Plan for Non-native Fish Control in the Colorado River Ecosystem 2002-2006

Submitted to:
Glen Canyon Dam Adaptive Management Program Technical Work Group
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Prepared by:

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 2
INTRODUCTION/ BACKGROUND 3
ASSUMPTIONS 5
PROBLEMS FACED BY NATIVE FISHES 6
Cold water temperature 6
Trout Predation 7
Channel Catfish, Bullhead, and Common Carp Predation 7
Predation and Competition with Other Non-native Fishes 8
STRATEGIES TO ADDRESS THE PROBLEMS 9
Brown trout and rainbow trout predation 9
Channel catfish, black bullhead and carp predation 10
Competition with non-native fishes 10
MONITORING AND RESEARCH 11
MANAGEMENT CONSIDERATIONS 12
Timing concerns 12
Social concerns 12
Biological concerns 13
Institutional concerns 13
RECOMMENDATIONS 13
Draft Work Plans for Research and Monitoring 2002-2006 15
Project 1: Feasibility Study to determine the efficacy of using a weir in Bright Angel Creek to capture brown trout. 15
Project 2: Mechanical removal of non-native fishes (primarily salmonids) from the Colorado River near the confluence with the Little Colorado River. 16
Project 3: Fluctuating Flows to Disadvantage non-native fishes. 16
Project 4: Evaluation of catfish and carp removal methods in Little Colorado River. 17
REFERENCES 18
APPENDICES 21
Technical Work Group ad hoc members: 23
Summary of committee work done 24
Copy of cover letter sent with non-native fish control matrix survey. 25
Copy of control matrix distributed to select individuals 26
Names of survey participants 27
FIGURES 33
Figure 1. Estimated humpback chub recruitment and rainbow trout catch per 10 hours of electrofishing near the mouth of the LCR. 33
Figure 2. Estimated humpback chub recruitment and brown trout catch per 10 hours of electrofishing near the mouth of the LCR. 34

EXECUTIVE SUMMARY

Non-native fish have been in the Colorado River system since the late 1800's. These non-native fishes compete with and prey upon endangered humpback chub (*Gila cypha*) in the vicinity of the Little Colorado River. Since implementation of the Record of Decision, salmonids have increased in number and appear to be specifically problematic. Other factors contribute to the endangered status of the humpback chub, but reducing the non-native pressure on humpback chub through mechanical control and flow modification appears to be the next best logical step to improve humpback chub recruitment and survival.

The Adaptive Management Work Group directed a Technical Work Group ad hoc committee to develop a research, monitoring, and management work plan for the period 2002-2006 that will address the need to reduce non-native fish predation/competition as stated in Management Objective 2.6. The committee assumes the non-native control plan's recommendations may not solve survival and recruitment problems of humpback chub and other native fish in the Grand Canyon, but in concert with other management activities will reduce some problems faced by these fish. The committee also assumes that maintenance of the Lees Ferry recreational trout fishery remains a goal for the Adaptive Management Program, and it is not the intent of non-native control to adversely impact that fishery.

Cold, clear water enhances conditions for salmonid non-natives and inhibits native fish recruitment and survival. Cold water temperature also suppresses spawning, growth, and distribution of warmwater non-native fish and associated pathogens and parasites. In addition to cold clear water, problems faced by native fish in the Colorado River Ecosystem include predation and competition at all life stages by trout, catfish and carp. Other species also become problematic for native fish under certain conditions.

Strategies to combat these problems include physical removal of predator/competitor fish; suppression of predator/competitor species spawning; and temperature, flow and turbidity management to disadvantage non-native species. Monitoring will be necessary to determine relative success of these actions. The ad hoc committee has provided recommendations to support these strategies and draft work plans for implementation during 2002-2006. Major recommendations include increasing public awareness concerning non-native fish impacts on native fishes, control of predatory trout in Bright Angel Creek, mechanical removal of trout near the confluence of the Little Colorado River by electrofishing, use of managed flows (increased daily fluctuations) to reduce non-native fish recruitment, and a temperature control device on Glen Canyon Dam. Any feasible methods to control non-native species should be implemented immediately because of the urgent need to protect humpback chub. We recommend appropriate

agencies be encouraged and supported in efforts to fund and implement efforts to control non-native fishes.

INTRODUCTION/ BACKGROUND

Native fish in the Colorado River, and specifically endangered humpback chub (*Gila cypha*) below Glen Canyon Dam, historically encountered extreme conditions of temperature, flow and turbidity. Few historic predators, long life span, high fecundity and hardy physiology allowed these fish to survive despite harsh environmental conditions.

Since the 1800's, approximately 67 fish species have been introduced to the Colorado River and fifty-seven have become established (USBR 1998). Twenty-four non-native fishes have been reported from Grand Canyon since 1958 and 13 are present today (Valdez et al. *in press*). Carp and catfish were two of the earliest non-native fish introduced by the U.S. Fish and Wildlife Service. Within 100 years of their introduction, these two species dominated the fish community, constituting about 90 percent of the fish captured (USBR 1995). The National Park Service introduced rainbow trout into Bright Angel Creek beginning in 1923 and continuing until 1964. Brown trout were also introduced into Bright Angel Creek in 1930 and 1934. After closure of Glen Canyon Dam, rainbow trout were introduced, establishing the prized Lees Ferry tailwater fishery. In response to suitable temperature, flow, and water quality, these salmonid species have expanded their presence into areas previously occupied by humpback chub (HBC) (Figures 1 and 2) (Coggins and Walters 2001). Rainbow and brown trout populations below Lees Ferry are now estimated to approach one (1) million fish although these estimates may be biased high (Speas 2001).

The few estimates which are available for native fish remaining in Glen and Grand canyons suggest they are at least two orders of magnitude less than the non-native fish population, i.e. less than one percent of the composite fish population (Speas et al. 2002, Coggins and Walters 2001). Native fishes, especially the endangered humpback chub have been in decline since before of the Record of Decision (ROD) was issued for Glen Canyon Dam operations in 1996. Recent studies indicate the decline has continued and possibly become more severe since implementation of interim and ROD flows (Coggins and Walters 2001, GCMRC unpublished data, Figures 1, 2). Although reasons for the decline in recruitment of HBC are not certain, cold water temperature, reduced turbidity, exotic parasites, modified flow regimes, and increased numbers of non-native predators and competitors are implicated.

In the Proceedings of a Symposium and Workshop on Restoring Native Fish to the Lower Colorado River, July 1999, Valdez et al. stated:

> Non-native fish occur sympatric with native species throughout the Colorado River in Grand Canyon as well as in tributaries (AGFD 1996, Valdez and Ryel 1997). Use of similar habitats and foods implies competition for many species and predation by channel catfish, black bullhead, brown trout, and rainbow trout has been documented on all four native fish species. In the LCR, Marsh and Douglas (1997) reported that approximately 4% of channel catfish collected contained 1-7 humpback chub and approximately 1.7% of rainbow trout and 16% of black bullhead examined contained humpback chub. In the mainstem Colorado River, Valdez and Ryel (1997) reported that 10.4% of brown trout and 1.5% of channel catfish contained an average of 2 and 1 humpback chub, respectively.

The current HBC population is reaching a level where attempts to increase recruitment may be critical to the continued existence of the species in the Colorado River Ecosystem (CRE). Control of predatory and competitive non-native fish is probably the first, best option to enhance recruitment and survival of native fish, specifically HBC, in the CRE. In response to the potentially critical condition of the Grand Canyon HBC population the AMWG gave direction for developing a five-year work plan for controlling impacts of non-natives on native fish recruitment and survival in the Grand Canyon. That direction was delivered in the form of the following motion, passed, as amended, January 18, 2002.

"In support of Goal 2, the AMWG recommends the following actions subject to environmental compliance to include assessing recreational use, ESA, and consultation with tribes and other affected state agencies:

1. Evaluate methods to remove non-native fish except for rainbow trout from Bright Angel Creek in 2002;
2. Evaluate methods to remove non-native fish from the LCR in 2002;
3. Gather public input, and conduct public education and environmental compliance on long-term removals in #1 and #2 above;
4. Establish a TWG ad hoc committee to develop a 2002-2006 research, monitoring and management work plan for meeting MO 2.5 and 2.6 of the 17 August 2001 draft of the AMP Strategic Plan. The TWG will report back to the AMWG at the next meeting.
5. Using data from #1 - #4 above, make recommendations on future removals."

The Management Objectives (MO) 2.5 and 2.6 (as referenced in the motion) are:

> MO 2.5. Attain humpback chub condition in the LCR and mainstem aggregations. Target is viable populations and removal of jeopardy.

MO 2.6. 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.

(Note: numbering of MO's is that used in the August 17, 2001 Draft AMP Strategic Plan).

The TWG ad hoc committee created by Item 4 in the motion is identified in the Appendix. In creating this document as directed, the committee reviewed the AMWG's specific intent in creating the motion. In reviewing the AMWG minutes from the January 18, 2002 meeting, the committee believed the focus of the AMWG discussion was non-native fish removal (i.e. control) in Grand Canyon. We recognize that there are other issues affecting native fishes that require attention, but did not feel the AMWG intended this group take on the larger, attendant charge of MO 2.5. We see this charge requiring a larger more comprehensive plan for aiding native fishes. This non-native control plan would become an integral part of that larger plan when created. Both plans need to be fully reviewed by and integrated with GCMRC's long-term monitoring and research plan. To assist in that effort we have provided the Information Needs associated with MO 2.6 and a brief synopsis of the status of those Information Needs in the Appendix to this report.

ASSUMPTIONS

The Committee's assumptions regarding non-native fish control efforts are as follows:

- Predation and competition by non-native fishes is a major threat to native fishes.
- Control of non-native fishes is not intended to adversely impact the Lees Ferry trout fishery (Goal 4 of the AMP).
- Although closely related, pursuing MO 2.5 is beyond the scope of the non-native control committee's report with regard to researching, monitoring, and managing non-native fish control for the benefit of native fish in the CRE.
- Non-native control derived from MO 2.6 will necessarily include consideration of mainstem Colorado River, Little Colorado River, and other appropriate tributary and watershed issues.
- Completion of the ad hoc charge may not result in complete control of the non-native problem or removal of jeopardy for humpback chub without other complimentary management actions. However, without some level of control of predation and competition from non-native fish, other measures to aid native fish may show limited success.

- Control of predation and competition from non-native fish using mechanical removal and increased daily flow fluctuations is the least risky and likely least costly of several options for enhancing recruitment of native fishes such as a Temperature Control Device and Low Steady Summer Flows.
- Control strategies will not eliminate all non-native fishes, but if used in the right place at the right time may provide enough suppression to give an advantage to native fishes and thereby benefit their recruitment and survival.
- Captured non-native fishes will be dealt with in a method that is socially acceptable, legal, and cost-effective.
- A method (or methods) can be found that will accomplish the desired control while meeting Park Service goals for use of "minimum tool."
- Actions that result in benefits to humpback chub may benefit other native fish species in a similar fashion.

PROBLEMS FACED BY NATIVE FISHES

Cold water temperature

Cold water has been implicated in the decline of warm-water native fishes in the CRE, through direct mortality, impacts on ability of native fishes to spawn, and by reducing survival and swimming ability of early life stages. At the same time, cold water limits parasites such as Asian tapeworm (*Bothriocephalus acheilognathi*) and proliferation of many warm-water non-native fish such as striped bass, various catfish, carp, shiners, and various centrarchids (sunfish species like bass, bluegill). Prior to the onset of year-round cold water in the canyon, carp and catfish comprised the majority of the fish community and now are less common. Cold water releases from Glen Canyon Dam limit warmwater non-native fish reproduction and survival in the mainstem just as they do native fish.

Rainbow and brown trout are the primary predators/competitors in most of the mainstem Colorado River. Their ranges overlap with native fish adults in the mainstem Colorado River but they are largely absent from warmwater fish spawning and nursery areas. While cold water restricts native fish spawning to warmer tributaries, it also isolates young warmwater native fish from the cold-water predators thus providing some relief from predation. Native fish are in a dilemma wherein they are both harmed and helped by cold water conditions due to the effects on their predators and competitors.

Trout Predation

Large-bodied BNT and RBT reduce recruitment of native fish through direct predation in the mainstem Colorado River (COR) and in the Little Colorado River (LCR). Mature BNT are piscivorous and rainbow trout are known opportunistic piscivores. Predation on HBC and other native fishes in Grand Canyon by brown trout and rainbow trout has been documented by several researchers (Minckley 1978, Carothers et al. 1981, Valdez and Ryel 1995, Marsh and Douglas 1997). Limited attention has been given to predicting population level effects on native fish, but Valdez and Carothers (1998) provided estimates of annual HBC predation in Grand Canyon and Miller (1968) attributed elimination of speckled dace in Tapeats Creek to effects of rainbow trout. Speckled dace were common in Bright Angel Creek in the 1970s (Minckley 1978) and were reported as very rare in the 1990s after an increase in BNT abundance (Otis 1994).

Data from a March 2001 monitoring trip produced population estimates of 369,000 RBT (95% CI: 216,000-474,000) between river mile (RM) 39-196, and 84,000 BNT (95% CI: 55,000-114,000) between RM 39 and 160 (Speas et al. 2002). Although both species of salmonids are being monitored on an annual basis, predation rates in the mainstem are uncertain. Recent studies suggest predation on native fishes may be a problem. Valdez and Ryel (1997) reported that 10.4% of brown trout in the mainstem contained an average of two humpback chub. Marsh and Douglas (1997) found during a four-year study in the LCR that humpback chub and other native fishes were significant components of the diet of introduced predatory fish species (including BNT and RBT) (13.7% frequency of occurrence in stomachs having food).

Channel Catfish, Bullhead, and Common Carp Predation

Channel catfish (CCF) were introduced into the Colorado River system in the 1890s (Tyus and Nikirk 1990). They are considered a major threat to the native fish fauna of the Colorado River basin by a majority of biologists surveyed (Hawkins and Nesler 1991, Tyus and Saunders 1996). Biologists surveyed for this report also ranked CCF high among perceived threats (see Survey Response section). They are known to prey on young Colorado pikeminnow, razorback sucker and *Gila* spp. (Coon 1965; Taba et al. 1965; Marsh and Brooks 1989) and there is evidence of attempted predation on humpback chub (Kaeding and Zimmerman 1983; Karp and Tyus 1990). Suspected impacts include predation on native fishes, especially larvae and juveniles, and competitive interactions (Lentsch et al. 1996).

Large-bodied ictalurids including channel catfish (CCF) and black bullhead (BBH), as well as carp (CRP) reduce recruitment of native fish through direct predation. Some data have been collected on predation within the LCR (Marsh and Douglas 1997); however, densities of CCF, BBH and CRP in the LCR are largely unknown. Present monitoring activities sample young-of-

the-year fishes but are not effective in capturing most adults. During 2002, evaluations to develop more effective capture and monitoring methods for adult CCF, BBH and CRP were relatively disappointing in that few fish were captured.

Evaluation of limited numbers of CCF stomachs in the LCR showed some predation on HBC, but most stomachs examined did not contain fish. Some adult HBC captured in the LCR have also been reported to have what appear to be CCF bite marks (Kaeding and Zimmerman 1983). Catfish as large as 16 pounds have been collected in the LCR, and fish of this size are capable of preying on large HBC. Black bullheads have also been demonstrated to prey on native fishes (Marsh and Douglas 1997), and bullheads are common in the LCR (GCMRC, unpublished data).

Common carp were introduced in the Colorado River about 1880 and are now common or abundant throughout the basin. Common carp are ranked fourth on a list of 28 non-native fish species considered to adversely impact native fishes in the Colorado River and southwestern streams (Lentsch et al. 1996). Respondents to the survey collected for this plan ranked CRP high on the list of species perceived as threats to native fishes.

Predation and Competition with Other Non-native Fishes

Other non-native fish are common in the CRE and may reduce recruitment of native fish through competition and predation. Small-bodied non-natives are capable of multiple spawns per year and inhabit backwater areas used by young native fish. These fish are capable of responding very quickly to favorable conditions. Impact of these non-native fish on native fish in the CRE is unknown, but competition, especially with young HBC, may be inferred by their occurrence in samples with HBC. Densities of fathead minnow (FHM), plains killifish (PKF), and red shiner (RSH) are highly variable in space and time, and densities are difficult to monitor. Striped bass, walleye, flathead catfish, and various sunfishes (bluegill, green sunfish, smallmouth and largemouth bass, and crappie) currently are not considered significant predators or competitors in Grand Canyon, possibly due to a combination of cold water and high velocities (See Survey Responses Section).

Large-bodied exotic fish also may reduce recruitment of native fish through competition which is defined as the shared use of a limiting resource (e.g. food, space, shelter). Habitat alteration caused by activities of CRP was listed as a possible impact by basin researchers (Hawkins and Nesler 1991). Direct documentation of competition is difficult, but is suggested by native and non-native fishes occupying the same habitat, and by their concurrent collections in a variety of habitats (GCMRC unpublished data).

Other concerns relate to non-native parasite introductions. Some non-native fishes (e.g. FHM and PKF) have been shown to carry parasites that infect humpback chub (Cole et al. 2002). Reduction of non-native fishes and preventing introduction of new fish species may help reduce transmission of parasites. Small-bodied non-natives are capable of multiple spawns per year and inhabit backwater areas used by young native fish. These fish are capable of responding very quickly to favorable conditions. In addition, anglers may illegally import small non-natives as baitfish and further exacerbate competition, predation and parasite impacts.

STRATEGIES TO ADDRESS THE PROBLEMS

Brown trout and rainbow trout predation

As a control strategy, AMWG has proposed a series of mechanical removals of salmonids using electrofishing from the Colorado River near the confluence with the Little Colorado River (GCMRC 2002). The project is designed to evaluate the potential effect of RBT and BNT predation on HBC recruitment and the efficacy of mechanical removal from the LCR inflow reach.

The National Park Service is initiating a feasibility study of brown trout removal in Bright Angel Creek in 2002-2003. If trout removal is successful in Bright Angel Creek, National Park Service will consider removal efforts in other tributaries in Grand Canyon National Park (J. Cross, personal communication) after appropriate public input. Ongoing genetics and isotope studies will help to identify natal streams of salmonids, but funding for this work may need to be increased for more than feasibility level results to accrue.

Broad-scale control of salmonid predators through regulation of Glen Canyon Dam releases will be evaluated during the experimental flows proposed for 2003-2004. This method, which involves increasing daily fluctuations of Glen Canyon Dam releases from January-March, is anticipated to reduce survival of eggs and aelvins in redds, and disadvantage fry and fingerlings in nearshore habitats. Determination of mortality from experimental flows and separation of these effects from other sources of mortality is a challenge that needs to be addressed.

Additional broad-scale control mechanisms for coldwater salmonids are a selective withdrawal device on Glen Canyon Dam and manipulation of mainstem turbidity. Late summer release temperatures from an appropriately placed selective withdrawal could easily produce water temperatures downstream of Lees Ferry above 20 sufficiently high to cause large-scale mortality of mainstream salmonids.

Increasing turbidity can disadvantage coldwater salmonids and other sight-dependent predators. Small-scale supplementation of sediment inputs below Lees Ferry, well below levels potentially necessary to balance the sediment budget in upper Grand Canyon may help reduce predation downstream. Fine sediments also might be used to choke interstices of salmonid redds, which could result in decreased water circulation and lowering of dissolved oxygen levels sufficient to cause mortality of developing embryos and aelvins. The exact mechanism for achieving this sediment augmentation strategy is unknown at this time. This strategy is not intended to adversely affect the Lees Ferry recreational trout fishery.

Channel catfish, black bullhead and carp predation

Channel catfish, black bullhead, and common carp are, in contrast to rainbow trout and brown trout, warmwater fish that successfully occupy highly turbid rivers. These species are omnivorous and eat a variety of plant and animal matter. Carp are well-known egg predators, particularly of eggs from fish who deposit them in soft sediments. Catfish and bullheads are similar to brown trout and rainbow trout in that they become more piscivorous with increasing age and size.

Little dedicated sampling of either catfish or carp has occurred under the Glen Canyon Environmental Studies or GCDAMP programs. Both species probably occupy the entire length of the Colorado River below Glen Canyon Dam, but their abundances increase with distance downstream from the dam probably due to warmer water.

Evaluation of methods to control catfish and carp should be continued as part of existing monitoring activities in the LCR and mainstem Colorado River. Effective capture methods may include netting, specialized electrofishing, or angling. All channel catfish, black bullheads, yellow bullheads, and common carp collected in the LCR as part of long term monitoring activities should be removed and their gut contents examined for evidence of predation. All channel catfish, black bullheads and yellow bullheads collected in the mainstem Colorado River should be removed and their gut contents examined. Carp are collected in electrofishing catches in the mainstem (during two electrofishing monitoring trips in 2002 approximately 300 carp were captured). Removal of carp at this point seems infeasible until appropriate carcass removal strategies are developed.

Competition with non-native fishes

In ecology, competition is the interaction between two or more organisms, or groups of organisms, that use a common resource in short supply. Measuring competition directly is extremely difficult. Strategies to reduce competition may include strategies identified above,

including mechanical removal, managed flows including evaluation of high flushing flows to reduce small-bodied non-natives and higher daily fluctuations to reduce salmonid recruitment.

MONITORING AND RESEARCH

In order to assess effects of management actions on both native and non-native fishes in Glen and Grand Canyon an effective long-term monitoring and research program needs to be in place before management actions are started. The Grand Canyon Monitoring and Research is in the process of developing such a long-term monitoring program. Certain parts of the long-term monitoring program are in place and appear effective, other parts are being refined. See the section on Information Needs in the Appendix for our assessment of the status of progress towards answering Information Needs related to MO 2.6.

We advocate that the AMWG support the following activities:

- Continue monitoring recruitment of HBC and FMS using stock synthesis models (SSM)
    - GCMRC and cooperators 2000-2003.
        - New Agreements are needed for 2004-2006
    - Continue to develop SSM for BHS
        - Current data appears inadequate for conventional stock synthesis modeling of BHS populations. Efforts are underway to attempt to mark greater numbers of BHS in the LCR and other tributaries.
    - Compile and analyze available monitoring data for SPD
        - This task has not been specifically assigned, and data are somewhat limited.
- Monitor population status of HBC in LCR during spring and fall.
    - GCMRC and cooperators 2000-2003 to be evaluated in 2004.
    - Continue lower 1200 m LCR long term monitoring to verify modeling efforts and population estimates.
- Continue to refine monitoring efforts for native fishes in CRE.
    - GCMRC and cooperators 2000-2003. There are still monitoring difficulties that need to be resolved in the mainstem CRE.
- Continue monitoring densities of adult RBT, BNT and CRP in mainstem
    - GCMRC and cooperators (thru RFP) 2000 – 2003. This part of the monitoring program appears adequate for assessing status and trends of RBT and BNT. Evaluation of CRP monitoring effectiveness needs to be continued through 2003. New agreements are planned for 2004-2006

- Develop methods to monitor densities of spawning and rearing BNT in Bright Angel Creek
    - NPS and cooperators 2002-2003. Future work will depend upon feasibility of weir studies conducted during winter 2002-2003.
- Evaluate importance of tributary streams to salmonid recruitment.
    - Complete and review genetic and isotope work conducted to evaluate natal streams of salmonids.
- Continue to develop methods to monitor densities of CCF and CRP in LCR and CRE
    - GCMRC and cooperators 2002-2006.
        - Ongoing monitoring activities in the LCR, investigation of other methods.
- Integrate fish monitoring activities with foodbase monitoring activities.
- Continue sampling of salmonid predators as part of GCMRC's core monitoring program coupled with evaluation of gut contents during the proposed mechanical removal project being undertaken by Bureau of Reclamation, National Park Service, and U.S. Geological Survey and the National Park Service's feasibility study of trout removal in Bright Angel Creek to provide information on the incidence of predation on native fishes.
- Diet and food availability for both native and non-native fishes should be evaluated through fish and aquatic food base monitoring to assess possible competitive interactions.

MANAGEMENT CONSIDERATIONS

Timing concerns

Humpback chub may be running out of time. Populations may be approaching levels too low to maintain genetic diversity. Feasible management actions to control non-native fish need to be taken immediately.

Social concerns

Killing fish without putting them to good use, especially in a sacred place, may be offensive to some stakeholders.

- Strategies
    - Continue and expand consultation and coordination with tribes, affected state agencies and the public on appropriate removal options.

- Disposal of carcasses needs to be conducted in a manner that provides some benefit.

Anglers are concerned about possible impact on Bright Angel Creek recreational brown trout fishery.

- Strategies:
  - Inform the public of AMP activities through public meetings.
  - Expand outreach efforts by research and monitoring crews in the field to better educate the public about AMP activities.

Biological concerns

Efforts to reduce non-native fish densities may adversely affect native fishes.

- Strategies:
  - Ensure that monitoring data to assess status and trends of native fishes are collected and reported in a timely manner.
  - Assess cumulative effects of electrofishing for non-native fish capture on native fishes.
  - Develop methods and specific timing that reduces likelihood of negative impacts to native species.

Institutional concerns

Efforts to reduce non-native fish may fall outside the scope of the AMP.

- Strategies:
  - Encourage appropriate agencies to seek additional funding to support and implement non-native control efforts.

RECOMMENDATIONS

The committee recommends that the Glen Canyon Dam Adaptive Management Work Group

1. **Improve public information and education efforts concerning non-native fish impacts on native fishes.**

   Control and suppression efforts will continue to generate public interest and controversy. Public information and education efforts are needed to move forward with these efforts.

2. **Evaluate methods to remove brown trout from Bright Angel Creek and consider the removal of rainbow trout after public input.**

   Continue to encourage and support the National Park Service in these efforts.

3. **Evaluate shocking and removal of rainbow trout near mouth of the Little Colorado River.**

   Work with GCMRC to resolve fish disposal issues. Continue core monitoring to cross validate efforts.

4. **Evaluate channel catfish, black bullhead and carp removal using nets and other appropriate methods in the Little Colorado River.**

   Continue to evaluate methods for capturing catfish and carp during normal monitoring activities.

5. **Evaluate managed flows to disadvantage trout and other non-native fish.**

   If planned experimental flows for 2003 are not implemented, follow through to attempt these flows in 2004.

6. **Evaluate the feasibility of a Temperature Control Device to improve humpback chub and native fish recruitment.**

   If designed and operated adequately, a temperature control device may provide great flexibility in controlling both warm and cold-water predator species.

7. **Consider sediment augmentation or redistribution to benefit native fishes.**

   Sediment augmentation or re-suspension of existing sediment through flow modification may also provide benefit to native fishes by increasing turbidity, which would limit the ability of sight feeding predators such as trout.

8. **Due to the urgency of the need to protect humpback chub, any feasible control methods should be implemented immediately.**

   Evaluations of non-native control mechanisms and other actions to improve native fish survival and recruitment should be completed expeditiously and followed quickly by the appropriate management actions. Draft work plans have been attached for the projects that are planned for 2002-2003.

Draft Work Plans for Research and Monitoring 2002-2006

Projects:

1. Feasibility Study to determine the efficacy of using a weir in Bright Angel Creek to capture brown trout.
2. Mechanical removal of salmonids
3. Experimental flows to disadvantage salmonids
4. Evaluation of catfish and carp removal methods in Little Colorado River.

Project 1: Feasibility Study to determine the efficacy of using a weir in Bright Angel Creek to capture brown trout.

Objective: 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.

Location: Bright Angel Creek

Project Leaders: Dr. Jeffrey Cross
Grand Canyon National Park
Bill Leibfried and Helene Johnstone, SWCA Environmental Consultants

Period: November 2002 – February 2003

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.

Budget:

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

Project 2: Mechanical removal of non-native fishes (primarily salmonids) from the Colorado River near the confluence with the Little Colorado River.

Objective: Evaluate mechanical removal of non-native fishes.

Location: Colorado River near confluence of Little Colorado River (River Mile 56.2 – 65.7)

Project Leader: Dr. Steven P. Gloss
Grand Canyon Monitoring and Research Center

Period: 2002 - 2006

Performance Measures:

1. Evaluate effectiveness of mechanical removal of rainbow and brown trout by electrofishing.
2. Evaluate impact of mechanical removal on humpback chub recruitment.
3. Prepare an annual progress report and final report.

Budget:
FY 2002-2003 GCMRC Est. $600,000-650,000 / year

Project 3: Fluctuating Flows to Disadvantage non-native fishes.

Objective: Evaluate effect of experimental flow regime on non-native salmonids recruitment.

Location: Colorado River from Glen Canyon Dam to Diamond Creek

Project Leader: Dr. Steven P. Gloss
Grand Canyon Monitoring and Research Center

Period: Experimental flows are proposed for 2003 and 2004 with ROD flows during 2005-2006 to act as experimental controls

Performance Measures:

1. Evaluate effectiveness of proposed experimental flow regime to reduce salmonids recruitment.
    a. Full experimental design has been outlined by GCMRC in their Experimental Flow Plan (GCMRC 2002).
2. Prepare annual progress report and final report.

Budget: ??? GCMRC- Appropriated funds to support experimental flows.

Project 4: Evaluation of catfish and carp removal methods in Little Colorado River.

Objective: Continue to evaluate new gear and methods to capture and monitor channel catfish and carp in the Little Colorado River as part of routine monitoring activities.

Location: Little Colorado River near confluence with Colorado River

Project Leaders: Arizona Game and Fish Department, U.S. Fish and Wildlife Service, other Cooperators

Period: 2002 - 2006

Performance Measures:

1. Continue to evaluate effectiveness of and test large mesh hoop nets, angling methods, and other methods to capture channel catfish and carp during routine monitoring activities.
2. Collect diet information from all exotic fishes captured in the LCR.
3. Prepare annual progress report and final report.

Budget:

FY 2002-2003 $10-20,000 ? (BOR, AGFD)

We are seeking outside funding to support this work (BOR, CUP, AGFD-SWG)

REFERENCES

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APPENDICES

INFORMATION NEEDS

We have attempted to provide a status summary for each of the Information Needs identified in the Draft AMP Strategic Plan under Management Objective 2.6. This non-native control report needs to be fully reviewed by GCMRC. To assist in that effort we have provided a list of IN's and an assessment of the status of the IN's.

> M.O. 2.6 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.

Core Monitoring Ins	**Status**
CMIN 2.6.1 Determine and track the abundance and distribution of non-native predatory fish species in the Colorado River ecosystem and their impacts on native fish.	On track for trout and carp through GCMRC AGFD monitoring through 2003. Further refinement of CCF monitoring methods is called for.
Research Ins	
RIN 2.6.1 What are the most effective strategies and control methods to limit non-native fish predation and competition on native fish?	Ongoing, part of this exercise. Evaluate diet of RBT, BNT, CCF and CRP in CRE as part of long-term monitoring to determine predation rates. Remove all CCF, BBH and CRP collected as part of long-term monitoring activities in the LCR.
RIN 2.6.2 Determine if predator suppression increases native fish populations?	This IN will take several years to assess. Need to make sure there are enough replicates of treatments to separate the 'signal' from the 'noise'.
RIN 2.6.3 To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?	Ongoing, part of this exercise.
RIN 2.6.4 What are the target population levels, body size and age structure for non-native fish in the Colorado River ecosystem that limits their levels to those commensurate with the viability of native fish populations?	This may be a modeling exercise. We don't have the information needed to answer this question.
RIN 2.6.5 What are the sources (natal stream) of non-native predators and competitors?	Ongoing, Philipp genetics work, Michigan isotope analyses.
RIN 2.6.6 What are the population dynamics of those non-native fish that are the major predators of native fish?	At present major predators appear to be brown trout, ictalurids (including channel catfish and black bullhead) and rainbow trout. Brown trout and ictalurids may be dependent on tributary spawning whereas

	rainbow trout spawn in the both coolwater tributaries and the mainstem Colorado River. Other aspects of population dynamics should be reviewed.
Effects Monitoring Ins	
EIN 2.6.1 How does the abundance and distribution of non-native predatory fish species and their impacts on native fish species in the Colorado River ecosystem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?	Ongoing, will take replicated experiments and long term monitoring.

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Summary of committee work done

Members of the committee held a conference call (24 September 2002) to elect a chair, discuss the assignment from the AMWG, and review a preliminary outline of the committee report prepared by the previous chair (Rick Johnson). The group agreed to continue working on the report. A revised outline was prepared by the Chair and distributed on September 27th. Comments were received from one member of the group on October 7, and a second draft of the report was distributed on October 9, 2002. No further comments were received by October 15, 2002, so the chair proceeded with the outline as presented.

The chair also prepared a non-native fish control strategy matrix survey for review by the committee prior to sending it to members of the Native Fish Work Group and fish biologists working in Glen and Grand Canyons. The survey was designed to help evaluate feasibility of different control strategies for non-native species perceived as threats. The survey was sent to approximately 30 fisheries workers on October 7, 2002, and returned by 11 persons. Results of the matrix survey are presented. The working members of the committee met on November 6, 2002 to review the charge, the draft outline and to assign sections of the report for completion by November 22, 2002. The chair presented a status report at the TWG meeting on November 8 with a revised schedule for completion. The working members of the committee held a conference call on November 21, 2002 to discuss final changes to the draft. A draft report was E-mailed to the full TWG on November 22 with comments due back to the chair on December 11. Comments were received from several reviewers and incorporated into the final draft report that was E-mailed to the TWG on December 17. A TWG phone poll was held on December 20 to recommend forwarding the final committee report to the AMWG on December 27with minor changes suggested by the group.

The AMWG met on January 28, 2003 and approved the plan.

Copy of cover letter sent with non-native fish control matrix survey.

October 7, 2002

On behalf of the non-native control group ad hoc committee, Glen Canyon Dam Adaptive Management Program Technical Work Group, we are conducting an informal survey of fishery biologists and other persons familiar with the Colorado River to assess perceived threats to the native fish community. We are asking your assistance in completing a brief survey to assess species that pose the greatest threat to native fishes and an assessment of possible control techniques for those species. **By "control" we mean reducing the non-native fish sufficiently to benefit the native species of concern (primarily humpback chub).**

In the attached spreadsheet, please:

1. Rank the listed species in order of perceived threat to native species, with 1 being the highest threat.
2. For each combination of species and control technique, assign a rank from 1 to 10 according to the expected effectiveness of the control technique in suppressing the target species impacts in the Colorado River Ecosystem (from Glen Canyon Dam to the western boundary of GC National Park). A rank of 1 means the control technique is expected to be highly effective; a rank of 10 means the control technique is expected to not be very effective. Leave a cell blank to indicate that a particular technique is not thought to be applicable for control of a particular species. This table is intended as a basis for discussion. Feel free to amend or add comments.
3. List other possible control methods you think might be effective, either in the indicated column, or in separate text accompanying your response.
4. List additional species that you perceive to be a threat in the supplied row or in separate text accompanying your response.

Feel free to contact me if you have any questions about this exercise. Responses will be summarized for presentation to the Technical Work Group and the Adaptive Management Work Group in a committee report, in November 2003. If you would like a copy of the committee's report please let me know and I will be sure and send you one.

Thanks in advance for your response.

Please return the spreadsheets (preferably by Email) by October 18, 2002 to:

Bill Persons
Research Program Supervisor

Non-native control ad hoc group chairperson
bpersons@gf.state.az.us <mailto:bpersons@gf.state.az.us>
(V) 602-789-3375
(F) 602-789-3918

Copy of control matrix distributed to select individuals

1. Please rank the listed species in order of perceived threat to native fish in column B.
2. For each combination of species and control technique, assign a rank from 1 to 10 according to the expected effectiveness of the control technique in suppressing the target species impacts in the Colorado River Ecosystem (from Glen Canyon Dam to the western boundary of GC National Park). Rank of 1 means the control technique is expected to be highly effective; a rank of 10 means the control technique is expected to not be very effective. Leave a cell blank to indicate that a particular technique is not thought to be applicable for control of a particular species. This table is intended as a basis for discussion. Feel free to amend or expand it as needed.

		Control Techniques						
Species	**Rank in order of perceived threat to native fish (1 = highest threat,16 = lowest)**	**Electrofishing or net**	**Traps or weirs**	**Seine**	**Chemical (1)**	**Managed flow (2)**	**Temperature Control**	**Other control methods (please list)**
Black bullhead								
Black crappie								
Bluegill								
Brown trout								
Channel catfish								
Common carp								
Fathead minnow								
Green sunfish								
Largemouth bass								
Plains killifish								
Rainbow trout								
Red shiner								
Smallmouth bass								
Striped bass								
Walleye								
Yellow bullhead								
Additional								

(1) Target spawning aggregations or other isolated assemblages.

(2) Primarily refers to increased daily fluctuations, can include flushing flows, low flows, sediment suspension flows, habitat disruptive flows. They may each be unique in timing, duration, and release form.

Control techniques applicable for target nonnative fish species. Based on Lentsch et al. 1995 in Tyus and Saunders 1996.

Please return completed sheet to:

Bill Persons

Arizona Game and Fish Department

2221 W. Greenway Road

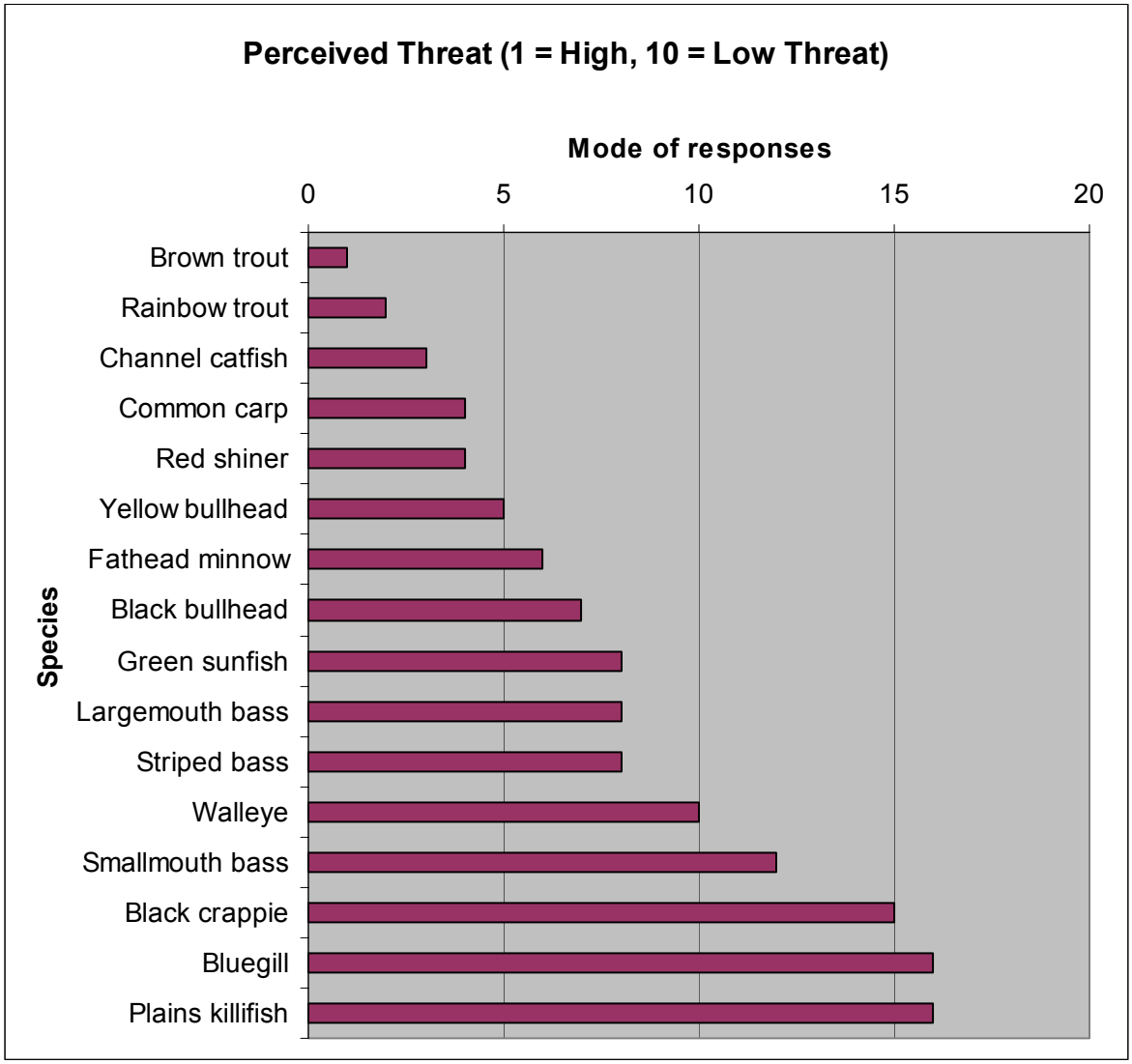
Phoenix, AZ 85023

bpersons@gf.state.az.us

Names of survey participants

Emailed survey	Responded
Bill Davis, Ecoplan Associates	X
Dennis Kubly, BR	X
Gary Burton, WAPA	X
Dennis Stone, USFWS	X
Dave Speas, AGFD	X
David Ward, AGFD	X
Scott Rogers, AGFD	X
Scott Reger, AGFD	X
Melissa Trammell, SWCA	X
Rich Valdez	X
Bill Persons, AGFD	X
Paul Marsh, ASU	x
Rob Clarkson, BR	x
Andre Potochnik, GCRG	
Chris Harris, CRBC	
Dave Foster, Marble Canyon Guides	
Jeffrey Cross, NPS	
John Shields, Wyoming	
Kerry Christiansen, Hualapai Tribe	
Mike Yard, GCMRC	
Nikolai Ramsey, Grand Canyon Trust	
Norm Henderson, NPS	
Pam Hyde, Southwest Rivers	
Rick Johnson	
Steve Gloss, GCMRC	
Ted Melis, GCMRC	
Pam Sponholtz, USFWS	
Randy Van Haverbeke, USFWS	
Andy Makinster, AGFD	
Michael Douglas, CSU	
Lew Coggins, GCMRC	
Josh Korman, Ecometrics	
Carl Walters, UBC	
Tony Robinson, AGFD	
Rob Bettaso, AGFD	
Steve Carothers	
X = Completed survey, x = commented but did not complete survey	

Ranking of perceived threat of nonnative species to native species by control survey matrix respondents. Low ranking indicates highest perceived threat.



Median rankings of control measures by species. Low numbers indicate control technique is expected to be effective, high numbers indicate control technique is expected to be relatively ineffective.

	Electrofishing or net	Traps or weirs	Seine	Chemical (1)	Managed flow (2)	Temperature Control
Black bullhead	7.5	5.5	6.5	8	8	7
Black crappie	5	5	7	5	5	5.5
Bluegill	5	5	8	5	5	5
Brown trout	**3**	**4**	**8**	**3**	**4**	**5**
Channel catfish	**7**	**5**	**8**	**5**	**7.5**	**5**
Common carp	4	5	7	3.5	7	7.5
Fathead minnow	8	5	6	5.5	4.5	6.5
Green sunfish	6	6	7	5	5	5
Largemouth bass	5	6	7	5	5	5
Plains killifish	8	5	5	2.5	5	5
Rainbow trout	**3**	**5**	**8**	**4**	**3**	**4**
Red shiner	8	5	5	4	4.5	6
Smallmouth bass	5	7	7.5	5	6.5	5
Striped bass	6	8	9	7	6	4
Walleye	5	6	9	6	6	6
Yellow bullhead	8	5.5	8.5	7	8	7
Table Total	5	5	8	5	5	5
Sum	98.5	93	124.5	85.5	95	93.5

Additional comments received from survey participants:

Attached is my first cut at the ranking sheet. Thanx for all your work getting this up and going. Regarding my conclusions: from this exercise, it becomes very apparent, temperature control suppresses the most species and the most; yet, we wish to throw this out to enhance the humpback chub. Perhaps, finding a way to suppress the few cold water species would be the most effective and result in improved survival of LCR humpback chub. It seems anything we do to try and enhance river survival for humpback will result in a multitude of other warm water species jumping on the band wagon regardless of our efforts to control the beneficial effects or target them only to humpback. The table demonstrates there are many warm water species that may pose a problem yet only a couple cold water species and these latter may be amenable to some control.
Bill Davis

A good attempt at getting some input on this type of problem, but I found it impossible to fill out your table because too many assumptions were ambiguous. For example, if you were looking for input on existing conditions, most of the fishes listed are not even present. If you were looking for input on what the fauna could look like following implementation of TCD, species such as rainbow trout presumably would not be a problem, at least in the LCR area and below. I'm afraid all I can do is list some general conclusions with multiple caveats.

In general, I believe green sunfish is the single most problematic species in the Gila basin, followed by red shiner and maybe smallmouth bass and the catfishes (including flathead). These species, if introduced to Grand Canyon, could become serious problems for natives following implementation of TCD. Obviously the two trouts and channel catfish seem to be the most problematic at present, however. For electrofishing, I doubt any significant population control could be gained except perhaps for the small-bodied fishes that reside in backwaters and nearshore areas, and maybe rainbow trout. The same (minus trout) holds for seining and maybe minnow trapping. Other trapping could be practical in certain tributaries, but I found I could not lump the mainstem and tribs into a single analysis due to their obvious physical differences. I doubt that chemical control is viable except if practiced system-wide. For example, TFM (lampricide) is highly selective against ictalurids (but not currently registered for use outside of the Great Lakes basin), and could be temporarily effective if administered at the headwaters on down. Similarly, an entire river-wide renovation with rotenone, followed by repatriation of natives, could effect significant population control of all non-native species, but such a scenario appears unlikely as an alterative at present. I considered that honking floods (>>50,000 cfs) could be effective against at least the small-bodied species and perhaps others, but that scenario doesn't look likely either. Daily fluctuations have been shown to kill a portion of rainbow trout spawn (and some adults), but such fluctuations have negative effects on other resources.

I continue to believe that TCD remains the best alternative for species control. Warming will immediately suppress downstream trout populations. If after some years of warming other non-native populations grow to undesirable levels, the warm water could be turned back off for a year or two to destablize the warmwater species. At least the natives will get off periodic mainstem spawns before one or the other nonnative group takes over.

Finally, if temperature control is implemented, stocking of squawfish might serve to suppress some populations (and might even if TCD is not implemented).

Sorry that I was unable to compartmentalize this stuff for you a little better. I will be interested in seeing how you summarize the input from others that might give you feedback. Good luck.

Rob Clarkson

Rob: Well, you pretty much said it all, and certainly expressed my thoughts on the matter. Bill -- I'm quite in agreement with Rob, and thus won't attempt to fill out the table. In fact, I tried and found that most of the entries were left blank -- the situation is just too complex and there are too many impinging variables. I'm not even sure what was intended as the baseline or geographic scope. Like your matrix, fish control in Grand Canyon is not a trivial matter, and it might be easier to approach the problem incrementally by addressing one question at a time, through which process all of the caveats, constraints, conflicts and assumptions could be identified and addressed.

In this approach, the individual species is perhaps the most useful incremental unit. Thanks for working on this, Bill. It is important. Paul Marsh/

Additional Comments received:

Comments from control techniques survey.		
Respondent:	Species or method:	Comment
R6	Electrofishing or net	EF effective for large bodied fish, probably better off with a seine for small ones
R6	Traps or weirs	mainchannel catch rates low during clear water; weir effective if tributary is significant recruitment source.
R6	Seine	See SWCA predator removal reports for efficiency of backwater seining. Not much promise for mechanical removal of cyprinids in upper basin, although catchability of same in backwaters is high. Maybe work in lower basin because they are restricted to backwaters?
R6	Chemical (1)	I never thought this was an option, but LCR seems to be the only area it might work.
R6	Managed flow (2)	Model say hi for RBT; others????
R6	Temperature Control	Likely a biological disaster; may limit RBT, but will just invite browns up to LCR region.
R6	Common carp	vegetated shallows in LCR; risk of killing HBC larvae
R5	Black bullhead	Upstream selective passage migration barrier
R5	Black crappie	Screen pond/reservoir outlets
R5	Bluegill	Screen pond/reservoir outlets
R5	Brown trout	Upstream selective passage migration barrier
R5	Green sunfish	Screen pond/reservoir outlets
R5	Largemouth bass	Screen pond/reservoir outlets
R5	Rainbow trout	Upstream selective passage migration barrier
R5	Striped bass	Upstream selective passage migration barrier
R5	Walleye	Screen pond/reservoir outlets
R9		1. I assumed present conditions and relative abundances for my rankings.
R9		2. An increase of temperatures would drastically change rankings of potential threat. It would also change relative effectiveness and applicability of different control methods
R9		3. You might want to consider asking folks to do a revised ranking with the assumption of a specific temp increase.
R9		As I ranked fish I tried to consider relative abundance, predation, resource overlap, and sympatry.
R9		4. I inserted comments on some of the methods
R9		5. A feasibility study we did for nonnative control methods in Utah lake to benefit the June sucker suggested that combinations of methods work best, e.g., for brown trout, you would want to both remove by electrofishing and weirs, and possibly even chemical treatment.
R9		6. Targeting the fish when most vulnerable is desired. Generally, when in spawning aggregations or as young juveniles.
R9	Electrofishing or net	not considered for NN rank>9. Assumes includes trammel nets , hoop nets, minnow traps, fyke nets, slat traps, etc.
R9	Traps or weirs - black bullhead	incidental to channel catfish removal efforts
R9	Traps or weirs	assumes only includes temporary or permanent weirs on tributaries

R9	Seine	This did not work in upper basin due to high reproduction, however, in temp limited GC may be more effective.
R9	Chemical (1)	assumes chemical treatment would only be used in tribs where no HBC occur, or in LF reach (sorry!)
R9	Chemicals, rainbow trout	probably ineffective to treat tribs due to mainstem spawning, treating LF reach would be very risky not to mention controversial
R9	Chemicals, carp	could be treated in some areas, but most are near LCR and chubs
R9	Temperature cntl (maintain) brown trout	Keeps them mostly downstream of LCR
R9	Temp control increase BNT	small increase could expand distribution upstream, larger increase could reduce
R9	Additional Species	Shark
R8	Other control methods (please list)	Watershed mgmt (assessments, stocking controls, local removal, and interception) should be components for most nonnatives, but particularly for small-bodied, rapidly spreading species
R8	Other control, channel catfish	Angling, Trot lines------3
R8	Other control, carp	Angling, Trot lines------4
R10	Other method	Barrier to upstream movement near lake mead (low head dam, or electric barrier) in combination with a TCD
R11	Bullheads	Slat traps
R11	Channel catfish	CC Virus?, Concentrated Angling?

FIGURES

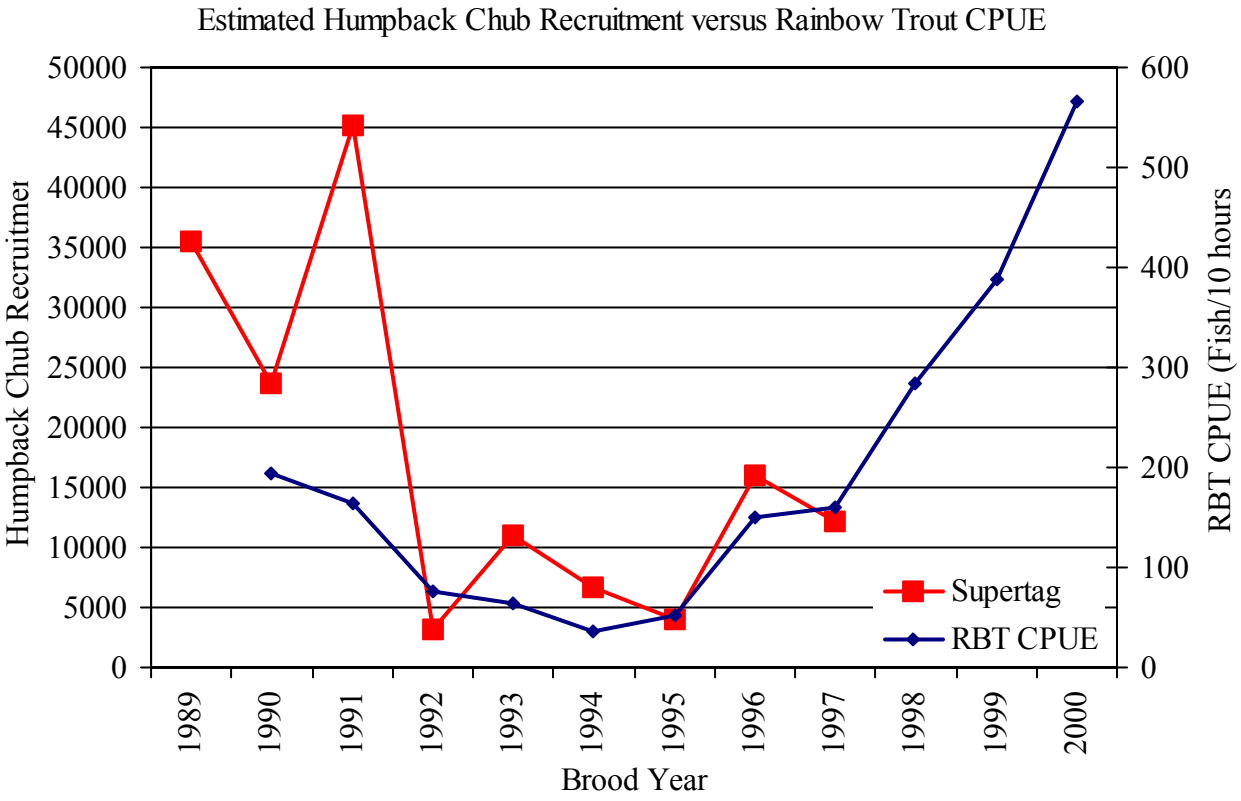


Figure 1. Estimated humpback chub recruitment and rainbow trout catch per 10 hours of electrofishing near the mouth of the LCR.

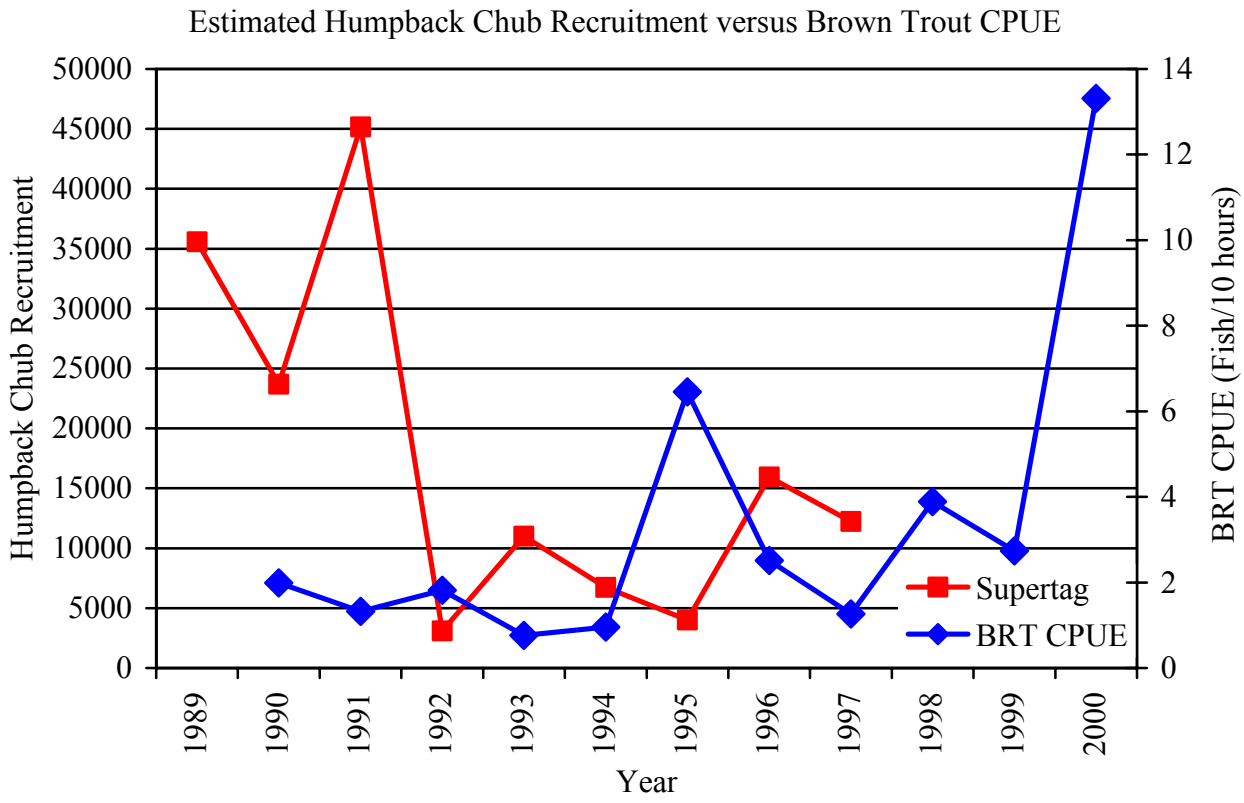


Figure 2. Estimated humpback chub recruitment and brown trout catch per 10 hours of electrofishing near the mouth of the LCR.