

Sandbars and Sediment Storage in Marble and Grand Canyons: Response to Recent High-flow Experiments and Long-term Trends

GCMRC Project 3

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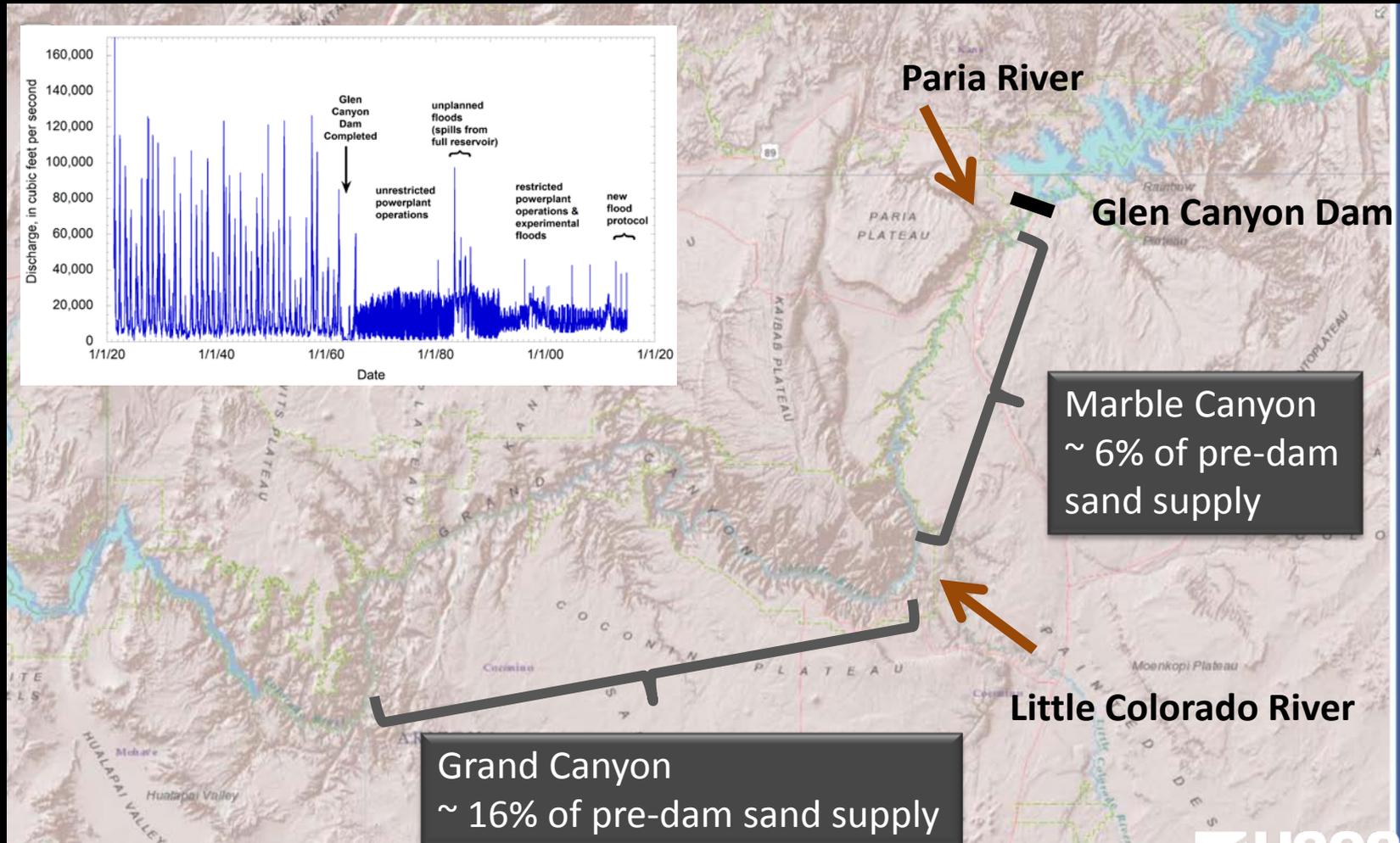
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Overview

- Sandbar response to High-Flow Experiments (HFEs) implemented under HFE protocol
- Changes in campsite area
- Relation between dam release volumes, sand retention, and sandbar erosion
- Modeling (Erich Mueller talk)
- Bedload transport (Daniel Buscombe talk)

Review of Problem: Sediment budget affected by disruption of sand supply and change in flow regime



River Mile (RM) 30 R



HFE Deposition →



Summer 2015 erosion →





RM 23: 2014 HFE – pre-flood



RM 23: 2014 HFE – post-flood



RM 23: 2014 HFE – 3 months post-flood



RM 23: 2014 HFE – 6 months post-flood



RM 23: 2014 HFE – 9 months post-flood



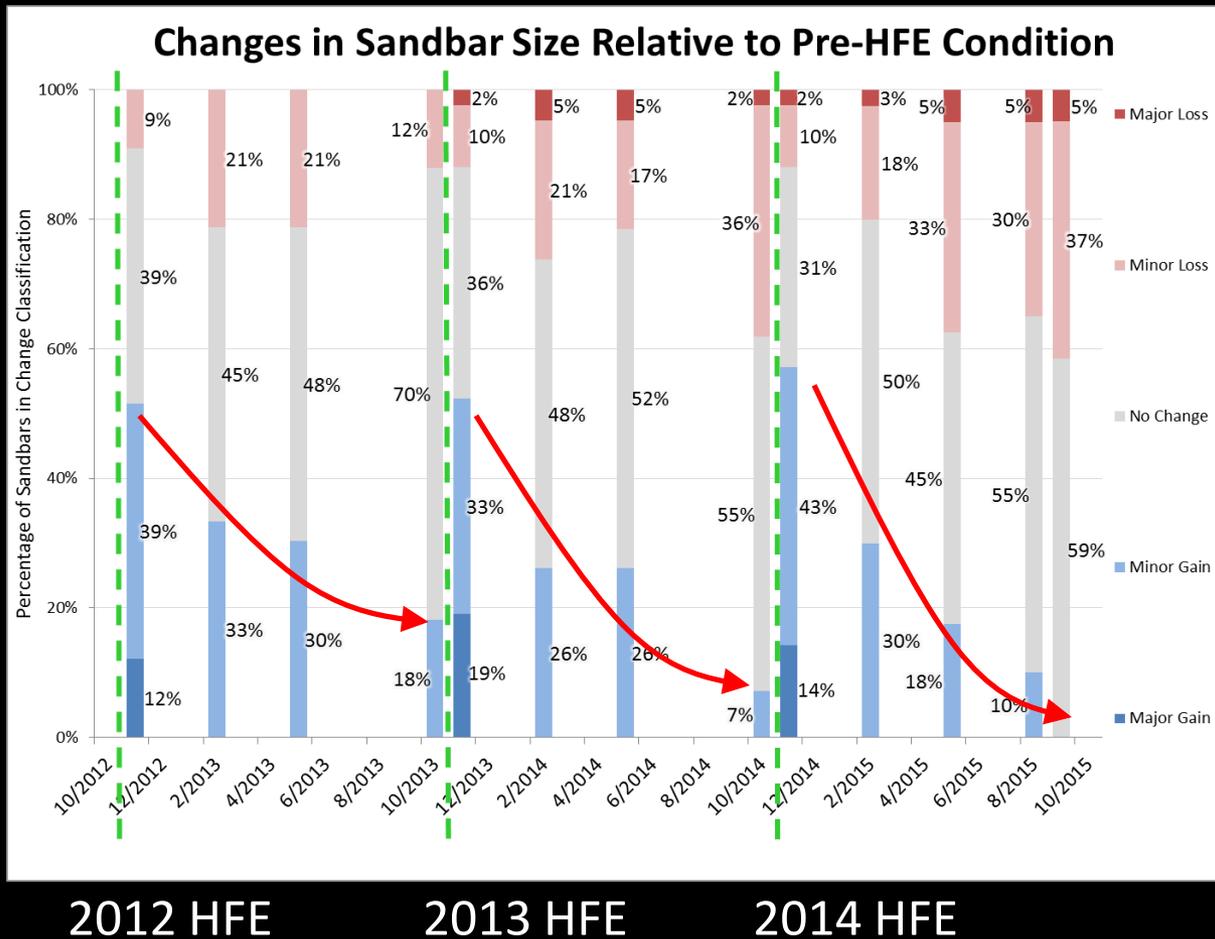
RM 23: 2014 HFE – 11 months post-flood

2014 HFE



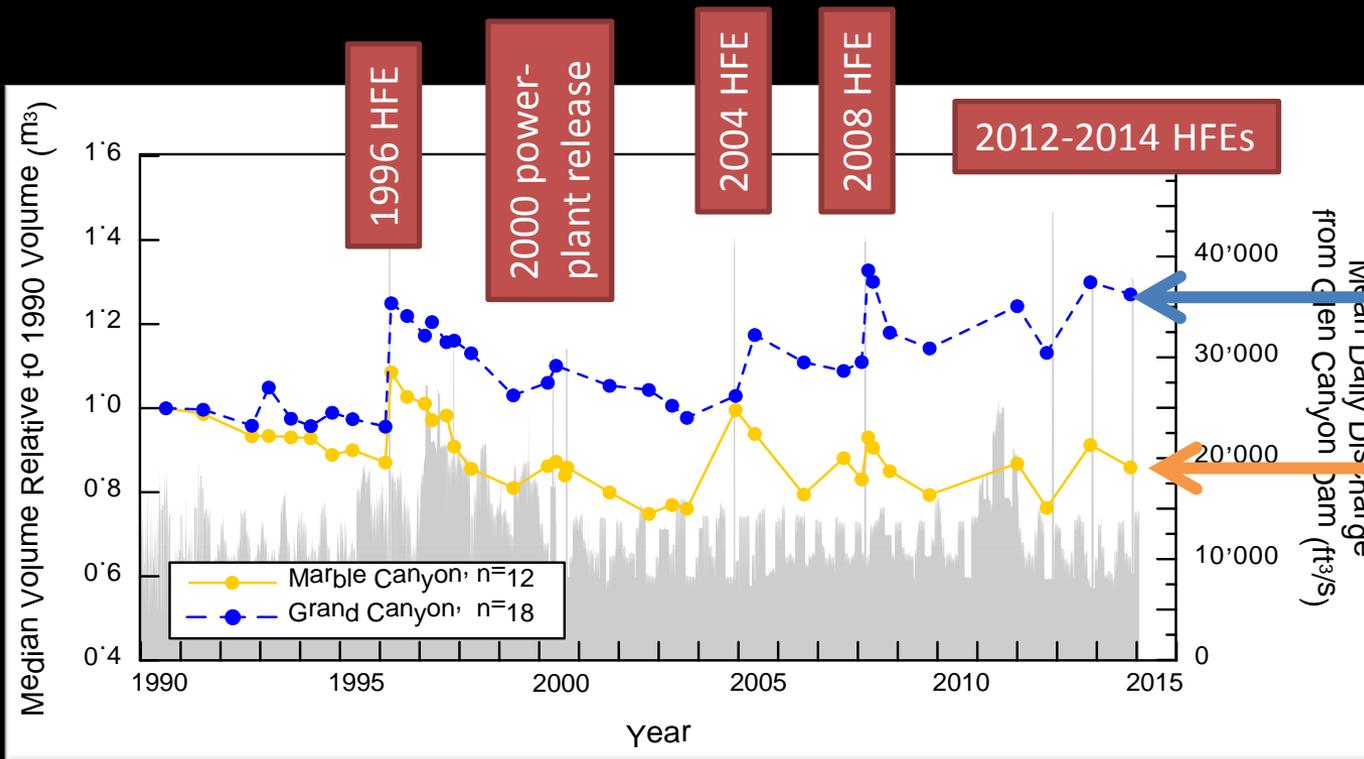
- Immediate post-flood
 - 22 sites (58%) larger
 - 11 sites (29%) no change
 - 5 sites (13%) smaller
- 11 Months post-flood
 - 24 sites (60%) no change
 - 17 sites (40%) smaller

Response to HFE Protocol



- Each of the three HFEs between 2012 and 2015 resulted in sandbar deposition
 - Bars eroded in 6 to 12 month period after each HFE
- By October 2015, no bars larger than before the 2014 HFE

Sandbars: 1990-2014



Grand Canyon: bars about as large as ever measured

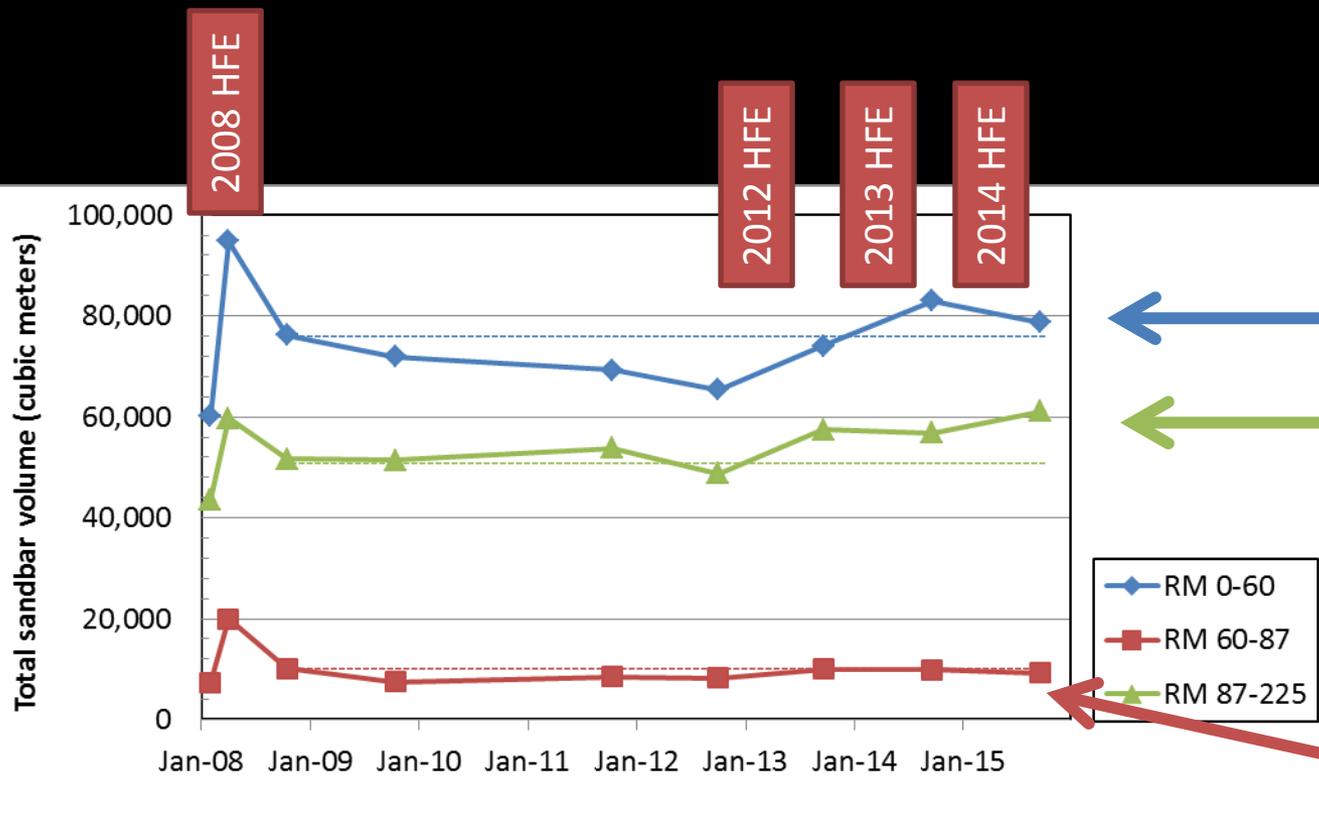
Marble Canyon: bars larger than low point; smaller than early 1990's

- 30 monitoring sites have data to 1990
 - 12 in Marble Canyon
 - 18 in Grand Canyon
- Increase in sandbar volume at sites in Grand Canyon
- Marble Canyon bars still less volume than 1990, but larger than low point of 2001-2003



preliminary data, do not cite

Sandbars: 2008-present



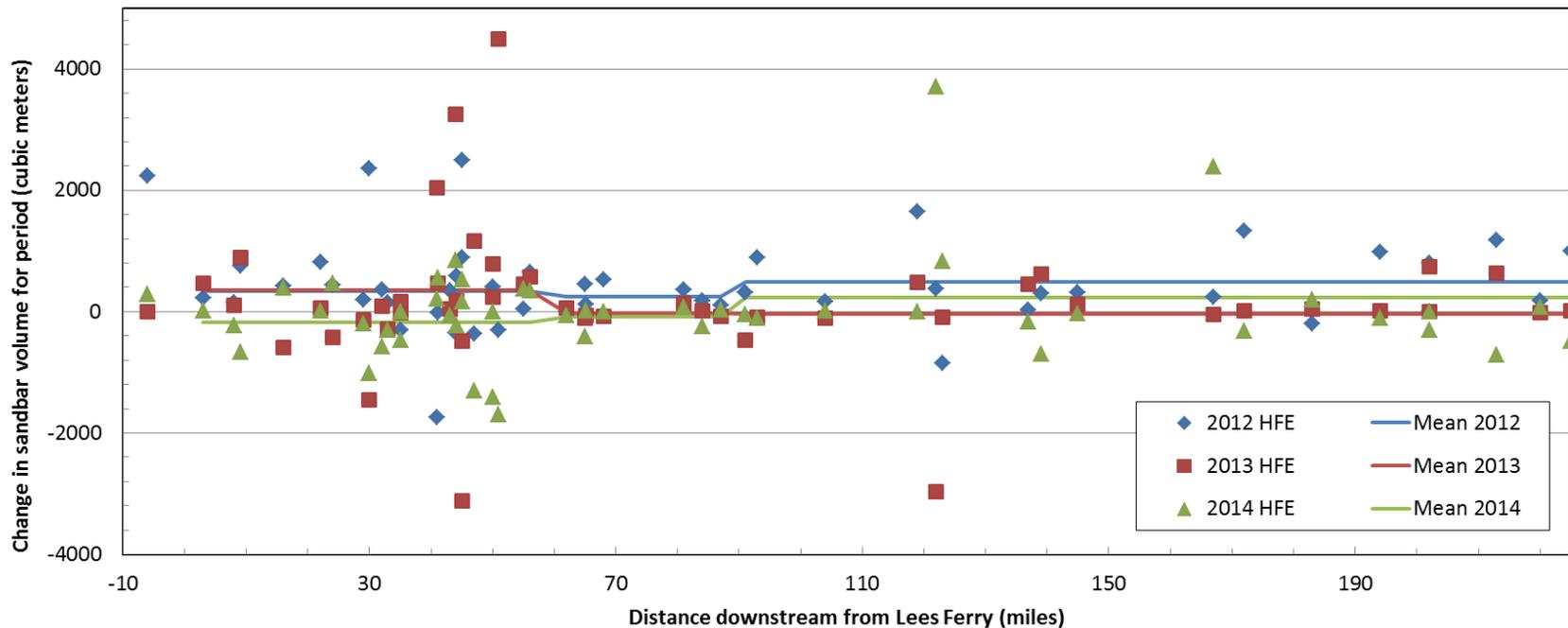
Marble Canyon:
slightly larger than
Oct. 2008

Grand Canyon
(below RM 87): large
relative to Oct. 2008

Grand Canyon
(RM60-87): same
relative to Oct. 2008

- 50 individual sandbars with data 2008-present
 - 25 in Marble Canyon
 - 7 in Grand Canyon (RM 60-87)
 - 18 in Grand Canyon (below RM 87)
- With October 2008 as reference (8-month post-HFE)
 - Increase in Marble Canyon and Grand Canyon (below RM 87)
 - No change in Grand Canyon (RM60-87)

Downstream Trends in Sandbar Response to recent HFE's



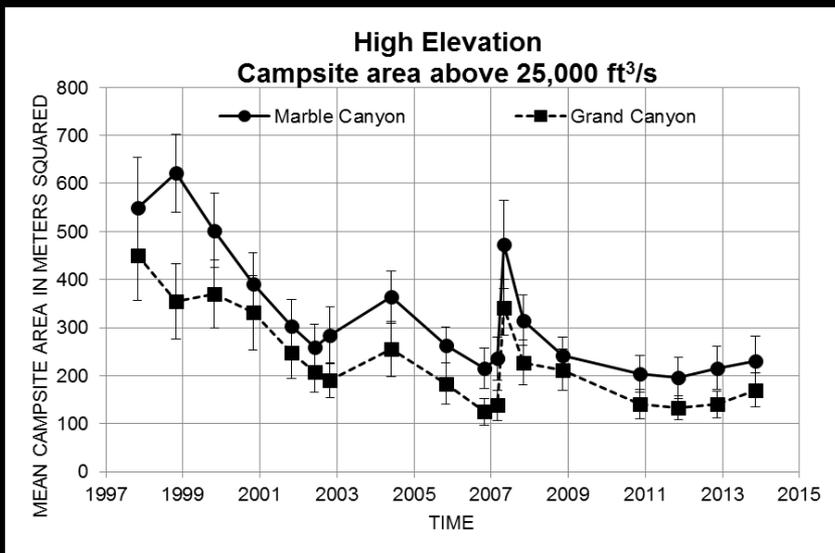
Sandbar volume evaluated 11 months following each HFE

- 2012 HFE
 - Mean positive response in all reaches
- 2013 HFE
 - Mean positive response in Marble Canyon only
 - Mean neutral in all of Grand Canyon
- 2014 HFE
 - Mean positive response in Grand Canyon (below RM 87) only
 - Slight negative response in Marble Canyon
 - Neutral response in Grand Canyon (RM 60-87)

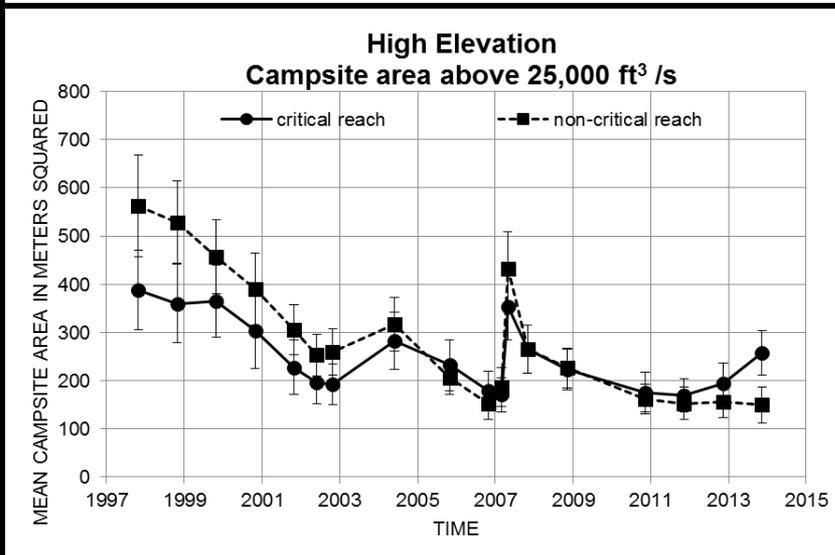
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Campsite Area: 1998-2014

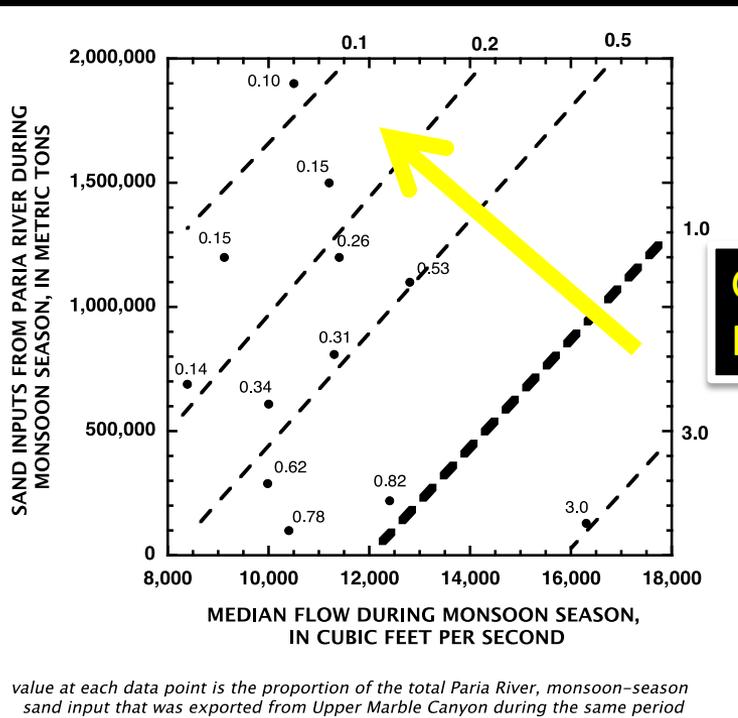


- Slight increases in Marble Canyon and Grand Canyon since start of HFE protocol
- Most of those increases occurred in “critical” campsite segments
- Net declines in campsite area between 2002 and 2009 result approximately equally from vegetation encroachment and sandbar erosion (Hadley, 2014)



preliminary data, do not cite

Relation between Dam Releases and retention of Paria sand inputs and sandbar response

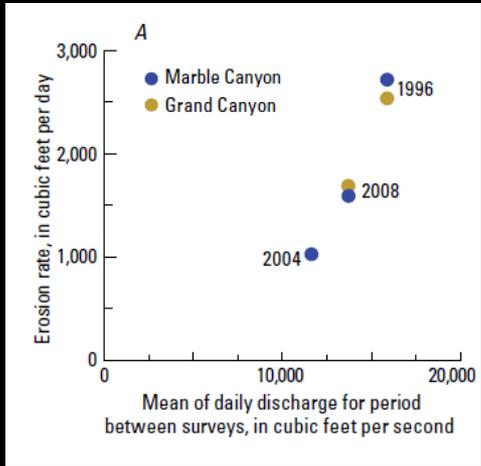


Greater retention of Paria River sand inputs

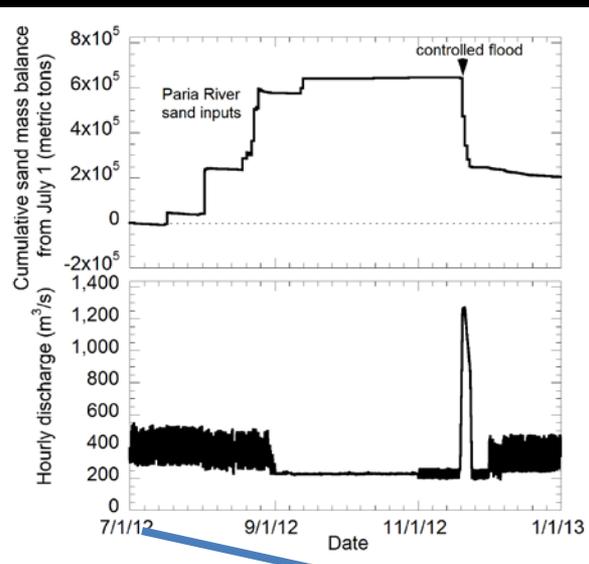
Larger average release volumes result in greater export of sand inputs (*Jack Schmidt plot of data from GCMRC web site*)

preliminary data, do not cite

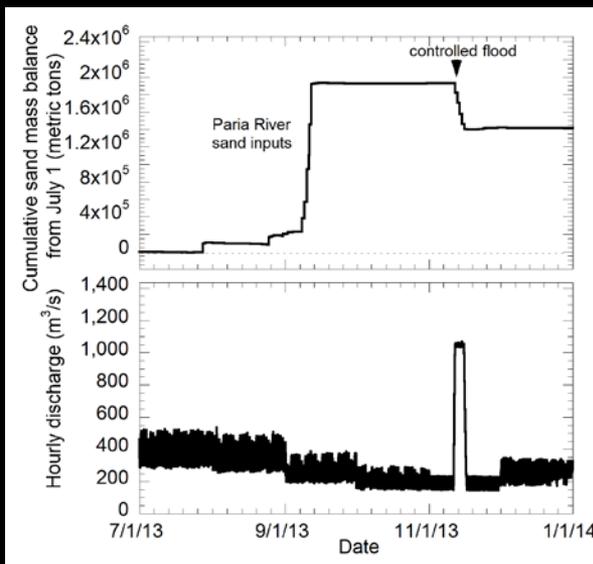
Larger average release volumes result in greater rates of sandbar erosion following HFE's (*Hazel et al., 2010*)



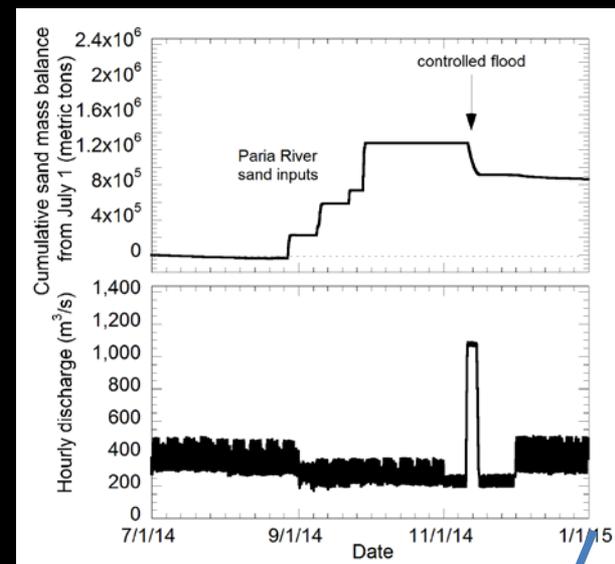
Sand Storage in Marble Canyon During HFE Protocol



2012 HFE

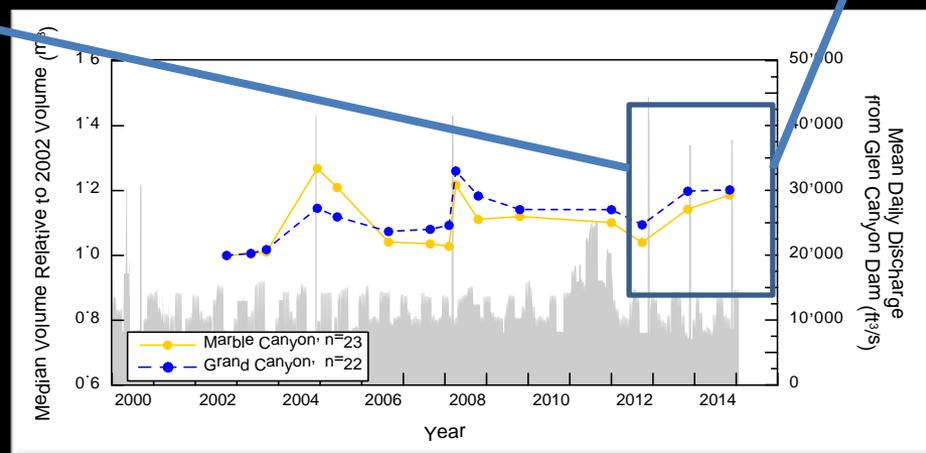


2013 HFE



2014 HFE

- Since 2012, each year has had enough sand accumulation to have a controlled flood and have sand accumulation
- Accumulation has more than replaced “evacuation” that occurred in 2011



preliminary data, do not cite

Summary

- HFEs continue to build sandbars
- Bars continue to erode between HFEs
 - Greater erosion in years of higher release volumes
- Sandbars larger than periods with no HFEs
- Bars larger now than at start of HFE protocol, but no evidence for “progressive” increases in sandbar size
- High-elevation Campsite area (above 25,000 cfs stage)
 - No net change in non-critical reaches
 - Increase from 2012 to 2014 in critical reaches
- First three years of HFE protocol were a period of low annual release volumes and good tributary sand supply
 - Bar deposition without depleting sand from storage
 - Sand accumulated in Marble Canyon, replenishing sand evacuated during 2011 equalization

