Monitoring Fine-Sediment Storage of the Colorado River Ecosystem below Glen Canyon Dam

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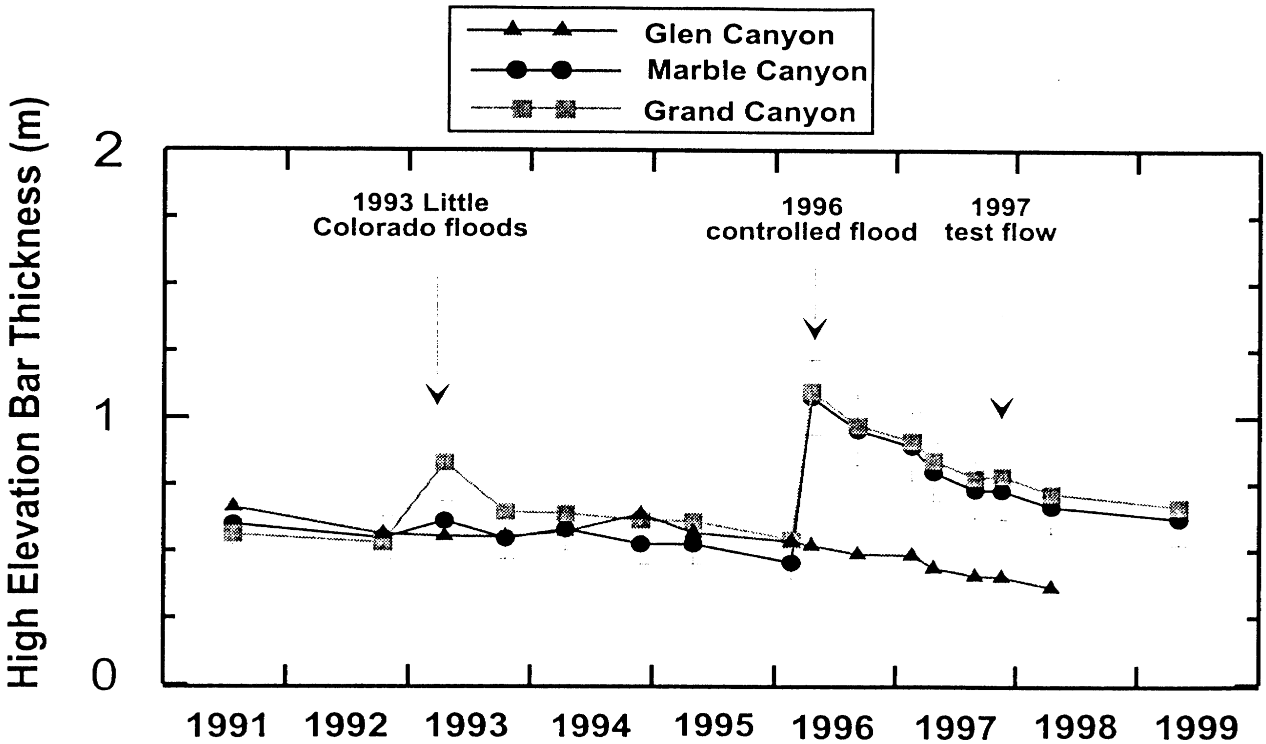
We have monitored the movement of sediment throughout the Colorado River ecosystem below Glen Canyon Dam from 1990 through 1999. Our approach is to conduct repeated topographic and hydrographic surveys at 35 long-term study sites to characterize reach and system-wide responses of sediment to dam operations (see Kaplinski et al., 1998 or Hazel et al., 1999 for a more in-depth description of our methodology and study sites). We compute changes in river-bed and bank sediment storage by examining changes to the main channel, eddy, and high-elevation sand bar environments at each study site. We use the terms low-elevation (below the 142 m /s [5,000 ft^3/s] stage elevation) to describe subaqueous storage changes, and high-elevation (above the 556 m^3 /s [20,000 ft^3/s] stage elevation) to describe changes above the water level reached by "normal" dam operations. In this report, we briefly summarize our monitoring, with particular emphasis on post-1996 controlled flood changes.

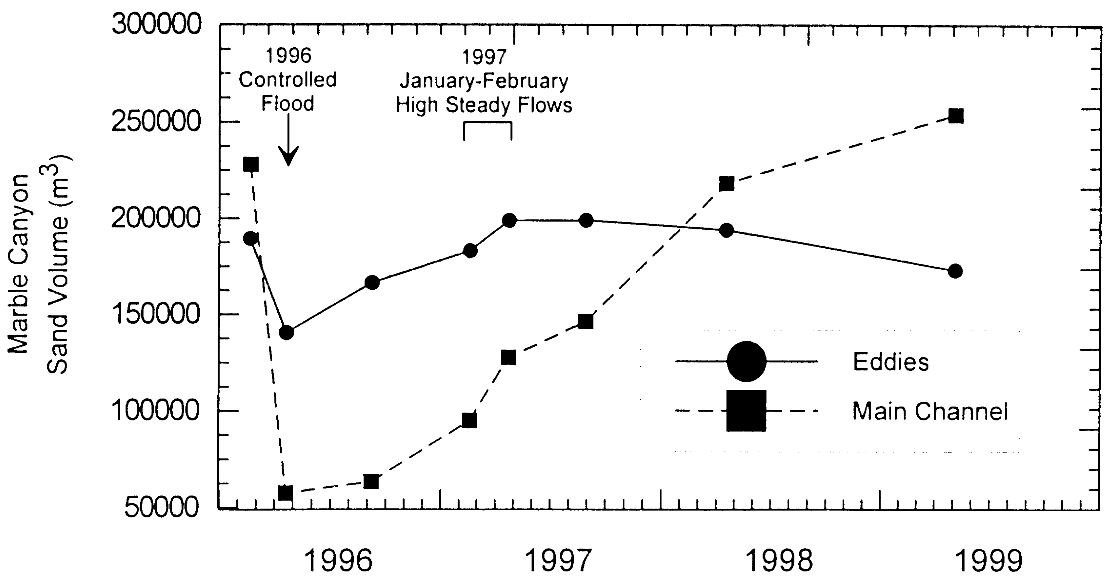
During the 1996 controlled flood, high-elevation sand bars at our study sites were aggraded, while low-elevation channel and eddy environments were scoured (Figure 1). Subsequent monitoring shows the opposite. Newly aggraded sand bars eroded rapidly during the first six months of "normal" dam operations, but erosion rates then decreased with time, while sand volume estimates within low elevation eddy and main channel environments increased. By May 1997, sand storage in eddies had recovered from the post-1996 floods scoured condition. Storage in the main channel did not reach pre-1996 controlled flood levels until above average sand inputs from the Paria River in 1997 and 1998 (see USGS presentation on Paria River sand inputs).

Following four floods from the Paria River in 1997, a short-duration, powerplant capacity test flow was released from Glen Canyon Dam. The 1997 test flow was intended to test the hypothesis that a shorter-duration, lower magnitude dam release could mimic the results of the 1996 controlled flood and transfer Paria-supplied sediment from the channel bed onto channel margin sandbars before the sand was transported downstream from Marble Canyon. Our monitoring shows that the 1997 test flow failed to achieve this objective. Net high-elevation sand bar volumes did not increase because deposition of sand on the bar was offset by erosion of the deposit above the stage elevation reached by the 878 m^3/s flow.

As of April 1999, monitoring at our study sites shows that high-elevation sand bar storage has declined and low-elevation storage within the channel and eddies had accumulated to levels near those measured before the 1996 test [Figure 1]. Our monitoring also shows no significant change to a slight decrease in low-elevation eddy storage following the 1998 inputs [Figure 2]. This suggests that low-elevation storage areas scoured by the 1996 controlled flood had filled with sand eroded from the channel margin and from the 1997 tributary inputs. In contrast, the main channel continued to accumulate sediment in 1998 and 1999; however, recent research indicates that only the coarsest size fractions are stored on the main channel bed (Topping et al., in press).

The volume of sand occupying depositional sites prior to flooding is an important factor in determining the magnitude and persistence of flood related deposition (Hazel et al., 1999). As of April 1999, high-elevation space is available on sand bars for high-elevation deposition, and low-elevation sediment is available for redistribution. Based on these observations, we hypothesize that a controlled flood similar in magnitude and duration as the 1996 controlled flood will result in similar deposition patterns.


Glen Canyon
Marble Canyon
Grand Canyon
High Elevation Bar Thickness (m)
2
1
0
1993 Little Colorado floods
1996 controlled flood
1997 test flow
1991
1992
1993
1994
1995
1996
1997
1998
1999


Marble Canyon Sand Volume (m3)
300000
250000
200000
150000
100000
50000
1996 Controlled Flood
1997 January-February High Steady Flows
Eddies
Main Channel
1996
1997
1998
1999