



GCMRC Science

Michael Moran and S
Grand Canyon Monitoring and
Southwest Biological Science

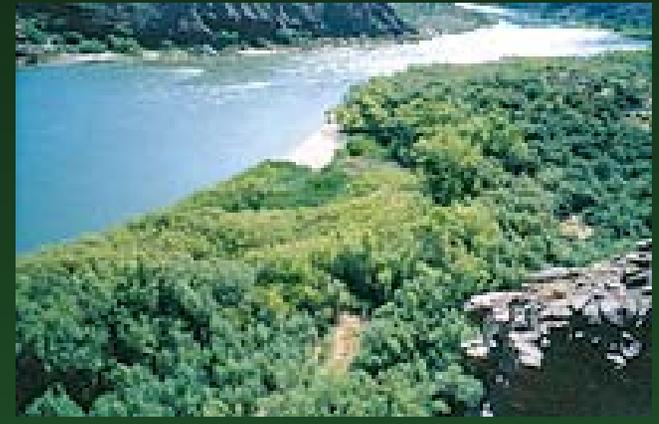
Adaptive Management Work
August 23, 2018



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

Riparian Vegetation Monitoring

- GCMRC scientists and their cooperators document the amount and types of vegetation found along the river corridor and determine plant cover, species richness, and diversity
- What are the effects of dam operations on riparian vegetation?



Riparian Vegetation Monitoring

River Mile 66

- GCMRC continues to work with volunteers to document riparian vegetation change along the river corridor using repeat photography

E.C. La Rue
08/14/1923



- To date, over 150 images from the 1923 Birdseye expedition have been precisely replicated

E. Hymans
02/24/1993



- GCMRC scientists document the plant assemblage visible in the current photographs

A.H. Fairley
05/10/2017



Riparian Vegetation Response to Climate and Hydrology

- Vegetation responses to climatic and hydrological variation are correlated
 - Vegetation responds strongly to spatial variation in low temperature
 - Vegetation does not track fine-scale variation in hydrology
 - Big differences between vegetation zones but not within them

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RESEARCH ARTICLE

Applied Vegetation Science



Hydrological regime and climate interactively shape riparian vegetation composition along the Colorado River, Grand Canyon

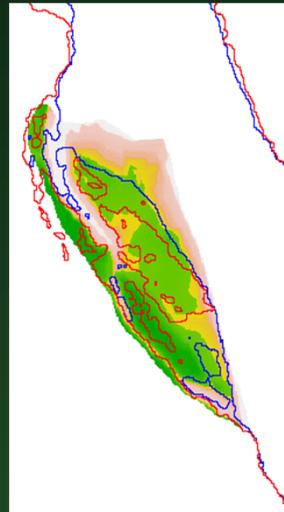
Bradley J. Butterfield¹ | Emily Palmquist^{1,2} | Barbara Ralston³

Riparian Vegetation-Sand Feedbacks

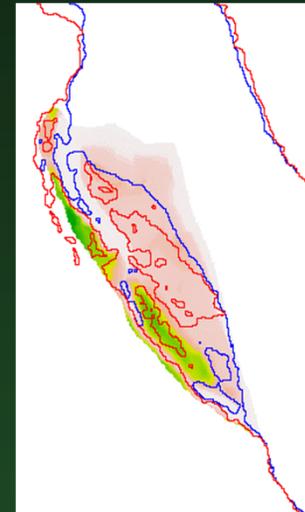
- Using niche models to understand the habitat suitability of dominant species
 - All Northern Arizona University sandbars
 - Data back to 1990
- Also examining changes in sandbar elevation to associate particular species with deposition and erosion

25k cfs
45k cfs

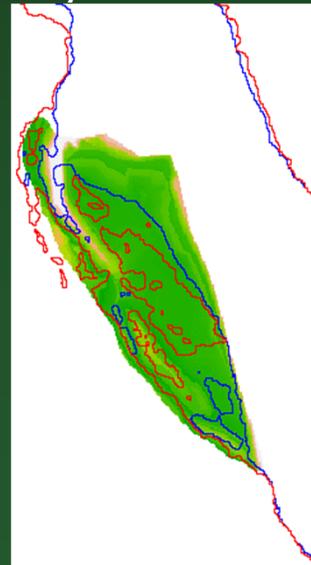
Arrow weed



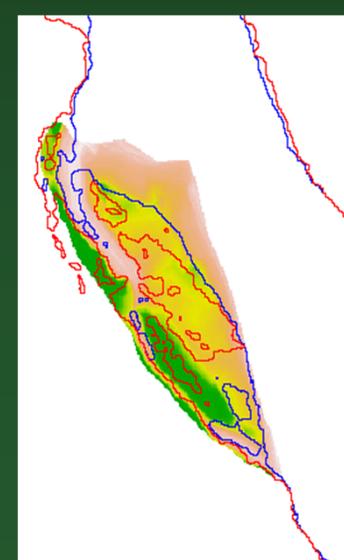
Mesquite



Coyote willow



Tamarisk



Habitat suitability
High
Low

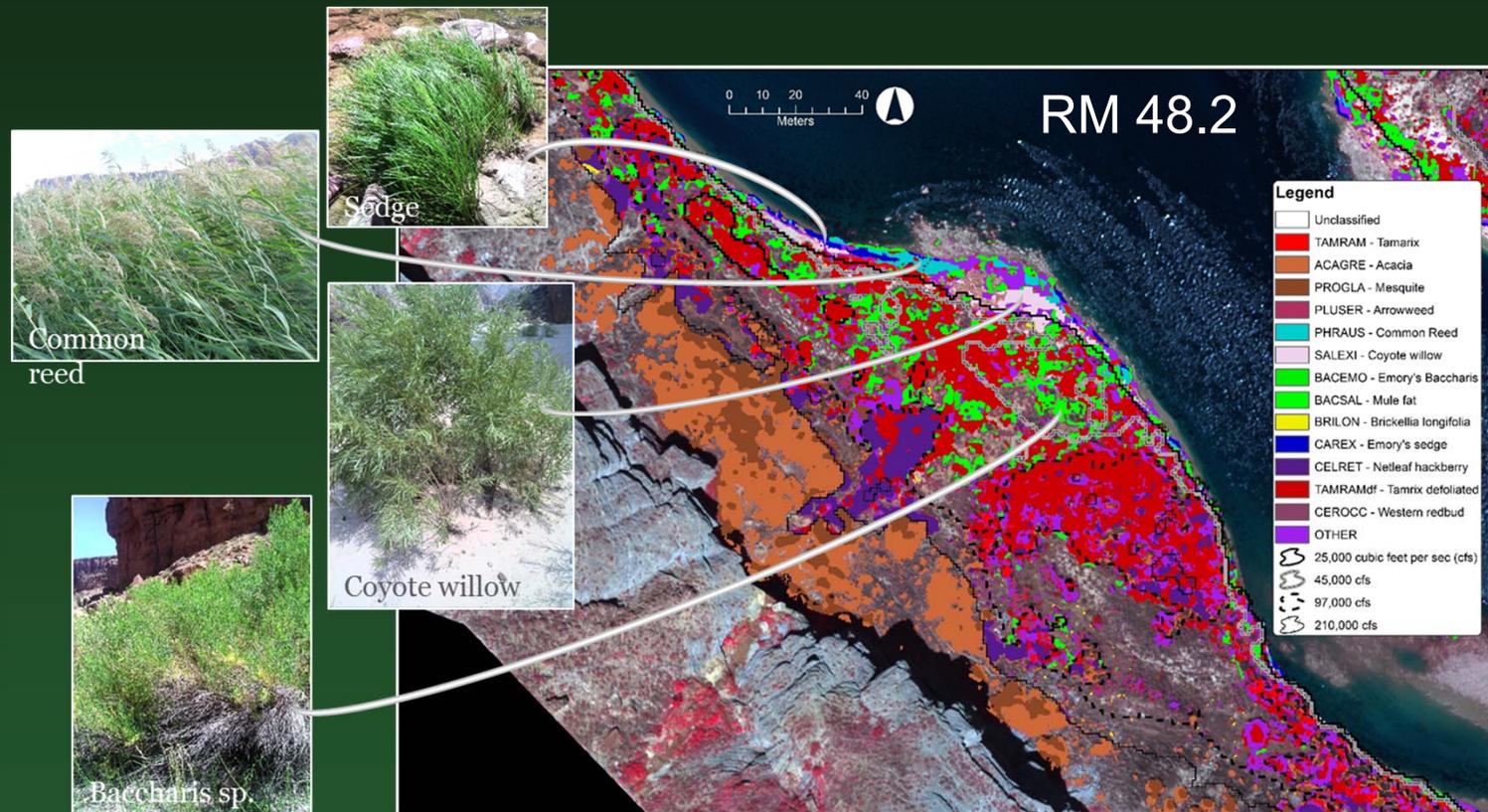
Physiological Basis of Climate and Hydrologic Response of Vegetation

- Ongoing research to examine physiological response of plants to heat and flooding
- Better understanding of the mechanisms that determine responses will help to predict plant suitability to different flow regimes and climate



Coyote willow cuttings with new roots

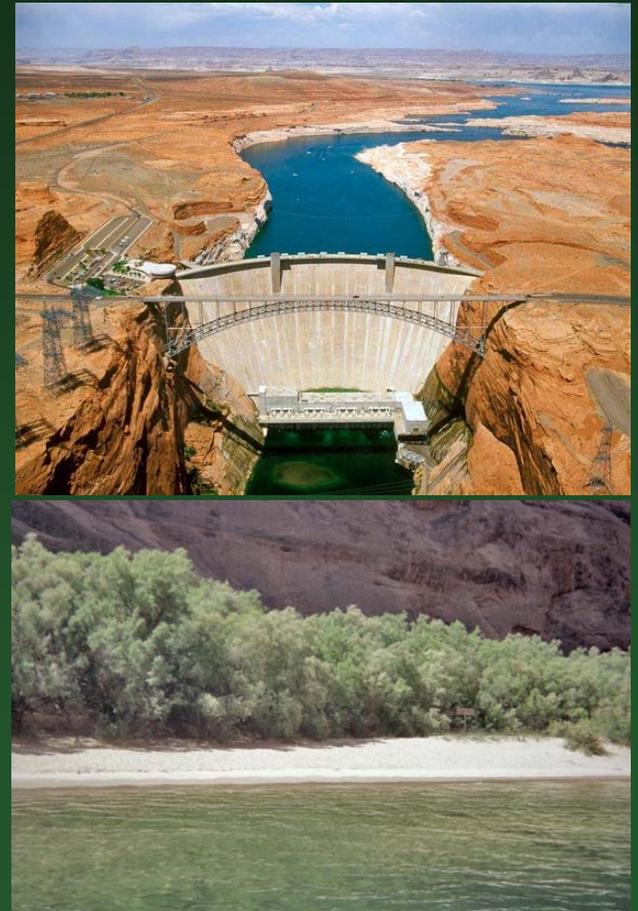
New Riparian Vegetation Classification Map from Overflight Imagery



- Species-level map of the Colorado River riparian zone from Glen Canyon Dam to Lake Mead
- Will be published as a USGS data series (Durning et al., *in review*)

Riparian Vegetation Management

- As part of the environmental commitments under LTEMP, experimental treatment of riparian vegetation is a mitigation for dam operation in the CRe [ES.8.3.3]
 - control non-native plants
 - develop native plants for replanting
 - replant natives at priority sites in the river corridor
 - remove vegetation encroaching on campsites
 - manage vegetation to assist with cultural site protection



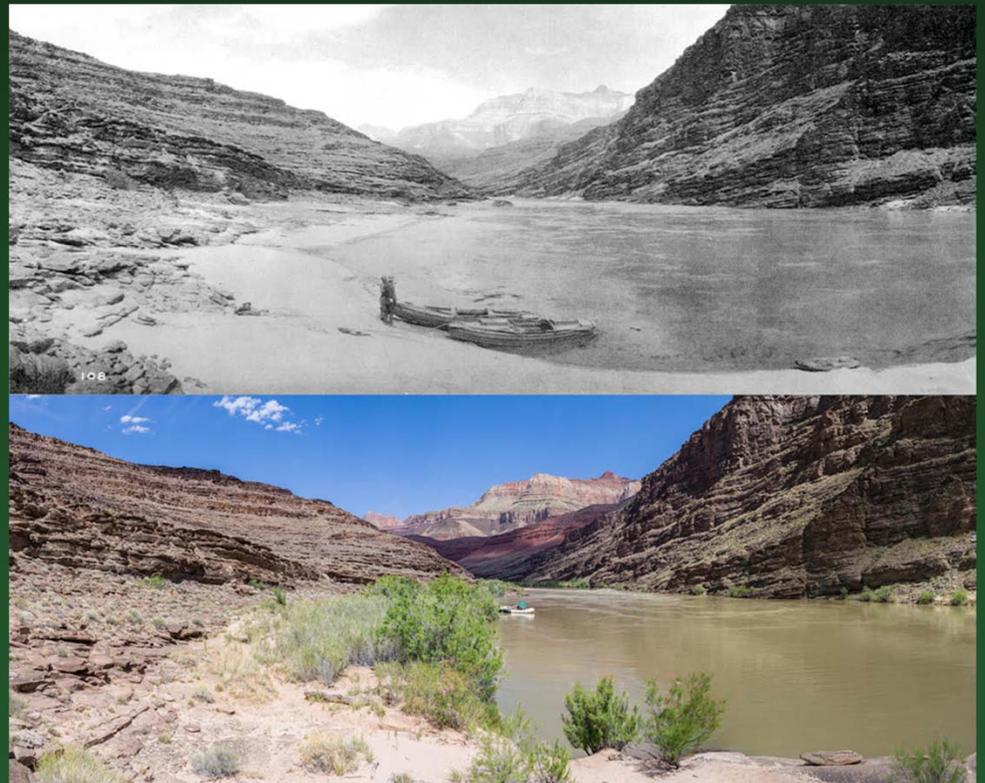
Riparian Vegetation Management

- Meetings, done as part of Triennial Work Plan Project Element C.4, have taken place with National Park Service, Tribes, Bureau of Reclamation, and GCMRC to:
 - Identify and prioritize potential project sites
 - Identify potential work at sites
 - Create a list of native species to be used for replanting
 - Identify common and differing vegetation management perspectives of the NPS and Tribes, with science guidance from GCMRC

A	B	C	D	E	F	G	H	I	J
River_Mile (GCMRC)	River Side	Site Name	Overall pilot priority (1=pull up at mtg, 2=store)	Number of LTEM Priorities Potentially Relevant	LTEM Priority Non-native Vegetation Control (1 = Site is Relevant to Priority)	LTEM Priority Replanting Native Vegetation (1 = Site is Relevant to Priority)	LTEM Priority Vegetation Encroachment on Campsites (1 = Site is Relevant to Priority)	LTEM Priority Vegetation Management for Cultural Site Protection (1 = Site is Relevant to Priority)	Number of Other Resource Management Priorities Potentially Relevant
-14.3	R	Ropes Trail Camp	1	3	1	1	1	?	3
-13.6	L	Tharion Mile Bar	2	2	1	1	0	?	2
-12.8	R	(-1):2R Beach	2	2	1	1	0	?	1
-12.2	L	Ferry Swale B	1	2	1	1	0	?	2
-11.5	L	Ferry Swale A	2	3	1	1	1	?	2
-10.5	L	Petroglyph Panel	1	2	1	1	0	?	2
-9.0	R	Nine Mile Camp	2	3	1	1	1	?	3
-8.8	L	Leopard Frog Marsh	2	1	1	0	0	?	4
-8.0	R	Eight Mile Camp	2	3	1	1	1	?	3
-7.0	L	Finger Rock/Lunch Beach	1	2	1	1	0	?	3
-6.5	L	Hidden Slough	2	2	1	1	0	?	4
-5.0	L	Three Mile Bar	2	2	1	1	0	?	2
0.0	R	Low Ferry	2	3	1	1	1	?	4
24.8	L	24.8 Mile	2	2	1	0	0	1	2
58.0	R	Melgosa Right - Downstream	2	2	1	0	0	1	2
70.0	R	Basalt	2	3	1	0	1	1	2
72.7	L	Above Unkar	2	2	0	0	1	1	1
78.8	L	Upper Nevills	2	2	1	0	1	0	2
122.8	R	122 Mile Camp	1	2	0	0	1	1	2
223.6	R	223.6 mile	2	2	1	0	0	1	2
274.3	L	Grand Canyon Youth Camp	1	3	1	1	1	0	5
5.9	R	6 Mile Camp	2	1	0	0	1	0	5
8.1	L	Jackson Canyon Camp	2	1	0	0	1	0	7
11.5	R	Soap Creek Camp	2	2	0	1	1	0	7

Bare Sand and Dunefields

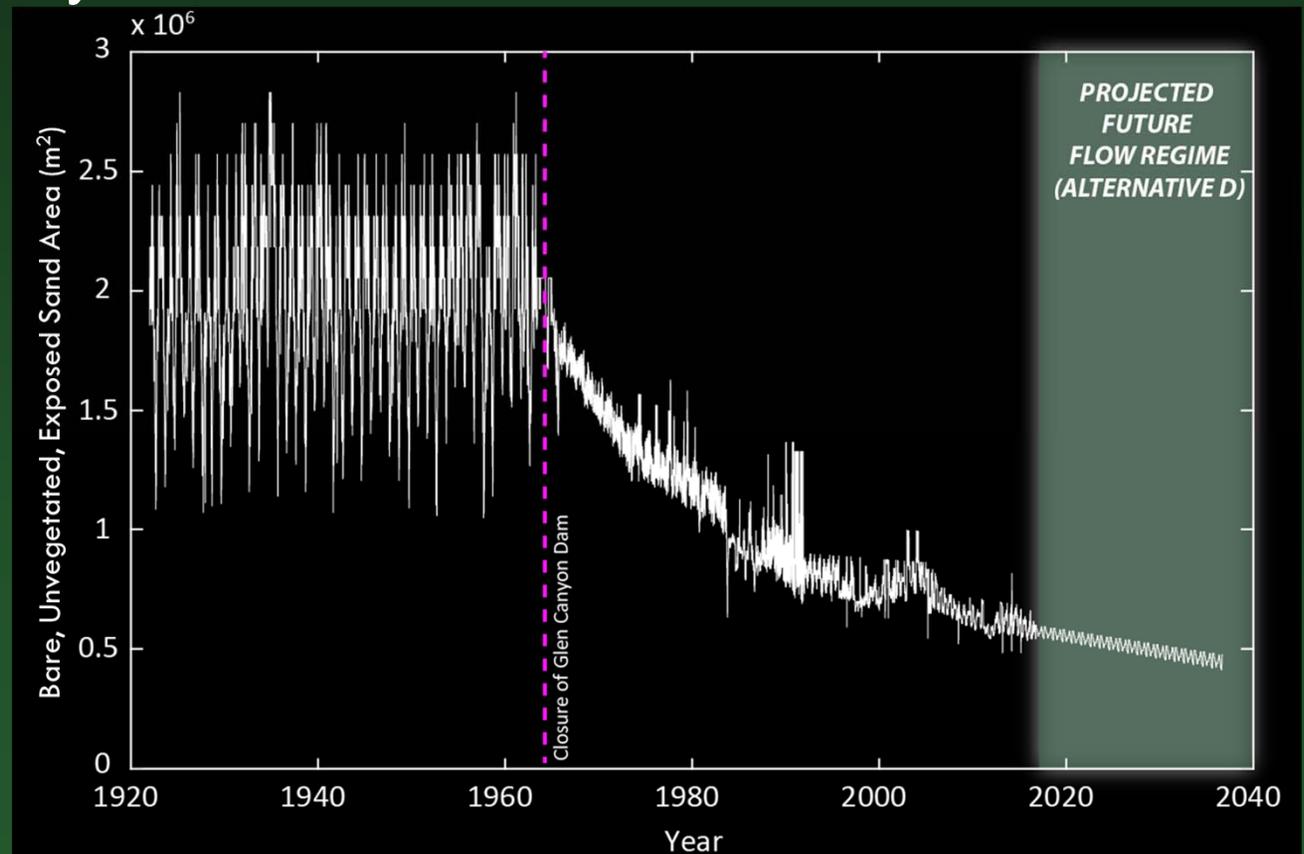
- Bare sand is an important resource for recreation, habitat, and cultural resources in the Grand Canyon
- What are the effects of dam operations on bare sand and aeolian sand dunes?



Bare Sand and Dunefields

- Bare sand area has decreased by 49% since 1965, and is projected to decrease by an additional 12% by 2037

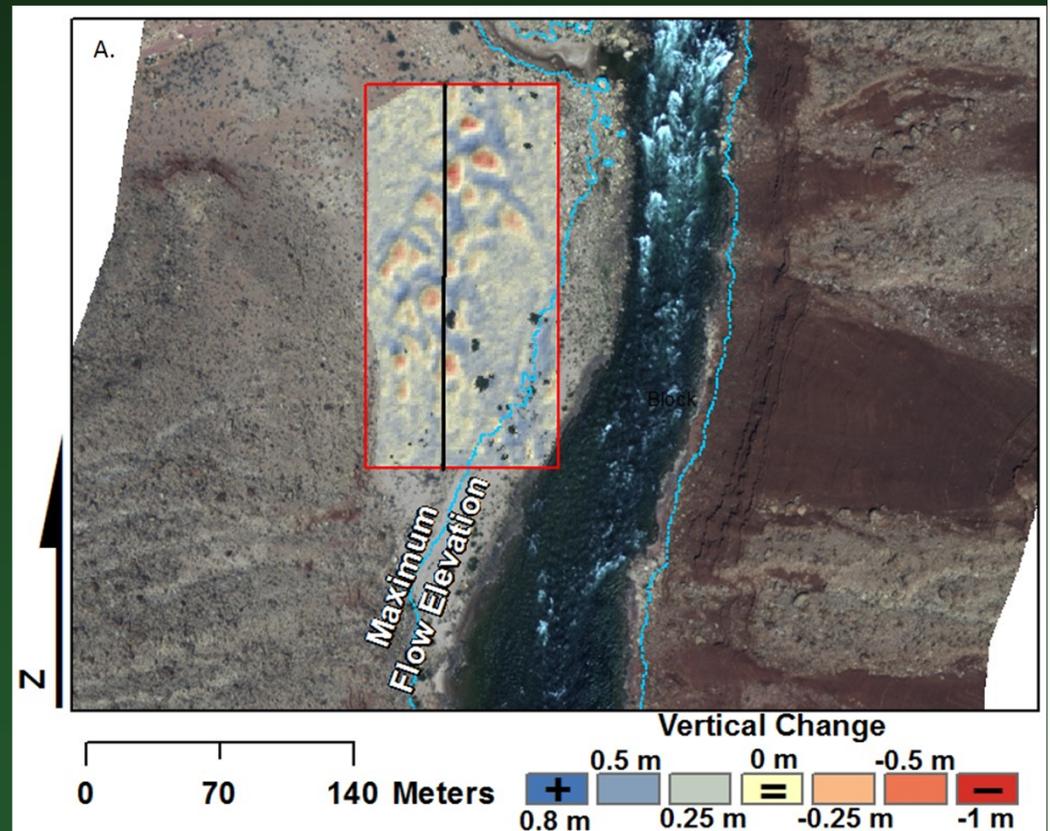
- 40% of bare sand is underwater almost all the time (8,000 cfs)



Dunefield Status

Soap Creek, RM11

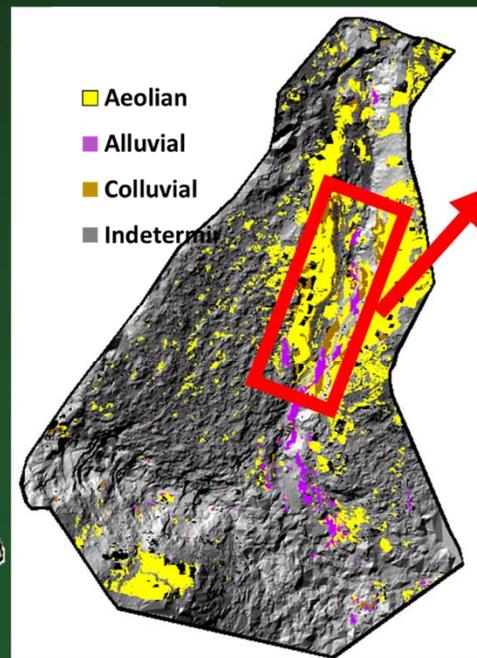
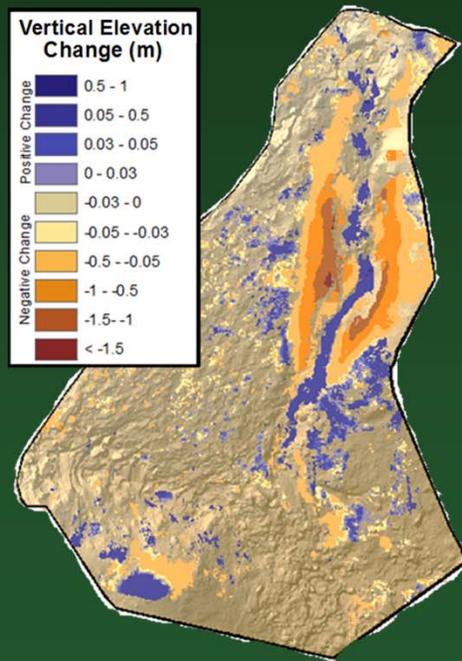
- Dunefield sediment resupply is analogous to resupply of sandbars
- High Flow Events supply sand for both sandbars and sandbars provide sand source for aeolian dunefields
- More frequent HFEs will increase sediment storage in dunefields



Sankey and others, 2018a,b

Sediment and Archeological Site Conditions

- Rates of erosion and deposition are being monitored
- Deposition rates tied to sandbars replenishment and transport by wind



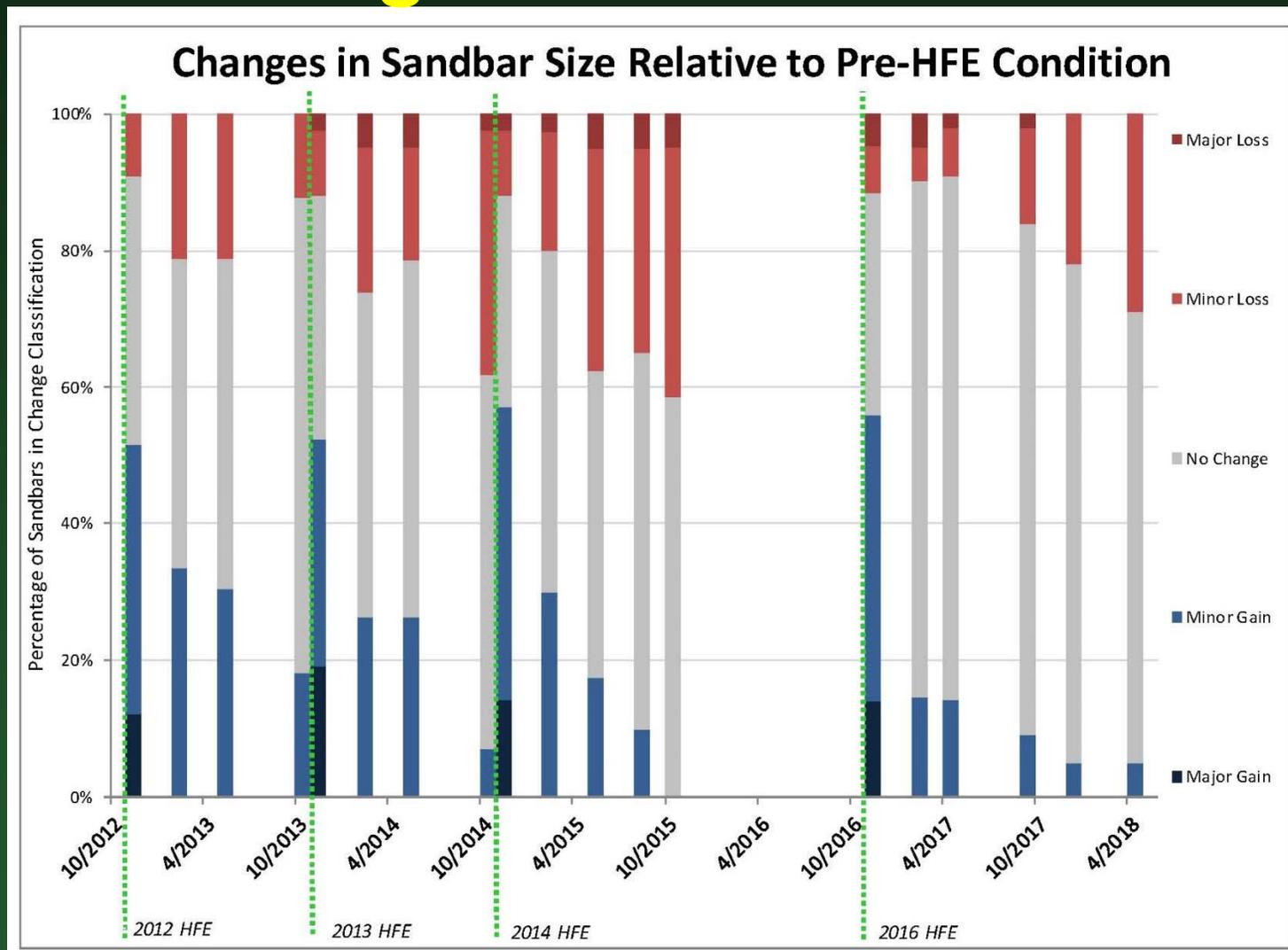
Fossil, RM125

Sediment and Sandbars

- GCMRC scientists and their cooperators monitor changes in suspended sediment, sandbars, and changes in the amount of sand stored on the bed of the river
- What are the effects of dam operations on building and maintaining sandbars?



Recent Changes in Sandbar Conditions



Changes in Sandbar Conditions Following 2016 HFE



RM 45.0 Pre-Flood (11/6/2016)



RM 45.0 Post-Flood (11/13/2016)

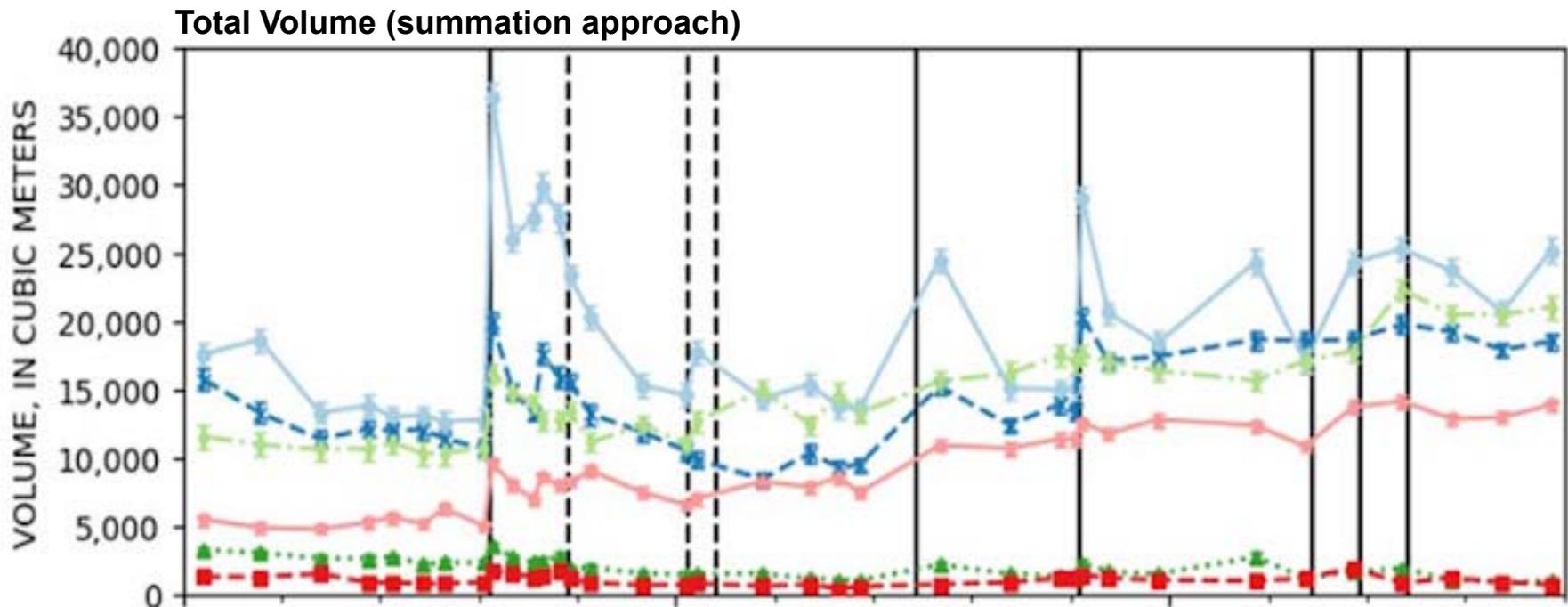


RM 119.4 Pre-Flood (11/6/2016)



RM 119.4 Post-Flood (11/13/2016)

Long-Term Changes in Sandbars



Groups 1a and 1b:

- relatively large and mostly open bare sandbars

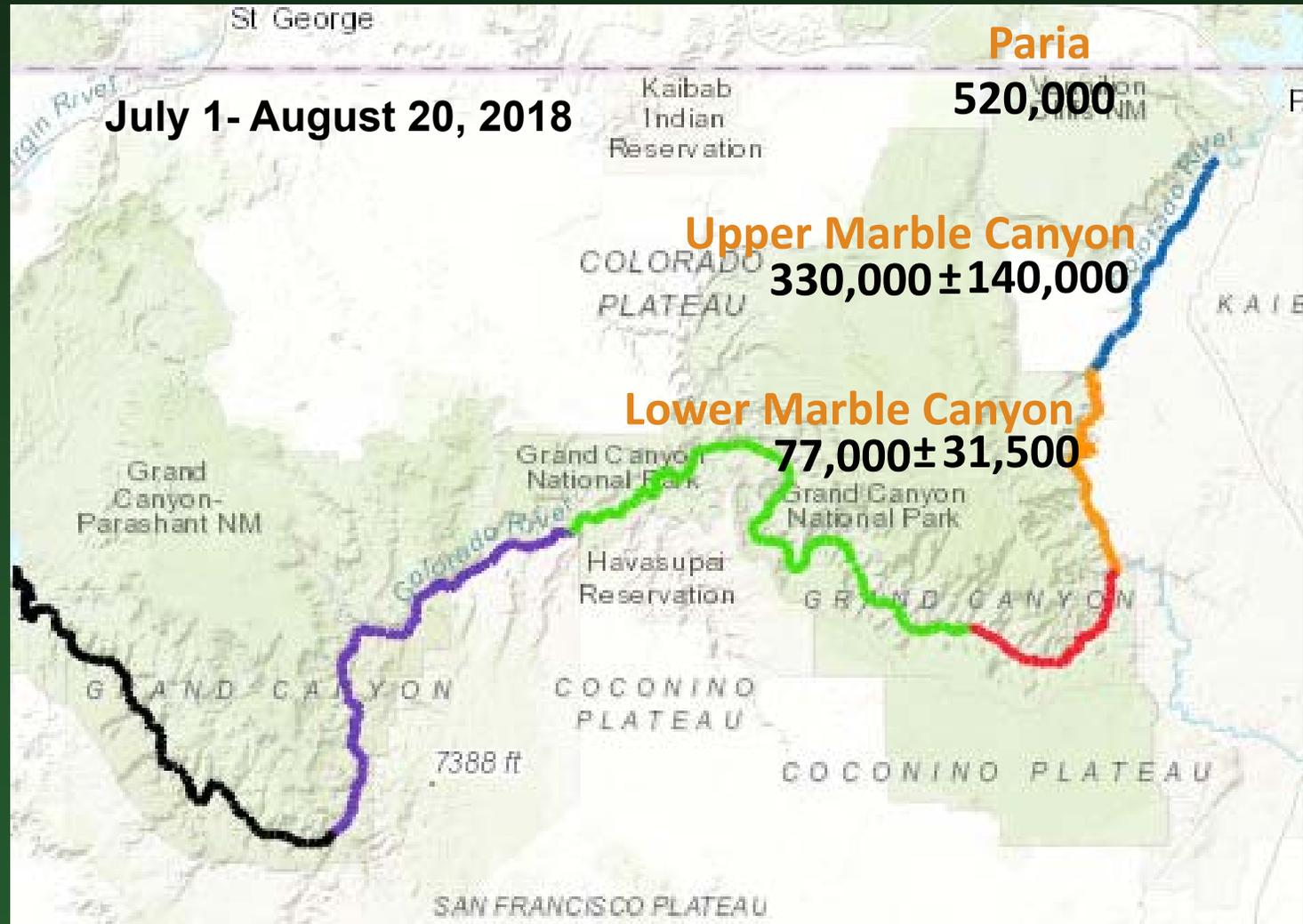
Groups 1c and 3:

- heavily vegetated bars

Groups 2 and 4:

- mostly smaller bars adjacent to debris fans

Changes in Sand Mass Balance (metric tons)

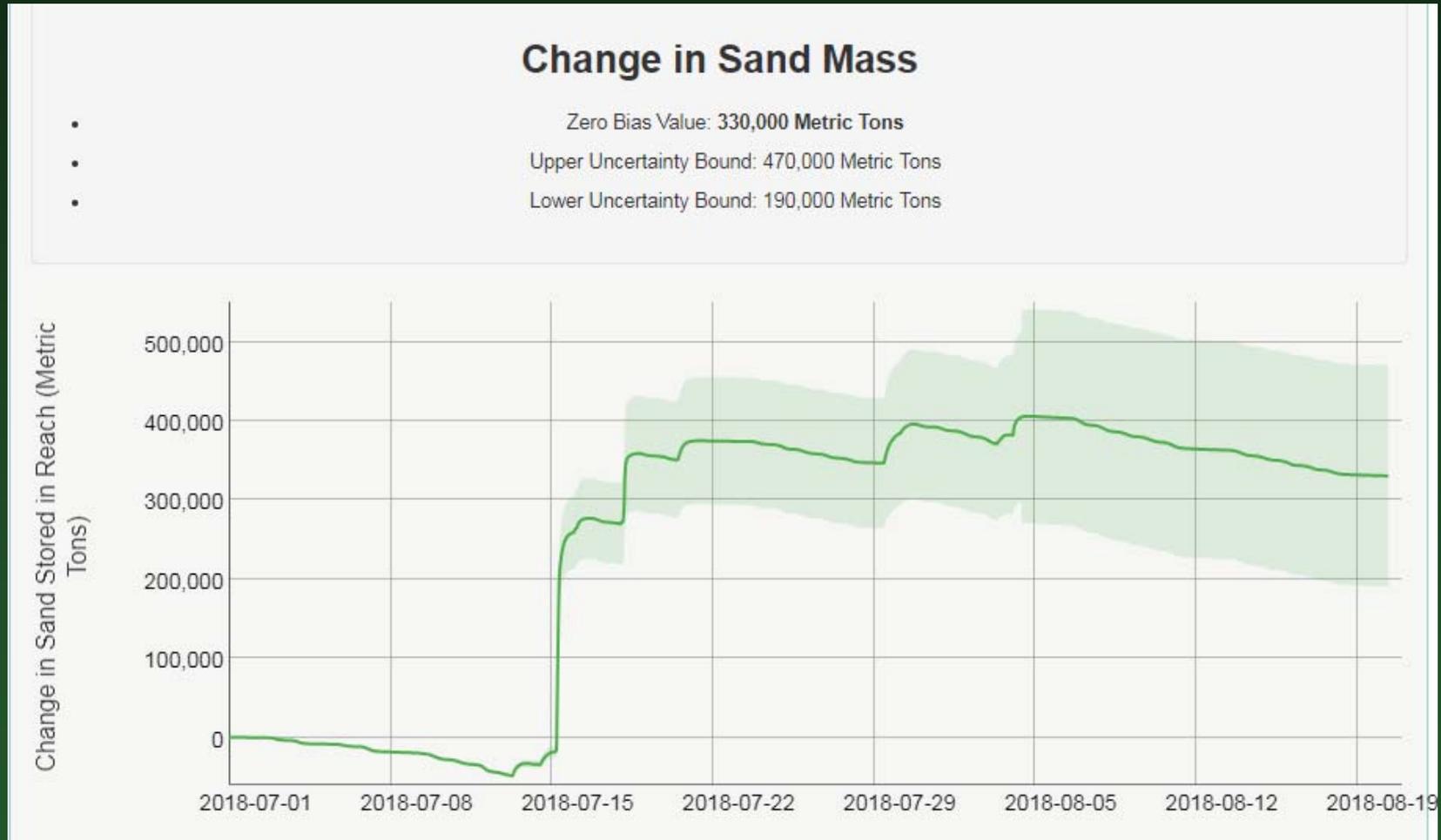


Paria River at Lees Ferry



July 1- August 22, 2018

Upper Marble Canyon



July 1- August 20, 2018

Lower Marble Canyon

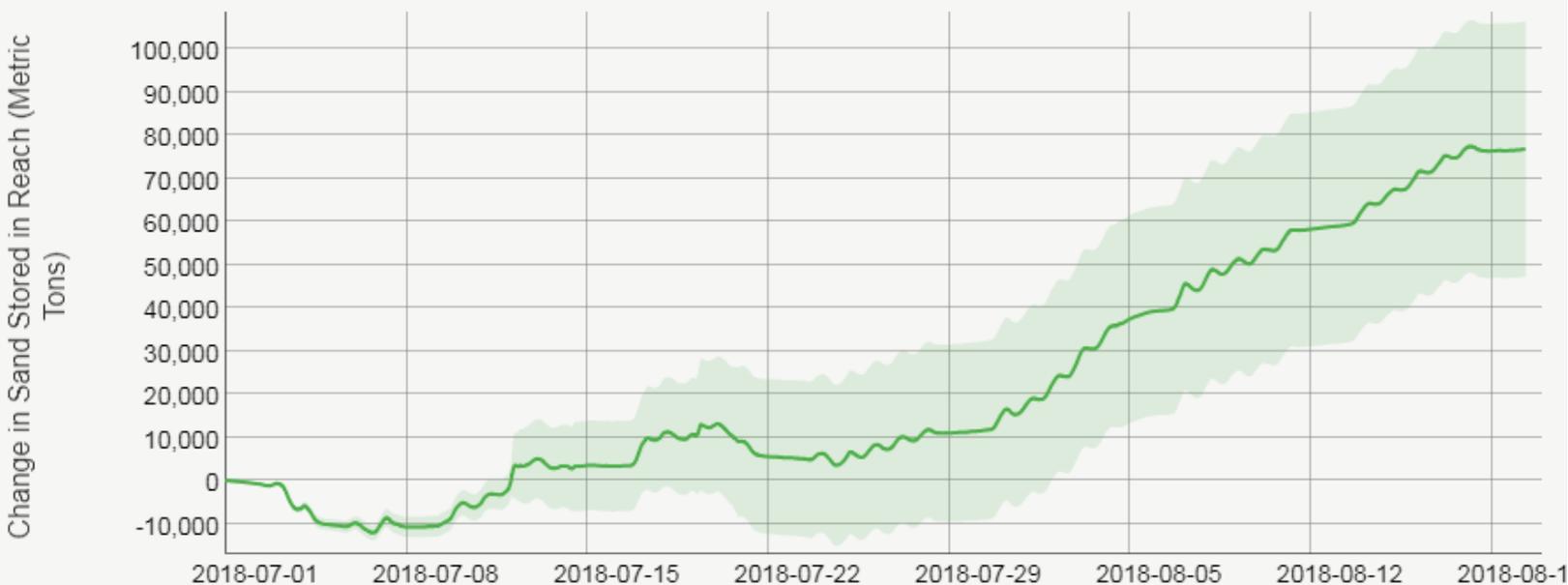
Change in Sand Mass

-
-
-

Zero Bias Value: 77,000 Metric Tons

Upper Uncertainty Bound: 110,000 Metric Tons

Lower Uncertainty Bound: 47,000 Metric Tons



Lake Powell Water Quality Program

- Water quality data has been collected by USGS, NPS, and BOR on Lake Powell and Colorado River since 1964 - initiated to insure compliance under the Salinity Control Act
- Since mid-1990s USGS and Bureau of Reclamation have cooperated to collect water quality data in order to:
 1. document conditions, status and trends for biennial report
 2. understand physical/biological processes that affect water quality



Water Quality Review

- Grand Canyon Monitoring & Research Center held a review of its water-quality program on October 24-26, 2017 in Page, AZ
- A panel of 5 recognized experts in water quality formed the review team
- Focus of review was on Lake Powell water quality work but also included discussion of upcoming work downstream of the dam



Water Quality Review

- The review included presentations, discussions, and field trips
- A report summarizing the conclusions and recommendations of the expert panel was received by the GCMRC on June 4, 2018

Grand Canyon Monitoring and Research Center Water-Quality Program Review

Panelists:

Stephen Hamilton, Professor, Kellogg Biological Station, Michigan State University
Chris Holdren, Environmental Consultant, Littleton, CO.
Edward Stets, Research Ecologist, USGS
Kristin Strock, Assistant Professor, Environmental Science, Dickinson College
Todd Tietjen, Regional Water Quality Manager, Southern Nevada Water Authority

Summary of review panel comments

The panel was impressed with the monitoring program and the dedication of the staff from multiple government agencies who have worked together to maintain the program in the face of daunting logistical challenges and bare-minimum funding. The long-term data record is invaluable for understanding how the linked Lake Powell-Grand Canyon Ecosystem functions, how management of the dam may affect ecosystem functions, values and services both above and below the dam, and how future changes in climate and runoff regimes may impose changes on the ecosystem.

The justification for the monitoring program, encompassing both the Grand Canyon as well as Lake Powell, is clearly articulated in the GCDAMP FY 2017 Knowledge Assessment. The major environmental concerns in the Grand Canyon are closely tied to the quality of water discharged from the dam, including nutrients as well as temperature and dissolved oxygen (DO), which in turn reflect limnological conditions in the reservoir. Therefore it is critical to understand the Lake Powell ecosystem from the standpoint of maintaining and enhancing the Grand Canyon ecosystem as well as protecting environmental values and recreational and aesthetic services afforded by the reservoir itself.

Altered temperature, high salinity and low DO are water quality attributes of particular concern, but inorganic phosphorus (measured as soluble reactive phosphorus, SRP) may

- Recommendations were made to 4 questions posed to the panel
- The panel also made recommendations regarding data management



Major Recommendations

- Improved data management is a high priority and will facilitate using historical data
- Quality Assurance/Quality Control, especially of the SeaBird data, needs to be improved
- Data from an additional meteorological station, thermistor string, or other automated sampling would be helpful



Major Recommendations

- The number of stations sampled during quarterly trips should be streamlined
- Continue to evaluate the role phosphorus plays in the ecology of Lake Powell and downstream
- CE-QUAL W2 model seems to be adequate but could be improved with better meteorological and temperature data



Major Recommendations

- Recommend using an existing, national data repository for storing water quality data such as:
 - **NWIS (USGS database)**
 - **WQX (EPA database)**
 - **BioData (for plankton and other biological data)**
- Developing metadata
- Identifying all data sources
 - **Screen data for inclusion**
- Document QA/QC procedures

USGS Water Data for the Nation

Search for Sites With Data

- Current Conditions** Sites with real-time or recent surface-water, groundwater, or water-quality data.
- Site Information** Descriptive site information for all sites with links to all available water data for individual sites.
-  Map of all sites with links to all available water data for individual sites.

Frequent Searches By Data Category

- Surface Water** Water flow and levels in streams and lakes.
- Groundwater** Water levels in wells.
- Water Quality** Chemical and physical data for streams, lakes, springs, wells and other sites.
- Water Use** Water use information.



Implementation of Recommendations

Some things GCMRC and BOR are starting to consider:

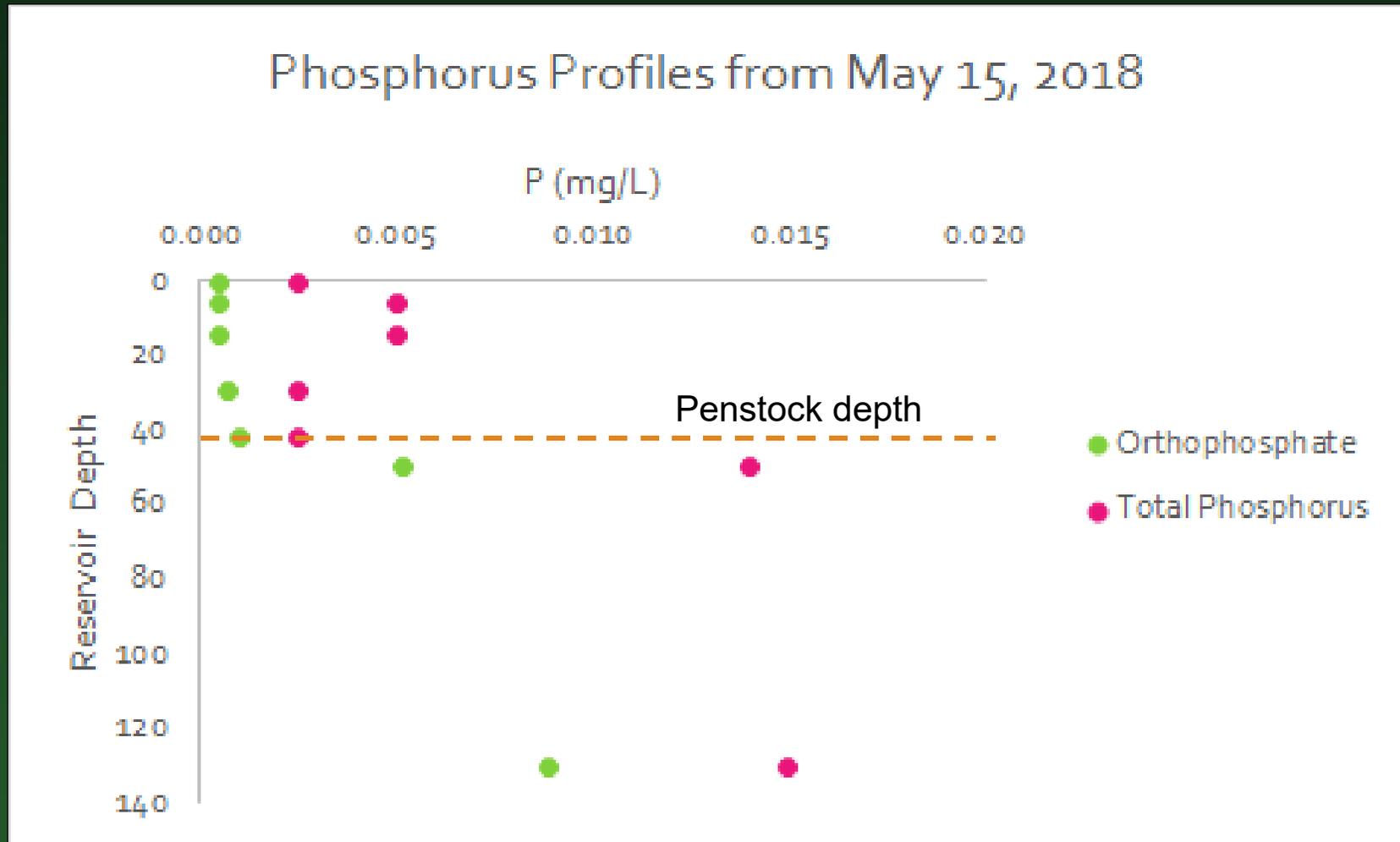
- Cross-check dissolved oxygen and temperature measurements made with Seabird
- pH calibration of Seabird prior to each sampling event to check for drift
- Increased vertical resolution of sampling at Wahweap
- Deployed new thermistor string
- Laboratory analyses now include Total Dissolved Phosphorus
- Freezing chlorophyll samples
- Improved data management and serving
- Purchasing benchtop pH meter for field pH measurements
- Adding phosphorus to sampling gages in tributaries

Current Status of Work

- Continued monthly surveys of forebay (Wahweap) and tailwater
- Continued quarterly surveys of entire reservoir to the inflows
- Begin comprehensive analyses of historical data – starting with nutrient data
- Begin characterizing nutrient dynamics, especially during high flow events



Recent Results – Vertical P Sampling



Current Status of Funding

- Old Interagency Agreement with Reclamation was deobligated and new 5-yr agreement was submitted
- 5-year agreement includes funding starting in Calendar Year (CY) 2018 and continuing through CY2022
- Agreement would fund continuance of long-term monitoring of Lake Powell water quality to insure Reclamation compliance under the Salinity Control Act and environmental concerns under the Grand Canyon Protection Act and Long Term Experimental and Management Plan for the Glen Canyon Dam operations

Socioeconomic and Cultural Resources

- GCMRC scientists identify preferences and economic values of resources in the CRe
- How are values of economic resources affected by dam operations?



Tribal Perspectives and Value of Resources

- Approval of population surveys on the Navajo Nation was recently granted
- Present the Hualapai survey to tribal council in September 2018
- Continued discussion is occurring with other tribes

Acknowledgments

- US Bureau of Reclamation
- National Park Service
- Arizona Water Science Center
- Northern Arizona University
- Tribal Partners