Project F: Bug Flows and food base update

Theodore Kennedy[1], Jeff Muehlbauer[2], Cheyenne Szydlo[1], Anya Metcalfe[1]

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

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

Glen Canyon Dam Adaptive Management Program Annual Reporting Meeting
January 24-25, 2023, Phoenix, AZ

Project F: Aquatic invertebrate ecology

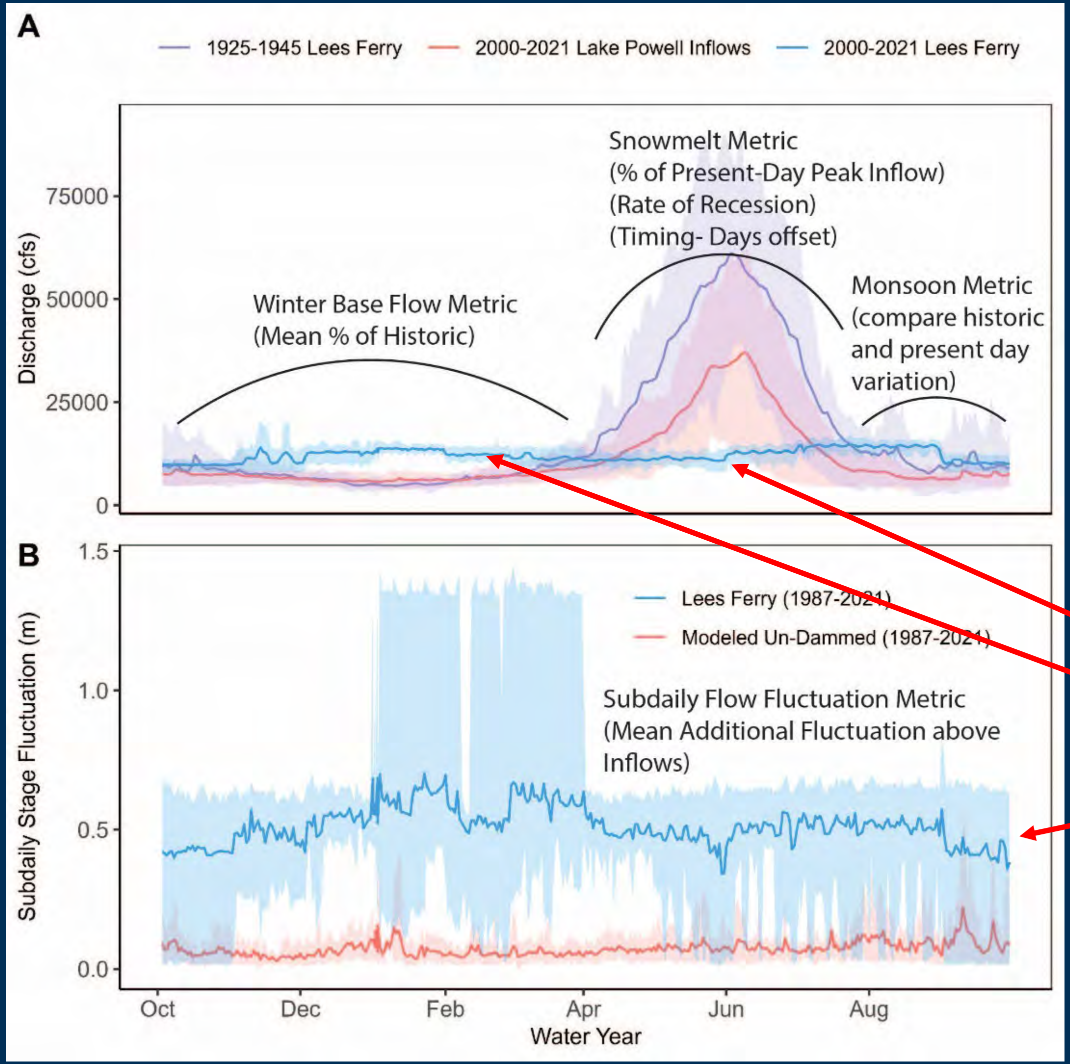
- **Project Elements and Objectives**
  - **F.1 Aquatic invertebrate monitoring in Marble and Grand Canyons**
  - **F.2 Aquatic invertebrate monitoring in Glen Canyon**
  - **F.3 Aquatic invertebrate monitoring of Grand Canyon tributaries**
  - **F.4 Fish diet studies**
- **Funding amount and source: $667,051 (AMP)**
- **Cooperators: Oregon State University**
- **LTEMP Resource goal:**

Natural Processes-*Restore, to the extent practicable, ecological patterns and processes within their range of natural variability, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems*

This work also supports all LTEMP goals for fish

USGS

Goal 2. Natural Processes



From Natural Processes-metrics draft, courtesy of Bridget Deemer & Emily Palmquist

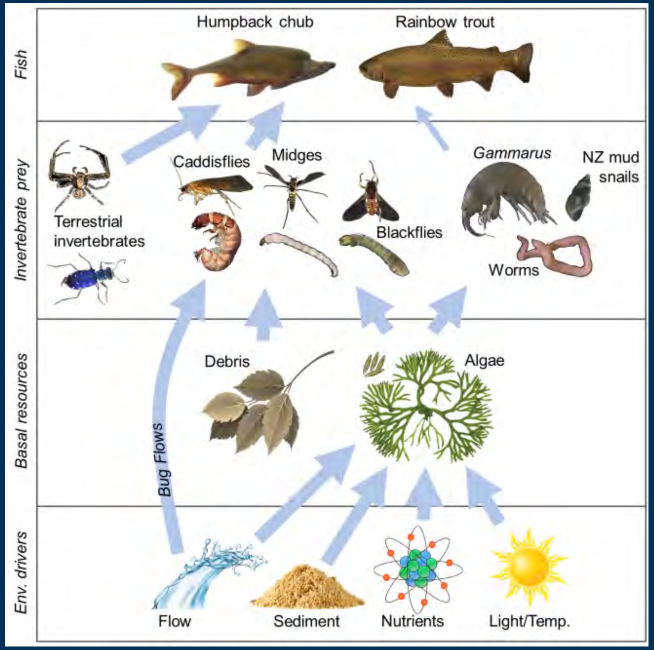
Flow regimes are a major driver of Natural Processes

Damming and regulation of the Colorado River have fundamentally altered flow regimes and natural processes.

Natural Processes?

Annual
Seasonal
Daily pattern
all different

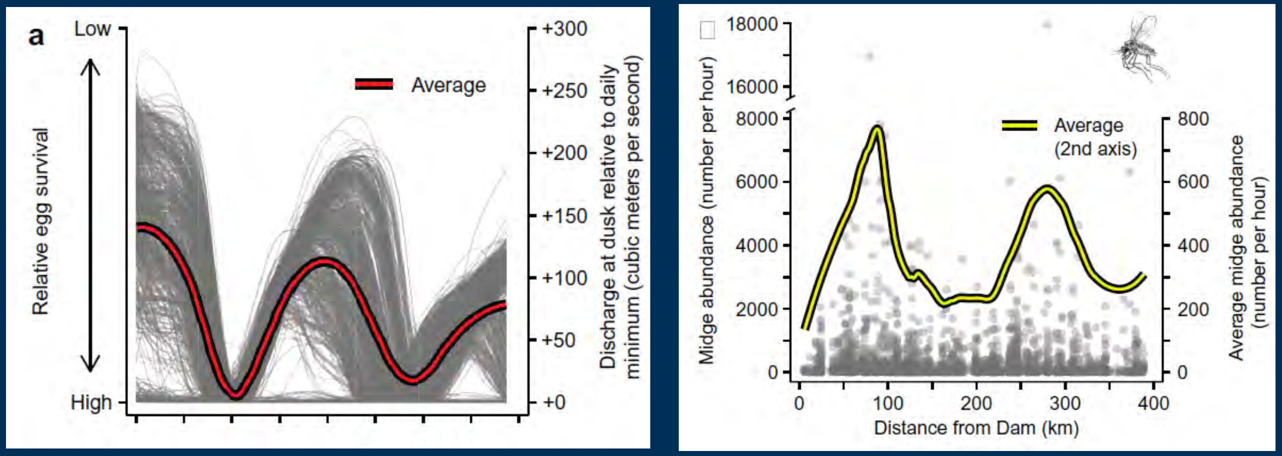
Colorado River Food Webs



Preliminary data, subject to change, do not cite

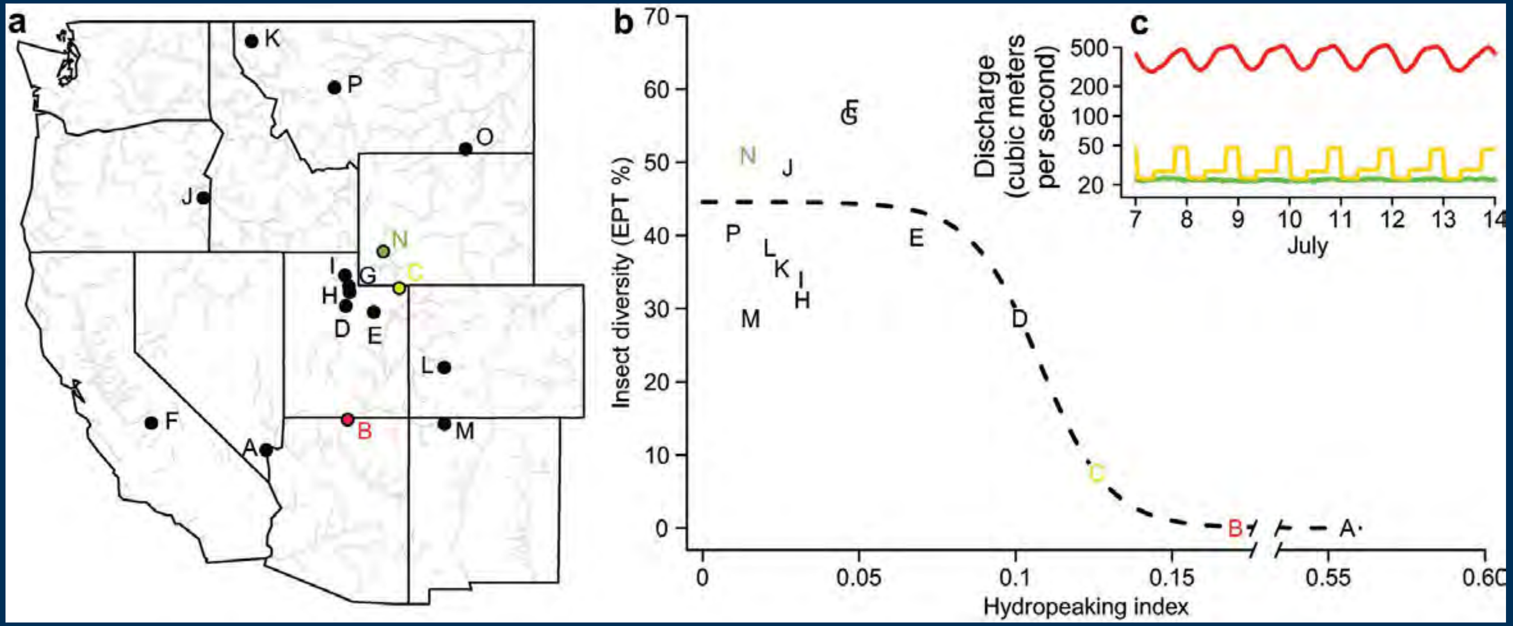
Why Bug Flows?

- **Insect production negatively related to tides in GC**



Abundance of midges in Grand Canyon is predicted by timing of tides.
If timing aligns with egg laying (dusk) relatively high egg survival

- **Insect diversity negatively related to tides across West**

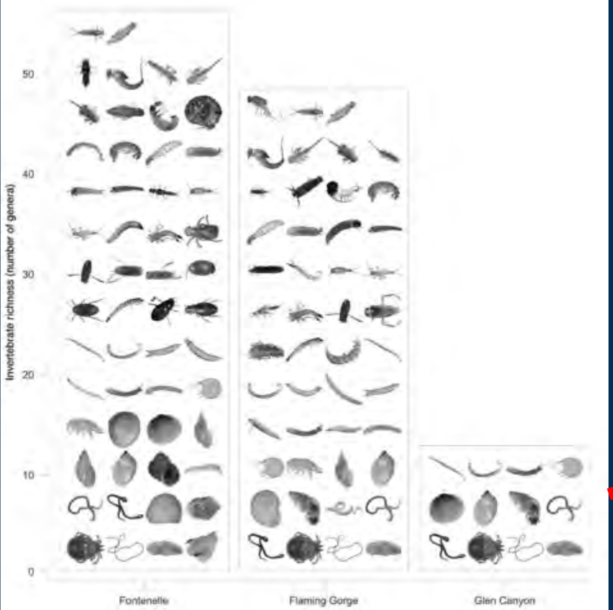


Insect diversity across 18 tailwaters in Western US. Tailwaters with large tides have low insect diversity (EPT)

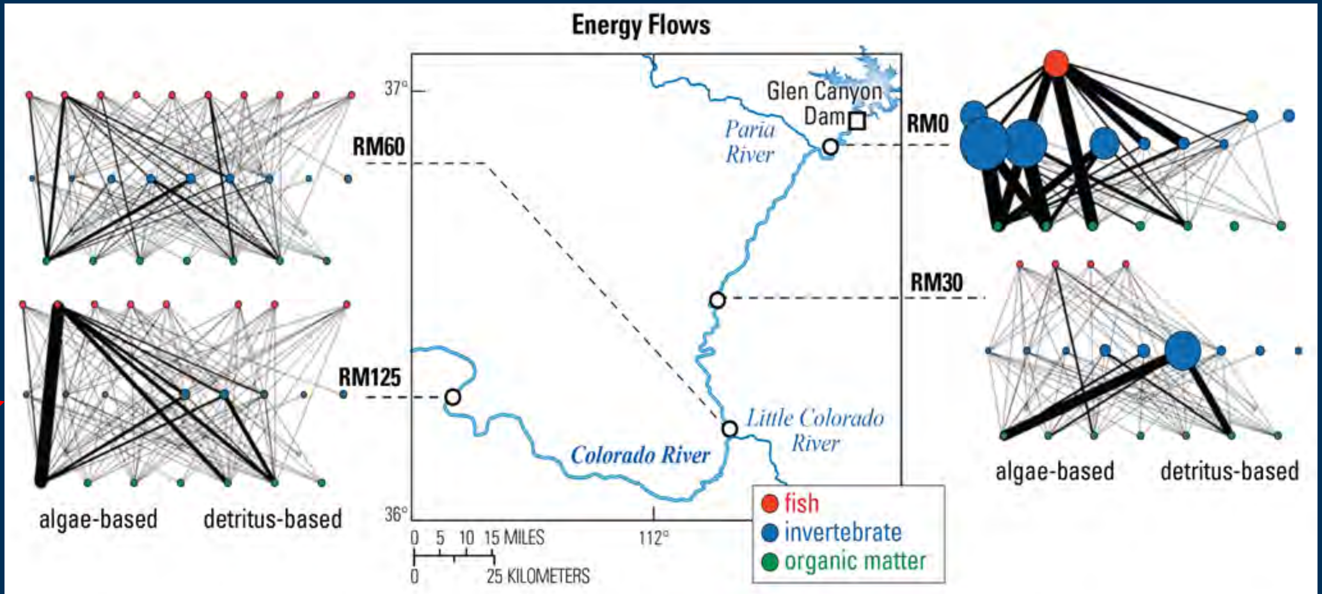
From Kennedy and others 2016

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.

USGS

Why Bug Flows?

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

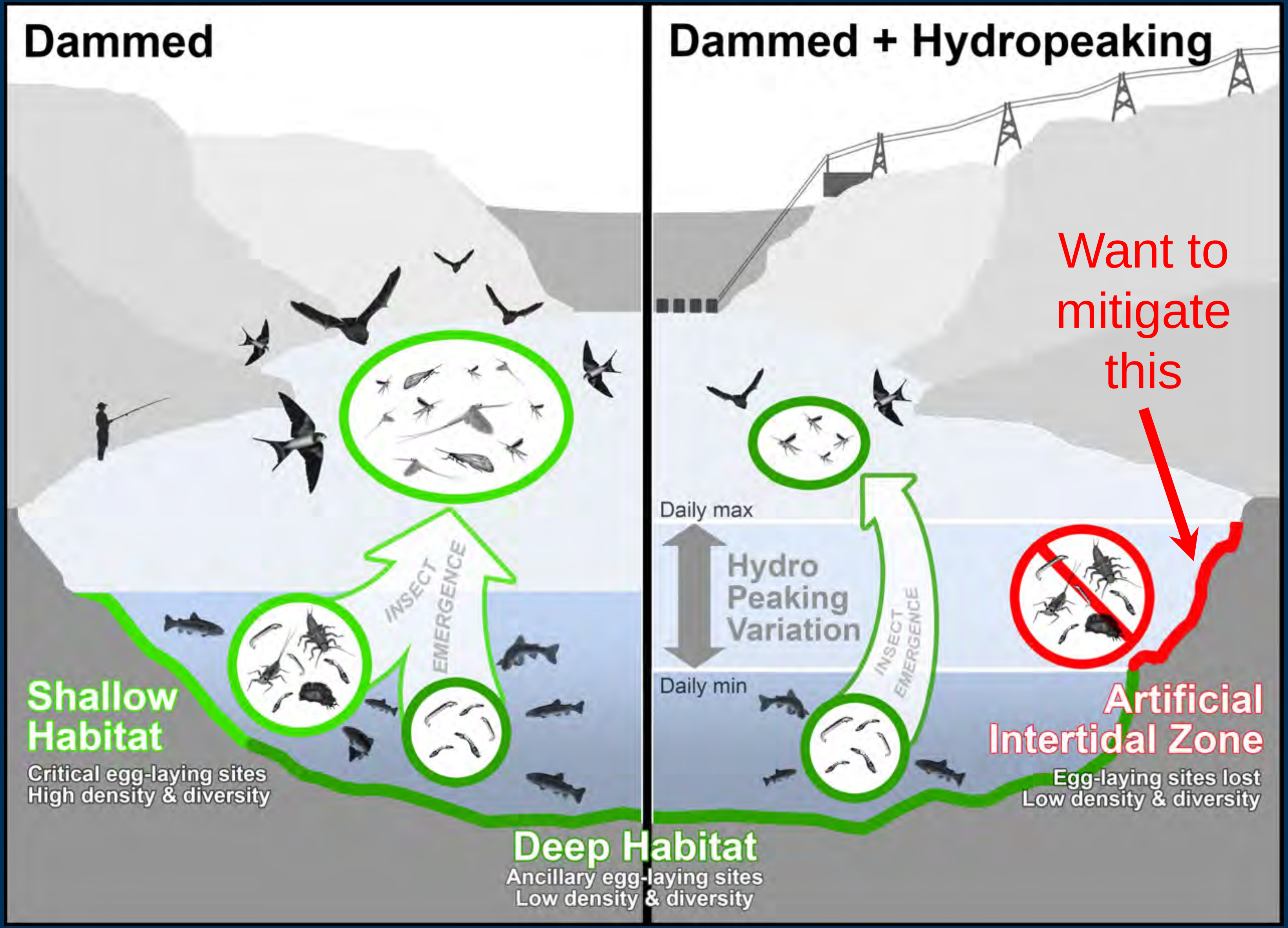


Illustration by Jeremy Monroe-Freshwaters Illustrated, from Kennedy and others 2016, Bioscience

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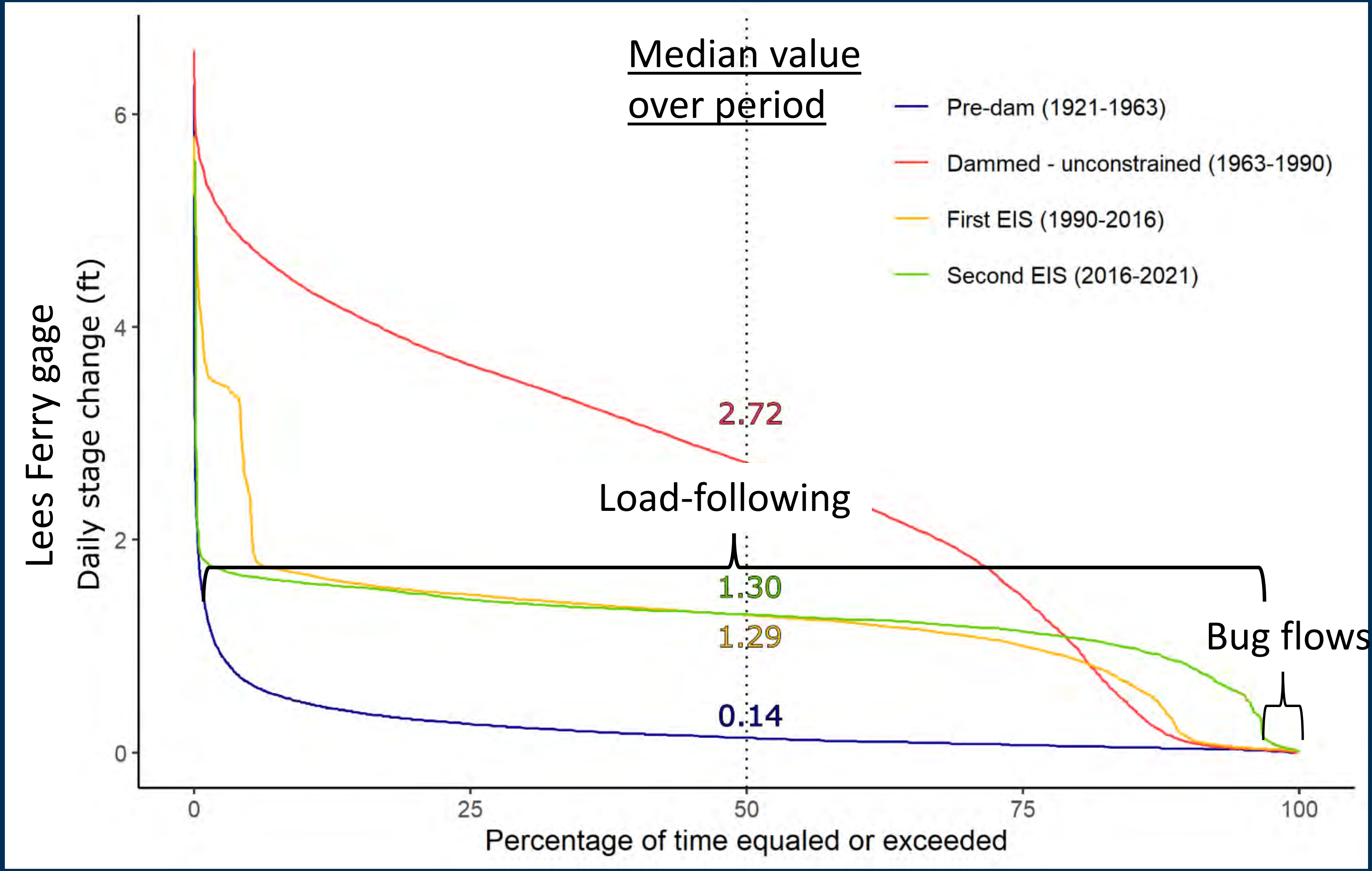
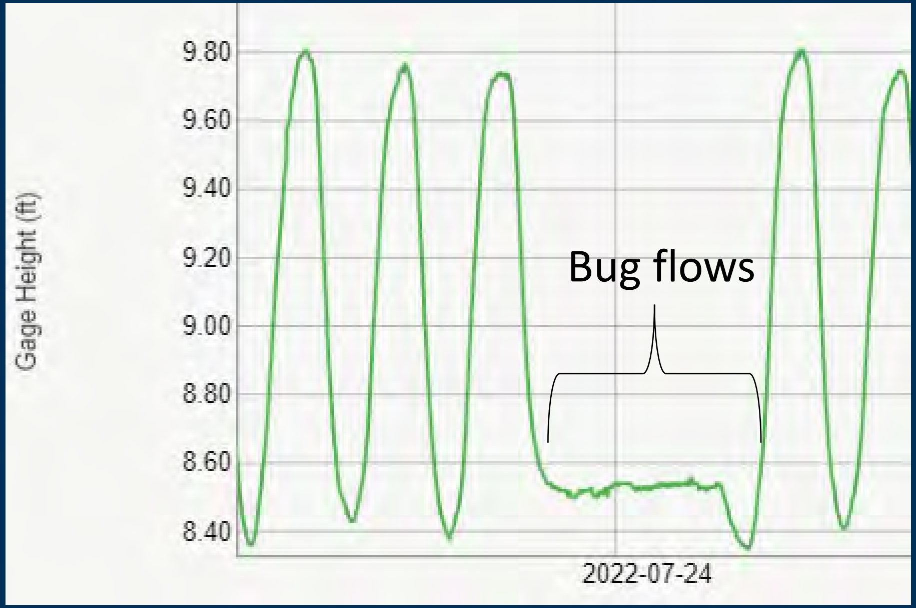
Why Bug Flows?

Daily Tides



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

Lees Ferry-discharge



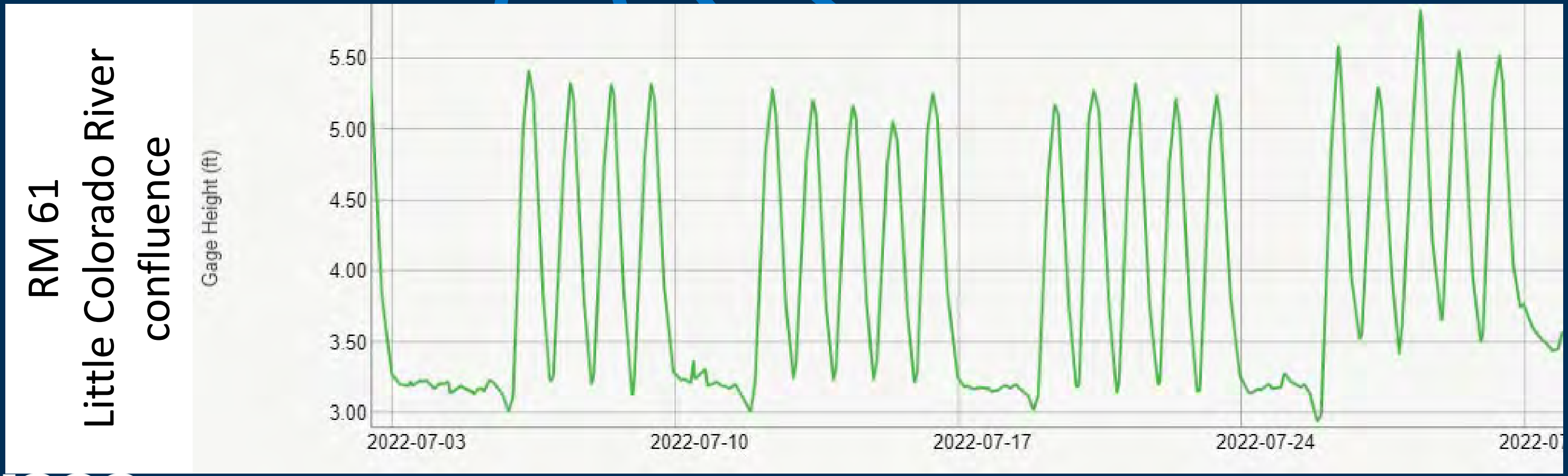
Why?

Stabilize near-shore habitats that are critical to insect egg laying.

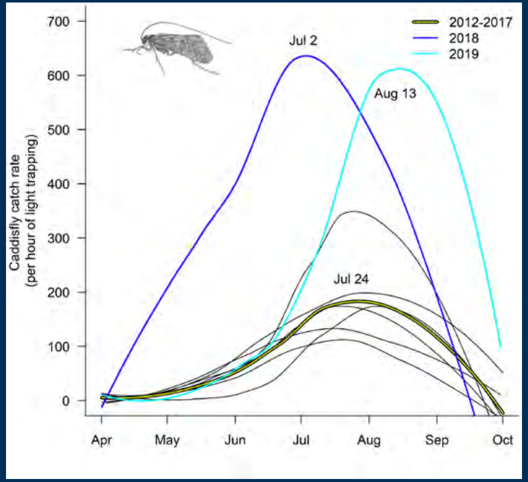
USGS

What is a Bug Flow?

- **Give bugs the weekends off**
  - **Enhance natural processes to support aquatic insects**
  - **Improve river health and food availability for fishes**
- **Weekend stable low flows from May-August**
  - **Reduces impact to hydropower**
  - **Experiment tested 2018-2020 & 2022**
- **Eggs laid on weekends never dry**



Peak egg laying activity occurs May-August



"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.

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

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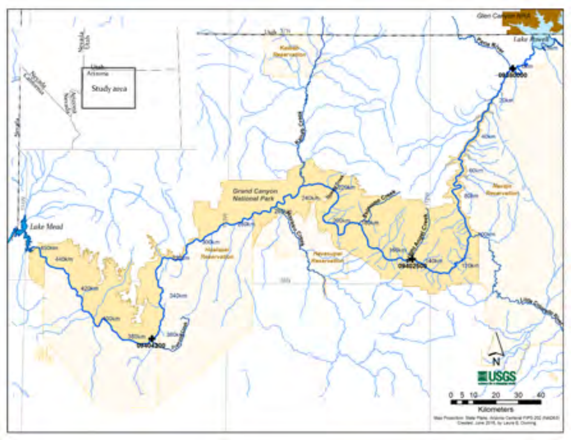
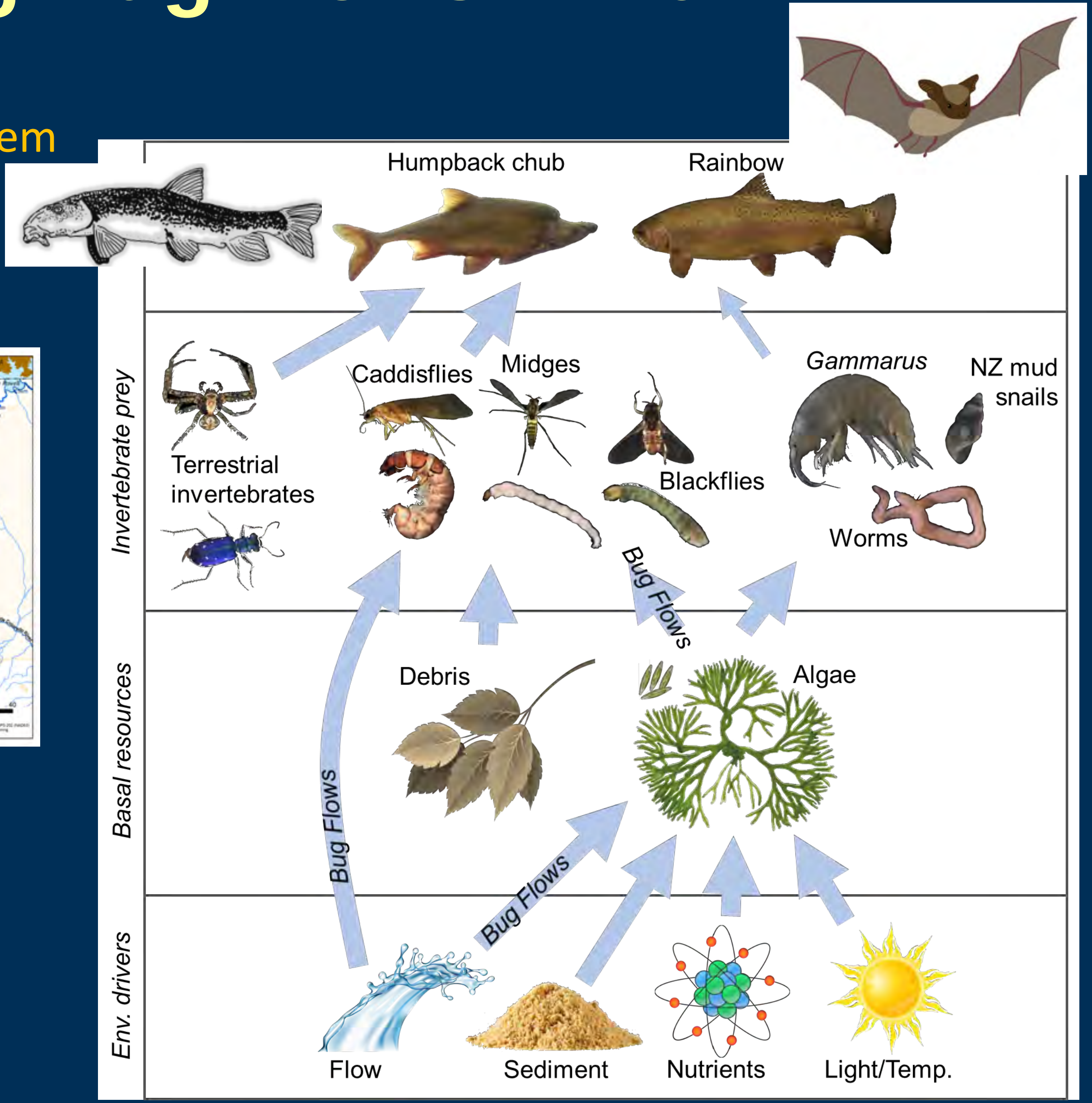
Monitoring Bug Flows in 2022

How to monitor ecosystem response over 400 river kilometers in remote canyon?





Preliminary data, subject to change, do not cite

Mark-Recapture studies

- **Estimate growth rates at seasonal intervals**
- **Estimate marginal effect of Bug Flow**
- **New: Diet studies in 2022**

Night fish sampling

Network of community scientists

- **Light trap monitoring of aquatic insects**
- **Robust scope**
- **New: Bat monitoring added in 2017**

Night bug sampling

Network of dissolved oxygen sensors

- **Model gross primary production in entire river**
- **Key ecosystem process**
- **Daily time step**

Dissolved oxygen sensor

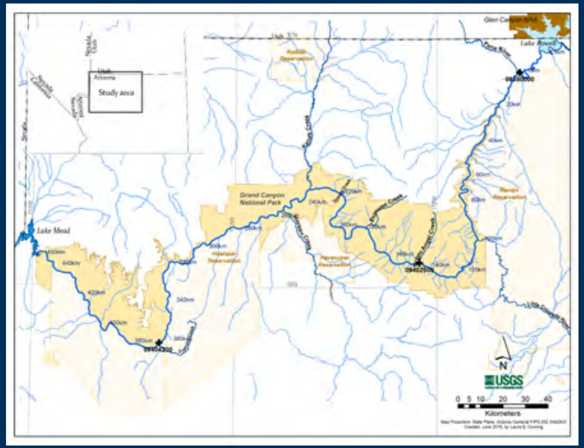
USGS

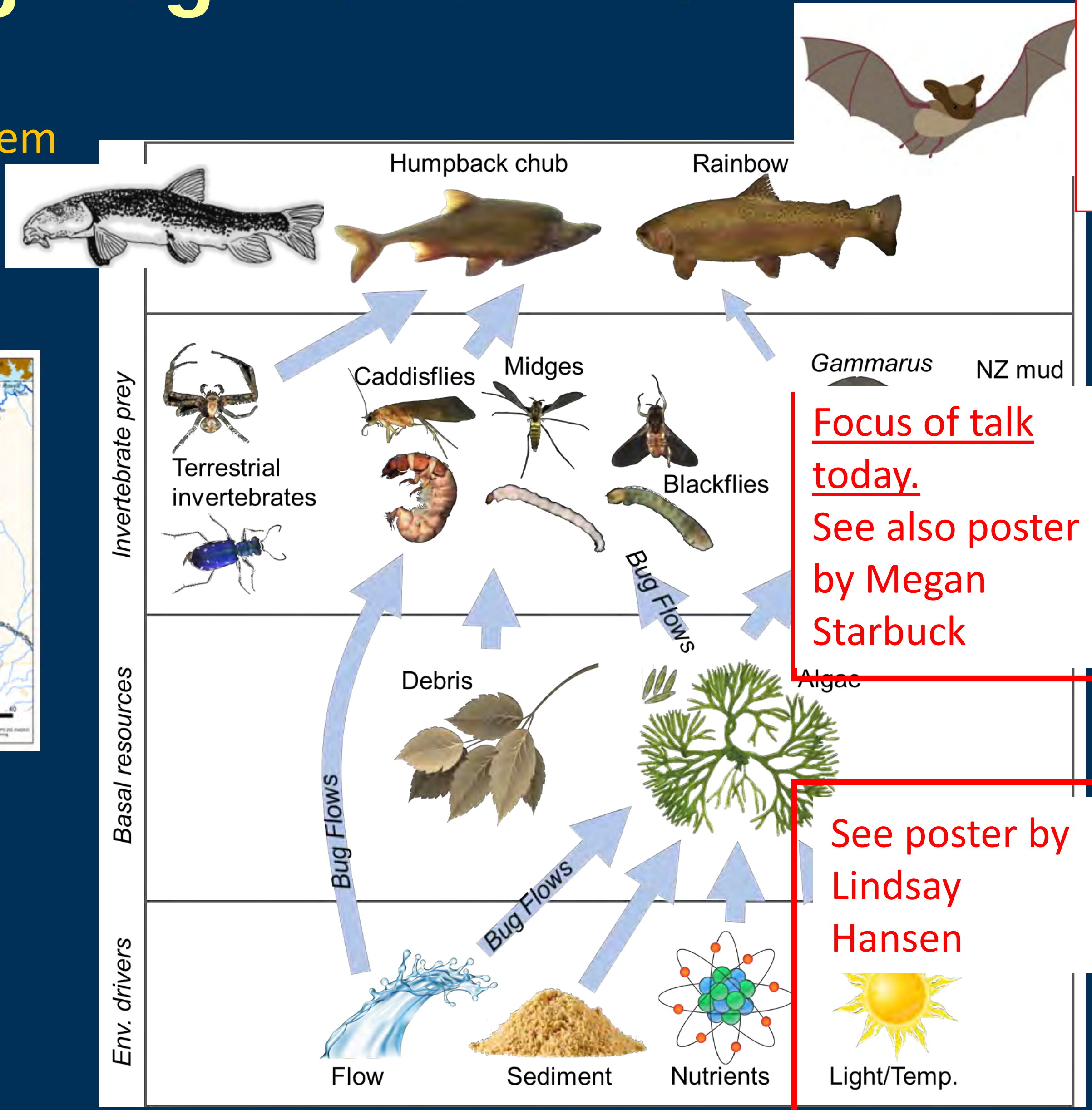
Monitoring Bug Flows in 2022

For Bats, paper accepted at Journal of Wildlife Management pending minor revision.

For trout, paper accepted at Canadian Journal of Fisheries & Aq. Sciences

How to monitor ecosystem response over 400 river kilometers in remote canyon?





Focus of talk today.

See also poster by Megan Starbuck

See poster by Lindsay Hansen

Preliminary data, subject to change, do not cite

- Estimate marginal effect of Bug Flow
- New: Diet studies in 2022

Night fish sampling

Network of community scientists

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Night bug sampling

Network of dissolved oxygen sensors

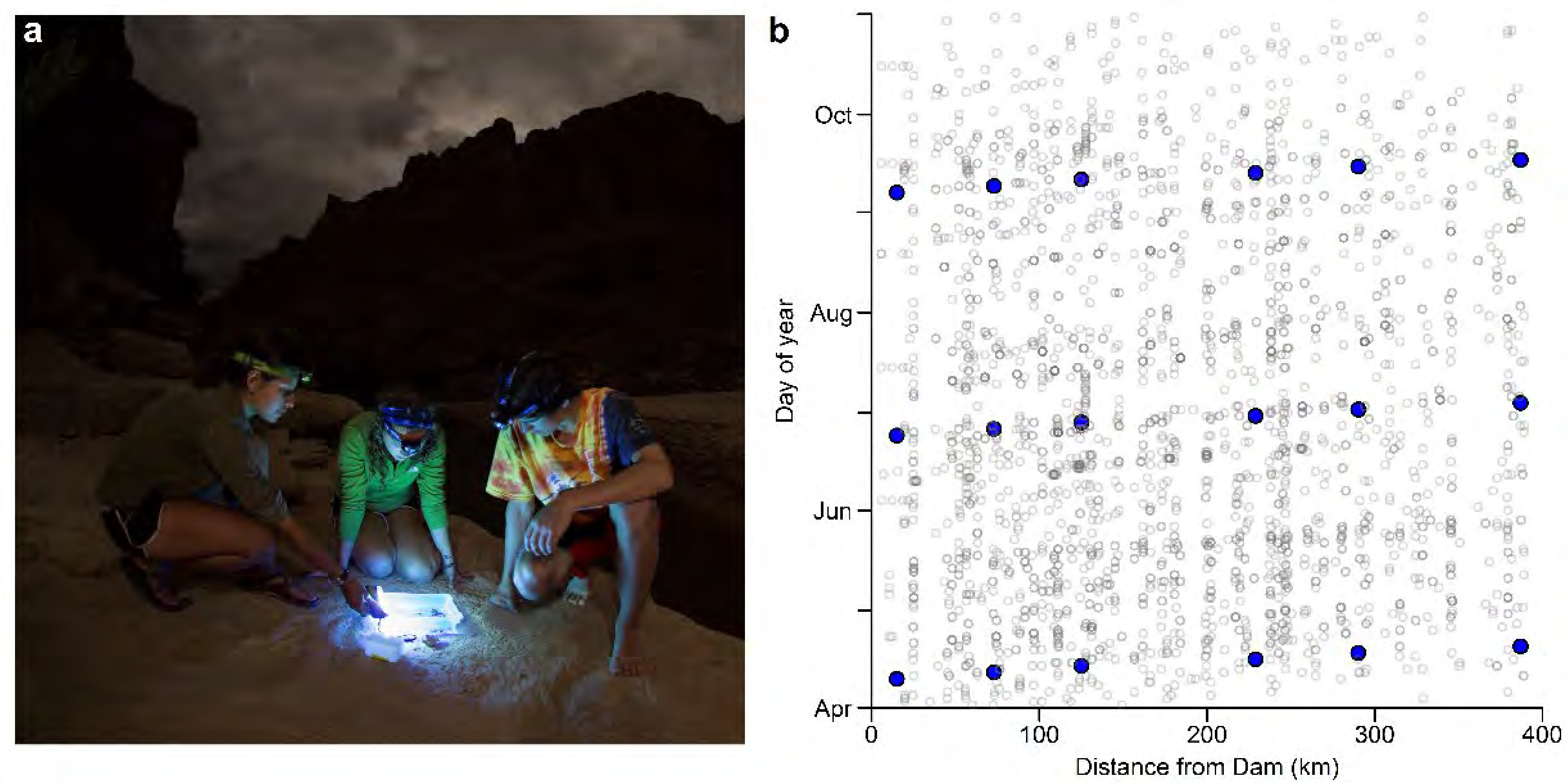
- Model gross primary production in entire river
- Key ecosystem process
- Daily time step

Dissolved oxygen sensor

USGS

Community science light trapping

- 600+ samples per year, throughout Canyon
- Robust dataset for tracking aquatic insect response



From Kennedy and others 2016, Bioscience

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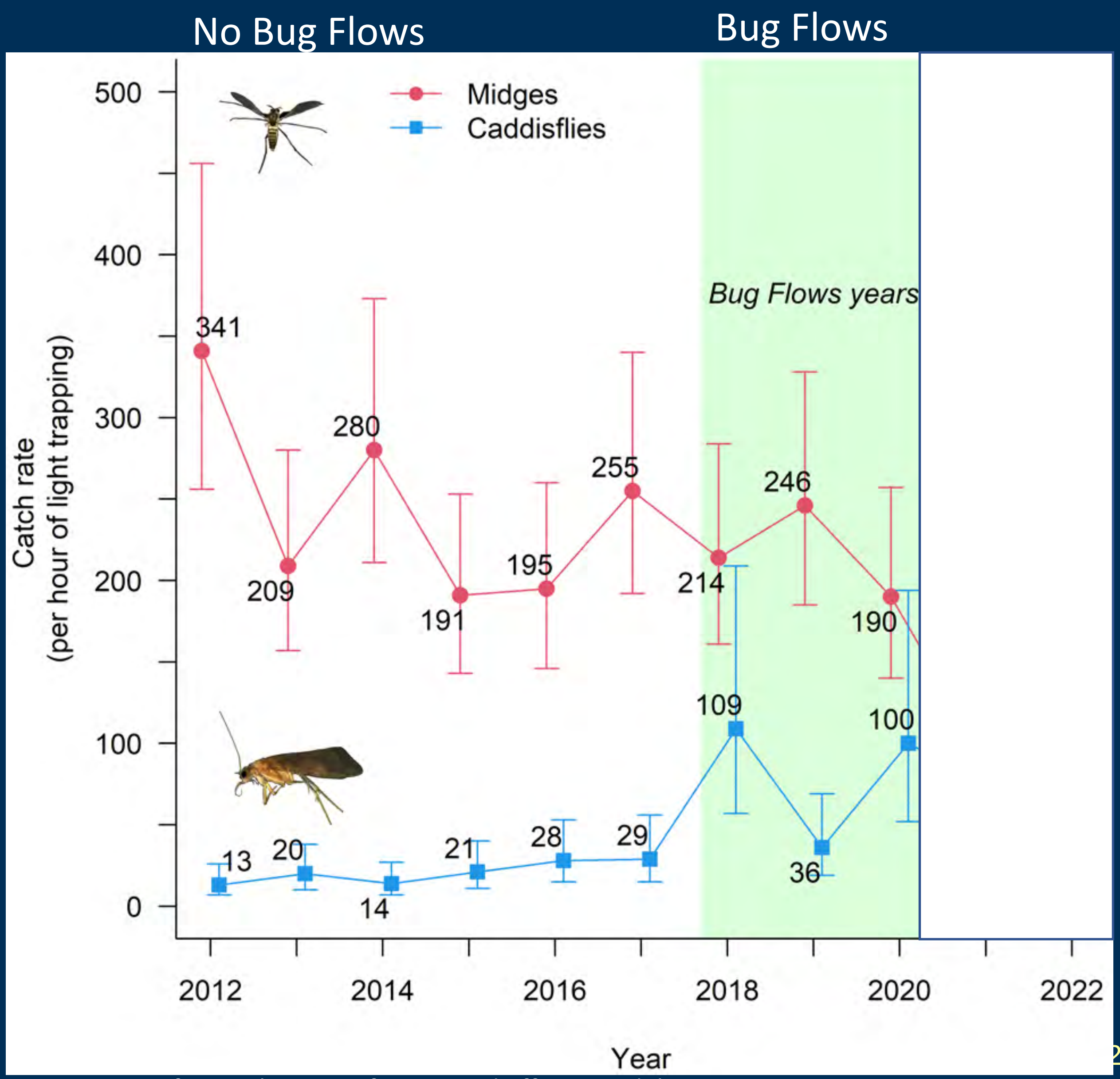
Insect response

- **2018-2020 Bug Flows**
  - **Midges: no change**
  - **Caddisflies: 400% increase in two of three years**

2018-2020 had low phosphorus concentrations, which is a driver of food base production



Estimates of annual average from mixed effects model

USGS

Unpublished data, subject to change, do not cite.

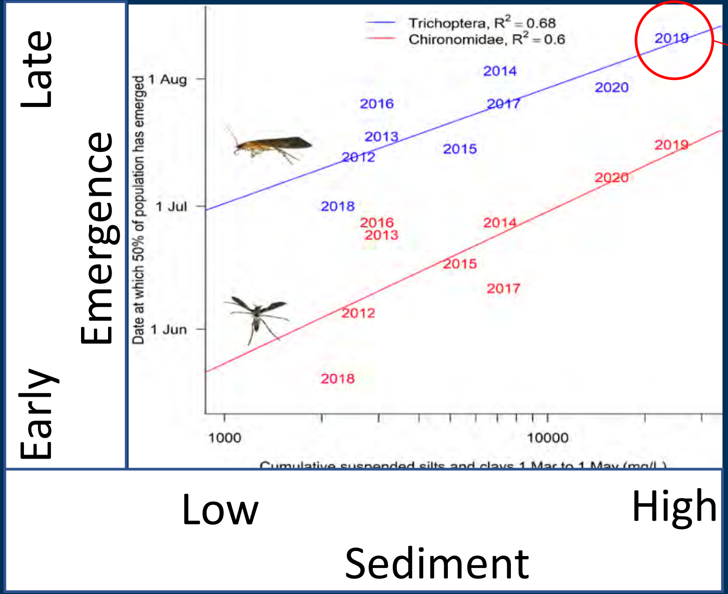
Insect response

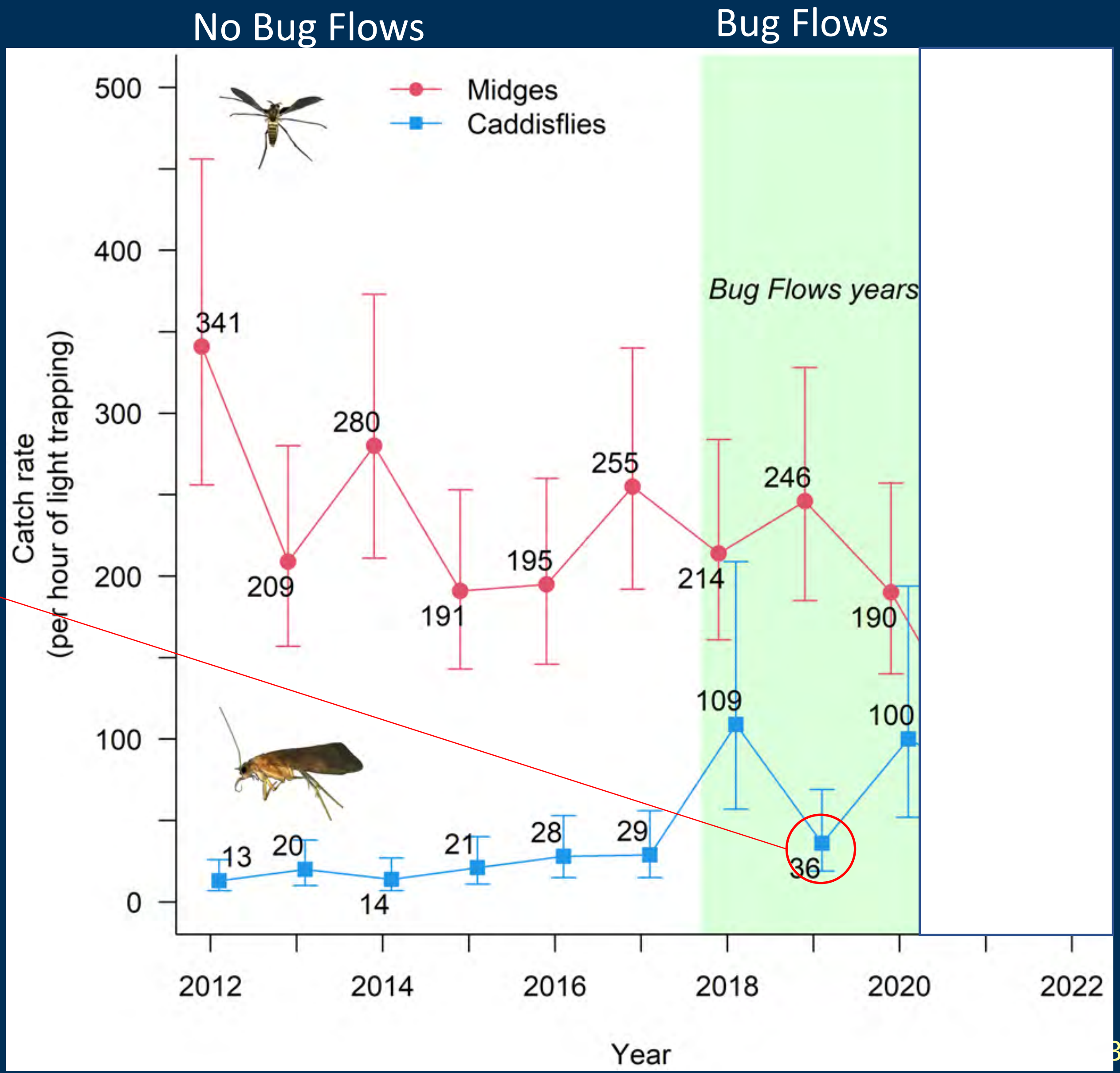
- **2018-2020 Bug Flows**
  - **Midges: no change**
  - **Caddisflies: 400% increase**

  in two of three years

2019-high sediment + fall HFE in prior year = poor growing conditions?

Graph showing relation between spring sediment and caddisfly emergence; emergence timing indicator of growing conditions





Estimates of annual average from mixed effects model

Unpublished data, subject to change, do not cite.

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Insect response

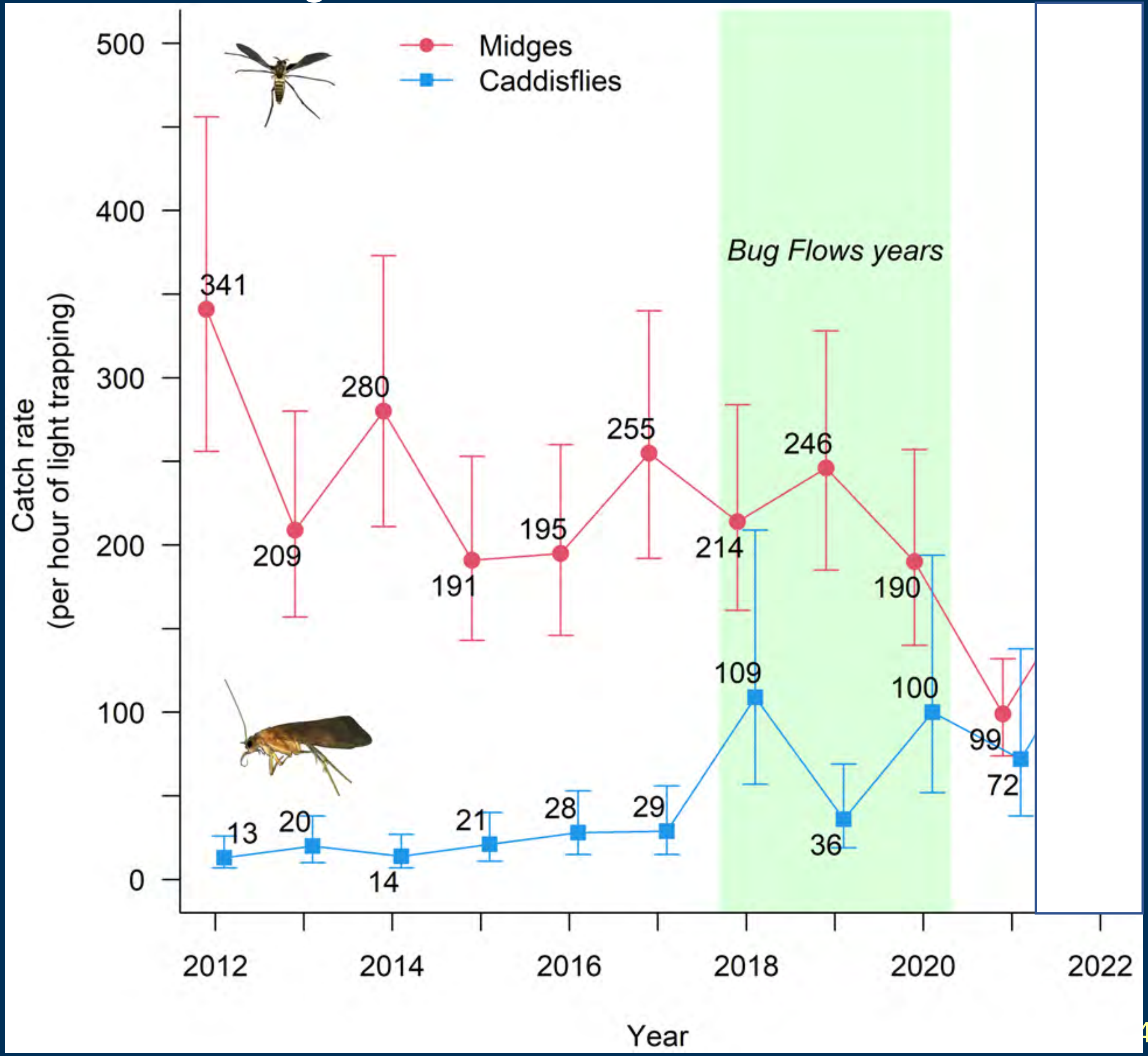
- **2021 cessation of Bug Flows**
  - **~50% decline in midges**
  - **no statistical difference in caddisflies**

Decline in midges consistent with hypothesis that Bug Flows was supporting midge populations

No Bug Flows

Bug Flows

No Bug Flows



Estimates of annual average from mixed effects model

2022 Caveats

- Only 50% of samples processed (320 completed out of 600)
  - But samples have been randomly pulled for processing
  - And models account for variation in sampling effort across years
- Remaining samples would need to have extremely low abundance to dramatically decrease numbers that you are about to see…

Insect response

- **2022 Bug Flows**
  - **80% increase in midges***
  - **120% increase in caddisflies***

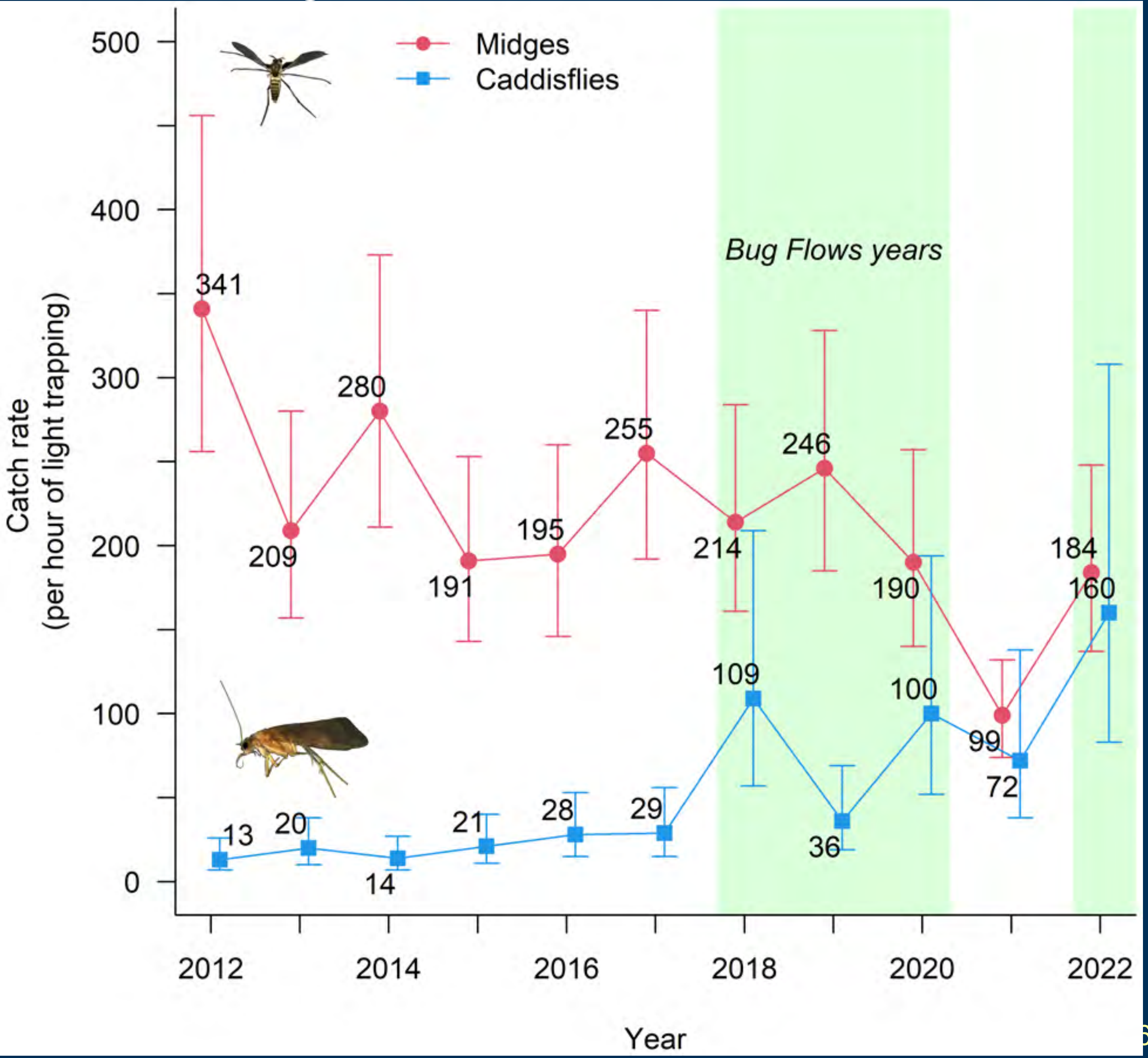
Consistent with hypothesis that Bug Flows supporting aquatic insect populations

Note that 2021 & 2022 had similar environmental conditions

-high suspended sediment (enough to trigger HFEs)
-warm water (1st and 2nd warmest years since dam filling in 1960s)

*only 50% of samples processed, numbers will change

No Bug Flows | Bug Flows | No Bug Flows | Bug Flows 2022



Estimates of annual average from mixed effects model

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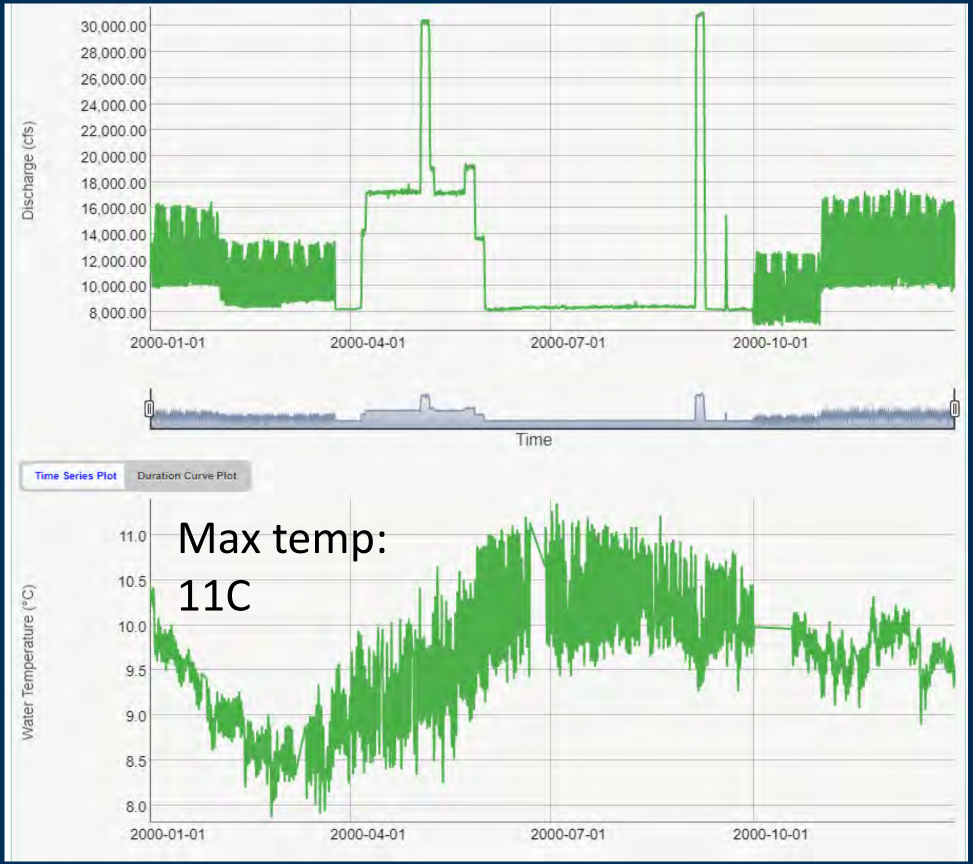
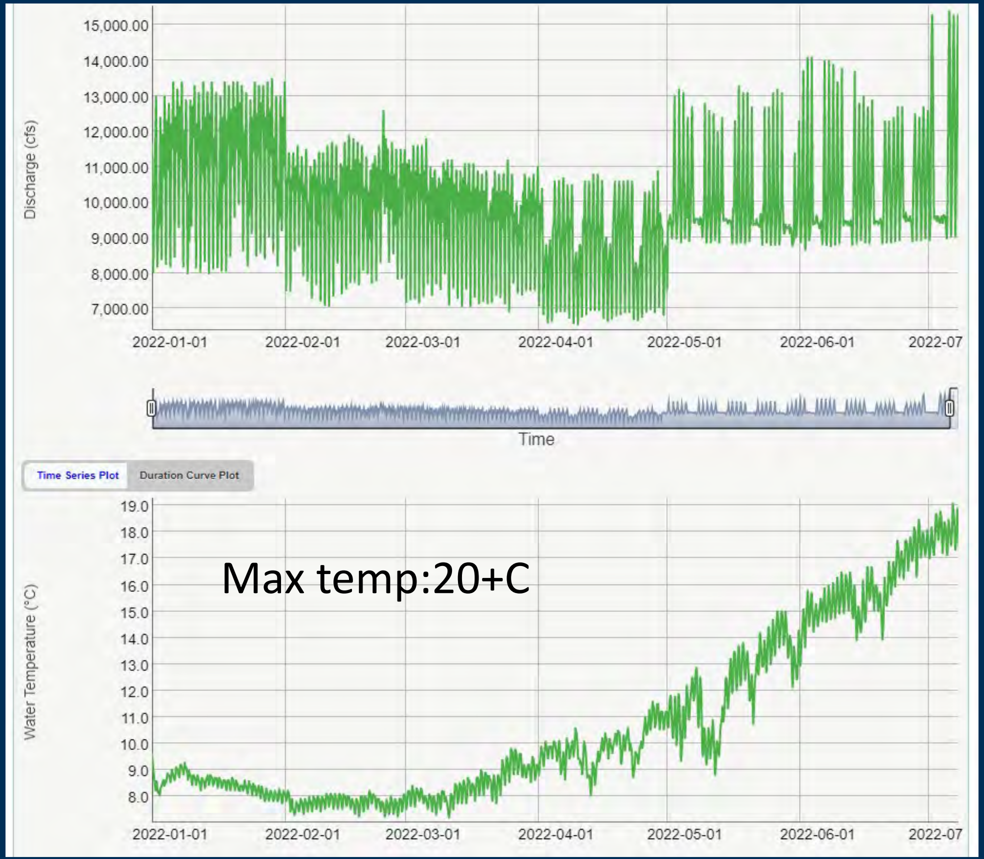
Smallmouth bass

2000-LSSF



2022-Bug Flows



- Water temperatures below critical thresholds for HBC growth (12C) and spawning (16C).
- Modest warming, if drives temps above thresholds, may be ecologically meaningful

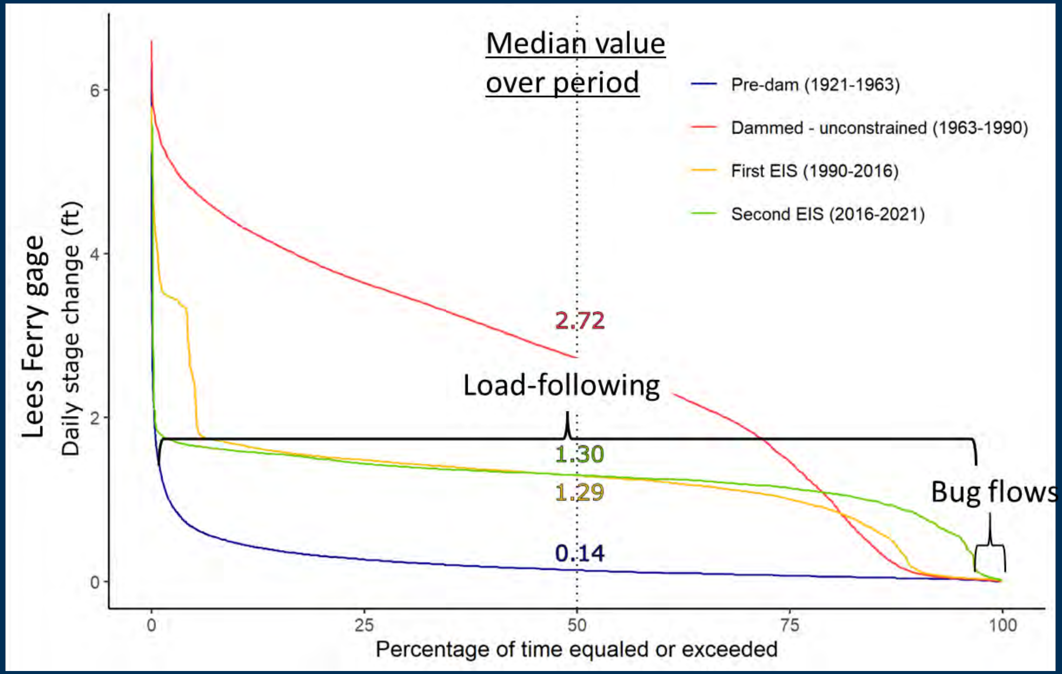
- Release temperatures near optima for SMB
- <u>Biggest risk factors are high rates of passage through dam and warm, canyonwide temperatures</u>
- Modest nearshore warming (2d/week, 4 mo/yr) does not represent meaningful risk factor in comparison

USGS

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

Conclusions

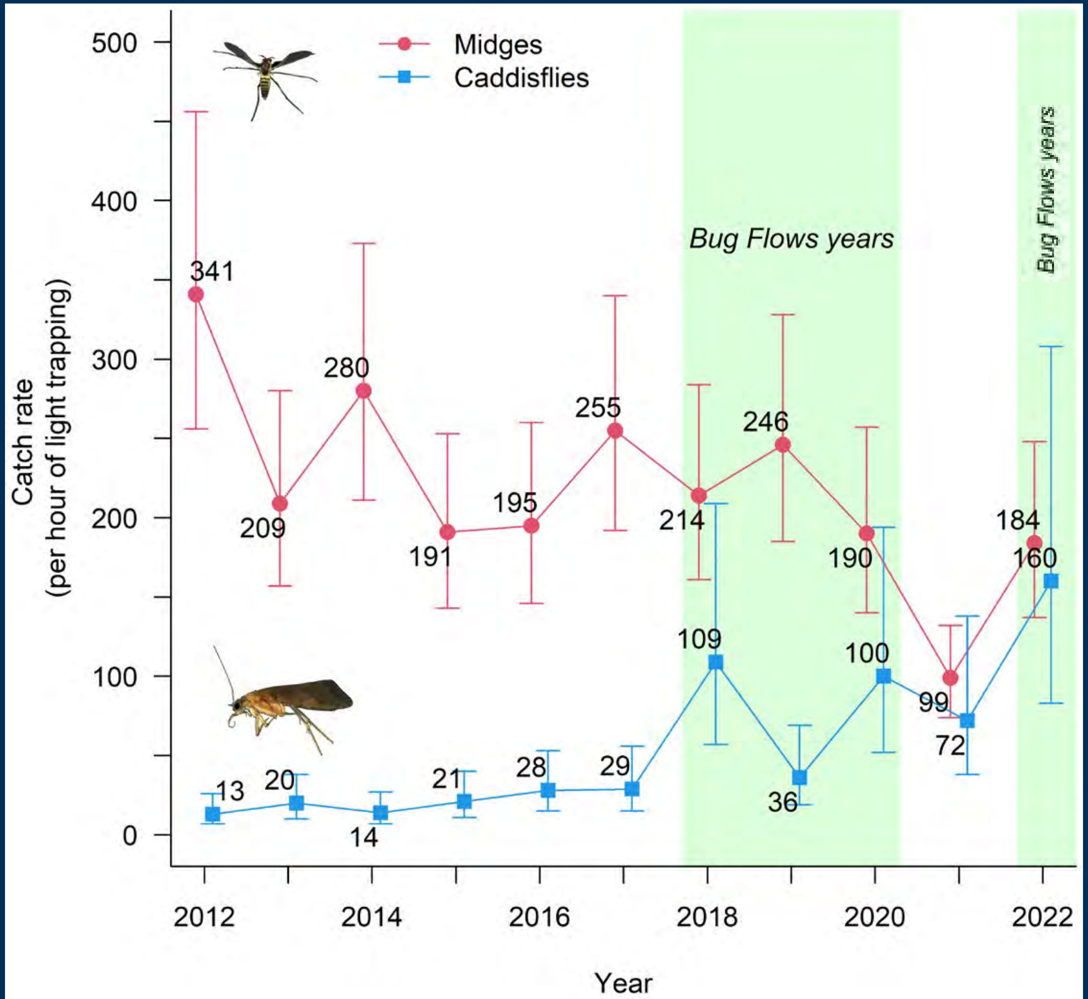
- **Bug Flows appears to be a useful tool for enhancing natural processes that sustain aquatic insect populations and the Colorado River ecosystem**



No Bug Flows 2012-2017

Bug Flows

Bug Flows



Kennedy's professional opinion: SMB represent far greater threat to native fish conservation than low diversity/production of prey base. SMB Flows take precedence over Bug Flows.

USGS

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