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13 January 2020
Grand Canyon Monitoring and Research Center
Southwest Biological Science Center
U.S. Department of the Interior
U.S. Geological Survey

Year 2 of Bug Flows

Ted Kennedy & Jeff Muehlbauer

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)

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Products

Title	Citation, URL, or Notes
Bug Flows implementation and resource response	Kennedy, T.A. and Muehlbauer, J.D., 2019, Bug Flows implementation and resource response—presentation: Phoenix, Ariz., March 12, 2019, TWG Annual Reporting Meeting.
Big flood, small flood, spring flood, fall flood: HFE timing affects food base response	Kennedy, T.A. and Muehlbauer, J.D., 2019, Big flood, small flood, spring flood, fall flood—HFE timing affects food base response—presentation: Phoenix, Ariz., March 13, 2019, TWG HFE workshop meeting.
Bug Flows implementation and resource response	Kennedy, T.A., 2019, Bug Flows implementation and resource response—presentation: Marble Canyon, Ariz., April 15, 2019, Meeting with fishing guides.
Bug Flows evaluation and recommendation for 2019	Smith, E.O., Kennedy, T.A., and Vanderkooi, S.P., 2019, Bug Flows evaluation and recommendation for 2019—presentation: Flagstaff, Ariz., April 22, 2019, LTEMP Planning and Implementation Team Webinar.
Bug Flows update	Kennedy, T.A., Muehlbauer, J.D., and Dodrill, M.J., 2019, Bug Flows update—presentation: Flagstaff, Ariz., May 1, 2019, TWG Webinar.
Bug Flows: LTEMP planning process and preliminary observations	Smith, E.O. and Kennedy, T.A., 2019, Bug Flows—LTEMP planning process and preliminary observations—presentation: Flagstaff, Ariz., May 22, 2019, AMWG Webinar.

Title	Citation, URL, or Notes
When flow food webs get fishy: Some challenges and opportunities	Baxter, C.V., Bellmore, J., Cross, W.F., Hall, R.O., Kennedy, T.A., Marcarelli, A., Paris, J., Rosi, E.J., 2019, When flow food webs get fishy—Some challenges and opportunities—presentation: Salt Lake City, Utah, May 20, 2019, Society for Freshwater Science Annual Meeting.
Genetic diversity of a vagile aquatic insect varies with river network structure	Metcalfe, A.N., Kennedy, T.A., Marks, J.C., Muehlbauer, J.D., 2019, Genetic diversity of a vagile aquatic insect varies with river network structure—presentation: Salt Lake City, Utah, May 20, 2019, Society for Freshwater Science Annual Meeting.
Food web controls on mercury flux and fate in the Colorado River, Grand Canyon	Walters, D., Rosi, E.J., Cross, W.F., Kennedy, T.A., Baxter, C.V., and Hall, R.O., 2019, Food web controls on mercury flux and fate in the Colorado River, Grand Canyon—presentation: Salt Lake City, Utah, May 20, 2019, Society for Freshwater Science Annual Meeting.
Hydropower and aquatic-terrestrial linkages in the Colorado River	Lupoli, C.A., Kennedy, T.A., Sabo, J.L., and Yackulic, C.B., 2019, Hydropower and aquatic-terrestrial linkages in the Colorado River—presentation: Salt Lake City, Utah, May 21, 2019, Society for Freshwater Science Annual Meeting.
Bug Flows: LTEMP planning process and preliminary observations	Smith, E.O. and Kennedy, T.A., 2019, Bug Flows—LTEMP planning process and preliminary observations—presentation: Flagstaff, Ariz., May 22, 2019, AMWG Webinar.
Colorado River ecosystem response to the 2018 Bug Flow experiment from Glen Canyon Dam	Muehlbauer, J.D. and Kennedy, T.A., 2019, Colorado River ecosystem response to the 2018 Bug Flow experiment from Glen Canyon Dam—presentation: Salt Lake City, Utah, May 23, 2019, Society for Freshwater Science Annual Meeting.
Preliminary observations from the Bug Flows Experiment	Kennedy, T.A. and Muehlbauer, J.D., 2019, Preliminary observations from the Bug Flows Experiment—presentation: Phoenix, Ariz., June 11, 2019, TWG Meeting.
Colorado River Ecosystem response to the 2018 Bug Flow Experiment from Glen Canyon Dam	Kennedy, T.A., Muehlbauer, J.D., and Rogowski, D.L., 2019, Colorado River ecosystem response to the 2018 Bug Flow Experiment from Glen Canyon Dam—presentation: Flagstaff, Ariz., September 11, 2019, 15th Biennial Conference of Research on the Colorado Plateau.

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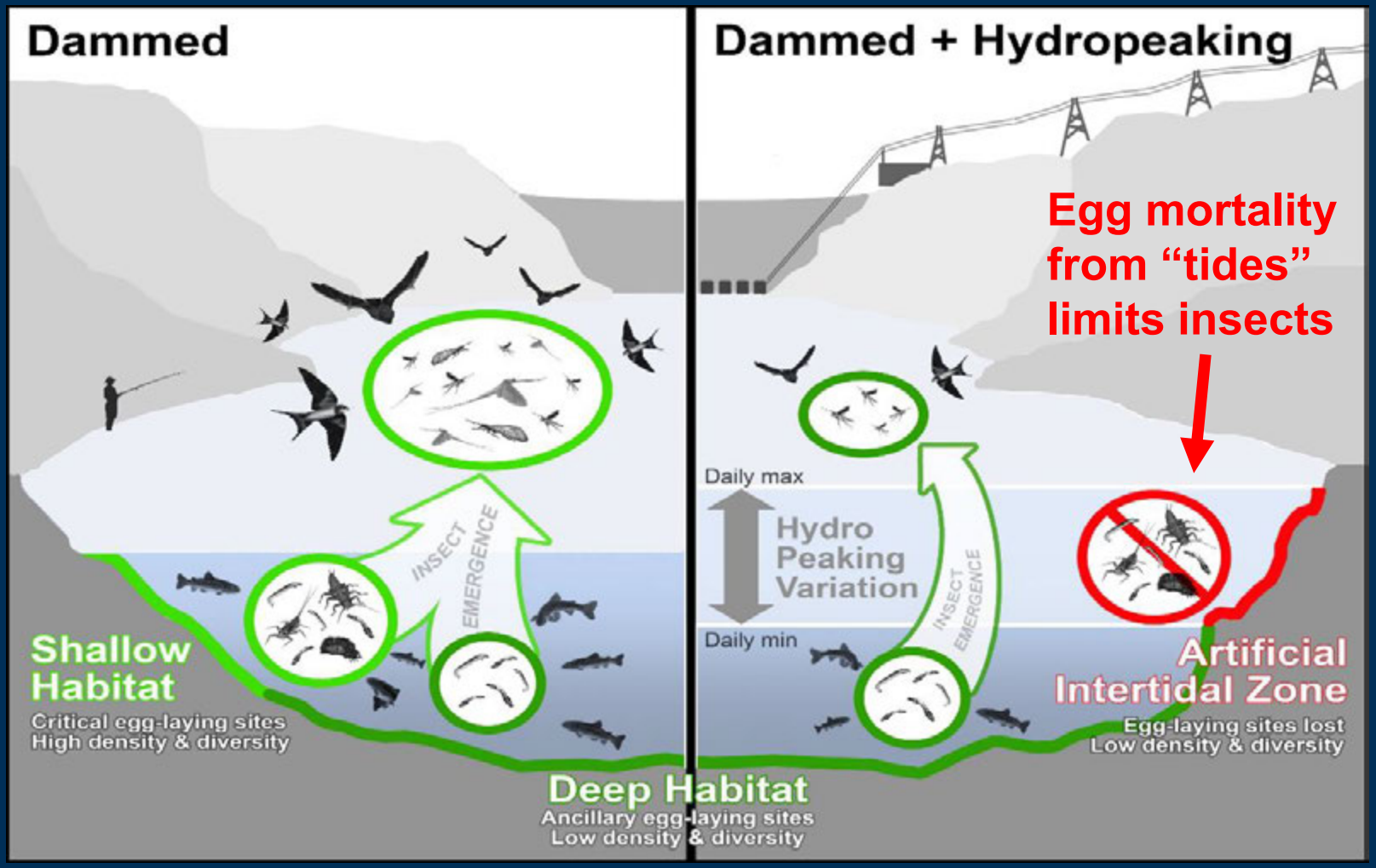
Theory behind Bug Flows



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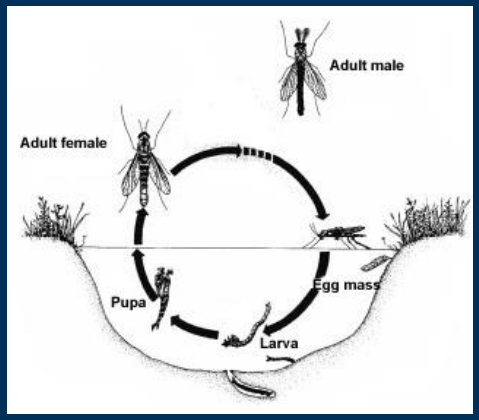
Kennedy et al. 2016 *BioScience*

Purpose of Bug Flows Experiment

Improve egg-laying conditions for insects!



Therefore:

- Increase midge abundance
- Increase sensitive EPT abundance/diversity (longer term?)

Ultimately:

- Improve fish food base

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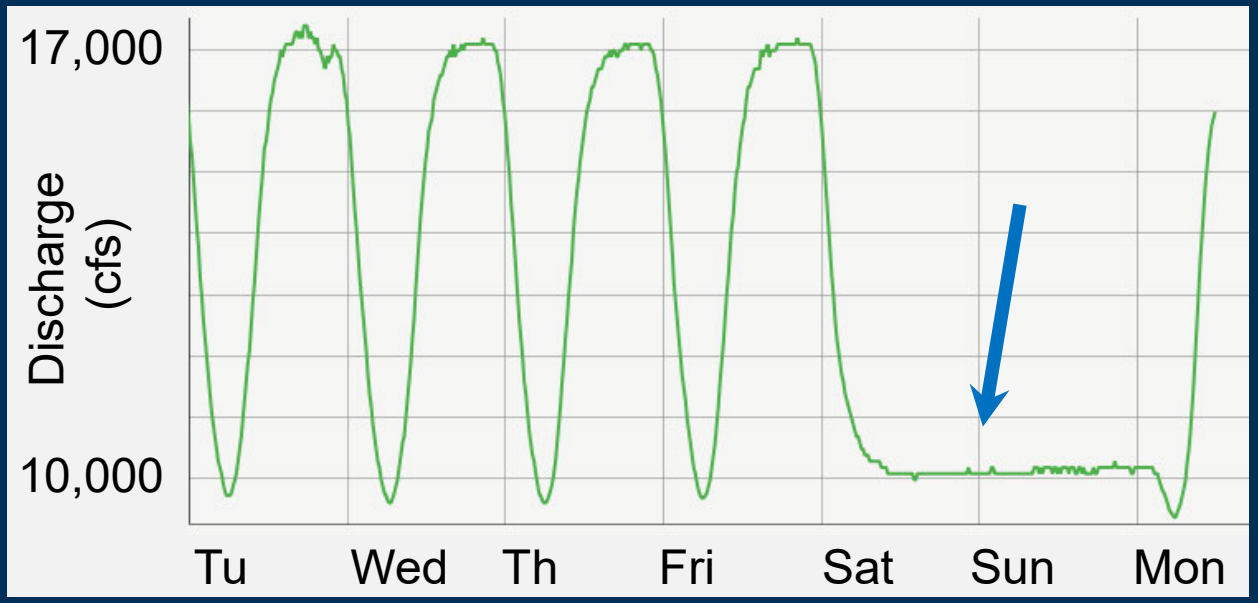
Design of Bug Flows

- "Give bugs the weekends off!"
- May – August 2018, 2019
- Stable, low flows on summer weekends
  - Eggs laid on weekends won't dry/die



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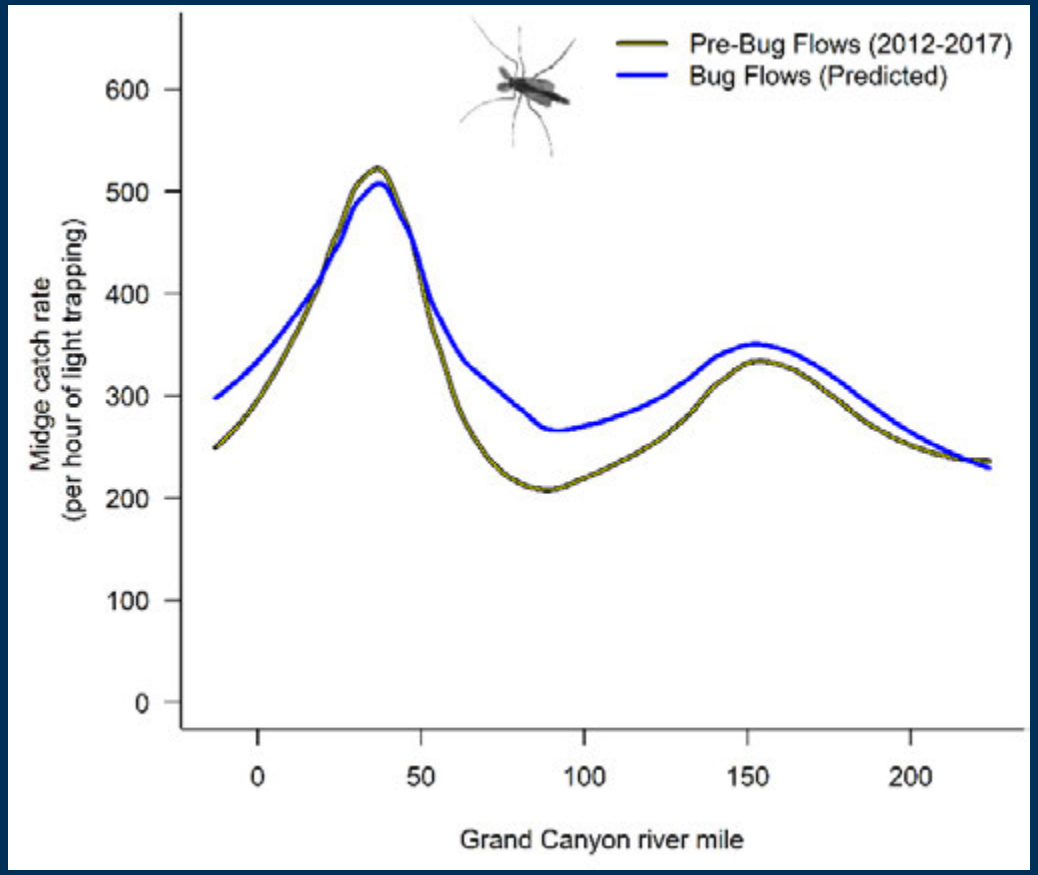
Predicted Responses (long-term)

Smoothing

of spatial pattern

More midges

throughout Canyon



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Predicted Responses (long-term), cont.

Smoothing

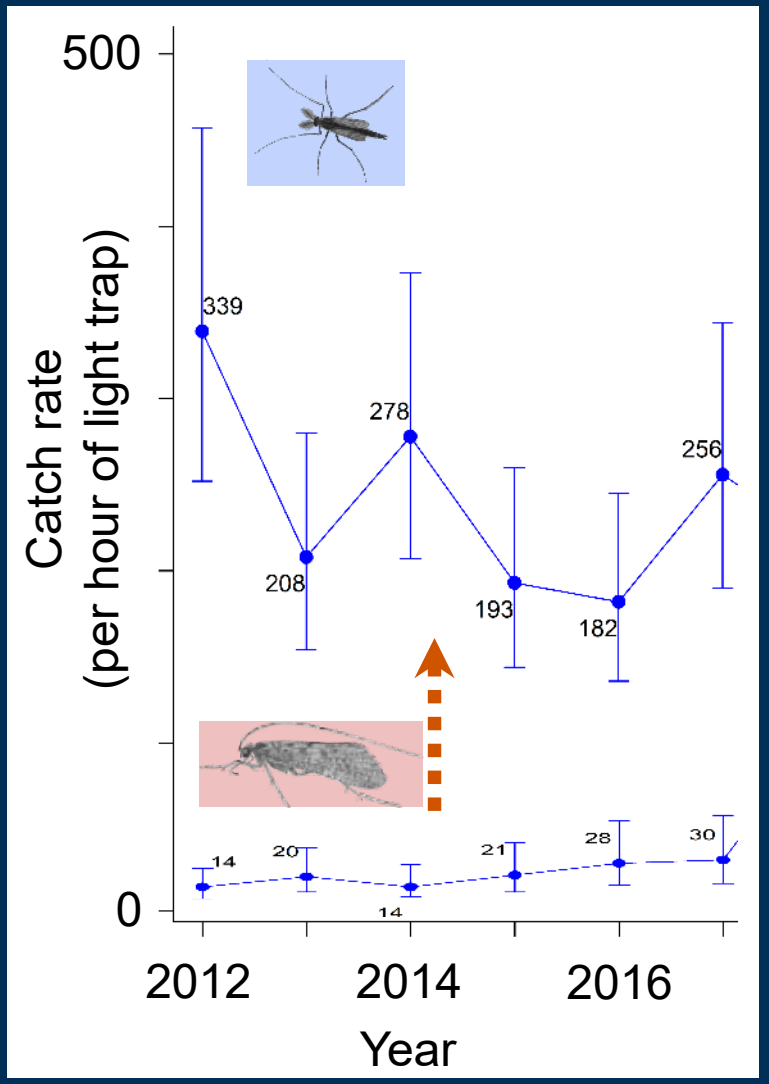
of spatial pattern

More midges

throughout Canyon

More caddisflies

(EPT)



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Unpredicted Responses Anglers ❤ Bug Flows

leesferrybackhaul.com

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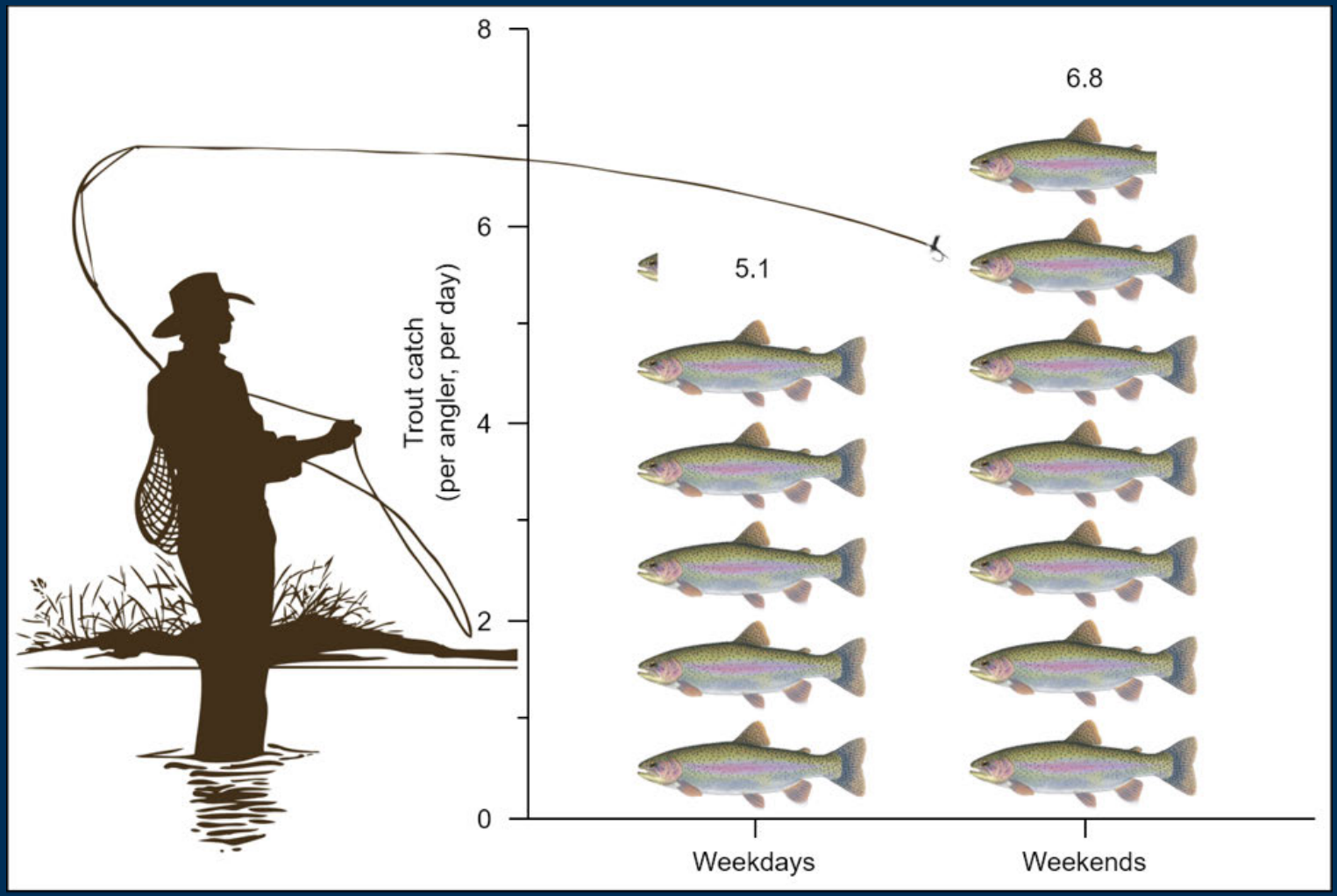
"The bug flows are providing great weekend fly fishing activity…."

Bug Flows = Better Fishing



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Metcalfe et al. 2020 *Boatman's Quarterly Review*

2019 Light Trap Caveat

- Only 569 / 959 light traps processed
  - 40% left

- Numbers can still change (dramatically!)

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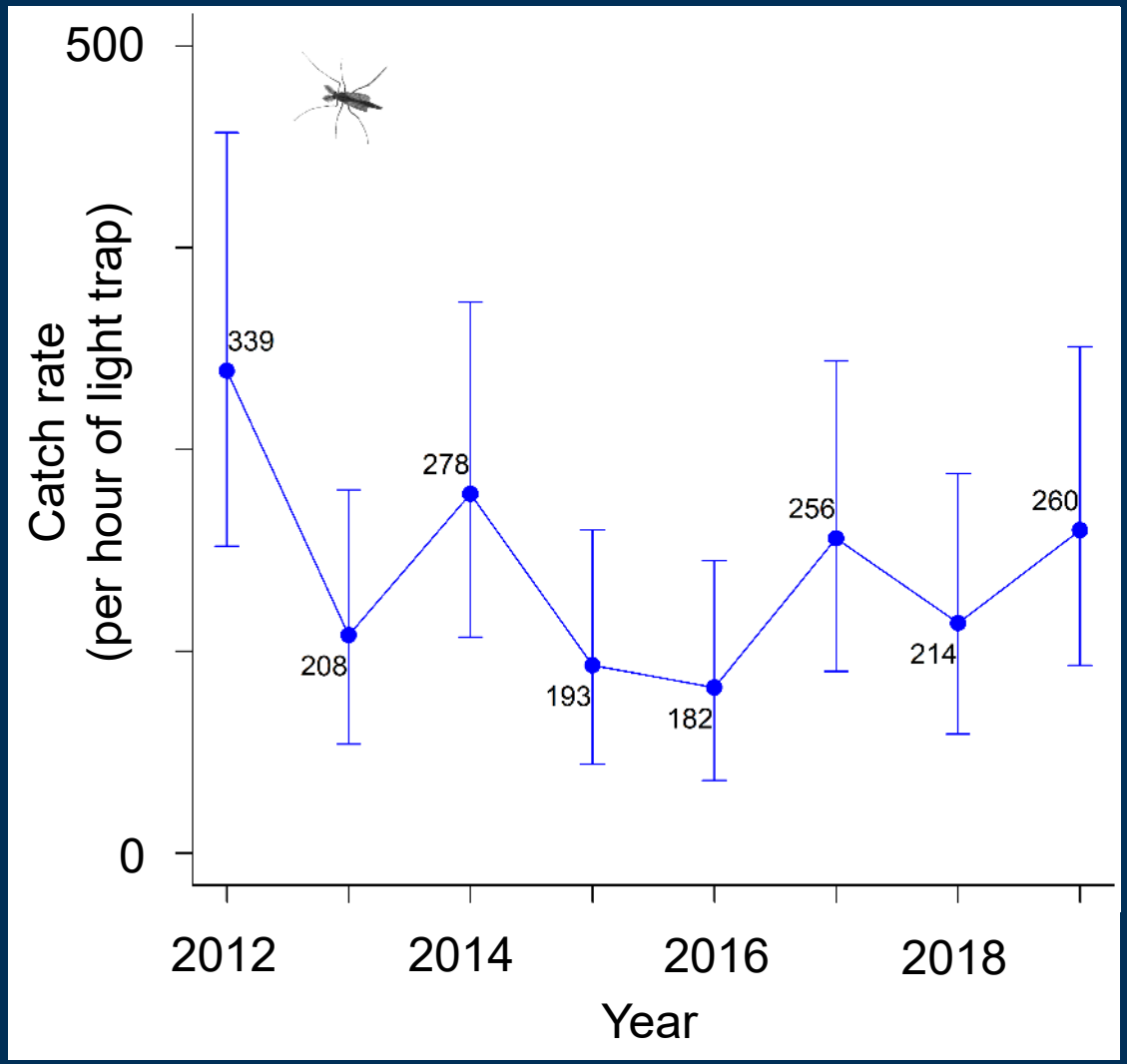
Midge Catch

- 2017: ~5 years of stability
- 2018: Stability continues
- 2019: Stability continues?



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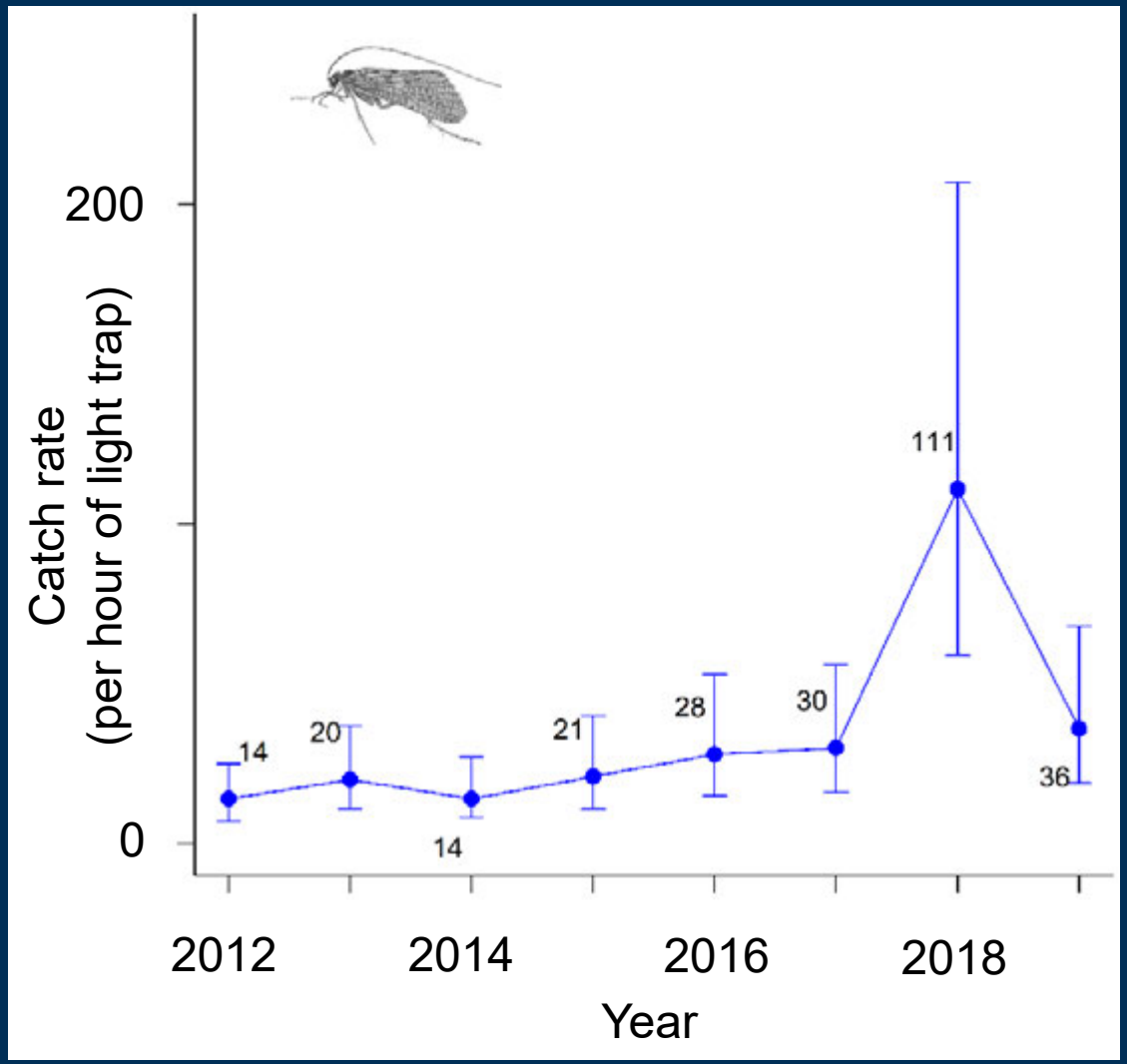
Caddisfly Catch

- 2017: Slow increase
- 2018: Explosion!
- 2019: Back to Earth?



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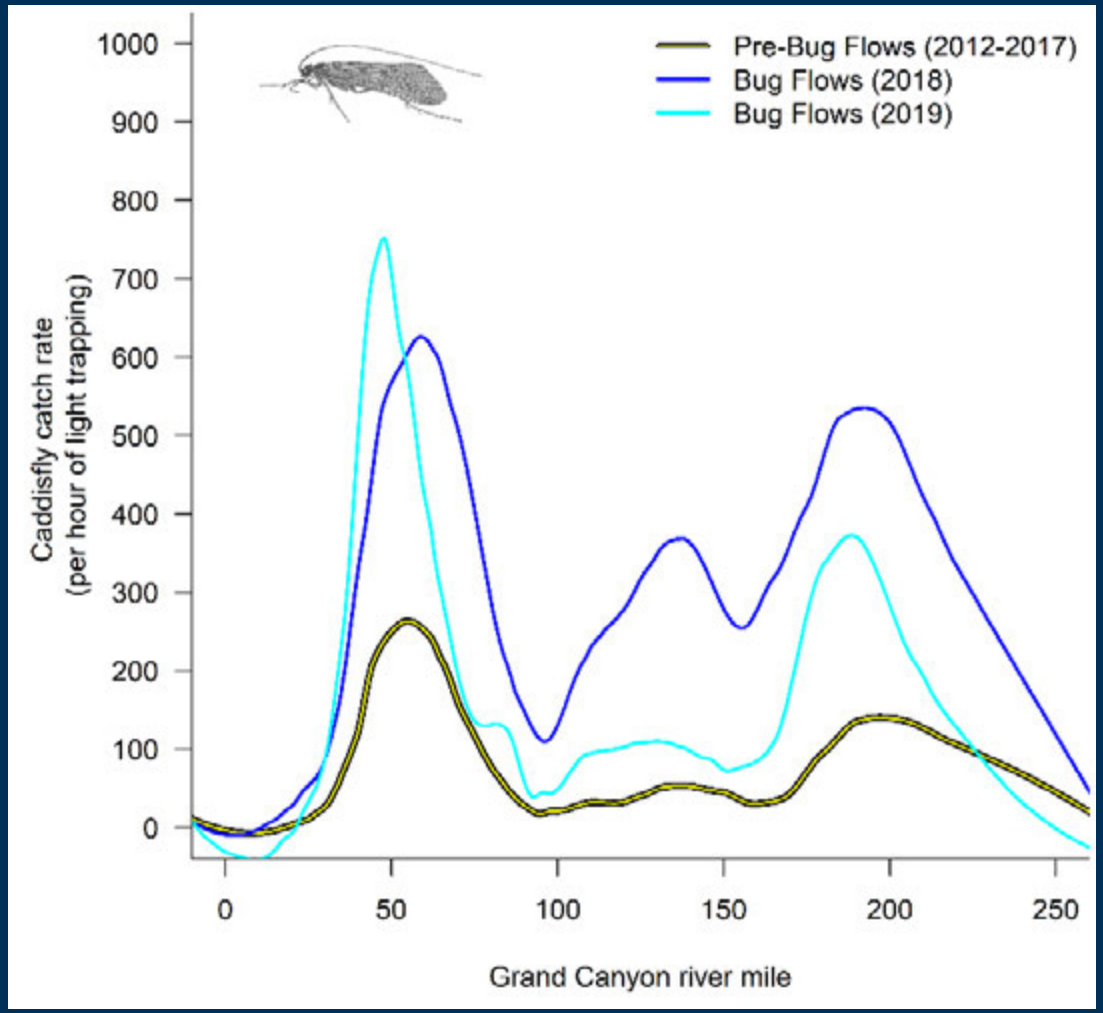
Caddisfly Spatial Pattern

- 2018: canyon-wide increase
- 2019: still impressive?



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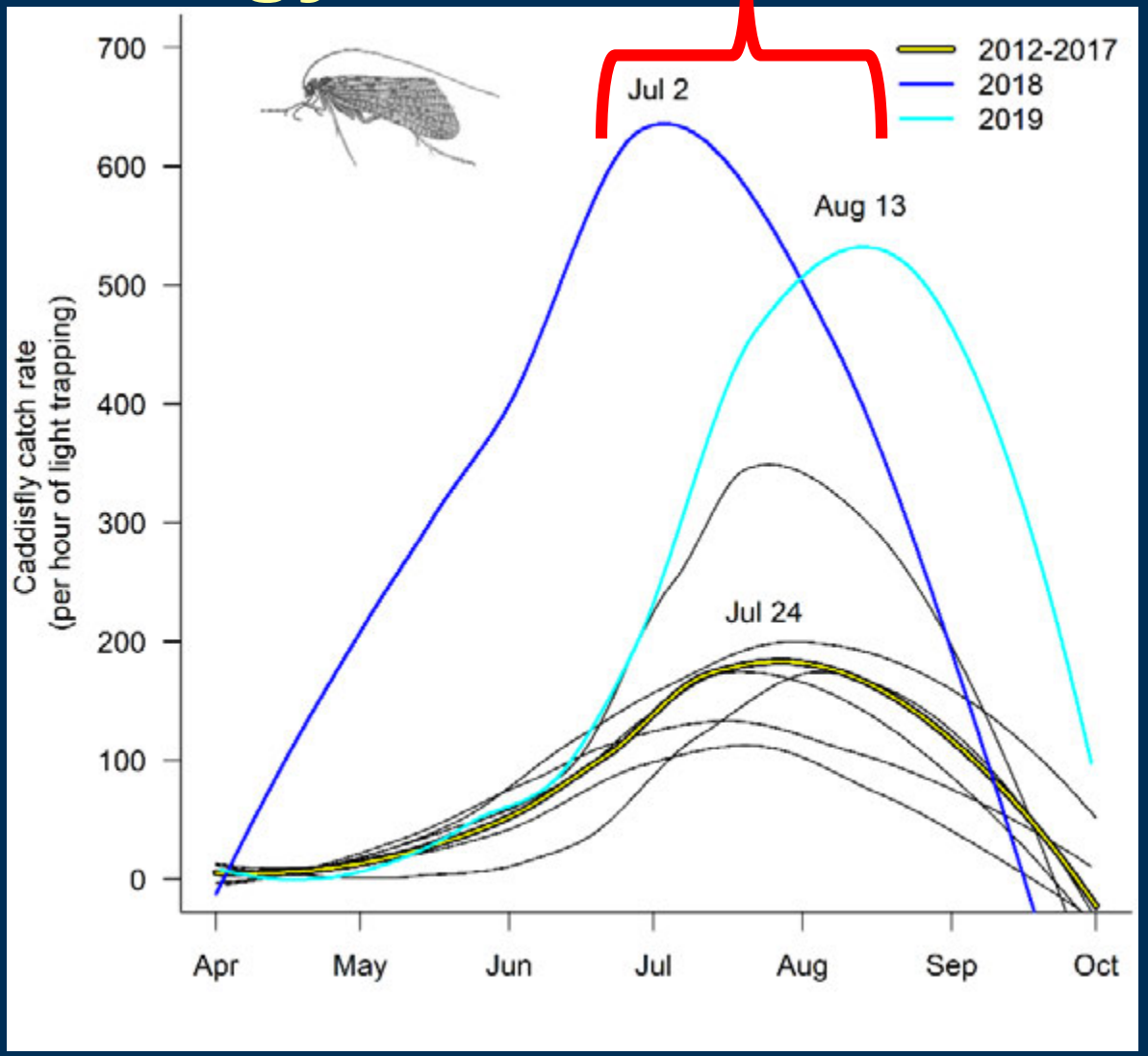
Caddisfly Phenology

- 2018: early
- 2019: late



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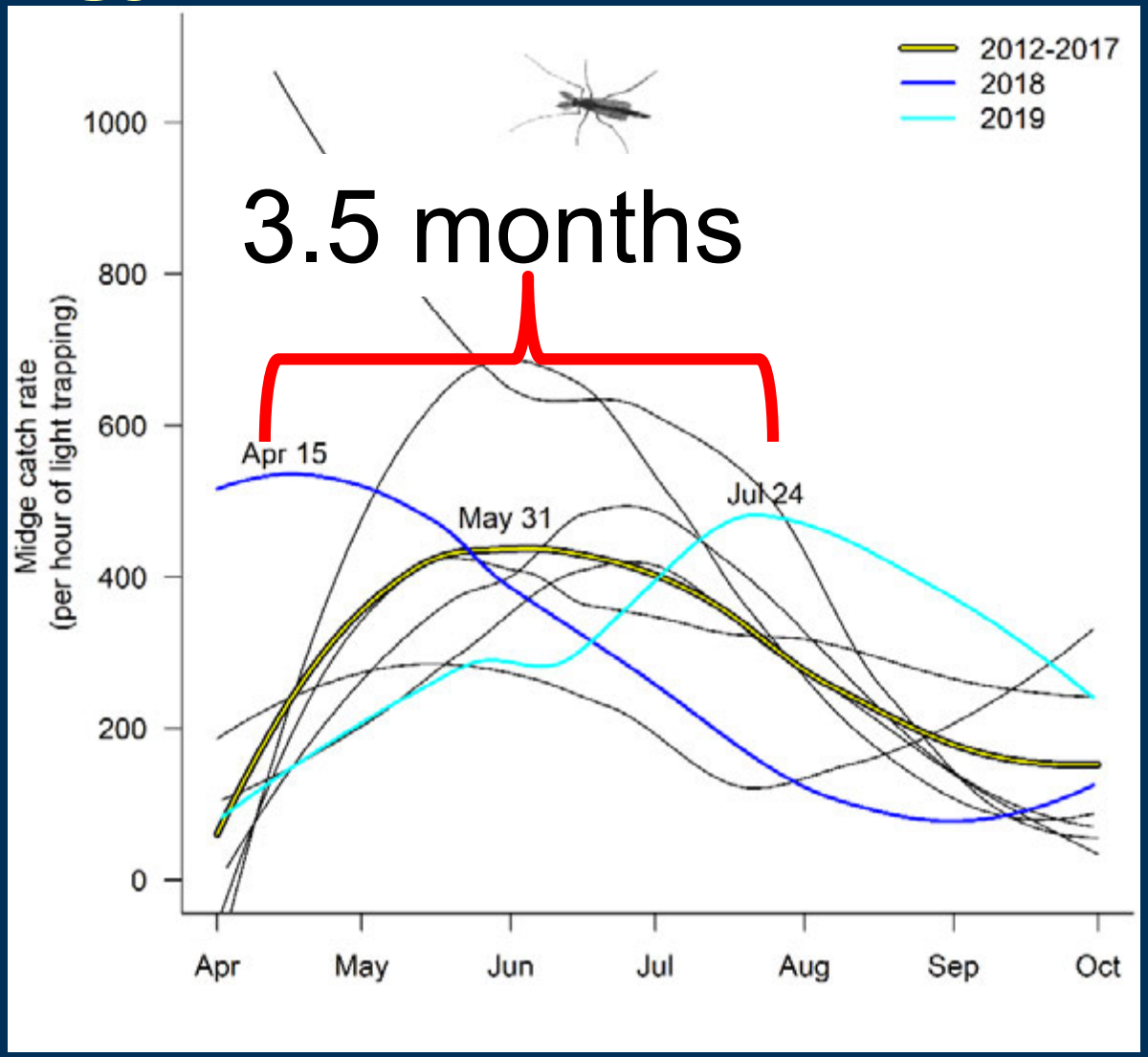
Midge Phenology

- 2018: very early
- 2019: very late



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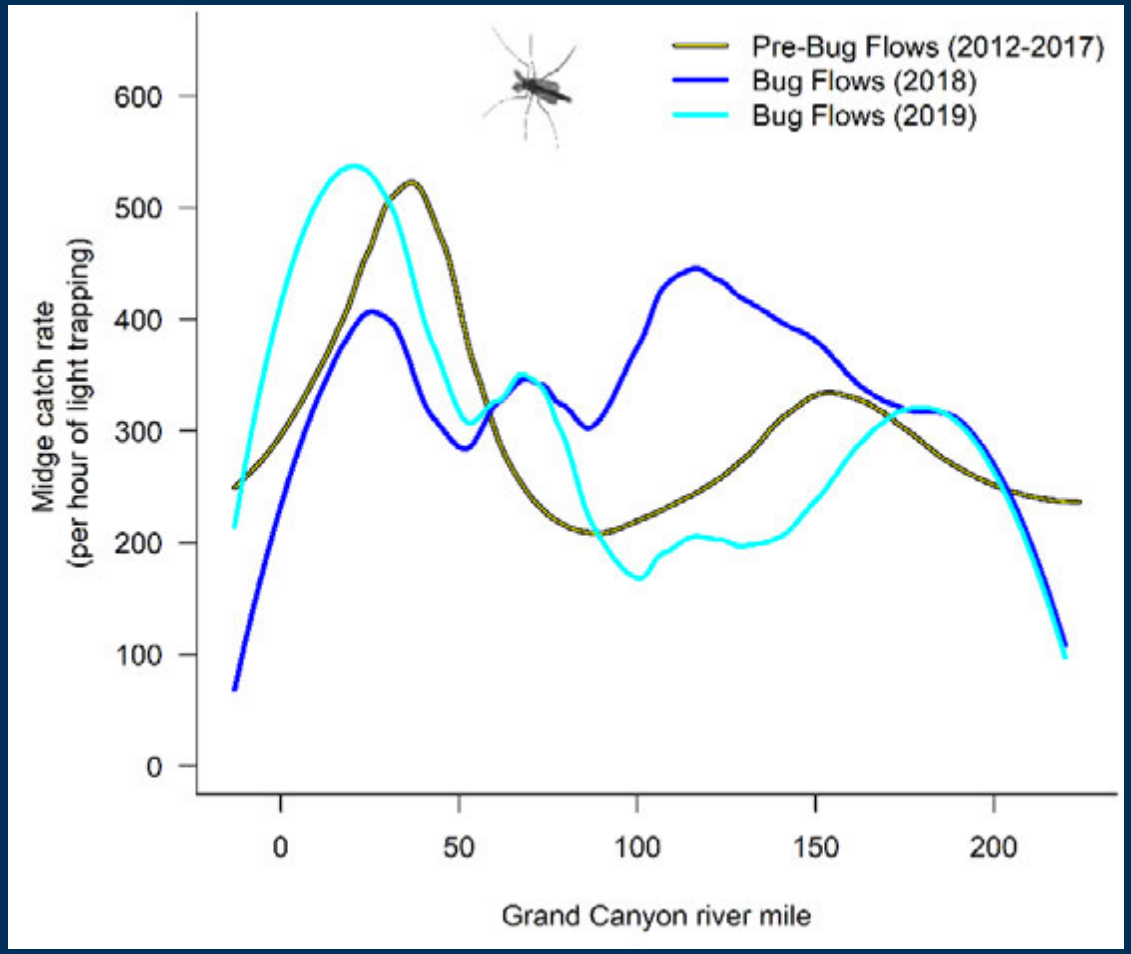
Midge Spatial Pattern

- 2018: Sine wave breaks down
- 2019: ??



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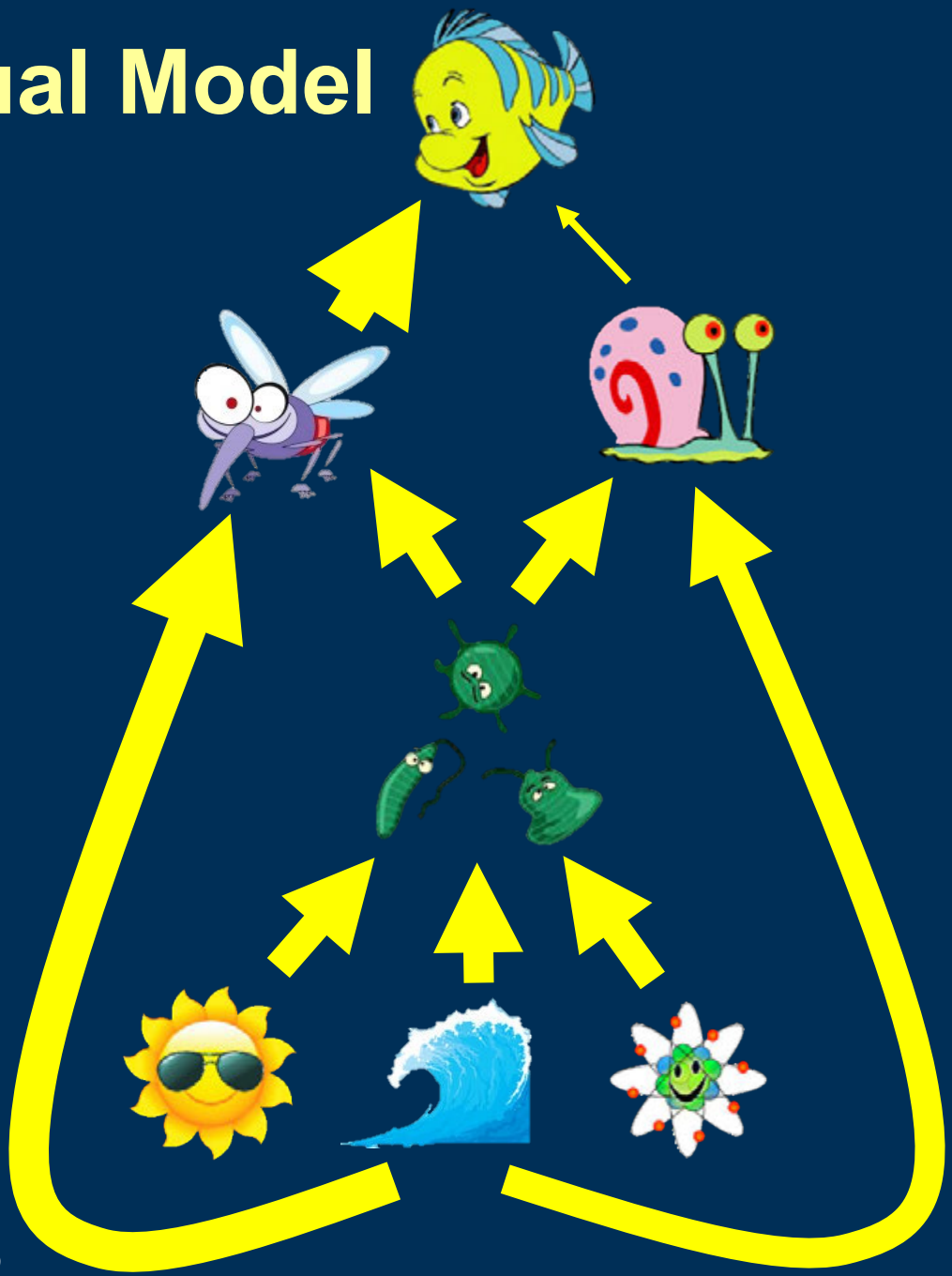
Conceptual Model



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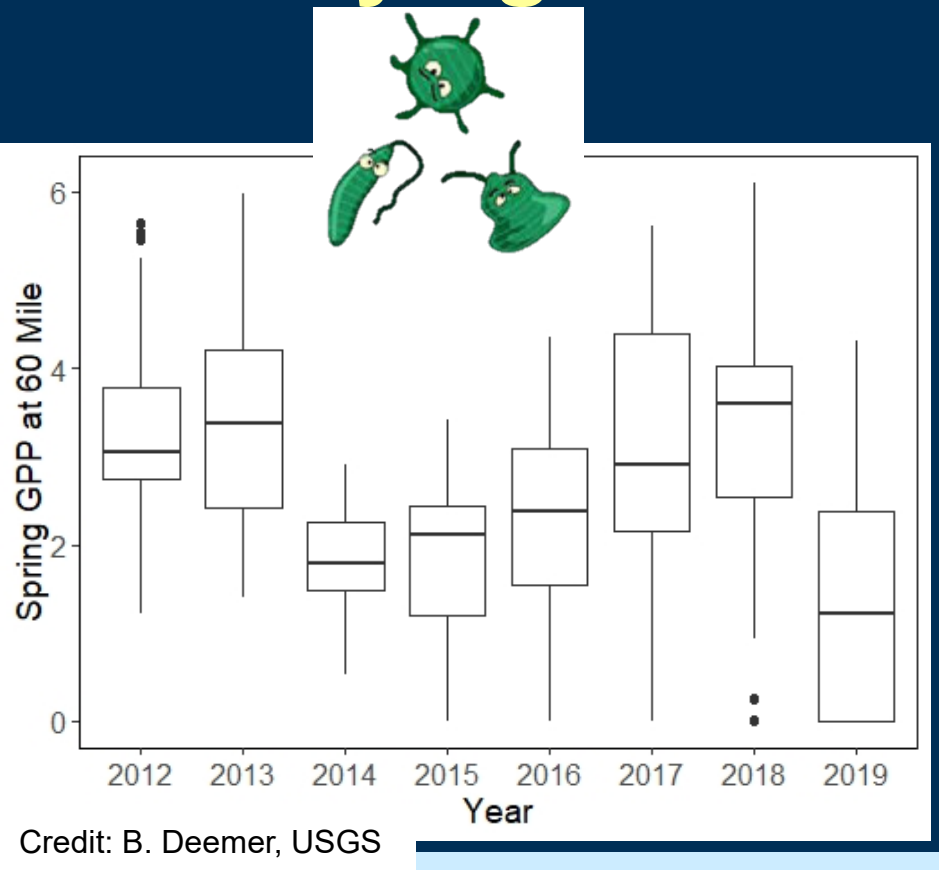
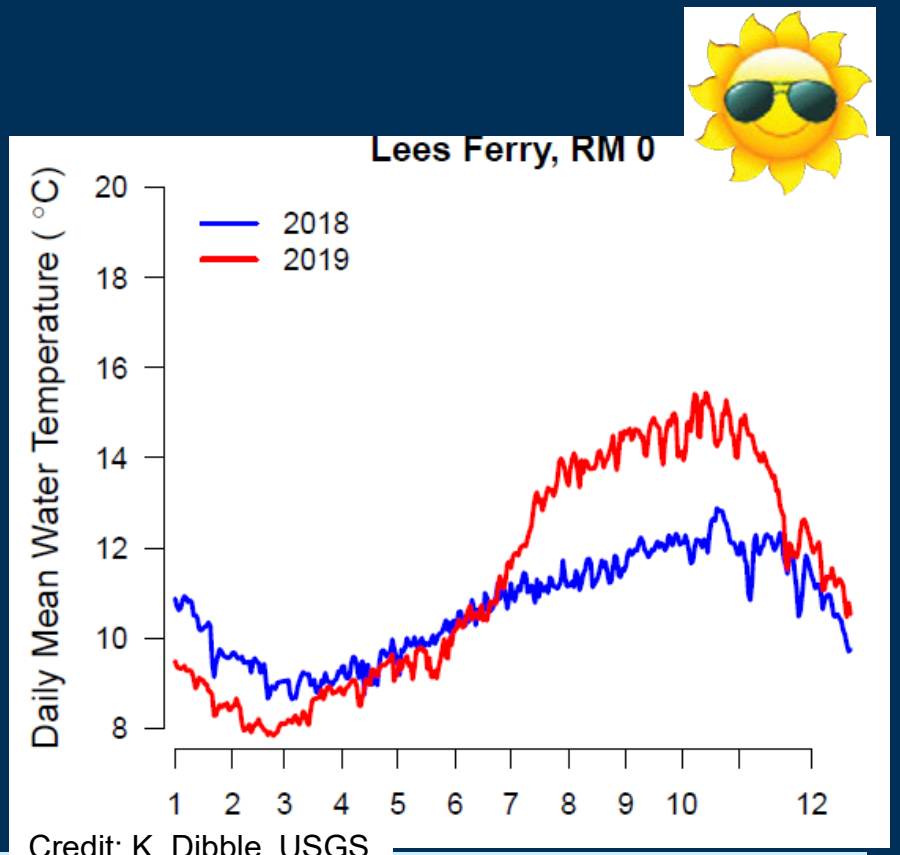
Muddying The Waters



Credit: B. Deemer, USGS



Credit: K. Dibble, USGS

- **2018: Lots of algae, average temperatures**
- **2019: Very little algae, warm temperatures**

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Unpublished data, subject to change, do not cite.

Summary

- Both ‘18 and ‘19 were exceptional years
- Both years complicated by other factors

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Conclusions

BUG FLOWS 2020

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