

**A REVIEW OF THE GCMRC
FOOD BASE SCIENCE PROGRAM
BY THE
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**A REVIEW OF THE GCMRC
AQUATIC FOOD BASE SCIENCE PROGRAM
BY THE
GLEN CANYON DAM ADAPTIVE
MANAGEMENT PROGRAM SCIENCE ADVISORS

CHARGE TO SCIENCE ADVISORS**

The Glen Canyon Dam Adaptive Management Program (GCD AMP) Science Advisors were charged, in December, 2003, to conduct a review of activities in the Grand Canyon Monitoring and Research Center's Aquatic Food Base Science Program. The review charge was as follows:

1. Evaluate the appropriateness of GCMRC's Aquatic Food Base Science Program conducted by NAU for the period 1991-2003, as related to serving current needs of the GCD AMP.
2. Evaluate recommendations of the 2001 GCMRC's Aquatic Food Base Science Program Evaluation Panel (PEP) Report, as related to the most appropriate aquatic food base science direction and proposed changes to the GCMRC/NAU Program.
3. Evaluate the GCMRC's proposed "2003 Long Term Aquatic Food Base Program," as regards the most appropriate aquatic food base program for future work.

The specific charge provided to the Science Advisors and other selected reviewers, is articulated in a memorandum of review requirements directed to reviewers in January, 2004 (Appendix A).

Scientists in this review included all GCD AMP Science Advisors (SAs) and two outside reviewers. Five of the nine GCD AMP SAs had primary responsibility for this review as did the two selected outside reviewers. These reviewers were selected for their background in aquatic ecology, fish ecology, limnology and biology. The four remaining SAs were required to review all draft and final reports, support documents and recommendations.

The Science Advisors Executive Secretary was required to conduct all review requirements of the primary reviewers. Also, as required by AMWG and GCMRC, the Executive Secretary coordinated the review process, assignments, documentation, etc.

This is the second SA review in which a team leader is selected because of the focused objectives. The team leader on this review is Dr. Margaret Palmer, Aquatic Ecologist, University of Maryland. We feel additional strength was gained from having Dr. Palmer chair this particular review.

This is the first SA review in which all individual review comments will be anonymous. We feel this protocol is important to insure review objectivity. All review statements and recommendations in the final SA report are the product of and endorsed by the entire Science Advisor Team.

This is also the first review in which the SAs requested outside anonymous reviewers to submit a formal review. Two such reviews are included in this evaluation. Also, two other scientists were contacted informally for input.

The SAs feel that our new protocols for operation of science reviews improve both the objectivity and quality of the developed reviews. The approach will be continued in 2004 and 2005 to assess effectiveness of our program.

IMPORTANCE OF THE AQUATIC FOOD BASE PROGRAM FOR THE COLORADO RIVER

An in depth understanding of the aquatic food base of the Grand Canyon National Park reach of the Colorado River is critical. Understanding the aquatic food base capability, components and dynamics is important to effective management and protection of this ecosystem. This is especially true in management for power, water, recreation, wildlife, T&E species habitat, etc. Specifically, regarding the endangered fish species humpback chub(HBC), it is critical that improved knowledge be developed regarding its food base interdependencies in the ecosystem.

The Grand Canyon Protection Act was specifically developed to mandate that appropriate protection and use practices were implemented in the Canyon to assure sustainability of its resource character, capability and structure. Among those critical resources, T&E species and especially the HBC, appear most imperiled. Critical to

stabilizing its population in the canyon is a clear ecosystem level understanding of the effects of the food base on the HBC population.

This review, therefore, is established to not only evaluate the ongoing food base science program, but also to critically assess its effectiveness in resolving answers to driving management questions, such as the potential effect of the river's food base on the stability of the HBC population. In short, is the current aquatic food base science approach the best approach to understand interactions in the ecosystem affecting the HBC? If not, what is a better approach?

Following are three areas of review that were completed.

1. Review of the historical aquatic food base program conducted by NAU.
2. Review of the 2001 Program Evaluation Panel (PEP) Report on the GCMRC aquatic food base program.
3. Review of the GCMRC 2003 proposal for future aquatic food base science.

In the following sections, each area is reviewed and recommendations are provided.

REVIEW OF THE HISTORICAL GCMRC AQUATIC FOOD BASE PROGRAM

The overall goal of the Northern Arizona University (NAU) aquatic food base program, conducted from 1991-2003, was to provide an assessment of the status and trends of the primary producers in the river. The approach used in this program was to monitor benthic algae, invertebrates, and organic material, and track changes in their composition and mass with changes in flow regimes.

This program was established to evaluate the critical role that the primary producers and their consumers play in supporting higher trophic levels. This is of great concern in regards to supporting the fish populations in the system, particularly the HBC. Thus, the target monitoring for this program is meant to serve as both an indicator of the "health" of the river, and an indicator of food availability to higher trophic levels.

Since 1991, the work for this program has been completed by scientists at NAU, with overall direction by GCMRC through an RFP process. The SAs were provided the RFP and three research reports that summarized the science procedures and findings over the period.

The consensus view of the SAs is that some form of biomonitoring is appropriate for the river food base and that in terms of the types of data that were gathered, the NAU team has responded to the RFPs that GCMRC released over the last decade. However, there was a strong sense among the reviewers that there are two problems in the NAU program that need to be viewed separately. First, the reviewers found the overall direction of the program (as specified by the RFPs) is inadequate for meeting the food base information needs required to inform GCD AMP management decisions. Second, the reviewers were in full agreement, that even given the science requested by the RFPs, the NAU work had significant weaknesses that should have been corrected as regards accepted methodological, statistical, and analysis/interpretation standards. The following comments are thus directed at each of these two separately.

Historical direction of the program. In terms of the overall program direction, it represents an inappropriate design for understanding the Colorado River food web and the trophic basis of endangered species. The historical approach is viewed as incomplete and not organized correctly to understand what controls trophic relationships in this system. One reviewer summarizes this general sentiment best. “The most serious shortcoming of the effort is the lack of the “big picture”, ecosystem-level perspective. Many of the individual studies in the 2002 document appear unrelated and/or unfocused and thus not directly relevant to the major issues for this system, ecosystem-level management of a federally endangered fish species (humpback chub) in a human-modified river system.” Another reviewer summarized the issue in the following way: “Nowhere in the 300 pages of documents provided on the aquatic food based program was there a list of actual products (I count maybe 7 published papers), nor (and this is worse) an evaluation of progress toward a goal. The fault does not lie solely with the researchers, but at least is partly the result of agencies and managers not knowing what kind of science to ask for, products to be expected, and how to use results.” Finally, one reviewer commented: “All of these reports together do not reflect a well-coordinated or thoughtful long term approach to food base evaluation. I assume this is not the researchers fault if they were responding to RFPs.”

Evaluation of NAU work given the overall direction and RFPs provided by GCMRC. The reviewers all recognized that a great deal of work was put into this

program by the NAU team. The goals were extremely ambitious, and the system very difficult to work in. Thus, the NAU team is commended for their efforts. However, all reviewers had significant concerns regarding use of appropriate science methods.

A less critical but bothersome issue was quality of the reports in terms of writing, literature citation, appropriate figures and overall presentation. The SAs assume these were final reports, and NAU/GCMRC had not accomplished appropriate editing of the reports. This inevitably leads scientists to the positions expressed by one reviewer; “The troublesome result of this lack of attentiveness to stylistic details, beyond being a distraction to the reader, is that it generates questions about the quality of the research.”

Of greater concern in this review was attention to scientific methods, analysis, and interpretation. The consensus opinions are captured in the following reviewers’ comments:

- “Many, many papers have been published outlining the criteria that can be used to best assess invertebrate and algal status in a system, and outlining how to determine how many samples are needed, what level of taxonomic resolution is required, and how to evaluate trends using sophisticated multivariate statistics. There is no evidence from the reports that any of this literature is known or that the methods (#samples, sample timing, taxonomic resolution, verification of sensitivity of approach, etc.) chosen for the monitoring are based on the best science available.”
- “There are a number of studies in similar systems that could guide a statistical design, sampling approach, and analysis program to provide a better and more complete picture of the status of the Colorado River benthic community. For example, the loose organization of taxonomy into various groups is stunning. All of the critical information (where species represent units of information), valuable in assessing and monitoring trends and changes, is not being considered. It is either lumped into loosely organized groups (e.g., MAMB) or burned to estimate ash-free dry mass. Lumping taxa together is fine, once they have been identified as far as possible. Productive and accomplished national and state monitoring programs use much more resolved taxonomic information. Most monitoring programs also test a number of approaches for representativeness, sensitivity, and

applicability. None of the reports here suggest any of the current approaches are representative and approaches that would provide powerful approaches for trends monitoring in the Colorado system.”

In sum, the general consensus of this review is that the NAU work provided some important information over long time periods of biomass and abundance of the benthos. However, the information developed is not adequate to derive several of the conclusions presented in the reports. In part, this is due to inadequate sampling, inadequate taxonomic work or inappropriate statistical analysis.

The SAs feel there is a failure of the historic GCMRC aquatic food base program to offer substantive understanding of the ecosystem basis of the aquatic food web. It is unclear why this was not resolved in the RFP process. The developed methods do not provide a clear understanding of linkages up the trophic ladder. Of greatest concern, the reports do not allow defensible conclusions to be reached concerning food availability for higher trophic levels in the river over time, or in response to dam management. As noted, this was the basic purpose for establishment of the GCD AMP and the science program, and must be considered strongly in redesign of the aquatic food base program.

**REVIEW OF THE GCMRC 2001 PROGRAM EVALUATION
PROTOCOL EVALUATION PANEL (PEP) REPORT OF THE AQUATIC FOOD
BASE SCIENCE PROGRAM**

The SAs propose that the complexity of issues expressed in an aquatic food base program requires an energetics framework to not only guide efforts in the food base program, but more importantly to guide linkages between different programmatic aspects of this very complex system. Such a framework should also serve to link to the physical sciences.

Several conclusions of the PEP Report were most appropriate and should be addressed immediately as follows:

1. The historical food base program was characterized as insufficient to provide clarification on ecosystem linkages. A very appropriate recommendation was made to modify the program to better clarify linkages to higher trophic levels, i.e., HBC.

2. A direction was proposed towards a total system carbon budget and food web elucidation for clarification of linkages, possibly through stable isotope work.
3. Assessments of impacts of carbon from all sources (autochthonous and allochthonous) is critical to an ecosystem level understanding of the aquatic food base.

The Panel also made observations regarding sampling of all fish species, food base resource assessments etc. Given that budget constraints do exist and sampling in this environment is difficult and expensive, pilot approaches should be considered to possibly reduce the magnitude of these science efforts and still greatly improve the existing food base knowledge.

THE SAs agree with the PEP Report that a modeling framework might be appropriate, and should include putative trophic linkages as well as the physical drivers in the system (e.g., temperature changes, flow, etc.). The need for far more coordination is evident and the ability to answer basic questions about energy flow (such as how much food is available for fish) and how this may be affected by changes in dam management have been hindered by inadequate understanding of linkages. Furthermore, such a modeling framework would point to what research questions need to be answered, where the uncertainties are high, and what linkages need to be studied.

The need for better oversight of a well-coordinated and integrative program was emphasized. A reviewer noted: “Someone needs to make sure that the studies are conducted in an integrated manner and the results are pertinent to management options and key scientific hypotheses about the system.”

While there may be some desire to establish or continue some routine monitoring of biomass, it is clear that the variability over space and time in the standing stocks of algae and invertebrates is so great that it is impossible to make inferences on the status and trends of the food base using the type of approach employed over the last 13 years.

Generally, the recommendation for terminating the GCMRC/NAU historic food base work is endorsed by the SAs. And, it is related directly to the need to focus the aquatic food base effort on a more appropriate ecosystem based approach. Specifically, recommendations by the panel to move to evaluations of production processes,

energetics, ecosystem level linkages, etc., is clearly superior to past efforts, and will respond much better to complex management issues being raised by managers.

GCMRC 2003 PROPOSAL FOR FUTURE FOOD BASE SCIENCE.

This proposal was written in the summer of 2003 by GCMRC staff in collaboration with two postdoctoral researchers.

The direction of the work proposed by the GCMRC was quite favorably received by the reviewers. They outline research to quantify where nutrients come from, the importance of external versus internal carbon sources, and the food web dynamics for very different reaches of the river. This broad question-driven perspective is crucial for informed management. It represents a dramatic shift in focus for the food base program, since historically the focus has been on biomass and standing stocks, not energetic considerations and fluxes. Shifting in this direction is important and has been called for in two of the last PEP reports. Thus, the merit of the general approach is excellent.

Despite the general positive response of reviewers to the ideas in this proposal, reviewers had many concerns about the specifics. First, given that two of the three authors of the proposal are no longer at GCMRC, it seems imperative that GCMRC researchers spend time working out methods, gathering preliminary data, and then expose that to peer review. Second, in its present form, the proposal is not hypothesis driven and the investigators do not clearly state how the results will influence or impact program goals. Third, details of the methods, number of samples, etc., were glossed over. Yet these are difficult methods and need to be carefully examined. Fourth, while the work would help establish the relative amount of allochthonous vs. autochthonous inputs or some combination, it will not tell us how this is transferred up the food web. In consideration of the above concerns, the proposal to do stable isotope work could be a first step to gaining required knowledge. The proposed program is excellent and should be done. However, given the difficulty in this type work, sample analysis might be completed by outside laboratories with extensive expertise in stable isotope food web analysis. Samples could be collected by GCMRC staff or other contractors and sent

away for analysis. This would allow the determination of what food supports the HBC and even possibly how important predation by trout is on HBC.

Finally it is imperative that remote samplers (e.g., ISCO) be used to collect water samples for the carbon analysis. Further, scientists should consider if and how they can capture samples during floods. Like all running water systems, the majority of C inputs often occur during floods.

In sum, the SAs strongly support the conceptual basis of the GCMRC's 2003 proposal. The SAs view this as the appropriate direction for the food base work to proceed.

Although the SAs support the new direction, concern exists that GCMRC does not currently have the staff qualified to carry out much of this research. Either new hires would need to be made or the work outsourced. Further, significant merit exists in initiating some elements of the work now and use these efforts to increase knowledge of the system, interactions, linkages etc. In so doing, efficiencies in both design and sampling can be determined for other segments. The stable isotope work provides capability to gain significant knowledge quickly about linkages among trophic levels. It can also act as a building block for several "next steps" in understanding food base linkages to other parts of the ecosystem. The apparent appropriate procedure for initiating this research activity would be through an open RFP process. The SAs offer their assistance, as needed, in this process.

CONCLUSIONS AND RECOMMENDATIONS

The Science Advisors appreciate again the opportunity to be meaningfully engaged in the GCD AMP. Although we have an ambitious schedule of reviews this year, we are pleased to provide a critique of science directions in the Aquatic Food Base Program.

The 12-year monitoring provided in the NAU/GCMRC program has been important in establishing several baselines in how to work in, and understand a very complex system in which it is difficult to conduct effective research and monitoring. The effort provides reference for the proposed new approach.

The Aquatic Food Base Program is clearly at a juncture where it must significantly change approaches and methodologies to provide the type of support needed by scientists and managers in the program. When making such a profound change in methods, science must evaluate objectively both the strength and weaknesses of the previous methods, to guide the decision process toward new methods.

The Science Advisors try to utilize the above philosophy in its reviews, especially where changes in protocols or methods are proposed. We offer the following conclusions and recommendations to AMWG and GCMRC regarding this review.

1. Review of the NAU Aquatic Food Base Research.

- a. The past Aquatic Food Base work was a valiant attempt to chart the status and trends in invertebrates and algae by NAU. It is a good beginning, but all reviewers found weaknesses in appropriate use of rigorous and status-of-science design, sampling and analysis, reporting of some science findings, research documentation in science literature, and conclusions drawn from available data.
- b. Most important, the state of the science in food base research is currently well beyond the work done by NAU researchers, and the past work by itself cannot be used effectively to evaluate persistent management questions and actions. Therefore, an entirely new science effort is recommended. As such the SAs concur with other reviews to terminate the historical food base program.
- c. The reviewers indicate a number of ways in which the past research and monitoring efforts would need to be modified in order to increase understanding of the food base and provide appropriate information to management, including; applying more rigorous and integrated methods and design and sampling and analysis, and developing a more ecosystem based effort that focuses on food webs and energetics.

2. Review of 2001 Program Evaluation Panel (PEP) Report

- a. Unfortunately parts of this document and its recommendations have been

- dated by new knowledge, and subsequent activities of GCMRC and others. The SAs felt they could have provided more useful input had they reviewed the report in 2002 (the report is now over 2 years old.).
- b. We recommend that reviews of this nature should be accomplished with the intent of utilizing the outcomes adaptively in some manner in a reasonable time frame. It is not clear from review of the NAU/GCMRC program from 2001-2004, that this was accomplished.
 - c. GCMRC development of a new proposed Aquatic Food Base Program in 2003 (the 2003 GCMRC Proposal, see 3 below) incorporates general tenants of the 2001 PEP Panel recommendations; (i.e., improved ecosystem approaches, need for assessment of factors of production, etc.), but more importantly incorporates new science understanding and a more comprehensive view of the aquatic food base issue. As such, the 2003 proposal was considered as the most current GCMRC food base putative plan.

3. Review of GCMRC 2003 Proposed Aquatic Food Base Program

- a. The program proposal is a critical step forward for GCMRC in that it is based on assessment of ecosystem processes, pursues issues of food web productivity and energetics in the system, as well as evaluates requirements of upper trophic levels, i.e., HBC.
- b. The general framework and many elements of the plan are endorsed by the SAs, but significantly greater definition of design and linkages, sampling procedures, interpretive analysis methods, etc must be provided. Importantly, there was full agreement that the techniques proposed are difficult and that at this time GCMRC does not have the staff to undertake this ambitious plan of work. As such, we recommend the proposal, considered as a total program, should be placed on hold, and only critical elements implemented in FY 2005.
- c. It is recommended that GCMRC draft an RFP for release for FY 2005 on aquatic food base science activity. The open RFP should identify a specific research effort for immediate startup that determines most

efficient and useful approaches for long-term monitoring/trends of the aquatic food base. This effort should involve stable isotope analysis of food web paths from the trophic base (detritus, algae) to invertebrates, to fish, i.e., HBC, that would help identify the energetic base in this system for production at higher trophic levels.

- d. It is recommended that the basic elements of the new proposed RFP direction be the subject of a workshop discussion by the GCMRC Chief, program managers, and scientists, AMWG and TWG members, and SAs possibly during the April Science River Trip. This is a proposal for the SAs to provide assistance to GCMRC managers on this critical issue. We would request that Dr. Carl Walters also be available for the workshop discussion if possible.
- e. The SAs would also make themselves available to assist with reviews of proposals received in response to this food web RFP, if the GCMRC Chief felt this would be helpful.
- f. These new proposed methods (food web analysis using multiple stable isotope signatures) are significantly complex, especially when combined with the vagaries of the research environment. The SAs strongly believe that input from a mid-career to senior level ecosystem ecologist needs to be available to the GCMRC staff, either through the RFP process or possibly as a staff position. The SAs believe a specialist with a broad perspective of ecosystem processes in aquatic systems, and experience in working intensively in interdisciplinary groups would be most helpful to the Center.

APPENDIX A
REVIEW CHARGE TO GCD AMP
SCIENCE ADVISORS

TO: GCD AMP Science Advisors
FROM: M3 Research; LD & PJ Garrett
DATE: January 15, 2004
SUBJECT: Updates on Food base Reviews

Margaret and I have worked on more details regarding specific outcomes we will want to pursue in this review. The following represents the questions we are asking the primary reviewers to address.

1. Did the GCMRC Program pursued through NAU for over a decade provide the best approach? If not, Why not?
2. Do the proposed approaches described in the 2001 PEP report provide the best approach. If not why not?
3. Does the new GCMRC alternative proposal provide the best approach. If not, why not?
4. Assessing all the above and other approaches being used in science what would be the best approach and why?

Each reviewer will accomplish the following:

Read;

1. Lovich letter to TWG (12-19-03)
2. RFP's from GCMRC
3. 2001_ PEP Panel Recommendations
4. NAU report (50 pgs)
5. NAU report (37 pages)
6. NAU report (277 pages)
7. GCMRC food base proposal dated August 2003

PREFACE: At this time, the primary concerns of the “food base science” in the GC are two- fold: to use a monitoring approach that will provide high quality data on the status and trends of the food base in the Colorado River below Glen Canyon Dam (this is essential for determining the ‘best’ management plan for flow releases) AND to provide high quality data that can contribute to understanding the link between the food base and the humpback chub (e.g., is system productivity sufficient to support chub given the many other species in the system).

I. Review all the work by Shannon et al. and provide a critical review of the following:

1. Appropriateness of the research approach given the RFPs
2. Quality of the science including sampling, analytical methods, statistics and the conclusions drawn given the data (you may also comment on the writing if you wish)
3. In your opinion, does this approach represent the best approach for assessing the food base in the river through the Grand Canyon given the *preface* above and

given *the PEP Panel recommendations*? (please note that this may have differed from what was stated in the RFPs)

II. Review the GCMRC food base proposal and provide a critical review of the following:

1. Appropriateness of the research approach *given the preface* above and given *the PEP Panel recommendations*?
2. Is the quality of the science including the proposed methods sound
3. Is there sufficient expertise to conduct the work?

III. Describe elements of an improved approach. i.e., some combination of these two approaches, only one approach, or an entirely new approach. If you suggest measuring multiple ‘things’ and/or experiments performed, rank them in terms of their importance in meeting the overall goals (preface). The latter is critical given the possibility of limited funding.