GCMRC Science Updates

Adaptive Management Work Group Meeting
August 19, 2021

Michael Moran
Southwest Biological Science Center
Grand Canyon Monitoring and Research Center

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

Recent Findings for Select Resource Areas

Sandbar Monitoring – Project B

- A morphodynamic model using sub-daily flow and sediment concentration data predicts decadal changes in average sandbar volume (Mueller and Grams, 2021)
- Model estimates sandbar volumes and their growth and decay relative to different flows including controlled floods
- Model runs demonstrates the importance of flood frequency and sand concentration for increasing average sandbar volume

AGU ADVANCING EARTH AND SPACE SCIENCE

Geophysical Research Letters

RESEARCH LETTER
10.1029/2021GL093007

Key Points:

- A simple morphodynamic model using sub-daily flow and sediment concentration data predicts decadal changes in average sandbar volume
- The model optimizes an erosion rate parameter and eddy exchange coefficient and is relatively insensitive to the calibration data
- Post-hoc modeling demonstrates the importance of flood frequency and sand concentration for increasing average sandbar volume

Supporting Information:

Supporting Information may be found in the online version of this article.

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A Morphodynamic Model to Evaluate Long-Term Sandbar Rebuilding Using Controlled Floods in the Grand Canyon

Erich R. Mueller[1] and Paul E. Grams[2]

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Abstract Controlled floods released from dams have become a common restoration strategy in river systems worldwide. Here we present a morphodynamic model of sandbar volume change for a subset of sandbars of the Colorado River in Grand Canyon National Park, where controlled floods are part of a management strategy focused on sandbar maintenance. We simulate sandbars as a triangular wedge, where deposition and erosion are modeled using physically based approaches that are driven by nearly continuous observations of flow and suspended sand concentration. We optimize an eddy exchange coefficient and erosion rate parameter by comparing model predictions to measured bar volumes. The model captures most of the variability in observed volume changes, and demonstrates the importance of flood frequency and sand concentration on average bar size. The model is easily implemented and adaptable, providing a means for predicting the future behavior of sandbars under a variety of streamflow and sediment supply scenarios.

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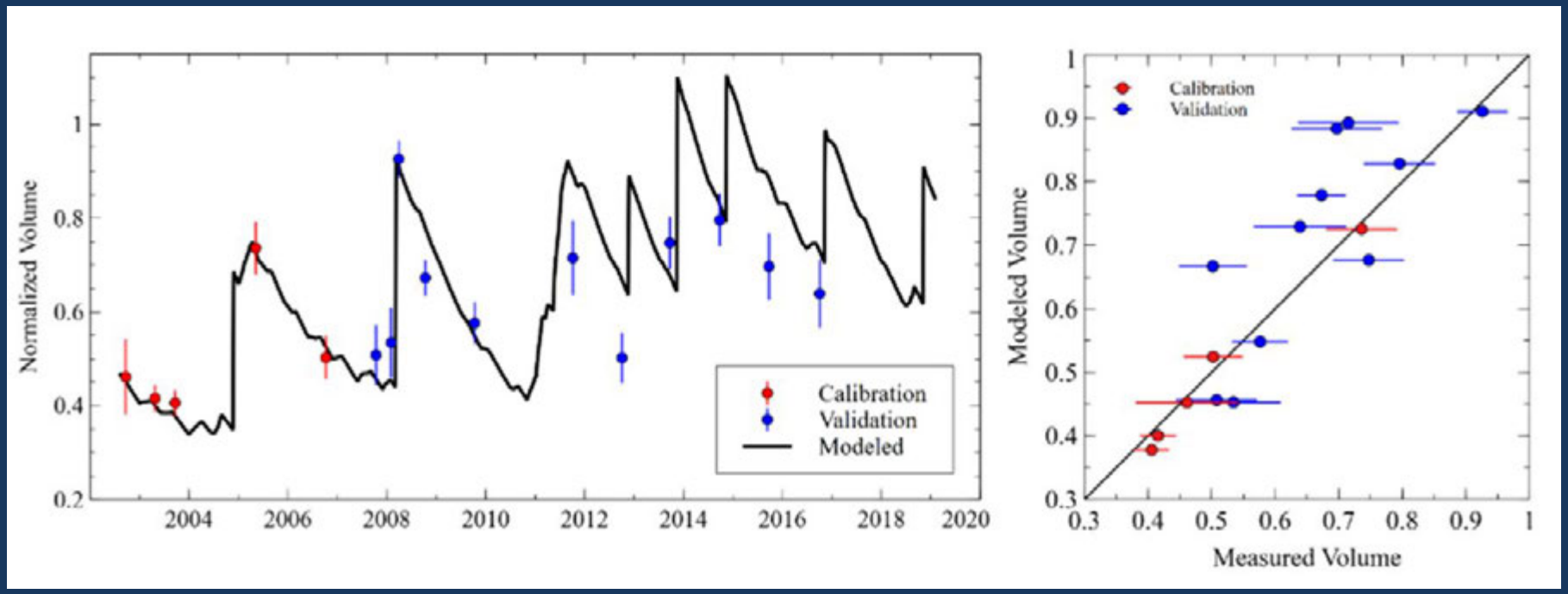
Sandbar Monitoring Continued (1)

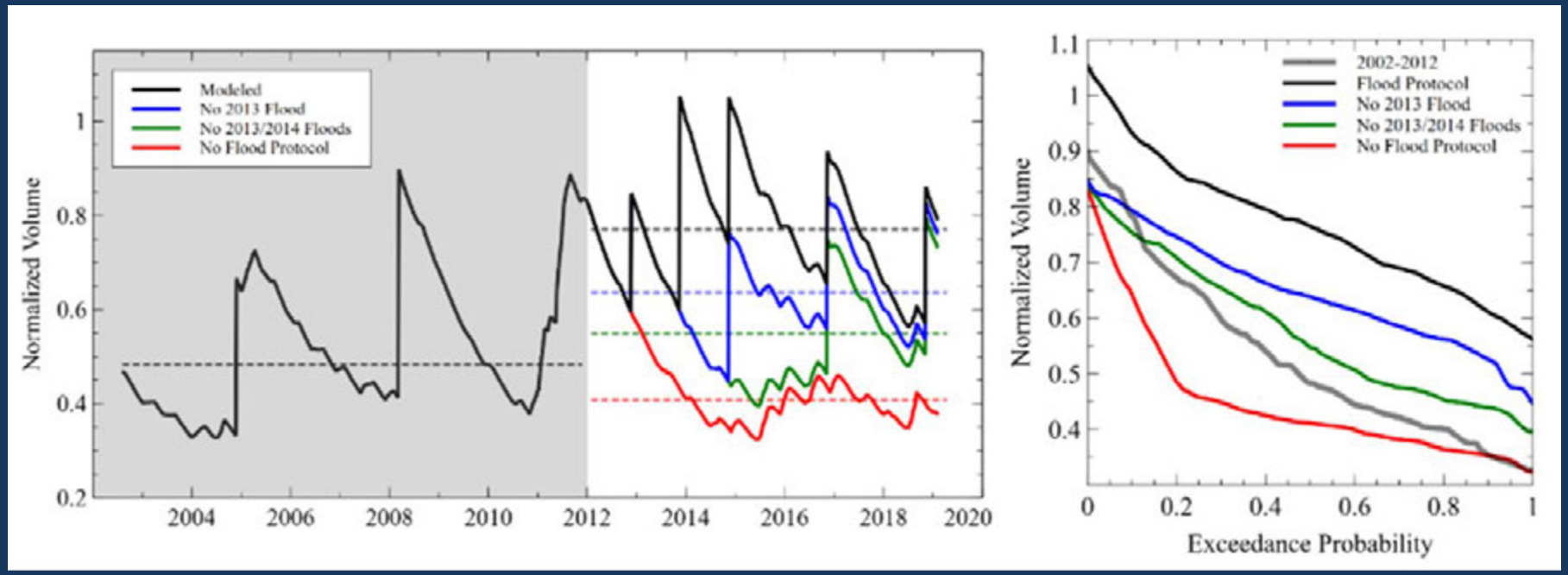


Mueller and Grams, 2021

- Model was calibrated on 5 measurements (2002-2007) and validated on 2008 to 2018 data
- The model reproduces peak volumes during floods and minima between floods well
- Sustained intermediate flows such as the 2011 equalization are more difficult to predict

USGS

Sandbar Monitoring Cont. (2)



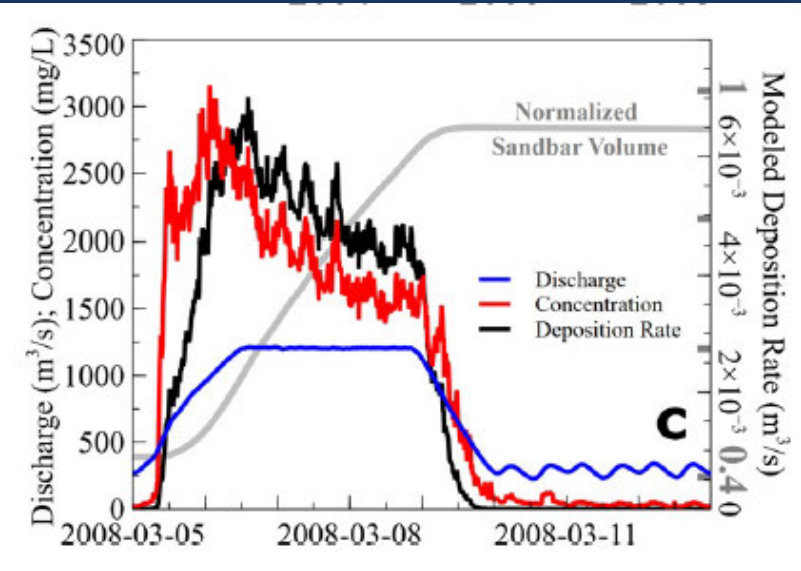
Mueller and Grams, 2021

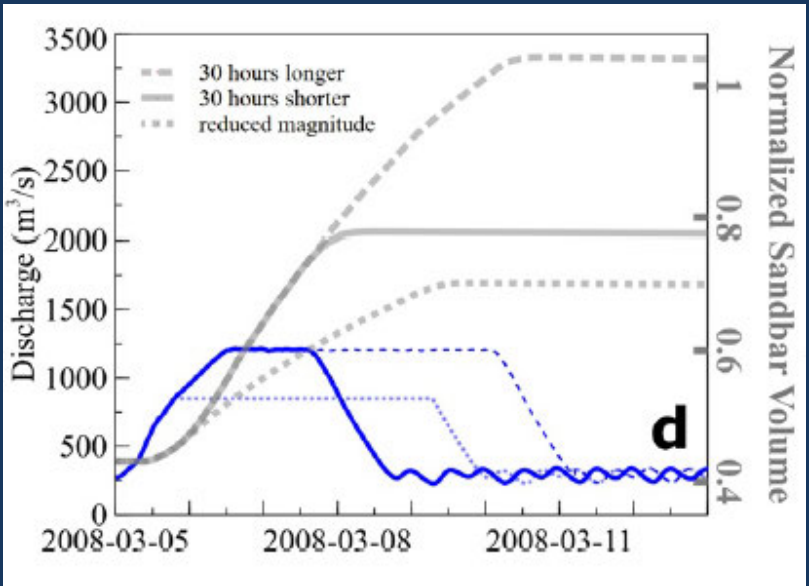
- Model runs were done to determine the effects of performing HFEs and not performing HFEs
- Sandbars are at least 70% of maximum observed size for 80% of the time
- HFEs increases sandbar volume about 1.3–2 times the pre-flood volume
- Fewer HFEs = reduced sandbar size

USGS

Sandbar Monitoring Cont. (3)

- Model runs were done to determine the effects of HFE duration and magnitude
- 30 hours longer = 15% more sandbar volume; 30 hours shorter = 15% less sandbar volume
- An HFE of 30,000 cfs instead of 45,000 cfs = 40% less sandbar volume





Mueller and Grams, 2021

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Riparian Vegetation Field Measurements – Project C

Two recently published studies:

1. Population genetic patterns of coyote willow, cottonwood, mesquite, Goodding's willow in the Grand Canyon region (Palmquist et al., 2021)

2. Riparian dependence of willows given wet to dry climates (Butterfield et al., 2020)

USGS

Riparian Vegetation Field Measurements Cont.

- Measured physiological responses of arrowweed (woody shrub) and tall fescue (grass) at Paria Beach during the spring disturbance flow
- Annual riparian vegetation monitoring in Glen, Marble, and Grand Canyons in August, September, October 2020 and scheduled for 2021
- Conducted an experiment to examine how dry vs. humid climates impact willow physiological response and water dependence, June-July 2021

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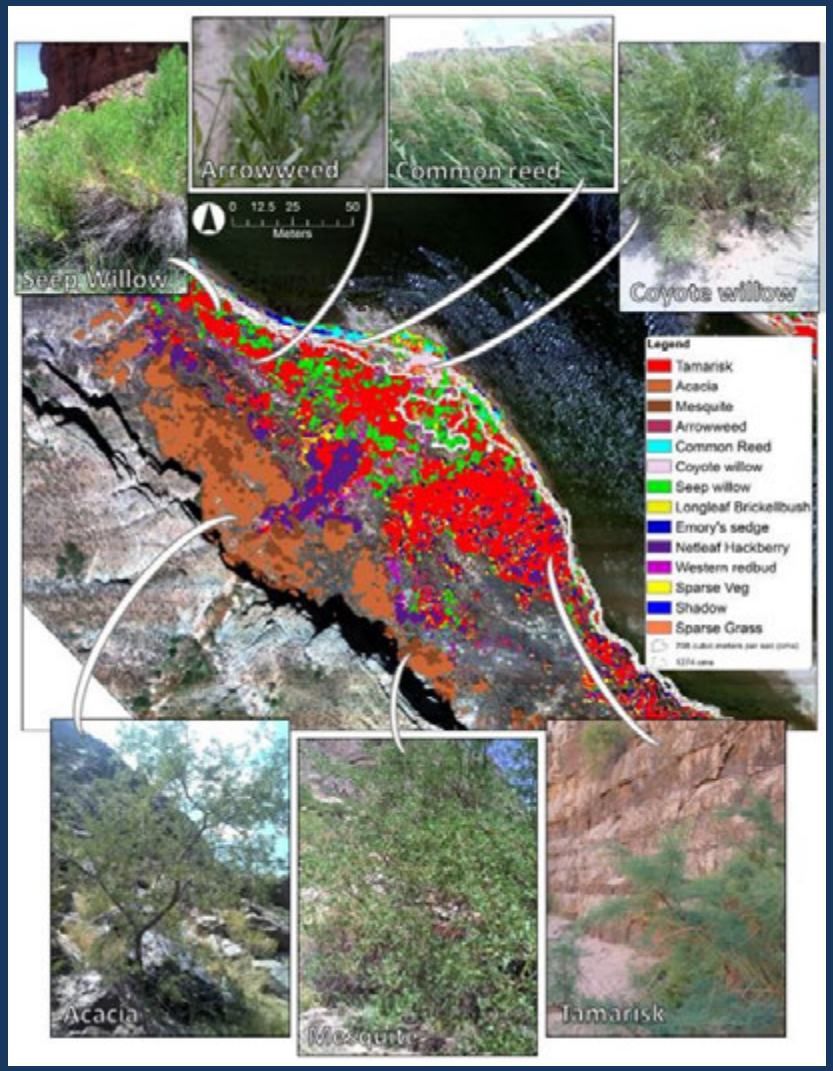
Riparian Vegetation Remote Sensing – Project C

- Durning et al., in press - represents the final major interpretation of 2013 overflight imagery before transitioning to analysis of 2021 overflight imagery
- Details encroachment of riparian plant species using 2002, 2009, 2013 overflight remote sensing datasets
- Informs modeling of vegetation response to future potential river flow regimes from dam operations



Durning et al., in press

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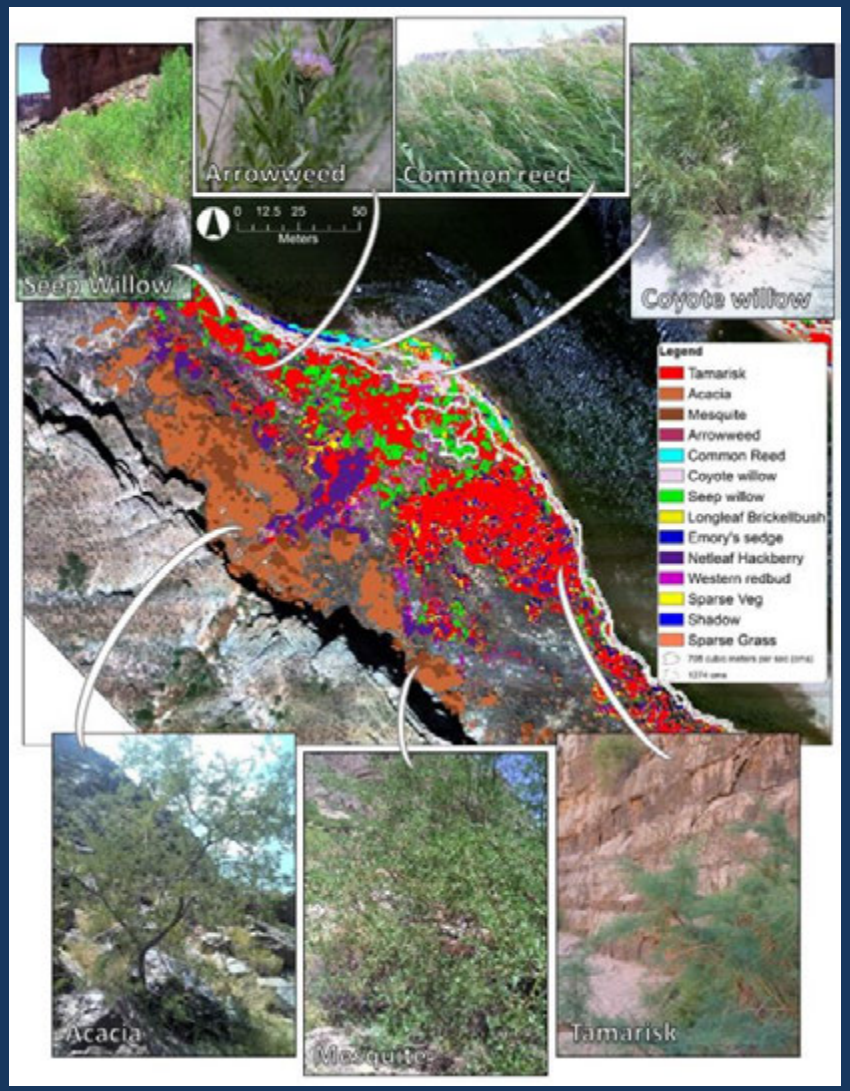
Riparian Vegetation Remote Sensing Cont.

- Vegetation expansion especially pronounced on sandbars inundated by daily hydro-peaking (load-following flows) and controlled floods (HFEs)
- Seep willow (Baccharis spp.), tamarisk (Tamarix spp.) and arrowweed (Pluchea sericea) primary encroaching woody species
- Common reed (Phragmites australis) and horsetail (Equisetum xferrissii) primary encroaching herbaceous species



Durning et al., in press

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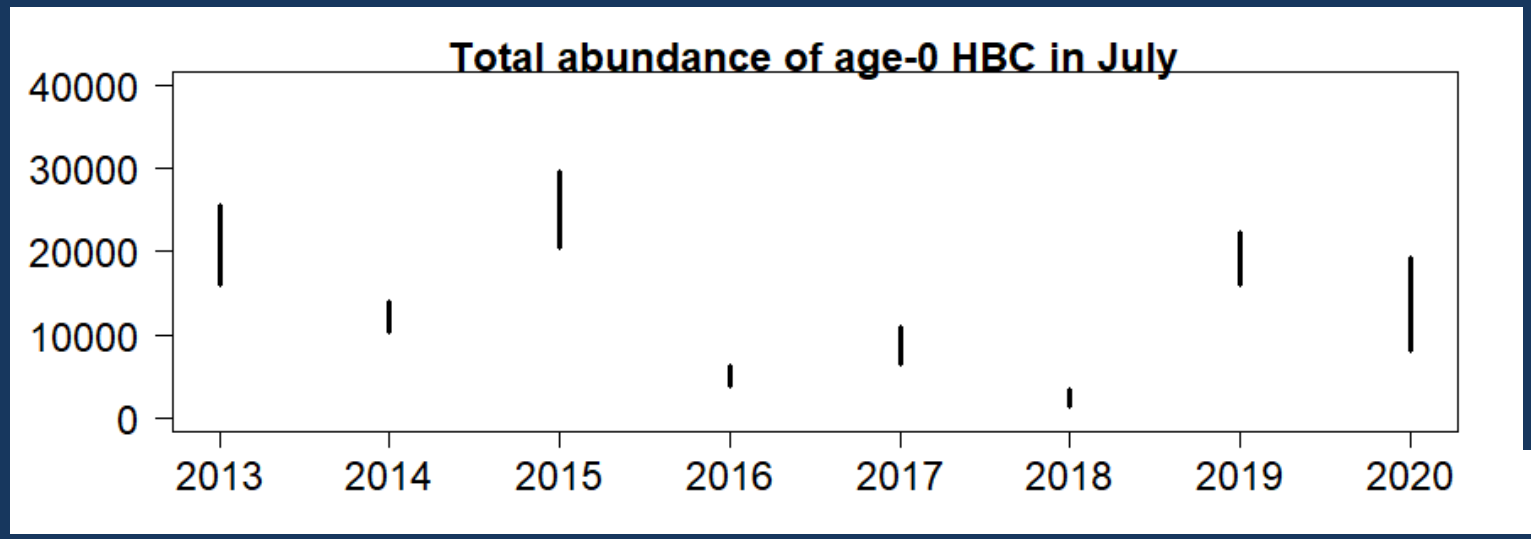
Humpback Chub – Project G

- Low number of juvenile humpback chub caught this year in the LCR
- Model hasn't been run yet but 2021 estimate will likely be lowest observed
- Lack of flooding in over 1 year



*
2021

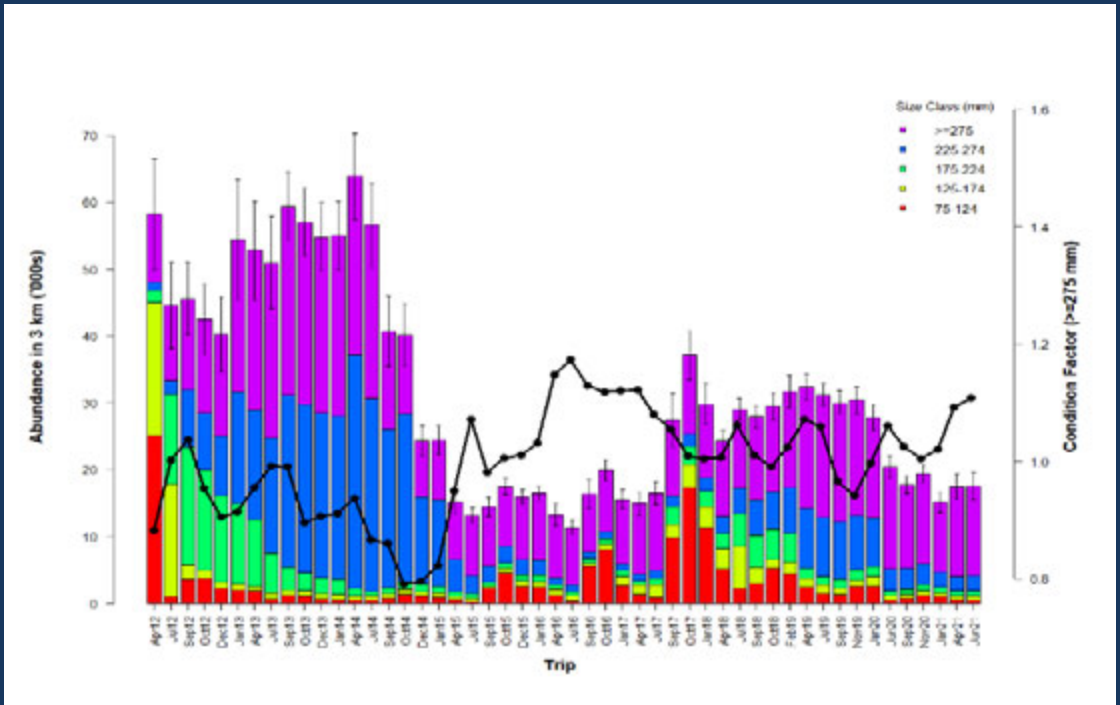
Humpback Chub Cont.

- LCR adult population is declining, due to combination of factors including poor juvenile production
- Translocations can be effective if done preemptively during good times but can't help if there is not juvenile production
- Western population is large, but don't we don't know how stable
- We are continuing to improve understanding of population dynamics

Rainbow/Brown Trout in Lees Ferry – Project H

Abundance of rainbow trout is currently low and only slightly greater than lowest point in summer of 2015

- The current population is dominated by individuals in the largest size class (>-275 mm)
- Largest trout will be most susceptible to decreases in food and oxygen concentrations and to increases in water temperature



USGS provisional data, do not cite or quote

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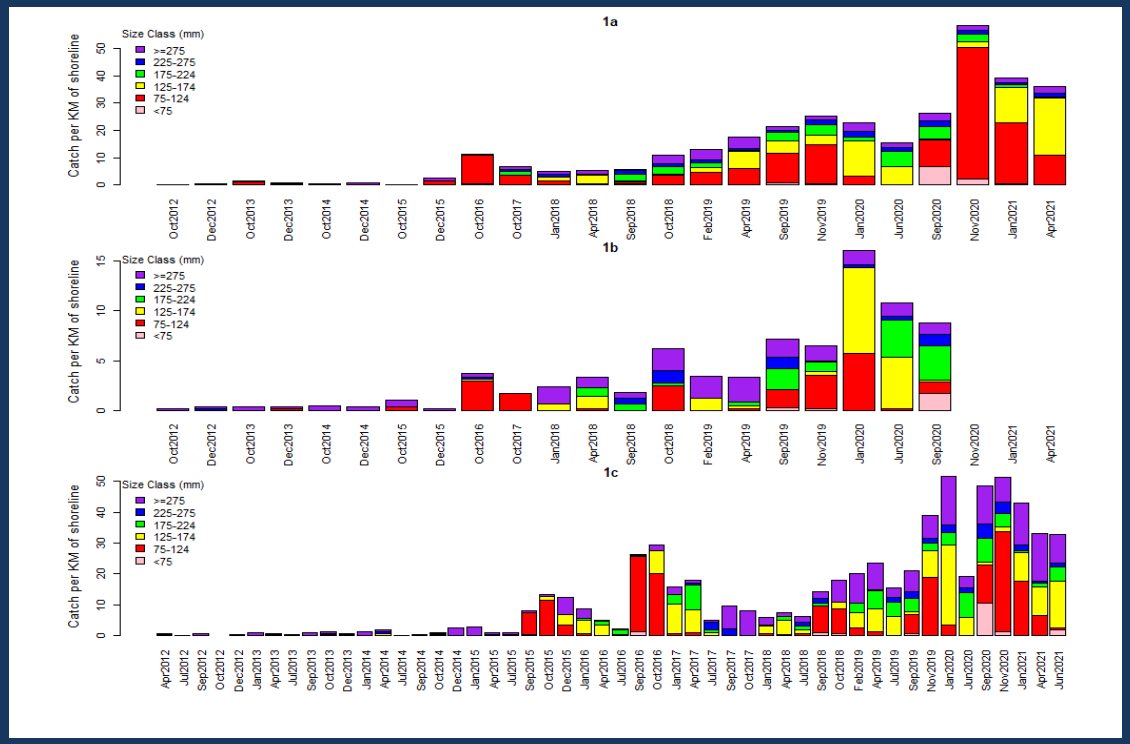
Brown Trout in Lees Ferry

Catch rates of brown trout in Lees Ferry are high and similar to 2020

- Note these are catch rates and not abundance
- Does not necessarily reflect the true variation in abundance



USGS provisional data, do not cite or quote

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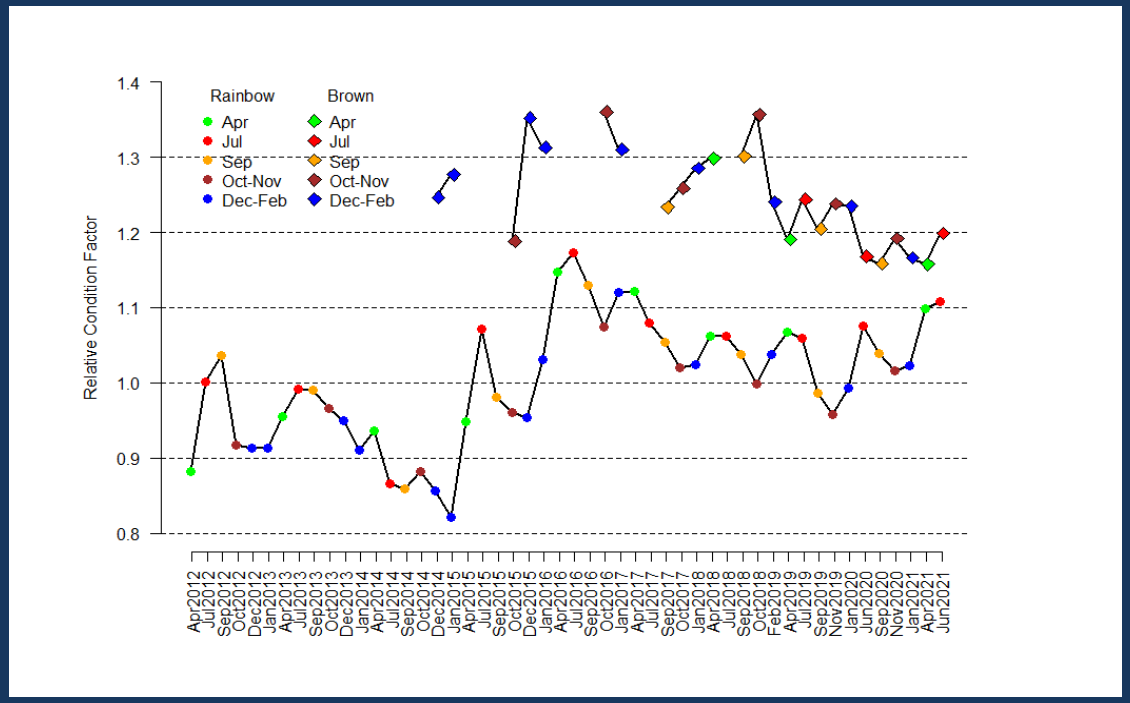
Trout Condition in Lees Ferry

Condition factor of rainbow and brown trout in Lees Ferry

- Brown trout have higher condition factor owing to higher growth rates, especially during fall and early winter
- Seasonal patterns in condition factor vary among rainbow and brown trout



USGS provisional data, do not cite or quote

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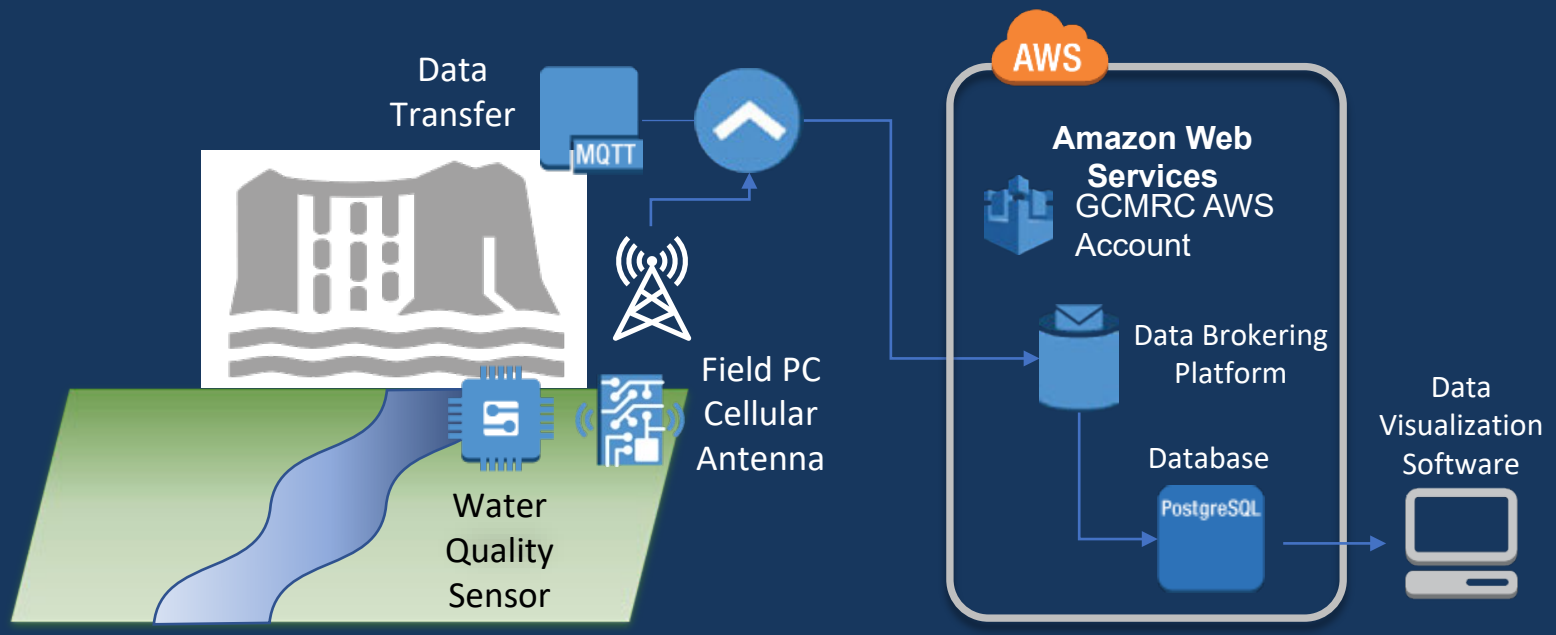
Geospatial and Data Science – Project K

- Currently have online connection to sonde located below dam
- Internet connection allows near-real time data on water quality parameters



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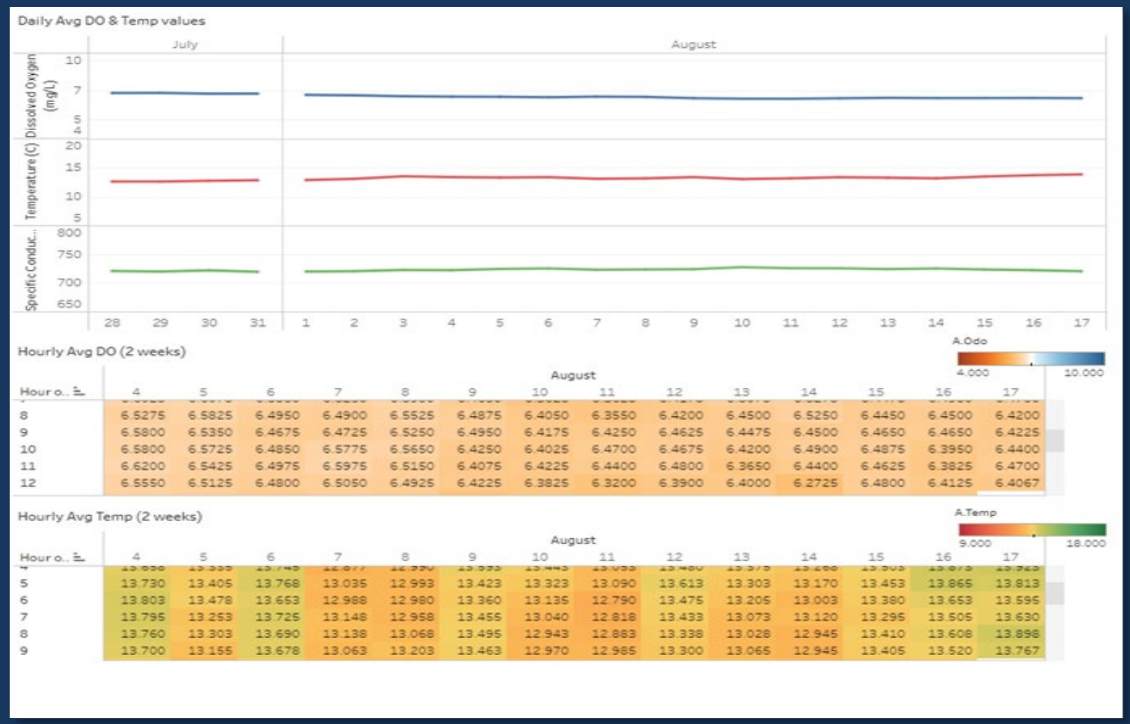
Geospatial and Data Science Cont.

- Tableau software allows graphing and other data visualization
- Working on internal process steps before the data can be released to stakeholders and the public



Estimated Drought Effects on Resources

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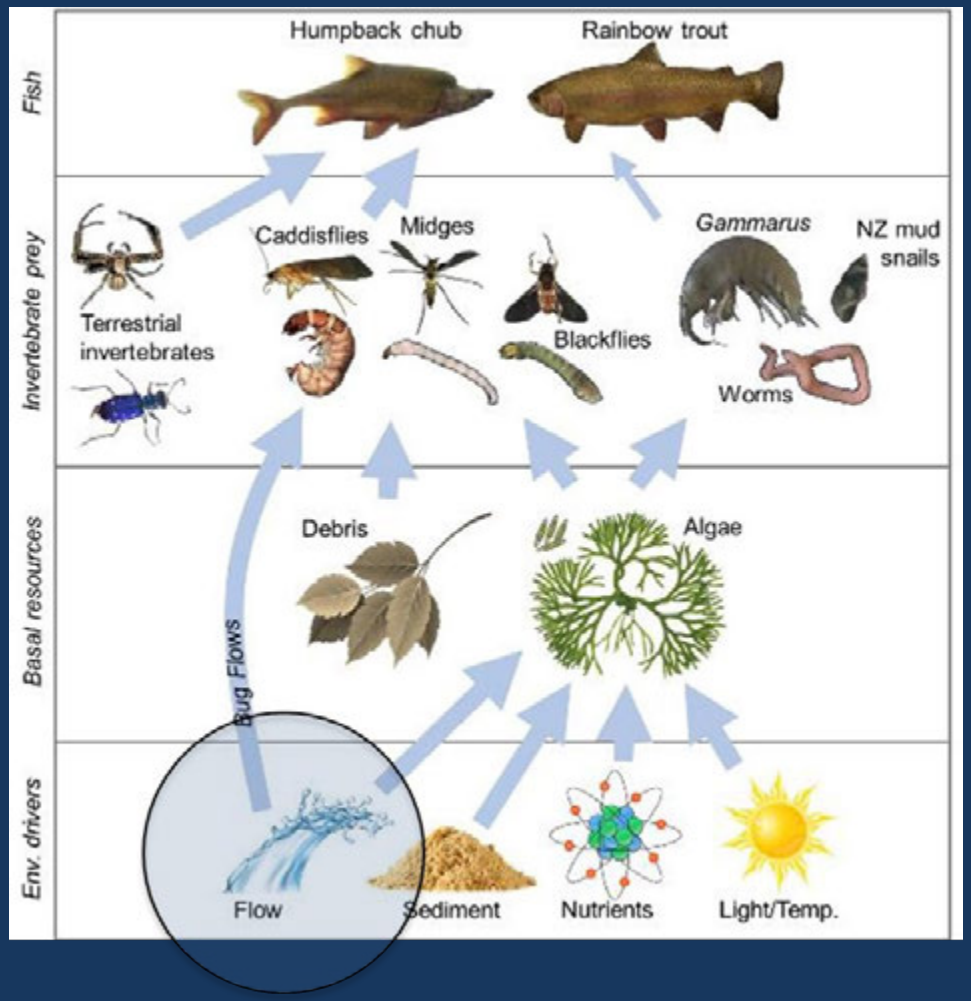
Drought Effects on Resources – Cont.

- Drought will have effects mainly on flow
- Changes in environmental flows will have effects up through the ecosystem
- Drought will likely result in warmer water temperatures in the CO River



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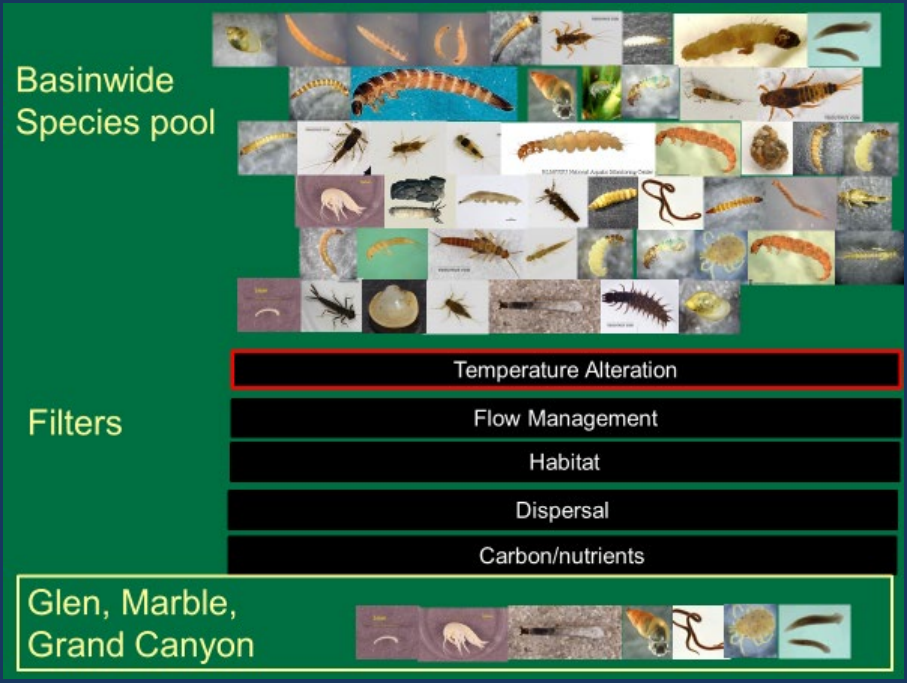
Water Temperature Effects on Aquatic Foodbase

- Warm water will eliminate ‘temperature’ filter and may lead to increases in insect diversity; unclear how existing food base (midges, blackflies) will respond

- In warm water, utilization of debris and its nutritive value in food webs may increase; however, bacterial growth may also increase

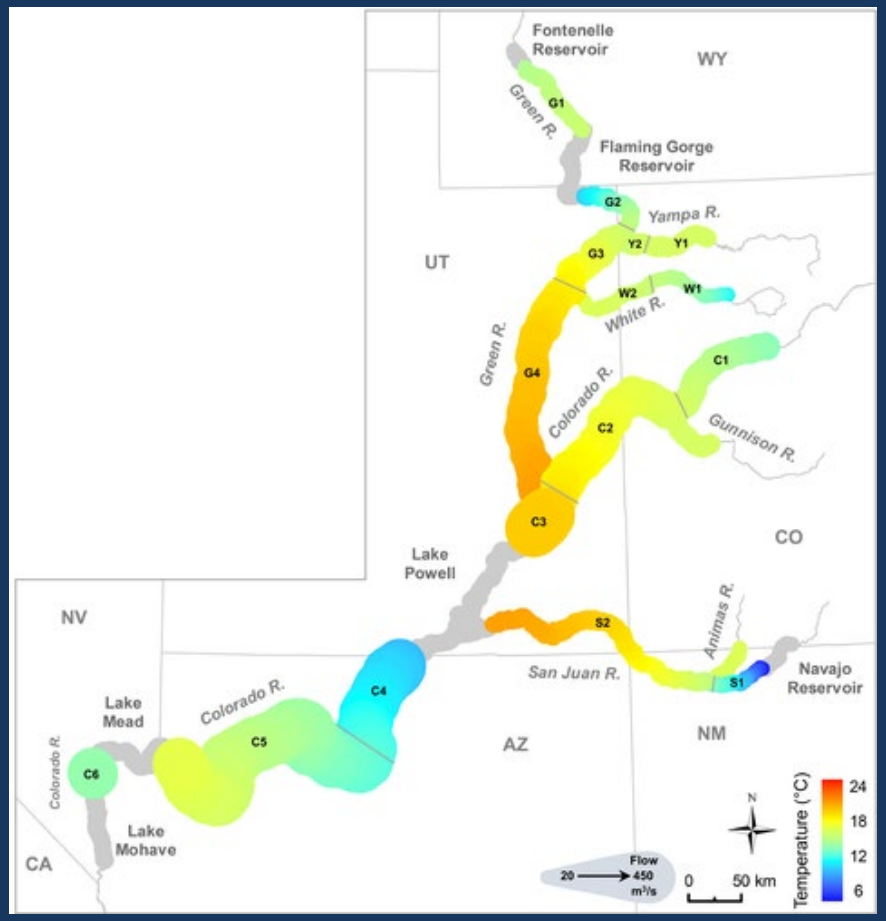


Kennedy, 2014

USGS

Water Temperature Effects on Fish

- Figure shows current temperature regime throughout the CO River Basin (1982-2010)
- Under future drought conditions, lower lake levels in Powell and Mead could increase release temperatures
- Effects on native and nonnative fish would be dependent on management strategies for Lakes Powell and Mead

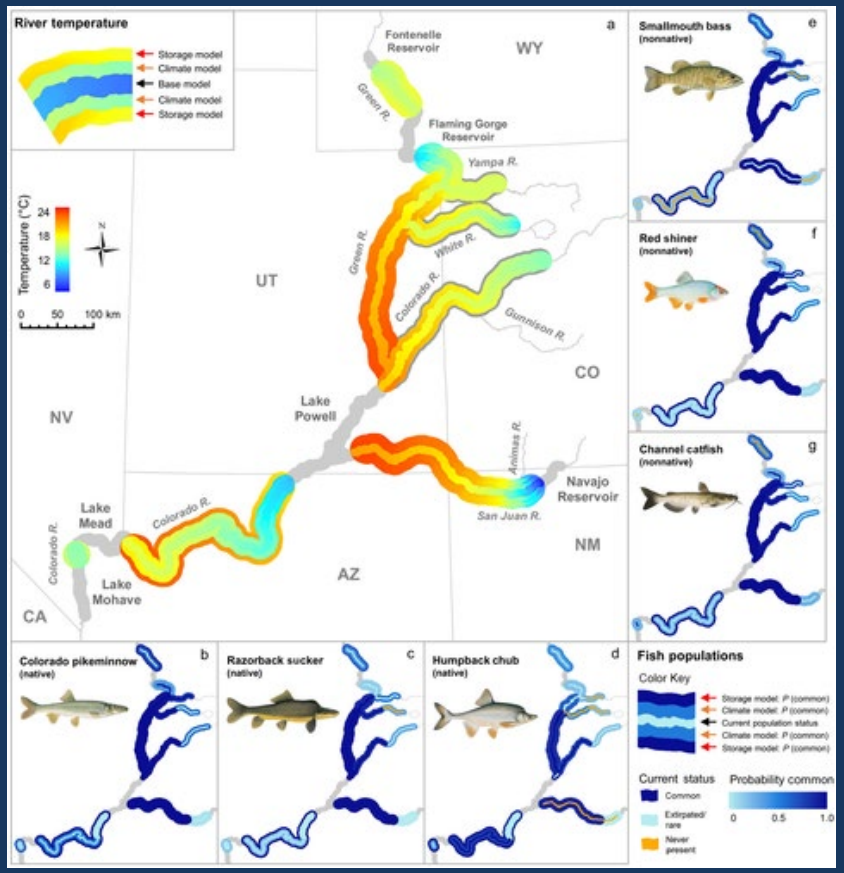


Dibble et al., 2021

USGS

Water Temperature Effects on Fish – Cont.

- Mid-century water temperatures estimates from climate models based on moderate emissions
- If storage in Lake Powell is prioritized, water temperatures in eastern Grand Canyon may be unsuitably cold for native fish species such as humpback chub
- If storage in Lake Mead is prioritized, warmer water temperatures throughout Grand Canyon could improve conditions for native and nonnative species alike; however, increased predation by warmwater nonnatives could be detrimental



Dibble et al., 2021

USGS

GCMRC Monitoring

- GCMRC monitors in all major areas of ecosystem on a long-term basis
- This routine monitoring will allow us to determine the effects of drought on all resource areas
- Some special monitoring could be added; but this could reduce regular monitoring in other areas

Questions?
USGS