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High Flow Experiment Assessment Summary

Adaptive Management Workgroup Webinar

May 22, 2019

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U.S. Geological Survey

Objectives from Action Item

- Assess effects of past High Flow Experiments (HFEs) on resources of concern
- Present findings at Annual Reporting meeting and to AMWG
- Provide a written summary

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Project A
Sediment and Water Quality

- GCMRC scientists and their cooperators monitor discharge, suspended sediment concentrations, and sediment mass balance at sites throughout Grand Canyon

- What are the effects of dam operations on suspended sediment concentrations and sand mass balance?

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Project A
Sediment and Water Quality

Results

- Because 90+% of sand is now being held back by the Glen Canyon Dam, deposition of sand downstream of the dam occurs mainly during High Flow Experiments (HFEs)
- For greatest effect, HFEs should be conducted when the river bed is rich in fine sand from tributary inflows
- Sediment-triggered spring HFEs unlikely to occur with fall sediment carryover due to erosion during high winter flows

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Project A
Sediment and Water Quality

Implications

- In order to maximize sandbar building, HFEs should be conducted when the most fine sand is available
- This would most likely occur after significant summer and fall inflows from the Paria and Little Colorado Rivers

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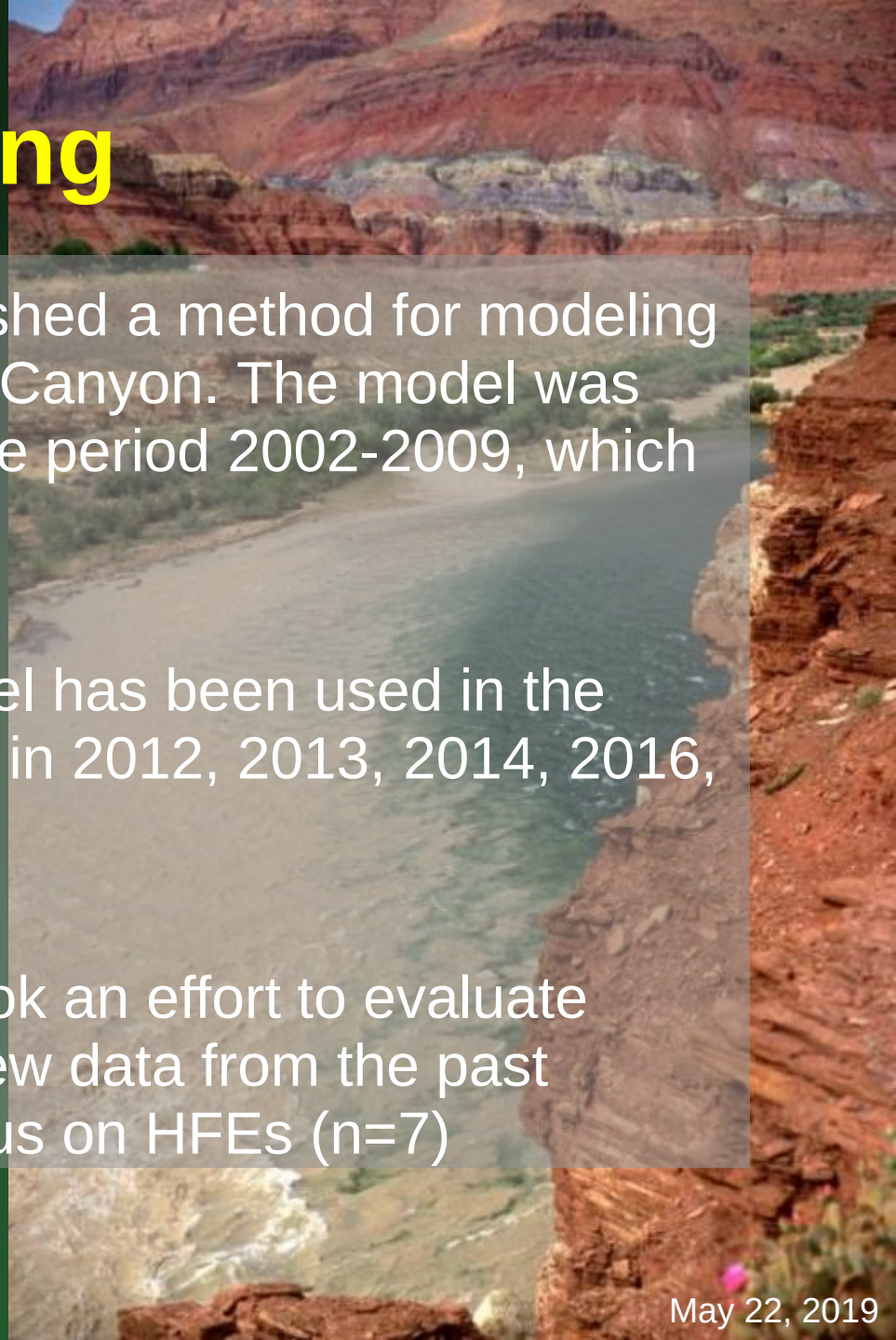
Sediment Modeling

- In 2010, Wright et al. published a method for modeling the sand budget of Marble Canyon. The model was calibrated and tested for the period 2002-2009, which included 2 HFEs
- Since publication, the model has been used in the planning process for HFEs in 2012, 2013, 2014, 2016, and 2018
- In 2018, S. Wright undertook an effort to evaluate model performance with new data from the past decade, with particular focus on HFEs (n=7)



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Sediment Modeling

Results

- The Upper Marble Canyon model predicts accumulation fairly well and was adjusted to measured values in February of this year
- The Lower Marble Canyon tends to underpredict accumulation and is closer to the lower bound of uncertainty
- Overall, the model does a good job of reproducing measured values in Marble Canyon and reproducing the amount of sand remaining post-HFE

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Sediment Modeling

Implications

- The current model is still useful but would be improved with additional enhancement to:
  - spatial resolution
  - tributary inputs
  - expanded particle size range to include silt and clay
  - adding a sandbar evolution component

- Additional funding would be required for these enhancements but funding costs could be reduced by use of post-graduate student assistance

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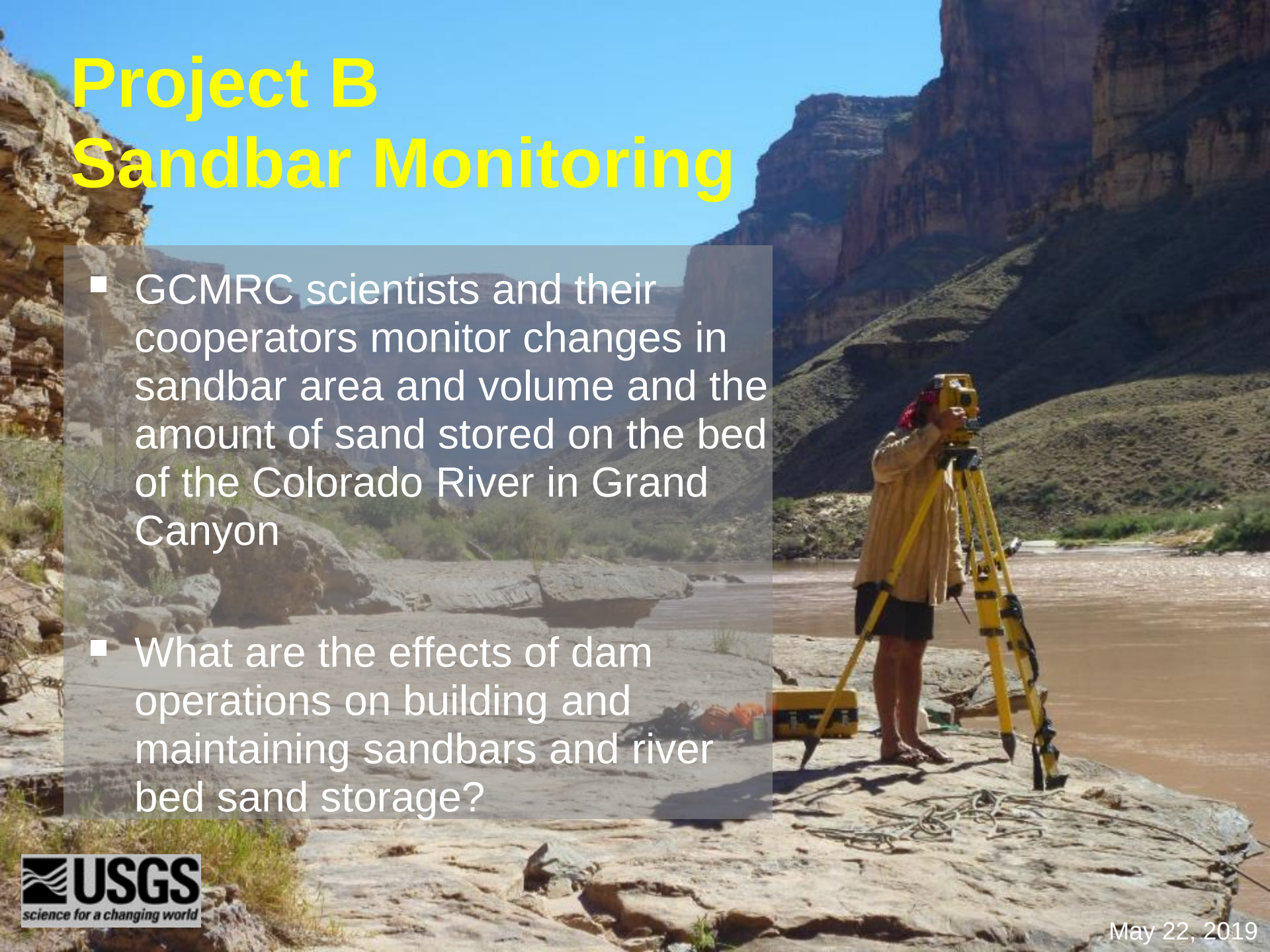
Project B
Sandbar Monitoring



- GCMRC scientists and their cooperators monitor changes in sandbar area and volume and the amount of sand stored on the bed of the Colorado River in Grand Canyon

- What are the effects of dam operations on building and maintaining sandbars and river bed sand storage?

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Project B
Sandbar Monitoring

Results

- Each HFE since 2012 has resulted in sandbar deposition
- Although bars erode, they are larger than they would be without HFEs
- There is evidence for cumulative increases in bar size at some sites

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Project B
Sandbar Monitoring

Implications

- Objective to cause sandbar deposition and increases in sandbar size without causing decreases in sand storage in Marble Canyon achieved with each HFE.

- Could experiment with hydrograph shape to affect sandbar shape (e.g., slope of bar front

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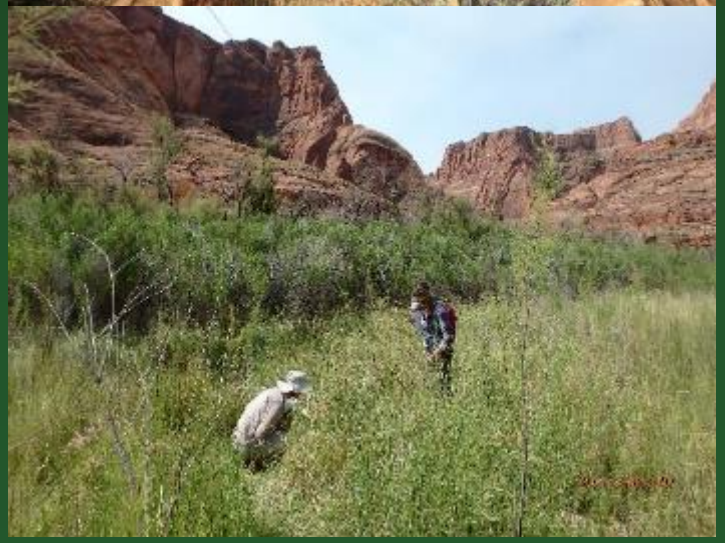
Project C
Riparian Vegetation Monitoring

- GCMRC scientists and their cooperators document the amount and types of riparian vegetation found along the Colorado River corridor and determine plant cover, species richness, and diversity

- What are the effects of dam operations on riparian plant communities?



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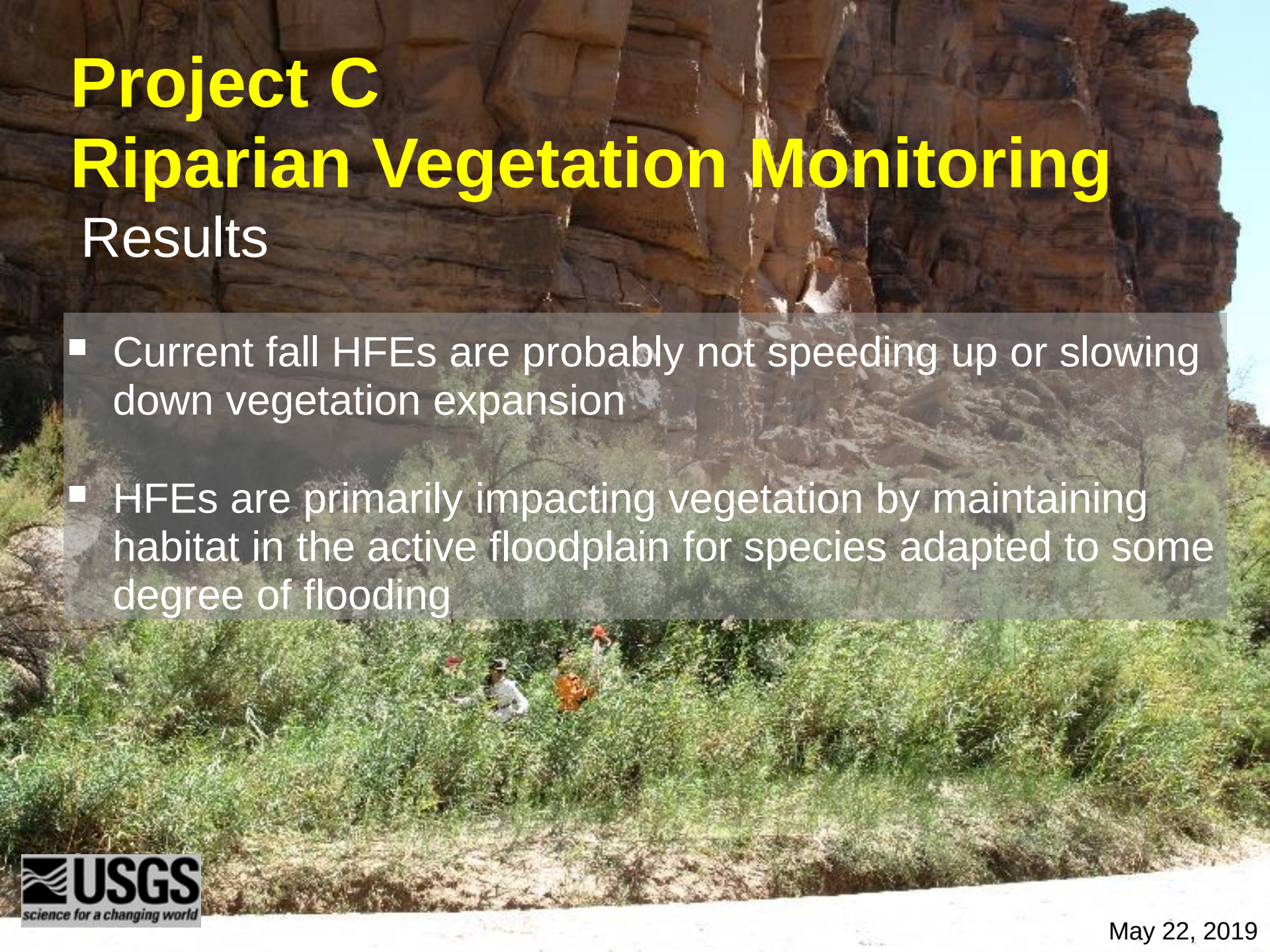
Project C
Riparian Vegetation Monitoring

Results

- Current fall HFEs are probably not speeding up or slowing down vegetation expansion
- HFEs are primarily impacting vegetation by maintaining habitat in the active floodplain for species adapted to some degree of flooding



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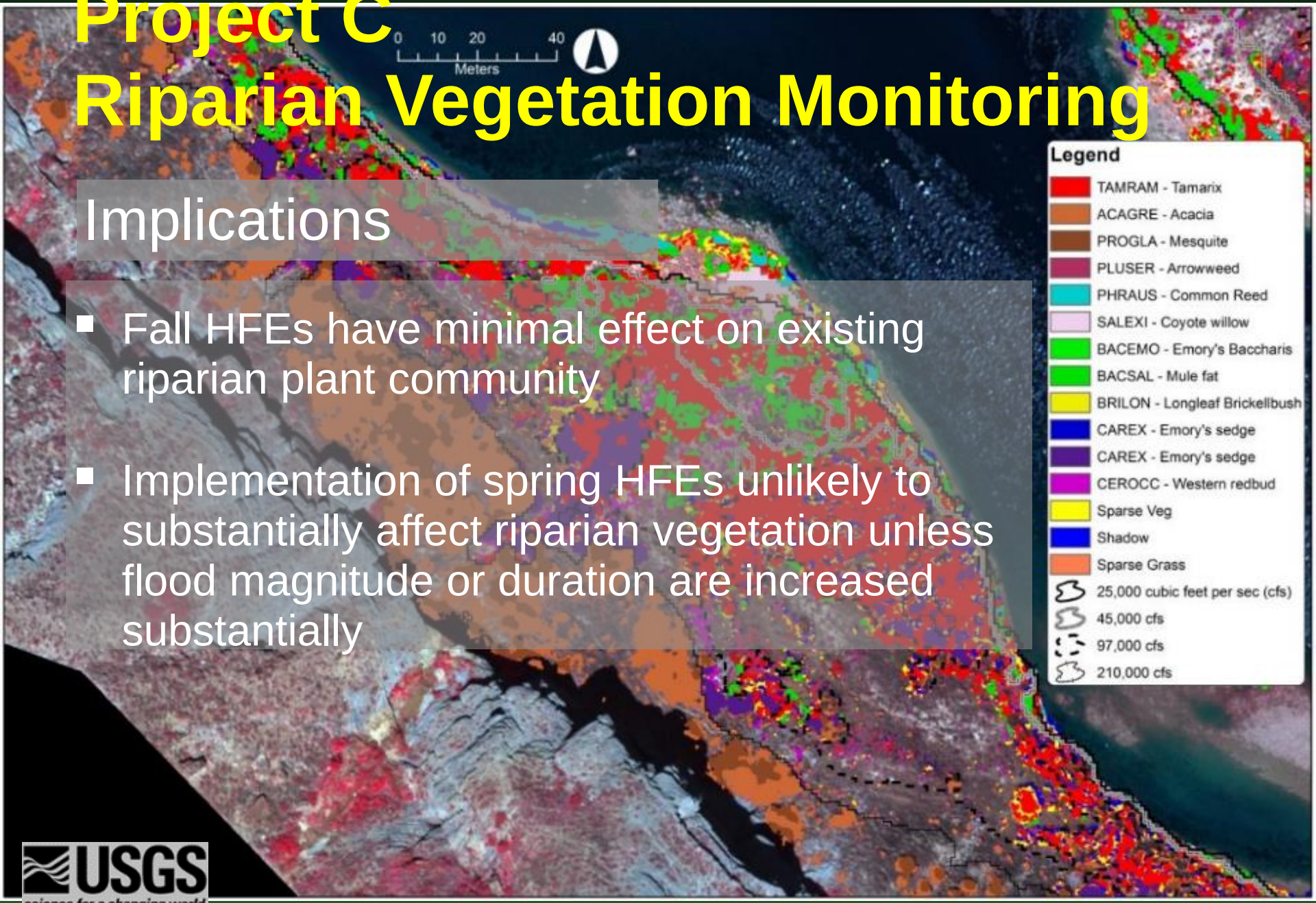
Project C
Riparian Vegetation Monitoring



Implications

- Fall HFEs have minimal effect on existing riparian plant community
- Implementation of spring HFEs unlikely to substantially affect riparian vegetation unless flood magnitude or duration are increased substantially

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Project D
Geomorphic Effects of Dam Operations and Vegetation Management for Archaeological Sites

- High elevation sand is an important resource for recreation, habitat, and cultural resources in Grand Canyon

- What are the effects of dam operations on bare sand and dunefields that serve as sources for aeolian transport?

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Project D
Geomorphic Effects of Dam Operations and Vegetation Management for Archaeological Sites

Results

- In Grand Canyon, ~ ½ of bare, unvegetated sand area derived from the Colorado River is located in 117 large dunefields
- Most not inundated by HFEs, but HFEs resupply dunefields by rebuilding upwind sandbars
- Aeolian dunefields resupplied with windblown sand from HFE deposits in half of instances monitored after 2012, 2013, 2014, and 2016 HFEs
- Frequency of dunefield resupply by HFEs analogous to resupply of sandbars by HFEs
- Dunefield sediment storage increases cumulatively when HFEs conducted annually, but decreased with 1-year hiatus from HFEs in 2015
- Sediment storage increased at dunefield archaeological sites owing to resupply from 2012-2016 HFE sand

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Project D
Geomorphic Effects of Dam Operations and Vegetation Management for Archaeological Sites

Implications

- When conducted consistently (annually), fall HFEs increase high elevation sand resources
- April 2019 – NPS implemented experimental vegetation removal treatments on several sandbars in Grand Canyon to increase aeolian sediment supply to dunefields that host archaeological sites
  - GCMRC will monitor the outcome of the treatments relative to future HFEs

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Project F
Aquatic Ecology

- GCMRC scientists and their cooperators monitor the aquatic food base to describe drivers and controls of aquatic food webs in the Colorado River in Glen and Grand Canyons

- What are the effects of dam operations on aquatic invertebrate diversity and abundance?

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Dave Herasimtschuk

FI/USGS

Project F
Aquatic Ecology
Results

- Results from 2012-2018 fall HFEs indicate that the effect on the aquatic foodbase has been minimal

- Results from spring HFEs (1996 and 2008) showed increased invertebrate diversity and higher abundance of high-quality insect taxa (i.e., midges and blackflies)








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Project F
Aquatic Ecology

Implications

- Spring HFEs might help to improve the food base but more events are needed
- Evidence from other rivers and streams throughout the US indicates that healthy invertebrate populations are present where high flows occur in the spring

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Projects G & I
Native and Nonnative Fish

- GCMRC scientists and their cooperators monitor humpback chub and other native fishes as well as potentially harmful nonnative species such as green sunfish and channel catfish in Glen and Grand Canyons to describe the abundance, distribution, and controls on populations

- What are the effects of dam operations on the abundance, distribution, condition, and population dynamics of native and nonnative fishes?

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Projects G & I
Native and Nonnative Fish

Results

- The abundance and distribution of native fish populations have increased significantly in the time period from 2010-2018

- However, the exact cause(s) of these increases are unknown and are unlikely related to HFEs


Photo: Randall Babb

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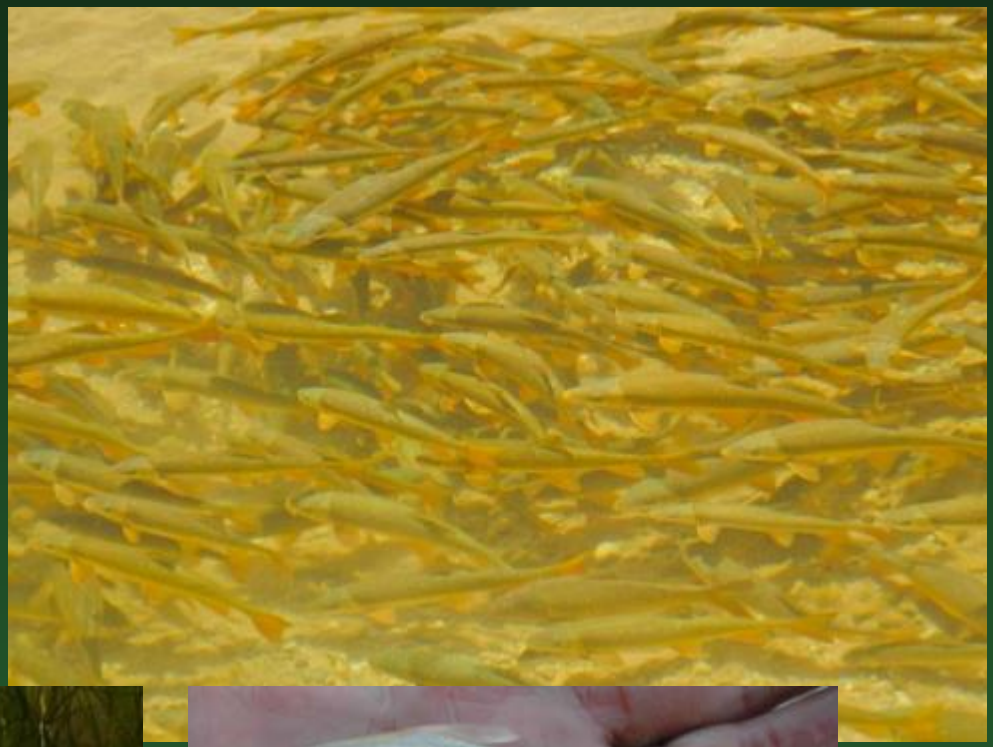
Projects G & I
Native and Nonnative Fish

Implications

- Probably no adverse or beneficial effect on native fish from fall HFEs

- Effect of spring HFEs is unclear due to limited data



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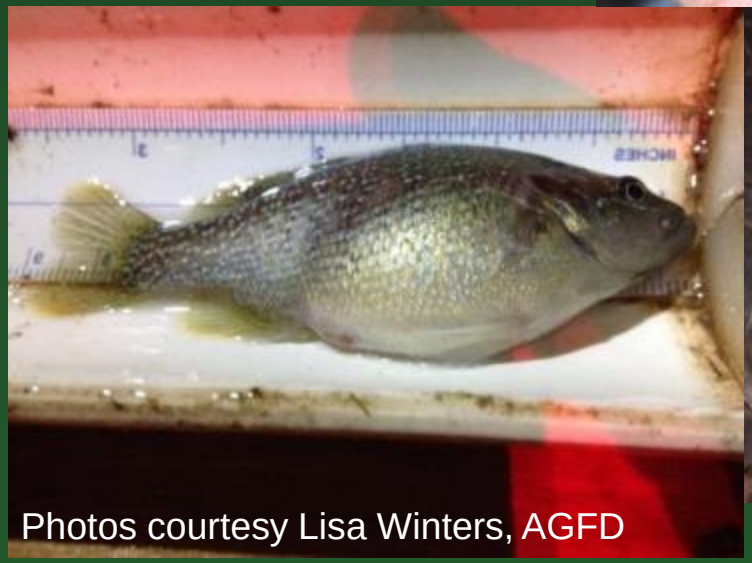
Projects G & I Native and Nonn

Implications

- HFEs could spread invasive species adapted to disperse during floods (e.g., green sunfish)



Photos courtesy Lisa Winters, AGFD

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Project H
Salmonid Research

- GCMRC scientists and their cooperators monitor rainbow trout and brown trout in Glen and Grand Canyons to describe abundance, distribution, and controls on populations

- What are the effects of dam operations on salmonid distribution, condition, and population dynamics?

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Photo: Dustin Patar

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Project H
Salmonid Research

Results – Rainbow Trout

- High rainbow trout recruitment has coincided with two spring-timed HFEs; however, recruitment may be due to multiple factors, some unrelated to flood timing

- Fall HFEs do not seem to have a significant impact on recruitment

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Project H
Salmonid Research

Results – Brown Trout

- Fall HFEs may serve as a migration cue to brown trout; however, such immigration pulses to Glen Canyon have not been observed in most fall HFE years

- Little evidence to show a relation between brown trout recruitment and years with or without fall HFEs

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Project H
Salmonid Research

Implications

- In Glen Canyon, the positive response of rainbow trout to spring HFEs is partially linked to the effect that spring HFEs have in increasing aquatic insect production

- Potentially a link exists between increased rainbow trout abundance in Marble Canyon and decreased turbidity attributable to fall HFEs. Only relevant in years without post-HFE tributary inputs.

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Projects J & N Socioeconomic and Hydropower Research

- GCMRC scientists identify preferences and economic values of resources in the Colorado River ecosystem
- How are values of economic resources affected by dam operations?
- GCMRC scientists work with cooperators to conduct research to meet hydropower and energy resource objectives

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Project J Socioeconomic Research

Results

- Economic effects of HFEs on day-use activities (e.g., angling, boating) unclear since substitute sites exist for these activities
- HFEs benefit whitewater rafters by increasing or maintaining campsite area
- Benefits of spring HFEs could be significantly greater than equivalent fall HFEs due to seasonal visitation and recreation specific preferences

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Project N Hydropower Research

Results

- Economic cost of an HFE is ~$1.6 million per experiment in both fall and spring

- 96 h or shorter HFEs are not anticipated to incur hydropower capacity costs, but extended duration HFEs could

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Project J/N Socioeconomic/Hydropower

Implications

- A systematic evaluation of recreational impacts of HFEs and the timing of recreational use would provide insight into the total recreational impact of HFEs

- Consideration of the HFE impact to power system emissions, along with the economic value of hydropower generation and capacity, could improve understanding of the effects of HFEs

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Next Steps

- Brief AMWG on major conclusions from HFE Assessment (this presentation)
- Post presentations from Annual Reporting meeting
- Distribute extended abstracts after peer review is complete and drafts finalized

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Next Steps

- “A next step would be for GCMRC to identify experimental flow options that would consider high valued resources of concern to the GCDAMP (defined above), fill critical data gaps, and reduce scientific uncertainties. ”

- June TWG meeting discussions

  - Spring HFEs - sediment trigger
  - Pre-emptive spring HFEs - release volume trigger
  - Powerplant capacity flows - spring
  - Slower downramp rates

  - Untriggered HFEs
  - Carryover sediment HFEs
  - Others?

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- GCDAMP

Questions?

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