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Sandbars and Floods in Grand Canyon: Current Research and Monitoring

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

Paul Grams, USGS

Overview

- What have we learned?
- When will we have another flood?
- How will we know if floods are working to rebuild sandbars?
- What do floods have to do with trout and chub?

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What do Floods do?

- Floods do build sandbars and there has been some net gain since before the first flood in 1996.
- Floods do cause net export of sand (more sand goes downstream than goes up on the banks).
- Sandbars erode following floods.
- Spring floods benefit rainbow trout populations as a result of improvements in spawning and rearing habitat (uncertainty exists for floods at other times)
- Floods have had no measurable positive impacts on humpback chub populations

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(High Flow Circular, chapters 3 and 4)

Floods build sandbars

(in lots of places)

Floods build sandbars

(not everywhere)

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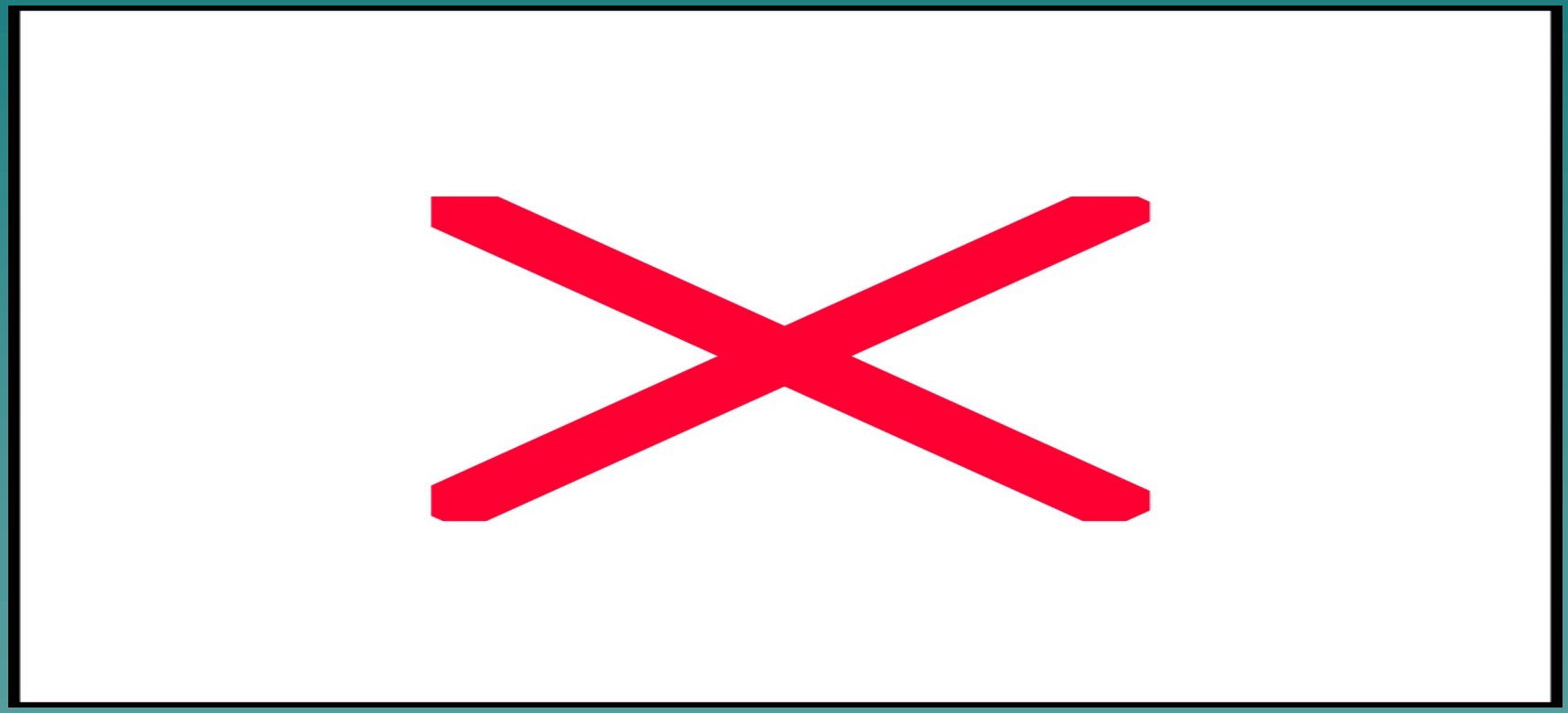
Changes in Sandbar Size in Marble Canyon and Eastern Grand Canyon, 1996-2009

10/20 bars are the same or larger in size than the 1996 pre-HFE condition



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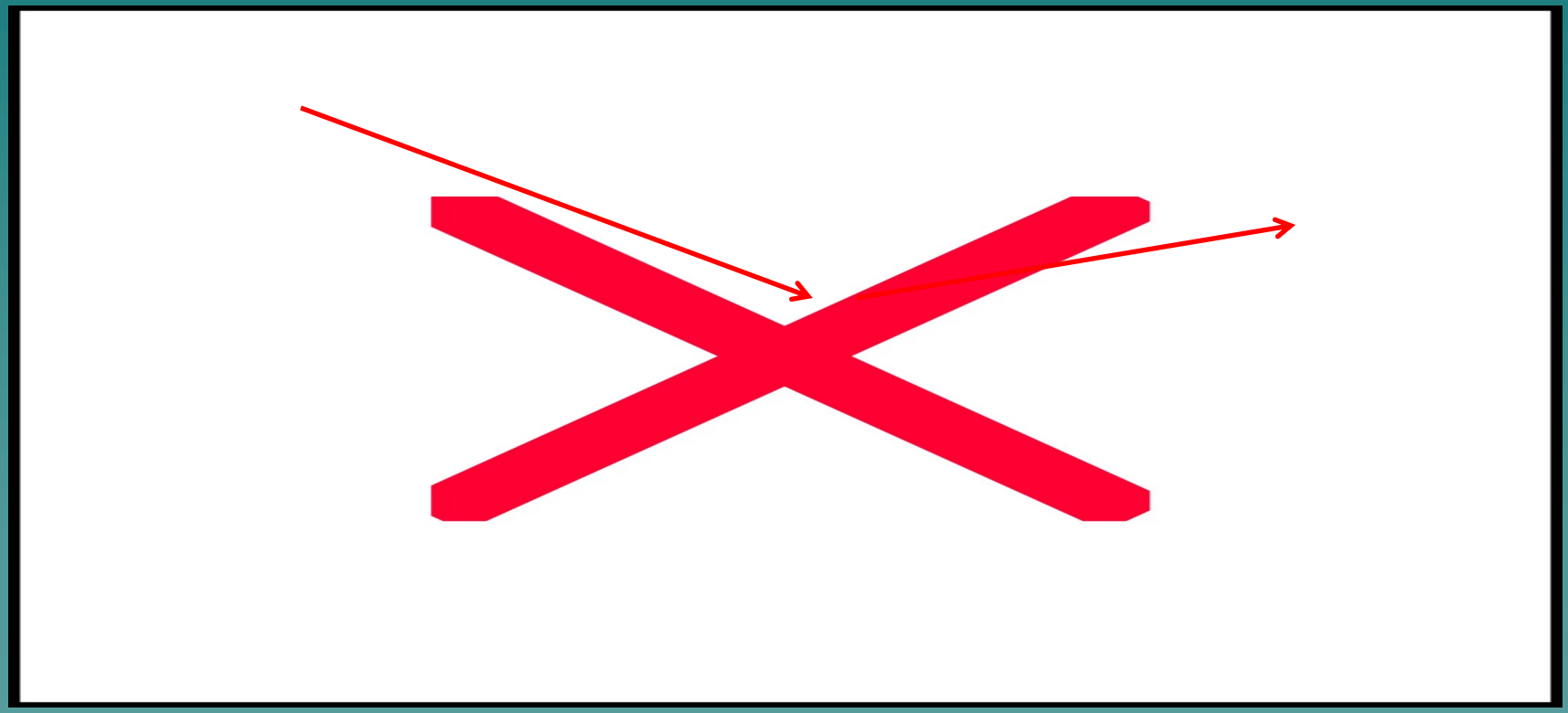
Adapted from Hazel and others, 2010

Changes in Sandbar Size in Central and Western Grand Canyon, 1996-2009

20/20 bars are the same or larger in size than the 1996 pre-HFE condition



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Adapted from Hazel and others, 2010

Floods do export sand

Event	Sand accumulated before flood	Sand exported during flood
2004 flood	0.64 ± 0.3 million tons	0.69 ± 0.3 million tons
2008 flood	3.5 ± 2.0 million tons	1.1 ± 0.1 million tons

- If conducted following periods of sand input from the tributaries, they don't have to export more than was accumulated

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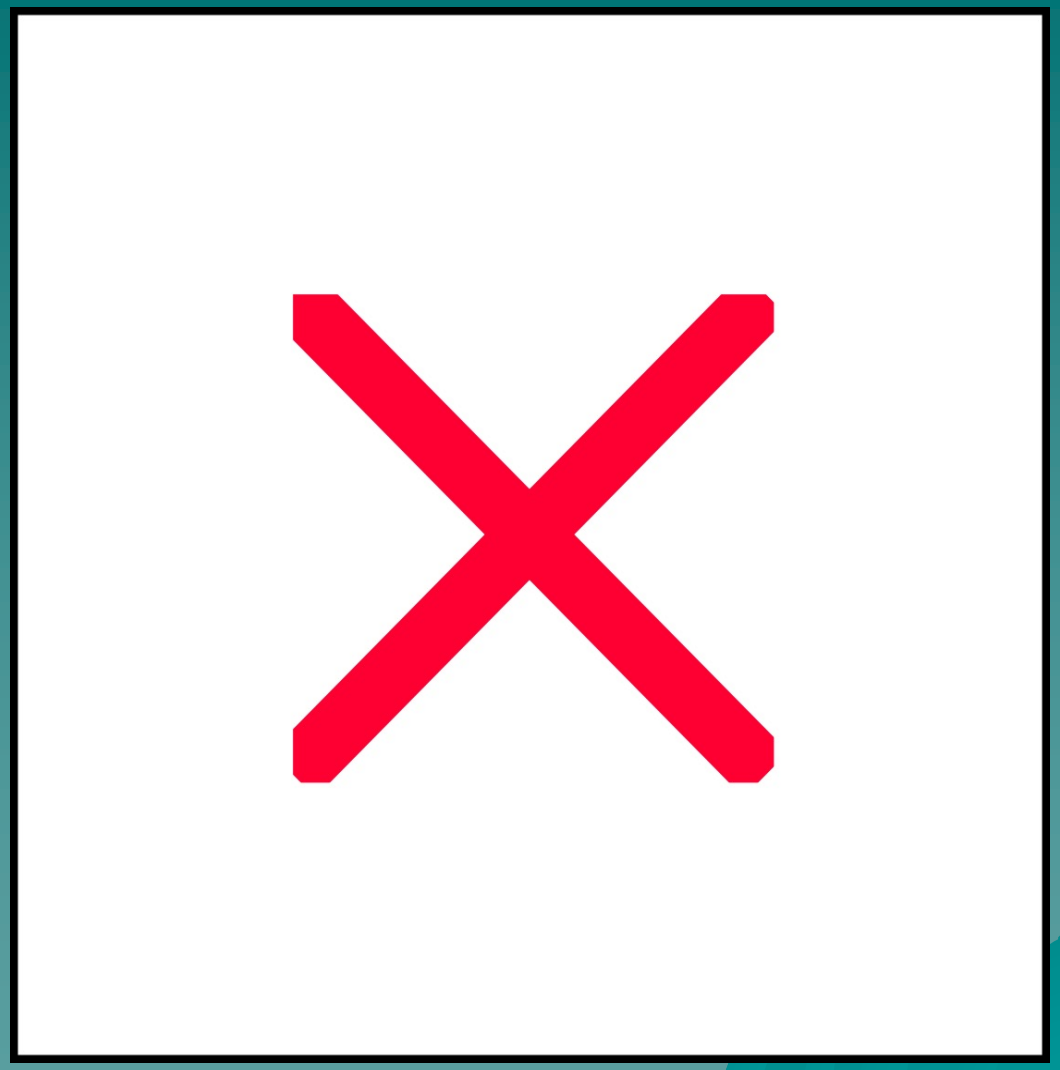
Adapted from Topping and others, 2010

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).

Deposition dominates above 8,000 cfs level, often at expense of erosion below

Demonstrates the difference between high- and low-elevation response



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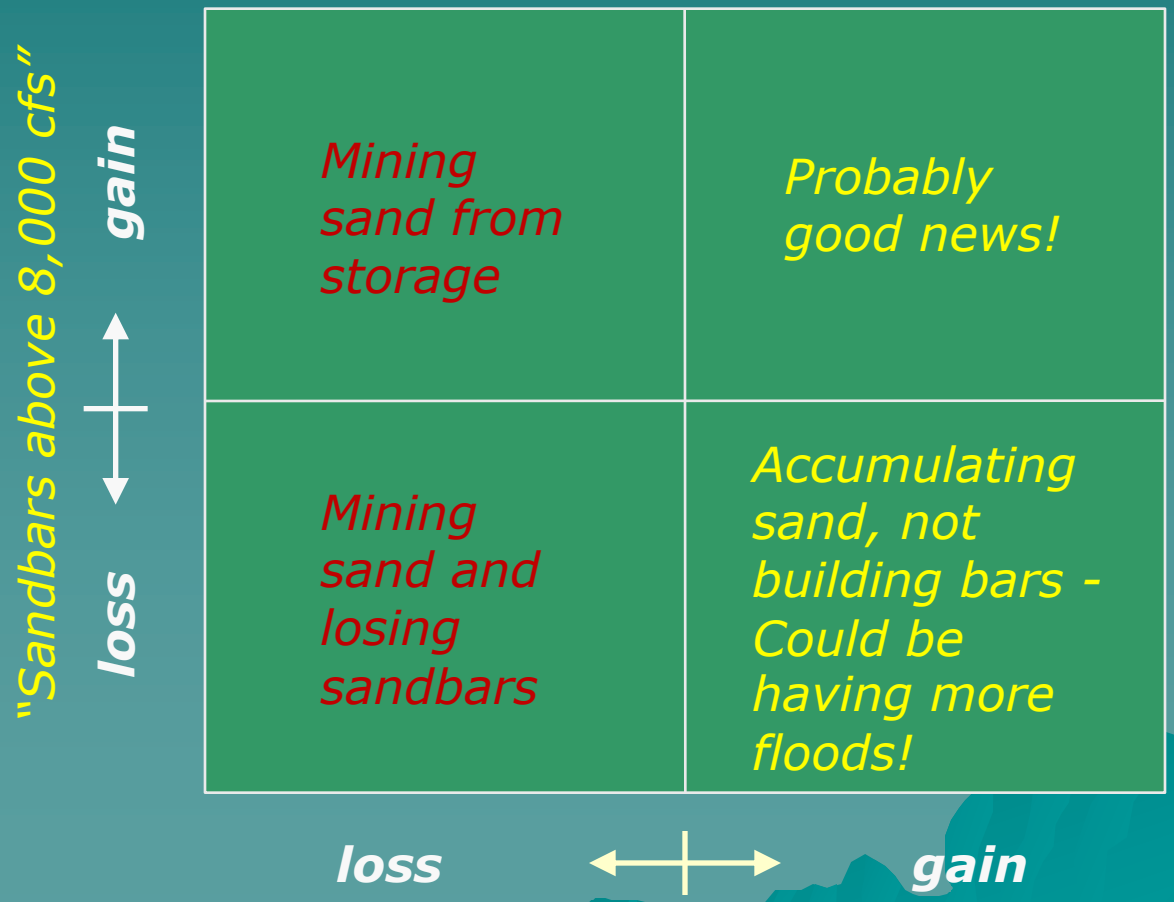
Hazel and others (2010)

Long-term monitoring designed to evaluate whether dam operations (including floods) result in declines in sand storage in the channel

Conceptual model for interpretation of repeat channel mapping information



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Long-term monitoring designed to evaluate whether dam operations (including floods) result in declines in sand storage in the channel

2011 channel mapping trip (launching next Saturday) is collecting these data between the LCR and Phantom Ranch

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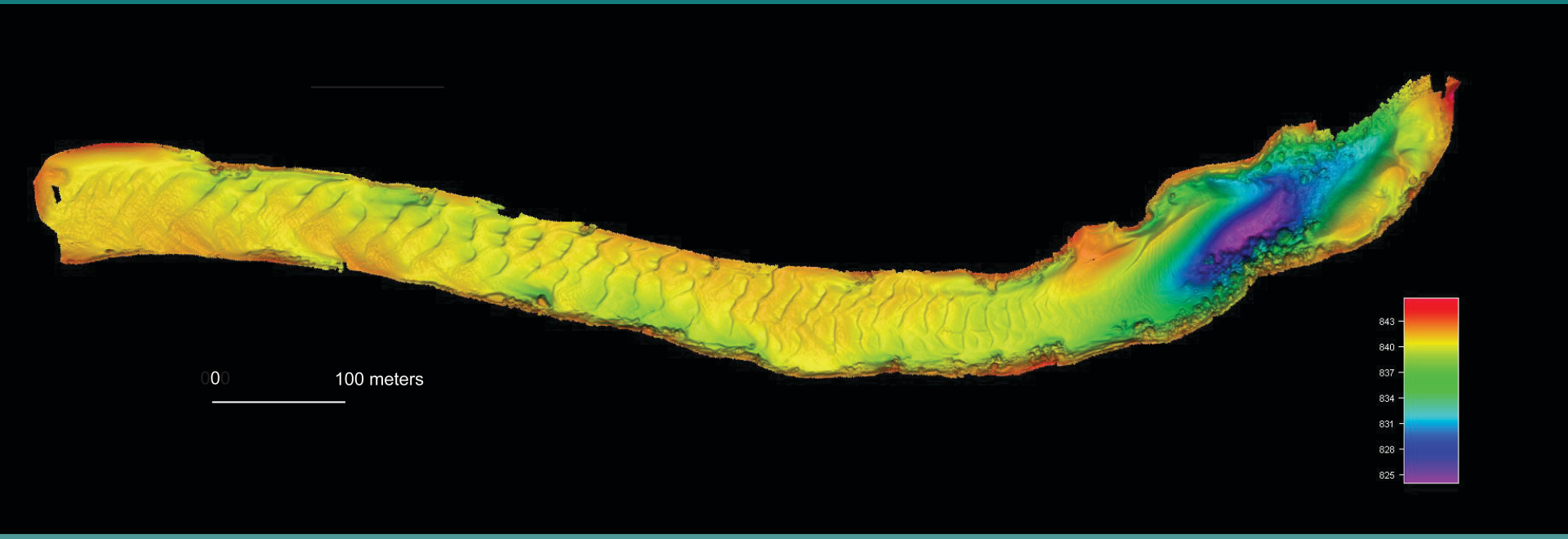
May 2009 near RM 36



- There is a lot of sand on the bed in some locations
  - Is the amount increasing or decreasing?
  - See Kaplinski talk this afternoon!

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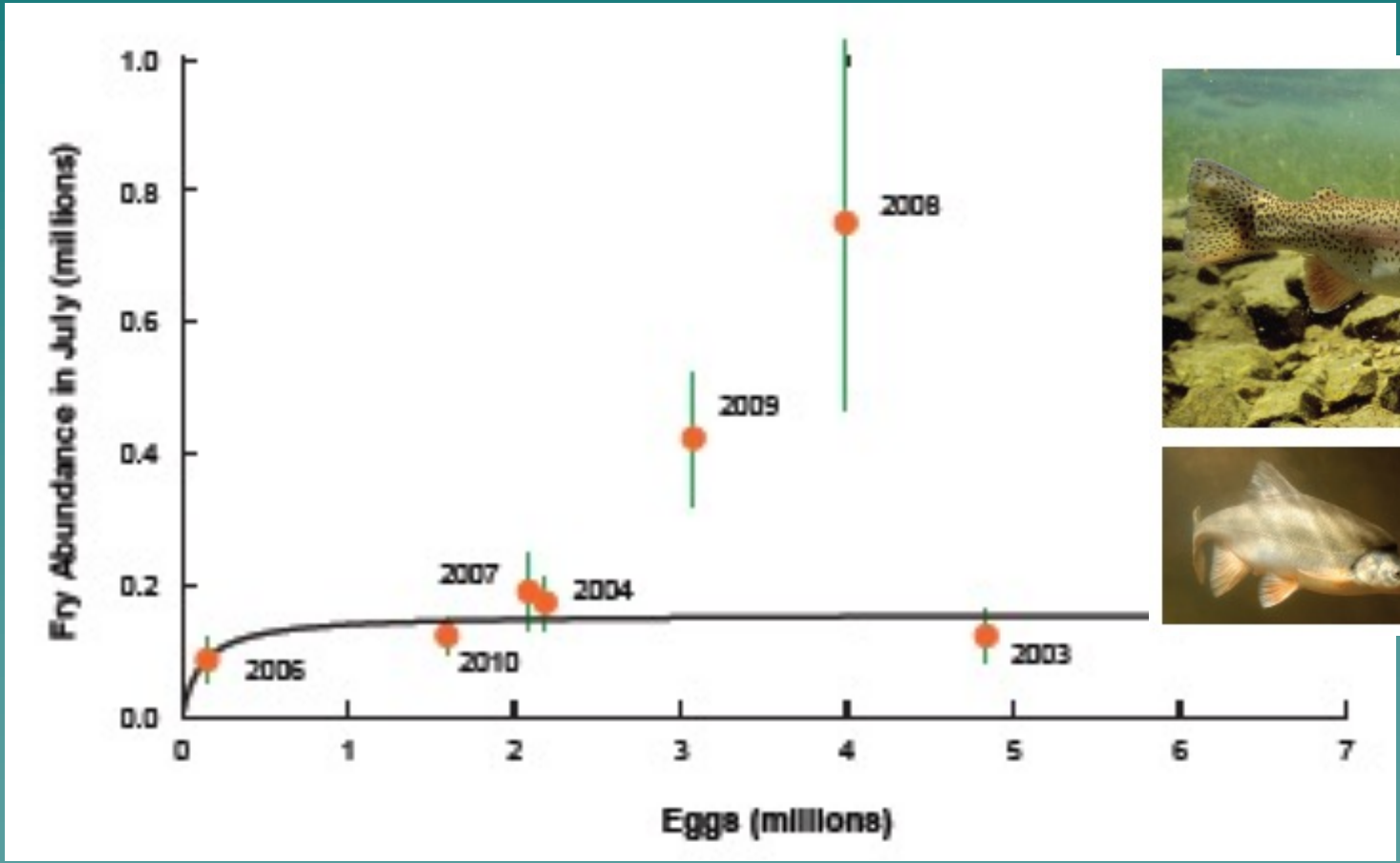
Most Significant Biological Response: More Trout

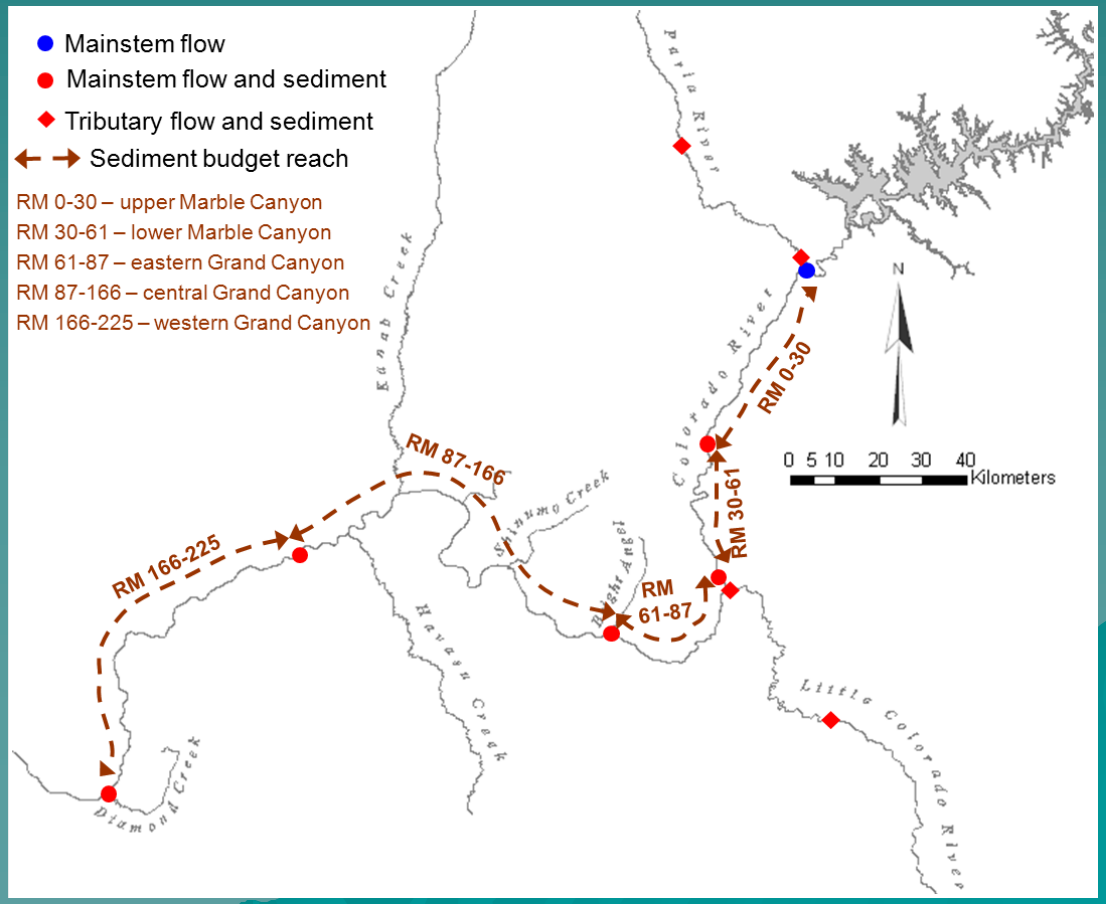


From Korman and Melis (2011)
Discussed in High flow circular ch. 4

How do we determine when to have high flows?

- **USGS Sediment Flux Monitoring Program in Grand Canyon**
- **Shifting rating curve sand routing model**

- Tracks tributary sediment inputs and mainstem transport at five locations to track status of the sediment "bank account."
- Provides the information needed to time high flows for building sandbars to follow periods of sand accumulation.



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

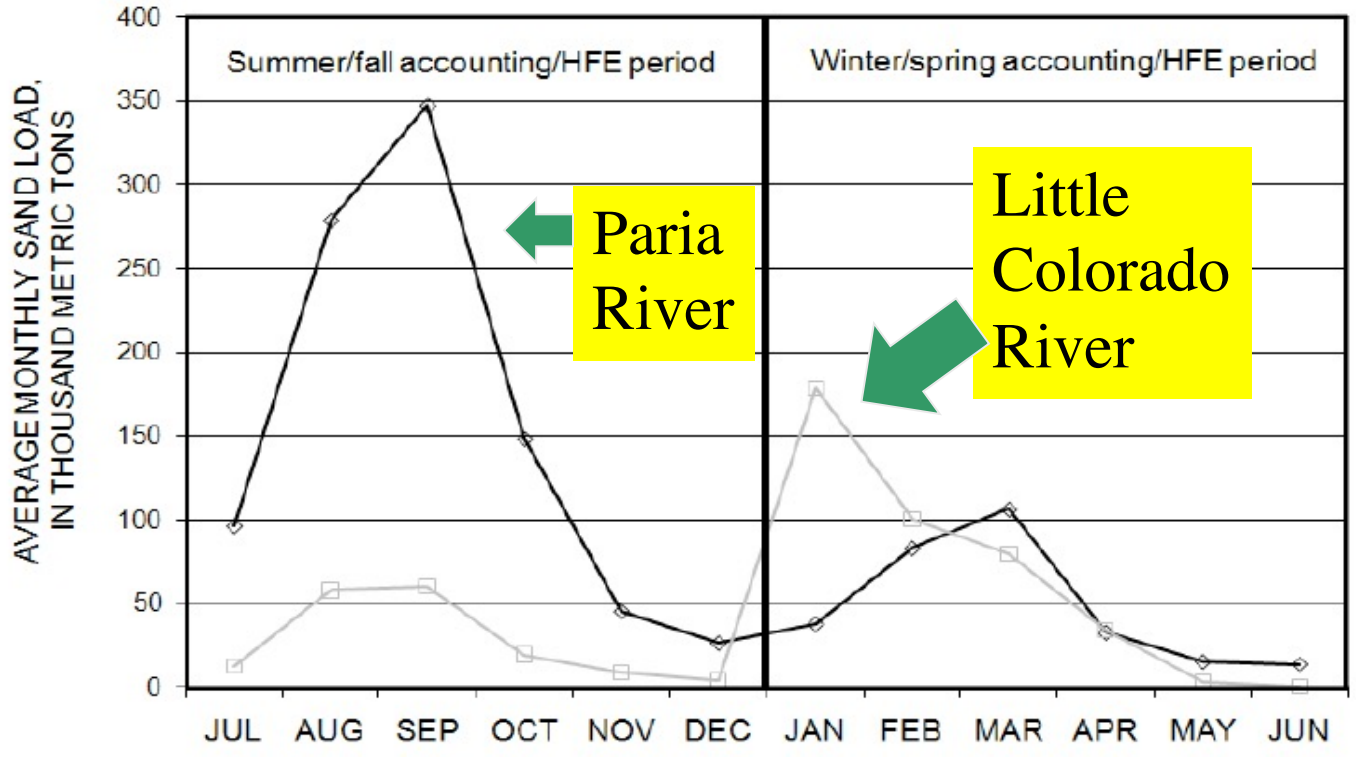

Figure 5. Illustration of a year with two sand-budget accounting periods and two HFE windows (fall and spring). Vertical axis shows the average monthly sand loads from the major tributaries (Paria River – diamonds; Little Colorado River – squares). The presence of two main periods of tributary activity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

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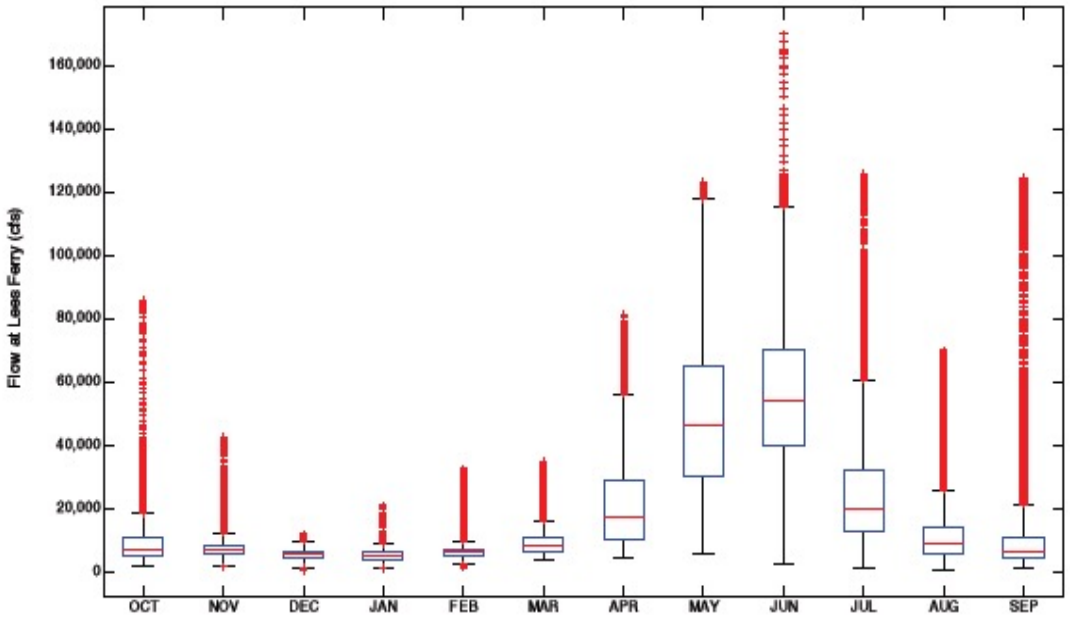
From High Flow Circular Chapter 5, figure 5)

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



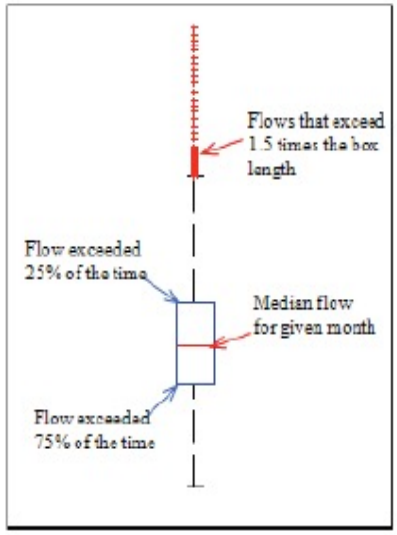


Figure 6. The pre-dam flow regime on the Colorado River at Lees Ferry (data from Topping and others, 2003). The plot shows box-and-whisker diagrams for each month of all instantaneous flow measurements from the beginning of the record (1921) to the beginning of flow regulation by Glen Canyon Dam (1963).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

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From High Flow Circular 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

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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

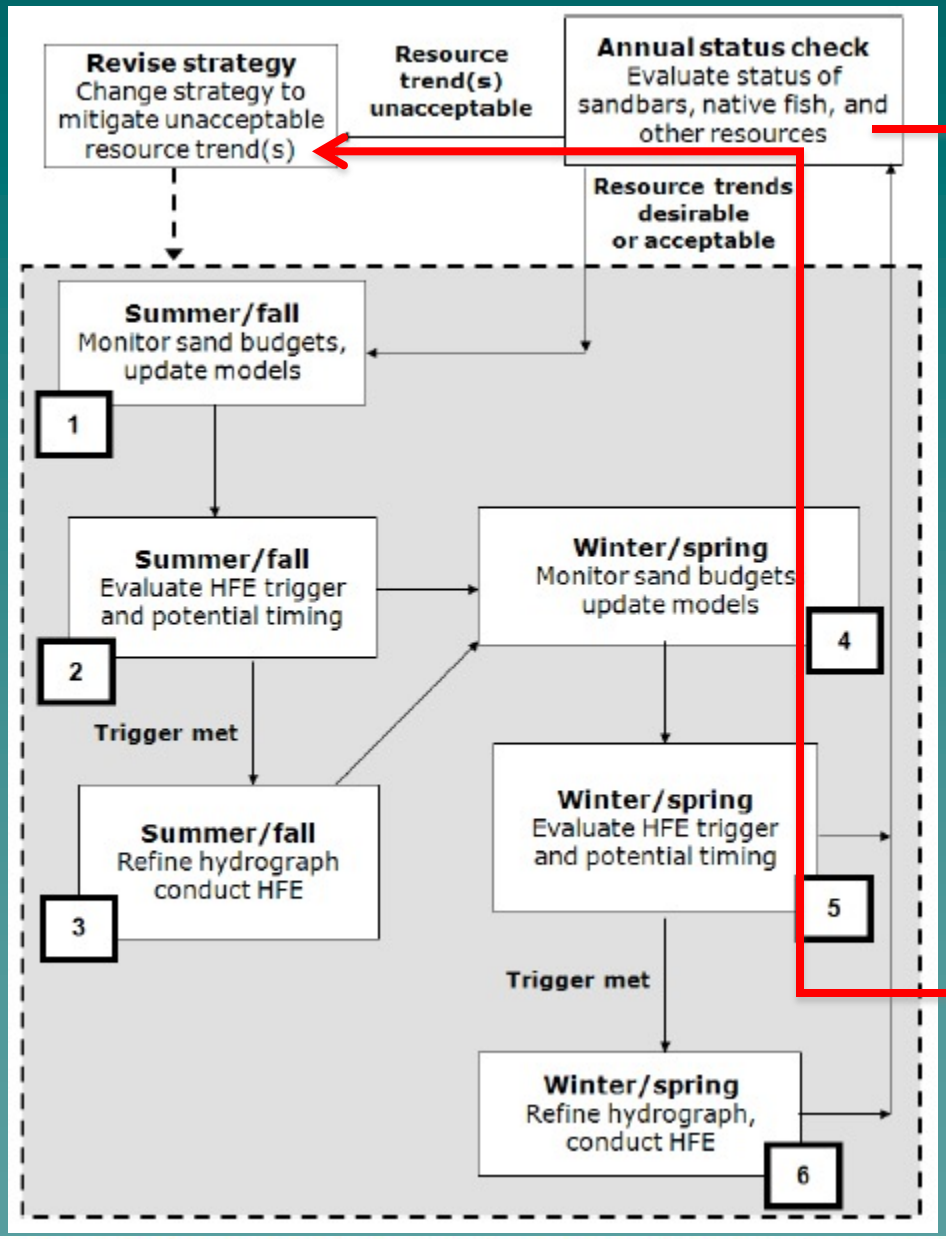

Figure 7. Flow chart illustrating the decision-making process for a science-based experimental strategy for tributary sand-input triggered HFEs with two sand-budget accounting periods and two HFE windows per year. Each box and decision point is described in detail in the text.

Monitoring for high flows

What questions will we want to answer if there are repeated high flows over the next 10 years?

1. *Will multiple high flows conducted over a period of several years result in net increases in sandbar area and volume*?
- *Addressed by monitoring sandbars above 8,000 cfs stage.*
  - Annual to every-other year monitoring of long-term sandbar monitoring sites.
  - Systemwide monitoring every 4 years by remote sensing overflights.

2. *With the available sand supply (i.e. tributary inputs) is the approach of using repeated floods to build sandbars sustainable?*
  - *Addressed by repeat mapping of the channel bed by multibeam sonar (bathymetric remote sensing).*

3. *How will the aquatic food web and fish populations respond?*

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