Big Dams and Park Resources: Water Management in the Colorado River Basin

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Abstract

The water of the Colorado River system is a precious commodity. Diverting and storing that water to support human activities (agriculture, hydropower, urban growth) is central to life in the seven states served by the river. In the twentieth century, immense dams were built on the Colorado and its tributaries to store water and promote a reliable supply. The operation of these dams has profoundly affected natural and cultural resources in some of America's most revered national parks, a factor generally overlooked in water management decision making. The National Parks Conservation Association's Center for Park Research summarized the impacts of dam operations on select park resources in five basin parks, Dinosaur National Monument, Black Canyon of the Gunnison National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park. Our research considered impacts to natural and cultural resources, finding a complex web of effects that cannot easily be resolved.

Introduction

In the arid West, water is a precious resource in high demand. In the Colorado River Basin, archaeological evidence indicates prehistoric peoples who lived in the Arizona region practiced floodwater farming along the lower Colorado River, and possibly ditch irrigation in the Grand Canyon. Spanish missions practiced some irrigation in the seventeenth and eighteenth centuries, also mostly on the lower Colorado River, along what is now the border between Arizona and California. Over the course of the nineteenth and early twentieth centuries, the rivers comprising the Colorado River system were manipulated and altered via a series of diversions and small dams; then, construction of major dams in the twentieth century radically altered the flow of the Colorado and its tributaries. Today, the Colorado River and its major tributaries are parts of a highly regulated system.

Prior to extensive and large scale diversions and dams, the Colorado River and its tributaries supported an array of habitats and human endeavors within the river's corridor. Natural resources included geological structures, habitats formed by alternating floods and low flows, and

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a diverse endemic fish fauna, to name a few (Schmidt 2007). Archaeological remains of prehistoric and historic peoples, and remnants of ranching and mining operations tell the stories of the many people who depended on these rivers (Geib 1996; Graham and Kupel 2000). The efforts to regulate and store water for users in the Colorado River Basin and beyond, which culminated in the dam building era of the nineteenth and twentieth centuries, have resulted in changes to, and degradation of, many natural and cultural resources along the rivers of the Colorado River Basin.

Many spectacular resources of the Colorado River Basin are contained within national parks managed by the National Park Service (NPS). The NPS manages nine units along the Colorado River and its major tributaries: Rocky Mountain National Park, Dinosaur National Monument (Dinosaur), Curecanti National Recreation Area, Black Canyon of the Gunnison National Park (Black Canyon), Arches National Park, Canyonlands National Park (Canyonlands), Glen Canyon National Recreation Area (Glen Canyon), Grand Canyon National Park (Grand Canyon), and Lake Mead National Recreation Area (NPS 2009, see Figure 1). The Center for Park Research examined selected natural and cultural resources in five of those parks: Dinosaur, Black Canyon, Canyonlands, Glen Canyon, and Grand Canyon. Our findings describe the impacts of water management activities through the lens of park resource condition. This research informed a published report that seeks to bring national parks and their resources into the broader discussion of water management in the Colorado River Basin.

Summary of major resource findings

From the perspective of natural resources, large dams in the Colorado River Basin have altered resources by fundamentally changing the ecological and environmental processes at play. In most cases, these changes have been mediated through the novel and highly unnatural flow regimes resulting from dam operating plans rather than natural hydrological cycles. Parks directly downstream of dams (Dinosaur, Black Canyon, Grand Canyon, and the short downstream stretch in Glen Canyon) have been affected by novel flows, including reduced peak flows, enhanced base flows, and the absence of a consistent and predominant spring flood. The implications of these flow changes are far reaching, affecting river geomorphic processes, riparian zone vegetation communities, and native fish reproduction. For example, Flaming Gorge Dam regulates the Green River through part of Dinosaur, and the riparian habitats in Browns Park, just outside Dinosaur, for example, have changed greatly compared to the riparian habitats along the undammed Yampa River, which also flows through Dinosaur (Merritt and Cooper 2000). While the immediate downstream effects might be obvious and dramatic, dam impacts are not limited to river stretches directly below the dam but instead can be observed hundreds of miles downstream. Canyonlands, at the confluence of the Green and Colorado Rivers, has lost riparian, as well as adjacent floodplain, habitats due to reduced floods.

Another major effect of basin dams has been to fragment the linear nature of these rivers. Before the dams were built, snowmelt from the Rocky Mountains would have thundered downhill, collecting and depositing sediment and nutrients along the way. Within the river, native fishes like the endangered Colorado pikeminnow (*Ptychocheilus lucius*) would have travelled upstream to spawn, and the larvae would have drifted back downstream to nursery grounds. Now, however, the dams throughout the basin have pinched off these pathways. Water is held behind dams until released. Sediment is trapped in upstream reservoirs. Native fish can still migrate, but migratory ranges are truncated. In effect, processes that in the past connected one end of the basin to the other, 1800 miles long (Schmidt 2007), are now constrained to a few hundred river miles.

The research findings also show that concern over declining populations of native Colorado River Basin fish has driven efforts to modify dam operations. These fish, evolutionarily adapted to the warm, muddy waters of the Colorado River, had faced a series of ecological challenges even before the dams were built, including direct fishing pressure, and competition with nonnative

Figure 1. Colorado River Basin and associated national parks.

sport fishes. Then, after dam construction, the river changed from a warm, sediment rich environment, to a cold, clear-water one. The altered temperature extremes and patterns influenced fish reproduction, and the resulting reproductive decline was exacerbated by the concomitant degradation of spawning and nursery habitat. The plights of four native fish led to endangered species listings, and the Endangered Species Act provided the strongest leverage to research river flows and alter dam operations to benefit these fish and, by extension, other resources. Unfortunately, the process of altering and revising flows, as it has played out at Grand Canyon and Dinosaur, has been a slow, somewhat adversarial one, and has provided at best an incremental benefit to resources.

Research also highlights the fact that our understanding of the impacts of dam operations is not equal among parks throughout the basin; this inequality mirrors the different distribution of financial resources and programs across the basin. For example, most attention has focused on Grand Canyon, and much of our understanding of dam impacts comes from the extensive research and monitoring program focused on that park, because of the Glen Canyon Dam Adaptive Management Program (GCDAMP). Just upstream of the dam, however, Glen Canyon receives much less attention and research. All the national parks along the river have unique resources, and spreading attention across those parks will only deepen our understanding of dam impacts, and potentially lead to other effective management strategies.

Many of the changes to the river environment known to affect natural resources impact cultural resources as well. Altered flow regimes and changes in the movement of sediment have created different erosion and deposition patterns that impact archaeological and historic sites and structures along the river bank. The extent to which these changes negatively impact cultural resources is not well understood; of the five parks in this study, only Grand Canyon (because of GCDAMP) has a monitoring program in place to assess these impacts (Fairley 2003), and even there, insufficient information exists, about patterns of erosion prior to dam construction, to clearly quantify the dam's impact. At Dinosaur, Canyonlands, and Glen Canyon, there are gaps in the survey and documentation of cultural resources in the river corridor, and no formal monitoring program to assess impacts. Black Canyon is the unusual park in the group from a cultural resources perspective: archaeological survey, the historic record, and Native American tradition all indicate there are no tangible cultural resources known to exist in the river corridor (Carpenter and Stiger 1980).

For the four parks with known cultural resources in the river corridor, there is a major indirect effect of water management impacting cultural resources: inadvertent damage and vandalism caused by river recreationists. While looting of archaeological sites was known to occur in pre-dam days at all of the parks, regulation of the river has brought as much as a thousand-fold increase in visitors, and changes in water levels, especially in Glen Canyon's Lake Powell, have made previously inaccessible sites into destination attractions. Cultural resource managers do not have the staff to monitor and protect these resources, and must rely on the ranger staff, concessionaires, and private river guides to educate visitors and report damage.

Finally, at Glen Canyon, there is no formal policy that determines which federal agency, the NPS or the Bureau of Reclamation, is responsible for management of resources exposed by the lowering of the water level in Lake Powell. A number of cultural resources that were inundated by the lake when it reached full pool are now partially or fully exposed above the present water line, and predictions of future lake levels indicate they will remain exposed. Without a determination of management responsibility, these resources, some of which may be nationally significant, are highly susceptible to erosion, wave action, and visitor impacts.

Recommendations and concluding thoughts

The regulation of the Colorado River and its tributaries has played a central role in the develop-

ment of the American West. The waters of the basin irrigate rich and productive agricultural lands from Colorado to California to Mexico. Those same waters also provide drinking water to major urban areas within the basin, including Las Vegas and Phoenix, as well as outside the basin, in Denver and San Diego. The hydroelectric energy generated at the dams has powered homes and businesses across the West.

Despite their economic importance, the operation of the major dams of the Colorado River Basin has damaged and degraded natural and cultural resources, including those protected in national parks. Concerns about some of those resources, such as the native fishes of the basin, or the sandbar habitats and camping beaches inside Grand Canyon, have led to research, and attempts to change how we operate these dams in order to reverse the declines in resource conditions. Other resources, including other riparian habitats and river corridor cultural resources, are understudied, yet appear to have declined in both direct and indirect response to river management.

The search for solutions to resource and water management issues in the Colorado River Basin must be approached holistically, instead of on a site-specific, dam-specific, or park-specific basis. Natural, cultural, and recreational resources all must be taken into account. Changes in dam operations affect both upstream and downstream resources, and especially for the largest dams, effects can reach well beyond the immediately adjacent parks. Our best hope to preserve resources throughout this fragmented landscape is extensive and real cooperation between federal, state, and local entities, as well as private landholders and citizens.

Resources and their condition, whether declining, improving, or unknown, need to have a seat at the table in any discussions on water management. The environmental impact statement process under the National Environmental Policy Act provides an access point for resource discussions, both quantitative as well as qualitative. The research on and study of dam operations and endangered fish exemplifies the utility and value of this administrative approach. Nonetheless, other resources, including cultural resources, must receive similar attention. Specifically, cultural resource monitoring programs need to be established at Dinosaur, Canyonlands, and Glen Canyon to gather data on the direct and indirect effects of water management activities on resources, and these research programs could be funded from the revenues generated by the dams of the Colorado River Storage Project. Natural resource monitoring must continue as well, but it must be more equitably spread across the basin. That said, natural and cultural resource research and monitoring should not be an end in themselves; both should feed directly into park management decisions and discussions that inform dam operations.

Recreational resources provide another access point for stewardship. The extent of private recreation makes it impossible for the NPS to reach the majority of river recreationists with existing stewardship programs, even with the help of park concessionaires. A community-based program of resource stewardship education could be established to reach that river recreation community and other water users. Resource stewardship education should focus on the natural and cultural resources within protected areas, as well as the water resources protected and managed by the dams and reservoirs, to help users understand the interrelationship of water, resources, and recreation in these national parks.

From the vantage point of a park, the resource concerns arising from a large upstream dam may seem daunting indeed. Unnatural flows and water temperatures, and sediment-hungry water alter river habitats, disrupt fish reproduction, and erode archaeological resources, to name a few well-documented impacts. A park manager, or any other land manager for that matter, will immediately consider ways to ameliorate or address those localized resource impacts.

Our research across several parks, though, suggests a more holistic approach to the problem. Managing resources under highly fragmented circumstances is difficult, and inter-park coopera-

tion and sharing of information can assist in this process. Parks across the basin demonstrate convergent resource themes, and they would benefit from more inter-park exchange on those issues.

From our position supporting an advocacy organization, understanding the problems at individual parks will always be a priority. Nonetheless, the next phase of resource management within the basin necessitates an integrated perspective, requiring better documentation and understanding of resource topics, a broader view of resource condition and the factors operating at larger scales, and then continual effort to advocate for those resources in all management discussions. This research is the first phase of a project that will seek to protect national park resources in cooperation with other organizations and water users throughout the Colorado River Basin.

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