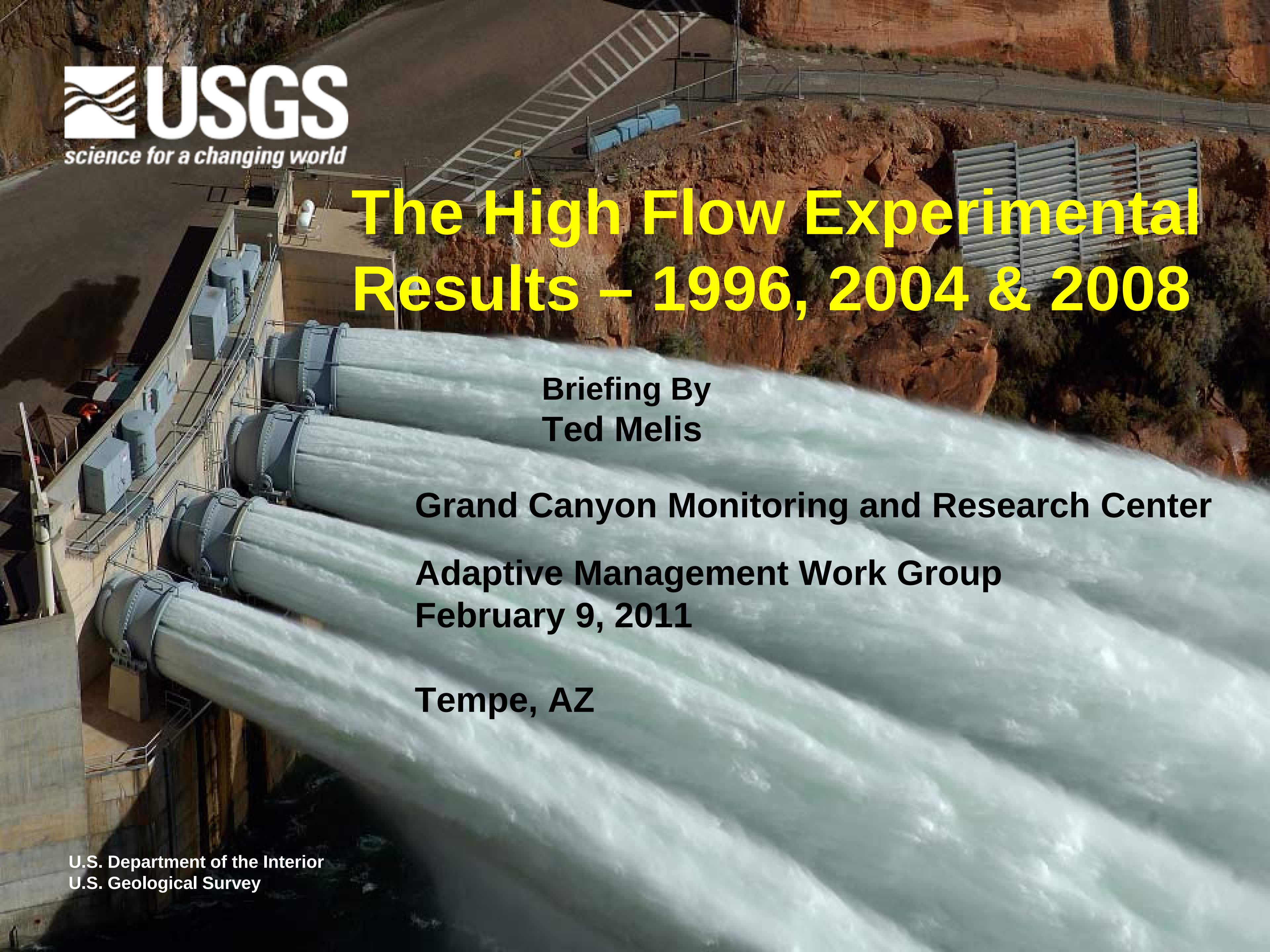

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The High Flow Experimental Results – 1996, 2004 & 2008

Briefing By
Ted Melis

Grand Canyon Monitoring and Research Center

Adaptive Management Work Group
February 9, 2011

Tempe, AZ

U.S. Department of the Interior
U.S. Geological Survey

HFE Synthesis Presentation Outline

- Background, Authorship & Outline of Circular 1366
- Physical Processes – Sediment/Sandbar Synthesis
- Biology Results – Aquatic/Terrestrial Synthesis
  - *USGS Fact Sheet 2011-3002 & The River Spol Case Study*
- A Science-Based Strategy for Future High-Flow Experiments

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HFE Synthesis: Scope & Schedule For 1996, 2004 and 2008 results

Driving Assumption Held by Authors: More & Larger Sandbars are Generally Desired by Resource Managers

U.S. Geological Survey Circular 1366: "Effects of Three High-Flow Experiments on the Colorado River Ecosystem Downstream from Glen Canyon Dam, Arizona"

- Requested by AMWG in AUG 2007, and as part of March GCMRC's 2008 Science Plan implemented by Interior
- AUTHORS: Paul E. Grams, Theodore A. Kennedy, Theodore S. Melis, Barbara E. Ralston, Christopher T. Robinson, John C. Schmidt, Lara Schmit, Richard A. Valdez and Scott A. Wright
- OUTLINE: CH 1: Overview & Introduction; CH 2: Understanding Physical Processes of the Colorado River; CH 3: The High Flows Physical Science Results; CH 4: Biological Responses to High Flow Experiments from Glen Canyon Dam; CH 5: Science-based strategies for future high flow experiments at Glen Canyon Dam

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Report Informs EA about Science-Based Options for HFE Triggering

- Monitoring & Research suggested tributary sand-input triggering after 1996 HFE
- 2004 & 2008 HFEs provided more data to identify details on current triggering strategy suggestions
- Sediment transport data and variable upper Colorado River Basin hydrology suggest that an *adaptive strategy* for future HFE triggering is needed

Glen Canyon Dam HFE release, March 6, 2008

Photograph courtesy of T. Ross, Bureau of Reclamation

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Strategic HFE Science Questions

- Based on AMWG's Concerns and GCDAMP Goals

- Tier off strategic science questions in 2007-11 MRP
- Focus of HFE report on sediment & humpback chub vs. rainbow trout responses/interactions

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Sediment Responses

Key Question: Can sandbar building during HFEs exceed sandbar erosion during periods between HFEs, such that sandbar size can be increased and maintained over several years?

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Sediment & Sandbars Synthesis

- 1) HFEs are effective at building sandbars by transferring sand from the channel bed to sandbars along the channel margins

- 2) HFEs conducted soon after tributary-derived sand has accumulated on the channel bed are more effective at building sandbars, and less likely to result in erosion of sand stored on the channel bed and in sandbars prior to the tributary inputs, compared to HFEs conducted when sand in the main stem is depleted

- 3) Sandbars tend to erode quickly in the weeks and months following HFEs, depending on flow releases from the dam as well as ongoing tributary sand supply

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Measured Sandbars Response FEB 1996 to OCT 2008

- On basis of a limited number of long-term sandbar study sites, about 74 percent of sandbars (25 of 34 sites) monitored in Grand Canyon were at least slightly larger (sand volume) in Oct. 2008 than in Feb. 1996; prior to first HFE

- This is true despite sandbar erosion documented at the study sites following each of the three HFEs

- There were 6 years of above 8.23 MAF releases and 7 years of 8.23 MAF releases over the time period that these sandbar monitoring data were collected

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The Data - FEB 1996 to OCT 2008

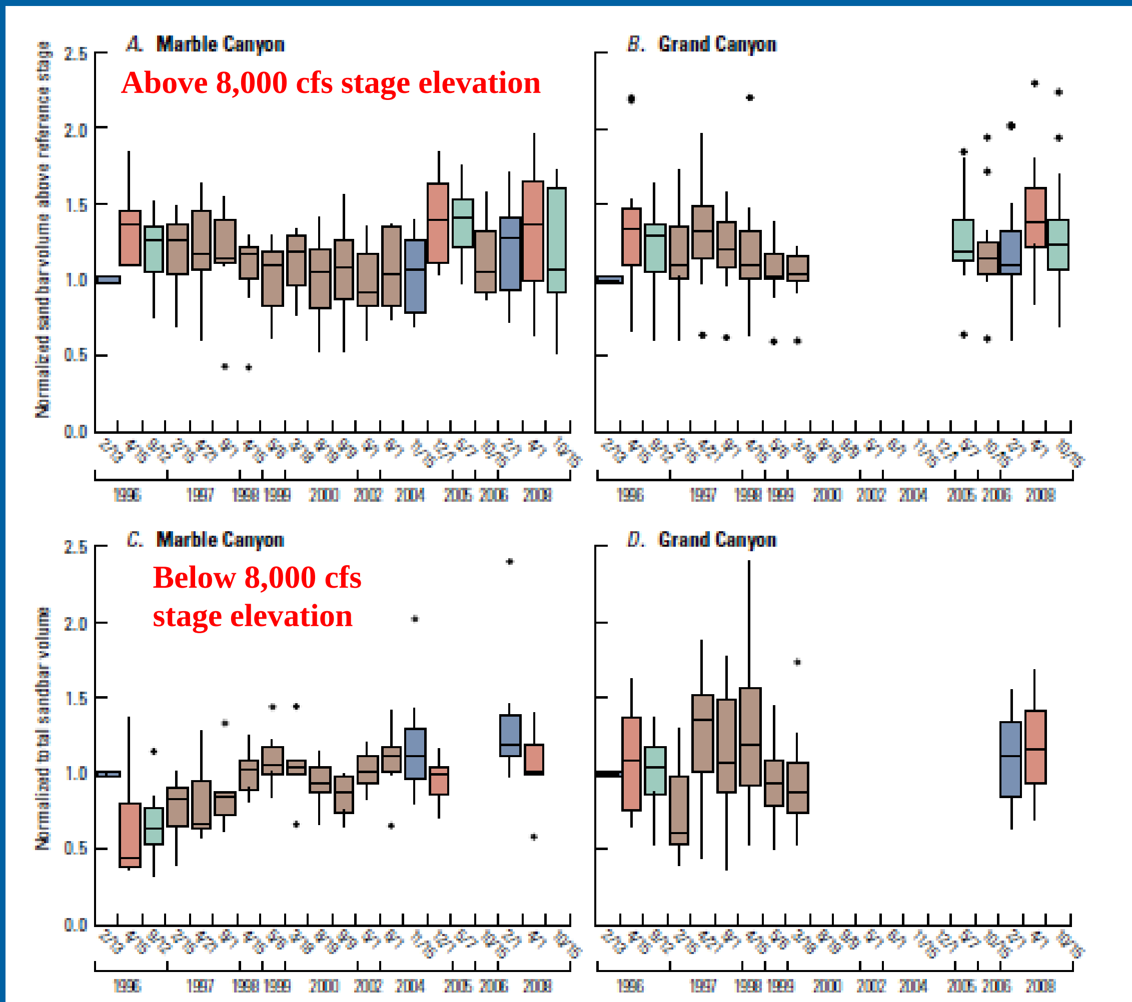

Figure 16 [from Grams, Hazel and others, as included in Chapter 3 of Circular 1366, p. 79]

QUESTION: “Where is the sand?”

~50 to 90% of the sand in Marble Canyon is stored in eddies. About 90% of the sand in eddies is stored below the stage elevation reached by a flow of 8,000 ft^3/s (Hazel et al., 2006, J. Geophys. Res., 11).

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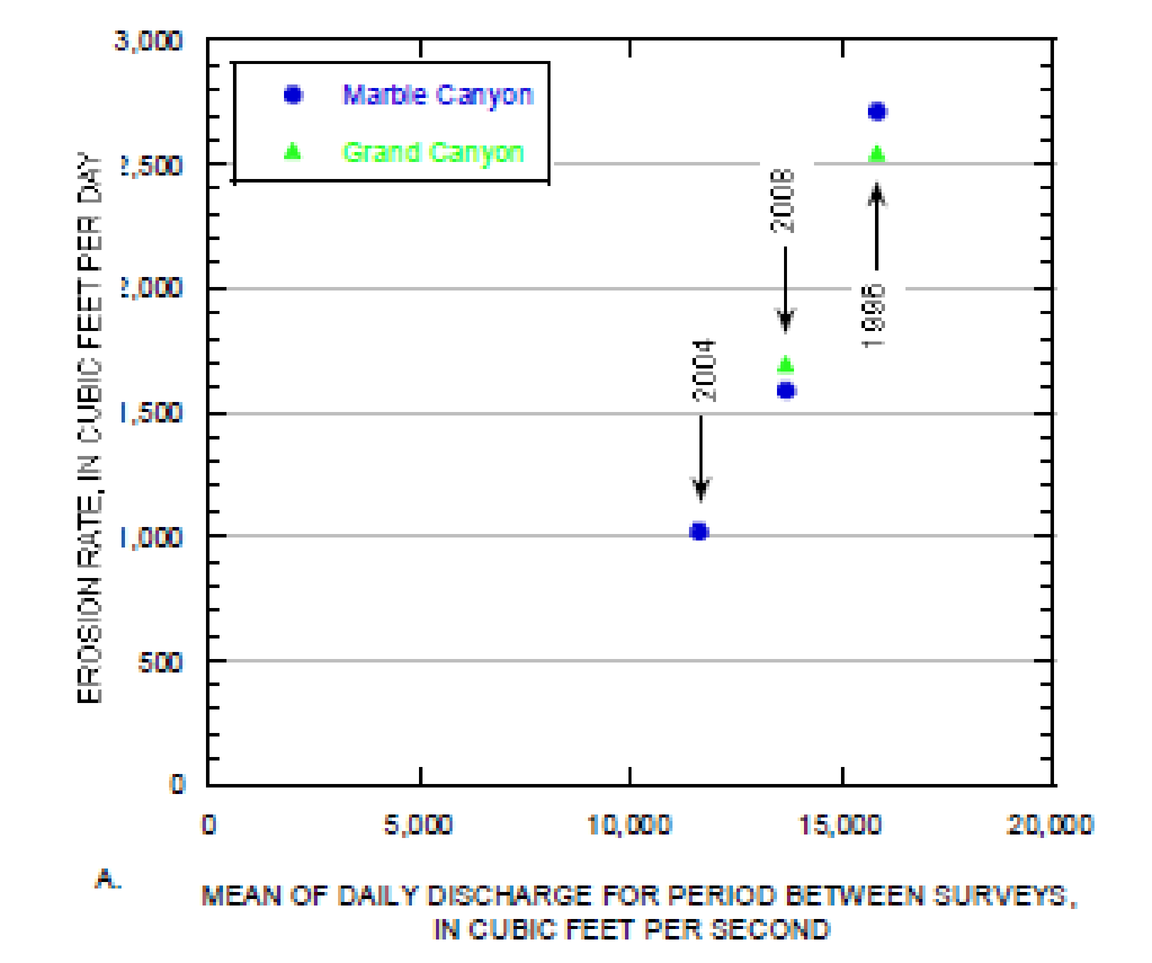
ANSWER: “Mostly under water – most of the time.”

Q: "How do Sandbars Respond to Higher Flows Post-HFE?" A: "Not Well"



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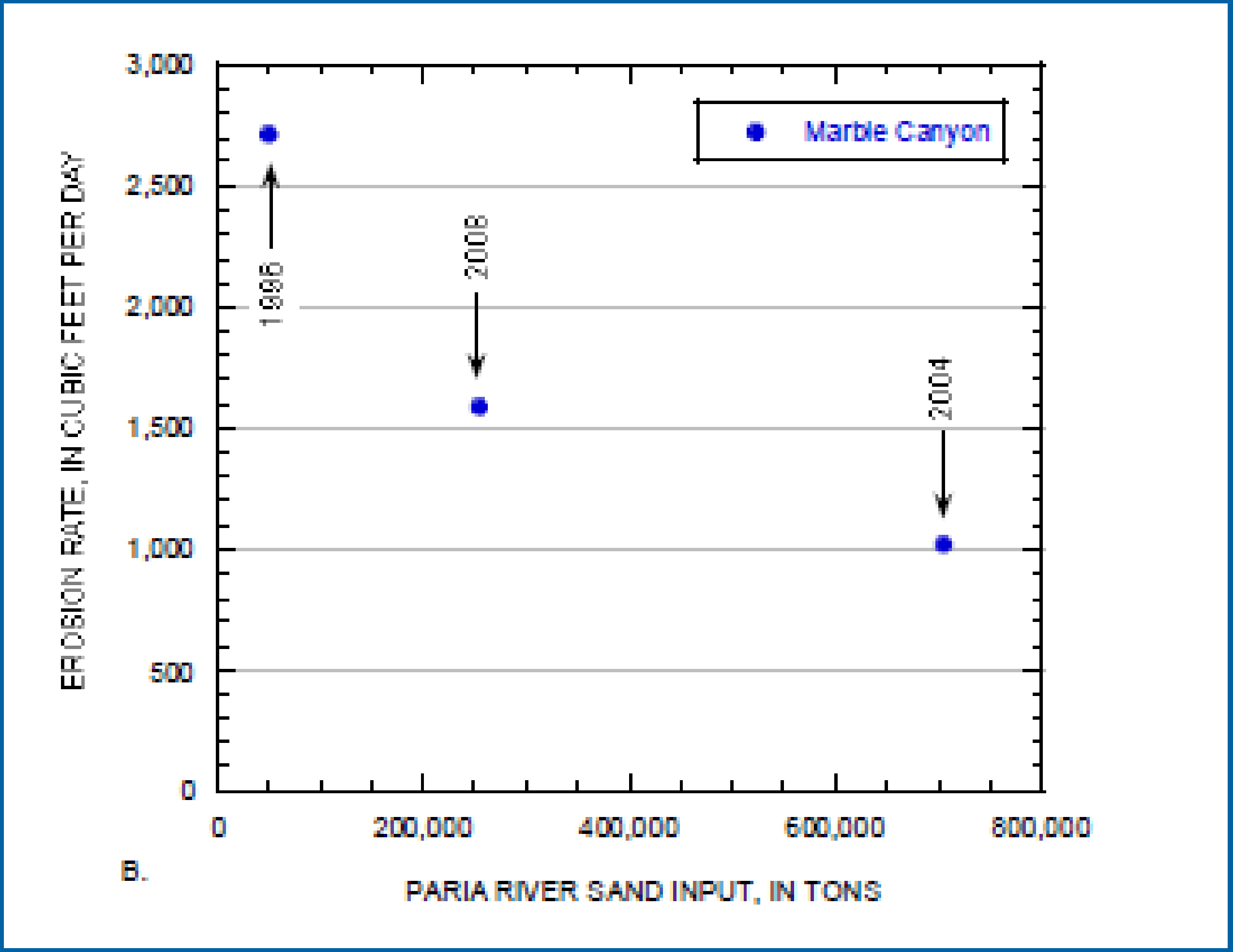
Sandbar Erosion Increases when Higher Mean Daily Discharges follow HFEs (from Grams and others, 2010)

Q: “How do Sandbars Respond to Sand Inputs after HFEs?” A: “Better”



Sandbar Erosion Decreases when Sand Inputs follow HFEs, as in 2004-05 (from Grams and others, 2010)

Science of Wind, Sand & Cultural Sites

- Photograph showing aeolian dune crest that formed on a High-Flow Event-deposited sandbar taken on July 29, 2008. From Draut and others (2010a)

Continued monitoring of these features and the wind-transport processes that form dunes near cultural sites is essentially needed whenever future HFEs are released from Glen Canyon Dam

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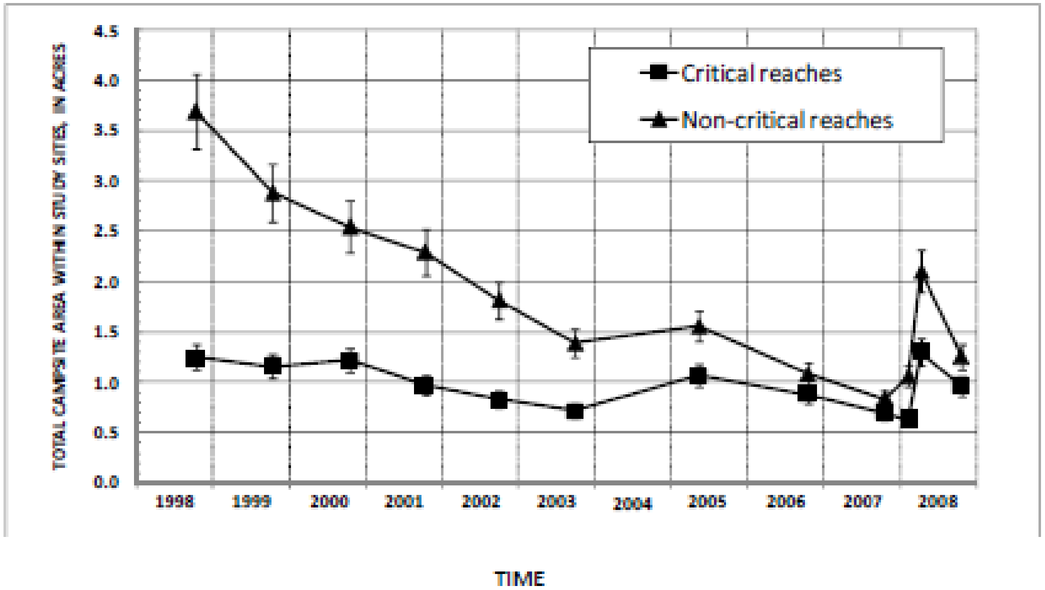
HFEs, Sandbars & Campsites

RIGHT - Repeat views looking across the Colorado River from the left bank at the sandbar and campsite located at River Mile 202.3. Between 1998 and 2006, woody vegetation, primarily arrowweed, expanded to cover large areas of the formerly sandy, unvegetated sandbar.

LEFT - High-elevation camp area in critical and noncritical reaches between 1998 and 2008. The error bars show plus and minus 10 percent uncertainty. Critical reaches are reaches where campsites are in scarce supply and non-critical reaches have more abundant campsites (Modified after Kaplinski and others (2010).



Studying Future Sediment Responses

Key Question: Can sandbar building during HFEs exceed sandbar erosion during periods between HFEs, such that sandbar size can be increased and maintained over several years?

Answer, so far: (after 3 HFEs): "Perhaps"

Biological Results

Riparian Vegetation Synthesis

- HFEs in early spring appear to be useful tool for meeting vegetation objectives (maintaining native marsh & riparian communities + reducing non-native species)

- Reductions in campsite area due to vegetation recovery and expansion following HFEs might offset the temporary increases in campsite area that have previously occurred due to sandbar building during HFEs

- Vegetation may also influence sandbar building because the presence of vegetation along shorelines reduces water velocities and decreases the capacity of the river to rework and redistribute sediment

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Riparian Vegetation Synthesis (cont.)

- The role that expanded post-dam vegetation is playing in sediment deposition and erosion dynamics in the Colorado River is largely unknown
- Future sediment studies might consider incorporating mechanical vegetation removal from shorelines to better understand the effects of vegetation on sediment deposition and sandbar building
- Lastly, the effects of HFE timing on riparian vegetation is highly uncertain because no data were collected around the 2004 HFE.

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Aquatic Synthesis Points

- 1) HFEs conducted in spring benefit rainbow trout populations as a result of improvements in spawning and rearing habitat (<u>uncertainty exists for other times</u>)

- 2) HFEs have had no measurable positive impacts on humpback chub populations

- 3) Large increases in rainbow trout populations near the Little Colorado River, after the 2008 HFE, are inconsistent with both the GCDAMP goals for humpback chub and rainbow trout, and also native fish management objectives of Grand Canyon National Park

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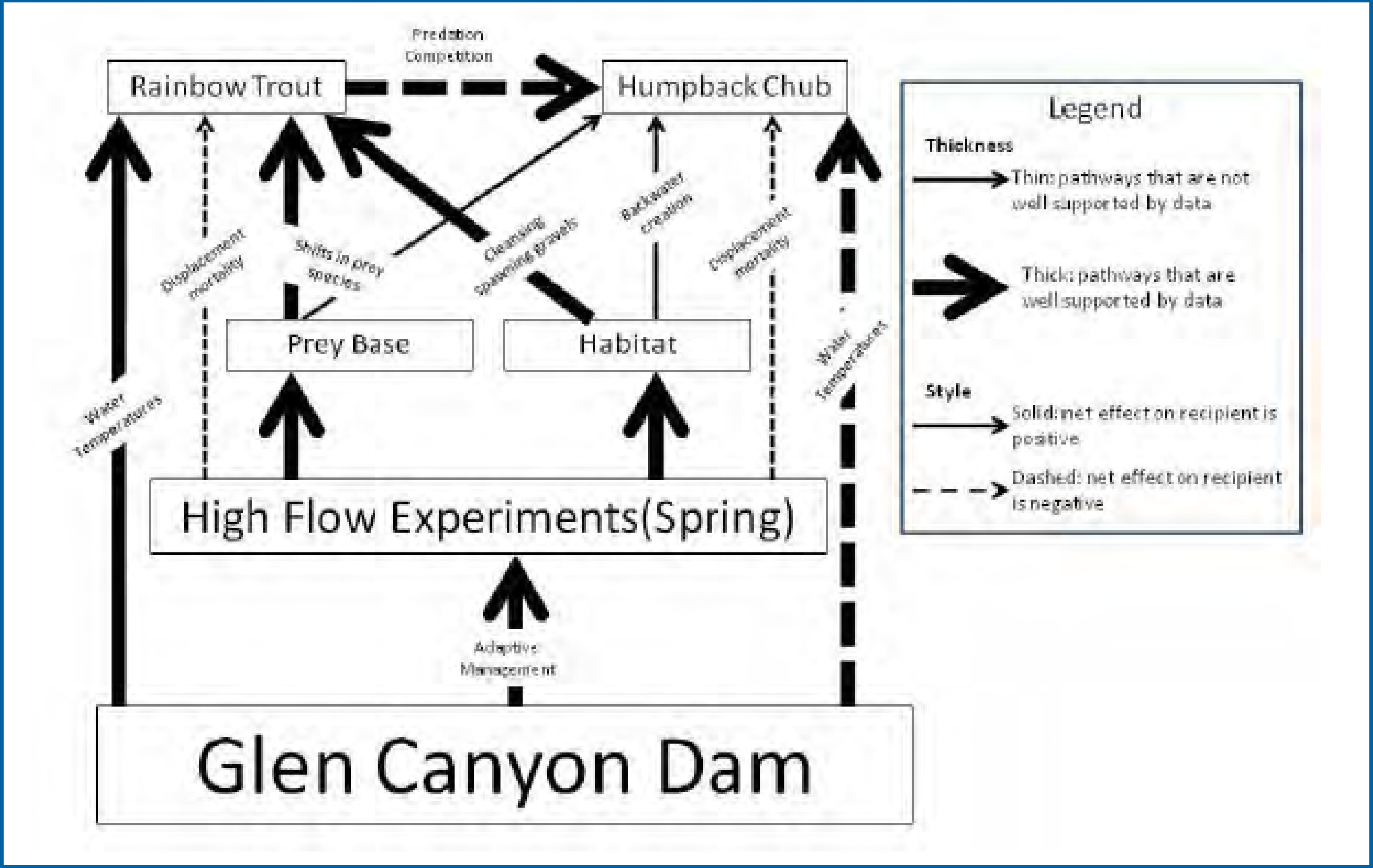
From Kennedy and Ralston (2011, see Chapter 4, figure)



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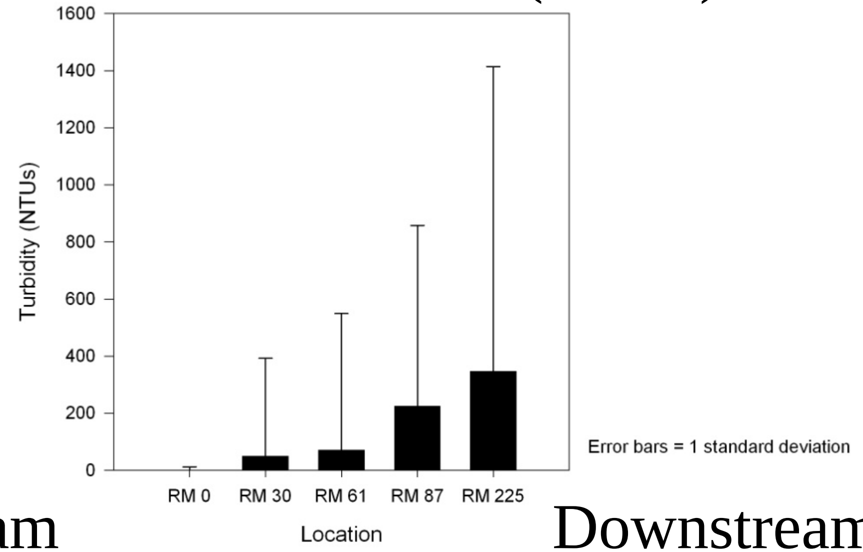
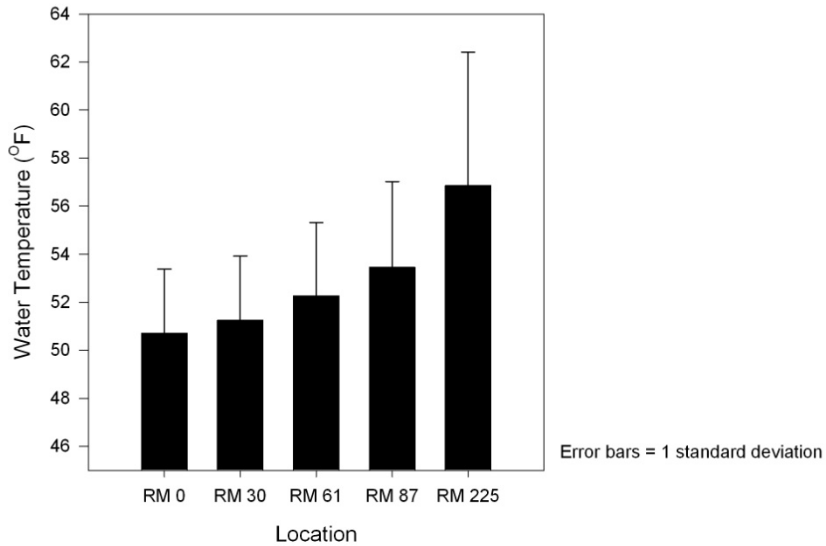
Focusing on Key Linkages/Pathways related to HFEs

AVE. TURBIDITY (NTUs)



Upstream

Downstream



AVE. TEMPERATURE (degrees F)

From Kennedy and Ralston (2011)

See Table 4 in Chapter 4 [USGS Data: 2006-09]

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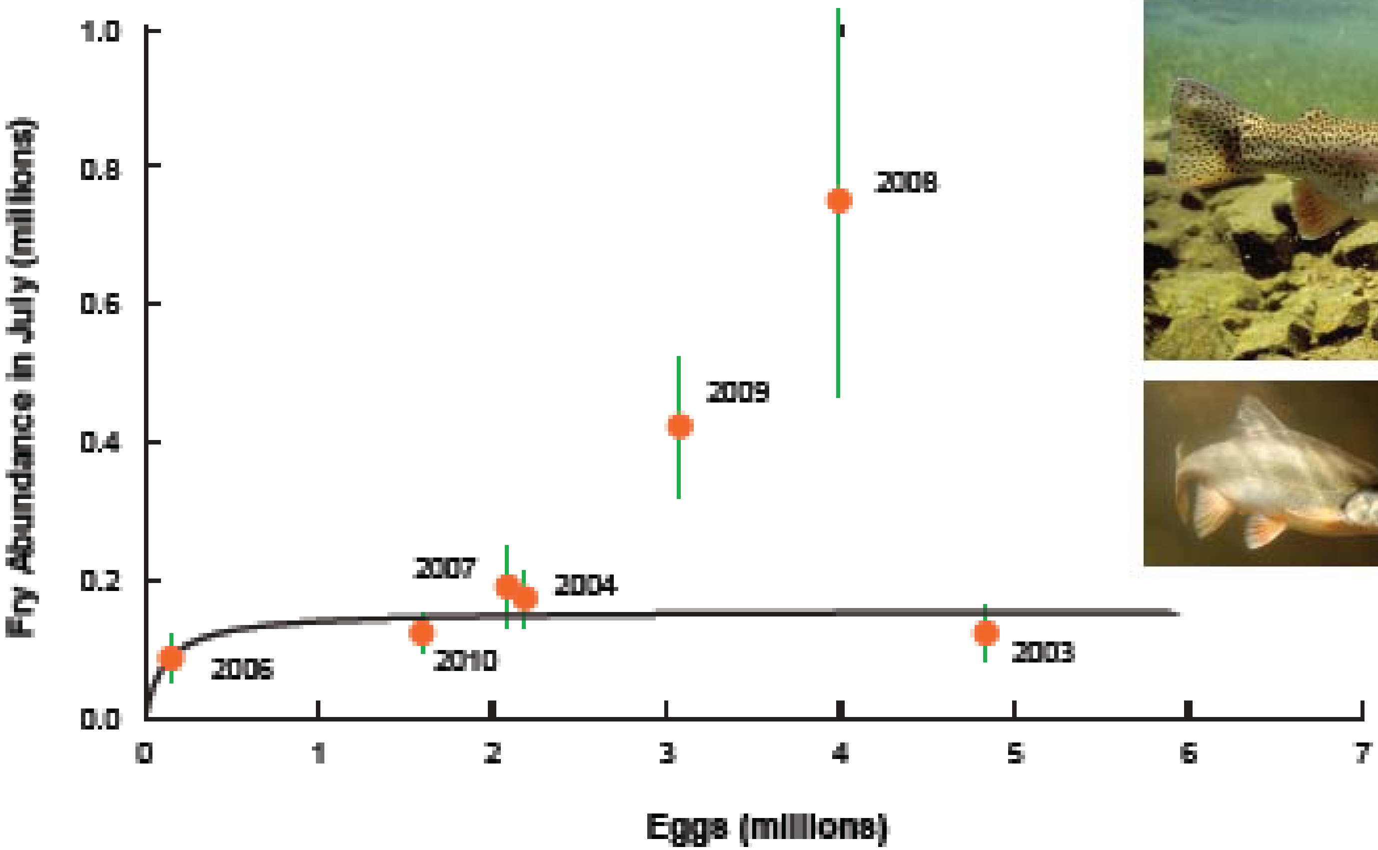
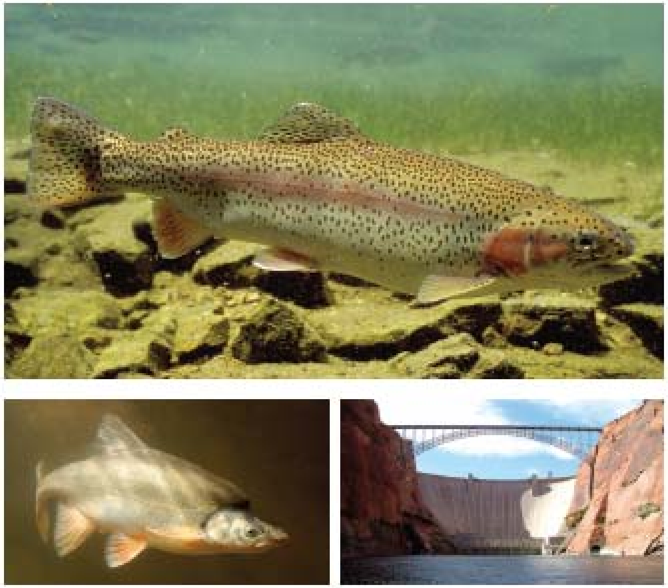


The relation between the number of viable rainbow trout eggs deposited in the Lees Ferry reach and the resulting population size of fry in mid-July for the years 2003–10 (no data for 2005). The thick black curve shows the best-fit relation between viable eggs and fry using data from all years except those affected by the March 2008 high-flow experiment (2008 and 2009), when survival was unusually high. The flat relation indicates that the survival rate from egg to fry stage increases with reduced numbers of eggs, a compensatory effect that minimizes the effect of egg losses on fry abundance. The green vertical lines show the 95-percent confidence limits of fry abundance estimates. (From Korman and others, in press).



From Korman and Melis (2011)

[Fact Sheet 2011-3002]

Discussed in Chapter 4

The River Spol Case Study

"The Swiss Experience"

- Repeated Floods from a Hydroelectric Dam in Alpine River Setting within Swiss National Park
- Native Brown Trout appear to be Benefitting from 20 Artificial Floods Released Over the Past Decade
- Food Web Shifted to taxa similar to those found in the Lees Ferry Reach Over the Course of Several Years
- Researchers Have Determined that Continued Artificial Floods are Needed to Sustain Responses

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See Sidebar in Chapter 4 (Valdez and others)

Studying Future Biological Responses

Key Question: Does the seasonal timing of HFEs influence the rainbow trout response?

Answer: "Uncertainty still exists about different timing of HFEs in late winter and early Spring, as well as about Fall-timed HFEs and RBT responses???"

Key Point: These uncertainties can be addressed through careful monitoring before, during and after future HFEs in either season

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HFE Triggering Concepts & Options

Science Strategy for Future HFEs

- If future flow experiments are strategically timed to follow a variety of tributary floods and HFE hydrographs are appropriately designed (peak magnitudes and durations) to match the volume of new sand annually delivered to the river, scientists hypothesize that it may be possible to enlarge and maintain sandbars through time.

- If monitoring under the suggested triggering strategy indicates that sandbars continue to erode or cannot be rebuilt and sustained at a desired level, then managers may choose other experimental options, such as further constraining dam releases, augmenting sand supply to Grand Canyon from sources in Lake Powell, or both.

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***Tracking the status and response of the aquatic food web and fish populations to HFEs is critical!

Sand Input Triggering Strategy Suggests that HFEs follow Historical Timing of Paria and Little Colorado River Floods (Fall & Spring)

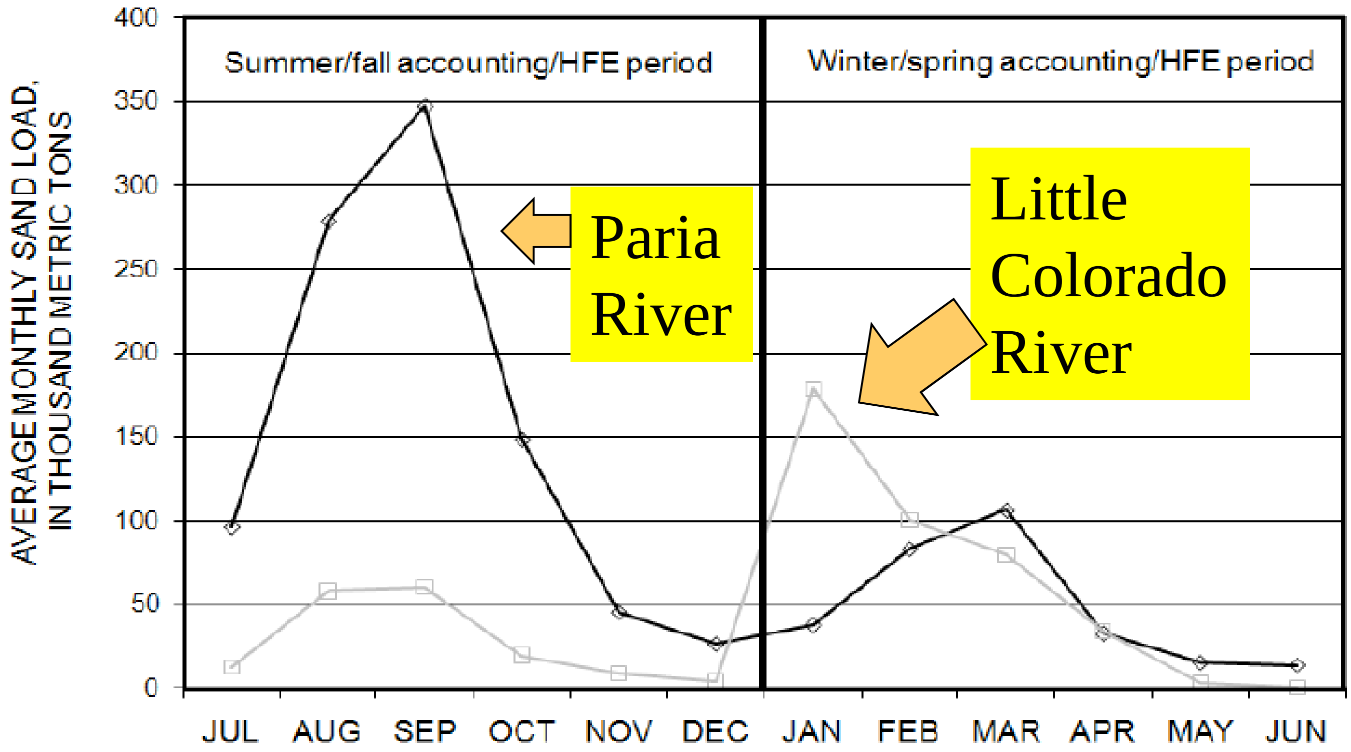

Figure 5. Illustration of a year with two sand-budget accounting periods and two HFE windows (fall and spring). Vertical axis shows the average monthly sand loads from the major tributaries (Paria River – diamonds; Little Colorado River – squares). The presence of two main periods of tributary activity supports the concept of two accounting/HFE periods per year.

From Wright and Kennedy, 2011 (see chapter 5, figure 5)

Fall & Spring Timing Associated with Suggested Triggering Strategy has Historical Precedent in Pattern of Natural Floods during Pre-Dam Record

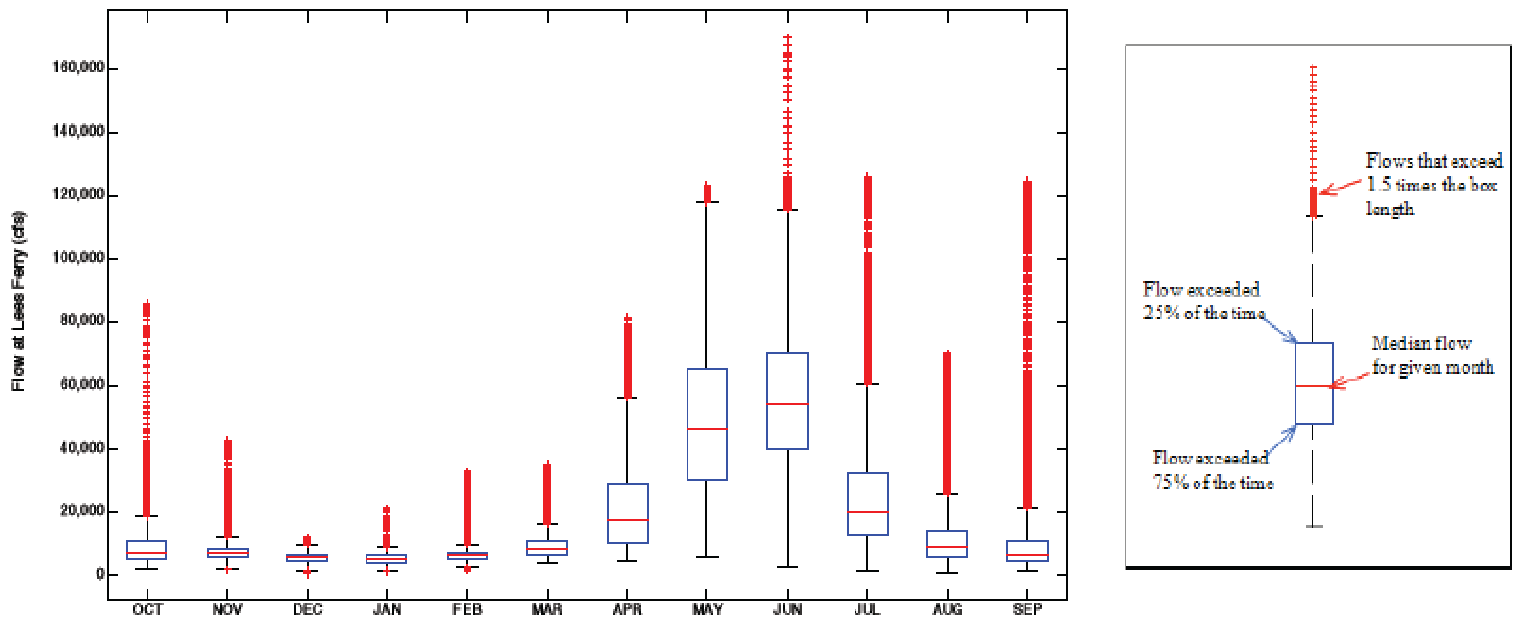

Figure 6. The pre-dam flow regime on the Colorado River at Lees Ferry (data from Topping and others, 2003). The plot shows box-and-whisker diagrams for each month of all instantaneous flow measurements from the beginning of the record (1921) to the beginning of flow regulation by Glen Canyon Dam (1963). The plot illustrates the strong snowmelt signal from APR – JUL as well as the higher flows in the late summer and early fall.

From Wright and Kennedy, 2011 (see chapter 5, figure 6)

FREQUENCY OF HFE TRIGGERING?

- The 85-year record of Paria River flow suggests that about 2/3 of HFEs are likely to be triggered in the Fall season – following sand inputs that occur from July into October

- In some years, but rarely, Paria River floods have occurred in winter, but LCR flooding is more common in that season

- Perhaps 1/3 of the HFEs triggered would occur in spring in response to LCR and/or Paria River sand inputs that occur between December and March

- In some years HFEs might be triggered in both spring and fall

UNCERTAINTIES STILL REMAIN

- It is unknown whether the suggested triggering option for long-term experimentation can rebuild & maintain sandbars at desired levels (desired conditions remain unclear)

- Factors influencing rainbow trout response in the Lees Ferry tailwater reach are still poorly understood – tests of alternative timing are needed

- Consistent long-term monitoring is critical for reducing the above uncertainties about future HFEs

- HFEs are the only known means for rebuilding eroded sandbars - without sand-enriched high flows, sandbar size will decrease through time

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From Chapter 5, Wright and Kennedy, 2011

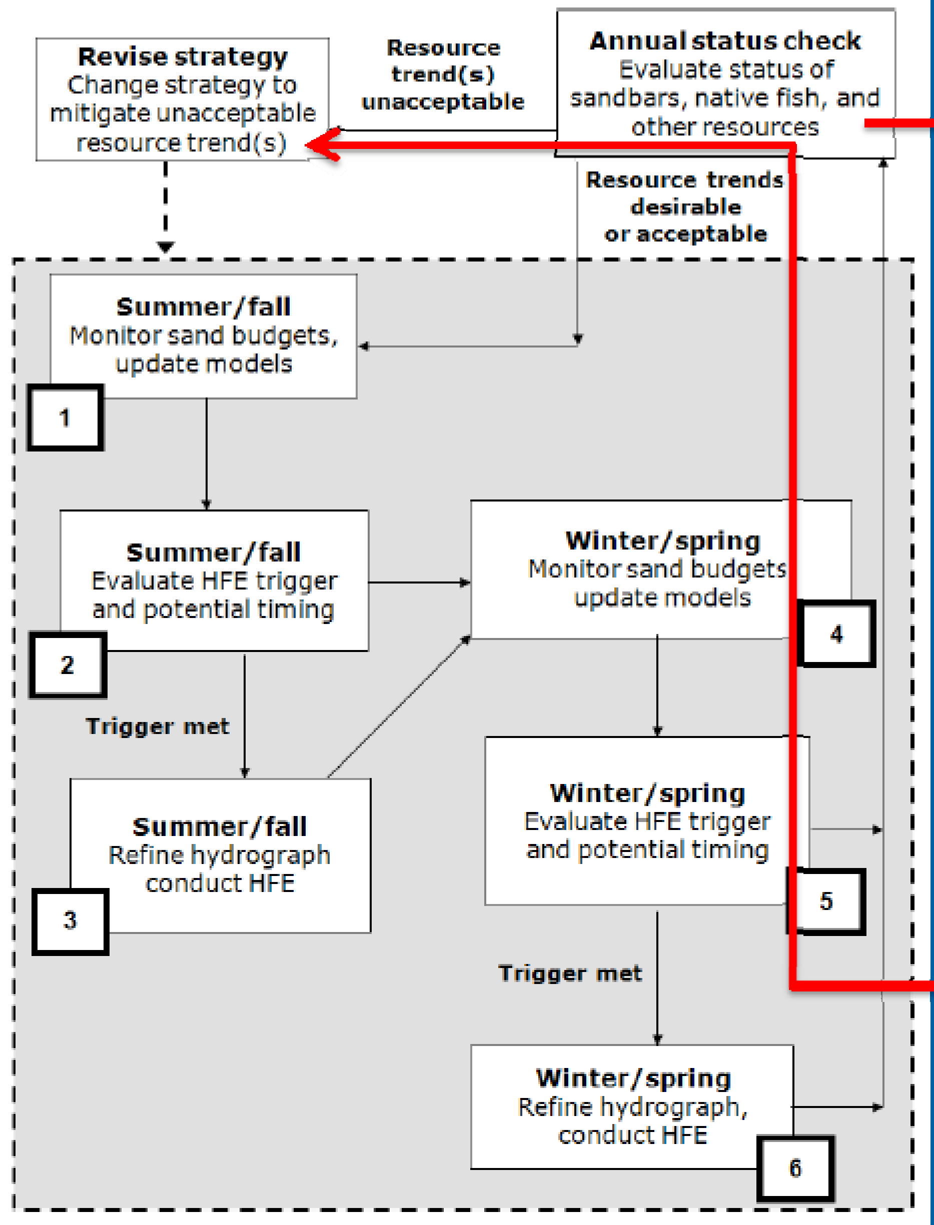

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Figure 7. Flow chart illustrating the decision-making process for a science-based experimental strategy for tributary sand-input triggered HFEs with two sand-budget accounting periods and two HFE windows per year. Each box and decision point is described in detail in the text.

ADDRESSING UNCERTAINTY

- If monitoring under the suggested triggering strategy indicates that sandbars continue to erode or cannot be rebuilt and sustained at a desired level,

<u>then,</u>

decision makers may choose other experimental options, such as further constraining dam releases, augmenting sand supply to Grand Canyon from sources in Lake Powell, or both

- Monitoring the status and response of the aquatic food web and fish populations to HFEs is critical

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Thanks are Owed to Scientists @:

- National Park Service (permitting, outreach & education)
- Bureau of Reclamation (NEPA compliance & dam releases)
- U.S. Fish & Wildlife Service (NEPA compliance)
- AZ Game & Fish Department
- Utah State University
- Northern Arizona University
- University of Wyoming
- USGS AZ, CA & WA Water Science Centers
- USGS Marine Geology Team
- GCDAMP
- Ecometric Research

Many others…. including all of you
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