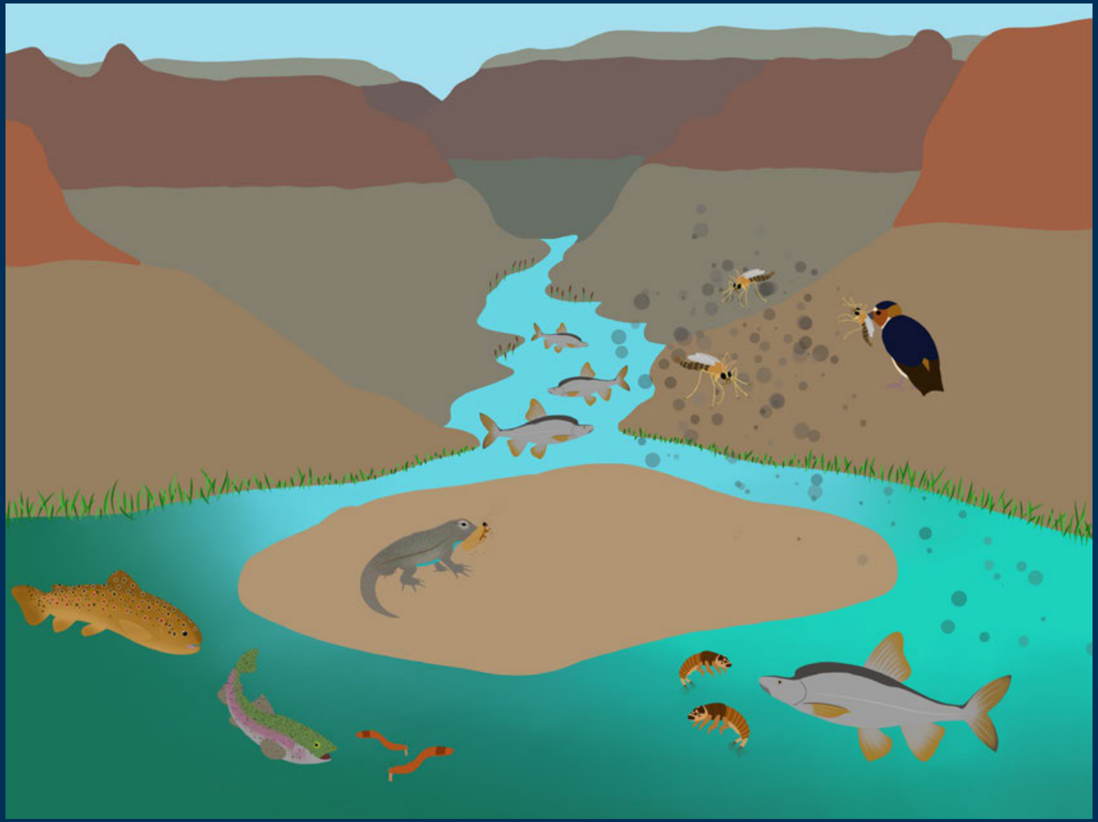
Project F: Aquatic Invertebrate Ecology



Conceptual model of select Natural Processes at the Little Colorado River confluence
Figure courtesy of Diana Valentine

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1-U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, AZ

2-U.S. Geological Survey, Alaska Cooperative Fish and Wildlife Research Unit, Fairbanks, AK

Ted Kennedy[1], Eric Scholl[1], Jeff Muehlbauer[2], Kate Behn[1], Anya Metcalfe[1], Morgan Ford[1], Cheyenne Szydlo[1], Charles Yackulic[1], Kyle Hanus[1], Megan Starbuck[1]

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

Outline

- **Background (2 slides)**
- **Invertebrate Drift Monitoring in Glen Canyon (3 slides)**
- **Citizen Science Monitoring in Grand Canyon (5 slides)**
- **Conclusions (2 slides)**

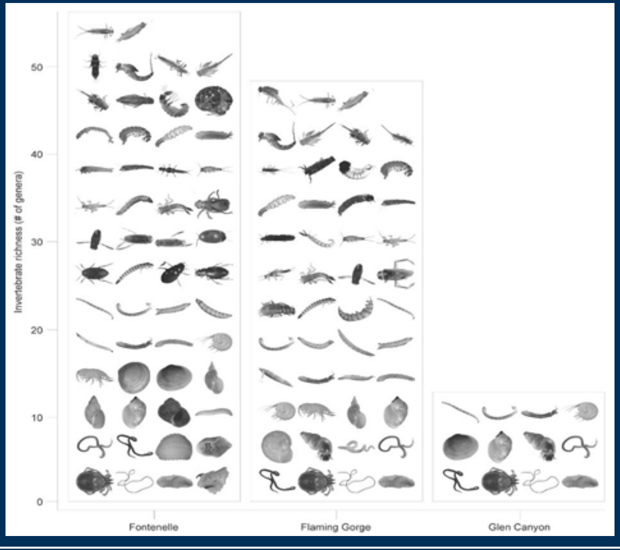
Damselfly
(Sub Order-Zygoptera)

Stonefly
(Order-Plecoptera)

Caddisfly
(Order-Trichoptera)

Photo credit: Freshwaters Illustrated, Dave Herasimtschuk

From Kennedy and others 2016, Bioscience



Bar graph showing invertebrate diversity below Glen Canyon Dam is low compared to other Colorado River tailwaters

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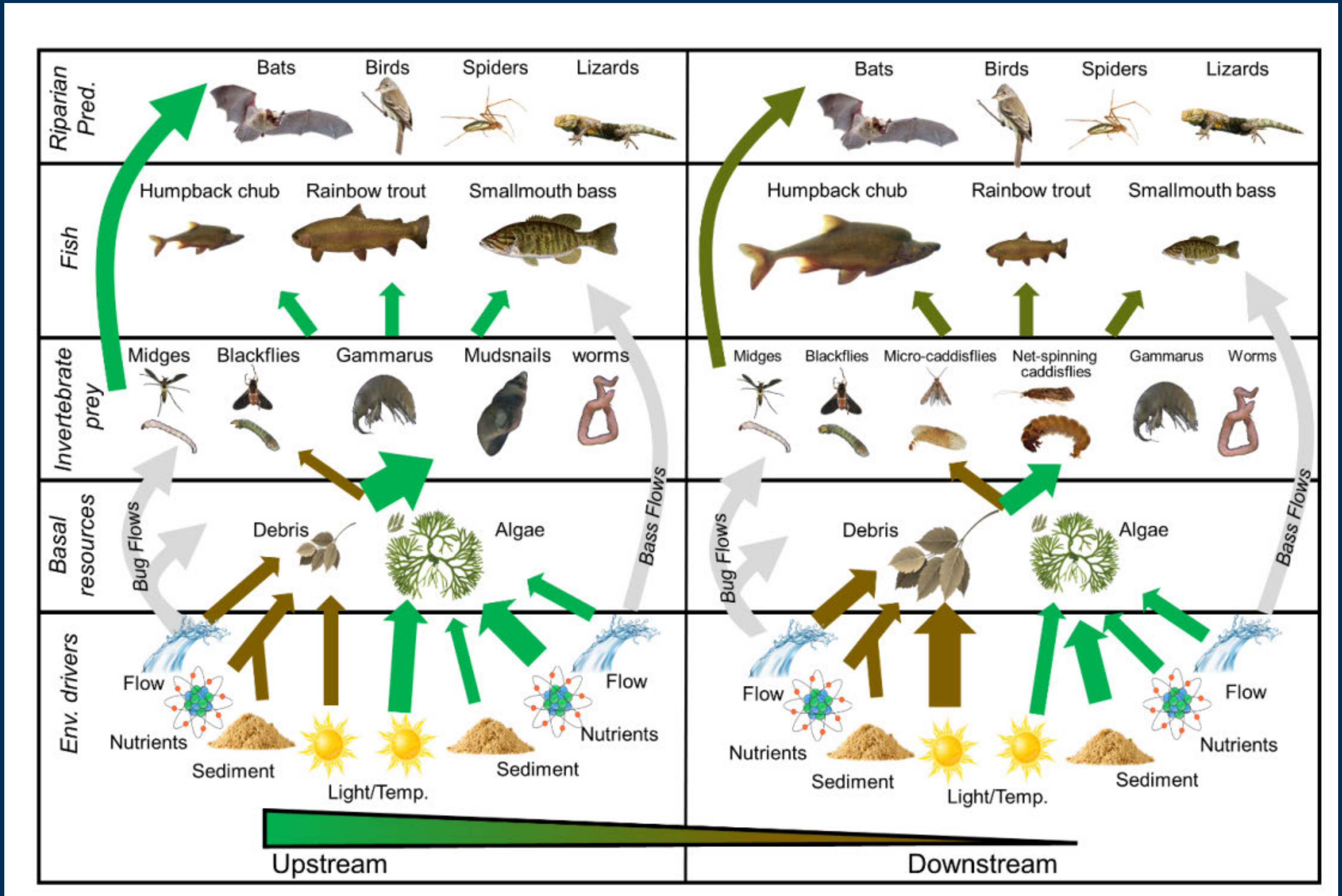
Why study food webs and the aquatic food base?

Key takehomes from 2006-2009 food webs studies:

- Fish food limited
- Very few aquatic insects
- Food webs built upon algae
- Flows & flow experiments can affect fish via changes in food resources

Therefore…

- Food base monitoring aids interpretation of fish monitoring data



Article describing food web dynamics and their response to 2008 HFE:
Cross, W. F., Baxter, C. V., Rosi-Marshall, E. J., Hall Jr, R. O., Kennedy, T. A., Donner, K. C., ... & Yard, M. D. (2013). Food-web dynamics in a large river discontinuum. Ecological monographs, 83(3), 311-337.

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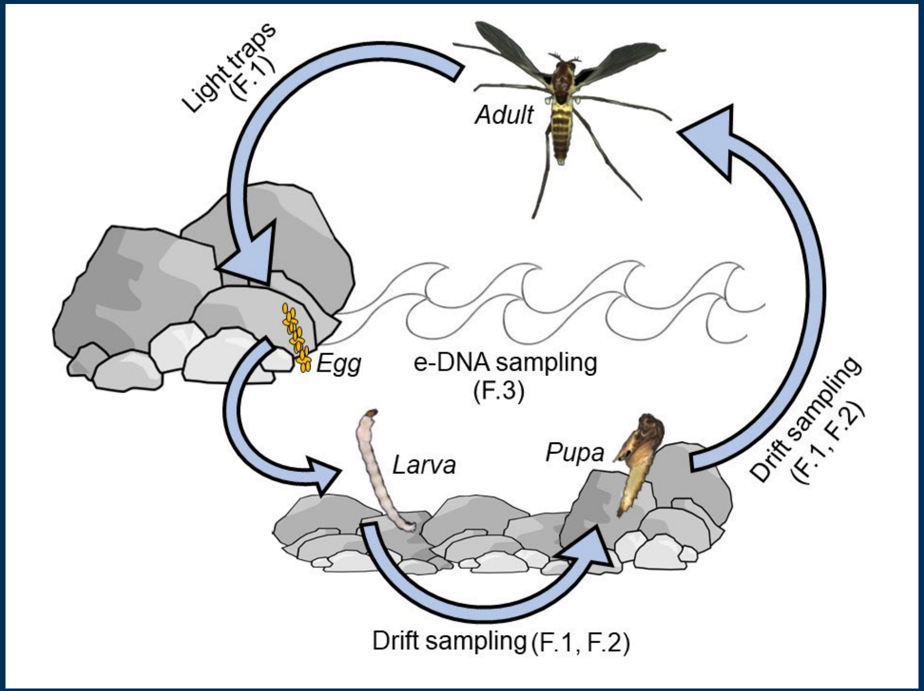
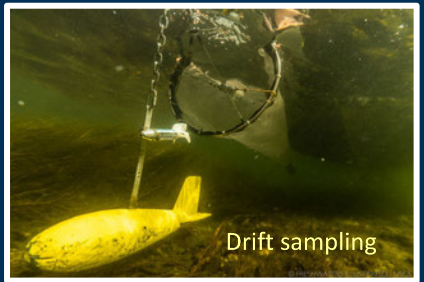
Monitoring food webs in a massive ecosystem

Aquatic insects have complex lifecycles



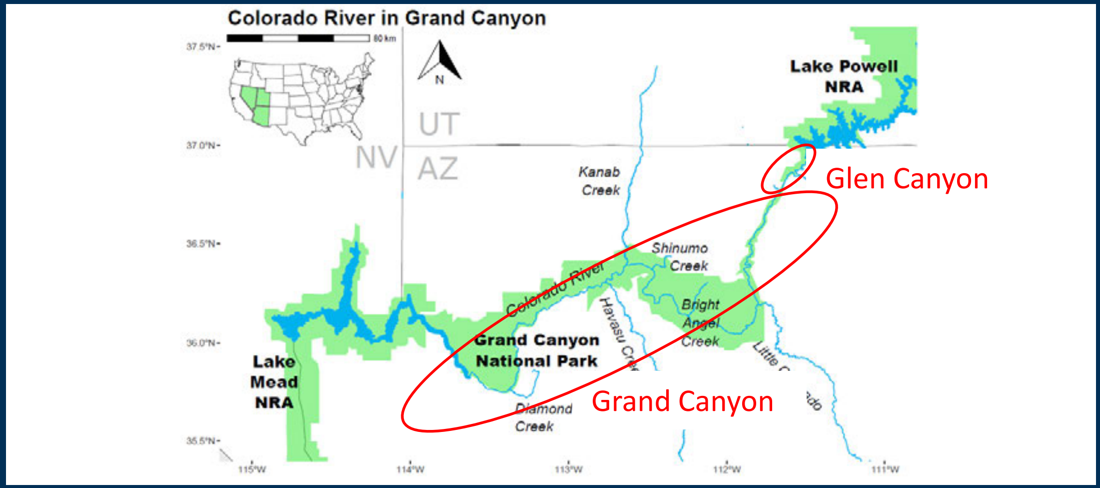


(Glen Canyon only, 2007- present)

(Grand Canyon only, 2012-present)

(Grand Canyon only, 2017-2024)

(Glen and Grand Canyon, 2021-present; see next talk)



Humpback Chub
in Grand Canyon

Rainbow trout
in Glen Canyon

<u>Article describing role of citizen science in adaptive management:</u>
Metcalfe, A. N., Kennedy, T. A., Mendez, G. A., & Muehlbauer, J. D. (2022). Applied citizen science in freshwater research. Wiley Interdisciplinary Reviews: Water, 9(2), e1578.

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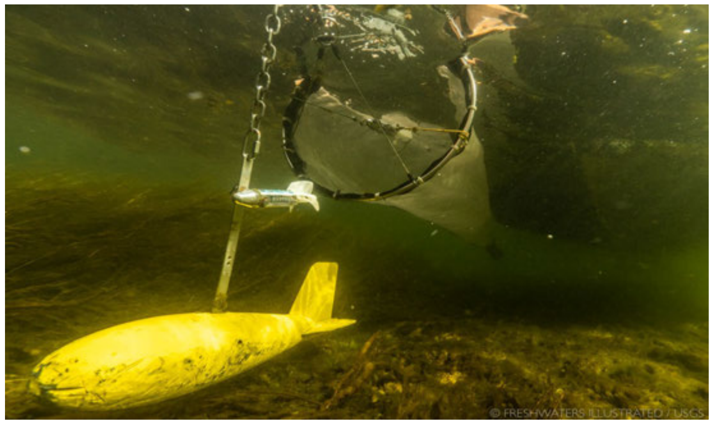
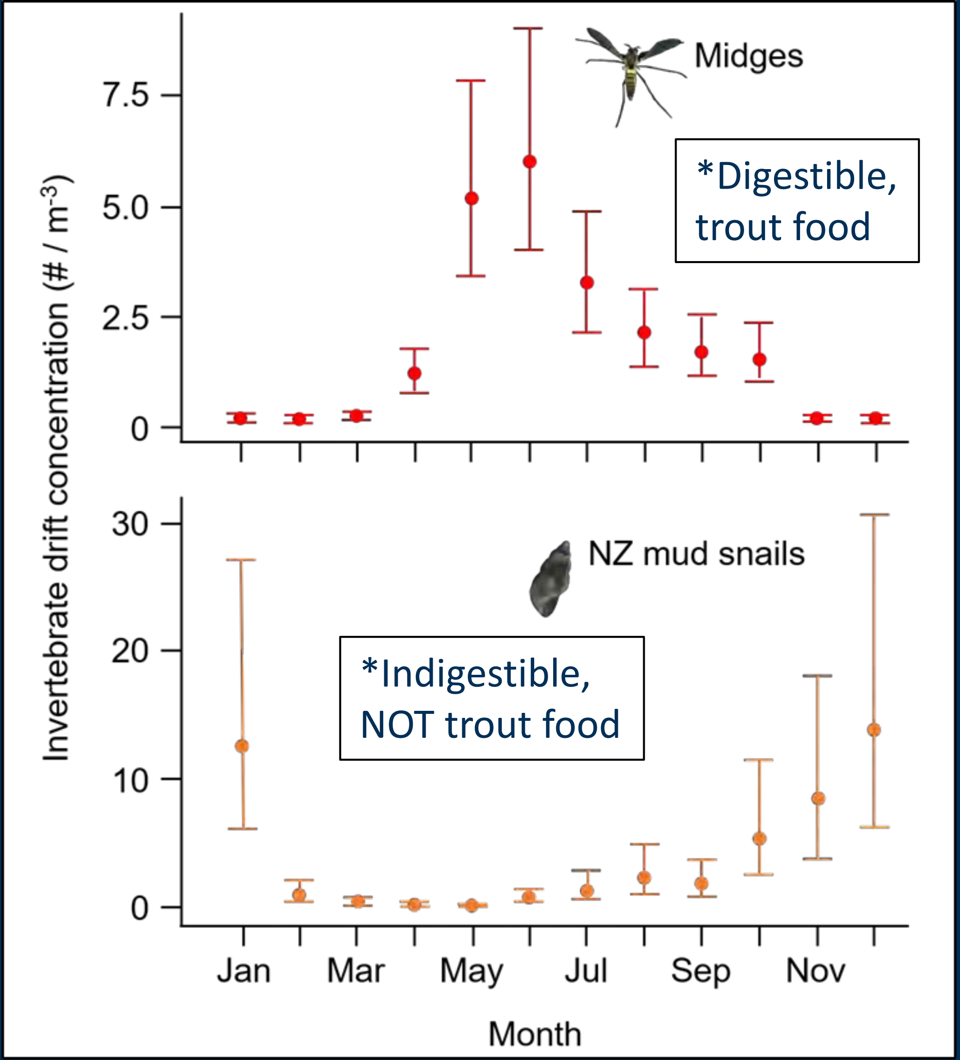
- **Metric of food availability for drift-feeding Rainbow Trout**
  - **2008-2024: monthly sampling**
  - **2025-present: quarterly sampling**



Humans sampling the drift

Rainbow Trout sampling the drift



Monthly patterns in drift abundance for two common invertebrates

<u>Article describing controls on invertebrate drift:</u>

Kennedy, T. A., Yackulic, C. B., Cross, W. F., Grams, P. E., Yard, M. D., & Copp, A. J. (2014). The relation between invertebrate drift and two primary controls, discharge and benthic densities, in a large regulated river. Freshwater Biology, 59(3), 557-572.

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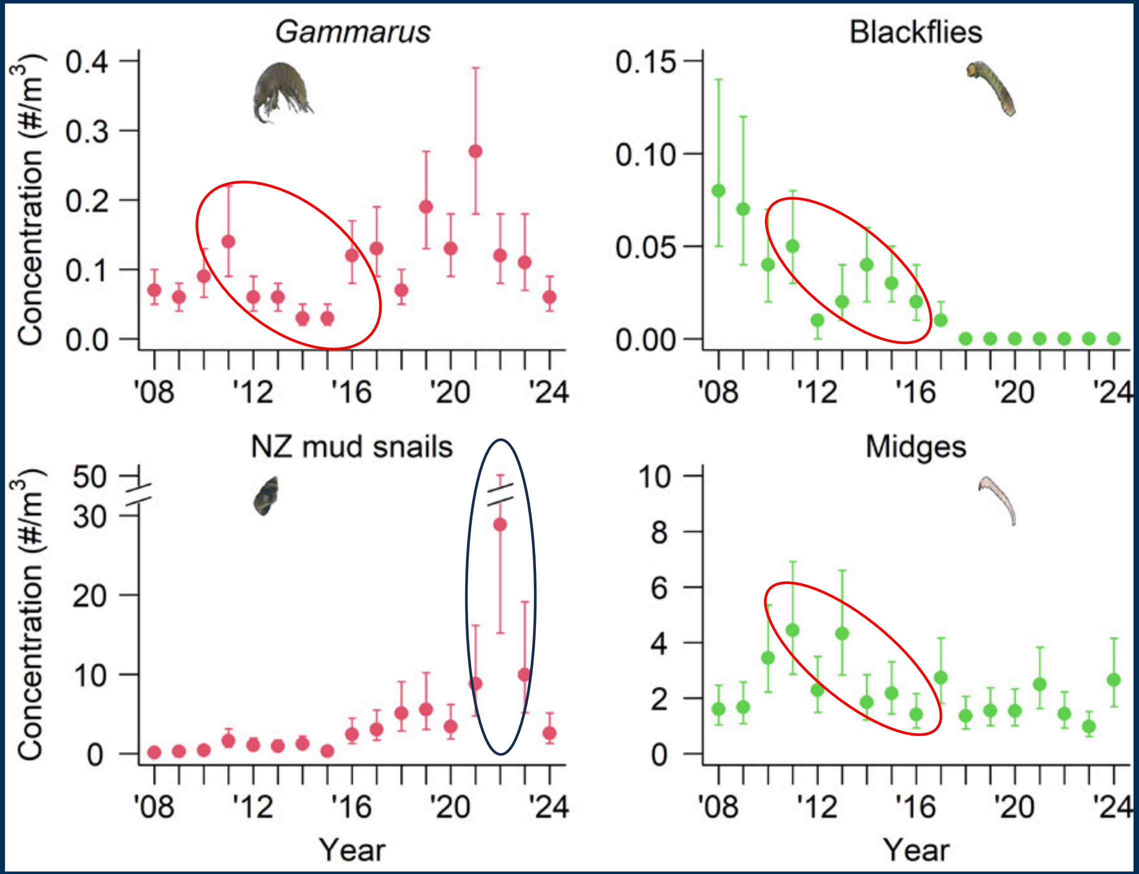
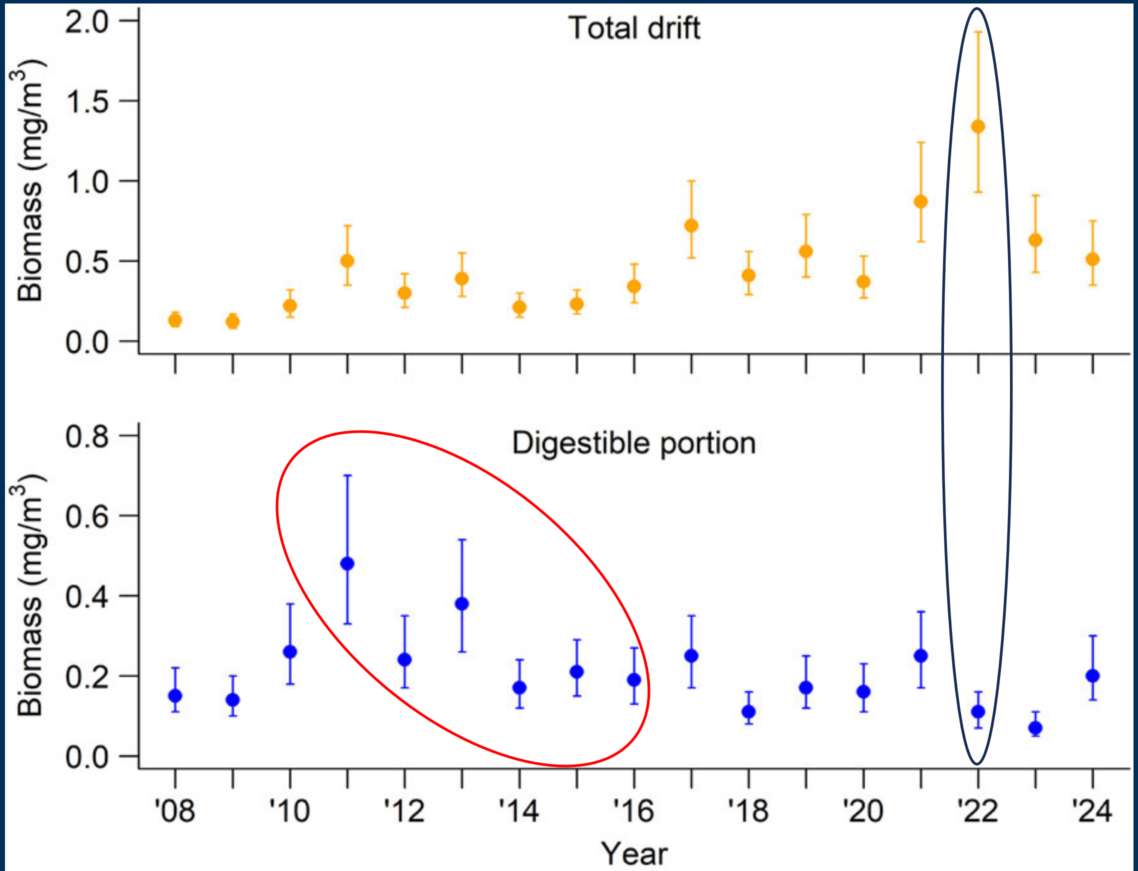
Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Drift monitoring: Long-term trends

Long-term trends for four common invertebrates



Long-term trends in total and digestible drift biomass



Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Article describing how decreases in prey (red circles) triggered collapse of the Rainbow Trout fishery:
Korman, J., Yard, M. D., Dzul, M. C., Yackulic, C. B., Dodrill, M. J., Deemer, B. R., & Kennedy, T. A. (2021). Changes in prey, turbidity, and competition reduce somatic growth and cause the collapse of a fish population. Ecological Monographs, 91(1), e01427.

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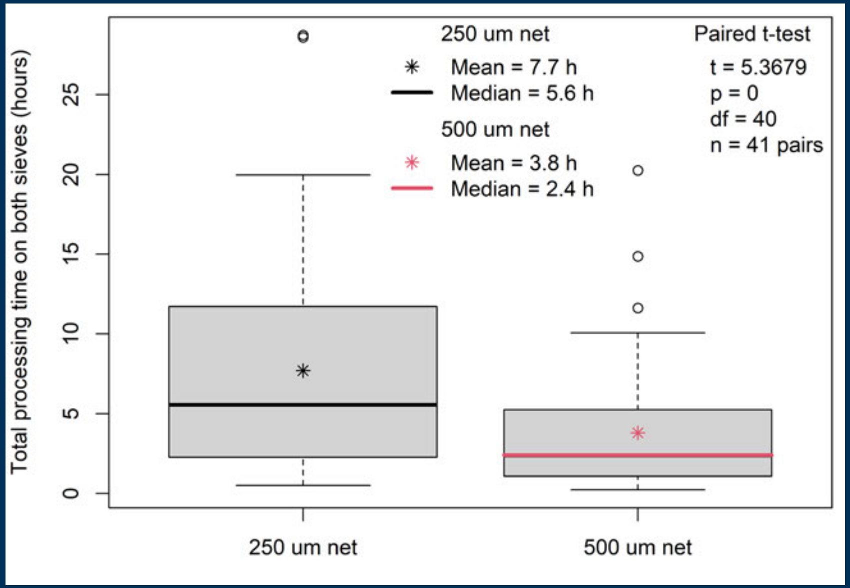
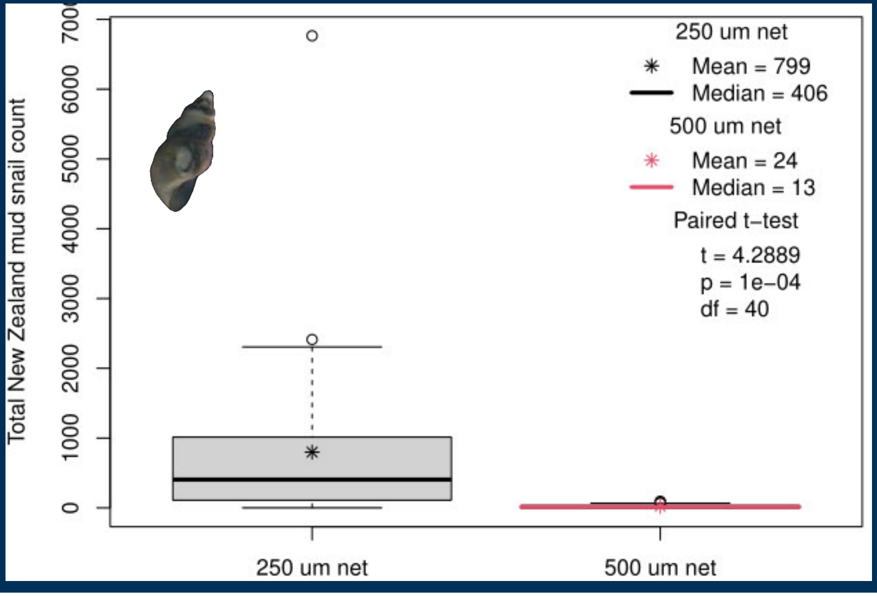
Drift monitoring: Net Mesh Size

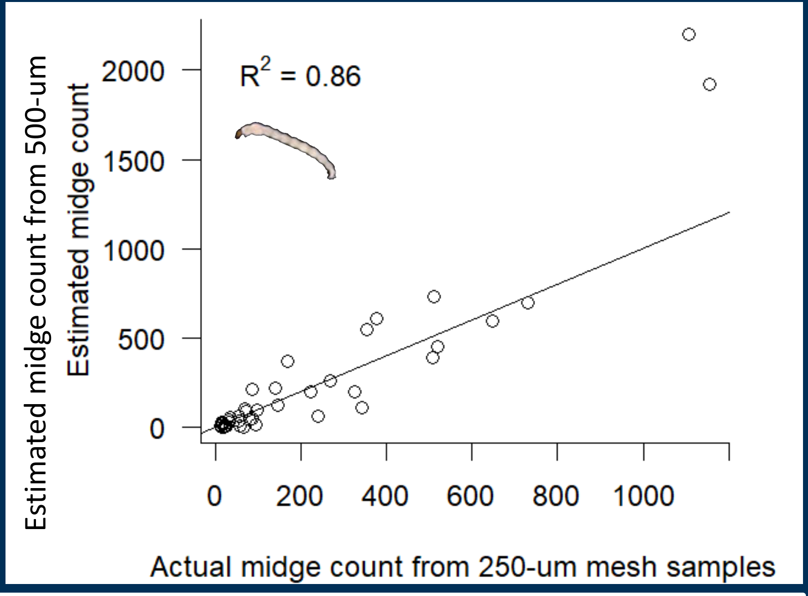
Lab processing time varies by net mesh size



Because



Mesh size correction/regression



<u>In a nutshell</u>

Briefly switched to coarse nets to speed processing times.

Fine-mesh nets (250 µm) : 2008-2019, 2023-present.

Coarse-mesh nets (500 µm): 2018-2023 i.e., both nets used in 2018 (n=40 paired samples w/ both nets).

Goal was to correct for mesh change, but frequency of zeroes for food base items increased, making corrections challenging.

<u>Reverted back to fine-mesh nets in February 2023.</u>

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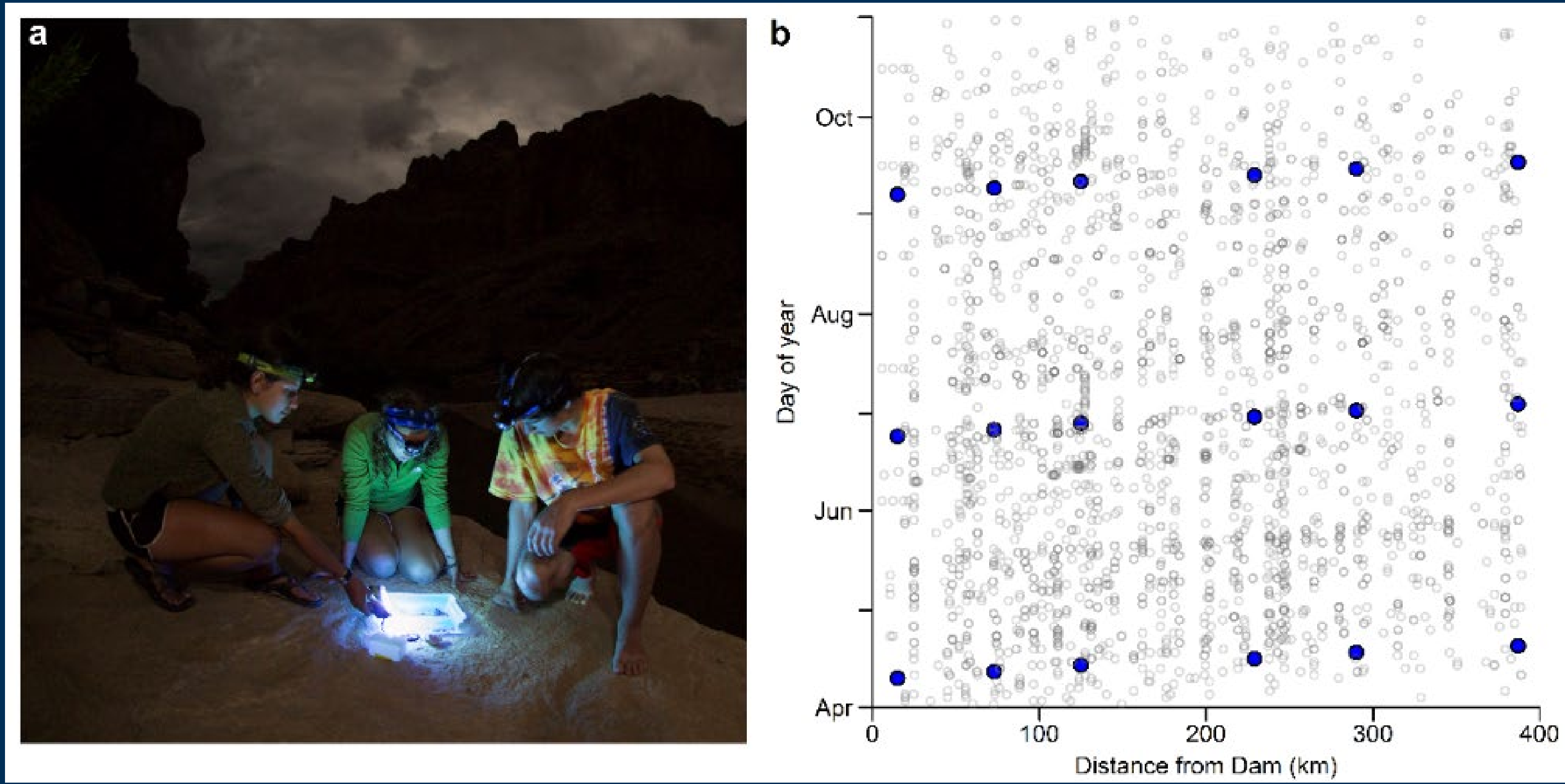
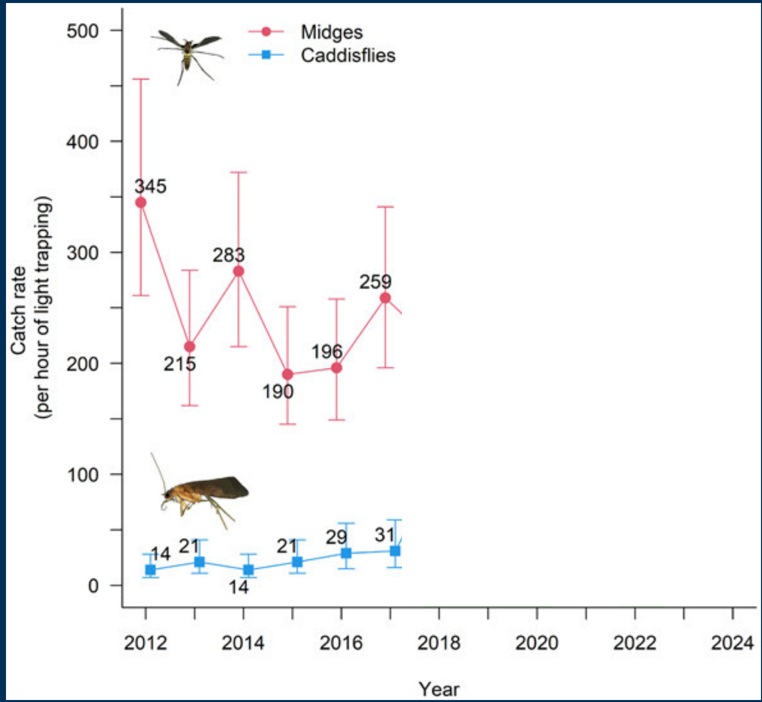
<u>Article describing how prey size influences Rainbow Trout feeding habits:</u>

Dodrill, M. J., Yackulic, C. B., Kennedy, T. A., Yard, M. D., & Korman, J. (2021). As the prey thickens: Rainbow trout select prey based upon width not length. Canadian Journal of Fisheries and Aquatic Sciences, 78(7), 809-819.

Citizen Science Insect Monitoring





In a nutshell

Citizen science monitoring started in 2012

~600 samples of adult aquatic insects per year

Robust dataset for monitoring aquatic food base in Grand Canyon

Informed a flow experiment that was tested at Glen Canyon Dam

Article that interprets light trap data and describes Bug Flow experiment:

Kennedy, T. A., Muehlbauer, J. D., Yackulic, C. B., Lytle, D. A., Miller, S. W., Dibble, K. L., ... & Baxter, C. V. (2016). Flow management for hydropower extirpates aquatic insects, undermining river food webs. BioScience, 66(7), 561-575.

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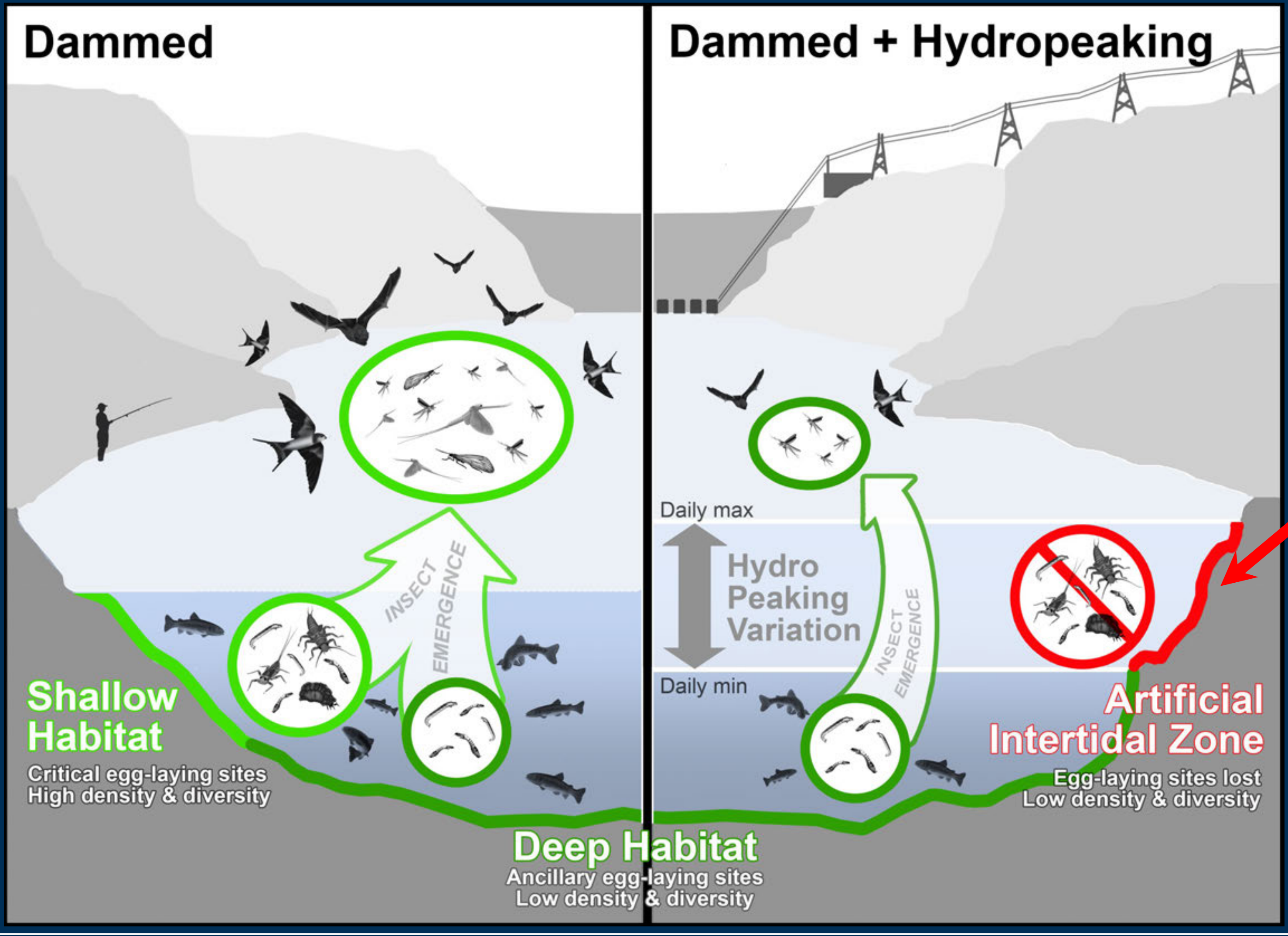
Bug Flows

- **Daily hydropower flows create "tides"**
- **Insects lay eggs at water line at dusk**
- **When tide drops, eggs dry, die**



From: Kennedy et al. 2016 *BioScience*

Bug Flows sought to mitigate this

A Perspectives article in the premier scientific journal *Science* about the Bug Flow experiment:
Poff, N. L., & Schmidt, J. C. (2016). How dams can go with the flow. Science, 353(6304), 1099-1100.

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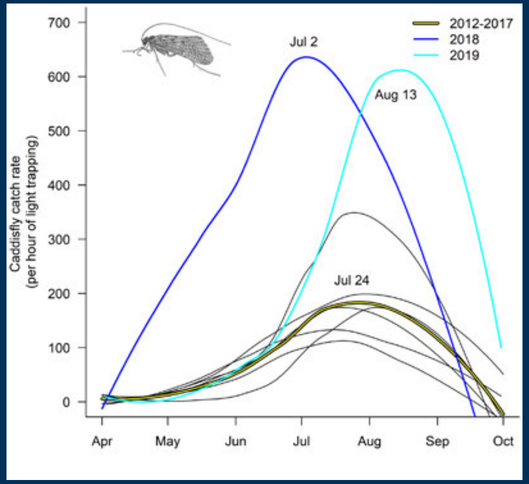
What Is A Bug Flow?

- **Give bugs the weekends off**
- **Weekend stable low flows from May-August**
  - **Minimizes impact to hydropower**
  - **Experiment tested 2018-2020 & 2022**
- **<u>Eggs laid on weekends won't dry</u>**

Adult caddisfly abundance



May-August

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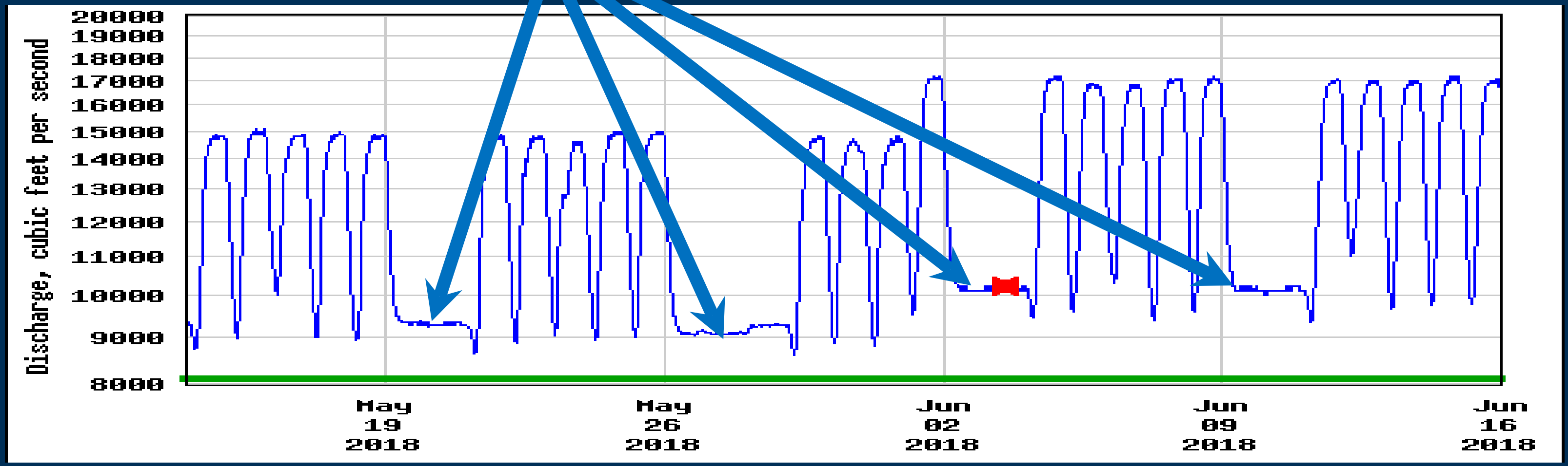

https://www.gcmrc.gov/discharge_qw_sediment/station/GCDAMP/09380000

"Objectives of Bug Flow Experiment: Improve food base productivity and abundance or diversity of mayflies, stoneflies, and caddisflies"
From 2016 Glen Canyon Dam EIS, Table 4.

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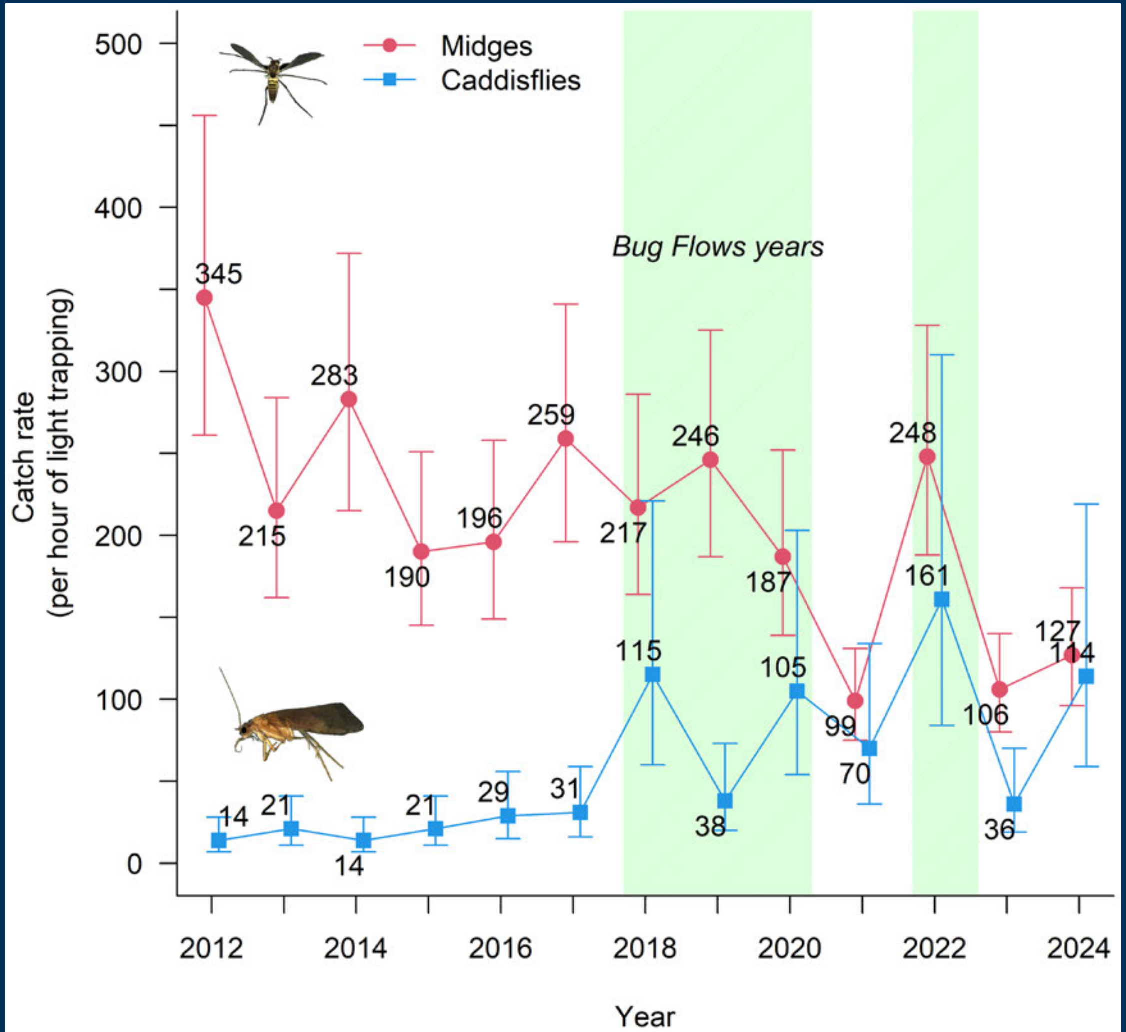
<u>A mass media article on the Bug Flow experiment:</u>
Hansman, H. (2019). Re-engineering the Colorado River: can dam releases that mimic natural flows restore the Grand Canyon ecosystem. Scientific American, 320(2), 64-70.

Higher aquatic insect abundance with Bug Flows



Estimates of annual average from mixed effects model

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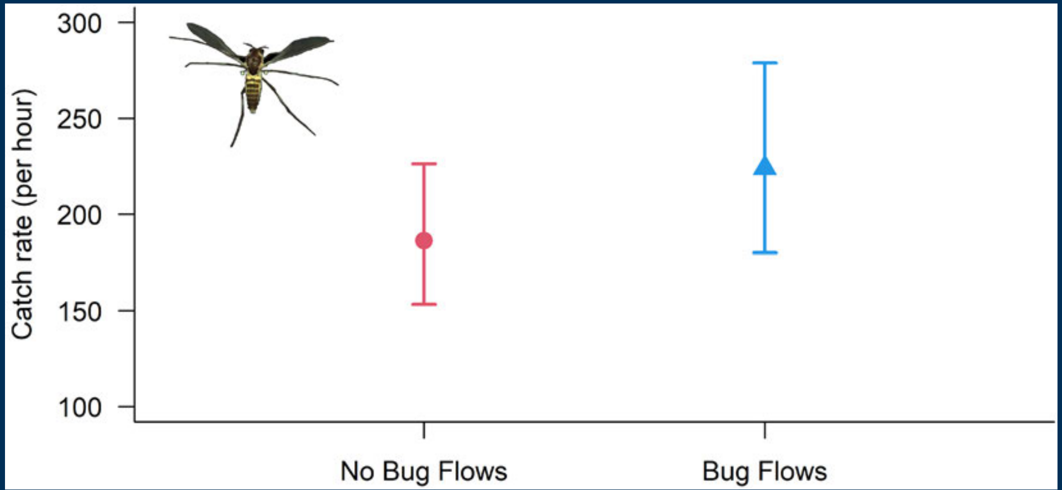

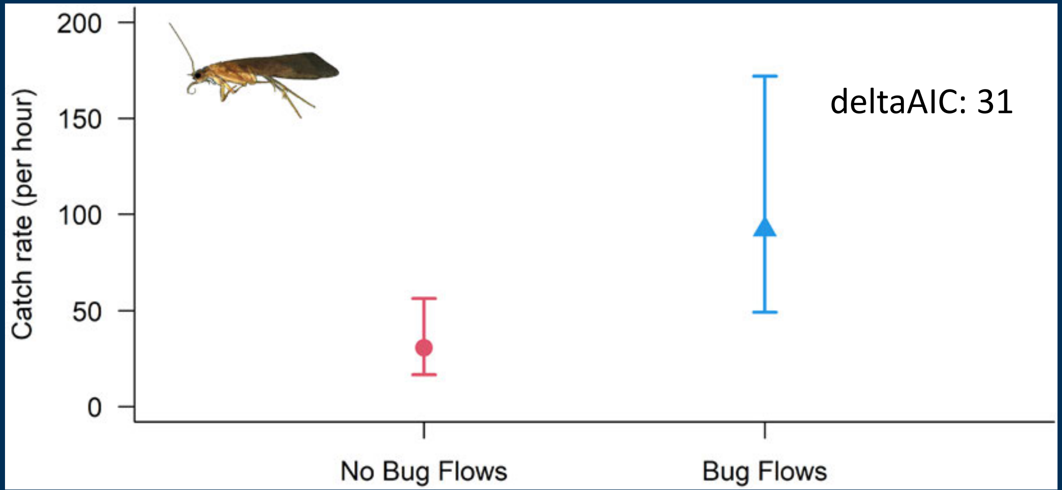

DeltaAIC > 8 considered very strong model support

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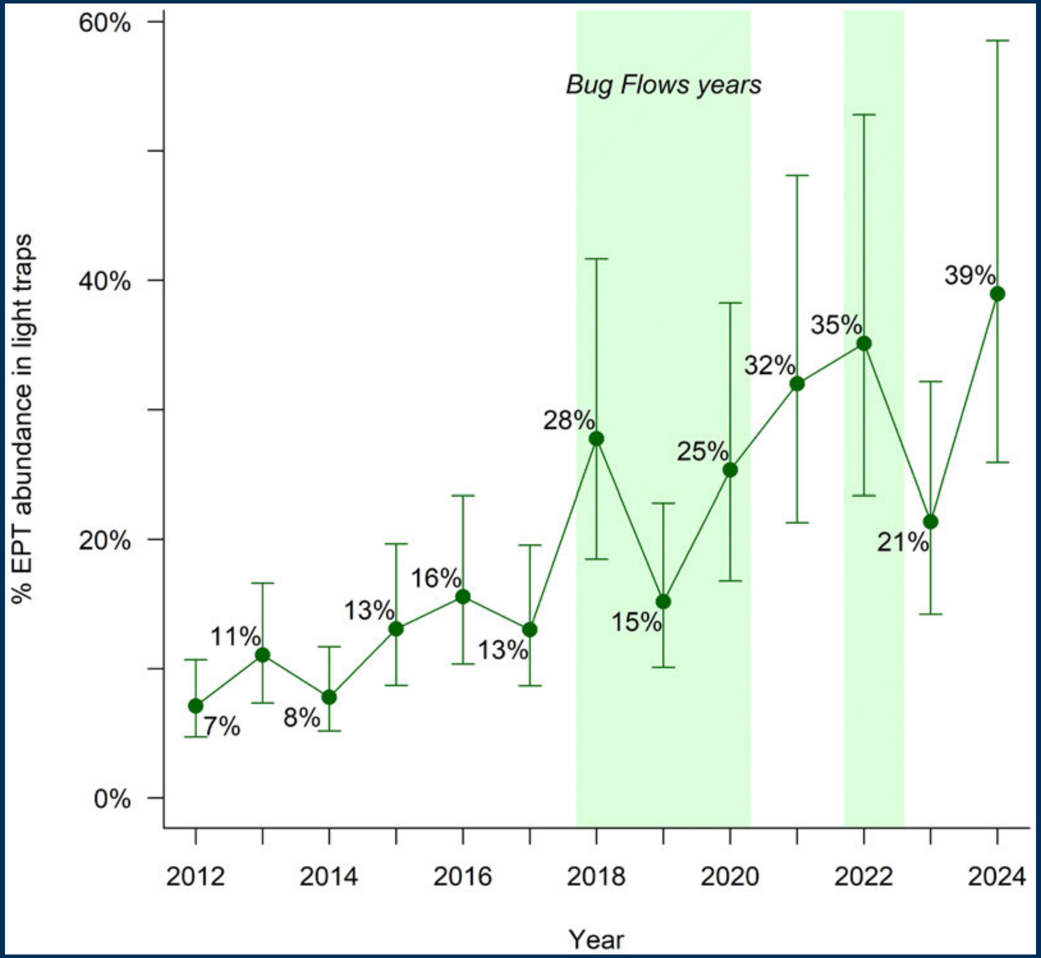
An outreach article to our river guide partners about Bug FLow results:

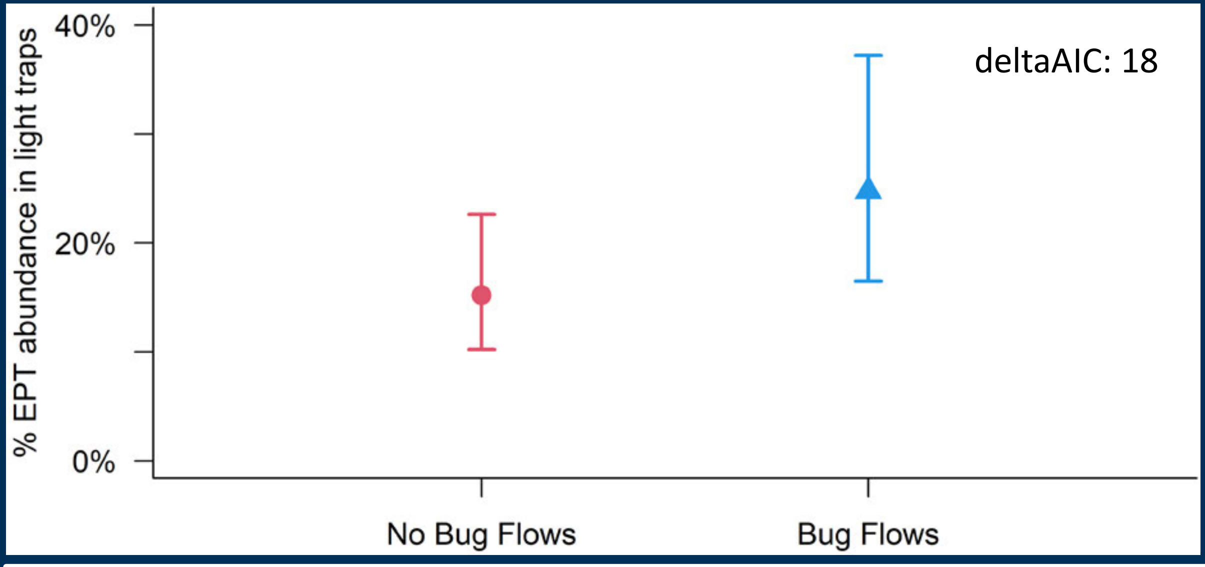
Kennedy, T., Metcalfe, A., Deemer, B., Ford, M., Szydlo, C. M., Yackulic, C., & Muehlbauer, J. (2022). Little bugs, big data, and Colorado River adaptive management: Preliminary findings from the ongoing bug flow experiment at Glen Canyon Dam. Boatman's Quarterly Review, 35(3), 26-31.

Higher Percent EPT with Bug Flows

Preliminary Information-Subject to Revision. Not for Citation or Distribution.



Estimates of annual average from mixed effects model
Provisional data, subject to change.



In a nutshell

-EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies)

-Formula: EPT in sample/total aquatic insects in sample

-Indicator river's ability to support diverse aquatic life

-Used globally as bioindicator

2024 EPT value driven by 3rd highest caddisfly and 3rd lowest midge value over period of record.

A comprehensive USGS report describing use of the EPT metric to assess the health of the Nation's streams and rivers:
Carlisle, D., & Woodside, M. D. (2013). Ecological health in the Nation's streams (No. 2013-3033). US Geological Survey.

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Next Steps…

- Continue modeling Bug Flow data in support of peer-reviewed publications
- Provide corrected drift data to fish cooperators

Implement some changes in 2025

- Decommission bat monitoring stations and citizen science
- Quarterly drift monitoring instead of monthly

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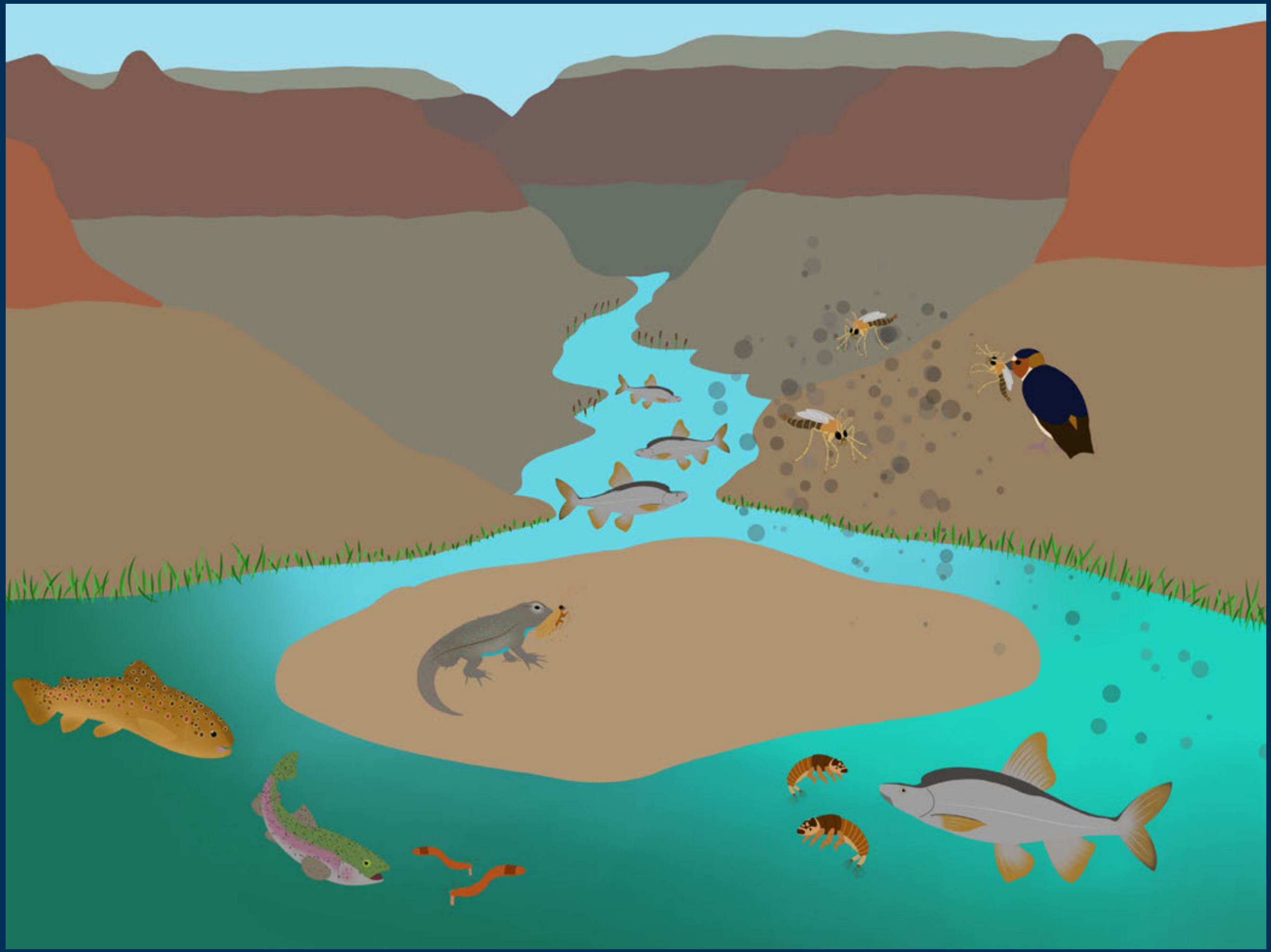
Conclusions

- **Food webs and food base monitoring useful tools for understanding changes in fish populations**
- **Bug Flow experiment appears to be useful tool for increasing production and diversity of aquatic food base**
- **THANKS to river guides, Grand Canyon Youth, and other citizen scientists that helped collect samples in 2024**



Conceptual model of select Natural Processes at the Little Colorado River confluence
Figure courtesy of Diana Valentine