GCMRC 2018 Annual Reporting Meeting Preview

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Adaptive Management Work Group Meeting
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Project 2. Streamflow, Water Quality, Sediment Transport, and Sand Budgets in the Colorado River Ecosystem

Purpose: To collect and analyze stage, discharge, sediment and water-quality data to determine status and trends

Some Example Questions:

How do operations at Glen Canyon Dam affect flows, water quality, sediment transport, and sediment resources in the Colorado River Ecosystem?

Does the long-term storage of sand in the Colorado River Ecosystem increase or decrease in a downstream direction?

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Results – Key drivers of sand transport and storage in the Colorado River Ecosystem

- Sand storage is self-limited in the post-dam Colorado River owing to the strong influence of changing bed-sand grain size on suspended-sand concentration under the relatively high discharges (i.e., >8,000 cfs) that are always released by Glen Canyon Dam

- Sign of upper Marble Canyon sand budget is typically negative unless Paria River has had a recent large flood

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Results – Key drivers of sand transport and storage in the Colorado River Ecosystem

- Bed-sand grain-size regulation of sign of monthly sand budget becomes more important downstream from upper Marble Canyon

- It remains unclear whether sand resources are sustainable unless Paria River sand inputs remain above average and dam releases are relatively low (i.e., <14,000 cfs)

- Spring HFEs will be triggered only rarely because large Paria River floods are extremely rare in the winter and early spring

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Project 3. Sandbars and Sediment Storage Dynamics

Purpose: To understand the long-term effects of GCD operations on sediment storage and sandbar dynamics

Some Example Questions:

What are the long-term trends in sand storage as sand bars in the Colorado River Ecosystem?

Can sandbar building during HFEs exceed sandbar erosion between HFEs?

What are the causes of variability in sandbar responses to floods and intervening dam operations?

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Results – Sandbar Monitoring

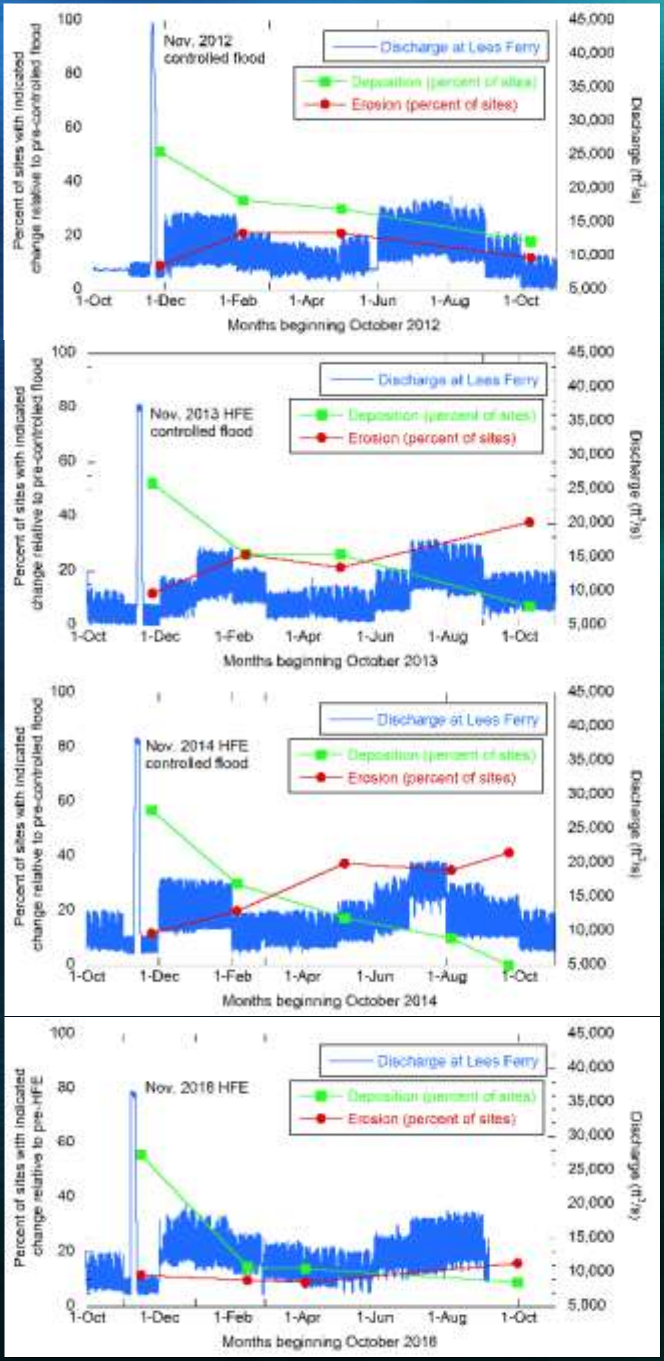
Results:

- HFEs cause increases in sandbar size at a majority of long term monitoring sites
- Sandbars consistently larger than periods without HFEs

Management implications

- HFEs continue to be effective in building sandbars
- Sandbars continue to erode following HFEs (continued HFEs required to maintain sandbar size)
- Not seeing substantial cumulative increase in sandbar size

Grams et al. (2015; 2018)



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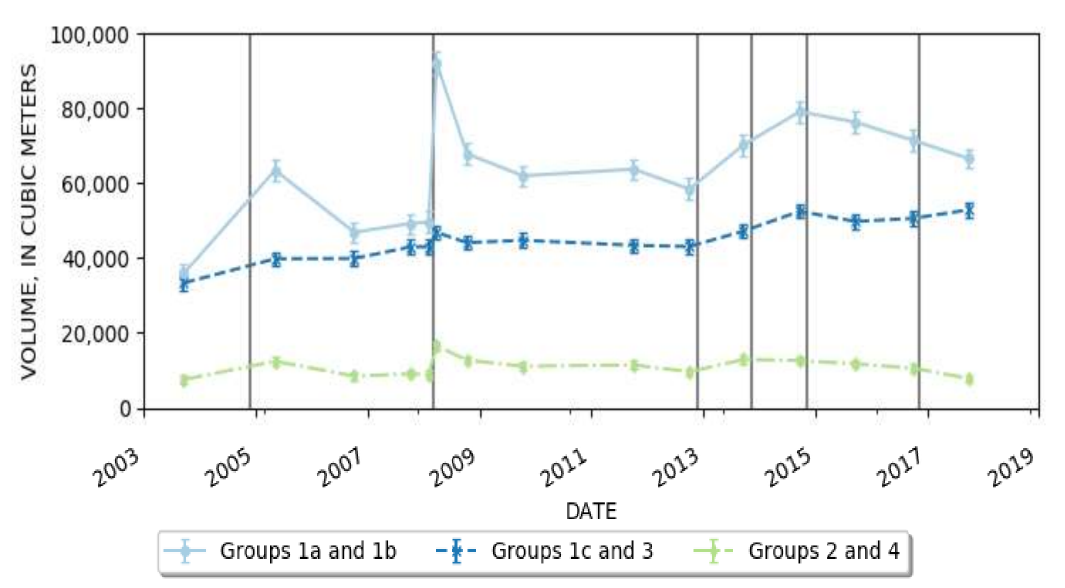
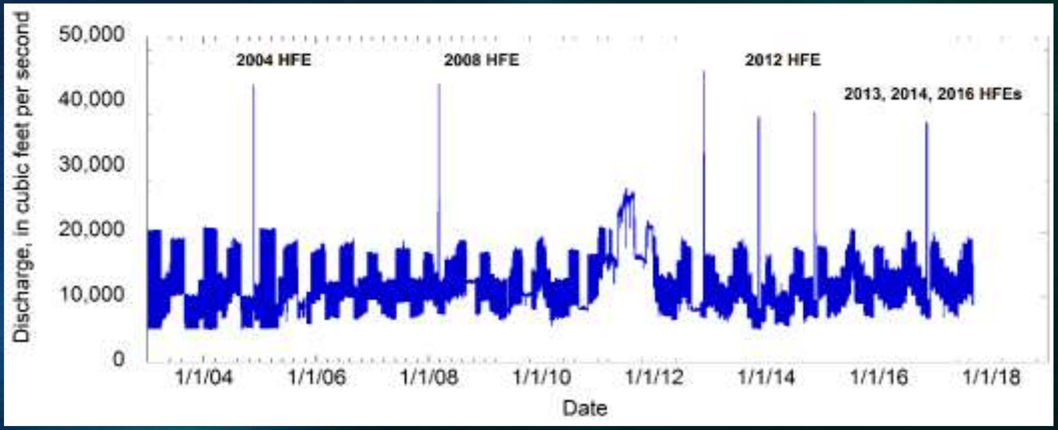
Results – Sandbar Monitoring

- Groups 1a and 1b:
  - relatively large and mostly open bare sandbars
  - Strongest response to HFEs
- Groups 1c and 3:
  - heavily vegetated bars
  - Less dynamic around HFEs, tend to accumulate over time
- Groups 2 and 4:
  - Mostly smaller bars adjacent to debris fans (don't project into eddy)
  - Tend to be most stable
  - HFEs still improve condition by filling gullies and burying/removing debris





Mueller et al. (2018)

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Results – Sand Storage Changes

Erosion in Lower Marble Canyon (2009-2012)

Sandbars: 22 cm decrease in sand thickness (10% of vol. change)

Eddies: 3 cm increase in sand thickness (7% of vol. change)

Channel: 10 cm decrease in sand thickness (83% of vol. change)

Erosion in Eastern Grand Canyon (2011-2014)

Sandbars: 8 cm increase in sand thickness (3% of vol. change

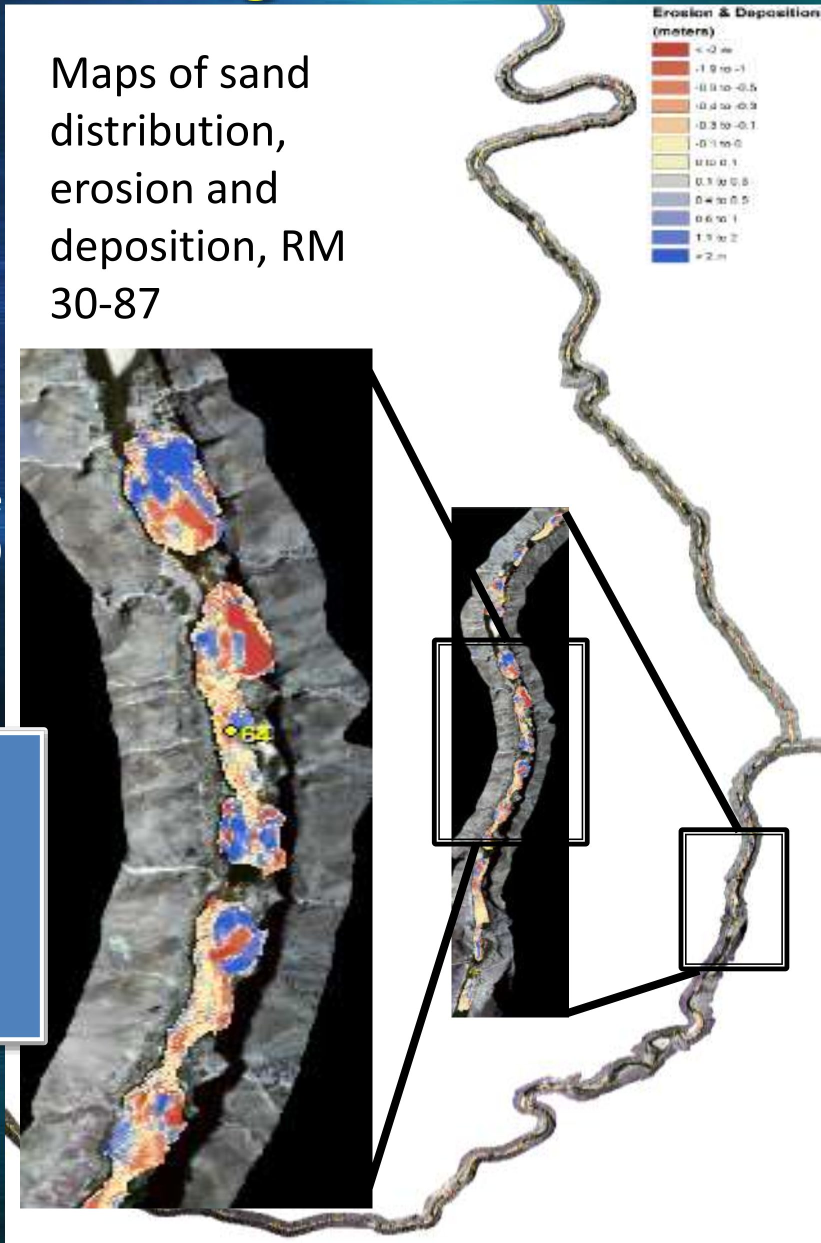
Eddies: 9 cm decrease in sand thickness (12% of vol. change)

Channel: 10 cm decrease in sand thickness (85% of vol. change)

- Equalization without HFEs → erosion everywhere
- Equalization followed by HFEs → erosion in channel and eddies, but deposition on bars
    - Sand patches decrease in thickness but are stable in area and location during evacuation

Grams et al. (2015; in review)
preliminary data, do not cite

Maps of sand distribution, erosion and deposition, RM 30-87



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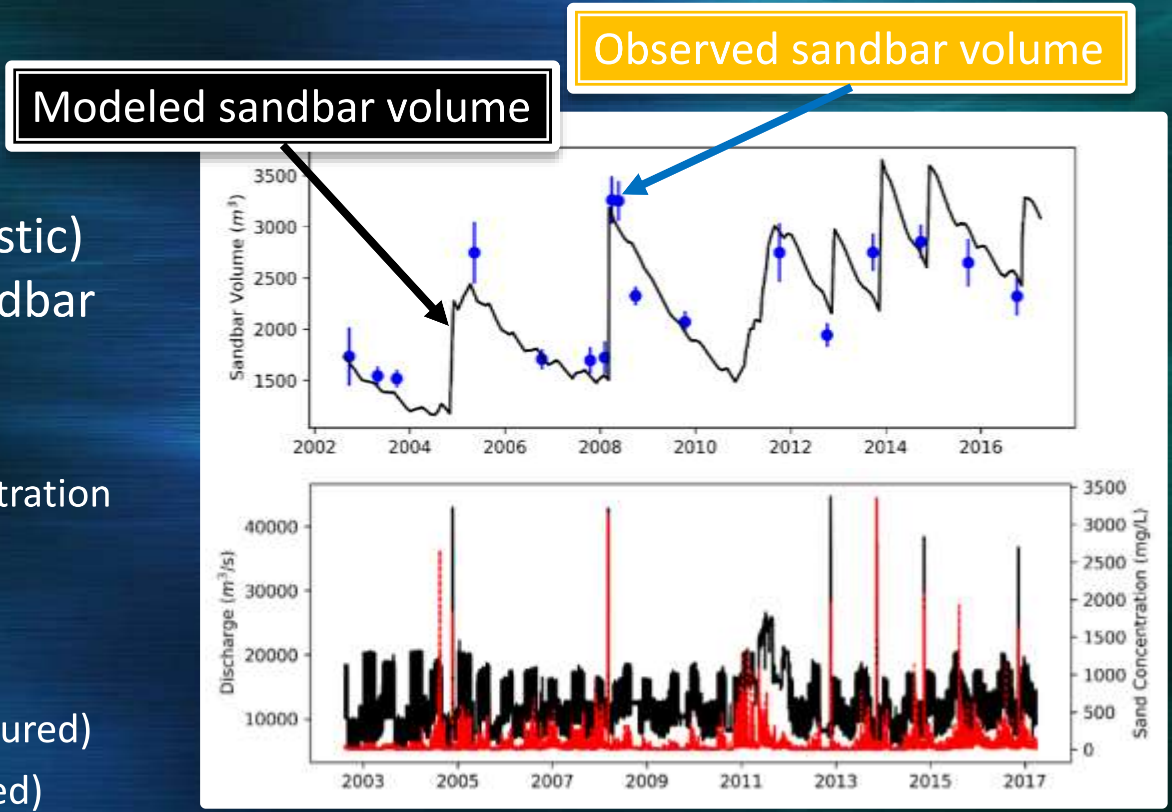
Results – Sandbar Modeling

New, physical-based (mechanistic) model predicts changes in sandbar volume based on:

- Discharge (observed)
- Suspended sediment concentration (observed)
- Sand grain size (observed)
- Water depth
- Sandbar and eddy size (measured)
- Eddy exchange rate (estimated)
- Sandbar erosion rate (estimated)



Mueller et al. (in prep.)
preliminary data, do not cite

Model can be applied to predict bar response over periods of many years with HFEs of different magnitude and frequency
Can be improved with additional measurements of bar erosion from analysis of remote camera images

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Project 4. Connectivity Along the Fluvial-Aeolian-Hillslope Continuum

Purpose: To monitor the effects of GCD operations on the integrity of archeological and cultural sites

Some Example Questions:

Do dam-controlled operations affect rates of erosion and vegetation growth at archeological or TCP sites?

How effective are various treatments, such as vegetation management, at slowing rates of erosion at archeological sites?

What are appropriate monitoring strategies for capturing change at archeological sites?

Why is this monitoring important?

Bare sand is important for recreation, habitat, and cultural resources along the Colorado River in Grand Canyon

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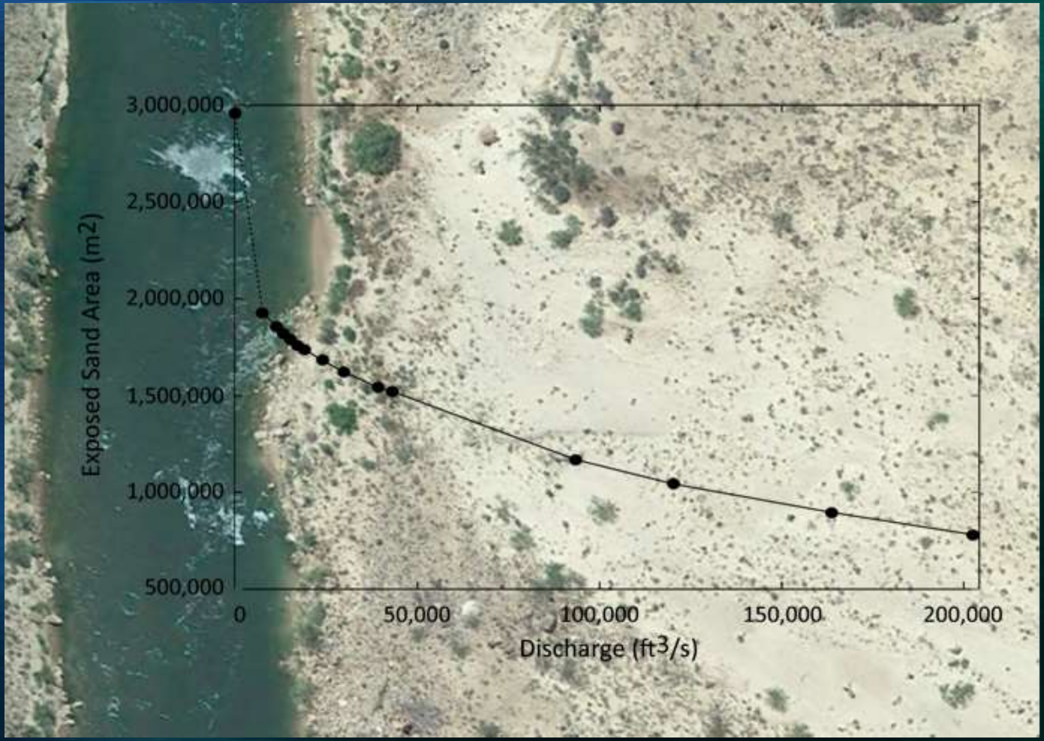
Methods used to monitor archeological sites

Remote sensing, topographic survey, river hydrology, and weather monitoring data were used to:

- quantify and forecast long-term changes in the distribution of bare, unvegetated Colorado River sand throughout the river corridor
- measure response of bare sand dunefields to High Flow Experiments



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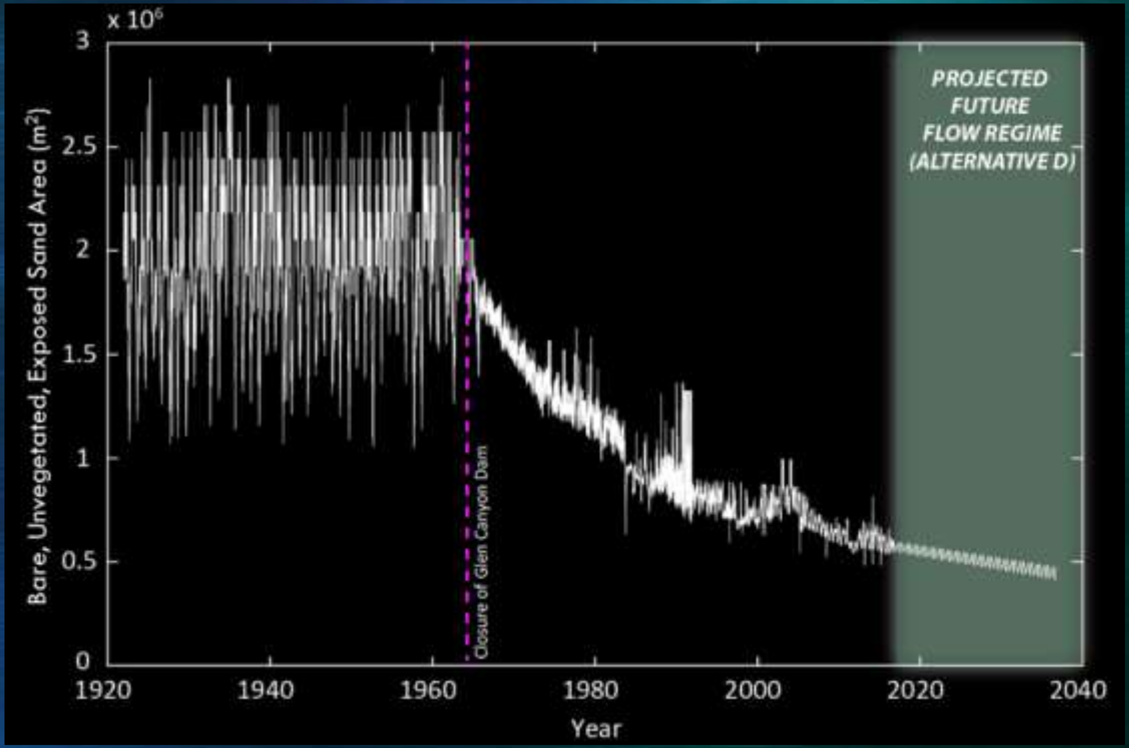
Results – Bare Sand Area

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

- Approximately ½ of the bare sand area is in the active river channel (primarily on the river channel bed, sandbars, and channel margins)

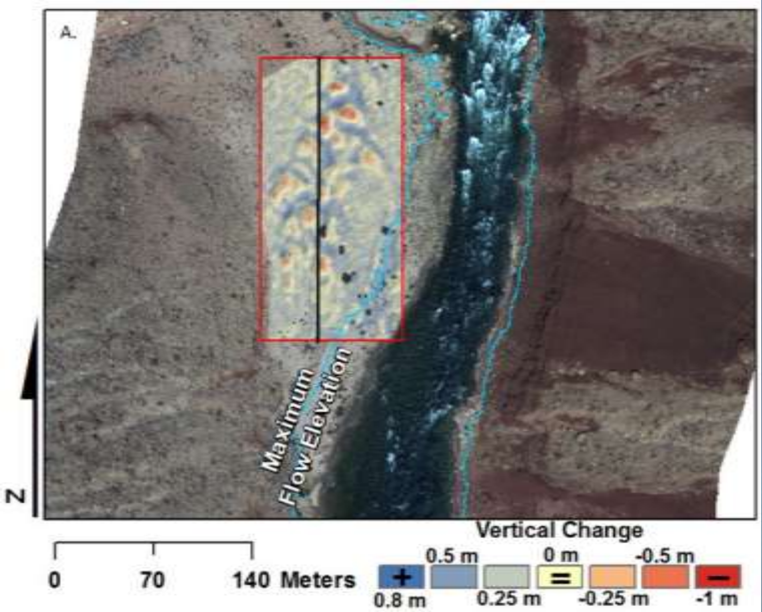
- Approximately ½ of the bare sand area is above the active river channel (primarily in 113 large dunefields and sand areas)



Unpublished Results Please Don't Cite: Kasprak et al., in review

Results – Dunefield Area

- Dunefields are resupplied with sand via aeolian transport from HFE sandbar deposits, and thus are affected by dam operations
- Frequency of <u>dunefield</u> resupply by HFEs is analogous to resupply of <u>sandbars</u> by HFEs
- More frequent, consecutive annual HFEs increase sediment storage in dunefields



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Unpublished Results Please Don't Cite: Sankey et al., in review

Project 11. Riparian Vegetation Monitoring and Analysis

Purpose: To utilize annual field measurements and digital imagery to monitor changes in riparian vegetation

Some Example Questions:

How does the composition of riparian vegetation vary spatially throughout the entire river corridor, and how have species have changed through time in comparison to previous classification?

Where and how much turnover between bare sand and riparian vegetation occurs due to erosion, deposition, establishment, and mortality within the stages of the riparian zone currently inundated by HFEs and other flow fluctuations?

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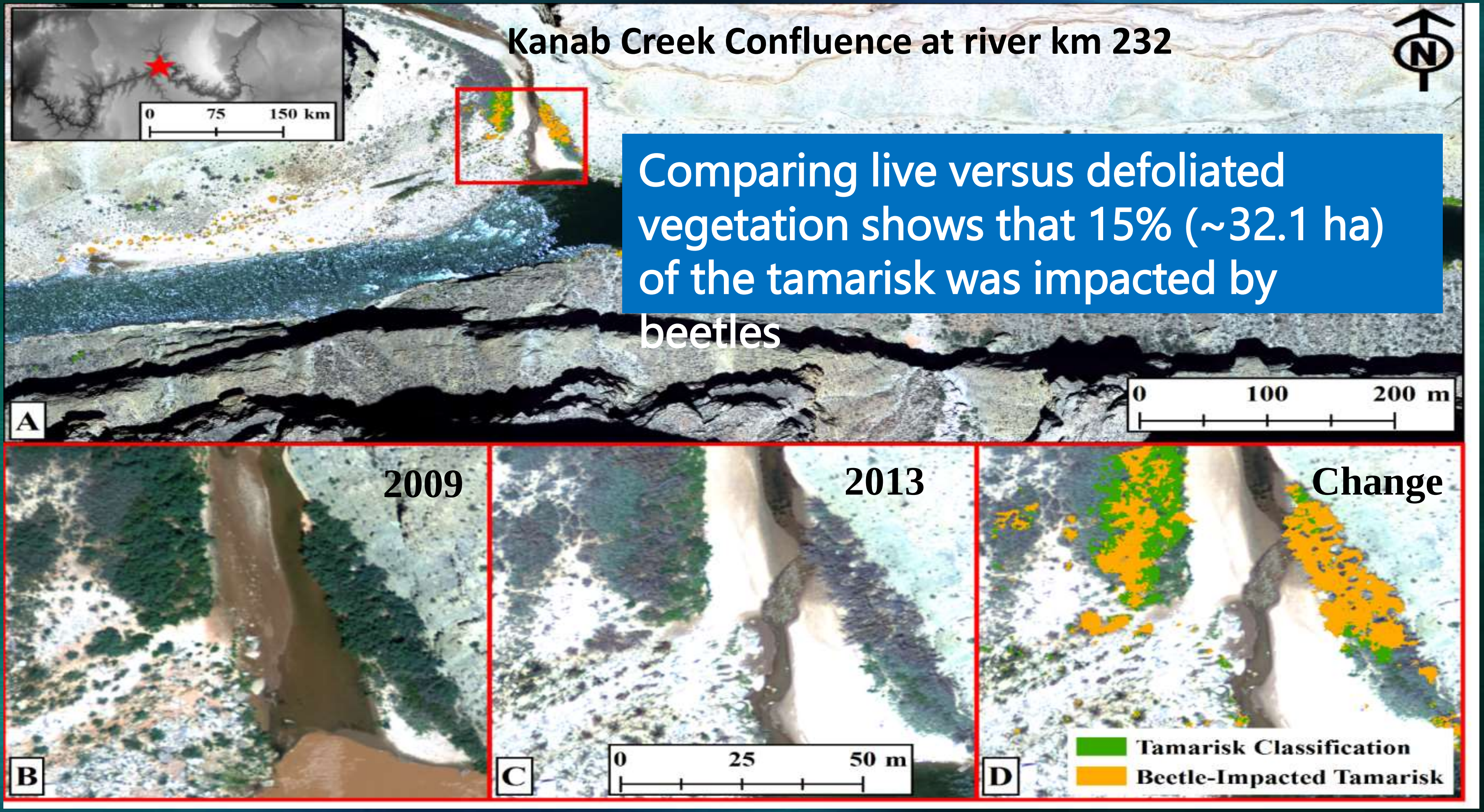
Results – Beetle Impact on Tamarisk



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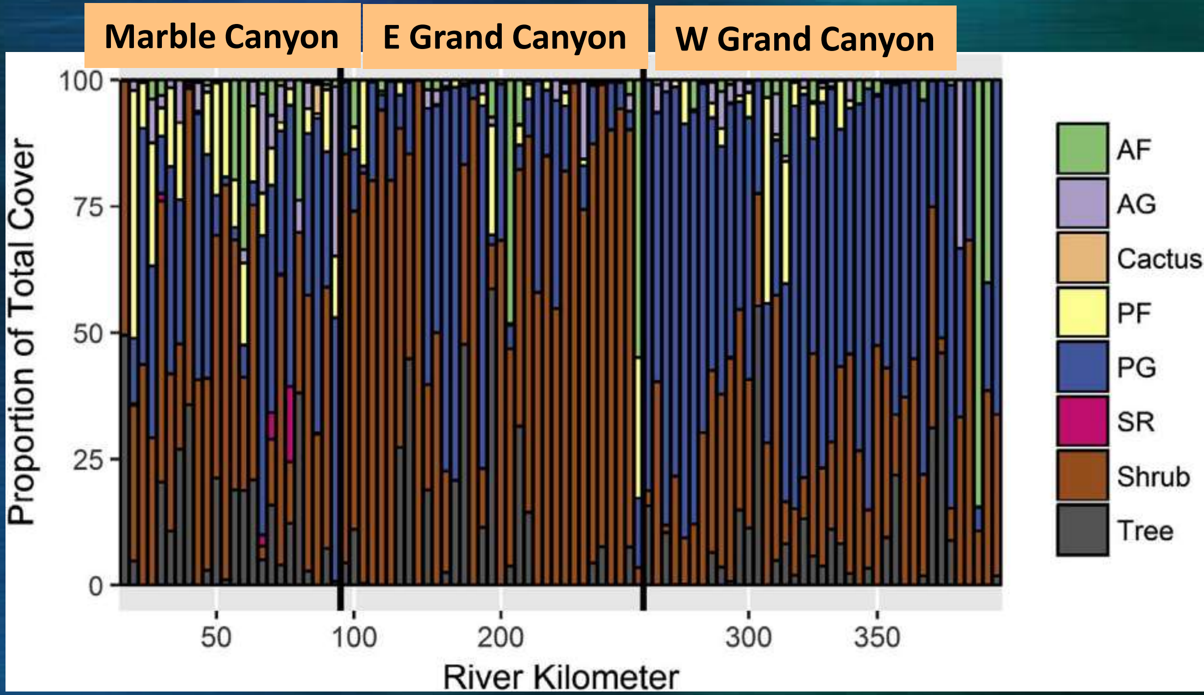
Total Tamarisk Area: 214.4 ha

(Bedford et al., Ecological Indicators, 2018)

Results – Vegetation Responses

- Marble Canyon is more floristically rich than rest of canyon
- Segments vary in floristic composition and may respond differentially to operations
- Climatic variation along river influences hydrological responses (Butterfield et al., In review)

Variation in Proportional Cover by Plant Functional Group
Palmquist *et al.* 2017 *Journal of Arid Environments*



Vegetation composition varies between 3 segments downstream of GCD and this variation may be result of differential responses to dam operations

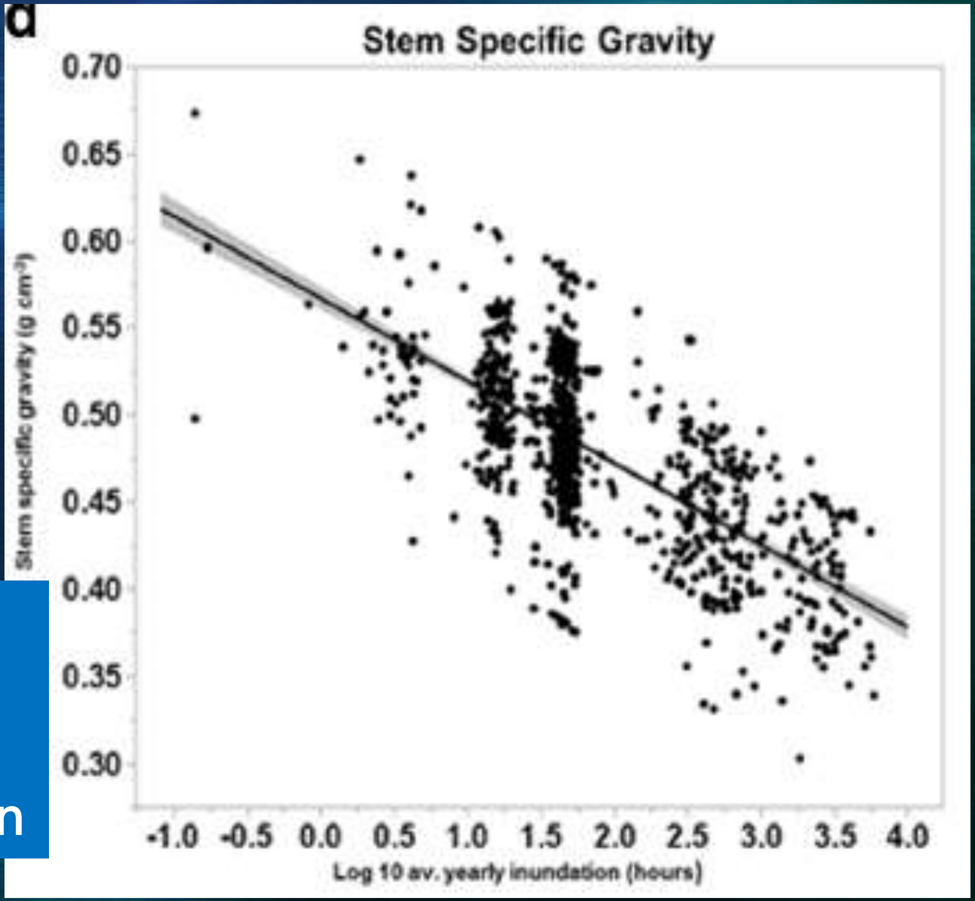
Results – Traits and Guilds

- Reveal underlying physiological and life-history factors that determine plant responses to dam operations
- Used to identify 16 flow-response guilds (Merritt *et al.*, In prep) from 104 species
- Flow-response guilds will help to simplify modeling responses to dam operations

Good relation between vegetation functional trait and hydrology that will allow us to predict vegetation as a function of dam operations

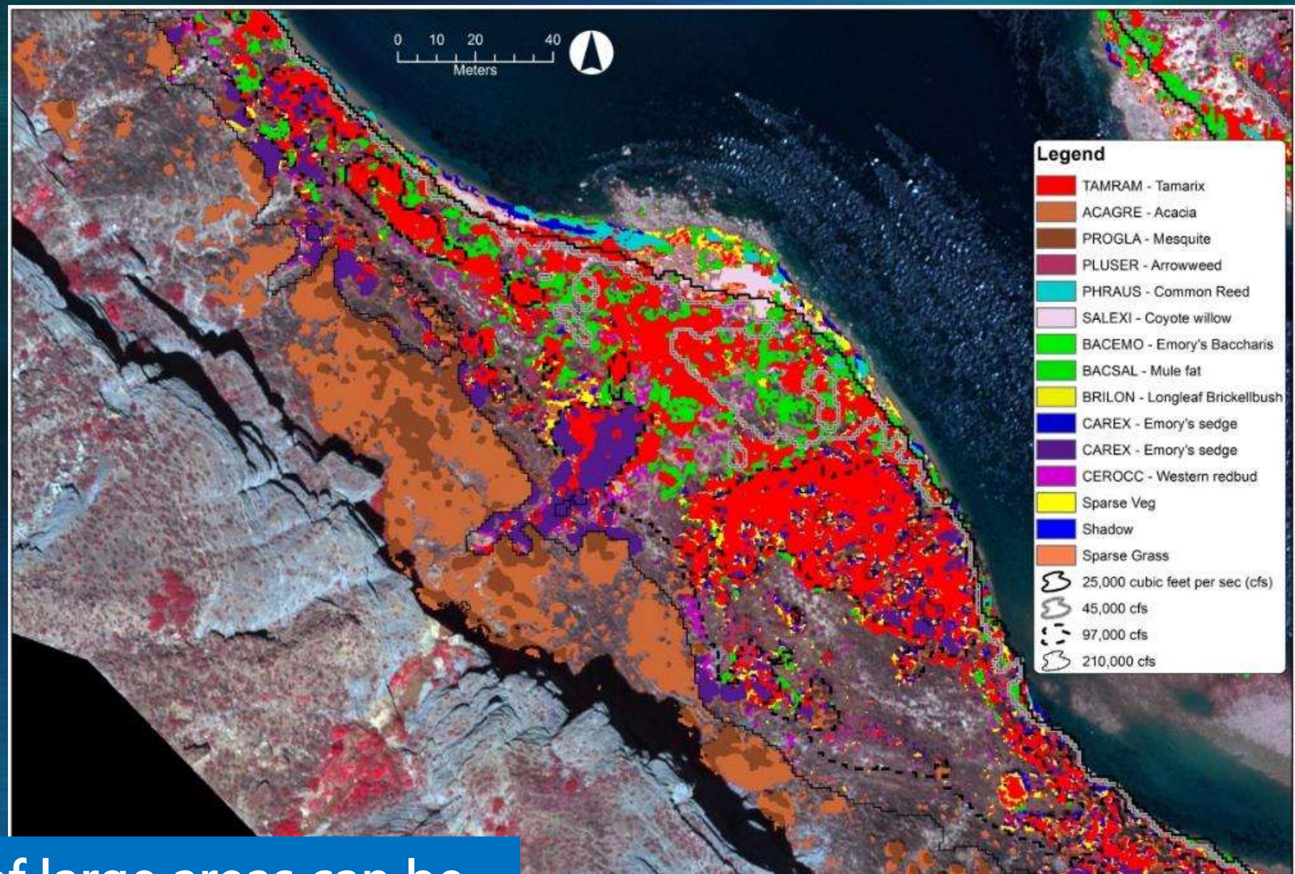
<u>Example of trait response to inundation</u>

McCoy-Sulentic *et al.* 2017 *Wetlands*



Results – Remote Sensing Classification

- Remote –sensing classification results overlap nicely with guild delineations
- Will facilitate future integration between remotely-sensed and ground-based monitoring and modeling



Mapping of large areas can be accomplished by using remote sensing informed and guided by field observations

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Project E. Nutrients and Temperature as Ecosystem Drivers

Purpose: 1) identify processes that drive spatial and temporal variation in nutrients and temperature within the CRe,

2) establish quantitative and mechanistic links among these ecosystem drivers, primary production, and higher trophic levels

Some Example Questions:

Do dam operations play an important role in spatio-temporal patterns of phosphorous?

Are nutrients, in particular SRP, important drivers of overall ecosystem productivity?

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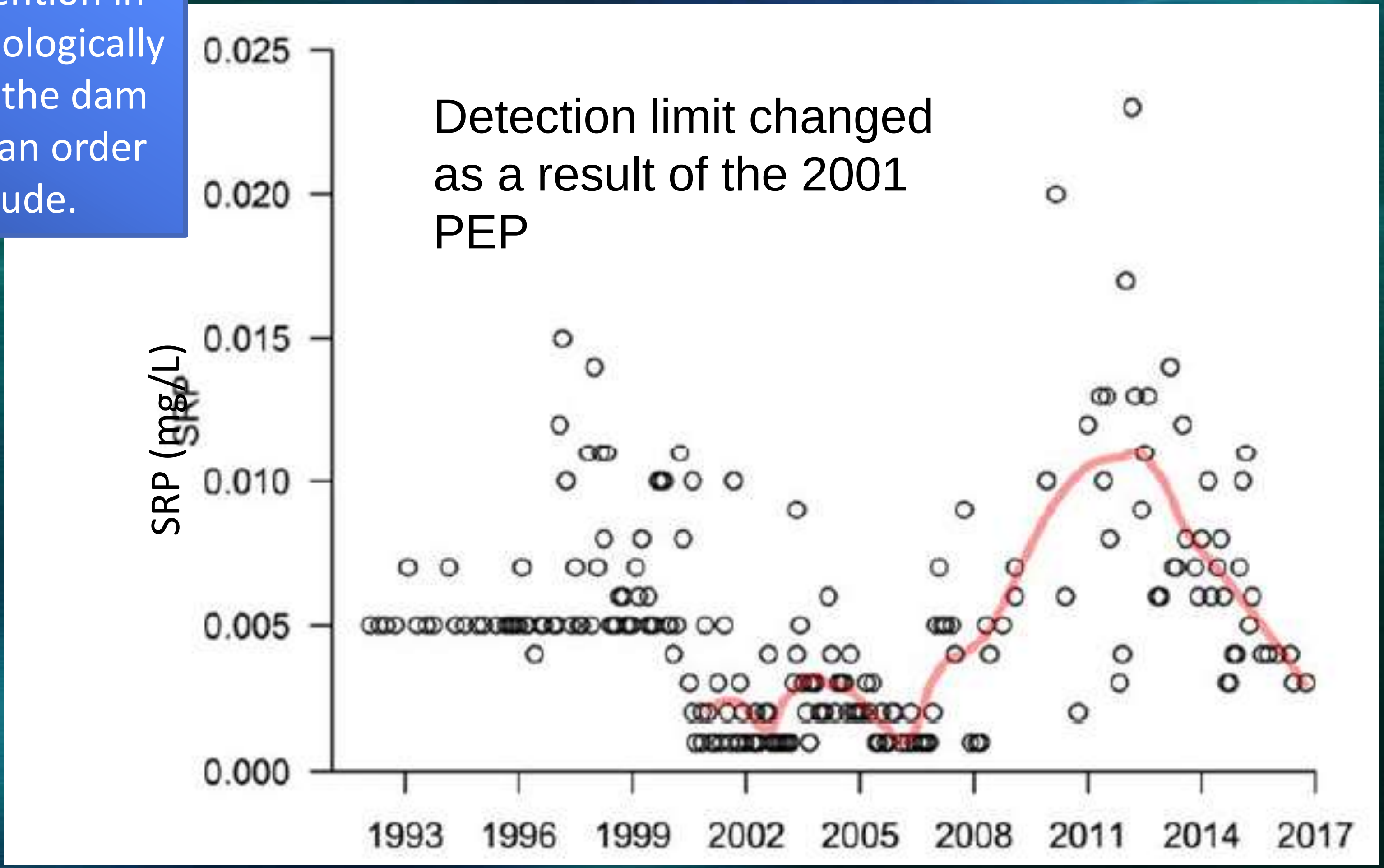
Rationale – Phosphorus is Limited in Lake Powell

- High P retention
- Soluble Reactive Phosphorus (SRP) is low (5 ug/L)
- Algal growth is SRP limited

Soluble Reactive Phosphorus (SRP) Concentrations at Glen Canyon Dam

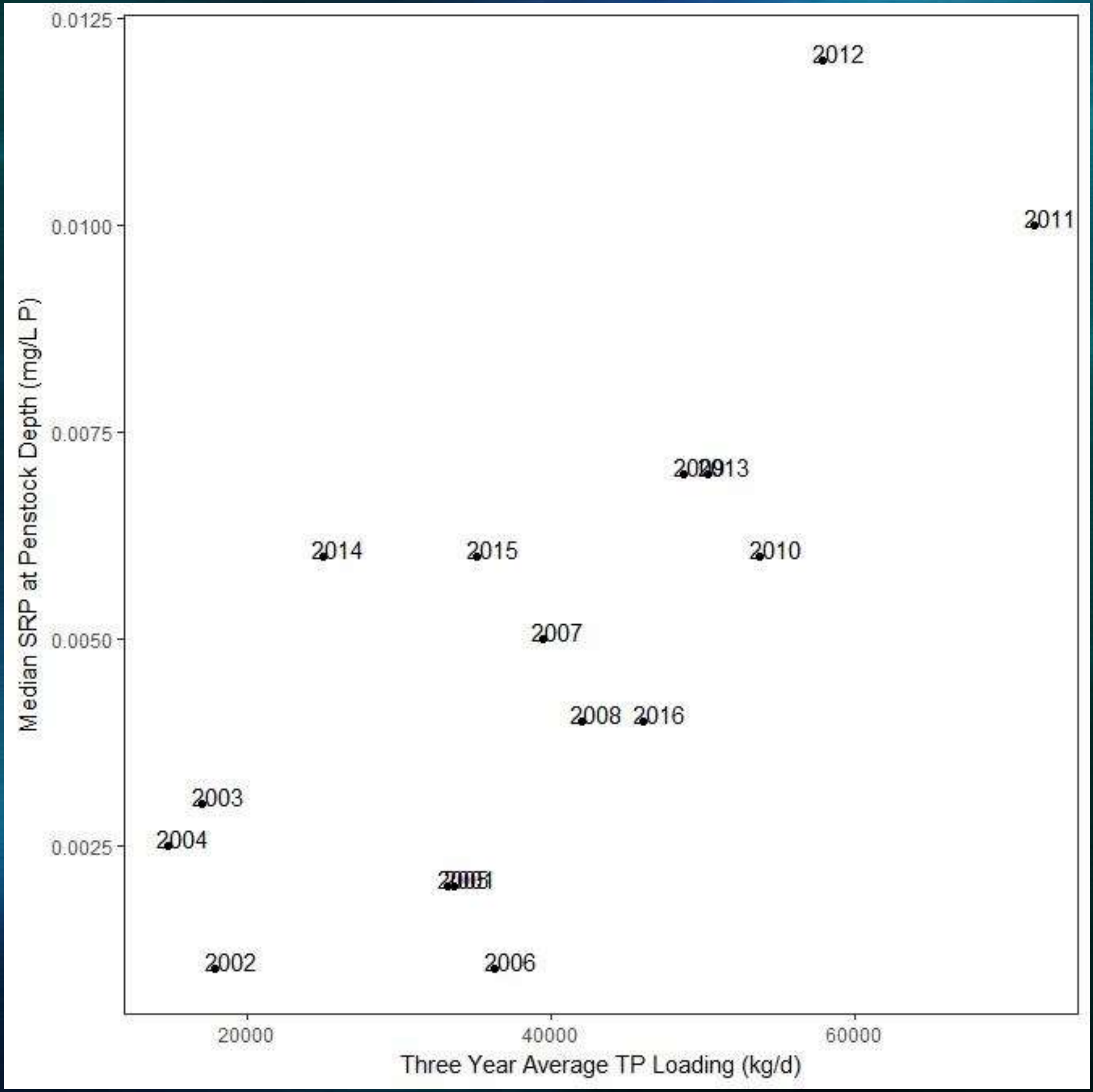
Despite P retention in Lake Powell, biologically available P at the dam still varies by an order of magnitude.



Yackulic, preliminary data, 2018. Do not cite.

Total Phosphorus Loading Only Explains Some of the Variability in SRP

Total phosphorus loading explains ~50% of the variance in penstock SRP availability



Yackulic, preliminary data, 2018. Do not cite.

Deltaic Sediment Dynamics Are Also Likely Important to SRP

- Sediment is deposited in the Colorado River delta at a rate of ~2-3 m/yr
- 60% of sediment is deposited with snowmelt

View from Highway 95 Near Hite Marina March 2002 (left) and March 2003 (right). Photos by John Dohrenwend

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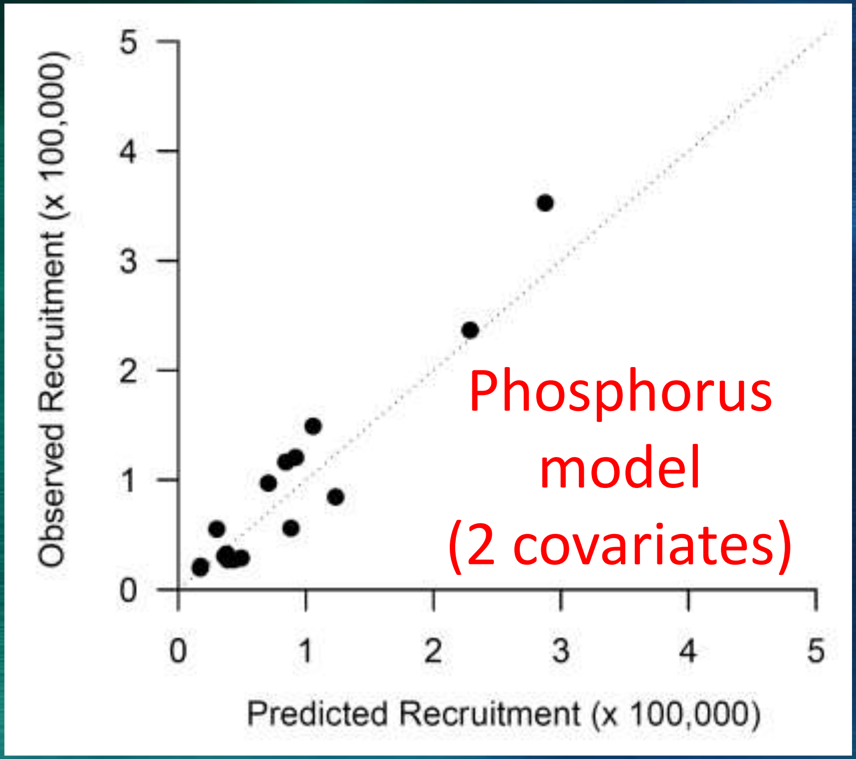
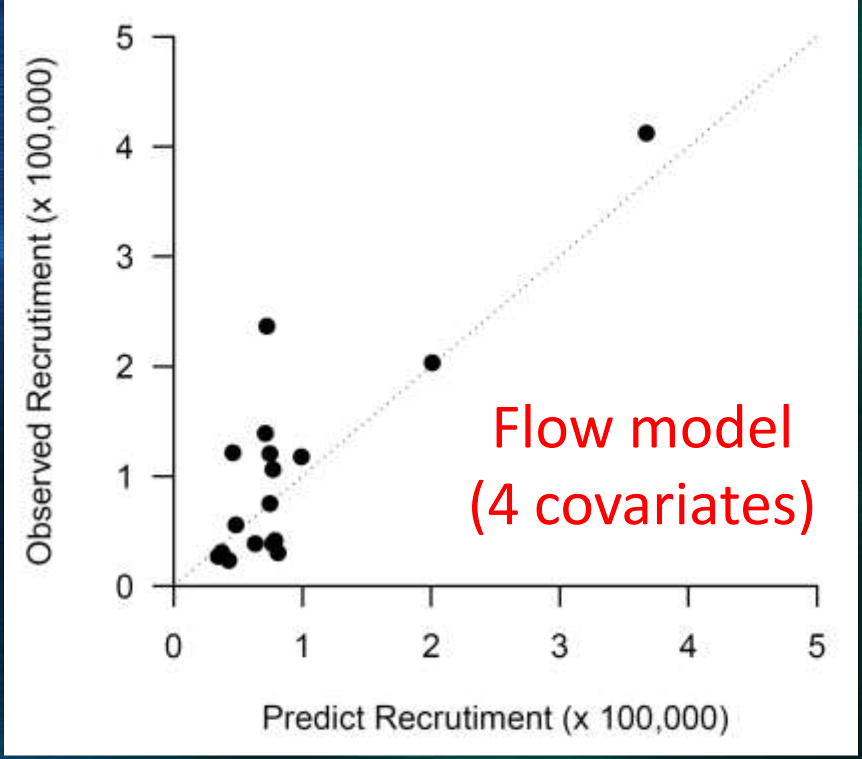
Phosphorous is more closely linked to rainbow trout recruitment than the suite of hypothesized flow based metrics





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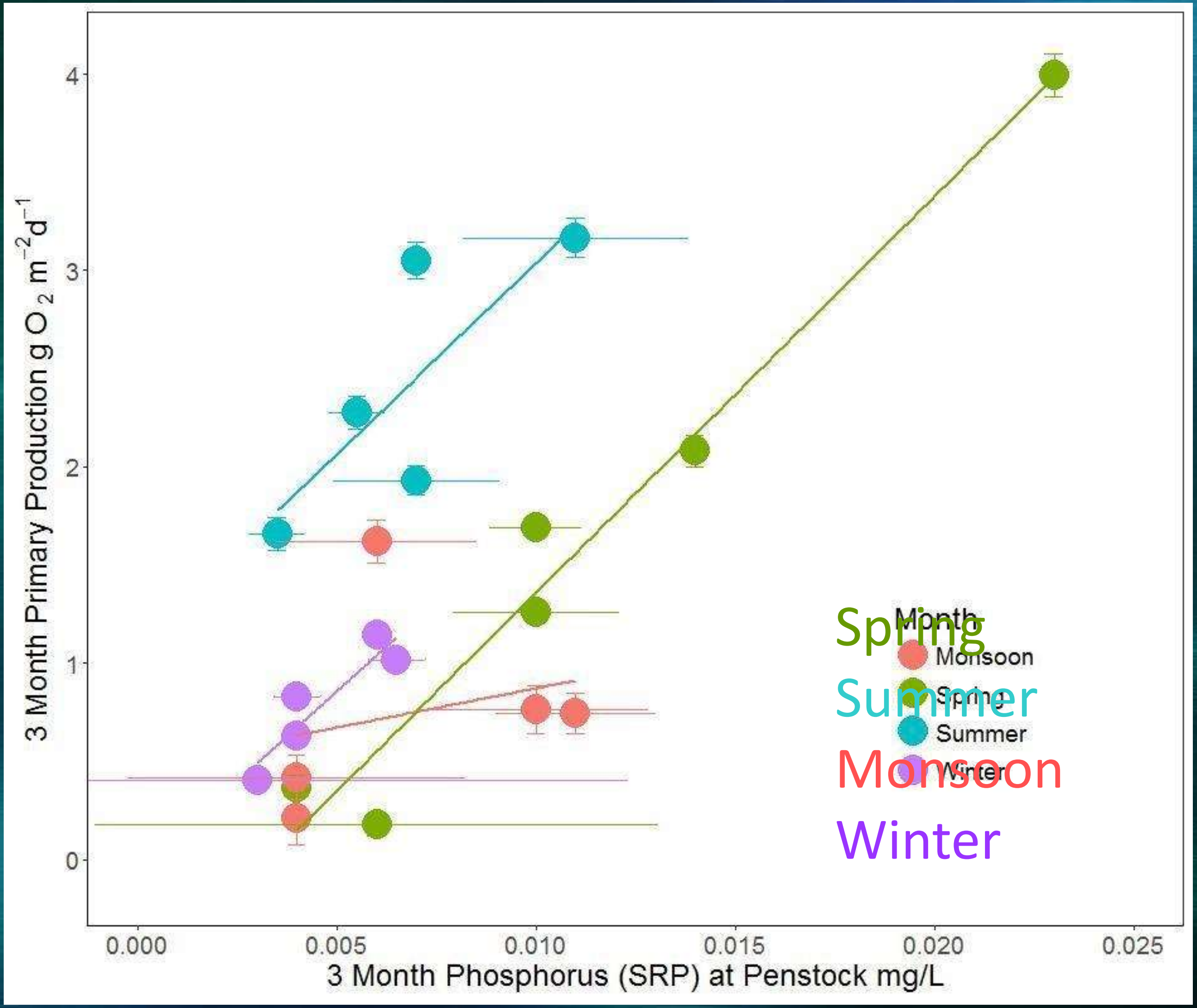
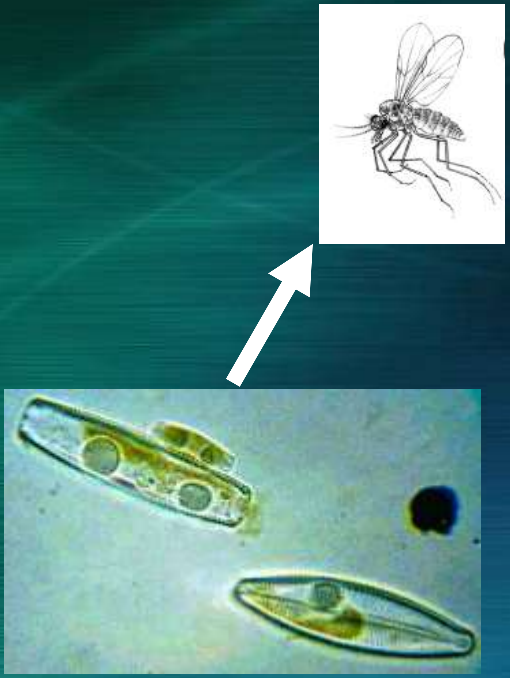
Yackulic, preliminary data, 2018.
Do not cite.

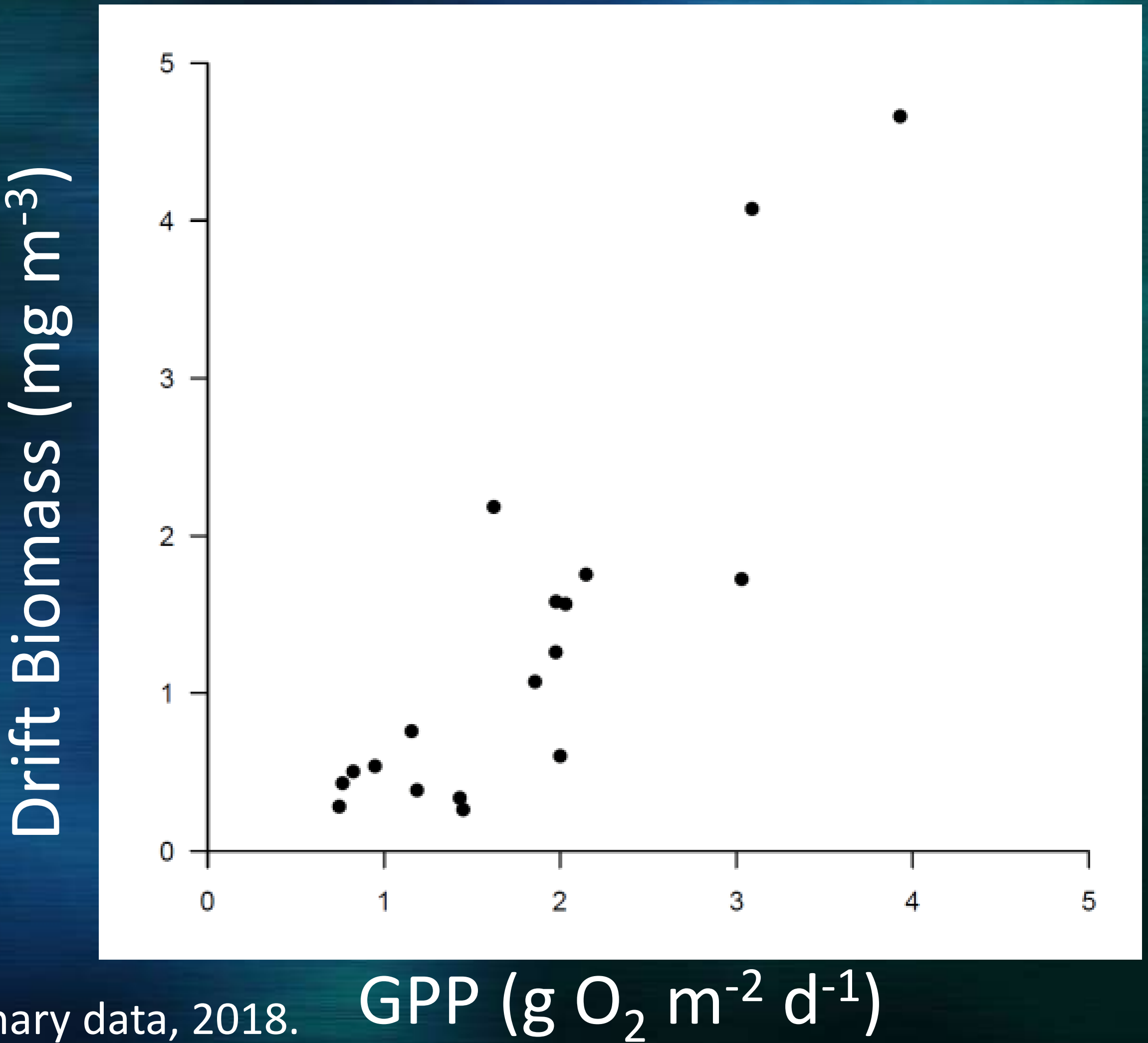
Nutrients are important for primary productivity



Yackulic, preliminary data, 2018. Do not cite.

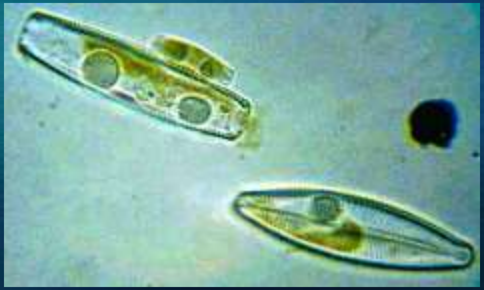
Primary productivity which forms the base of the food web

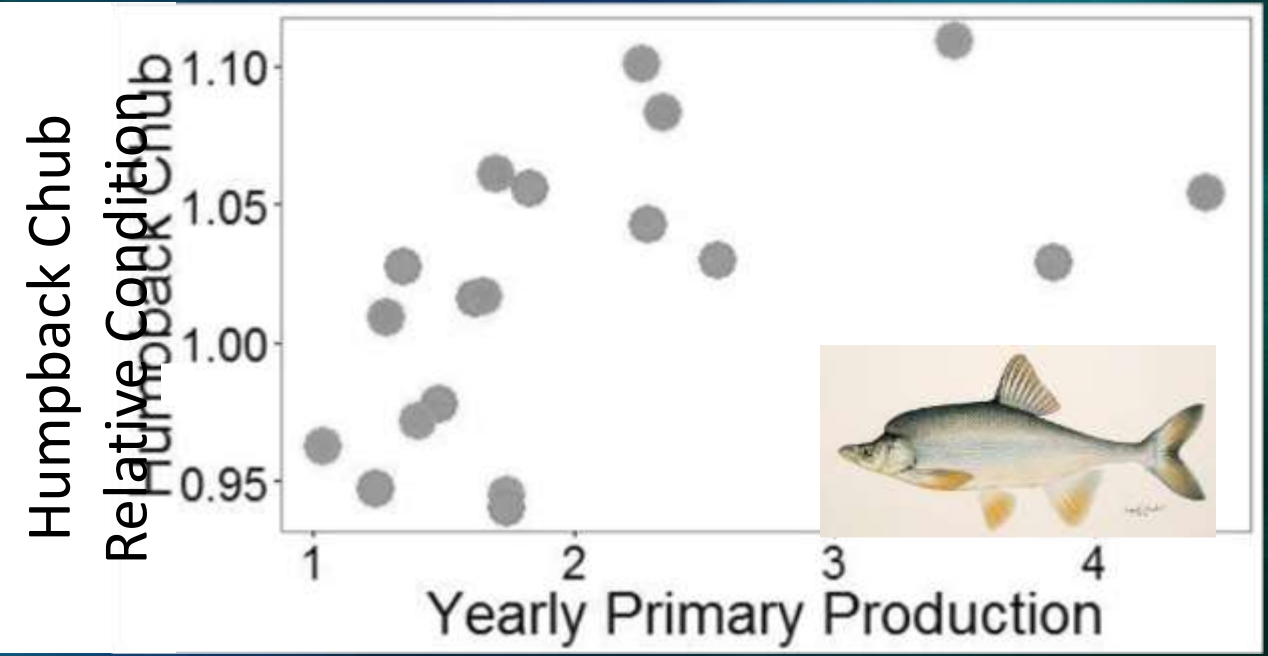




Yackulic, preliminary data, 2018.
Do not cite.

Primary productivity is related to native fish condition (fat/skinny) and spawning rates in humpback chub





Yackulic, preliminary data, 2018.
Do not cite.

Project 5. Food Base Monitoring and Research

Purpose: To characterize and understand the aquatic food base in Glen, Marble, and Grand Canyons

Some Example Questions:

Why is the diversity and productivity of the aquatic food base so low in Glen, Marble, and Grand Canyons?

Is recruitment limitation primarily due to low midge and black fly production?

Do water level stage changes due to hydropeaking lead to low aquatic invertebrate production?

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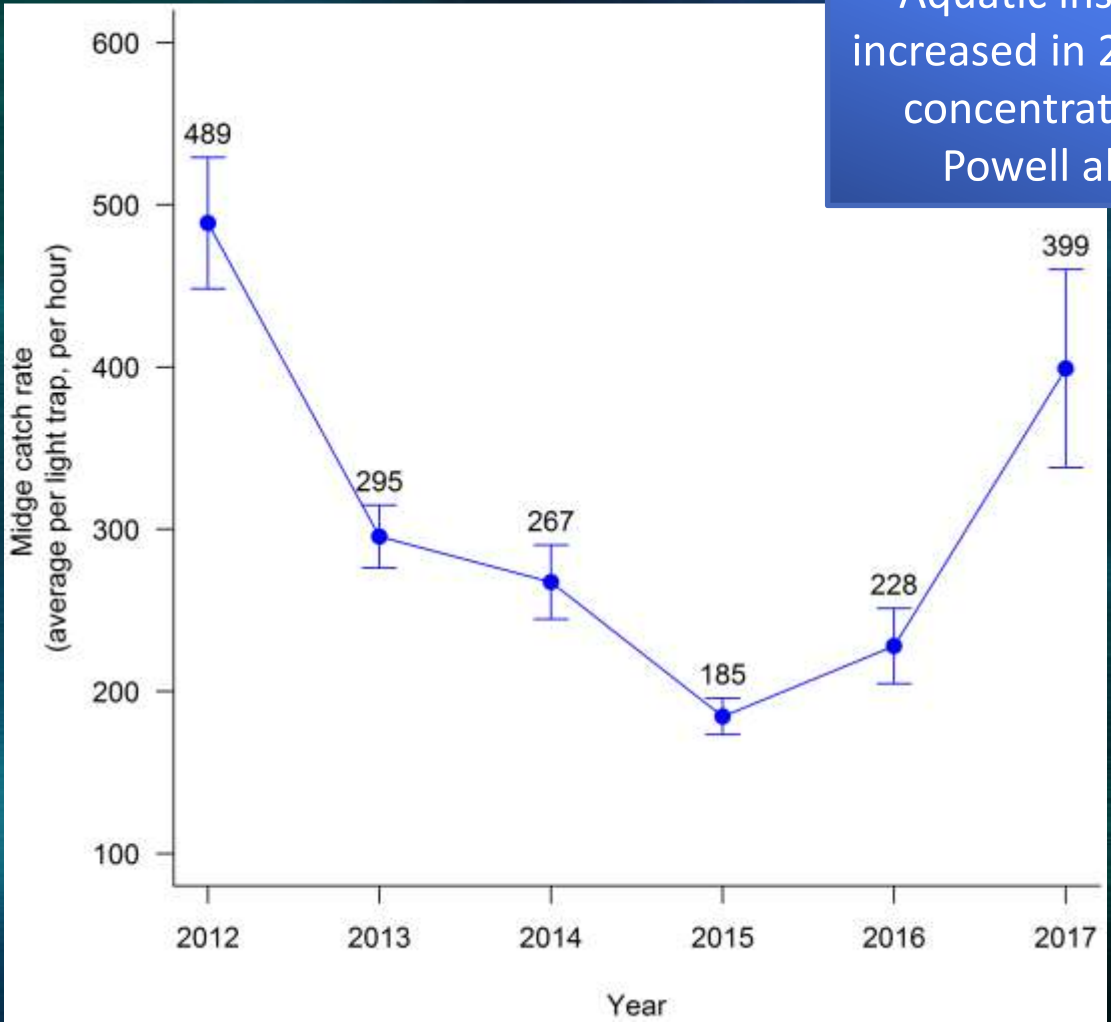
Average Light Trap Catches of Midges in Grand Canyon – 2012-2017

Aquatic insect abundance increased in 2017. Phosphorus concentrations from Lake Powell also increased

Chironomidae adults



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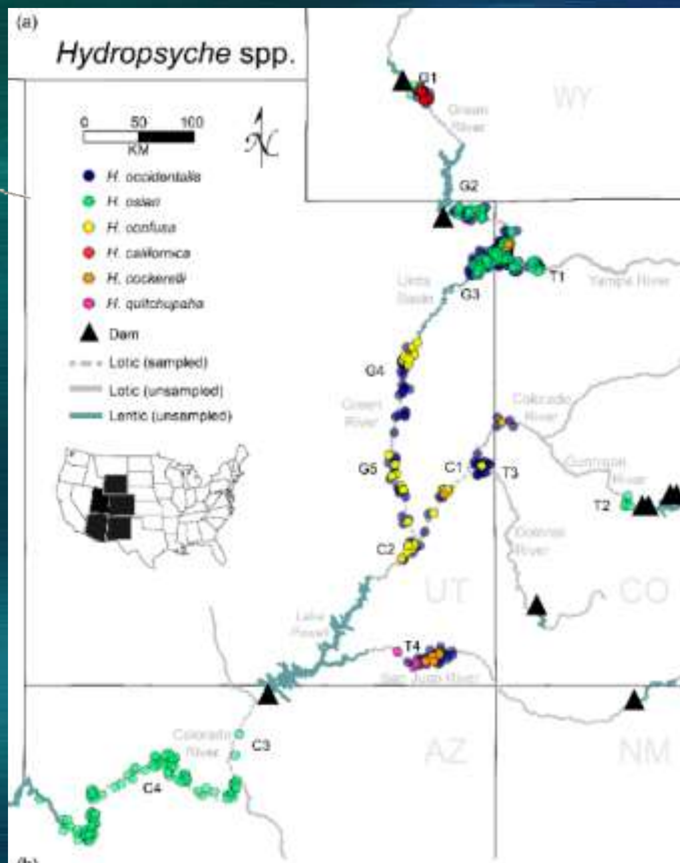
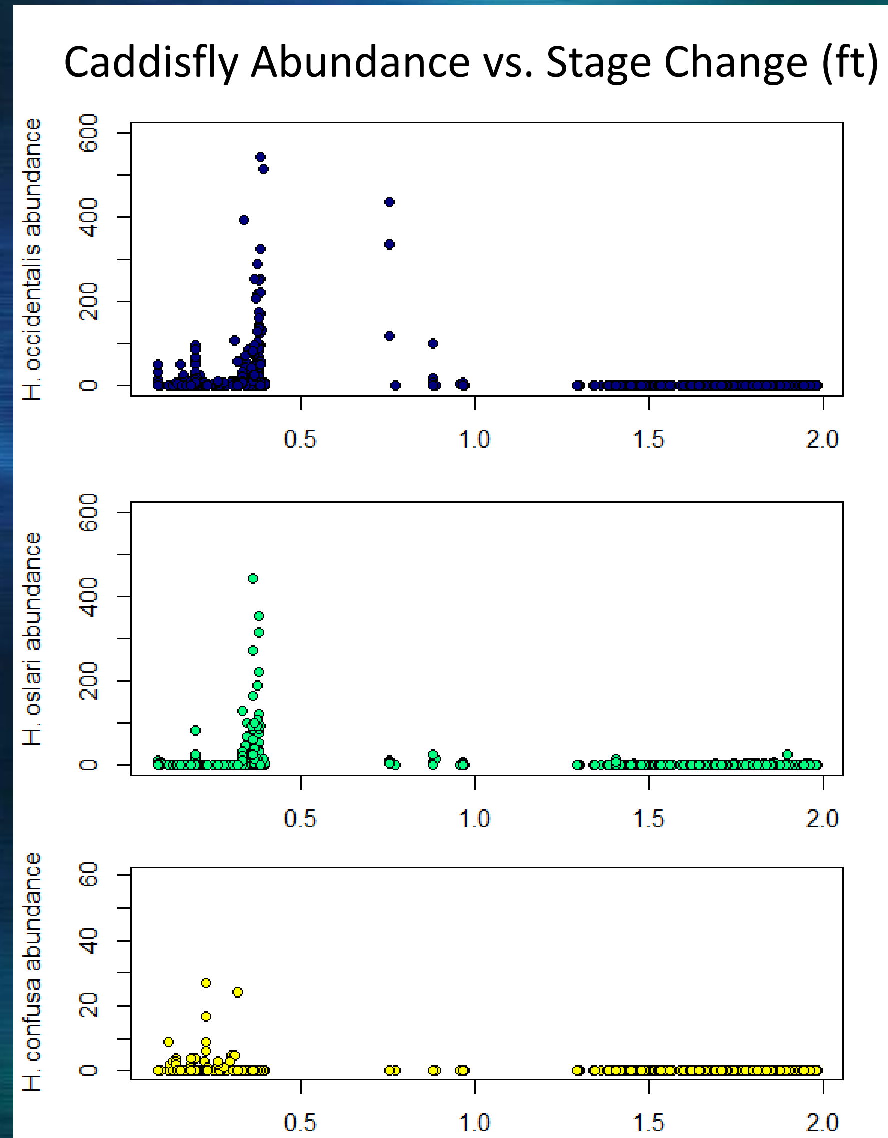
Provisional data from Kennedy and Muehlbauer, subject to change. Do not cite.

Daily Stage Change Affects EPT (i.e., sensitive mayflies, stoneflies, and caddisflies)

Abundance of caddisfly species consistently drops with stage change > 0.5 ft.

Hydropsyche species





Provisional data from Metcalfe, subject to change. Do not cite.

Project 9. Understanding Factors Affecting Rainbow Trout

Purpose: To understand key drivers of rainbow trout population size, movement, survival, and reproduction

Some Example Questions:

How do physical conditions, such as turbidity and temperature, affect rainbow trout populations?

What are the trends in fish abundance and how are these trends affected by lower trophic levels?

What GCD operations maximize rainbow trout abundance?

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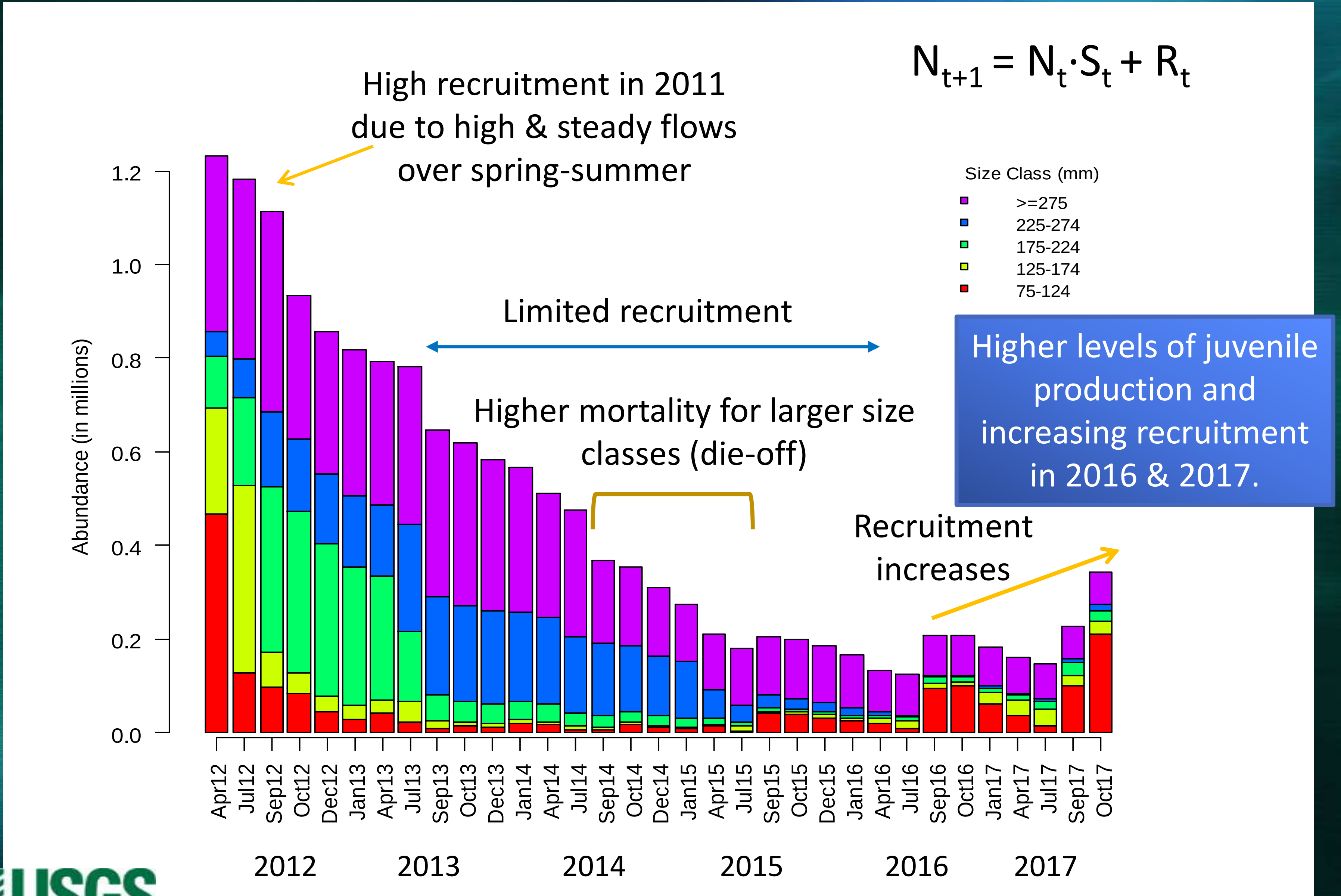
Rainbow Trout Abundance in Glen Canyon

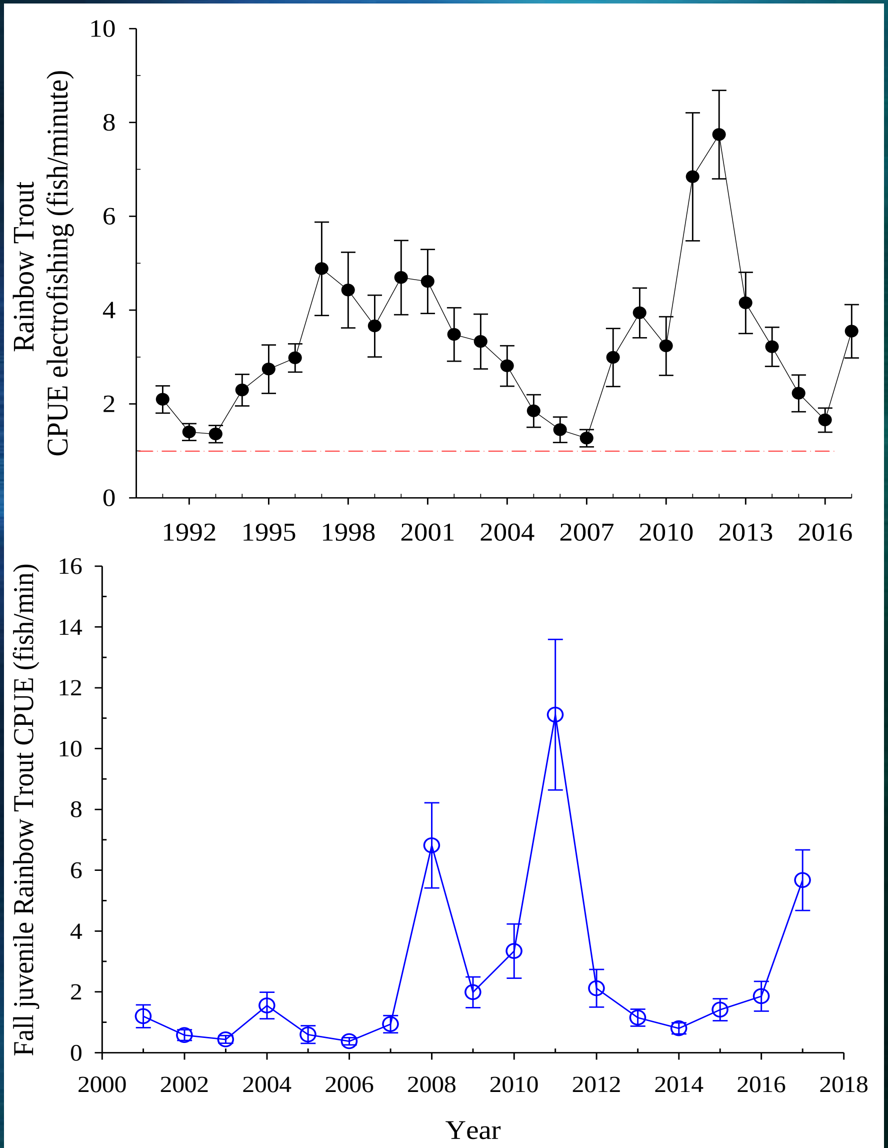


(Preliminary data from Korman and Yard 2018. Do Not Cite.)

Rainbow Trout Catch Per Unit Effort (CPUE): Lees Ferry

Average yearly CPUE (fish/min) combined three trips: spring, summer, and autumn

Fall juvenile CPUE (<152 mm total length)



Long-term catch data and abundance estimates (previous slide) show similar trends – recent increases in rainbow trout in Glen Canyon.

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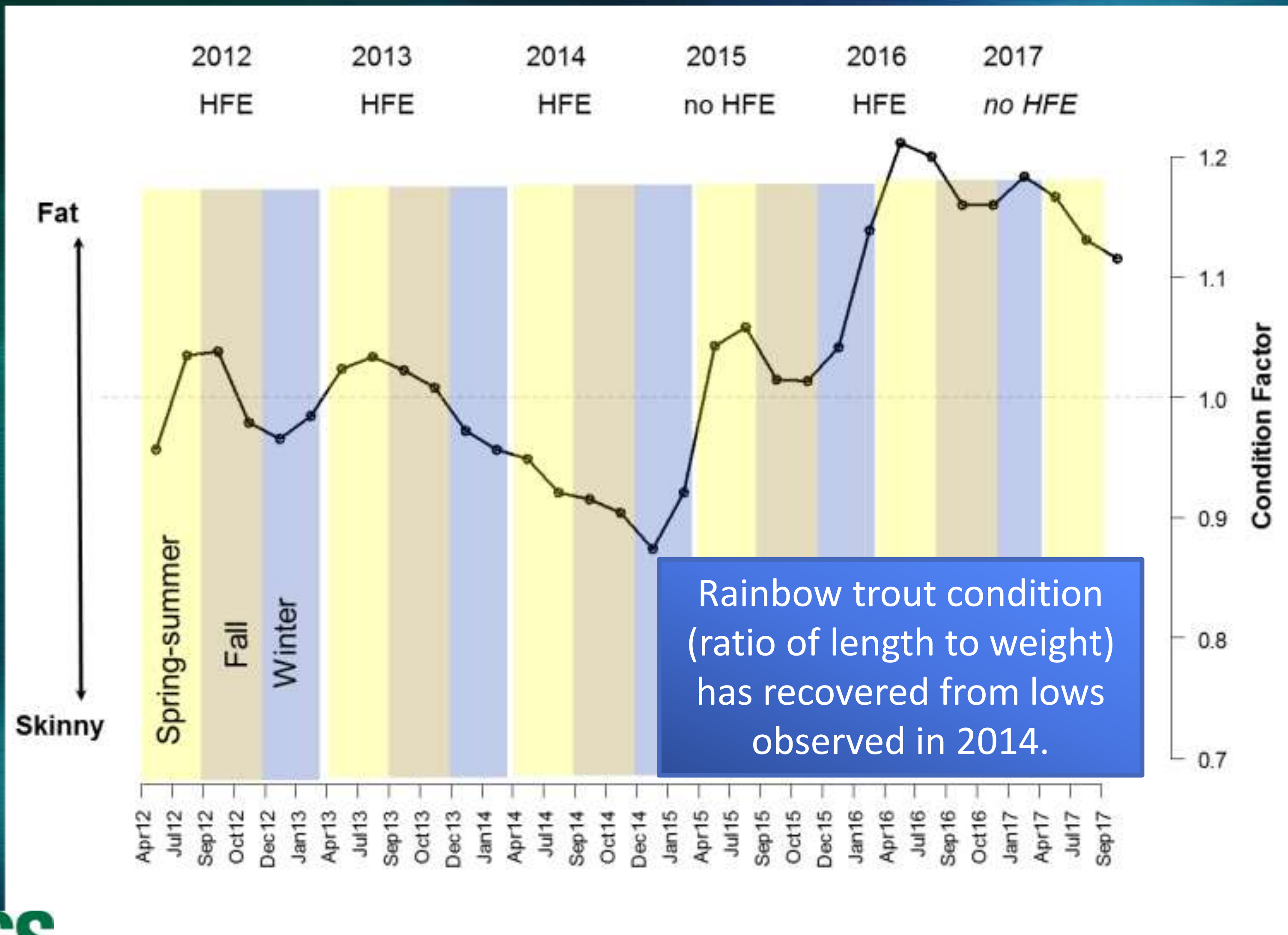
(Preliminary data from Rogowski, AZ Game & Fish Dept., 2018. Do Not Cite.)

Trends in Condition of a 300 mm Rainbow Trout (~260 g) in Glen Canyon



Rainbow trout condition (ratio of length to weight) has recovered from lows observed in 2014.

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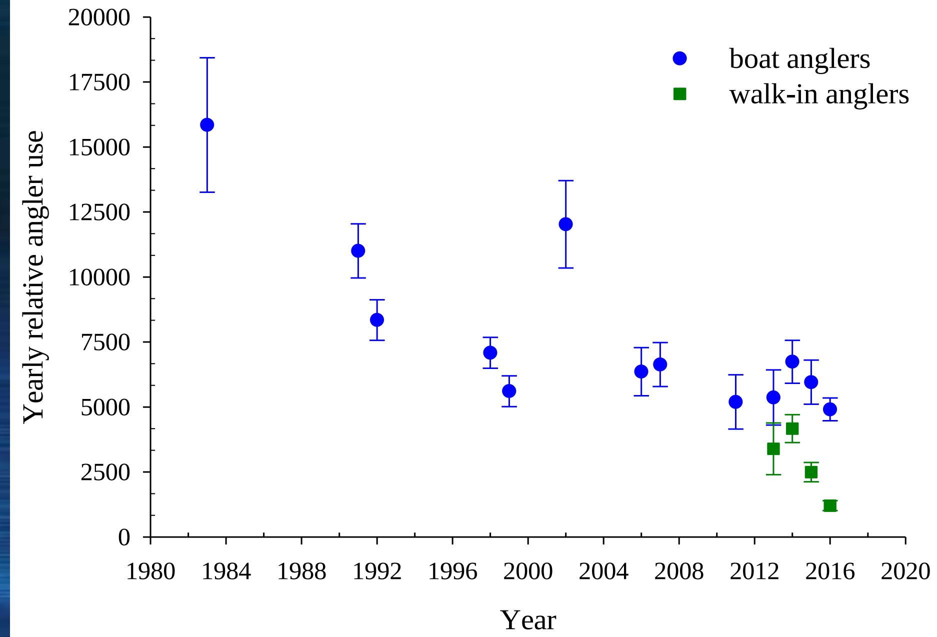
(Preliminary data from Korman and Yard 2018. Do Not Cite.)

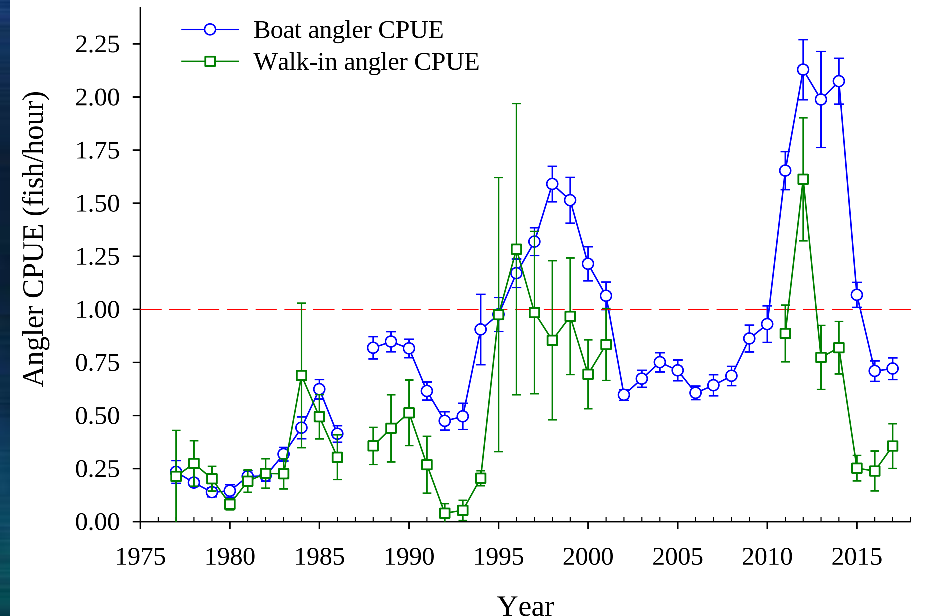
Angler Surveys: Lees Ferry

Relative angler use



Angler use (number of people) has declined over the last few years. Boat angler numbers similar to levels observed over the last decade, but below peaks of past decades. Catch rates considerably lower than recent record peaks, but may have stabilized and an increase is anticipated.

Angler CPUE (fish/hour)



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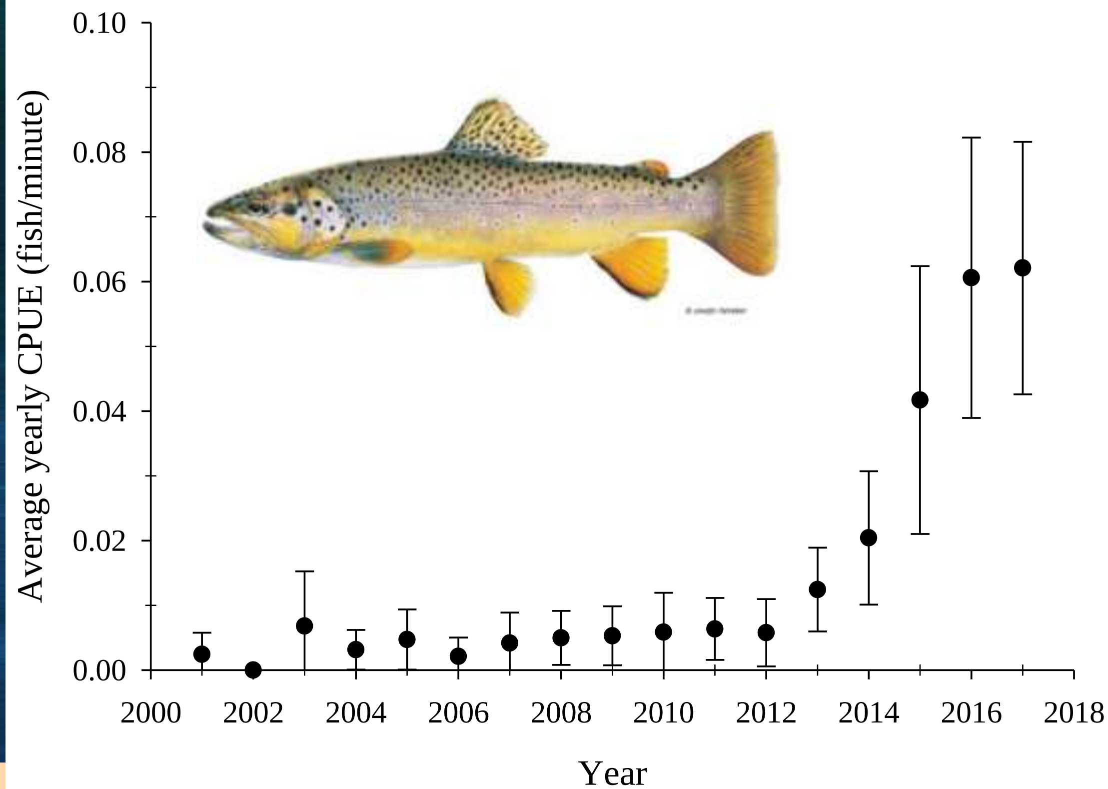
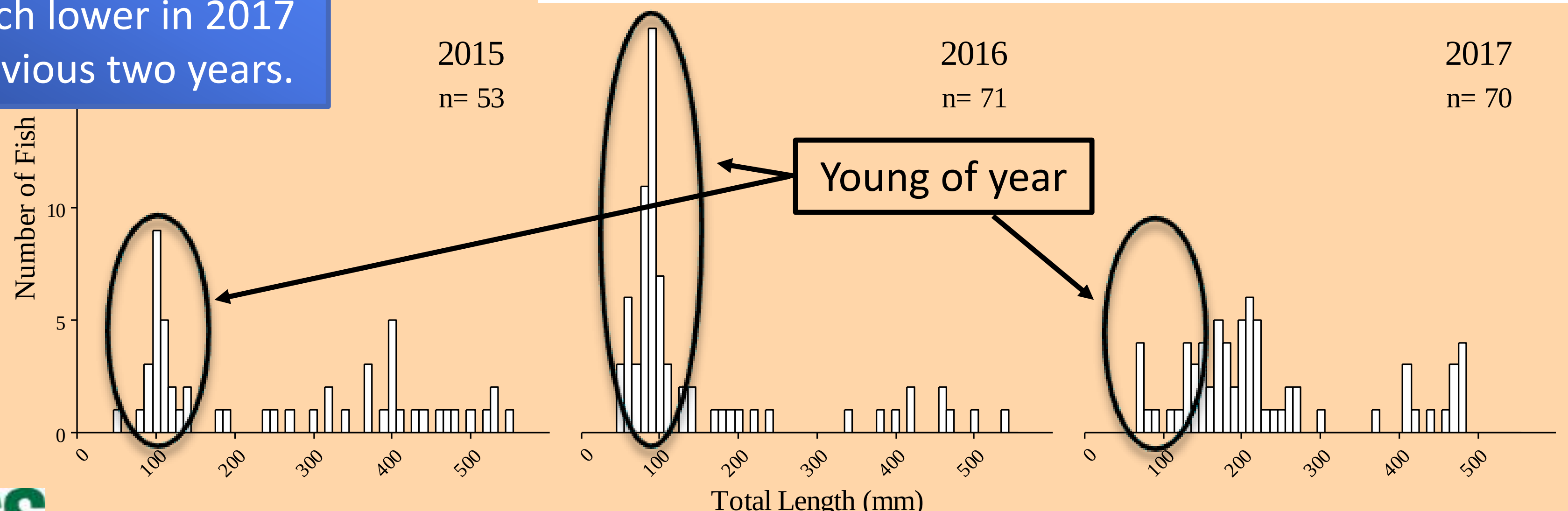
(Preliminary data from Rogowski, AZG&F, 2018. Do Not Cite.)

Brown Trout in Glen Canyon

- 1.68% of fish community
- Average CPUE/year
- Length Frequency histograms

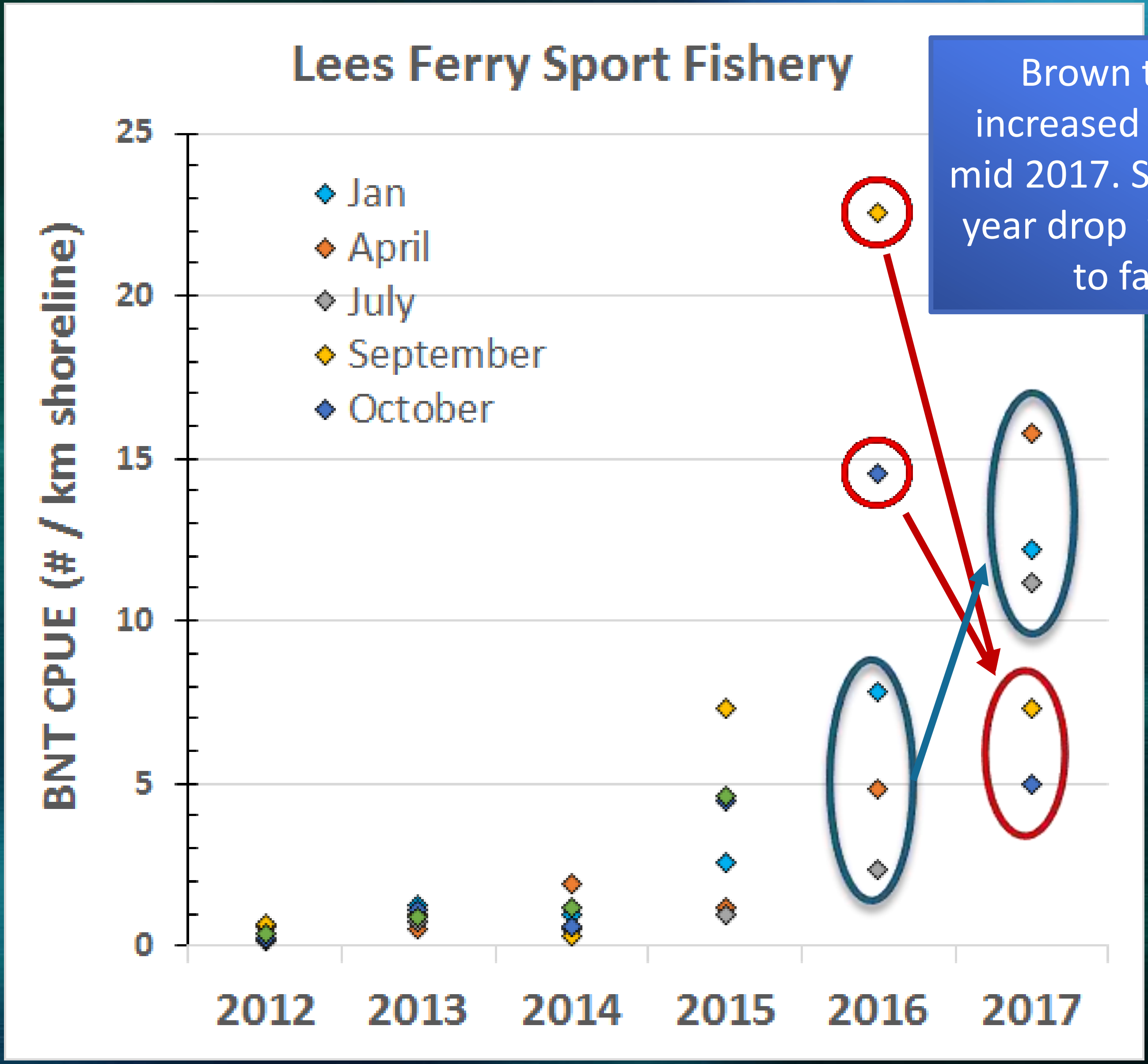
Brown trout still small proportion of fish in Glen Canyon. Catch of young of year much lower in 2017 than previous two years.





(Preliminary data from Rogowski, AZG&F, 2018. Do Not Cite.)

Seasonal Brown Trout Catch in Glen Canyon



Brown trout catch increased from 2012 to mid 2017. Sharp year over year drop from fall 2016 to fall 2017.

(Preliminary data from Yard and Korman, 2018. Do Not Cite.)

Brown Trout telemetry at Lees Ferry and Grand Canyon, Arizona

Robert Schelly, Brian Healy, Clay Nelson, Benjamin Vaage, David Ward, Brandon Albrecht, Ron Kegerries, Harrison Mohn, Jan Boyer

National Park Service
U.S. Department of the Interior

Grand Canyon National Park

Brown Trout Telemetry in Lees Ferry and Grand Canyon

- Work done by National Park Service, Grand Canyon National Park
- Funded by BOR, NPS, and GLCA

Objectives

- Gather data on movements and habitat preferences, both daily and seasonally, and better identify spawning period
- Identify periods of vulnerability and invulnerability to electrofishing (shallow nearshore vs. deep habitats)
- Improve understanding of rates of adult migration downstream from Lees Ferry
- Potentially identify new spawning aggregations

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Results After One Year of Tracking 10 Fish

- In the 2-3 months following Feb tagging, most detections remained within ~1 mi upstream or downstream of -4 mi bar
- Utility of day / night telemetry passes reconsidered; hydrophone too imprecise to identify small movements
- Diminishing contacts through time
- Of initial 10 fish, 3 tags were found to have stopped transmitting upon recapture this season
- 2 fish were angled, and tags returned
- 2 or 3 individuals spent summer months in deep, electrofishing invulnerable eddy at -2.5 mi (including the 1 female tagged in Feb)
- 2 outmigrations from Ferry, with detections again next season

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NPS preliminary data, do not cite

Project 8. Experimental Actions to Increase Abundance and Distribution of Native Fishes in Grand Canyon

Purpose: To increase survival of juvenile native fishes in Grand Canyon

Some Example Questions:

What are the most limiting factors to successful humpback chub adult recruitment in the mainstem Colorado River?

What are the most effective strategies and control methods to limit nonnative fish predation on, and competition with native fishes?

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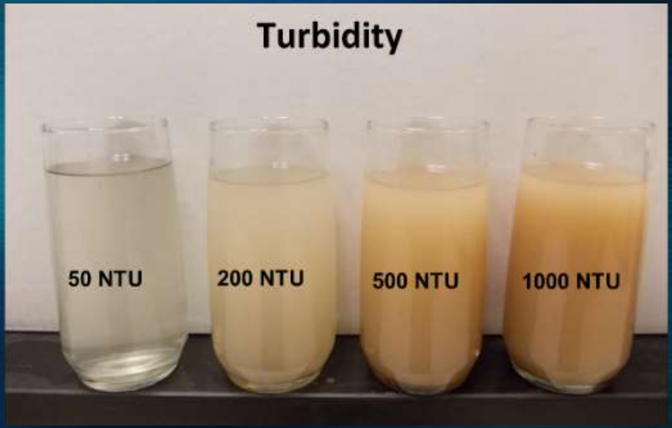
Turbidity* as a management tool to constrain rainbow trout downstream of the Paria River

- Relatively low turbidity (100 NTU) for as little as 30 days results in reduced condition of rainbow Trout in laboratory trials – even with abundant food (Ward, preliminary data, do not cite)

- Reduced condition following extended duration turbidity is also very evident from field data for Rainbow Trout in Marble Canyon (Korman and Yard, preliminary data, do not cite)



*Turbidity is not just influenced by suspended sediment concentration, but also dependent upon both grainsize of suspended sediment, and sediment color - See Sutherland et al. 2000 (Marine Geology 162, 2000. 587–597)

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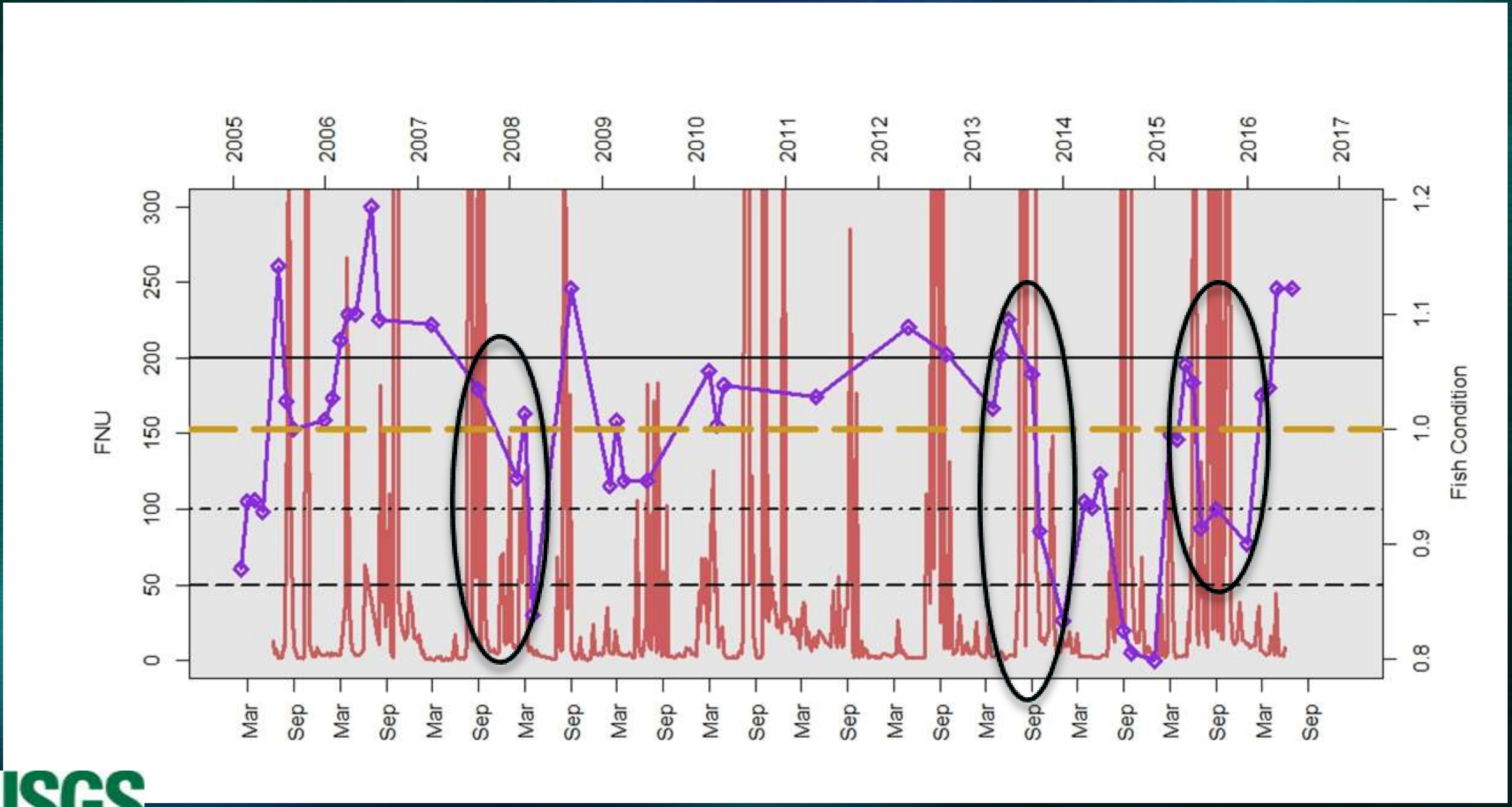
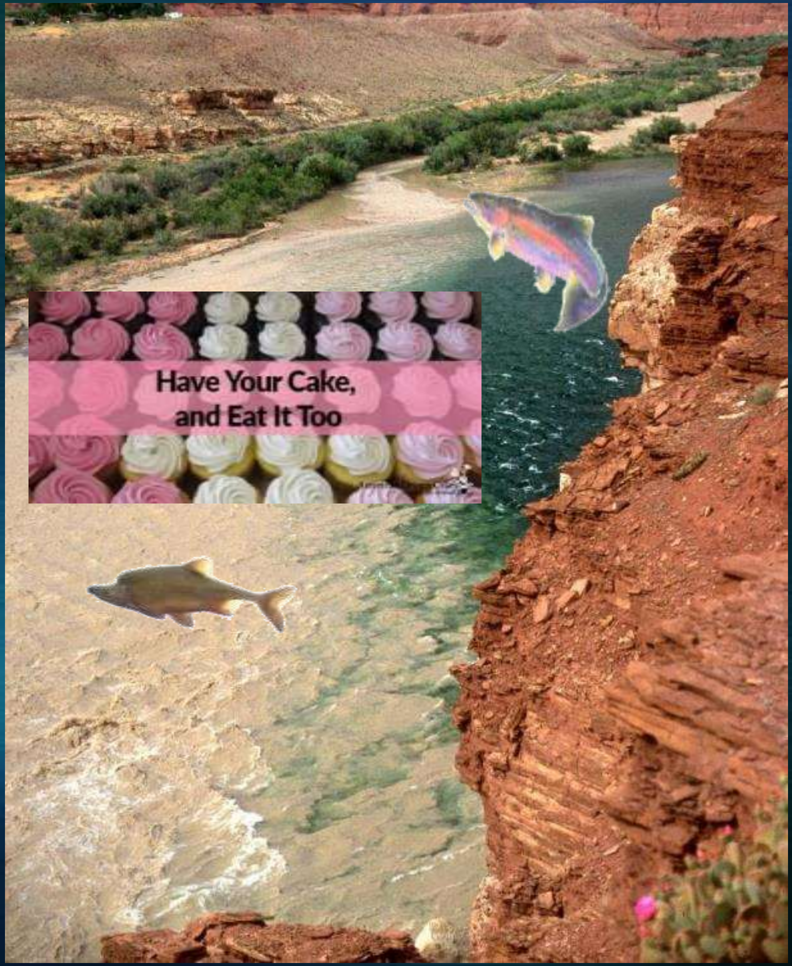
When turbidity (red line) at 30 mile gage persists for any length of time, often see a rainbow trout condition (purple line) decline below target levels (orange dashed line) soon after (black ovals).



(Preliminary data from USGS-GCMRC, 2018. Do Not Cite.)

Manipulation of turbidity from the Paria River to benefit downstream native fish (without impacting Lees Ferry Rainbow trout) may warrant further evaluation



**and
we have ideas on
how to do it!**

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National Park Service
U.S. Department of the Interior

Grand Canyon National Park

Mechanical suppression of nonnative trout leads to increases in abundance of native fishes, Bright Angel Creek, Grand Canyon

Brian Healy , Robert Schelly, Emily Omana Smith, Clay Nelson, Melissa Trammell, Rebecca Koller, Marianne Crawford

Joe Tomelleri Illustrations

Mechanical Suppression of Nonnative Trout, Bright Angel Creek

- **Goals:**
  - Enhance native fish populations in Bright Angel Creek
  - Reduce risk of predation upon Humpback Chub in Colorado River
  - Foster meaningful tribal relations and integrate perspectives into management
- **Mechanical Removal Objectives:**
  - Reduce trout abundance by 80% (a potential threshold for benefits to native fish would be realized; Mueller 2005)
  - Maintain/improve native fish populations in Bright Angel Creek
  - When trout reduction objective met, translocate Humpback Chub
- Methods
  - Fish weir and electrofishing (creek and mainstem)
  - Beneficial use of removed fish

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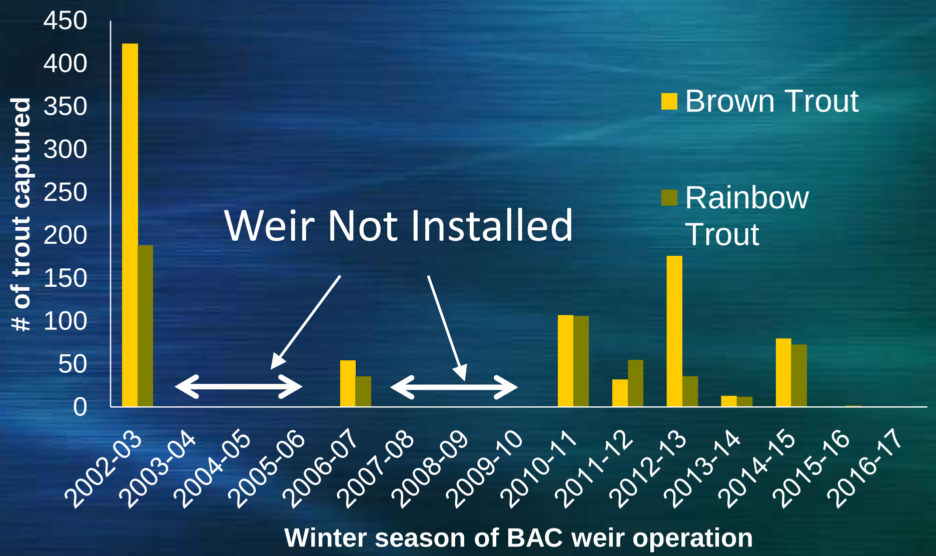
Results – Bright Angel Creek Fish Weir

Two weir designs employed. Low catch rates in recent years.

2002-2012



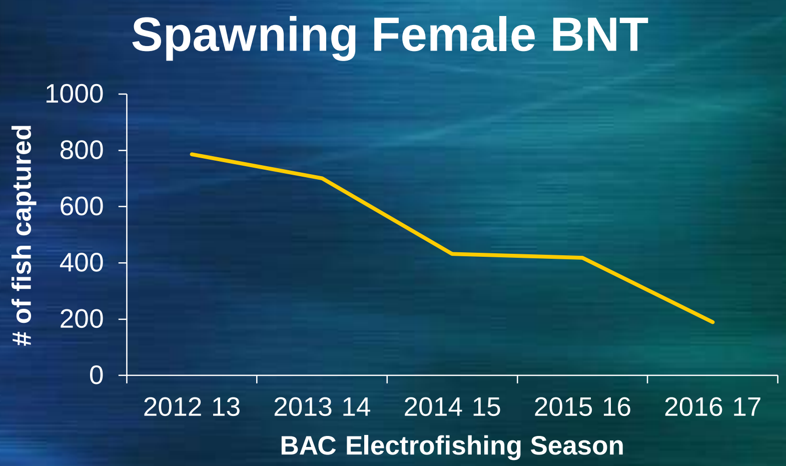
2012-2017

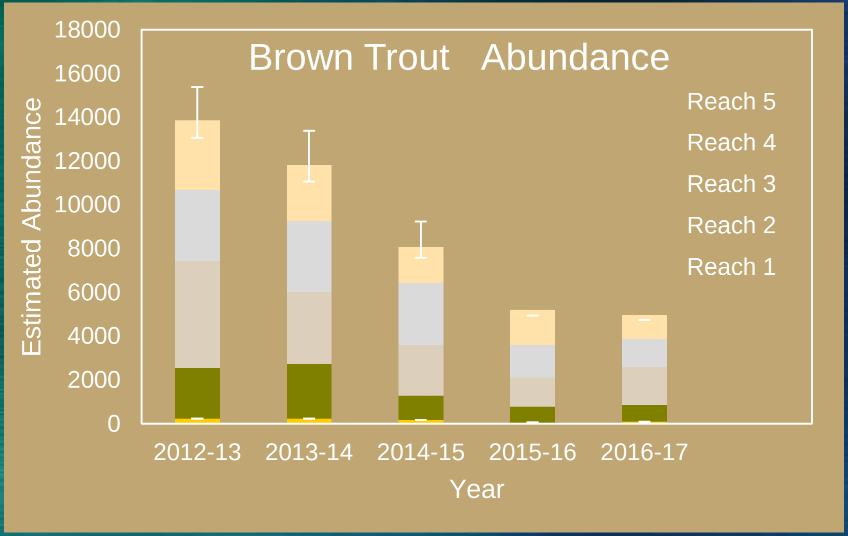
NPS preliminary data, do not cite

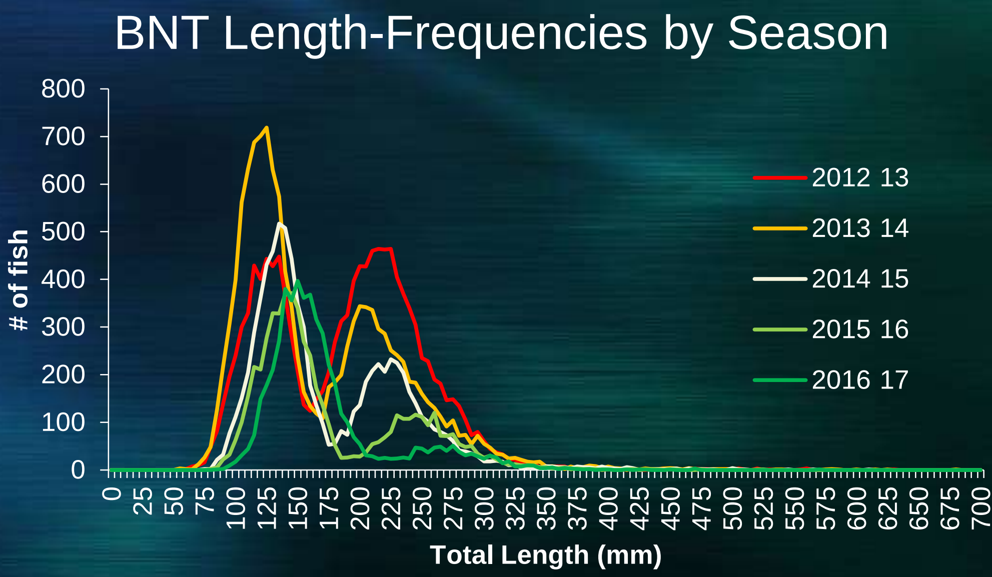
Results – Trout Population Metrics

Brown Trout:

- Overall decline of 64%
- Decline of larger/spawning fish
- Increased growth rate





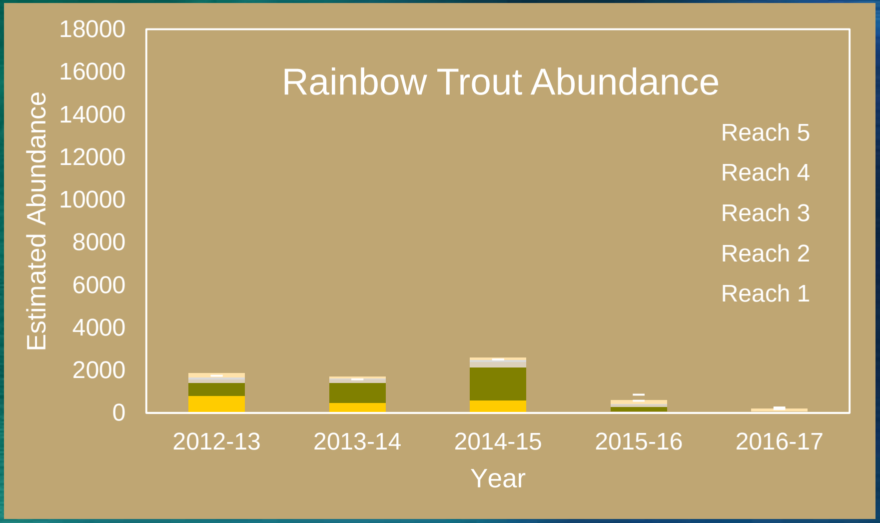


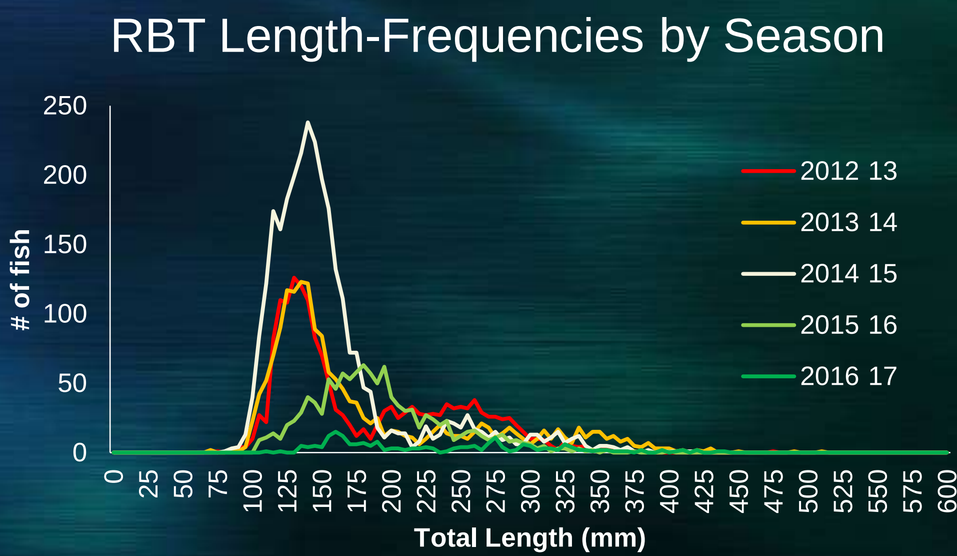
NPS preliminary data, do not cite

Results – Trout Population Metrics

Rainbow Trout:

- Overall decline of 90% (to n=184 fish)
- Large 2014 cohort





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NPS preliminary data, do not cite

Project 6. Mainstem Colorado River Humpback Chub Aggregations and Fish Community Dynamics

Purpose: To understand the effects of GCD operations on the status and trends of humpback chub in the mainstem Colorado River

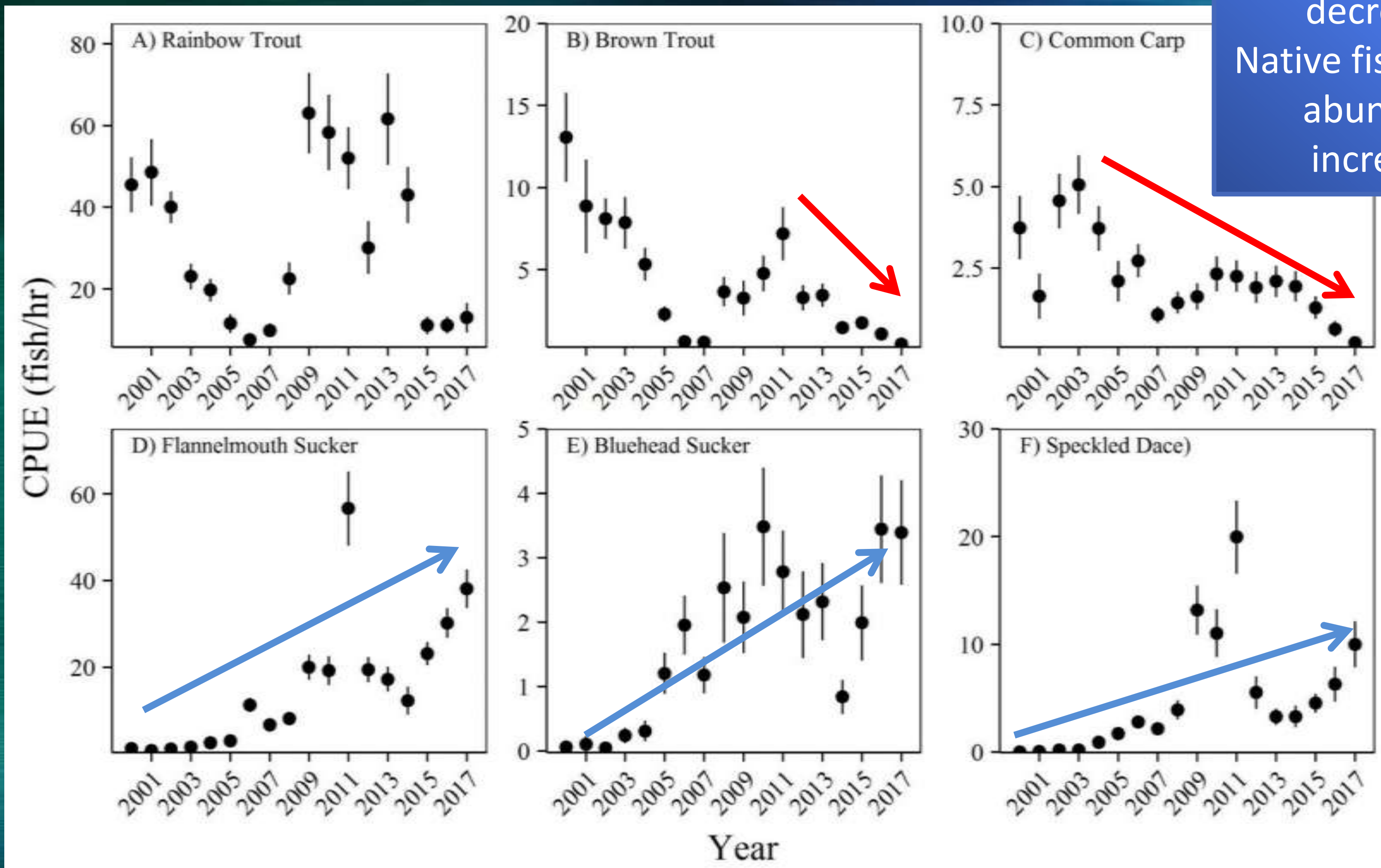
Some Example Questions:

To what extent are adult populations of native fish controlled by production of young fish from tributaries?

What is the abundance and distribution of native and nonnative fish species in the Colorado River?

AGFD System Wide Electrofishing Catch Per Unit Effort (2000 – 2017)

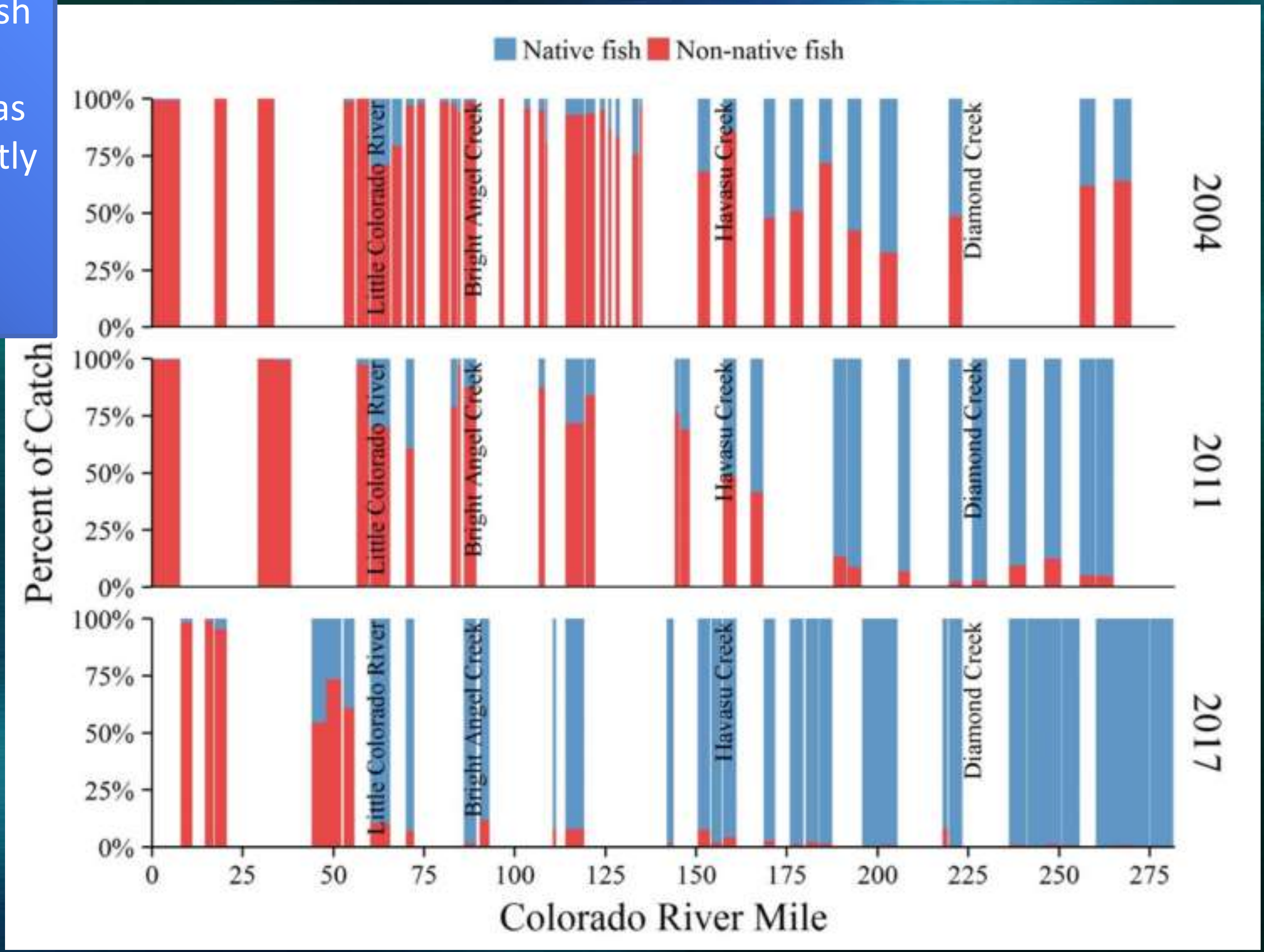
Non-native fish: relative abundance decreasing
Native fish: relative abundance increasing



(Preliminary data from Rogowski, AZG&F, 2018. Do Not Cite.)

AGFD System Wide Electrofishing (2000-2017)

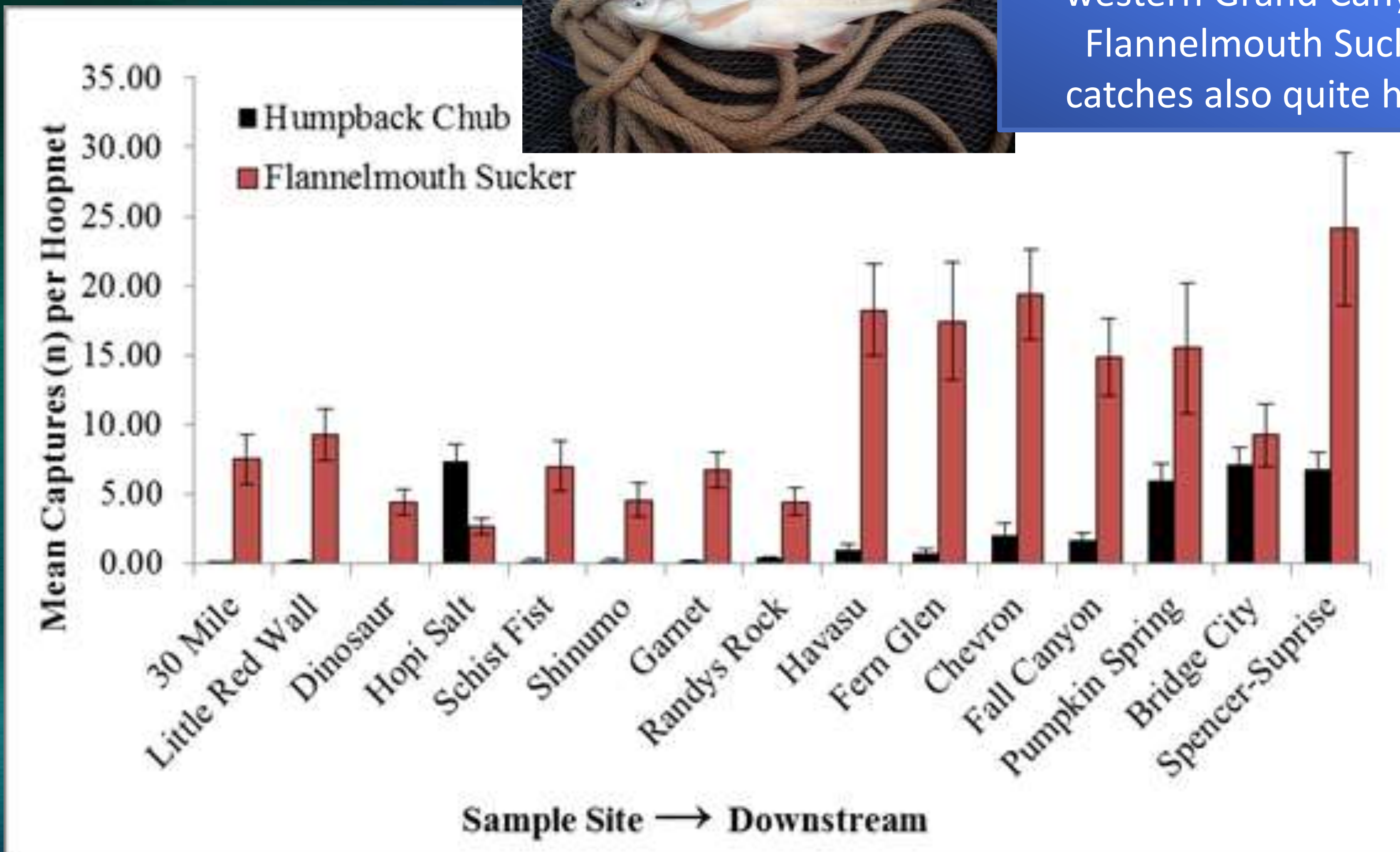
Colorado River fish assemblage in Grand Canyon has shifted from mostly nonnative to mostly native species.



(Preliminary data from Rogowski, AZG&F, 2018. Do Not Cite.)

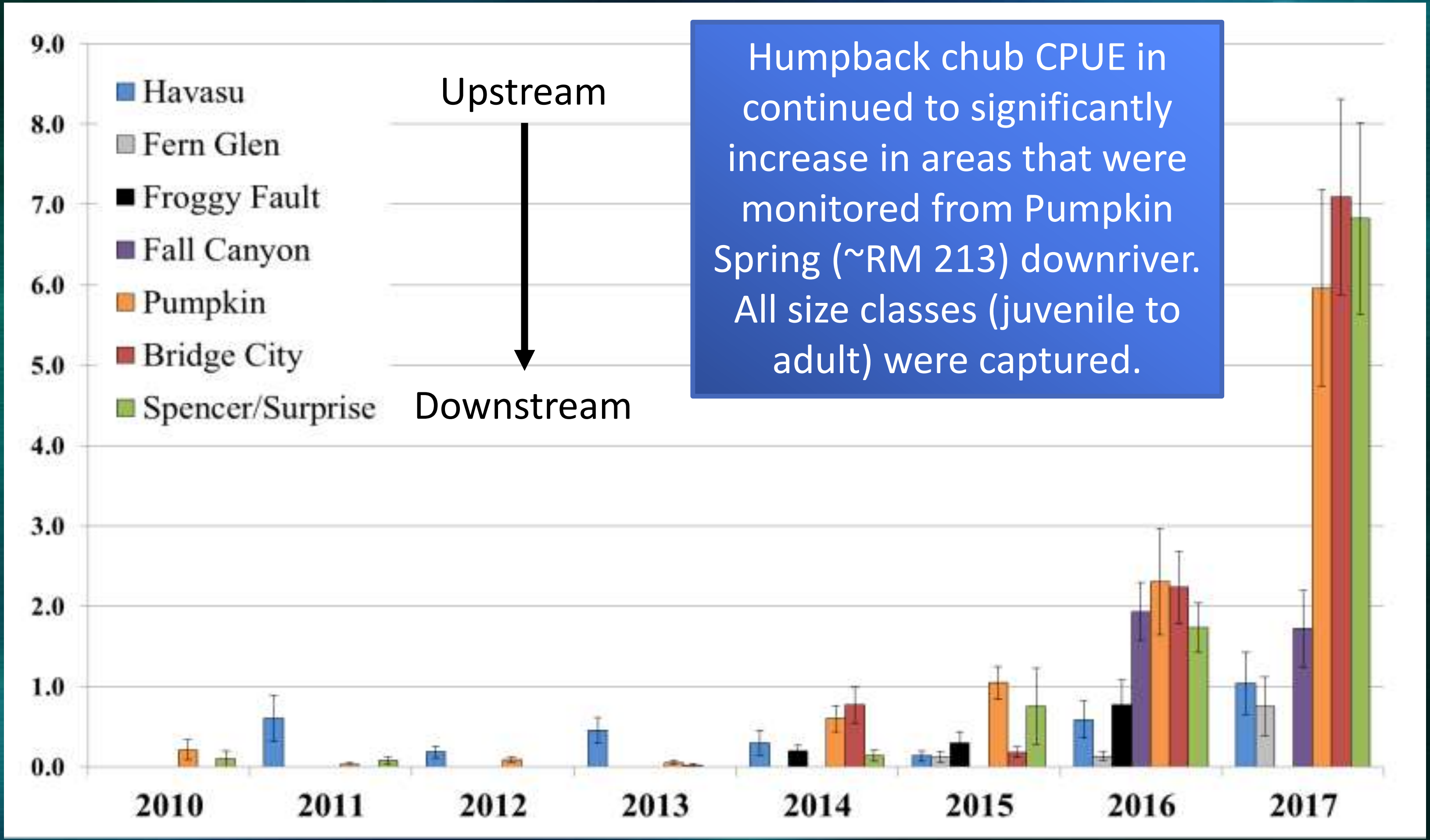
2017 Mainstem Humpback Chub Aggregation Monitoring

Humpback chub being captured in good numbers in western Grand Canyon. Flannelmouth Sucker catches also quite high.



(Preliminary Data from VanHaverbeke et al. USFWS. 2017. Do Not Cite.)

Humpback Chub CPUE by Year in Western Grand Canyon



Mean Captures per Hoop Net Set (n)

Year

(Preliminary Data from VanHaverbeke et al. USFWS. 2017. Do Not Cite.)

Project 7. Population Ecology of Humpback Chub In and Near the LCR

Purpose: To identify factors that affect humpback chub survival, growth, and reproduction in and near the LCR

Some Example Questions:

What are the most important factors affecting humpback chub survival and growth?

To what extent does young humpback chub production in, and outmigration from, the LCR vary?

Do other factors, not yet accounted for, affect or bias the estimates of adult size and population?

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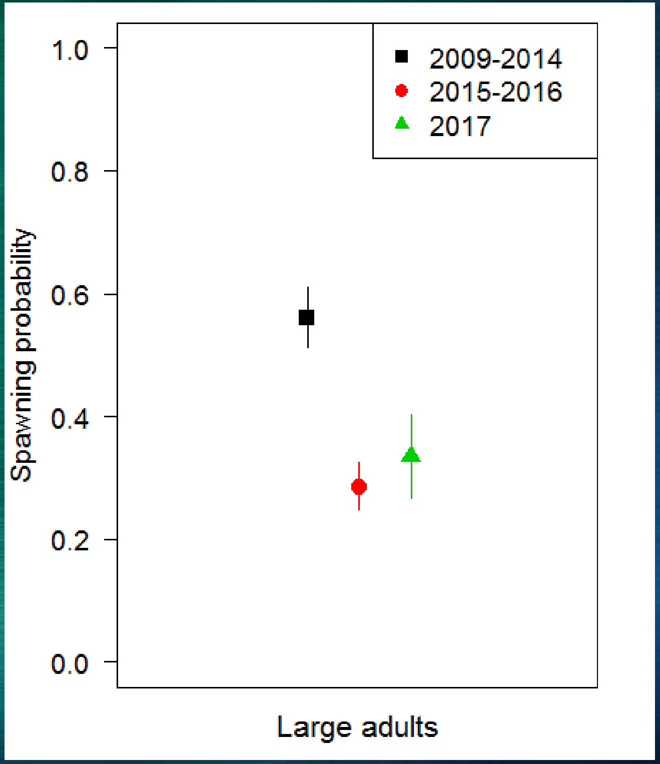
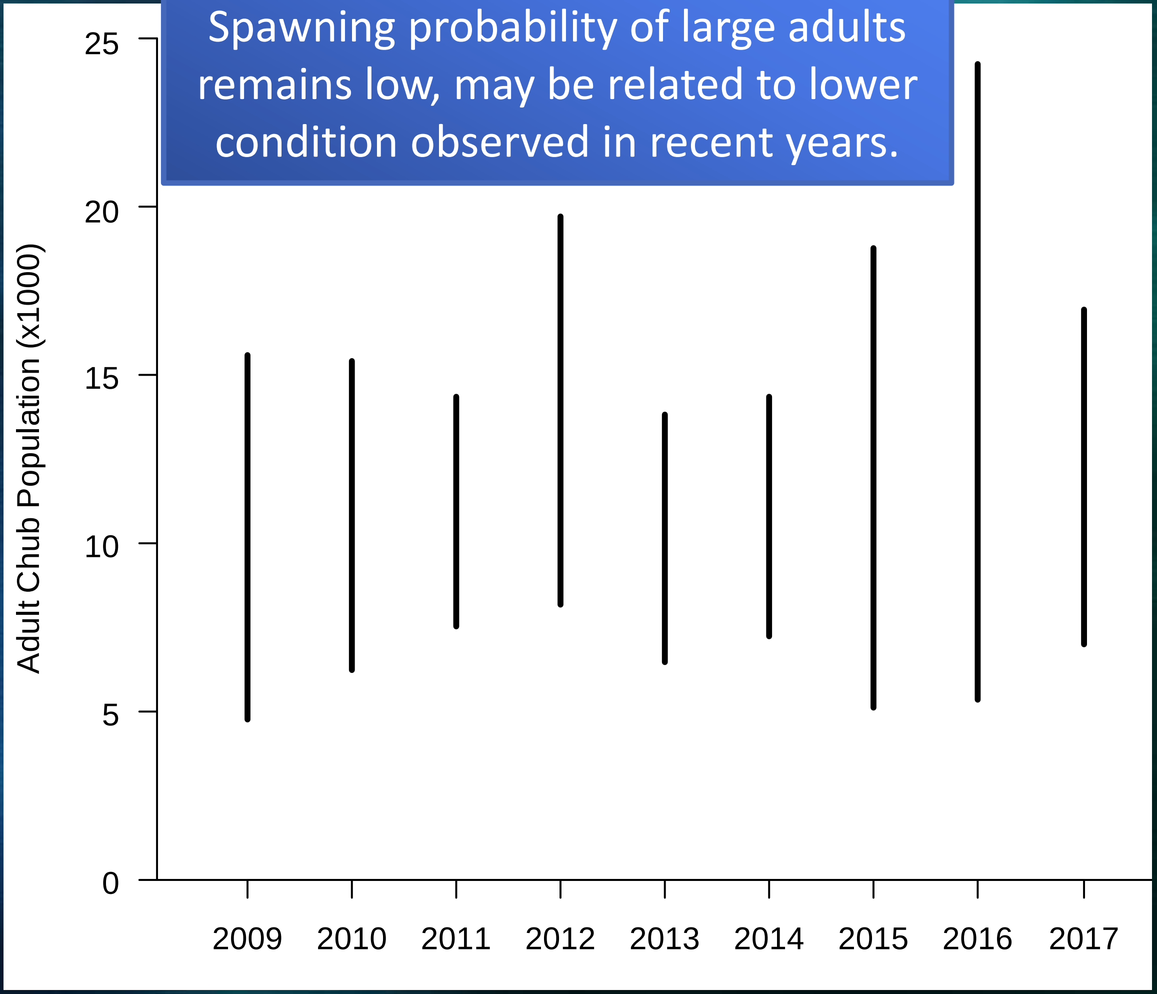
Adult Humpback Chub Population Estimates

Adult humpback chub abundance appears stable. Point estimate of ~11,000 – 12,000 adults exceeds 2016 BiOp tier-1 trigger level of 9,000. Spawning probability of large adults remains low, may be related to lower condition observed in recent years.





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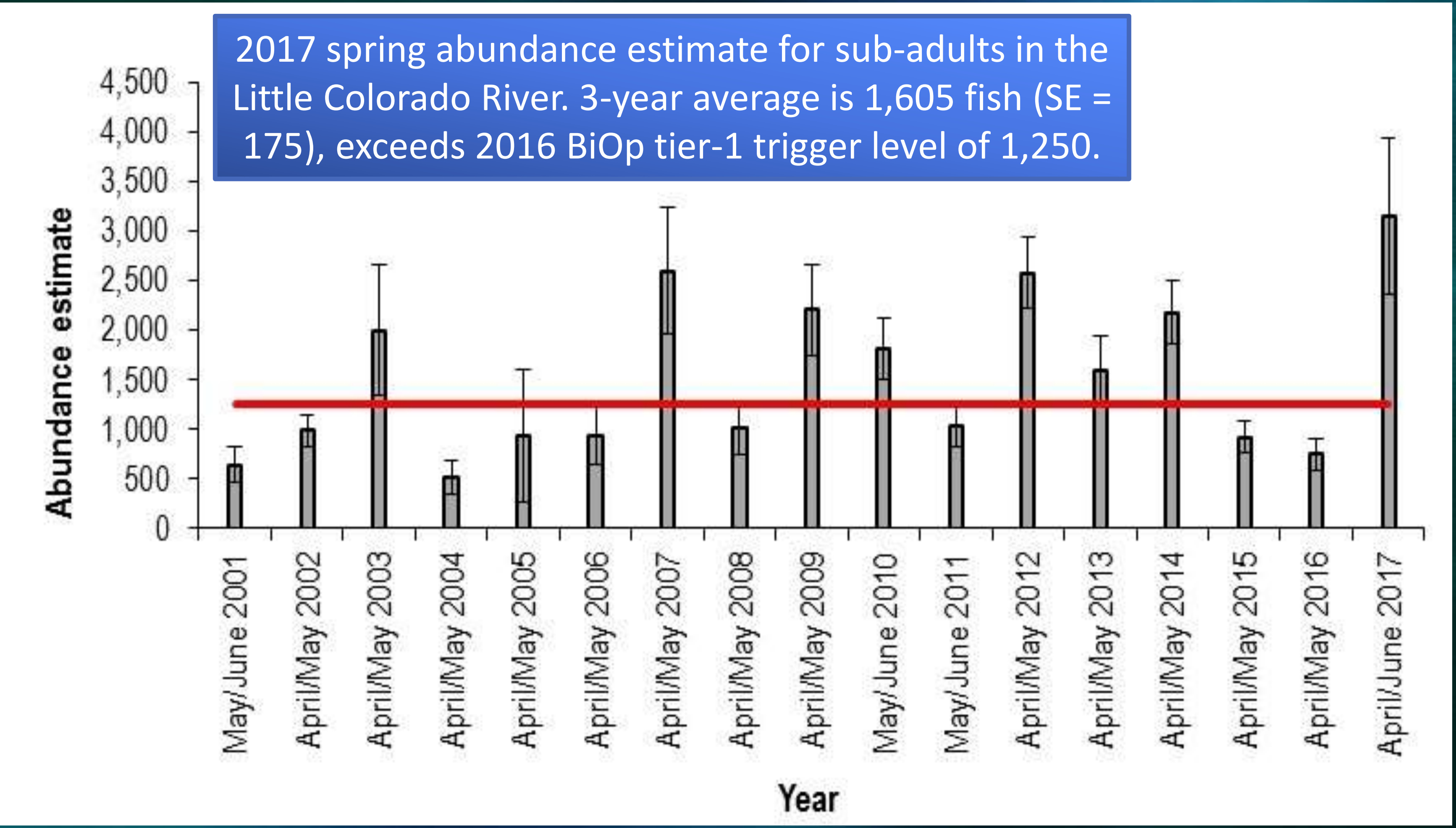
(Preliminary data from Yackulic, 2018. Do Not Cite.)

Annual Spring Abundances of Humpback Chub 150-199 mm in Lower 13.6 km of LCR



(Preliminary Data from VanHaverbeke et al. USFWS. 2017. Do Not Cite.)

Chute Falls Translocations and Monitoring

- Translocations- In October 2017, 315 juvenile humpback chub (66-120 mm) were successfully translocated to above Chute Falls

- Monitoring - For 2017, it was estimated that there were 292 (SE = 19) humpback chub ≥100 mm in the Chute Falls reach, of which 179 (SE = 12) were adults ≥200 mm

(Preliminary Data from Stone et al. USFWS. 2017. Do Not Cite.)

Project 13. Socioeconomic Monitoring and Research

Purpose: To identify recreational and tribal preferences for, and values of, downstream resources influenced by GCD operations and to develop a decision support system to improve the ability of the GCDAMP to evaluate and prioritize management actions, monitoring and research

Some Example Questions:

What are the most effective and efficient strategies to rainbow trout populations in order to meet long-run adult humpback chub abundance goals?

Does the operation of the GCD influence the economic value of angling or whitewater floating in Glen Canyon or Grand Canyon?

Do tribal preferences for, and values of, downstream resources differ among resource attributes?

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Applied Decision and Scenario Analysis

Develop a bioeconomic model to identify the cost-effective management strategy for rainbow trout that achieves humpback chub population goals.

Goal is to integrate economic information with data and predictive models from long-term and ongoing physical and biological studies to develop integrated assessment models (multidisciplinary models that incorporate social and economic considerations). Will improve ability of GCDAMP to evaluate and prioritize management actions, monitoring and research

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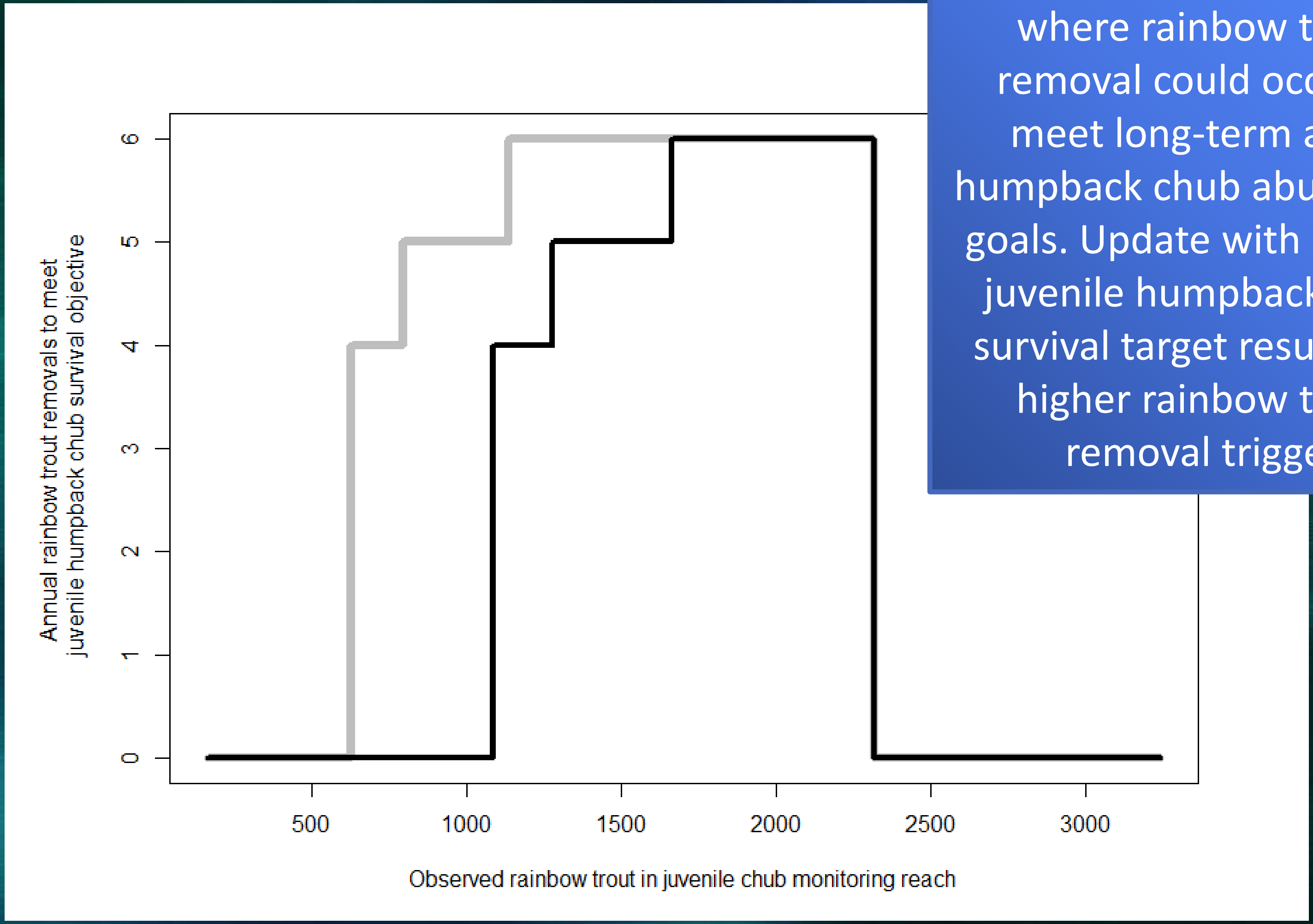
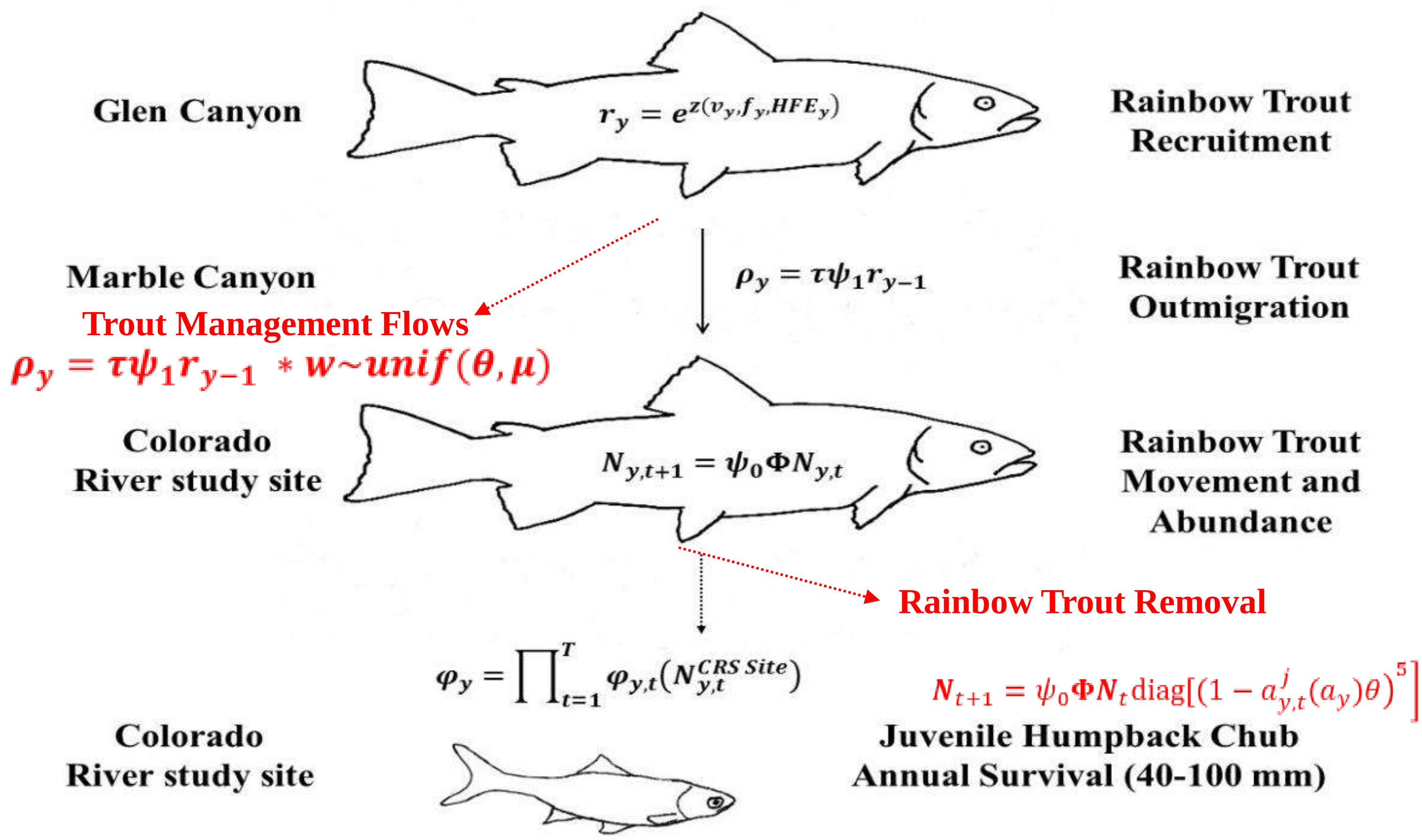
Bioeconomic Model Results



Initial and updated levels where rainbow trout removal could occur to meet long-term adult humpback chub abundance goals. Update with refined juvenile humpback chub survival target results in a higher rainbow trout removal trigger

(Bair et al., Biological Conservation, 2018)

Bioeconomic Model Refinement



Adding other management options to model. Estimates of the cost-effectiveness of trout management flows at meeting adult humpback chub abundance goals added to the model (in red).

Bair and Yackulic, preliminary data, do not cite

Adaptive Management

- Reducing parameter uncertainty may improve long-run management (i.e., reduce costs) but it incurs short-run costs
- For example, model development will not only help identity the effectiveness and efficiency of trout management flows but when and how experimentation might occur

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Acknowledgements

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- US Fish and Wildlife Service
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Questions?
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