The role of nutrients in Colorado River ecosystem dynamics

Annual Reporting for FY16
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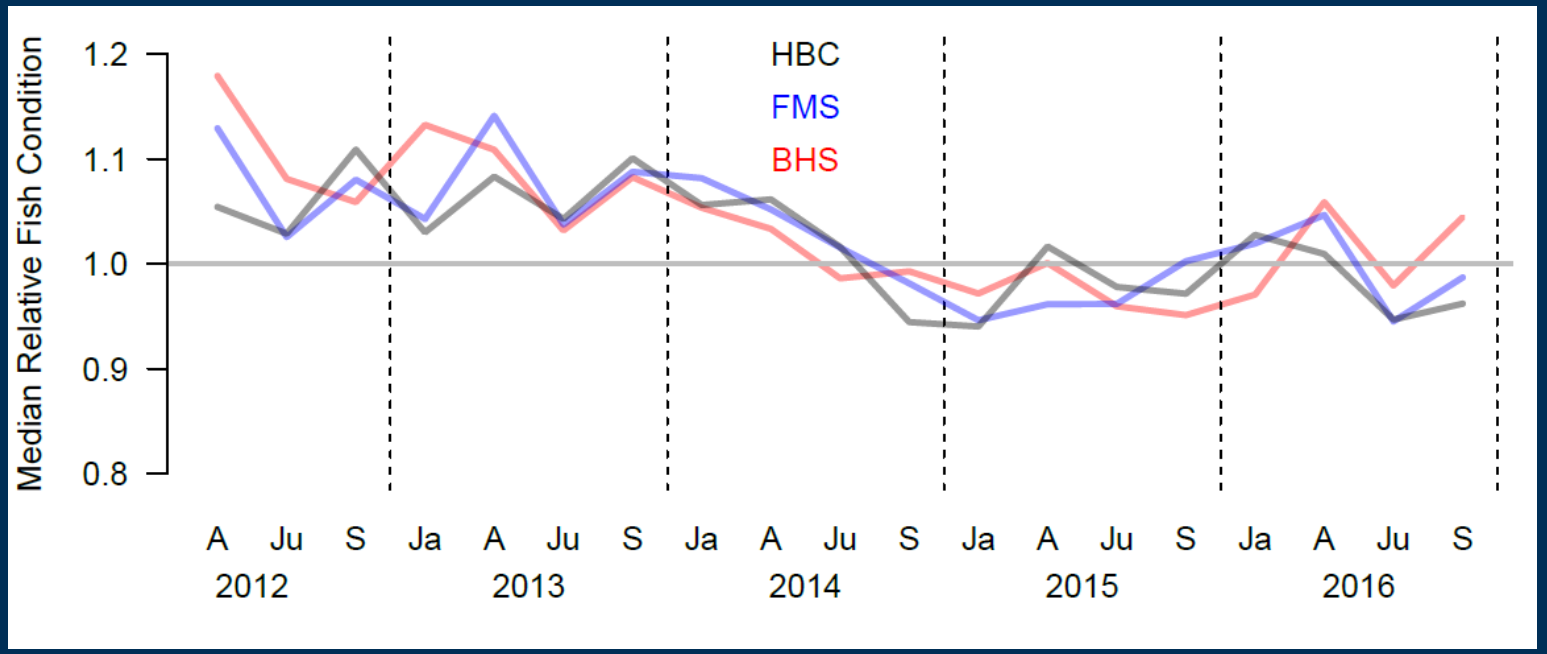
With lots of help from Bridget Deemer, Michael Yard, Theodore Kennedy, Bob Hall, and many others

U.S. Department of the Interior
U.S. Geological Survey

Are these just coincidences?

- Rainbow trout populations crash at the ferry…and all the way through Marble Canyon.
- Large-bodied native fish get skinny.



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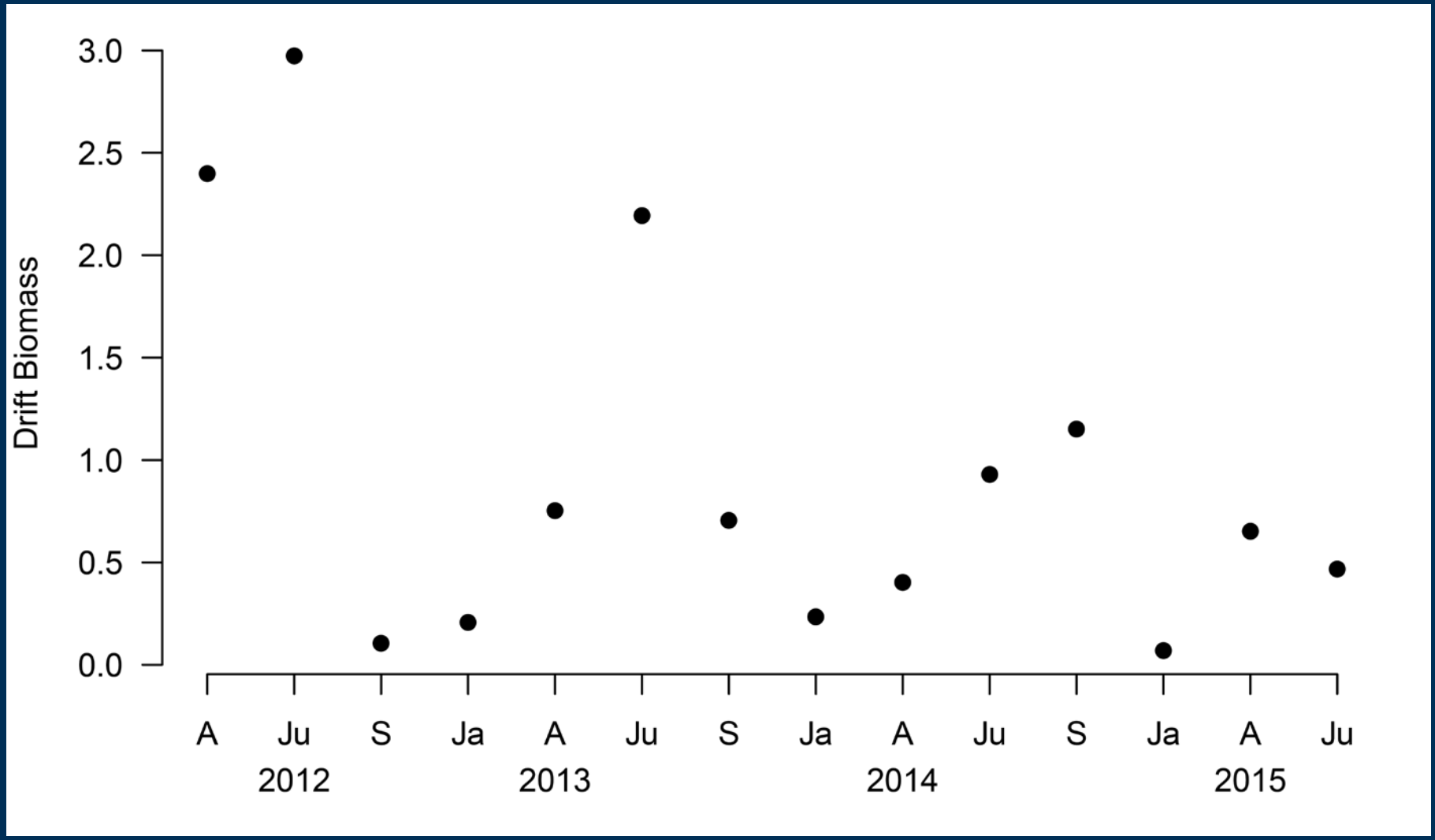
Preliminary data. Do not cite.

It was food!



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Preliminary data. Do not cite.

But, what caused the decline in the foodbase? Let's consider the usual suspects,

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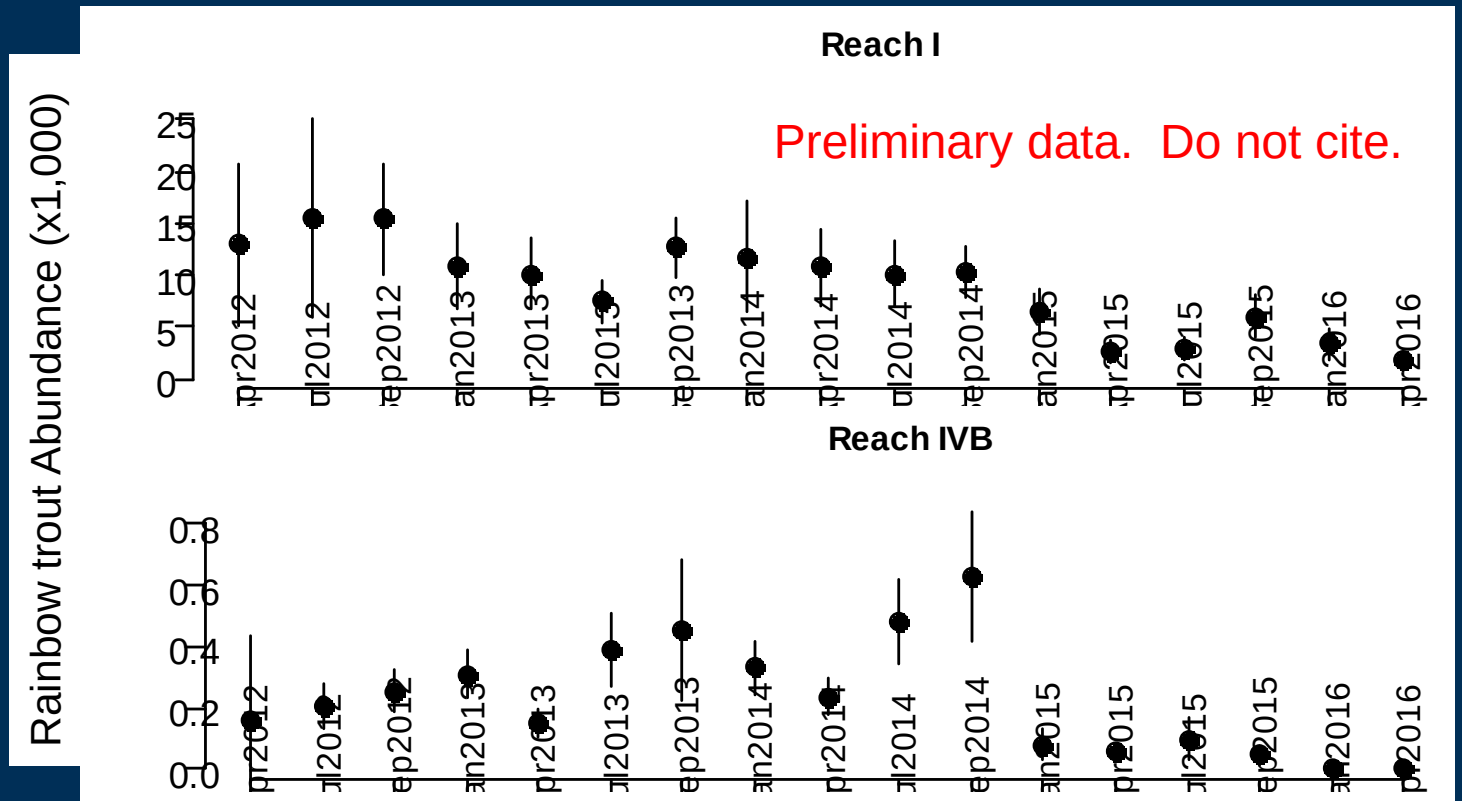
We know density dependence and interspecific interactions matter.



But how can density dependence explain declines separated by 70 river miles, and where densities vary by an order of magnitude? Also can a drift feeding fish really drive invertebrate populations down?

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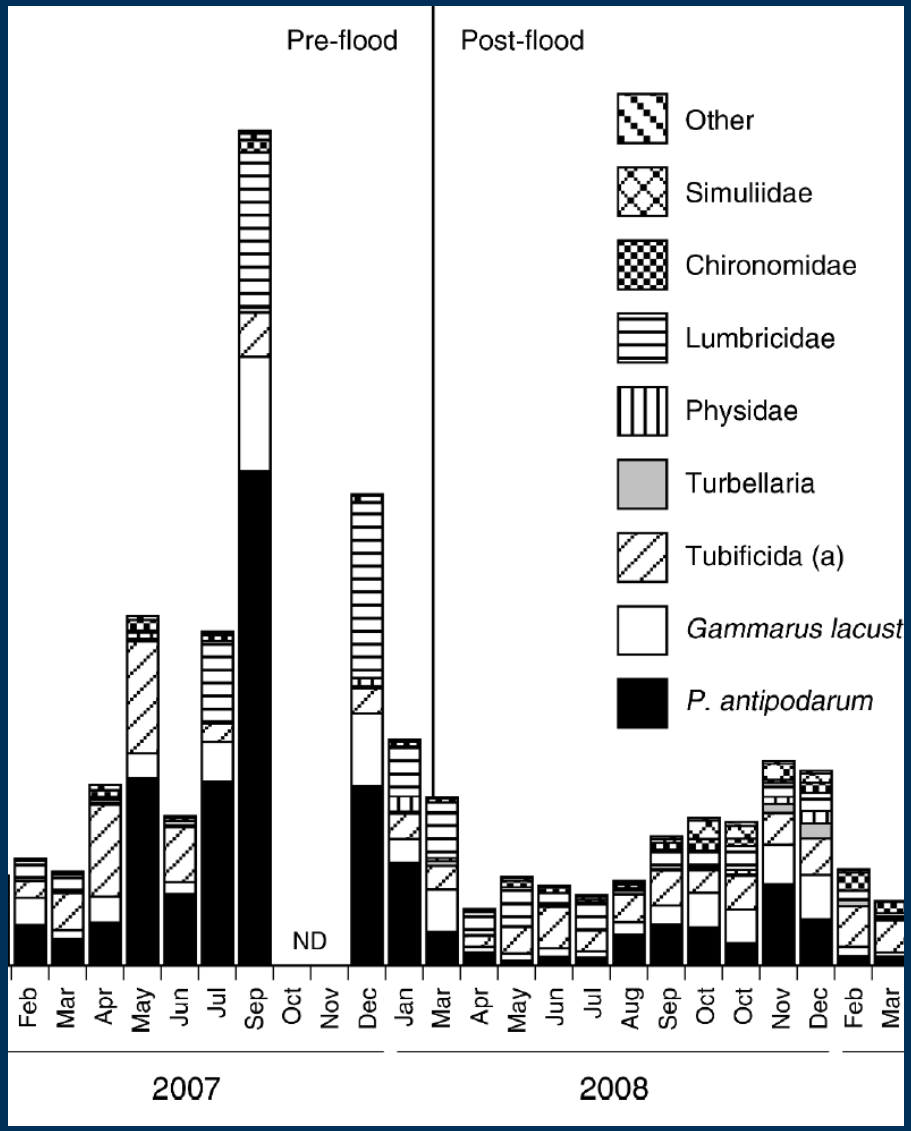
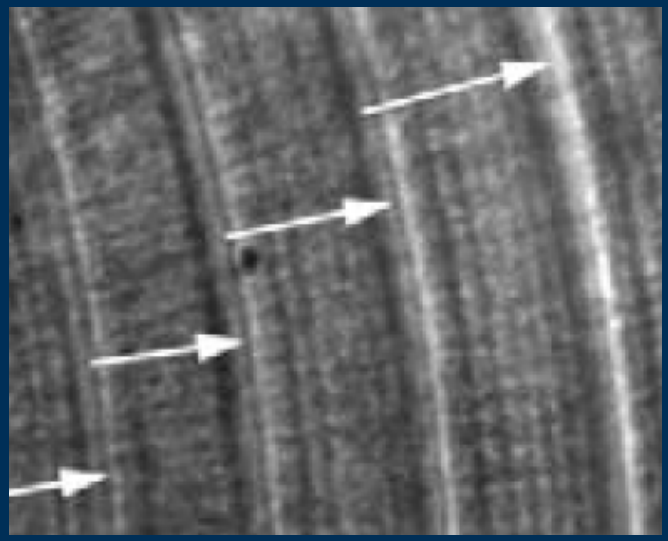


Cross et al., 2011

Flow management also affects the Colorado River ecosystem. But this particular decline doesn't neatly line up with any clear changes in flow.



Korman and Campana, 2009

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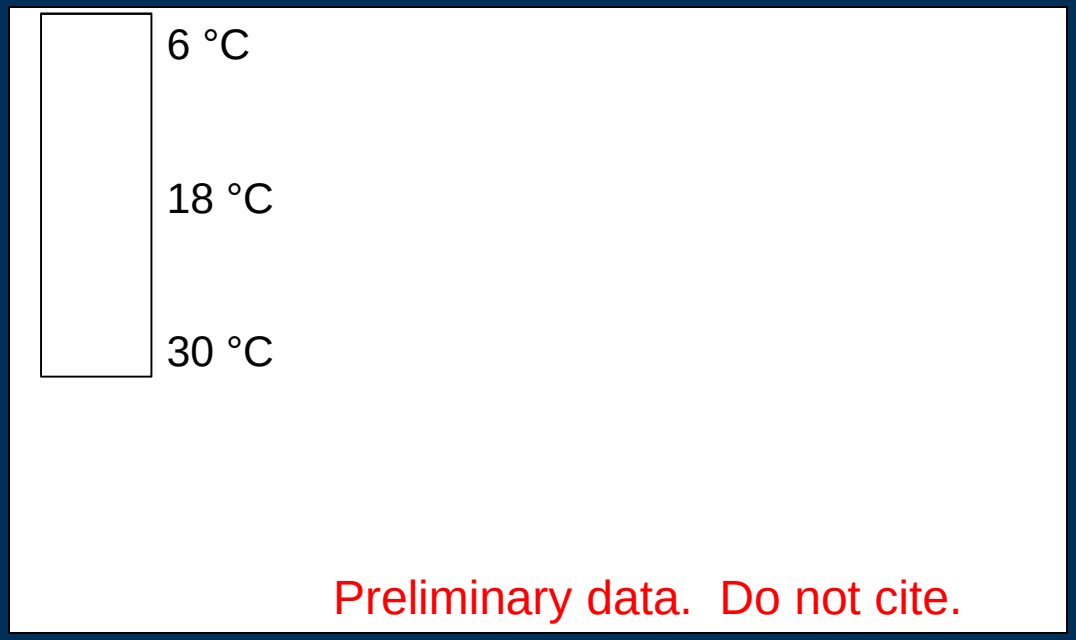
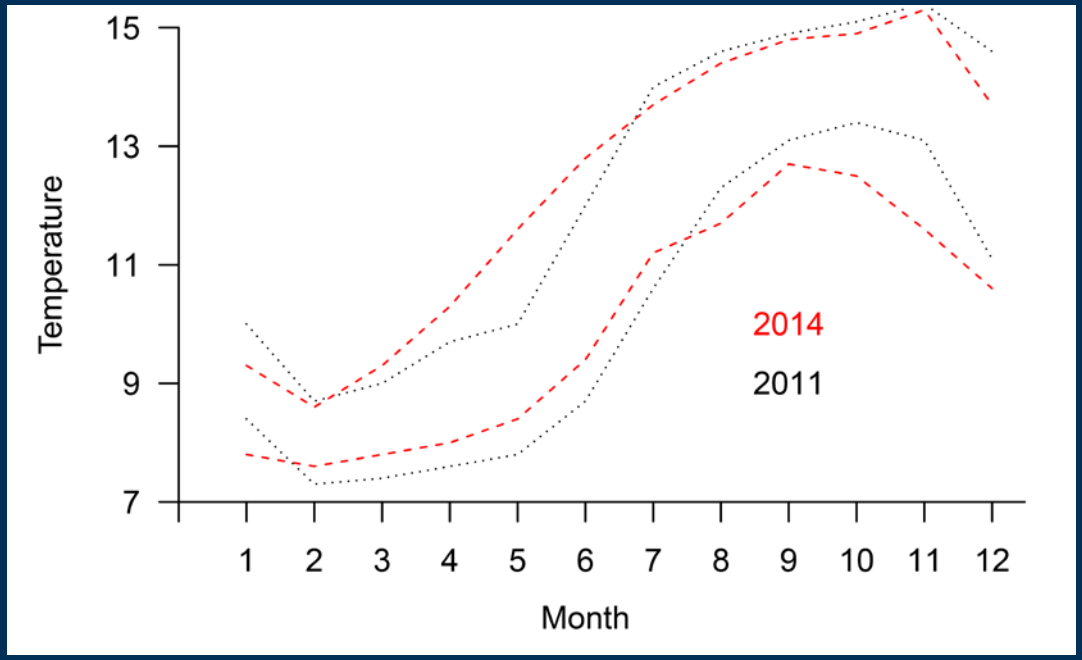


Preliminary data. Do not cite.

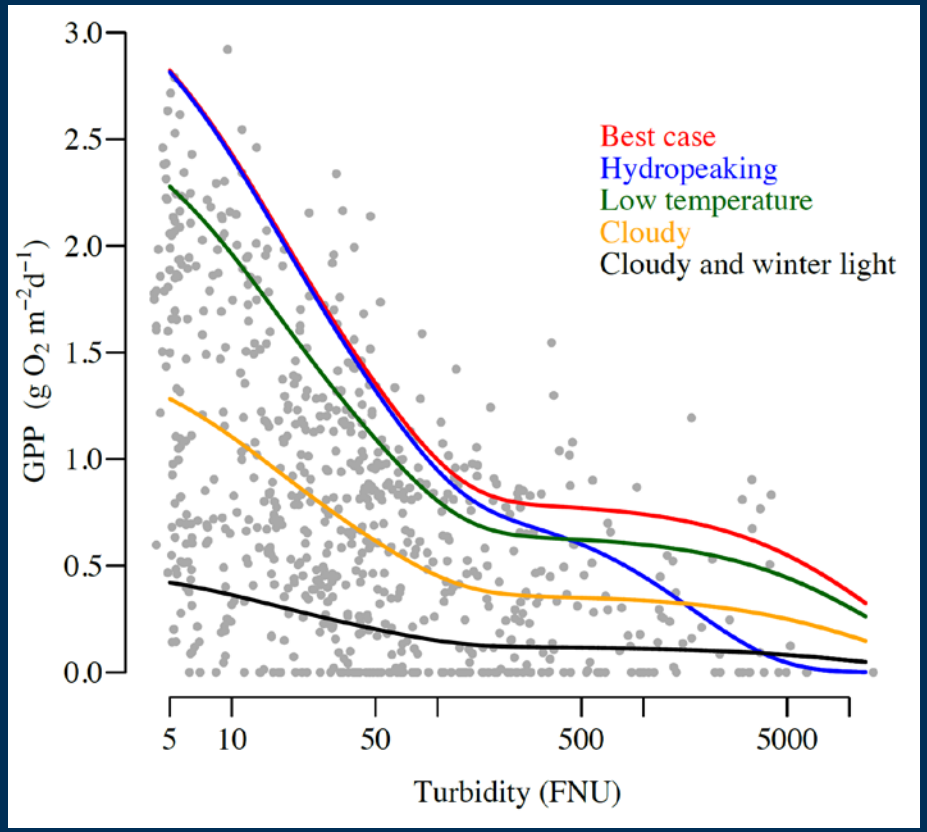
Water temperature also matters, and may change dramatically in near future.

But temperatures were not that anomalous in 2014.



Preliminary data. Do not cite.

Tributaries also play important roles, as a spawning ground for native fish and sources of food and turbidity. But Lees Ferry is relatively free of tributary influences.



Hall et al., 2016

Wait, I didn't notice that guy over there, who is he?

Biotic interactions

Flow

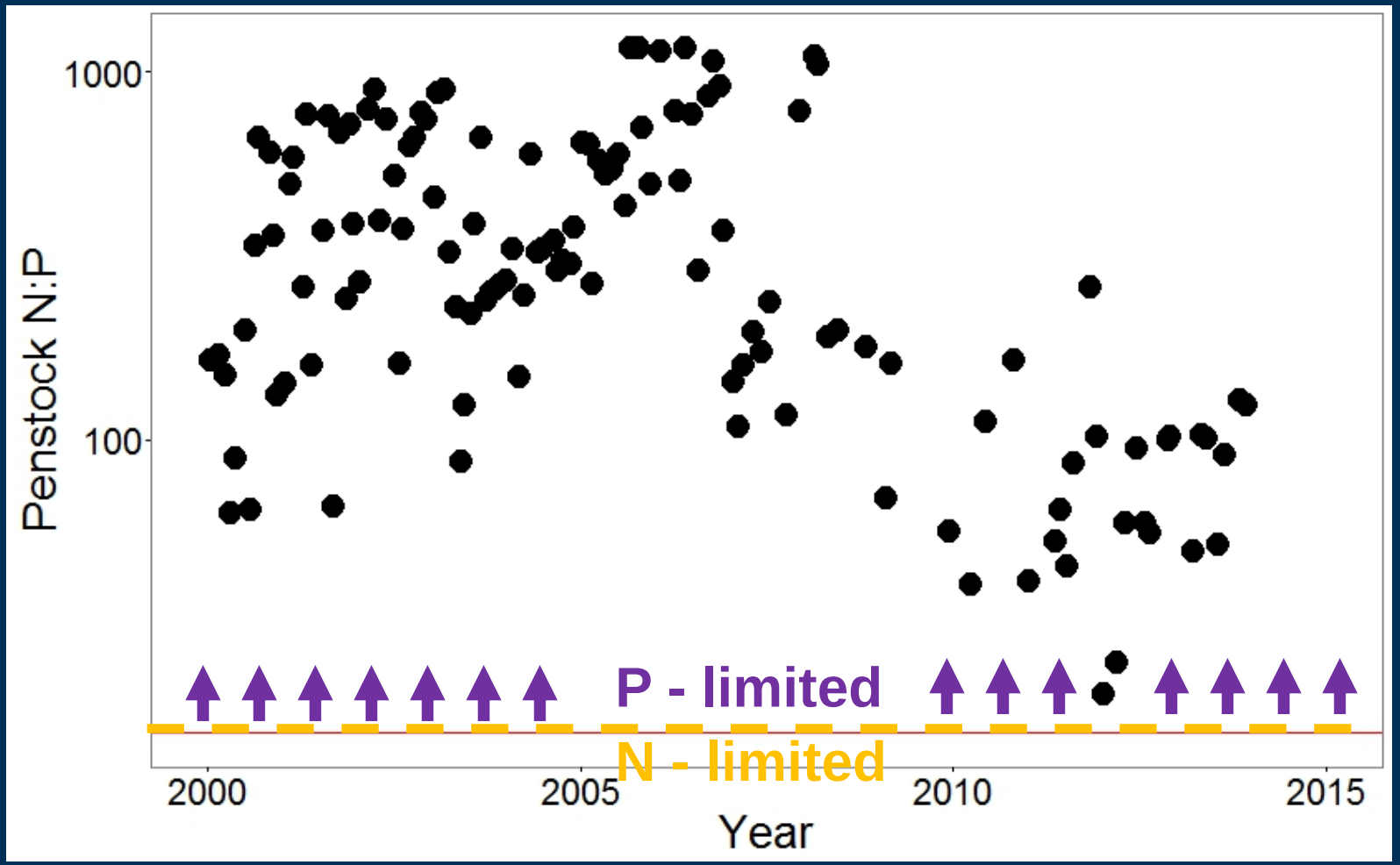
Temperature

Turbidity

Mr. P

USGS

If our primary producers in the Colorado River are nutrient limited, phosphorous is a prime suspect.



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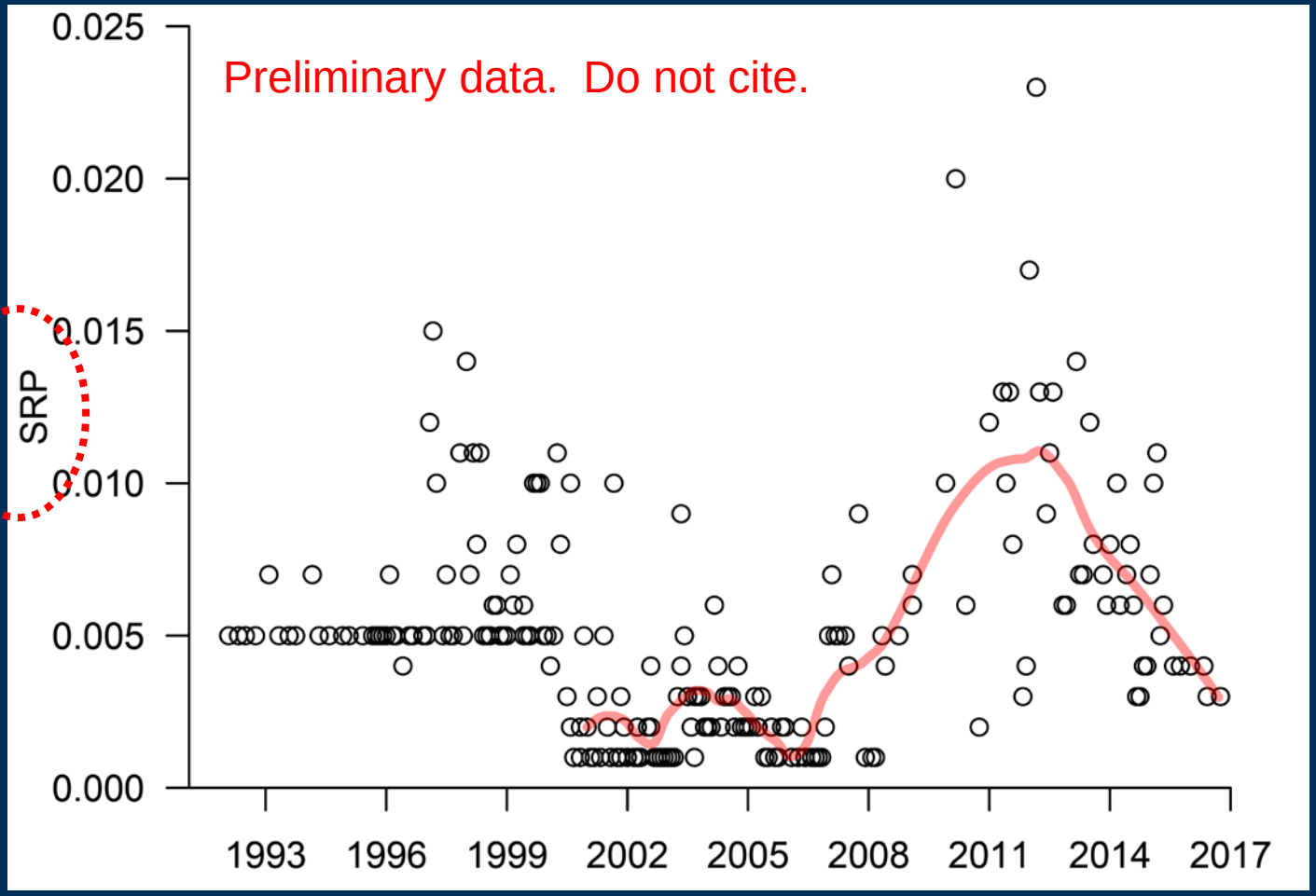
Preliminary data. Do not cite.

Reservoirs, remove P from water. The CR has low and variable P.



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Soluble reactive phosphorus (SRP) – phosphorous that is readily available to plants

R^2 – an aside

- Proportion of variance explained by one or more predictors
- 0 – doesn't explain anything
- 1 – perfectly related
- What is a good R^2 depends on the question (i.e., may expect to explain more variance when dealing with a simple system).

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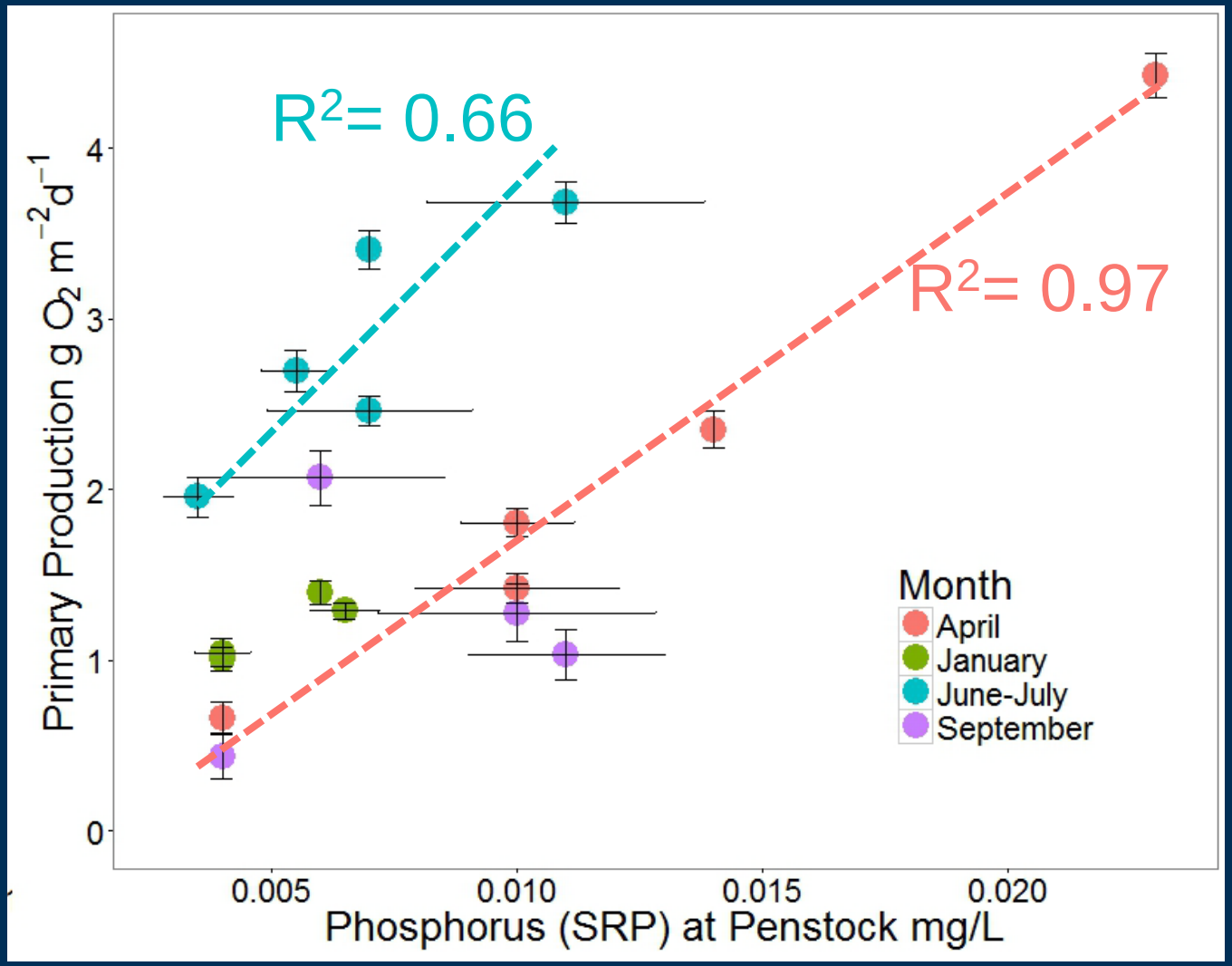
Seasonal estimates of gross primary production just above the LCR (~70 rm below the dam) are highly correlated with SRP at the penstocks.



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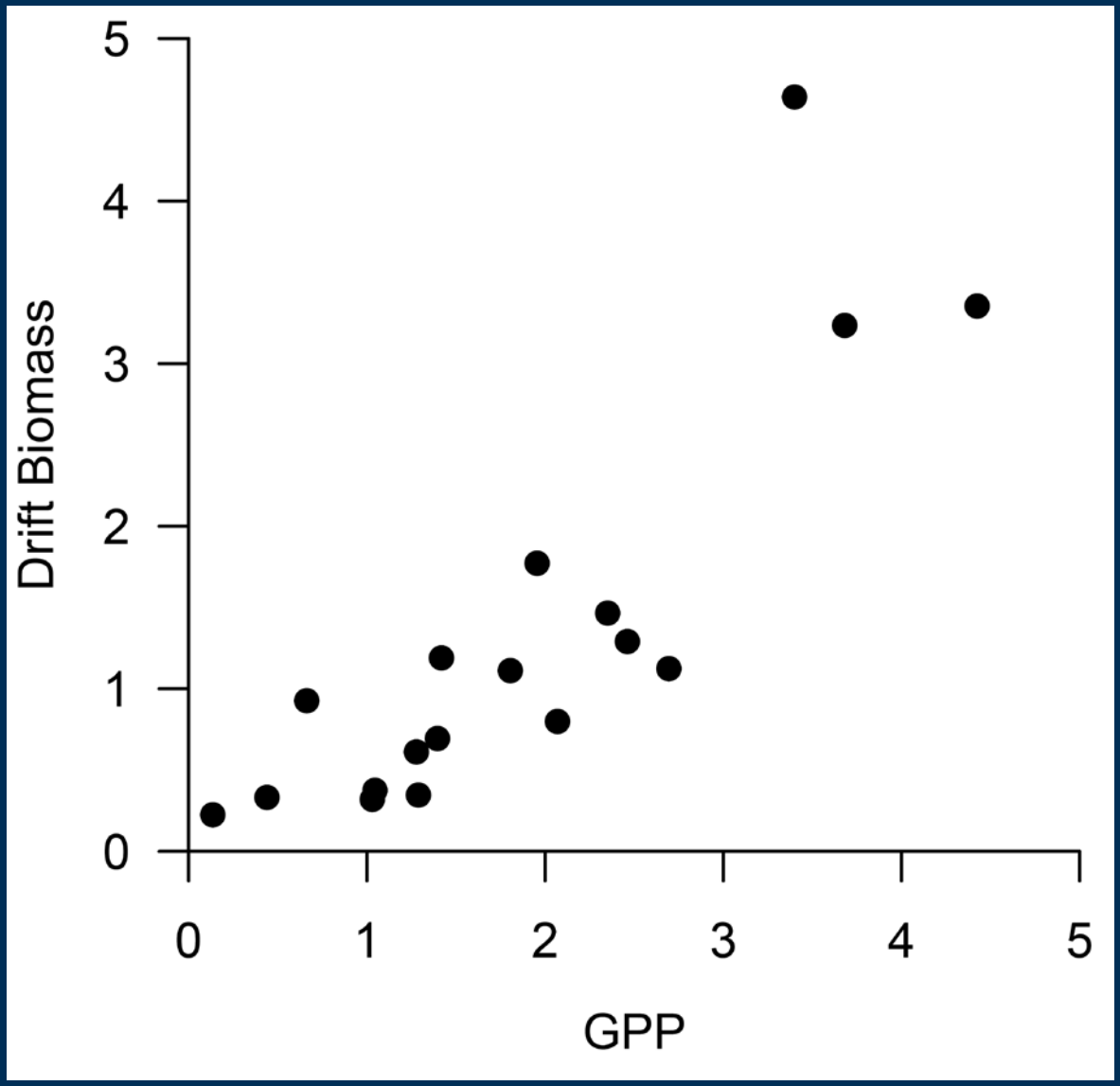
Preliminary data. Do not cite.

And gross primary production is linked to bugs.



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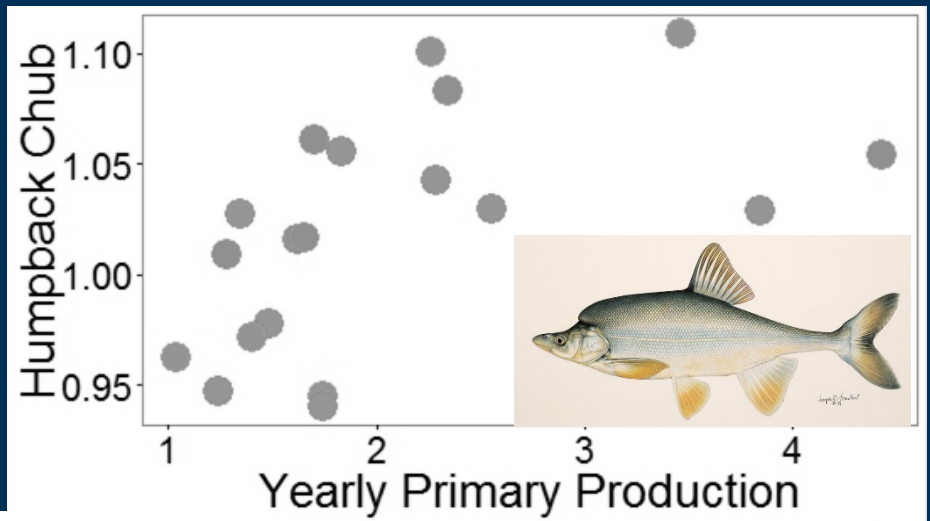
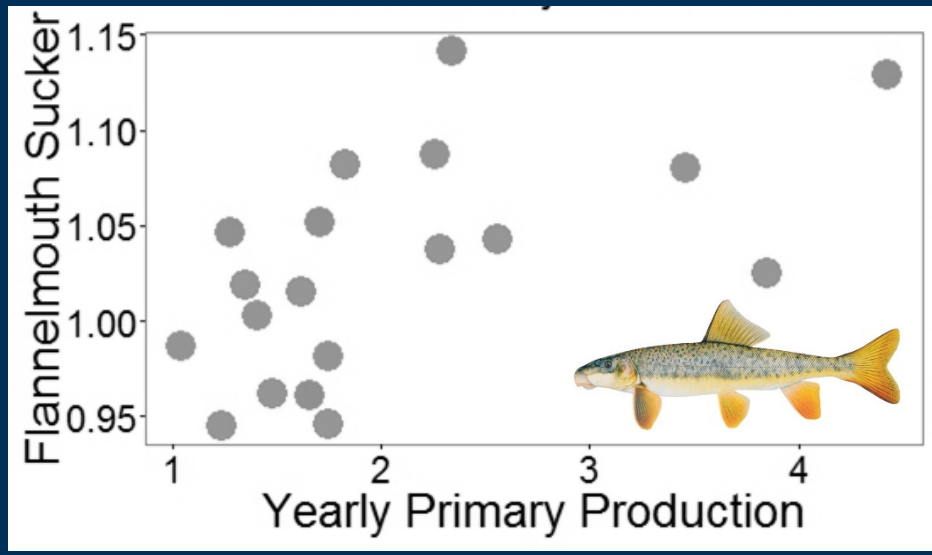
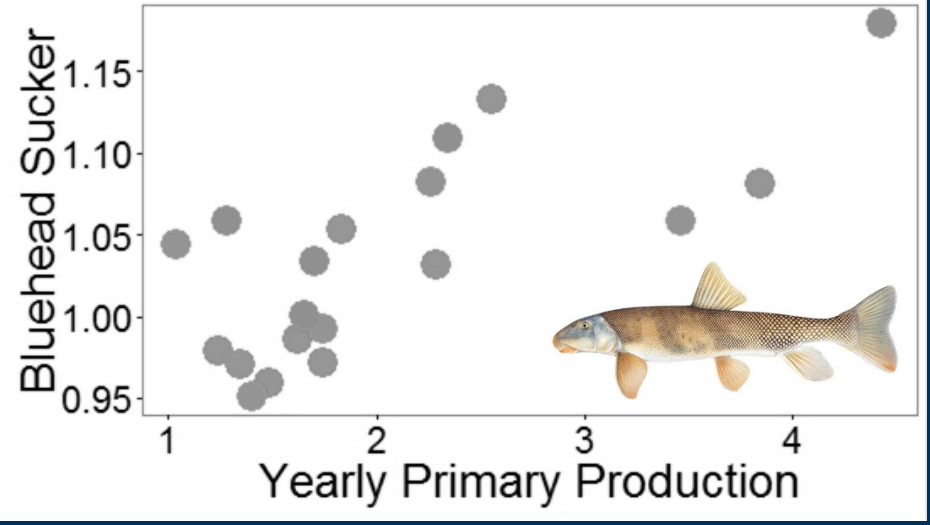
Preliminary data. Do not cite.

And native fish condition (fat/skinny).







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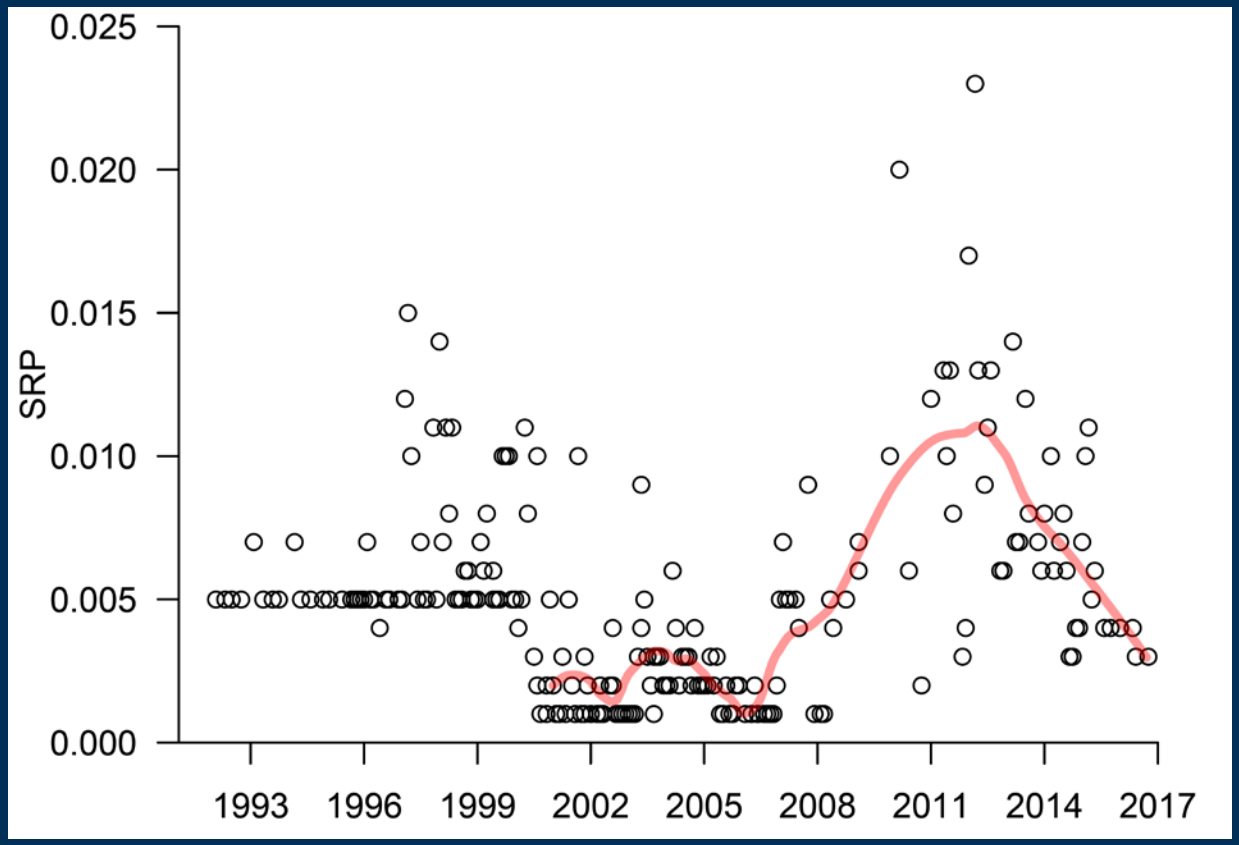
Preliminary data. Do not cite.

Mr. P, what else might you be responsible for?



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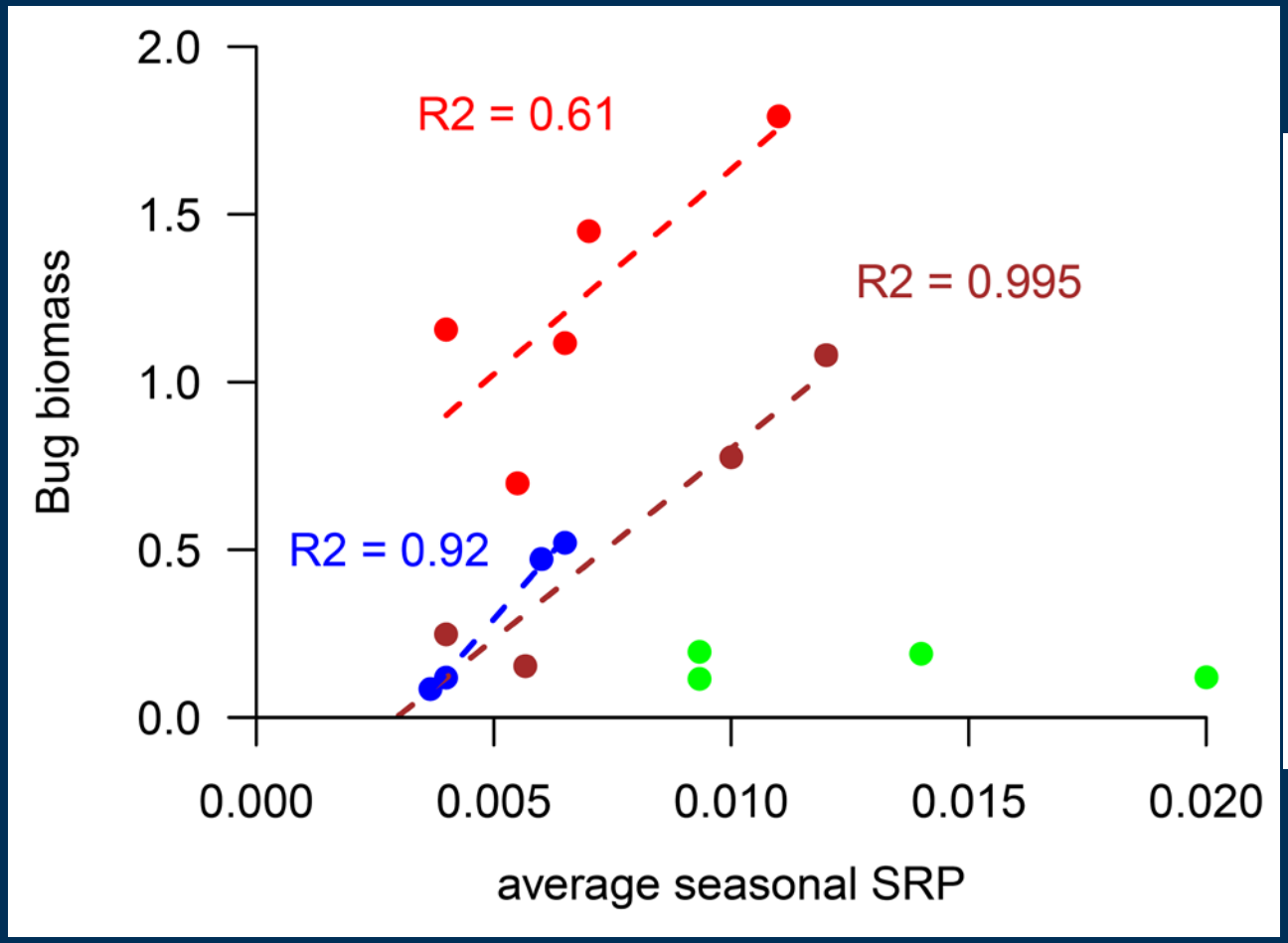
P vs. bugs in Glen Canyon



Near -4 rm
2012 – 2016
April
June/July
Sept
Jan

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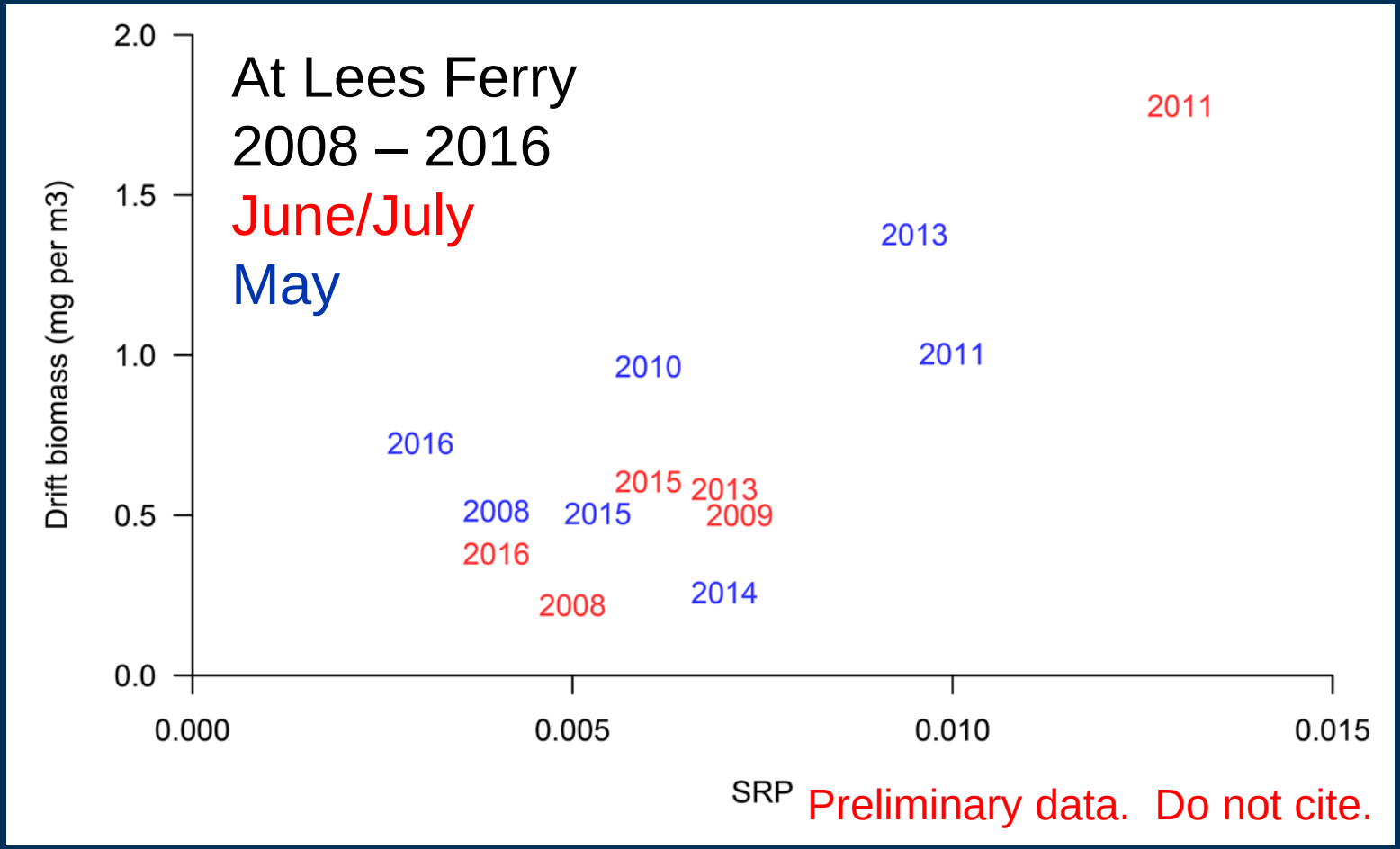
Preliminary data. Do not cite.

P vs. bugs in Glen Canyon



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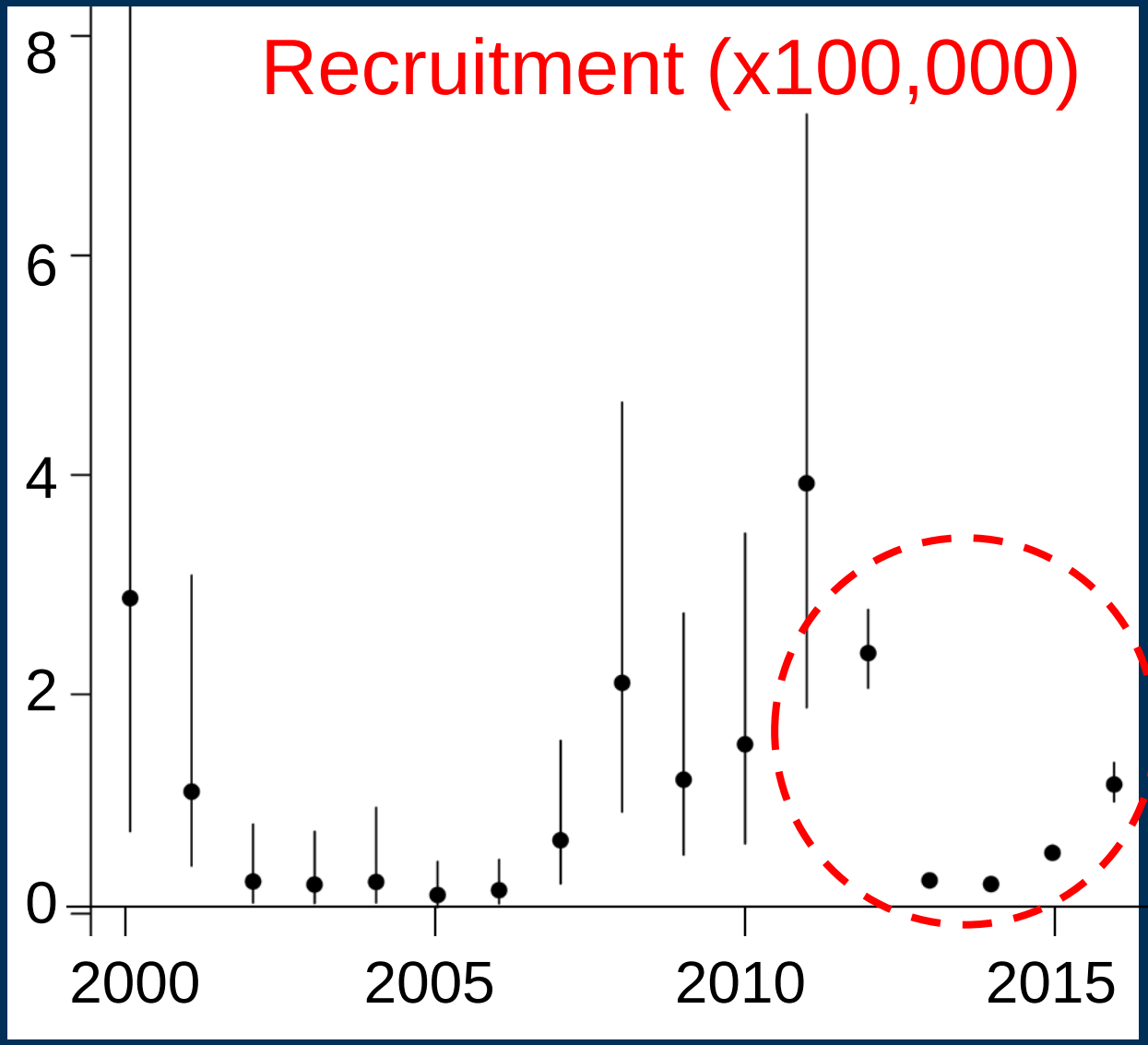
But what about RBT?

Lees Ferry RBT recruitment model

- An attempt to combine NO, AZGF, and RTELLS data in a relatively simple model focused solely on recruitment.



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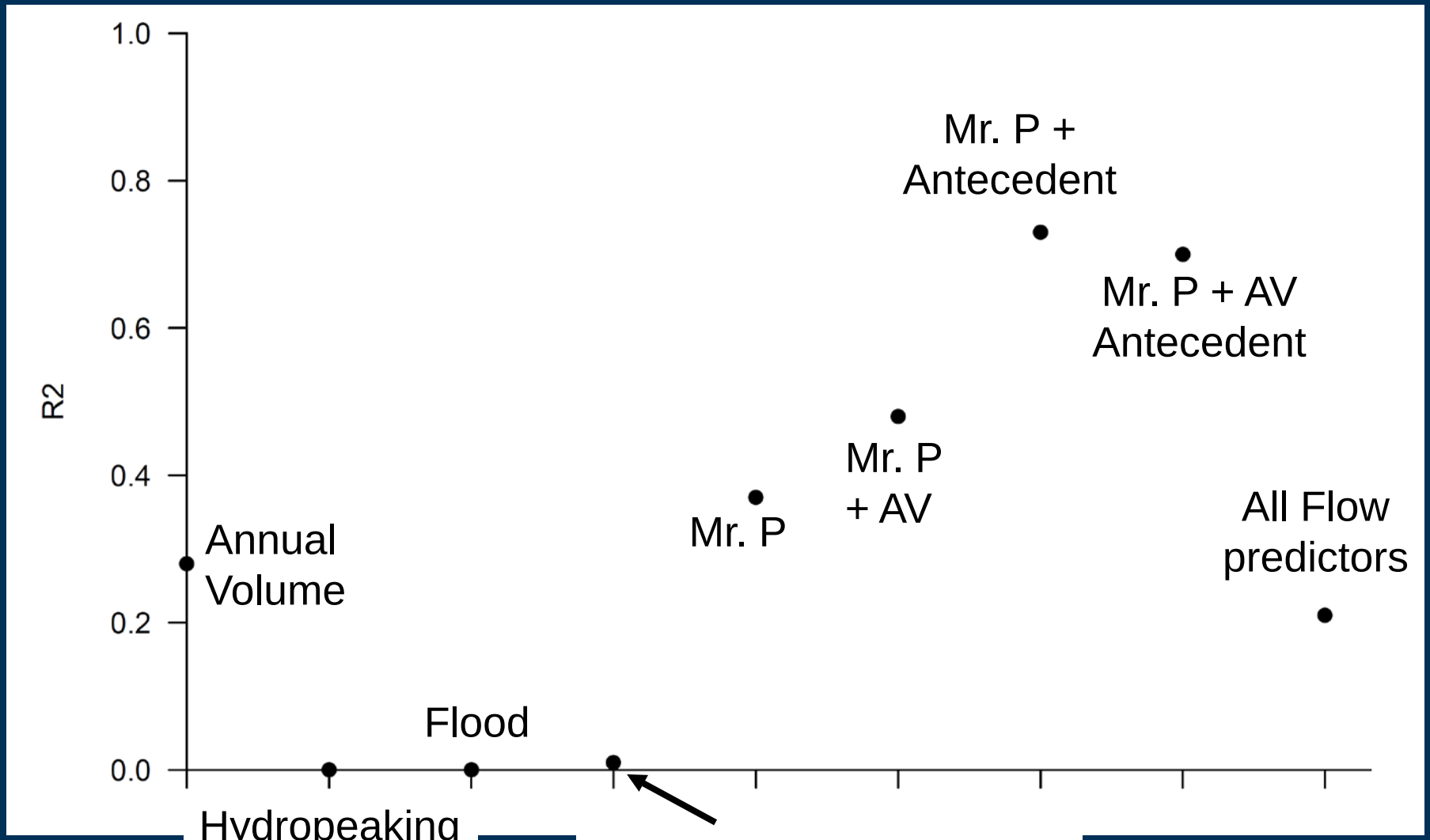

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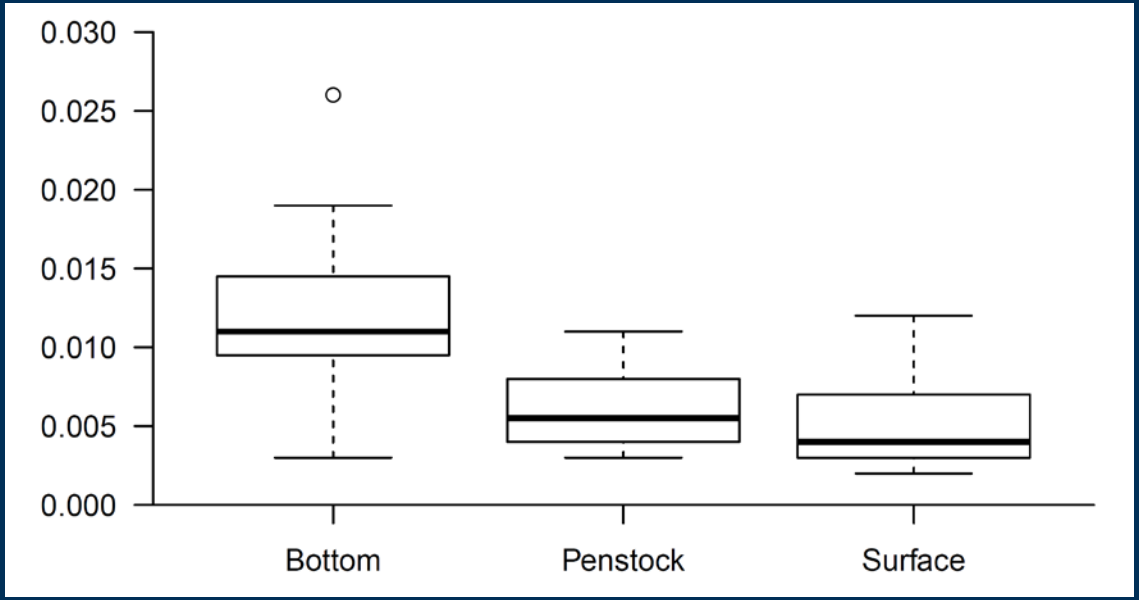
Preliminary data. Do not cite.

So what causes variation in SRP at penstocks?

- Inflows (strength, timing, and how they travel across Lake Powell)?
- Penstock location?
- Other factors?



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Preliminary data. Do not cite.

Take home messages

- While many factors likely drive ecosystem responses, the role of nutrients has been understudied in our system, and phosphorous is the most likely nutrient to be limiting.
- Recent declines in gross primary production, invertebrate drift biomass and native fish condition near the LCR all line up with trends in P.
- Invertebrate drift at two sites in Lees Ferry also line up with trends in P since 2008.
- The combination of existing rainbow trout populations and P can explain much of the observed variation in recruitment since 2000.

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Future steps

- More modelling of existing nutrient, gross primary production (DO data), inverbrate drift biomass, and fish condition or demographics to test potential role of Phosphorous.

- Research into and improved monitoring of nutrients, especially P, in the Colorado River over time and space.

Not GCDAMP, but worth considering

- Maintaining (and potentially) expanding nutrient (especially SRP) monitoring and research in Lake Powell will likely aid our understanding of trends in the Colorado River ecosystem.

- Development of models to predict SRP outflow will likely improve our ability to predict CR ecosystem responses.

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Acknowledgements

- Bureau of Reclamation, Nick Voichick, Bill Vernieu, Mark Anderson, Glen Canyon National Monument and others for maintaining reservoir monitoring.

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- Glen Canyon Dam Adaptive Management Program.

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