Molecular and modeling tools for tracking food base dynamics in changing environments

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Molecular and modeling tools for tracking food base response in changing environments

Project Elements and Objectives:
F.3 Invertebrate monitoring in tributaries
O.1 Does disturbance timing affect food base response?
Funding amount and source: $100,000 (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.

Quagga Mussels in exposed algal mats at RM -14

Two goals:

1. <u>eDNA</u> water samples to detect and inventory aquatic invertebrates

2. <u>Population models</u> to project changes in aquatic invertebrate abundances due to changing environment and management actions

Aquatic invertebrate diversity is low in the Colorado River below GCD

Tributaries have the potential to act as sources of biodiversity to the mainstem CR

Bright Angel Creek

Crystal Creek

Kanab Creek

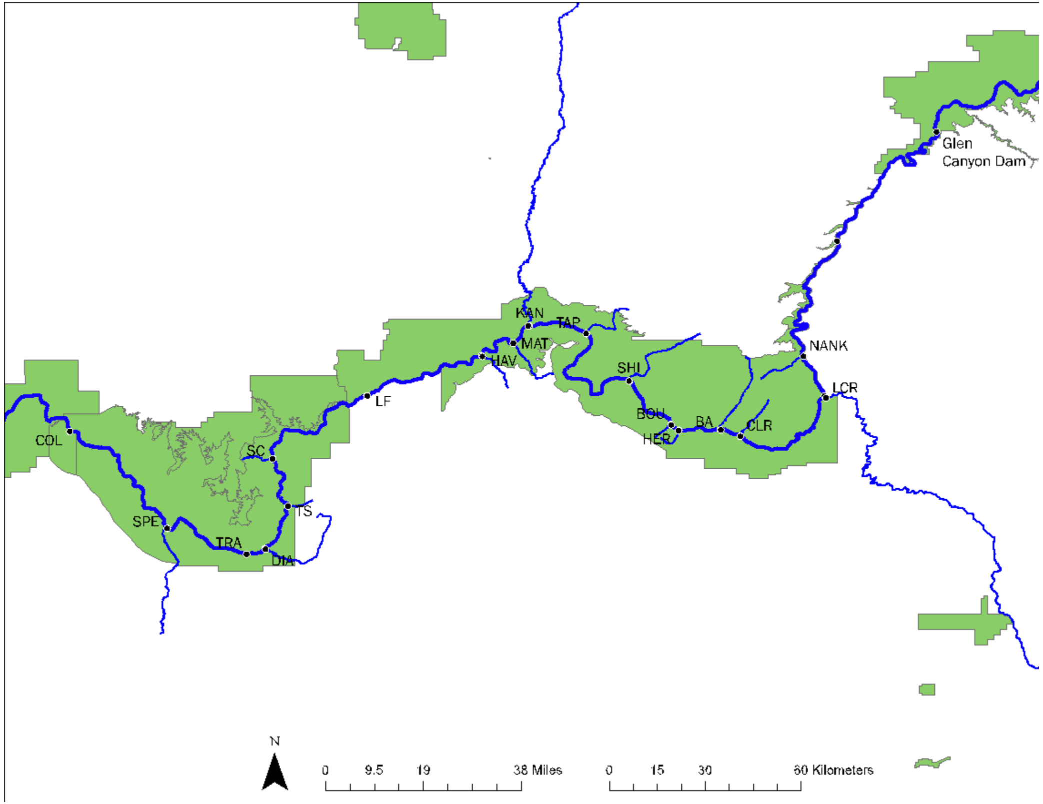
But tributaries have different physico-chemical properties than the mainstem; can they support similar species?

Tapeats Creek flows into the Colorado

eDNA techniques allow for broad scale analysis of community composition; it's a snapshot of the ecosystem state

How do invertebrate communities differ between tributary and mainstem reaches of the Colorado River within Grand Canyon?

eDNA water samples taken from paired tributary and mainstem sites within Grand Canyon



eDNA-derived community dataset

142bp fragment of COI gene amplified with degenerate primer set targeting aquatic invertebrates (Leese et al, 2021)

Amplicons sequenced using Illumina Miseq platform

Sequences were filtered and clustered into OTUs using the R package JAMP v0.77

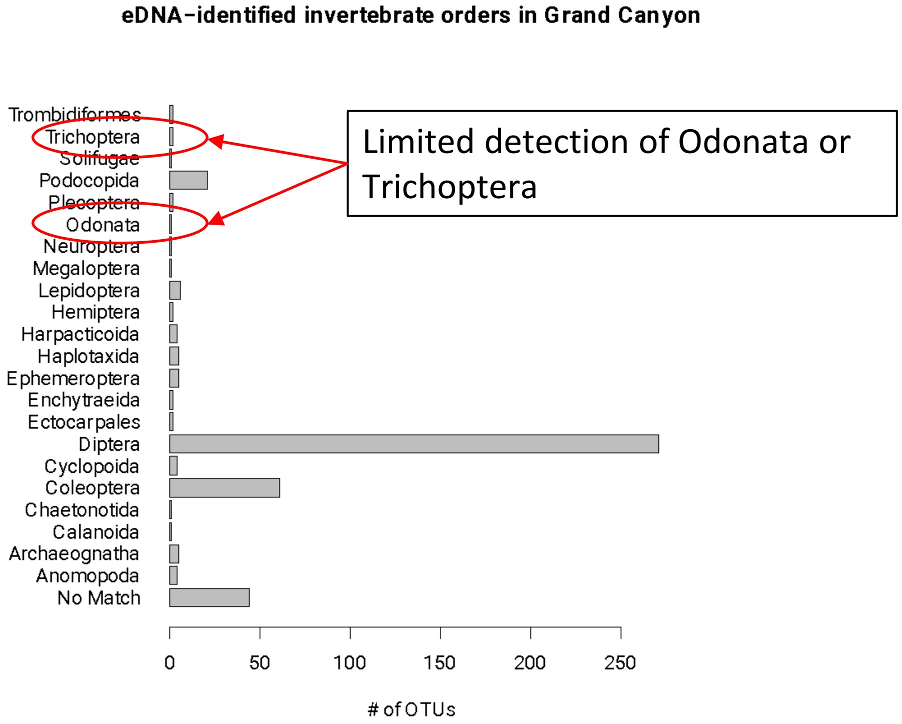
Taxonomic identification with BOLD database identified a large diversity of aquatic invertebrates

407 OTUs were ID’d to the level of order, spanning:

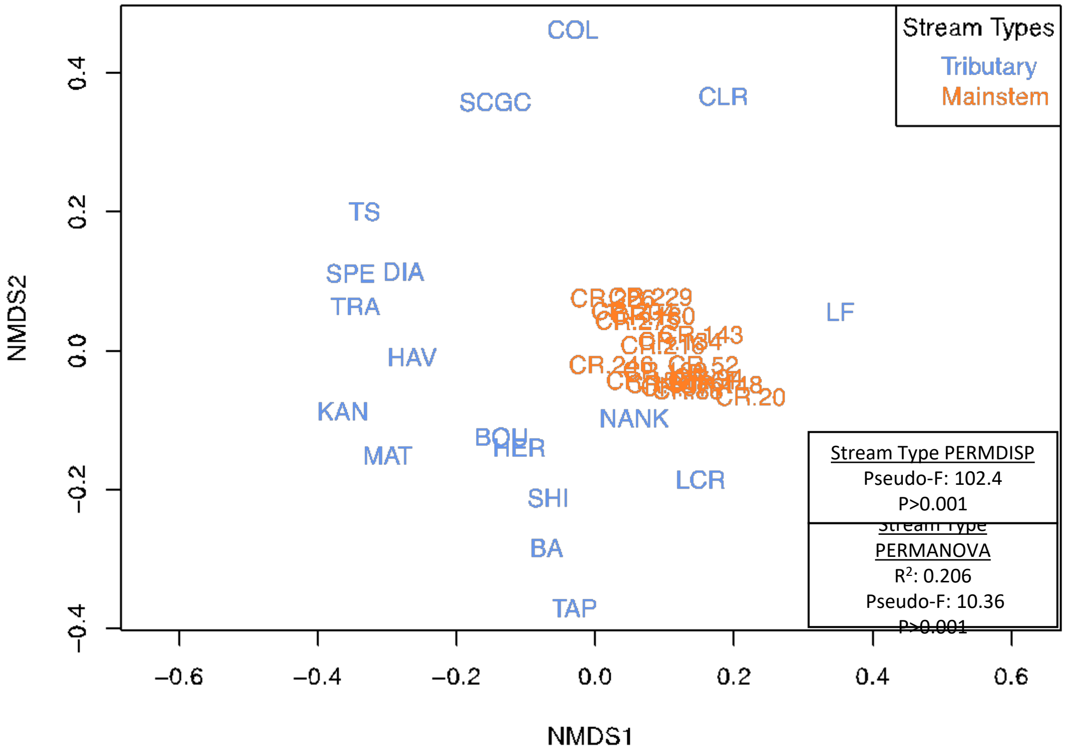
- 24 orders
- 75 families
- 84 genera
- 66 species

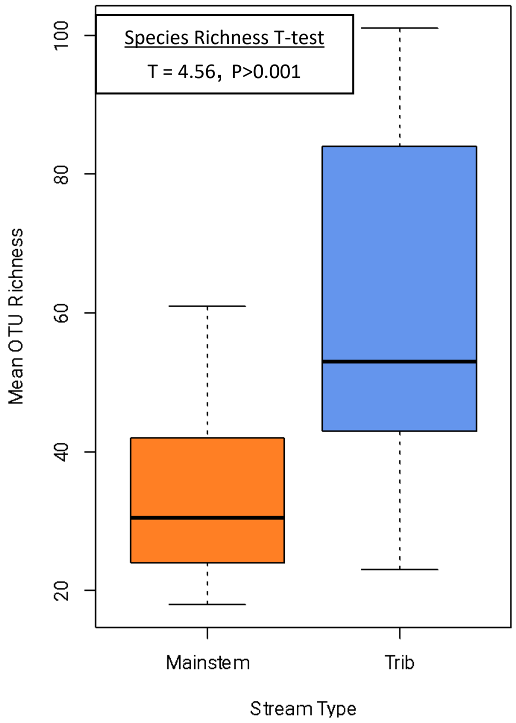
For contrast: Oberlin (1999) found only 42 genera across 10 tributaries

Diptera were most common invertebrate order identified, with 60% of OTUs (271 OTUs)

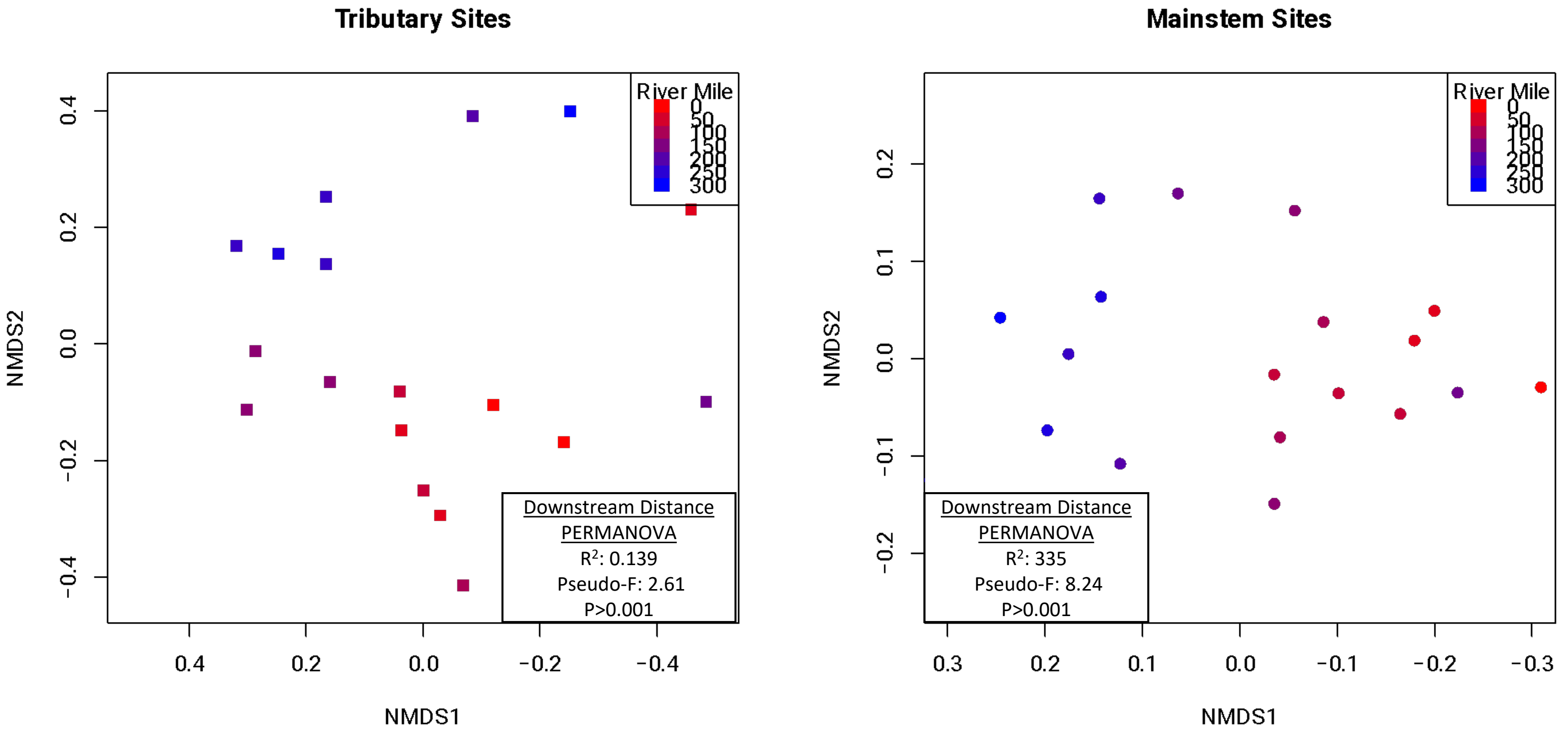


Aquatic invertebrate communities in tributaries are distinct from those in the mainstem, and harbor greater species richness





Downstream distance influences community composition in Grand Canyon tributary and mainstem sites



Key takeaways - eDNA

- Tributaries harbor distinct communities of aquatic invertebrates vs. mainstem habitats
- Large diversity of food base invertebrates detected with eDNA methods
- eDNA is promising for future biomonitoring of the ecosystem, although primer bias issues need to be addressed
- Next: using same eDNA samples to examine fish diets and parasite communities

Population models for food base communities

1. Construct matrix population models for each relevant species

Species A

$$\begin{pmatrix} 0 & 0 & F_A \\ G_{1A} & P_{2A} & 0 \\ 0 & G_{2A} & P_{3A} \end{pmatrix}$$

Species B

$$\begin{pmatrix} 0 & 0 & F_B \\ G_{1B} & P_{2B} & 0 \\ 0 & G_{2B} & P_{3B} \end{pmatrix}$$

Species C

$$\begin{pmatrix} 0 & 0 & F_C \\ G_{1C} & P_{2C} & 0 \\ 0 & G_{2C} & P_{3C} \end{pmatrix}$$

Species Z

$$\begin{pmatrix} 0 & 0 & F_Z \\ G_{1Z} & P_{2Z} & 0 \\ 0 & G_{2Z} & P_{3Z} \end{pmatrix}$$

1. Parameterize with vital rates according to major event types: mortality and growth rates in response to HFEs, LFEs, hydropeaking, and temperature changes.

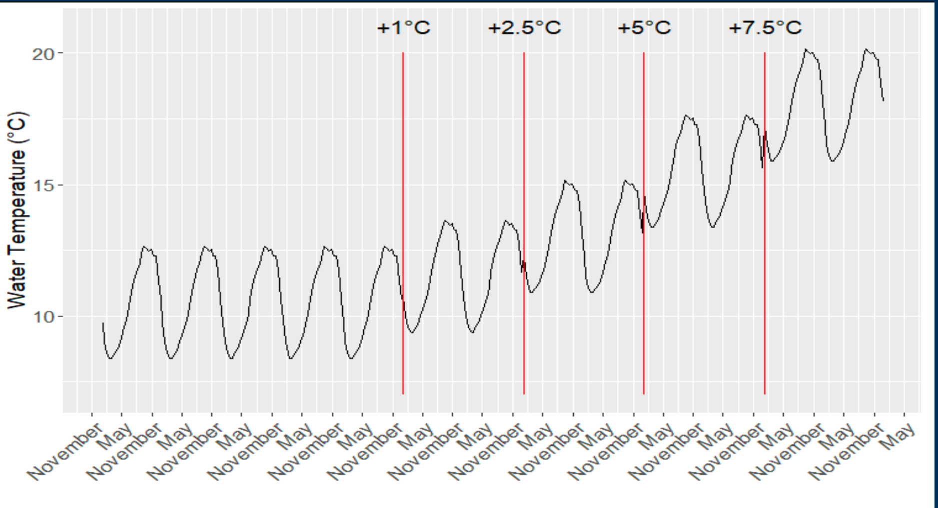
1. Use model to ask “what if” questions about future flow scenarios

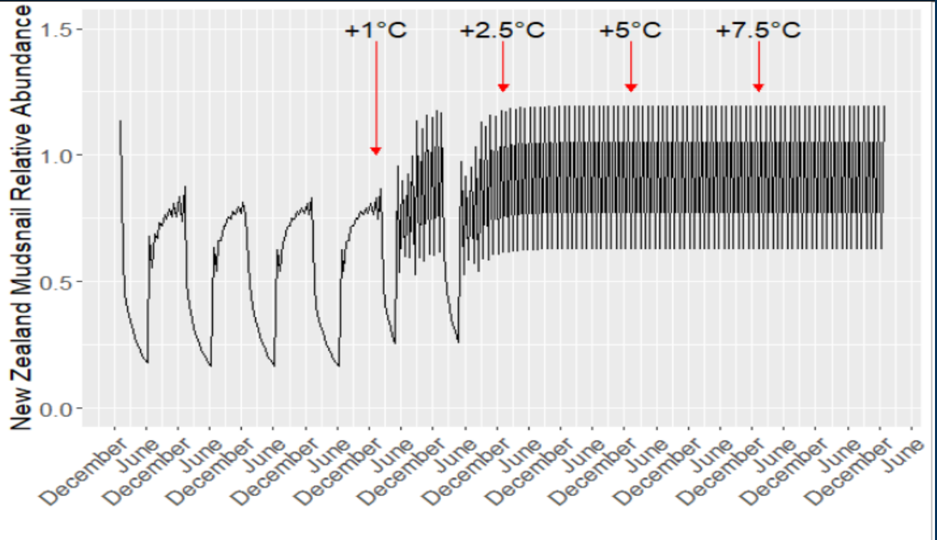
Model attributes:

Temperature can affect growth, development, and fecundity

Flow events cause mortality but also enhance habitat

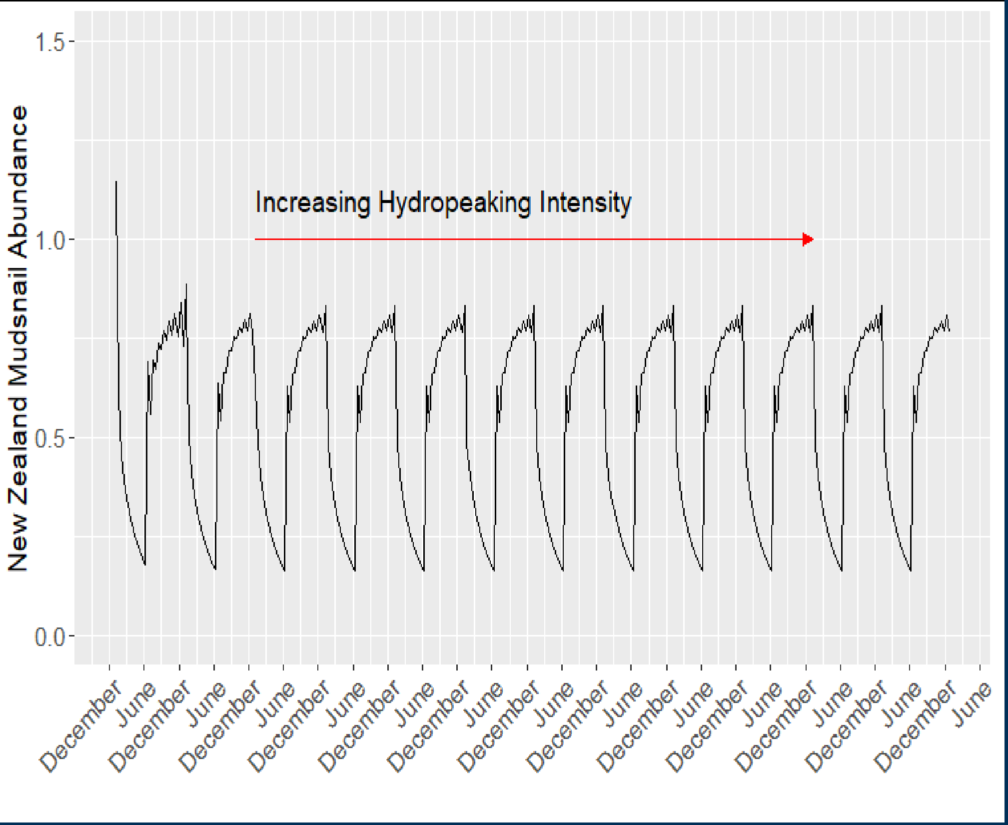
Hydropeaking affects egg establishment (for some species)





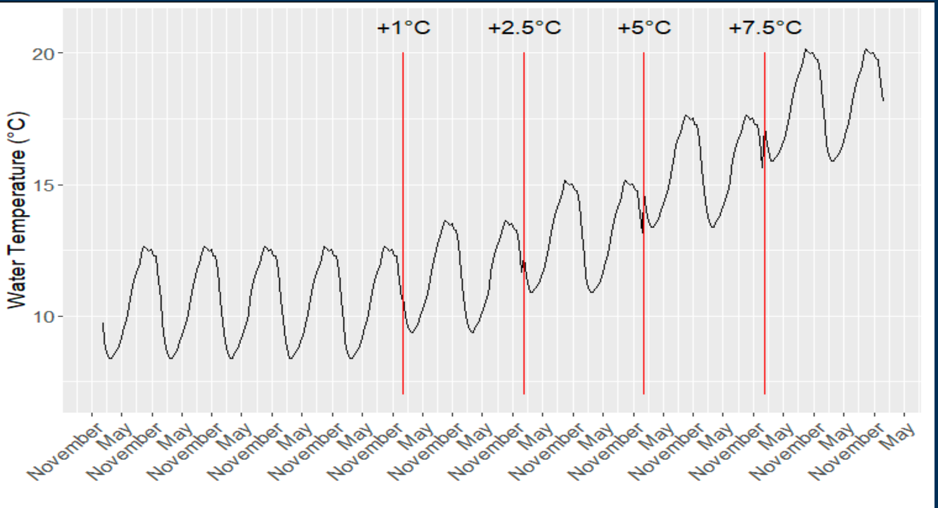
NZ mudsnails under future warming:

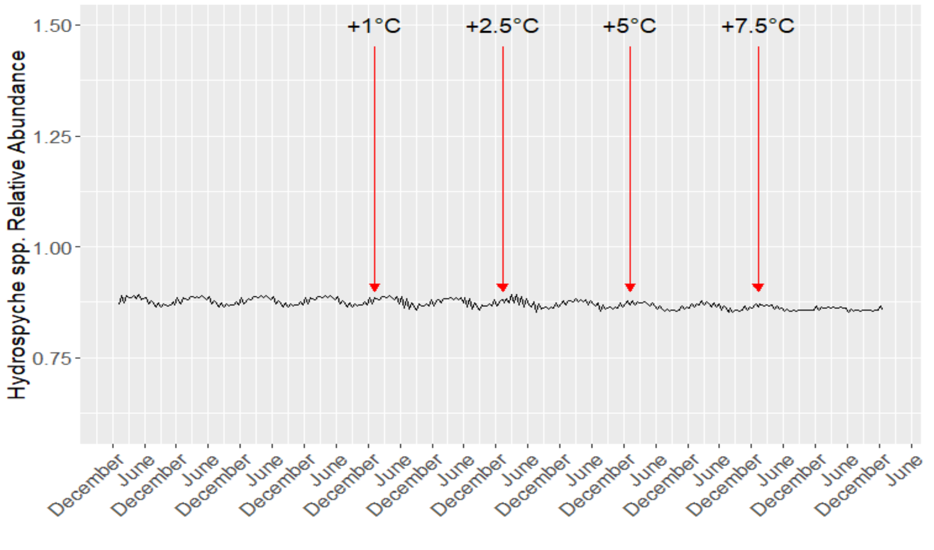
- Fecundity is temperature limited (10-27 C ; Bennett et al. 2015)
- NZMS currently winter limited
- Small winter temperature increase could increase mean population size



NZMS under hydropeaking:

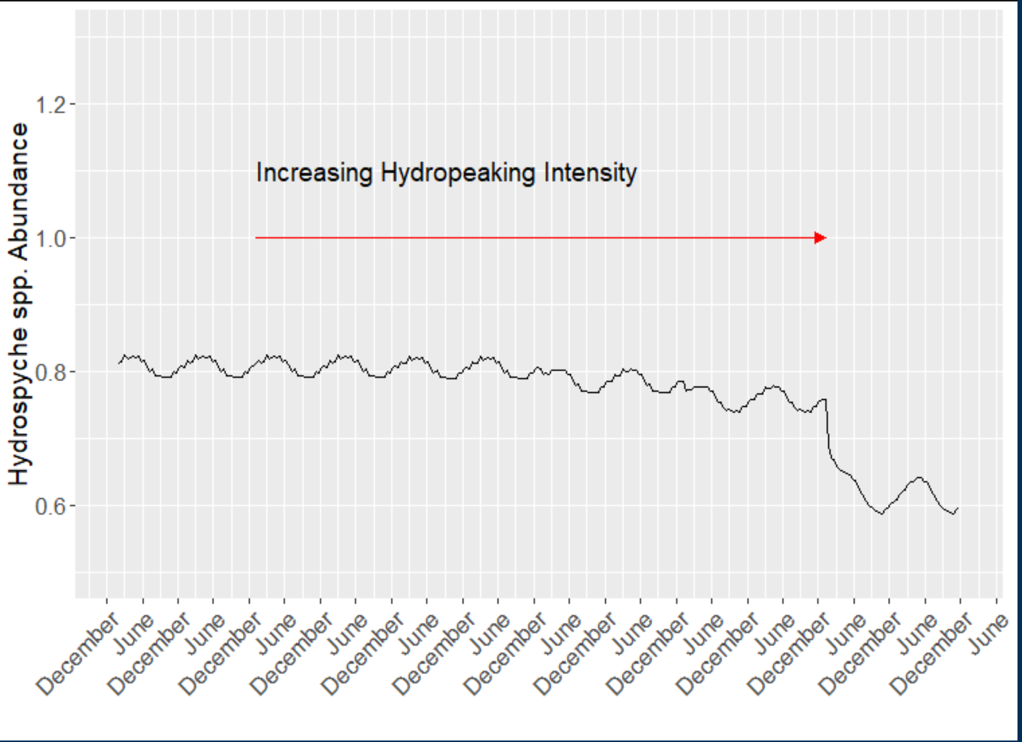
- Relatively insensitive to hydropeaking, since they bear live young that can survive out of water >3 d





Hydropsyche caddisflies under future warming:

- Relatively temperature-tolerant
- Little change due to temperature alone
- Temperature-related decrease in average body size and fecundity



Hydropsyche caddisflies under hydropeaking:

- Sensitive to hydropeaking, although ther seems to be a threshold effect
- Remains to be seen how hydropeaking interacts with temperature and flow events

Key Takeaways - population models

- Still in development; ongoing calibration and testing
- Promising for understanding effects of temperature and flow scenarios (HFEs, LFEs, hydropeaking) on the invertebrate food base

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General population model structure