Status and Management Strategy for Humpback Chub in Grand Canyon

Report of the Humpback Chub Ad Hoc Committee to the
Adaptive Management Work Group of the
Glen Canyon Dam Adaptive Management Program

May 22, 2003

1.0 INTRODUCTION

1.1 Background

In 2002 the Grand Canyon Monitoring and Research Center (GCMRC) reported a continuing decline in the Grand Canyon population of humpback chub (*Gila cypha*) (GCMRC 2003). Causes for the decline are unknown, but stock synthesis models indicate lower recruitment for most of the previous 10 years.

In response to concerns about the status of humpback chub on January 29, 2003, the Glen Canyon Dam Adaptive Management Work Group (AMWG) created the Humpback Chub Ad Hoc Committee and directed that the committee "… will consider actions to implement a comprehensive research and management program for the HBC (humpback chub) … (and make) a recommendation to the AMWG …." The approved motion further indicated that the Ad Hoc Committee would consist of individuals from the AMWG, TWG (Technical Work Group), GCMRC, and science advisors. The Ad Hoc was directed to develop recommendations and report to AMWG at a special session. Meetings of the Ad Hoc Committee were held February 12, March 12, April 1, 21, and 22, and May 6, 19, and 20, 2003. Conference calls were held April 16 and 25, 2003. Committee members are listed in Appendix A.

1.2 Charge to the Ad Hoc Committee

The Humpback Chub Ad Hoc Committee will consider actions to implement a comprehensive research and management program for the humpback chub. They will meet in preparation for making a recommendation to the AMWG.

2.0 STATUS OF HUMPBACK CHUB IN THE COLORADO RIVER BASIN

2.1 Status of Humpback Chub Population Grand Canyon

An overview of the status and trend of the Grand Canyon population of humpback chub was prepared by GCMRC for the AMWG on April 22, 2003 (see Appendix B). That report stated that recent analyses of historical data on humpback chub in Grand Canyon have caused considerable concern, because of uncertainties about the current size of the population and the strong probability that the population has been declining steadily for at least a decade. The most recent assessment indicates that the spawning

population is probably somewhere between 2,000 and 4,000 age-4 and older fish. A different estimate, using the "Supertag" assessment model, resulted in an estimate of 1,100-1,200 adults in 2001. Estimates of the LCR spawning population for 1992-1995 were 2,000-4,700 adults (Douglas and Marsh 1996). The assessment model also determined a lower level of recruitment (i.e., fish reaching maturity at age-4) over the last decade. The GCMRC report also stated that if recruitment continues to be stable at an average of the 1995-98 rate, the population will likely stabilize at 1,000-3,000 adults.

2.2 Status of Humpback Chub Populations in the Upper Colorado River Basin

There are currently six self-sustaining populations of humpback chub in the Colorado River Basin, including one in Grand Canyon and five in the upper basin. The six populations are in the following locations and their approximate numbers are as follows:

1. Yampa Canyon: Population small, about 400, based on model using 1998-2000 data (Haines and Modde 2002). Effort is being expanded in 2003 to develop a more precise estimate.
2. Desolation/Gray Canyon: Estimates from 2001 and 2002 were 1,500 and 1,700, respectively (Hudson and Jackson 2003a).
3. Black Rocks Canyon: About 1,000 (McAda 2002).
4. Westwater Canyon: 2,200-4,700 based on 3 sampling sites in 1998-2000 (Hudson and Jackson 2003b); effort is being expanded in 2003.
5. Cataract Canyon: About 500 (Valdez 2002); a mark-recapture effort will be investigated in 2003 (this effort was scheduled to begin in 2002 but was postponed due to low flows).
6. Grand Canyon: Between 2,000 and 4000 (GCMRC 2003).

Recovery goals exist for the humpback chub in the Colorado River Basin, and include all six populations (U.S. Fish and Wildlife Service 2002). They provide guidance on recovery of the species, basin-wide, and identify site-specific management actions, and objective, measurable criteria for achieving recovery. The Recovery Goals identify actions necessary to conserve and recover the Grand Canyon population of humpback chub, as well as the role of the Grand Canyon population in recovery of the species. They were used by the Ad Hoc Committee in the development of this comprehensive plan.

In regard to developing the proposals attached to this report, a need was identified for a coordinated effort to develop broad nonnative fish stocking procedures. The UCRRP developed procedures in the mid-1990s with goals potentially similar to these needs in mind (see Section 2.3). Also, a Recovery goal that is not identified in any of the current attached proposed projects is under Factor D – Adequate regulatory mechanisms: #9. mechanisms determined for legal protection of adequate habitat in mainstem Colorado River through the Grand Canyon and the Little Colorado River. This may be determined later, and much of it is probably already under Federal lands or could be included in future conservation plans that also need to be developed under Factor D.

2.3 Programs in the Colorado River Basin that Contribute to Humpback Chub Conservation

The Glen Canyon Dam Adaptive Management Program (GCDAMP). The GCDAMP is a conservation program that was established by the Secretary of the Interior in 1996 following the Record of Decision on the Environmental Impact Statement assessing operation of Glen Canyon Dam (U.S. Department of the Interior 1995). The AMWG is Federal Advisory committee that provides recommendations to the Secretary of the Interior regarding operation of Glen Canyon Dam and other measures to protect and/or enhance the Colorado River Ecosystem through Grand Canyon (i.e. mainstem Colorado River and its tributaries from Glen Canyon Dam downstream to Lake Mead National Recreation Area). The GCDAMP consists of a diverse group of stakeholders, including State and Federal agencies, water users, energy distributors, environmental groups, recreation interests, and American Indian tribes, that directs coordinated scientific studies conducted by the GCMRC of the U.S. Geological Survey. The GCDAMP addresses elements of the EIS on the operation of Glen Canyon Dam as well as the reasonable and prudent alternatives contained in a jeopardy biological opinion for the humpback chub and razorback sucker in Grand Canyon. This adaptive management program takes findings of the GCMRC and a group of Science Advisors as information for dam reoperations and conservation of the endangered fishes.

Upper Colorado River Endangered Fish Recovery Program (UCRRP): The UCRRP is a recovery program that was initiated under a Cooperative Agreement signed by the Secretary of the Interior on January 22, 1988, as a coordinated effort of State and Federal agencies, water users, energy distributors, and environmental groups to recover four endangered fishes in the upper basin downstream to Glen Canyon Dam, excluding the San Juan River (U.S. Department of the Interior 1987; Wydoski and Hamill 1991; Evans 1993). It functions under the general principles of adaptive management and consists of seven program elements, including instream flow protection; habitat restoration; reduction of nonnative fish and sportfish impacts; propagation and genetics management, research, monitoring, and data management; information and education; and program management. As stated in the governing document of the UCRRP (U.S. Department of the Interior 1987), the program goal is to recover the endangered fishes while allowing water development to proceed in compliance with State and Federal laws, including the Endangered Species Act (ESA), State water laws, interstate compacts, and Federal trust responsibilities to Native American tribes. Funding for the UCRRP will continue through 2011 under legislation passed in October 2000 (P.L. 106-392); Congress will review the UCRRP to determine if funding should be authorized beyond 2011.

Recovery Implementation Plan Scientific Workgroup (RIPSWG): In 1999, the U.S. Fish and Wildlife Service (USFWS), Region 2, convened a group of biologists, formally named the Scientific Workgroup, to develop a Recovery Implementation Plan for the native fishes of the Lower Colorado River Basin from Glen Canyon Dam to the Gulf of California (Mexico). Primary emphasis was to be placed on recovery of bonytail, humpback chub, Colorado pikeminnow, and razorback sucker. The RIPSWG met

regularly initially but then less frequently in subsequent years. The RIPSWG has begun more frequent meetings and this summer is scheduled to submit a draft management plan for the Lower Colorado River Basin to the USFWS Regional Director for the Southwest Region. A Comprehensive Action Plan for humpback chub in Grand Canyon could be wholly incorporated into the management plan that the RIPSWG is at this time developing.

Lower Colorado River Multi-Species Conservation Program (LCR-MSCP): The LCR-MSCP was established in response to environmental compliance needs of water and power entities in Arizona, California and Nevada. The LCR-MSCP is working toward the recovery of listed species, including the razorback sucker, bonytail, and humpback chub, while accommodating current water diversions and power production. In return LCR-MSCP stakeholders are seeking incidental take authorization under the ESA from the USFWS to allow for implementation of covered activities and conservation measures over the next 50 years. The LCR-MSCP planning area encompasses the Colorado River from the Lake Mead full pool elevation of 1229 feet to the Southerly International Boundary with Mexico. At this elevation, the inflow area of the Colorado River is influenced by the reservoir as far upstream as Separation Rapids (River Mile [RM] 239.5). This rapids is about 37 river miles upstream of Grand Wash Cliffs [RM 276.5], the western boundary of the GCDAMP, thus there is a geographic overlap between the two programs. LCR-MSCP has tentatively identified the need to support the AMWG program for humpback chub as follows: "Provide $10,000/year for 50 years (total: $500,000) to the Glen Canyon Dam Adaptive Management Workgroup to support implementation of planned, but unfunded, species conservation measures and, as appropriate, to fund species conservation measures in the lower canyon of the Colorado River upstream of Lake Mead."

3.0 THREATS TO HUMPBACK CHUB

Threats to humpback chub in Grand Canyon identified by the Ad Hoc Committee, correspond to threats identified in the Humpback Chub Recovery Goals (U.S. Fish and Wildlife Service 2002). Past and/or current threats to the humpback chub in Grand Canyon listed by recovery factor are as follows:

Recovery Factor A.— Adequate Habitat and Range for Recovered Populations Provided

1. Habitat affected by streamflow regulation
    - extreme daily flow fluctuations destabilize habitat, especially for young fish
2. Flows necessary for all life stages
    - high summer/fall base flows inundate juvenile rearing habitat
3. Cold water temperature
    - cold hypolimnetic releases inhibit egg hatching and larval survival
    - cause thermal shock of fish <50 mm TL descending from seasonally warmed tributaries

- enhance reproduction/survival of trout, predators of humpback chub

Recovery Factor B.—Protection from Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

4. Handling for scientific studies
    - repeated capture and marking (PIT tagging) may lead to delayed mortality
5. Effects of recreational use
    - Recreational use of the LCR may affect reproductive habitat or interfere with reproduction

Recovery Factor C.—Adequate Protection from Disease or Predation

6. Asian tapeworm, *Lernaea* anchor copepod
    - Asian tapeworm is currently at a high incidence of infestation in the Little Colorado River (LCR) (about 90% of large juveniles and adults are infested); require cyclopoid copepod as intermediate host, require 20 C to mature and reproduce; severe infestation can impact gut, lead to death
    - *Lernaea* anchor copepod; require 20°C to mature and reproduce; usually does not lead to death, although anchor wounds may fester and infect
    - Note: whirling disease and intestinal nematodes are not found in humpback chub, but could become problematic for trout in the tailwater fishery with warmer water temperatures.
7. Escape of nonnative fish into the Colorado River and its tributaries in Grand Canyon
    - Numerous potential predators and competitors of humpback chub occupy various tributaries and can invade Grand Canyon, given suitable conditions
8. Predation by nonnative warm water fish species
    - Channel catfish and black bullhead are known predators of humpback chub
    - Common carp may consume large numbers of incubating eggs
    - Red shiners and fathead minnows compete with and prey upon young native fish in nursery habitats
9. Predation by nonnative cold water fish species
    - Brown trout and rainbow trout are known predators of humpback chub

Recovery Factor D.—Adequate Existing Regulatory Mechanisms

10. Protection of habitat and flow
    - Long-term legal protection of habitat and flow in the LCR and mainstem is necessary for long-term conservation of humpback chub
11. Need for Conservation Plans
    - Recovery Goals call for Conservation Plans to be implemented at the time of delisting to assure continued and long-term conservation of humpback chub

Recovery Factor E.—Other Natural or Manmade Factors for which Protection Has Been Provided

12. Non-source pollutants in the LCR watershed
    - A number of potential sources of hazardous materials exist in the LCR watershed. Collectively, these affect water quality in occupied and critical habitat in the LCR and could affect reproduction and survival of all life stages of humpback chub
13. Hazardous materials spills at the Cameron Bridges
    - A spill from an overturned tanker truck at one of the Cameron Bridges could be transported downstream to occupied and critical habitat, resulting in possible losses of all ages of humpback chub at the only spawning location for the species in Grand Canyon

Threats to the species and corresponding recommended management actions are provided in the strategy section 4.0 and the project timeline shown in Appendix D. Of the 13 threats previously identified, addressing some requires more immediate attention than others. The immediate threats to humpback chub in Grand Canyon and current actions are linked to the following:

- Flow regimes from dam releases: The effects of dam releases are not fully understood, but experimental flows continue to provide information under adaptive management.

- Water temperature: Cold water releases are known to inhibit mainstem reproduction, swimming ability, and growth of humpback chub. A risk assessment is currently being conducted by Bureau of Reclamation for a temperature control device on Glen Canyon Dam. If environmental compliance proceeds on schedule, a temperature control device (TCD) could be in place by spring of 2007 to provide a tool for warming downstream releases. Meantime, some aspects of experimental flows (i.e., low steady releases) could provide for some longitudinal and near-shore warming that may benefit survival and growth of humpback chub.

- Predators: Predator control was implemented in 2003 for rainbow trout and brown trout in the mainstem near the LCR inflow and for brown trout in Bright Angel Creek. These efforts should be continued, since predation is perceived as a major threat to humpback chub in Grand Canyon.

- Hazardous materials spills: The risk of hazardous materials spills continues to loom over the LCR. Immediate actions are needed to implement a plan to minimize the risk and for cleanup.

- Parasites: Asian tapeworms and *Lernaea* anchor copepods are the two parasites of most concern for humpback chub; investigations

should continue to assess extent of infestation, risk of warmer water from a TCD, and possibly treatment for reducing infestation to the population.

4.0 STRATEGY FOR IMPROVING CONDITIONS FOR HUMPBACK CHUB

Our goal is to remove jeopardy and assist in achieving recovery goals for humpback chub in Grand Canyon by expanding the population size and reducing threats to the humpback chub. This will be accomplished by (1) expanding the range of spawning and rearing in Grand Canyon for humpback chub, (2) increasing survival and recruitment of humpback chub, and (3) reducing the threat of catastrophic events or unintended consequences that may negatively affect the wild population of humpback chub.

4.1 Expanding the Range of Spawning and Rearing for Humpback Chub

The primary mechanism for expanding range would be to increase the suitability of the mainstem for reproduction and recruitment of humpback chub. This would be accomplished by warming dam releases and providing flows necessary for spawning and rearing.

Until the TCD is approved and constructed, actions such as the translocation of young humpback chub from the LCR into Grand Canyon tributaries and/or mainstem could provide safe refugia for wild fish and possibly expand the current range of humpback chub. To be successful, translocations would need to occur concurrently with non-native control efforts, and with consideration of other factors such as water quality, flows, and tribal concerns. Use of a grow-out facility may be considered to increase growth and survival of wild fish to be translocated. If there are genetic concerns, these would need to be addressed, perhaps through establishing connectivity between the tributary populations and the mainstem population or other actions. These genetic concerns will be evaluated by conservation geneticists.

4.2 Increasing Survival and Recruitment of Humpback Chub

This would be accomplished through a combination of temperature modification, non-native control, dam operations, turbidity management, control of disease and parasites, reduction of impacts of scientific and recreational activities, and preventing invasion of new non-native species. These actions may include:

(1) Construct and test a temperature control device with the intent of improving spawning and rearing habitat in the mainstem for humpback chub. Providing adequate temperatures for mainstem spawning and rearing may increase other threats such as non-native predation and parasitic infestation.
(2) Control non-native predators and competitors to reduce impacts to humpback chub and other native species. This would also help ensure that any negative impacts from temperature modification would not be on top of an already high predator/competitor load. Additional research may be needed to determine which non-natives have the

greatest impact on humpback chub mortality. Mainstem and tributary control actions would target non-native species using a variety of methods. Monitoring of native and non-native fish species must be able to detect changes in these populations that may result from management actions, e.g., non-native control efforts and the warming of dam releases. Development of a stocking plan for non-native fish similar to the agreement between the Fish and Wildlife Service and the states of Utah and Colorado would help to prevent further incursions of predators and competitors into Grand Canyon.

(3) Use experimental dam releases to reduce mortality of young-of-year (YOY) humpback chub leaving the LCR, particularly prior to operation of the TCD. These actions may include releases that would impound the LCR during periods when young humpback chub are leaving the LCR, stabilize habitat near the LCR confluence, reduce non-native spawning and recruitment, displace or disadvantage non-native fish, and maintain levels of turbidity that reduce predation by sight-feeding non-natives in the mainstem. Following construction of the TCD, the focus of dam operations might change to improving spawning and rearing habitat for native fish in the mainstem and controlling the spread of non-natives and parasites.

(4) Control parasites and diseases. Additional monitoring and research is needed to determine the level of infestation and to develop control methods. Warmer dam releases may increase the spread or impact of parasites on humpback chub in the mainstem.

(5) Use other management actions such as sediment/turbidity augmentation (to disadvantage non-native fish and provide cover for native species), invasive species management plans, and reduction of impacts from scientific and recreational uses.

4.3 Reducing the Threat of Catastrophic Events

There is a risk of extirpation from catastrophic events in the LCR because it is currently the principle spawning location for humpback chub in Grand Canyon and is occupied by much of the population at any given time. Also, operation of the TCD and other management actions intended to benefit the humpback chub carry the risk of unintended consequences that may negatively affect the humpback chub population. The Science Advisors are currently evaluating the risks associated with the TCD, and the NEPA evaluation of the TCD will include actions that would be taken if negative consequences occur.

The top priorities to protect against such risks are (1) expand the range of the population both above and below the LCR confluence (both mainstem and tributaries) so that a catastrophic event is less likely to negatively affect the population, (2) develop and implement an action plan to alleviate threats that originate in the LCR watershed, and (3) establish a captive breeding population for restoring the Grand Canyon population in case of extirpation.

A genetics management plan should be prepared that guides preservation of the genetic diversity of the humpback chub in Grand Canyon. Developing a captive breeding population needs to follow this peer-reviewed comprehensive plan as well as USFWS

policy on controlled propagation. Developing the broodstock should not compromise the viability of any extant aggregations (i.e., it may be appropriate only to collect gametes or YOY from the mainstem aggregations). Gametes, YOY, or adult fish may be collected specifically for a new captive breeding population following development of the comprehensive plan and genetic analysis. The disposition and use of the existing humpback chub at Willow Beach National Fish Hatchery must be determined, and may include research or serving as part of a captive breeding population.

5.0 PROPOSED PROJECTS AND IMPLICATIONS TO OTHER RESOURCES FROM IMPLEMENTATION

The Ad Hoc Committee developed a number of proposed projects to address threats to humpback chub, included as Appendix C, and a timeline chart, included as Appendix D. Potential completion of a TCD on Glen Canyon Dam in spring 2007 would create a major landmark in terms of management actions, research, and monitoring.

Implementation of management actions to benefit the humpback chub may impact other resources in Grand Canyon. These impacts may occur as a result of redirected efforts and funding of humpback chub research and monitoring. Implementation of these management actions must be done consistent with the mission and management objectives of the GCDAMP. Management actions recommended in this report are intended to complement and support the mission of GCDAMP, but it is also recognized that implementing a part or all of these management actions will likely require additional funding.

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APPENDIX A:

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APPENDIX B: GCMRC HBC Status Report

AN OVERVIEW OF STATUS AND TREND INFORMATION FOR THE GRAND CANYON POPULATION OF THE HUMPBACK CHUB, *Gila Cypha*[1]

Prepared by the
Grand Canyon Monitoring and Research Center
U.S. Geological Survey, Flagstaff, AZ[2]

For the
Glen Canyon Dam Adaptive Management Work Group
Ad Hoc Committee on Humpback Chub
April 22, 2003

[1] Includes a critique of past population estimates– see Table 1.

[2] Contributing authors: Lew Coggins, Carl Walters, Craig Paukert, Steve Gloss

CURRENT STOCK ASSESSMENT METHODS IN SUPPORT OF ADAPTIVE MANAGEMENT FOR GRAND CANYON HUMPBACK CHUB

Recent analyses of historical data on humpback chub in Grand Canyon have caused considerable consternation because of uncertainties about the current size of the population and because of the strong probability that the population has been declining steadily for at least a decade. Our most recent assessment models indicate that the current spawning population is probably somewhere between 2000 and 4000 age 4 and older fish, i.e. suggesting this population might be considered as contributing to ESA delisting based on the current population abundance, but has likely declined by at least 50% since 1990, i.e. does not meet the stable population criterion for delisting (Figures 1-3). We remain quite uncertain about the absolute population size because of uncertainties about whether field procedures have met some assumptions of the main method used to estimate absolute abundance (mark-recapture sampling) and because of limited sample sizes, but all the assessment methods clearly agree that the population is in decline. This includes not only the mark-recapture population estimates, but also several population trend indices based on catch-per-effort (CPUE) in sampling gear that has been fished consistently over the years (Figure 4). Only one trend indexing method, trammel netting in the Colorado River mainstem, fails to indicate a downward trend in abundance. This is likely due to high variability in trammel net CPUE and previous sampling targeting known aggregations of humpback chub.

One assessment model (called "Supertag") resulted in a considerably lower estimate for recent adult abundance (1100-1200 fish in 2001), but we now believe that estimate was biased downward because of using two inappropriate assumptions in the calculations: the population was assumed to have a stable age structure in the early 1990s, and older chubs were assumed to be equally vulnerable to sampling programs. Grand Canyon assessments and data analyses are greatly complicated by the migratory life history of the chubs that spawn in the Little Colorado River (LCR) and by inconsistency over the years in sampling relative to the timing of the spawning migration. Older fish are over-represented in samples taken in the LCR during spawning runs, but are underrepresented in samples taken there outside the spawning season. The opposite effect occurs in mainstem sampling. Further, there are indications that older fish do not spawn every year, making them less vulnerable to sampling when sampling effort was/is concentrated in the LCR where it is easy to catch fish for marking. The Supertag method did not account for these complexities in interpretation of historical data.

There are two strategic options for monitoring and population assessment in Grand Canyon: (1) make independent population (and/or trend index) estimates each year using multiple-trip mark-recapture experiments (mark fish on successive trips and measure the proportion of the population made up by these "known" marked numbers) along with index CPUE sampling; and/or (2) use more elaborate stock assessment models to integrate current and past information into more complex estimators of current abundance. It should be noted that virtually all fisheries management programs for important harvested fish stocks are based on integrated assessment approaches, particularly considering that annual point estimates can "bounce around" a lot due to chance sampling factors so that if each estimate were taken too seriously there would be inappropriate (unnecessary or even dangerous) management responses to those chance factors. It might make scientists more comfortable to pretend that only the most recent, independently

collected data are to be used for calculating population size, without any assumptions about historical data. However, at some point the noisy independent estimates must be somehow integrated into longer-term assessments of population change. One way to do that integration is to plot the independent estimates then use visual or statistical regression methods to identify trend patterns. The problem with this simple "state reconstruction" approach is that it fails to offer guidance about causes of decline (e.g. changes in recruitment of young fish versus changes in survival rate) and to properly weight estimates of varying quality due to changes over the years in sampling methods, locations, etc.

Within-year methods for stock assessment using mark-recapture experiments are easily understood. We go out and mark a known number of fish, then examine what proportion of later samples are made up of these individuals. So for example if we mark 500 fish, and find that marked fish are 20% of the fish seen in recapture samples later that year, we would conclude that 500 is 20% of the population size, i.e. the population size was 2500. It does not, of course, work this nicely in the field. The percentage of fish marked in recapture samples can vary a lot by chance alone (luck of the draw): marked fish may be less vulnerable to capture later than unmarked ones (wariness, movement induced by sampling), movement of fish into and out of the marking region may dilute the mark rate, and there may be differential loss of tagged fish or tags. So any single point estimate must be treated with great caution.

More complex assessment models, such as the ones we have called "ASMR" (Age-Specific Mark-Recapture) and "Supertag" in Grand Canyon studies, attempt to integrate information and estimates over time by using knowledge or assumptions about how the observations are linked through population dynamics processes. That is, we first build an accounting model for population changes (how the numbers of fish of each age die off over time over the months and years after they recruit to the population), then use this model to predict the observed historical data (both within the most recent year and from past years), then use statistical estimation methods to find the population model parameters (recruitment and survival rates) that best agree with the data. So when such a method is "looking" at the 2001 data, it is using calculations of the 2001 population structure (numbers of fish of various ages) that are based in part on observations of those fish made in earlier years when the fish were younger. Any such approach requires a key assumption, namely that the survival rates of fish from year to year are at least somewhat predictable. Part of the model development and testing process is to search for indications about whether such assumptions have been violated. We do see some indications that survival rates of age 3 and older chub have varied over time, and there is consistent, strong variation in survival rate with age of fish—older fish appear to have consistently higher annual survival rates.

One way to think about the integrated assessment methods is that they produce point estimates for each year of population trend, as we could obtain from fitting a line through independent annual population estimates. But the points along the assessment model trend line are calculated from population dynamics accounting relationships (recruitment and survival) rather than just some trend formula that is "unconstrained" by any knowledge of ecological relationships that have given rise to the trend. Further, the assessment model trend estimate for each year consists of both fish that were seen (tagged) in earlier years (and are likely to have survived to the year in question), and fish that were first seen in later years, but at sizes and ages implying that they

must have been present in that year. That is, the assessment model trend estimates use sampling information both forward and backward in time, and thus should be most accurate for years (mid 1990s) where there are many surrounding observations. Conversely, they are least accurate for the most recent year(s), particularly for younger (recruiting) fish, about which we have the fewest direct observations.

Integrated assessment methods involve first constructing a population accounting model, to produce a table of predicted numbers of fish at age (or size) over time given input estimates of initial age structure, recruitments, and age-time survival patterns. These predicted numbers are then compared to observed capture and recapture patterns, using statistical measures called "likelihood functions" that estimate the odds of obtaining the data if the population model estimates were correct. Then the model estimates are systematically varied (using computer search routines) to seek the "maximum likelihood" estimates. There are two basic ways to carry out the population accounting calculations, called "stock synthesis" and "virtual population analysis".

In the stock synthesis approach, the numbers of fish of each age present in 1989 and each cohort of young fish recruited since 1989 is treated as a separate unknown, and population structure is calculated forward in time from these starting numbers. This is what we did with "Supertag", and to reduce the number of unknowns we assumed the population to have a stable age structure in 1989. We did not notice that the size-age data available for the early 1990s contain a much larger proportion of older fish than would a stable age distribution, and we now interpret that bulge as indicative of considerably higher recruitments during the 1970s-80s than in more recent years.

In the virtual population analysis approach, we simply reverse the population accounting calculations. We initialize the accounting calculations with estimates of numbers of fish at age in the most recent year, and we back-calculate how many additional fish must have been present in earlier years (and ages) in order to account for numbers of fish tagged and recaptured over time while allowing for natural mortality along the way. We believe that this approach gives a much better estimate of the population age structure in 1989, from which we can make inferences about how much higher recruitments must have been prior to 1989 in order to have produced that initial age structure. This approach has been implemented in a relatively simple (annual data only) way in a spreadsheet model called "Tagage" or " Annual -ASMR", and we are currently developing a much more detailed implementation that will make better use of within-year information (e.g. within-year mark-recapture observations; Monthly - ASMR) to improve the estimates of both long-term recruitment trend and of the most recent population size.

In Grand Canyon adaptive management, a key issue is whether various management policies can improve humpback chub juvenile survival and recruitment. Integrated stock assessment methods are particularly critical for recruitment assessments. Our first real chance to look quantitatively at the abundance of each year class or cohort of chubs as it recruits, is in the late fall of the year after that cohort has reached age 2+, when many of the fish have reached the 150mm body length at which it is safe to tag them with PIT tags. In the last few years, fall mark-recapture programs in the Little Colorado River have started to give us such early point estimates of recruitment, but these estimates are quite unreliable (unknown and variable proportion of each cohort large

enough to tag, unknown proportions of fish attempting to rear in mainstem vs LCR, relatively low numbers of fish captured and recaptured). If such noisy early estimates were our only recruitment "indices", we would have serious doubts interpreting the results of any experiment aimed at improving recruitment (e.g. exotic fish removal). But with stock assessment models, we can integrate these early estimates with data collected in subsequent years as the fish grow and become fully vulnerable to tagging (and other indexing methods). This integration still requires assumptions about stability of survival rates (otherwise when we first see some of the recruits from a given cohort as 3-yr olds, 4-yr olds, etc. we would have no way to estimate how many additional young fish must have been present earlier in order to have produced these survivors).

Stock assessment data analysis should be viewed to some degree as a problem in risk management, where we must tradeoff between using noisy point sample (short-term mark-recapture and catch per effort index) information, versus using more complex methods built around assumptions (particularly about stability of survival rates over time) that cannot be fully tested with the available historical data. We can demonstrate that assessments of population trend (but not current abundance) are highly robust to such assumptions (we get about the same downward trend pattern for every survival assumption that we have thought to test so far). Furthermore this downward trend suggested by the stock assessment models is also indicated by independent catch rate data (a measure of relative abundance) in the LCR. However, this does not mean that we have obtained the "correct" answer to date. In short, there is no fundamentally "right" or "wrong" methodology, and no single "best" estimate of stock status and trend.

There has been some demand by Grand Canyon stakeholders to "give us a number" representing scientific consensus about the best assessment methodology and best point estimate of current chub stock size. Such demands are common in fisheries assessment and management situations in general, and represent a fundamental misunderstanding (or deliberate misrepresentation) about what scientists can and should provide. What we can provide is a set of probability distributions for stock size and trend, based on alternative assumptions about the data.

Scientists cannot, and should not, be expected to agree upon how to deal with the risk management problem of which assumptions to "trust", and for us to pretend such consensus might exist would be dishonest and misleading. Moreover, it is not a requirement or even a real need for effective policy design that we do produce a particular number or estimate. Perfectly reasonable judgments about management can be made on the basis of probabilistic assessments and statements about relative likelihood of various outcomes, just as humans must do in practically all decision situations that involve substantial public and private investments. To demand a single number from scientists is as unrealistic as it would be for a stock market investor to demand a single earnings number from a stockbroker. However, your stockbroker may be able to give sound advice about how your portfolio is trending and whether or not strategic changes in your investments are wise. It is this type of information that we are able to provide relative to status and trends of humpback population dynamics. Although there is considerable uncertainty in the absolute abundance of humpback chub, particularly with regard to most recent abundance, the suite of models including competing assumptions and formulations all depict a "down-turn in the market" (Figure 6).

Probably the most important judgment call that needs to be made soon in relation to humpback chub is whether to abandon planned testing of various simple options for improving juvenile survival in favor of treating the evidence of recent spawning stock decline as an "emergency" warranting simultaneous application of a whole suite of mitigation measures (TCD, hatchery supplementation, etc.). Straight-line extrapolation of the recent trend estimates would imply a significant risk of extinction for the LCR spawning population within the next 10-15 years. However, this prediction is not supported by estimates of recruitment rates of 2-year old fish. Those rates appear to have been relatively stable since the early 1990s, though at considerably lower levels than would be needed to maintain the spawning population at 1989 levels. If recruitments continue to be stable, we predict that the spawning population will soon stop declining, and will stabilize at an average spawning abundance of roughly 50% of its current level, and that average will most likely be between 1000 and 2500 fish (Figure 7). That is, the assessment data do not in fact support demands for emergency policy actions. In terms of present, (and almost certainly continuing) uncertainty about the stock size estimates, it is hard to imagine picking a worse target or goal to try to confirm or deny than the current recovery goal of 2000 fish. Given existing investments in stock assessment data gathering, there is almost no chance that we will be able to say confidently whether or not this goal has been exceeded over the next decade, unless there is some really dramatic and obvious change in recruitment rate.

So what should be done…..?

Stay the present course of experimental actions using reasoned responses and treatments to inform future decisions. Be active about policy experimentation to promote learning and reduce uncertainty while simultaneously developing contingency plans for 'emergency ' actions. Then use this toolbox of actions as an attempt to thwart extinction of this population in the next few years if further decline and lack of stability in the population becomes more apparent. A number of these actions, e.g. rearing young of the year fish in a hatchery or in another tributary as a refugia population, could be implemented sooner rather than later without materially affecting our ability to 'learn' about responses to management actions.

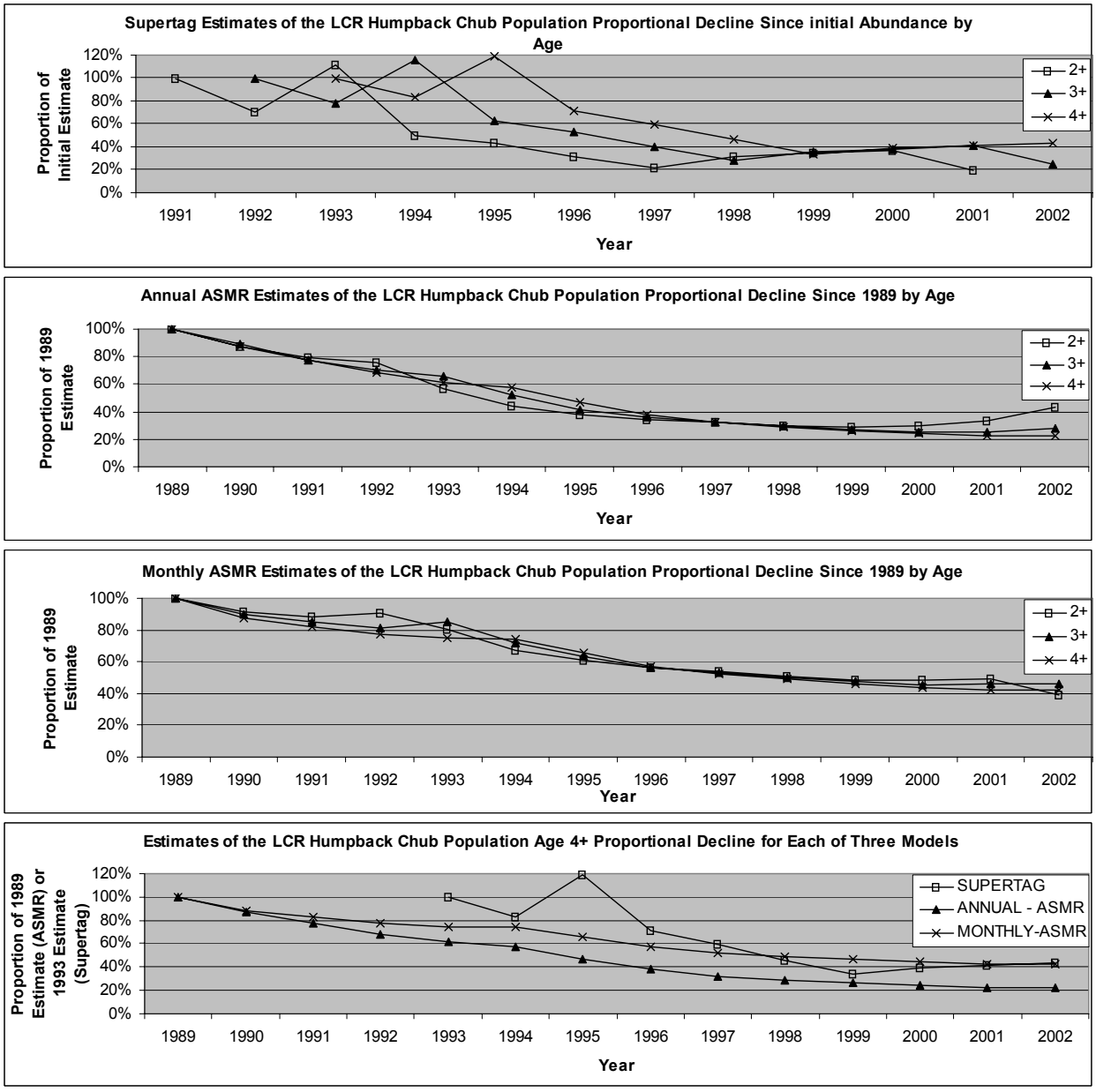


Figure 1 Estimates of proportional decline (ages 2+, 3+, and 4+) from three open population models.

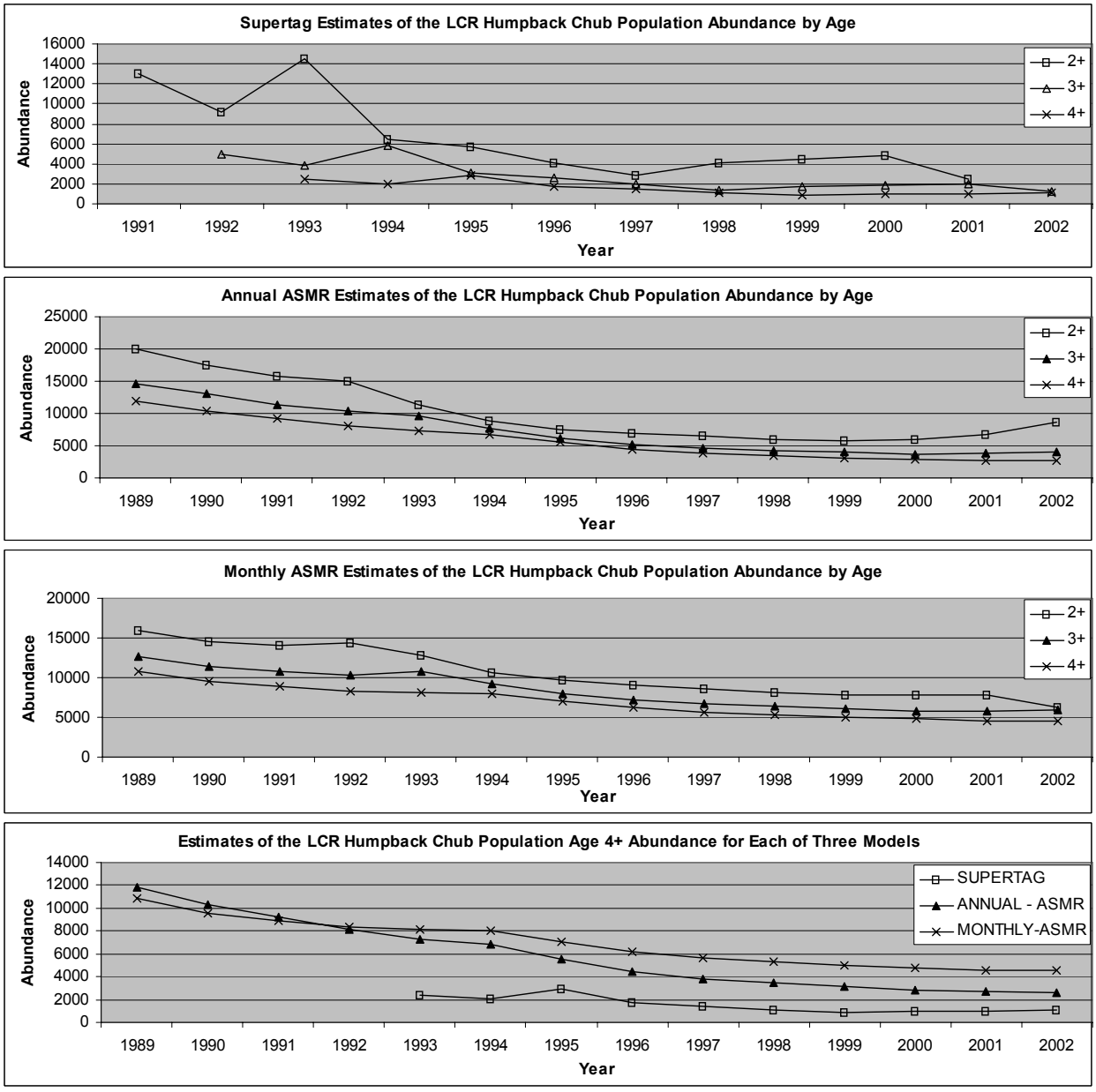
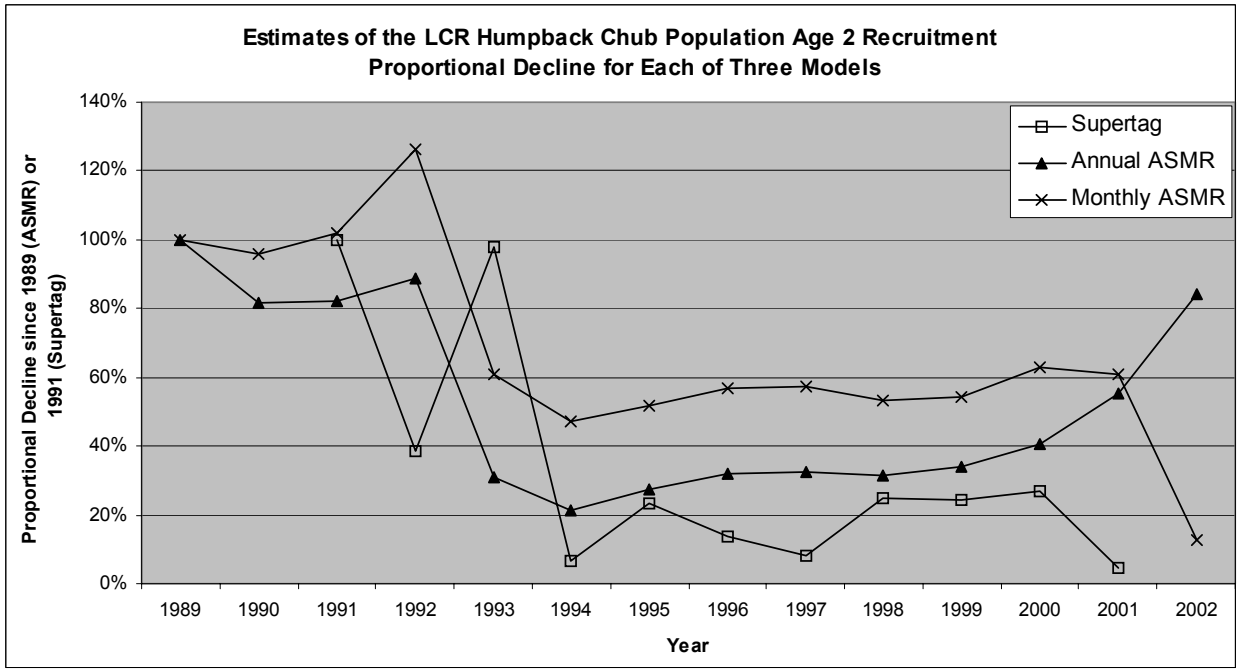


Figure 2 Estimates of abundance (ages 2+, 3+, and 4+) from three open population models.



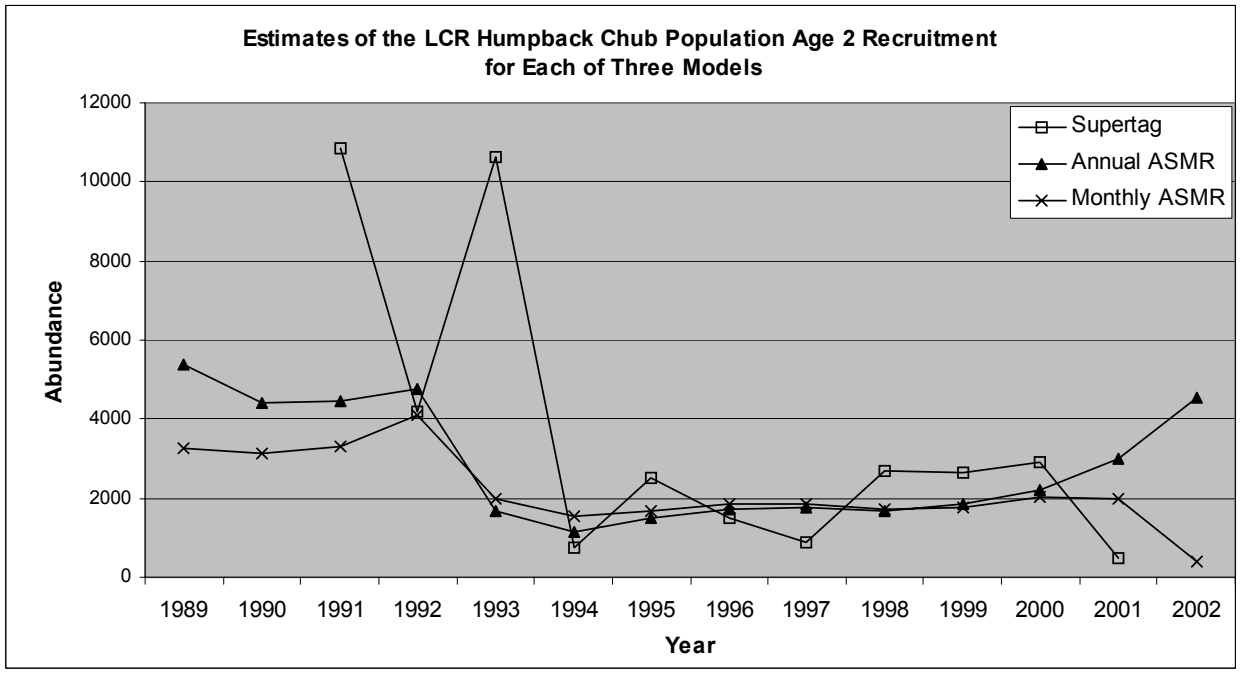


Figure 3 Estimates of recruitment (proportional decline and absolute abundance) from three open population models.

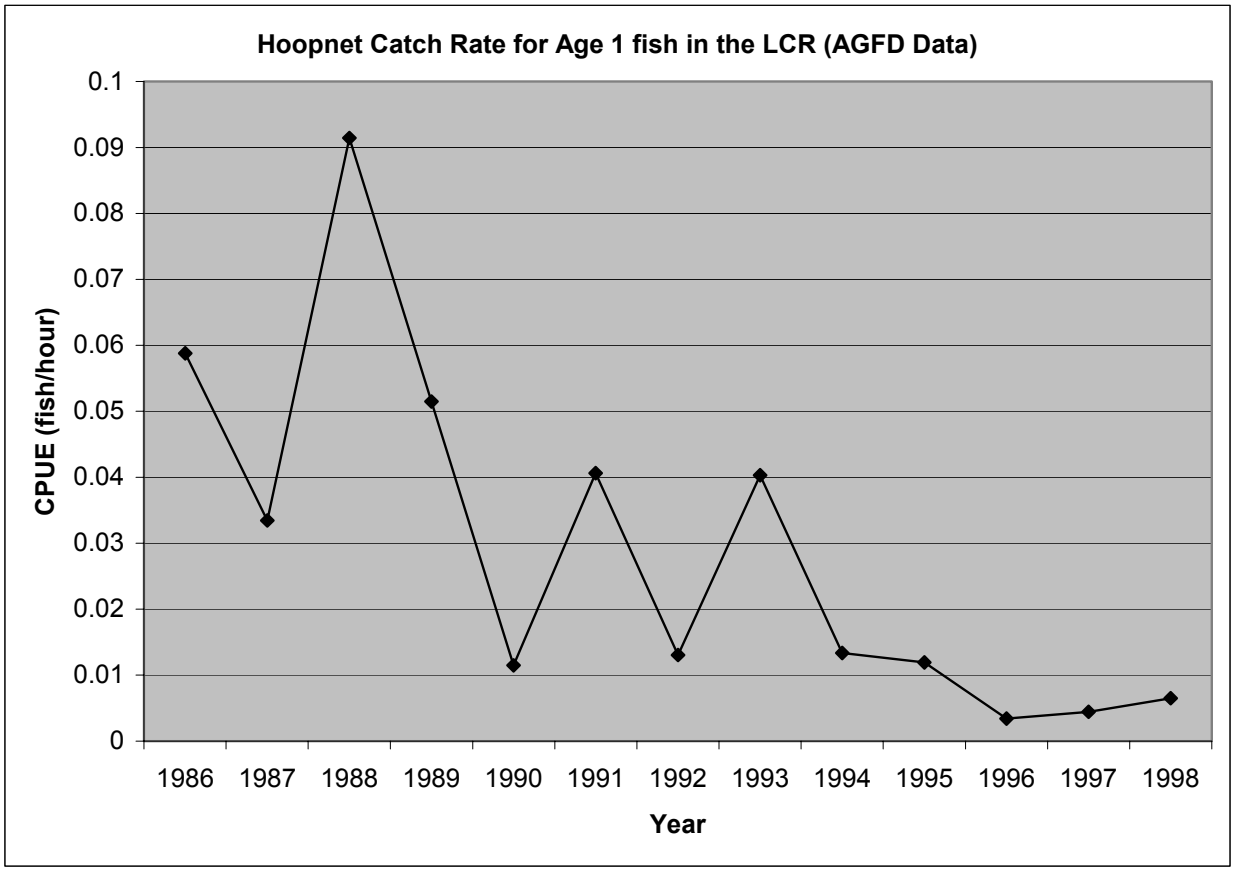


Figure 4 Estimated catch rate (CPUE) from hoopnet sampling in the LCR.

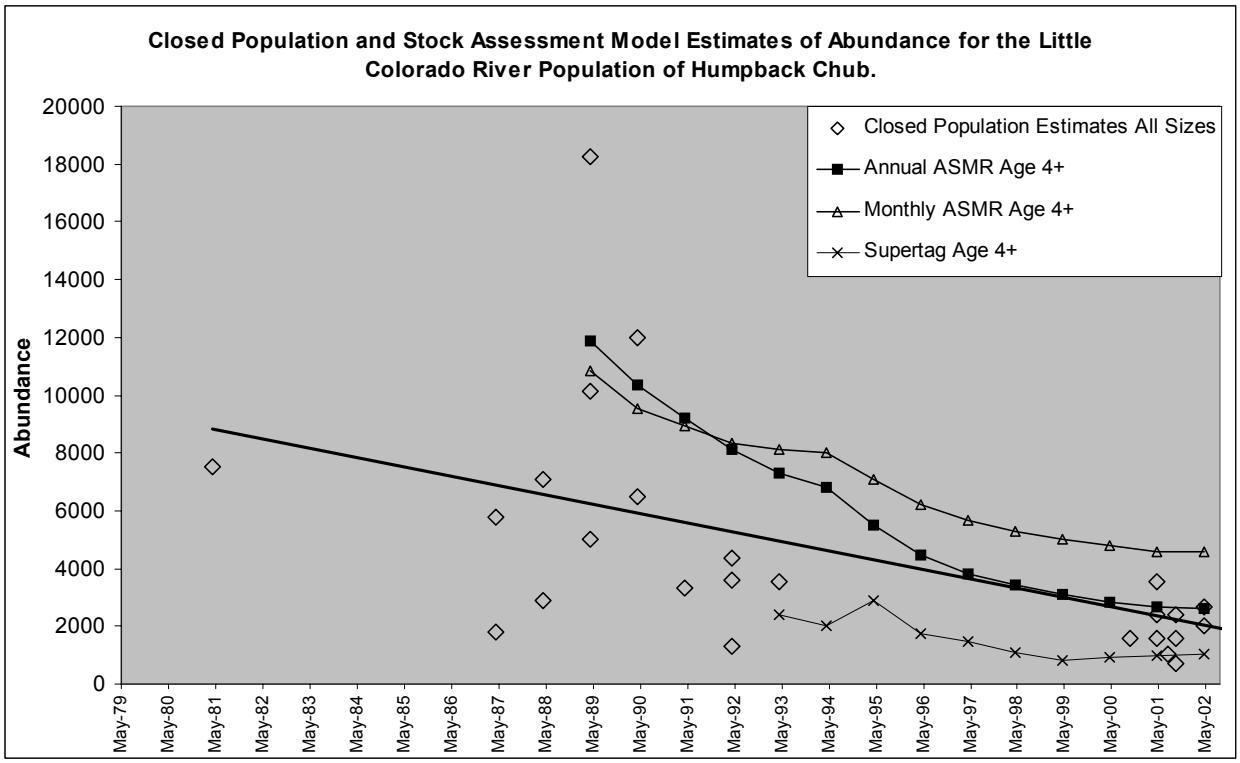


Figure 5 Closed and open population model estimates of the abundance of the LCR humpback chub population. The sources and "quality" of closed population estimates plotted in Figure 5 are described in Table 1. This table is followed by Figures 8-13, which depict the population trend using all or selected combinations of these point estimate data

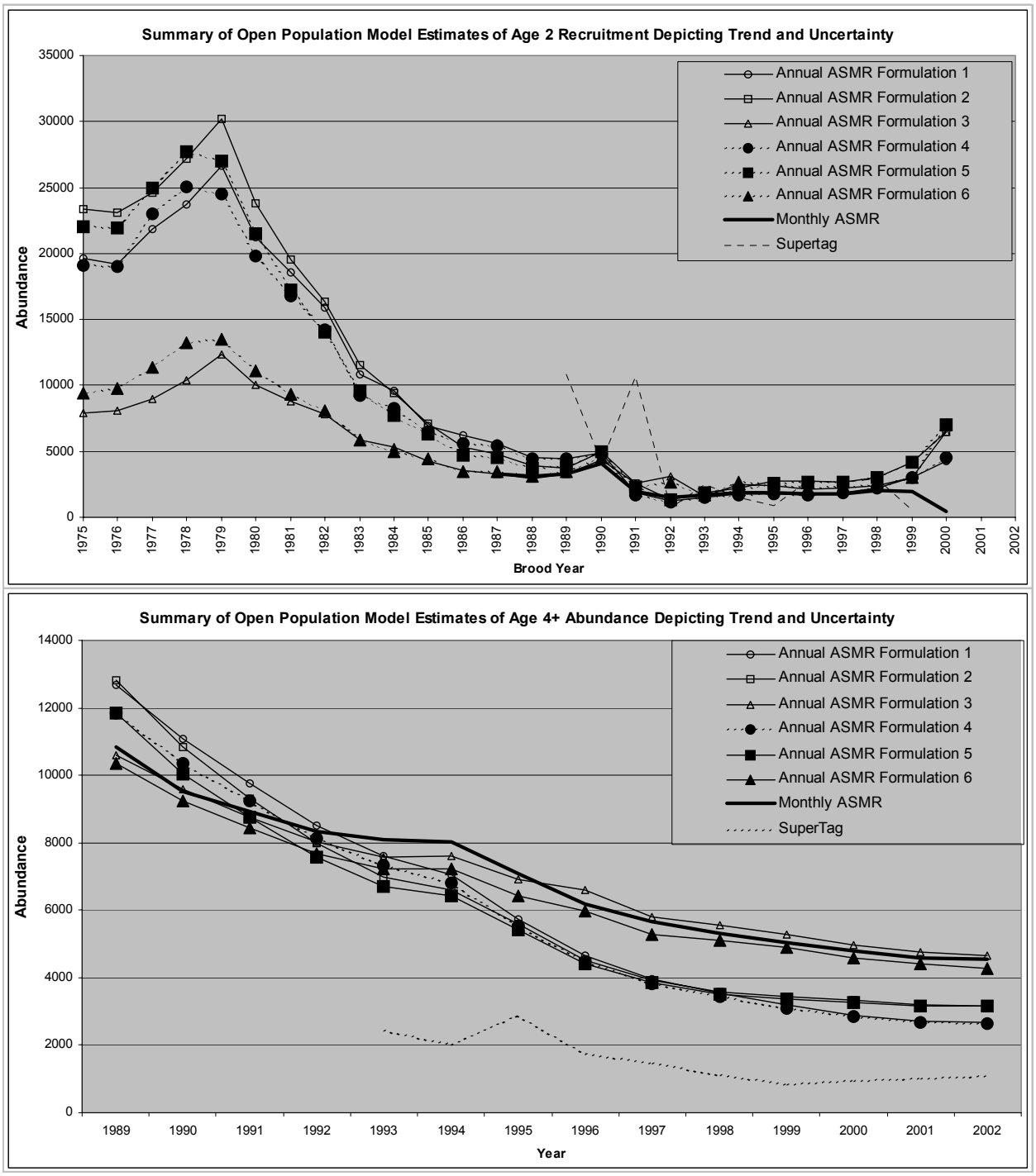


Figure 6 Summary of the LCR humpback chub abundance estimates (ages 2 and 4+) among different open population models.

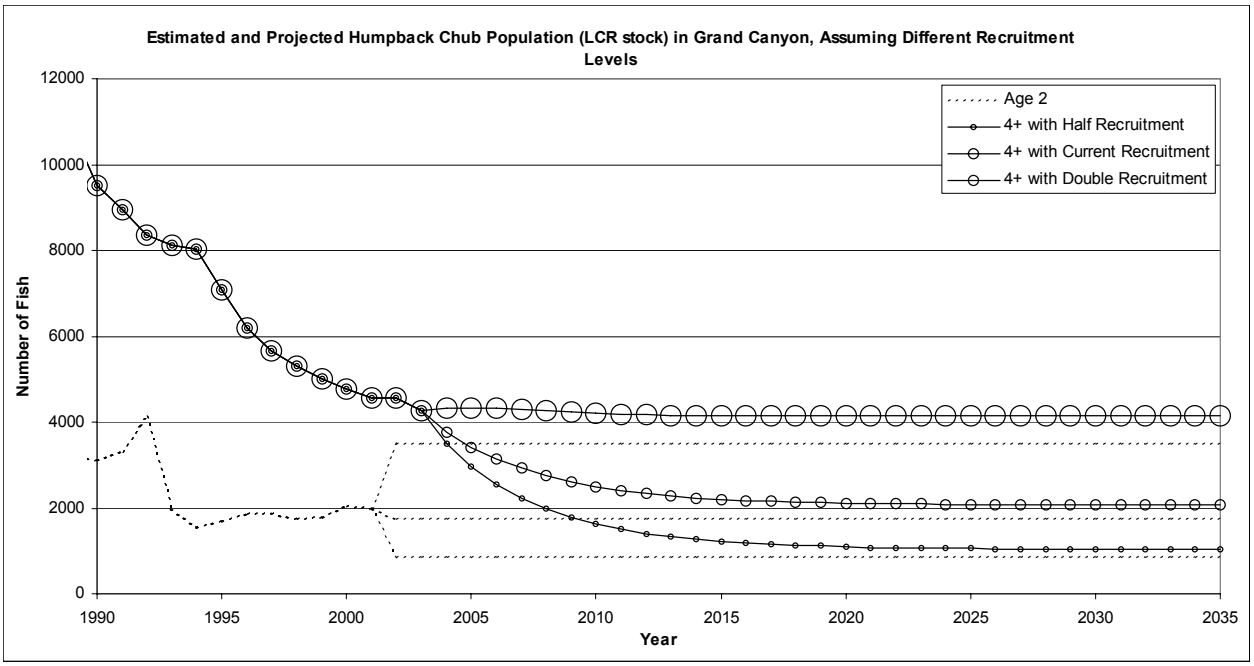


Figure 7 Estimated and projected abundance of the LCR humpback chub population (Ages 2 and 4+) for different recruitment scenarios.

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Table 1. Summary of closed population abundance estimates for the Little Colorado River population of humpback chub.

AUTHOR	LOCATION	DATE	FISH SIZE	ABUNDANCE ESTIMATE	METHOD	COMMENTS
Kaeding and Zimmerman 1982	LCR Inflow[a] and LCR.	1980-1981	>200 mm	7,000-8,000	Schnabel, Modified Schnabel, and Schumacher/Eschmeyer	Authors claim this is a "ballpark" estimate due to assumption violations.
Minckley 1988	LCR confluence (<1.2 km)	May 1987	>120 mm	5,783	Petersen	Invalid sample design; no distinction between mark and recapture efforts
Kubly 1990	LCR confluence (<1.2 km)	May 1987	>140 mm	1,800	Schnabel	Author states estimate is biased and precision is poor.
Minckley 1988	LCR confluence (<1.2 km)	May 1988	>120 mm	7,060	Petersen	Invalid sample design; no distinction between mark and recapture efforts
Kubly 1990	LCR confluence (<1.2 km)	May 1988	>140 mm	2,900	Schnabel	Author states estimate is biased and precision is poor.
Minckley 1989	LCR (<15 km)	May 1989	>150 mm	18,253	Petersen	Invalid sample design; no distinction between mark and recapture efforts.
Kubly 1990	LCR (<15 km)	May 1989	>140 mm	5,500-25,000 (estimate stabilized near 5,000 fish)	Schnabel	Author states estimate is biased and precision is poor.
Minckley 1989	LCR confluence (<1.2 km)	May 1989	>150 mm	10,120	Petersen	Invalid sample design; no distinction between mark and recapture efforts.

[a] Kaeding and Zimmerman defined the LCR Inflow Reach as Colorado River miles ~51.5-71.5
[b] Valdez and Ryel 1995 defined the LCR Inflow Reach as Colorado River miles 57-65.4
[c] Trammell and Valdez 2002 defined the LCR Inflow Reach as Colorado River miles 56.3-68.3

Table 1. Summary of closed population abundance estimates for the Little Colorado River population of humpback chub (continued).

AUTHOR	LOCATION	DATE	FISH SIZE	ABUNDANCE ESTIMATE	METHOD	COMMENTS
Minckley 1990	LCR confluence (<1.2 km)	May 1990	>150 mm	6,492	Petersen	Invalid sample design; no distinction between mark and recapture efforts.
Minckley 1990	LCR (<15 km)	May 1990	>150 mm	11,985	Petersen	Invalid sample design; no distinction between mark and recapture efforts.
Douglas and Marsh 1996	LCR confluence (<1.2 km)	May 1992	>150 mm	1,320	Program CAPTURE (many estimators used; statistically determined the best one)	Appears sound; peer-reviewed journal publication.
Douglas and Marsh 1996	LCR (<15 km)	May 1992	>150 mm	4,363	Program CAPTURE (many estimators used; statistically determined the best one)	Appears sound; peer-reviewed journal publication.
Valdez and Ryel 1995	LCR Inflow[b]	1991	>200 mm	3,315	Program CAPTURE (many estimators used; statistically determined the best one)	Appears sound; peer-reviewed contractor report.
Valdez and Ryel 1995	LCR Inflow[b]	1992	>200 mm	3,572	Program CAPTURE (many estimators used; statistically determined the best one)	Appears sound; peer-reviewed contractor report.
Valdez and Ryel 1995	LCR Inflow[b]	1993	>200 mm	3,558	Program CAPTURE (many estimators used; statistically determined the best one)	Appears sound; peer-reviewed contractor report.
Coggins and Van Haverbeke 2001	LCR (< 14.2 km)	Oct. 2000	> 135 mm	1,590	Chapman-Petersen	Appears sound; peer-reviewed agency report.
Van Haverbeke and Coggins 2003	LCR (< 14.2 km)	May 2001	>100 mm	3,527	Length – Stratified Chapman-Petersen	Appears sound; peer-reviewed agency report.
Van Haverbeke and Coggins 2003	LCR (< 14.2 km)	May 2001	>150 mm	2,387	Length – Stratified Chapman-Petersen	Appears sound; peer-reviewed agency report.
Van Haverbeke and Coggins 2003	LCR (< 14.2 km)	May 2001	>200 mm	1,568	Length – Stratified Chapman-Petersen	Appears sound; peer-reviewed agency report.

[a] Kaeding and Zimmerman defined the LCR Inflow Reach as Colorado River miles ~51.5-71.5
[b] Valdez and Ryel 1995 defined the LCR Inflow Reach as Colorado River miles 57-65.4
[c] Trammell and Valdez 2002 defined the LCR Inflow Reach as Colorado River miles 56.3-68.3

Table 1. Summary of closed population abundance estimates for the Little Colorado River population of humpback chub (continued).

AUTHOR	LOCATION	DATE	FISH SIZE	ABUNDANCE ESTIMATE	METHOD	COMMENTS
Trammell and Valdez 2002	LCR Inflow [c]	August 2001	>200 mm	1,044	Chapman-Petersen	Appears sound; peer-reviewed contractor report
Van Haverbeke and Coggins 2003	LCR (< 14.2 km)	Oct. 2001	>100 mm	2,424	Length – Stratified Chapman-Petersen	Appears sound; peer-reviewed agency report.
Van Haverbeke and Coggins 2003	LCR (< 14.2 km)	Oct. 2001	>150 mm	1,555	Length – Stratified Chapman-Petersen	Appears sound; peer-reviewed agency report.
Van Haverbeke and Coggins 2003	LCR (< 14.2 km)	Oct. 2001	>200 mm	695	Length – Stratified Chapman-Petersen	Appears sound; peer-reviewed agency report.
Van Haverbeke *In Review*	LCR (< 14.2 km)	May 2002	>150 mm	2,666	Length – Stratified Chapman-Petersen	Author suggests estimate may contain positive bias.
Van Haverbeke *In Review*	LCR (< 14.2 km)	May 2002	>200 mm	2,002	Length – Stratified Chapman-Petersen	Author suggests estimate may contain positive bias.
Van Haverbeke *In Review*	LCR (< 14.2 km)	Oct. 2002	>100 mm	4,777	Darroch and Length – Stratified Chapman-Petersen	Author suggests estimate is unbiased.
Van Haverbeke *In Review*	LCR (< 14.2 km)	Oct. 2002	>150 mm	2,774	Darroch	Author suggests estimate is unbiased.
Van Haverbeke *In Review*	LCR (< 14.2 km)	Oct. 2002	>200 mm	839	Darroch	Author suggests estimate is unbiased.

[a] Kaeding and Zimmerman defined the LCR Inflow Reach as Colorado River miles ~51.5-71.5
[b] Valdez and Ryel 1995 defined the LCR Inflow Reach as Colorado River miles 57-65.4
[c] Trammell and Valdez 2002 defined the LCR Inflow Reach as Colorado River miles 56.3-68.3

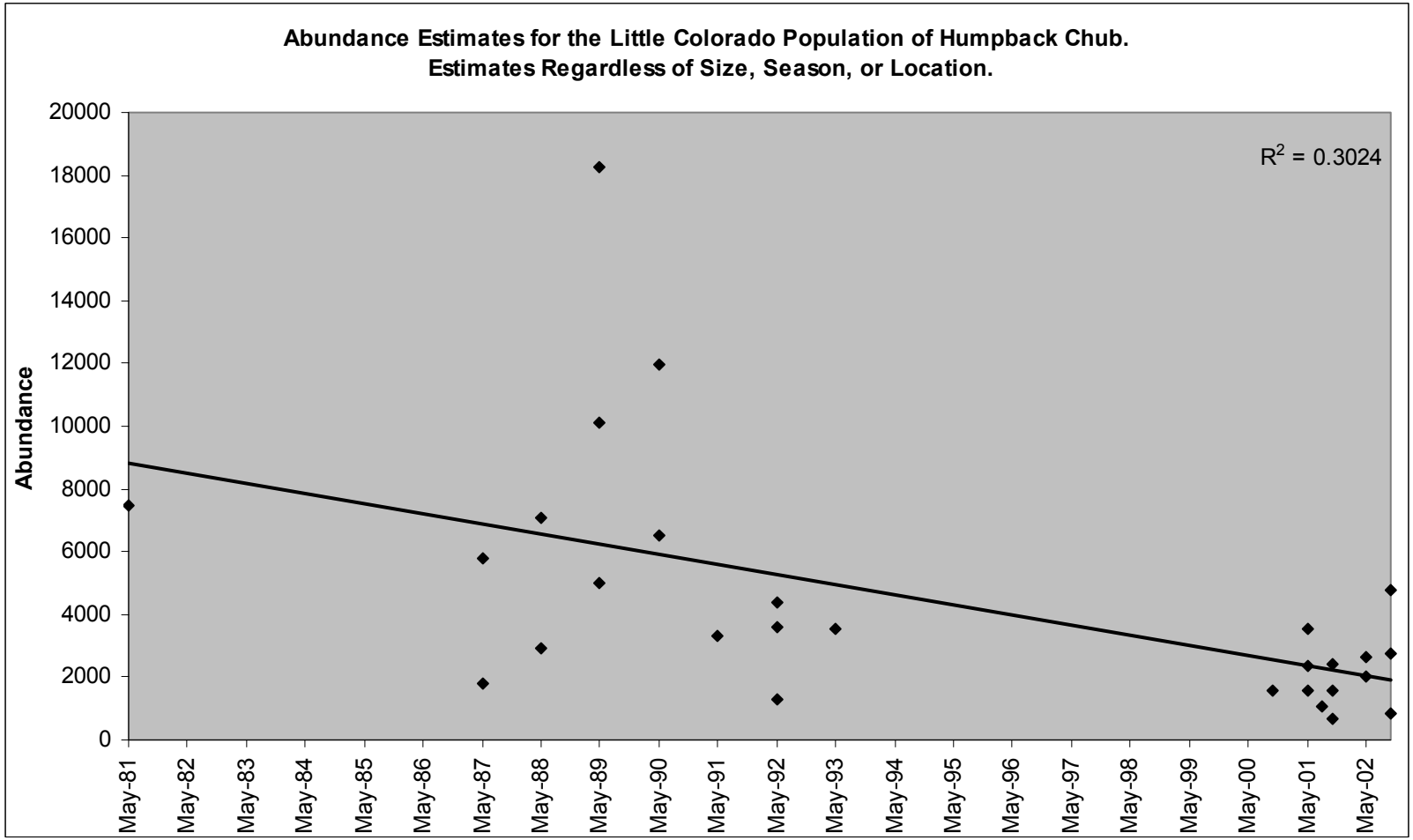

Figure 8 Abundance estimates for the Little Colorado River population of humpback chub regardless of size, season, or location.

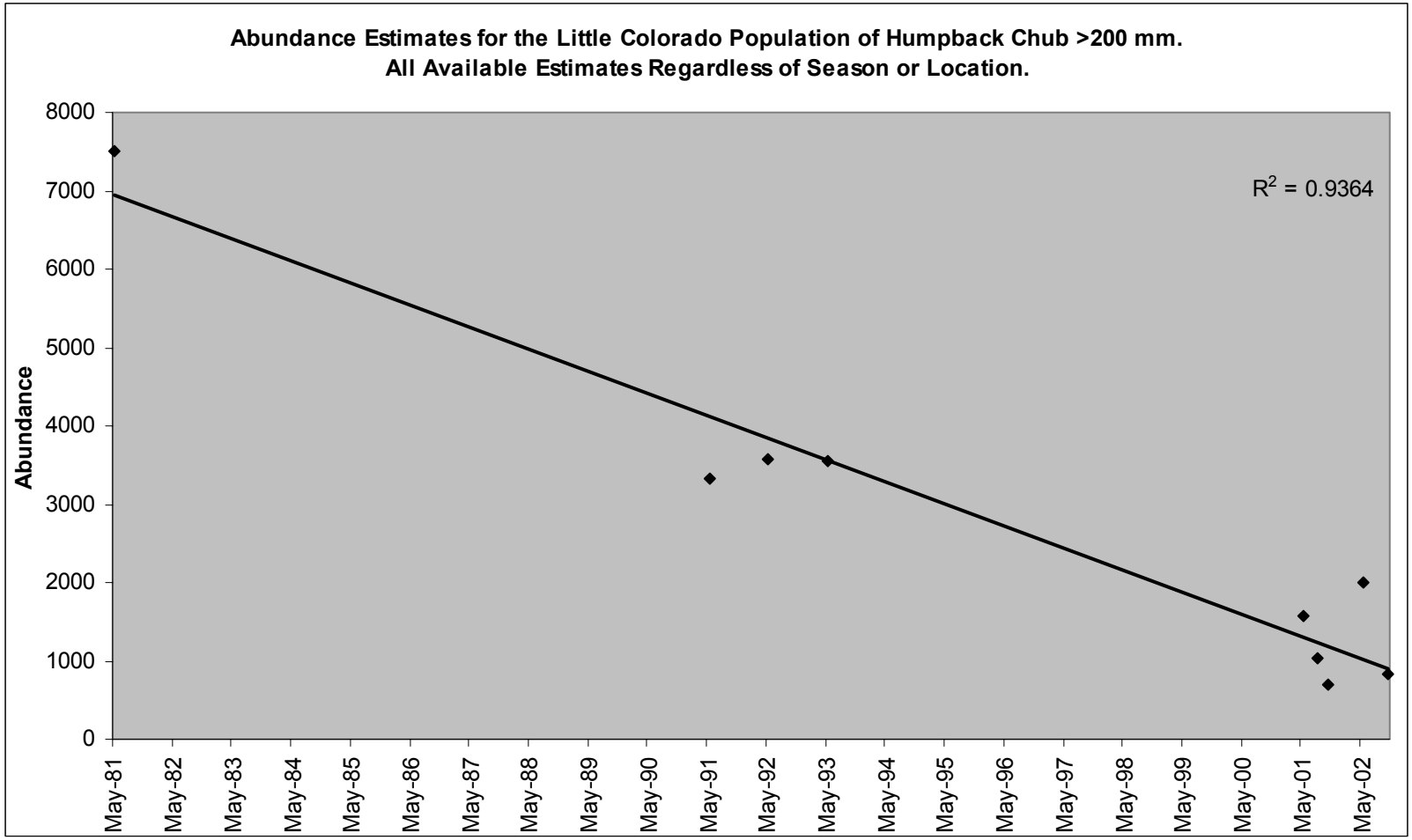

Figure 9 Abundance estimates for the Little Colorado River population of humpback chub >200mm regardless of season or location.

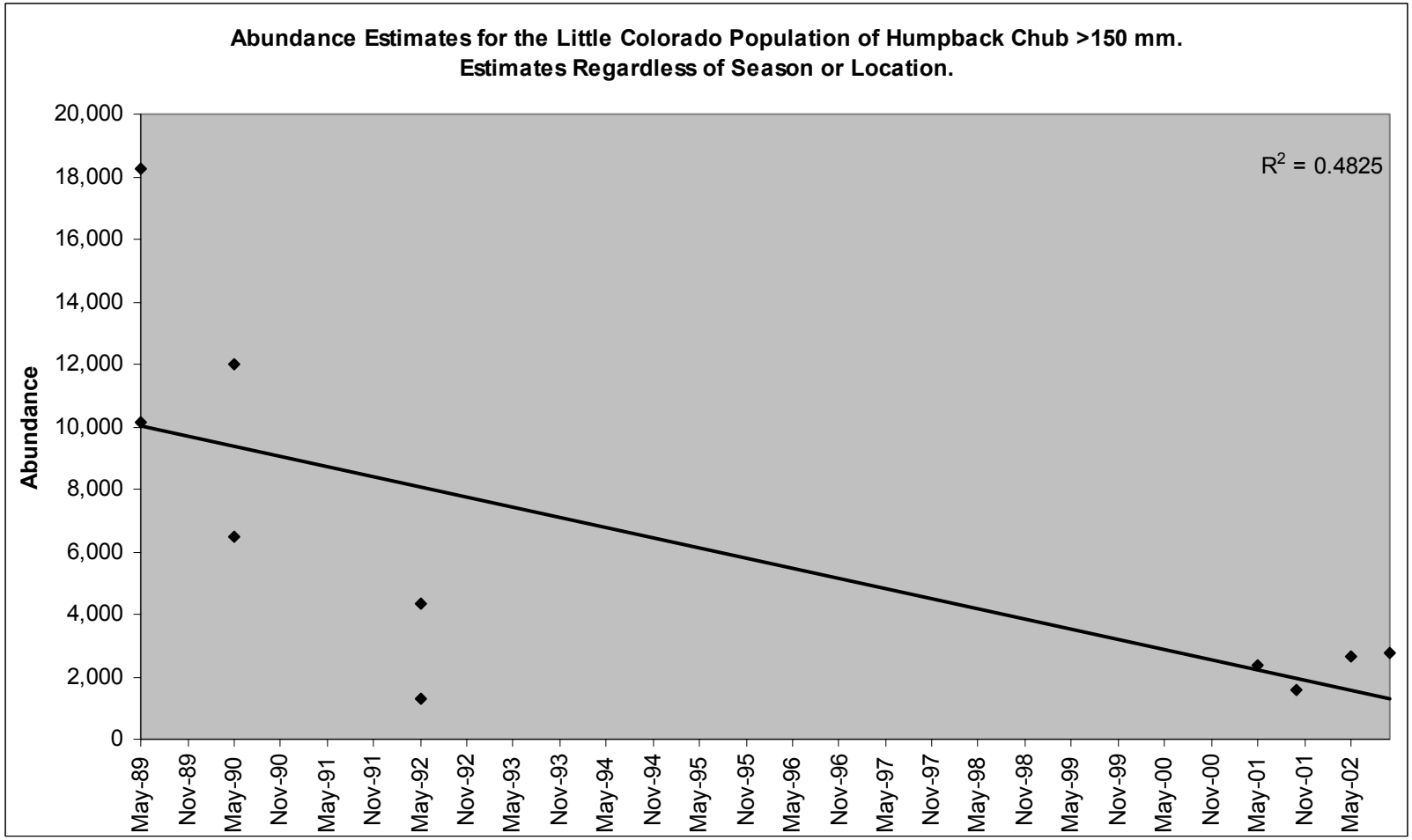

Figure 10 Abundance estimates for the Little Colorado River population of humpback chub >150mm regardless of season or location.

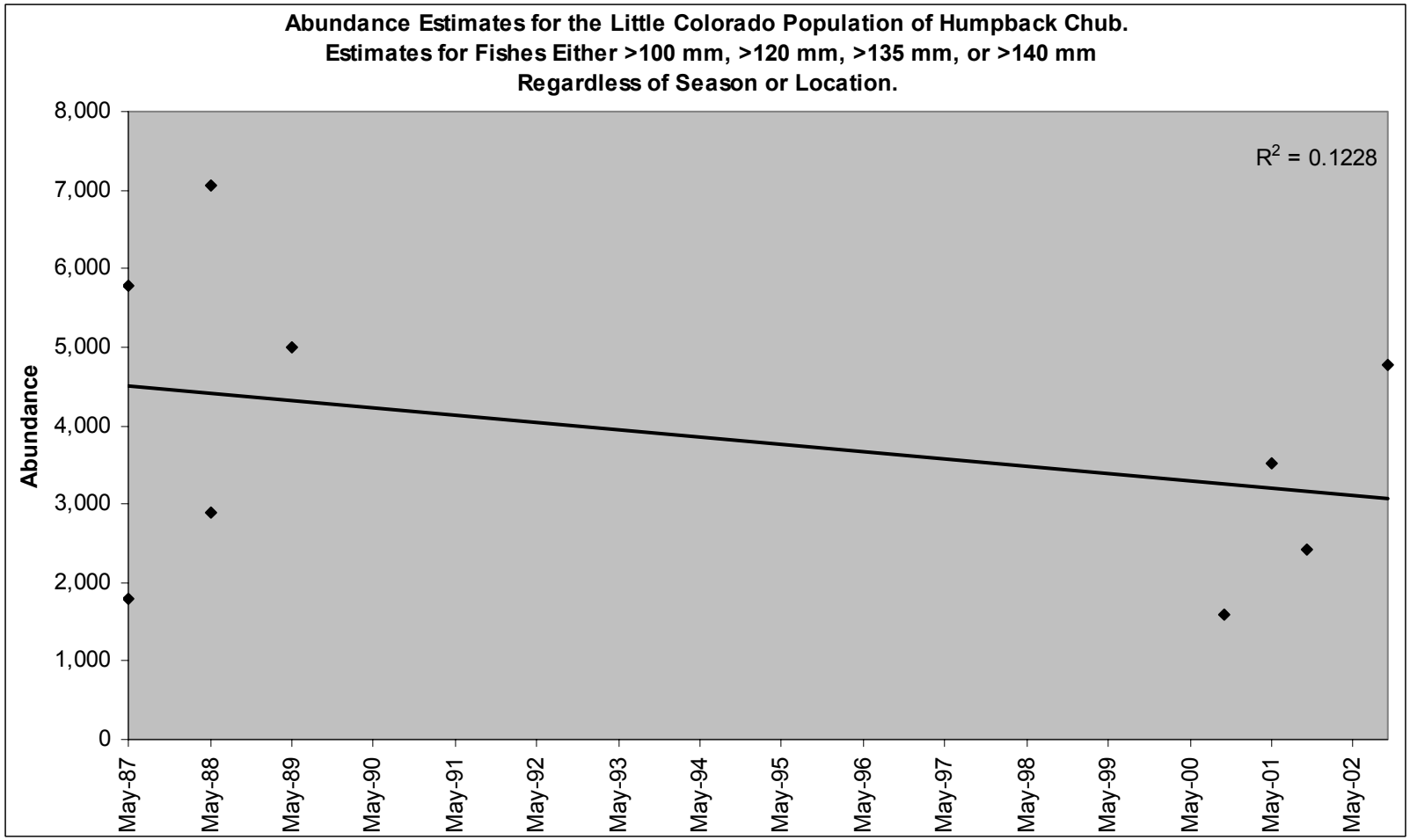

Figure 11 Abundance estimates for the Little Colorado River population of humpback chub. Estimates for fishes either >100mm, >120mm, >135mm, or >140mm, regardless of season or location.

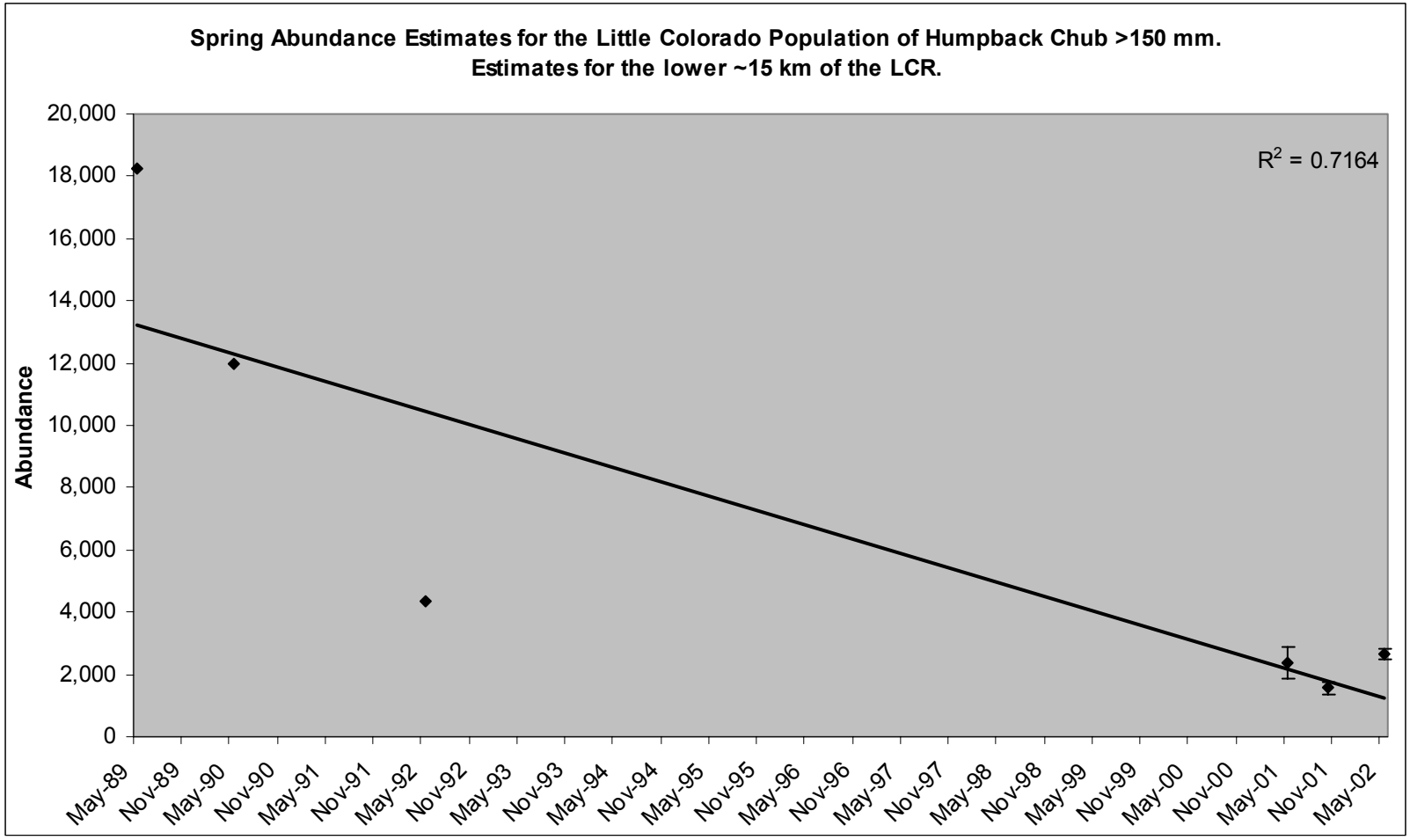

Figure 12 Spring abundance estimates for the Little Colorado River population of humpback chub >150mm. Estimates for the lower ~15 km of the LCR Inflow.

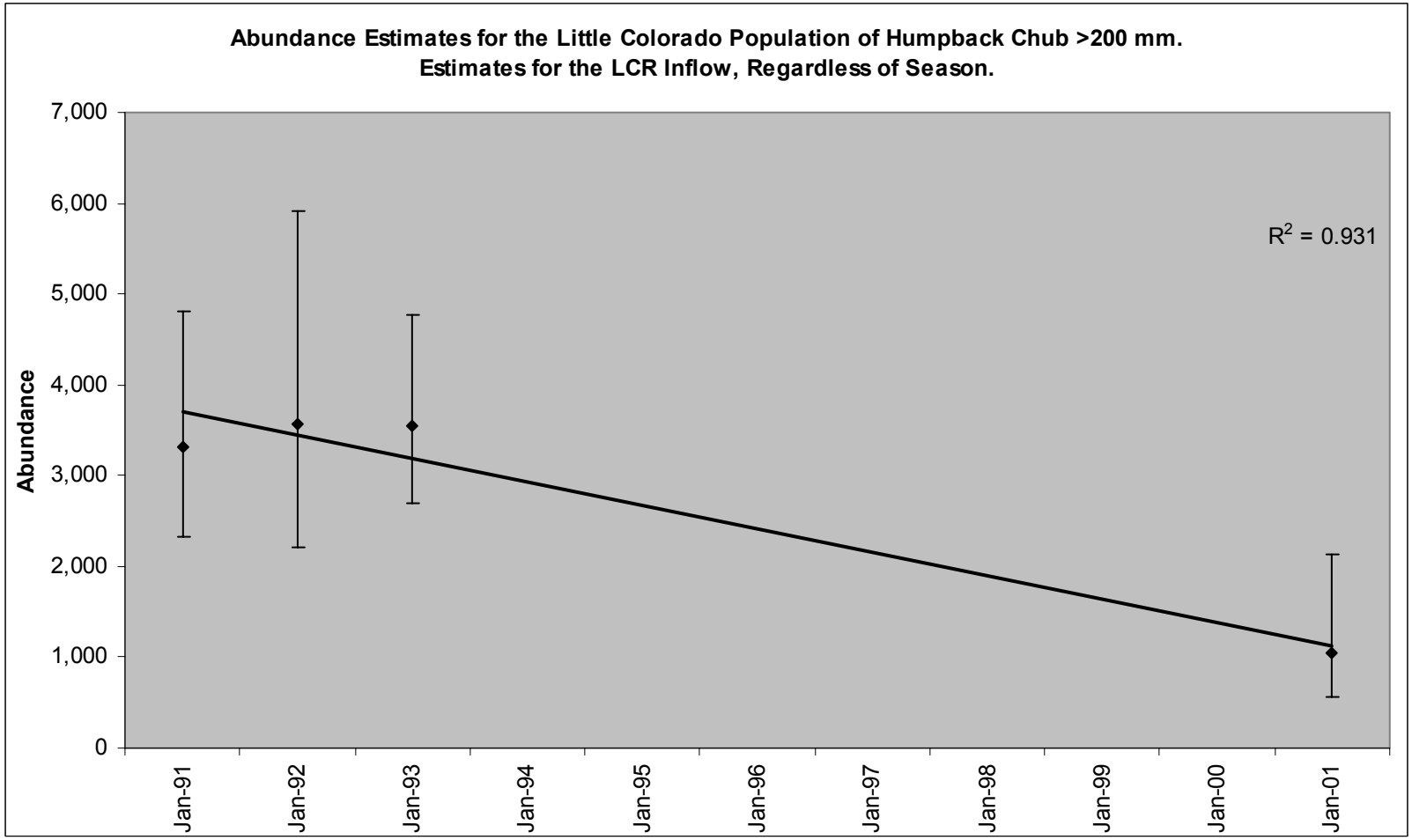

Figure 13 Abundance estimates for the Little Colorado River population of humpback chub >200mm. Estimates for the LCR Inflow, regardless of season.

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APPENDIX C. Project Proposals

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 01

I. Title: Assess Humpback Chub Currently at Willow Beach NFH as Potential Broodstock.

II. Relationship To Programs: This section provides insight into the relationship between the proposed action and the Adaptive Management Program goals and objectives, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program: The goals and management objectives of the Adaptive Management Program that apply are:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)

Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Biological Opinion: Elements of the Reasonable and Prudent Alternative that apply are as follows. Successful completion of the RPA is necessary to remove jeopardy to the humpback chub from the proposed action (operation of Glen Canyon Dam under a Modified Low Fluctuating Flow alternative described in the Final EIS and ROD).

Element 2: Establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam.

III. Study Background/Rationale and Hypotheses:

IV. Study Goals, Objectives, End Product:

Study Goal

Develop a brood stock of humpback chub from the Little Colorado River population.

Study Objectives (Performance Measures)

Determine if humpback chub currently on station at Willow Beach NFH would be suitable as a potential broodstock.

1. Collect tissues from fish at Willow Beach NFH and any other available archived tissues (approx. 120 from Willow Beach NFH plus 40-50 reference samples).
2. Perform microsatellite analysis using existing loci.
3. Perform statistical analysis and report.
4. Using genetic information, develop captive broodstock management plan.

End Product

An assessment of the suitability of the humpback chub currently at the Willow Beach National Fish Hatchery as a potential brood stock.

V. Study Area: Willow Beach NFH.

VI. Study Methods/Approach:

VII. Task Description and Schedule:

VIII. FY 2004 Work:

June 2003 - December 2004.

IX. Budget Summary:

FY03-04: $120,000

X. Reviewers:

XI. References:

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 02

I. Title: Remove humpback chub from mainstem Colorado River at 30-Mile to maintain genetic stock in refugia.

II. Relationship to Adaptive Management Program, Recovery Goals, and Biological Opinion

Goal 2 in the AMP Strategic Plan (August 17, 2001) is "Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat". Management Objective 2.2 is to "Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy."

The Adaptive Management Work Group, in their April 24, 2002 meeting, recommended that the Secretary "Initiate all needed activities (consultation [include HBC], compliance, development of a science plan, public outreach, development of a captive breeding population of Grand Canyon Humpback Chub.)"

The Biological Opinion requires a second spawning population of humpback chub (in addition to the Little Colorado River (LCR) aggregation). The 30-Mile aggregation of HBC has been documented to spawn occasionally and young fish have been collected immediately downstream of the 30-Mile location however there appears to be no recruitment to the aggregation. The genetic relationship between the 30-Mile aggregation and the Little Colorado River (LCR) aggregation are unknown. Genetics studies are currently underway (GCMRC), but it is unknown if they will identify any unique characteristics of the 30-Mile fish.

A genetics management plan and refugia plan are desired prior to removal of fish from the wild. However, if the wild stock is only comprised of 50 old adults, and they represent a unique genetic stock, it may be critical to remove fish before a genetics management plan and refugia plan are fully developed.

III. Study Background/Rationale and Hypotheses:

Valdez and Ryel (1995) estimated a population of approximately 52 HBC at 30-Mile, comprised primarily of large (> 350 mm) adults and occasionally young-of-the-year (y.o.y.) fish. Young-of-the-year fish were collected in 1993, 1994, and 1995 between 30-Mile and 45-Mile, frequently in a backwater at 44.27 mile (GCMRC unpublished data). These young-of-the-year fish were presumed to have originated from the 30-Mile aggregation. However, juvenile sized fish (> 125 mm to < 330 mm) have not been collected near 30-Mile. The 30-Mile aggregation is likely comprised of old, large adults with little or no recruitment to the spawning population. There is a concern that if the 30-Mile aggregation represents a unique stock of fish that are better suited to mainstem spawning they should be protected. If the 30-Mile HBC are not recruiting, natural

mortality may eliminate the few remaining adults, thus there is a need to evaluate removal of fish for protection in a hatchery facility. It is probably more desirable to remove gametes or y.o.y. fishes than to remove the few remaining adults, however it will likely be more difficult to capture y.o.y. fishes or gametes.

IV. Study Goals, Objectives, End Product:

1. Develop a refugia plan and secure necessary permits for removing fish from the wild and holding them.
    i. Development of a refugia plan may include examination of genetic samples to evaluate uniqueness of 30-Mile HBC. Development of a refugia plan should be coordinated with development of a genetics management plan.
2. Collect adult or juvenile HBC or gametes from the 30-Mile aggregation.
    i. Number to be collected will be determined as part of the planning process and genetics analysis.
3. Prepare annual progress report and final report.
4. End product is a refugia population of 30-Mile HBC.

V. Study area

1. 30-Mile and vicinity.

VI. Study Methods/Approach

1. A refugia plan will be developed by May 2004 and permits will be secured.
2. Adult fish will be collected by trammel net during the May-June 2004 period. Young-of-the-year fish will be collected by hoop-net, seine, and minnow trap if available and desired, during the July – October period. If gametes are to be removed, sampling should likely take place during May-June. Fish will be removed by the most appropriate method depending on NPS regulations. Fish may be transported to the Little Colorado River for helicopter transport to a suitable hatchery facility.

VII. Task Description and Schedule

1. 2003-2004 Develop plan and secure permits.
2. 2004 Collect and remove fish or gametes.
3. 2005-2020? Maintain fish.

VIII. FY-2003-2004 Work

1. Estimated $25,000 - $50,000 to develop a plan; to evaluate and select a refugia location; and to secure permits for removal of genetic material.
2. Estimated $40,000 to secure space at a suitable refugia location.
3. Estimated $120,000 to capture and move fish from 30-Mile to a refugia location.
4. Estimated $10,000/year to maintain fish, depending on brood-stock management plan and genetics evaluation.

IX. Budget Summary

FY-2003 $ 90,000

FY-2004	$125,000
FY-2005	$ 10,000
Total:	$225,000

X. Reviewers

XI. References

Valdez, R.A. and R.J. Ryel. 1995. Life history and ecology of the humpback chub (*Gila cypha)* in the Colorado River, Grand Canyon, Arizona. Final report to the Bureau of Reclamation, Salt Lake City, Utah, Contract No. 0-CS-40-09110. BIO/WEST Report No. TR-250-8. BIO/WEST, Inc., Logan Utah.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 03

I. Title: Genetic relationships within and among populations of the endangered *Gila cypha* (humpback chub) in the Colorado River ecosystem

II. Relationship to AMP Management Objectives:

Management Objective 2.2- Sustain or establish viable HBC spawning aggregations outside of the LCR in the Colorado River Ecosystem below Glen Canyon Dam to remove jeopardy.

Research Information Need 2.2.1 –What is a viable population and what is the appropriate method to assess population viability of native fish in the CRE. What is an acceptable probability of extinction over what management time period for humpback chub throughout the CRE

Research Information Need 2.2.4-.What is the relationship between the "aggregations" in the mainstem and LCR? Are mainstem aggregations "sinks" of the LCR? Are aggregations real or due to sampling bias?

III. Study Background/Rationale and Hypotheses:

The Conservation Genetics and Larval Fish laboratories at Colorado State University, Fort Collins (CO) will collaborate with researchers at other academic institutions and federal and state agencies to evaluate interrelationships among populations of the endangered *Gila cypha* within Grand Canyon (GC). Five populations from the Upper Colorado River basin will also be included in the study to gain perspective on basin-wide intraspecific relationships. Life history of *G. cypha* in GC is mostly enigmatic and interrelationships among subpopulations are virtually unknown. Lack of an historic baseline further complicates understanding of present-day patterns, and causal relationships between physical and biological parameters are merely the source of speculation. The most pressing questions pertain to genetic distinctiveness of aggregations in the mainstem Colorado River (MCR), the interrelationships among these and tributary populations, and how the sum can be adaptively managed in a dam-perturbed environment. Objectives of the proposed study are therefore to infer interrelationships among populations of *G. cypha*, to identify (if possible) genetically distinct units, and to derive a management strategy for this endangered species

IV. Study Goals, Objectives, End Product:

A combination of molecular markers will be employed to investigate genetic relationships within- and among-populations of *G. cypha*. Mitochondrial (mt) DNA sequence data from two regions of that molecule will allow identification of phylogenetic lineages within GC

and elsewhere in the basin. Evolutionary Significant Units (ESU) can then be identified, and findings compared with unpublished data from other Reclamation-funded studies (i.e., Gila Taxonomy Project). Genetic variation will also be analyzed on a finer scale within- and among-populations by evaluating faster evolving DNA regions, including 15 microsatellite loci and at least one intron region. Genetic structure will be assessed among *G. cypha* populations, and levels of gene flow will be identified. This approach will determine if distinct Management Units (MUs) are present either within GC or the entire Colorado River basin, and if indeed this is a factor to be considered in recovery efforts. By contrasting results from different molecular markers, recent or historic population events can be inferred. Further, estimates for population parameters such as N_e (effective population size), and N_m (number of migrants) can be explored. Assessment of genetic relationships and estimates of population parameters based on molecular data will produce a solid basis from which to derive recommendations for adaptive management of *G. cypha* within GC.

V. Study area: Colorado River Basin (known HBC distribution)

VI. Study Methods/Approach :

For a statistically sound analysis, a sample size of 50-100 individuals/population will be needed. In this regard, the PIs have already compiled numerous tissue samples during the past five years of research on *G. cypha* populations. The following have been extracted and 211 of these evaluated for sequence variation: 214 MCR individuals, 200 from Little Colorado River (LCR), and 113 from Upper Basin populations. However, additional samples are needed to meet project objectives. Based upon their GC experiences, the PIs suggest these can best be obtained from research trips that maximize fishing effort at particular MCR areas. Sampling efforts must therefore be site-specific and must require trips in addition to those already scheduled for standard GCMRC monitoring efforts. Analytical procedures will be placed in a deductive framework by using rigorous statistical procedures to test hypotheses arranged within a hierarchical setting. Considerable efforts have already been undertaken by the PIs, not only with regard to familiarity with sample sites within GC and the compilation of samples, but also through establishment of methodologies, techniques, requisite permits and collaborations.

VII. Task Description and Schedule:

This project was implemented in FY02 and will be completed in FY04

VIII. FY-2002 Work
- Deliverables/Due Dates: Quaterly Reports–
- Budget: $52,491

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FY-2003 Work
- Deliverables/Due Dates: : Quarterly reports
- Budget: $ 51,298

FY-2004 Work
Deliverables_ Final Report Due Jan 1, 2005

Budget: $34,219
$1,987

IX. Budget Summary

	Total Costs/Year
FY02	**$52,491**
FY03	**$51,298**
FY04	**$34,219**
FY05	**$1,987**
Total Funds:	**$139,995**

X. Reviewers

GCMRC Peer Review Process

XI. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 04

I. Title: Feasibility of Developing a Program to Augment the Population of Humpback Chub (*Gila cypha*) in Grand Canyon

II. Relationship To Programs: This section provides insight into the relationship between the proposed action and the Adaptive Management Program goals and objectives, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program: The goals and management objectives of the Adaptive Management Program that apply are:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)

Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Biological Opinion: Elements of the Reasonable and Prudent Alternative that apply are as follows. Successful completion of the RPA is necessary to remove jeopardy to the humpback chub from the proposed action (operation of Glen Canyon Dam under a Modified Low Fluctuating Flow alternative described in the Final EIS and ROD).

Element 2: Establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam.

III. Study Background/Rationale and Hypotheses:
There has been concern among biologists and managers regarding the continued downward trend in HBC populations within Grand Canyon. In response to this concern, in the fall of 2002, GCMRC asked the Arizona Fishery Resources Office in Flagstaff to prepare a feasibility study on augmentation of HBC in Grand Canyon.

IV. Study Goals, Objectives, End Product:

<u>Study Goal</u>
Provide a comprehensive overview of the literature and background associated with hatchery augmentation and captive propagation.

<u>Study Objectives (Performance Measures)</u>

1. Examine the feasibility of establishing a supplemental stocking program for humpback chub in Grand Canyon using wild caught young of year (YOY) humpback chub removed from the Little Colorado River (LCR) and grown out to a large size in captivity.
2. Examine the feasibility of developing a captive broodstock to be used for a captive breeding program for humpback chub.
3. Examine the feasibility of establishing a second spawning (or expand the current) population of humpback chub in Grand Canyon.

End Product (Performance Measures

1. For the feasibility of supplemental stocking using growout facilities, the project will answer the following questions:
   a. Where could the supplemental fish be grown?
   b. What size fish should be collected, how, from where, and when?
   c. What is the best size to grow out captive fish before release?
   d. How many fish will need to be released into the wild in order sufficiently supplement the population of humpback chub in Grand Canyon?
   e. Where and when will fish be released back into the wild?

2. For the feasibility of establishing a supplemental population using broodstock, the project will answer the following questions:
a. Is a captive adult broodstock needed at this point in time, and what will it contribute?
b. Identification of components necessary to develop a broodstock management plan.
c. Where to hold broodstock, where to raise fish, what size to raise fish, how many, where/when to release?

3. For the feasibility of extending the range of the Little Colorado River population, the project will focus on:
   a. Transplanting fish above Chute Falls
   b. Refugia population in Havasu Creek and other tributaries

4. Report and evaluation of each objective, including recommendations for future action.

V. Study Area: Colorado River Basin

VI. Study Methods/Approach:

VII. Task Description and Schedule:

VIII. FY 2004 Work:

February 2003 – June 2003

IX. Budget Summary:

FY 2003: $23,000

X. Reviewers:

References:

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 05

I. Title: Translocation of native fishes to tributaries of the Colorado River, Grand Canyon National Park and tribal lands

Relationship To Prog**rams:**
Glen Canyon Dam Adaptive Management Program Information Needs
M.O. 2.1 *Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.*

M.O. 2.6 *Maintain (flannelmouth sucker, bluehead sucker and speckled dace) abundance and distribution in the Colorado River ecosystem below Glen Canyon Dam for viable populations.*

Section 7 Consultation on Proposed Experimental Releases from Glen Canyon Dam and removal of Non-native fish, December 6, 2002

Conservation Measure: Approximately 300 HBC will be removed from the LCR and Colorado River confluence and transported upstream to above Atomizer Falls in the LCR.

III. Study Background/Rationale and Hypotheses:
Native fishes, including the endangered humpback chub (HBC), were historically found in many tributaries within Grand Canyon. However, with the exception of the Little Colorado River, HBC are no longer found within these tributaries due to high predator loads. In conjunction with concurrent predator removal/suppression efforts (see project 1), transplanted HBC may be able to exploit available habitat and remain in these tributaries until they reach larger sizes and are less predator susceptible. The second objective of this project is a direct management action to try and prevent the large-scale loss of HBC in the 60-100mm size class in the Little Colorado River. Data suggest that once smaller life history stages enter the Colorado River from the Little Colorado River, either through high flows or downstream drift, that a combination of cold temperatures and predation significantly reduce recruitment. It appears that once HBC exceed the 150-200 size range that survival significantly increases. If transplanted HBC can remain in these tributaries to reach these larger size classes, they may have an increased chance of survival once they enter the mainstem Colorado. In addition, since the largest remaining population is within a single tributary, translocations of HBC to other tributaries would spread out the risk of a single catastrophic event (such as a chemical spill upstream) that could significantly impact the LCR population.

This project proposes to start with a translocation within the Little Colorado River in July 2003 and move approximately 300 50-100mm HBC above Chute Falls. In addition to a conservation action named in the December 2002 BO, this action addresses the Recovery Goal factor titled Other Natural or Manmade Factors. The Chute Falls translocation project is a precursor to other actions in other tributaries and is intended to expand the demographic range of HBC within the LCR.

IV. Study Goals, Objectives, End Product:

The goal of this project is to expand the demographic range of HBC and use warmer tributaries as growout areas for small HBC. The objective is to transplant small HBC into appropriate tributaries within Grand Canyon National Park and within tribal lands found in the Little Colorado River. The end product may be several tributaries containing HBC as they did historically and effectively expanding the current range of HBC.

V. Study area

Tributaries of the Colorado River within Grand Canyon National Park and on tribal lands in the Little Colorado River

VI. Study Methods/Approach

The approach to this project will first include a review of past studies on tributaries and identification of information gaps such as discharge, habitat, water quality and existing fish densities. Biologists will be taken to the lower end of the Little Colorado River at Boulder's Camp to obtain approximately (300) 50-100mm HBC. Near the confluence of the Colorado River, HBC are most vulnerable to being washed into the mainstem and long-term survival is reduced. The minimum size that HBC can be elastomer marked is approximately 50mm total length. Due to the limited number of fish being moved, every opportunity to detect fish movement out of the tributaries and be able to identify translocated individuals needs to be pursed. Capture methods used will include seining, minnow traps and hoop nets. Due to the warm ambient air temperatures in the LCR during summer, all capture efforts will be conducted during early morning and late afternoon to reduce stress and mortality of captured fishes. Captured fish will be measured for length, and implanted with an elastomer tag with a unique color. During subsequent monitoring effort and pending approval by the National Park Service and the Navajo Nation, all captured nonnative fishes will be sacrificed. All other fishes will be returned to point of capture. All captured HBC will be held in 1/8 mesh live cars in the LCR until transport. Fish will be transported to the release site in an aerated tank or cooler stored within the helicopter. At the release site, fish will be tempered both for temperature, pH and potentially CO2 levels until differences between parameters are within 1 mg/l and 1°C. Following tempering, translocated fish will be held in live cars at several locations within each tributary. At each location fish will monitored for stress and mortality for a minimum of 24 hours. Following 24 hours of monitoring, fish will be released into the tributary. Monitoring efforts and evaluation of transplant success will occur twice per year.

For the initial Chute Falls translocation, the benefits of this action include introduction of HBC into presently unoccupied habitat in the LCR. It will provide an opportunity for growth of young fish to a size where they have a higher likelihood of surviving should they be carried or dispersed to the mainstream. Risks include the probability that a flood will carry them to the mainstream before sufficient growth increases their likelihood of survivorship. There is some very small genetic risk that a reproducing founder population with limited genetic diversity will become established. The probability that transplanted fish will remain there until reproductive age is very small, but in the event that such might occur, remedial actions can be taken to remove the population from that reach of the river or to periodically augment it with from the lower LCR to enhance genetic diversity.

Only only native speckled dace and nonnative carp presently occupy the reach of the LCR above Chute Falls. Fish removed from the lower LCR will utilize habitat and other resources in the reach above Chute Falls that would have otherwise have been used in the lower LCR. HBC that remain in the lower LCR will have reduced intraspecific competition from that fraction of the cohort that has been removed to above Chute Falls, taking advantage of the unused fraction of the carrying capacity.

Task Description and Schedule
Task 1: Chute Falls translocation: July 2003
Task 2: Literature search, identify information gaps (water quality, discharge), secure permits for additional tributaries, Fall 2003
Task 3: Reconnaissance level survey to fill in information gaps
Task 4: Remove fish from LCR and transplant to identified tributaries
Task 5: Monitoring and additional translocations
Task 6: Write and publish report

VIII. FY-2003-2004 Work

IX. Budget Summary

FY2003: $25,000
FY 2004: $50,000 (will depend on the number of tributaries selected for translocation)
FY 2005: $50,000
FY 2006: $25,000

X. Reviewers

XI. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 06

I. Title: Complete feasibility study of selective withdrawal on Glen Canyon Dam and, if feasible, finish compliance, construct, and test the device

II. Relationship To Programs:

Recovery Goals:

Humpback Chub 5.2.2.1 Factor A. - Adequate habitat and range for recovered populations provided

Management Action A-3. - Investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon that would allow for range expansion of the Grand Canyon numpback chub population and provide appropriate water temperatures if determined feasible and necessary for recovery.

Task A-3.1 - Determine the effects and feasibility of a temperature control device for Glen Canyon Dam under the Glen Canyon Dam Adaptive Management Program (U.S. Bureau of Reclamation 1999) to increase water temperatures in the mainstem Colorado River through Grand Canyon that would allow for range expansion of humpback chub.

Task A-3.1.2. - Implement a temperature control device for Glen Canyon Dam if determined feasible and necessary for recovery of humpback chub.

Biological Opinion:

Element 1C: Determine responses of native fishes in Grand Canyon to various temperature regimes and river flows of the experimental flows and other operations of Glen Canyon Dam. Studies will emphasize collection of information necessary to remove jeopardy to federally-listed species and identify actions necessary to enhance their recovery. Reclamation will provide technical assistance and funding for research to accomplish the following studies:

i. Determine the effects of water temperature on reproductive success, growth, and survivorship of Grand Canyon fishes.

vii. Determine the effects of dam operations, including modifications to regulate water temperature, on the parasites and disease organisms of endangered and native fishes in Grand Canyon.

III. Study Background/Rationale and Hypotheses:

Cold-water releases from Glen Canyon Dam are below optimal for the existing trout fishery and far below those temperatures needed to allow the humpback chub to thrive in the mainstem of the Colorado River. Cold-water releases make it easy for trout to prey on young, native, warm-water fish.

Thermal shock from cold mainstem temperatures has been recognized as a likely cause of mortality for young endangered fish leaving seasonally warmed tributaries. In their integration report on studies in Glen and Grand Canyons, Valdez and Carothers (1999) concluded that, "We believe that most larval flannelmouth suckers, bluehead suckers, and humpback chub descending from warm natal tributaries into the cold mainstem die of thermal shock or from predation elicited by erratic swimming behavior. For those fish old enough to survive the transition, swimming ability may be reduced by as much as 98 percent by cold mainstem temperatures." Early results from FWS studies at their Willow Beach National Fish Hatchery show no appreciable growth in young humpback chub after 90 days at 12°C while growth is rapid at 24°C and intermediate at 18°C. Clearly the life history data, growth studies, the extinction of several species, and endangered status of humpback chub amount to reasonable evidence that native fish are likely injured (at least in part) by cold releases.

Increasing the temperature of dam releases could be an effective tool to reduce thermal shock during the relatively short period of time that the humpback chub are descending into the mainstem.

Ho_1: Warming Glen Canyon Dam releases through the use of a selective withdrawal structure will neither significantly increase the range nor significantly increase the recruitment of humpback chub.

Ho_2: Warming Glen Canyon Dam releases through the use of a selective withdrawal structure will not detrimentally alter the aquatic foodbase, particularly in the Lees Ferry reach.

Ho_3: Warming Glen Canyon Dam releases through the use of a selective withdrawal structure will not significantly benefit non-native fish to the detriment of the humpback chub in the CRE.

IV. Study Goals, Objectives, End Product: Through a combination of the Science Advisors' risk assessment and completion of a NEPA document, the proposal to construct a selective withdrawal structure on Glen Canyon Dam will be evaluated. The end product is a decision by the Department of the Interior on this proposal.

V. Study area: Colorado River mainstem between Glen Canyon Dam and the western boundary of Grand Canyon National Park.

VI. Task Description and Schedule:

Task 1. Complete risk assessment by AMP Science Advisors, July 2003.
Task 2. Complete NEPA compliance document and facilitate an AMWG recommendation to the Secretary of the Interior, Jan 2004.
Task 3. Complete design for selected structural alternative, September 2004.
Task 4. Complete construction, June, 2007.
Task 5. Implement AMP testing program following construction.

VII. Study Methods/Approach:

Evaluation of the selective withdrawal structure will be accomplished through a NEPA process, which would include an assessment of the risks associated with construction and operation. While many of these risks may only be answered by actually constructing the structure, the assessment will help guide both the decision process and the formulation of a science plan for testing its operation.

If constructed, testing of the selective withdrawal structure will be accomplished through the AMP using a science plan developed by GCMRC in cooperation with the Science Advisors and the Technical Work Group. Funding for monitoring will be from a combination of AMP funds and Section 8 CRSP appropriated funds. The latter funds will be available for 3 years, primarily to ensure the adequacy of the construction using Reclamation's authority under the 1956 CRSP Act. Under the 2001 Energy and Water appropriations bill, monitoring and research for ESA issues would be handled within the AMP. These tasks would be accomplished within the AMP budget.

VIII. FY-2003 Work

Task 1 - Deliverables/Due Dates
- Science Advisors workshop, May 2003
- Draft report, June 2003
- Report at AWMG meeting, July 2003
- Final report, August 2003
- Budget: Total $80,000

Task 2 - Deliverables/Due Dates
- Draft NEPA document, September 2003
- Budget: Total $50,000

FY-2004 Work

Task 2 - Deliverables/Due Dates
- Final NEPA document/decision, December 2003
- Budget: Total $50,000

Task 3 - Deliverables/Due Dates
- Design preparation, September 2004
- Budget: $150,000

Task 4 - Deliverables/Due Dates
- Construction
- Budget: $4,000,000

FY-2005 Work

Task 4 - Deliverables/Due Dates
- Construction
- Budget: $4,000,000

FY-2006 Work

Task 4 - Deliverables/Due Dates

- Construction
- Budget: $4,000,000

FY-2007 Work
Task 4 - Deliverables/Due Dates
- Complete construction
- Budget: Balance to complete and schedule dependent on selected alternative

FY-2008 through 2010 Work
Task 5 - Deliverables/Due Dates
- Complete performance testing
- Budget: $300,000 / year

IX. Budget Summary:

FY-2003	$80,000 AMP, $50,000 Reclamation appropriations
FY-2004	$200,000 Reclamation appropriations
FY-2005	$4,000,000 Reclamation appropriations
FY-2006	$4,000,000 Reclamation appropriations
FY-2007	unknown - Reclamation appropriations
FY-2008 - FY-2010	$300,000 for three years - Reclamation appropriations

Total: Dependent on structural alternative selected.

X. Reviewers:

Peer reviewers (1999)
AMWG and TWG (1999 and 2003)
Science Advisors (2003)

XI. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 07

I. Title: Use Dam Operations to Benefit Humpback Chub

II. Relationship to Recovery Goals:

Humpback Chub 5.2.2.1 Factor A. - Adequate habitat and range for recovered populations provided

Management Action A-1. - Investigate the role of the mainstem Colorado River in maintaining the Grand Canyon humpback chub population and provide appropriate habitats in the mainstem as necessary for recovery.

Task A-1.1 - Identify life stages and habitats of humpback chub in the mainstem Colorado River and determine the relationship between individuals in the mainstem Colorado River and Little Colorado River.

Task A-1.2 - Provide appropriate habitats for humpback chub in the mainstem Colorado River (as determined necessary under Task A-1.1).

Management Action A-2 - Provide flows necessary for all life stages of humpback chub to support a recovered Grand Canyon population, based on demographic criteria.

Task A-2.1 - As determined necessary and feasible, continue to operate Glen Canyon Dam water releases under adaptive management to benefit humpback chub in the mainstem Colorado River through Grand Canyon.

Task A-2.3 - Provide flow regimes (as determined under Tasks A-2.1 and A-2.2 that are necessary for all life stages of humpback chub to support a recovered Grand Canyon population.

III. Study Background/Rationale and Hypotheses:

As identified in the 1996 Glen Canyon Dam FEIS and the 1995 FWS Biological Opinion, the operation of Glen Canyon Dam directly and indirectly affects the endangered humpback chub. There are linkages between such variables as temperature, flow, food base, native / non-native interactions, and water quality. Beginning in 1996, the AMP has conducted numerous ecosystem experiments designed to test specific physical and biologic hypotheses (1996 Beach/Habitat Building Flow, 1997 and 1999 Habitat Maintenance Flows, 2000 Low Steady Summer Flow, Spring LCR Ponding Flow and Habitat Maintenance Flow, and the 2003 - 2004 experiment underway).

These experiments not only investigated the ecosystem reaction to flow perturbations, but also attempted to determine what habitat conditions are necessary to sustain a recovered population of humpback chub. Future flow experiments are also expected in conjunction with the selective withdrawal structure, if it is constructed. Examples of potential research hypotheses include:

Ho_1: The emergence of larval humpback chub from the LCR are unrelated to seasonal timing or water flow levels in the LCR.

Ho_2: This is no relationship between dam operations and the timing or success of humpback chub spawning.

Ho_3: Dam operations have no effect on habitat occupied by larval humpback chub emerging from the LCR.

Ho_4: Spring dam operations that impound the LCR have no effect on survival or recruitment of larval humpback chub emerging from the LCR.

Ho_5: Fluctuating dam releases during the winter have no effect on spawning, survival, or recruitment of trout.

Ho_6: Dam operations have no effect on tributary spawning of native or non-native fish.

IV. Study Goals, Objectives, End Product:

The 1994 Biological Opinion on the operation of Glen Canyon Dam contains an element of the reasonable and prudent alternative that addresses dam releases. The biologic information available at that time led the FWS to opine that steady flows (high in the spring and low the remainder of the year) would remove jeopardy from the humpback chub. Recent monitoring has shown that in some months of the year, flow stabilization from post-ROD dam operations has dramatically increased the non-native fish population, with adverse consequences to the humpback chub. Reclamation has committed to implement a program of experimentation to benefit the humpback chub through the adaptive management program. It has engaged the AMP in numerous discussions during the last two years on this topic, resulting in the current 2003 - 2004 experimental flow effort and the proposed 16-year experimental flow design, both from GCMRC scientists. With respect to the humpback chub, the program of experimentation and this comprehensive strategy will attempt to determine what actions are necessary to support a recovered population as instructed by the Recovery Goals.

V. Study Area:

Colorado River mainstem between Glen Canyon Dam and the western boundary of Grand Canyon National Park.

VI. Study Methods/Approach:

Task 1. Literature review to identify habitat requirements at each life stage. Conduct monitoring of mainstem near-shore and backwater habitats to identify temporal emergence of larval humpback chub from the LCR and resulting survival.
Task 2. Literature review of basinwide research of humpback spawning cues. Analysis of historic data to identify relationships between spawning and dam releases.

Task 3. Identify specific hypotheses related to near-shore habitat condition and HBC recruitment. Identify sampling protocols and analyses to evaluate survival and recruitment results sooner than would be obtained from age 4+ adult HBC population estimates. Monitor temperature, nutrients, turbidity, and velocity of these habitats as well as the status of native and non-native fish using these habitats during fall experimental flow conditions. Compare results with monitoring of ROD operations during 2001 and 2002.
Task 4. Review historic temperature and velocity data at the mouth of the LCR to evaluate effect of flow levels in both rivers on larval habitat. Using the results of Task 1, recommend experimental dam releases during humpback chub larval emergence following 2003 - 2004 experiment. Include other tributaries in Grand Canyon that may be suitable humpback chub habitat in an analysis of habitat suitability. In conjunction with non-native control and humpback chub range expansion efforts, conduct test of tributary impounding dam releases.
Task 5. Using Lees Ferry trout population estimates and results of 2003 - 2004 experiment, predict population response to various winter flow scenarios. Identify flow regime to limit Lees Ferry population to Management Objective targets.
Task 6. Using advice from Science Advisors and results from Tasks 1 - 5, design a program of experiments intended to benefit the humpback chub that will identify those aspects of dam operations and other management actions necessary to support a recovered humpback chub population, and that will allow the identification of cause and effect relationships. Because of the interrelationships between flow, non-native fish, temperature, and parasites/disease, this experimental regime should be integrated with the other proposed projects. In formulating this integrated program, hypotheses such as non-native reduction, habitat stabilization, potential spawning cues, and sediment conservation should be considered.

VII. Task Description and Schedule:

Task 1. Determine habitat requirements (thresholds and optima) and timing for each life stage of HBC in both the LCR / Grand Canyon tributaries and the mainstem Colorado River that can be affected by dam operations (e.g. spawning, incubation, emigration from tributaries).
Task 2. Determine spawning cues for HBC and evaluate impact of dam operations on HBC spawning.
Task 3. Conduct fall steady / minor fluctuating flow regime as part of the Autumn Sediment Input Scenario of the 2003 – 2004 experiment now in progress. If this scenario does not occur in 2003, test effect of a similar fall flow regime during September - October 2003.
Task 4. Evaluate the effects of an LCR-ponding spring flow on humpback chub survival and recruitment.
Task 5. Following completion of 2003 – 2004 experiment, review results of non-native fish suppression releases and make recommendations for future flow-related actions to limit non-native fish populations in the Grand Canyon.
Task 6. Develop a program of experimentation that includes dam releases. Such flows would be implemented in conjunction with other factors that address threats to the humpback chub.

VIII. FY-2003 Work

Task 1 - Deliverables/Due Dates
- Literature review, September 2003
- Budget: $10,000

Task 2 - Deliverables/Due Dates
- Literature review, September 2003
- Budget: $10,000

Task 4 - Deliverables/Due Dates
- Literature review, September 2003
- Budget Total $10,000

FY-2004 Work

Task 1 - Deliverables/Due Dates
- Monitoring of larval emergence from LCR, September 2004
- Final report, December 2004
- Budget: $50,000

Task 2 - Deliverables/Due Dates
- Analysis of historic spawning data, December 2003
- Final report, December 2003
- Budget: $20,000

Task 3 - Deliverables/Due Dates
- Fall experimental flow data collection, October 2003
- Final report, September 2004
- Budget: $80,000

Task 5 - Deliverables/Due Dates
- Evaluation of trout spawning suppression flows, September 2004
- Budget: Included in 2003 - 2004 experiment

FY-2005 Work

Task 6 - Deliverables/Due Dates
- Design/Implementation of experimentation program, January 2005
- Budget: $20,000

IX. Budget Summary:

FY-2003	$30,000 AMP
FY-2004	$150,000 AMP
FY-2005	$20,000 AMP

Total:

X. Reviewers:

Comments Received:

YOY larval HBC leave the LCR in free drift in early April/May and larger YOY HBC swept out by high LCR flows later in the summer. Timing of monsoon events may be related to YOU survival (HBC reaching some minimum size). Relationship between LCR and mainstem flows may be important (ponding of LCR flows). Add LCR temperature data during 45,000 cfs flows as well as Gonzales and Protiva data.

Add Black Rocks data attempting to correlate flows and time of spawning. Purpose of Task 2 is to determine if there is a relationship between dam operations and spawning cues. Some type of synthesis of existing data would be helpful.

2000 LSSF fall 31,000 cfs spike flow significantly reduced numbers of flannelmouth and bluehead suckers utilizing backwater and near shore habitats. Concern over reduction of Lees Ferry foodbase as a result of low steady flows. Such flow reductions may have different effects depending on the relative level of water year releases (high vs. low release years). Suggestion to have synthesis and presentation at future TWG meeting. Concern over confounding current 2003 – 2004 experiment by moving to steady fall flows next year.

There is an obligation to push forward on conducting Biological Opinion flows during 8.23 maf years. Need to analyze the sequence of things we need to do to move forward with an experiment.

Suggestion to replace “the public” with “ratepayers”.

XII. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 08

I. Title: Consider sediment augmentation to benefit native fish (e.g. sediment pipeline from San Juan River), both long-term feasibility and short term experiment

II. Relationship to Recovery Goals: Humpback Chub 5.2.2.1 Factor A. - Adequate habitat and range for recovered populations provided

Management Action A-1. - Investigate the role of the mainstem Colorado River in maintaining the Grand Canyon humpback chub population and provide appropriate habitats in the mainstem as necessary for recovery.

Task A-1.2 - Provide appropriate habitats for humpback chub in the mainstem Colorado River (as determined necessary under Task A-1.1 [of the Recovery Goals]).

III. Study Background/Rationale and Hypotheses:

Ho_1: Increasing the turbidity of mainstem Colorado River water below the Paria River will not significantly increase the recruitment of humpback chub.

Ho_2: Increasing the turbidity of mainstem Colorado River water below the Paria River will not significantly decrease non-native fish predation and competition on humpback chub.

Ho_3: Increasing the sediment concentration of mainstem Colorado River water below the Paria River will not significantly affect humpback chub habitat during normal GCD powerplant operations.

Ho_4: Increasing the sediment concentration of mainstem Colorado River water below the Paria River will not significantly affect the formation of backwater and near-shore humpback chub habitats during Beach/Habitat Building Flows.

IV. Study Goals, Objectives, End Product:

Evaluate the effects of increased turbidity on native and non-native fish, particularly near the confluence with the LCR. A feasibility analysis will be performed which investigates the potential for sediment augmentation and an experimental test of increased turbidity is proposed to determine the ecological impacts of such augmentation. In conjunction with the ongoing 2003 - 2004 experimental flow regime, evaluate the effects that increased sediment concentrations have on sandbar and native fish habitat reworking.

V. Study Area:

Colorado River mainstem between the Paria River confluence and the western boundary of Grand Canyon National Park.

VI. Study Methods/Approach:

Task 1. Evaluate alternatives for long term sediment augmentation of the mainstem Colorado River downstream of the Paria River confluence. Alternatives should focus on increasing turbidity to assist native fish, but should also consider broader implications and possibilities for increasing the sediment load through Grand Canyon to benefit other resources.
Task 2. Test effects of increasing turbidity of mainstem Colorado River downstream near the LCR confluence. This experiment may involve small scale or short term efforts to test the effects of increased turbidity and would attempt to determine whether sediment augmentation is important or necessary in the recovery of the humpback chub. This would include monitoring of non-native predation rates, effects of increased turbidity on near shore and backwater habitats, and impacts on the food base.

VII. Task Description and Schedule:

Task 1. Develop feasibility estimates for various sediment augmentation alternatives.
Task 2. Test effects of increasing turbidity of mainstem Colorado Ri ver downstream near the LCR confluence.

VIII. FY-2004 Work

Task 1 - Deliverables/Due Dates
- Final feasibility report, September 2004
- Budget: Total $200,000

Task 2 - Deliverables/Due Dates
- Develop experimental hypotheses, concept, science plan, September 2004
- Budget: Total $10,000

FY-2005 Work

Task 2 - Deliverables/Due Dates
- Conduct experiment as part of comprehensive HBC strategy, September 2005
- Budget: $1,000,000 (monitoring and research)

FY-2006 Work

Task 2 - Deliverables/Due Dates
- Final monitoring/research reports, September 2006
- Budget: $0

IX. Budget Summary:

FY-2004	$210,000 AMP
FY-2005	$1,000,000 AMP

Total: $1,210,000.

X. Reviewers:

XI. Comments Received:

Proposal should be tied to a demonstrated need for sediment augmentation. Alternatively, there may be need for augmentation for both sand conservation and turbidity for native fish purposes. Add " turbidity management" to performance measures. Feasibility analysis should be broad in scope. Higher turbidity may decrease non-native fish feeding and increase native fish activity. Focus should be on turbidity over sediment augmentation. Attention should be paid to impacts on food base.

XII. References:

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 09

I. Title: Understand the effect and identify the threats of scientific work and recreational activities on humpback chub populations in the Grand Canyon area (review Upper Basin Recovery Program, etc.).

Relationships:
Recovery Goals: **Humpback Chub 5.2.2.2 Factor B.–– Protection from overutilization for commercial, recreational, scientific, or educational purposes.**

Management Action B-1.--Protect humpback chub populations from overutilization for commercial, **recreational**, **scientific**, or educational purposes.

Task B-1.1. --Reevaluate and, if necessary, identify actions to ensure adequate protection from overutilization for commercial, **recreational**, **scientific**, or educational purposes; not currently identified as an existing threat (see section 4.2).

Task B-1.2.--Implement identified actions (as determined under Task B-1.1.) to ensure adequate protection from overutilization for commercial, **recreational**, **scientific**, or educational purposes.

Recovery Factor B.—Protection from overutilization for commercial, **recreational**, **scientific**, or educational purposes.

2. Overutilization of humpback chub for commercial, **recreational**, **scientific**, or educational purposes reevaluated and, if necessary, actions identified to ensure adequate protection (Task B-1.1).

Biological Opinion Elements (or parts there of):

RPA Element 1. – "…Therefore, Reclamation shall develop an adaptive management program that will include implementation of studies required to determine impact of flows on listed and native fish fauna, recommend actions to further their conservation, and implement those recommendations as necessary to increase the likelihood of both survival and recovery of the listed species."

Incidental Take ¶ 2. – "The Service anticipates that the proposed operation of Glen Canyon Dam according to the operating and other criteria of the MLFF, as described in the Draft EIS, and as changed by the reasonable and prudent alternative will result in incidental take of the Humpback chub…."

AMP Goals and MOs:

Goal 2: "Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification of teir critical habitats,"

M.O. 2.1: "Maintain or attain humpback chub <51 to >200 mm) abundance and year-class strength in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy."

RIN 2.1.2 "What are the sources of mortality for humpback chub <51 mm in rearing habitats in the LCR and mainstem and how are they related to dam operations?"

M.O. 2.2 "Sustain and establish viable HBC spawning aggregations outside of the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy."

RIN 2.2.11 "What are the impacts of current recreational activities on mortality, recruitment and the population size of Humpback chub?"

Goal 9: "Maintain or improve the quality of recreational experience for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals."

M.O. 9.1: "Maintain or improve the quality and range of recreational opportunities in Glen and Grand Canyons within the capacity of the Colorado River ecosystem to absorb visitor impacts consistent with the NPS and tribal river corridor Management Plans."

RIN 9.1.2: "Are the visitor capacities for recreational activities consistent with NPS management plans? Are the NPS management plans consistent with Colorado River ecosystem capacities to absorb visitor impacts?"

Goal 12: "Maintain a high quality monitoring, research, and adaptive management program."

M.O. 12.2: "Attain or improve monitoring and research programs to achieve the appropriate scale and sampling design needed to support science-based adaptive management recommendations."

Study Background/Rationale and Hypotheses:

HO_1: Repetitive disturbance, recapture, and handling associated with aquatic research and monitoring protocols in the AMP do not negatively impact humpback chub populations in the CRE.

HO_2: Research and monitoring protocols cannot remain effective if they are modified to reduce negative impacts to humpback chub populations in the CRE.

HO_3: Repetitive disturbance associated with recreational activities do not negatively impact humpback chub populations in the CRE.

The Humpback Chub (HBC) populations of the Grand Canyon, particularly the Little Colorado River population, have endured significant environmental manipulation and individual physical handling for the last 20 years. PIT tagging efforts alone have resulted in a majority of adult HBC being recognized individually from multiple recaptures over time. Sediment, flow, and (soon)

temperature studies, among others, affect mainstem populations to some degree through habitat disruption and invasion by investigative crews and equipment. Targeted studies affect HBC directly; studies targeting other species affect HBC indirectly, as an unintended consequence. Repetitive disturbance, recapture, and handling are continual sources of stress, health risk, and potential injury for individuals and the population as a whole. One handling estimate indicates adult HBC may suffer a one in ten chance of mortality after handling (Kubly & Walters, personal communication), but this estimate has not been verified.

Upper basin managers and investigators have similar concerns, but have not initiated specific studies to directly quantify the effect. They have, however, produced several studies investigating the impacts of electrofishing on native fish and developed modified protocols to minimize the risks (Muth, 1996, Hawkins, 2002, others). They, also, have limited population estimate efforts to three initial estimate years followed by alternating two years off and two years on to reduce the stress of population monitoring on HBC populations (Tom Chart & Tom Czapla, personal communication, Valdez & Ryel 2000).

Scientific investigation and monitoring must continue in support of the knowledge base we rely on to address CRE issues. However, in trying to learn more and more about very limited resources, the threat exists that the same activities intended to help target species, may in fact have a detrimental effect. This effect is ongoing for the foreseeable future and may have immediate consequences for HBC as long as intensive scientific effort is focused on this species and their habitat. The physical risk of injury and death associated with repeated handling and disturbance needs to be evaluated. Research and monitoring protocols modified to reduce frequency and severity of handling and disturbance could allow continued data collection with minimal impact to HBC. However, the cost of implementing such modified protocols must be weighed against the sacrifice of scientific and statistical precision required to make appropriate adaptive management decisions.

The same line of thought extends to the seasonal disturbance associated with recreational activities (boating, swimming, fishing, etc.) in the CRE and especially in the lower portions of the LCR. Repetitive disturbance is a continual source of stress, health risk, and potential injury for individuals and the population as a whole. There are no assessments of the potential impact of such activities on HBC. If feasible, a quantitative assessment would be difficult and expensive to obtain. An alternative approach is proposed.

IV. Study Goals, Objectives, End Product:

Assess the impacts of repetitive habitat disturbance, recapture, and handling on Grand Canyon humpback chub populations and develop modified protocols and management policies to maximize recreation opportunity and scientific information collection while minimizing the impacts of these activities on HBC individuals and populations. Progress or final results reports on each active study task will be presented at the end of each calendar year. The three final results reports will be combined into a final project report with implementable recommendations for AMWG approval in January 2007.

V. Study Area:

CRE below Lees Ferry, including the Little Colorado River and other significant tributaries, to the inflow of Lake Mead.

VI. Task Description and Schedule:
Quantify scientific recapture and handling i nduced mortality, FY-2004.
Assess habitat disturbance effects on displaced HBC, FY-2004.
Evaluate possible modifications to scientific gear applications, experimental protocols (research/monitoring), or recreation management policies that would reduce effects on HBC.
Assess the loss of scientific precision associated with implementing modified protocols, FY-2005-6.
Prepare annual progress reports and final report, 2004-7.
Maintain liaison with Upper Basin RIP to exchange and incorporate new techniques, ongoing.

VII. Study Methods/Approach

Task 1. Statistical analysis of existing capture/recapture data and any related mortality that might establish a pattern and rate of handling mortality related to gear types and existing handling protocols. Laboratory study using excess, cultured HBC or a surrogate species (excess bonytail?) to establish the handling mortality rates associated with various levels and methods of repeated capture, handling, and surgical or other techniques.

Task 2. Determine the level and seasonality of scientific and recreational disturbance at locations in the CRE critical to the HBC. Quantitative assessment of specific impact will be difficult and expensive (if feasible). There may be bioenergetic modeling applications that could be employed. A reasonable alternative would be to conduct a workshop of Colorado River system principal investigators and agency authorities to accept disturbance (scientific and recreational) as a negative impact at some level, and identify reasonable methods and opportunities to minimize disturbance impacts. Workshop participants would recommend monitoring and research protocol designs and recreation management policies that would limit disturbing activities to the extent reasonable.

Task 3. Test various modified protocols for capture gear types and methods (settings, configuration, placement, duration, timing, frequency, etc.) using excess, cultured HBC or a surrogate species to identify the most effective methods for study purposes that produce the least negative effect on HBC. Compare the levels of scientific precision associated with standard and modified sampling protocols.

Task 4. Progress or final reports on the status or findings of each task will be prepared at the end of each FY and reported at the end of each calendar year. All results reports will be synthesized to provide combined recommendations for presentation to the AMWG.
Task 5. Maintain liaison with related Upper Basin investigations, evaluate those findings, and recommend incorporation of appropriate modified methods and sampling protocols.

VIII. FY-2004 Work:
Task 1 Deliverables/Due Dates
Initiate and complete handling mortality evaluation, April 2004
Complete Task 1 Results Report (Task 4), September 2004
- Budget: Labor, Travel, Equipment, Other
Total = $10,600

Task 2 Deliverables/Due Dates

Conduct HBC disturbance evaluation workshop, spring 2004
Complete Task 2 Results Report (Task 4), September 2004
- Budget: Labor, Travel, Equipment, Other

Total = $30,600
Task 5 Deliverables/Due Dates
Ongoing Communication/Information Exchange – No additional cost
Report any appropriate advances annually

FY-2005 Work
Task 3 Deliverables/Due Dates
Initiate year 1 of gear and protocol evaluations,
- Complete Progress Report (Task 4), September 2005
- Budget: Labor, Travel, Equipment, Other

Total = $45,600
Task 5 Deliverables/Due Dates
Ongoing Communication/Information Exchange – No additional cost
Report any appropriate advances annually

FY-2006 Work
Task 3 Deliverables/Due Dates
- Complete gear and protocol evaluations, summer 2006
- Complete Results Report (Task 4), September 2006
- Budget: Labor, Travel, Equipment, Other

Total = $45,600
Task 5 Deliverables/Due Dates
Ongoing Communication/Information Exchange – No additional cost
Report any appropriate advances annually

FY-2007 Work
Task 4 Deliverables/Due Dates
Complete Task 1, 2, and 3 Synthesis and Recommendations Report, and present to AMWG, December 2006
- Budget: Labor, Travel, Equipment, Other

Total = $1,400
Task 5 Deliverables/Due Dates
Ongoing Communication/Information Exchange – No additional cost
Report any appropriate advances annually

IX. Budget Summary

Task 1.	$ 10,000	$ 10,000 (1yr)
2.	$ 30,000	$ 30,000 (1 yr)
3.	$ 45,000 (/yr)	$ 90,000 (2 yrs)
4.	$ 600 (/interim report)	$ 2,400 (4 rpts)
	$ 1,400 (final report)	$ 1,400 (1 yr)
5.	$ 0	$ 0 (4 + yrs)
		$133,800

FY-2004 - $41,200
FY-2005 - $45,600
FY-2006 - $45,600
FY-2007 - $ 1,400

Total: $133,800

Reviewers: AMWG HBC ad hoc

XI. References:

Hawkins, X-Ray Assessment of Electrofishing Injury of Colorado Pikeminnow. 2002.
Muth & Rupert, Effects of Two Electrofishing Currents on Captive Ripe Razorback Suckers and Subsequent Egg-Hatching Success. 1996.
U.S. Fish and Wildlife Service, Biological Opinion on Operation of Glen Canyon Dam.1993.
U.S. Fish and Wildlife Service, Recovery Goals for the Humpback Chub (*Gila cypha*) of the Colorado River Basin. 2002.

- Valdez, R.A. and R.J. Ryel. 2000. Statistical guidelines: population estimates of Colorado pikeminnow and humpback chub in the Upper Colorado River Basin. Unpublished report. SWCA, Inc., Flagstaff, Arizona.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 10

I. Title: Evaluate the use of a temporary weir in Bright Angel Creek to remove non-native salmonids from the Colorado River Ecosystem during 2002 and 2003.

II. Relationship to Programs:

Recovery Goals:

Factor C.—Adequate protection from diseases and predation.

Brown trout and rainbow trout control programs developed and implemented to identify levels of control that will minimize predation on humpback chub in the Colorado River through Grand Canyon (Task C-3.3).

III. Study Background/Rationale and Hypotheses:

This project should move to the management phase (rather than evaluation) after NEPA compliance in 2003 and may include removal of all exotic species and evaluation of removal at Clear Creek and Tapeats Creek. Project may also expand to include collection and tagging of native fishes during the spring (primarily flannelmouth and bluehead suckers).

IV. Study Goals, Objectives, End Product:

Performance Measures:

1. Evaluate the use of a temporary weir in Bright Angel Creek to remove non-native salmonids.
2. Remove brown trout (*Salmo trutta*) from the Creek.
3. Examine size, stage of sexual condition and diet of brown trout.
4. Examine all brown trout and native fish for presence of PIT tags.
5. Mark and release all rainbow trout (*Oncorhynchus mykiss*)
6. Prepare an annual progress report and final report.

V. Study Area:

Bright Angel Creek

VI. Study Methods/Approach:

VII. Task Description and Schedule:

November 2002 – February 2003

VIII. FY 2002-2003: $30,000 BOR, Contract with SWCA.

FY 2003-2006	$562,000, National Park Service for implementation if feasible and after NEPA compliance

IX. Budget Summary:

X. Reviewers:

XI. References:

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 11

Title: Removal/suppression of Nonnative Fish in tributaries of the Colorado River in Grand Canyon National Park and tribal lands

Relationship To Programs: This section provides insight into the relationship between the proposed action and the Adaptive Management Program goals and objectives, Recovery Goals for the humpback chub, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program: The goals and management objectives of the Adaptive Management Program that apply are:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)

Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)

Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Recovery Goals: The site-specific management actions and objective, measurable criteria from the Humpback Chub Recovery Goals that apply are:

5.2.2.3 Factor C.—Adequate protection from diseases and predation

Management Action C-3.—Control problematic nonnative fishes as needed.

Task C-3.1.—Develop rainbow trout, channel catfish, black bullhead, and common carp control programs in the Little Colorado River to identify levels of control that will minimize predation on humpback chub (see section 4.3.2 and A.8 for discussion of effects of nonnative fishes).

Task C-3.2.—Implement identified levels (as determined under Task C-3.1) of rainbow trout, channel catfish, black bullhead, and common carp control in the Little Colorado River.

Biological Opinion: Elements of the Reasonable and Prudent Alternative that apply are as follows. Successful completion of the RPA is necessary to remove jeopardy to the humpback chub from the proposed action (operation of Glen Canyon Dam under a Modified Low Fluctuating Flow alternative described in the Final EIS and ROD).

Element 2. Protect humpback chub spawning population and habitat in the LCR by being instrumental in developing a management plan for this river (i.e., Little Colorado River).

Study Background/Rationale and Hypotheses: Recovery Goals amend the Humpback chub Recovery Plan and establish "Site-Specific Management Actions to Achieve Recovery." For Grand Canyon, it states the need to:

ÿDevelop and implement rainbow trout, channel catfish, black bullhead, and common carp control programs in the Little Colorado River to identify levels of control that will minimize predation on humpback chub.

In response to this requirement and the Goals and Management Objectives contained in the AMP, the Adaptive Management Work Group ad hoc committee outlined the following action to achieve these purposes:

Initiate Removal of Nonnative Fishes in the Little Colorado River (lower 17.5 km) by targeting harmful nonnative fishes.

Study Goals, Objectives, End Product:

Study Goal

The goal is to explore the feasibility of reduction/removal of nonnative fishes in tributaries of the Colorado River in Grand Canyon that may include the Little Colorado River, Tapeats Creek, Havasu Creek, Shinumu Creek and Kanab Creek. This project addresses tributaries in conjunction with Project 12 that addresses removal/suppression of mainstem nonna tive populations. Nonnatives that will be targeted include salmonids, carp, channel catfish, and yellow/black bullhead but may include other nonnatives as well. The level of control necessary to reduce nonnatives, including most efficient removal methods, including reduction of bycatch and how long suppression lasts will be investigated. This project would precede efforts (Project 11) to reintroduce HBC and other native fishes once nonnative fish are removed and/or suppressed. Other tributaries, such as the LCR may not require high levels of removal/suppression due to high flow events. In addition, since the LCR contains one of the last strongholds for HBC in the lower basin, removal should be sensitive to incidental bycatch and may have to use highly selective capture methods.

Study Objectives (Performance Measures)

In cooperation with concurrent studies to identify methods to effectively capture nonnative cyprinids and ictalurids, use species-specific methods to reduce nonnative predator loads in lower 17.5 km of the Little Colorado River and other tributaries
Determine effect of removal efforts on nonnative and native fish densities, including how long do suppression efforts take for an effect to be measurable and how long do suppression efforts last
Determine habitat overlap between natives and nonnatives
Monitor changes in biomass and reproductive potential of nonnatives in response to removal efforts
Work at the watershed level to identify upstream sources of nonnative fish that may be potential sources during high flow events (**Ad Hoc group considering this a separate project**)
Work with local landowners on conservation agreements to prevent re-invasion of nonnatives from upstream sources (**Ad Hoc group considering this a separate project**)

End Product

Develop and implement a plan to effectively control nonnative fishes in Grand Canyon tributaries to levels that will minimize predation on humpback chub and other native fishes.

Study Area: Tributaries to the Colorado River within Grand Canyon National Park and the lower 17.5 km of the Little Colorado River including tribal lands

Study Methods/Approach: Removal methods will include trammel nets, fyke nets, hoop nets, angling and weirs at the mouth of tributaries. Feasibility of electroshocking using canoes, rafts and backpack units will also be explored as it relates to species specific capture frequencies and minimization of incidental bycatch. Sample size will be related to initial capture densities and be modified based on success or failure of a particular method.

Task Description and Schedule:

2003-2004: Literature search, develop operational plan, secure permits, identify information gaps and conduct reconnaissance level surveys for water quality and nonnative densities.
2004: Begin nonnative suppression in appropriate tributaries in spring and fall, monitor results and initiate dialogue with upstream landowners to address upstream sources of nonnative fish
2005-2006: Continue removal efforts; adjust suppression efforts as necessary, initiate conservation agreements with landowners
2006: Final report

FY-2004 Work: This project was initiated in 2002 and is expected to be completed in 2006. However, nonnative suppression efforts may have to be extended indefinitely to maintain low population levels of nonnative fishes.

Budget Summary:

FY 2003: $25,000
FY 2004: $100,000
FY 2005: $100,000
FY 2006: $50,000

X. Reviewers:

Peer reviewers (1999)
AMWG and TWG (1999 and 2003)
Science Advisors (2003)

XI. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 12

I. Title: Mechanical removal of non-native fishes from the Colorado River near the confluence with the Little Colorado River.

II. Relationship to Adaptive Management Program, Recovery Goals, and Biological Opinion

Goal 2 in the AMP Strategic Plan (August 17, 2001) is "Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat". Management Objective 2.6 is to "Reduce native fish mortality due to non-native fish predation as a percent of overall mortality".

III. Study Background/Rationale and Hypotheses:

A hypothesized factor in the decline in humpback chub recruitment in recent years 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. Increased recruitment of rainbow (RBT) and brown trout (BNT) has occurred since initiation of Modified Low Fluctuating Flows (MLFF), and populations in the Colorado River have increased dramatically. This project is the continuation 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 project was initiated by Grand Canyon Monitoring and Research Center in 2002 and was proposed as a multi-year treatment (GCMRC 2003).

IV. Study Goals, Objectives, End Product:

Study goals, objectives and end products were identified in the original proposal (GCMRC 2003). Hypotheses include:

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.
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.
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 change (±) 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.

V. Study area

Colorado River near Little Colorado River confluence (56.2 RM - 65.7 RM).

VI. Study Methods/Approach

Methods are fully described in GCMRC (2003).

VII. Task Description and Schedule

Tasks and schedules are fully described in GCMRC (2003).

VIII. FY-2003-2004 Work

Sampling trips are scheduled for Jan. Feb. Mar, Jul. Aug. and Sept. 2003. Interim reports are to be provided to the AMWG on a 6-month schedule.

IX. Budget Summary

Estimated cost is $600,000 - $650,000 /year for calendar years 2003 and 2004.

X. Reviewers

XI. References

Grand Canyon Monitoring and Research Center. 2003. Proposed Two-Year Science Plan for Experimental Flow Treatments and Mechanical Removal Activities in WY's 2002-2004

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 13

I. Title: Develop a monitoring program for the Colorado River downstream of Diamond Creek to detect changes in habitat and fish communities resulting from operation of Glen Canyon Dam and Lake Mead.

II. Relationships

This section provides insight on the relationship between the proposed action and the Adaptive Management Program goals and objectives, the Lower Colorado River Multi-Species Conservation Program performance standards, Recovery Goals for the humpback chub, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)

Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Management Objective 2.3: Monitor HBC and other native fish condition and disease/parasite numbers in LCR and other aggregations at an appropriate level for viable populations and to remove jeopardy. (Sequence order 2, 3 and 3.5).

Management Objective 2.4: Reduce native fish mortality due to non-native fish predation/competition as a percentage of overall mortality in the LCR and mainstem to increase native fish recruitment. (Sequence order 2, 2.5, 3)

Management Objective 2.5: Attain Razorback sucker abundance and critical habitat condition sufficient to remove jeopardy as feasible and advisable in the Colorado River ecosystem below Glen Canyon Dam. (Sequence order 4.5)

Management Objective 2.6: Maintain (flannelmouth sucker, bluehead sucker and speckled dace) abundance and distribution in the Colorado River ecosystem below Glen Canyon Dam for viable populations. (Sequence order 5 and 6)

Goal 7. Establish water temperature, quality and flow dynamics to achieve GCDAMP ecosystem goals.

Management Objective 7.1: Attain water temperature ranges and seasonal variability in the mainstem necessary to maintain or attain desired levels of desirable biological resources (e.g., native fish, foodbase and trout). (Sequence 3, 4, 5)

Management Objective 7.2: Maintain water quality in the mainstem of the Colorado River ecosystem. (Sequence order 4.5)

Lower Colorado River Multi-Species Conservation Program:

The LCR-MSCP has established basic performance standards to meet to be in compliance with terms and conditions of an incidental take permit for covered projects. The LCR-MSCP identified the need to provide a level of support to the AMP for humpback chub:

Provide $10,000/year for 50 years ($500,000) to the Glen Canyon Dam Adaptive Management Workgroup to support implementation of planned, but unfunded, species conservation measures and, as appropriate, to fund species conservation measures in the lower canyon of the Colorado River upstream of Lake Mead.

Recovery Goals:

Site-specific Management Actions to Achieve Recovery

Lower Basin recovery Unit

5.2.2.1 Factor A – Adequate habitat and range for recovered populations provided

Management Action A-1 – Investigate the role of the mainstem Colorado River in maintaining the Grand Canyon humpback chub population and provide appropriate habitats in the mainstem as necessary for recovery.

Task A-1.1 - Identify life stages and habitats of humpback chub in the mainstem Colorado River and determine the relationship between individuals in the mainstem Colorado River and Little Colorado River.

Task A-1.2 - Provide appropriate habitats for humpback chub in the mainstem Colorado River (as determined necessary under Task A-1.1)

Management Action A-2 – Provide flows necessary for all life stages of humpback chub to support a recovered Grand Canyon population, based on demographic criteria.

Task A-2.1 - As determined necessary and feasible, continue to operate Glen Canyon Dam water releases under adaptive management to benefit humpback chub in the mainstem Colorado River through Grand Canyon.

Task A-2.3 - Provide flow regimes that are necessary for all life stages of humpback chub to support a recovered Grand Canyon population.

Management Action A-3 – Investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon that would allow for range expansion of the Grand Canyon humpback chub population and provide appropriate water temperatures if determined feasible and necessary for recovery.

Task A-3.1 – Determine the effects and feasibility of a temperature control device for glen Canyon Dam under the Glen Canyon Dam Adaptive Management Program to increase water temperatures in the mainstem Colorado River through Grand Canyon that would allow for range expansion of humpback chub.

5.2.2.3 Factor C. – Adequate protection from diseases and predation

Management Action C-3 – Control problematic nonnative fishes as needed.

Task C-3.3 – Develop brown trout and rainbow trout control programs in the Colorado River through Grand Canyon to identify levels of control that will minimize predation on humpback chub.

Task C-3.4 – Implement identified levels of brown trout and rainbow trout control in the Colorado River through Grand Canyon.

5.2.2.4 Factor D. – Adequate existing regulatory mechanisms

Management Action D-1. – Legally protect habitat necessary to provide adequate habitat and sufficient range for all life stages of humpback chub to support a recovered Grand Canyon population, based on demographic criteria.

Task D-1.1 – Determine mechanisms for legal protection of adequate habitat in the mainstem Colorado River through Grand Canyon and the Little Colorado River through instream-flow rights, contracts, agreements, or other means.

Task D-1.2 – Implement mechanisms for legal protection of habitat in the mainstem Colorado River and the Little Colorado River that are necessary to provide adequate habitat and sufficient range for all life stages of humpback chub to support a recovered Grand Canyon population.

Management Action D-2 – Provide for the long-term management and protection of humpback chub populations and their habitats.

Task D-2.1 – Identify elements needed for the development of conservation plans that are necessary to provide for the long-term management and protection of humpback chub populations; elements of these plans may include…minimization of the risk of hazardous-materials spills…

Task D-2.2 – Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, Native American tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered humpback chub populations will be maintained.

5.225 Factor E. – Other natural or manmade factors for which protection has been provided.

Biological Opinion:

Elements of the Reasonable and Prudent Alternative. Successful completion of the RPA is necessary to remove jeopardy to the humpback chub from the proposed action (operation of Glen Canyon Dam under a Modified Low Fluctuating Flow alternative described in the Final EIS and ROD).

1A. Experimental flows will include high steady flows in the spring and low steady flows in summer and fall carried out during low water years (releases of approximately 8.23 maf).
1B. During moderate and high release years, Reclamation shall operate Glen Canyon Dam according to requirements of the MLFF.
3.A Determine the responses and impacts on endangered and native fishes in Grand Canyon by experimental flows provided in element 1 and obtain information necessary to adjust

operational criteria so they are beneficial for the endangered fishes and other resources affected by Glen Canyon Dam.
5. Make every effort to establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam.
6. Reclamation shall determine the feasibility of a selective withdrawal program for Lake Powell waters using the following guidelines (A-F).
7. Reclamation shall develop an adaptive management program that will afford flexibility to provide for adequate studies to review impacts to endangered and native fish species and recommend actions to further their conservation.

III. Study Background/Rationale and Hypotheses:

In the Lower Colorado River Basin, the humpback chub's largest extant population occurs in and around the confluence of the Little Colorado River and the Colorado River (River Mile (RM) 61). This is about 178 miles upstream of Separation Canyon (RM 239.5), considered the uppermost influence of Lake Mead, and 215 miles upstream of Grand Wash Cliffs, the western boundary of Grand Canyon National Park. Small aggregations of humpback chub occur up- and downstream of the LCR population. They are routinely found upstream and within 25 miles of Separation Canyon (RM 215) and adults have been captured on occasion downstream of Separation Canyon (R.Valdez (1994) "Effects of Interim Flows from Glen Canyon Dam on the Aquatic Resources of the Lower Colorado River from Diamond Creek to Lake Mead," Annual Report – 1993 to Hualapai Wildlife Management Dept. and Glen Canyon Environmental Studies, BIO/WEST Report No. TR-354-01). Critical habitat for humpback chub ends at RM 208.

Lake Mead's full pool elevation is at 1229 feet (NGVD). At this elevation, the inflow area of Colorado River is influenced by the reservoir as far upstream as approximately Separation Rapids (RM 239.5). This location is about 37 miles upstream of Grand Wash Cliffs (RM 276.5), the western boundary of Grand Canyon National Park and the eastern boundary of Lake Mead National Recreation Area. The 1992 Grand Canyon Protection Act (GCPA) uses Grand Wash Cliffs as the western boundary of the Adaptive Management Program. Under the Act, an Adaptive Management Program (AMP) was set up to provide recommendations to the US Bureau of Reclamation on Glen Canyon Dam operations to "protect, mitigate adverse impacts to and improve" downstream National Park Service resources without interfering with the "Law of the River." The Grand Canyon National Park western boundary at Grand Wash Cliffs defines the extent of responsibility for the AMP under the GCPA.

Factors such as cyclic drought and wet hydrologic periods and downstream water demands result in fluctuating Lake Mead levels. By responding to these factors, USBR reservoir and dam operations alter the inflow habitat conditions. In most respects, the inflow area alternatively changes from a lentic (slack water) environment to a lotic (moving water) environment. Such changes can dramatically affect aquatic species like fish. Changes occur to such key components as metabolic energy demands, foraging conditions, food sources, predators and competitors, shelter and spawning and rearing conditions. Although there have been and will continue to be upstream actions by USBR and others through the AMP to enhance habitat conditions and population numbers for humpback chub, these actions may be enhanced, neutralized or degraded through independent actions by the USBR and others at Lake Mead.

This area overlaps with the planning area for the Lower Colorado River Multi-Species Conservation Program (MSCP). The MSCP participants are committed to developing and implementing a program to meet a three-part goal, the first part reading as follows: "conserve habitat and work toward the recovery of threatened and endangered species, as well as reduce the likelihood of additional species listings under the federal ESA and CESA." Conserving the humpback chub not only fits within the MSCP program goal but by joining with the AMP to implement portions of its actions, the MSCP can assist in meeting recovery goals for the chub. The MSCP has indicated an interest in providing some financial support to the AMP to achieve this end.

It is unknown whether humpback chub are currently adversely affected by operations of Glen Canyon Dam or MSCP covered activities that would benefit from conservation measures. No comprehensive fish surveys have been conducted in the reach below Diamond Creek in nearly 10 years; however, we do know chub were present in the recent past. In addition, a small razorback sucker population exists in Lake Mead and has been successfully recruiting. The locations of this population's spawning and rearing areas are currently under study; but the Colorado River inflow area has not been ruled out as a site.

IV. Study Goals, Objectives, End Product:

Study Goal

Develop a monitoring program for the river downstream of Diamond Creek to detect changes in habitat and fish communities resulting from dam operation or Lake Mead.

Study Objectives

Define parameters unique to lentic and lotic environments, e.g., flow, food sources, shelter, temperature, turbidity, predation, etc.
Inventory past data sets and assess usefulness.
Establish an acceptable monitoring program including parameters, locations, frequency, etc.
Implement monitoring program.
Assess fish community (i.e. presence, advancement, or absence of native and nonnative fish species) indices relationship to habitat values.
Prepare annual progress report.

End Product

An acceptable, effective monitoring program that will track the condition of native fish populations or aggregations, and specifically humpback chub, as well as their aquatic habitats, so that trends may be determined and used to adaptively manage.

Study Area**:**

The Colorado River ecosystem downstream of Diamond Creek to Grand Wash Cliffs.

Study Methods/Approach**:**

Methods and approach will be integrated with and consistent with existing and ongoing fish and aquatic habitat monitoring efforts of the GCMRC.

VII. Task Description and Schedule:

VIII. FY 2004 Work:

We anticipate work beginning October 1, 2004 and to continue as part of an ongoing CRE monitoring program.

IX. Budget Summary:

Estimated $50,000 in the first year and $25,000 in subsequent years.

X. Reviewers:

XI. References:

Grand Canyon Protection Act of 1992. Section 1805. Long-term Monitoring of the effect of the Secretary's actions on resources of Grand Canyon National Park and Glen Canyon National Recreation Area.

Adaptive Management Work Group, Glen Canyon Adaptive Management Program. Final Draft Information Needs, November 7, 2002.

Lower Colorado River Multi-Species Conservation Program, Memorandum of Agreement, August 1995.

Lower Colorado River Multi-Species Conservation Program, Memorandum of Clarification, July 1996.

U.S. Fish and Wildlife Service, Biological Opinion on Operation of Glen Canyon Dam, 1993.

U.S. Fish and Wildlife Service, Recovery Goals for the Humpback chub (*Gila cypa*) of the Colorado River Basin. 2002.

Lower Colorado River Multi-Species Conservation Program, Lower Colorado River Conservation Program Reclamation/States Conservation Proposal, April 1, 2003.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 14

I. Title: Develop an invasive species management plan for the Colorado River Ecosystem (CRE)

II. Relationship to RIPRAP/other programs

III. Study Background/Rationale and Hypotheses:

Study Goals, Objectives, End Product: Develop a response plan to detect and quickly act should additional nonnative species become established in the CRE as well as development of additional measures to prevent further introductions. The focus should be to prevent further introductions, yet with potential temperature modification, a coordinated response that acts quickly to contain the nonnative introduction and prevent further spread is necessary.

Evaluate effective ways to detect new species within CRE
Designate interagency response team to respond to new introductions. Participant time should be funded by project monies
Develop a response plan that would go into effect if new introductions were detected, including necessary NEPA compliance
Report and evaluation of response, including recommendations for future action

V. Study area: Lower Basin Colorado River and tributaries

VI. Study Methods/Approach

VII. Task Description and Schedule:
2003: Develop plan, and implement immediately and indefinitely
2004-?: Modify plan as necessary

VIII. FY_2003 Work
_ Deliverables/Due Dates
_ Budget: $50,000 for development of plan and response team _
Labor
_ Travel
_ Equipment
_ Other
_ Total

FY_2004 Work (for multi_year study)
_ Deliverables/Due Dates
_ Budget estimate

FY_2005 etc. (for multi_year study)

IX. Budget Summary

FY_2003 $50,000 for development of plan and response team

FY-2004 $100,000-$200,000 if response action is needed to address new nonnative introduction into the CRE, will depend on extent of introduction and how quickly team members can initiate action.

FY_2005

Total:

Reviewers

References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 15

I. Title: Monitoring fish parasites and diseases, Colorado River Ecosystem.

II. Relationship to Adaptive Management Program, Recovery Goals, and Biological Opinion

Goal 2 in the AMP Strategic Plan (August 17, 2001) is "Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat". Management Objective 2.2 is to "Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy."

Management Objective 2.5 refers to attaining native fish disease and other parasite levels at an appropriate, but as yet undetermined level.

Recovery Goals:

5.2.2.3 Factor C.—Adequate protection from diseases and predation

Management Action C-1.—Control Asian tapeworm as needed.

Task C-1.1.—Develop an Asian tapeworm control program in the Little Colorado River to identify the levels of control that will minimize the negative effects of parasitism on the humpback chub population (see section 4.3.1 and Appendix A for discussion of diseases and parasites).

Task C-1.2.—Implement identified levels (as determined under Task C-1.1) of Asian tapeworm control in the Little Colorado River.

III. Study Background/Rationale and Hypotheses:

At least four exotic parasites are known to infect fishes of the LCR. Two of these parasites, Asian fish tapeworm *Bothriocephalus acheilognathi* (Cestoda) and anchor worm *Lernaea cyprinacea* (Copepoda) infect humpback chub at a higher rate than any other species in the system (Brouder and Hoffnagle 1997; Hoffnagle and Cole 1999; Hoffnagle et al 2000). Both *B. acheilognathi* and *L. cyprinacea* have been reported as pathogenic and potentially fatal (directly or indirectly) to fish of various age classes (Schäpperclaus 1986). *Bothriocephalus acheilognathi* has caused high mortality in native fishes that it has infected outside of its native range (Hoffman and Schubert 1984). These parasites cannot complete their life cycles in the mainstem Colorado River under present, cold water conditions. However, they may be transported by infected individuals to other warmer tributaries, such as Kanab Creek.

Information on disease and parasite distribution, and impact of water temperature regimes

is requested managers for making decisions regarding the future operation of Glen Canyon Dam and the proposed multi-level intake structure. Previous studies (Brouder and Hoffnagle 1997, Hoffnagle and Cole 1999, Hoffnagle et al 2000, Cole et al 2002) have identified parasites of native and non-native fishes of the lower LCR but have not surveyed fish diseases and parasites of the colder Colorado River and other tributaries in Grand Canyon. These studies should be conducted as part of the evaluation possible impacts of a temperature control device.

IV. Study Goals, Objectives, End Product:

Monitor fish parasites and diseases in the Colorado River ecosystem. Inventory parasites and diseases present in the mainstem Colorado River and larger tributaries. Examine distribution and abundance of parasites and diseases in relation to water temperature and river location. In addition, laboratory studies examining the impact of *B. acheilognathi* on growth and survival chub are being proposed through other funding sources (Cole 2002).

V. Study area

Colorado River ecosystem from Glen Canyon Dam to Lake Mead, including selected tributaries. Tributaries considered for re-establishment of native fishes should be surveyed for existing disease and parasites.

VI. Study Methods/Approach

Fish parasites and diseases will be monitored during 2004 following the methods of Cole et al (2002a). The effort will require one river trip of approximately 15 days. The work will require a separate river trip because investigators need to examine fish in the field immediately after capture in order to detect various bacteria and viruses that are not able to be preserved for later examination.

VII. Task Description and Schedule

1. September 2003 – February 2004. Fully develop study plan, secure funding and secure necessary permits.
2. February 2004 – June 2004. Obtain necessary supplies and equipment for field sampling.
3. June 2004 – August 2004. Conduct fieldwork; collect samples and complete preliminary analyses of samples.
4. August 2004 – January 2005. Prepare draft report.

VIII. FY-2003-2004 Work

IX. Budget Summary

Task	Start	Finish	Estimated Cost
Secure funding or issue rfp thru GCMRC	Sept 2003	Oct 2003	$9,000.00
Develop study plan and secure permits	Sept 2003	Febr 2004	$15,000.00
Collect samples	June 2004	Aug 2004	$12,000.00
Lab analysis	June 2004	Aug 2004	$12,000.00
Data analysis	June 2004	Aug 2004	$12,000.00
Prepare reports	Aug 2004	Jan 2005	$12,000.00
Total			$126,600.00

X. Reviewers

XI. References

Brouder, M. J. and T. L. Hoffnagle. 1997. Distribution and prevalence of the Asian fish tapeworm, *Bothriocephalus acheilognathi*, in the Colorado River and tributaries, Grand Canyon, Arizona, including two new host records. Journal of the Helminthological Society of Washington 64:219-226.

Cole, R.A. 2002. Proposal to investigate life cycle and impact of *Truttaedacnitis truttae* on Lees Ferry rainbow trout and conduct preliminary parasite inventory on flannelmouth sucker from the Lees Ferry reach. Proposal submitted to USGS State Partnership Grant and Grand Canyon Monitoring and Research Center, 2002.

Hoffman, G. L. and G. Schubert. 1984. Some parasites of exotic fishes. Pages 233-261 *in* W. R. Courtney, Jr. and J. R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. Johns Hopkins University Press, Baltimore.

Hoffnagle, T. L. and R. A. Cole. 1999. Distribution and prevalence of *Lernaea cyprinacea* in fishes of the Colorado River and tributaries in Grand Canyon, Arizona. Proceedings of the Desert Fishes Council 29:45-46.

Hoffnagle, T. L., A. Choudhury and R. A. Cole. 2000. Parasites of native and non-native fishes of the lower Little Colorado River, Arizona. 2000 Annual Report. Arizona Game and Fish Department, Phoenix.

Schäpperclaus , W. 1986. Fish diseases, volume 2. Akademie-Verlag, Berlin.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 16

I. Title: Reclamation will lead a review of Little Colorado River (LCR) watershed management plan

II. Relationship to Recovery Goals: Humpback Chub 5.2.2.4 Factor D. - Adequate existing regulatory mechanisms

Management Action A-2 - Provide flows necessary for all life stages of humpback chub to support a recovered Grand Canyon population, based on demographic criteria.

Task A-2.2 - Identify, implement, evaluate, and revise (as necessary through adaptive managment) a flow regime in the Little Colorado River to benefit humpback chub.

Management Action D-2. - Provide for the long-term management and protection of humpback chub populations and their habitat..

Task D-2.2 - Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered humpback chub populations will be maintained..

III. Study Background/Rationale and Hypotheses:

This project does not necessarily involve hypothesis testing or research, but focuses on the improvement and protection of the LCR watershed to ensure appropriate habitat conditions downstream on the LCR in the area occupied by the humpback chub. Potential issues to be addressed include surface and groundwater quantity and quality, pesticides and other hazardous substances, and non-native fish stocking.

The LCR watershed is a large area with many political jurisdictions and authorities. For this effort to be successful, these parties must work cooperatively together as they bring their various ideas and responsibilities. The Little Colorado River Multi-Objective Management (LCRMOM) group has been organized to facilitate discussions among these various interests. Reclamation, AGFD, and FWS have been involved in past discussions of the group. The purpose of Project 22 is to review the status of the LCRMOM and its development of a watershed management plan, then assist in the development and implementation of such a plan.

IV. Study Goals, Objectives, End Product:

This project will assist in meeting the Recovery Goal of assuring continued protection of conditions needed for humpback chub recovery. This will be accomplished through assisting the development of a watershed management plan for the Little Colorado River.

V. Study Area:

Little Colorado River basin above the confluence with the Colorado River..

VI. Study Methods/Approach:

Task 1. Work with Executive Director of the LCRMOM in determining current status of the LCRMOM and what options exist for development of a watershed management plan. Identify agencies, tribes, local governments, and organizations, including watershed groups, who have authority, responsibility, or interest in future of endangered humpback chub in Grand Canyon. Review Recovery Goals document and other GCDAMP publications to compile list of threats to humpback chub that arise in the LCR basin, both internal and external to the CRE.

Task 2. Convene one or more workshops to identify the vulnerability of humpback chub and actions that should be taken to address these threats, to identify authorities for addressing these threats, and to lay the foundation for a watershed-based management plan to integrate authorities, threats, and actions.

Task 3. Cooperatively develop a watershed-based management plan to provide a strategy for protecting the endangered humpback chub and other federally listed species while at the same time continuing with necessary water and resource development, prioritize necessary actions to achieve these goals, identify funding sources, construct management objectives and targets for measuring success, develop the framework for cooperative agreements, and identify a timeline for completion of tasks and measurement of successes.

VII. Task Description and Schedule:

Task 1. Review status of LCRMOM and evaluate current/projected threats to humpback chub.

Task 2. Conduct workshop with LCRMOM.

Task 3. Assist in development of watershed management plan.

VIII. FY-2004 Work:

Task 1 - Deliverables/Due Dates

- Final overview report, May 2004
- Budget: $5,000

Task 2 - Deliverables/Due Dates

- Convene workshop(s), September 2004
- Budget: $15,000

FY-2005 Work

Task 3 - Deliverables/Due Dates

- Assist in preparation of LCR watershed management plan, September 2005
- Budget: $30,000

IX. Budget Summary:

FY-2004	$20,000 Reclamation
FY-2005	$30,000 Reclamation

Total: $50,000.

X. Reviewers:

XI. Comments Received:

Need to better understand the goals of the LCR MOM, which may be organized more from an information perspective than an action perspective. Possibility for increased interaction between GCD AMP and the LCR MOM. Need some specific reason for watershed management, emphasizing partnering, that ties upper watershed management with issues in lower end of watershed. Discussion about what exactly should be in the watershed plan. Rich already included many of these threats in the Recovery Goal document. Next step is threat identification, MOM attendance, and FWS involvement in watershed activities (ESA section 9 & 10).

XII. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 17

I. Title: Conduct concurrent estimates of HBC in LCR and mainstem to develop/confirm population estimates. Evaluate the age group survivability for all age classes, including recruitment.

II. Relationship to Programs:
AMP Management Objectives:

Management Objective 2.1-Maintain and attain humpback chub abundance and year class strength in the LCR and other aggregations at appropriate target levels for viable populations and to remove jeopardy.

Core Monitoring Objective 2.1.2-Determine and track abundance and distribution of all sizes of HBC in the LCR and mainstem.

Recovery Goals:

5.3.1.1.2 Lower basin recovery unit

1. The Grand Canyon population is maintained as a core over a 5-year period, starting with the first point estimate acceptable to the Service, such that:
   a. the trend in adult (age 4+;. 200 mm TL) point estimates does not decline significantly, and
   b. mean estimated recruitment of age-3 (150–199 mm TL) naturally produced fish equals or exceeds adult mortality, and
   c. each core population point estimate exceeds 2,100 adults (MVP).

III. Study Background/Rationale and Hypotheses:

Currently population estimates for HBC are conducted in the LCR in the fall of each year to estimate abundance of smaller chub and to get a 'first' signal about the survival and potential recruitment of a given year class. Sampling is also conducted in the spring primarily aimed at marking as large a number of chub as feasible to provide information through capture and subsequent recapture for stock assessment models. Depending on the quality of data with respect to meeting assumptions of mark-recapture population estimation models, these spring data may also be used to generate a point estimate of the population size. There has and continues to be uncertainty regarding how well point estimates derived solely from LCR sampling may represent the status and trends of the 'LCR population' individuals from which are known to spend time in both the LCR and mainstem-with movement in and out associated primarily with spawning activity in the adult population. There is also concern about adopting consistent population estimation

procedures for populations of HBC in the Upper and Lower Basin vis-à-vis Recovery Goals.

IV. Study Goals, Objectives, End Product:

This project will produce estimates of abundance for HBC in the LCR and LCR confluence area of the CRE in spring of 2004 and 2005. These estimates will be used to compare with estimates obtained using only LCR sampling and using various stock synthesis models

V. Study Area:

Little Colorado River upstream 9 miles from confluence with CR and Mainstem CR from RM 56-65

VI. Study Methods/Approach :

This project would expand sampling effort in the spring to include the mainstem Colorado River near the LCR confluence from RM 56-65. Sampling would be done with a combination of hoop nets and trammel nets. HBC would be marked with either a temporary mark or PIT tag depending on size. Sampling will involve a single marking and recapture trip. These data would also be used as input data for the annual stock assessment model runs.

An additional option being considered in conjunction with this proposed action and the 'routine' LCR sampling is the implantation of sonic tags in adult HBC to yield additional information regarding the frequency and extent of movement of fish in and out of the LCR, as well as to try and determine the proportion of LCR fish which may not spawn every year, i.e. skip spawners.

Considerations- Movement and distribution of HBC seasonally complicate finding the ideal sampling schedule for this effort. It is assumed that 'most' of the population goes into the LCR for spawning and may or may not remain there during part or all of the mark-recapture sampling there, i.e. the timing of movement in and out varies from year to year and we have not good predictors of when it will occur between about March and June. Sampling in the spring would add information about the distribution of fish and their movement but could violate model assumptions for simple mark-recapture population estimation. Simulation modeling of population estimates using estimated capture probabilities and various levels of hypothetical populations suggest that the best population estimates will be obtained using the above procedures.

VII. Task Description and Schedule:

This project would be implemented in the spring of FY04 & FY05

VIII. FY-2004 Work

- Deliverables/Due Dates: Annual Report – December, 2004
- Budget:
- $220,000 two population estimation trips, $50,000 sonic tags and detectors

FY-2005 Work
- Deliverables/Due Dates: : Annual Report – December, 2005
- Budget estimate:
- $220,000 two population estimation trips,

FY-2005 etc. (for multi-year study)

IX. Budget Summary *[Provide total AND break-out by funding target (e.g. station)]*[*]

FY-2004 : $270,000
FY-2005: $220,000

Total: $490,000

X. Reviewers

GCAMP AMWG HBC AdHoc

XI. References

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 18

I. Title: Development of an Adaptive Management Work Group Outreach Program.

II. Relationship to Adaptive Management Program, Recovery Goals, and Biological Opinion

Goal 12 of the Adaptive Management Program is "Maintain a high quality monitoring, research, and adaptive management program". Management Objective 12.9 is to "build AMP public support".

III. Study Background/Rationale and Hypotheses:

AMWG has been established to develop consensus recommendations to the Secretary of the Interior on the operations of Glen Canyon Dam. Direction for AMWG can be found in the Grand Canyon EIS and the Grand Canyon Protection Act. Without an active outreach plan and program AMWG has suffered from "Agency Writers Cramp", with very little information getting to the public and what does reach the public is, normally, only from a single agencies perspective and not AMWG. For example, when the decision was made to reduce the population of trout near the LCR there was not a coordinated press release. The press ran with information from one source or another and most of us were left picking up the pieces. Rumors abounded about elimination of trout from the entire river, fluctuating flows scouring the riverbed, and attempts to break the backs of angling guides. Of course none of the rumors were true. In addition, because we do not have a coordinated outreach program, we were unable to relay a consistent message to the public. Along with the development of a comprehensive plan for humpback chub, a public outreach plan is necessary to inform the public of our goals and objectives, as well as to inform them of ongoing activities that may impact them.

IV. Study Goals, Objectives, End Product:

The goal of this project is to develop a single, consistent, and coordinated outreach program. AMWG needs to develop a process by which it can agree on the intent and content of all press releases and other outreach mechanisms.

V. Study Area

VI. Study Methods/Approach

1. An AMWG Outreach Committee will be developed, consisting of, at a minimum a representative of each governmental agency that is member of AMWG as well as Grand Canyon Monitoring and Research Center. Participation on the Outreach Committee will be limited to AMWG members or their alternates.
2. The committee will develop an outreach plan by 2004 to guide AMWG's outreach process for the next 10 years.
3. Each AMWG governmental agency will assign a Public Information Officer (PIO) to be a member of a team for coordination of all press releases. The PIO's will develop a mechanism of having input to each press release before it is presented. While desirable, the PIO may be a representative other than an AMWG member.
4. AN AMWG Outreach Team (consisting of the AMWG Outreach Committee and the PIO's) will meet twice each year prior to each AMWG meeting.
5. A representative from the AMWG Outreach Team will brief AMWG on its activities each AMWG meeting.

VII. Task Description and Schedule

July 2003 – January 2004	Develop AMWG outreach committee comprised of AMWG members.
July 2003 – January 2004	Assign PIO's to outreach team.
January 2004 – July 2004	Meet to develop an outreach plan. Estimate a need for a 3-day meeting followed by Email and conference calls.
July 2004	Draft outreach plan delivered to AMWG.
January 2005	Outreach plan approved by AMWG.
January 2005 – January 2007	Conduct outreach activities, review progress at each AMWG meeting.

VIII. FY-2003-2004 Work

Develop AMWG outreach committee and PIO's.
Draft outreach plan

IX. Budget Summary

Task	Start	Finish	Cost
Revitalize the AMWG outreach committee	April 2003	July 2003	$400.00
AMWG outreach committee meeting after July AMWG meeting	July 2003	July 2003	
Develop 10-year outreach plan	July 2003	August 2003	
Governmental agencies assign PIO to committee	August 2003	August 2003	
PIO's conduct outreach activities and participate in 2 annual AMWG meetings	October 2003	Sept 2004	$72,000.00
Travel costs for PIO's SLC 2 PHX Plus lodging	July 2003	January 2004	$2,520.00
Outreach team to brief AMWG at each AMWG meeting	July 2003	January 2004	$2,400.00
Publication costs, educational materials, printing,	2003	2004	$7,680.00
Total	April 2003	Sept 2004	$85,000.00

X. Reviewers

XI. References

Grand Canyon Monitoring and Research Center. 2003. Proposed Two-Year Science Plan for Experimental Flow Treatments and Mechanical Removal Activities in WY's 2002-2004

Project 19 – Genetics Management Plan

I. Title: Develop and Implement a Genetics Management Plan for Humpback Chub in Grand Canyon.

II. Relationship To Programs: This section provides insight into the relationship between the proposed action and the Adaptive Management Program goals and objectives, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program: The goals and management objectives of the Adaptive Management Program that apply are:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.
Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)
Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3).

Recovery Goals:

A genetics management plan is a necessary precursor to stocking from captive breeding stocks to augment declining wild populations of humpback chub. Such a plan has been developed for humpback chub and the other three big river endangered fish for use in the Upper Colorado Endangered Fish Recovery Program (Czapla 1999). Genetic considerations for recovery of humpback chub are provided in the Humpback Chub Recovery Goals (Service 2002, p. 15).

Propagation and genetics management is one of the seven elements of the Upper Colorado Endangered Fish Recovery Program. Recovery is achieved when management actions and associated tasks have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources. Population viability and self-sustainability are the cornerstones to defining a recovered species. Factors that determine population viability and self-sustainability are demographics (size and age structure of populations), population redundancy (number and distribution of populations), habitat carrying capacity (resource limitations), and genetic considerations (inbreeding and genetic viability). A core population for recovery is an independent self-sustaining population sufficiently large to maintain genetic and demographic viability.

Biological Opinions:

Element 2: Establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam.

Study Background/Rationale and Hypotheses: The genetics management plan would (1) provide justification for identification and classification of endangered humpback chub in Grand Canyon (2) describe the rationale for decisions related to genetics management of specific stocks (3) establish priorities for effective and rational genetics management actions for maintaining genetic integrity and diversity, and (5) establish criteria for initiating stocking actions.

Study Goals, Objectives, End Product: The genetics management plan would act as a foundation for annual captive breeding operating plans, broodstock plans, stocking plans, research plans, and facilities operations plans.

Study Methods/Approach: The genetic management plan would be developed using guidelines for endangered fishes in the Upper Colorado River Basin (Czapla 1999) to satisfy recovery needs of endangered humpback chub in Grand Canyon (Service 2002). Documents and authorities used to develop those guidelines would be consulted and information from ongoing studies on the genetics of humpback chub in Grand Canyon would be incorporated.

Task Description and Schedule: The genetics management plan should be in place and in use prior to removal of humpback chub for captive propagation of individuals as a source for restocking in Grand Canyon. Removal of animals for research purposes, if done separately from propagation for restocking, would not be subject to the same restrictions.

FY 2004 Work: The genetics management plan should be completed in FY 2004.

Budget Summary: FY 2004 $40,000

References:

Czapla, T.E. 1999. Final Revised Genetics Management Plan Upper Colorado River Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Denver, Colorado. 48 p.

U.S. Fish and Wildlife Service, 2002. Recovery Goals for the Humpback chub (*Gila cypa*) of the Colorado River Basin.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 20

Title: Development of Emergency Response/Contingency Plan for Protection of Downstream Species from Spills into the Little Colorado River at Cameron or other Potential Sites.

Relationships

This section provides insight on the relationship between the proposed action and the Adaptive Management Program goals and objectives, Recovery Goals for the humpback chub, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.
Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)
Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Goal 7. Establish water temperature, quality and flow dynamics to achieve GCDAMP ecosystem goals.
Management Objective 7.2: Maintain water quality in the mainstem of the Colorado River ecosystem. (Sequence order 4.5)

Recovery Goals:

5.2.2.4 Factor D. – Adequate existing regulatory mechanisms

Management Action D-2 – Provide for the long-term management and protection of humpback chub populations and their habitats.

Task D-2.1 – Identify elements needed for the development of conservation plans that are necessary to provide for the long-term management and protection of humpback chub populations.

Task D-2.2 – Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, Native American tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered humpback chub populations will be maintained.

5.225 Factor E. – Other natural or manmade factors for which protection has been provided.

Management Action E-1. Minimize the risk of hazardous-materials spills in critical habitat.

Task E-1.1 – Review and recommend modifications to State and Federal hazardous-materials spills emergency-response plans to ensure adequate protection for humpback chub populations from hazardous–materials spills, including prevention and quick response to hazardous-materials spills.

Task E-1.2 – Implement State and Federal emergency-response plans that contain the necessary preventive measures for hazardous-materials spills.

Task E-1.3 – Identify measures to minimize the risk of hazardous-materials spills from transport of materials along U.S. Highway 89 at and near the two Cameron bridges spanning the Little Colorado River.

Task E-1.4 – Implement measures to minimize risk of hazardous-materials spills from transport of materials along U.S. Highway 89 at and near the two Cameron bridges spanning the Little Colorado River.

Biological Opinions: Elements of the Reasonable and Prudent Alternative. Successful completion of the RPA is necessary to remove jeopardy to the humpback chub from the proposed action (operation of Glen Canyon Dam under a Modified Low Fluctuating Flow alternative described in the Final EIS and ROD).

2. Protect humpback chub spawning population and habitat in the LCR by being instrumental in developing a management plan for this river.

7. Reclamation shall develop an adaptive management program that will afford flexibility to provide for adequate studies to review impacts to endangered and native fish species and recommend actions to further their conservation.

Study Background/Rationale and Hypotheses:

Recovery Goals amend the Humpback chub Recovery Plan and establish "Site-Specific Management Actions to Achieve Recovery." For Grand Canyon, it states the need to:

Review and modify, if necessary, state and federal hazardous spills emergency response plans to insure adequate protection from spills, including prevention and quick response to spills; develop and implement a hazardous spills protocol for the Cameron Bridge.

In response to this requirement and the Goals and Management Objectives contained in the AMP, the Adaptive Management Work Group ad hoc committee outlined the following action to achieve these purposes:

Develop a well-designed Contingency Plan providing details about each step involved in preparing for, and responding to, spills of materials into the Little Colorado River channel at Cameron Bridge on Highway 89 for the express purpose of protecting fish species in the Little Colorado River.

Study Goals, Objectives, End Product:

<u>Study Goal</u>

Develop a well-designed Contingency Plan providing details about each step involved in preparing for, and responding to, spills of materials into the Little Colorado River channel at Cameron Bridge on Highway 89 or other potential sites for the express purpose of protecting fish species in the Little Colorado River.

Study Objectives

Identification of Background Information

Description of highway corridor, including types and volume of traffic, specific destinations, links to other highways.
Description of natural setting of Protected Corridor, including biology, habitat, specific species of concern.
Description of Protected Corridor including dimensions of the channel, surface water flow rates, seasonal variations, occurrence of groundwater, soil types, geology.
Identification of access points along Protected Corridor.
Listing of response personnel including names and phone numbers of individuals who work with tribal, state, and federal agencies, plus local people and private companies who can help with the response.
Description and location of response equipment available in the area.
Description of communications systems that will be used to coordinate the various personnel and agencies involved in the control and cleanup effort.

Identification of Spill Scenarios

Description of hazardous materials transportation practice affecting bridge including types/volume of hazardous materials crossing bridge, any posted restrictions on hazardous materials.
Description of non-hazardous materials that may also adversely impact sensitive species and their occurrence at bridge crossing.
Development of potential spill scenarios including, but not limited to, the kind of spill that is "most likely" to occur, and the "worst case" scenario.
Identification of physical, chemical, and biological techniques that can be used to contain or clean up a spill.
Description of potential necessary response time for protection of species, based on developed scenarios (i.e. higher risk to lower risk).
Describe preventative measures that could be involved such as signage, notices, speed limits,

Identification of Response Actions

Notification procedures to tribal and government authorities and agencies, including those in Grand Canyon, and private companies responsible for cleanup efforts.
Procedures for getting trained personnel and equipment to site and establishing communications.
Procedures for establishing protection of personnel health and safety and for protecting downstream fish and recreational users.

Delegation of responsibilities for identifying the type of spill, potential fate and transport scenario, potential for impacting sensitive species.
Directions for spill containment, removal, and disposal.
f. Description of follow up reporting and communication requirements**.**

End Product

An acceptable, effective Contingency Plan that will provide the best response to spills into the Little Colorado River at highway bridges at Cameron or other potential sites.

Study Area:

State Highway 89 bridge over the Little Colorado River at State Highway 89 in Cameron and other potential sites identified in the initial stages of investigation.

Study Methods/Approach:

Three elements will be completed including: Identification of Background Information; Identification of Spill Scenarios; and Identification of Response Actions. Within each element, a series of sub-elements will be completed as described above under IV. Study Objectives. Extensive coordination and communication with responsible entities, agencies and individuals will be needed to achieve a successful Contingency Plan.

Task Description and Schedule:

Objective 1: Identification of Background Information, including sub-elements *a-g* will be prepared in the first three months after notice to proceed. Objective 2: Identification of Spill Scenarios, including sub-elements *a-f* will be prepared within the first six months. Objective 3: Identification of Response Actions, including sub-elements *a-f* will be completed within the first nine months. A draft Contingency Plan will be completed within 10 months and a final within 12 months.

FY 2004 Work:

We anticipate work beginning October 1, 2004 and being completed by September 30, 2005.

Budget Summary:

Objective 1:	$30,000
Objective 2:	$30,000
Objective 3:	$40,000

References:

US Fish and Wildlife Service, Recovery Goals for the Humpback Chub (*Gila cypha*) of the Colorado River Basin: A supplement and amendment to the Humpback chub Recovery Plan, Mountain-Prairie Region (6), Denver, Colorado. 2002.

Adaptive Management Work Group, Glen Canyon Adaptive Management Program. Final Draft Information Needs, November 7, 2002.

U.S. Fish and Wildlife Service, Biological Opinion on Operation of Glen Canyon Dam, 1993.

U.S. Fish and Wildlife Service, Recovery Goals for the Humpback chub (*Gila cypa*) of the Colorado River Basin. 2002.

GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM Project 21

I. Title: Develop pollution control plan for Little Colorado River watershed that includes capability.

II. Relationship To Programs: This section provides insight into the relationship between the proposed action and the Adaptive Management Program goals and objectives, Recovery Goals for the humpback chub, and the Biological Opinion RPAs on Glen Canyon Dam operations.

Adaptive Management Program: The goals and management objectives of the Adaptive Management Program that apply are:

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

Management Objective 2.1: Maintain or attain humpback chub abundance and year-class strength in the LCR and other aggregations at appropriate levels for viable populations and to remove jeopardy. (Sequence order 1, 1.5 and 2)

Management Objective 2.2: Sustain or establish viable HBC spawning aggregations outside the LCR in the Colorado River ecosystem below Glen Canyon Dam to remove jeopardy. (Sequence order 2, 2.5, and 3)

Goal 7. Establish water temperature, quality and flow dynamics to achieve GCDAMP ecosystem goals.

Management Objective 7.2: Maintain water quality in the mainstem of the Colorado River ecosystem. (Sequence order 4.5)

Recovery Goals: The site-specific management actions and objective, measurable criteria from the Humpback Chub Recovery Goals that apply are:

5.2.2.4 Factor D. – Adequate existing regulatory mechanisms

Management Action D-2 – Provide for the long-term management and protection of humpback chub populations and their habitats.

Task D-2.1 – Identify elements needed for the development of conservation plans that are necessary to provide for the long-term management and protection of humpback chub populations.

Task D-2.2 – Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, Native American tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered humpback chub populations will be maintained.

5.2.2.5 Factor E. – Other natural or manmade factors for which protection has been provided.

Management Action E-1. Minimize the risk of hazardous-materials spills in critical habitat.

Task E-1.1 – Review and recommend modifications to State and Federal hazardous-materials spills emergency-response plans to ensure adequate protection for humpback chub populations from hazardous-materials spills, including prevention and quick response to hazardous-materials spills.

Task E-1.2 – Implement State and Federal emergency-response plans that contain the necessary preventive measures for hazardous-materials spills.

Biological Opinion: Elements of the Reasonable and Prudent Alternative that apply are as follows. Successful completion of the RPA is necessary to remove jeopardy to the humpback chub from the proposed action (operation of Glen Canyon Dam under a Modified Low Fluctuating Flow alternative described in the Final EIS and ROD).

Element 2. Protect humpback chub spawning population and habitat in the LCR by being instrumental in developing a management plan for this river (i.e., Little Colorado River).

III. Study Background/Rationale and Hypotheses: Recovery Goals amend the Humpback chub Recovery Plan and establish "Site-Specific Management Actions to Achieve Recovery." For Grand Canyon, it states the need to:

- Review and modify, if necessary, state and federal hazardous spills emergency response plans to insure adequate protection from spills, including prevention and quick response to spills.

In response to this requirement and the Goals and Management Objectives contained in the AMP, the Adaptive Management Work Group ad hoc committee outlined the following action to achieve these purposes:

- Develop a Pollution Control Plan for The Little Colorado Rvier that provides a comprehensive evaluation of threats to the humpback chub and its critical habitat that may arise from activities in the watershed and suggest potential actions to ameliorate these threats.

IV. Study Goals, Objectives, End Product:

<u>Study Goal</u>

Develop a Pollution Control Plan for The Little Colorado Rvier that provides a comprehensive evaluation of threats to the humpback chub and its critical habitat that may arise from activities in the watershed and suggest potential actions to ameliorate these threats.

Study Objectives (Performance Measures)

Review potential threats to the humpback chub population that may arise from activities in the watershed and suggest potential actions to ameliorate these threats.

1. Identification of Background Information

a. Description of state and federal water quality standards, water quality control plans and pollutant sources.
b. Description of natural setting of watershed, including biology, habitat, and specific species of concern.
c. Description of watershed, including surface water flow rates, seasonal variations, occurrence of groundwater, soil types, and geology.
d. Identification of nonpoint pollutant sources in the watershed.
e. Listing of responsible entities, including names and phone numbers of individuals who work with tribal, state, and federal agencies, plus local people and private companies.
f. Description and location of response equipment available in the area in the event of a spill, upset or other unauthorized discharge of pollutants.
g. Description of communications systems that will be used to coordinate the various personnel and agencies involved in control and cleanup efforts.

2. Identification of Pollution Scenarios

h. Description of pollution control practices affecting water quality including types/volume of pollutants, locations, and treatment methods.
i. Development of potential spill scenarios including, but not limited to, the kind of spill that is "most likely" to occur, and the "worst case" scenario.
j. Identification of physical, chemical, and biological techniques that can be used to contain or clean up a spill, upset or other unauthorized discharge of pollutants.
k. Description of potential necessary response time for protection of species, based on developed scenarios (i.e. higher risk to lower risk).

3. Identify Response Actions

l. Notification procedures to tribal and government authorities and agencies, and private companies responsible for cleanup efforts.
m. Procedures for getting trained personnel and equipment to site, establishing communications.
n. Procedures for establishing protection of personnel health and safety.
o. Delegation of responsibilities for identifying the type of spill, potential fate and transport scenario, potential for impacting sensitive species.
p. Directions for spill containment, removal, and disposal of pollutants.
q. Description of follow up reporting and communication requirements

End Product

A Pollution Control Plan for The Little Colorado Rvier that provides a comprehensive evaluation of threats to the humpback chub and its critical habitat that may arise from activities in the watershed and suggest potential actions to ameliorate these threats.

V. Study Area: Principally in the Little Colorado River watershed as little to no buffer exists between humpback chub critical habitat and sources of potential pollutants; however, other potential pollutant sources in other areas tributary to humpback chub habitats would be included in the plan depending on the perceived risk.

VI. Study Methods/Approach:

<<Information Needed>>

VII. Task Description and Schedule:

<<Information Needed>>

VIII. FY 2004 Work: We anticipate work beginning October 1, 2003 and being completed by September 30, 2005.

IX. Budget Summary:

Depending on the availability of existing watershed pollution control plans, this could take up to $100,000 over 24 months to complete.

X. Reviewers:

XI. References

APPENDIX D. Timeline

Appendix D. Draft timeline for implementation of project proposals in comprehensive humpback chub research and management plan. Revised 5/22/03

Recovery Goal Factor	Management Action	FY-2003	FY-2004	FY-2005	FY-2006	FY-2007	FY-2008	FY-2009	FY-2010
Demographic Criteria	Genetics	<-Assess Genetics Structure of ----> Grand Canyon HBC (P 01, 03)							
		<--Dev Genetics Mgmt Plan (P 19)-->							
	Captive population	<-- Research Plan ----------> <--Collect HBC---> <-- Maintain captive population for research and restoration if needed (P 02) ---------->							
		<----Short Term Grow-out Plan -----> <--Collect HBC---> <-- Remove, grow out, and replace HBC if needed ---------->							
		<---Captive Broodstock Plan (P 04)-> <--Collect HBC---> <-- Augment HBC if needed ---------->							
	Translocations	<--Transl. Plan --><-Translocate HBC above Chute Falls (P 05) -><----Monitor and augment as needed to maintain genetic variability ---------->							
		<--Eval feas of other transl. NEPA --> <--Bright Angel transl. -><- Monitor and augment as needed to maintain genetic variability ---------->							
		<-- Other trib --> <-- Monitor and augment as needed to maintain genetic variability ----------> transl.							
	Develop LCR/Mainstem Pop Estimate of HBC	<--Conduct joint LCR/Mainstem Pop estimate and test model assumptions (P 17) --> <-- Implement protocols ---------->							
Adequate Habitat and Range for Recovered Populations Provided	Temperature Control Device	<--Risk Assess-><-NEPA-><----------TCD Construction (P 06)----------> <-- Test TCD ---------->							
		<----------Implement Pre-TCD Monitoring----------> <----------Implement TCD Evaluation/Monitoring---------->							
	Use Dam Operations To Disadvantage NNF And Assist Native Fish	<--- Conduct / Evaluate Current ---> Exp Flows (P 07)							
		<-----Design Experimental Flow Program ----------><-- Implement Experimental Flow Program ---------->							
	Sediment Augmentation	<------Evaluate Sed Augm (P 08)-----> <-- Implement Augmentation if Feasible ---------- NEPA							
	Manage Turbidity To Disadvantage NNF And Assist Native Fish	<---Feas Study---> <--Turbidity Exp--> (P 08)		<----------Implement Turbidity Management if feasible---------->					

(P xx) refers to project numbers in Appendix C

Protection from Overutilization for Scientific Pur. or Recreation	Impacts of Recreation and Scientific Activities	<--Evaluate Threats-> <-- Implement actions to reduce threats from recreational and scientific activities ----------> from Scientific Work or Recreation (P 09)							
Adequate Protection from Diseases or Predation	Non-Native Fish Control	<--NEPA (NPS)-><-----Remove non-native fish from mainstem and tributaries (P 10, 11, 12)---------->							
	Control Invasive Species	<---Establish Baseline and monitor non-native fish below Diamond Creek (P 13)----------> <--Develop Invasive Species--> <-- Implement invasive species management plan ----------> Mgmt Plan (P 14)							
	Parasites and Disease Control	<----Survey Parasites and Diseases, monitor, and if feasible, implement control program (P 15)-------->							
Adequate Existing Regulatory Mechanisms		Several supporting regulatory mechanisms exist (e.g. NEPA, GCPA) and additional mechanisms could be established to protect habitat.							
Protection from Other Natural or Manmade Factors	Implement Toxic Spill Management / Prevention at Cameron Bridge	<--Collaborate with others --> <-- Implement spill response and pollution control plans (P 20, 21) ----------> to develop spill response and pollution control plans							
	Review LCR Watershed Mgmt	<--Identify Threats--><--Collaborate with---><--Assist with implementing actions to decrease threats ----------> to LCR LCRMOM to dev plan (P 16)							
Supporting Actions	Outreach Program	<----------Develop and implement outreach program (P 18)---------->							
	Develop Recovery Implementation Plan	<------Develop Recovery Agreements----------><----------Implement Recovery Action Plan---------->							
Recovery Goal Factor	**Management Action**	**FY-2003**	**FY-2004**	**FY-2005**	**FY-2006**	**FY-2007**	**FY-2008**	**FY-2009**	**FY-2010**