Nutrients, Primary Production, and the Colorado River Foodbase

USGS

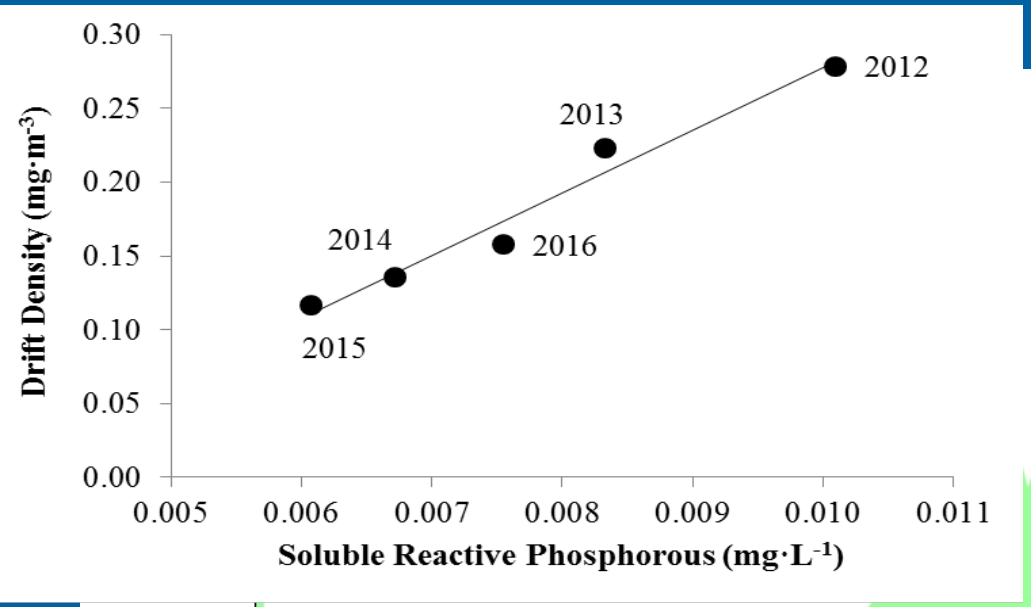
Slides compiled for AMWG Meeting, February 10, 2021
by Bridget Deemer, Ted Kennedy, Jeff Muehlbauer, and Charles Yackulic

Conceptual model

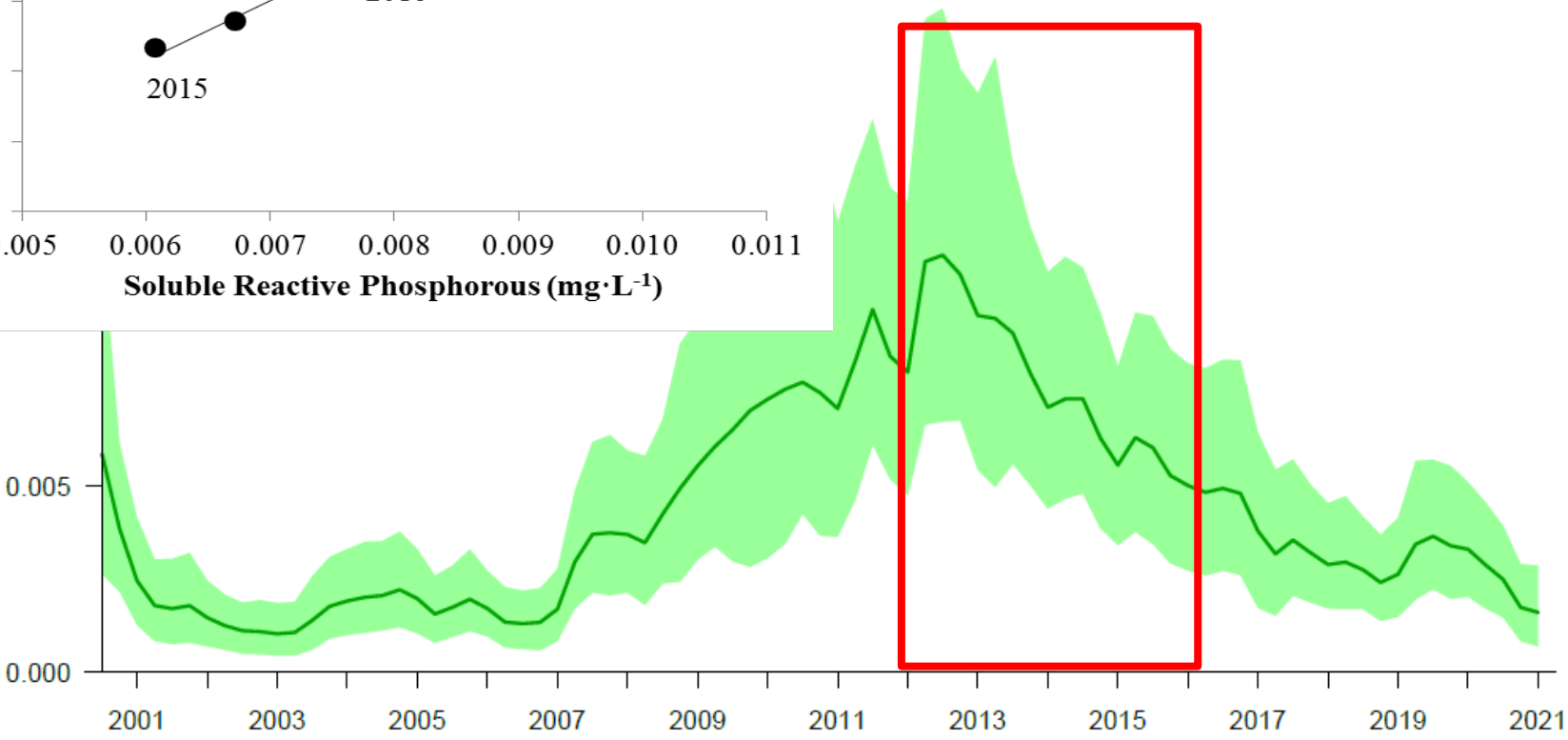
P

USGS

Dam SRP concentrations determine aquatic insect drift in Glen Canyon

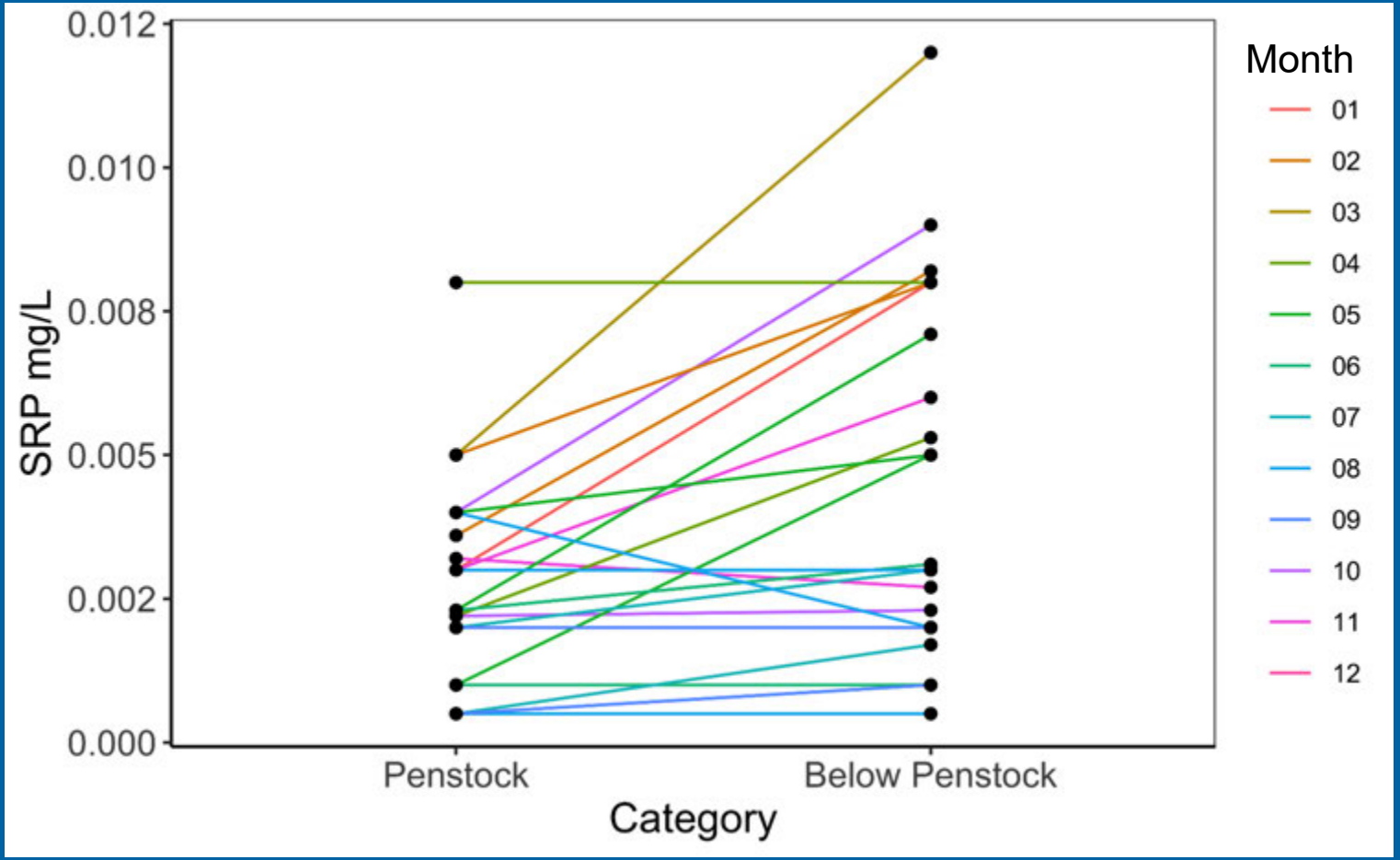


← Korman et al. 2020



Yackulic and Deemer unpublished

SRP Often Higher Below Penstocks



USGS

Unpublished data, subject to change, do not cite.

Average gradient of 0.002 mg/L SRP per 10 m drop below penstock

Conceptual model (1)

P

USGS

Management Change in Recent Years: Bug Flows

- "Give bugs the weekends off"
- Weekend stable low flows May-August
- Eggs laid on weekends never dry

USGS

Conceptual model (2)

P

USGS

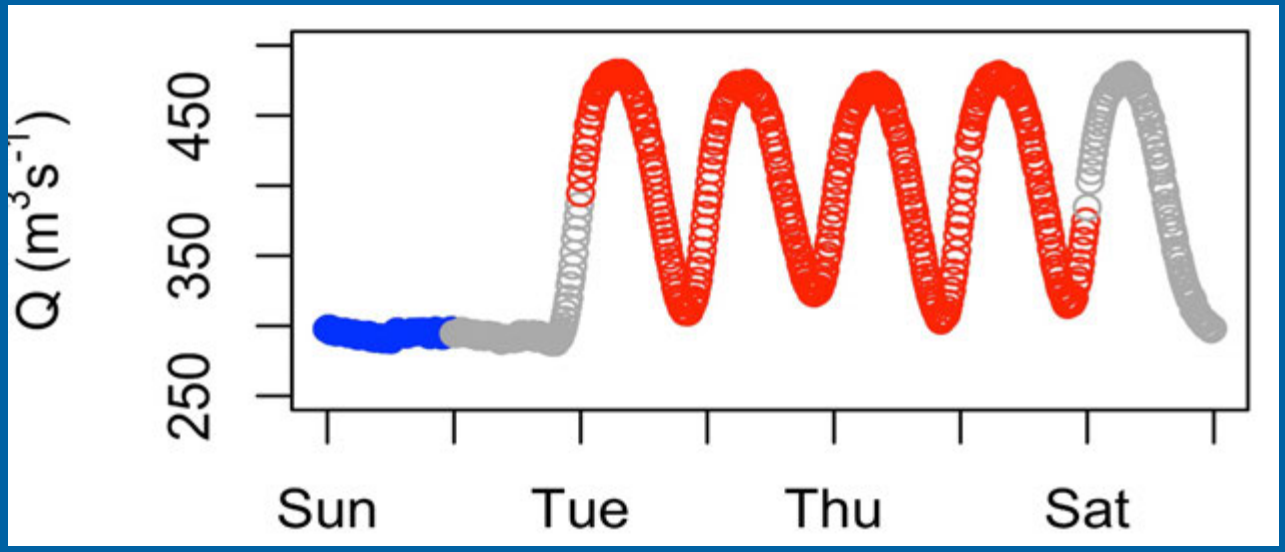
Gross Primary Production (GPP) and the Food Web

- GPP = total amount of oxygen produced during photosynthesis in the river
- O_2 production = carbon production
- High-quality algae-carbon is preferred food of
  - aquatic insects
  - bottom-feeding suckers

USGS

Quantifying effect of Bug Flows on GPP in Grand Canyon

- Detailed dissolved oxygen budgeting
  - Sensors every ~15 miles
- Compare GPP on weekends vs. weekdays
- Mixed effects models to quantify the role of depth, turbidity, month, site, Bug Flows
  - Focused on clear water months (May, June)

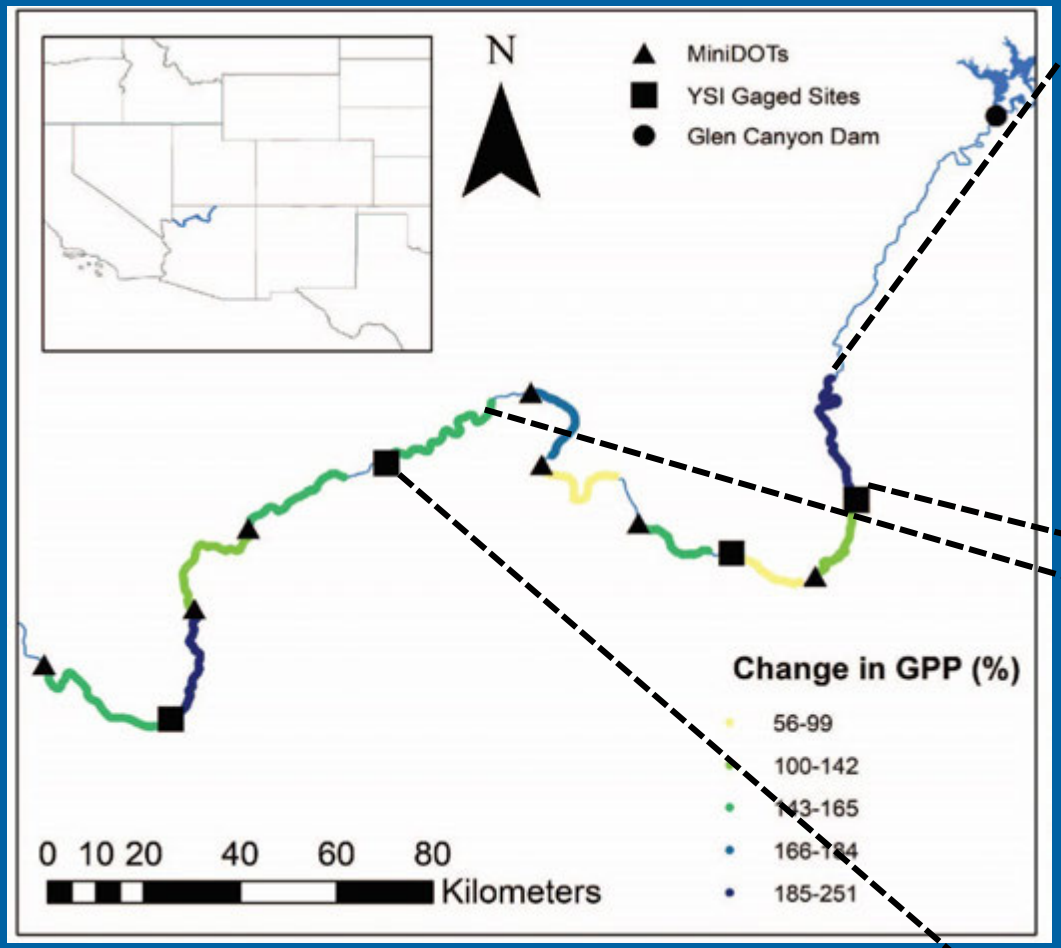


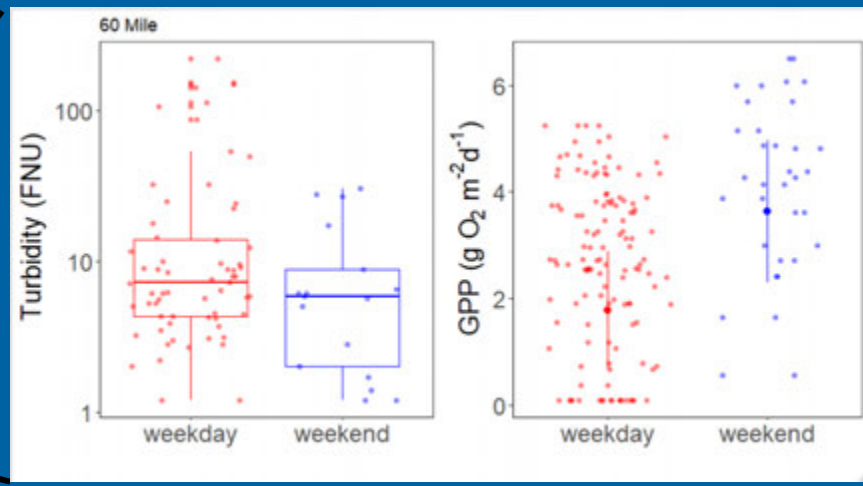
USGS

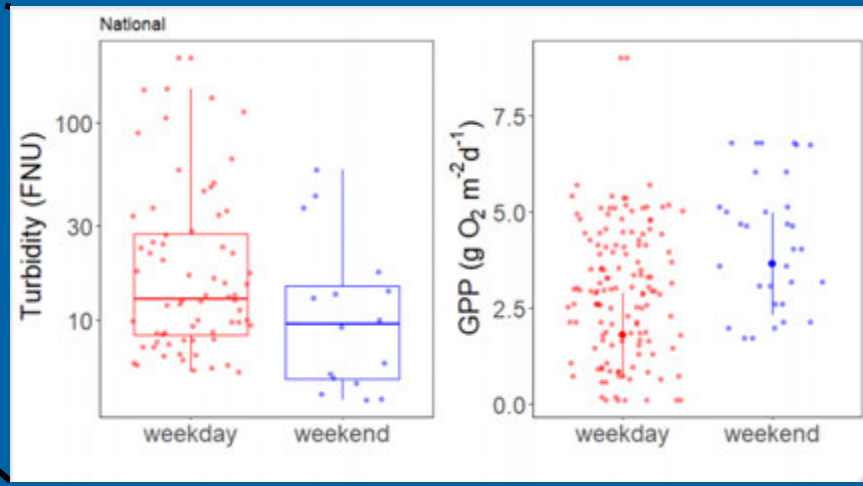
Unpublished data, subject to change, do not cite.

River-wide increase in GPP on weekends (45% higher = +100 metric tons carbon/yr)

Much of this GPP effect is turbidity driven







USGS

Unpublished data, subject to change, do not cite.

Deemer, Yackulic and others unpublished


USGS
science for a changing world
Bug Flows

Why Bug Flows?

1. **Very few insect species present**
   - Low diversity = low resilience

2. **Insect production low**
   - Not enough insect prey for fish

3. **5 Year HBC Species Status Assessment**
   - Greatest threat to HBC in Grand Canyon = inadequate & unreliable food supply

Resource Category	Upper Basin					Lower Basin
	Black Rocks	Westwater Canyon	Desolation/ Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
	Extant				Extirpated	Extant
1. Diverse rocky canyon river habitat						
2a. Suitable flow						
2b. Suitable temperature						
3. Adequate and reliable food supply						
4. Minimal threat from nonnative predators and competitors						
5. Suitable water quality						
6. Unimpeded range and connectivity						
7. Persistent populations						
8. High genetic diversity						

Table from 2018 USFWS 5-year review on Humpback Chub

USGS

Cross et al. 2013 *Ecol. Monographs;*
Kennedy et al. 2016 *BioScience*

Goals of Bug Flows

Improve egg-laying conditions for bugs

Thus:

- Increase abundance of midges
  - A couple years?
- Increase abundance/diversity of EPT
  - (mayflies, stoneflies, caddisflies)
  - A few years?
- Improve fish condition
  - Several years?

Caddisfly (Trichoptera)

USGS

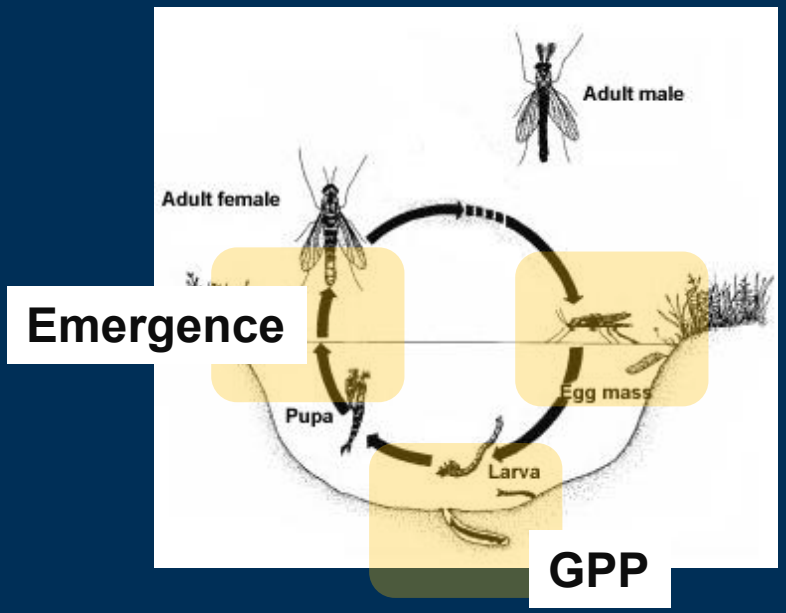
Bug Flows, cont.

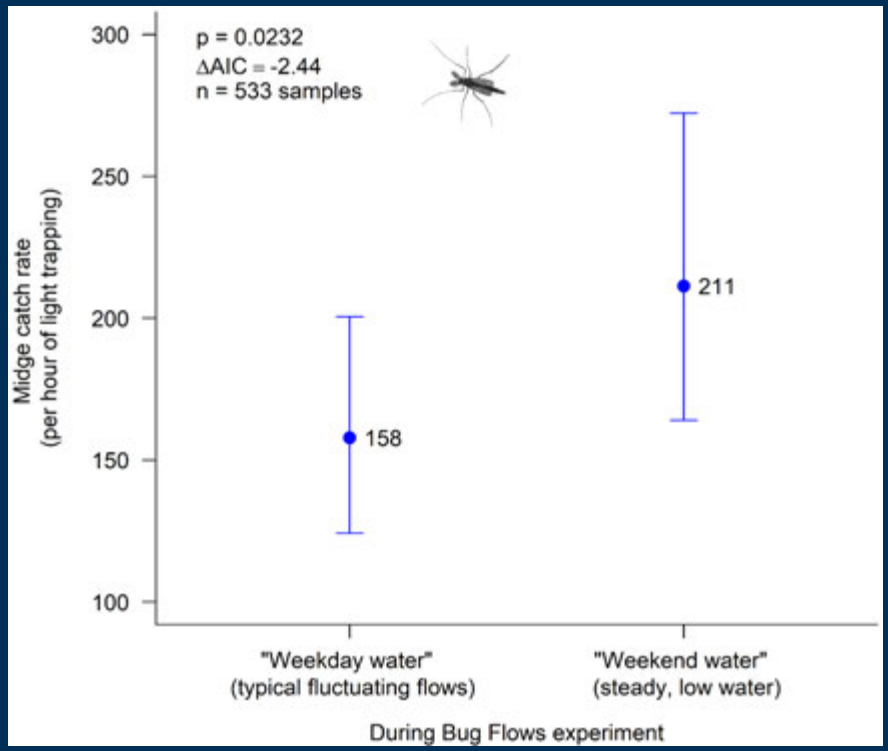
Goal was to improve egg survival, but…

Benefits to other natural processes evident

- **↑GPP**
  - **↑ larval growth**
- **↑Emergence**

More emerging insects on weekends



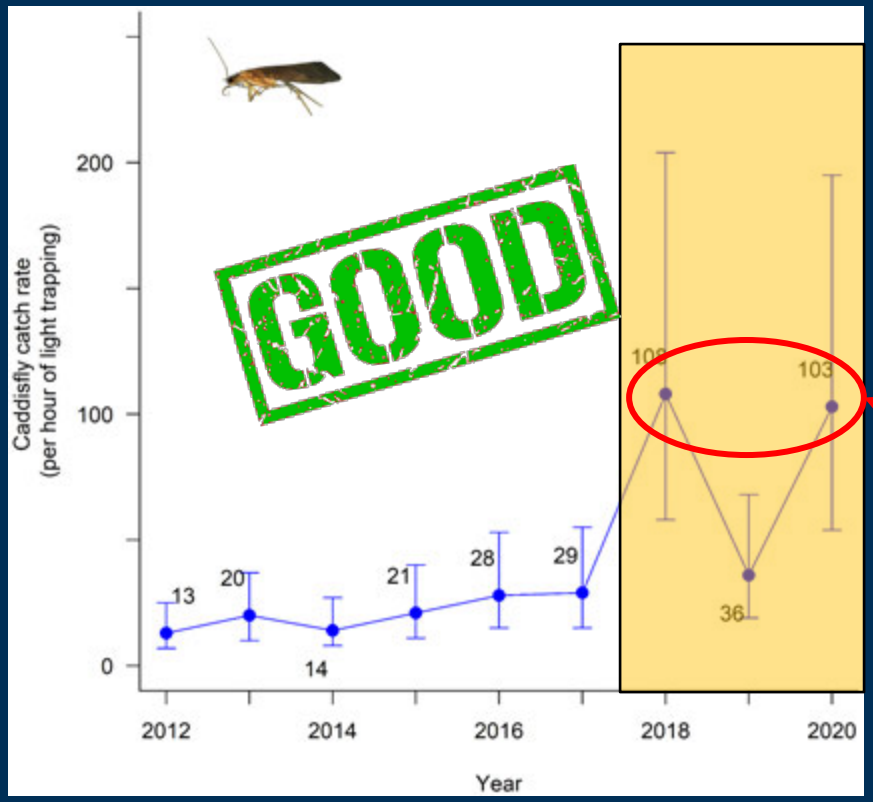


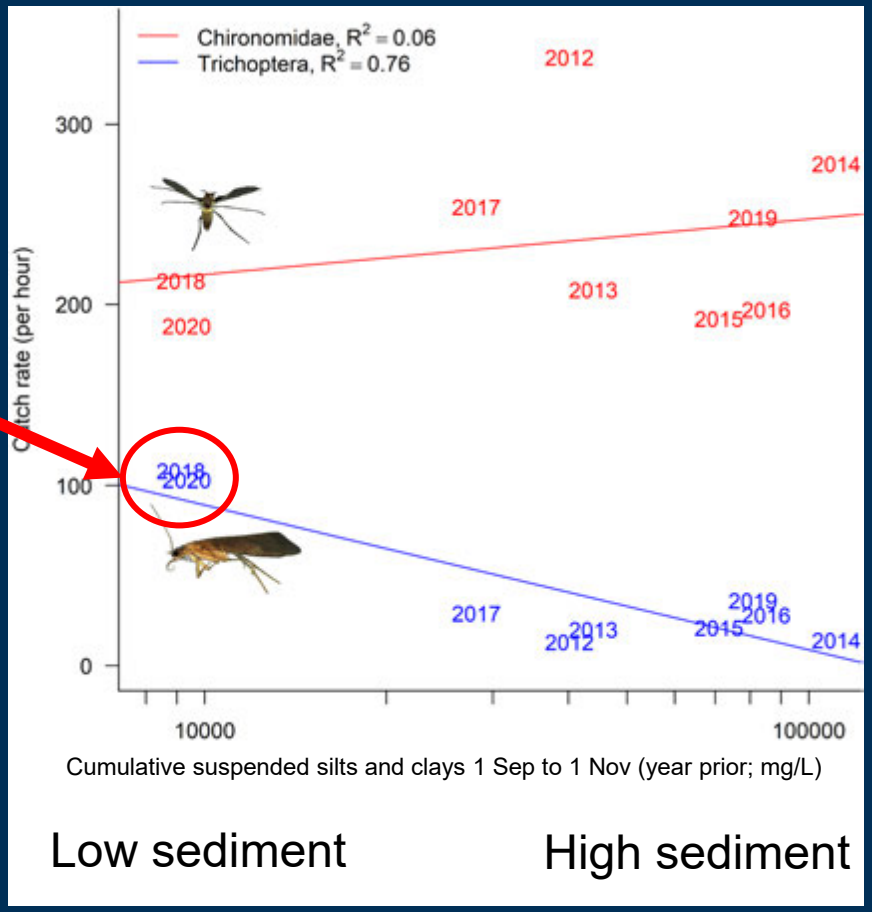
USGS

Insect response to Bug Flows (1)

400% increase in caddisflies during 2 of 3 Bug Flow Years

Or are these 2 good years just because of low sediment?



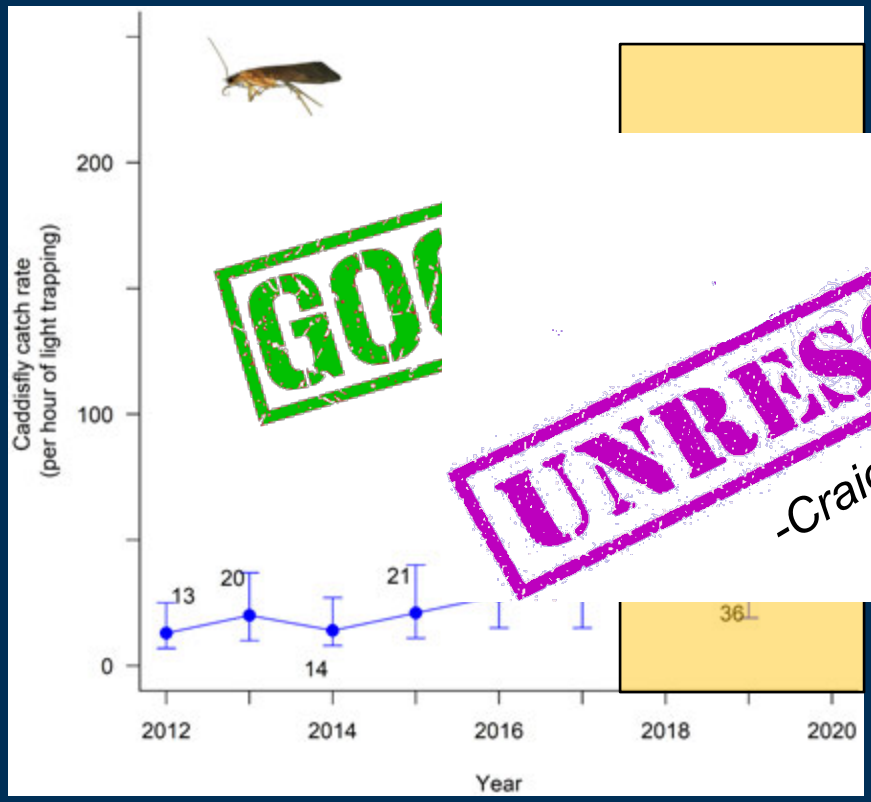


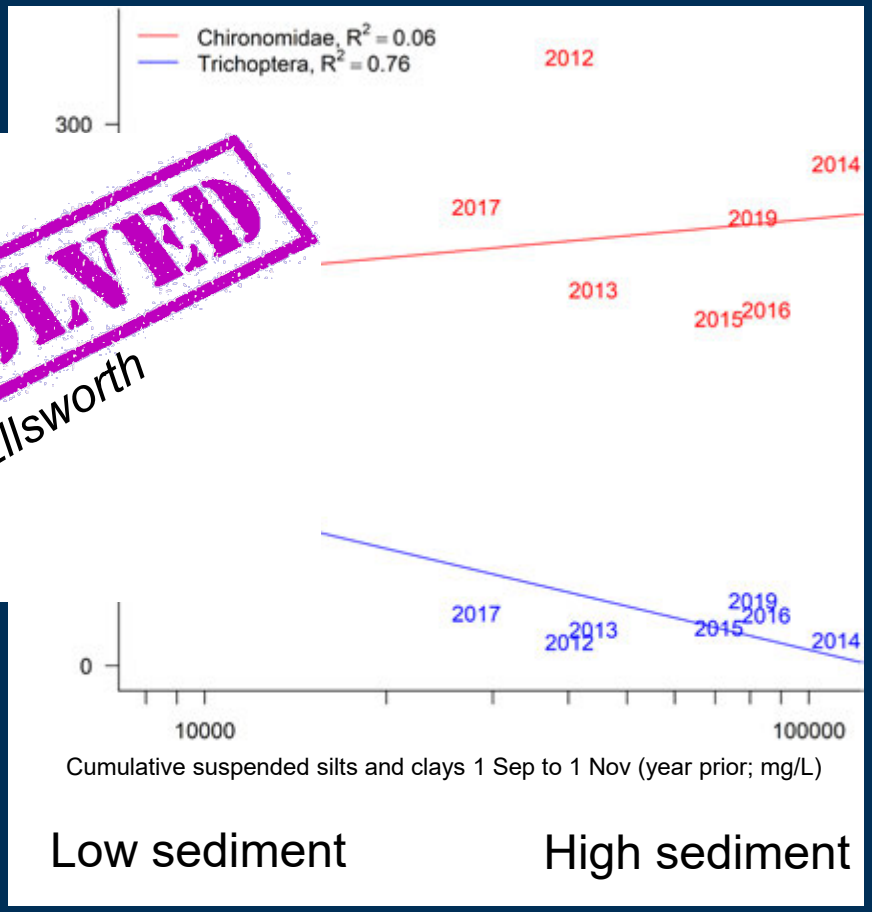
USGS

Insect response to Bug Flows (2)

400% increase in caddisflies during 2 of 3 Bug Flow Years

Or are these 2 good years just because of low sediment?





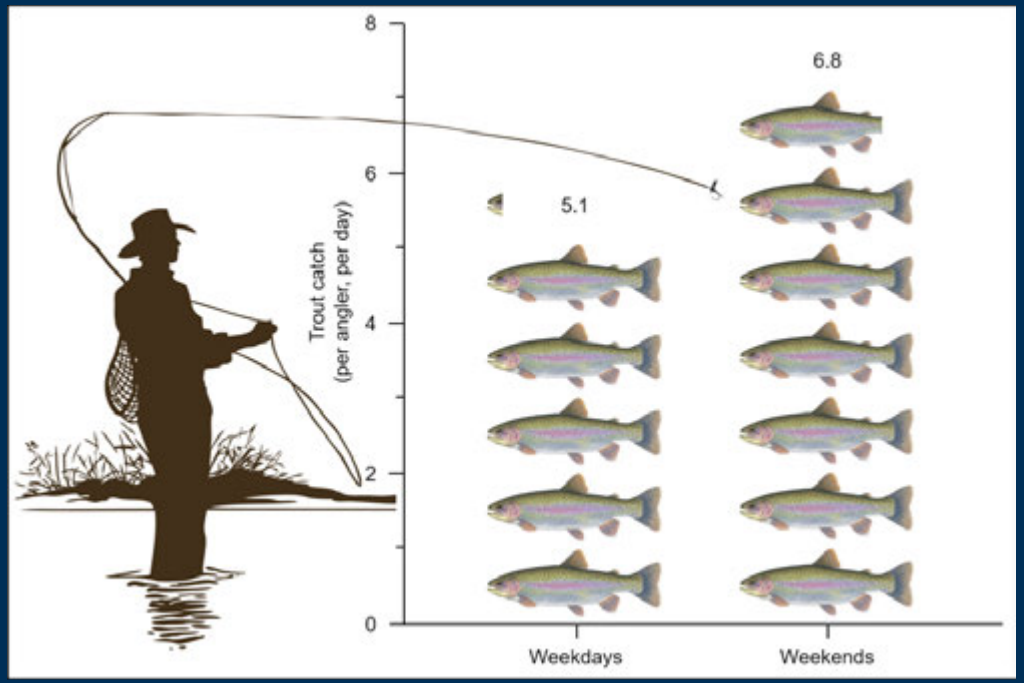
UNRESOLVED

-Craig Ellsworth

USGS

Bug Flow Angling and Diet Study (1)

- June and August, 2019
- ~20 volunteer anglers
  - Fished on Fri-Sat OR Sun-Mon
- Conclusion: Better fishing on weekends

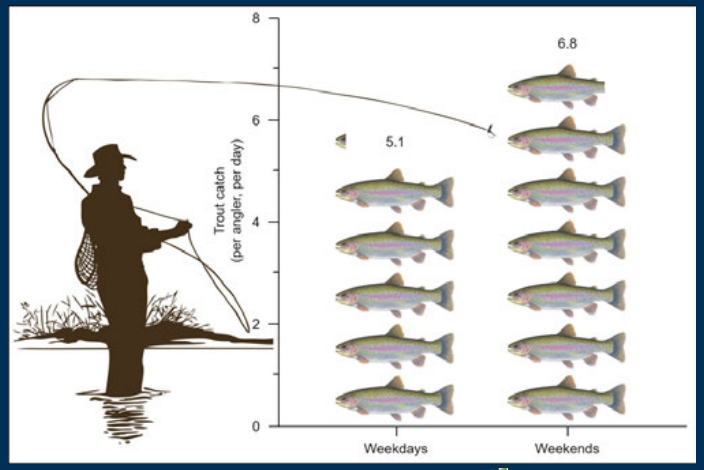


Metcalfe et al. 2020
Boatman's Quarterly Review

USGS

Bug Flow Angling and Diet Study (2)

- June and August, 2019
- ~20 volunteer anglers
  - Fished on Fri-Sat OR Sun-Mon
- Conclusion: Better fishing on weekends



Metcalfe et al. 2020
Boatman's Quarterly Review

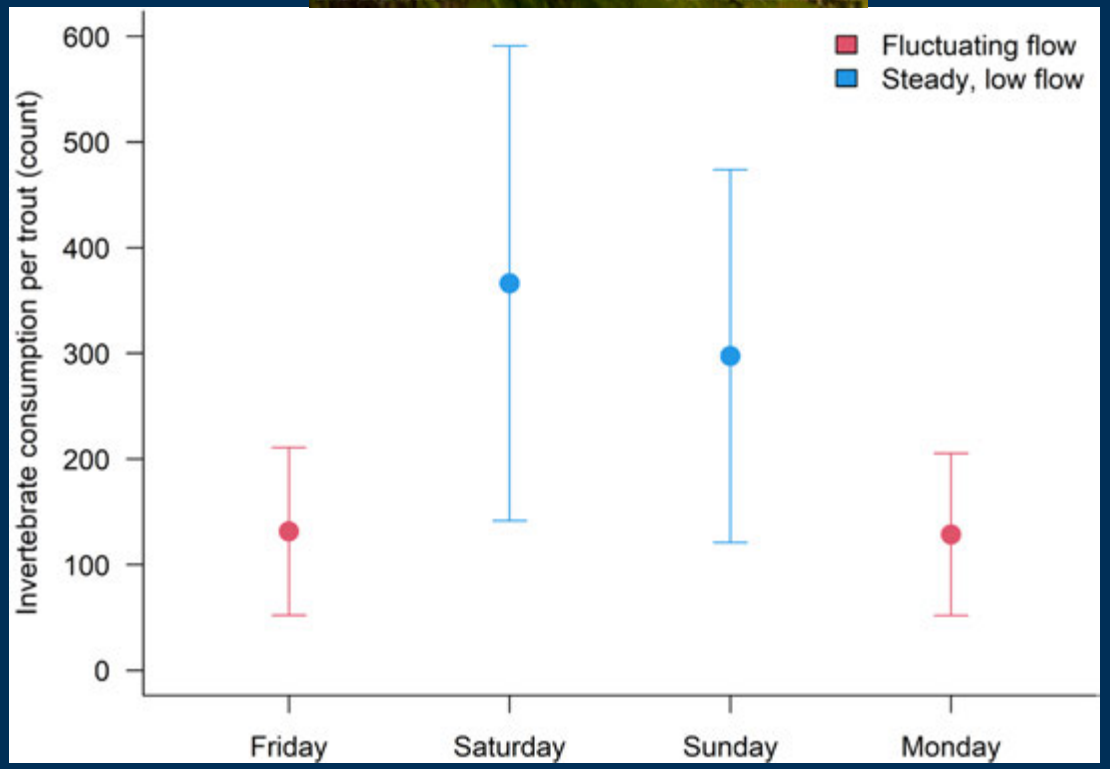
-As part of angling study, stomachs pumped
-Compare weekend vs. weekday feeding habits.

Question: Do Bug Flows affect food availability over short time-scales? (answer on next slide)

USGS

Food availability higher during Bug Flow weekends (1)

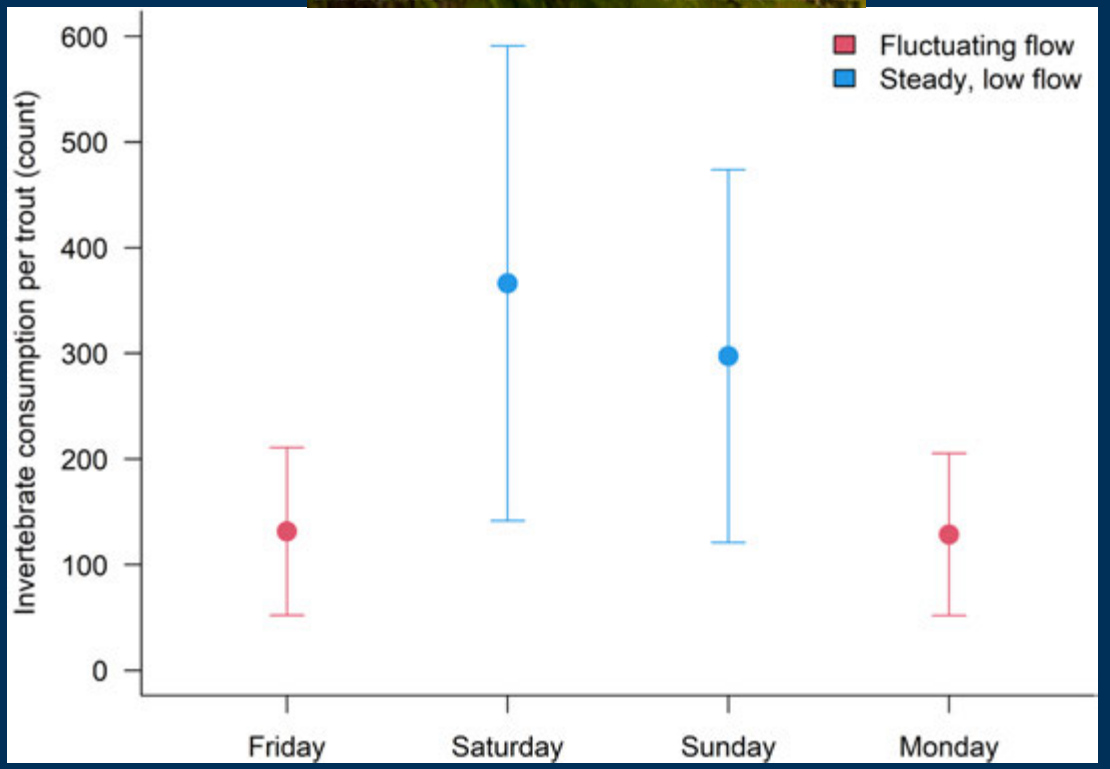
More insects emerging on weekends →more insect prey available on weekends



USGS

Food availability higher during Bug Flow weekends (2)

More insects emerging on weekends →more insect prey available on weekends



Critical Uncertainty: Is the same thing occurring in Grand Canyon with native fish?

USGS

Unpublished data, subject to change, do not cite.

Critical Uncertainties to resolve in 2021?

- ***#1 Do Bug Flows increase food availability for humpback chub and other native fish over short-time scales, like has been observed for rainbow trout in Lees Ferry?***



- ***#2 Do Bug Flows increase food availability for humpback chub and other wildlife populations (i.e., bats) over long-time scales?***
  - ***Are increases in algae production and caddisfly abundance directly contributing to improved growth and condition of native fishes?***
  - ***Are increases in caddisfly abundance sustaining terrestrial wildlife populations such as bats, birds, lizards, and spiders?***

USGS

Unpublished data, subject to change, do not cite.

Project F.4 in Fy21-23 TWP is poised to tackle these uncertainties