Glen Canyon Dam Adaptive Management Work Group
Agenda Item Information
August 24-25, 2011

Agenda Item
Grand Canyon Monitoring and Research Center Updates

Action Requested
✓ This is an information item.

Presenter
Jack Schmidt, Chief, Grand Canyon Monitoring and Research Center, USGS

Previous Action Taken
N/A

Relevant Science
✓ See below.

Background Information

2011 Knowledge Assessment Workshops
In June and July 2011, two of five planned Knowledge Assessment Workshops (KAWs) were held: one concerning the aquatic biological sciences (June) and one concerning sediment transport and geomorphology (July). A KAW for terrestrial resources, which will cover cultural resources, recreation and vegetation is planned for August 16-18 and a hydropower KAW will be held the week following the AMWG meeting (August 31-September 2). These KAWs are intended to identify topics and issues about which the scientific community is in general agreement and those topics for which significant uncertainty remains.

A fifth stakeholder workshop in October will focus on the integration of the outcomes of each of the summer's KAWs. There are several primary objectives of the October workshop: to provide an opportunity for stakeholders to obtain an improved scientific background and explanation about key scientific findings to date; to ensure that stakeholders have a clear understanding of the nature of scientific uncertainty in addressing areas of management concern and scientific interest; and to review the suite of science-based issues of greatest concern to stakeholders.

I. General Statement about Geomorphic and Sediment Transport Processes
Geomorphologists and sediment transport experts recognize that the Colorado River corridor through Marble and Grand Canyons behaves much like a pipe, *albeit* a pipe with a very rough boundary of bedrock and boulders with pockets of sand and mud that persist as eddy bars and channel-margin deposits that resemble narrow floodplains. The "pipe" accumulates mud and sand on its bed and in some eddies whenever the Paria, Little Colorado, or other tributaries have floods that deliver fine sediment to the main-stem river. Subsequently, this fine sediment is transported downstream. Thus, the "pipe" sometimes has periods when the amount of sand and mud is elevated

and periods when there is less fine sediment. A small proportion of the fine sediment occurs at high elevation, having been deposited during floods, including HFEs, or deposited by wind.

Construction of Glen Canyon Dam greatly decreased the amount of fine sediment that once was transported through Marble and Grand Canyons, thereby causing a decrease in the amount of fine sediment that is temporarily stored on the bed and along the edges of the “pipe.” Operations of the dam result in a flow regime that is capable of transporting to Lake Mead all of the sand occasionally delivered from the tributaries. The periods of elevated fine-sediment conditions in the “pipe” last only a few months after each large tributary flood.

Short-duration HFEs that occur when the “pipe” has elevated fine sediment in storage have high suspended-sediment concentrations. These high concentrations leave new deposits at higher elevation. On the other hand, if short-duration HFEs occur when the “pipe” has small amounts of fine sediment on its bed and in eddies, then the new high-elevation deposits will be small and some bars will be eroded.

There are linkages between the size and abundance of sand deposits in the “pipe” and the habitat for aquatic and riparian species, as well as other natural resources. Scientists understand that the distinctive topography of eddy sand bars gives rise to the distinctive backwater habitats utilized by some native fish species. These backwater habitats are well formed and abundant immediately after floods and decrease in abundance as bars erode. Scientists are in general agreement that exposed sand bars are one of the sources of the fine wind-blown sediment that covers some archaeological sites. Scientists understand that small eddy sand bars and higher base flows result in smaller sand source areas available for redistribution by wind.

Scientists agree that planning of HFEs must be based on precise and accurate accounting of the amount and sizes of fine sediment in storage at the time a high flow occurs. High flows transport more sediment, and the duration of HFEs must be carefully tuned to the available supply, lest more sand is eroded and transported out of the system than is supplied by the tributaries.

Although there are some antecedent conditions that allow HFEs to have beneficial effects, there is skepticism among scientists as to whether enough sand is delivered from tributaries on a sufficiently regular basis to sustain sufficiently frequent high flows that in turn would lead to a significant increase in the area and volume of eddy sand bars. Significant progress has been made in developing numerical models that can be used to predict the outcomes of HFEs, however, there is no substitute for a comprehensive monitoring program that measures the amount of fine sediment delivered from tributaries, transported by the Colorado River, and temporarily stored on its bed and along its edges.

Models have been developed that successfully predict the rate of warming of the main-stem flow. Empirical data indicates that the magnitude of near shore warming is small. Near shore warming is thought to be of importance to native fish.

II. General Statement about Aquatic Biological Processes

The Colorado River aquatic ecosystem downstream from Glen Canyon Dam has been dramatically altered by modifications of flow, temperature, and sediment and introductions of non-native species. Populations of several native fishes, including endangered humpback chub, have been adversely affected by these modifications and introductions. Likely mechanisms for species decline include loss of spawning and rearing habitat, competition with nonnative fish for food and resources, and predation by nonnative fish. Understanding how these factors influence native fish populations will help guide future management actions intended to recover these species.

Fish populations throughout the Colorado River appear to be limited by the availability of high-quality food resources. Two taxa of aquatic insects—*simuliids* and *chironomids*—appear to be particularly important food resources for fish populations, because annual consumption of these insects by fish closely matches independent estimates of their availability. This pattern holds true for fish populations throughout Glen and Grand Canyon. Annual production of both taxa is highest in cobble/gravel habitats and lower in all other habitat types including backwaters. These aquatic insects consume algae and detritus almost exclusively, but the proportion of algae consumed is high relative to its availability. Algae biomass is also highest in cobble/gravel habitats and lower in all other habitat types including backwaters. Algae production in Grand Canyon is strongly limited by suspended sediment turbidity. Algae and invertebrate production in cobble/gravel habitats may also be limited by the quality of the physical habitat; a matrix of mud (Marble and Grand Canyons only) and senescent algae (Glen, Marble, and Grand Canyons) accumulates on cobble/gravel unless some form of disturbance removes this material. Periodic disturbance of cobble/gravel habitats using high-flow experiments or short-duration low flows may increase the production of key food web components—algae, *chironomids*, and *simuliids*—thereby benefitting fish populations.

There is evidence that various flow regimes employed in the Colorado River influence fish populations, particularly nonnative rainbow trout in Lees Ferry. Rainbow trout populations in Lees Ferry increased from 1991 to 1997 following implementation of a more steady flow regime, but declined from about 2000 to 2007. The precise mechanisms for this system-wide decline in rainbow trout are unknown, but ecosystem modeling indicates trout suppression flows, warmer water temperatures, and low dissolved oxygen conditions in Lees Ferry during this time period may have all played a role. Adult abundance in 2008 and 2009 was high compared to previous years, which was likely the result of increased juvenile survival caused by improved habitat and food conditions following the 2008 HFE at Glen Canyon Dam. Modeling indicates rainbow trout from the Lees Ferry reach likely move downriver, but rates and timing of emigration are not understood. Further, it is unclear to what extent downriver rainbow trout populations are dependent on this downriver emigration from Lees Ferry.

Predation has been hypothesized as a mechanism contributing to the decline of native Colorado River fishes in Grand Canyon, including endangered humpback chub. During 2003–2006, over 23,000 nonnative fish, including approximately 19,000 rainbow trout, were removed from a 15-km segment of the Colorado River near the Little Colorado River confluence. Fish community composition shifted rapidly from one dominated by salmonids to one composed primarily of native fishes. On average, 85% of the fish ingested by rainbow trout and brown trout were found to be native fishes. Although rainbow trout were less piscivorous than brown trout, they were also 50 times more abundant, resulting in a greater cumulative effect (65% of the total estimated fish consumed). Even at these levels, it is unclear if trout predation negatively affects recruitment of young humpback chub into the adult population. Native fish appear to have responded positively to nonnative fish suppression (see below). Observed changes in humpback chub and other native fish abundance, however, cannot be attributed solely to fish removal efforts due to other confounding physical and biological factors (e.g., temperature, movement, and survival). Although fish removal was measurably effective in controlling trout abundance at a local scale, it occurred during the previously mentioned system-wide decline in trout abundance independent of fish suppression.

Population trends for native humpback chub indicate numbers have been increasing since 2000, to an estimate between 7,500 and 10,000 adult fish. It should be noted, however, that our ability to detect changes in adult populations of humpback chub in response to management actions is somewhat limited. This is because the current model used to estimate humpback chub abundance lacks the precision to estimate the actual age of a fish recruiting into the adult population. In other words, a strong cohort of humpback chub spawned in a given year because of a management action or environmental variation (e.g., warm water) will not be identified in the model. Instead, it will appear as a gradual increase in populations over several years, thus making it difficult to identify the mechanism responsible for the increase. Other native fishes have also seen apparent increases in populations in recent years. Flannelmouth sucker densities have increased since 2004, particularly in western Grand Canyon, while bluehead sucker populations have also shown dramatic increases since 2005. Reasons for these increases are poorly understood, but are likely related to a period of warmer than average releases from Glen Canyon Dam, and declines in non-native fish abundance.

Sediment and Water Quality Update

Tributary sediment inputs were minimal during the period following recession of the 2008 HFE -- between spring 2008 and summer 2010. During this period, more sand was evacuated from Marble Canyon than was delivered from the Paria River and minor tributaries; thus, evacuation involved removal of sand that had been delivered to upper Marble Canyon before 2008. Floods on the Paria River and on smaller tributaries in late summer and fall 2010 delivered a large amount of sand to upper Marble Canyon. These floods delivered more new sand than had been evacuated during the 2008-2010 period. Since January 2011, releases of large volumes of water have initiated a new period of sand evacuation that has the potential to completely remove the sand that had been delivered in late summer and fall 2010. Computations of the sand mass balance for each part of Marble and Grand Canyons are now being completed, and these data will allow estimation of whether or not the entire 2010 sand supply has already been removed from upper Marble Canyon. The sand mass balance for the post-2008 period will be compared with sand budgets for previous years.

The unprecedented combination of high upper Colorado River basin runoff, low storage levels in Lake Powell, and high Glen Canyon Dam release volumes have also affected downstream water temperature. Mid-July release temperature was about 12 degrees Celsius and increasing. These are the warmest releases by one degree or more than have occurred since 2005, when the release temperature was about 14 degrees Celsius.