Long Term Monitoring of Camping Beaches in Grand Canyon: A Summary of Results from 1996 – 2003

Annual Report of Repeat Photography
By Grand Canyon River Guides, Inc.[1]
(Adopt-A-Beach Program)

by
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INTRODUCTION

Adopt-a-Beach (AAB) is a program of repeat photography that monitors the condition of camping beaches from year to year. This program is conducted through volunteer efforts and implemented by Grand Canyon River Guides, Inc. (GCRG), a nonprofit, grassroots organization that represents the interests of the Grand Canyon river running community. River guides (including commercial, private, and scientific groups), who work throughout the summer months on the Colorado River, are interested in how controlled-flow releases from Glen Canyon Dam affect beaches that are used for campsites. Furthermore, factors other than controlled flows that might be affecting campsite change are addressed in this study. Throughout the continued period of this program, 1996-2002, guides have observed changes to beaches, have recorded this information through repeat photography and written comments associated with each photograph.

In 1981, the Glen Canyon Environmental Studies (GCES) began under the administration of the Bureau of Reclamation to study the effects of controlled flow releases from the dam on the downstream river ecosystem (U.S. Department of Interior 1987), including effects on sediment supply and recreational resources. Studies of sediment dynamics showed that fluctuating flow releases from the dam have had a degrading effect on sand bar deposits (Hazel and others 1993, Schmidt and Graf 1990) since the closure of the dam. However, beaches can also be replenished by high flows adequate to entrain bedload sand and cause deposition to high elevation areas of beaches (Parnell and others 1997, Wiele and others 1999). Studies of campsite resources demonstrated that impact to sand bars due to erosion decreases the carrying capacity and campable area available for river parties and backpackers (Kearsley and Warren 1993, Kearsley and Quartaroli 1997).

In 1992, the Grand Canyon Protection Act was passed by Congress to ensure that ecological and cultural resources downstream of the dam would be monitored for changing conditions imposed by operations of the dam. The October, 1996 Record of Decision for operation of the dam states that the dam:

> "….must be managed in such a way as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park….were established, including, but not limited to, natural and cultural resources and visitor use" (U.S. Department of Interior 1996).

The Grand Canyon Dam Environmental Impact Statement recommends that scheduled, high-flow releases of short duration be periodically implemented (U.S. Department of Interior 1995). Sand bars form when sediment carried by the river, either from bed load or suspended load, is deposited by the action of eddy currents in recirculation zones. This occurs primarily on the downstream end of debris fans, but also in areas along the river's channel margin (Schmidt 1990). Habitat maintenance flows (HMF) are within powerplant capacity (31,500 cfs), whereas those above this discharge are beach/habitat building flows (BHBF). The former were intended to maintain existing camping beaches and wildlife habitat; the latter to more extensively modify and create sand bars, thus restoring some of the dynamics that resulted from flooding in the ecosystem.

Inception of Adopt-a-Beach was a result of the first scheduled BHBF of 45,000 cfs scheduled for spring 1996. Specifically, the AAB program was launched by GCRG to document the effects of the high flow on camping beaches. Guides photographed beaches and recorded information about changing conditions prior to the high flow, just after the high flow, and throughout the 1996 commercial river season. The overall conclusion of that study demonstrated that the BHBF was highly effective in depositing new high-elevation sand, but that the post-BHBF high steady summer flow schedules caused rampant erosion of sand bars (Thompson and others 1997).

Camping beaches are an important resource for river guides conducting trips through Grand Canyon. Both commercial and private river trips, as well as backpackers, rely on wide sandy areas for camping and recreating. As a way to contribute to resource management, AAB now submits annual results to the Adaptive Management Program. The results and conclusions are synthesized through a representative that serves on Technical Work Group (TWG) board. River guides make the program possible, contributing 100% of the manpower, the entire data set of repeat photographs, and valuable input about the condition of beaches throughout each season and between years. Monitoring includes information on natural and human-induced impacts to beaches such as cutbank retreat, wind erosion and dune formation, rain gully formation and the effects of visitation and camping. The purpose of this report is to present the cumulative findings of data specific to this program up through the commercial boating season of 2003. Furthermore we summarize documented observations by professional river guides.

The river season of 2003 was subjected to medium and low fluctuating flows, preceded by a high daily fluctuating flow of 5000-20,000 cfs throughout January, February and March. Specific research questions imposed this year target the changes to campsite beaches following the winter's high fluctuating flow. These questions combined with findings from cumulative years are as follows:

- How have beaches changed following the daily high fluctuating flows of 5,000-20,000 cfs implemented during winter of 2003?
- How does the quality of camping compare during Low Steady Summer Flows (LSSFs) to that during medium fluctuating flows?
- What are the main processes causing decreased beach size throughout the summer?
- Is the 1996 flood deposit of 45,000 cfs still present and how has it changed on beaches over time?
- Based on these results, what does the AAB program conclude about future resource management of campsite beaches?

Through analysis of photos and data sheets completed by guides, this report attempts to answer these and other research questions.

METHODS

Data Collection

The primary method of assessing camping beaches in this study is through analysis of repeat photography. During the summer months (April 1-October 31) volunteers (river guides, scientists, GCNP personnel) photograph a specific "adopted" beach every time they pass through the river corridor. Disposable waterproof cameras and data sheets, provided by GCRG, are distributed to all adopters of beaches. At the end of the commercial season (October), guides mail cameras and data sheets back to GCRG for analysis. A qualified scientist, who is active in Grand Canyon issues and is very familiar with AAB study sites, is contracted from year to year to analyze photographs and data, draw up results and offer conclusions to resource managers concerned with recreational and cultural interests in Grand Canyon.

This project allows each participant to take stewardship of a site, and enables him or her to detect ongoing changes over the course of a season. During each visit, guides photograph their adopted beach from pre-established photo locations that provide different views of the beach: specifically, the beachfront and an overview of the camp. In sites where overviews are impossible, a photo location is selected to reveal as much of the camp as possible. In the last 6 years, however, thick tamarisk encroachment has led to recent re-establishment of many photo locations. Re-establishment of photo locations will be on-going as needed, in order to obtain the necessary photo angles.

A data sheet (Appendix A) accompanying each photographed visit allows the adopter to comment on changes to the condition of the beach and the possible causes of changes that are visible. Also included are site location, date, time, and approximate river flow. Photographed visits for each beach average 4 per season. The number of visits for each beach can range from one to eight. Many guides take the initiative to also photograph different episodic events such as debris flow or flash flooding that recently occurred on or near their beach. Such photos can be highly beneficial to many different researchers concerned with monitoring a particular resource at a given area.

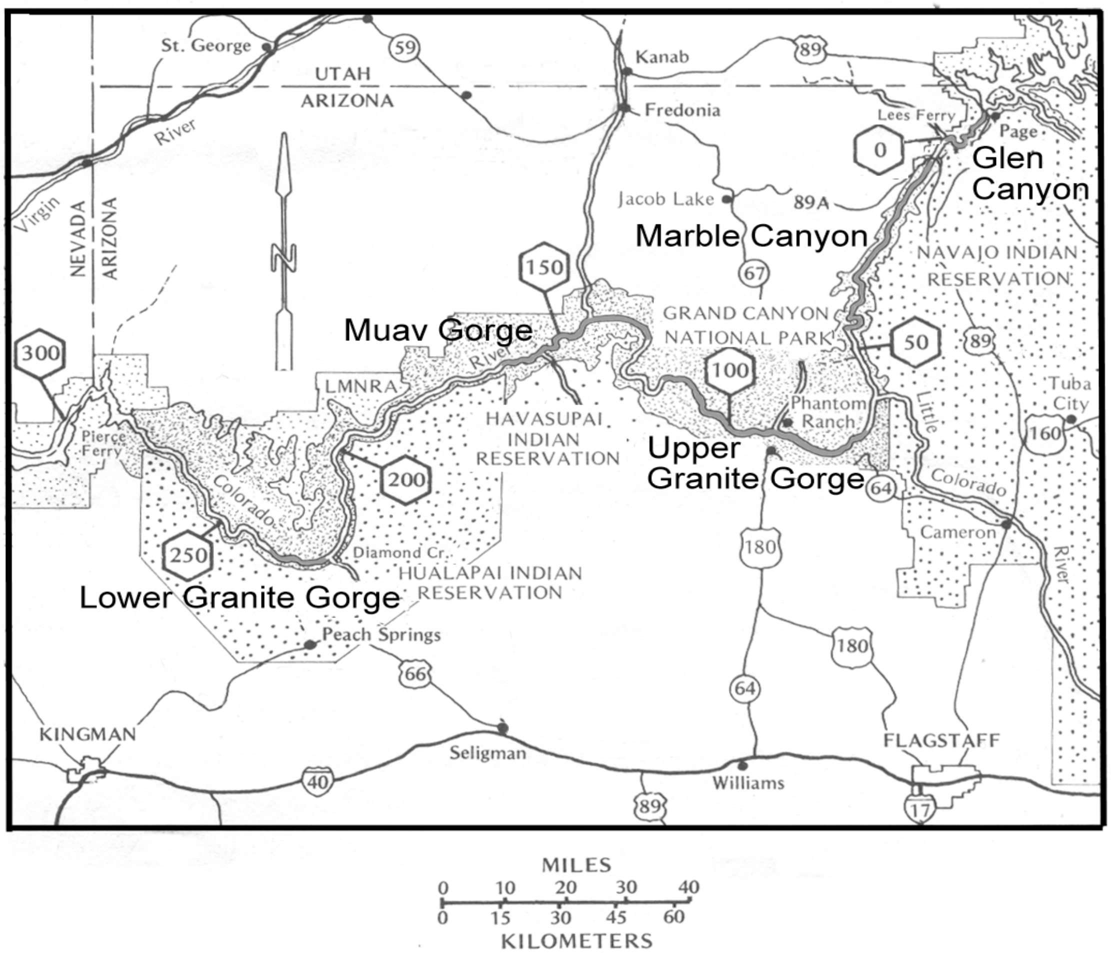
The photographs for all beaches of all years have been carefully labeled and are physically archived at the Grand Canyon River Guides office. Photographs from years 1996 through 2003 have been archived digitally onto compact discs which can be obtained from the GCRG office or the GCMRC library.

Information gleaned from photographs and from data sheets are entered into a master database using Access 2000. A cross check of the two different sources of information help to fill gaps in data and help to standardize changes from one visit to the next. For instance, if guide comments lack information about a site at the time a photograph was taken, the photo is used to assess the site for that visit. If the photo reveals little information and the guide's data sheet provides enough descriptive information about conditions throughout the site, the comments receive priority. The current Access database contains over 1,500 records of assessed changes and guide comments throughout monitoring years 1996-2003.

Study Locations

Since 1996 the AAB program has studied an average of 38 beaches pwr year from within three *critical reaches* of the river corridor (Figure 1). The practice of assessing camping beach resources within critical reaches was first developed by Kearsley and Warren (1993), and modified for the 1996 Adopt-a-Beach study by Thompson and others (1997). A critical reach is defined as a section of the river where camps are in high demand and few in number. The same reach system has been in use for all years of study, 1996-2003. They are as follows: 1) Marble Canyon, river miles 9-41; 2) Upper Granite Gorge, river miles 71-114; and 3) Muav Gorge, river miles 131-165.

Two new critical reaches have been added since the 2002 monitoring season. The purpose is to increase the sample set of beaches in order to more widely represent the effects of beach erosion and building throughout the whole river corridor below Glen Canyon Dam. These new reaches now include Glen Canyon, from the dam to Lees Ferry (river mile 0), and Lower Granite Gorge, from Diamond Creek (river mile 226) to Gneiss Canyon (river mile 236). Results from these reaches are not included in this Annual Report as data is still being collected.



Defines a critical reach for campsite beaches along the Colorado River

Figure 1. Locations of five critical reaches in Grand Canyon National Park.

Table 1 shows all popular campsites (n = 45), many of which were originally inventoried in 1996, and include beaches added in 2000 and 2001. Every beach in the inventory has an established photographic location that shows an optimum view of the beachfront and as much of the actual camping area as possible. Each year, GCRG motivates guides to adopt as many beaches as possible. To encourage a relatively complete data set from year to year, GCRG encourages adoption of high-priority beaches (n = 27) first. These beaches have been adopted for most of the study years. Usually, they are camps that can be used year after year by the river community, and thus are continually in high demand. The remaining beaches are adopted once high-priority beaches have been claimed.

The number of adopted beaches with useable data in 2003 totaled 45, which demonstrates a volunteer effort of 100% and the popularity of the program with guides. Each record in the data base represents an individual visit to a beach where each beach has 1-5 photos associated with it. As encouraged by other Grand Canyon researchers, several adopters took extra snapshots of various episodes such as flash flooding in Schist Camp (August 2002) and Last Chance Camp (August 2001) and debris flows at Hot Na Na (July 2000). These documented events and data are available to any interested researchers through Grand Canyon River Guides or Grand Canyon Monitoring and Research Center. Part of the Adopt A Beach program is to provide photos of unusual natural events in Grand Canyon to interested parties.

The time-series photos taken within study locations allow assessment of relative change over the course of each season and between monitoring years. Assessment is standardized according to the highest average fluctuating flow of the season and to a zone of 20,000 cfs when comparing 1996 photos (determined by Kaplinski and others 1994). From year to year GCRG assesses the number of beaches that change in size and evaluates campsite space up to the 45,000 cfs zone, the level of the 1996 BHBF. Should any flows exceed 45,000 cfs in the future, GCRG would analyze beach change up to the height of the new deposit or scour line.

Table 1. Sample set of camping beaches inventoried in 2003 that lie within five critical reaches.

Glen Canyon		Marble Canyon		Upper Granite Gorge		Muav Gorge		Lower Granite Gorge	
Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp
-13.0	Dam Beach	11.0	Soap Creek	15.6	Below Nevils	131.1	Below Bedrock	235.1	Travertine
-8.0	Lunch Beach	12.2	Salt Water Wash	76.6	Hance	132.0	Stone Creek	240.0	Gneiss
		16.3	Hot Na Na	81.3	Grapevine	133.0	Talking Heads		
		19.1	19 Mile	84.0	Clear Creek	133.5	Race Track		
		19.9	20 Mile	84.5	Zoroaster	133.7	Lower Tapeats		
		20.4	North Cyn	91.6	Trinity	134.6	Owl Eyes		
		23.0	23 mile	96.0	Schist	137.0	Back Eddy		
		29.3	Silver Grotto	96.7	Boucher	143.2	Kanab		
		34.7	Nautiloid	98.0	Crystal	145.6	Olo		
		37.7	Tatahatso	99.7	Tuna	148.5	Matkat Hotel		
		38.3	Bishop	107.8	Ross Wheeler	155.7	Last Chance		
		41.0	Buck Farm	108.3	Bass	164.5	Tuckup		
				109.4	110 Mile	166.4	Upper National		
				114.3	Upper Garnet	166.6	Lower National		
				114.5	Lower Garnet				

Data are analyzed according to the particular research questions asked for that year. For each year, data are grouped into two time periods: (1) summer season, beginning on April 1st and ending October 31st; and (2) winter season, the intervening period that begins November 1st and ends March 31st. Data are also categorized according to critical reach in order to rank which reaches would show more change over time. In order to determine longevity of the BHBF flood deposit, beach area at the end of summer season is compared to its pre-BHBF area. Finally, guides comment about the changing quality of campsites regarding vegetation encroachment, boat parking, steepness of slope for camp access, and rockiness. These comments together with the photographs provide an overall qualitative assessment of campsite changes over time.

Specifically, relative change to beach size, as seen either in the photos or written on field data sheets, are evaluated according to increase, decrease, or no change with respect to the previous visit. Changes pertain to the whole beach up to the 45,000 cfs line, delimited in the photo frame, using individual physiologic features such as rocks for reference. Individual factors (see Appendix A) affecting camp quality changes are recorded as better, worse, or the same.

For the season of 2000, photos of beaches that immediately preceded and followed each HMF were assessed for change. Data collected from the LSSF time frame were treated separately. Comparisons of beaches between time periods and between critical reaches were standardized by calculating percentages.

Water year 2003 contained a test flow that was implemented in January through March, where daily flows fluctuated between 5000 and 20,000cfs. Any beach change after this test flow period was assessed as well as changes from summer season flows.

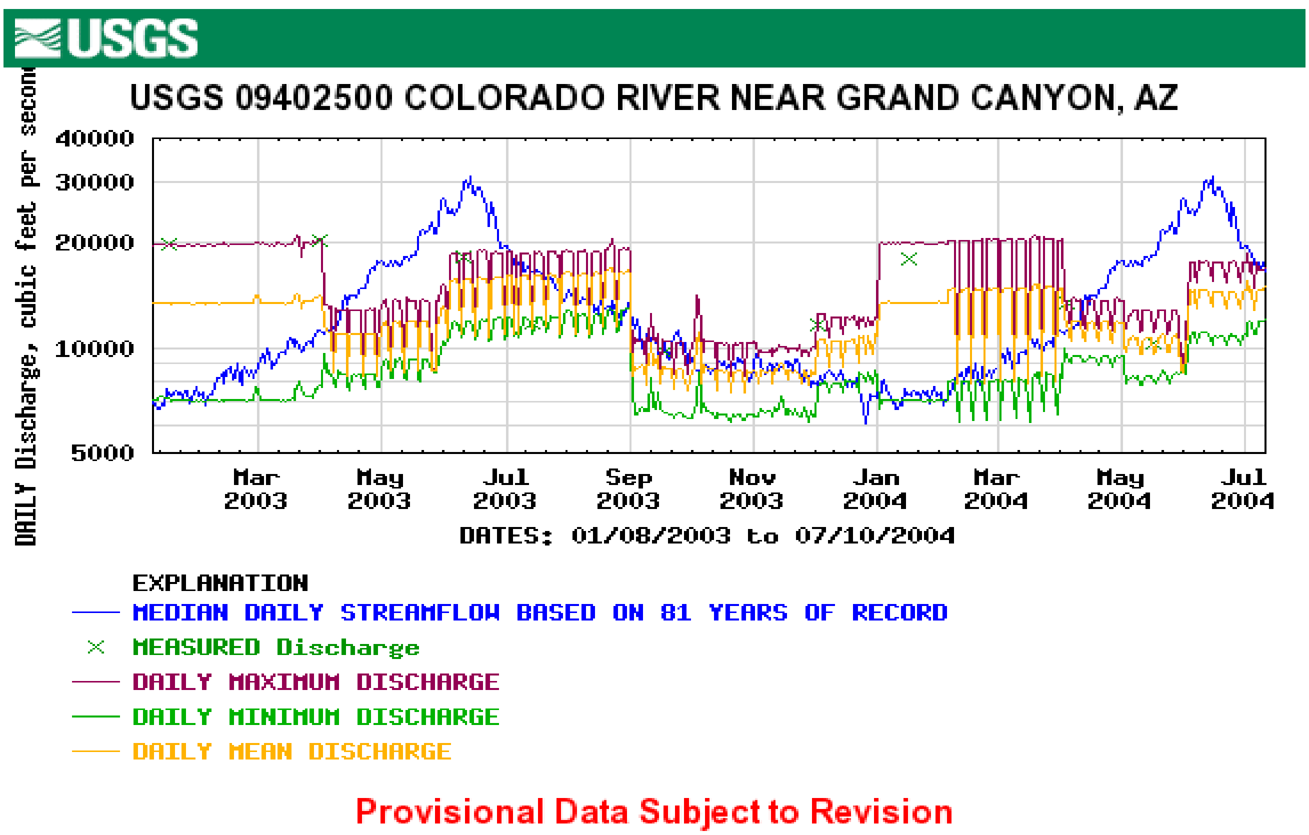


Figure 2. Hydrograph of Colorado River in Grand Canyon from winter 2003 through summer 2004. Graph downloaded from USGS website..

This section provides both a summary of results from previous data collected around significant flow events and new results that stem from 2003 events.

Longevity of Beaches Since the 1996 Beach/Habitat Building Flow

The success of the Beach/Habitat Building Flow of 1996 demonstrated the need for periodic beach building for maintaining the campsite beaches in Grand Canyon. Over 25,000 river runners and backpackers to the Colorado River in Grand Canyon rely on these campsites for recreation. In March 1996, Glen Canyon Dam released a flow of 45,000 cfs in order to suspend sediment stored in eddies, and deposit it to high elevation sand bars. While this test flood flow benefited a large majority of campsites in Grand Canyon (Kearsley and Quartaroli 1997, Thompson and others 1997), it mined out lower elevation bars and sediment in the river channel due to its long duration (Topping and others 2000). A multitude of sediment studies determined that future BHBFs can be extremely beneficial if the duration of the high flow release is limited to 48 hours and if the Colorado River has received recent sediment inputs from the major tributaries (Rubin and others 2002, Lucchitta and Leopold 1999, Topping 1997).

Today, the persistence of this deposit is of great interest to resource managers and users of these high elevation bars. Each year, end-of-season photos are compared to pre-BHBF photos (taken in March 1996) to determine if and how many sites have returned to their original pre-BHBF condition. In a few cases, sites appear to have lost more area compared to its pre-BHBF condition.

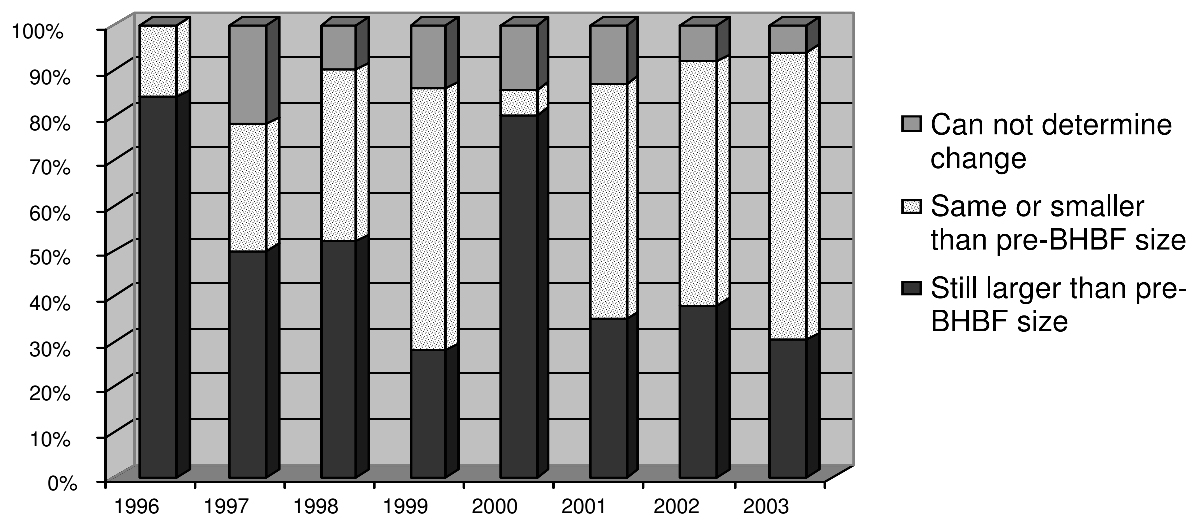


Figure 3. Relative size of beaches for each year compared to their pre-BHBF 1996 size. Comparisons were made using end-of-season photos for each year compared to February 1996 photos.

Figure 3 shows a trend in which the percent of beaches that have returned to the pre-BHBF size, have continually gone up until year 2000, when the HMF of 30,000 cfs was imposed. The percent of beaches showing rampant erosion is especially prevalent in 1999, at which point 58% of beaches had returned to the pre-BHBF condition. The HMFs in year 2000 improved area for 80% of beaches. However, sand replenished to this deposit mostly affected low-elevation bars, as the spike flows were limited in stage height. By fall 2001, erosion had progressed to the point that over 45% of beaches had returned to their pre-BHBF size. Results for 2002 and 2003 are similar to those in 2001. This indicates a level of quasi-stability with the remaining BHBF deposit. The declining rate of decrease exemplifies the initial rapid adjustment of newly aggraded bars to relatively normal dam releases following the 1996 BHBF. This data agrees with that of Hazel and others (2001), where sand bar thickness has been decreasing every year since 1996, but at a decreasing rate.

Longevity of the Habitat Maintenance Flows of Year 2000

Two spike flows of 30,000 cfs were released from Glen Canyon Dam for four days in early May 2000 and again in September 2000. Both flows showed similar results where an average of 60% of beaches increased in size (Figure 4). The Spring HMF increased campsite area to more beaches, probably because antecedent long-term erosion had created more accomodation space for deposition compared to antecedent conditions for the Fall HMF. Most beach area was gained at the beachfront for both HMFs. Deposition from the HMFs increased beach elevation at most by approximately 0.1 meters on the higher elevation bars up to the 30,000 cfs line. When the two HMFs were compared by reach, most beaches in Muav Gorge benefited over the other reaches. The net increases to Muav Gorge beaches may be a result of greater sediment supply due to two factors: (1) distance below the Little Colorado River

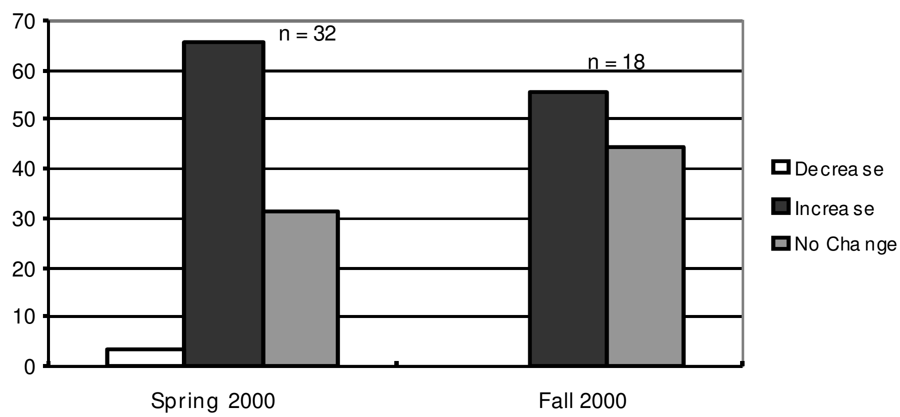


Figure 4. Number of beaches showing change due to the spring and fall HMFs

(Schmidt 1990, Webb 1996) where cumulative inputs from this tributary benefit downstream reaches in Grand Canyon; and (2) upstream erosion of beaches in Marble Canyon and Upper Gorge that ultimately benefit beaches located further downstream (Hazel and others 2002).

Photos taken in fall 2001, compared to those taken shortly after the fall 2000 HMF event, show little to no evidence of the HMF deposit remaining. Only 11% of beaches showed evidence of this deposit. By 2002, only 3 beaches showed any evidence of this deposit. Either the deposit had been mostly scoured away or the deposit is now too insignificant in size to be detected in many of the photos. This evidence supports the preliminary conclusion that the HMF deposits only last as long as flows remain very low (Thompson 2001, Hazel and others 2002). Otherwise, the HMF deposit is eroded away within a few months to a year after its emplacement

Results of the 2003 Winter High Fluctuating Flows (January 1 to March 31, 2003)

The effects of erosion or deposition on beaches after the test flow in winter 2003 was assessed by comparing photos taken in November 2002 and those taken in April 2003. Figure 2 shows the high daily fluctuations imposed during the winter. Visible changes to beaches, as determined from photos, were assumed to be from these flows. If fresh gullies were seen in the photos, we presumed that rainfall caused the predominant change. Erosion from camping is either non-existent or minimal due to the "off-season" of river traffic. The category "Don't Know" is recorded for those beaches whose photos or data could not be clearly interpreted.

Out of 38 beaches for which data was available, 21% showed a decrease, 18% showed an increase, and 56% showed no change in visible area, although a fresh coverage of sand was apparent on many beaches (Figure 5). Overall, more beaches increased in size compared to the previous winter season changes in 2002, at which time only 3% of beaches showed an area increase. Marble Canyon beaches showed equal numbers of decreases, increases ,and no change to their net areas. Only a few beaches in 2003 showed the prominent cutbanks that were so widespread in winter 2002. Gullies that were present in year 2002 were infilled by April 2003. This implies that some beneficial maintenance of campsite beaches were due to the high fluctuating flow regime over winter 2003. However, most beaches in the sample set stayed the same net size, although fresh sand was clearly visible in photos. Beaches that displayed decreased areas had deflated beach fronts and built-up benches in their eddies, rendering boat parking problematic.

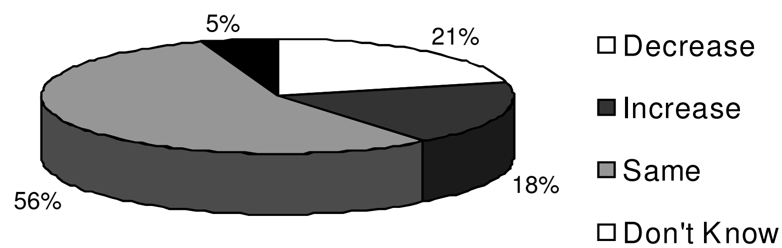


Figure 5. Percent of beaches (n=38) showing change over the 2003 winter season.

In separating the data by reach, Marble Canyon contained the highest percent of beaches showing increases (Figure 6). Most increases were reported to be at the beachfronts, where eddies had also been scoured out and sand was re-deposited at the lower beach area. This beachfront maintenance is valuable for keeping recreation near the river. In looking at Marble Canyon as a whole, the number of beaches that gained sand, lost sand, or stayed the same were mostly equally distributed. Between 10% to 15% of beaches showed loss of sand due to the daily high fluctuating flows.

Higher elevation sand (above the 30,000-cfs line) continues to be reworked by wind and incorporated into the 1996 BHBF deposit. Few remnants of the HMF deposit remain on only a few beaches. Furthermore, no guides reported that winter season rainfall caused any decreases to beach size. All decreases were attributed to primarily the high daily fluctuating flow and secondarily to wind, based on guide reports.

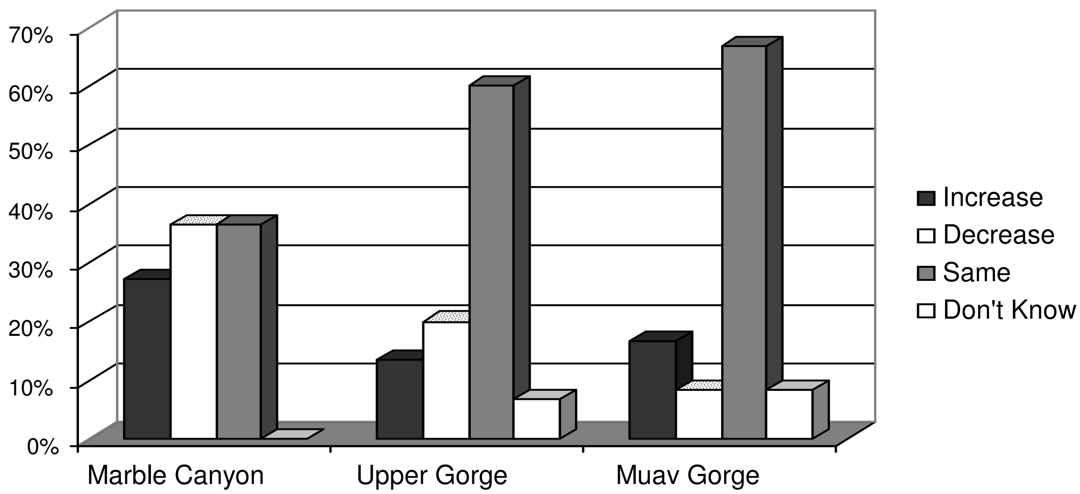


Figure 6. Percent of beaches by reach that shows change following the daily high fluctuating flows from winter 2003.

Summer Season Change and Processes Causing Decreased Beach Size

In order to determine primary causes of erosion, various processes causing beach change, whether erosional or depositional, were recorded via guide comments and analysis of

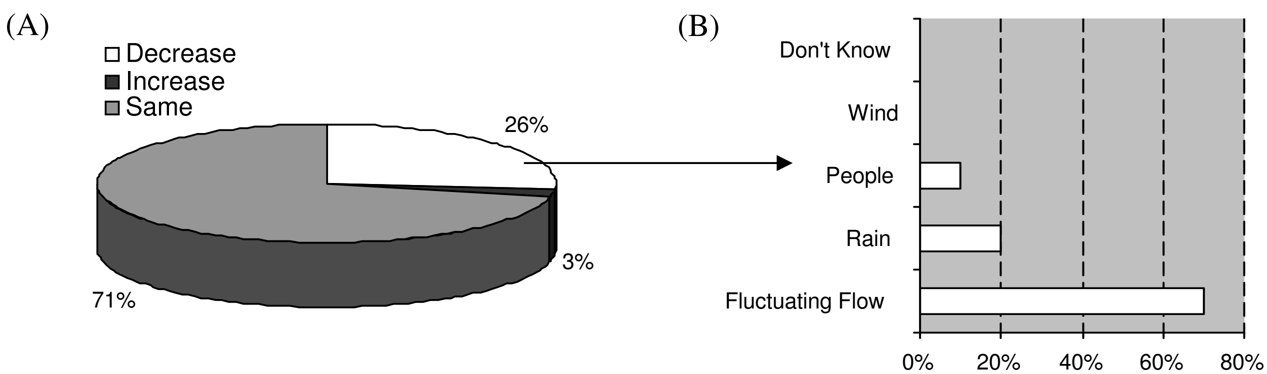


Figure 7. (A) Percent of beaches showing cumulative change throughout the 2003 river season. (B) Dominant process causing the 26% of beaches to be negatively impacted

photographs. Morphological characteristics were recorded as outlined on the data sheet in Appendix A. One primary and one secondary cause were identified for each visit per site.

Figure 7 shows all identifiable processes that contribute to change on beaches. Erosional processes resulted primarily from medium fluctuating flows throughout the months of July and August and secondarily from flash flooding during the monsoon season. Beaches impacted by fluctuating flows showed progressive cutbank retreat through the month of August. Beaches impacted by rain showed loss in area due to gullies or rock and gravel influx. Erosion from people was less significant,

In separating data by reach (Figure 8), impacts from fluctuating flows and rainfall were

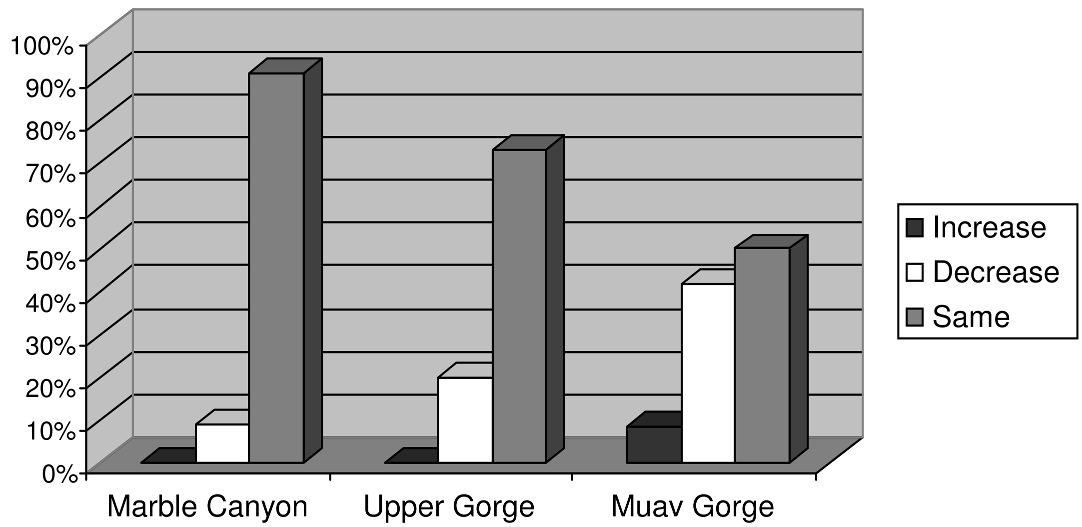


Figure 8. Summer season changes to beaches separated by reach.

most evident in Muav Gorge. Intense monsoon conditions created gullies through these camps. Marble Canyon beaches showed little relative change since the winter test flows and only a couple camps showed erosion from fluctuating flows and flash flooding. In previous years, Marble Canyon typically showed the least number of beaches decreasing in size, probably because so much erosion had already occurred in reaches above the Little Colorado River.

Camping Quality

To summarize, the Low Steady Summer Flows (LSSFs) of year 2000, provided the best campsite quality and accomodation space since the BHBF of 1996. During the LSSF many small new beaches, upstream and downstream of their adopted beach, became available for camping. Also, adopted beaches such as Clear Creek, Olo, and Talking Heads (all of which are mostly under water at higher flows), again became useable camps under the LSSF. With the onset of the LSSF after the spring HMF (Figure 9(A)), 51% of beaches showed "much improved" camping, according to guide responses. These camps contained more sandy beachfront property, decreased rockiness for better boat parking, and a relatively flat bench for kitchen set-up and camping. The rest of the sampled beaches remained either the same for useable space or became more inaccessible due to increased rockiness for boat parking.

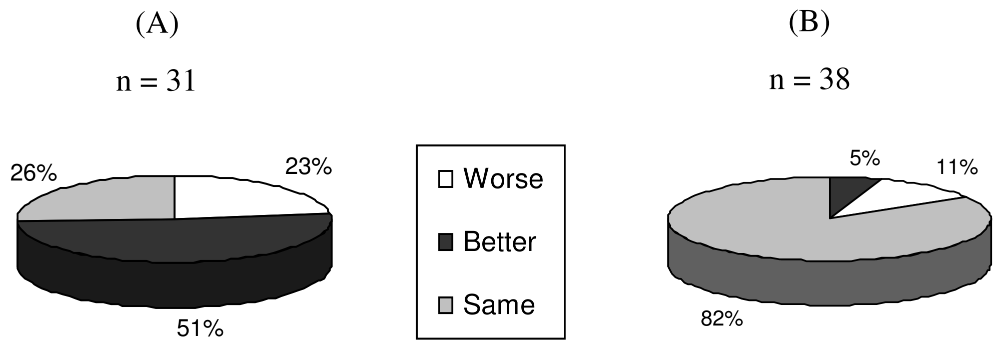


Figure 9. Campsite conditions: (A) during the LSSF of 2000- first response by guides with the onset of the LSSF and; (B) after the high fluctuating flows of winter 2003 – the first response of the season by guides.

Campsite conditions following the high fluctuating flows in winter 2003, largely stayed the same, according to guide responses (Figure 9(B)). Guides reported variable camping conditions after the winter high fluctuations. Although there was an influx of fresh sand on some lower bench areas, many eddies below beaches contained subsurface sandbars. Overall, guides felt that the previous winter flows only maintained the beaches slightly by leveling off lower camp areas on some beaches while steepening the slope on others. Gullies from the previous monsoon season had been infilled.

A few remarks were recorded regarding increasing tamarisk encroachment and the increased presence of red ants at some campsites. Increasing vegetation can be clearly seen at most campsites in the photos from year to year. The winter high fluctuating flows can help in "cleaning up" camps below the 30,000 cfs zone, where much recreational activity takes place.

CONCLUSIONS

Results of this study since 1996 show that beaches have continued to decrease in size, system-wide even after the HMFs of 2000 and the high fluctuating flows of 2003. Over years 1996-1999, the net effect of controlled flow releases from Glen Canyon Dam resulted in the continued winnowing of beachfronts, cutbank retreat, and loss of camping areas. Most negative impacts from fluctuating flows were reported in 1997 (O'Brien and others 2000). Erosion to beaches through years 1998-1999 continued, but effects were not as profound. This decreased magnitude of change through the years since 1996 reflects two geomorphic processes: (1) the increased stability of beach fronts as they attain an angle of repose, and (2) decreased amounts of sediment that can be eroded from beaches (O'Brien and others 2000, Hazel and others 2002). By fall 2001, most beaches that had initially gained area from the HMFs of 2000 had returned to their 1999 condition. These conditions persist today.

Many factors are contributing to long-term erosion of these beaches. Primarily, erosion from medium and high fluctuating flows that contain low sediment concentrations have resulted in conditions that are similar to those before the BHBF of 1996. Secondary processes contributing to erosion are listed here ranked according to magnitude of impact: (1) gullying and flash-flooding from rainfall; (2) beachfront erosion from campers; and (3) wind deflation. Some campsite area loss is due to encroachment of vegetation, mostly tamarisk.

Campsite area and quality can be greatly enhanced by implementing BHBFs well above power plant capacity, given there is available sediment inputs from the Paria and/or Little Colorado Rivers (Lucchitta and Leopold 1999, Hazel and others 2002, written responses by Grand Canyon river guides 2001). Over 80% of guides agreed that camping (useable space and quality) had improved dramatically during the LSSF that followed the spring HMF 2000. Moreover, camps that would normally be under water became available for use. By spring 2001, most guides reported worse camping conditions. This is attributed to relatively higher fluctuating flow zones on beaches, rendering the lower camping area more useless, and eroded beachfronts that presently expose rocks. The lack of a lower camping area will inevitably force camping and recreation into higher zones, into the more fragile ecosystem.

The results of 8 years from this monitoring program show that the BHBF of 1996 was the most beneficial management action for replenishing and rebuilding beaches for campsite use. All other subsequent test flows produced small new deposits that only lasted for 7-12 months, at most. These results suggest that any newly deposited sand within power plant capacity will be quickly eroded if followed by high fluctuating flows released from Glen Canyon Dam. This was evidenced by 3 events: (1) High fluctuating flows (of about 27,000 cfs) following the 1996 BHBF eroded much of the new deposit at all beach sites through the summer of 1996 and 1997; (2) High fluctuating flows following the fall HMF of 1997 stripped away the new deposit entirely by spring 1998; and (3) Medium fluctuating flows following the fall HMF of 2000 eroded most of the new deposit by spring 2001. To date, less than 30% of beaches still show evidence of high-elevation sand (above 30,000 cfs line) deposited by the 1996 BHBF. However, the amount of sand is diminishing year after year, due to wind erosion and the lack of new flood sand deposited by the river.

Annual implementation of HMFs in spring and in fall would help preserve camping beaches by maintaining the beachfront. High fluctuating flows (5,000-20,000 cfs) are an acceptable winter flow regime, as beaches did not lose as much sand over winter months as in previous years. However, high winter fluctuating flows should not be a replacement for HMFs or BHBFs. A regimen of BHBFs that exceed power plant capacity followed by low fluctuating flows is needed periodically to rebuild campsite areas above the 30,000 cfs line. However, future BHBFs need to have enough sediment in the system so as to preserve Marble Canyon beaches and lessen impacts on lower beach areas (below the 20,000 cfs line) systemwide.

Acknowledgments

Grand Canyon River Guides, Inc., would like to thank first and foremost the adopters for volunteering the time to pull over and photograph their beaches trip after trip and year after year, and for their valuable written observations and comments. It takes time and effort to do this, and the dedication shown by guides has literally kept this program alive for eight years. The result is the most comprehensive collection of repeat photographs of critical camping beaches in existence for Grand Canyon. An added benefit is the outreach to the public about this effort, and how our resource in Grand Canyon is affected, degraded or maintained by the influence of man and technology. Special thanks go to Lynn Hamilton for exhaustive work in support of this project; Joe Pollack for his persistence in helping to analyze data and scan photos; Andre Potochnik for his continued hard work as GCRG's (and therefore, this project's) representative of recreational interests in the Adaptive Management process. Finally, big thanks go to our contributors: the Grand Canyon Monitoring and Research Center and the Grand Canyon Conservation Fund.

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