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The FLAHG Hydrograph

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Grand Canyon Monitoring and Research Center
Southwest Biological Science Center
U.S. Geological Survey
U.S. Department of the Interior

Preliminary results subject to review and revision

Predicted Effects of a Spring Disturbance Flow on LTEMP Resources—a report by the FLow Ad Hoc Group (FLAHG) of the Glen Canyon Dam Adaptive Management Program

I. Background

Disturbance is a critical natural process in streams and rivers (Resh and others 1988, Poff and others 1997). By disrupting ecosystem structure and altering the availability of substrates and resources, flood disturbance helps maintain native biological diversity (Bunn and Arthington 2002, Carlisle and others 2017). Disturbance magnitude, for example the extent of drying at low flow or the proportion of the bed that is mobilized at high flows, can influence ecosystem outcomes by, for example, determining the extent of biomass loss and the quantity of newly scoured habitat patches available for recolonization by algae and aquatic insects (Lake 2000). Disturbance frequency and timing (e.g., spring vs. fall) can also influence the rate and trajectory of ecosystem recovery from disturbance (Figure 1 and Lytle and Poff 2004). The life cycles of many species of algae, insects and fish are directly tied to flood disturbances (Lytle and Poff 2004) and alterations to river flood regimes can adversely affect ecosystem health. In fact, a national synthesis of flow and biological data from over 700 streams and rivers in the lower 48 states found that healthy communities of native aquatic invertebrates and fish were most often present where flood disturbance still occurred, and where flood timing was seasonally appropriate (i.e., similar to the natural condition; Carlisle and others 2017). Although the Colorado River in Grand Canyon could not be included in this 2017 synthesis owing to the absence of pre-dam ecological data, the mechanisms linking periodic flow disturbance to stream ecosystem health were evaluated in a wide variety of streams and regions (Carlisle 2020). It is therefore reasonable to predict that similar mechanisms linking appropriately timed flow disturbance to ecosystem health also operate in the Colorado River.

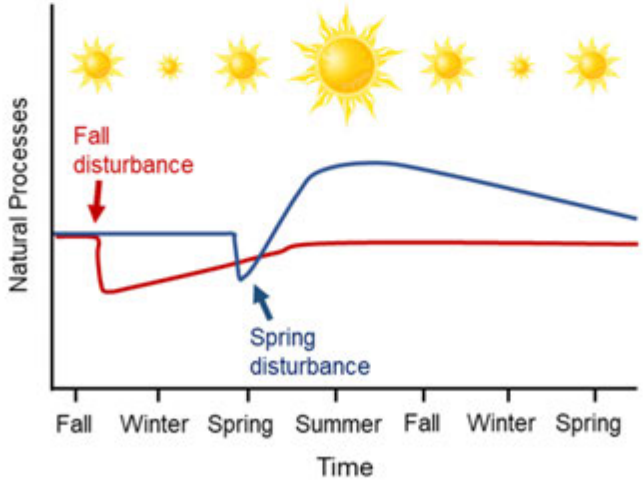

Figure 1. Conceptual figure showing the potential role of spring disturbance in enhancing natural processes (e.g., algae and aquatic insect production) of the Colorado River ecosystem.

Outline

- Background (5 slides)
- FLAHG hydrograph (3 slides)
- Knowledge Assessment (14 slides)
- Contingencies, conclusions (5 slides)

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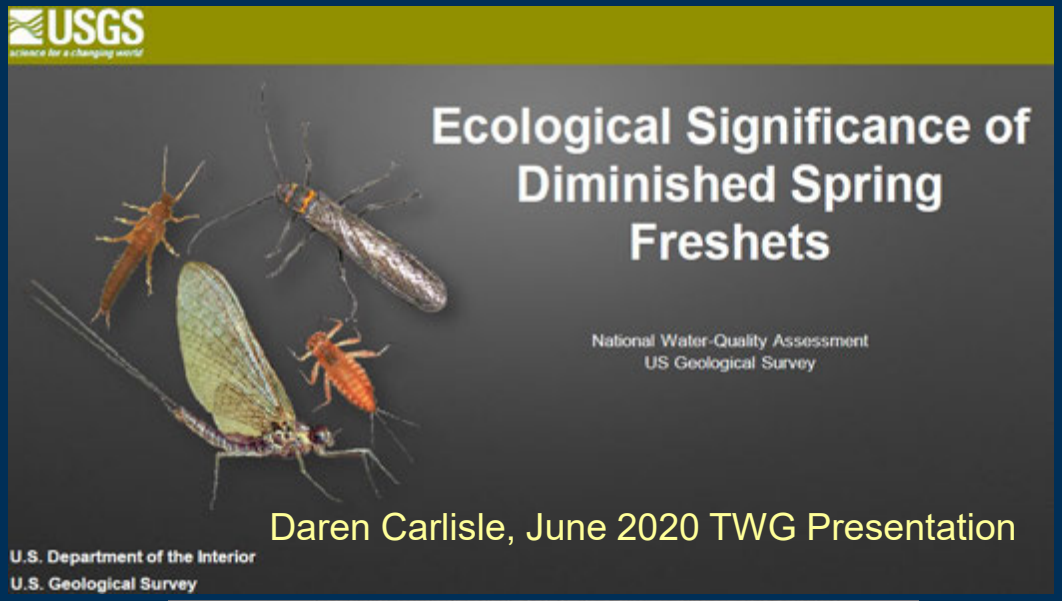
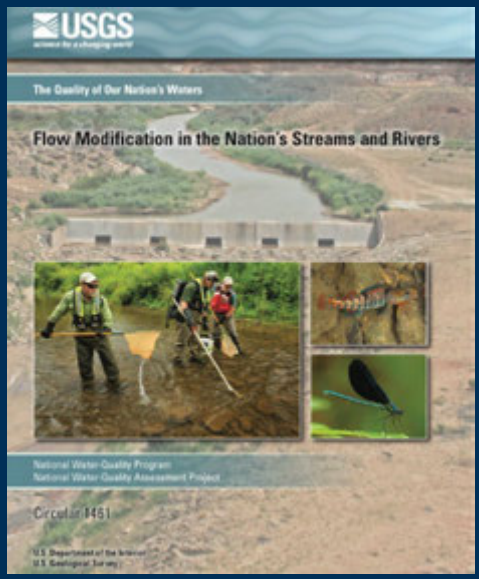
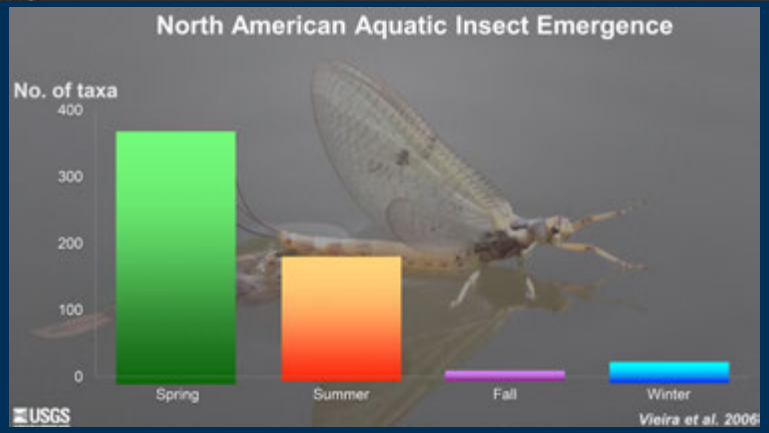
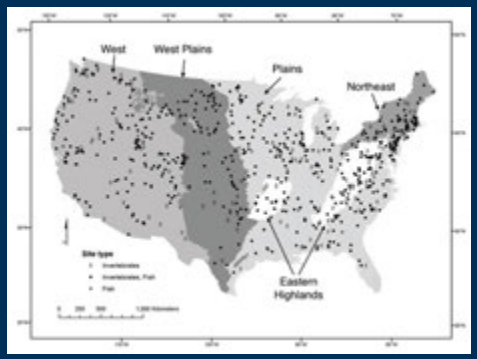
Spring floods = healthy ecosystems

"…the apparent nationwide importance of high flows in spring (March, April, May) also indicates that the timing…of high flows is critical."









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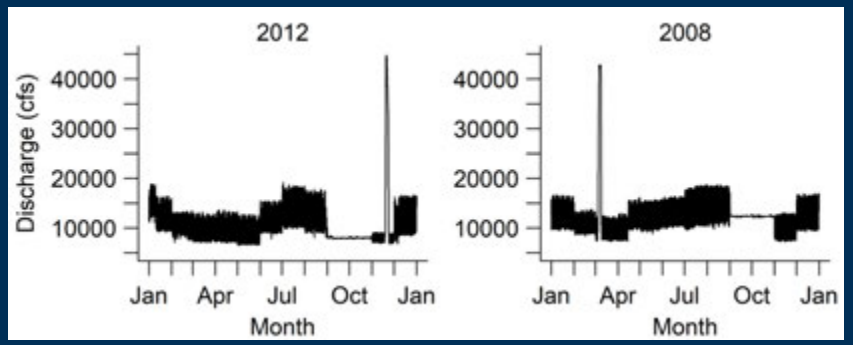
Regular Testing of Fall HFEs

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2010	2011	2012	2013	2014	2015	2016	2017	2018	2019



Fall HFE

Spring HFE

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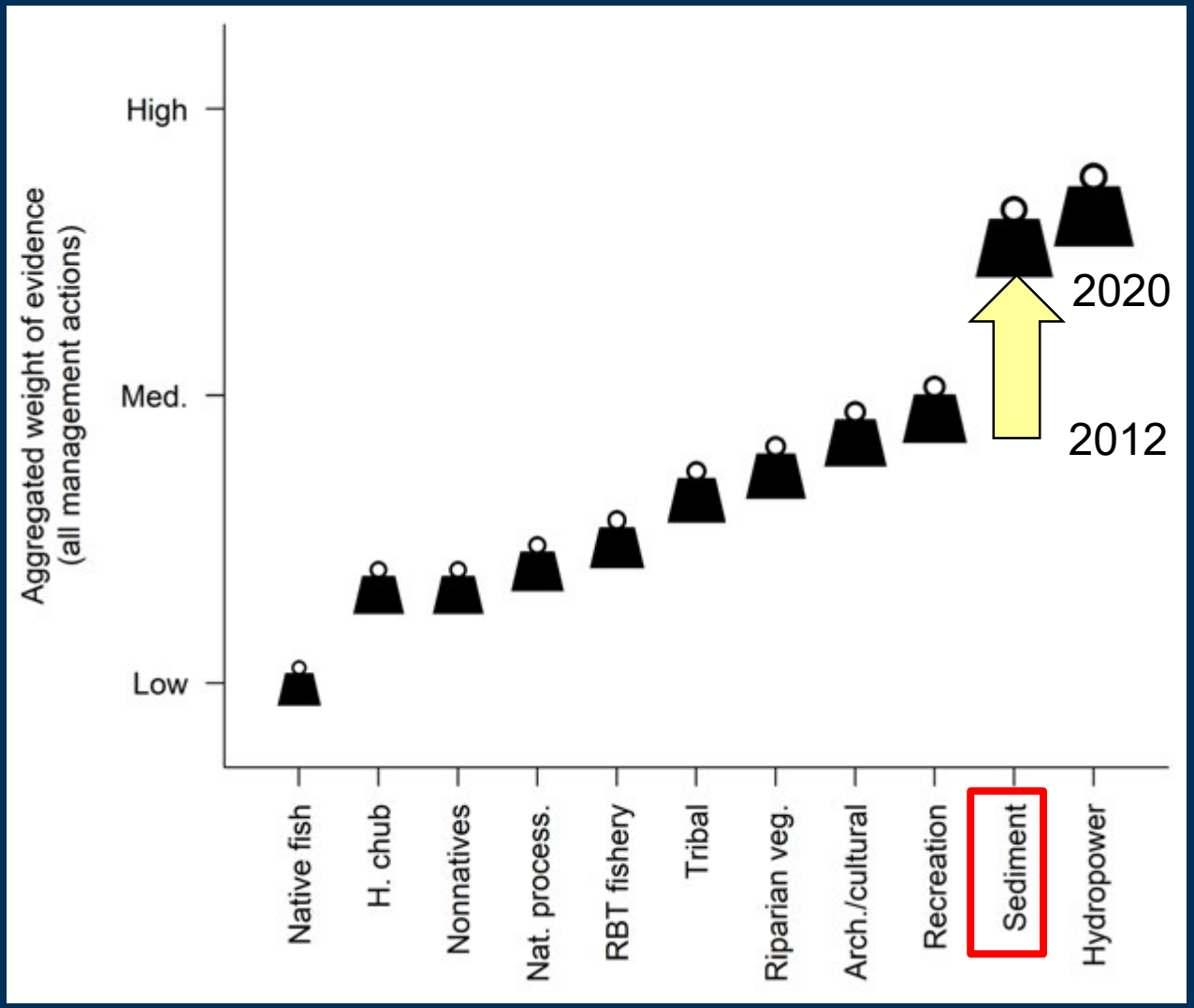
Some benefits of regular Fall HFE testing

Reduced critical uncertainties for HFE → sediment

Sandbar resource improved



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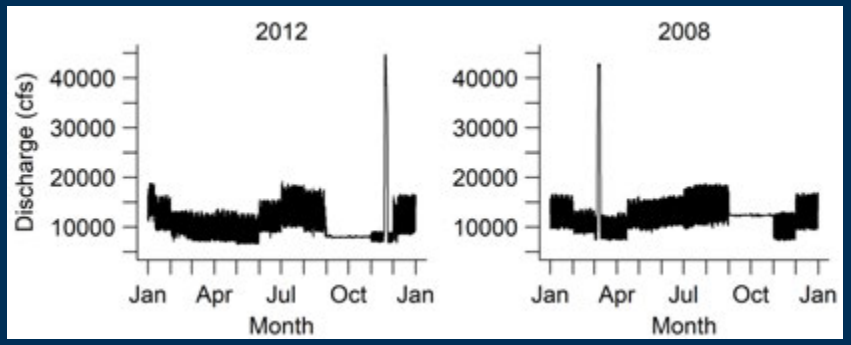
Why so few Spring HFEs?

- They were prohibited
  - 2011 HFE EA initially prohibited
  - 2016 LTEMP extended thru 2019
- Why prohibit Spring HFE?
  - Study HFE → sandbar w/o creating RBT at LCR
    - Key finding from 2008 spring HFE
- Prohibitions were superfluous
  - Spring sediment trigger not reached in 8 years
    - See Grams and Topping, June 2020 TWG presentation



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A Path Forward

FLow Ad Hoc Group (FLAHG) formed in 2019

"As a starting point, the FLAHG shall consider the benefits of and opportunities for conducting higher spring releases within power plant capacity" **–FLAHG charge**

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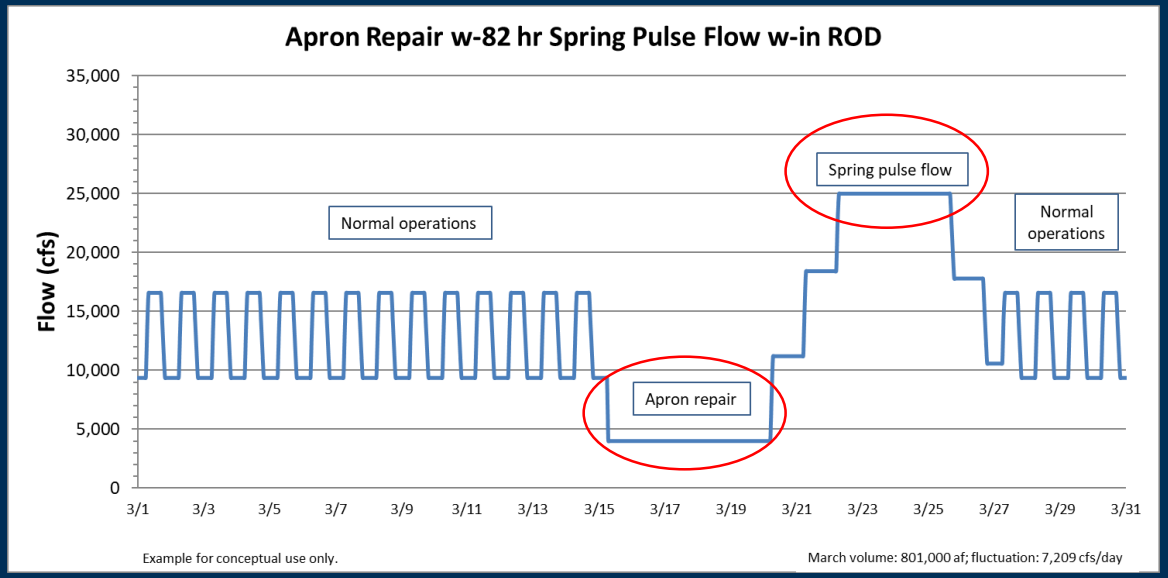
Proposed FLAHG hydrograph

- Spring disturbance flow (March proposed)
- Apron repair is unique opportunity
  - 5 days at 4,000 ft^3/s for dam maintenance
  - Low flows = disturbance
- Combine with spring pulse flow disturbance
  - low + pulse >> low OR pulse alone



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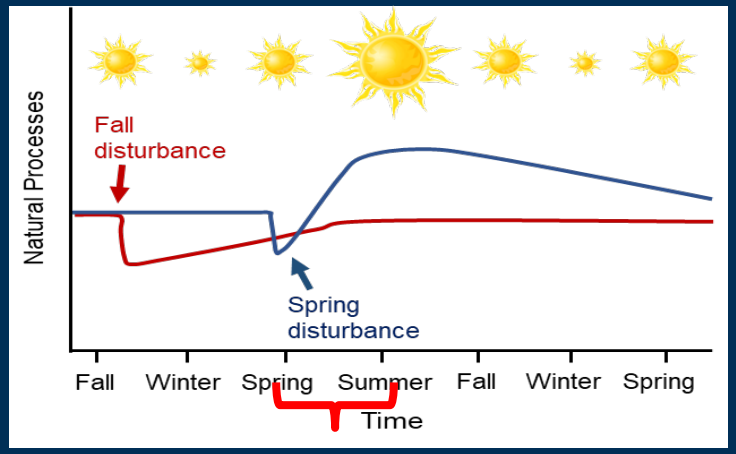
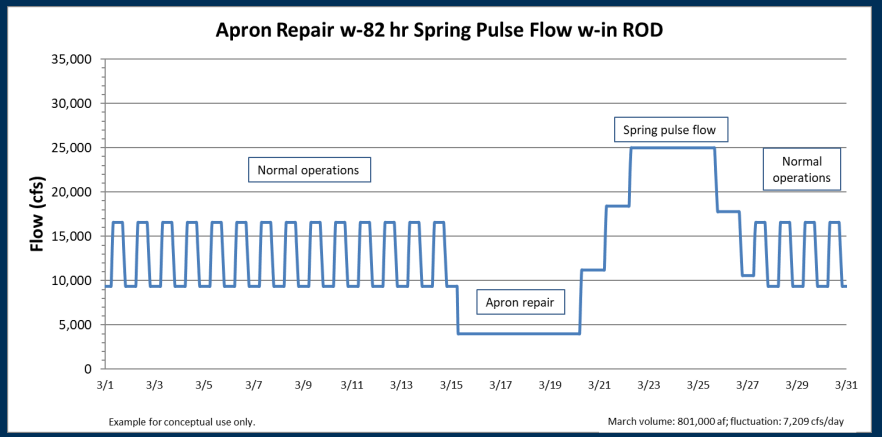
Why March?

- **Keep it simple…**
  - Prior Spring HFEs (‘96 & ’08) were in March
  - Favorable natural process response documented
  - Simplifies comparison of FLAHG & HFE data
  - Avoids commercial motor season in April





Down the road….Could explore April, May, or June disturbance flows
But for right now (FLAHG hydrograph) March makes a ton of sense.

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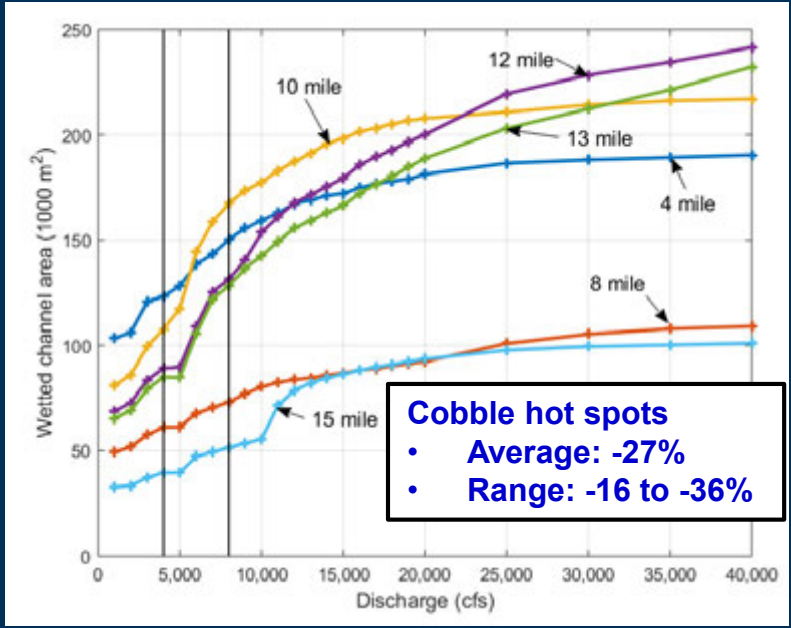
Desiccation & scour potential

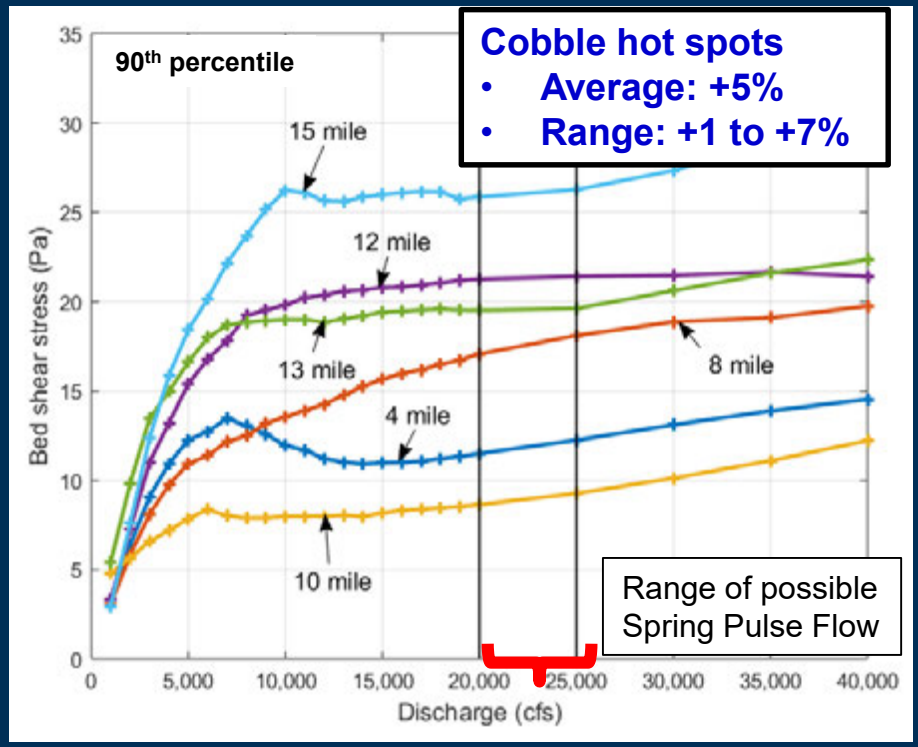
Low Flow = Desiccation

In a nutshell
Large area change between 4,000 and 8,000 cubic feet per second (cfs)
-Change in area = metric of drying potential
Cobble hotspots:
27% of habitat exposed to drying
Reach wide:
12% of habitat exposed
Fun fact: Flow of 4000 cfs last occurred in early 90s



Pulse Flow = Scour

In a nutshell
Shear stress = shearing force of water on bed
-Direct measure of scour potential
Cobble hotspots:
~5% increase in scour at 20,000 vs. 25,000 cfs
Reach wide: ~13% increase in scour
Fun fact: Since '96, flows of 20,000 cfs or greater have occurred just ~7% of the time.



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Why a Knowledge Assessment?

- Stakeholder requested
- Forces communication among scientists
  - Must work in groups, think deeper, get in weeds
- Facilitates communication with stakeholders
  - Translate science with easy-to-understand symbols
- Rubric updated in 2017 & 2019
  - Clear definitions and guidance for scoring
  - Relatively quick and easy to conduct

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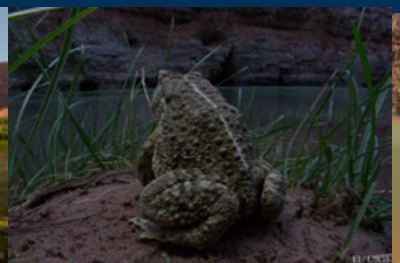

Knowledge Assessment Teams

- Cultural & Archaeological: Peter Bungart, Jen Dierker, Jakob Maase, Joel Sankey
- Natural Process: Ted Kennedy, Jeff Muehlbauer, Bridget Deemer, Jess Gwinn, Larry Stevens
- Humpback chub: Charles Yackulic, Kirk Young, Mike Yard, Maria Dzul
- Hydropower & Energy: Craig Ellsworth, Leslie James, Lucas Bair
- Other Native Fish: Brian Healy, Melissa Trammel, Bob Schelly, Charles Yackulic, Mark McKinstry
- Recreational Experience: Lucas Bair, Kim Dibble, Jim Strogen, David Brown, Leslie James, Craig Ellsworth, David Rogowski
- Sediment: Paul Grams, David Topping, Lucas Bair, Matt Kaplinski, Joe Hazel, David Brown, Ben Reeder
- Tribal Resources: Peter Bungart, Jakob Maase
- Rainbow Trout Fishery: Kim Dibble, Charles Yackulic, Mike Yard
- Nonnative Invasive Species: David Ward, David Rogowski
- Riparian Vegetation: Emily Palmquist, Brad Butterfield, Barb Ralston, Larry Stevens

33 participants from 12 different agencies:

US Geological Survey, National Park Service, Hualapai Dept. of Cultural Resources, US Fish and Wildlife Service, Grand Canyon Wildlands Council, Western Area Power Administration, Colorado River Energy Distributors Association, Bureau of Reclamation, Federation of Fly Fishers, Grand Canyon River Guides, Arizona Game and Fish Dept. Northern Arizona University

Specific Measures = bookends

- Cultural & Archaeological: 5 measures
- Natural Process: 4 measures
- Humpback chub: 1 measure
- Hydropower & Energy: 5 measures
- Other Native Fish: 2 measures
- Recreational Experience: 7 measures
- Sediment: 3 measures
- Tribal Resources: 1 measure
- Rainbow Trout Fishery: 2 measures
- Nonnative Invasive Species: 2 measures
- Riparian Vegetation: NA

Use as bookends

Example: Rainbow Trout Fishery
1) RBT at Lees Ferry
2) RBT at LCR

→ Lowest performing measure

Highest performing measure

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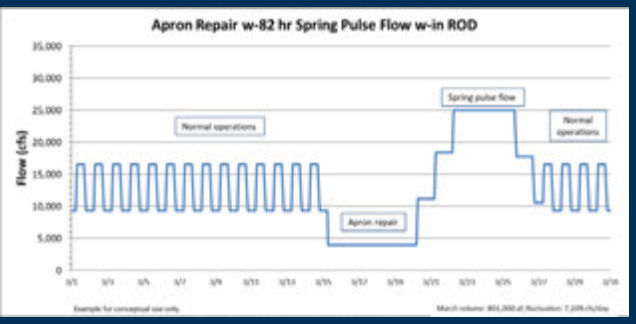
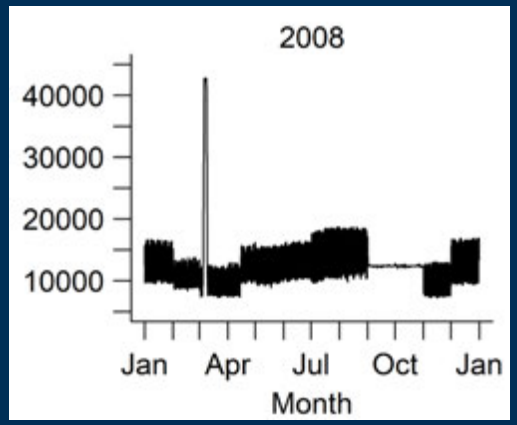
Knowledge Assessment

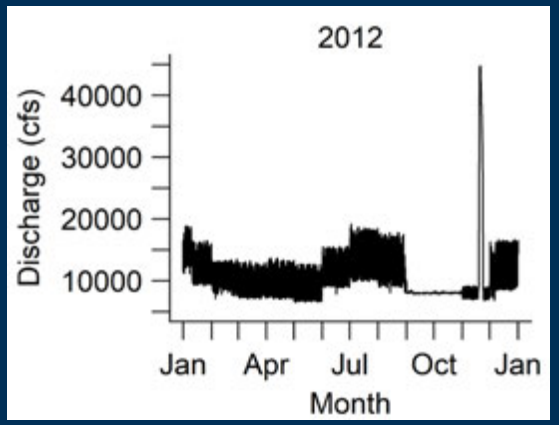
- Used rubric from 2019
- Evaluated 3 management actions
  - Spring disturbance flow (FLAHG hydrograph)
  - Spring HFE
  - Fall HFE



FLAHG hydrograph



Spring HFE



Fall HFE

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Old KA Symbols

Strength of Effect		Direction of Effect		Confidence in Strength & Direction Assessments	
	Strong Effect	⇧	Positive (Beneficial) Effect	○	High
	Moderate Effect	⇔	No Effect	○	Medium
	Weak Effect	⇩	Negative (Detrimental) Effect	○	Low
	Strength of Effect Unknown	.....	Direction of Effect Unknown	(n/a)	

Distaste for term 'confidence'

Not intuitive what colors mean

Distaste for arrows

Not intuitive what outline means

	Archaeological and Cultural	Natural Processes	Humpback chub	Hydropower and Energy	Other Native Fish Species	Recreational Experience	Sediment	Tribal Resources	Rainbow Trout Fishery	Nonnative Invasive Species	Riparian Vegetation
Spring HFE	⇔	⇧	⇧	⇩		⇔	⇧		⇧	.....	⇧
Fall HFE	⇔	⇩	⇧	⇩		⇔	⇧			⇩	⇩

Hard to visualize data, see patterns

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New KA Symbols

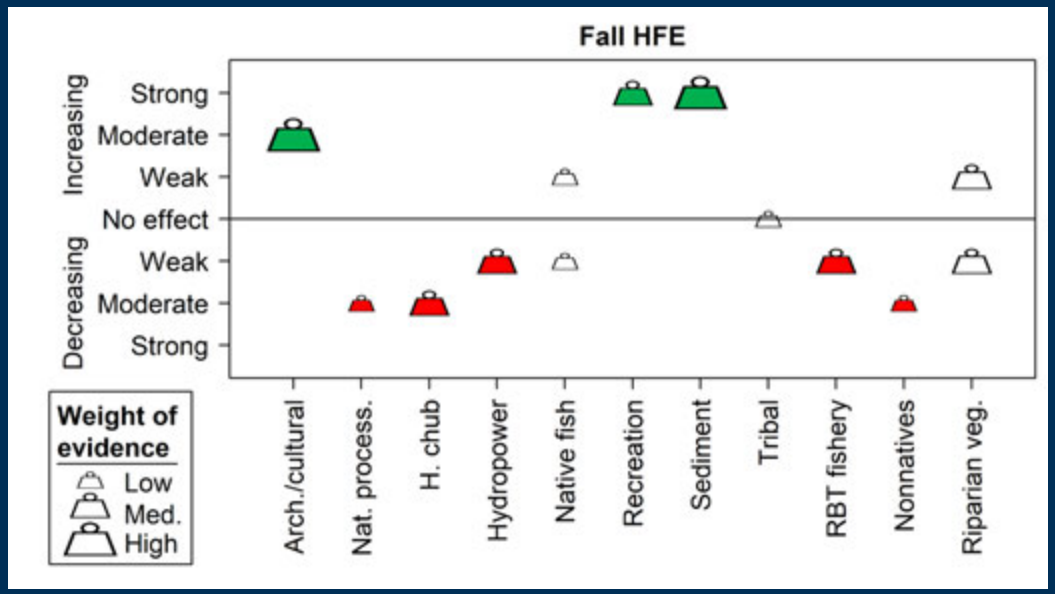
Goals of Redesign:
1) Make symbols more intuitive,
2) Improve data visualization (i.e., quickly compare +/- of actions)

Stronger Effects

Y-axis = strength

Stronger Effects

Dumbbell Size = Weight of evidence



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Direction Unknown
Strength Unknown
No Effect

Decreasing

Increasing

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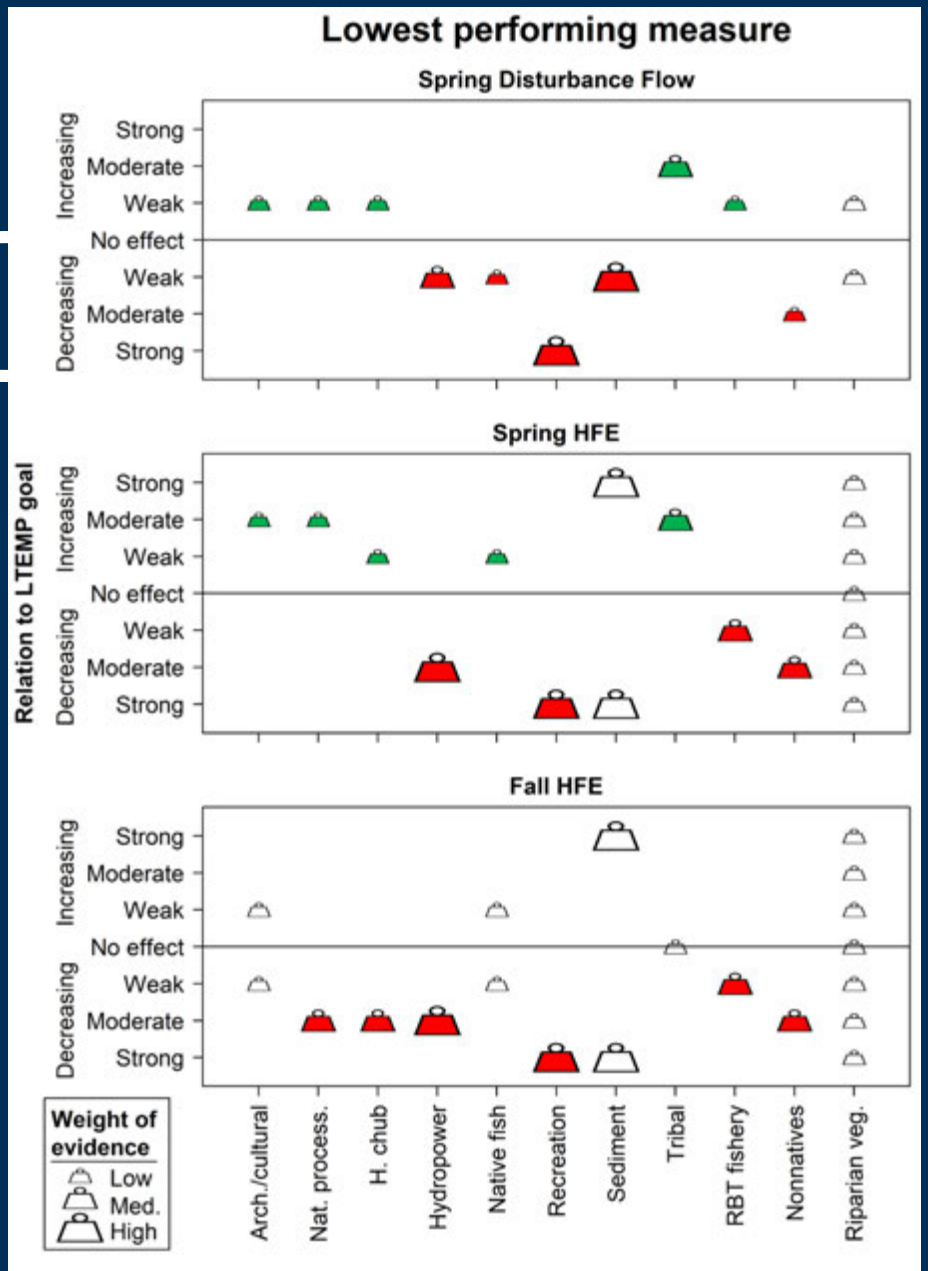
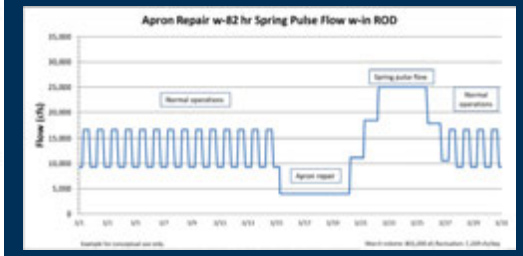
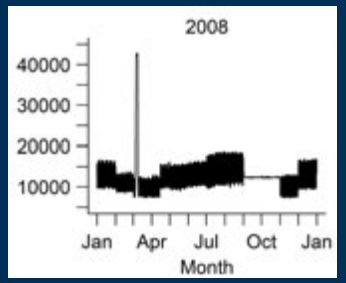
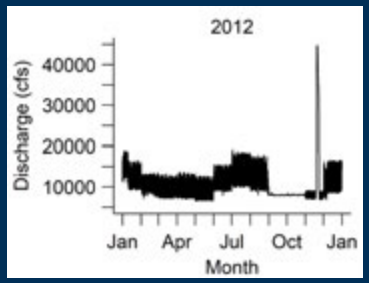
Lowest Performing Measure

Appears to be relatively low risk









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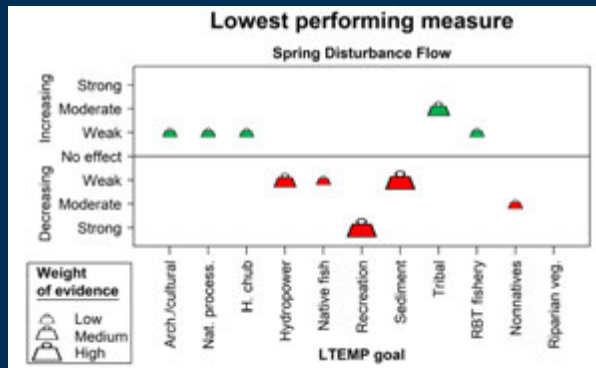
Potential Decreases identified in KA

- *Hydropower & Energy*
  - Small decrease in 'load following capability' predicted
- *Other Native Fish*
  - Razorback spawning period, eggs may dry at 5d low flow
- *Recreational Experience*
  - Crowding and navigation risk during low flow
- *Sediment*
  - Small decrease in 'total sand volume' predicted
- *Nonnative Invasive Species*
  - Pierce Ferry may be barrier, low flow may allow greater movement



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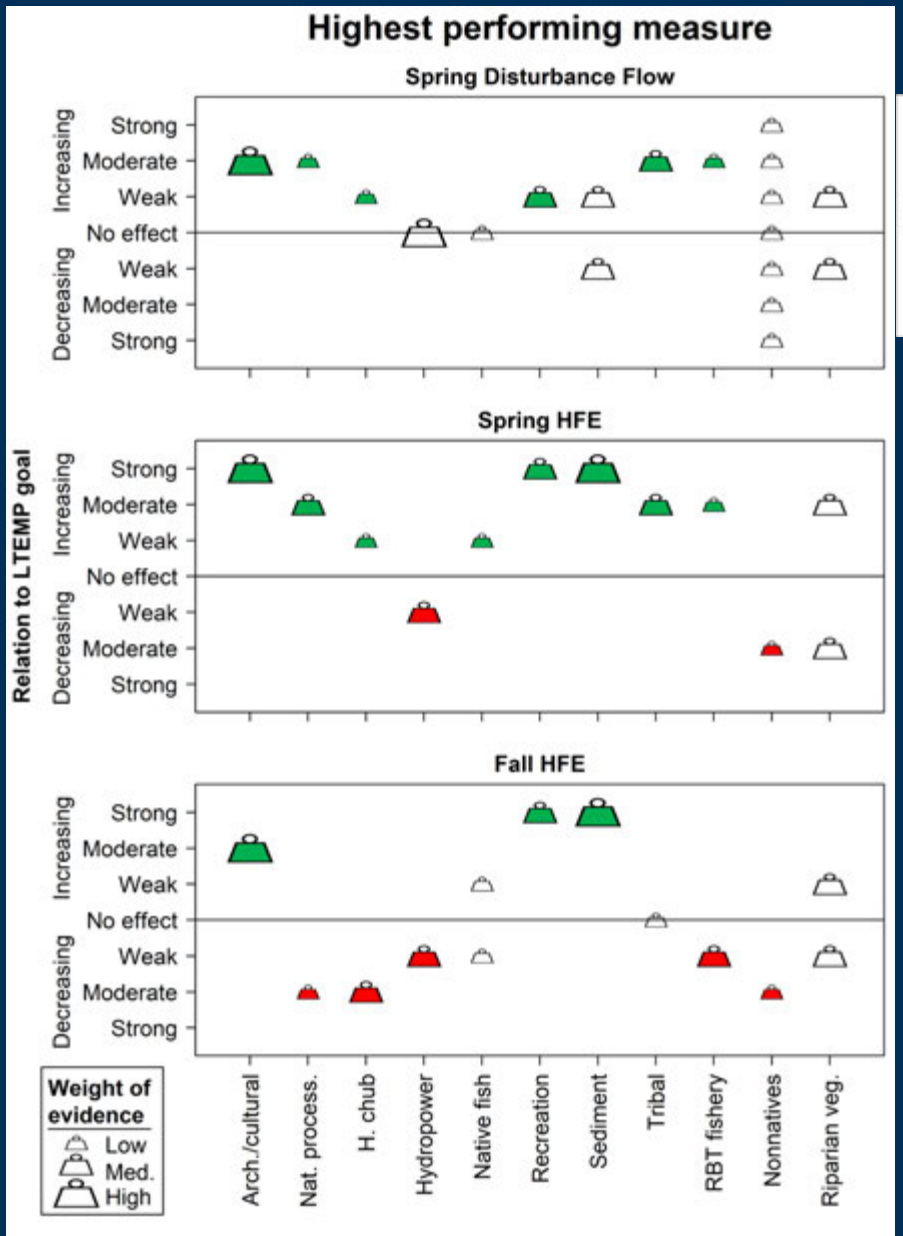
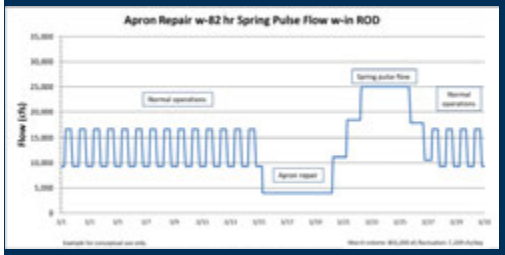
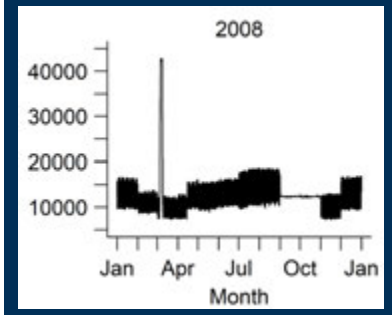
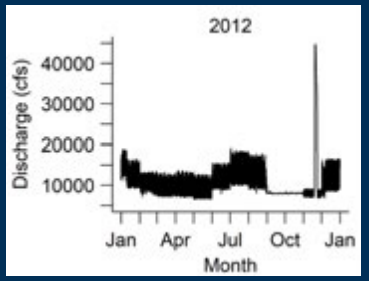
Highest Performing Measure (1)

Because sometimes 'No Effect' is a Win









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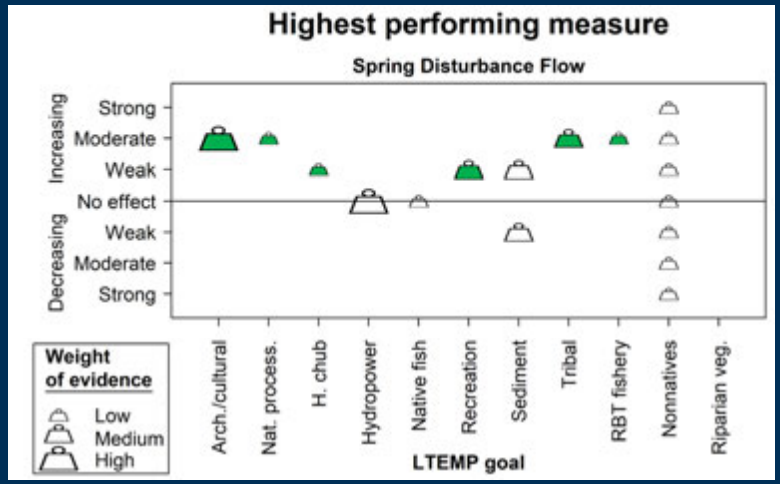
No Effects identified in KA

- *Hydropower and Energy*
  - Electric generation not affected, no bypass, shoulder month
- *Other Native Fish*
  - No effect predicted, outside of spawning window for FMS/BHS
- *Sediment*
  - Volume of deposition/erosion small, bc pulse flow small
- *Nonnative Invasive Species*
  - Unknown effects, low confidence



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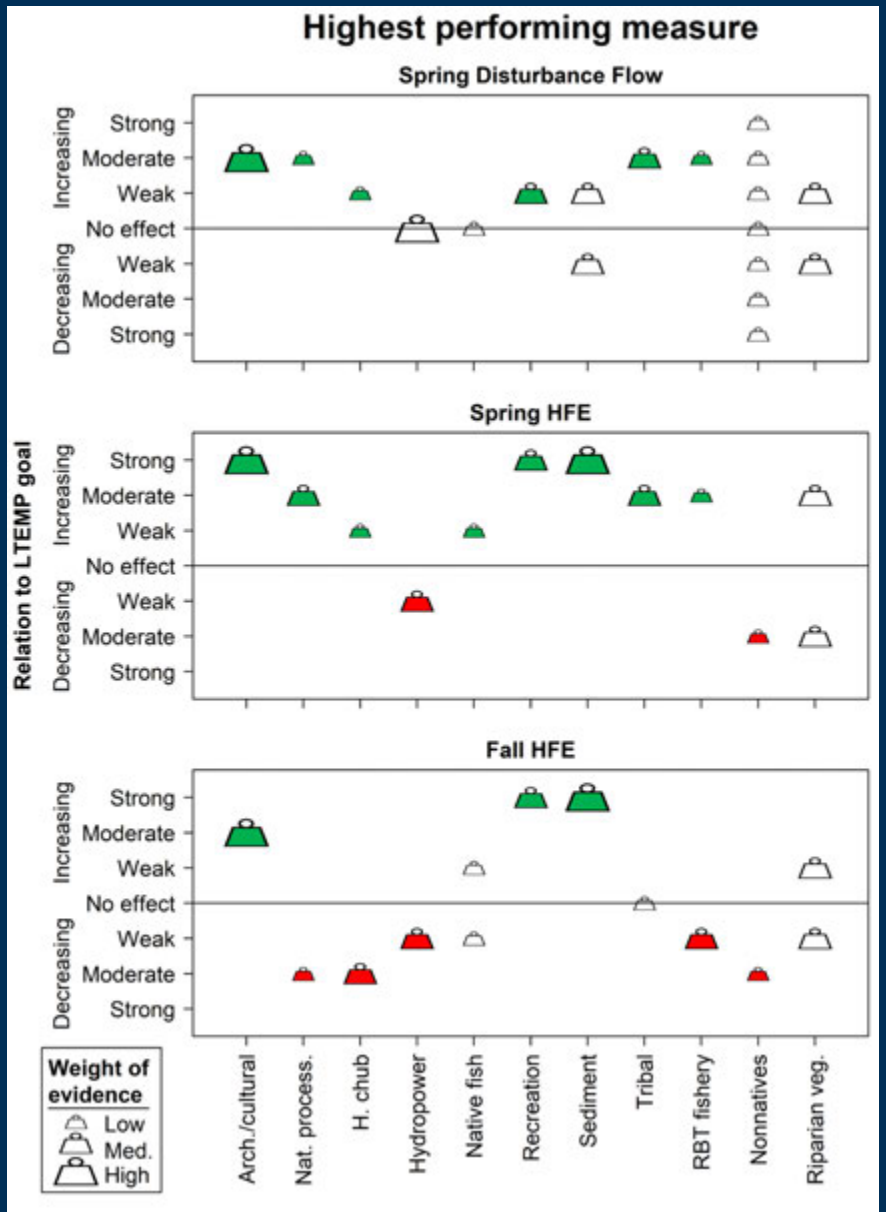
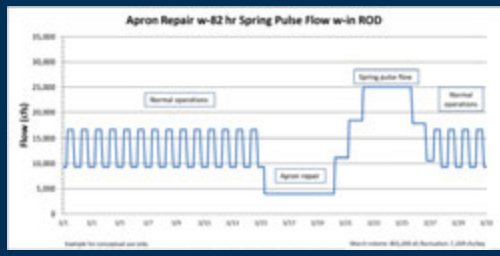
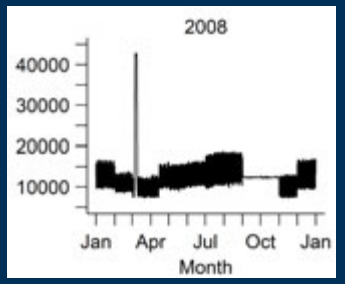
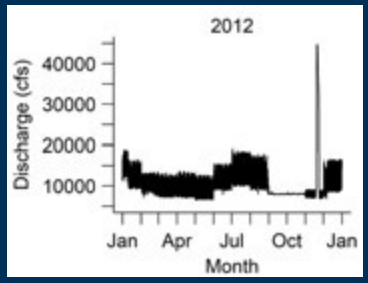
Highest Performing Measure (2)

Some intriguing potential upsides









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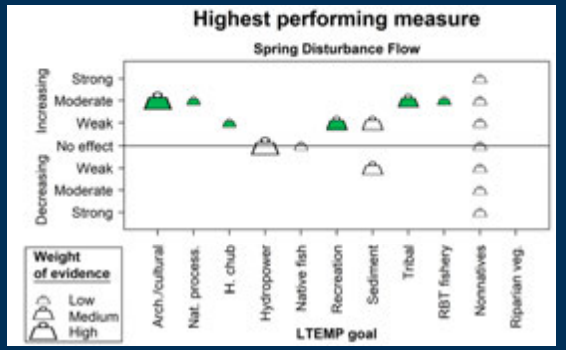
Potential Increases identified in KA

- *Cultural and Archaeological Resources*
  - Potential increase in available sand for aeolian transport
- *Natural Processes*
  - Potential increase in production & diversity of algae and insects
- *Humpback chub*
  - Potential indirect effect on HBC via food base
- *Tribal Resources*
  - Potential increase in ecosystem health
- *Rainbow Trout Fishery*
  - Potential indirect effects on RBT via food base, spawning
- *Nonnative Invasive Species*
  - Spring disturbance disfavors Brown Trout



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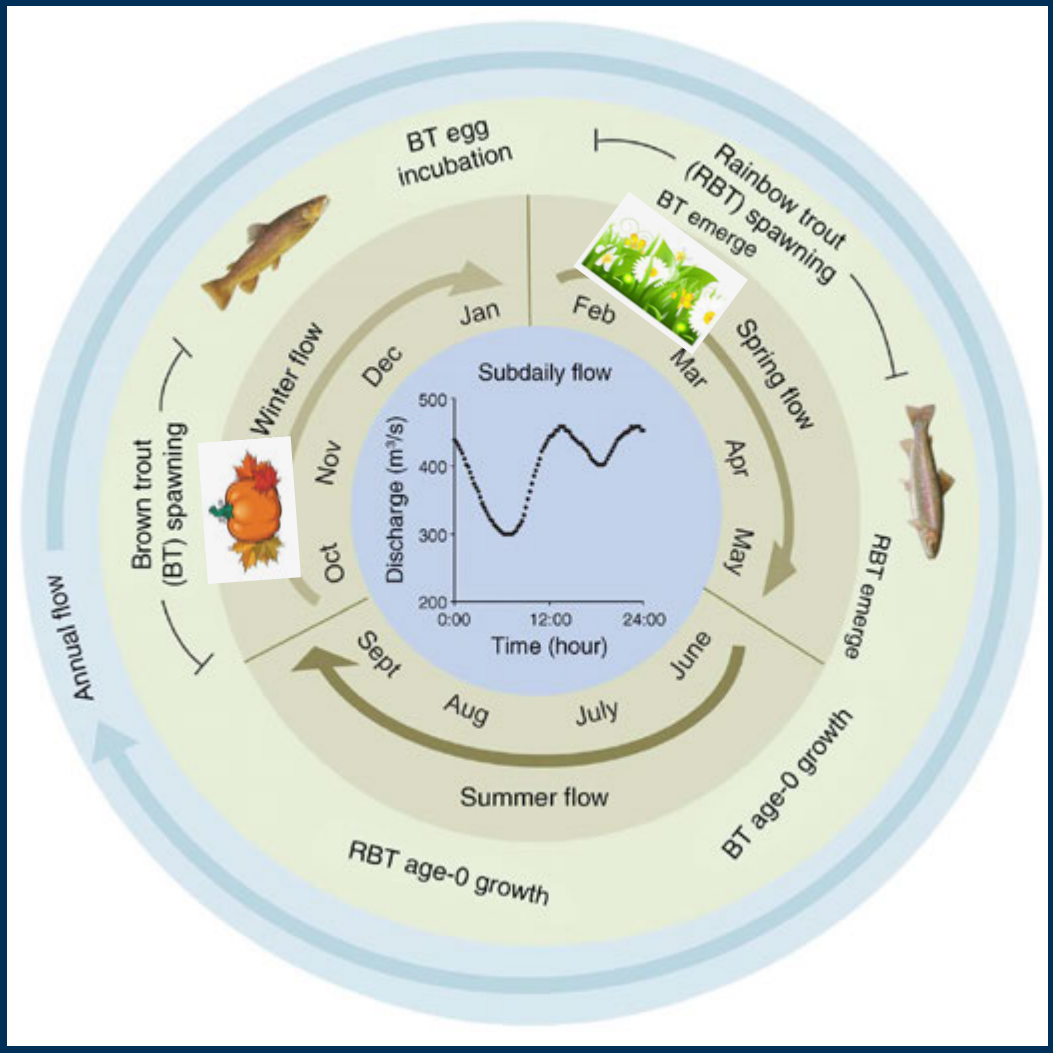
Spring timing does not align with brown trout spawning calendar


Spring HFE


Fall HFE



From Dibble et al. 2015, *Ecological Applications*.

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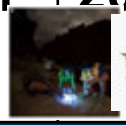
FLAHG Hydrograph
Essential Context

- **Provides 'contrast' to last 5 fall HFEs**
  - **Key biology projects are poised to study**

1990	1991	1992	1993	1994	1995	1996 	1997	1998	1999
2000	2001	2002	2003	2004 	2005	2006	2007	2008 	2009 
2010 	2011	2012  	2013 	2014 	2015	2016 	2017	2018 	2019

 2009-Juvenile chub monitoring (JCM) starts

 2010-Gross primary production monitoring starts

 2012-Citizen science insect monitoring starts

 Spring HFE

 Fall HFE

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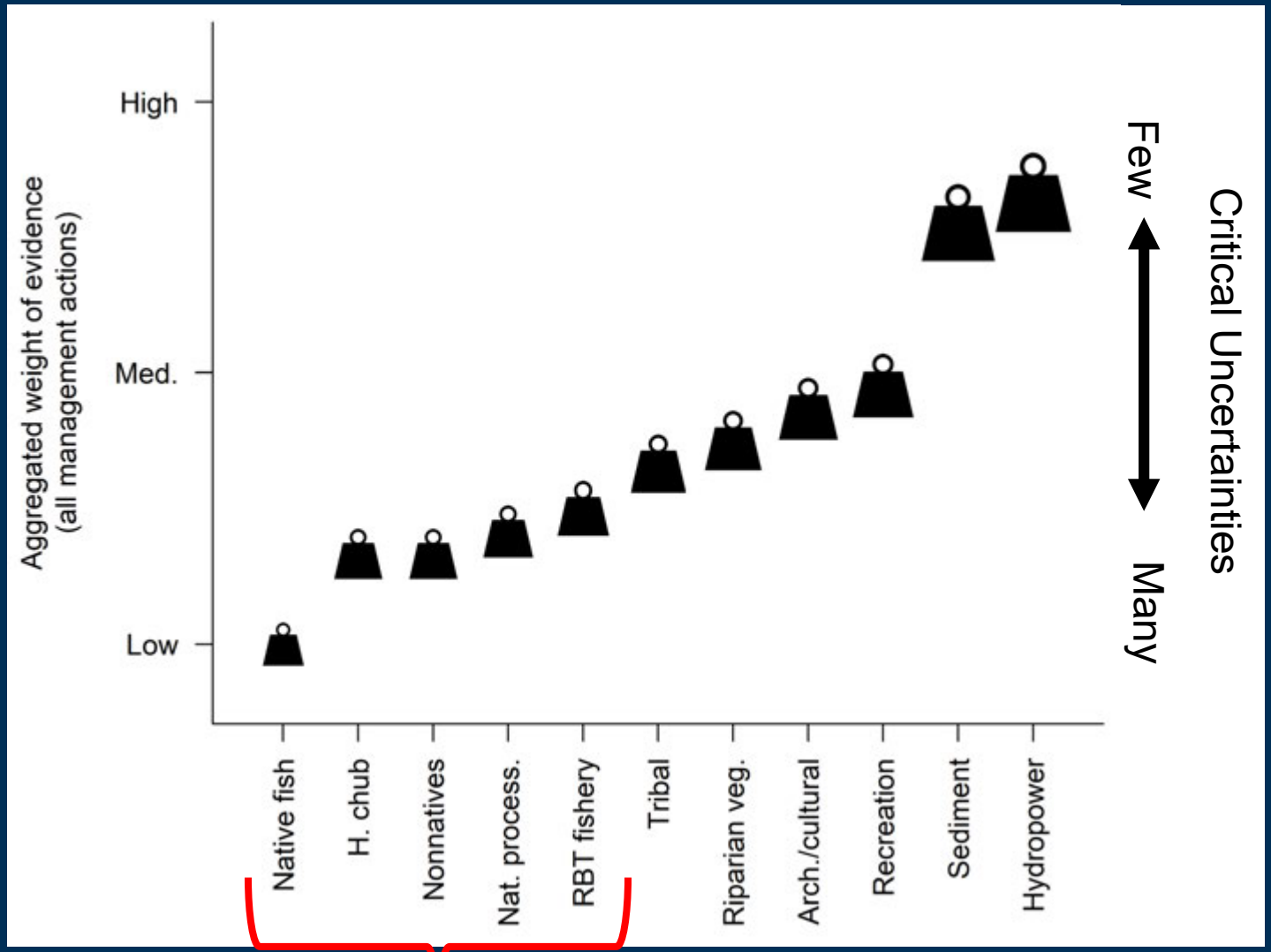
FLAHG hydrograph will reduce uncertainties



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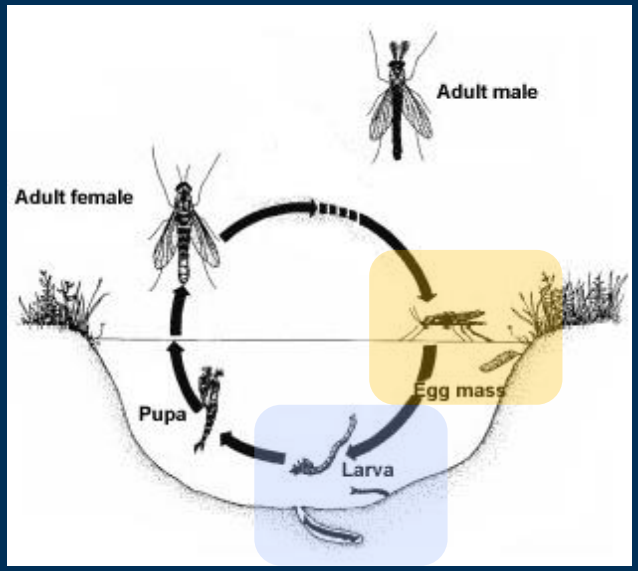
In particular, critical uncertainties for fish and aquatics will be reduced if FLAHG hydrograph tested and Project O funded.

What about Bug Flows?

- Complementary? Yes
  - Bug Flows: Egg stage
  - FLAHG flow: Larval stage
- Complicating? Yes
  - Will make data analysis harder
- Confounding? No
  - Effects can be disentangled



Bug Flows

- Sine wave pattern
- Grand Canyon focus

FLAHG flow

- Insect, NZ mudsnail count
- Lees Ferry focus

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No (scientific) issues with FLAHG flow + Bug Flows in 2021

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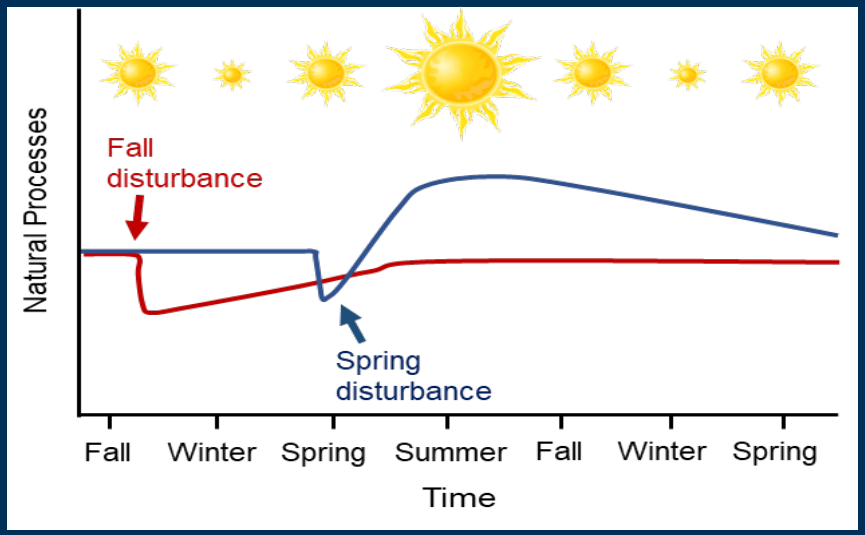
FLAHG hydrograph qualitative narratives

- Tribal Resources
  - Spring timing aligns with Father Earth's calendar
- Natural Processes
  - Spring timing aligns with Mother Nature's calendar
- Recreational Experience
  - Spring timing aligns with human calendar



USGS

Preliminary results subject to review and revision

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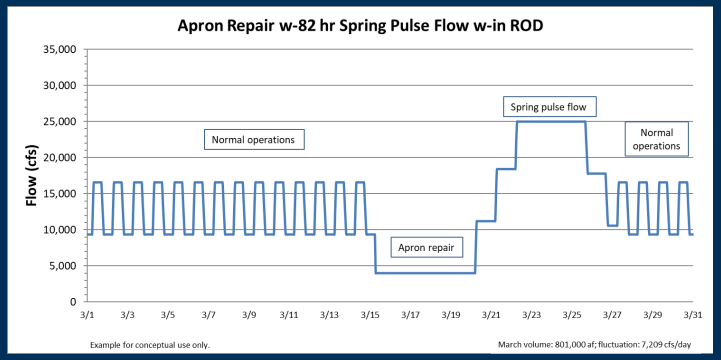
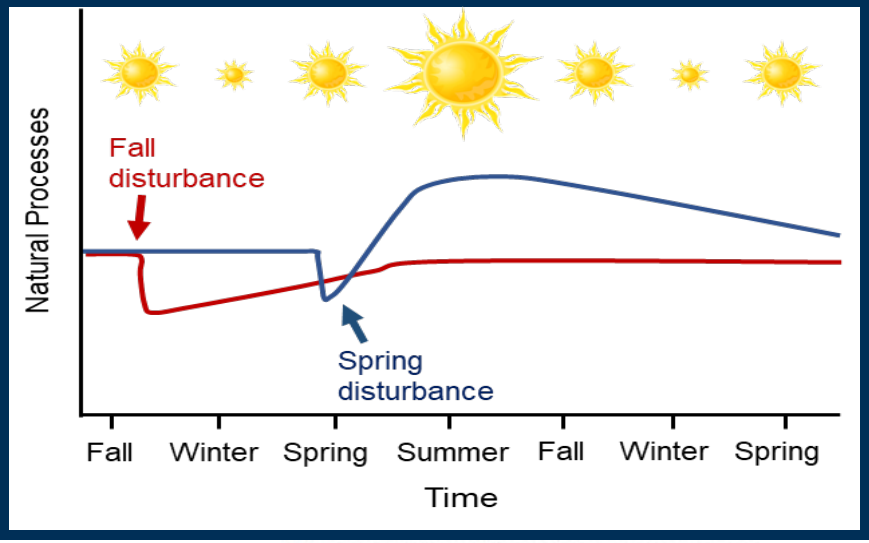
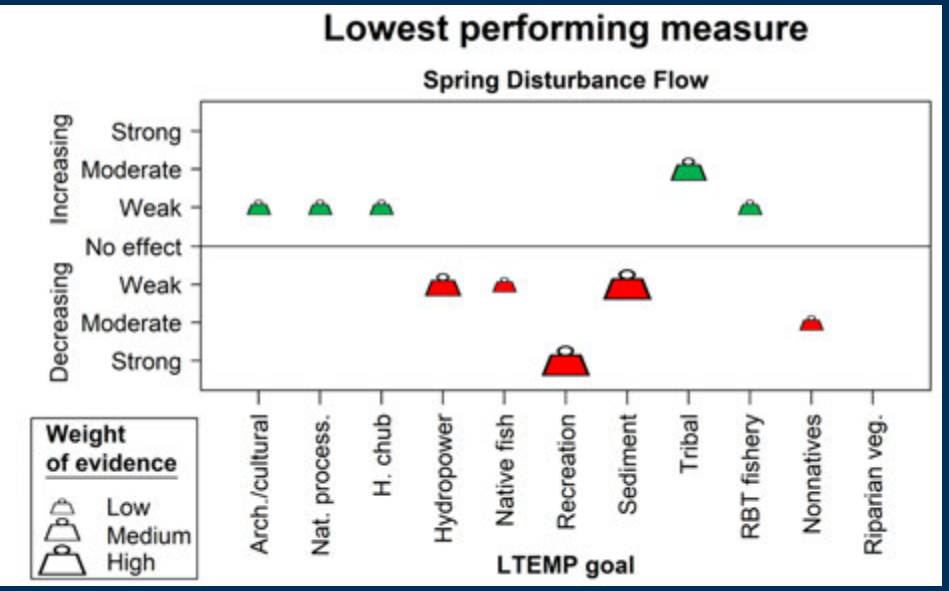
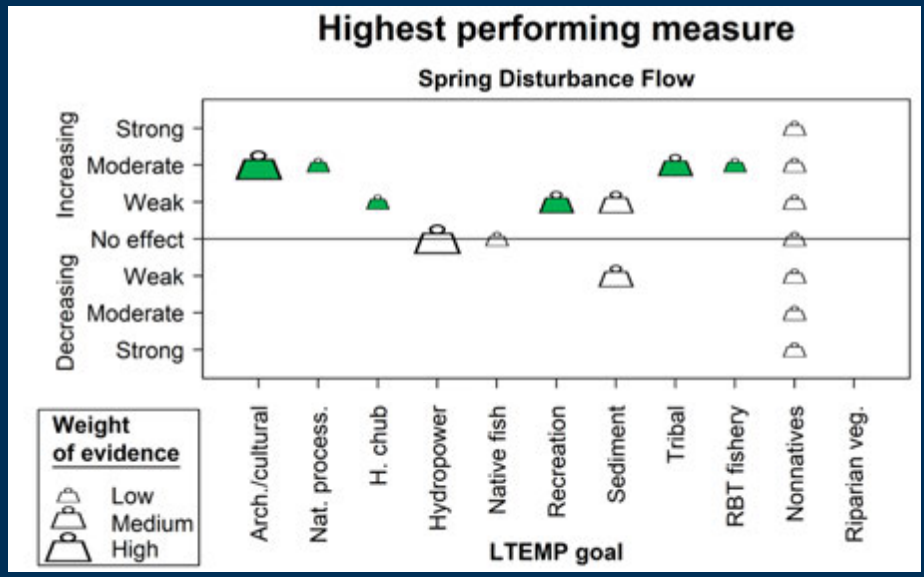
Questions?









Preliminary results subject to review and revision