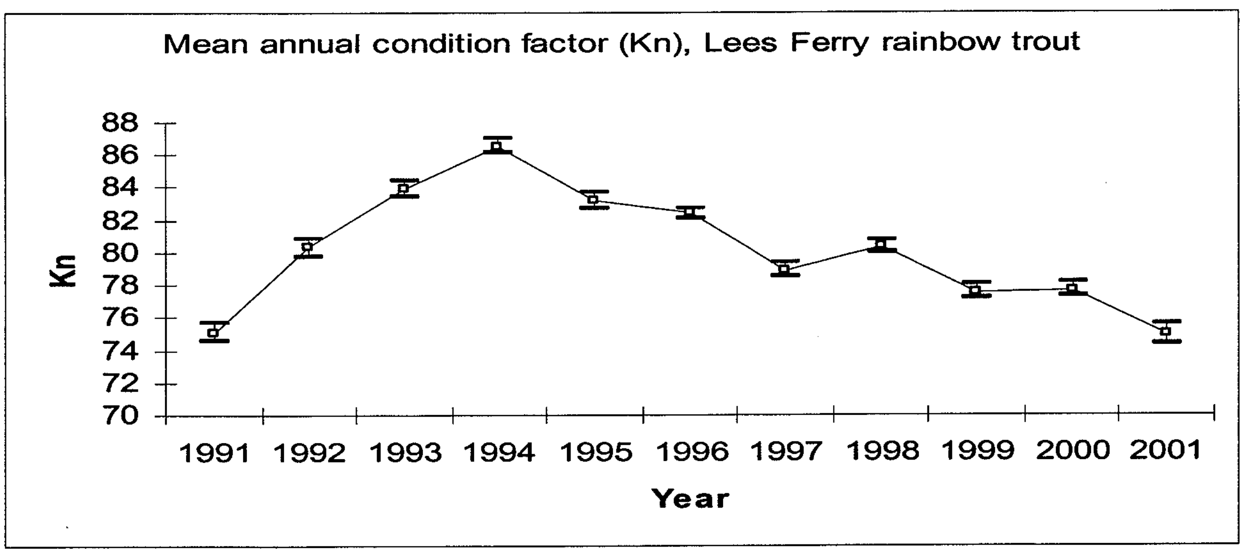


Figure 3. Condition factor by year for Lees Ferry trout (1991-2001).

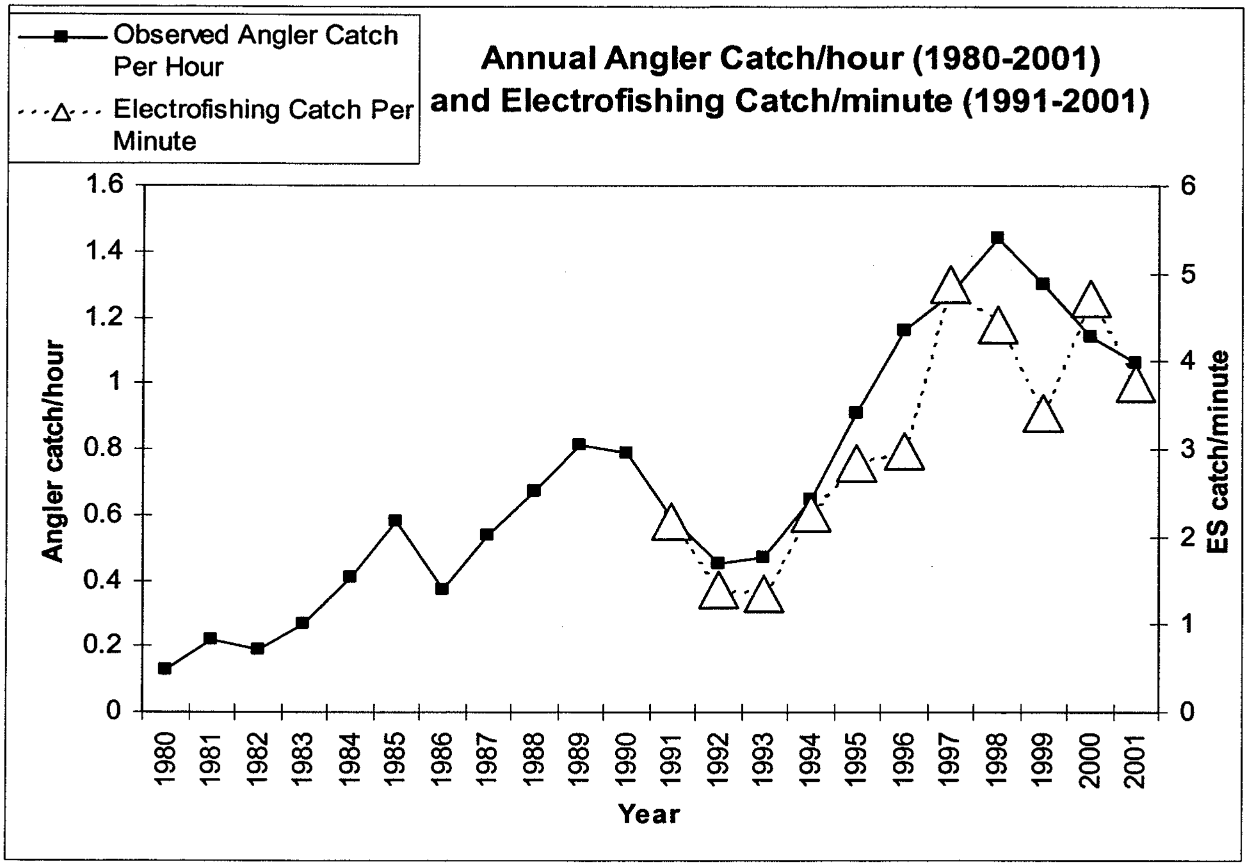


Figure 4. Mean annual electrofishing catch per minute (1991 – 2001; triangles) and mean annual angler catch per hour (1980 – 2001; squares).

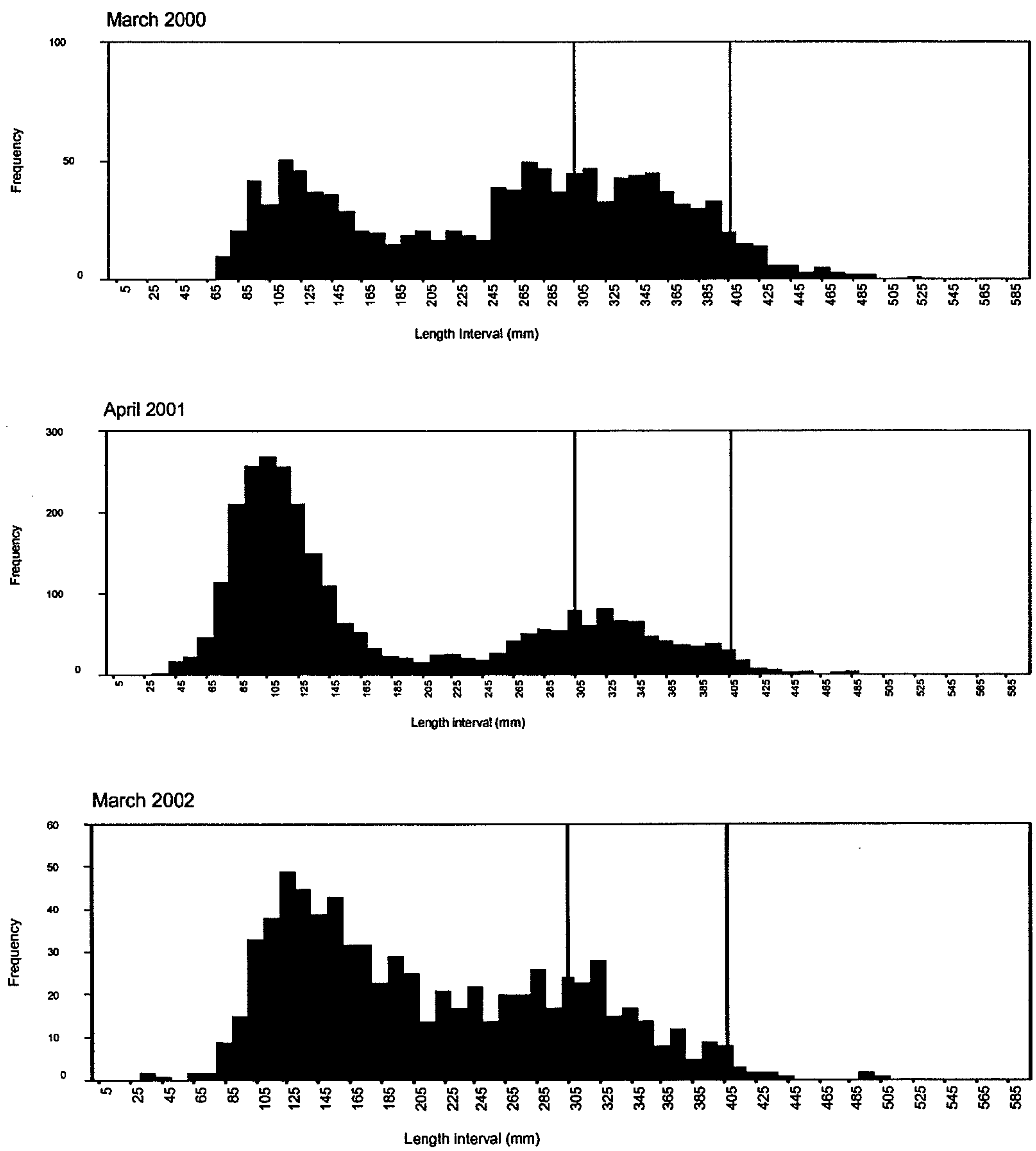


Figure 5. Observed length frequency distributions of rainbow trout captured using electrofishing methods in the Lees Ferry reach during March 2000- 2002. Vertical lines are at 305 mm (12 inch) and 406 mm (16 inch).

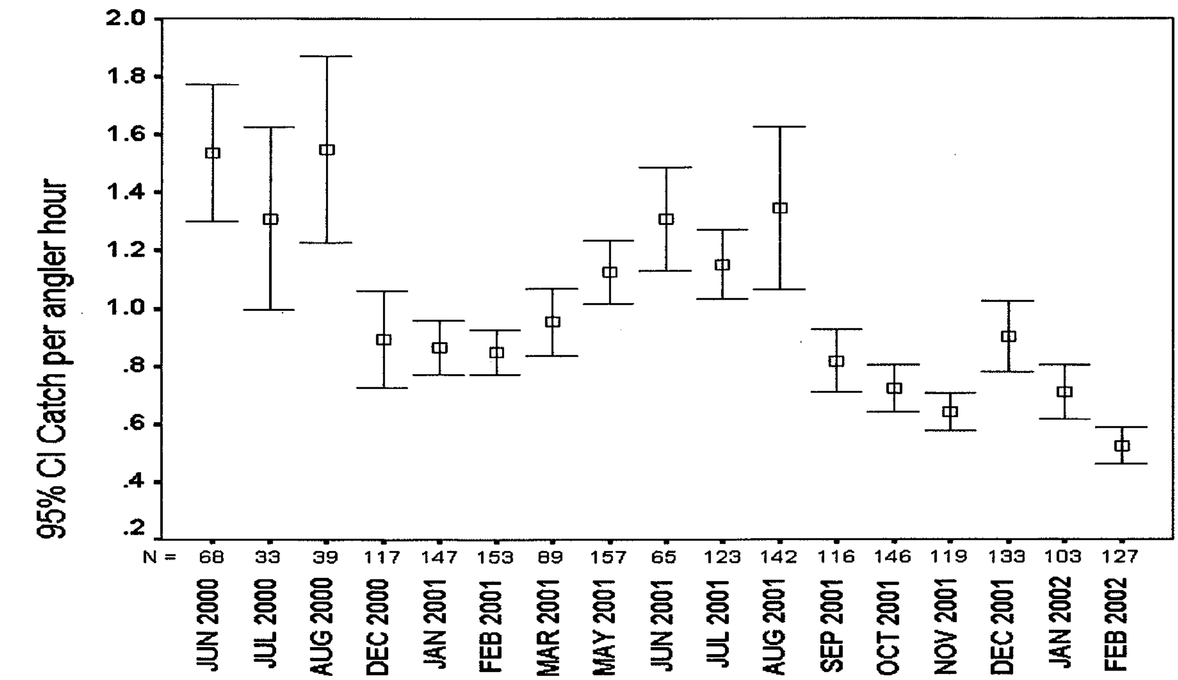


Figure 6. Mean and 95% confidence interval, catch of rainbow trout per angler hour, Lees Ferry June 2000-February 2002. Region II creel data provided by Jodi Niccum, 3/23/02.

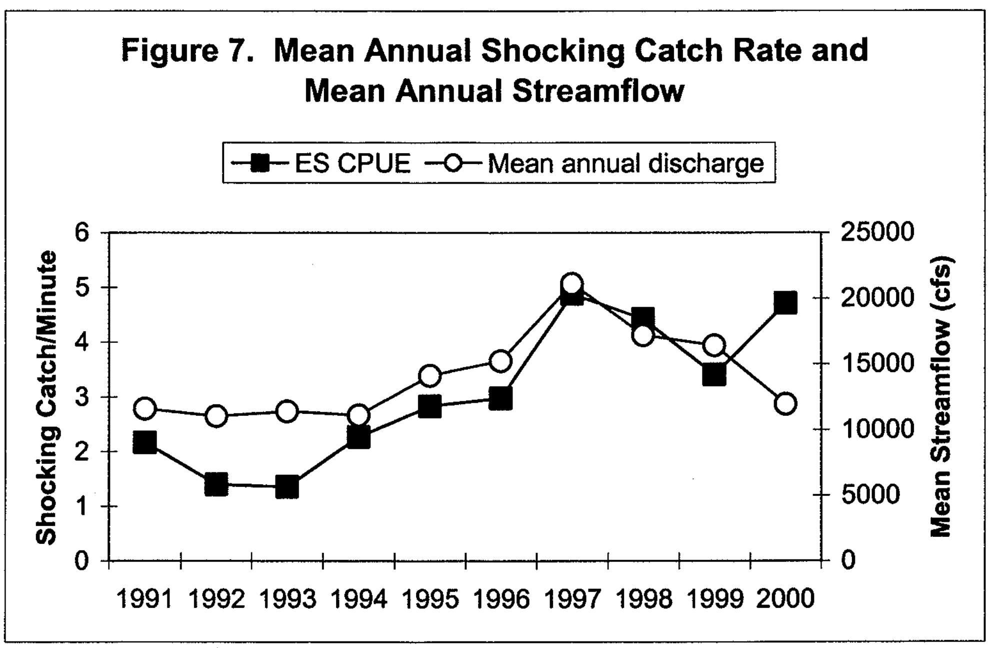


Figure 7. Fish density as reflected by mean annual electrofishing catch per minute and the amount of available habitat as reflected by mean annual streamflow.

Section 2 – Plausible explanations of the data

Are there plausible explanations for the divergence in creel catch rates and catch rates reported by the Lees Ferry trout guides and the data from electrofishing monitoring?

1) Long-term electrofishing data may not be sensitive to short-term changes.

Data from March 13, 2002, using both the Achilles and Coffelt boats, suggested no significant decline in electrofishing catch rates from 2001. However more recent data (March 27, 2002) from only the Coffelt boat (as was used from 1991 – 2001) shows a significant decline in the catch rate between 2001-2002, see Figure 1.

2) The electrofishing data may not be representative of the population due to poor sampling design.

In fisheries jargon this is known as hyperstability, that is the sampling always produces consistent catches because sampling is done where biologists know they will catch fish. The electrofishing effort is based on a random selection of sampling sites, which should eliminate this problem if it existed. Examinations of electrofishing and creel data suggest that hyperstability is not a problem. Electrofishing and creel data from 1991 – 1998 are well correlated, however beginning in 1999 angler catch rates and electrofishing catch rates have diverged. There is also a possibility that the time series is reflecting that some sort of asymptote (i.e., theoretical limit in fish density or carrying capacity) has been reached and the trend is in an oscillatory phase.)

3) The food base may have declined or been over-exploited causing fish behavioral changes making them less vulnerable to anglers.

There is some likelihood that the food base was reset in September 2001 to a level commensurate with the 5,000 cubic feet per second (cfs) flows, allowed under the Record of Decision for an 8.23 million acre feet (maf) year. This level may represent the "carrying capacity" at which this fishery should be managed. It has been suggested that minimum flows of 8,000 cfs should be established to protect the food base. Existing data suggest there is not much area difference between 5,000 and 8,000 cfs flows.

Additional factors related to the food base may be influencing both access to food by fish and access to fish by anglers. There has been a fairly major shift in the composition of the invertebrate community in the Lees Ferry reach wherein snails now heavily dominate the community and preferred aquatic invertebrates are less abundant than in the early 1990's. This shift may represent a well-known ecological pattern; lack of disturbance, or conversely stability in habitat, causes lower diversity in the kinds of organisms present and tends to result in dominance by a few forms. Moreover, when the food base is found mostly at <5,000 cfs levels, this probably causes fish to move into those areas which at least under fluctuating (higher) flows make them less accessible to anglers-particularly shore and wading anglers.

In the discussion of carrying capacity, one should recognize that as water flows have decreased, carrying capacity has also likely decreased. This may be reflected in Figure 7. If our goal is to manage for a stable quality fishery we should base our objectives on a stable food base reflected by probable minimum flows allowed under the current Record of Decision of 5,000 – 8,000 cfs.

4) The data are saying the same thing -- too many fish, therefore fish are smaller, in poorer condition and not feeding, therefore anglers don't catch them.

Recent catch rate data from anglers does show a significant decline in catch rates (Figure 6.). The trend depicted in Figures 1, 2, and 3 reflects a well-known response of rainbow trout populations termed conservation of biomass. Whether stocked or naturally reproduced, available food and habitat can only support so much biomass or total weight of fish. Therefore more fish equate to smaller average size.

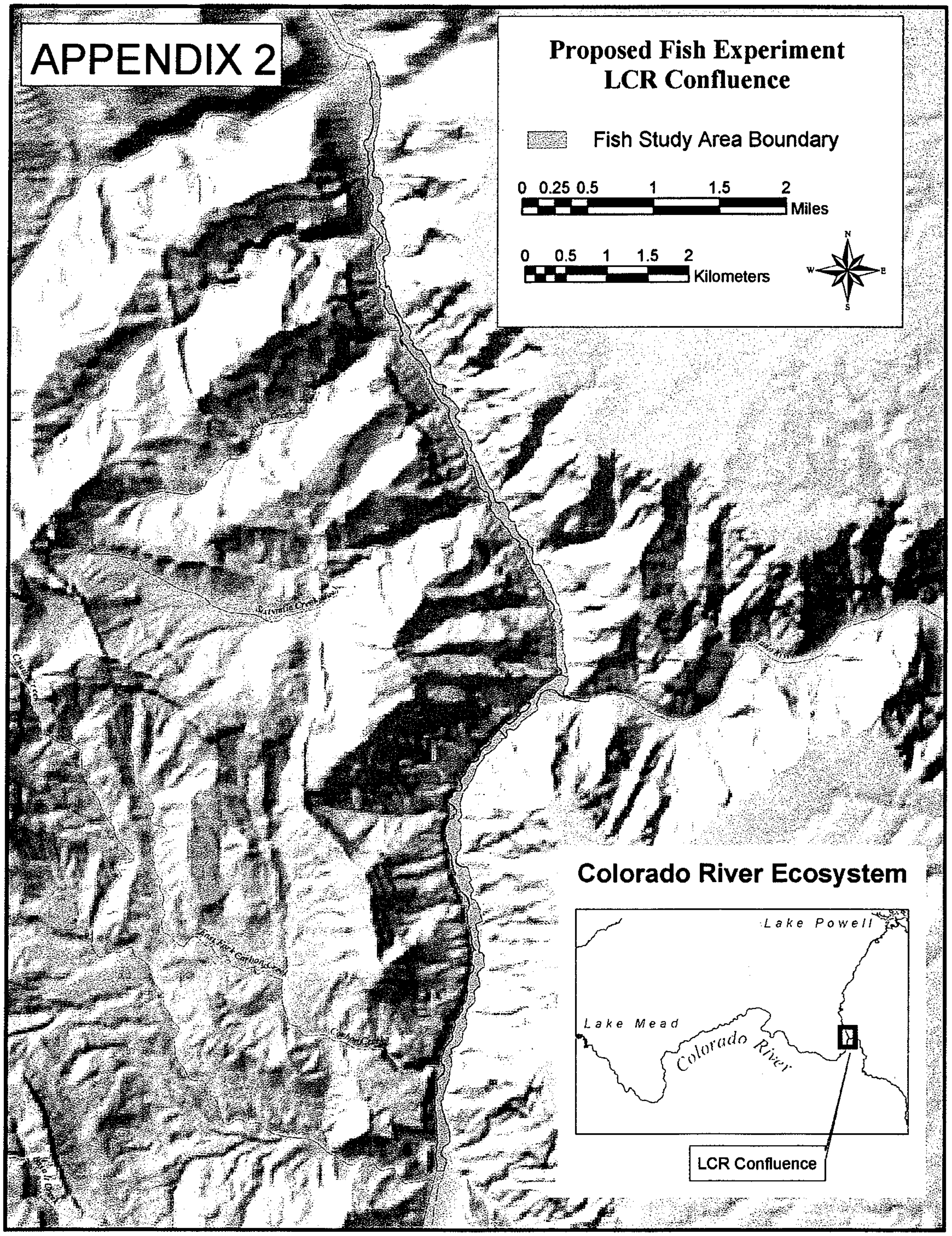
Higher density of fish is expected to produce a higher catch rate for both angler caught and fisheries management sampling efforts (Figures 1 & 4). However as reflected in the overall structure of the population, while the rate of catch goes up, the size of fish caught goes down. The most recent size frequency distribution for the population (spring 2002) shows a very high proportion of fish in the sub-catchable size ranges (<200mm; Figure 5). Fish in the 200-300mm (8-12 in) size range are not considered desirable by many Lees Ferry anglers.

Section 3 – Most probable explanations

In the judgment of GCMRC, it is likely that the final two explanations are the most probable. Over the time period 1993 – 1997, rainbow trout abundance appears to have reached a level approaching or exceeding carrying capacity. Since then, continued strong recruitments have likely had the effect of depressing growth and fish condition further. Beginning in September of 2001, minimum flows from Glen Canyon Dam may have decreased carrying capacity even more contributing to additional stress that is possibly being manifested in behavioral changes causing angler catch rate to decrease. If the fluctuating flows are successful at reducing recruitment, we should see fish condition, growth rates, and PSD increase as fish density is reduced.

Conclusions

The data presented above support the perspective that the Lees Ferry trout population and fishery have been in a state of decline over the past several years. This is manifest in smaller size fish and now in apparent declines in catch rates by anglers. The prescribed management action of reducing recruitment by a combination of reducing spawning success and reducing survival of young trout is expected to reverse both of these trends and improve the overall quality and stability of the fishery. Concerns remain regarding the potential for stranding some adult fish during the fluctuating flows in Jan-March. We are hopeful that these concerns can be addressed by further refining the specific upramp and downramp characteristics of the flows, by monitoring for stranding, and implementing other mitigation measures as necessary. The detailed approaches to this and other issues remain to be worked out. GCMRC and AGFD remain committed to mitigating these and other concerns, if possible.


APPENDIX 2
Proposed Fish Experiment
LCR Confluence
Fish Study Area Boundary
0 0.25 0.5 1 1.5 2
Miles
0 0.5 1 1.5 2
Kilometers
N
W
E
S
Colorado River Ecosystem
Lake Powell
Lake Mead
Colorado River
LCR Confluence

APPENDIX 3

	Actions		LCR Reach Initial Indicators For Humpback Chub			
Date	LCR Reach Salmonid Removal	Fluctuating Flows	Juvenile HBC Mainstem Mortality [a]	LCR HBC Recruitment and Length Frequency Indicators [b]	Mainstem CPUE and Length Frequency Indicators [c]	HBC Recruitment [d]
Aug/2002	XXXXXXX					
Sep/2002	XXXXXXX					
Oct/2002						
Nov/2002						
Dec/2002				2001 Brood Year	2000 and 2001 Brood Years	
Jan/2003	XXXXXXX	XXXXXXX				1999 Brood Year
Feb/2003	XXXXXXX	XXXXXXX	2002 Brood Year			
Mar/2003	XXXXXXX	XXXXXXX				
Apr/2003						
May/2003						
Jun/2003	XXXXXXX					
Jul/2003	XXXXXXX					
Aug/2003	XXXXXXX					
Sep/2003						
Oct/2003						
Nov/2003						
Dec/2003				2002 Brood Year	2001 and 2002 Brood Years	
Jan/2004	XXXXXXX	XXXXXXX				2000 Brood Year
Feb/2004	XXXXXXX	XXXXXXX	2003 Brood Year			
Mar/2004	XXXXXXX	XXXXXXX				
Apr/2004						
May/2004						
Jun/2004	XXXXXXX					
Jul/2004	XXXXXXX					
Aug/2004	XXXXXXX					
Sep/2004						
Oct/2004						
Nov/2004						
Dec/2004				2003 Brood Year	2002 and 2003 Brood Years	
Jan/2005	XXXXXXX					2001 Brood Year
Feb/2005	XXXXXXX		2004 Brood Year			
Mar/2005	XXXXXXX					
Apr/2005						
May/2005						
Jun/2005	XXXXXXX					
Jul/2005	XXXXXXX					
Aug/2005	XXXXXXX					
Sep/2005						
Oct/2005						
Nov/2005						
Dec/2005				2004 Brood Year	2003 and 2004 Brood Years	
Jan/2006	XXXXXXX					2002 Brood Year
Feb/2006	XXXXXXX		2005 Brood Year			
Mar/2006	XXXXXXX					
Apr/2006						
May/2006						
Jun/2006	XXXXXXX					
Jul/2006	XXXXXXX					
Aug/2006	XXXXXXX					
Sep/2006						
Oct/2006						
Nov/2006						
Dec/2006				2005 Brood Year	2004 and 2005 Brood Years	
Jan/2007						2003 Brood Year
Jan/2008						2004 Brood Year
Jan/2009						2005 Brood Year
Jan/2010						2006 Brood Year

[a] Hoopnet sampling at index sites below the LCR confluence will be used to estimate annual mortality/dispersal rate of juvenile HBC.
[b] Fall hoopnet sampling in athe LCR will give first reliable estimate of cohort strength within the LCR using mark-recapture abundance estimators.
[c] Mainstem monitoring program will give CPUE and length frequency information to provide inshight into cohort strength.
[d] Open population model will give best estimate of cohort cohort strength using multiple years of data.

Date	LCR Reach Salmonid Removal	Fluctuating Flows	RBT & BNT Abundance and Size Distribution [a]	RBT & BNT Immigration Rate [b]	RBT Recruitment [c]	RBT & BNT Abundance and Size Distribution [d]
Aug/2002	XXXXXXX					
Sep/2002	XXXXXXX		Aug/2002			
Oct/2002			Sep/2002	August to September		
Nov/2002						
Dec/2002						
Jan/2003	XXXXXXX	XXXXXXX	Jan/2003			
Feb/2003	XXXXXXX	XXXXXXX	Feb/2003	September to January	2002 Brood Year	
Mar/2003	XXXXXXX	XXXXXXX	Mar/2003	January to February		Feb/2003
Apr/2003				February to March		Mar/2003
May/2003						
Jun/2003	XXXXXXX					
Jul/2003	XXXXXXX		Jun/2003			
Aug/2003	XXXXXXX		Jul/2003	March to June		
Sep/2003			Aug/2003	June to July		
Oct/2003				July to August		
Nov/2003						
Dec/2003						
Jan/2004	XXXXXXX	XXXXXXX				
Feb/2004	XXXXXXX	XXXXXXX	Jan/2004			
Mar/2004	XXXXXXX	XXXXXXX	Feb/2004	September to January	2003 Brood Year	Feb/2004
Apr/2004			Mar/2004	January to February		Mar/2004
May/2004				February to March		
Jun/2004	XXXXXXX					
Jul/2004	XXXXXXX		Jun/2004			
Aug/2004	XXXXXXX		Jul/2004			
Sep/2004			Aug/2004	March to June		
Oct/2004				June to July		
Nov/2004				July to August		
Dec/2004						
Jan/2005	XXXXXXX					
Feb/2005	XXXXXXX		Jan/2005			
Mar/2005	XXXXXXX		Feb/2005	September to January	2004 Brood Year	Feb/2005
Apr/2005			Mar/2005	January to February		Mar/2005
May/2005				February to March		
Jun/2005	XXXXXXX					
Jul/2005	XXXXXXX		Jun/2005			
Aug/2005	XXXXXXX		Jul/2005			
Sep/2005			Aug/2005	March to June		
Oct/2005				June to July		
Nov/2005				July to August		
Dec/2005						
Jan/2006	XXXXXXX		Jan/2006			
Feb/2006	XXXXXXX		Feb/2006	September to January	2005 Brood Year	
Mar/2006	XXXXXXX		Mar/2006	January to February		Feb/2006
Apr/2006				February to March		Mar/2006
May/2006						
Jun/2006	XXXXXXX		Jun/2006			
Jul/2006	XXXXXXX		Jul/2006			
Aug/2006	XXXXXXX		Aug/2006	March to June		
Sep/2006				June to July		
Oct/2006				July to August		
Nov/2006						
Dec/2006						

[a] Rainbow trout and brown trout abundance and Size distribution will be estimated during each depletion effort.
[b] Immigration rate will be estimated using abundance estimates derived in sequential depletion efforts.
[c] RBT and BNT recruitment trends will be inferred from CPUE of 1 year old fish.
[d] Comparing trends in abundance and size distribution among the LCR reach and the rest of the river will be used to separate the effects of fluctuating flows versus mechanical removals on rainbow trout population size structure.

	Action	Lees Ferry Indicators	
Date	Fluctuating Flows	RBT Abundance and Size Distribution[a]	RBT Spawning Success and Juvenile Survival[b]
Jan/2003	XXXXXXX		
Feb/2003	XXXXXXX		
Mar/2003	XXXXXXX		
Apr/2003		Mar/2003	
May/2003			
Jun/2003			
Jul/2003			2003 Brood Year
Aug/2003			
Sep/2003			
Oct/2003			
Nov/2003			
Dec/2003			
Jan/2004	XXXXXXX		
Feb/2004	XXXXXXX		
Mar/2004	XXXXXXX		
Apr/2004		Mar/2004	
May/2004			
Jun/2004			
Jul/2004			2004 Brood Year
Aug/2004			
Sep/2004			
Oct/2004			
Nov/2004			
Dec/2004			
Jan/2005			
Feb/2005			
Mar/2005			
Apr/2005		Mar/2005	
May/2005			
Jun/2005			
Jul/2005			2005 Brood Year
Aug/2005			
Sep/2005			
Oct/2005			
Nov/2005			
Dec/2005			
Jan/2006			
Feb/2006			
Mar/2006			
Apr/2006		Mar/2006	
May/2006			
Jun/2006			
Jul/2006			2006 Brood Year
Aug/2006			
Sep/2006			
Oct/2006			
Nov/2006			
Dec/2006			

[a] March electrofishing surveys provide information on abundance and size composition of trout in the Lees Ferry fishery.
[b] June electrofishing surveys provide information on YOY relative abundance.

APPENDIX 4

TRIP SCHEDULES

Project 6. Fine-Sediment Transport Modeling Verification
Trip Schedule – ***Same field efforts for Treatments #1 and #2***

Trips (2003)	Trip Dates	FY-Year	Trip Length	Research Personnel	Logistical Personnel
High-Resolution Eddy Monitoring within Marble Canyon	2 – 10 Jan, 2003	2003	9-Day	6	2

Project 7. Coarse-Grained Sediment Monitoring
Trip Schedule - ***Treatment #1 Only unless new debris flows occur in summer 2003***

Trips (2002-03)	Trip Dates	FY-Year	Trip Length	Research Personnel	Logistical Personnel
Debris Fan+Rapid Reworking (Webb et al.)	28 Dec, 2002 – 8 Jan, 2003	2003	12-Day	10	2

Project 17. Mechanical Removal of Non-Native Fishes (Primarily Salmonids) from the Colorado River Near the Confluence with the Little Colorado River
Trip Schedule

Trip Type	Trip Date	FY-Year	Trip Length	Research Personnel	Logistical Personnel
Electrofishing Depletion	1 – 15 Sep	2002	15 - day	7	7
Electrofishing Depletion	15 – 30 Jan	2003	15 - day	7	7
Electrofishing Depletion	15 – 30 Feb	2003	15 - day	7	7
Electrofishing Depletion	15 – 30 March	2003	15 - day	7	7
Electrofishing Depletion	1- 15 Jul	2003	15 - day	7	7
Electrofishing Depletion	1- 15 Aug	2003	15 - day	7	7
Electrofishing Depletion	1- 15 Sept	2003	15 - day	7	7
Electrofishing Depletion	3 trips Jan-Mar	2004	15 - day	7	7
Electrofishing Depletion	3 trips Jul-Sep	2004	15 - day	7	7
Electrofishing Depletion	3 trips Jan-Mar	2005	15 - day	7	7
Electrofishing Depletion	3 trips Jul-Sep	2005	15 - day	7	7

Project 1. Part E - Ongoing Sediment Mass Balance (Fluctuating Flow Treatment)
Mass-Balance Trip Schedule (Parts A – E)
Treatment #1 (Low-Flows in summer/fall)

Mass-Balance Trips Treatment #1 (2002-03)	Trip Dates	FY-Year	Trip Length	Research Personnel	Logistical Personnel
Suspended-Sediment Sampling and Support	9 – 19 Aug, 2002	2002	10-day	4	1
Suspended-Sediment Sampling and Support	15 - 21 Dec, 2002	2003	6-day	3	1
Suspended-Sediment Sampling at 30-Mile and 60-Mile (BHBF-A)	2 – 12 Jan, 2003	2003	10-day	4	1
Suspended-Sediment Sampling at 30-Mile and 60-Mile (BHBF-B)	2–12 Jan, 2003	2003	10-day	4	1
Suspended-Sediment Sampling and Support	9-15 Feb, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Mar, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Apr, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 May, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Jun, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Jul, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Aug, 2003	2003	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Sep, 2003	2003	6-day	3	1

Mass-Balance Trip Schedule (Parts A – E)
Treatment #2 (ROD Operations + Peak Power-Plant Releases)

Mass-Balance Trips Treatment #2 (2003-04)	Trip Dates	FY-Year	Trip Length	Research Personnel	Logistical Personnel
Suspended-Sediment Sampling and Support	15 - 21 Dec, 2003	2004	6-day	3	1
Suspended-Sediment Sampling at 30-Mile and 60-Mile (BHBF-A)	2 – 12 Jan, 2004	2004	10-day	4	1
Suspended-Sediment Sampling at 30-Mile and 60-Mile (BHBF-B)	2–12 Jan, 2004	2004	10-day	4	1
Suspended-Sediment Sampling and Support	9-15 Feb, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Mar, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Apr, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 May, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Jun, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Jul, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Aug, 2004	2004	6-day	3	1
Suspended-Sediment Sampling and Support	9-15 Sep, 2004	2004	6-day	3	1

Project 2. Part D – FIST Trip Schedule (Parts A – D)
Treatment #1 (Low-Flows in summer/fall)

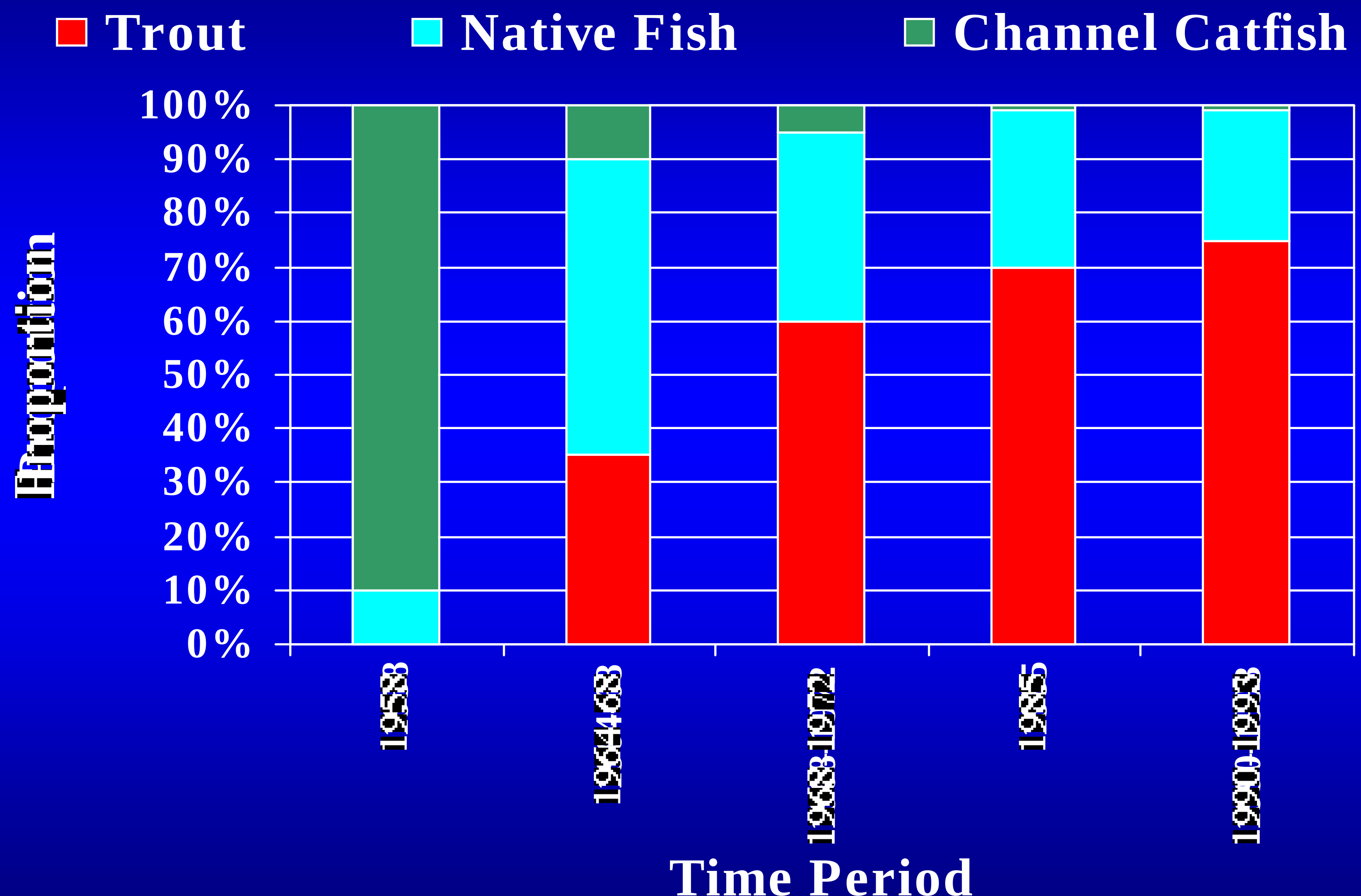
FIST Trips Treatment #1 (2002-03)	Trip Dates	FY-Year	Trip Length	Research Personnel	Logistical Personnel
NAU Sand Bars and Camping Areas	5– 23 Oct, 2002	2003	18 - day	16	6
FIST – Reaches 2-6 Marble Canyon Hydro. + Panel Deployment Trip in all Integrated Reaches	5 – 20 Dec, 2002	2003	16 - day	16	6
FIST – Reaches 2-6 Marble Canyon Only	5 – 17 Jan, 2003	2003	12 - day	16	5
FIST – Reaches 1-11 Panel Retrieval Trip	25 – 30 Jan, 2003	2003	5 - day	3	2
FIST – Reaches 2-6 Sandbar Sedimentology + Field Test of Down Ramping Rates	10 – 20 Mar, 2003	2003	11- day	8	3
FIST – Reaches 1-11 Full Protocol	15 – 30 May, 2003	2003	15 - day	7	7

FIST Trip Schedule (Parts A – D)
Treatment #2 (ROD Operations + Peak Power-Plant Releases)

FIST Trips Treatment #2 (2003-04)	Trip Dates	FY-Year	Trip Length	Research Personnel	Logistical Personnel
NAU Sand Bars and Camping Areas	5– 23 Oct, 2003	2004	18 - day	16	6
FIST – Reaches 1-5 Marble Canyon Hydro. + Panel Deployment Trip in all Integrated Reaches	5 – 20 Dec, 2003	2004	16 - day	16	6
FIST – Reaches 1-5 Marble Canyon Only	5 – 17 Jan, 2004	2004	12 - day	16	5
FIST – Reaches 1-11 Panel Retrieval Trip	25 – 30 Jan, 2004	2004	5 - day	3	2
FIST – Reaches 1-11 Full Protocol***	15 – 30 May, 2004	2004	15 - day	7	7

***The May 2004, FIST trip is already planned and funded under the FY 2004 Annual work plan as part of the normal biennial schedule for sand-storage monitoring.

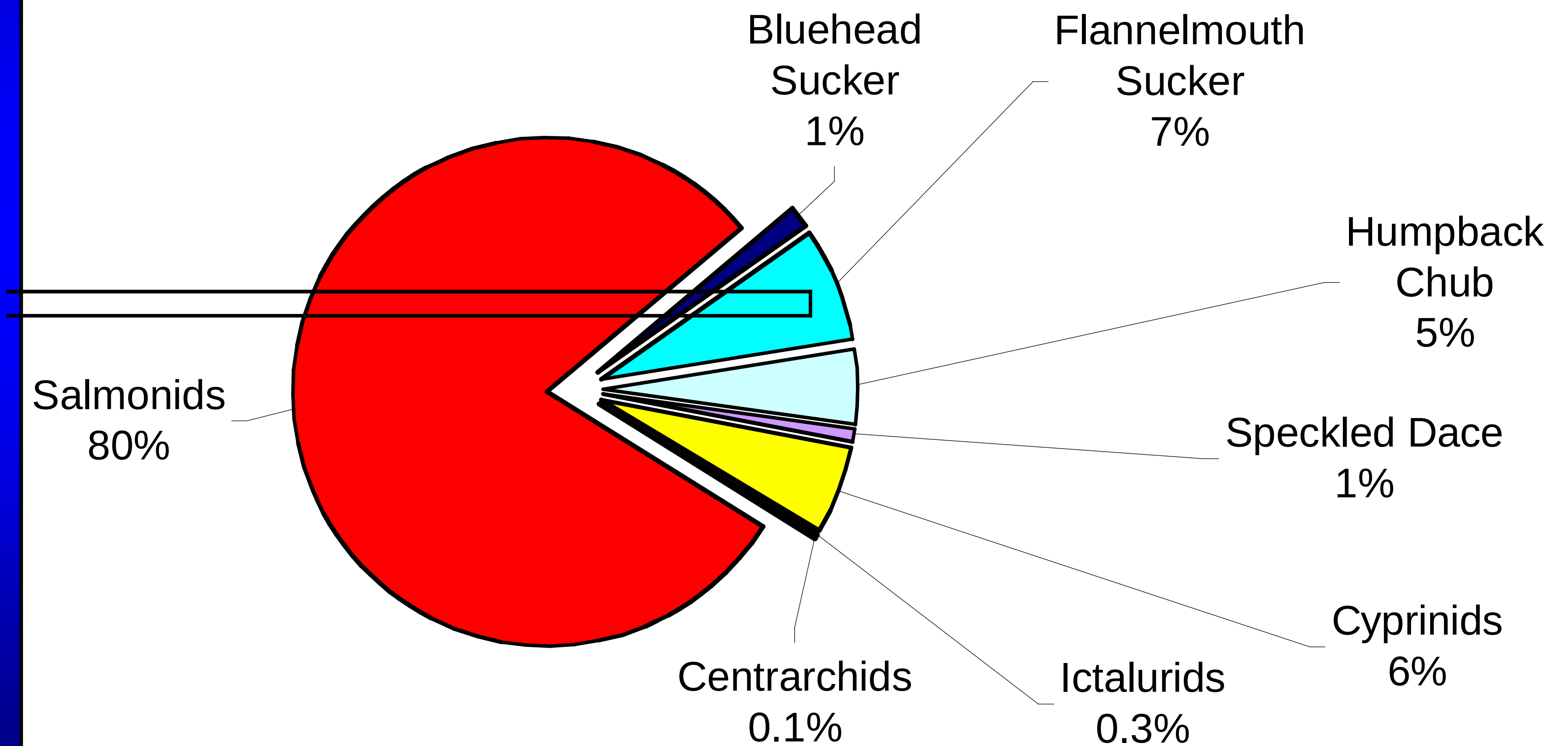
Fish Community Composition Change



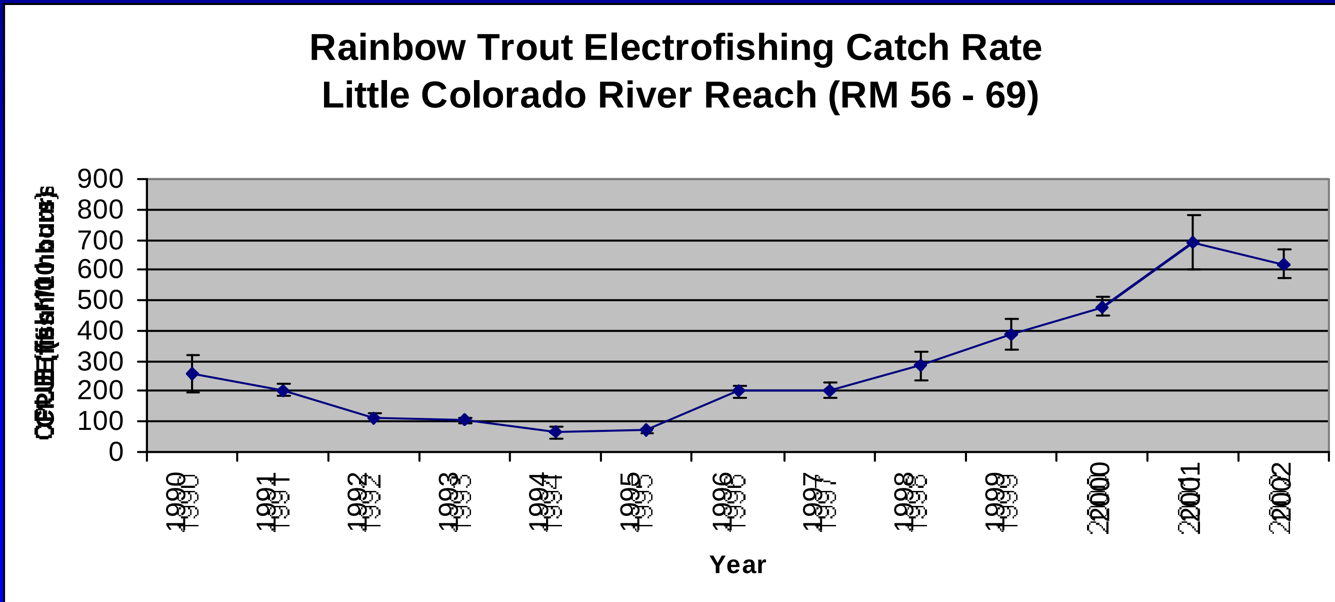
Leibfried and Zimmerman 1994

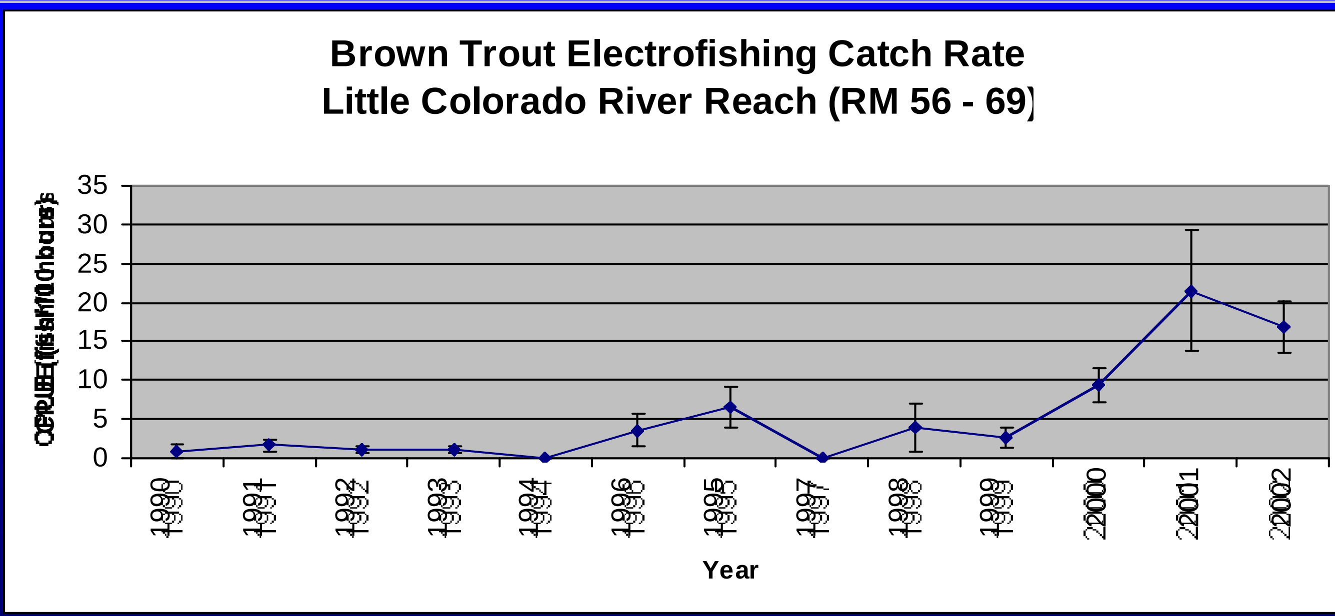
The Present Fish Community in Grand Canyon

2000-2001 Observed Species Composition in the Colorado River Using Electrofishing and Netting Methods

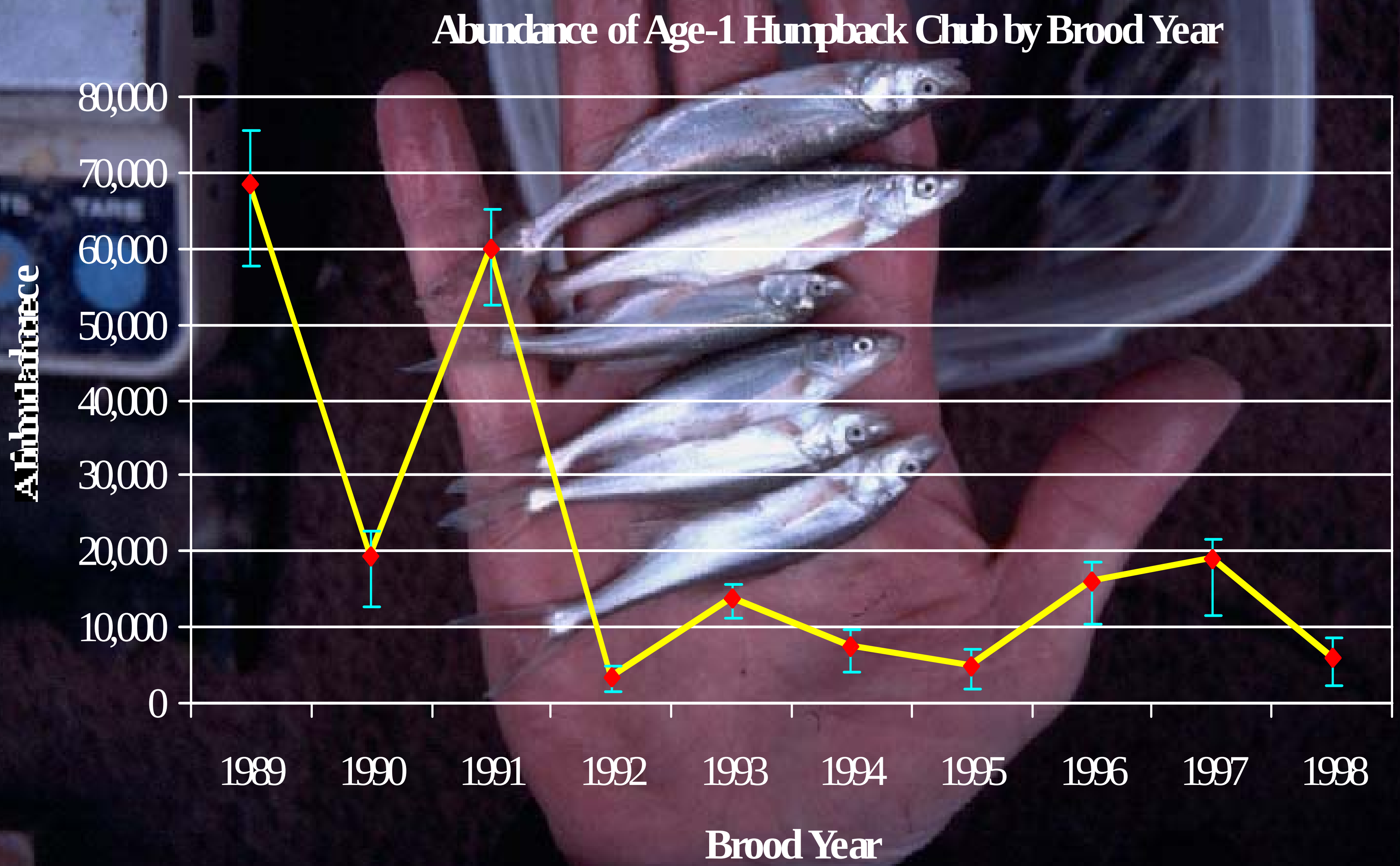


Recent Trends in Salmonid Abundance

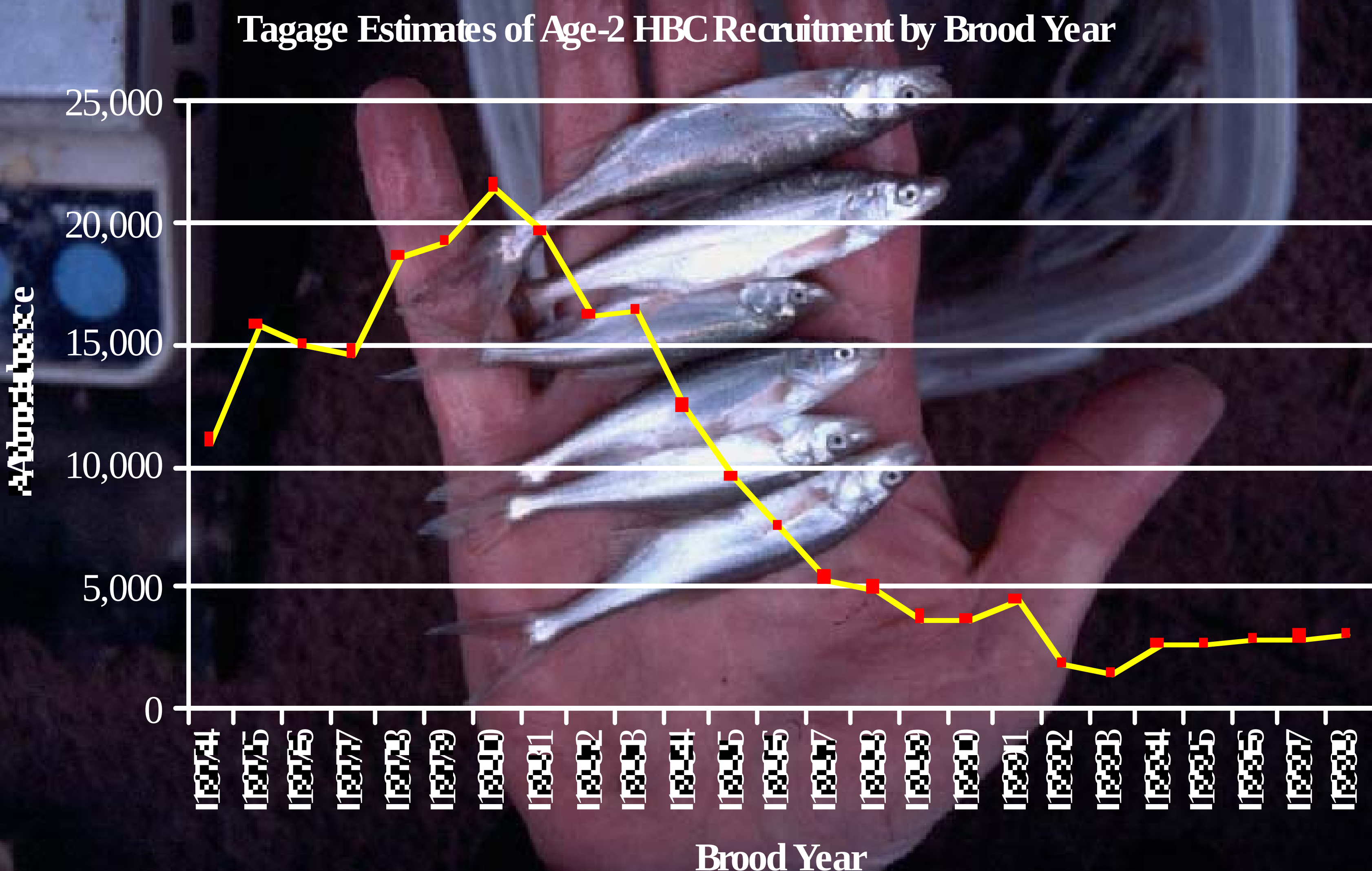




Recent Recruitment Trends in the Little Colorado River Population of Humpback Chub

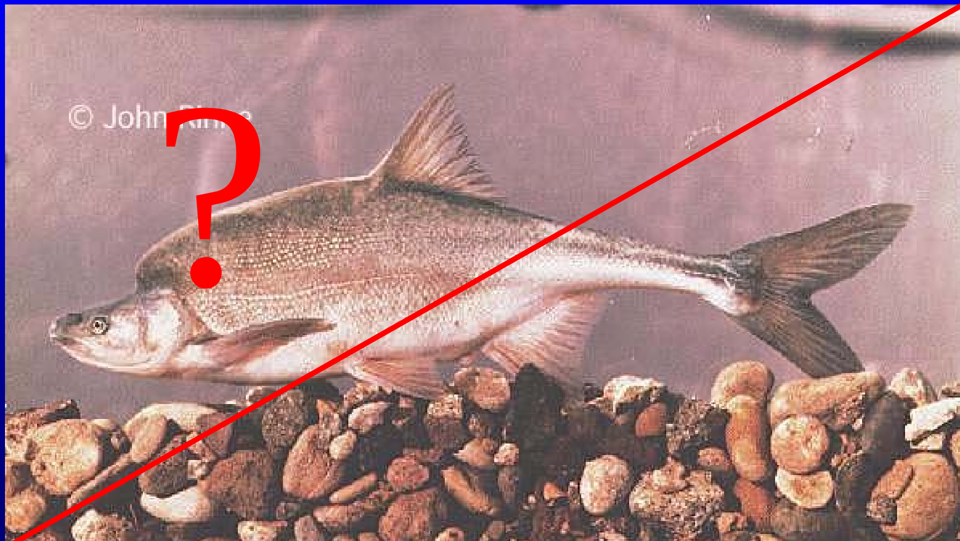


Recent Recruitment Trends in the Little Colorado River Population of Humpback Chub



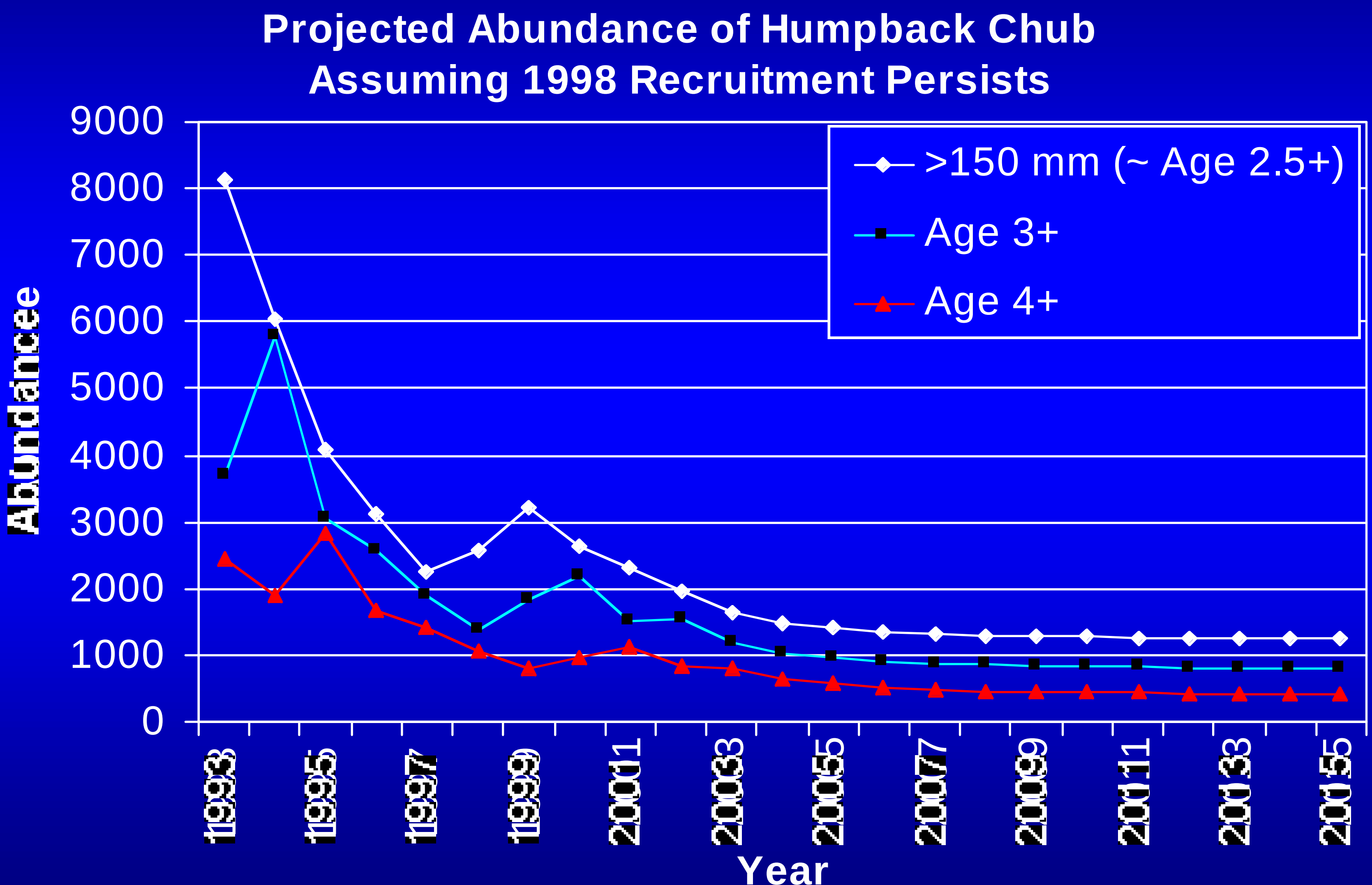
The Future Grand Canyon Fish Community?

- Humpback Chub???
- What is driving the apparent long-term downturn in Humpback Chub recruitment?
  - Interaction with Non-Native Fishes
    - Lassuy 1995, Marsh and Douglas 1997, Tyus and Saunders 2000
  - Asian Tapeworm
  - Little Colorado and Colorado River Hydrology
  - Other Factors?

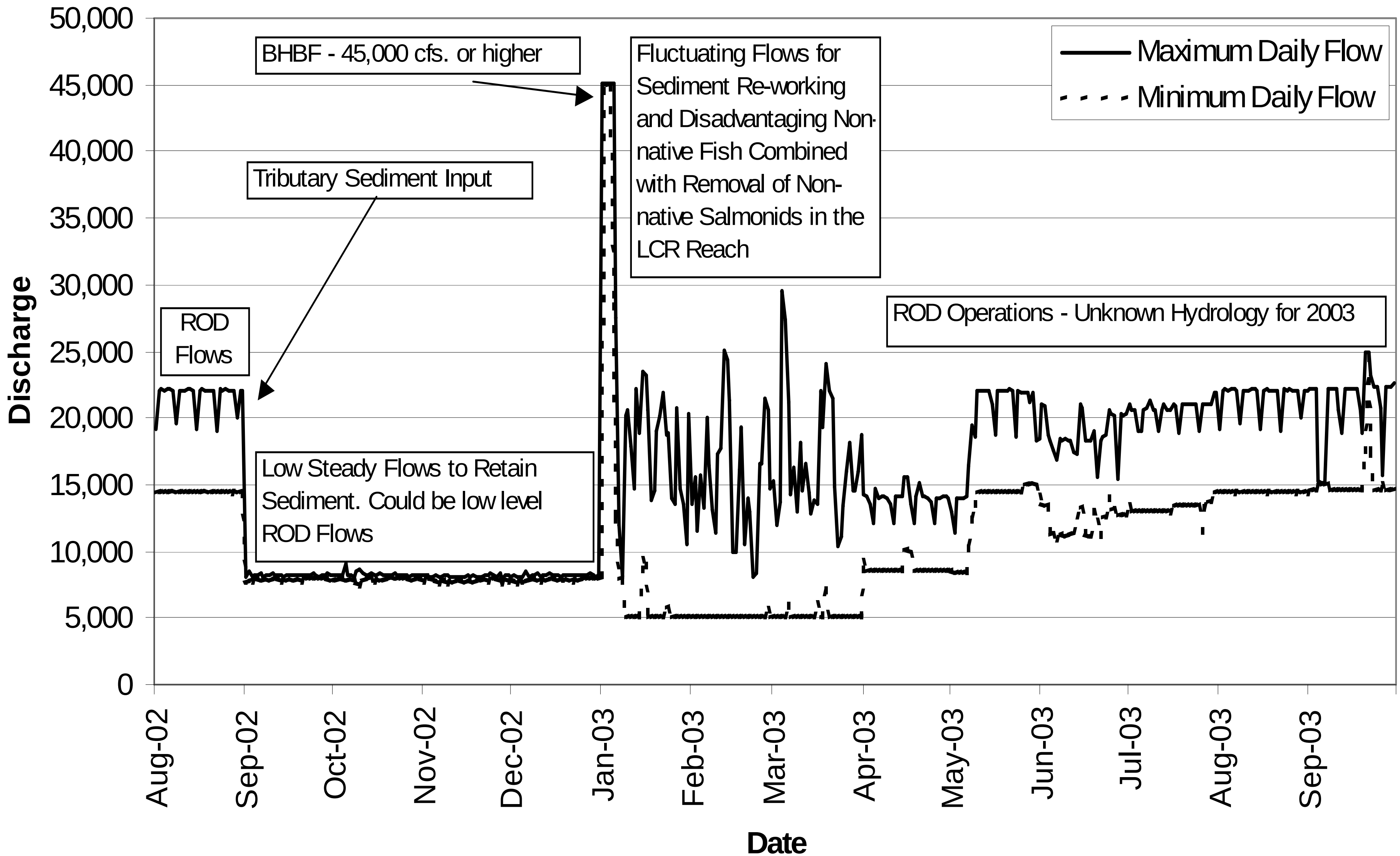


USGS

The Future Grand Canyon Fish Community?

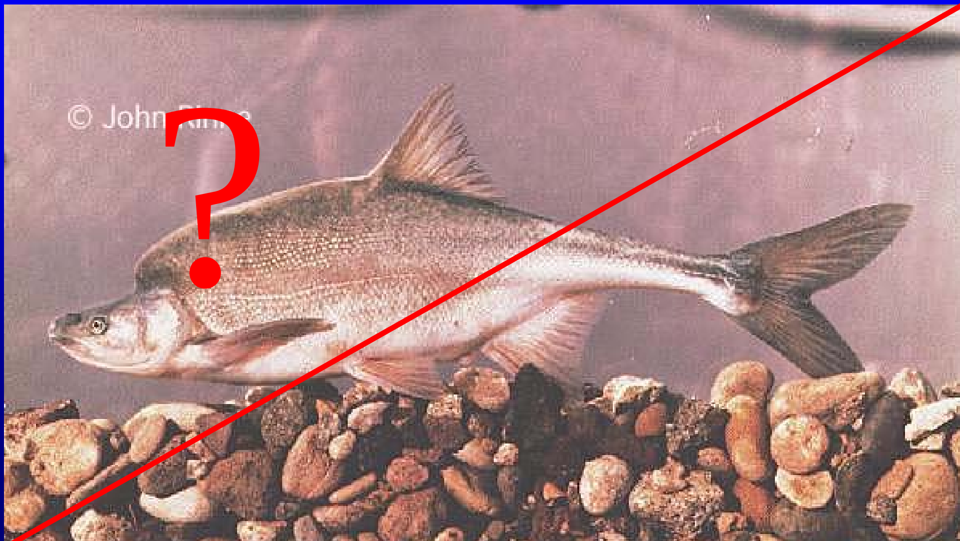


Scenario 1. GCMRC Recommended Water Year 2002-03 Treatment



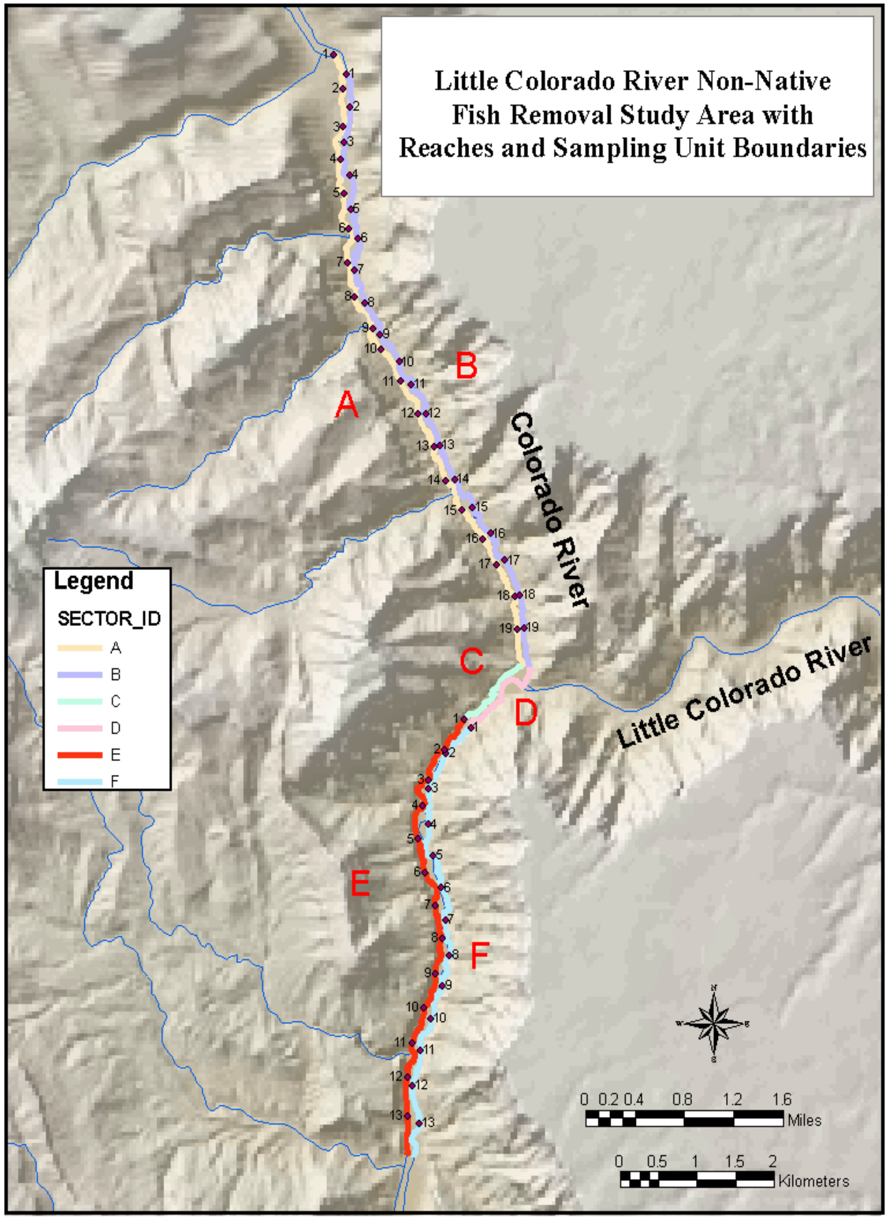
Proposed Experimental Treatments

- Manipulate (lower) the abundance rainbow and brown trout in the Colorado River.
  - Large Winter/Spring Flow Fluctuations to limit rainbow trout recruitment.
  - Mechanical removal of rainbow and brown trout in the Little Colorado River reach of the Colorado River (RM 56-66)



Proposed Experimental Treatments

- Mechanical Removal (electrofishing) of rainbow and brown trout in the Little Colorado River reach of the Colorado River (RM 56-66).
    - 6 trips/year during 2003-2005
- Mechanical Removal Objectives:
    1. Can we reduce the abundance of rainbow and brown trout in a 10 mile reach of river (depletion abundance estimates, changes in size distribution).



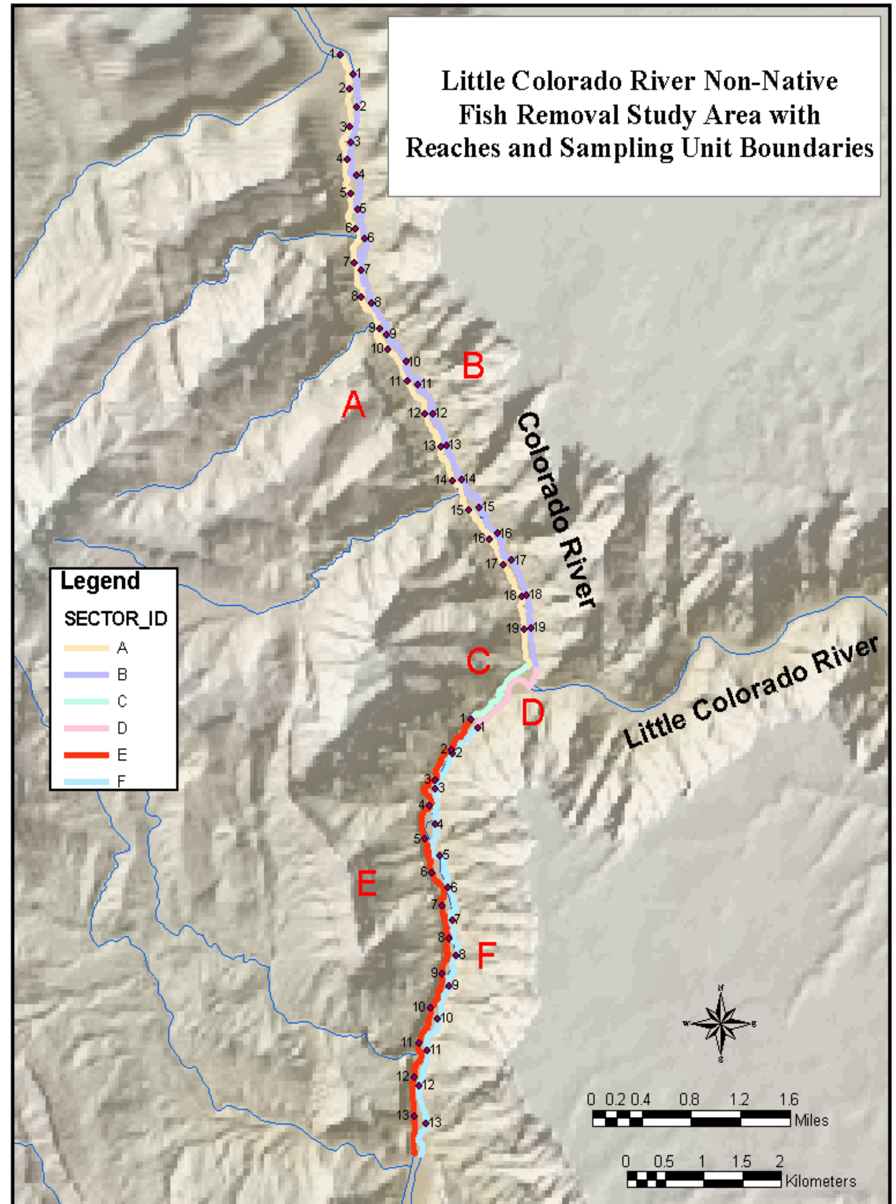
USGS

Proposed Experimental Treatments

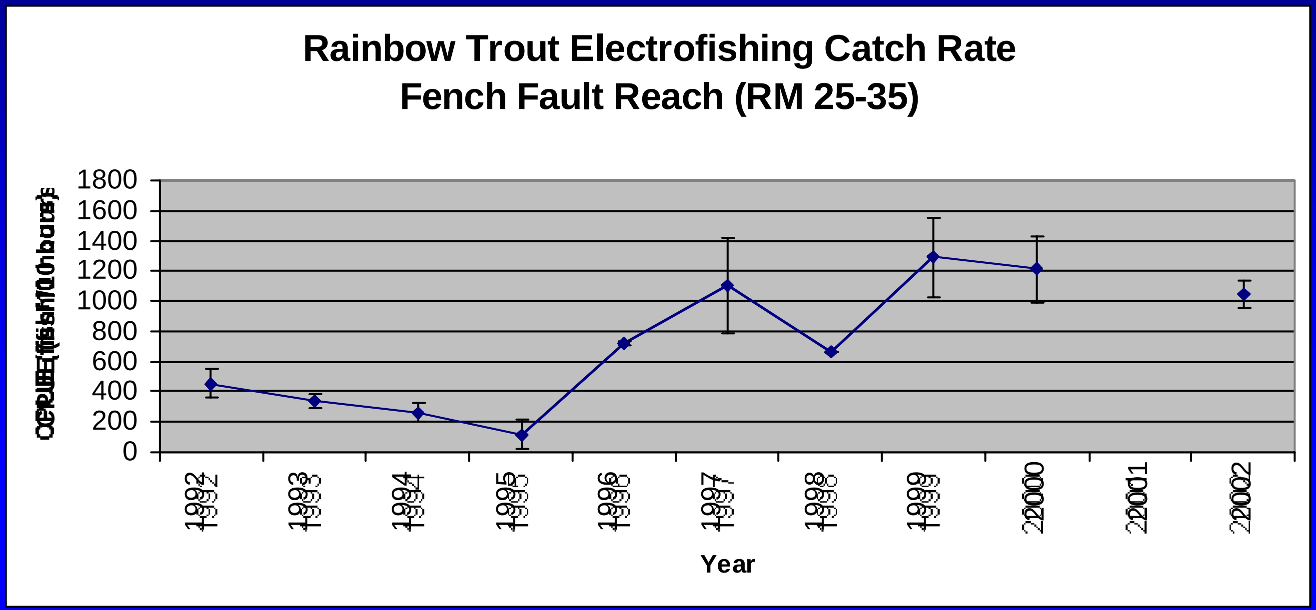
•Mechanical Removal Objectives:

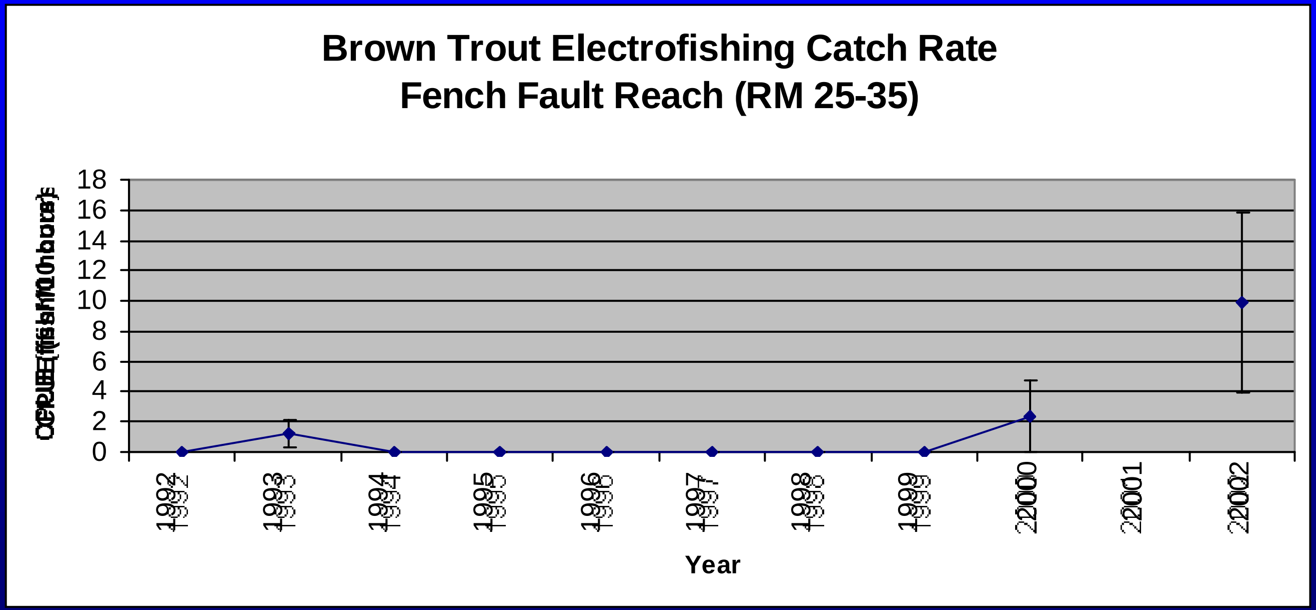
2. Evaluate piscivory as a function of: predator species, predator size, prey size, prey abundance, predator abundance.

3. Overtime, evaluate the relationship between rainbow and brown trout abundance and humpback chub recruitment and survival.

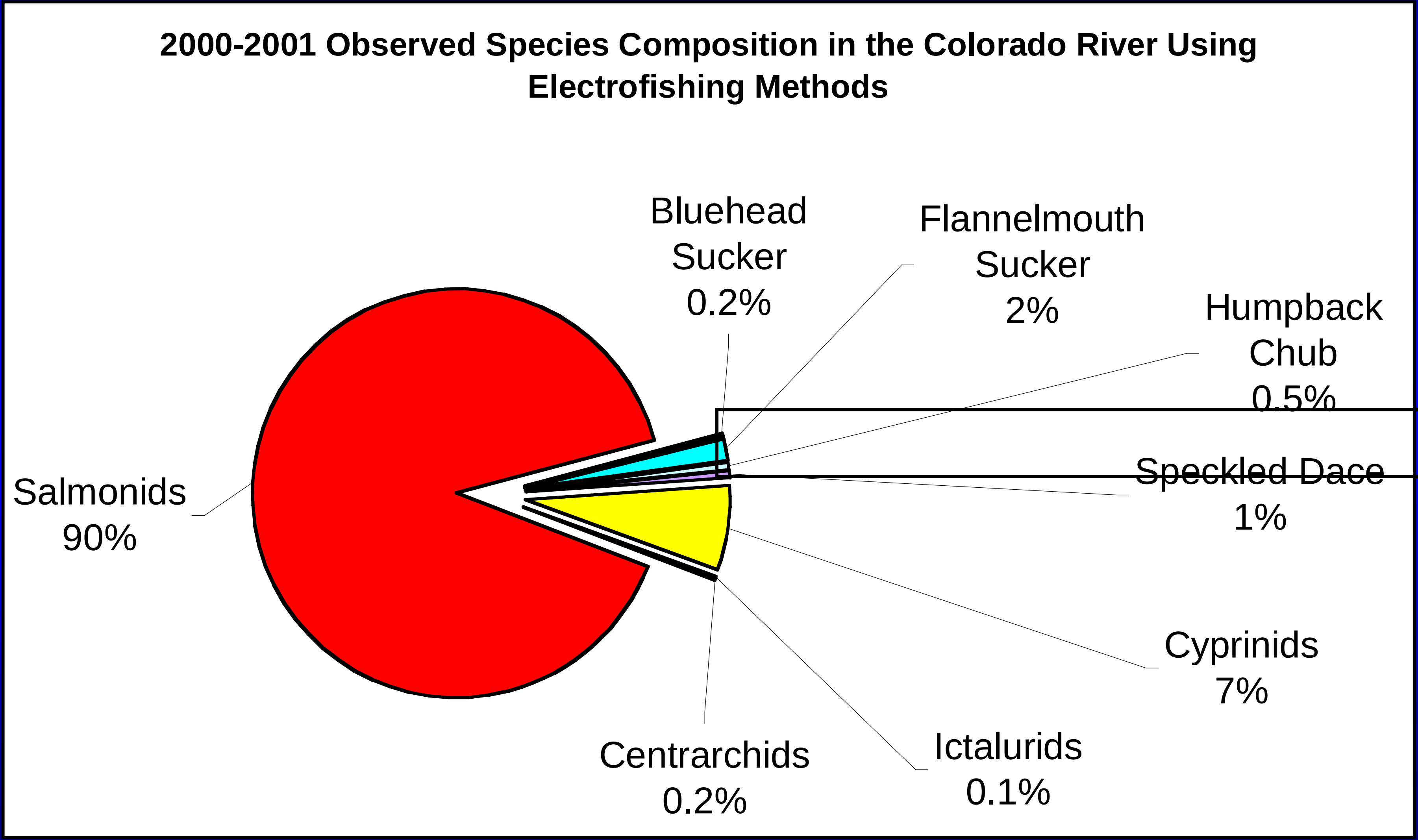


Recent Trends in Salmonid Abundance

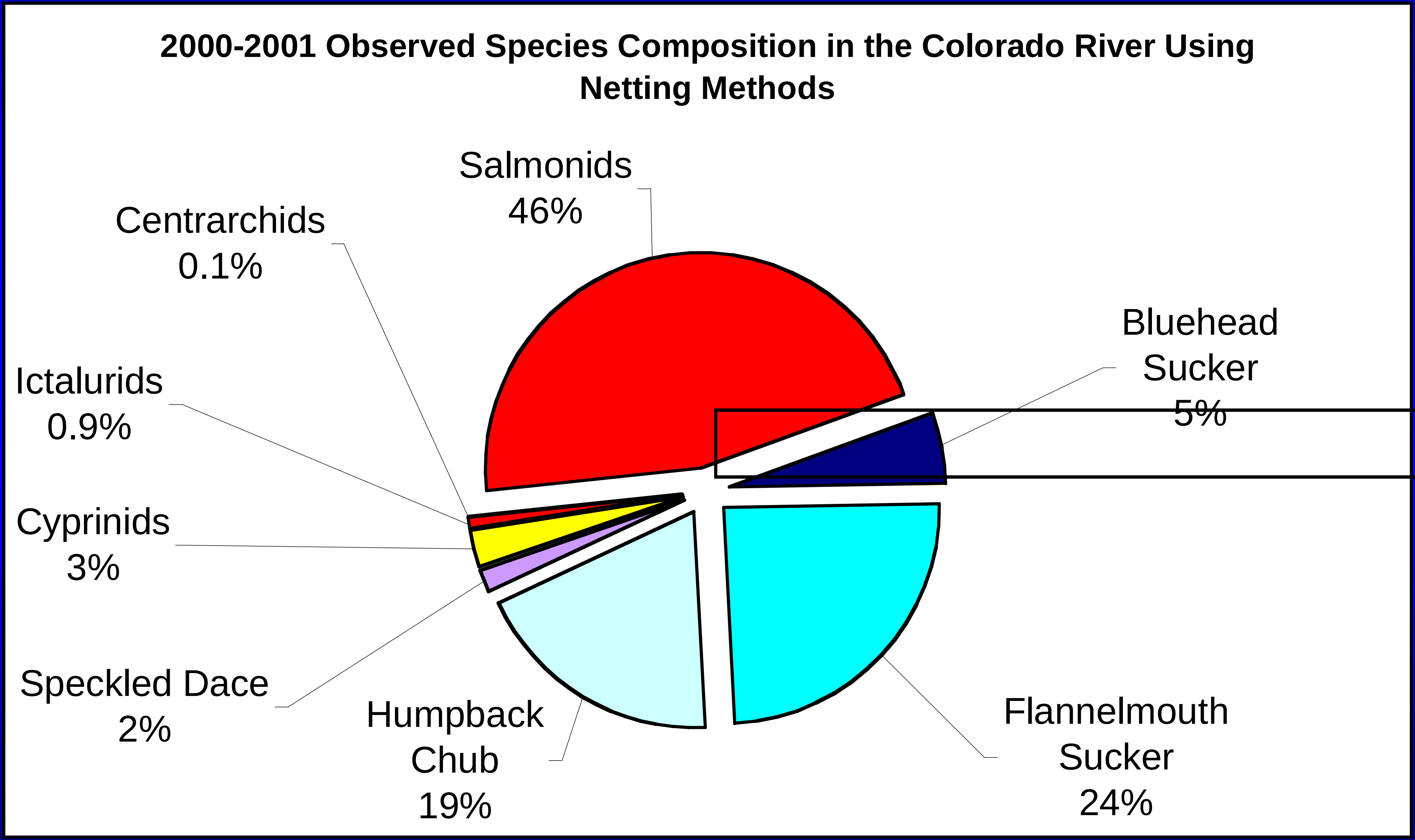




The Present Fish Community in Grand Canyon



The Present Fish Community in Grand Canyon



Core Fish Monitoring Projects-Lees Ferry Trout

- **4 annual monitoring trips to estimate electrofishing CPUE, abundance, size distribution, and PSD.**

Downstream Non-native Fish Monitoring *(primarily Salmonids and Carp)*

- **2 annual monitoring trips to estimate electrofishing CPUE, abundance, size distribution, and condition. Detect presence and distribution of all non-native species.**

LCR Humpback Chub monitoring

- 4 annual trips to estimate spring and fall abundance, spring spawning abundance, fall recruitment form previous year class, open population model to estimate recruitment and abundance using 1989-present PIT tag database

Downstream Native Fish Monitoring

- 2 annual trips to estimate relative abundance (CPUE), size distribution, condition (HBC, FMS, BHS). Look for HBC recruitment (changes in size distribution and mark rate).

Approximate Catch of HBC per trip based on 4 boats fishing 8 hours per night
Analysis based on Catch rates observed from October 1990 - January 2000 fr
Catch rates would likely be even lower if I had data summaries that included th
that we will be fishing (I.e. ~56 - 65).

		CPUE/10 hours		**Catch**	
	Effort/trip (hours)	HBC<200	HBC>=200	**HBC<200**	**HBC>=20**
Mean	320	11.94	0.45	**382**	**15**
Median	320	5.16	0.27	**165**	**9**
Minimum	320	0.00	0.00	**0**	**0**
Maximum	320	89.15	5.61	**2853**	**18**