USGS
science for a changing world

Developed in cooperation with the Glen Canyon Dam Adaptive Management Program

Strategic Science Plan to Support the Glen Canyon Dam Adaptive Management Program, Fiscal Years 2007-2011

Prepared by the USGS Grand Canyon Monitoring and Research Center

Final
March 22, 2007
Amended and approved
April 29, 2009

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation:
U.S. Geological Survey, 2007, Monitoring and research plan in support of the Glen Canyon Dam Adaptive Management Program: Flagstaff, Ariz., U.S. Geological Survey, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, 149 p.

Preface

This "Strategic Science Plan to Support the Glen Canyon Dam Adaptive Management Program, Fiscal Years 2007-2011" is one element of an overall science-planning process used by the Grand Canyon Monitoring and Research Center (GCMRC) to provide independent, objective science support to the Glen Canyon Dam Adaptive Management Program. We designed the plan to be responsive to the goals and the priority information needs identified by the Adaptive Management Work Group The Adaptive Management Work Group is a Federal Advisory Committee that makes recommendations to the Secretary of the Interior on the operation of Glen Canyon Dam and other management actions intended to meet the U.S. Department of the Interior's obligations under the Grand Canyon Protection Act. The strategies presented here will be used to guide the development and implementation of monitoring and research activities for fiscal years (FY) 2007–11. The Plan was updated in April 2009 to reflect provisions of several NEPA documents and U.S. Fish and Wildlife Service biological opinions related to the operation of Glen Canyon Dam.

Copies of this plan are available at *http://www.gcmrc.gov/*.

Introduction and Background

This strategic science plan (SSP) identifies strategies to be pursued by the U.S. Geological Survey's (USGS) Grand Canyon Monitoring and Research Center (GCMRC) to provide credible, objective scientific information to the Glen Canyon Dam Adaptive Management Program (GCDAMP) during the next 5 years. The study area of interest to the GCDAMP is the Colorado River corridor from Glen Canyon Dam to Lake Mead, an area known as the Colorado River ecosystem (CRE). For the study area, the GCMRC will develop scientific information regarding (1) the effects of the operation of Glen Canyon Dam and other factors on CRE resources, using an ecosystem approach, and (2) flow and nonflow measures to mitigate adverse effects on CRE resources caused by dam operations. This SSP will be carried out by the GCMRC in cooperation with participants of the GCDAMP.

The GCDAMP was established in 1996 by the Secretary of the Interior to implement the Grand Canyon Protection Act of 1992, the 1995 Operation of Glen Canyon Dam Final Environmental Impact Statement, and the 1996 Record of Decision. Adaptive management—the dynamic interplay of stakeholder collaboration, resources management, and scientific research—was envisioned as a new paradigm to address the complex environmental problems related to the operation of Glen Canyon Dam. The GCDAMP consists of five components (fig. 1):

- The Adaptive Management Work Group (AMWG) is a Federal Advisory Committee that facilitates the implementation of the GCDAMP. The AMWG is made up of 25 stakeholders and the Secretary of the Interior's Designee. The AMWG makes recommendations to the Secretary of the Interior on how dam operations can be modified or other management actions taken to fulfill the U.S. Department of the Interior's obligations under the Grand Canyon Protection Act.
- The Secretary of the Interior's Designee serves as the chair of the AMWG and as a direct link between the AMWG and the Secretary of the Interior.

- The Technical Work Group (TWG) translates AMWG policies and goals into information needs, provides questions that serve as the basis for long-term monitoring and research activities, and conveys research results to AMWG members.
- The USGS Grand Canyon Monitoring and Research Center provides credible, objective scientific information on the effects of Glen Canyon Dam and related factors on natural, cultural, and recreational resources along the Colorado River from Glen Canyon Dam to Lake Mead (see table 1 for GCMRC responsibilities).
- Independent review panels assesse proposals and research products to ensure scientific objectivity and credibility. The science advisors, a formal group of academic experts in fields germane to the GCDAMP, are an example of an independent review panel.

Adaptive Management

The GCDAMP is based on an adaptive environmental assessment and management (AEAM) approach to natural resources management (Holling, 1978; Walters, 1986), now commonly called "adaptive management." The approach assumes that managed natural resources will always change, that scientific understanding of ecosystems is constantly improving, and that natural resource managers need the best available information to make decisions. AEAM unites the strengths of different scientific disciplines to meet the information needs of resource managers. It encourages scientists and managers to work collaboratively to use scientific information in the management process.

AEAM consists of two parts—adaptive assessment and adaptive management. Assessment investigates how ecological systems work and evaluates management alternatives to achieve goals. Management involves learning by doing and testing, which may include monitoring system responses to natural changes (passive adaptive management) or deliberate manipulation of key processes (active adaptive management).

Adaptive management acknowledges that policies must satisfy social objectives, but policies also need to adapt to both changes in understanding and changes in managed systems. Managers using an AEAM approach learn how a natural system works and how their actions affect the system; this knowledge helps them to perform better in complex and uncertain environments. This SSP is based on an AEAM approach articulated in the draft GCDAMP strategic plan (2000), which includes the following activities:

1. Development of models on the effects of policies, activities, or practices being considered for implementation
2. Formulation of questions as testable hypotheses regarding the expected responses or linkages of the Colorado River ecosystem to dam operations and management actions
3. Execution of experiments to test hypotheses and answer questions
4. Implementation of management actions to reveal the accuracy or completeness of earlier predictions through monitoring and evaluation of results
5. Incorporation of new information produced through experimentation into management discussions and recommendations to the Secretary of the Interior

Science Planning Process

The GCDAMP science planning process aims to develop a credible, objective science program that is responsive to AMWG goals and priority needs. The AMWG specified 12 goals that

provide general guidance for planning, monitoring, and research efforts (table 2). In August 2004, the AMWG reviewed these goals and identified five priority questions to help guide the GCDAMP science program:

1. Why are the humpback chub not thriving, and what can we do about it? How many humpback chub are there and how are they doing?
2. Which cultural resources, including traditional cultural properties, are within the area of potential effect, which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration?
3. What is the best flow regime?
4. What is the impact of sediment loss and what should we do about it?
5. What will happen when a temperature control device is tested or implemented? How should it be operated? Are safeguards needed for management?

The GCMRC will use these five priority questions as the primary, but not exclusive, basis for designing the science program to be implemented during the next 5 years. Other sources of information that will be considered include the following:

- AMWG management objectives and associated information needs, including core-monitoring information needs
- Protocol evaluation panel recommendations
- Knowledge assessment report findings and recommendations
- U.S. Fish and Wildlife Service biological opinion requirements related to the operation of Glen Canyon Dam
- National Historic Preservation Act requirements
- NEPA documents and U.S. Fish and Wildlife Service biological opinion requirements related to the operation of Glen Canyon Dam. For example, the Environmental Assessment: Experimental Releases from Glen Canyon Dam, Arizona, 2008 through 2012 dated February 29, 2008, the Final Biological Opinion for the Bureau of Reclamation's Operation of Glen Canyon Dam, February 27, 2008, and the Final Biological Opinion for the Bureau of Reclamation's Proposed Adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, December 12, 2008 will be used to provide direction for several research, monitoring, and experimental activities that will be carried out in FY2008-20212 including a March 2008 High Flow Experiment and a 5-year Nearshore Ecology-Steady Flow Experiment.

The science program will also incorporate the findings of an environmental impact statement (EIS) on a long-term experimental plan (LTEP) for the operation of Glen Canyon Dam and associated management activities if and when such an EIS is completed. An EIS process was begun by the Bureau of Reclamation in late 2006; however, the process was suspended in 2008 to allow the agency to focus on Endangered Species Act and National Environmental Policy Act compliance required for the 5-year plan of experimental flows from Glen Canyon Dam referenced above.

To create a balanced adaptive management program and to ensure that all key resources are addressed by the science program, this science plan also anticipate that generally the GCMRC will propose at least one science activity for each GCDAMP goal (table 2) in its work plan.

Science Planning Documents

The GCMRC will design and implement the GCDAMP science program in cooperation with GCDAMP stakeholders through collaboration on four stepdown planning documents:

1. The GCDAMP strategic plan (AMPSP) is a long-term plan drafted in August 2001 by GCDAMP and GCMRC participants that identifies the AMWG's vision, mission, principles, goals, management objectives, information needs, and management actions (Glen Canyon Dam Adaptive Management Program, 2001).
2. The GCMRC SSP (this document) identifies general strategies for the next 5 years to provide science information responsive to the goals, management objectives, and priority questions as described in the AMPSP and other planning direction approved by the AMWG.
3. The GCMRC monitoring and research plan (MRP) specifies (1) core monitoring activities, (2) research and development activities, and (3) long-term experimental activities consistent with the strategies and priorities established in this SSP to be conducted over the next 5 years to address some of the strategic science questions associated with AMWG priority questions. (Other strategic science questions will be addressed through the LTEP EIS.)
4. The GCMRC biennial work plan (BWP) identifies the scope, objectives, and budget for monitoring and research activities planned for a 2-year period. When completed, the biennial work plan will be consistent with the MRP. A transitional annual work plan (AWP) was developed for fiscal years 2007 and 2008. The first BWP is currently in progress.

Figure 2 depicts the flow of information in the stepdown science planning and implementation process.

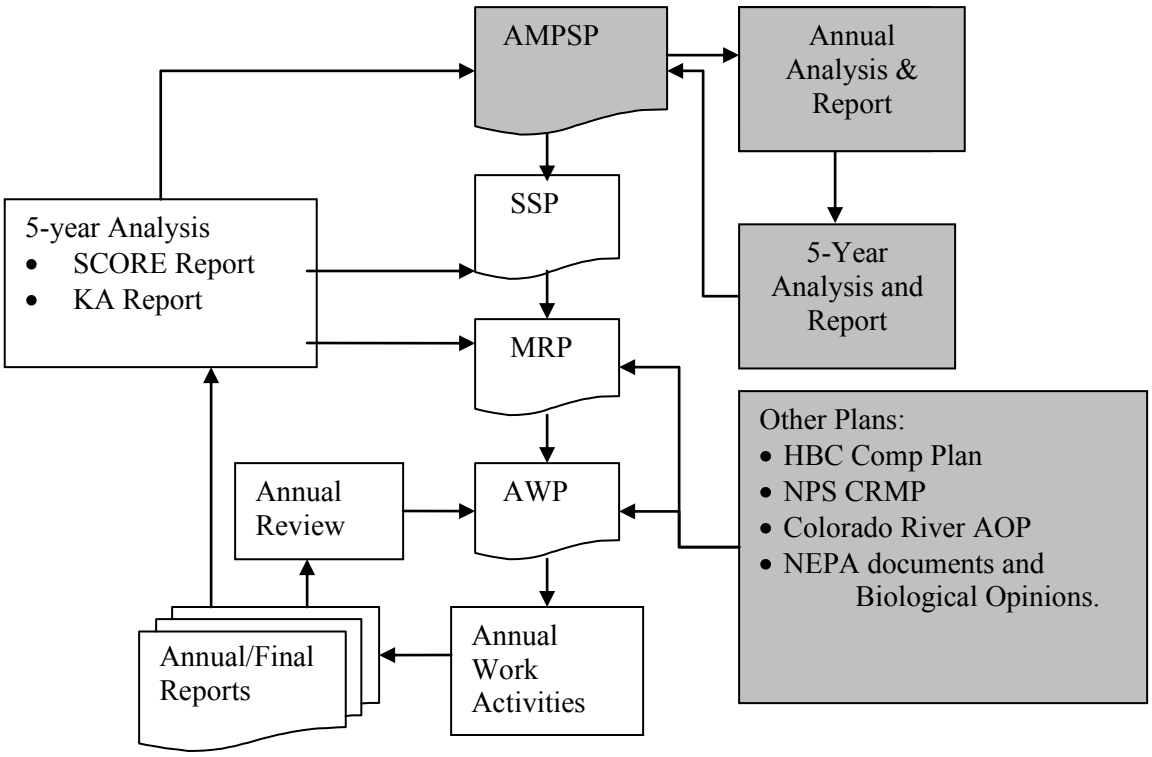

Figure 2. Collaborative science planning and implementation process. The Glen Canyon Dam Adaptive Management Program and the U.S. Department of the Interior have lead responsibility for the shaded boxes. The Grand Canyon Monitoring and Research Center has lead responsibility for the boxes that are not shaded.

The GCMRC will report annually on completed projects presented in the biennial work plan and evaluate whether scientific research has contributed to fulfilling GCDAMP goals and management objectives. At 5-year intervals, the GCMRC will consolidate new scientific knowledge in updated versions of "The State of the Colorado River Ecosystem in Grand Canyon" (SCORE) report (Gloss and others, 2005), knowledge assessment report (Melis and others, 2006), and elsewhere, as appropriate. Priority information needs and science questions will be evaluated by scientists and managers to determine whether program revisions are needed. Planning documents, including the SSP and the MRP, will also be revised to reflect program updates.

GCMRC science planning will be most effective if it is conducted in conjunction with a periodic review of the GCDAMP strategic plan, including priority goals, information needs, management objectives, and management treatments and actions. Completing concurrent reviews will help ensure the science program is properly aligned with current management objectives and priorities.

Science Strategies

This SSP is based on the adaptive management paradigm discussed above wherein new science information is continually cycled into application by managers, and outcomes are monitored by scientists and managers for effectiveness. This process requires highly focused applied science projects that address specific management information needs. Consistent with the adaptive management paradigm, the GCMRC's science strategy will emphasize four elements:

- Performing interdisciplinary, integrated river science
- Building bridges between science and management
- Formulating strategic science questions to address the AMWG's priority goals and questions
- Addressing critical research and monitoring needs outside the scope of the GCDAMP

Interdisciplinary, Integrated River Science

The GCMRC will increase its emphasis on an interdisciplinary, integrated science approach over the next 5 years. This approach supports AMWG goals to manage competing resource values to benefit both human beings and the natural ecosystems that are important to them. This means that single resources (and research related to them) will not be studied in isolation from other resources or from the socio-cultural context. Interdisciplinary, integrated river science will seek to understand how resources respond to human activities, outside forces, and internal natural ecosystem drivers (e.g., floods, drought, plankton blooms, etc.). Understanding will come through core monitoring, research and development, and long-term experimental activities. Prediction will be developed from a synthesis of findings in a quantitative modeling framework.

In 1998, Walters and others conducted an adaptive environmental assessment and management workshop to assist Grand Canyon scientists and managers to develop a conceptual model of the Colorado River ecosystem affected by Glen Canyon Dam operations (see Walters and others, 2000). The Grand Canyon Model that resulted proved to be useful at identifying knowledge gaps and predicting the response of some ecosystem components to policy change. However, a lack of data for some resource responses limited the effectiveness of the model to produce predictions in several key areas, including long-term sediment storage, fisheries responses to habitat restoration, and socioeconomic effects. Several improvements to the model have been suggested to increase its utility in science planning and management processes. Suggested improvements include making the model more user-friendly, ensuring that the model provides information that is relevant to each high-priority AMWG goal and question, and incorporating advanced statistical and mathematical methods.

In 2007, the GCMRC will work with the science advisors to identify and evaluate opportunities for incorporating an interdisciplinary, integrated ecosystem science and modeling approach into the current science program, including the refinement and use of conceptual and predictive ecosystem models and decision-support tools. The feasibility of various approaches will be assessed based on their ability to satisfy the information needs of resource managers; usefulness for designing an integrated, interdisciplinary science program for the GCDAMP; and implementation costs.

Building Bridges between Science and Management

The GCMRC's ability to design studies that will produce relevant scientific information depends on how well the GCDAMP participants define and agree on resource goals, management objectives, and desired outcomes. To be successful, GCMRC scientists and GCDAMP participants must work together as partners—partners with distinct but complementary roles. These individual roles and responsibilities are outlined in table 3. A more complete discussion of roles and responsibilities of various GCDAMP entities and the GCMRC is presented in the report of the Roles Ad Hoc Group of the GCDAMP (2006).

The success of the GCDAMP is dependent not only on the GCMRC's ability to produce scientific information that is relevant to management needs but also upon the effective and timely use of that

information by managers in the decision-making process. The challenge for scientists is to synthesize large amounts of diverse and often highly technical data into a form that is relevant to a decision that has implications for multiple resources in different areas and timeframes. A clear example of this challenge is the issue of how to operate Glen Canyon Dam. Over the past decade, there have been great advances in the development and application of a suite of decision-support tools to assist scientists and managers in understanding the interrelationships, data uncertainty, and relative influence of scientific knowledge on resource management decisions.

The GCMRC proposes a collaborative strategy among scientists and GCDAMP participants to assess how to better integrate scientific information into the GCDAMP process. The assessment will address (1) the feasibility of using decision-support tools to integrate scientific information into science planning and AMP recommendation processes, including resource tradeoff assessments, and (2) strategies to address the value-based conflicts of diverse interests in the GCDAMP. Pilot approaches will be tested during the FY2007–11 program period.

Addressing Priority Goals and Questions

In general, the GCMRC science program will monitor the status and trends of CRE resources and evaluate treatments or management actions (e.g., changes in dam operation, nonnative fish control, beach/habitat-building flows, etc.) to restore or protect downstream resources. The science program will address AMWG priority questions and key strategic science questions, presented in the following section, that were identified in the knowledge assessment report (Melis and others, 2006). Providing answers to these key questions will provide the information needed by managers to improve management of priority CRE resources and reduce the uncertainties associated with various flow and nonflow treatments or management actions being considered by the GCDAMP.

The strategic science questions will be addressed through the following general categories of activities:

1. Core-monitoring activities are scientifically validated protocols or methods to assess the condition and trend of priority GCDAMP resources (humpback chub, sediment, food base, etc.).
2. Research and development activities include research projects aimed at (1) addressing hypotheses or information needs related to a priority GCDAMP resources or (1) developing and testing new technologies or monitoring procedures.
3. Long-term experimental activities include a suite of flow and nonflow treatments, monitoring and research, and management actions (1) to improve the condition of target resources (humpback chub, cultural sites, sediment, etc.) and (2) to understand the relationship between treatments and management actions and target resources.

Activities will be defined in the MRP and BWP and will be based on the knowledge assessment report, core-monitoring information needs, research information needs, NEPA and ESA compliance requirements, and other relevant information. The MRP and BWP will identify each activity's objectives, methods, outcomes, and costs by fiscal year. An interdisciplinary, integrated science approach as described above will be used, where appropriate.

The GCMRC will coordinate its research activities with other institutions conducting research in the CRE to ensure a cost-effective ecosystem approach. All GCMRC work plans and reports will

be subjected to independent peer review consistent with the USGS Fundamental Science Practices, a set of guidelines and policies to ensure the world-class quality of USGS science products, and periodic comprehensive reviews of planned research or scientific work by panels of independent scientists.

AMWG Priority Questions and Related Strategic Science Questions

In 2004, the AMWG identified five priority questions related to the 12 goals that provide general guidance for planning, monitoring, and research efforts (table 2). The strategic science questions that appear below each of the five AMWG priorities were identified through two knowledge assessment workshops and presented in a summary report (Melis and others, 2006). The bracketed dates associated with each strategic science question indicate the time anticipated to complete monitoring and research activities required to address the question.

AMWG Priority 1: Why are the humpback chub not thriving, and what can we do about it? How many humpback chub are there and how are they doing?

Key Strategic Science Questions

1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions? [FY2006–11]
2. Does a decrease in the abundance of rainbow trout and other coldwater and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population? [FY2006–11]
3. Do rainbow trout immigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon immigrants support the population in Marble and eastern Grand Canyons? [FY2007–11]
4. Can long-term decreases in the abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species. [FY2007–11]
5. What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations? [FY2006–09]
6. Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (e.g., lipids), correlated with patterns in invertebrate flux? [FY2006–09]
7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made usable and maintained? [FY2008–09]
8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling? [FY2007–11]

AMWG Priority 2: Which cultural resources, including traditional cultural properties (TCP), are within the area of potential effect, which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration?

Key Strategic Science Questions

1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how? [FY2007–11]
2. How do flows impact old high water zone terraces in the CRE (where the majority of archaeological sites occur), and what kinds of important information about the historical ecology and human history of the CRE are being lost due to ongoing erosion of the Holocene sedimentary deposits? [FY2004–11]
3. If dam-controlled flows are contributing to (influencing rates of) archaeological site/TCP erosion, what are the optimal flows for minimizing future impacts to historic properties? [FY2009–11]
4. How effective are various treatments (e.g., check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term? [FY2006–11]
5. What are the TCPs in the CRE, and where are they located? [FY2006–11]
6. How can tribal values/data/analyses be appropriately incorporated into a science-driven adaptive management process in order to evaluate the effects of flow operations and management actions on TCPs? [FY2006–08]
7. Are dam-controlled flows affecting TCPs and other tribally valued resources in the CRE, and, if so, in what respects are they being affected, and are those effects considered positive or negative by the tribes who value these resources? [FY2006–11]

AMWG Priority 3: What is the best flow regime?

Key Strategic Science Questions

1. Is there a "flow-only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal time scales? [FY2008–11]
2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidity or dam-controlled high-flow releases? [FY2007–08]
3. What are the hydropower replacement costs of the modified low fluctuating flow (annually, since 1996)? [FY2007–08]
4. What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase experimental design)? [FY2006–07]
5. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations? [FY2006–09]
6. What Glen Canyon Dam operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability? [FY2007–08]
7. How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE? [FY2007–08]
8. What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes? [FY2007–09]
9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience? [FY2009–11]
10. How can safety and navigability be reliably measured relative to flows? [FY2007–08]

11. How do varying flows positively or negatively affect visitor safety, health, and navigability of the rapids? [FY2007–09]
12. How do varying flows regimes positively or negatively affect group encounter rates, campsite competition, and other social parameters that are known to be important variables of visitor experience? [FY2007–09]

AMWG Priority 4: What is the impact of sediment loss and what should we do about it?

Key Strategic Science Questions

1. Is there a "flow-only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales? [FY2008–11]
2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows? [FY2007–11]

AMWG Priority 5: What will happen when we test or implement the temperature control device (TCD)? How should it be operated? Are safeguards needed for management?

Key Strategic Science Questions

1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE? [FY2006–08]
2. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations? [FY2006–08]
3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish? [FY2003–08]
4. What is the relative importance of increased water temperature, shoreline stability, and food availability on the survival and growth of YoY and juvenile native fish? [FY2003–08]
5. Will increased water temperatures increase the incidence of Asian tapeworm in humpback chub or the magnitude of infestation, and if so, what is the impact on survival and growth rates? [FY2003–08]
6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance? [FY2007–11]
7. How do warmer releases affect viability and productivity of native/nonnative vegetation? [FY2007–11]

Other Critical Research and Monitoring Needs

This section focuses on the critical need to address issues outside the CRE that impact the GCDAMP mission and goals. The GCMRC is currently constrained from using GCDAMP funds to evaluate some potentially significant external threats to CRE resources. For example, the largest aggregation of humpback chub in the CRE is dependent on the quality of water leaving the Little

Colorado River. However, Little Colorado River water quality is evaluated on an infrequent basis and then only in the first few miles of its confluence with the Colorado River. No science activity currently exists to identify changes in Little Colorado River water quality and quantity resulting from upstream diversions, pollution, or catastrophic hazardous material spills.

The primary determinant of water quality in the CRE is the quality of the water released from Lake Powell. As a result, the water quality and dynamics of Lake Powell have major implications for the design of a device to regulate the temperature and other characteristics of releases from Glen Canyon Dam. While extensive physical and biological data on Lake Powell water quality have been collected for more than two decades, the data have not been synthesized, extensively analyzed, or modeled. A synthesis of historical Lake Powell data is needed to identify trends in water quality and their relationship to dam operations, basin hydrology, and climate variability. These assessments could significantly advance knowledge of potential future water quality in Lake Powell and the appropriate design for the proposed temperature control device.

Clearly, to be successful, the GCDAMP needs to ensure that key external factors that could affect the attainment of GCDAMP goals are addressed. To this end, the GCMRC proposes to (1) work closely with the AMWG and the Department of the Interior to develop an endangered fish recovery program for the lower basin (Grand Canyon), (2) evaluate and report on the key external issues identified above that could affect attainment of GCDAMP goals, and (3) work with GCDAMP participants and others to secure funding for research on the issues that pose the highest risk or opportunity.

Administration and Budget

Staffing

The GCMRC's goal is to deliver in the next 5 years a comprehensive ecosystem science program that responds to management needs. Effectiveness will be measured by science and management accomplishments that enhance CRE resource conditions and create a better understanding of the cause-and-effect relationship between dam operations and resource conditions. Improving science administration is essential to meeting the need for a more comprehensive ecosystem science program in a flat budget environment. Improving science administration will require significant accomplishment in several areas, including science planning, personnel structure, goal and objective setting, collaboration and partnerships, and research design focused on priority information needs and cost effectiveness.

Productive, well-qualified personnel are critical to creating an effective ecosystem science program. In recognition of this fact, efforts have been made to restructure personnel responsibilities at the GCMRC to maximize existing management and science skills. Contractors and cooperators will be used to conduct a large amount of the field work, and they will work collaboratively with GCMRC scientists to analyze and synthesize data and publish findings. GCMRC personnel will implement field research and monitoring when in-house staff members with the appropriate expertise are available and their use is cost effective. In every case, the GCMRC will hold its own work to the same level of rigorous outside peer review as all others. The core GCMRC staff includes the following key positions:

Chief

The Chief establishes GCMRC's science policies and strategic direction and provides budget accountability. The Chief ensures that science managers, contract and budget officers, logistics

specialists, external and resident scientists, and other personnel plan and implement timely science activities that respond to GCDAMP priority information needs. The Chief also interfaces with USGS management, the Secretary of the Interior's Designee, and GCDAMP participants to ensure that quality science is provided in a timely manner on priority issues identified by the GCDAMP leadership.

Deputy Chief

The Deputy Chief supervises the science program, ensuring that integrated ecosystem procedures are used in science design and analysis. This position also has responsibility for monitoring peer-review processes using accepted procedures, tracking science project performance, and reporting program outcomes to ensure timely responses to GCDAMP information needs.

Program Managers

Program Managers are responsible for the timely execution of GCMRC science activities within their program area and interaction with other program areas to develop integrated ecosystem approaches to science products. Program Managers are therefore responsible for ensuring the quality of products produced by GCMRC staff, contractors and cooperators; overseeing contracts, agreements, and budgets for their program area; and providing reports to GCDAMP work groups as needed. GCMRC activities now encompass five major program areas:

1. The Physical Science and Modeling Program conducts research and monitoring of physical elements of the Colorado River ecosystem, including studies of sediment storage and transport in the regulated river, and integrated downstream water-quality monitoring and research. The program has conducted several experiments to determine if high-flow releases from Glen Canyon Dam have the ability to conserve sediment resources for building beaches and improving habitat for native aquatic species in the Colorado River. More recently, the program developed a downstream temperature model for the ecosystem.
2. The Data Acquisition, Storage, and Analysis Program provides GIS, data quality control, data management, and library services to all program areas. In addition, this program oversees the GCMRC peer-review process.
3. The Biological Program provides scientific information that supports the maintenance of the Lees Ferry trout fishery and the conservation of native species in Grand Canyon. Elements of the program include assessing the effects of Glen Canyon Dam operations on fishery resources, characterizing the aquatic food base, evaluating terrestrial contributions to the aquatic food base, improving fish community monitoring, developing and testing of techniques to control nonnative fishes, evaluating terrestrial vegetation changes as a result of dam operations, and water-quality monitoring and modeling in Lake Powell and the Colorado River below Glen Canyon Dam.
4. The Cultural and Socioeconomic Program focuses on culturally significant sites and artifacts and recreation activities based in Grand Canyon. Currently, the program is working on the development of comprehensive monitoring programs to assess the condition of the culturally significant sites affected by the operation of Glen Canyon Dam.
5. The Logistics Program supports up to 40 river trips per year and coordinates research permit management for the Grand Canyon Monitoring and Research Center. The Logistics Program also provides survey support to various programs and activities.

The GCMRC will rely on the USGS Southwest Biological Science Center, the parent organization of the GCMRC within the USGS, for administrative, budget, and contracting services; information technology; and policy support. The GCMRC will also work with the Southwest Biological Science Center to reduce shared costs and overhead burden assessed by the USGS on GCDAMP funds.

As part of the strategy to improve science administration effectiveness, the Chief will collaborate with the Department of the Interior, U.S. Department of Energy, and the AMWG and TWG to (1) ensure that the direction of the GCDAMP strategic plan is kept current and reflects the revision of priority goals, information needs, and desired future resource conditions; (2) develop approaches for resolving GCDAMP budget limitations in the face of increasing science and management needs; (3) facilitate the design of a partnership plan and program to transition major science treatments into management actions with appropriate responsibilities, authorities, and funding; and (4) develop greater interaction among the Upper Colorado River Recovery Implementation Program and the Lower Colorado River Multi-Species Conservation Plan to share science findings, methods, and management actions.

Budget

A general assessment of the GCMRC's budget needs during the next 5 years, FY2007–11, indicates that the planned science activities could be accomplished with moderate increases in current budget allocations. To advance a comprehensive science program with moderate budget increases will require the effective management of priorities, the termination of selected programs, and the extension of proposed timeframes for activities related to lower priority goals and information needs. Additionally, the implementation of experimental research projects will require careful planning to avoid major disruptions to planned and ongoing activities.

To obviate the impacts of unpredictable events to the program over the next 5–10 years, the GCMRC will pursue the following selected budget management strategies:

- Develop and approve detailed project descriptions and budgets in the biennial work plan
- Develop protocols for establishing a contingency fund sufficient to support anticipated future experimental projects
- Conserve a percentage of overall funds for reallocating at the discretion of the Chief when savings or shortfalls occur in specific areas
- Develop protocols for guiding external budget development by the GCMRC to respond to issues affecting the GCDAMP, but currently outside the GCDAMP budget process
- Seek additional congressional funding to support research to address (1) testing and possible operation of a temperature control device and other large capital projects and (2) external factors or issues outside the scope of the GCDAMP that impact GCDAMP goals

References Cited

Gloss, S.P., Lovich, J.E., and Melis, T.S., eds., 2005, The state of the Colorado River ecosystem in Grand Canyon: U.S. Geological Survey Circular 1282, 220 p.

Holling, C.S., 1978, Adaptive environmental assessment and management: Chichester, New York, Wiley, 785 p.

Melis, T.S., Wright, S.A., Ralston, B.E., Fairley, H.C., Kennedy, T.A., Andersen, M.E., Coggins, L.G., and Korman, J., 2006, Knowledge assessment of the effects of Glen Canyon

Dam on the Colorado River ecosystem: U.S. Geological Survey, Grand Canyon Monitoring and Research Center, 88 p.

Glen Canyon Dam Adaptive Management Program, 2001, Strategic plan—Glen Canyon Dam Adaptive Management Program, http://www.usbr.gov/uc/rm/amp/strategic_plan.html, accessed June 6, 2008.

Roles Ad Hoc Group of the Adaptive Management Work Group, 2006, Report and recommendations to the secretary's designee: Glen Canyon Dam Adaptive Management Program.

Walters, C., Korman, J., Stevens, L.E., and Gold, B., 2000, Ecosystem modeling for evaluation of adaptive management policies in the Grand Canyon: Journal of Conservation Ecology, v. 4, no. 2, http://www.consecol.org/vol4/iss2/art1, accessed October 25, 2006.

Walters, C.J., 1986, Adaptive management of renewable resources: New York, Macmillan, 374 p.