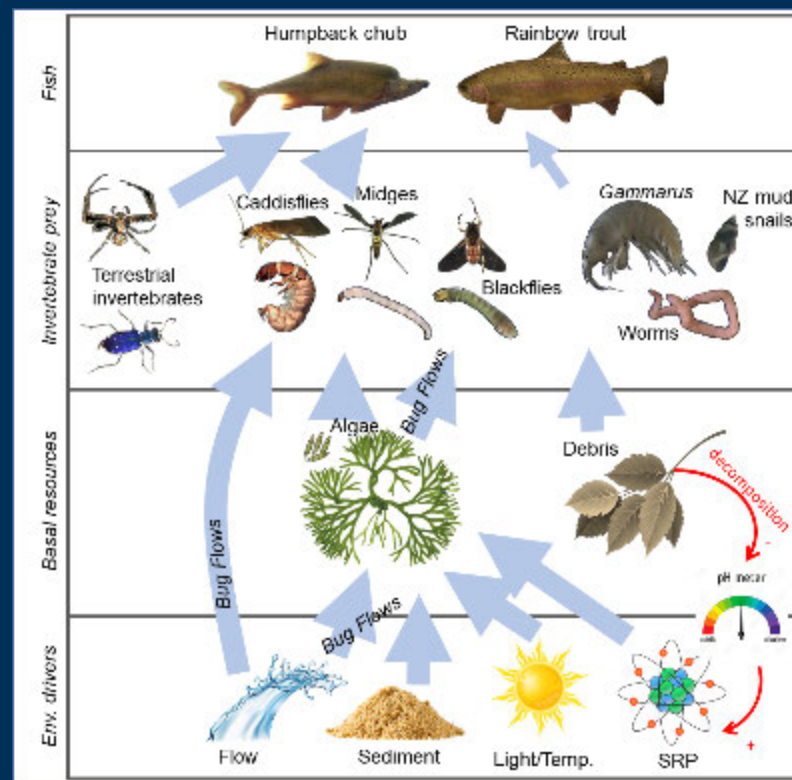


# Project F: Aquatic ecology and food base monitoring

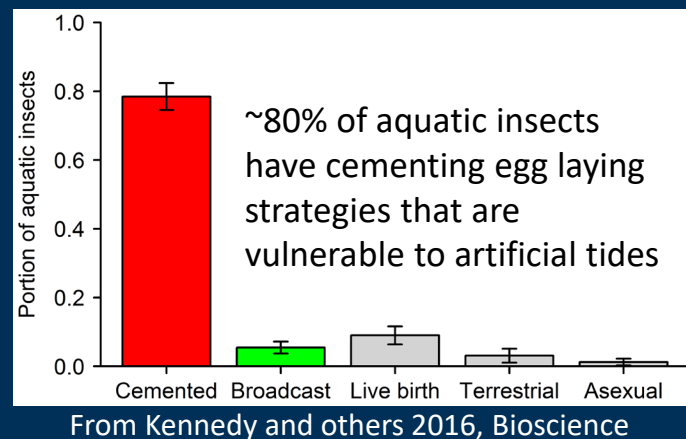
Ted Kennedy<sup>1</sup> & Jeff Muehlbauer<sup>2</sup>



1-US Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, AZ

2-US Geological Survey, Alaska Cooperative Fish and Wildlife Research Unit, Fairbanks, AK

# Why Bug Flows?



Year-round hydropower fluctuations do not support natural processes essential to diverse and resilient invertebrate assemblages

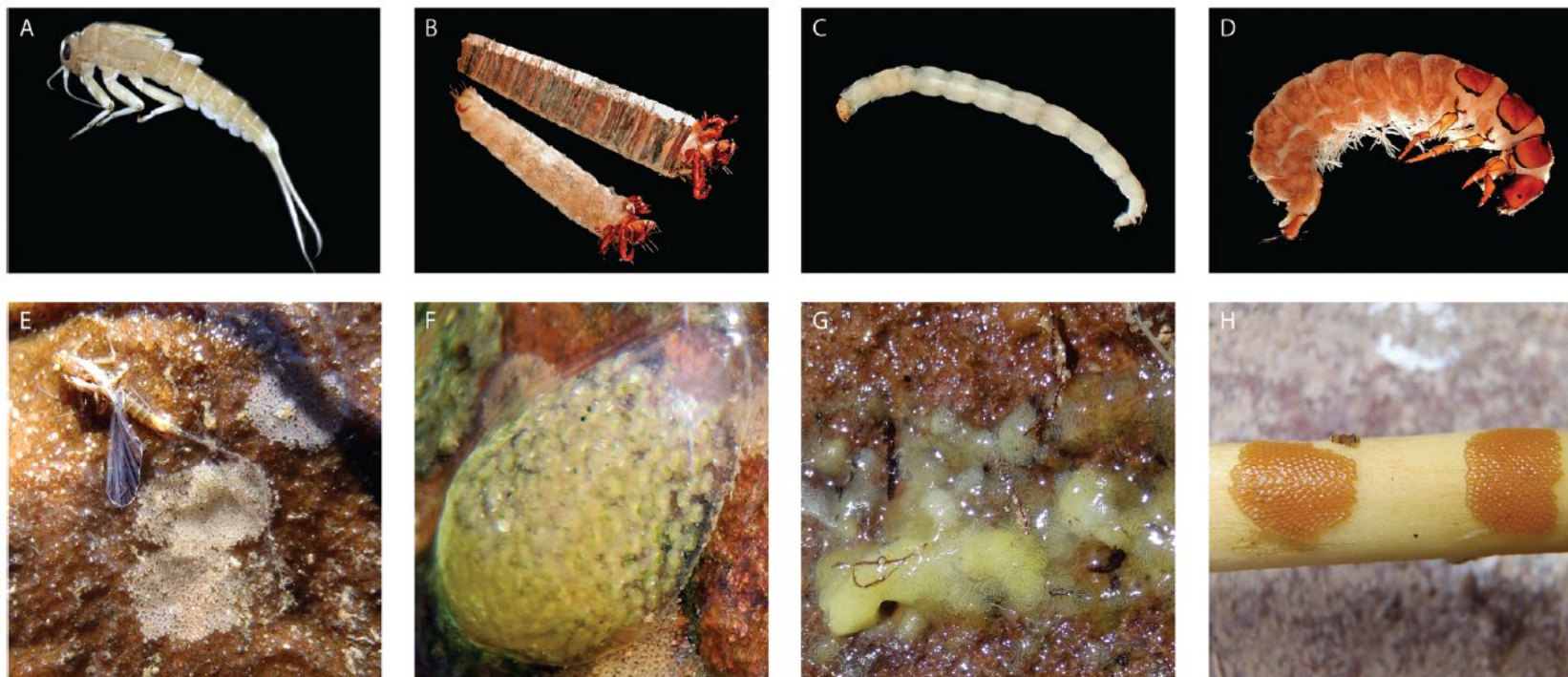
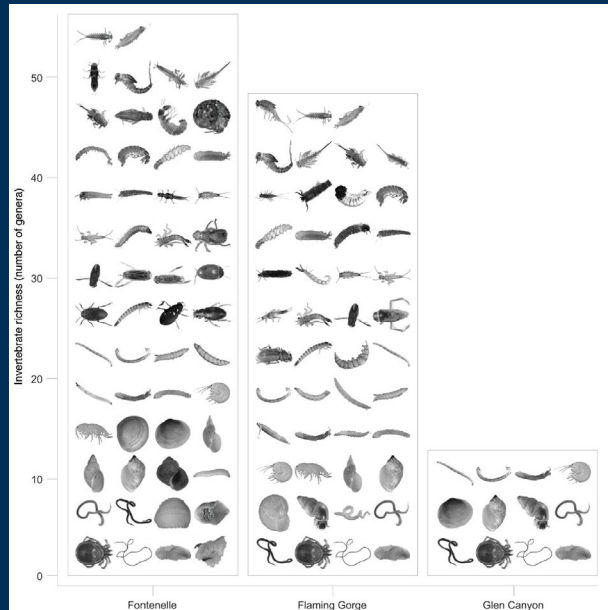


Figure 2. Larval and egg mass photos of *Baetis* spp. (Ephemeroptera) (A, E), *Brachycentrus occidentalis* (Trichoptera) (B, F), Chironomidae (Diptera) (C, G), and *Hydropsyche occidentalis* (Trichoptera) (D, H). Photo credits: Morgan Ford (A), Greg Wada (B, C, D), and Matt Schroer (E, F, G).

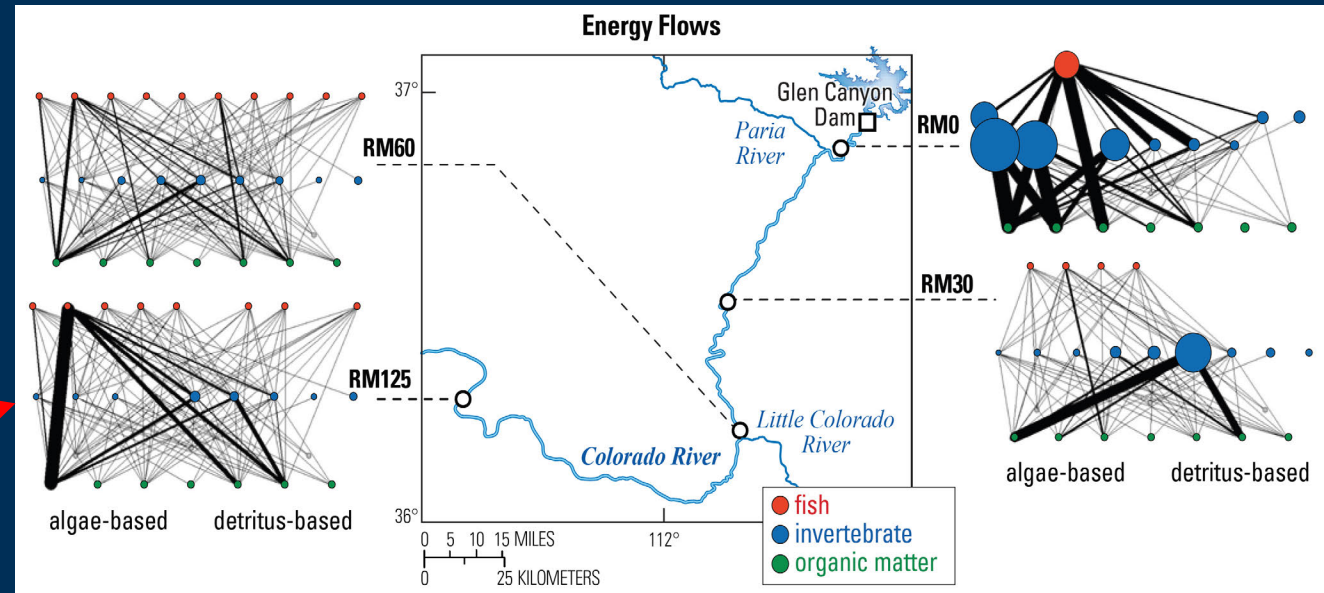
Photos of aquatic insects (top) and eggs cemented on various substrates (bottom).  
From Miller and others 2020, Freshwater Science

# Why Bug Flows?

- Not enough insect prey for fish
- Low diversity, inherently unstable
- Food webs built on algae



Colorado River downstream of Glen Canyon Dam only 1/3 the invertebrate genera of other tailwaters. From Kennedy and others 2016 BioScience.

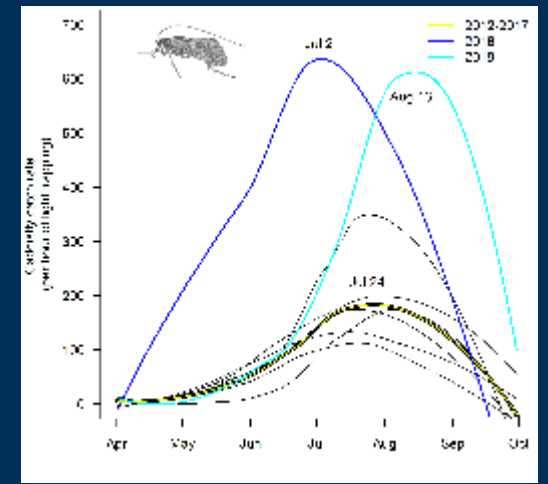


Food webs of the Colorado River circa 2006-2009. From Kennedy and others 2014 USGS Fact-Sheet.

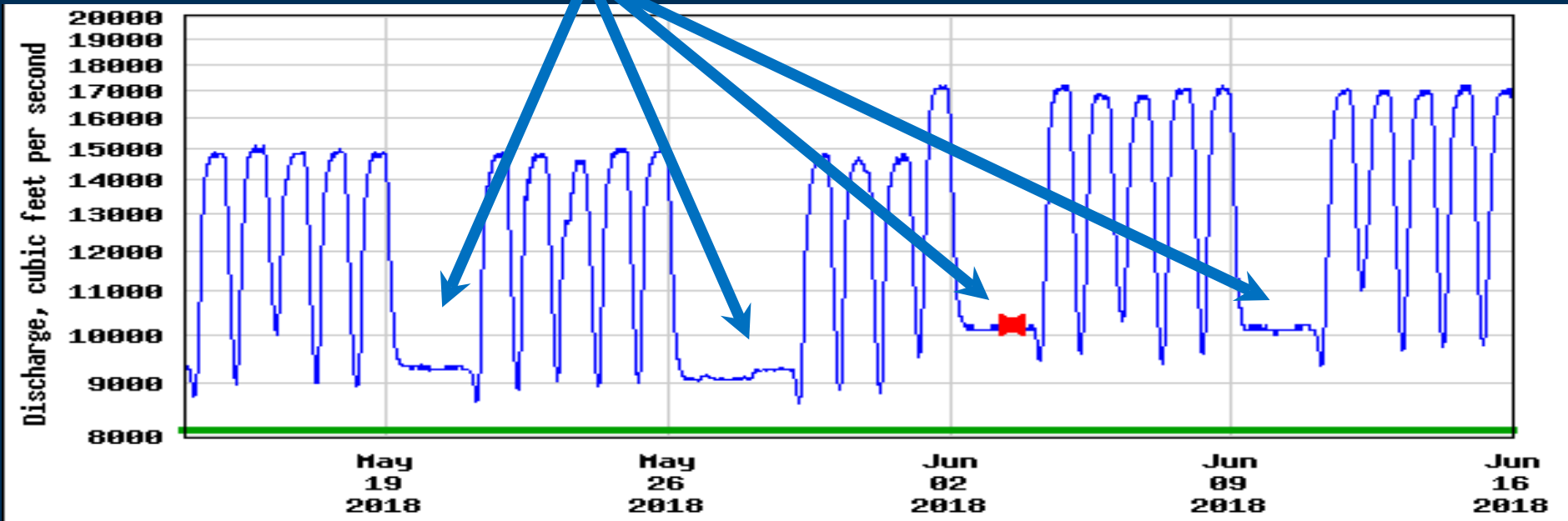


# What is a Bug Flow?

- Give bugs the weekends off
- Weekend stable low flows from May-August
  - 34-36 days/years
  - Tested 2018-2020
- Eggs laid on weekends never dry



May-August  
Unpublished data, subject to change, do not cite.



# Science Advisor Review Timeline

- October 12-GCMRC submits Bug Flow synthesis
- October 28-Bug Flow workshop #1
- November 4-Bug Flow workshop #2
- January 4-Science Advisor review completed
- January 11-ARM presentation w/ 2021 light trap data
- January 13-TWG meeting
- February 9-AMWG meeting (today)

## By the numbers:

4-number of coauthors on synthesis

37-number of pages in synthesis

149-number of pages of comments on synthesis (SA + stakeholder)

U.S. Department of the Interior  
Bureau of Reclamation  
Interior Region 7 – Upper Colorado Basin

## Glen Canyon Dam Adaptive Management Program *Bug Flows Synthesis & Review (Draft)*

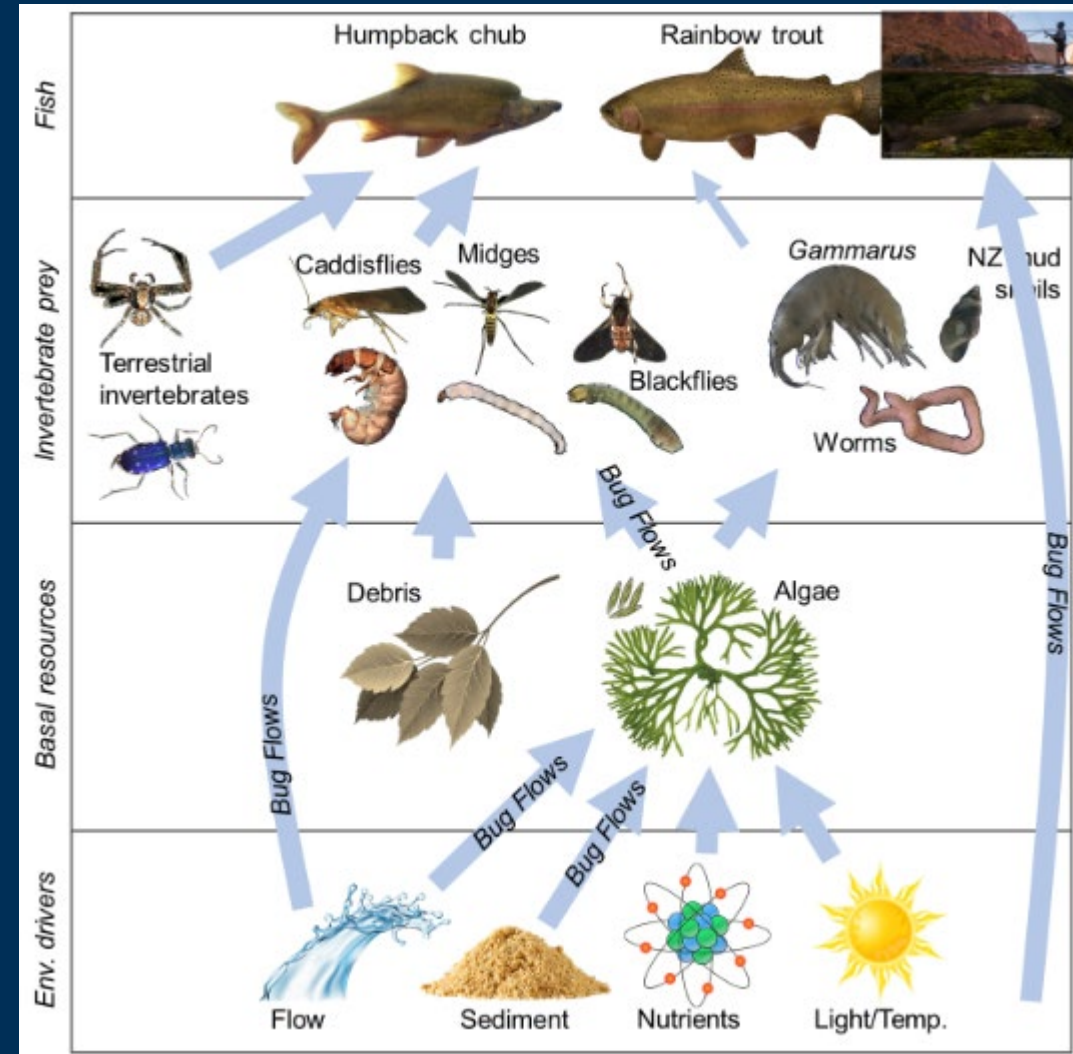


- Draft Bug Flows Synthesis Report - *GCMRC*
- Science Advisors' Review - Summary Report – *Wood LLC*
- Stakeholder Review Comments
  - Hopi Tribe
  - Recreational Anglers
  - National Park Service
  - California
  - WAPA
  - CREDA

# Bug Flows Synthesis Key Findings

- Enhanced natural processes and improved food base
  - More egg laying substrates
  - More insect emergence
  - More caddisflies (but not midges)
  - More GPP
- Enhanced rainbow trout fishery
  - Higher catch rates

“Objective: Improve food base productivity and abundance or diversity of mayflies, stoneflies, and caddisflies” LTEMP Table 4.



# Take Homes from Science Advisors

- Bug Flows were successful
  - Ruhi: “...Bug Flows were successful, overall, in enhancing natural processes...”
  - Downes: “Experiment successfully met proximate and ultimate objectives”
  - Kroll: “...high likelihood the experiment has worked...”
  - Colvin: “The Bug Flows are meeting primary and proximate objectives and the science being conducted is cutting edge.”

# Take Homes

- **National Park Service:**

## Discussion

Totally agree with this statement: "Continued experimentation with steady flows, such as the Bug Flows experiment, may be merited based on the caddisfly response alone." I wonder how

- **Fly fishers:**

While recent power generation considerations have changed the equation, it is still a very worthwhile experiment that I feel would continue to benefit both the trout and native fishes in the river.

- **Hopi:**

This is a project that looks at the interconnectivity of things and should continue. The mixed results mean more studies should continue. The Hopi would like to see more results as they like the interconnectedness of the project, but the mixed results provide them mixed feelings on it.



# Take Homes

## ■ WAPA:

We appreciate the opportunity to comment on the bug flows synthesis paper, and we want to recognize the tremendous amount of work that has gone into the experiment and synthesis. We appreciate the opportunity to be involved with the study design and the ability to try to reduce impacts to hydropower. This collaboration has decreased the impact of the experiment on the hydropower resource and provided interesting results.

### Conclusions

Although the hypothesis regarding the bug flow experiment was promising, the data collected during the experiment does not appear to have established a link between weekend steady flows and increased production at higher trophic levels (i.e., aquatic insects and fish). During the three years of the bug flow experiment, we have seen:

## ■ CREDA:

Using multiple lines of evidence, Kennedy and others (2016) demonstrated hydropeaking induced mortality of aquatic insect eggs was likely a major factor limiting the production and diversity of aquatic insect assemblages in the Colorado River (Figure 4.1). The goal of the Bug Flows experiment, therefore, was to reduce this hydropeaking stressor to the extent possible



we continue to have concerns with the use of "hydropeaking", and subjective terms such as a "major factor". Further, to characterize the hydropower resource, an authorized purpose, and LTEMP goal, as a "stressor" may be inappropriate.

## ■ California

We are seeking to improve our understanding of the following outstanding questions:

- Given lowest abundance on record during the three years of bug flows, what is the likelihood that bug flows are detrimental to midges and/or black flies?
- What is the likelihood that bug flows may lead to an increase in the size of the brown trout population? What is expected magnitude of any such increase?

# Take Homes from Science Advisors

- Report should include more details
  - More statistics
  - Include summary table
  - Better link to hypotheses and objectives
  - Separate direct vs. indirect effects

- Summary table of research question, hypotheses, and expectations is needed

Michael Colvin

- A table summarizing all data available would be useful. Adding basic metadata would be valuable for the reader and could spur research synthesis

Albert Ruhi

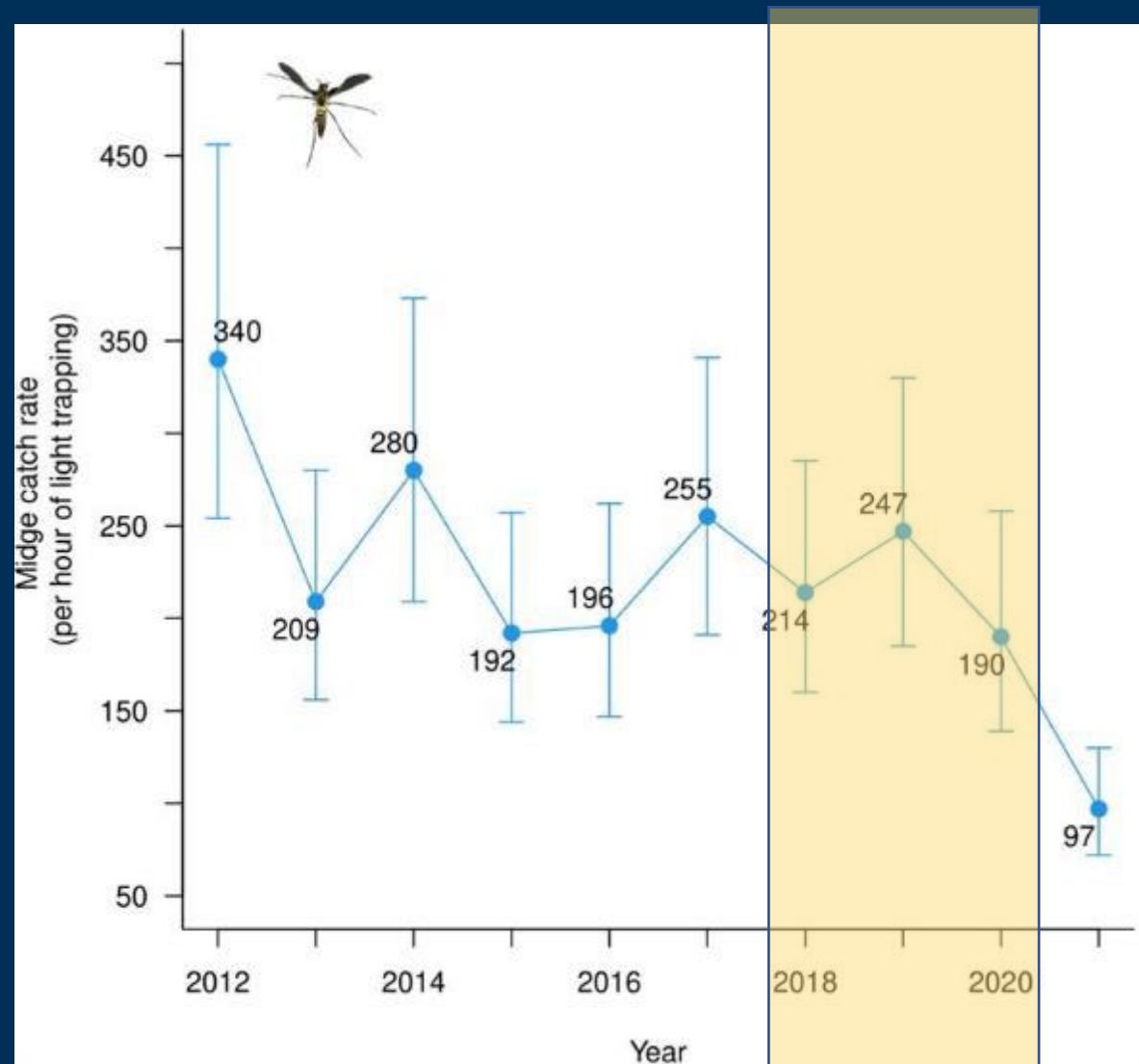
- Present hypotheses and their associated predictions in the introduction, unexpected results should not be considered “failures”

Barbara Downes

# UPDATED RESULTS

- Cessation of Bug Flows associated with ~50% decline in midges

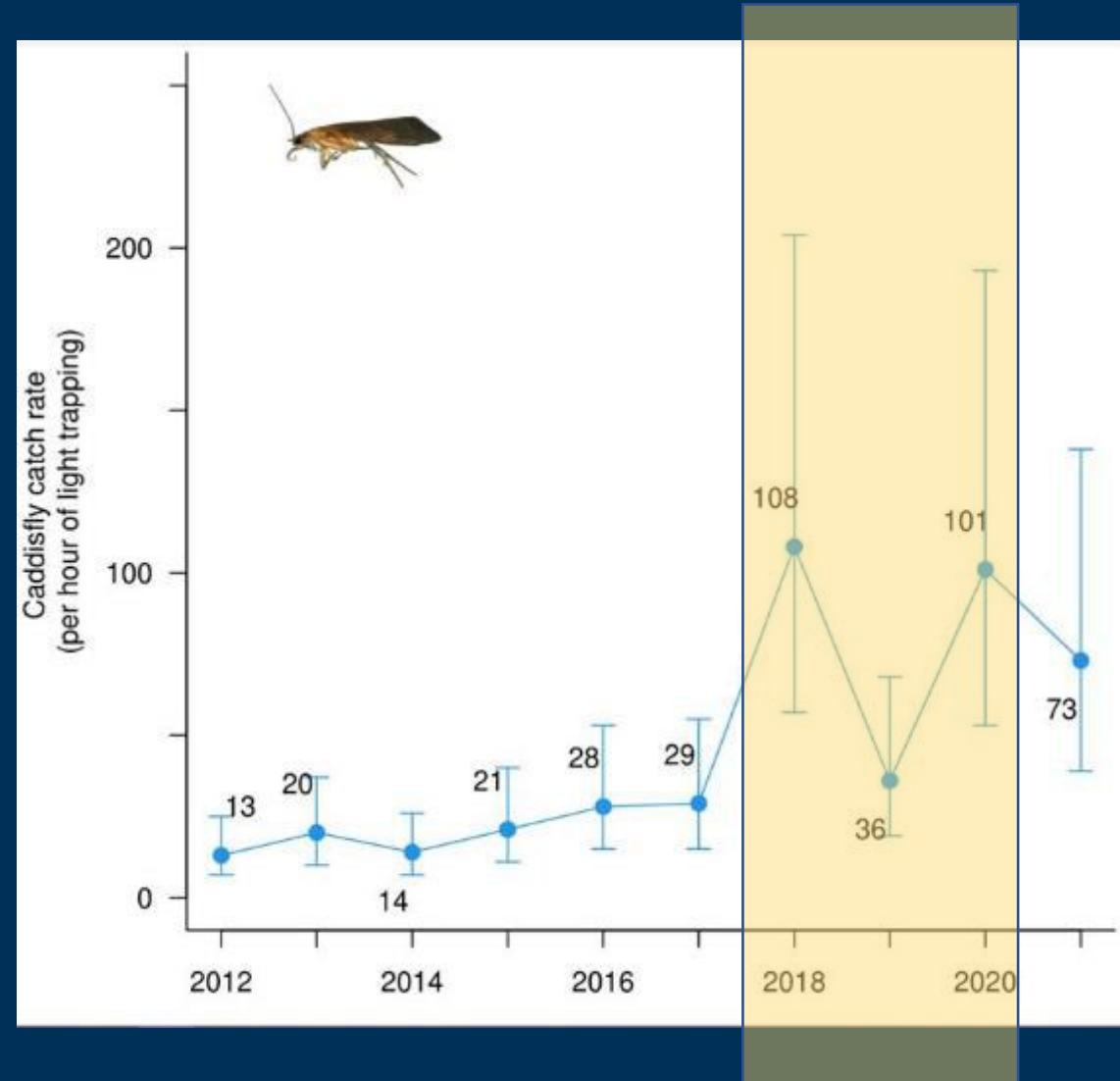
Consistent with hypothesis that Bug Flows were improving conditions for midges



# UPDATED RESULTS

- Cessation of Bug Flows associated with ~25% decline in caddisflies

Tough to untangle what 2021 means  
- no direct benefits to larvae or emergence  
+ multiple years of good egg laying

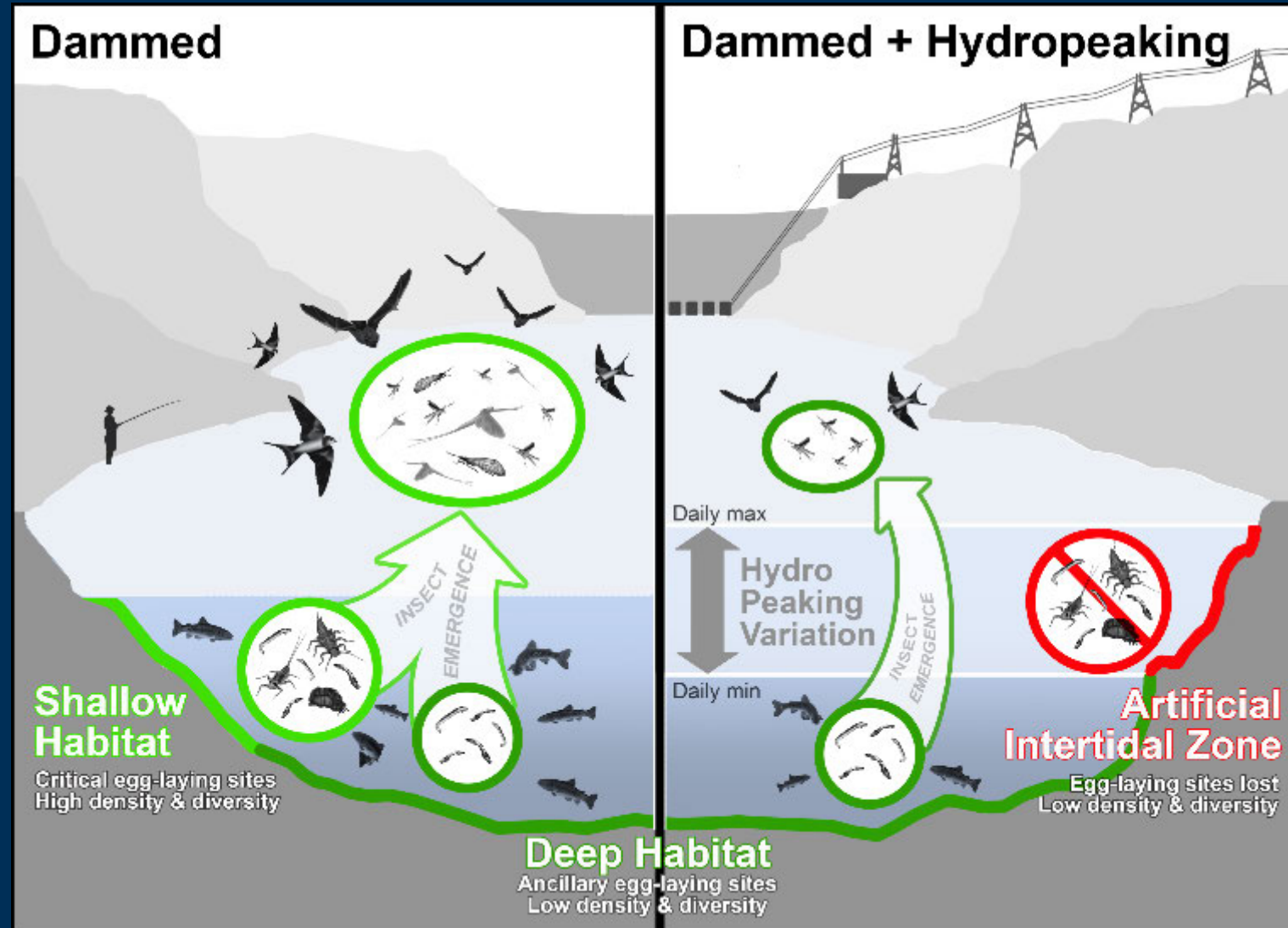


## Next steps

- Revise report based on SA and stakeholder feedback
- Continue analyzing food base data to squeeze more insight

## Conclusion

The best available science continues to indicate that Bug Flows were successful at enhancing Natural Processes



From Kennedy and others 2016 BioScience.