RECREATION IN THE COLORADO RIVER ECOSYSTEM, GRAND CANYON

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EXECUTIVE SUMMARY

Recreation in the CRE between Glen Canyon Dam and Lake Mead consists primarily of boat-based use of the blue ribbon trout fishery and day rafting trips in Glen Canyon National Recreation Area, and multi-day whitewater rafting trips in Grand Canyon National Park. Hikers and foot-based anglers also access the river corridor. Raft trips originating at Lees Ferry are recognized as internationally significant and unique; and managed by the National Park Service to provide a Wilderness river experience. Continually affected by operations at Glen Canyon Dam, recreation resources are cited commensurately with physical, biological and cultural resources in the Grand Canyon Protection Act, Environmental Impact Statement and Record of Decision, which established the Colorado River Adaptive Management Program (AMP) and the GCMRC.

This document delineates the relevance and scope of a recreation resource component for the Grand Canyon Monitoring and Research Center (GCMRC) and the Colorado River Adaptive Management Program (AMP). The significance of Colorado River recreation is specifically addressed in legislation and guiding documents for the AMP, but has been only partially articulated by subsequent direction given to the AMP and GCMRC. Because recreation resources have been incompletely defined, there is a tendency to equate them with biophysical settings, while important social components of recreation experiences are frequently overlooked. Professional expertise and knowledge gained through recreation and other social science research should be more fully utilized to understand recreation resources in the Colorado River ecosystem (CRE).

Notably, the GCMRC mentions wilderness experience opportunities in its 1998 Draft Strategic Plan, and is supporting research into attitudes and preferences of users toward recreation opportunities and setting attributes related to river flows, changing attitudes and preferences of users, and user attitudes and preferences in relation to stakeholder visions. The GCMRC has also instituted a more focused effort toward monitoring of camping beaches in critical reaches of the river corridor.

GCMRC-supported recreation research is currently limited to investigation of river flow related effects, while most other experiential aspects that underlie significant individual and societal benefits of this world-class resource remain poorly understood. Current research is geographically restricted to the Colorado River in Grand Canyon,

although other resources are analyzed regionally to establish baseline comparisons and potential substitutes. Due, perhaps, to the interdisciplinary nature of factors that comprise recreation resources, the ways recreation fits within other GCMRC resource programs are not clearly presented by the 1998 Draft Strategic Plan. Explanation of the substantial social and economic benefits of Colorado River recreation is incomplete.

Based on a more precise conceptualization of wildland recreation (anchored in the professional literature and supported by ongoing research) the following definition is proposed: **Recreation resources in the Colorado River ecosystem consist of a spectrum of actual and potential, non-substitutable, world-class experience opportunities (comprised of an array of interactions between biophysical, socioeconomic, cultural and managerial factors) that produce many market and nonmarket benefits for individual visitors, social groups and society.**

To be consistent with the spirit of the Grand Canyon Protection Act, Environmental Impact Statement and Record of Decision, it should be clarified within the Adaptive Management Program that recreation opportunities in the Colorado River ecosystem are unique and of international significance. The biophysical, social and managerial components of recreation resources are highly interrelated, indicating that research in more than one discipline is necessary to understand linkages between recreation and other types of resources.

Two additional information needs are suggested as being necessary for the AMP to properly account for recreation resources in the Colorado River ecosystem:

1. **"Characterize and define the scope of recreation experience opportunities presently and potentially available in the Colorado River ecosystem, and individual and social benefits associated with them. Consistent with the adaptive ecosystem management paradigm, include both biophysical and sociocultural parameters, and describe relationships between them. Compare and contrast these experience opportunities with other river recreation opportunities in the region."**

2. **"Generate an up to date valuation of market and nonmarket, individual and social benefits generated by use of recreation resources in the Colorado River ecosystem. Include multiplier effects and a thorough regional economic analysis. Use market economic measures as well as contingent valuation, travel cost,**

conjoint analysis and other professionally accepted nonmarket economic techniques where relevant and needed."

To meet these information needs, a recreation research component for the Colorado River AMP is suggested, consisting of:

1. Onriver research to establish (1) why and how the experience is perceived as unique, and (2) an inventory of benefits (physical, psychological, personal/social, spiritual) that visitors value, the relative importance of these benefits, and their relationship to ecological factors in specific reaches.

2. A regional comparison of river recreation experience opportunities to complement regional comparisons of substitutes for other resources.

3. An up to date inventory of all camping beaches currently used on a regular basis.

4. A unified effort to monitor a subset of camping beaches inventoried: all camping beaches in critical reaches, and sample of camps in non-critical reaches. These sites should be established through consultation with commercial and private river runners.

5. Analysis of regional market and nonmarket economic benefits of Colorado River recreation to complement data used to regionally analyze other economic resources.

Portions of this research component are being addressed by current and proposed GCMRC studies, but other portions are not.

Finally, it is suggested that implicit valuations of social benefits associated with various resources should be made explicit to the degree possible (as the National Research Council advises) by acknowledging the normative nature of statements in AMP planning documents, and generating better and more complete economic data for recreation and other socioeconomic resources.

Introduction

The 240-mile reach of the Colorado River through Grand Canyon supports one of the world's premier wilderness river trip experiences. Approximately 22,000 visitors per year take part in trips on various portions of the river, spending from 3 to 21 days floating, running rapids, day hiking and camping in the river corridor. Between Diamond Creek and the upper reaches of Lake Mead the river is utilized by a commercial river running business operated by the Hualapai Tribe, which offers 2-3 day trips. The last remaining riverine section of Glen Canyon (the 15-mile segment of the Colorado River between the tailwaters of Glen Canyon Dam and Lees Ferry) also supports day rafting trips in which more than 33,000 people participate annually. The renowned rainbow trout fishery in this reach is visited by more than 20,000 anglers each year, and supports about 20 commercial fishing guiding services.

Several aspects of these unique recreation resources are continually and significantly affected by operation of Glen Canyon Dam. Concern about effects on recreational, natural and cultural resources along the river led to the Grand Canyon Protection Act of 1992, a Final Environmental Impact Statement for Operation of Glen Canyon Dam (1995), a Record of Decision (1996) and ultimately to creation of the Grand Canyon Monitoring and Research Center (GCMRC) in late 1996. Currently, the GCMRC is charged with overseeing monitoring and research of the effects of dam operations on downstream resources, including recreation resources, as part of an Adaptive Management Program (AMP) for Glen Canyon Dam and the Colorado River ecosystem. For the purposes of the AMP, "the Colorado River ecosystem is defined as the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park, a distance of approximately 300 river miles" (GCMRC 1998, p. 1).

The purposes of this paper are to:

1. Review AMP/GCMRC guiding documents that delineate the GCMRC Recreation Resource Program, and describe the rationale for a recreation resource research and monitoring component.

2. Summarize the current state of knowledge and relevant literature concerning recreation resources in the Colorado River ecosystem, including both previous and current studies.

3. Generate a more explicit description/definition for recreation resources.

4. Discuss gaps in current knowledge and monitoring of recreation resources in the Colorado River ecosystem, and suggest studies and alternative methodologies which could be utilized to increase understanding and effectively monitor these resources.

CHAPTER 1

RATIONALE FOR THE RECREATION COMPONENT OF THE GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM: A REVIEW OF GUIDING DOCUMENTS

Recreation resources of the Colorado River ecosystem are managed by the National Park Service (NPS) through its administration of Grand Canyon National Park (GCNP) and Glen Canyon National Recreation Area (GCNRA). Areas affected by Glen Canyon Dam are within GCNP and GCNRA, which is why the NPS is the major stakeholder in the AMP. Language describing NPS management objectives for recreation and visitor use is contained in the General Management Plan and Colorado River Management Plan for GCNP (USDOI National Park Service 1995). Because most of GCNP (including the Colorado River) is potential wilderness, the scope of recreation experience opportunities that are managed for here is also governed by the Wilderness Act.

The Grand Canyon Protection Act (GCPA, 1992), Final Environmental Impact Statement for Operation of Glen Canyon Dam (EIS, USDOI Bureau of Reclamation, 1995a) and Record of Decision (ROD, USDOI 1996) are the principal guiding documents for the AMP. They clearly specify visitor use and recreation as resources that fall within the purview of activities overseen by the AMP for Glen Canyon Dam and the Colorado River ecosystem. Other documents that frame AMP/GCMRC activities concerning recreation are the Charter for the Adaptive Management Work Group (USDOI 1998), the Department of Interior Assistant Secretary for Water and Science Guidelines for the GCMRC (USDOI Office of the Assistant Secretary for Water and Science, undated), the GCMRC 1998 Draft Strategic Plan (GCMRC 1998) and the Programmatic Agreement. The Department of Interior Office of the Solicitor's report (USDOI Office of the Solicitor 1999) and the National Research Council review of the AMP (National Research Council 1999) provide very specific guidance regarding the program's scope and direction.

In this chapter, pertinent language from each of these documents is examined in detail. First, the basis for considering recreation a downstream resource of concern to the AMP is introduced by reviewing NPS management plans that address recreation opportunities in the Colorado River ecosystem. Relationships between the Wilderness Act, river recreation, NPS management and the AMP are then outlined. Next, the GCPA, EIS,

ROD and Solicitor's report are analyzed for language that describes how the authors of these guiding documents envisioned recreation resources fitting within the AMP. Finally, the GCMRC 1998 Draft Strategic Plan and 1999 NRC review of the AMP are examined for specific directions the GCMRC is currently taking regarding recreation-oriented research and monitoring.

The Grand Canyon National Park General Management Plan and Colorado River Management Plan

The United States National Park system was initiated when Yosemite National Park was protected (though not yet named as such) in 1864, and Yellowstone National Park was established in 1872. Grand Canyon National Monument was designated in 1908 and elevated to national park status in 1919. The National Park Service itself came into being with passage of the National Park Service Act in 1916. The purpose of national parks, as defined in a key clause of the act drafted by Fredrick Law Olmstead, Jr., "is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." (Runte 1987.) While the dialectic between visitor use and ecological preservation in national parks continues to spark debate, opportunities for humans to enjoy them (i.e. recreation) is a primary reason the parks were designated, and continues to be one of their principal purposes today.

Administration of Grand Canyon National Park is guided by the 1995 General Management Plan (GMP) and more detailed plans for specific park regions. The GMP specifies that the park will be managed to:

1.) preserve and protect its natural and cultural resources and ecological processes, as well as its scenic, aesthetic and scientific values

2.) provide opportunities for visitors to experience and understand environmental interrelationships, resources and values of the Grand Canyon without impairing the resources (USDOI National Park Service 1995b, p. 1).

Among reasons the GMP cites for the national and international significance of GCNP are its status as a World Heritage Site, and recreational opportunities on the Colorado River, recognized as "…one of the world's premier river experiences, including one of

the longest stretches of navigable whitewater on earth" (U.S. Department of Interior, National Park Service 1995b, p. 3). Several management objectives listed for the Colorado River in the GMP pertain to recreation or recreational conditions in the river corridor:

1. To the maximum extent possible, restore altered ecosystems to their natural conditions.

2. Manage the Colorado River corridor through Grand Canyon to protect and preserve the resource in a wild and primitive condition. Actively pursue the designation of eligible sections of the Colorado River and its tributaries as part of the National Wild and Scenic River System.

3. Provide a variety of primitive recreational activities consistent with Wilderness and NPS policies on accessibility. In deciding which opportunities would be provided in the Park's undeveloped areas, consider both the recreational opportunities available in Park developed areas, and recreational opportunities outside the Park.

4. Consistent with park purposes and the characteristics of each landscape unit, preserve and protect the maximum opportunities in every landscape unit of the park for visitors to experience the solitude, natural conditions, primitiveness, remoteness and inspirational value of the Grand Canyon.

5. Provide a Wilderness river experience on the Colorado River. This objective will not affect decisions regarding the use of motorboats on the river.

6. Establish indicators and standards for desired visitor experiences and resource conditions, monitor those indicators on a regular basis, and take action to meet the standards if they are not being met. (USDOI National Park Service 1995b, p. 7-8, 11.)

Thus, the NPS intends to manage Colorado River trip experience opportunities to be as close to the intent of the Wilderness Act as possible (within the constraint of prior existence of motorized trips). The relative substitutability or uniqueness of river experience opportunities within park boundaries will be assessed by considering them in relation to recreational opportunities beyond the actual park borders. NPS management of the River Corridor is also currently guided by the older, but more specific Colorado River Management Plan (CRMP) of 1989. Among the goals and objectives listed in the 1989 CRMP are these concerning river recreation:

-To provide Colorado River users the opportunity to participate in and appreciate a variety of the unique experiences offered by Grand Canyon National Park (GCNP) as a whole and by the riverine environment in particular.

-To provide a quality Colorado River experience through GCNP by determining the impact of crowding and use levels on visitor experience (considering trip size, number of contacts per day, visitor expectations, and time of year) through social science research.

-To establish, design, and implement an integrated, long-term monitoring program to assess changes in the status of [natural, cultural and] experiential resources.

- To initiate social science research to develop visitor profiles and user expectations for the Colorado River whitewater experience.

-To allow for visitation to attraction sites, for hiking side canyons, and for general off-river versus on-river time.

-To provide the opportunity to experience solitude, quiet, and the unique and natural environment of the canyon.

To meet these objectives, the year was divided into a high density use *primary* season (6/1-8/15), medium density use *primary shoulder* seasons in the spring and fall (5/1-6/1, 8/15-9/30), and a low density use *secondary* season (10/1-4/30). Among assumptions made during development of these guidelines were (1) that commercial trip customers taking a trip during the primary season have the least defined set of preferences and will be the least impacted by high density use, (2) secondary season visitors likely have the most defined expectations with respect to crowding and solitude, and (3) that both private and commercial visitors who wish to avoid the periods of highest density use could visit during the primary shoulder season. Density is managed by varying the number of people allowed to launch (daily or weekly) during each season. Specific numbers of contacts with other groups, and probabilities of camping within sight or sound of another group are targeted for each season as well, and monitored via the Limits of Acceptable Change approach (U.S. Department Of the Interior, National Park Service 1989).

At the time of this writing, the 1989 CRMP is being revised to conform with direction given in the 1995 GMP, and to be more consistent with the GCNP Wilderness Management Plan. River management issues identified through the scoping process will be addressed, and methods described to manage and distribute recreational use along the

River will be based primarily on meeting resource protection and Wilderness management objectives (USDOI National Park Service 1997). The revised CRMP is scheduled to be submitted in draft form in late 2000, and finalized in 2001.

The 1995 GMP also expresses the intention of park managers to integrate (to the extent possible given that management objectives sometimes conflict) their goals with regional plans and projects beyond park boundaries: "The revised [CRMP] will…conform to NPS direction and responsibilities as set forth in the *Operation of Glen Canyon Dam Environmental Impact Statement* (Bureau of Reclamation)" (USDOI National Park Service 1995, p. 57). This language reflects the spirit of the AMP, in which the various stakeholders are to address ramifications of decisions and goals that cross jurisdictional boundaries, and to be cognizant of how managing for one kind of resource affects others.

The Wilderness Act

The NPS 1995 General Management Plan includes the management objective to "provide a wilderness river experience on the Colorado River" (U.S. Department of the Interior, National Park Service 1995). Although management of river experiences is primarily the responsibility of the NPS, wilderness qualities of these experiences are inextricably linked to, and affected by, operations of GCD. In 1993 the NPS updated its 1980 recommendation for designating 980,088 acres within Grand Canyon National Park as wilderness and proposed an additional 131,814 acres of potential wilderness additions, much of this along the River Corridor. This "potential proposed" designation is currently undergoing legal and policy review within the NPS (USDOI National Park Service 1998a) and action by Congress on the recommendation is pending, though the issue is unlikely to be resolved soon. In the meantime, as noted in the EIS, "NPS is mandated by the Wilderness Act to protect wilderness values in the park, including those along the river, and to take no action that would potentially compromise future wilderness suitability" (USDOI Bureau of Reclamation 1995a, p.154).

The EIS points out that "wilderness is both a legal and philosophical concept- an area that appears to be influenced primarily by the forces of nature" (USDOI Bureau of Reclamation 1995a, p. 154). The Wilderness Act of 1964 gave legal definition to

wilderness as “an area where the earth and its community of life are untrammeled [uncontrolled] by man…retaining its primeval character and influence, without permanent improvements…”, and instructed managers to “administer [wilderness areas] for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness” (quoted in USDOI National Park Service, 1998b). As many have noted (e.g. Nash 1982, Oelschlager et al. 1989), wilderness is at the same time a rather fuzzy philosophical concept, with connotations that have changed over time. Our prehistoric ancestors would have been baffled by ideas of wilderness as somehow separate from daily routines. Historically, wilderness was often characterized as useless at best, and at worst as dangerous, forbidding and in need of human control. Conversely, in late 20th century industrial societies most people live in greater isolation from the natural world than ever before, and the concept of wilderness is generally viewed much more positively. Knowledge of legal details concerning the Wilderness Preservation System may be limited among the general public (Hall 1999), but there is broad awareness that wildernesses are valuable as ecological refuges, and as counterpoints to built environments where humans can find solitude and recover from pressures of modern life. Although the exact meaning of wilderness varies between people, three central themes consistently emerge: *experiential*, the direct value of wilderness experiences in wilderness; the *scientific* values of wildernesses as environmental baselines, and the *symbolic* and *spiritual* values of wilderness to the nation and the world (Hendee, Stankey and Lucas 1990).

Use of designated wilderness areas and national parks is increasing, leading to the suggestion that managers should concentrate more of their efforts on the quality of wildland experiences (Cole 1996). Travelers on the Colorado River value wilderness aspects of it highly: enjoying a wilderness experience is one of the attributes of an excellent or perfect trip most frequently mentioned by river runners (Bishop et al. 1987, Hall and Shelby, forthcoming). The EIS states that Glen Canyon Dam itself does not render the Colorado River in Grand Canyon unsuitable for wilderness designation, but that operation of the dam can influence wilderness attributes downstream. As the EIS notes, “the feeling of being in a wilderness area can be affected by fluctutations in daily flows since changes in releases from the dam would continually remind boaters of human

control over riverflow and thus of the recreational environment." (USDOI Bureau of Reclamation 1995a, p. 154). Many visitors do believe daily fluctuations detract from the river's wilderness qualities (Shelby, Brown and Baumgartner 1992); Bishop et al. (1987) found that most river runners are aware of daily fluctuations, and most felt that these fluctuations make the trip seem less like a natural setting. The magnitude of fluctuations between high and low daily flows, and the rates at which flows are increased and decreased (ramping rates) have been attenuated since late 1992 to comply with provisions of the GCPA, EIS and ROD. It is presumed, but not known, that these changes in water release patterns have reduced dam-related impacts on wilderness experience quality.

Beach erosion decreases wilderness quality by making it more difficult for river trips to camp out of sight and earshot of one another, and because it is perceived as a human impact that degrades natural qualities of the ecosystem. Solitude is considered one of the most important aspects of a wilderness experience (Hendee, Stankey and Lucas 1990), although other research suggests that while escaping crowds is important, visitors may value natural aspects of wilderness environments even more highly (Watson et al. 1992). In any case, opportunities for solitude, and settings where evidence of human impact is minimal are two critical components of wilderness river experiences that are affected by dam operations. Language in the Wilderness Act, and NPS responsibilities to manage the River Corridor as potential wilderness, leave no doubt as to the relevance of GCMRC studies that assess river experiences vis a vis wilderness, and how operations of GCD can be altered to mitigate impacts on wilderness qualities along the river.

The Grand Canyon Protection Act

The most specific legal basis for a recreation component within the AMP is language in the GCPA, Section 1802(a) which directs the Secretary of the Interior to "…operate Glen Canyon Dam in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park…[was] established, including, but not limited to, natural and cultural resources and visitor use." For the purposes of this document, "visitor use" is assumed to be synonymous with "recreation".

Section 1804(b) of the GCPA refers to an audit of costs and benefits to water and power users, and to natural, recreational and cultural resources in GCNP resulting from

long-term operational policies for GCD. Section 1805(b) specifies that "long-term monitoring of GCD shall include research and studies to determine effect of the Secretary [of Interior's] actions…[of adoption of criteria and plans for the operation of GCD]…on natural, recreational and cultural resources of GCNP…".

It is important to note here that no hierarchy of the relative importance of natural, recreational, or cultural resource areas is mentioned or implied in the language of the GCPA. These are all values for which the park was established and therefore equally worthy of research, monitoring, protection and enhancement.

The Final Environmental Impact Statement for Operation of Glen Canyon Dam

As specified in the GCPA, recreation resources downstream of Glen Canyon Dam in Glen and Grand Canyons were addressed by the EIS. Among the resource issues determined to be of concern by the initial scoping process were these that relate directly to river-based recreation: beaches, rafting/boating, fish, Grand Canyon wilderness, and non-use values. Public interests and values identified during the scoping process that may also relate to river-based recreation included expressions about the Grand Canyon, nonquantifiable values, nature vs. human use, and complexity of GCD issues.

The EIS team consolidated and refined issues of concern to the public and Federal, State and Tribal Governments, and identified resources and significant issues to be examined in detail. Although the eleven issues identified are interrelated in many ways, one pertained specifically to recreation: How do dam operations affect recreation in the study area? Indicators identified for this issue include whitewater boating trip attributes, camping beaches, safety and wilderness values. Also identified was a biological resource related to the rainbow trout fishery and recreational fishing: "How do dam operations affect FISH-their life cycles, habitat, and ability to spawn?" Biological indicators identified for this issue which indirectly concern recreational fishing are abundance of cladophora and associated diatoms for the aquatic food base, level of interactions between native and non-native fish, and reproduction, recruitment and growth of trout.

Perhaps most importantly, the EIS identified non-use value as a significant issue relevant in the decision making process. Non-use values are described as values in which "…the nonmarket good is the status of particular attributes of the physical environment",

and arise because “the state of the natural environment affects people both in how they use the environment and how they would prefer the environment to be”. One component of non-use value is described as the “desire to preserve the natural ecosystem to maintain the option for future use.” (USDOI Bureau of Reclamation 1995a, p. 174, all quotes.)

The EIS clearly describes aspects of river recreation in the Colorado River ecosystem as unique, stating that “the Colorado River through Marble and Grand Canyons is the longest stretch of river (278 miles long, with over 160 recognized rapids) for recreational use entirely within a national park”, and that “some of the world’s most challenging and exciting whitewater occurs here” (USDOI Bureau of Reclamation 1995a, p.148). It was also noted that “river-based recreation activities in Glen and Grand Canyons are nationally and internationally renowned for their quality and scope”. The EIS further acknowledges that “dam operations affect the experience of recreationists using the Colorado River in Glen Canyon and Grand Canyon…”, states that resources downstream of GCD are interrelated, and emphasizes “…the holistic pattern of system behavior” (USDOI Bureau of Reclamation 1995a, p.69). It was recognized that a complete scientific study of the Colorado River ecosystem was beyond the scope of the EIS process, that linkages among downstream resources were not fully understood and that a program of monitoring and adaptive management were required to expand understanding of how changes in processes affect the system.

Recreation resources are perhaps the least understood of those identified by the GCPA and EIS. Direction provided by this and aforementioned language in the EIS specifically gives the GCMRC latitude to fund studies designed to expand understanding and more clearly define the world-class recreation resources in the Colorado River ecosystem, and linkages between these and other downstream resources.

The Record of Decision

The Record of Decision (ROD) signed on October 8, 1996 documented Secretary of the Interior Bruce Babbitt’s decision to implement operating criteria specified in the Modified Low Fluctuating Flow (MLFF) alternative described in the EIS (U.S. Department of the Interior 1996). Section 1802[a] of the GCPA (to which the GCMRC would often refer when delineating its activities) was again cited, including the

stipulation requiring the Secretary to "…protect, mitigate adverse impacts to, and improve values for which GCNP was created…including…visitor use." The ROD also reiterated issues of public concern identified during the public scoping, and noted that this process was accompanied by "…national attention and intense interest in the EIS." (Issues of public concern that relate to river-based recreation are covered in the discussion of the EIS, above.)

It was noted that modification of upramp rates and maximum allowable releases that occurred between the draft and final EIS phases were controversial among certain interest groups, and allowed for review of the revised maximum flow if impacts differing from those described in the EIS were identified by the AMP. Among the purposes of the EIS process that reevaluated GCD operations, the ROD listed "…mitigating, consistent with law, adverse impacts on….Native American interests in…Grand Canyon…". Native American interests include the Hualapai commercial river running operation between Diamond Creek and Lake Mead.

The ROD is the first document guiding GCMRC activities that specifically includes results of the GCES non-use value study, and thus significantly modifies and updates language in the GCPA and EIS relating to GCMRC responsibilities concerning recreation. It states that "although there would be a significant loss of hydropower benefits due to the selection of the preferred alternative (between $15.1 and $44.2 million annually) a recently completed non-use value study conducted under the Glen Canyon Environmental Studies [GCES] indicates that the American people are willing to pay much more than this loss to maintain a healthy ecosystem in the Grand Canyon." (U.S. Department of the Interior 1996).

In addition, the ROD notes a finding of the GCPA-mandated audit conducted by the General Accounting Office (GAO) on the ways costs and benefits were calculated in the EIS that there were "…shortcomings in the application of certain methodologies and data…". These shortcomings may have resulted in overestimation of impacts to hydropower, and underestimation of impacts to recreation in the EIS. The ROD cites findings that "reclamation's assumptions do not explicitly include the mitigating effect of higher electricity (price elasticity)", that "Reclamation's assumptions about natural gas prices were relatively high and that two computational errors were made during the third

phase of power analysis" and that "according to the GAO, these limitations suggest that the estimated economic impacts are subject to uncertainty." Regarding impact analysis for recreation, the ROD states that "certain data [for impact analysis] were incomplete or outdated, particularly data used in assessing the economic impact of alternative flows on recreational activities" (U.S. Department of the Interior 1996).

Despite these qualifications, the ROD endorsed the preferred alternative without reassessment of cost and benefit accounting procedures and results contained in the EIS. This decision was based on National Research Council (NRC) reviews generally finding the analysis to be adequate, and GAO conclusions that the shortcomings and limitations identified were "…not significant and would not likely alter findings with respect to the preferred alternative and usefulness of the document [EIS] in the decision-making process." Notwithstanding this endorsement, the NRC did find that power interests had an undue amount of influence in the economic research, particularly the work of the Power Resources Committee (NRC 1996). That the issue has not yet been re-examined may indicate that values and benefits of river recreation experiences are poorly articulated and understood. The problem of incomplete economic data for recreation and other socioeconomic concerns has been reinforced by a more recent NRC review of AMP and GCMRC activities (NRC 1999).

The Glen Canyon Adaptive Management Work Group Charter

On December 28, 1998 Secretary of Interior Bruce Babbitt signed a document officially describing the background, purpose, parameters and responsibilities of the Adaptive Management Work Group (AMWG, U.S. Department of Interior 1998). The Charter paraphrases oft-cited language in the GCPA directing the "…Secretary of the Interior, among others, to operate GCD in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon…was created, including but not limited to…visitor use." The phrase "among others" (referring to those who operate GCD) is added to this version, although these "others" are not identified. The AMWG is directed to "define and recommend resource management objectives for development and implementation of a long-term monitoring plan, and any necessary research and studies required to determine the effect of the operation of GCD on the natural, recreational and

cultural resources of the Grand Canyon National Park…" and to "monitor and report on compliance of all program activities and applicable laws, permitting requirements, and the [GCP] Act." An important stipulation is that "the duties and functions of the AMWG are in an *advisory capacity only.*" This language gives the GCMRC latitude in proposing studies not necessarily originating with, or endorsed by the entire AMWG, provided these studies are consistent with the meaning and spirit of the GCPA and EIS.

The Office of the Solicitor's Report on Federal Advisory Committee Act Guidance for the Glen Canyon Dam Adaptive Management Program

Responding to issues raised in late 1998 by stakeholders in the Adaptive Management Work Group (AMWG), the DOI Office of Solicitor researched and answered a list of questions developed by the AMWG which were intended to clarify several aspects of the ROD that remained ambiguous. Responses were returned to the AMWG and GCMRC in mid-1999 in a document referred to by these entities as the Solicitor's Report, or herein as simply the report (U.S. Department of Interior, Office of the Solicitor 1999). Aspects of this report that help clarify GCMRC responsibilities and activities regarding recreation resources are discussed here.

The report quotes language in the Senate Report on the GCPA, stating this bill's primary purpose as "…to prevent damage to downstream resources, principally [from] the dam's power operations" to the extent possible within the existing "Law of the River". The report also states that "it is clear that Congress understood that these objectives would have certain costs in the form of lost hydropower generating opportunity", and that "the basic question Congress was addressing was "how can GCD operations be modified so as to improve conditions for downstream resources?"

The report emphasizes that the EIS was a "..rough answer to [this] question…", that the ROD selection of the Modified Low Fluctuating Flow (MLFF) alternative was the DOI's "…best first answer" and that discussions and analyses in the EIS "…provide a starting point for the state of the science at the time the decision was made to implement the [MLFF]…". Accordingly, Congress added section 1805 to the GCPA specifically acknowledging that more "…experience and knowledge with operations might further improve downstream resource conditions…". Language from the GCPA referring to

protection, mitigation of adverse impacts to, and improvement of "…the values for which GCNP…was established" is once again reiterated. Since "visitor use" (i.e. recreation) is explicitly mentioned as one of these values, this language reaffirms that GCMRC activities assessing GCD operational impacts on recreation are consistent with the intention of the GCPA.

The report explains the scope of AMWG responsibilities as "…to identify aspects of dam operations that can be modified to beneficially affect…downstream resources...". After listing several very specific aspects of dam operations and effects as examples, the report states that the AMWG is additionally charged with investigating "…any aspect [of dam operations]…which has a reasonably demonstrable effect on the downstream resources sought to be improved by the GCPA."

Language in the Charter for the AMWG authorizing it to "…recommend research and monitoring proposals outside the [GCP] Act which complement the AMP process [that] will be funded separately, and [should] not deter from the focus of the Act" is clarified by the solicitor as meaning "…anything the committee considers relevant but tangential or attenuated in its effects on riparian resources downstream of the dam, as identified above." This language is still vague, but may include factors related to river recreation. The same can be said for Senate Report language stating that the Secretary should consider and may implement non-operational measures to address downstream effects of GCD if such other remedial measures meet this title's goal of protecting, mitigating damage to, and improving the resources downstream of the dam.

As with other guiding documents for the GCMRC, the most important point is that recreation is a downstream resource commensurate in significance with biophysical concerns such as endangered fish and sediment, so the language quoted above also applies specifically to recreation. The report specifies that "…long term monitoring and research…are intended to enable finer and finer tuning of operations over time, as additional knowledge and experience are gained." This should include efforts to delineate recreation resources as specifically as possible given the current state of knowledge (in the same manner as is being done for all other affected resources), to update this knowledge on a regular basis, and to incorporate it as it becomes available into operational planning.

The United States Department of the Interior Office of the Assistant Secretary of Water and Science Guidelines for the Grand Canyon and Monitoring and Research Center

As the Secretary of the Interior's Designee, the Assistant Secretary for Water and Science drafted a document for the GCMRC, which "…specifies guidelines for organization and administration of both short and long-term monitoring and research programs called for in the Grand Canyon Protection Act." (U.S. Department of Interior, Office of the Assistant Secretary for Water and Science, undated). In stating the rationale for research and monitoring, the guidelines paraphrase pertinent language from the GCPA, including the now familiar reference to "…natural, recreational, and cultural resources…" and "…visitor use." It is noted that "the [AMP] decision and management process is constantly evolving, with continuous input of new information and science from a Research Center", presumably including information on poorly defined recreation resources.

The guidelines offer a definition of the role of the GCMRC: "To conduct short and long-term ecosystem monitoring and research programs of alternative dam operation criteria and other information needs specified by the AMWG. To evaluate ecosystem resource impacts and changes resulting from alternative dam operating criteria to aquatic, terrestrial and cultural resources in the river corridor. To inform the AMWG of resource protection, management and use implications of alternative dam operating criteria." It is notable that all resources except recreation are reiterated here, even though recreation resources are specified by the GCPA.

The mission of the GCMRC is defined as "…to operate within the AMP and with the AMWG/TWG to develop and implement scientifically sound monitoring, research and information archiving and transfer programs for the Colorado River and associated resources in Glen, Marble and Grand Canyons." These "…associated resources…" include recreation resources, as specified by the GCPA, EIS, ROD and other documents.

The Grand Canyon Monitoring and Research Center Draft FY2000-2004 Monitoring and Research Strategic Plan

The GCMRC Draft Strategic Plan (GCMRC 1998) outlines scientific programming that the GCMRC proposes to implement to fulfill its role within the AMP, toward the goal of meeting the statutory requirements of the GCPA, EIS, and the ROD. Scientific activities to be implemented over a 5-year period are described for physical, biological, cultural, socioeconomic and recreational resources and "…will relate to known or hypothesized resource impacts, primarily in the Colorado River ecosystem within Grand Canyon National Park and Glen Canyon National Recreation Area, resulting from '…the effects of the Secretary's actions…'". The "Secretary's actions" are defined as including "…dam operations or alternative operating criteria as well as other authorized actions". The background, status of knowledge, management objectives and information needs for socio-cultural resources are presented separately for cultural resources, recreational resources, and economic market activities.

Though recreation resources are not specifically defined, the Draft Strategic Plan implicitly acknowledges that they consist of experience opportunities by stating that "the preferred alternative considered impacts on recreation and has attempted to enhance the recreational experience (e.g. opportunities to experience wilderness, natural quiet and solitude, etc.) in the river corridor" (p. 100). An experiential definition for recreation is also implied by objectives listed for long-term monitoring and research: "…to determine whether recreational experiences and safety are affected [by] dam operations, and whether changes in recreational patterns resulting from selected dam operational conditions have any effect on the downstream resources" (p. 100).

The plan states that "recreational use of the river has economic and environmental importance" and that "…as a major public use within Glen and Grand Canyons, recreation creates jobs and financial support within the region and also has affects on other resources" (p. 100). Discussion of the environmental importance of recreational use is limited to potential impacts on biophysical and cultural resources. Aside from acknowledgement that recreation has economic importance by creating jobs and financial support in the region, no mention is made of the unique character of experience

opportunities on the river, or of the range of benefits these experiences produce for individuals and social groups.

A critical component of the AMP is establishment by the AMWG of Management Objectives (MOs) and Information Needs (INs) for each resource area. MOs and INs are prioritized and communicated to the Technical Work Group (TWG) and ultimately to the GCMRC, where they are formulated into work projects that become the basis of science programming. MOs and associated INs for many resource issues have been identified by the AMWG since its inception. Revision and prioritization of MOs and INs was the focus of several meetings of the TWG in early 1998; INs were officially prioritized by 14 members of the TWG on April 23, 1998 (Grand Canyon Monitoring and Research Center 1998). The current MOs for recreation resources, the relevant INs, and their relative priority (as judged by the TWG) are presented in Appendix A.

The GCMRC is currently supporting research into attitudes and preferences of users toward recreation opportunities relative to river flows, changing attitudes and preferences of users, and user attitudes and preferences in relation to stakeholder visions (Stewart et al. 1997). Results from this study are due in FY2000. The GCMRC has also instituted a more focused effort toward monitoring of camping beaches, by supporting a study integrating methods developed by Kearsley et al. (1994, 1999) and Kaplinski et al. (1998). This study will concentrate on 15 camping beach sites in critical reaches, and will supplement ongoing research on the changes in Colorado River ecosystem sandbars. GCMRC has also provided limited support for the Grand Canyon River Guides' Adopt-A-Beach Program (O'Brien et al. 1999).

Funding of sociological studies concerning flow related aspects of river visitor experiences, and increased attention to monitoring of camping beaches, are encouraging efforts on the part of the GCMRC to bring recreation research into parity with other resource areas. Loss of campsites, and reductions in campable area at existing campsites, are among the most critical issues facing recreation managers and those who benefit from recreation resources. Studies of how visitors perceive and interact with beaches, as well as studies of camping beach dynamics, are thus important components of understanding recreation resources. However, new research is also needed to delineate the river experience itself. This suggestion is discussed in detail in chapter 3.

The National Research Council review of the Glen Canyon Dam and Colorado River Ecosystem Adaptive Management Program

Periodic external review of center activities is important to ensure that work undertaken by the GCMRC is rigorous, focused and relevant to goals that guide the AMP. As part of this ongoing process, the National Research Council (NRC) recently completed a review of the 1997 version of the Draft GCMRC Strategic Plan and its component programs in physical, biological, sociocultural and information technology programs. Findings of the NRC are contained in a report entitled "Downstream: Adaptive Management of Glen Canyon Dam and the Colorado River ecosystem" (National Research Council 1999).

In an early chapter, the reviewers discuss the lack of a coherent vision for the AMP and attribute this in part to disparity among objectives of the various stakeholders. For the AMP to meet the tenets of the GCPA, EIS and ROD, say the reviewers, a coherent vision of the Colorado River ecosystem is needed that merges concepts of conservation ecology and social welfare. Later, they observe that "among the most important and least understood issues for social research are the following: *what* resource effects are valued by different groups, *how* they are experienced and valued, and *how much* they are valued. Previous research within the GCES addressed the 'what' and how much questions, with less formal research on identifying common ground and basic differences, or on changes in 'how' downstream resources and resource effects are experienced and valued" (NRC 1999, p. 76). This suggests the need for research that will adequately demonstrate how downstream *recreation* resources and resource effects are experienced and valued, for comparison with other resources of concern.

Overall, the NRC is quite critical of the GCMRC socioeconomic program, stating that "discussion of the socioeconomic dimensions of the [Draft] Strategic Plan differs from the discussion of its other components because the plan provides little to evaluate" (NRC 1999 p. 81), and that "…management objectives and information needs for the Socioeconomic Resources Program contain major omissions…making it unclear how this…program is to meet the goals of adaptive management" (NRC 1999, p. 55). Regrettably, the reviewers do not explicitly discuss how recreation resources fit into the

larger socioeconomic program, although GCMRC support of "…important research on recreational sociology in the Grand Canyon…, [a] useful project on recreation" is acknowledged, in reference to the work of Stewart et al. (1997). (NRC 1999, p. 9, 81.) Other than these brief references to research on experiential aspects, recreation is addressed in the context of nonmarket economic "…social benefits associated with improved ecological or recreational conditions in the [river corridor]…" (NRC 1999 p. 83).

The reviewers unequivocally state that a priority for the GCMRC should be deriving values for benefits associated with recreational experiences, to complement more readily available figures for hydropower revenue (NRC 1999, p. 82-3), and specifically note that current measures of recreation user values are incomplete (NRC 1999, p. 9). "Economic theory is clear", they maintain, "on the fact that revenues of collateral business activity do not represent a measure of social value of the existence of a resource, let alone the change in social values associated with variations in the resource's condition….at best [such measures address] distributional consequences of some change, not the overall benefits to society of that change" (NRC 1999, p. 83). They add that "understanding the social benefits associated with improved ecological or recreational conditions in the [Colorado River ecosystem] requires information about society's willingness to pay for enhancement of ecological conditions or for better recreational opportunities" (NRC 1999, p. 83).

To support their argument for more transparent and explicit analysis of resource tradeoffs, the NRC reviewers point out that decision makers often use implicit value judgements to decide whether physical resource effects are gains or losses, who wins and who loses, and how important these gains and losses are. They note that this informal process stands out in sharp contrast to the rigor with which many physical effects are measured, and that while economic values of downstream resources were included in the EIS and previous NRC reviews, these values have not been incorporated in GCMRC resource programs. The reviewers emphasize the importance of addressing implicit value imputations with the same rigor as scientifically measured physical effects, and reiterate that there "…is only one Grand Canyon" (NRC 1999, p. 85).

CHAPTER 2

THE STATE OF KNOWLEDGE CONCERNING RECREATION IN THE COLORADO RIVER ECOSYSTEM

Wildland recreation is an area of increasing interest within U.S. land management agencies as commodity extraction and development on public land declines and the amount of recreation use rises. Growth in demand for outdoor recreation activities that take place in undeveloped environments is outpacing supply, a trend that is expected to continue (English et al. 1993). Outdoor recreation overall is increasing faster than the rate of population growth (Cordell et al. 1995). Participation in outdoor recreation is also projected to diversify, and to grow fastest in activities that are popular with older adults (Dwyer 1994).

Parker (1999) suggests that natural resource managers need to reconceptualize resources by understanding their "social content" (p. 63). Accepting that there are both biophysical and social components to resources within ecosystems can shed light on complex relationships among designated resource categories in the CRE. In this chapter, a brief overview of Colorado River recreation is presented, followed by discussion of recreation from physical, biological, cultural, hydropower and economic resource perspectives. The complex interface between recreation and hydropower is introduced by discussing the ways in which GCD has influenced the present state of recreation resources, although for AMP purposes the existence of GCD is to be taken as a given (USDOI Office of the Solicitor 1999). Relationships between recreation and power production, which are directly linked to dam operations and therefore within the scope of AMP activities, are also covered. Economic components of recreation, and their relationships to hydropower revenue, are treated in the section dealing with recreation as an economic resource.

Overview of recreation in the Colorado River ecosystem

The Colorado River through Grand Canyon has acquired a reputation as the premier wilderness river trip in the world, frequently described as the trip of a lifetime. Rafting trips on the Colorado are internationally famous, and supporting them has become a major industry. Commercial trips have been available since 1938, when Norm Nevills'

Mexican Hat Expeditions first took paying customers down the river (Lavender 1985) but the huge popularity of river running has occurred more recently. In 1960, only 205 people ran the river; by 1972 that number had reached 16,000 annual visitors. Increasing use led to unacceptable ecological impacts and several years of studies to improve management. River traffic is now closely monitored by the NPS, and allocated through a fixed number of user days per year. Currently 115,500 user days are allocated annually for commercial trips, and 54,450 for private groups (USDOI Bureau of Reclamation 1995).

About 75% of commercial passengers take part in 5-8 day trips on 30 to 40-foot motorized rafts. The other 25% participate in longer (12-18 day) trips, mostly in 14-20' oar or paddle-powered rafts, but also in hard-hulled dories, kayaks and even canoes. More than 50% of participants choose partial trips and either hike in or out at Phantom Ranch or fly in or out using a helipad located on Hualapai Tribal land near Whitmore Wash. Private boaters must apply for permits that are given out in the order that applications are received. The waiting list for a private permit is currently 15-20 years, but about 40% of applicants obtain a permit sooner due to cancellations. In all, about 22,000 people run all, or a multi-day portion of the river each year.

Use is heavily skewed toward the summer months, when the NPS enforces a 166 person per day launch limit. Trips during this time are usually arranged a year in advance; some companies sell their entire allocation of user days in a 24-hour period (Stavely 1999). Commercial use is virtually non-existent from November until April, but hardy private boaters run the river all winter long, on trips as long as thirty days. One Colorado River concessionaire is authorized to run day river trips on the 15-mile section of Glen Canyon between the dam and Lees Ferry. In 1991, over 33,000 visitors took half-day tours of this reach. The Hualapai Tribe also offers commercial raft trips, taking groups on one or two day tours from Diamond Creek (approximately 240 miles below Glen Canyon Dam) to Lake Mead. The Lees Ferry fishery in the 15-mile Glen Canyon reach of the river is currently serviced by about 20 fishing guides, each working approximately 150 days per year. Current estimates are that commercial fishing guides support about 7100 customer days annually, with private fisher/days numbering roughly 30,000 (Gunn 1999).

Colorado River recreation experiences affect, and are affected by physical, biological, cultural and economic factors, and are thus highly interrelated with these resources (Manning 1999). In most cases, managing for biological or physical considerations will also enhance the river running experience, because interacting with intact biophysical resources is a key component of wildland recreation. Recreation opportunities and ecological values are mentioned in the same context by the NRC (1999), and recreation and biophysical resources are often managed for concurrently within the AMP, as they were during the 1996 BHBF experiment. These examples illustrate the difficulty of disentangling CRE resources into discrete categories, and of attributing management goals to strictly biophysical or recreation resource values.

There are some exceptions to the general congruence between managing for recreation and biophysical resources, although conflicts between recreation and other resource goals are less obvious for downriver recreation than for trout fishing. The Lees Ferry trout fishery depends totally on ecological changes caused by the dam for its existence, and what has been good for introduced trout has been bad for native fish. The potential conflict between goals to maintain a blue ribbon trout fishery in the Lees Ferry reach, and protect and restore native fish populations is an instance of divergence between recreation and other resource goals within the AMP. Similarly, if it were determined that recreational visitation at Vasey's Paradise threatens the endangered Kanab ambersnail, such visitation might need to be curtailed. Minor restrictions of this type are implemented routinely in wildland recreation areas; visitors are generally supportive of them if they understand why they are necessary. Management actions that are perceived to threaten entire classes of recreation experiences, such as efforts to install a temperature control device to benefit endangered fish, are likely to be much more controversial.

Recreation and physical resources

Perhaps no other issue illustrates the complexity and tradeoffs inherent in managing the CRE than the issue of sediment resources in the context of camping beaches. Arguably, river runners have benefited from the longer seasons and relatively predictable flows resulting from GCD (see discussion below) but the way the dam is managed has also resulted in serious negative consequences. Of most concern are dam operations that

cause a loss of beaches that border the river intermittently between rocky slopes and cliffs, which comprise most of the river corridor. Prior to construction of the dam, the Colorado River carried an average of 380,000 tons of sediment a day through Grand Canyon (Carothers and Brown 1991). Now suspended sediment drops out of the river in upper Lake Powell, and water released through the dam is crystal clear.

Beaches and sandbars serve as campsites for rafting groups, and are thus highly valued. Camps are preferred to varying degrees on the basis of size, boat mooring quality, wind protection, access to side canyon hikes, scenery and shade. Finding a suitable unoccupied camp during the summer months can challenge rafting parties, and occasional conflicts over camps occur. Prime camps in critical reaches of the river are occupied by 15-40 person groups on most nights during the summer. Historically, these beaches were replenished annually by sand and silt transported by the river during spring runoff. Since this sediment now settles out in Lake Powell, the beaches downstream are being inexorably carved away by the river's clear, sediment free flows (Kearsley et al. 1994). Some camping beaches in Granite Gorge (a critical reach in the central part of the river corridor) eroded a horizontal distance of more than 30 feet from 1974 to 1984 (Carothers and Brown 1991). Most predam beaches are now considerably smaller, and some have disappeared completely. Camping beaches are also being eroded through gullying induced by monsoon rainstorm runoff, a phenomenon related to the GCD in that degraded beaches are not replenished under normal operations, but might be under BHBF scenarios.

Although the Modified Low Fluctuating Flow water release regime has attenuated this critical dam-related impact, erosion and/or inundation of camping beaches remains one of the principal concerns in efforts to balance hydropower and recreation values (Kearsley and Warren 1993, Kearsley 1995). Kearsley et al. (1994) analyzed change in campable area of campsites over time by generating an inventory of campsites through interviews with guides and then comparing aerial photographs of the River Corridor taken 1965, 1973, 1984 and 1990. In 1999, Kearsley, Quartaroli and Kearsley evaluated the effects of the 1996 controlled flood on campsites. Conclusions from these studies offer a good synopsis of the effects of GCD operations on campsites through time, and the potential for future controlled floods to mitigate these effects:

> "Loss of Colorado River campsites continues after nearly 30 years of dam operations, but the rate of decline has slowed. No combination of high flows or fluctuating discharges has reversed this process. The pattern of change has been one of system-wide decrease in sites (1965-73), variable change during years of regulated high flows (1983-6) and a system-wide decrease in campsites since 1984.
>
> Sandbars in Grand Canyon do not all respond in the same manner to high flows, fluctuating flows or vegetation encroachment, and the response differs between narrow and wide reaches. Despite a system-wide increase in campsites between 1973 and 1983, the [social] carrying capacity of campsites in critical (narrow) reaches decreased. Campsite availability within critical reaches is the limiting factor in determining the river's aggregate [social] carrying capacity. Thus, river managers should focus on long-term responses of campsites in critical reaches by implementing strategies that create new or increase the size of sand deposits there. Strategies that lead to net aggregate deposition along the river but which cause net campsite loss in critical reaches will only exacerbate the current problems with concentrated use at the few medium and large campsites remaining in these reaches." (Kearsley et al. 1994.)

> "The increase in campsite number and size resulting from both the 1983 flood and the 1996 controlled flood have been of short duration. Therefore, the long-term trend from these data suggest that similar floods will temporarily increase campsite number and size, then campsites will continue to erode slowly. While flood effects to campsites are temporary, they are the only feasible means of depositing sediment above normal fluctuations, where sand is otherwise continually eroding." (Kearsley et al. 1999.)

Studies continue under both the GCMRC Socio-cultural and Physical Programs, but it seems clear that campsite number and quality will continue to decrease (particularly in critical reaches) although erosion occurs at a slower rate now than in the initial period after GCD became operational. Thus far, it has not been necessary for the NPS to decrease use level; river guides have been able to adjust trip itineraries to cope with decreases in camp number and size through time. Development of computer models for river trip scheduling and behavior offers the chance to optimize launch schedules and allow the same number of trips to launch with fewer contacts, or accommodate greater numbers of private boaters who may currently wait a decade or longer to obtain a launch permit.

Recreation and biological resources

Experiencing biological resources in undisturbed native ecosystems is important component of wilderness river recreation. Desert flora and fauna are exotic and unusual for many visitors, who especially value sighting larger animals such as desert bighorn, and bird species such as peregrine falcons or reintroduced California condors. Vegetated side canyon riparian areas characterize several popular attraction sites. Many visitors are concerned about endangered species, and exposure to issues surrounding their management in the CRE is the basis of important environmental learning benefits (c.f. Roggenbuck et al. 1990). Recreational use can have negative effects on riparian biota, some of which are linked to interactions between dam operations and spatial distribution of river trips, vegetation patterns, native fauna, beach morphology and other conditions. Recreationist impact on biological resources (e.g. endangered species, vegetation cover) is a relevant topic for future studies within the GCMRC, and should be amenable to quantitative biological or physical research techniques. The NPS supports a Limits of Acceptable Change (LAC) approach to monitoring recreation impacts along the Colorado River (USDOI National Park Service 1989). The LAC and a number of other management frameworks developed to assess and monitor biophysical impacts are summarized in Cole and McCool (1997).

Colonization of camping beaches by the non-native tree species tamarisk, facilitated by dam controlled flows, has been both a blessing and a bane to river runners. On one hand tamarisk offers wind and sun protection, privacy for individual campsites, and attenuates beach erosion, on the other hand it eventually takes over beaches, making them unsuitable as campsites (Phillips et al 1986). Post-dam beach colonization by native species such as arrowweed has also contributed to a reduction in usable campsites area and number.

The relationship between the Lees Ferry trout fishery, because it is entirely a product of changes incurred by GCD, is discussed below under the heading “recreation and hydropower resources”.

Recreation and cultural resources

In addition to many easily accessed Hitsatsonom (Anasazi) archaeological sites, cultural resources utilized for recreation in the CRE include landscapes important to the Hopi, Navajo, Southern Paiute, Zuni and Navajo people. Experiencing cultural resources and learning about native lifeways are highly valued by southwestern park visitors (Lee and Stephens 1995) and satisfying curiosity about the significance of the CRE to past and present native cultures is an important component of interpretation efforts by commercial river guides. River trips run by the Hualapai offer excellent opportunities for visitors to hear from the Hualapai themselves what the landscapes mean.

Laxson (1991) observes that many Americans, faced with the pressures of modern Anglo society, are curious about native spiritual beliefs which are perceived to encompass closer relationships with the natural world. While romantic notions regarding native connections with nature are common, there is apparently substantial validity to this perception. Several authors (e.g. Jostad et al. 1996, Booth and Kessler 1996) have cited the potential of Native American land ethics to provide guidance for moving toward more ecologically-attuned wildland management and decision-making.

The possibility of recreation use impacts on cultural resources such as Traditional Cultural Properties and other archaeological sites, ethnoecological resources (Nazarea et al. 1999) and cultural landscapes (Stoffle et al. 1997) is an important issue (Johnson and Vande Kamp 1996). To the extent that dam operations affect river travel times and camping beach size, they also indirectly affect the number and duration of stops commercial river trips make at archaeological attraction sites, and camps near these sites. If camping beaches become unusable due to erosion and/or vegetation encroachment, river trips may begin to utilize previously unvisited areas. In these ways, dam-related variables that affect the spatial distribution of river trips may also impact cultural resources (Leap et al. 1999).

In addition, development of the Lees Ferry rainbow trout fishery has attracted many thousands of anglers annually to the reach of Glen Canyon immediately below the dam. These anglers often stop for lunch and to camp at sites adjacent to the river that were similarly attractive to prehistoric inhabitants of the area. Changes in river stage level and attendant effects on beach size affect angler access to archaeological sites, which in turn

may result in impacts to cultural resources in this reach (Leap et al. 1999). Thus, activities of both river runners and anglers may necessitate assessment of impacts to cultural resources that arise from patterns of recreational use that develop in relation to dam operations.

The Programmatic Agreement directs federal agencies to cooperate with Native American tribes in monitoring and mitigation of impacts to federally listed Traditional Cultural Properties within GCNP and GCNRA, and is administered in the Colorado River ecosystem by the NPS River Corridor Monitoring Program. Additional cultural resource concerns associated with GCD operations are overseen by the parallel GCMRC Sociocultural Program. Assessment of impacts to cultural resources resulting from recreation use may fall within the purview of the NPS River Corridor Monitoring Program, the GCMRC Sociocultural Program, or both. The intent here is simply to note important connections between river-based recreation, cultural resource monitoring and preservation, and dam operations.

Recreation and hydropower resources

The popularity of river running in Grand Canyon (and the success of the industry which supports it) is not solely the result of nationwide growth in this type of recreation. Colorado River trips would likely be popular in any event, but control of river flows by GCD has facilitated a stable and thriving outfitting industry. Prior to the dam's completion, river flow volume varied greatly from year to year, and from season to season. Spring runoff could produce flows in excess of 100,000 cubic feet per second; by fall water levels were often less than 3000 cfs (Carothers and Brown 1991). Monsoon rainstorms could cause the river to rise 15 or 20 feet in a matter of hours. Control of extreme and erratic flows (the norm prior to construction of GCD) has resulted in less complicated, more predictable, and arguably safer conditions for river runners.

GCD operations affect the Colorado River's famous rapids by making them relatively more or less dangerous, and more or less exciting, depending on water level (Jalbert 1992, Bishop et al. 1987, Brown and Hahn 1987). Flows in the range of 10,000 to 17,000 cfs appear to be the safest, with the chance of hitting rocks decreasing as flow increases. The risk of accidents varies with type of boat. At very low flows (<5000 cfs) motor rigs

have the highest incident of accidents; at very high flows (>30,000 cfs) smaller boats have more accidents. Larger rowboats have the lowest incidence of accidents over the range of flows (Brown and Hahn 1987, Jalbert 1992, USDOI Bureau of Reclamation 1995a). Slow current associated with low flows adds to river travel time, resulting in fewer and shorter duration stops at attraction sites (Underhill and Borkan 1986, Bishop et al. 1987).

GCD has been a factor in shaping the river running industry by ensuring (generally) that the river doesn't interfere with scheduling of trip launches by being dangerously high or unrunnably low. Flows now rarely exceed 25,000 cfs or drop below 5000 cfs, except for Beach/Habitat Building Flows (BHBFs), and stay within this range year round, so dam control has also lengthened the season in which the river can be dependably run. This has benefited commercial outfitters; commercial enterprises usually do better in a stable environment, and Colorado River trip outfitters are no exception.

The effects of the dam on the actual river visitor experience are less clear. Little is known of pre-dam river recreation, other than it existed in viable form (Lavender 1985), so comparisons can only be speculative. It seems likely that the demographic range of commercial and private river visitors has been expanded due to greater predictability and perceived safety of dam controlled flows. That said, national park visitor experiences cannot and should not be all things to all people (Sax 1980). Prior to the dam, outfitters utilized different sized watercraft (depending on river conditions) that made high or low water river trips practical, and to this day many recreationists prefer to experience wildlands in an uncontrolled state. This is the definition of a wilderness experience, an NPS management objective for the river (USDOI National Park Service 1995). Similarly, clear water released from the dam undoubtedly affects river visitors, but it is unclear whether overall effects are positive or negative. River runners may favor clear water over muddy in a narrow aesthetic sense (all other things being equal) but in a larger sense prefer to encounter an uncontrolled, i.e. “natural” river rather than a dam-controlled one, muddy or not.

The change from a warm and muddy to a cold and clear water ecosystem has unequivocally benefited trout anglers, as the trout fishery simply wouldn’t exist without GCD. Soon after the dam’s completion, the river was stocked by the Arizona Game and

Fish Department (AGFD) with thousands of rainbow trout, which thrived in the cold, clear water. By the early 1970's, trout as large as fifteen pounds had been caught in the Lees Ferry reach, and 40-pound bag limits of ten fish range were not uncommon. The Lees Ferry fishery declined after the late 1970's due to increasing fishing pressure, variable rates of fish stocking and fluctuations in GCD water releases, though it recovered somewhat after 1992, and will most likely be sustainable under current flow regimes (McKinney and Persons 1999).

Fishing is currently very good by most standards. The AGFD has stated a management objective to provide a blue-ribbon fishery in this reach, and has limited the harvest of fish by implementing low daily bag limits, size limits and fishing gear restrictions. Angler use of the fishery (measured by angler hours/year) peaked in the early 1980's, declined for several years in response to poorer fishing (measured by fish/hour/angler) but was rising again by mid 1990's. This turnaround in fishing quality is probably due to establishment of a self sustaining "wild trout" fishery with the advent of the Modified Low Fluctuating Flow (MLFF) regime (McKinney and Persons 1999; Cohen 1999). Wild trout fisheries are more highly valued by anglers than fisheries sustained through stocking of hatchery fish (Cohen 1999).

Other recreation activities and attendant experiences, such as backpacking, waterfowl hunting, trout fishing accessed below Lees Ferry, and river trips operated by the Hualapai Nation have probably also been influenced by the dam, but little is known about these effects.

GCD is operated as a peaking power facility, in which power production is increased and decreased rapidly in accordance with times of peak power demand. Peaking power is usually needed during the summer months, when on some days Phoenix, Arizona may use twice as much Glen Canyon hydropower as Colorado and Utah combined. Prior to the passage of the GCPA, peaking power releases from the dam fluctuated from as low as 3000 to as high as 31,500 cfs and back to the previous low in a 24-hour period. Patterns of large diurnal fluctuations were followed for many weeks or months, during which time the river would rise and then drop 10 or more vertical feet daily 5 or 6 days per week. A peak flow takes more than 48 hours to reach Diamond Creek, 240 miles below the dam, so daily "high tides" reached groups camped along the river at all times of day or night,

depending on their distance from the dam. Rapid flow decreases, or downramp rates exacerbate beach erosion and cause considerable problems for raft trips in the form of stranded boats, exposed rocks at rapids, and extra hours spent on the river and missed attraction sites because of low flows (USDOI Bureau of Reclamation 1995a). Operation of GCD also affects the Lees Ferry rainbow trout fishery. Prior to passage of the GCPA, peaking power flow regimes hindered anglers' access to preferred fishing sites and their ability to safely wade in the river (Lee and Grover 1992). Large water fluctuations also cause considerable trout mortality by stranding them in pools where they die of overheating.

The number of kilowatts produced from a given volume of water varies with changes in elevation difference between the surface of Lake Powell and the river at the foot of the dam (hydraulic "head"). Income derived per unit of this hydropower is very sensitive to the time of day or week power is delivered, and also the season. Conversely, the amount of hydraulic head available for hydropower production at any given time is largely unrelated to diurnal variation in volume of water released. Hydraulic head is a function of complex interactions between annual runoff, monthly release schedules and downstream water commitments. In short, modifications of water release patterns at GCD to meet adaptive management goals affect hydropower *revenue* to a greater degree than they affect hydropower *production*.

Attenuation of flow ramping rates and the magnitude of fluctuations between high and low flows, instituted on an interim basis with the GCPA in 1992 and codified (with some modifications) by the ROD in 1996, have resulted in a reduction in fluctuation-related impacts on the river running experience. McKinney and Persons (1999) conclude that attenuation of fluctuations under the MLFF alternative has also benefited the trout fishery by mitigating the negative impacts of extended low flows on available habitat, foodbase and spawning areas. The NRC has recommended that the AMP generate information regarding the value of improved conditions such as these for comparison with impacts on hydropower revenue (NRC 1999). Attenuation of peaking power releases beyond that already prescribed by the ROD (if needed) would have additional negative impacts on peaking power income, which would need to be weighed against the benefits of such actions.

Recreation and economic resources

The national, regional and local market economic benefits of recreation are well documented (e.g. Driver and Brown 1983, Walsh 1990), as are the contributions of expenditures by anglers and whitewater rafters to job creation and gross business revenues (Cordell 1990). Bishop et al. (1987) have confirmed the magnitude of economic benefits in the Colorado River ecosystem, although the EIS specifically acknowledges that their estimates represented a "snapshot in time", and are thus now well out of date.

Commercial passengers pay an average of $215 per day for the services of one of 17 NPS authorized river outfitting concessionaires, the largest of which have permits to use more than 14,000 user days annually. In 1998, according to the Grand Canyon Commercial River Outfitters Association, there were 479 motorized and 170 non-motorized trip launches from Lees Ferry; a total of 649 commercial trips that served 19, 383 passengers. This activity produced a direct gross income for commercial outfitters of around $25 million (Grisham 1999). No up to date estimates are available for employment effects and secondary spending in the region by commercial river visitors and businesses that serve them, or of the economic impact of private river trips.

In 1991 (the most recent year for which actual data is available for all recreation resources) direct expenditures by anglers, and commercial and private rafters below the dam totaled $14,452,000. Since these locally dispensed dollars are often then respent in the area, it was calculated that direct expenditures generated an additional $23,115,000 in local economic activity (multiplier effects based on estimators generated by Bishop et al. 1987; figures quoted from USDOI Bureau of Reclamation 1995a). Douglas and Harpman (1995) estimate expenditures by day-use rafters, anglers, and commercial and private whitewater rafters at over $29 million in 1990 dollars, and that these activities generated nearly 600 jobs in the region.

Money spent on fishing related guide services, lodging, food, tackle and other incidentals in the Lees Ferry area has been recently estimated at around $3 million annually, not including transportation costs or multiplier effects of money respent in the region by guiding businesses (Gunn 1999). In 1991, the Hualapai owned and operated business Hualapai River Runners generated 33% of the tribe's total income, including

fees for river trip shuttle services, tows across Lake Mead and use of the Diamond Creek access road for river trip takeouts (USDOI Bureau of Reclamation 1995a). More recent estimates for direct income, and for multiplier effects of secondary spending by clientele for these trips in the economically depressed town of Peach Springs, are not available.

Bergstrom and Loomis (1999) state that "the overall goal of economic valuation of ecosystem management is to measure the *total economic value* of natural resources affected by management actions" including values for which no market data is available (p. 184, italics in original). The EIS addressed the issue of non-use, or existence values, acknowledging that the CRE holds value for people who may not physically utilize resources there. Non-use value constitutes substantial economic value for CRE resources (Welsh et al. 1995). Although option value (such as the option to partake in a future Colorado River trip) was cited by the EIS as component of non-use value, this is not unequivocally accepted by economists. The term non-use value arose to acknowledge that a resource does not have to be physically used to be valued, and was seen as particularly applicable to unique or special resources, such as the CRE. More recently, total economic value has been recast as consisting of two categories, active use value and passive use value (Bergstrom and Loomis 1999). For example, former river visitors who may not visit again but still care about preserving river recreation opportunities for others likely hold substantial passive use values for recreation resources in the CRE.

Contingent valuation (CV) methods used to generate monetary estimates for this type of value are now well established in the economics literature (e.g. Arrow et al. 1993, Loomis 1987a,b, Loomis 1996) and are seen as critical to generating estimates of nonmarket values in ecosystem assessments (Bergstrom and Loomis 1999). Carson et al. (1996) evaluated CV in relation to more conventional revealed preference (RP) techniques by analyzing 616 direct comparisons of CV to RP estimates, and found that, overall, CV estimates were slightly smaller than their RP counterparts. They conclude that although some CV estimates exceed RP estimates of the same value, arbitrarily discounting CV estimates as some critics have suggested, is unwarranted. The NRC notes that substantial progress has been made in recent years towards refining techniques for generating monetary estimates for environmental goods, such as improved ecological conditions or better recreation opportunities (NRC 1999).

Economic valuation of all resources is stipulated by the GCPA; but the NRC (1996, 1999) concludes that this important area has been neglected by the GCMRC. Integrated resource assessments encompassing human dimensions of ecosystems should include economic analysis of recreation and other socioeconomic resources (Lessard et al. 1999), including direct spending, multiplier effects and nonmarket social benefits associated with recreation, as noted by the NRC (1999). The GCMRC Draft Strategic Plan recognizes this need in stating that "a proposed [Cost/Benefit Analysis or CBA] model should accommodate evaluation of all associated market and nonmarket costs and benefits, including intrinsic and existence values of key resources" (GCMRC 1998, p. 106).

Glen Canyon Dam is operated as a peaking power facility. This is optimum from a market economic efficiency standpoint because hydropower plants can respond to daily peaks in power demand more easily than coal-fired or nuclear plants, and also because this peak demand power is sold at a premium. Sales of GCD hydropower are administered by the Western Area Power Administration (WAPA), established by the Department of Energy Organization Act. WAPA markets and transmits Federal electric power to wholesale preference customers including rural electric cooperatives, municipalities, public utilities, Federal and state agencies, irrigation districts and Bureau of Reclamation projects and facilities. This involves the operation and maintenance of nearly 17,000 miles of transmission lines and 260 substations to deliver power from more than 50 Bureau of Reclamation, U.S. Boundary Water Commission and U.S. Army Corps. of Engineer hydroelectric plants, including GCD. Hydropower sales are required by law to recover marketing, operating, maintenance and purchase power expenses and repay the government's investment in building generation and transmission facilities within 50 years. Colorado River legislation of 1956 and 1968 requires that Glen Canyon hydropower revenue must contribute to the support of other CRSP projects. Thus rates must be set to cover other costs Congress has assigned to power users, such as irrigation costs in excess of water users ability to repay and interest expenses on the unpaid balance of power-related principal (United States Department of Energy, Western Area Power Administration 1991).

Income from the sale of Glen Canyon hydropower is currently about $80 million per year. Though the dam has paid for itself several times over, it is tied to nearly four billion dollars in other Colorado River Storage Project (CRSP) financial responsibilities (Moore 1998) mainly upstream diversion, salinity and irrigation projects which could not survive financially without support from the Glen Canyon Dam "cash register". Current repayment obligations on these projects extend through the year 2080 (USDOI Bureau of Reclamation 1995b). The result is resistance to any limitation on WAPA's ability to generate peaking power from those who are asked to make up shortfalls in revenue by paying higher rates. Beneficiaries of the sale of Glen Canyon hydropower are represented by the Colorado River Energy Distributors Association (CREDA), which lobbies WAPA for the lowest possible rates on hydropower. Changes in dam operations to improve biophysical conditions on which river recreation depends have resulted in impacts on hydropower revenue. The value to river recreationists of these improved biophysical conditions is unknown.

Wildland recreation as experiences and benefits

Beginning in the early 1970's it was recognized that recreation events are not merely activities and the settings in which they occur but, as Driver and Tocher (1970) put it, "experiences resulting from recreational engagement[s]". Following this paradigm shift, research (e.g. Clark and Stankey 1979, Knopf 1983, Driver et al. 1987) focused on defining and managing recreation resources as experience opportunities. This conceptualization undergirds most research in the profession and has led to wide-spread adoption of a management approach known as the Recreation Opportunity Spectrum (ROS). The ROS is a hierarchical conceptual framework for classifying, managing and encouraging diversity in outdoor recreation opportunities (Manning 1999). It is grounded on the assumption that recreation consists of three basic components: activities, settings and experiences. Because combinations of activities and settings vary along a spectrum, so too will the realization of recreation experiences (Driver et al. 1987). The ROS incorporates behavioral definitions of user preferences and desired psychological outcomes, setting characteristics, and managerial factors into a hierarchy of six broad types of recreation experience opportunities ranging from pristine to rural. The NPS is

applying a variant of the ROS concept to manage for a spectrum of river experiences that varies across different seasons (USDOI National Park Service 1998a).

The experiential paradigm on which the ROS is based has evolved to include benefits that accrue to humans as a result of recreation experiences (Driver and Peterson 1986, Driver et al. 1991.) Humans engage in wildland recreation for instrumental purposes of realizing specific expected benefits (see Parsons et al. 1993) but many experiences also have an emergent quality, benefiting recreationists in unforeseen ways that may be more important determinants of satisfaction than predetermined expectations (Williams and Patterson 1999). This is especially true for longer and highly novel recreation experiences like Colorado River trips (Arnould and Price 1993). The relative influence of genetic, cultural, biophysical, psychological and socioeconomic factors on recreation experiences and benefits is the subject of current academic discussion (see Williams and Patterson 1996) but no one working in the field today seriously maintains that recreation resources consist solely of physical settings.

Benefits-Based Management (BBM; in Canada known as Benefits Driven Management or BDM) focuses on identifying specific psychological and physiological benefits that people accrue during and as a result of outdoor leisure activities, and the circumstances associated with these benefits (Driver et al. 1991, Bruns et al. 1994, Manfredo et al. 1996). BBM is essentially an extension of experienced-based management to address a wider range of positive outcomes, including those that occur offsite (Driver 1996, Lee and Driver 1999). In this sense, benefits are defined specifically as the "realization of desired and satisfying on-site psychological experiences; changes that are viewed to be advantageous or improvements in condition (psychological and physiological) to individuals, to groups, to society, or even to another entity such as an endangered species; and...the prevention of worse conditions." (Bruns et al. 1994.)

Improved environmental awareness, better physical health, reduced stress and depression, strengthened social bonds, relationships with nature, spiritual growth, and achievement are some of the many benefits that have been linked with wildland recreation activities by progressively more reliable and valid typologies that address virtually all positive outcomes resulting from wildland recreation activities (e.g. Driver

and Brown 1986; Driver et al. 1991; Bruns et al. 1994). Surveying and subsequent monitoring of benefits has been suggested as important management tools for outdoor recreation areas (Driver 1996). BBM also fits conceptually with the ROS, defined recently as "…a framework for understanding and interactions between benefits and settings" (USDA Forest Service 1997a, p. 30). BBM has been integrated with the ROS in the Sedona District of Coconino National Forest (USDA Forest Service 1997a,b) and implemented on several other public wildlands (Bruns et al. 1994).

Evidence for physiological benefits such as stress reduction and improved physical health (Ulrich et al. 1990; Brown 1991; Paffenburger et al. 1991; Ulrich et al. 1991) is perhaps the most empirically compelling as it is derived from heart rate and other quantifiable indicators. Specific physiological mechanisms for the stress-reducing effects of exposure to natural environments have been proposed by Parsons (1991), who attempts to ground Ulrich's (1983) work on preference for natural environments in models of subcortical affective processing and neuro-endocrine responses, which he feels offer tentative support for two types of affect (mood) initiation systems.

Though more difficult to quantify, an array of positive psychological experiences and attendant benefits has also been identified in studies conducted over the past fifteen years that encompass a variety of activities and settings. For example, recreation facilitates learning benefits (Roggenbuck, et al. 1990) and is positively related to family satisfaction, interaction and stability (Orthner and Mancini 1990). The linkage between on-site benefits and those that occur offsite and at a later time has been termed the benefit *chain of causality* (Lee 1995.)

Learning about rivers, geology, and ecology were cited in Shelby's (1976) work as personal benefits strongly associated with satisfaction. Recreation in the Colorado River ecosystem results in positive environmental impacts (benefits) as well as negative ones, although causal linkages between recreation and environmental benefits are harder to make than with negative impacts. Improving ecological literacy has been cited as critical to the success of ecosystem management (Cartwright and Burns 1994), learning of this type on river trips can lead tangentially to other benefits, both individual and societal. Real-time lived experiences in natural environments are critical to environmental learning for people of all ages (Finger 1994, Kellert 1996) and thus have indirect, but very real,

environmental benefits. Learning benefits that accrue to river visitors (c.f. Roggenbuck, Loomis and Dagostino 1990) can increase environmental awareness (Driver and Brown 1983), concern for river ecosystem management, protection of native species (Rolston 1991) and interest in preserving cultural resources.

Similarly, evidence suggests people who take a whitewater rafting trips experience reductions in stress and improved physical fitness, which can lead to better long-term health, family relations, work productivity and economic stability. Psychologists have belatedly begun to note how the pace of industrial civilization and balancing work and family gives rise to mental stress; at the same time sedentary lifestyles and the dominance of white collar desk jobs in the modern workplace have led to record levels of health problems related to poor physical conditioning. Natural environments appear to possess intrinsic healing and mental restoration capacities (Kaplan 1995, Kaplan and Kaplan 1989, Ulrich 1993). As Roszak (1996) notes, "when highly stressed people are asked to visualize a soothing scene, nobody imagines a freeway or a shopping mall. Rather images of wilderness, forest, seascape and starry skies invariably emerge".

The scale and variety of a trip down the Colorado River results in a multi-phase experience described by turns as relaxing, exciting, challenging, awe-inspiring, invigorating, and spiritually and psychologically renewing. Such trips offer the longest immersion in a natural setting that most visitors will ever experience, unparalleled opportunities for wilderness adventure, introspection and solitude that are increasingly rare in modern life. Colorado River trips afford unique opportunities for virtually every type of benefit associated with wildland recreation, but these benefits and their value to individuals, social groups and society remain largely unaccounted for in the AMP process. The Recreation Opportunity Spectrum and Benefits Based Management frameworks offer a unified conceptual orientation for putting the social benefits of river recreation (cited by the NRC as necessary to account for) in a specific, contextual and empirically grounded context.

Crowding and social carrying capacity

Among the many factors that can affect the motivations, experiences, benefits and satisfaction of recreationists, perhaps the most frequently studied is crowding. Originally

it was assumed that increases in density equal increases in crowding, but Shelby et al. (1989) conclude that most available evidence indicates this is overly simplistic. Density and crowding are now understood as separate constructs. Density is a numerical *description* of the actual number of people per unit area, and is thus objectively neither good or bad. Crowding, on the other hand, is explicitly defined as a negative *evaluation* of a particular level of density.

Schneider and Hammitt (1995) submit three possible responses to recreation crowding: product shift, rationalization, and displacement. Product shift occurs when visitors change their definition of the experience; rationalization involves cognitive reevaluation of crowding in a more positive direction (most common in high expenditure activities, e.g. Colorado River trips). Displacement is empirically supported more often than product shift or rationalization and occurs when "...users leave the site due to an unacceptable change in social, managerial or resource conditions" (Schneider and Hammitt 1995).

Shelby and others' work (e.g. Shelby 1976, Shelby and Heberlein 1986), in which a 9-point crowding scale ("not at all crowded" to "extremely crowded") was used to establish crowding norms, has furthered understanding of this challenging issue. However, Graefe et al. (1984) conclude that use density alone is a rather weak predictor of perceived crowding; visitor expectations, preferences, prior experience and commitment to the activity, and situational influences (e.g. the coping behaviors identified by Schneider and Hammitt [1995]) are also important variables. Dawson and Watson (1996) and Whisman and Hollenhorst (1996) also note the lack of empirical support for a strong relationship between density and perceived crowding, despite an abundance of studies on the issue over a 20-year period.

Notwithstanding the complexity of density/crowding relationships, use level is a practical, easily measured and to some extent manageable indicator of recreation quality, particularly at sites where activity types are relatively homogeneous. Moreover, density and crowding are related to the concept of *social carrying capacity*, an idea borrowed from the biological sciences and expanded to include (in addition to physical constraints) the psychological dimension of perceived crowding. As Manning et al. (1995) note, despite some theoretical difficulties with the concept, social carrying capacity and its

application in the Limits of Acceptable Change (LAC) framework are now entrenched within land management agencies, making abandonment of it problematic from a practical standpoint.

With good reason, much research on recreation in the Colorado River ecosystem has focused on the relationship between social carrying capacity and camping beaches in the River Corridor. Nearly 25 years ago, Borden (1976) identified camping beaches in critical reaches of the river (i.e. Supai Gorge, Upper Granite Gorge, Muav Gorge) as the factor that limited social carrying capacity for river trips. A substantial number of studies since that time have focused on beaches in the context of recreation (Brian and Thomas 1984, Philips et al. 1986, Kearsley and Warren 1993, Kearsley 1994, Kearsley 1995, Kearsley et al. 1999, O'Brien et al. 1999) and more general efforts to assess and monitor the sediment budget in the River Corridor (e.g. Hazel et al. 1993, Kaplinski et al. 1995).

Prior studies of Colorado River recreation:

The first scientific assessment of attitudes and perceptions of Colorado River recreationists was Dr. Bo Shelby's work, completed in 1976 (Shelby 1976a,b,c,d). Data were gathered through observations, as well as written and oral surveys of river runners on commercial and private trips during the 1974 and 1975 seasons. Visitors were surveyed at the end of their trips by ride-along observers who accompanied them the entire way. The theoretical basis of Shelby's work was the crowding model of user satisfaction, which holds that perceived crowding is the major variable affecting visitor satisfaction in wilderness and wilderness-type settings.

Among Shelby's findings were:

> -Around 90% of river travelers define their trip as a wilderness experience.
>
> -Perceptions of crowding were unrelated to contacts with other groups, and did not correlate well with visitors' overall satisfaction with their trip. (This unexpected finding was explained by the fact that 90% of river travelers were first time visitors, and 49% had been on no other river trips of any kind. Thus, most people had no pre-existing norm about encounters, and didn't have a frame of reference to decide what was appropriate.)
>
> -Variables *positively* related to visitor satisfaction: learning (about geology, rivers, ecology, and nature in general); quality group experiences; friendly, interesting and accessible guides; clear understanding of passenger roles; "being in

> wilderness" as a primary motivation for taking the trip; and perception of the trip as "leisurely".
>
> -Variables *negatively* related to visitor satisfaction: perception of the trip as "noisy"; perception of use impact as "high"; perception of the weather as "bad"; and preference for more conveniences and facilities. (Shelby 1976c.)

Bordon (1976) conducted a study resulting in a definition of human carrying capacity for the Colorado River. As Shelby (1976c) points out, the concept of carrying capacity is problematic when defined as the point at which aggregate satisfaction declines. With increasing use, under this definition, visitors who desire a wilderness-type experience are simply displaced by greater numbers of visitors who are less discriminating. Aggregate satisfaction continues to rise (because of growing numbers of visitors) and carrying capacity, defined this way, is never reached.

Bordon addressed this problem by proceeding from a specific policy statement about what kind of experience was to be provided for, and by considering constraints within which carrying capacity would be defined. The degree of "uniqueness" of each of five river trip dimensions (visual, aural, adventure, sociological, and wilderness) was considered, and a consolidated evaluation of them given: "it is not any one dimension alone that accounts for the uniqueness of the over-all river running activity. [Rather] it is the combination of such high, simultaneously attainable levels of the visual, aural, adventure and wilderness dimensions that make Grand Canyon river running truly unique" (Bordon 1976). (The most recent guidelines available for what type of river running experience will be managed for are listed under the heading for NPS General Management Plan and Colorado River Management Plan in Chapter 1.)

Campsite size and availability in critical sections of the River Corridor were found to be the limiting parameters of carrying capacity, within the constraints of the type of experience the NPS sought to provide. Bordon recommended limiting departures from Lees Ferry to a total of 148 people (three groups of 40, one group of 20 and one group of eight) and prescheduling camps in critical reaches. Currently, 166 people are allowed to launch daily during the primary seasons, and two trips per day during the secondary season (USDOI National Park Service 1989). Campsite prescheduling in critical reaches has not been implemented.

As noted previously, water release schedules and other factors related to GCD operations have considerable influences on the ecology and morphology of the river corridor, which in turn substantially affect the river visitor experience. In a study conducted as part of the Bureau of Reclamation's Glen Canyon Environmental Studies, Bishop et al. (1987) assessed the impact of Glen Canyon Dam water releases on river runners in Grand Canyon National Park using attribute and mail-back contingent valuation surveys. (No onriver surveys of visitor attitudes and perceptions were employed.) Initially, attributes of recreational "quality" were identified through a survey of whitewater guides and private river trip leaders. Among the attributes mentioned by at least 15% of all (288) respondents were:

-time for layovers and stops at attraction sites

-good/exciting rapids

-a wilderness experience

-not feeling crowded

In the second phase of their study, Bishop et al. (1987) administered a contingent valuation survey to 532 commercial and private river trip passengers, who were asked what they would be willing to pay for each of a range of different water release patterns. (A good overview of the contingent valuation method, CV or CVM for short, is Mitchell and Carson 1991.) Responses indicated that trip quality was the highest at 25-30,000 cubic feet per second, and fell off steeply above and below that level.

Current studies of river recreation

Interest in obtaining more current information on aspects of river recreation has risen lately, and three studies are now in progress. Of the three social science/recreation projects now underway on the river, only one is making systematic contact with visitors during their experience in the Canyon. This project, supported by the Grand Canyon Association and conducted by Dr. Troy Hall of the University of Vermont, is duplicating and updating Shelby's work during the 1970's. As with Shelby's work, data is gathered by observers who ride along on river trips and administer questionnaires to passengers on the last night of the trip concerning crowding levels, and factors that added to, or detracted from their experience and perceptions of wilderness. Of 48 trips sampled, 9

were private, 39 were commercial, 22 were motorized and 17 were oar-powered. Eleven-page written surveys were completed on the last night of the trip by 465 commercial motor passengers, 449 commercial oar passengers, 112 private boaters, and 99 commercial guides.

Preliminary data from this study (Hall 1999) indicate several trends. Mean annual income for commercial passengers was over 3 times the U.S. national average, suggesting that high trip cost (a function of strong demand and limited supply) restricts commercial passengers to a fairly affluent subset of the general public. Private boaters' mean annual income was only slightly higher than the national average.

Motivations for taking Colorado River trips rated as "very important" by a majority of respondents were seeing the canyon from the river, the excitement of river running, being in the wilderness, and being with family and friends. Around 90% of respondents rated the trip as either "excellent" or "perfect". It is important to note here that while high percentages of satisfied river runners may suggest that conditions of biophysical aspects of recreation resources are not of immediate concern, this isn't necessarily true. The question did not directly address biophysical conditions, and in any case about 80% of commercial passengers had never been on the river before, and thus had no frame of reference with which to make a judgement (see Shelby 1976c). People may modify their expectations and preferences as a means of reducing the negative effects of perceived crowding (Shelby et al. 1983, Schneider and Hammitt 1995). In other words, high levels of apparently satisfied first time visitors tell us nothing about how the river experience has changed through time as camps and campable beach area have decreased. As Peine et al. (1999) point out, people interviewed onsite tend to be clearly tolerant of the conditions at hand, while displaced visitors and their perceptions are not easily identified.

Furthermore, recreation satisfaction is an extremely complicated issue, only a portion of which is related to biophysical settings, making uniformly high levels of overall satisfaction limited in usefulness to researchers exploring relationships between recreation opportunities and experiences (Manning 1999). Finally, if biophysical conditions deteriorate beyond limits of acceptable change, managers may be forced to limit or reduce visitation (Cole and Stankey 1997). In these cases, individual satisfaction may remain very high but fewer people are able to engage in satisfying experiences. This

important issue is related to recreational, or social carrying capacity, discussed previously.

Another study currently in progress is being funded by the National Science Foundation and undertaken by a team from the University of Arizona and Northern Arizona University. This project is utilizing data concerning a number of different variables to develop "intelligent agents" that will simulate the behavior of various types of river trips in a computer model. Information gathered from river runners such as launch schedules, time spent at camps, attraction sites and in transit on the river is being used in conjunction with data on river flow speed and other biophysical factors. The purpose of the model is to optimize launch schedules for trips of different lengths and behavior patterns, so that contacts between river parties and conflicts over camps are minimized.

A third study, funded by the GCMRC, has three objectives: (1) determine attitudes and preferences of current users toward recreation opportunities and setting attributes as they relate to river flows; (2) evaluate changing attitudes and preferences of users; and (3) compare and contrast user attitudes and preferences to stakeholder objectives. Investigation of the effects of river flow level on recreation experiences is being conducted through the use of mailback surveys with computer manipulated, photorealistic images portraying a range of variation in selected recreation setting attributes (e.g. beach quality) that are potentially affected by dam operations.

Finally, the GCMRC is also supporting an extension of current sandbar monitoring efforts to include surveys and monitoring of a sample of camps in critical and non-critical reaches of the river corridor. This effort is part of a greater emphasis on integrating existing knowledge (e.g. O'Brien et al. 1999, Kearsley 1994, 1995, Kearsley et al. 1999) with more rigorous campsite monitoring.

CHAPTER 3

RECREATION AND THE COLORADO RIVER ADAPTIVE MANAGEMENT PROGRAM

The current GCMRC Strategic Plan does not address the facts that many parameters of river recreational experiences (and by extension how they are affected by dam operations) remain poorly understood, and that as a consequence the GCMRC lacks a clear definition of what constitutes the recreation resources it is charged with monitoring. Therefore, the purpose of this chapter is to provide an overview of ways the recreation component of the AMP can be strengthened. The problem of accurately characterizing recreation resources within an ecosystem management paradigm is addressed. It is argued that social science has been underutilized within the AMP and should be accorded a more prominent role. A more explicit, scientifically grounded definition of recreation resources is offered. Suggestions for a more unified and focused treatment of recreation in the GCMRC Strategic Plan are made, along with recommendations for additional Management Objectives, Information Needs, and future research. Finally it is suggested that more explicit characterization of normative assumptions, and valuation of social benefits associated with various resources is important to the AMP.

The role of social science in the Adaptive Management Program

The GCMRC is guided by an adaptive ecosystem management approach, which stresses broad-scale and hierarchical integration of ecological, social and cultural factors, and is characterized by an iterative process of research, incremental policy change, and monitoring. Ecosystem management emphasizes the need to conceptualize and define resource associations holistically, but without good working definitions and understanding of what each "resource" area encompasses, and utilization of best available social science knowledge and research techniques, determining the effects of GCD operations on "…the values for which GCNP was established" will be problematic.

Presumptions that ecosystem management science will be handled by ecologists while social considerations are relegated to the managerial or political domains are pervasive in the ecosystem management field. In most cases, "…the role of social science per se is not to study humans as interacting elements of ecosystems (having both positive and

negative effects, with ecosystems providing essential commodities or experiences for humans) but simply as deterrents to natural processes. Instead of systematically analyzing the interaction of humans in ecosystems, the social component enters the decision process only haphazardly (i.e. unscientifically) in the political arena after the biophysical or 'scientific' data are collected" (Endter-Wada et al. 1998, p. 893). Underappreciation of social science knowledge and methods appears to be a general trend; this synopsis unfortunately parallels (with rare exceptions) the approach the AMP has taken with regard to socioeconomic resources (National Research Council 1999, p. 82-85).

For example, the Assistant Secretary of Water and Science Guidelines state that the mission of the GCMRC includes "…[evaluation of] ecosystem resource impacts and changes resulting from alternative dam operating criteria to aquatic, terrestrial and cultural resources…" and that "science is clearly a powerful mechanism to learn about natur[al] processes…". The guidelines unfortunately fail to note that science can also tell us much about social processes, both those concerning variables that affect recreation experiences, and economic valuation of socioeconomic resources. This oversight may be due to an implicit assumption that recreation resources begin and end with biophysical elements of ecosystems, and will thus automatically be encompassed by research and monitoring of biological, physical and cultural resources. (This does not explain, however, why the guidelines make no mention of economic analysis, often viewed as the most developed of the social sciences. Economic considerations form part of the social component of recreation, just as they form part of the social component of other resources. Rigorous market and nonmarket economic research and valuations will be indispensable to the AMP in order to meet directives for benefit/cost analyses called for the in the GCPA.)

The guidelines also state that "all new [GCMRC] research programs will adopt ecosystem science approaches, which will require integrated resource science assessments across space and time." Ecosystems include humans, and nonconsumptive recreational use of the Colorado River ecosystem by humans is a significant component of the resources the AMP and GCMRC are charged with evaluating. By established definitions of the term, an "integrated resource assessment" must include the human

dimensions of Colorado River ecosystem resources (e.g., Boyden 1993, Christensen et al. 1996, Cordell and Bergstrom 1999, Kaufmann et al. 1994, Salwasser and Pfister 1993).

A concerted effort to integrate social science research into the AMP is critical in order to include the world-class recreation and other socioeconomic resources of the Colorado River ecosystem within a realistic vision for managing it. One important role of social science within the AMP is to provide rigorous market and nonmarket economic analysis to evaluate costs and benefits to resource users (stakeholders) under different dam management scenarios. As the NRC (1999) notes, there is a large and growing body of literature on environmental economics that the AMP has not yet availed itself of. Social science in the form of onriver and post hoc investigations, using established recreation research techniques, also has a key role to play in generating specific information for recreation resources. A proposed definition for these resources, and ways that social science can better delineate and support it, are discussed in the next section.

The problem of defining recreation resources

As explained in Chapter 1, language in the GCPA, EIS and ROD leaves no doubt that "visitor use", "recreation" and "recreation resources" are included among affected downstream resources under the purview of the AMP, and that these resources are commensurate in importance with physical, biological and cultural resources. However, the holistic nature of ecosystem processes and related human activities can make it difficult to differentiate and define various ecosystem and resource components in the Colorado River ecosystem into manageable science program areas.

This is especially true for socioeconomic resources, in which non-human biophysical ecosystem considerations interface with human ecology and culture. The AMP lacks clear definitions of the recreation resources it is charged with attending to, and a certain degree of variability and vagueness is thus apparent as one tracks the way recreation is addressed through pertinent AMP legal documents, directives and reviews. Dam-affected recreation resources are frequently (though implicitly) construed as merely the biophysical substrate on which recreation occurs, namely rapids, river flow speed, stage changes, and especially camping beaches. This characterization, though partially correct, is incomplete. Research literature is clear on the fact that recreation also includes a

variety of social and experiential factors, and has demonstrated the utility of a range of methods for addressing them (see, for example, Manning 1999, Williams and Patterson 1999).

Treatment of recreation in the GCMRC Draft Strategic Plan is a good example of the difficulty of categorizing these resources. The plan explains that the sociocultural resources program "…incorporates the cultural resources program and the socioeconomic program (recreation and economic issues) into one resource program area". The background, status of knowledge, management objectives and information needs for the sociocultural program are then addressed in separate sections for cultural resources, recreational resources, and economic market activities. Separate presentation of them in the plan implies that recreation resources and economic market activities are independent concerns. This is curious, because recreation in the Colorado River ecosystem is unquestionably related to substantial market activities, as was clearly demonstrated by research conducted for the EIS (Bishop et al. 1987). Moreover, this distinction is inconsistent with language in the plan's more detailed discussion of recreational resources, which acknowledges that visitor use of the river corridor *does* have economic importance through direct employment and multiplier effects in the region.

Given that recreation on the river has substantial biophysical *and* social components, placing it in separate category could potentially have merit, but such a multidisciplinary approach is only hinted at. The Draft Strategic Plan should either (1) explain the way recreation resources have been categorized separately by clearly outlining their multidisciplinary nature, or (2) return to the format of previous documents, where recreation and hydropower are treated as subcategories under the more general heading of socioeconomic resources.

NRC reviewers allude to the problem of defining recreation resources by acknowledging various uses of the term "socioeconomics", including environmental economics, geography, historical studies, institutional and policy analysis, and recreational sociology. Their analysis of the Physical Resource Program notes that recreation resources encompass more than biophysical features with this statement: "research and monitoring are focused on understanding how to maintain adequate

volumes and appropriate morphology of [sand] deposits, in order to preserve…ecological, *recreational*, and cultural resources." (NRC 1999, p. 65, emphasis added.)

The preceding discussion, of course, begs the question that if recreation resources aren't just a set of biophysical parameters (i.e. settings) then what exactly *are* they? As previously outlined, recreation consists of *experience opportunities*, but more specificity is needed to adequately describe recreation in the CRE. (The evolution of recreation research, and gestation of this general definition are discussed in the section dealing with recreation experiences and benefits.) Merriam Webster's Collegiate Dictionary (Tenth Edition, Merriam-Webster, Inc. 1994) defines a "resource" as:

1. (a) a source of supply or support; an available means
   (b) a natural source of wealth or revenue
   (c) computable wealth
   (d) a source of information or expertise

2. something to which one has recourse in difficulty
3. a possibility of relief or recovery
4. a means of spending one's leisure time
5. an ability to meet and handle a situation

Several of these alternative definitions are applicable to recreation resources. A recreation resource can be an *available means,* and *something to which one has recourse in difficulty* (the stress-reducing, restorative effects of natural environments are well-documented). It is also, obviously, *a means of spending one's leisure time.* Manning (1999) suggests several principles for understanding, researching and managing recreation:

1. Outdoor recreation should be considered within a threefold framework, the natural environment, the social environment and the managerial environment; each of which has important implications for defining outdoor recreation experiences and opportunities

2. Outdoor recreation is most appropriately defined in terms of motivations and benefits rather than participation in activities

3. Quality in outdoor recreation can be defined as the degree to which recreation opportunities provide the experiences for which they are designed and managed; type and quality of outdoor recreation opportunities are distinct concepts

4. There is a high degree of interrelationship among outdoor recreation issues and variables

Experience opportunities are comprised of biophysical settings, social factors such as motivations and benefits of recreationists, and managerial components, a description widely accepted by researchers. Recently it has been suggested that because humans benefit from these experiences, recreation can also be characterized as range of benefit opportunities (Lee and Driver 1999).

Based on established professional knowledge, the following definition is submitted: **Recreation resources in the Colorado River ecosystem consist of a spectrum of actual and potential, non-substitutable, world-class experience opportunities (comprised of an array of interactions between biophysical, socioeconomic, cultural and managerial factors) that produce many market and nonmarket benefits for individual visitors, social groups and society.**

A critical point in defining recreation resources in terms of experience opportunities in the Colorado River ecosystem is the fact that these opportunities are for the most part *unique and not substitutable*. This is particularly true for downriver float trips, as evidenced by the worldwide reputation of river trips through the Grand Canyon and its designation as a World Heritage Site (USDOI National Park Service 1995). Other multi-day river float trip experience opportunities are available in the United States and internationally, but none are even roughly comparable in terms of rapids, variety and quality of scenery, campsites, off-river hiking opportunities, attraction sites, or length.

Clearly, biophysical factors related to dam operations, such as river flow level, rapids and especially camping beaches are crucial to the continued existence of these experience opportunities, and the AMP is correct in focusing significant research efforts on how these variables affect recreation experiences. Because human influences can easily dominate and obscure understanding of other ecosystem processes, it may be appropriate for natural scientists to take a lead role in attempting to define baseline conditions in the Colorado River ecosystem independent of humans (Houck 1998). It is, however, equally important to bring rigorous social science techniques to bear on defining the experiences and benefits of human recreational uses of the ecosystem. Recognition of social factors

in an explicit definition for recreation will make the AMP more effective in addressing its responsibilities to research, monitor, mitigate adverse impacts to, and improve recreation resources under an ecosystem management paradigm (Peine et al. 1999). Such a definition should be incorporated into all planning documents that address recreation within the AMP.

Differentiating between biophysical or social factors is useful for investigative purposes, but in the real world of recreation humans and the ecosystems they experience are inextricably connected. Although non-human ecological factors are integral, it may be more germane to understand physical and psychological relationships *between* humans and the Colorado River ecosystem that characterize visitor experiences and benefits. That visitors do indeed derive benefits from experiences in the CRE can be imputed from the fact that river trips are quite expensive by most standards, but demand still greatly exceeds supply. What specific benefits are most valued, how much they are valued, and linkages between benefits and reach-specific biophysical factors of the ecosystem are critical areas for future research (Peine et al.1999, NRC 1999). Inventoried wildland recreation benefits can serve as indicator variables for experience quality when monitoring recreation resources (Driver 1996). This approach is especially amenable to cooperative efforts between the GCMRC and NPS, which has expressed an intention to manage for wilderness oriented experiences and benefits in the CRE. It also has potential for empirically linking economic analysis of social benefits (NRC 1999) with specifically described benefits of river recreation. We already know that people visit parks to enjoy nature, Williams and Patterson (1999) note, but little about "…what is meant by 'to enjoy nature', i.e. the content of what is enjoyed, the process through which people attend to and perceive nature…" (p. 151).

Suggestions for updating information needs and future research

It has been suggested that priorities for social science programming at the GCMRC include onriver research to clarify what is unique and highly valued about the experience, and the types of benefits visitors accrue. In addition, a regional comparison of river recreation alternatives, as well as an updated regional economic assessment of recreation in the Colorado River ecosystem are necessary to adequately understand the scope of

these resources. Here, specific strengths and weaknesses of present GCMRC recreation/socioeconomic research efforts are discussed, and suggestions for new research recapitulated in more specific terms.

To its credit, the GCMRC is funding a project (Stewart et al. 1997) assessing *attitudes and preferences of users toward recreation opportunities and setting attributes related to river flows, changing attitudes and preferences of users, and user attitudes and preferences in relation to stakeholder visions*. This study began to address IN 1.1, "determine criteria and aspects that are important to or detract from recreational experience[s]", by investigating flow-related factors that affect recreation experiences. Consistent with biophysical and cultural resources, recreation experiences must be researched holistically, as suggested by the adaptive ecosystem management approach. Since both biophysical variables and humans are involved, this research should encompass aspects of Colorado River ecology, human ecology (including psychological aspects of the recreation experience) and sociocultural concerns, and is a necessary precursor before any meaningful assessment of dam operation effects can take place.

A new IN for recreation would address this broader range of relevant considerations concerning recreation:

> **"Characterize and define the scope of recreation experience opportunities presently and potentially available in the Colorado River ecosystem, and individual and social benefits associated with them. Consistent with the adaptive ecosystem management paradigm, include both biophysical and sociocultural parameters, and describe relationships between them. Compare and contrast these experience opportunities with other river recreation opportunities in the region."**

Onriver data collection would be the most ecologically valid way to establish what benefits visitors are accruing over the course of their experiences (based on an established body of research linking recreation experiences and benefits) and linkages between these experiences and benefits, and ecosystem parameters. A methodology consisting of written questionnaires administered to river visitors at all points along the river corridor is suggested as means for linking data gathered with biophysical features of the CRE. This would meet objectives of establishing reach-specific facets of the CRE that contribute to recreation experiences, how these parameters are experienced, and benefits that accrue to visitors as a result. Such data would allow a much more specific

understanding of the social benefits related to recreation use, and could be coupled with a follow-up mailback survey to document the persistence of recreation benefits over time. Although they have the advantage of a proven track record with researchers and land management agencies, management frameworks such as the Recreation Opportunity Spectrum and Benefits Based Management have been criticized as being too restrictive by characterizing recreation is just another "production process" (Williams et al. 1992). In any case, it is important to study recreation experiences in real time (Manfredo et al. 1996, Stewart and Hull 1992), although less restrictive alternative methodologies exist such as phenomenological approaches (e.g. Fishwick and Vining 1992).

Second, validating the existence of the social benefits of recreation resources is important to frame economic valuation of recreation in the Colorado River ecosystem, an issue insufficiently addressed by the Strategic Plan. Explicit description and valuation of recreation is needed to provide meaningful cost/benefit assessments as social carrying capacity either increases or decreases under different operating criteria for GCD. This economic component has been neglected by previous research efforts, with the result that losses (or gains) in recreation values under 35 years of dam operations remain largely unknown. The GCMRC may have difficulty weighing costs and benefits of effects on recreation under various dam operation scenarios without a clear picture of what the benefits associated with recreation are, and rigorous up-to-date economic analysis of them. This suggests a second new IN:

> **"Generate an up to date valuation of market and nonmarket, individual and social benefits generated by use of recreation resources in the Colorado River ecosystem. Include multiplier effects and a thorough regional economic analysis. Use conventional economic measures as well as contingent valuation, travel cost, conjoint analysis and other state-of-the-art nonmarket economic techniques where relevant and needed."**

To complement conventional market economic analysis, an environmental economics approach should be adopted to properly account for nonmarket social benefits, as the NRC suggests. A good starting point would be a rigorous update of work conducted by Bishop et al. (1987), data for which is now 15 years old. Information concerning the economic value of hydropower is readily available and current, but corresponding information for recreation and other socioeconomic values is dated to the point that it

may no longer be relevant. Moreover, as the NRC (1999) notes, there have been substantial advances in environmental economic techniques since the last time such values were estimated for the Colorado River. The GCMRC also needs to include important work completed as part of the EIS process that empirically describes benefits that accrue to people who may or may not ever visit the ecosystem physically (Welsh et al. 1995, 1999).

Third, having four separate INs for camping beaches, each prioritized differently, may lead to poorly-coordinated efforts to address this critical issue. Campsite size and number are decreasing (along with the range of options for use level/contact tradeoffs) as a result of operations of GCD, while demand for river experiences increases. This has an important implication for GCMRC recreation research: monitoring of social carrying capacity should continue and be expanded. This should be a multi-faceted effort including monitoring campsite size and number on regular intervals (as discussed in the critique of the GCMRC Strategic Plan) coupled with a regular program of monitoring contacts between river trips. Measurable indicators such as these (Manning 1999) provide objective data necessary to track changes in river recreation quality through time.

To its credit, the GCMRC has instituted efforts to focus sediment research more specifically on camping beaches in critical reaches. As part of this effort, INs 2.1, 2.2 and 2.3 should be condensed and addressed concurrently. The GCMRC should (1) develop a comprehensive and up to date inventory of all regularly used campsites in the River Corridor between Lees Ferry and the headwaters of Lake Mead, synthesizing work by Kearsley and associates (Kearsley and Warren 1993, Kearsley 1994, Kearsley 1995, Kearsley et al. 1999), (2) validate this list with current full-time guides and update as needed; archive valuable anecdotal evidence, and (3) annually monitor all camps in critical reaches, and a substantial sample of camps in other reaches. This work should be coordinated with conceptual systems modeling efforts to ensure that data gathered is relevant to the model.

The following INs pertaining to wilderness river experiences (identified by the AMWG previously) have been omitted from the Draft Strategic Plan:

> -determination of criteria and aspects that are important to or detract from [a] wilderness experience

-characterization [of] procedures to mitigate those aspects of flows that detract from [the] wilderness character of the river

These INs were restated to say "recreation" instead of "wilderness" (Lambert 1999), but given the importance of this issue to the general public (USDOI National Park Service 1998a) and its relevance to NPS management objectives, the GCMRC may want to specifically address how GCD operations affect wilderness qualities. A study conducted by Hall (1999) addressed wilderness qualities in the River Corridor, but considered only questions relating to social carrying capacity and motorized use.

Finally, the recommendation that recreationists' "…values and concerns…" be monitored only every five years is not commensurate with the uniqueness and global importance of Grand Canyon river trips. Large changes in beach morphology (to name one parameter that affects recreation) can take place in weeks or months (Kearsley et al. 1999). Monitoring every five years may fail to detect how such changes affect recreation values until well after the fact. Annual or biannual monitoring is recommended.

Social benefits and the Adaptive Management Program

The NRC (1999) states that "among the most important and least understood issues for social research [in the AMP] are the following: *what* resource effects are valued by different groups, *how* they are experienced and valued, and *how much* they are valued", and that "understanding the social benefits associated with improved ecological or recreational conditions in the [Colorado River ecosystem] requires information about society's willingness to pay for enhancement of ecological conditions or for better recreational opportunities" (NRC 1999, p. 76). The NRC reviewers point out that decision makers often use implicit value judgements to decide how important various resource gains and losses are, and that this informal process stands out in sharp contrast to the rigor with which many physical effects are measured. Recurrent issues in the NRC review are the "social benefits" of socioeconomic resources, and the importance of addressing implicit value imputations with the same rigor as scientifically measured physical effects.

Although hydroelectric power facilities are indisputably among the cleanest available from a pollution standpoint, implicit value judgements and conclusions as to the social benefits of western water development and power marketing have changed dramatically over the past 50 years (Martin 1989, Wilkinson 1992, Worster 1985). The social benefits of maximizing peaking power revenue to pay for otherwise uneconomic diversion, salinity and irrigation projects have similarly been questioned (Carothers and Brown 1991, Parker and Rozzi 1997). These changes in public attitudes contributed in large part to the GCPA, EIS and finally the current AMP. Economic analysis within the GCMRC socioeconomic program is needed to address the dialectical and pluralistic situation existing within the AMP with regard to hydropower, recreation and related ecological resources (National Research Council 1999). In some situations, consensus on the relative social benefits of each may not be achievable because of competing worldviews. Progress toward the goals of the AMP in these cases may be stymied unless the best possible research is brought to bear on definition and valuation of affected resources.

Hydropower resources are relatively easy to define and information for hydropower revenue is readily available. However, for difficult to define and measure, but important recreation resources, information lags behind that available for hydropower and other resource areas. This is problematic, given that language in the EIS and elsewhere acknowledges that Grand Canyon National Park, and the Colorado River ecosystem contained therein are of international significance. Although they undergird political processes that led to the AMP, the benefits to society of Colorado River recreation and related ecological resources, are only hinted at in documentation pertaining directly to the AMP.

These are the kind of implicit value judgements the NRC argues should be made explicit (NRC 1999). No matter what definition is most applicable to the sense in which resources are understood in the AMP, it will be difficult to keep values out of the process whether the issue is hydropower or recreation. A critical role for social science in addressing this situation is to empirically validate whether benefits assumed to accrue to people from river trip experiences actually do, and use state of the science market and nonmarket economic techniques to generate an estimate of value for them. Rather than basing decisions on implicit normative comparisons, the benefits derived from recreation

resources in the Colorado River ecosystem could then be more explicitly compared to benefits derived from maximization of hydropower revenue.

Tradeoffs may have to be made between maximizing the value of hydropower, and ecological protection and recreation. The recommendations offered here offer a viable approach to inclusion of world class recreation resources, and associated but hard to define ecological values as the AMP works to form a vision for managing Glen Canyon Dam and the Colorado River ecosystem for the good of all stakeholders.

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APPENDIX A
MANAGEMENT OBJECTIVES AND INFORMATION NEEDS FOR RECREATION RESOURCES

MO1) Provide quality recreation experiences consistent with other resource objectives.

IN 1.1 Determine criteria and aspects [of dam operations] that are important to or detract from recreational experience[s]. (Priority 2.)
IN 1.2 Determine the impacts of scientific activity on recreational experience[s]. (Priority 10.)
IN 1.3 Characterize procedures to mitigate those aspects of flows that detract from quality recreational experiences. (Priority 3.)
IN 1.4 Determine angler satisfaction, use and harvest. (Priority 7.)
IN 1.5 Determine potential impacts of increased heavy metals on sport fishing. (Priority 16.)

Proposed research activities in support of this MO, and status of these activities are listed as:

1.) Research user preferences and attitudes assessing recreational experience[s] relative to differing flow regimes. This study is ongoing and results will be available in FY2000. The study results may suggest other work in this area.
2.) Monitor trout angler use and satisfaction through creel census and cooperative monitoring program with fishing guides and Trout Unlimited. This study is proposed to begin in FY2000 with information available in FY2001.
3.) Monitor beach changes and user preferences through cooperative programs with boating guides. This study is proposed to begin in FY2000 with information available in FY2001.

MO2) Maintain flows (under approved operating criteria) and sediment processes that create and adequate quantity, distribution and variety of beaches for camping, as long as such flows are consistent with management of natural recreation and cultural resource values (other natural resource values).

IN 2.1 Determine adequate beach quantity, quality, distribution, character and structure for camping throughout the system. (Priority 11.)
IN 2.2 Evaluate impacts of operating criteria on establishing and maintaining adequate beaches and distribution of other resources, quality, character and structure. (Priority 1).
IN 2.3 Develop methodology to evaluate distribution, quantity and quality changes in all campable beaches through time. (Priority 15.)
IN 2.4 Develop models to predict flow regimes (under approved operating criteria) for building and maintaining beaches. (Priority 6.)

Proposed research activities in support of this MO, and status of these activities are:

1.) Use past monitoring, research and cooperative studies to develop synthesis of campsite beach changes through time associated with differing flow regimes, i.e. camping area, vegetation changes, etc. This study is proposed to begin in FY2000 with information available in FY2001.
2.) Evaluate effectiveness of new monitoring protocols for long-term assessments of camping beach changes from differing flow regimes. This study is proposed to begin in FY2000 with information available in FY2001. Beach area data will be monitored using aerial videography or photography at the same discharge levels every other year. Changes in beach camping area at high discharge levels can be determined through digitized video or aerial photographs and validated on a sample basis through ground truthing coordinated with beach surveys under the sediment dynamics component of the long-term monitoring and research program. Validation of campsite area change can be determined by digitizing the on-river mapping.

MO3) Maintain flows (under approved operating criteria) that minimize impacts to navigability by authorized watercraft and for boaters, waders, and campers in the riverine corridor.

IN 3.1 Determine if operating criteria maintain safe and adequate powercraft navigability in Glen Canyon and upper Lake Mead. (Priority 13.)
IN 3.2 Evaluate effects of operating criteria on recreation safety. (Priority 4.)
IN 3.3 Determine if operating criteria maintain whitewater raft navigation in Grand Canyon. (Priority 5.)
IN 3.4 Define ecosystem and other resource impacts of flow regimes (under approved operating criteria) required to maintain navigation. (Priority 12.)
IN 3.5 Develop methodology to evaluate potential conflicts of day rafting and other resources (e.g. bank degradation, sport fishing, bird watching, etc.) (Priority 8.)

Proposed research activities in support of this MO, and status of these activities:

The NPS is currently compiling information on whitewater rafting and safety. This information should be available in FY2001 and will provide information to formulate projects in this area, if warranted.

MO4) Maintain flows (under approved operating criteria) and habitat suitable for quality cold water fishery opportunities in Glen Canyon.

IN 4.1 Determine flow regimes (under approved operating criteria) necessary to maintain fish populations of 100,000 adult trout (age class II plus). (Priority 9.)

Proposed research activities in support of this MO, and status of these activities:

Data on flow regimes and trout populations are currently being addressed in the biological resources program. At this time, no projects are being proposed in this recreational area.

MO5) Maintain flows (under approved operating criteria) and habitat suitable for waterfowl sport hunting and wildlife viewing opportunities in Glen Canyon.

IN 5.1 Define patterns of waterfowl hunting use and satisfaction and other wildlife use and conflicts to other uses. (Priority 14.)

Proposed research activities in support of this MO, and status of these activities:

Information from ongoing projects addressing recreational isues will be assembled to evaluate future projects in this area. No specific projects are proposed at this time.