GCMRC Annual Reporting Meeting 2017 Update - Part 2

Adaptive Management Working Group Meeting
February 15, 2015

by
Michael Moran
Grand Canyon Monitoring and Research Center


National Park Service

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Presentation Outline

- **Project 2 – Streamflow, Water Quality, Sediment Transport, and Sand Budgets**

  David Topping[1], Ron Griffiths[1], Dave Dean[1], Nick Voichick[1], Tom Sabol[1], Nancy Hornewer[2], Joel Unema[2], Jon Mason[2], Megan Hines[3], Eric Everman[3], Brad Garner[4]

  [1]U.S. Geological Survey, Grand Canyon Monitoring and Research Center
  [2]Arizona Water Science Center
  [3]CIDA
  [4]Office of Water Information

- **Project 3 – Sandbars and Sediment Storage Dynamics**

  Paul Grams[1], Daniel Buscombe[1], Tom Gushue[1], Keith Kohl[1], Erich Mueller[1], Robert Ross[1], Robert Tusso[1], Joseph Hazel[2], Matt Kaplinski[2], Dan Hamill

  [1]U.S. Geological Survey, Grand Canyon Monitoring and Research Center
  [2]Northern Arizona University

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Presentation Outline

- **Project 4 – Connectivity Along the Fluvial-Aeolian Hillslope Continuum**

Joel Sankey[1], Alan Kasprak[1], Joshua Caster[1], Helen C. Fairley[1], Amy E. East[1], Paul Grams[1], Daniel Buscombe[2]

[1]U.S. Geological Survey, Grand Canyon Monitoring and Research Center
[2]Northern Arizona University

- **Project 13 – Socioeconomic Monitoring and Research**

Lucas S. Bair[1], Charles B. Yackulic[1], Michael R. Springborn[2], Matthew N. Reimer[3], Craig A. Bond[4]

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[2]University of California at Davis
[3]University of Alaska at Anchorage
[4]RAND Corporation

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Project 2: Streamflow, Water Quality, Sediment Transport, and Sand Budgets

How do operations at Glen Canyon Dam affect flows, water quality, sediment transport, and sediment resources in the Colorado River Ecosystem?

- **Continued development of database and website with user-interactive tools for data visualization and downloading (New tool this year)**
- **Publication of 3 peer-reviewed interpretive books/papers and 5 abstracts presented at AGU**
- **Real-time to monthly posting of all discharge, qw, and sediment data (available on website)**
- **Monthly updates of the mass-balance sand budgets (available on website)**

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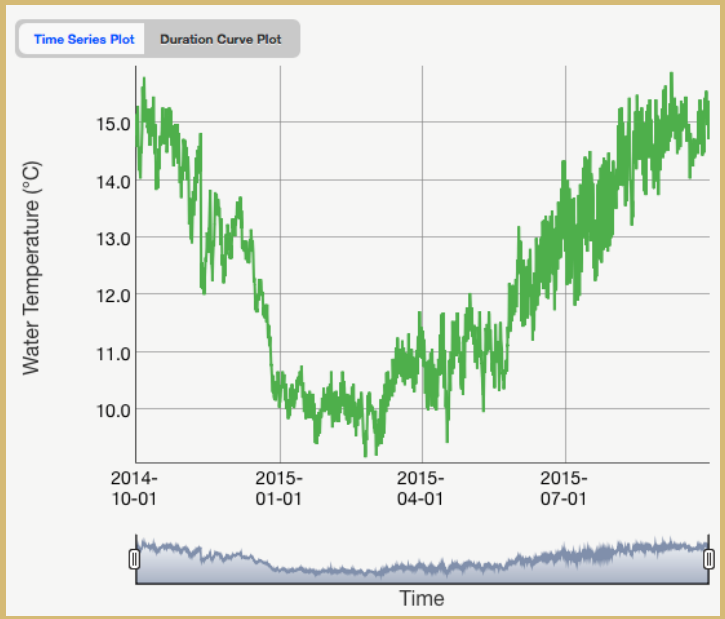
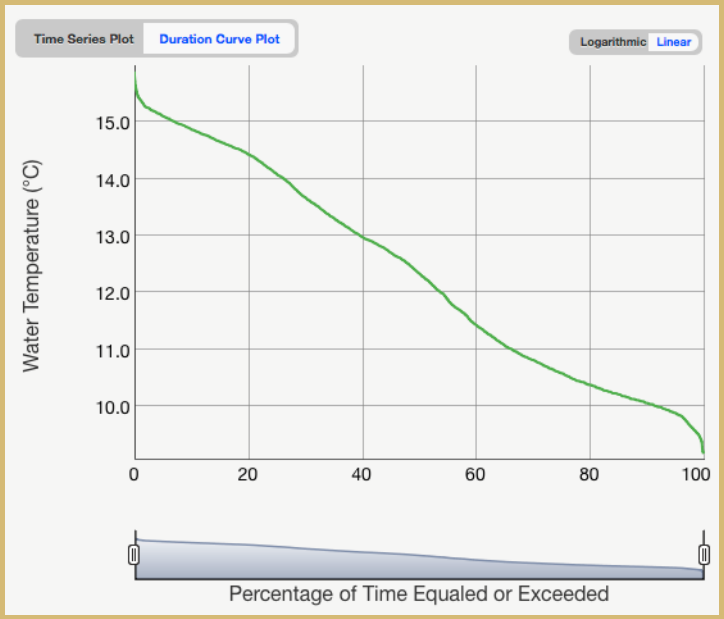
Duration Curve Tool

WY 2015 Colorado River near river mile 66
below the mouth of the Little Colorado River





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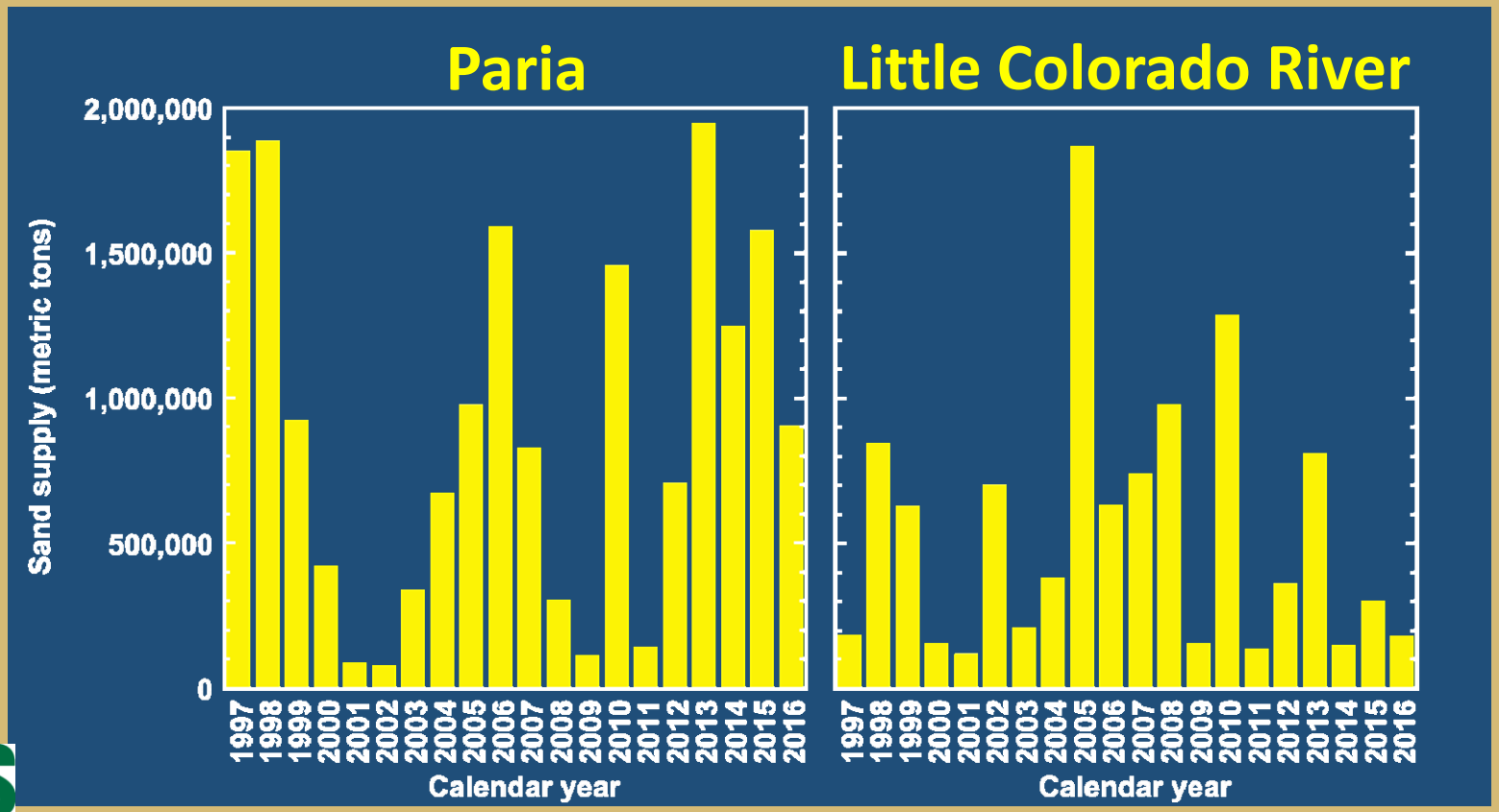
Temporal Pattern of Sand Different Between Tributaries



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Effects of HFEs

Although sandbars have generally been built in each reach during the 2004, 2008, 2012, 2013, 2014, and 2016 HFEs…

…these controlled floods have had different systematic effects on the sand budget in each reach

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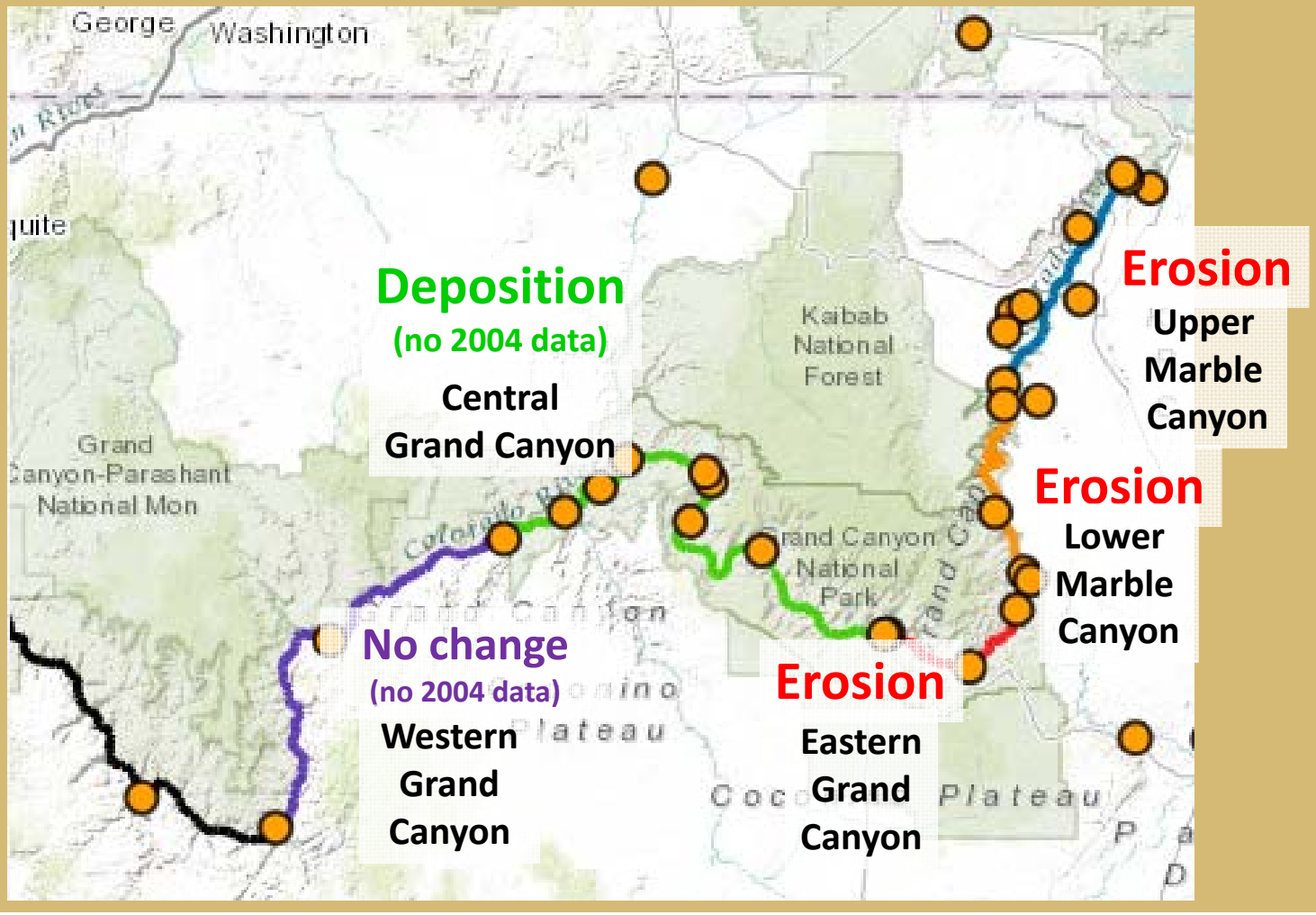
Over the flood hydrographs of the 2004 and 2008 HFES, the following occurred…



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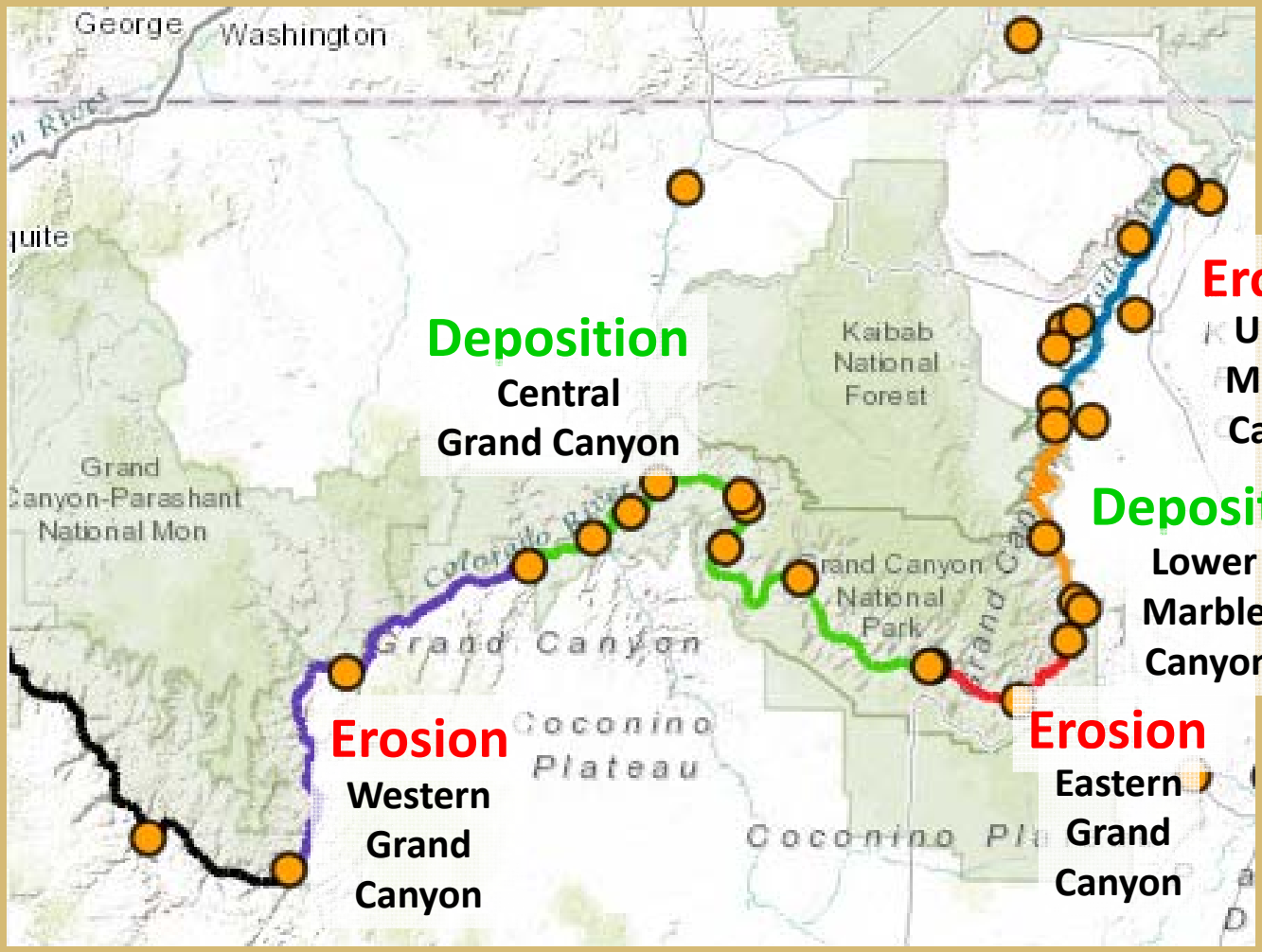
Over the flood hydrographs of each of the 2012, 2013, and 2014 HFES, the following occurred…



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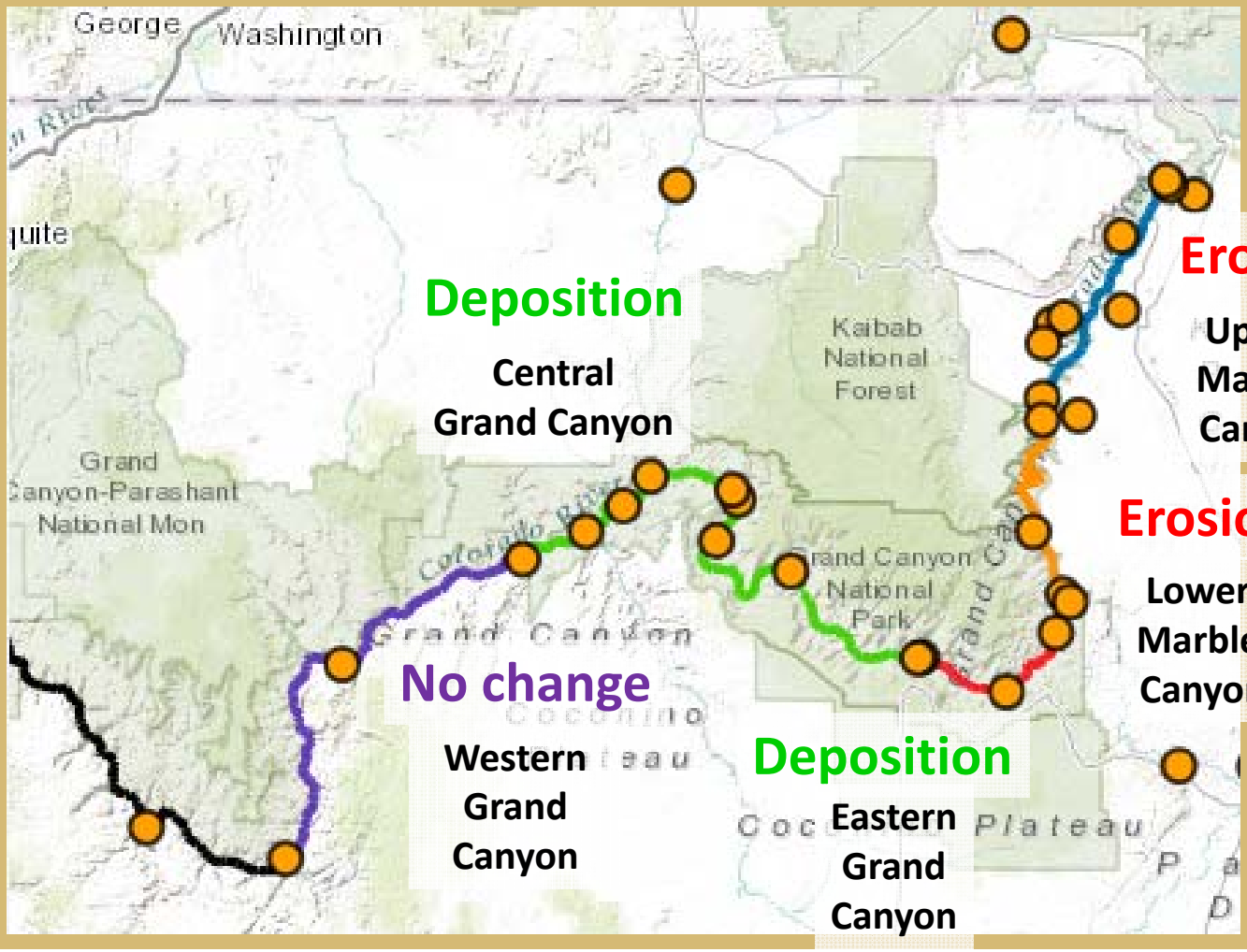
Over the flood hydrograph of each of the 2016 HFE, the following different response occurred…



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Project 3: Sandbars and Sediment Storage Dynamics

On-going data collection, processing, storage, and analysis

- **Web tool for data storage and viewing**
- **Scripted data processing tools**
- **New database for centralized storage and data management**
- **Progress towards a process-based model for sandbar response to various factors**

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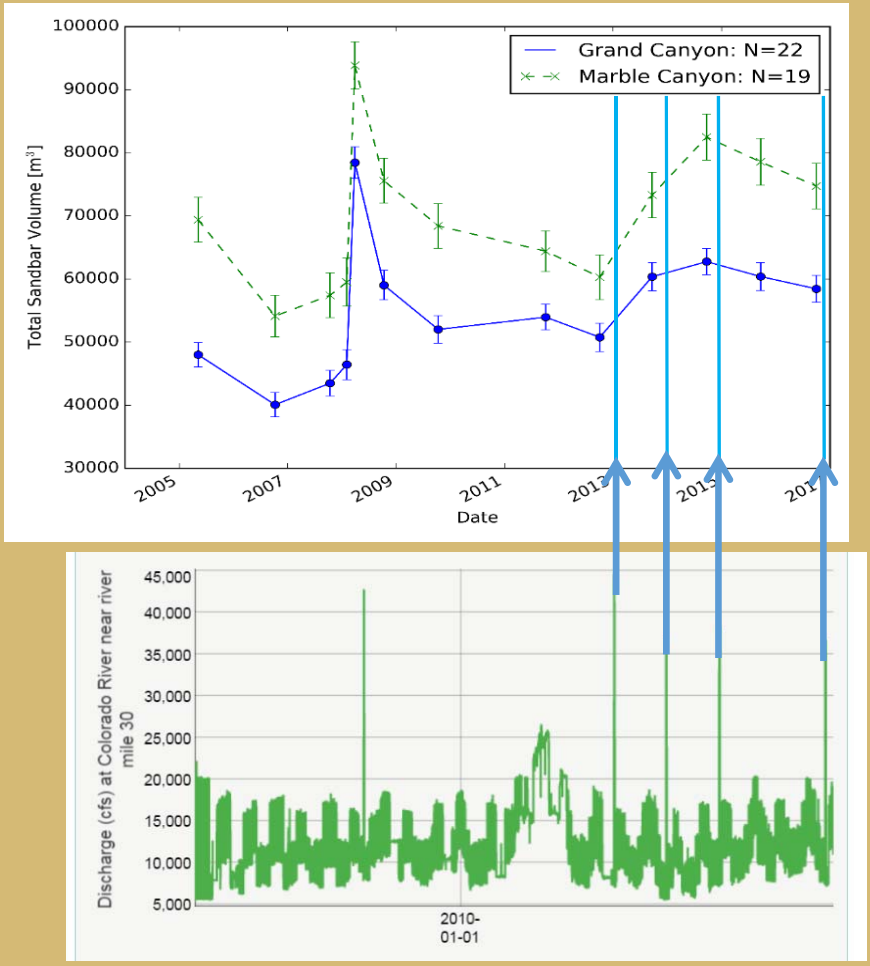
Annual Sandbar Monitoring



preliminary data, do not cite

Period of HFE Protocol

- **Largest increase is during 2012 HFE**
- Bars largest in October 2014
- **"Balancing" flows peaking at 20,000 cfs likely caused more erosion than previous years;** *consistently larger than "average" for period without regular HFE's*

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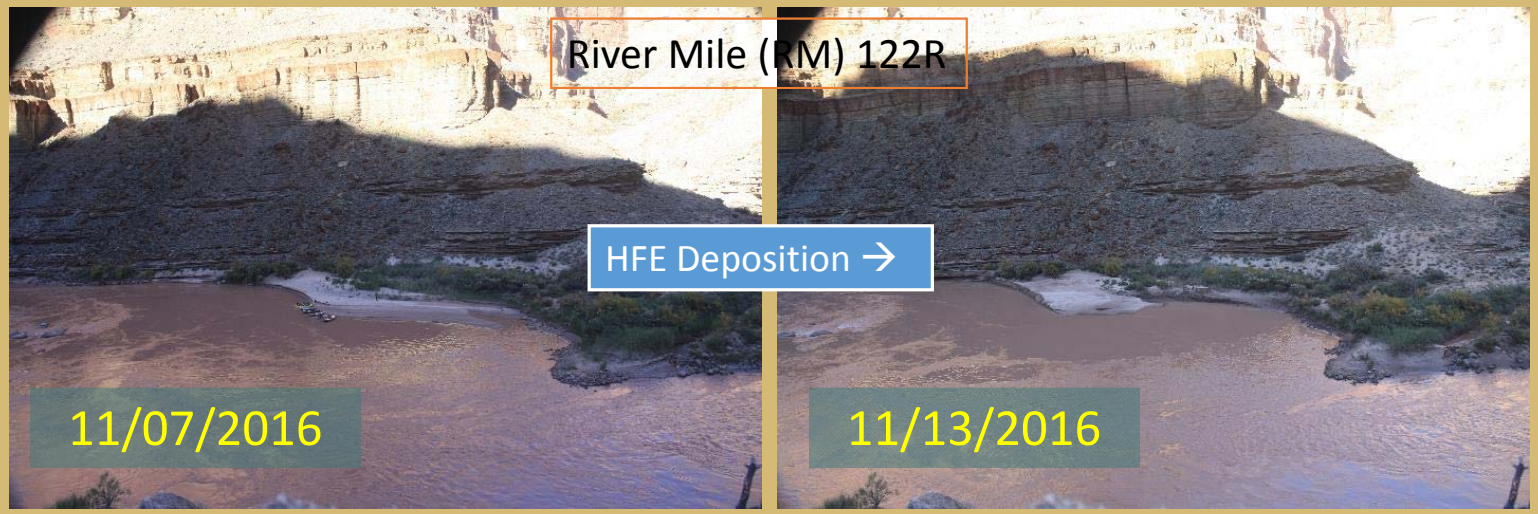
November 2016 High-flow Experiment Sandbar Deposition



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November 2016 High-flow Experiment Sandbar Deposition

Post 2016 HFE images available from 14 out 45 monitoring sites.

Net deposition at 9 sites

Erosion at 2 sites

No net change at 3 sites

Images from remaining sites will be collected in February

preliminary data, do not cite

Next Steps in Sandbar Monitoring: Sandbar Modeling (Project 3.3)

- What is relation between channel shape and sandbar characteristics?
- What is relative importance of site characteristics, streamflow, and sediment supply in determining sandbar response to HFEs?

We know what the monitoring sites are doing, less confident extrapolating to “all sandbars”

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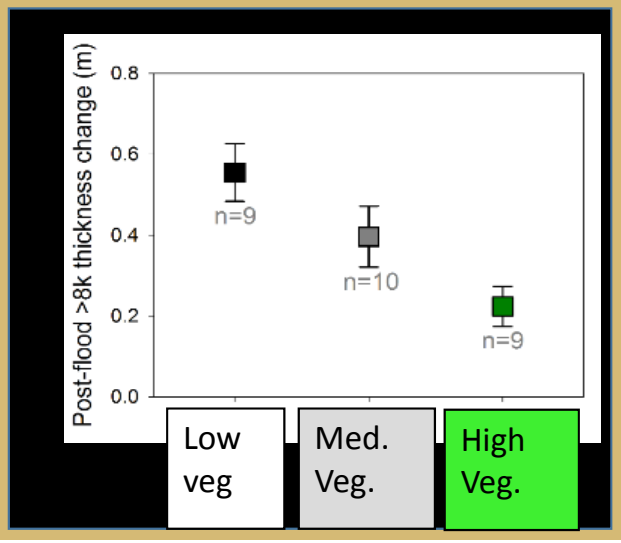
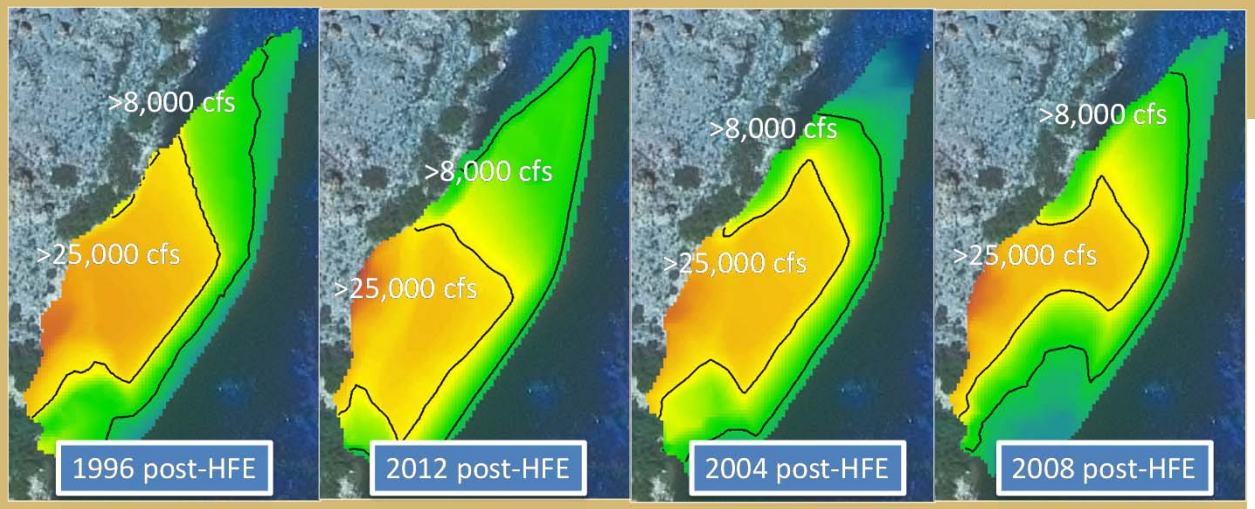
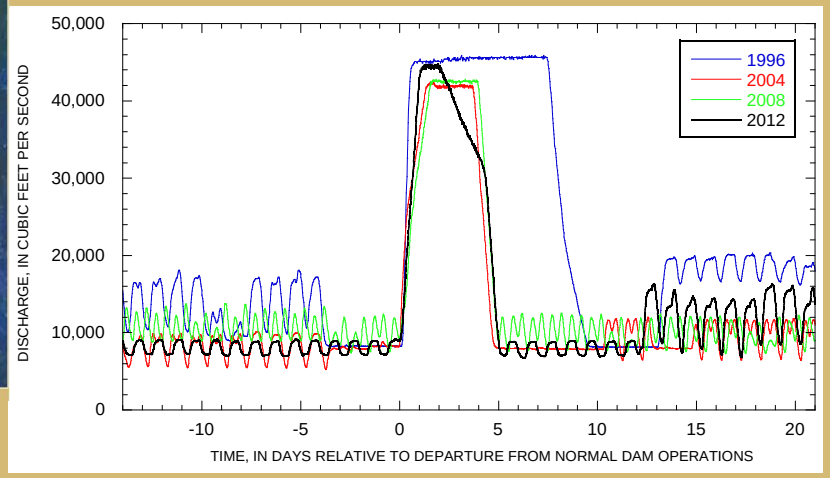
- Many variables have an influence on sandbar production and survival
- For example, vegetation cover is a strongly related to post-flood sandbar thickness
- Sandbar volume is also related flow duration and volume during HFEs







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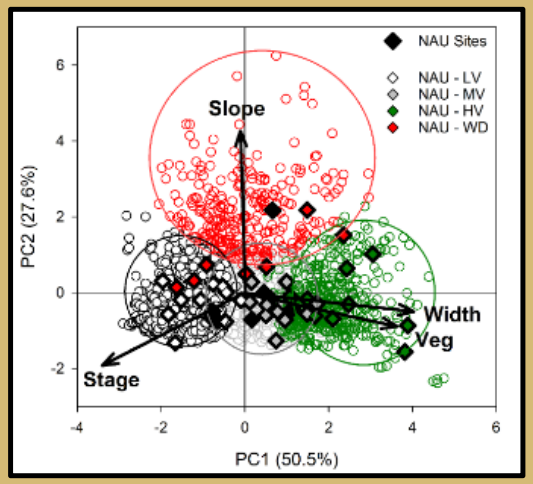
preliminary data, do not cite

Progress is being made towards a process-based model for sandbar response

- Understanding the important variables/drivers for sandbar building and maintenance.
- Building a physical model of a recirculation eddy
- Can describe flow and morphology for comparison and validation with numerical model



preliminary data, do not cite

Colorado River in Grand Canyon

St. Anthony Falls Hydraulic Lab, University of Minnesota

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Project 4: Connectivity Along the Fluvial-Aeolian Hillslope Continuum

Most archaeological sites are situated above HFE stage throughout Grand Canyon…

To preserve these sites through river management:

- *Option 1:* Flood and bury sites with larger, sediment-rich HFEs
- *Option 2:* Rely on wind to move sediment from sandbars to sites

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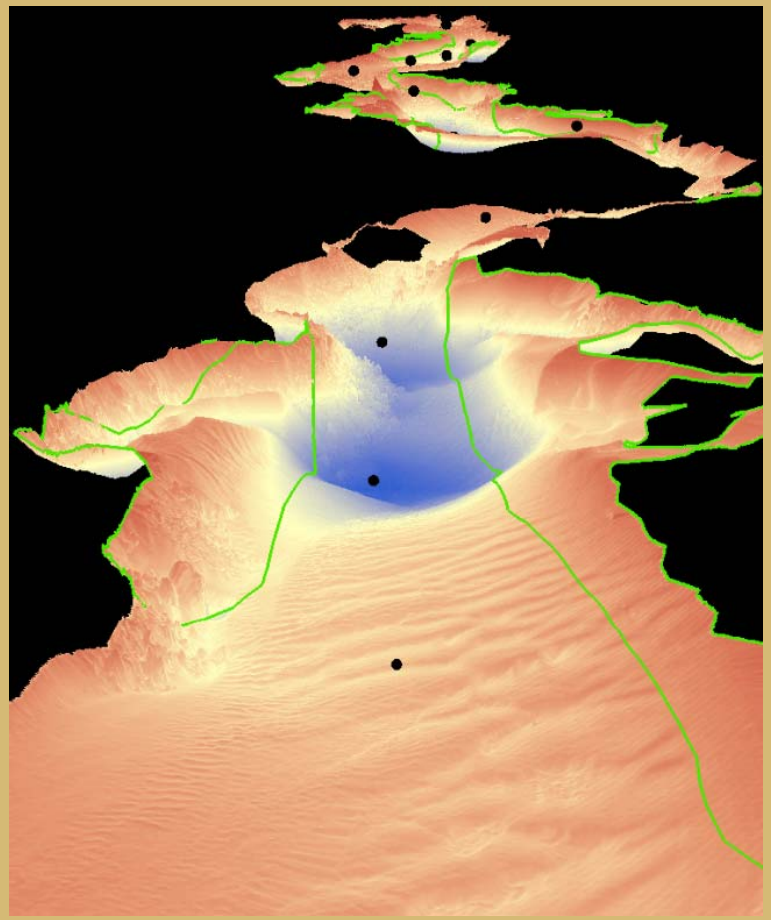
Mapping Sand Along the Colorado River in Grand Canyon

Channel bed mapping with multibeam sonar

Validation using underwater camera

Total station surveys of exposed sand



Upstream-looking DEM
(black dots are 1/10 mile intervals)

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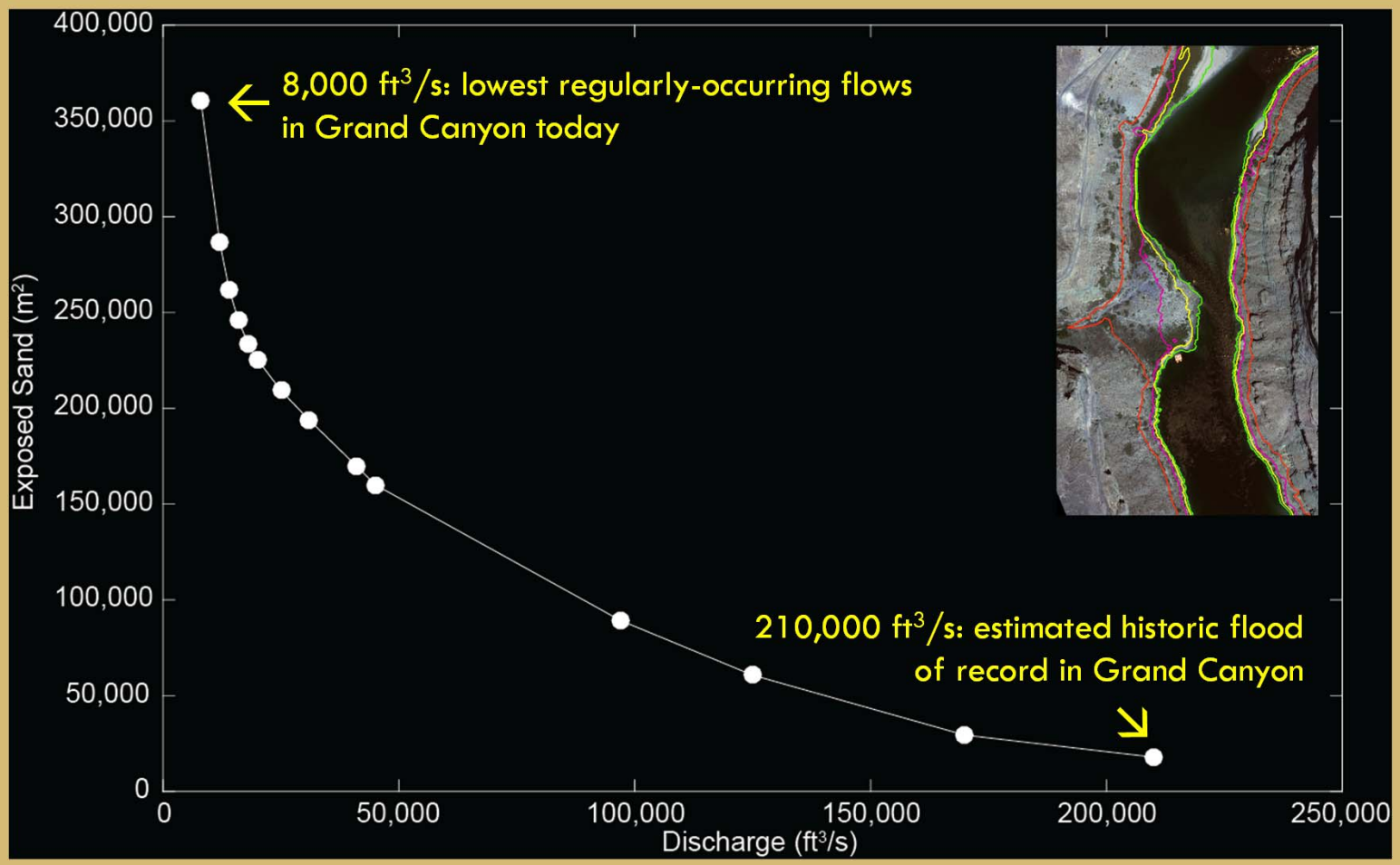
Hydraulic Modeling

What area of sand will be exposed for a given discharge from Glen Canyon Dam?



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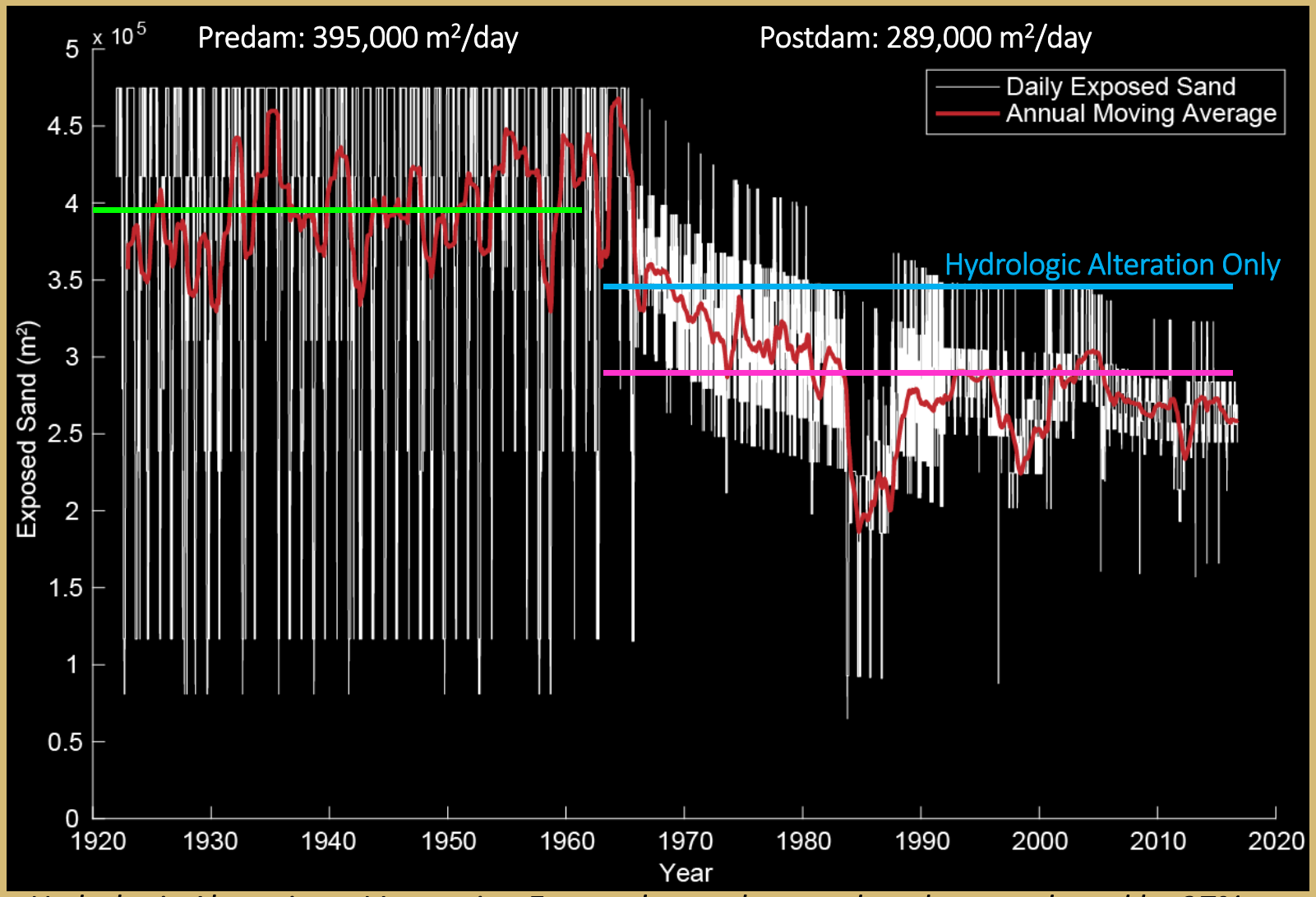

Hydrologic Alteration + Vegetation Encroachment have reduced exposed sand by 27%

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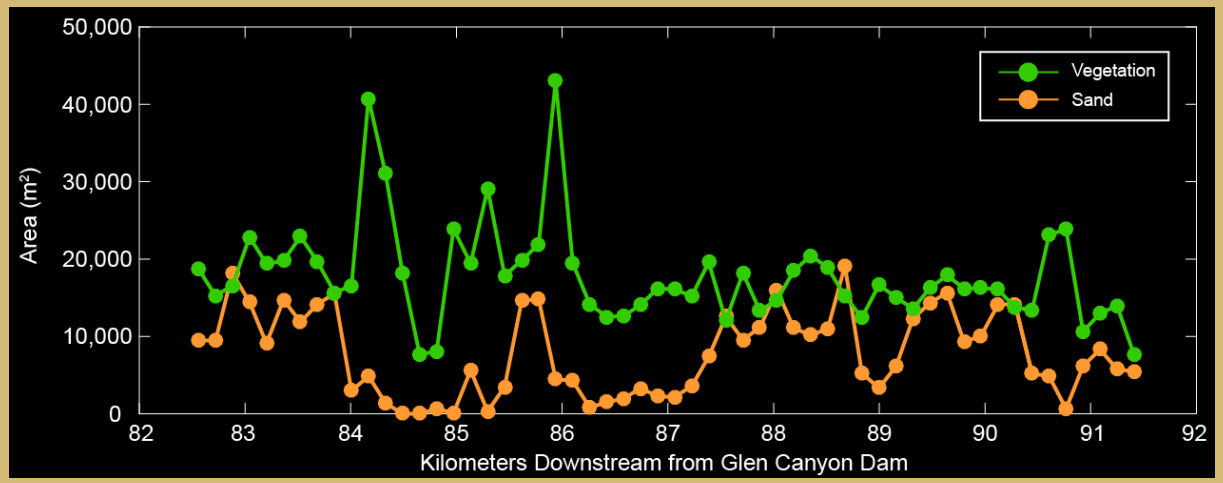
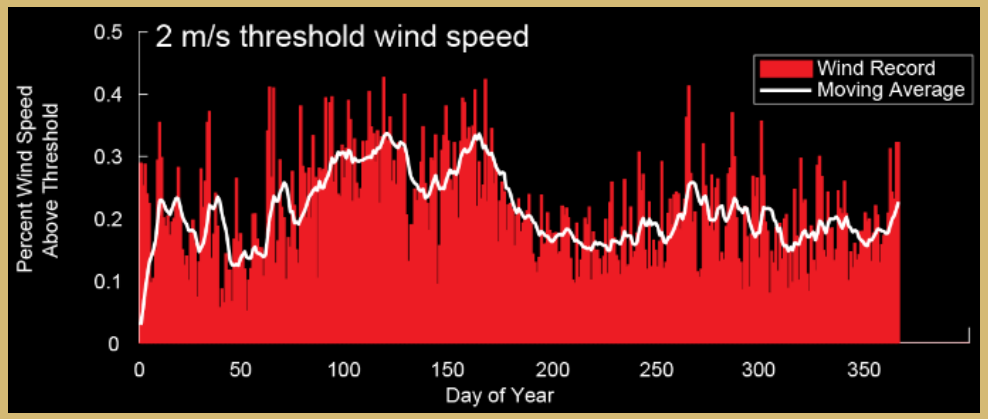


Neither sand nor vegetation are uniformly distributed along the river…

→ Use stage-discharge models to tailor flows for sand exposure



Wind speed is also variable throughout the year…..

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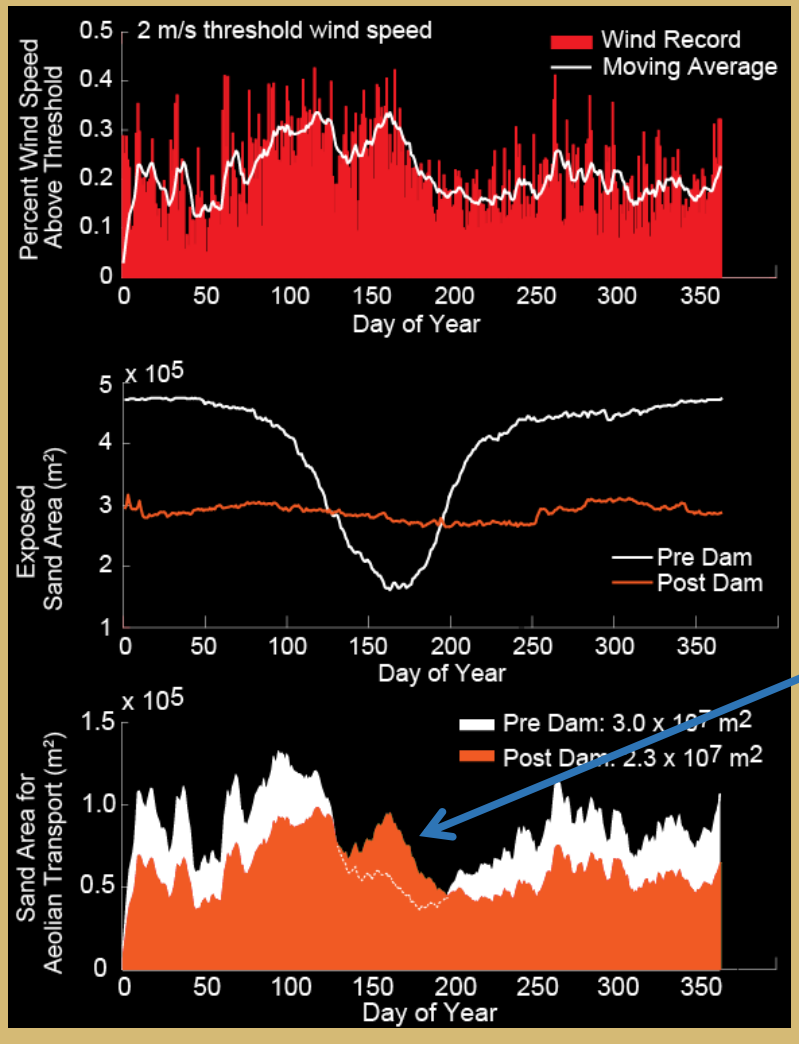
Results Relative to River Management



There may be opportunities at certain times of the year to effect an increase in the amount of wind-blown sand available for transport

- could be enhanced by vegetation removal

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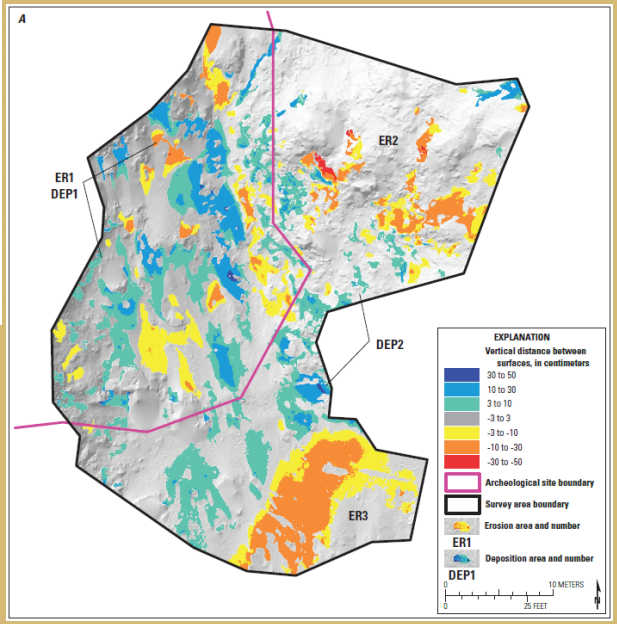
Quantifying the Relative Importance of River-Related Factors to Archeological Site Stability (Project Elements 4.1 & 4.2)

Previous Work Involved Measuring Landscape Change at Archeological Sites Receiving Sand Supply After HFEs



New Approaches

- Use modelling to demonstrate expected characteristics of archaeological sites in dunefields that are re-supplied with windblown sand from HFE deposits
- Use geomorphic change detection of lidar survey monitoring data to make inferences for individual sites and dunefields during the time period of the current HFE protocol

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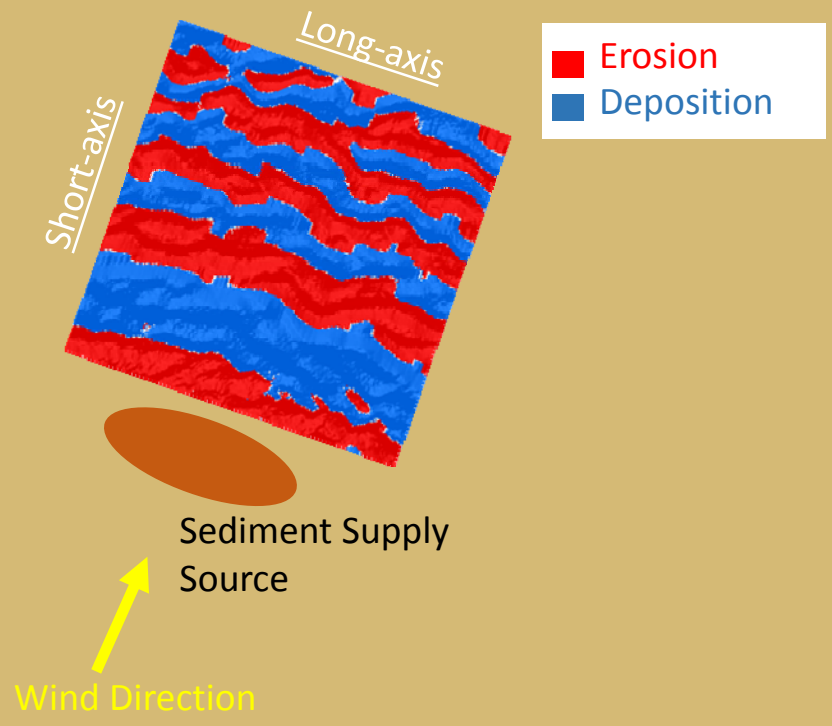
Modeling dunefield changes as a function of sediment supply



Model Scenario	Net change in sediment volume
No sediment supply	-
Weak sediment supply	+
Strong sediment supply ($x10^1$)	++

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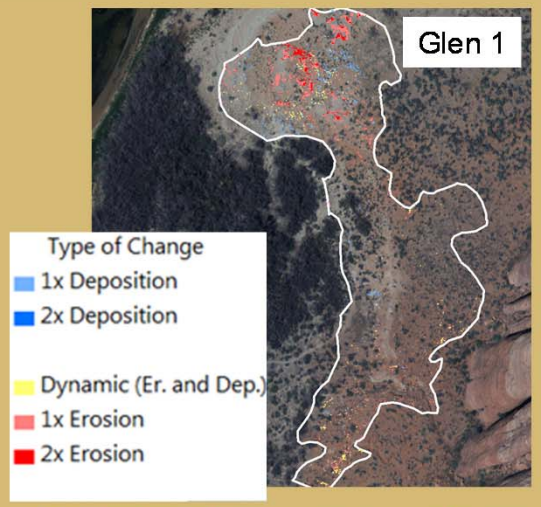
LIDAR Surveys in Glen Canyon

Glen Canyon Sites

Aeolian Topographic Changes in 2 DoDs Spanning 2012, 2013, & 2014 HFEs at 4 Glen Canyon Sites



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LIDAR Surveys in Grand Canyon

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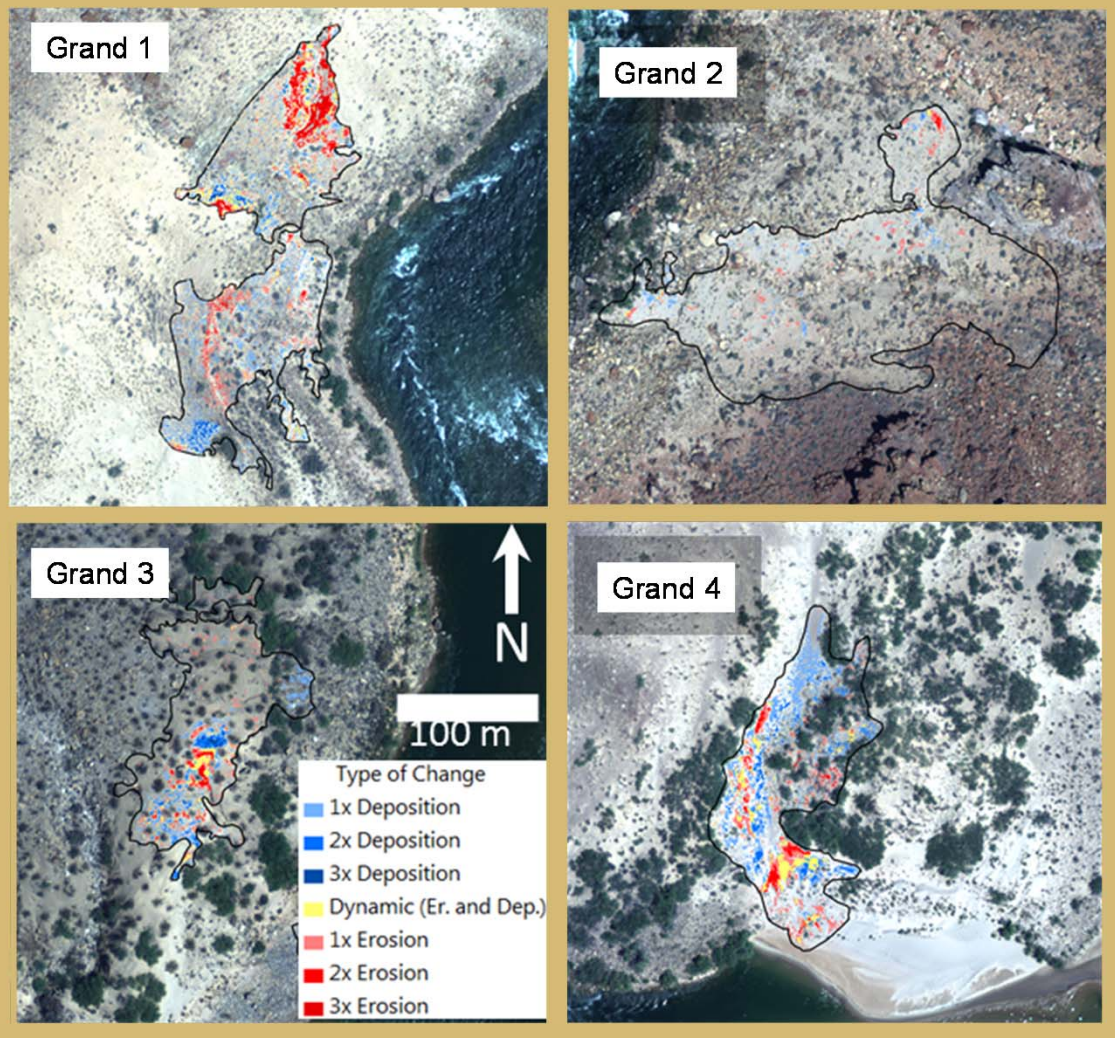

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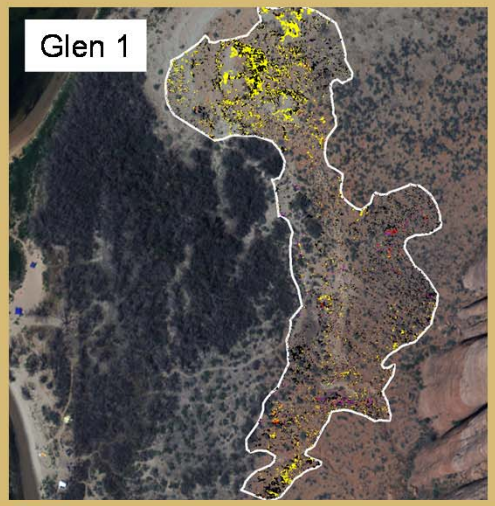
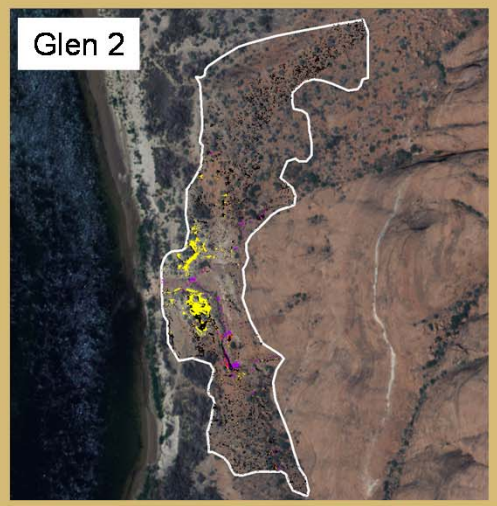
Transport Mechanisms in Glen Canyon

Glen Canyon Sites

Predicted Transport Mechanism

- Aeolian
- Alluvial
- Colluvial
- Fluvial
- Not Determined
- Dynamic





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Transport Mechanisms in Grand Canyon

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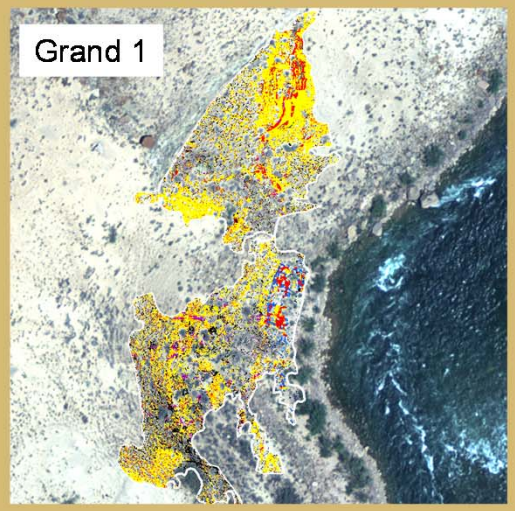

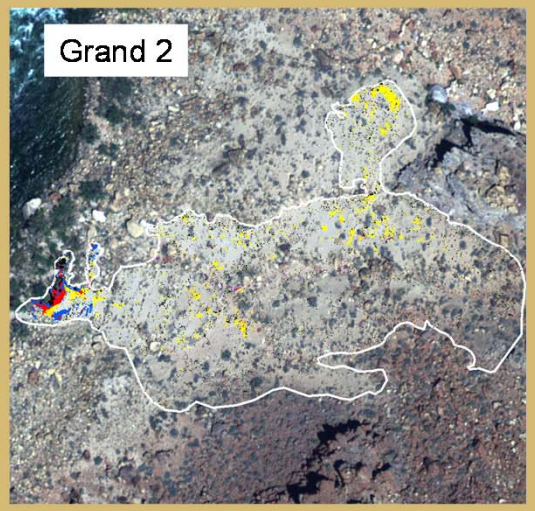

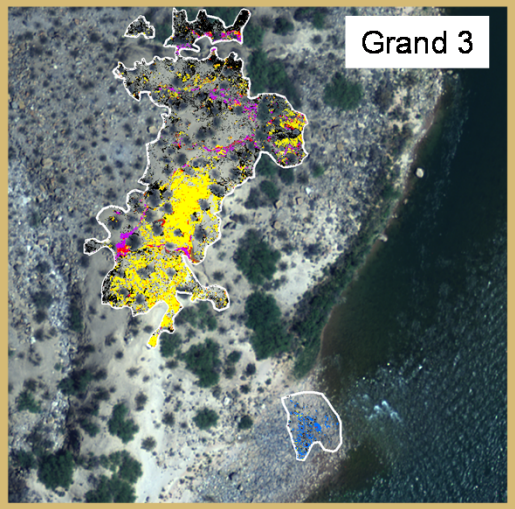

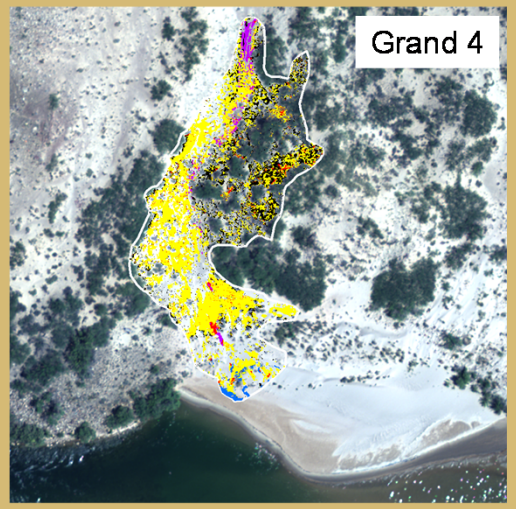

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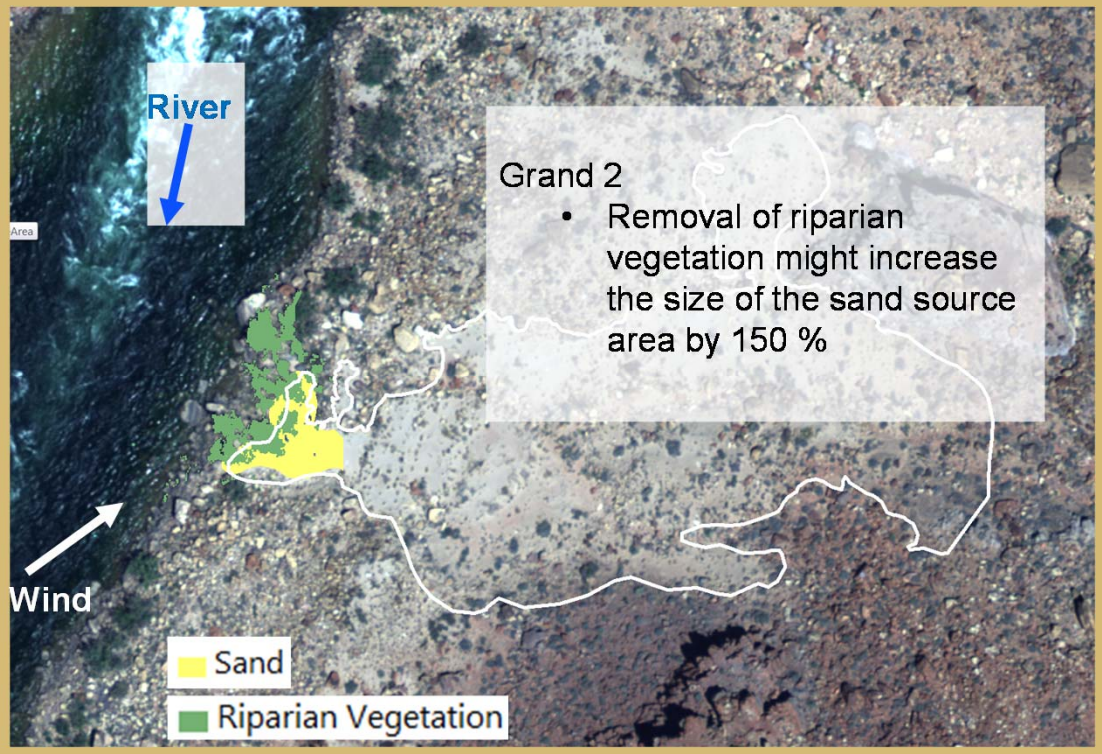
Results Relative to River Management

- Sandbars (aeolian source areas) range widely in size
- Vegetation covers 15-50% of sand at sites
- Management opportunity
  - Vegetation removal might increase the size of the sand source area by 25-150%



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Project 13: Socioeconomic Monitoring and Research

Is rainbow trout control necessary, and if so what is the most cost-effective approach?

Develop a bioeconomic model to identify the cost-effective management strategy for rainbow trout that achieves humpback chub population goals

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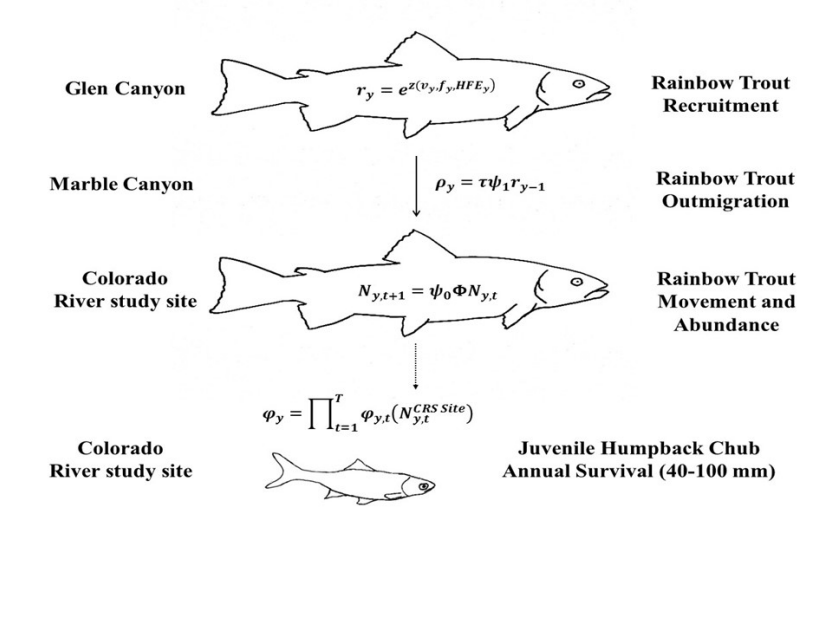
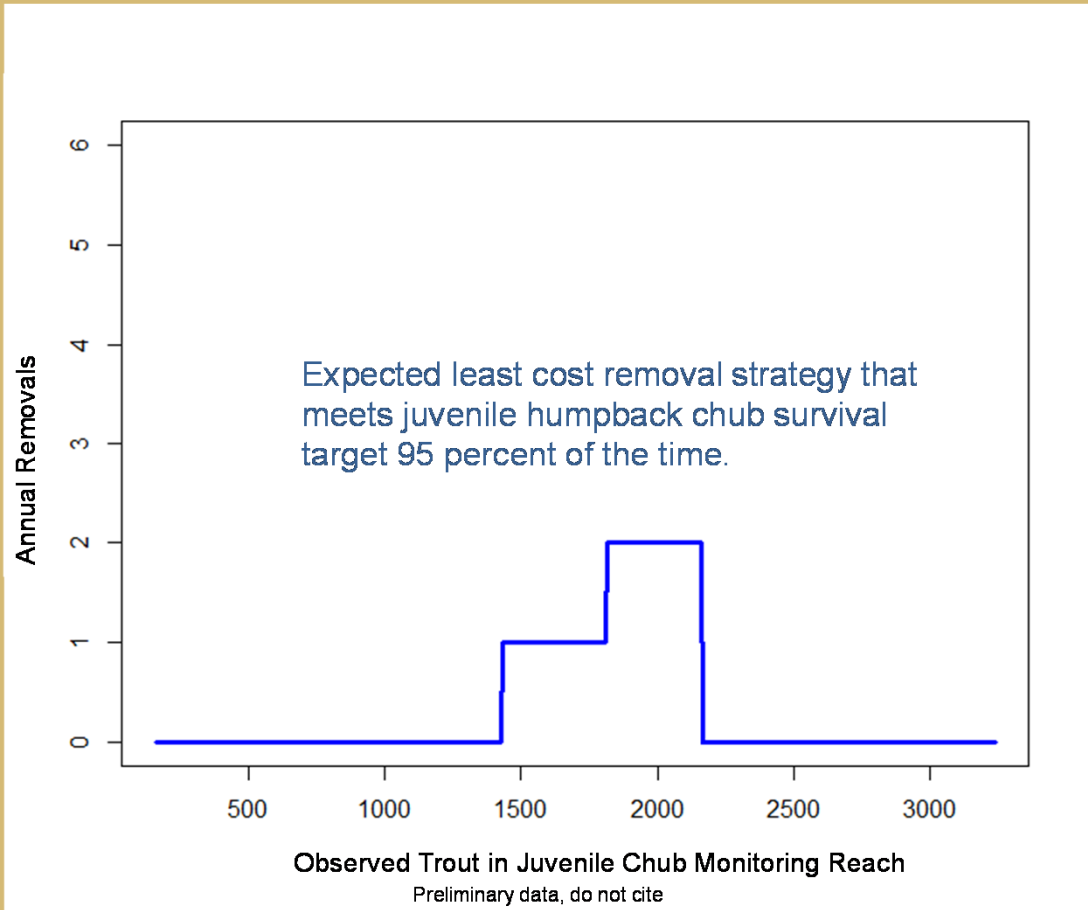
Bioeconomic Model

Simulate population component over 20 year period with:

- Random rainbow trout recruitment at Lees Ferry
- Fixed policy strategy where removals are triggered by rainbow trout numbers in the juvenile humpback chub monitoring reach



Using various removal rate options…..



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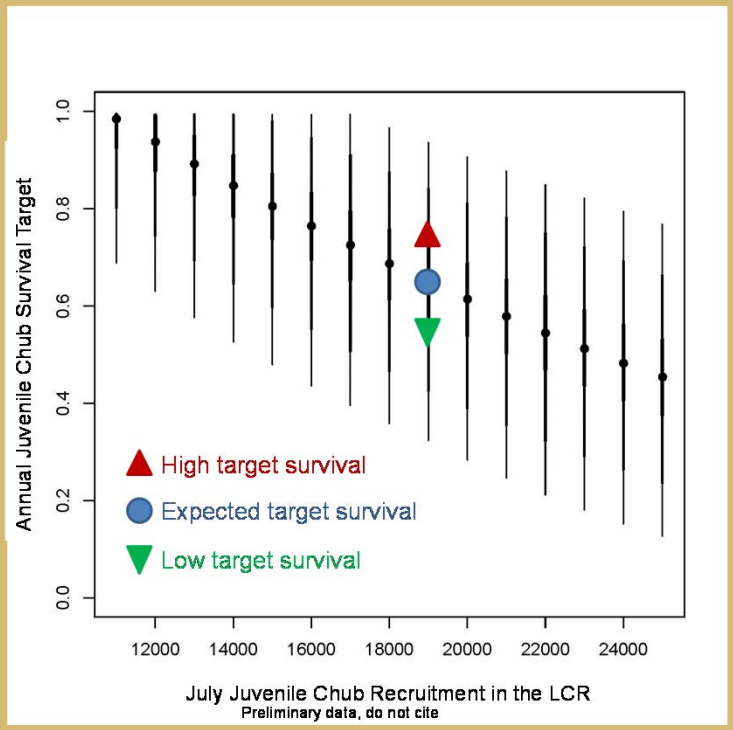
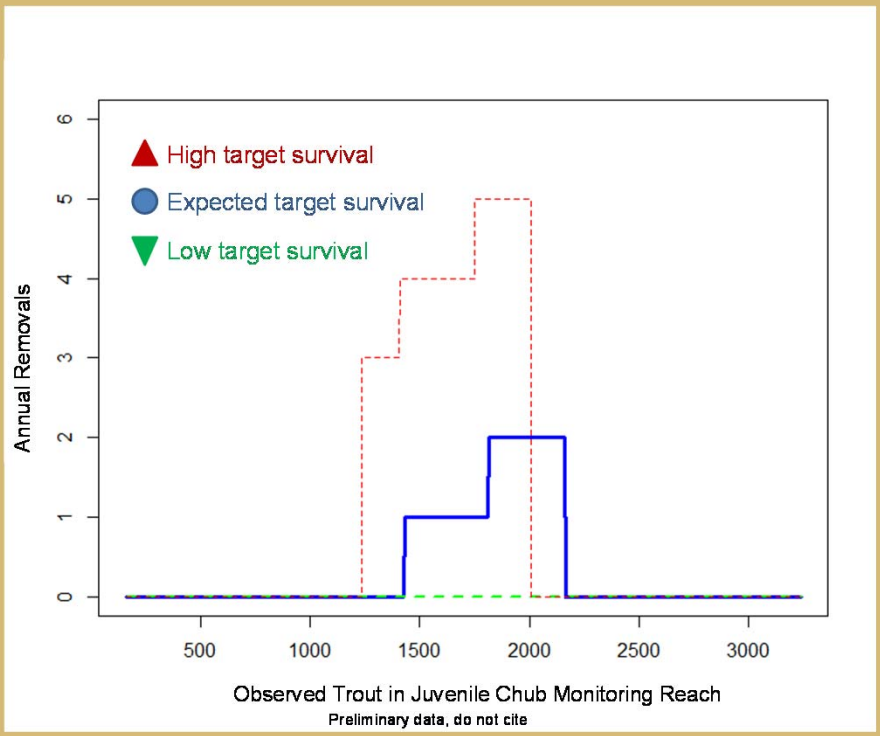
Humpback chub population parameter uncertainty





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Ongoing Workplan Research

- Humpback chub and trout population parameter uncertainty
  - Identify the importance of parameter uncertainty in prioritization of monitoring and research.
- Trout management flows
  - Incorporate additional management options and associated costs, such as trout management flows to improve humpback chub survival.

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Management Implications

If trout removals are necessary, they are cost-effective when implemented under moderate trout numbers, not too high, not too low

- too low and removals are unnecessary
- too high and removals are never effective

A bioeconomic approach is useful for prioritizing research and evaluating experiments (e.g., TMFs) or other management actions (e.g., removal triggers)

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