Update on the Bug Flow Experiment: Background, Monitoring, and New Analyses

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Why Bug Flows?

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

“The post-dam aquatic macroinvertebrate fauna in the Grand Canyon portion of the Colorado River is remarkably depauperate compared with other rivers. Virtually no Ephemeroptera [mayflies], Plecoptera [stoneflies] or Trichoptera [caddisflies] were collected...”

Excerpt from:

Figure from:
Kennedy, Theodore A. and others. “Native and non-native fish populations of the Colorado River are food limited—evidence from new food web studies. USGS Fact-Sheet 2013-3039.
Why Bug Flows?

Daily Tides

- **Median value** over period (ft)
- **Load-following**
- **Bug flows**

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**Regulated Flows**

Since start of **LTEMP**, median daily change in river height at Lees Ferry is **1.30 ft (15.6 inches)**

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**Natural Flows**

In pre-dam river, median daily change in river height at Lees Ferry gage was **0.14 ft (1.7 inches)**

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[Graphs and data from USGS and GCMRC, linked resources included]
Why Bug Flows?

- Midge abundance negatively related to tides in GC

- Insect diversity negatively related to tides across West

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 across 18 tailwaters in US West. Tailwaters with large tides have low insect diversity (EPT).
Why Bug Flows?

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

Conceptual Model

Want to mitigate this

Illustration by Jeremy Monroe-Freshwaters Illustrated, from Kennedy and others 2016, Bioscience
What is a Bug Flow?

- Give bugs the weekends off
  - Support natural processes essential to aquatic insects
- Weekend stable low flows from May-August
  - Reduces impact to hydropower
  - Experiment tested 2018-2020 & 2022
- Eggs laid on weekends never dry

“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.

Preliminary data, subject to change, do not cite

https://www.gcmrc.gov/discharge_qw_sediment/station/GCDAMP/09383100
Monitoring Bug Flows in 2022

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

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

Network of community scientists
- Light trap monitoring of aquatic insects
- Key life stage
- Robust scope

Network of dissolved oxygen sensors
- Model gross primary production in entire river
- Key ecosystem process
- Daily time step

August 2022 Update: Monitoring going as planned

Preliminary data, subject to change, do not cite
These findings show that dam management can affect photosynthetic rates, thus affecting carbon supply to food webs over large spatial extents.

Citation:
Monitoring Insect Response

Tough to untangle what 2021 means - no direct benefits to GPP, larvae or emergence - But multiple years of good egg laying & very clear water (low sediment turbidity)

- Cessation of Bug Flows in 2021 associated with:
  - Midge: ~50% decline
  - Caddisflies: no change from year prior

Unpublished data, subject to change, do not cite.
Monitoring Insect Response

Community science light trap monitoring of aquatic insects in 2022 going as planned...

Community Science light trap collection during June 2022 Grand Canyon Youth river trip

Unpublished data, subject to change, do not cite.
Analyzing Insect Monitoring Data—New Population Models

1. Construct matrix population models for each relevant species

2. Parameterize with **vital rates** according to major event types: mortality and growth rates in response to floods, low flows, steady flows, hydropeaking, etc.

3. Use models to ask “what if” questions about flow experiment and scenarios

Preliminary data, subject to change, do not cite David A. Lytle and Angelika Kurthen, Oregon State University
GPP and Fish—New Analyses

Increase in GPP arising from Bug Flows increases flannelmouth sucker growth by ~1.5mm/month.

The increase in flannelmouth growth arising from Bug Flows → GPP is equivalent to growth increase associated with a 1°C temperature increase.

Next Steps: develop similar models for Humpback chub

Unpublished data, subject to change, do not cite.

New results from mark-recapture studies. Hansen, L. and others, manuscript in review
Conclusions

- **Natural Processes from LTEMP:**
  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.

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

Unpublished data, subject to change, do not cite.