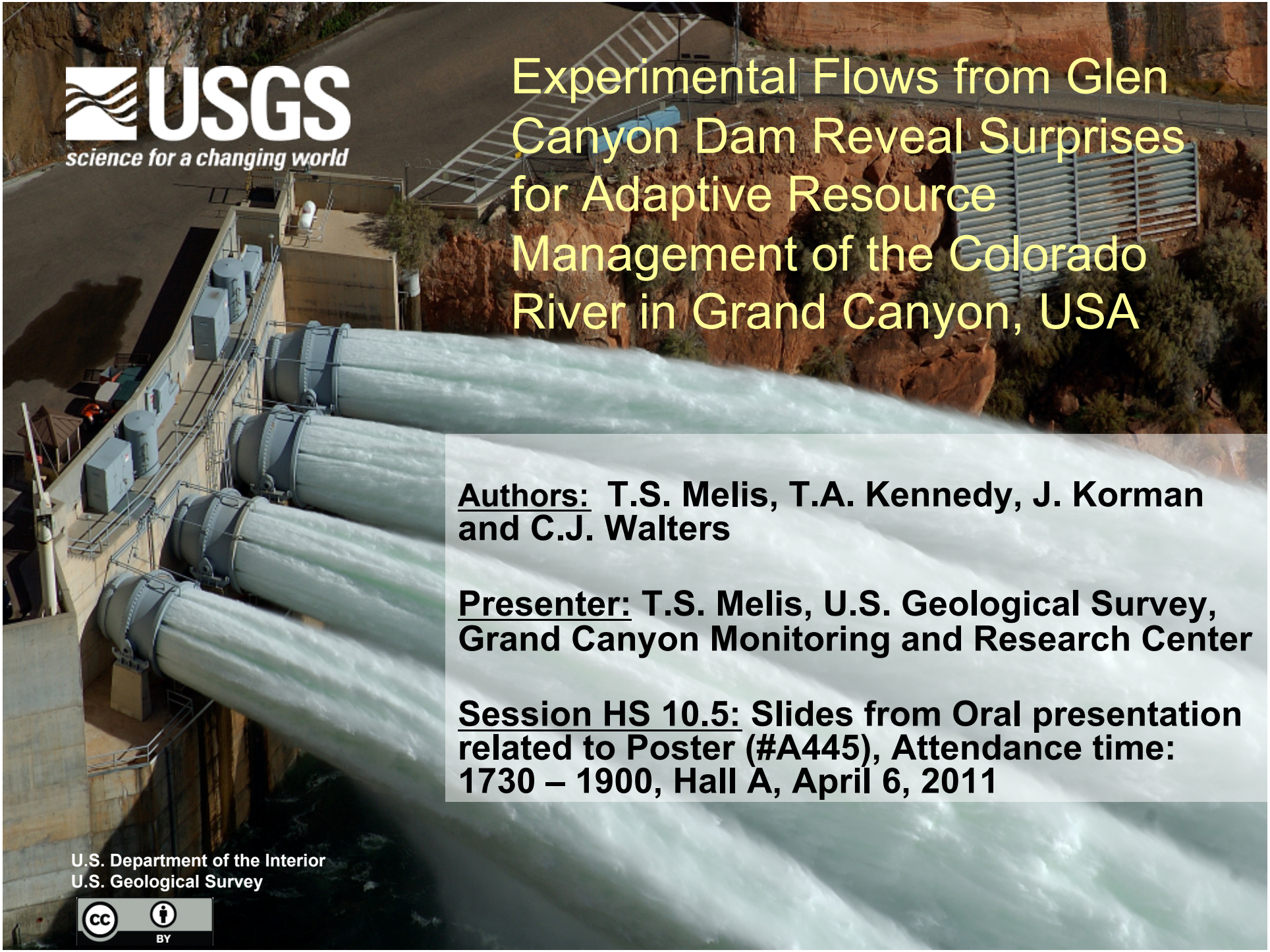

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Experimental Flows from Glen Canyon Dam Reveal Surprises for Adaptive Resource Management of the Colorado River in Grand Canyon, USA

Authors: T.S. Melis, T.A. Kennedy, J. Korman and C.J. Walters

Presenter: T.S. Melis, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Session HS 10.5: Slides from Oral presentation related to Poster (#A445), Attendance time: 1730 – 1900, Hall A, April 6, 2011

U.S. Department of the Interior
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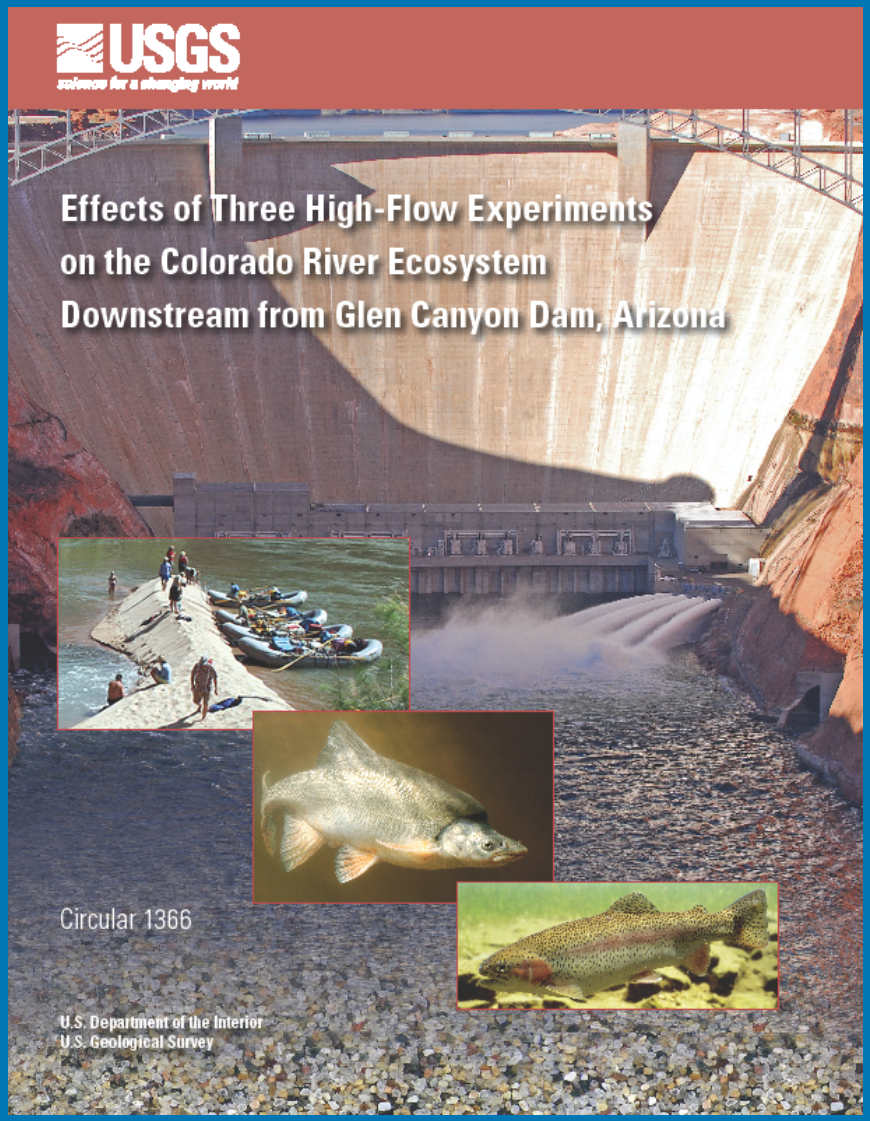
2011 High Flow Experiment Synthesis (USGS Circular 1366, copies available today)



Need - Inform Future Long-Term Controlled Floods from Glen Canyon Dam

Objective – Rebuild & Maintain Eroded Sandbars using Existing Downstream Sand Supply

Also see: ***USGS Fact Sheets 2011-3002 & 2011-3012 + RRA paper by Melis et al. in press***

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Presentation Outline – *Melis et al.*

I – Background & History of Glen Canyon Dam Project

II – Role of "Surprises" as Opportunities for Learning

Learning - Value of Monitoring, Modeling and Experiments

III – Next Phase of Experimental Dam Operations?

Role of Floods - Sandbars vs. endangered fish (chub)

IV – Summary of Main Points

Critical Role of Monitoring – "fast & slow" variables

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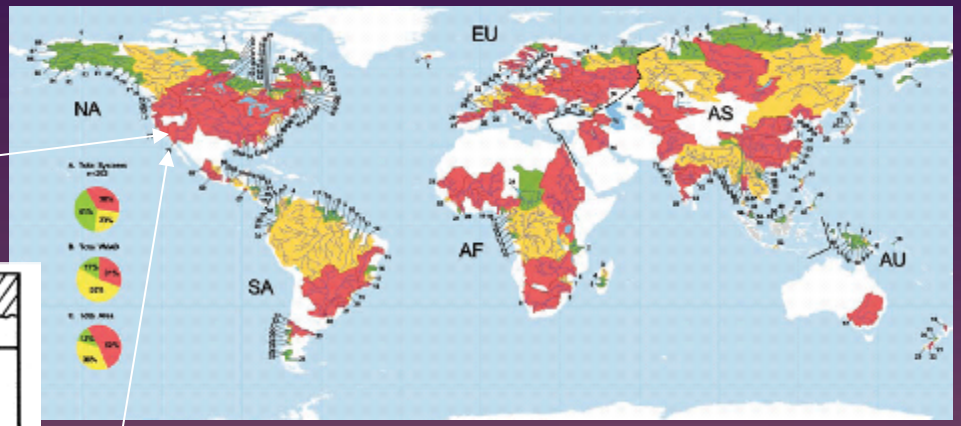
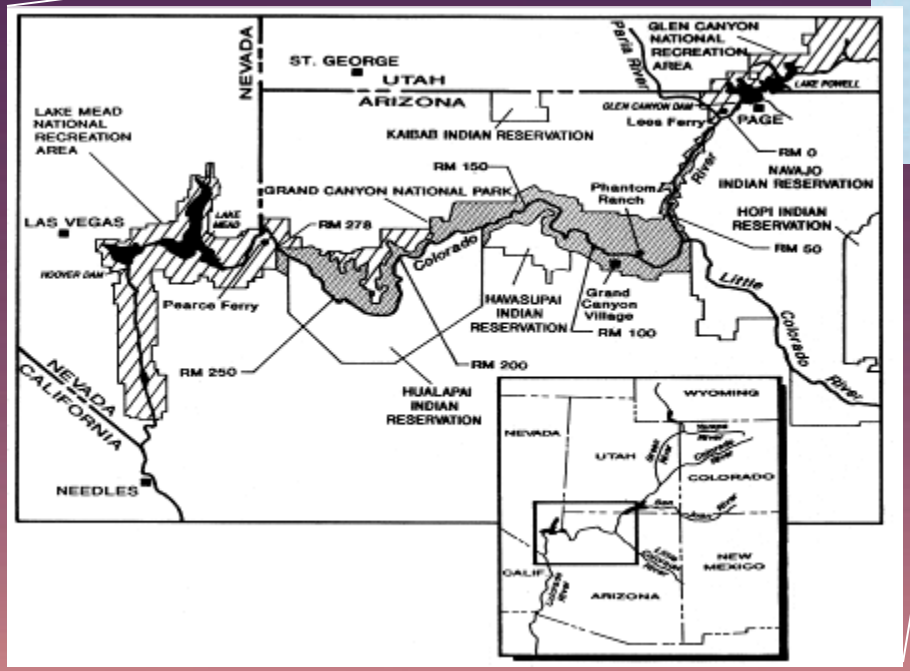
Colorado River Resources & Glen Canyon Dam





Experimental Study Reach
~ 450 kilometers long

Glen Canyon Dam

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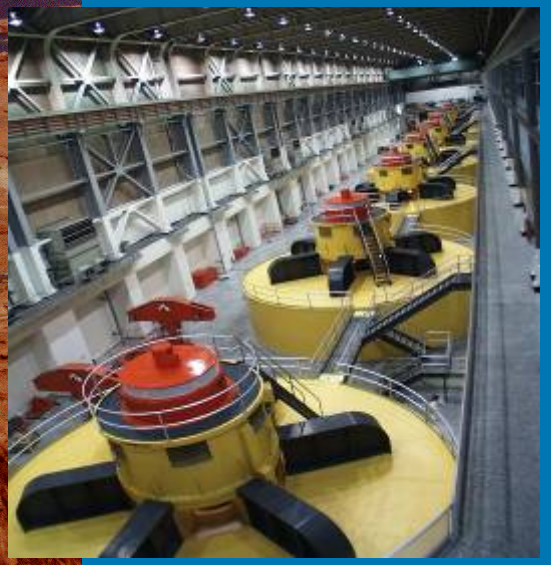
RECLAMATION
Managing Water in the West

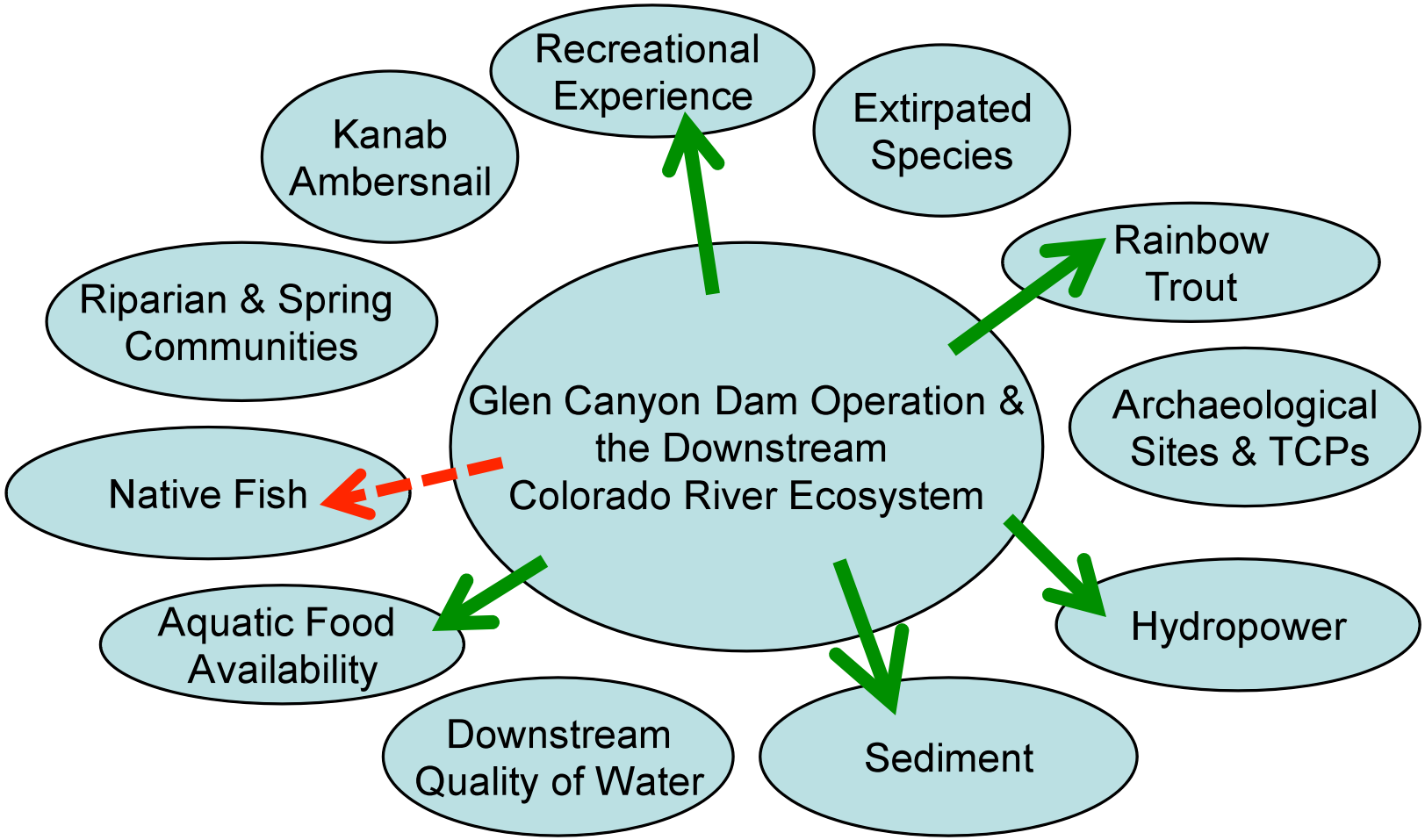


8x150 MW units w/ High-Value Peaking Power!

Studies on Downstream Impacts to River Since Early 70's

Lake Powell - Retains ~ 94% Upstream Sand Supply & Colder River Temperatures

Adaptive Management Goals for Colorado River in Grand Canyon



Long Term Quality Adaptive Management Program Experiments

I – Background & History (closed ’63)

- **Water storage, but also “peaking” hydropower**
- **Unconstrained operations for power (1966 – 1990)**
- ***Environmental Studies 1970s to present***
- **Major Environment Impact Statement 1990 – 1995**
- ***Hourly Operating rules imposed since 1996***
- ***Three Controlled Floods since 1996 (‘96, ‘04, ‘08)***

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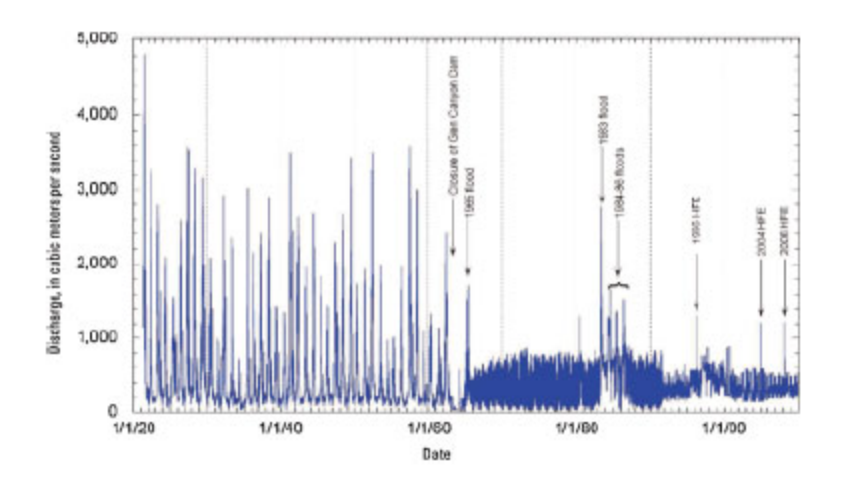
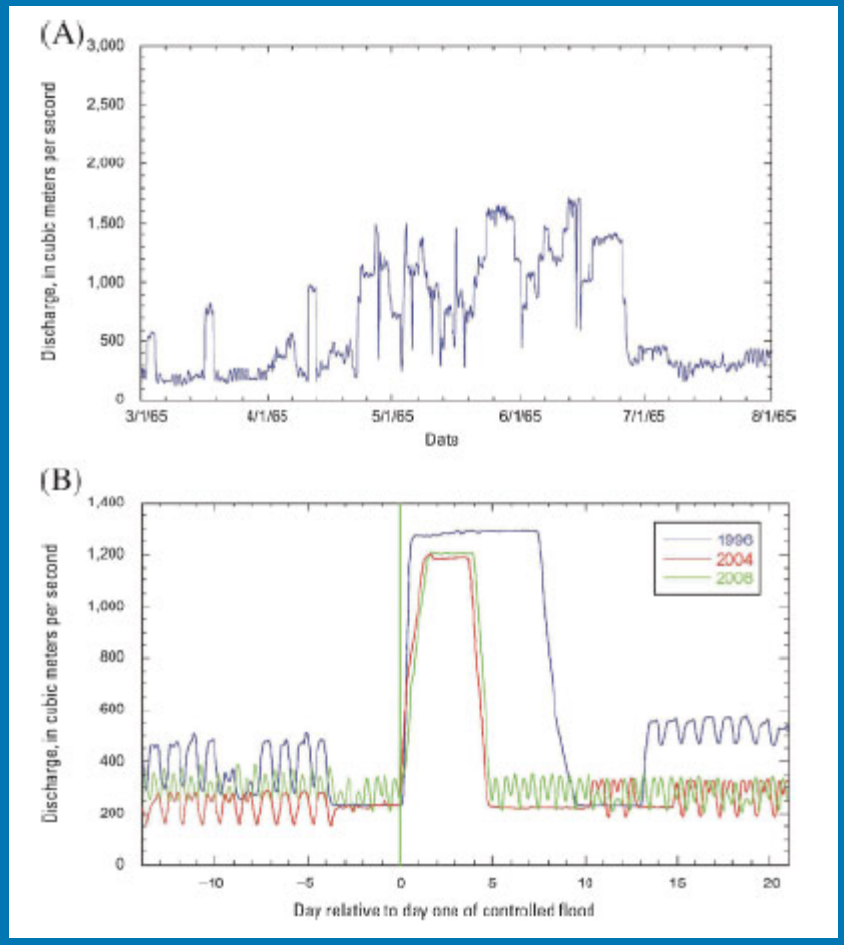
I – Background & History – "Influence of Regulation and Early '*High Flow*' Operations"





Typical Example of River Regulation:
Food Frequency Compressed + altered timing of high & low flow seasons

Just Like I Like it!
Clean & Stable

- **Earliest Dam operations in 1965 - Scoured Tailwater Reach of Sand and Fines**
- **Preparing for Introduction of Rainbow Trout as Recreational Sport Fishery**
- **Flows were similar to "Artificial Floods" released in 1996, 2004 and 2008**

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Humpback Chub (*Gila cypha*)

Listed Species under Endangered Species Act

Hey – I'm the "protected" Fish in this program!

Sandbar Camping Areas Highly Valued for River Recreationists in Grand Canyon National Park

Introduced Rainbow Trout

- Endemic to Colorado River
- Largest Population Found in Grand Canyon National Park
- Recently Increases in Adults followed Decline in 1980s-90s

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II – Learning from Surprises

"1st Big Surprise – *Shifting Sediment Rating Curve* tied to Tributary Flooding"

1995 EIS Sediment Conservation Paradigm Overturned (1997)!

Monitoring revealed that reoperation of GCD powerplant did not allow multi-year sand accumulation to occur before periodic controlled floods

(Schmidt and Grams 2011, Wright et al. 2008, Topping et al. 2006,, Rubin et al. 2002)

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Recent HFE Synthesis: “Sandbars”

Monitoring data - after 3 floods (2 with new sand supply) beaches in Grand Canyon are about the same size or slightly larger than before artificial flooding started in 1996

BUT, How many do managers need? Goal is still unclear?

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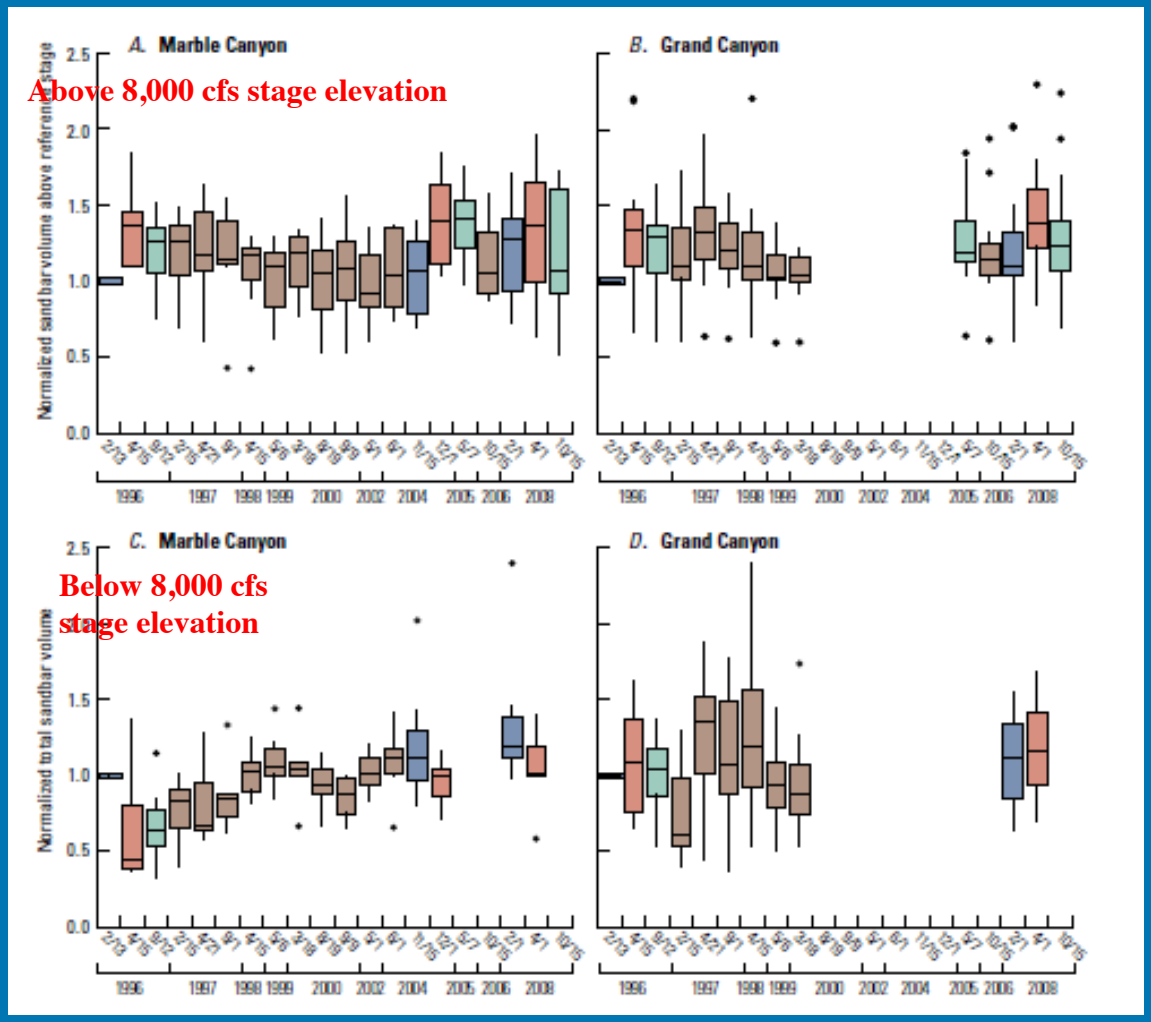
The Data - FEB 1996 to OCT 2008



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

II – Surprises & Learning

"2nd & 3rd Big Surprises"

Re-operation of Power Plant benefited nonnative salmonids (rainbow trout) in tailwater, while native chub continued to decline (1991 – 2000)

"Good and Bad News"

Managers hoped stable flows = sandbars & native fish in Grand Canyon, but introduced trout were first to show increases from natural reproduction following 25 years of required stocking to maintain sport fishery below the dam!

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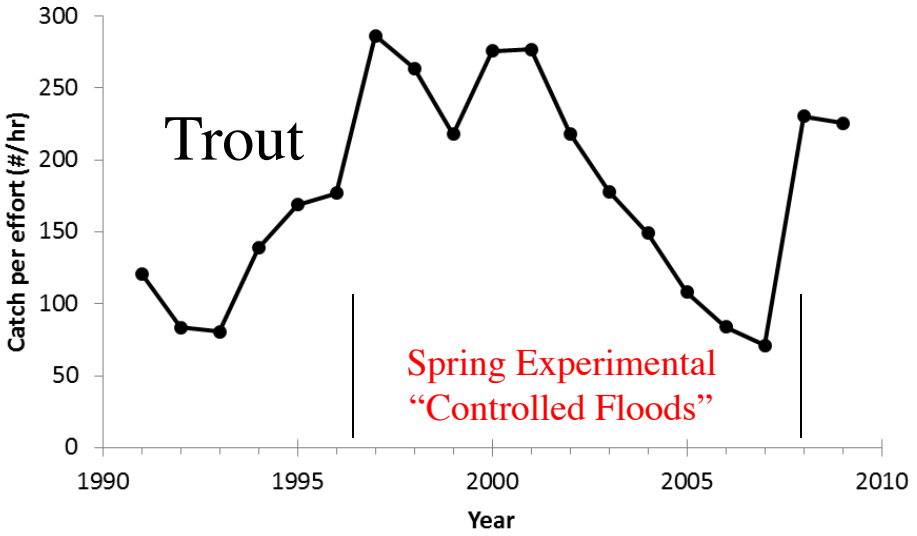
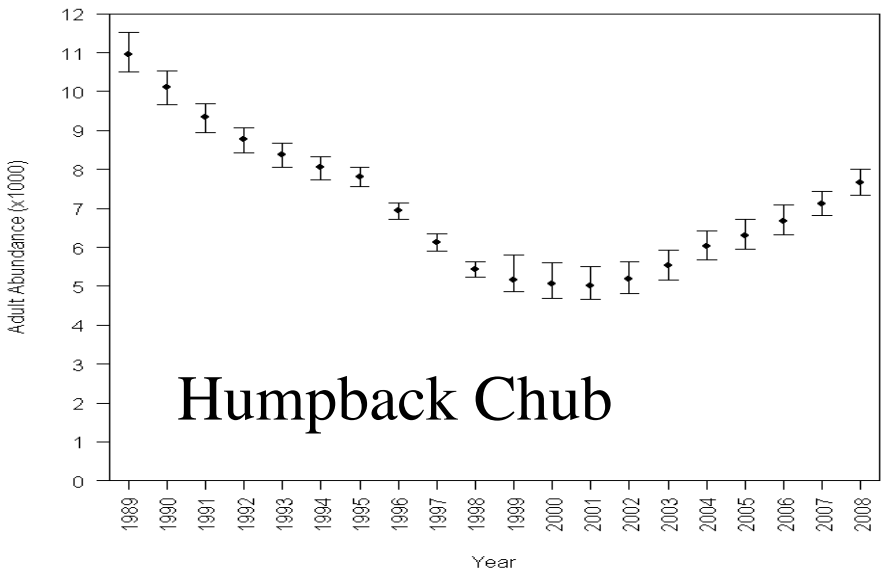
Rainbow Trout vs. Chub Trend Data



Trout peak in about 2000, then abruptly decline, while Native Chub stabilize and start to increase



Finally – a "Welcomed" Surprise for the Managers!

BUT - Spring Controlled Floods March 2008 & 1996 produce Large Trout Production!

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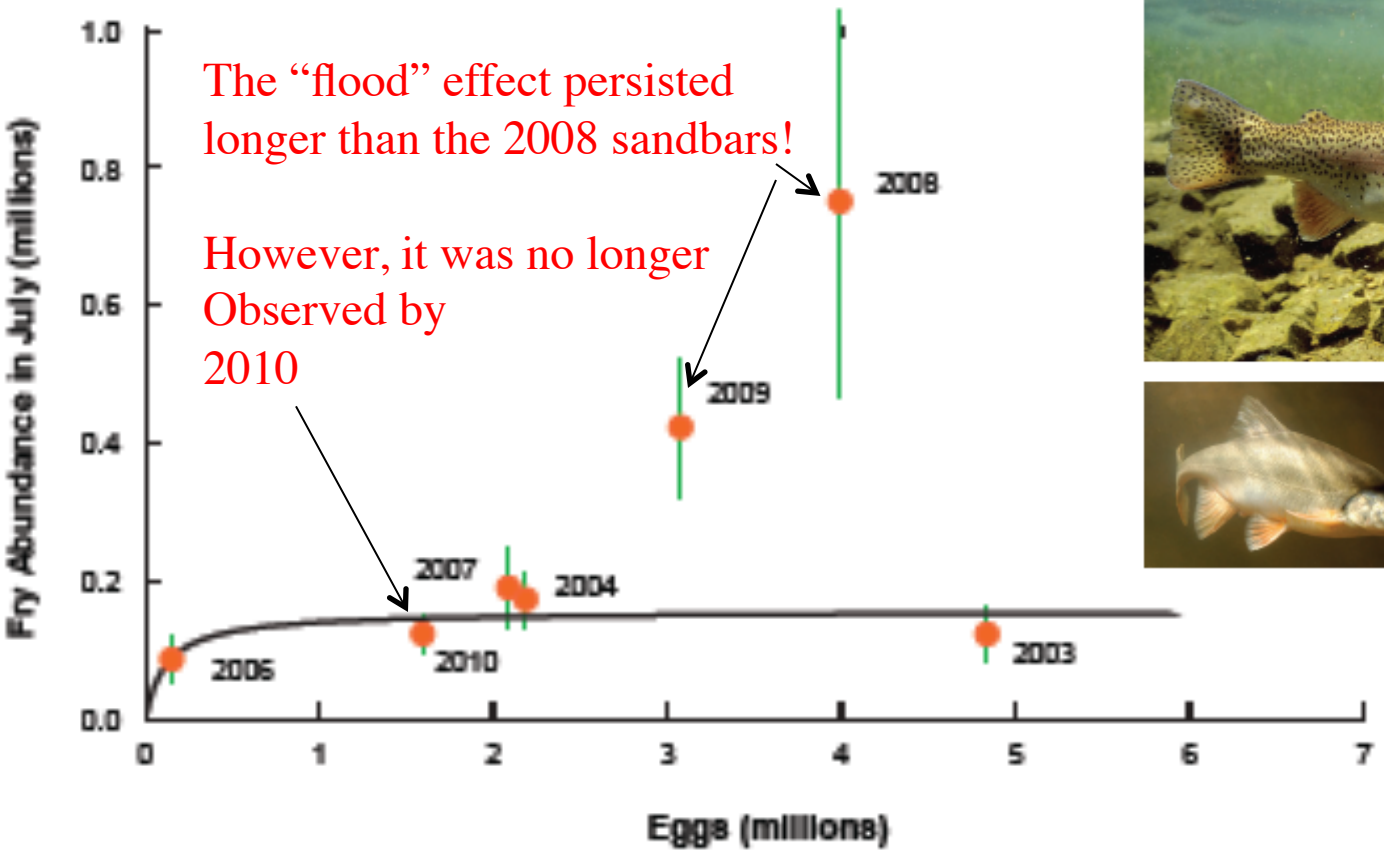

The relation between the number of viable rainbow trout eggs deposited in the Lees Ferry reach and the resulting population size of fry in mid-July for the years 2003–10 (no data for 2005). The thick black curve shows the best-fit relation between viable eggs and fry using data from all years except 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)

[see USGS Fact Sheet 2011-3002, copies here or at: www.usgs.gov]

Also discussed in Chapter 4 of USGS circular 1366

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II – Surprises & Learning

"4th Big Surprise"

Shifts in Production of Invertebrates

Spring 2008 Controlled Flood = an overall decrease in total production, but increased drifting taxa that allowed juvenile trout in 2008-09 access to higher quality food items in drift – there was a shift toward taxa more prone to drifting and trout are drift feeders

Channel cleaning of gravels in the tailwater (recall the 1965 High Flow releases) appears to have improved the spawning habitat for rainbow trout & shifted production to taxa afterward that were more available in drift and supported increased fry recruitment

(Please see Poster #A443 by Kennedy et al. in Hall A)

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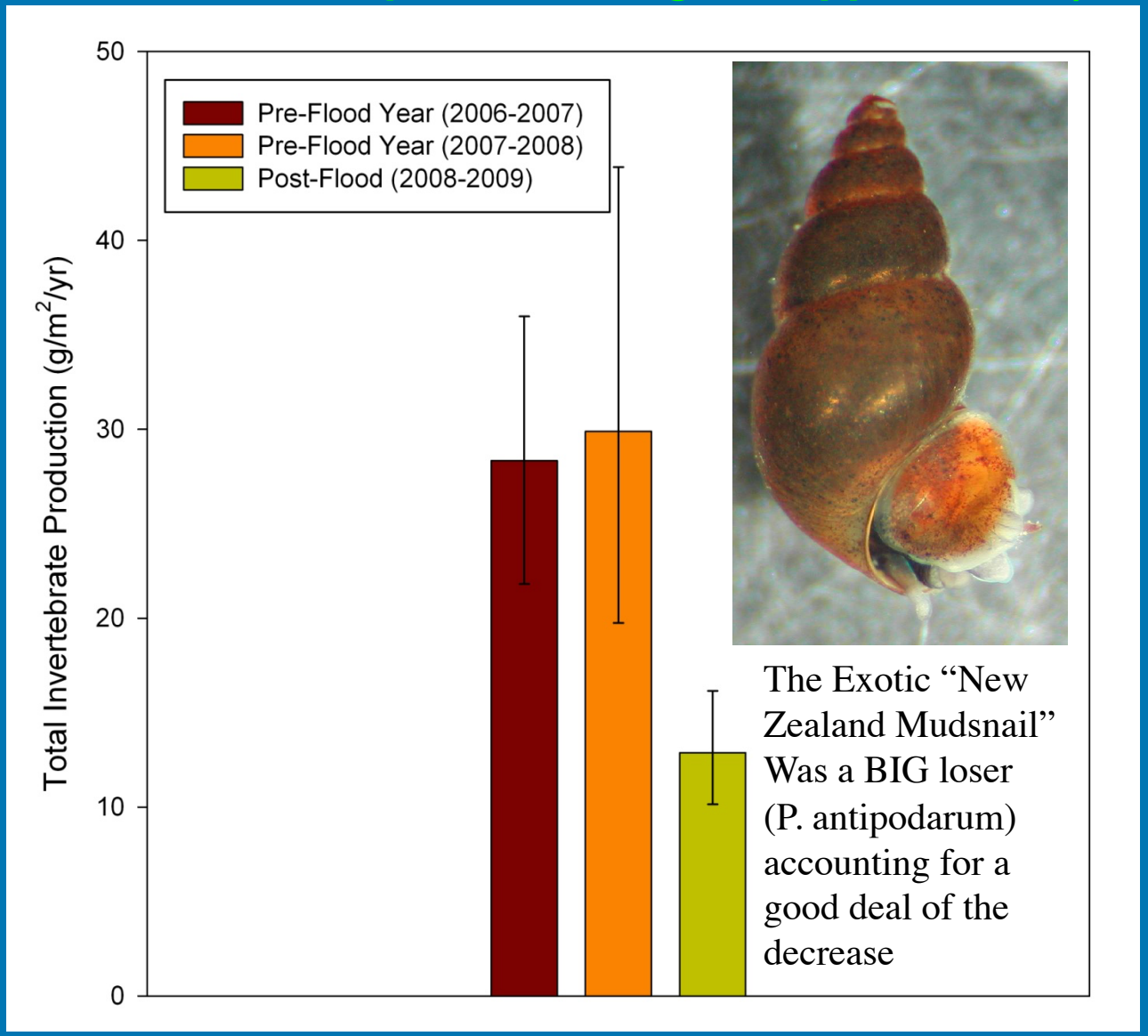
Artificial Flood in Glen Canyon Tailwater Reduced Invertebrate Production

(see Cross et al. in press, *Ecological Applications*)



The Exotic "New Zealand Mudsnail" Was a BIG loser (P. antipodarum) accounting for a good deal of the decrease

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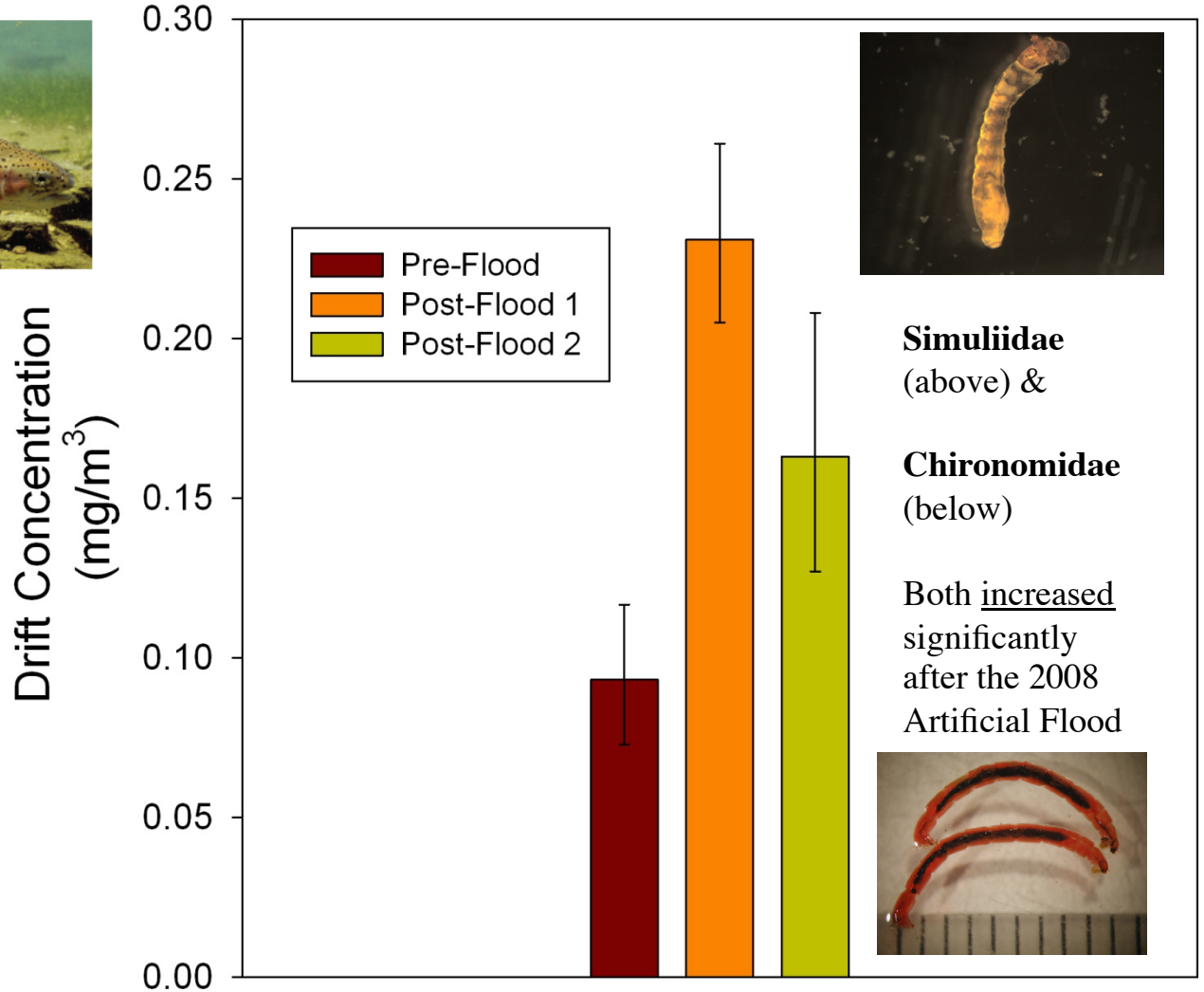
Artificial Flood in Glen Canyon Tailwater Increased Food Available for Salmonids In Drift

(see Cross et al. in press, *Ecological Applications*)



Simuliidae (above) &

Chironomidae (below)

Both <u>increased</u> significantly after the 2008 Artificial Flood

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The River Spol Case Study

(learning from others – Where is Chris?)

"*The Swiss Experience*"

- Repeated Floods from a Hydroelectric Dam in Alpine River Setting within Swiss National Park (the Colorado River is more alpine now than desert)
- Native Brown Trout appear to be Benefitting from ~20 Artificial Floods Released Since 2000
- Food Web Shifted to taxa similar to those found in the Glen Canyon Tailwater - Over Several Years
- Researchers Have Determined that Continued Artificial Floods are Needed to Sustain Responses - (BUT, can such sustained responses be managed in the Colorado River in Grand Canyon??)

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See Sidebar in USGS 1366
Chapter 4, pp. 114-116
(Valdez, Robinson and Melis)

II – Surprises & Learning

"5th & Final Big Surprise"

Rainbow Trout Can Swim Downstream (and they do)

Yard et al. in press (Transactions of the American Fisheries Society) have shown that rainbow trout prey on juvenile chub and other native fish in Grand Canyon – and also are known (Kennedy, personal communication) to compete with chub for limited food and habitats in the Colorado River below the tailwater reach

Implications of Artificial Flood Biotic Responses on Chub?

Aquatic Synthesis Points

- 1) **Artificial Floods -** conducted in spring benefit rainbow trout populations as a result of improvements in spawning and rearing habitat (uncertainty exists for other times)

- **Experimental Flow Research -** no measurable positive impacts on humpback chub populations

- 3) **Monitoring** - rainbow trout in Grand Canyon - after the 2008 HFE, are ***inconsistent*** with goals for humpback chub, rainbow trout, and native fish management in Grand Canyon National Park

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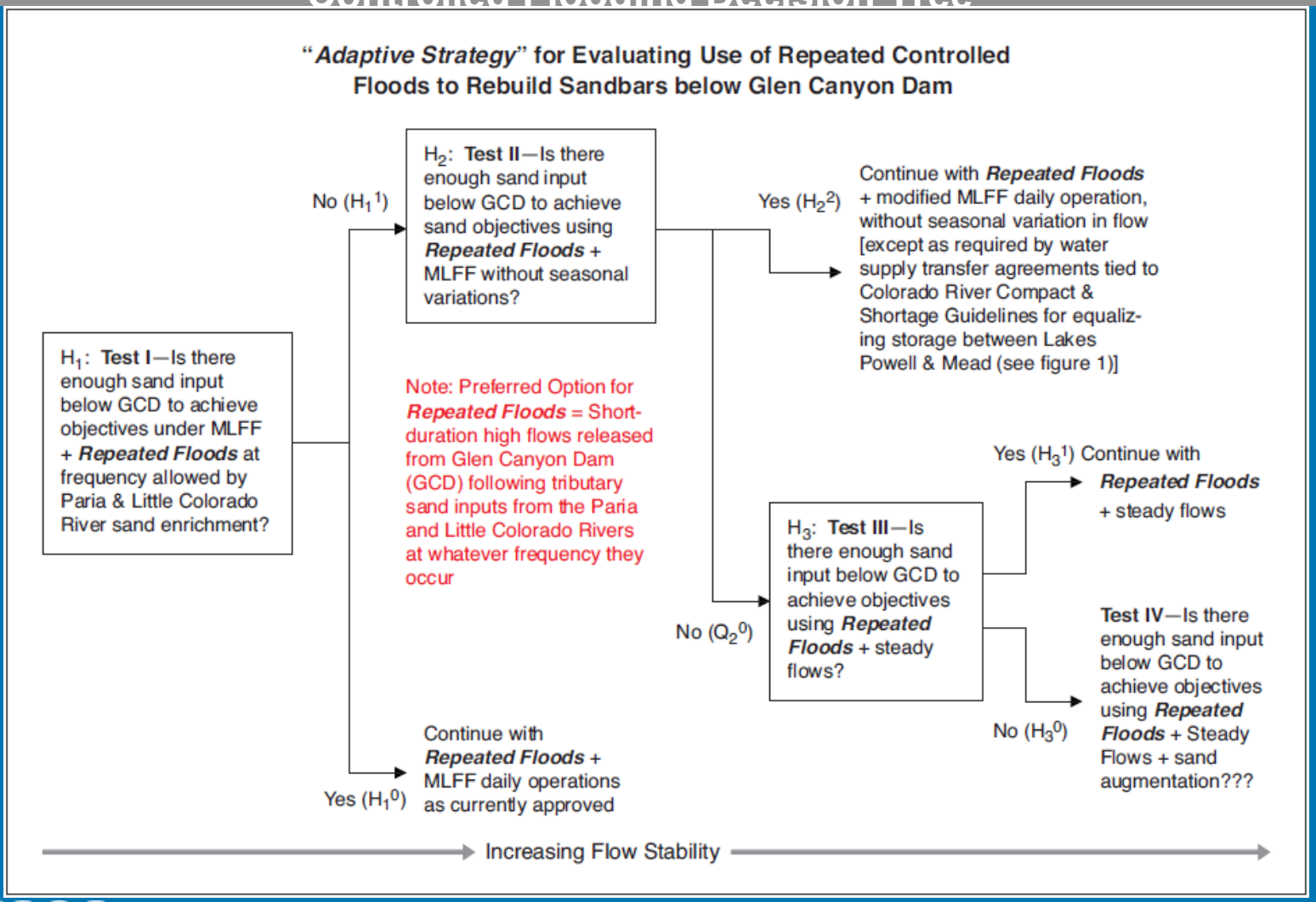
III – Next Phase of Experimental Dam Operations?

One Example of Adaptive Strategy

"Controlled Flooding Decision Tree"



To date, data and models suggest that flow stability = Trout

IV – Summary of Main Points

- Dam Operations - (repeated floods) to rebuild sandbars pose a risk to endangered, native humpback chub (strongest measured response to spring floods = salmonids)

- Proposal for "River Spol" type experiment now being planned for Colorado River in Grand Canyon – knowledge transfer occurring

- Repeated release of artificial floods will require "experimental" nonnative fish control

- Monitoring the "slow" variables is critical for anticipating future "surprises" that managers & scientists should expect

- Our models are not able to predict these slower responses

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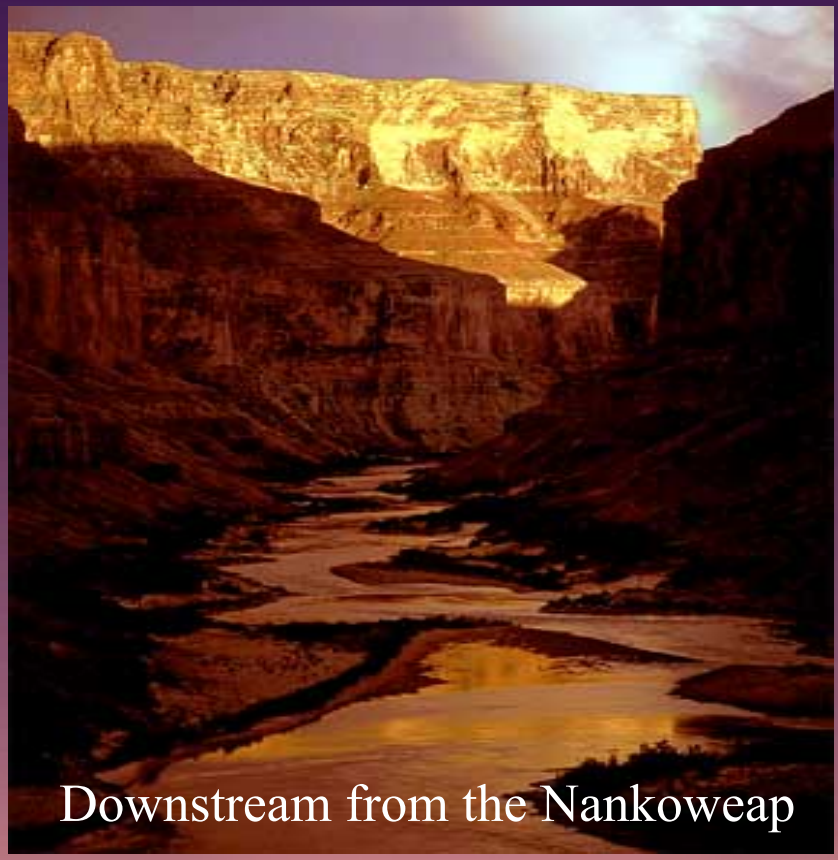
Thank All of You for Your Attention!

Redwall Cavern of Marble Canyon



Downstream from the Nankoweap

Correspondence: tmelis@usgs.gov

Hoping to see you at the American Geophysical Union Meeing – December 2011!