

Bug Flows

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Grand Canyon Monitoring and Research Center
Southwest Biological Science Center
U.S. Geological Survey
U.S. Department of the Interior

Workplan Project Summary

- **Project F: Aquatic Invertebrate Ecology**
 - **F.1: Influence of dam operations on the food base**
 - **F.2: Aquatic food base status at humpback chub monitoring locations**
 - **F.4: Glen Canyon aquatic food base monitoring and research**
- **Project Objectives: “To determine how the aquatic food base responds to LTEMP flow experiments such as macroinvertebrate production flows”**
- **Funding Amount and Source: GCDAMP \$779,000 (for Project F)**
- **Products (FY20): 9 presentations, 5 articles. See Annual Report**

***Upshot: We study bugs.
AKA “Foodbase”***



Why Bug Flows? (1)

1. River dominated by 1 taxon (midges)

- Low diversity = low resilience



2. Total insect abundance low

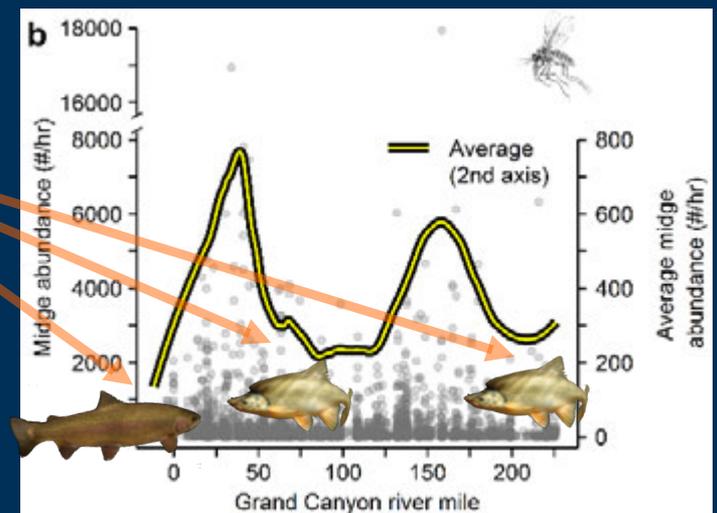
- Not enough “bug meat” for fish



3. Insect abundance not distributed evenly

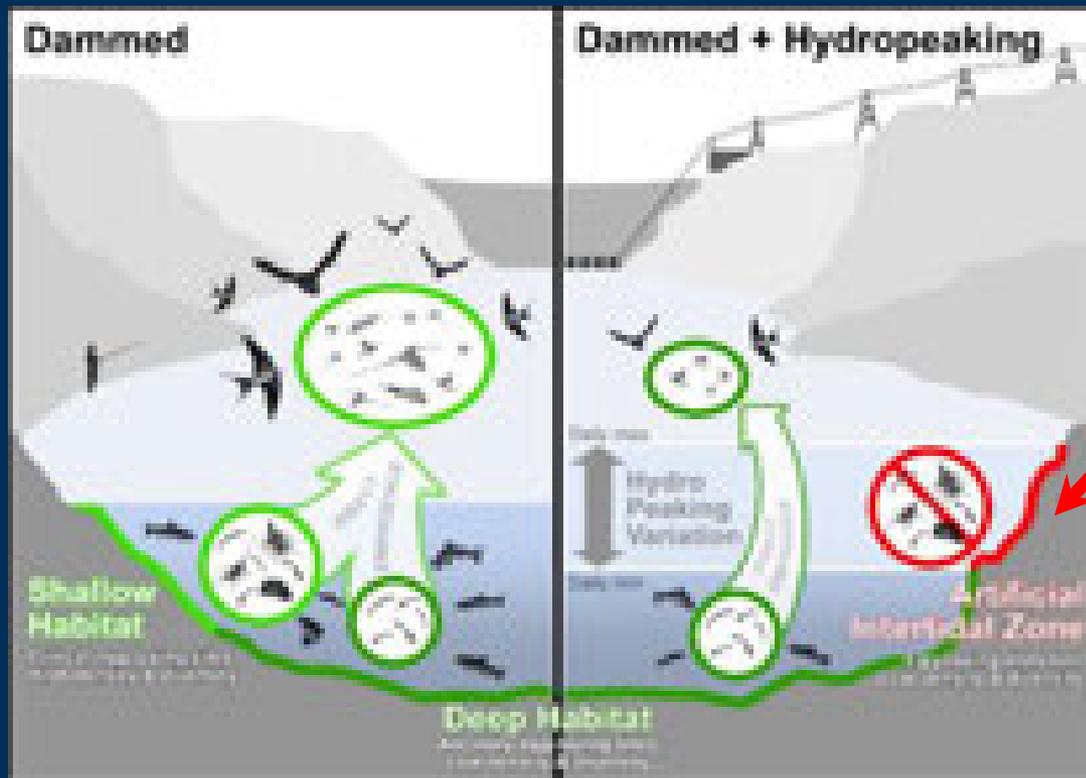
- Peaks/troughs of “bug meat”
- Not where we want it (for fish)

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



Theory Behind Bug Flows (1)

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



Want to avoid this

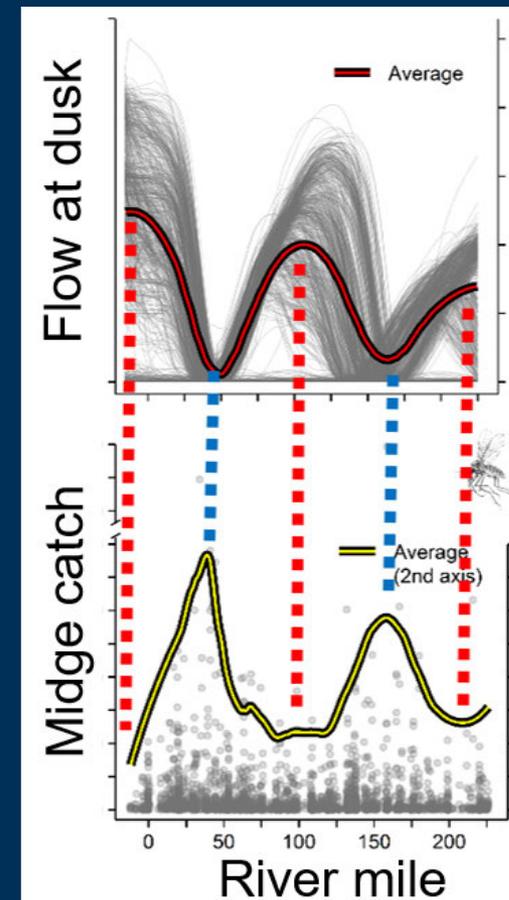
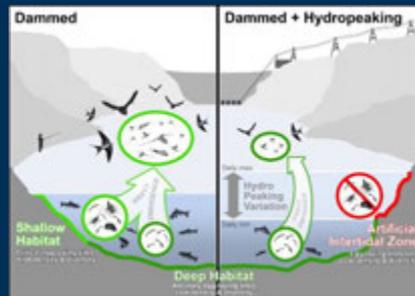
Kennedy et al.
2016 *BioScience*



Theory Behind Bug Flows (2)

- Daily hydropower flows create “tides”
- Insects lay eggs at water line at dusk
- When tide drops, eggs dry, die
- Mechanism to explain:
 - Low diversity
 - Low abundance
 - Peaks/troughs →

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?



Midge
(*Chironomidae*)

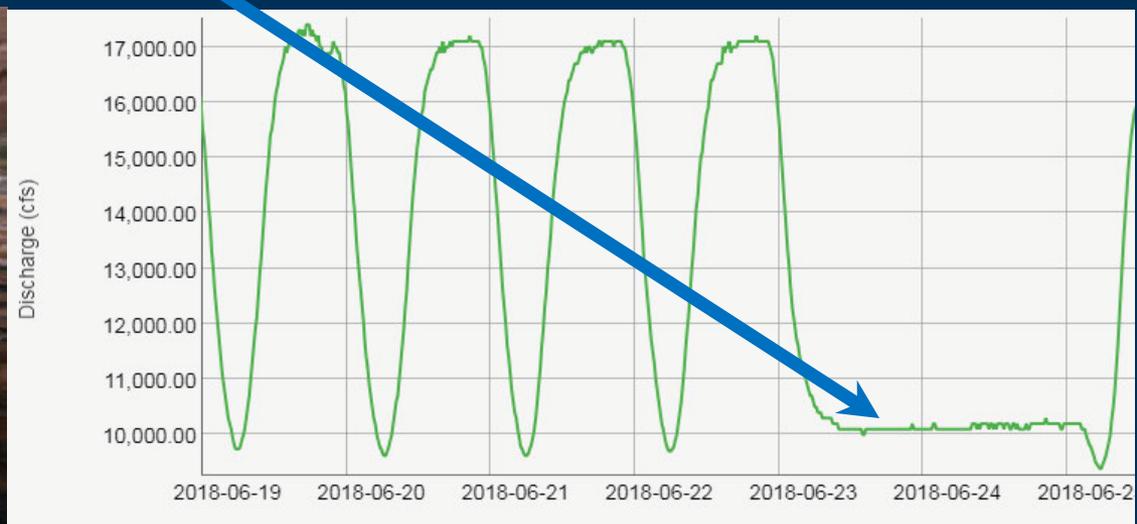


Caddisfly
(*Trichoptera*)



Design of Bug Flows

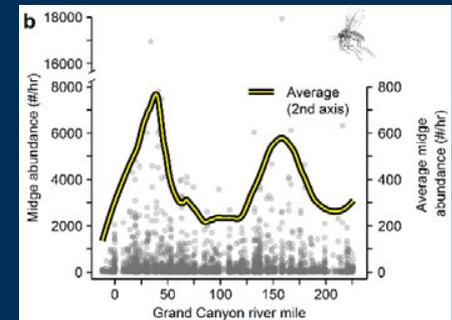
- Give bugs the “weekends off”
- Stable, low flows on weekends, May-August
- Eggs laid on weekends won’t dry/die



*Tested at Glen Canyon Dam
2018, 2019, 2020*

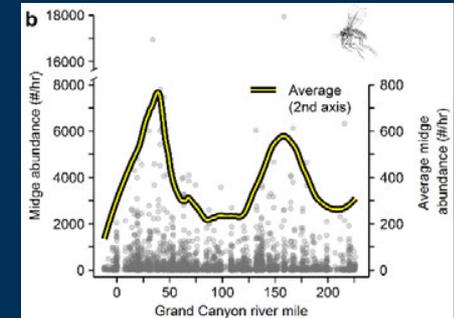
How we monitor Bug Flows (1)

- Citizen science light trapping
 - Give river guides a light trap
 - 1 hr, at dusk, nightly
- Typical year:
 - 757 samples
 - April to September
 - Canyon-wide



How we monitor Bug Flows (2)

- Citizen science light trapping
 - Give river guides a light trap
 - 1 hr, at dusk, nightly



- Typical year:
 - 757 samples
 - April to September
 - Canyon-wide
- 2020 (COVID closures):
 - 355 samples
 - Mid-June to September
 - Unusual focus on Lees Ferry, Phantom Ranch



What have we learned? (1)



Why Bug Flows?

1. River dominated by 1 taxon (midges)
 - Low diversity = low resilience
2. Total insect abundance low
 - Not enough “bug meat” for fish
3. Insect abundance not distributed evenly
 - Peaks/troughs of “bug meat”
 - Not where we want it (for fish)

What have we learned? (2)

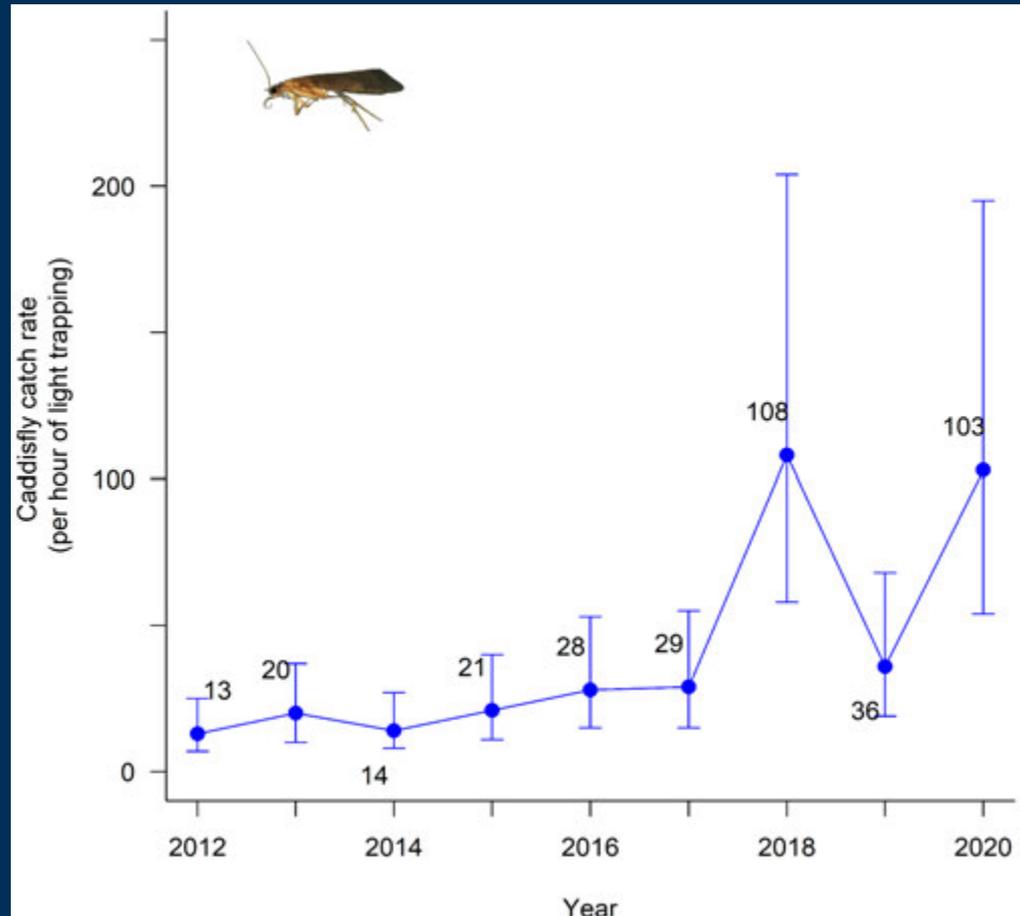
Why Bug Flows?

1. River dominated by 1 taxon (midges)
2. Total insect abundance low
3. Insect abundance not distributed evenly

Caddisflies enter the scene

GOOD

- ...but why so quickly?



Unpublished data, subject to change, do not cite.

What have we learned? (3)

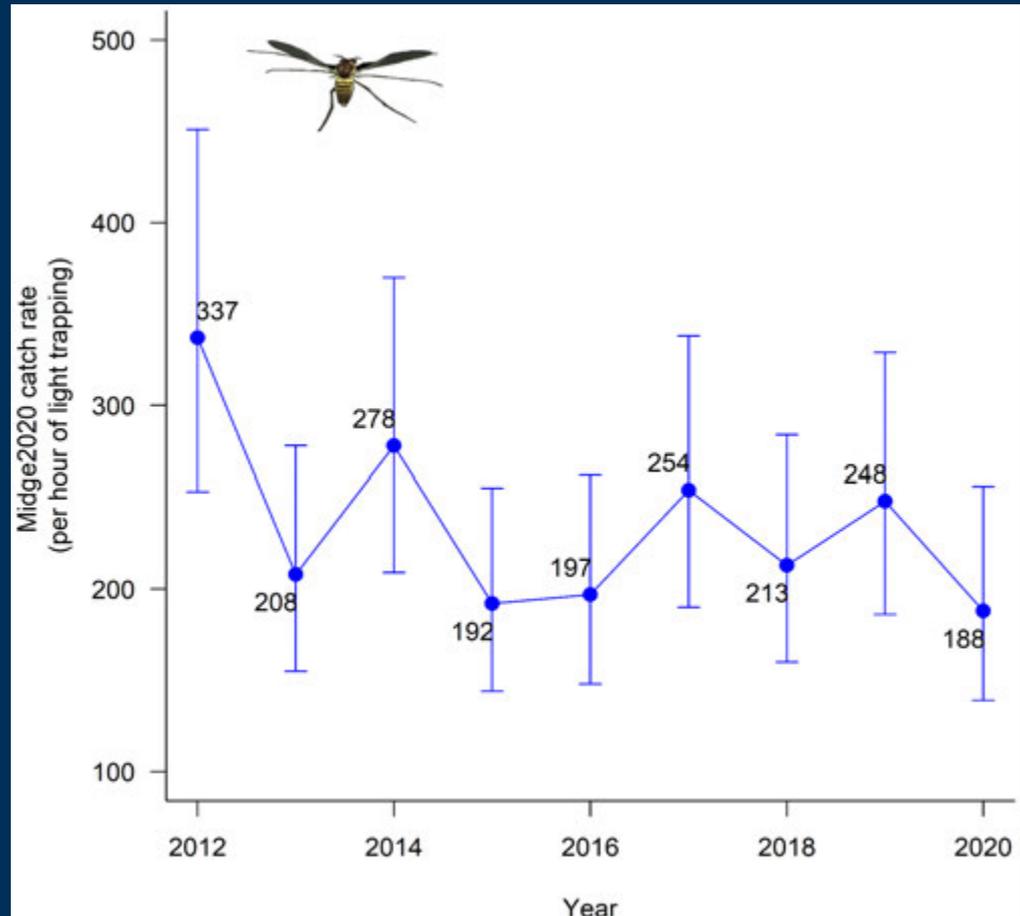
Why Bug Flows?

1. River dominated by 1 taxon (midges)
2. Total insect abundance low
3. Insect abundance not distributed evenly

- Midge counts unchanged
 - Predicted 27% increase

NOPE

- ...but do we trust 2020?



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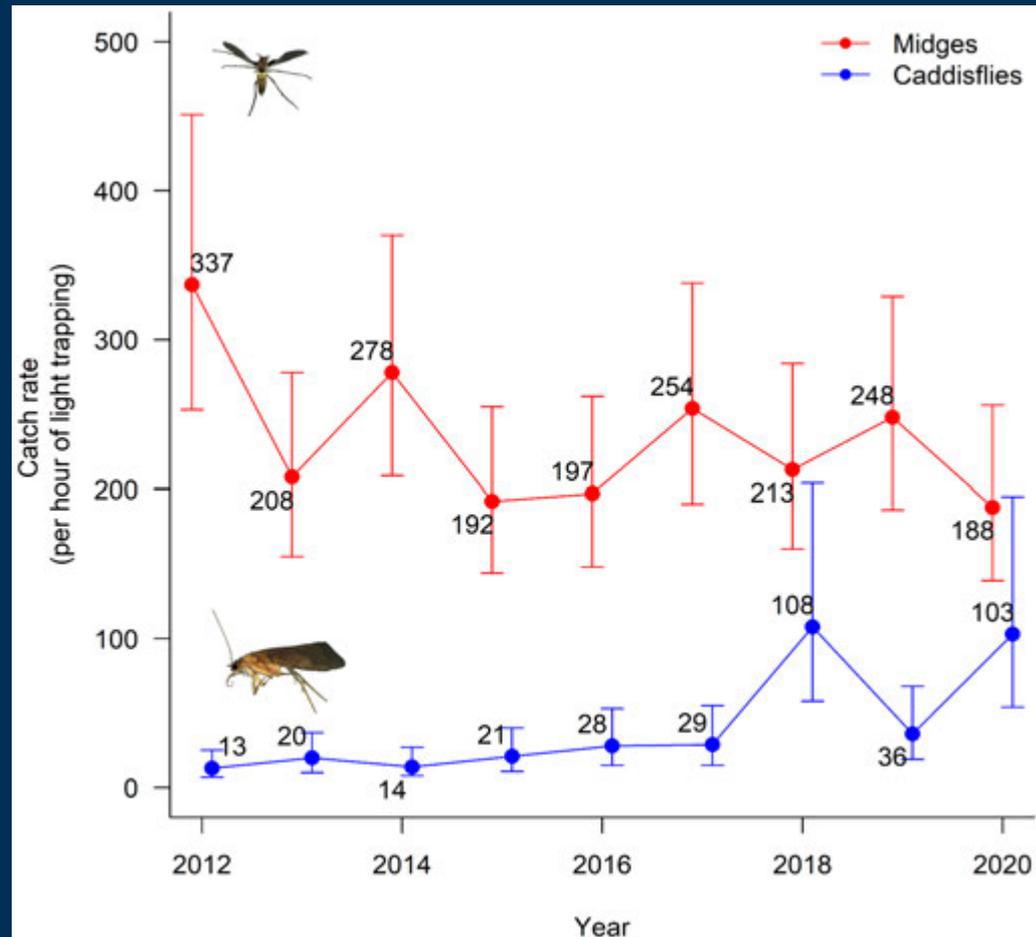
What have we learned? (4)

Why Bug Flows?

1. River dominated by 1 taxon (midges)
2. Total insect abundance low
3. Insect abundance not distributed evenly

- Midge counts unchanged
 - Predicted 27% increase
- Total aquatic abundance increases ~20%

GOOD



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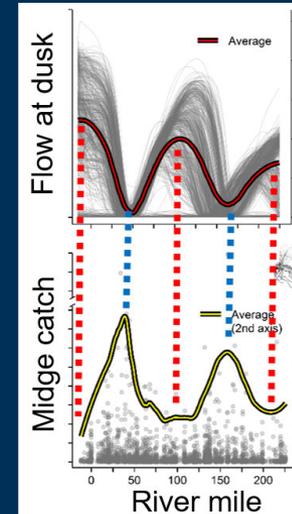
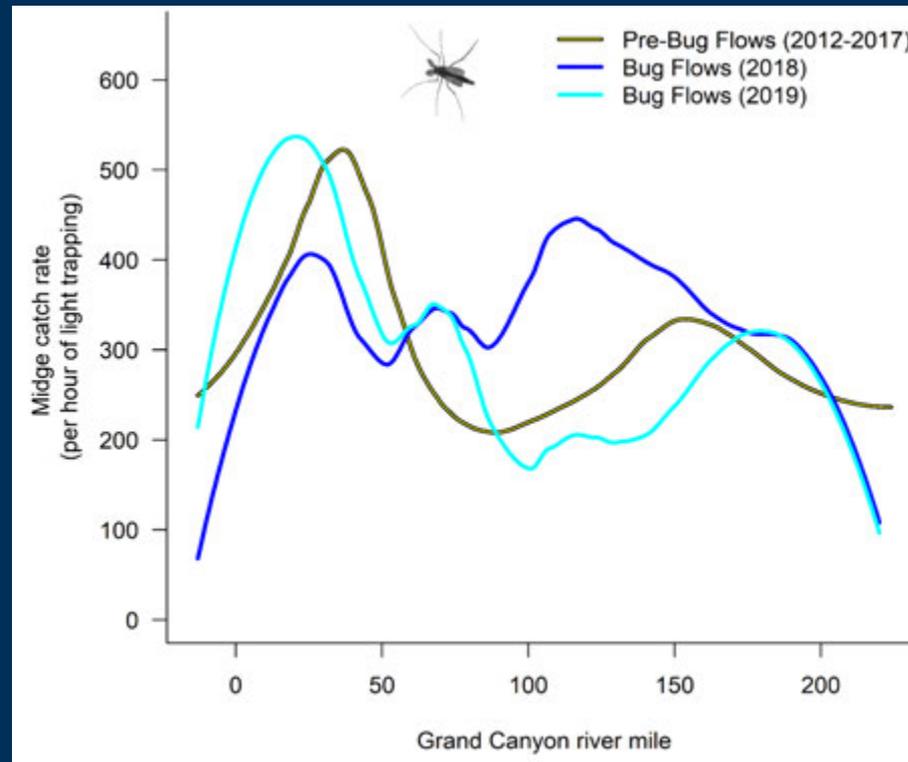
What have we learned? (5)

Why Bug Flows?

1. River dominated by 1 taxon (midges)
2. Total insect abundance low
3. **Insect abundance not distributed evenly**

- Midge spatial “sine wave”
 - 2018: Breaks down
 - 2019: More typical
 - 2020: Too few samples (COVID)

UNRESOLVED



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What have we learned? (6)

Why Bug Flows?

1. River dominated by 1 taxon (midges)
2. Total insect abundance low
3. **Insect abundance not distributed evenly**

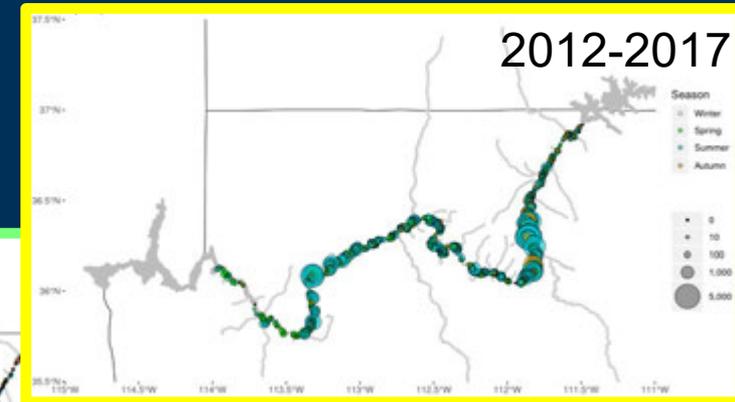
- Midge spatial “sine wave”
 - 2018: Breaks down
 - 2019: More typical
 - 2020: Too few samples (COVID)

- Caddisflies go where chub live

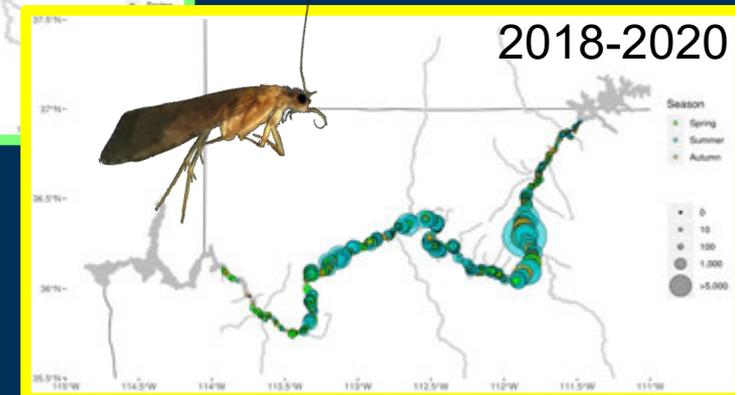
GOOD



Hydropsychids (Fall Cyn)
~0 abundance pre-2018



Hydroptilids (LCR)

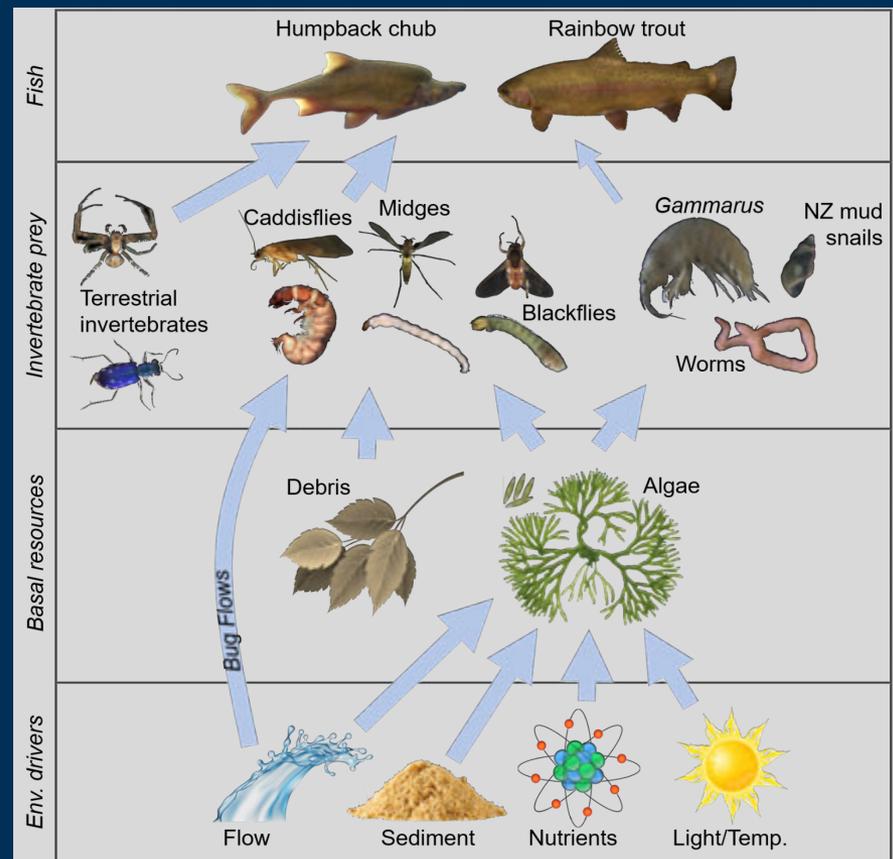


Bug Flows is about more than eggs (1)

Increased weekend GPP (algae growth)

- See Deemer and Yackulic's presentation!

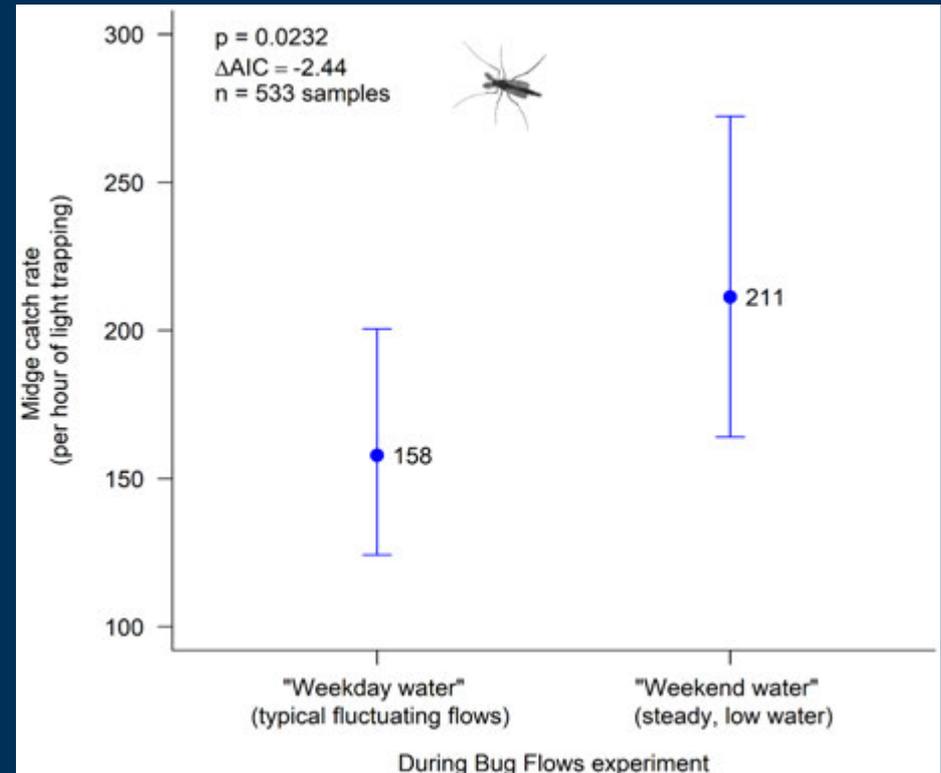
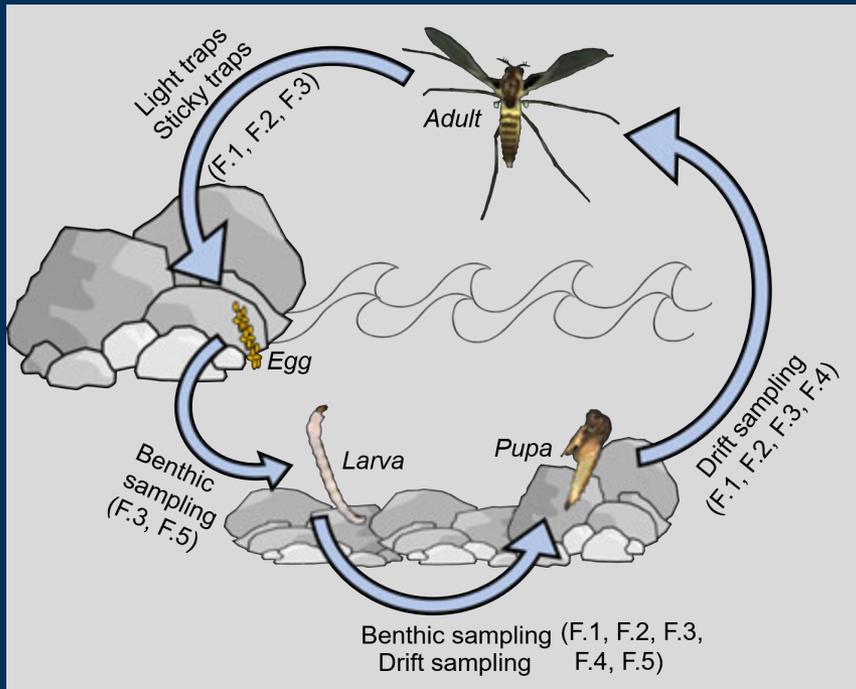
GOOD



Bug Flows is about more than eggs (2)

- Increased weekend GPP
- Increased weekend emergence

GOOD

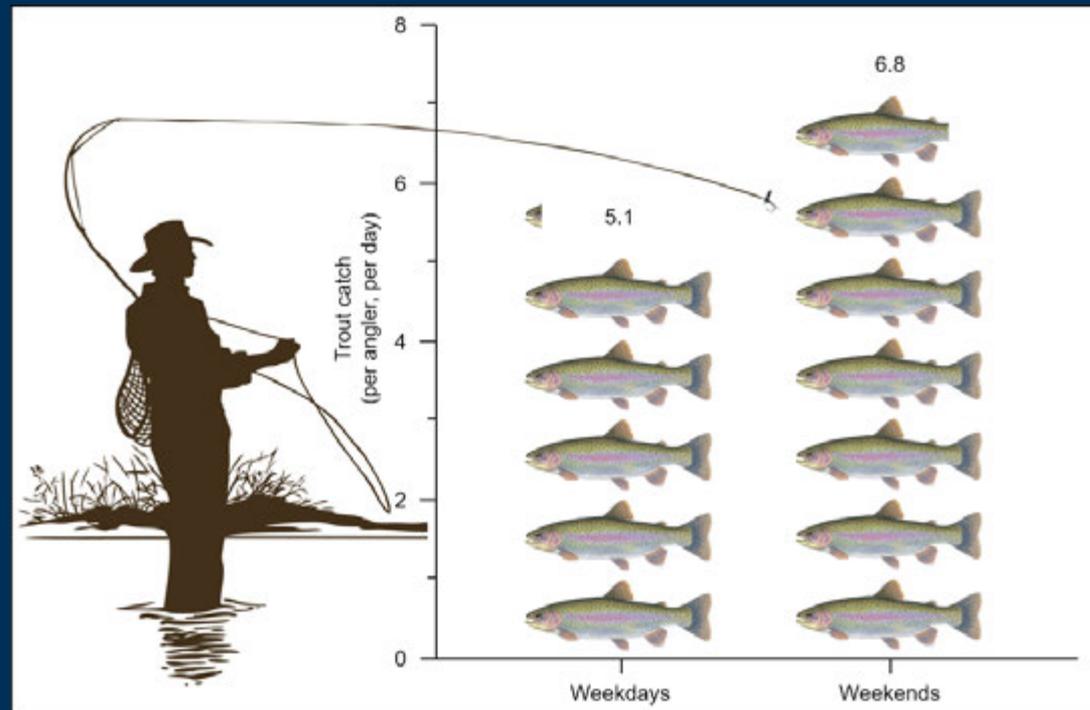


Unpublished data, subject to change,
do not cite.

Bug Flows is about more than eggs (3)

- Increased weekend GPP
- Increased weekend emergence
- Improved weekend fishing

GOOD



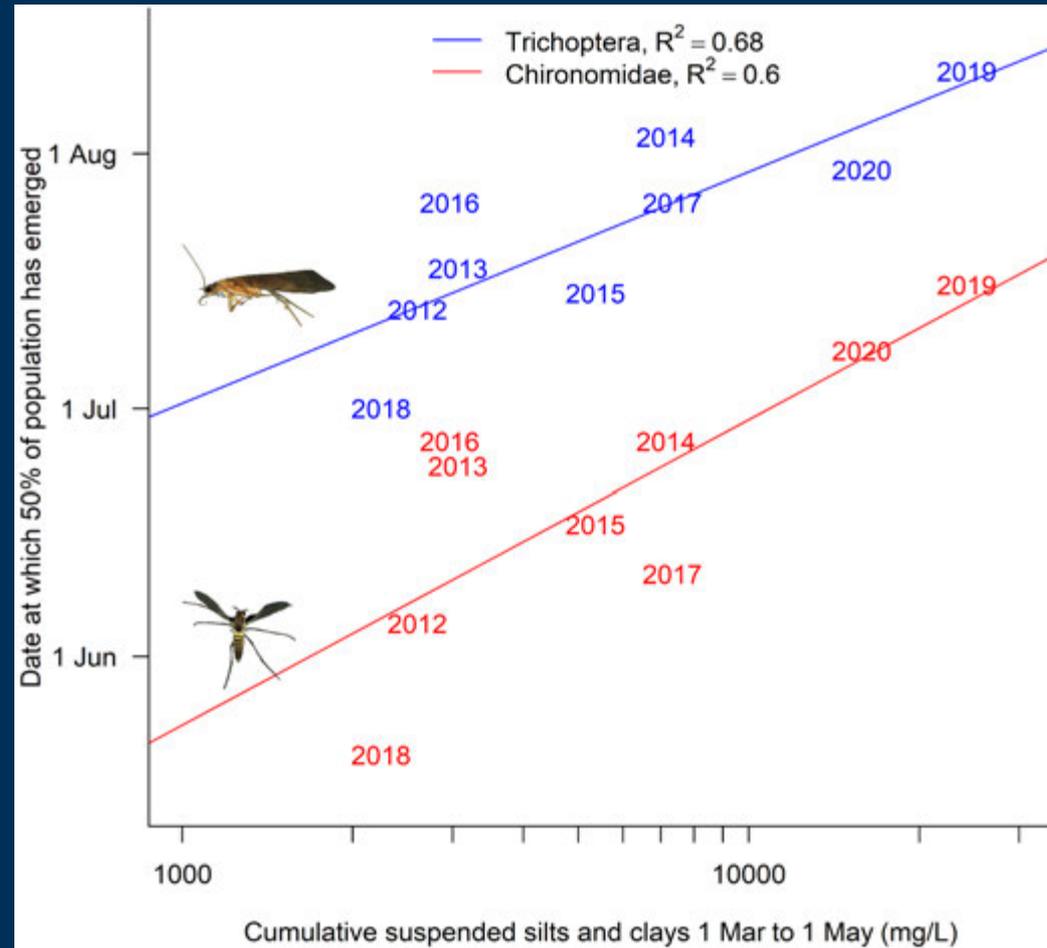
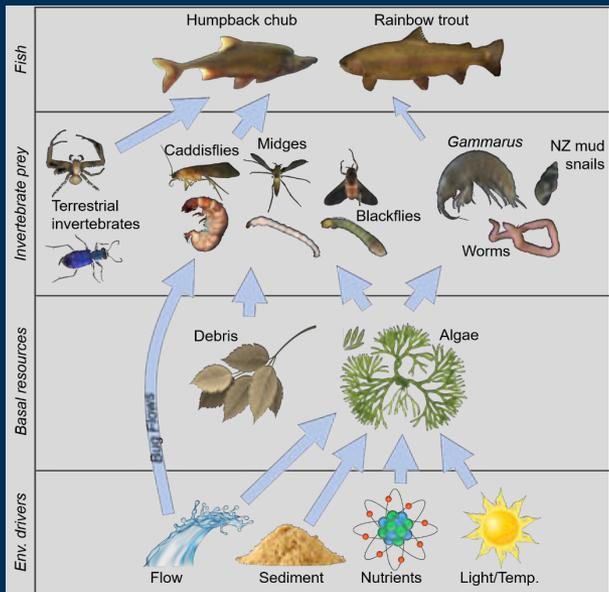
Metcalfe et al. 2020
Boatman's Quarterly Review



Bug Flows aren't the only driver (1)

Spring "mud"

- Affects midge and caddis timing (and size?)

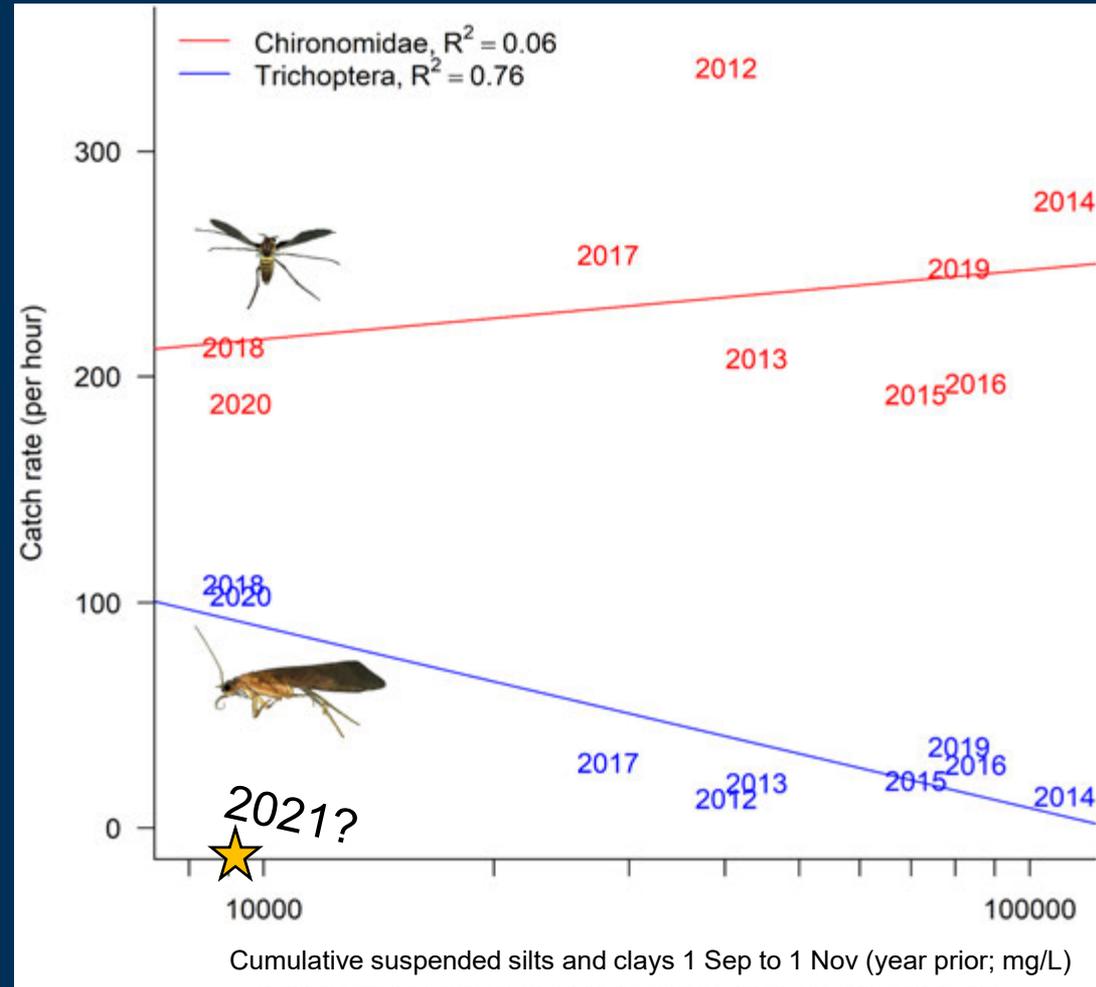
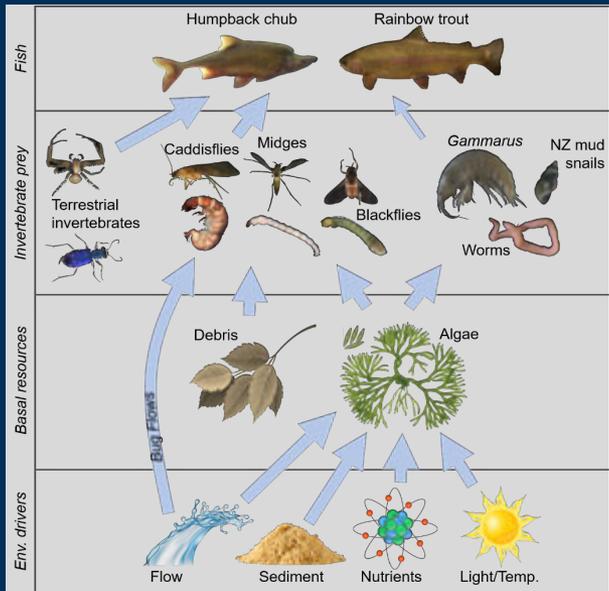


Unpublished data, subject to change,
do not cite.

Bug Flows aren't the only driver (2)

Fall "mud"

- Affects caddis (but not midge) survival?



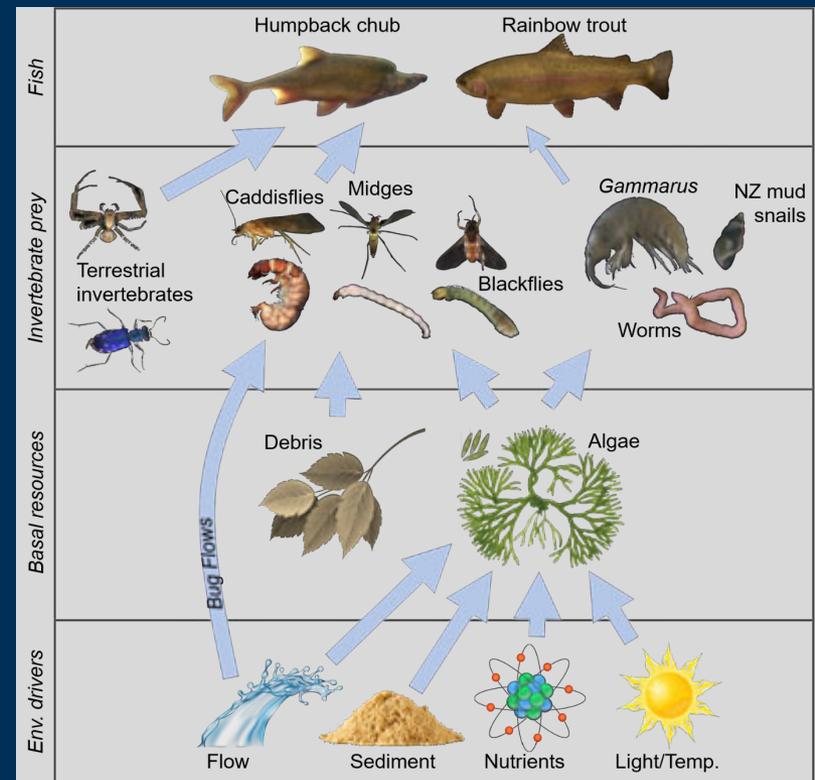
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With thanks to Craig Ellsworth!

Bug Flows aren't the only driver (3)

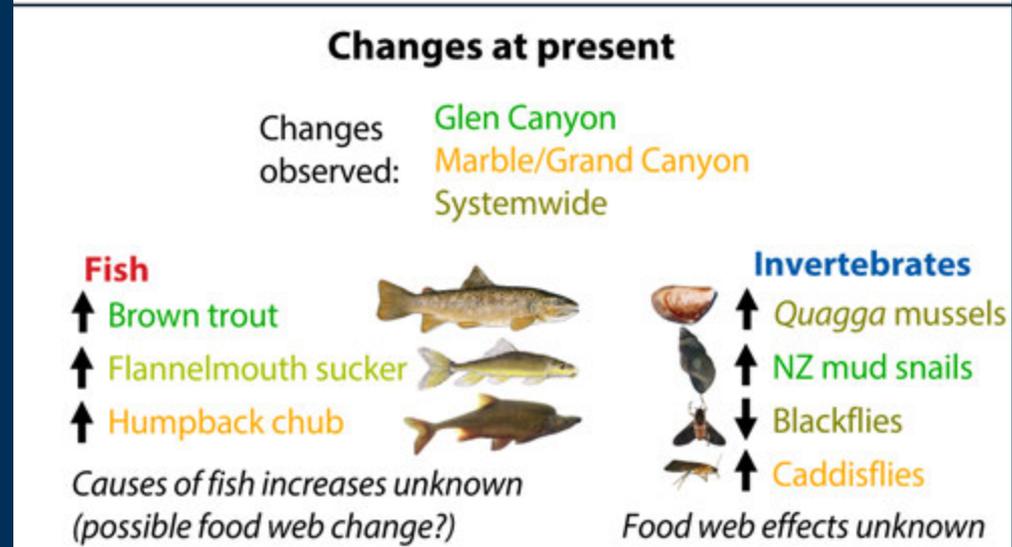
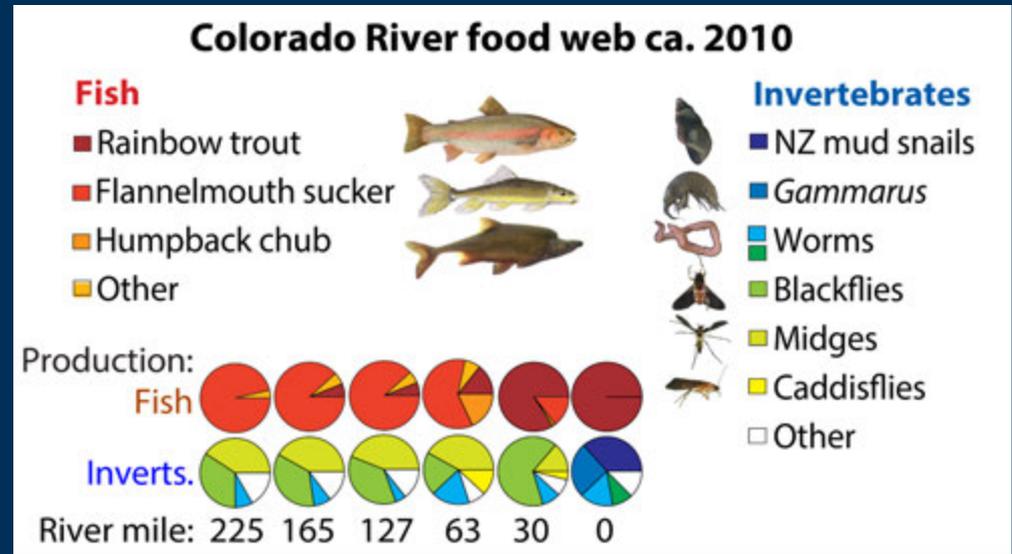
Temperature, nutrients, substrate

- See Michael Cavallaro's poster about Davis Dam!



What can Bug Flows still teach us? (1)

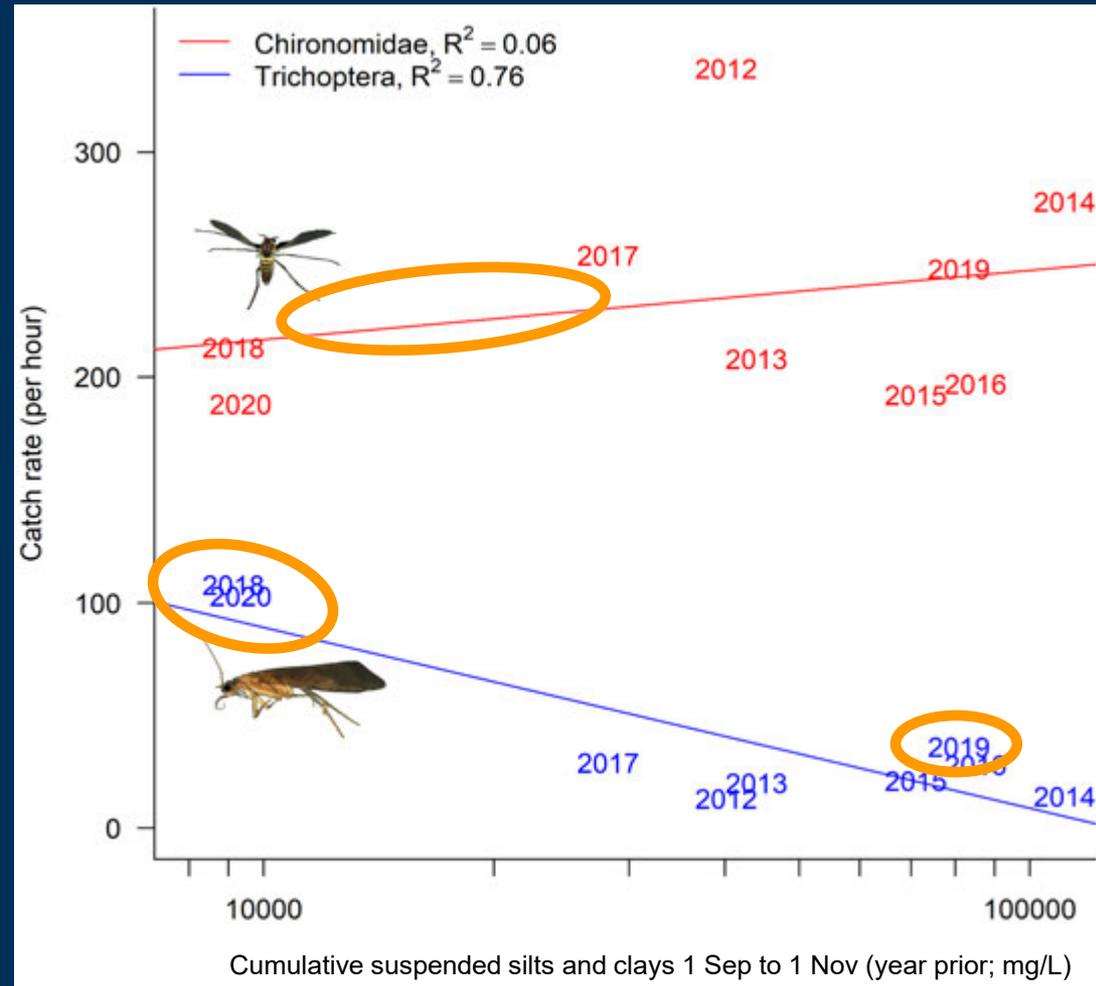
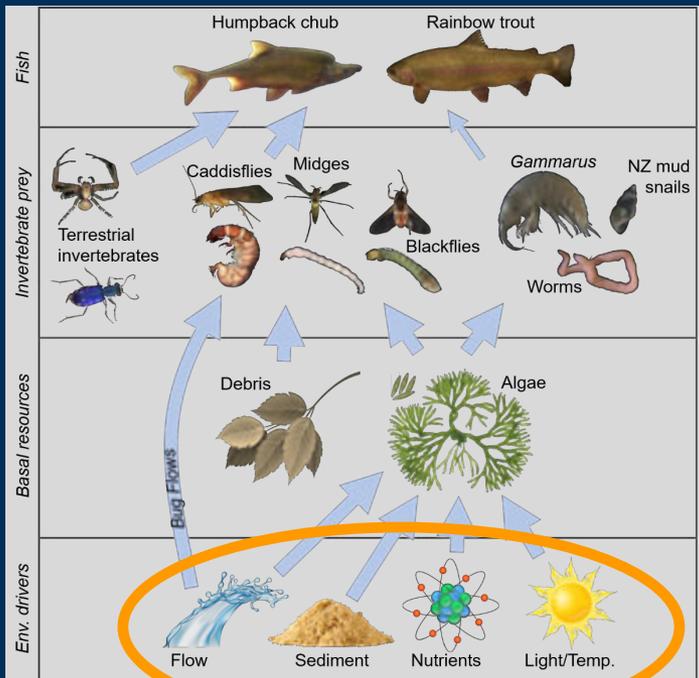
Links to fish



Unpublished data, subject to change, do not cite.
Courtesy of Anya Metcalfe.

What can Bug Flows still teach us? (2)

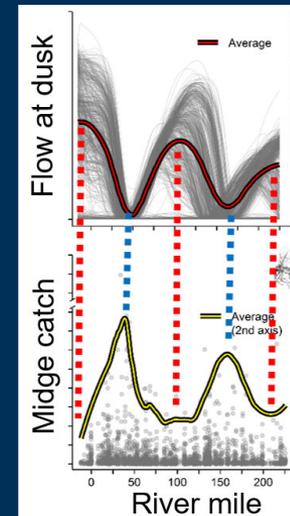
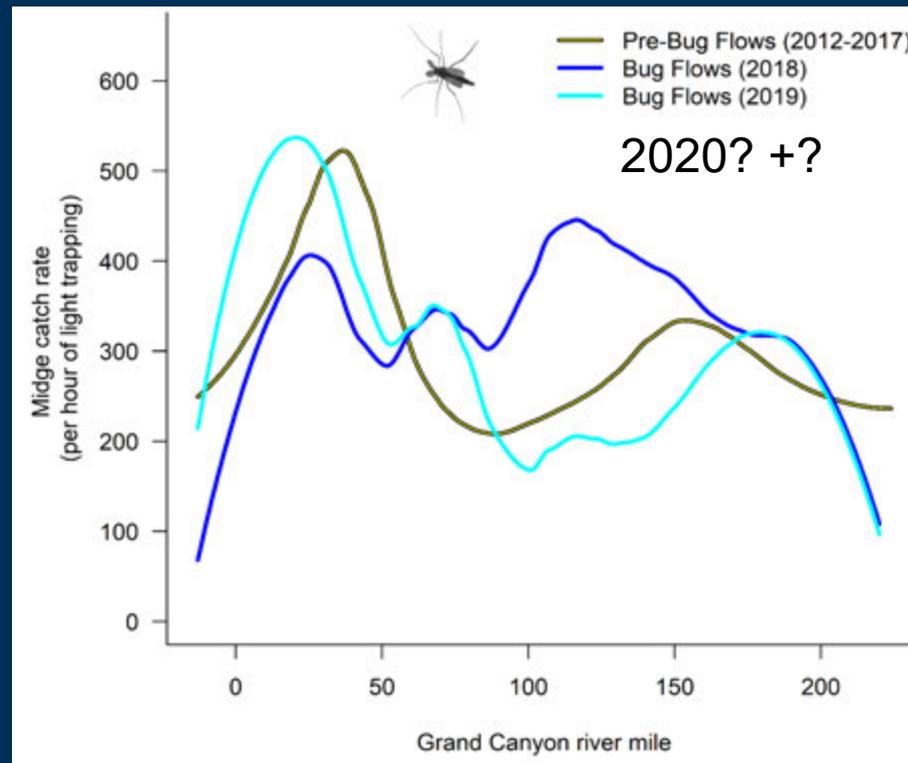
Links to other drivers



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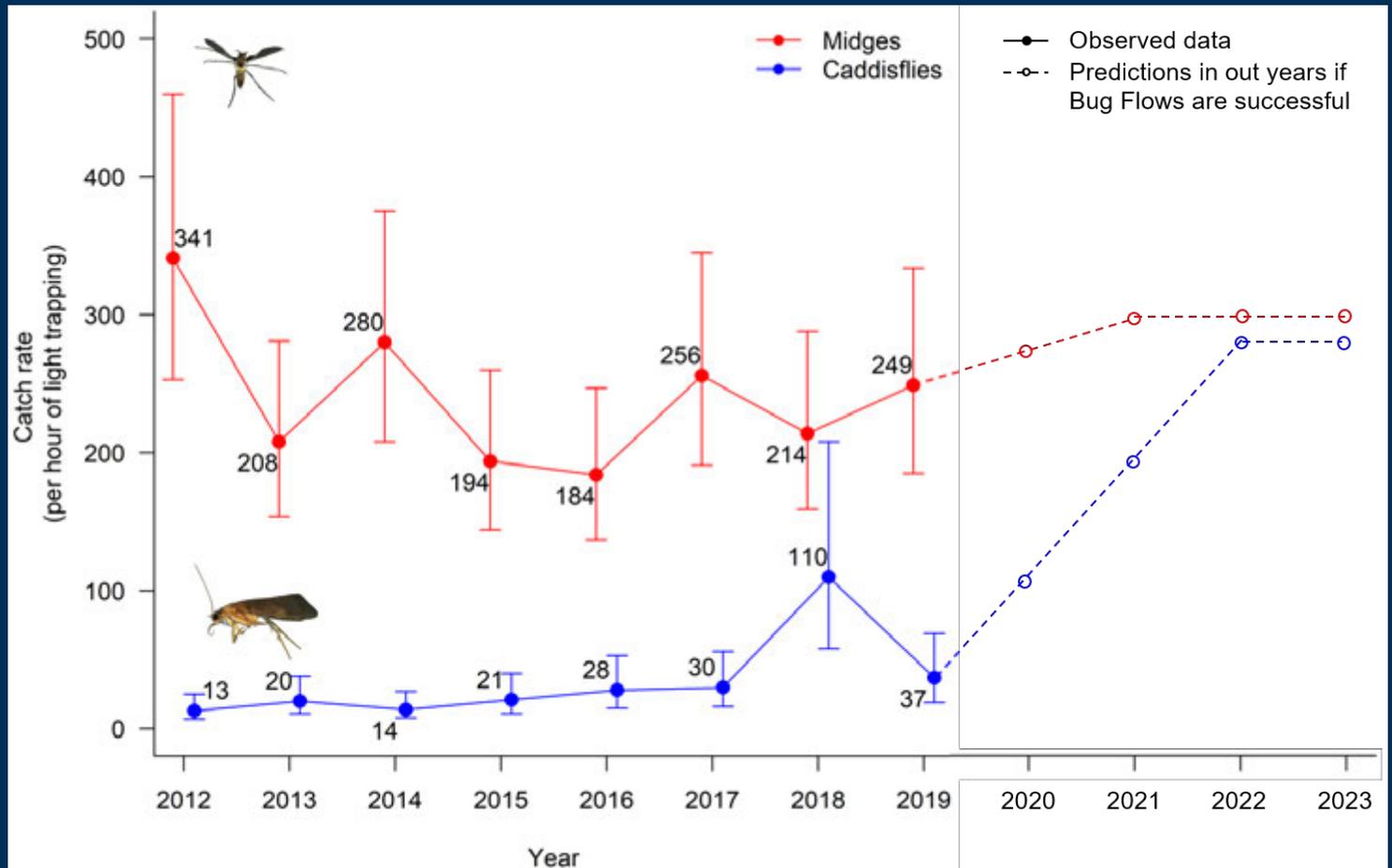
What can Bug Flows still teach us? (3)

- Definitive spatial change
- Is egg-laying hypothesis viable?



What can Bug Flows still teach us? (4)

Long-term trajectories



Why Bug Flows? (2)



1. River dominated by 1 taxon (midges)

- ✓ Low diversity = low resilience



2. Total insect abundance low

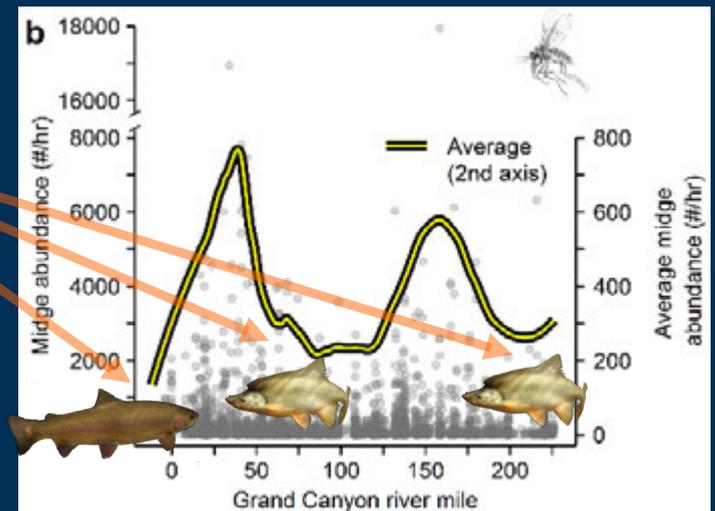
- ✓ Not enough “bug meat” for fish



3. Insect abundance not distributed evenly

- ? Peaks/troughs of “bug meat”
- ✓ Not where we want it (for fish)

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



Why not Bug Flows?

- **Tangible weekend benefits**
 - GPP (algae), fishing, bug emergence
- **Possible caddisfly benefits**
 - Into chub reaches, population increase
- **Critical uncertainties: Insects**
 - Spatial “sine wave”, egg-laying success
 - Interaction with sediment/other conditions
- **Critical uncertainties: Fish**
 - Feeding/diet link to insect increases?
- **Hydropower cost**

