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Lake Powell as a Regulator of Downstream Water Quality and Ecosystem Productivity

Glen Canyon Dam Adaptive Management Program

Annual Reporting Meeting, January 13, 2020

Bridget R Deemer

In collaboration with: Charles Yackulic, Ted Stets, Bob Hall, Ted Kennedy, Jeff Muehlbauer, Nick Voichick and others

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

Project Information, slide 1

- **Project E: Nutrients and Temperature as Ecosystem Drivers: Understanding Patterns, Establishing Links and Developing Predictive Tools for an Uncertain Future**
- **Project Element E.2: Linking Temperature and Nutrients to Metabolism and Higher Trophic Levels**
- **Project Objective: *Determine drivers of ecosystem metabolism (including primary production and respiration) throughout the Cre***
- **LTEMP Resource Goals Addressed or Studied: 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.

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Project Information, slide 2

- Project Title: Lake Powell Water Quality Monitoring Program
- Project Elements:
  - Revisions to Existing Program
  - Characterizing Nutrient Dynamics During Experimental Flows
  - Historical Data Analysis
- Project Objectives:
  - Determination of water-quality status and trends in Lake Powell and GCD releases
  - Documentation of the effects of the structure and operation of GCD on the quality of water in Lake Powell and GCD releases
  - Integration with GCDAMP information needs and downstream monitoring programs
  - Documentation of the density structure and associated nutrient distribution in the water column at the GCD forebay and other locations in the reservoir to determine the quality of water available for release from GCD
- Funding Amount and Source: $196,904.91 for CY 2018, 5 Year Interagency Agreement R18PG00108
- Cooperators: Bureau of Reclamation, National Park Service

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Project Information, slide 3

- Water Quality Knowledge Assessment Completed January 7, 2020
- Team: Bridget Deemer, Peggy Roefer, Todd Tietjen, Robert Radtke, Charles Yackulic
- Status and Trends:
  - SIGNIFICANT CONCERN, UNKNOWN TREND: GCD outflow temperature and dissolved oxygen in support of Rainbow Trout
  - GOOD CONDITION, INCREASING TREND: GCD outflow temperature in support of Humpback Chub
  - SIGNIFICANT CONCERN, UNKNOWN TREND: GCD outflow phosphorus concentrations in support of ecosystem productivity

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Talk Outline, slide 1

- Gross Primary Production and the Food Web
- Drivers of Gross Primary Production
- Soluble Reactive Phosphorus as a Control
- Flow as a Control

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Gross Primary Production (GPP) and the Food Web

- Total amount of oxygen produced during photosynthesis in the river
- Some of this carbon is available to higher trophic levels, some of it is consumed by bacterial and autotrophic respiration

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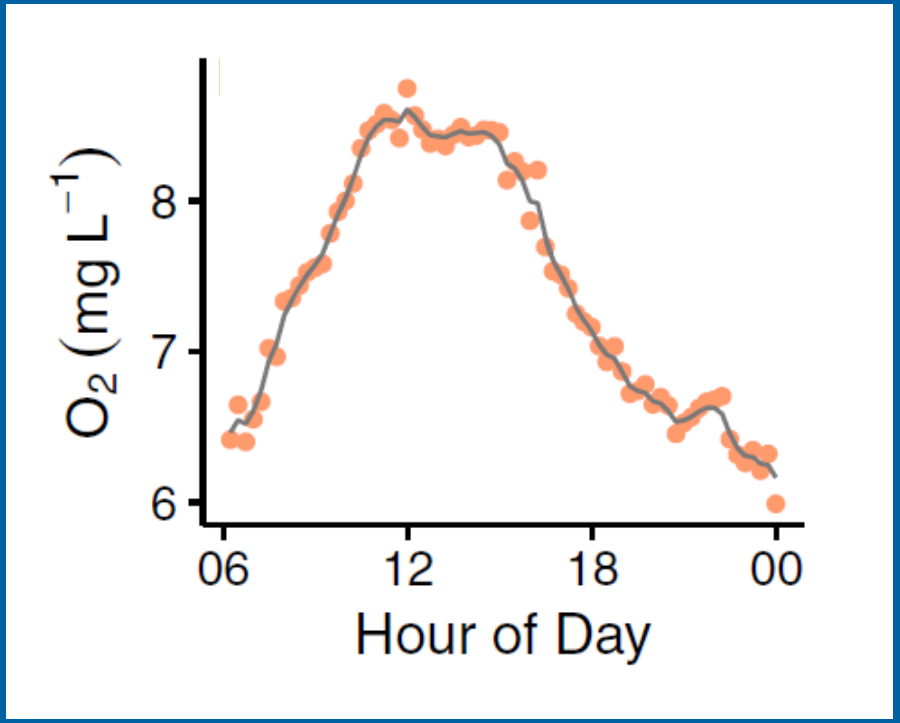
Oxygen Data for Modeling GPP

- Lees Ferry (two station)
- 30 Mile (two station)
- 60 Mile
- Bright Angel
- National Canyon
- Diamond Creek



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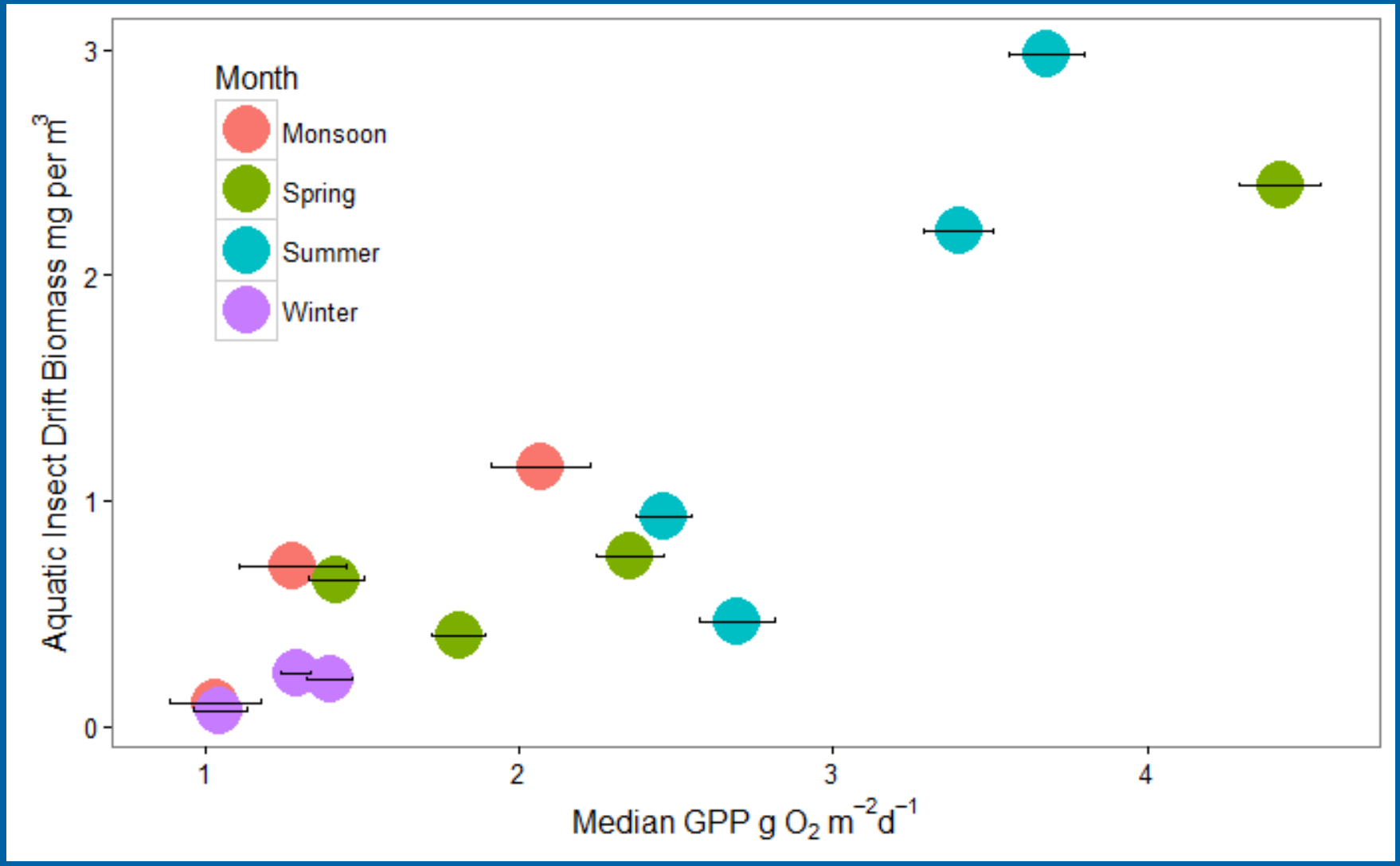
Appling & Yackulic et al. 2018 JGR Biogeosciences



- **GPP has been linked to aquatic insect densities– suggesting some bottom-up control on the foodbase**

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Unpublished data, subject to change, do not cite.

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Is Primary Production in the Colorado River below Glen Canyon Dam Nutrient Limited?

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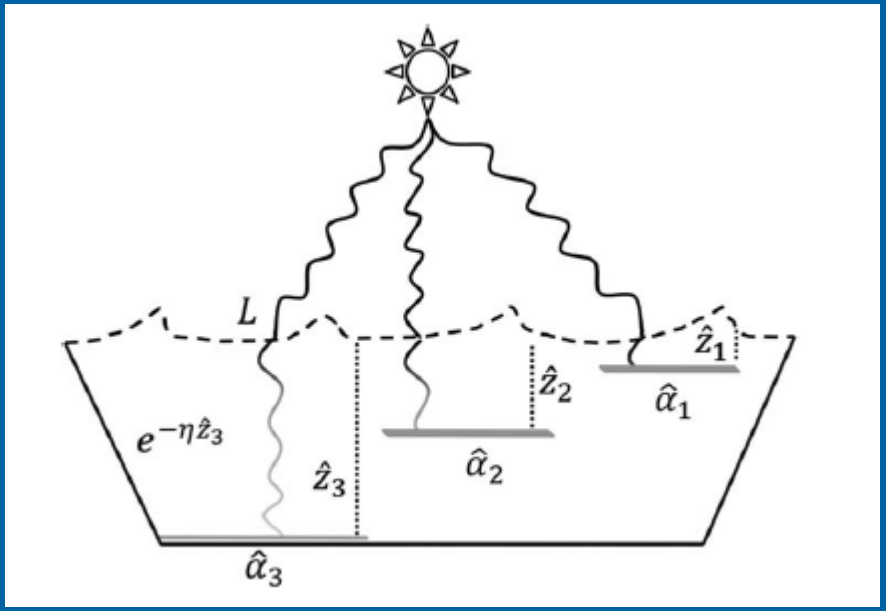
Semi-mechanistic Modeling

- Light (PAR)
- Clouds
- Turbidity
- Temperature
- Discharge (Hydropeaking)
- Soluble Reactive Phosphorus (SRP)



Approach based on Hall et al. 2015 L&O

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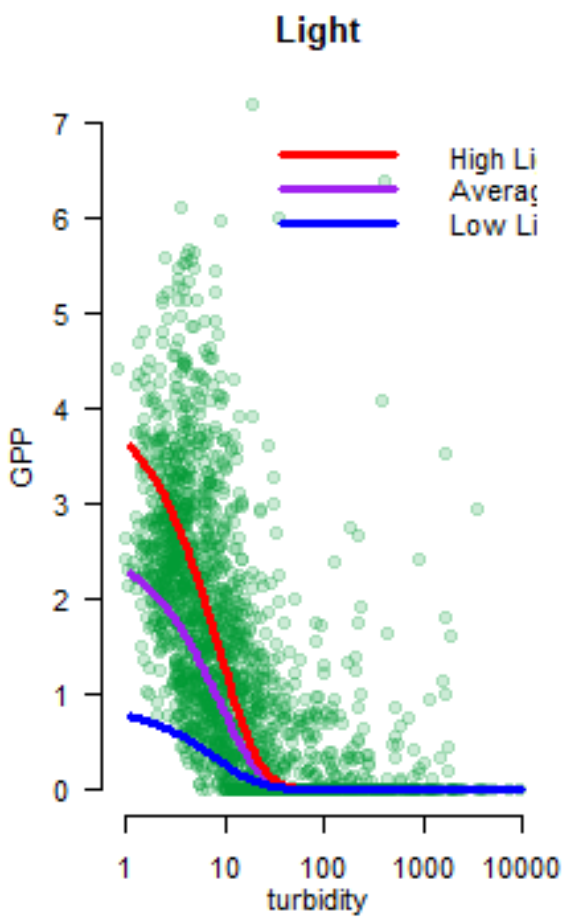
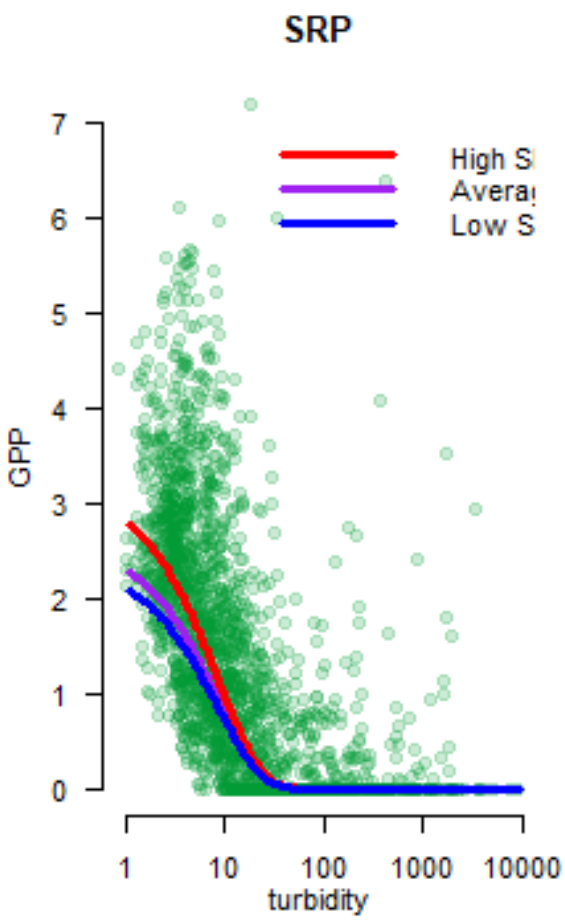
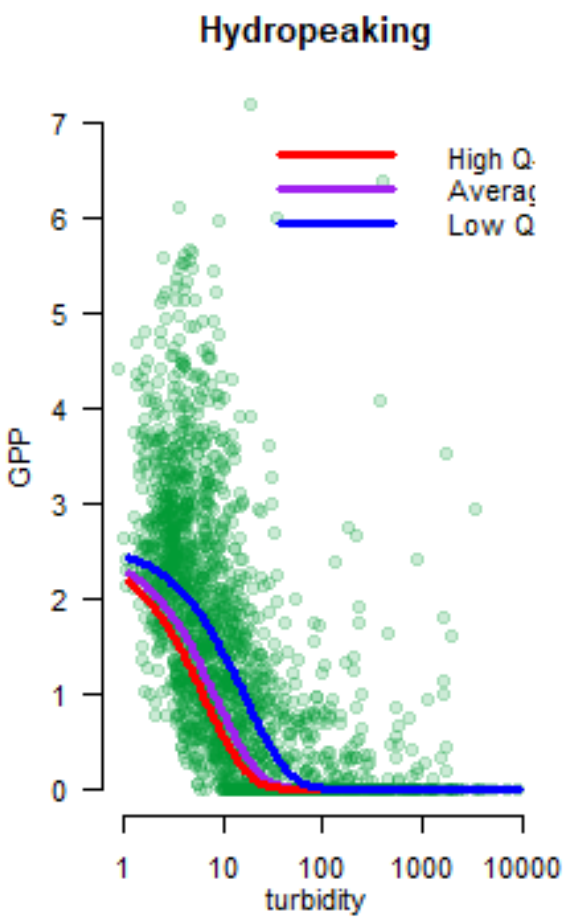
Light, SRP, and Flow







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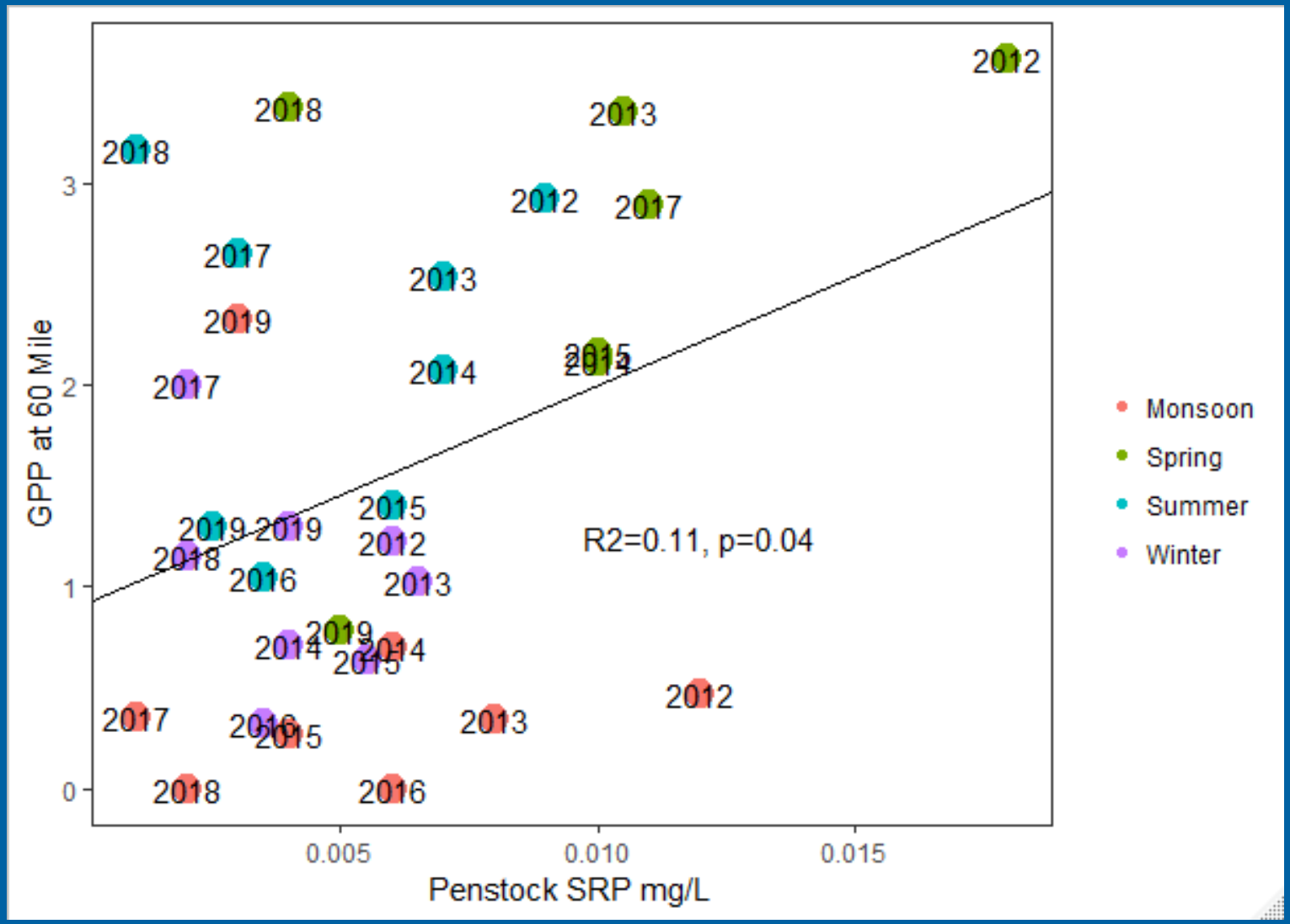
SRP Control GPP



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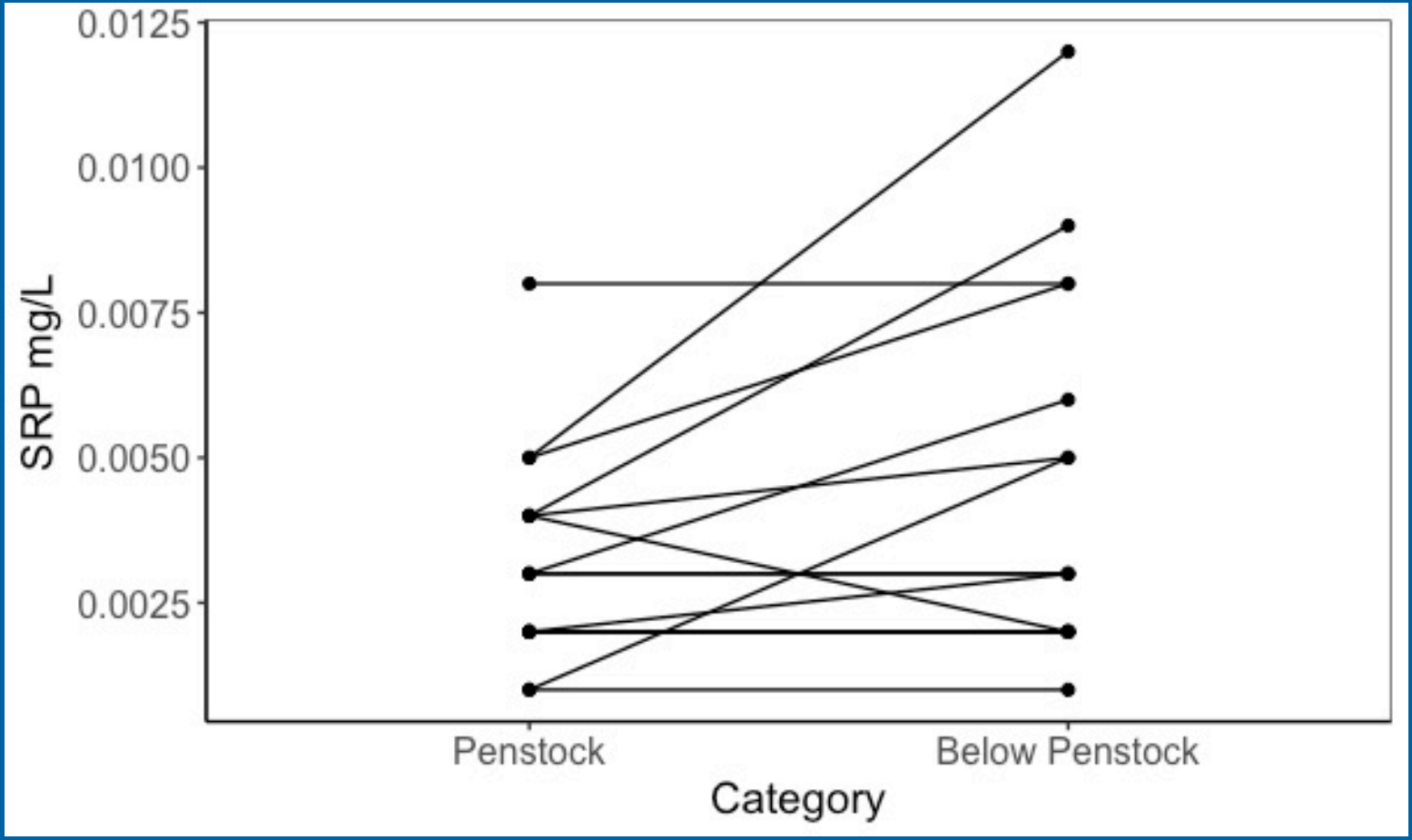
Soluble Reactive Phosphorus as a Control



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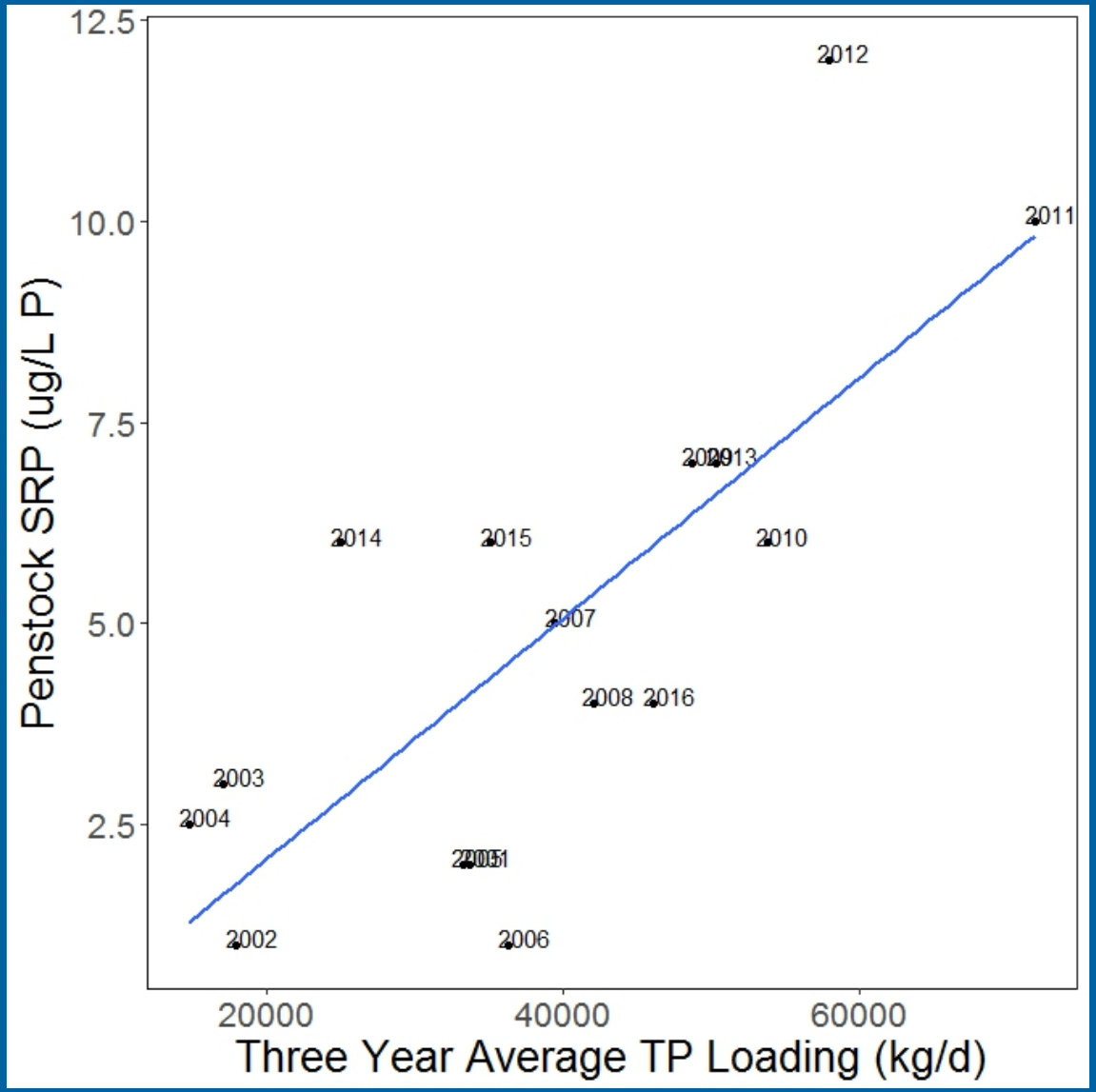
TP Loading is a Strong Predictor of P availability at Dam

Total phosphorus loading explains ~55% of the variance in penstock SRP availability



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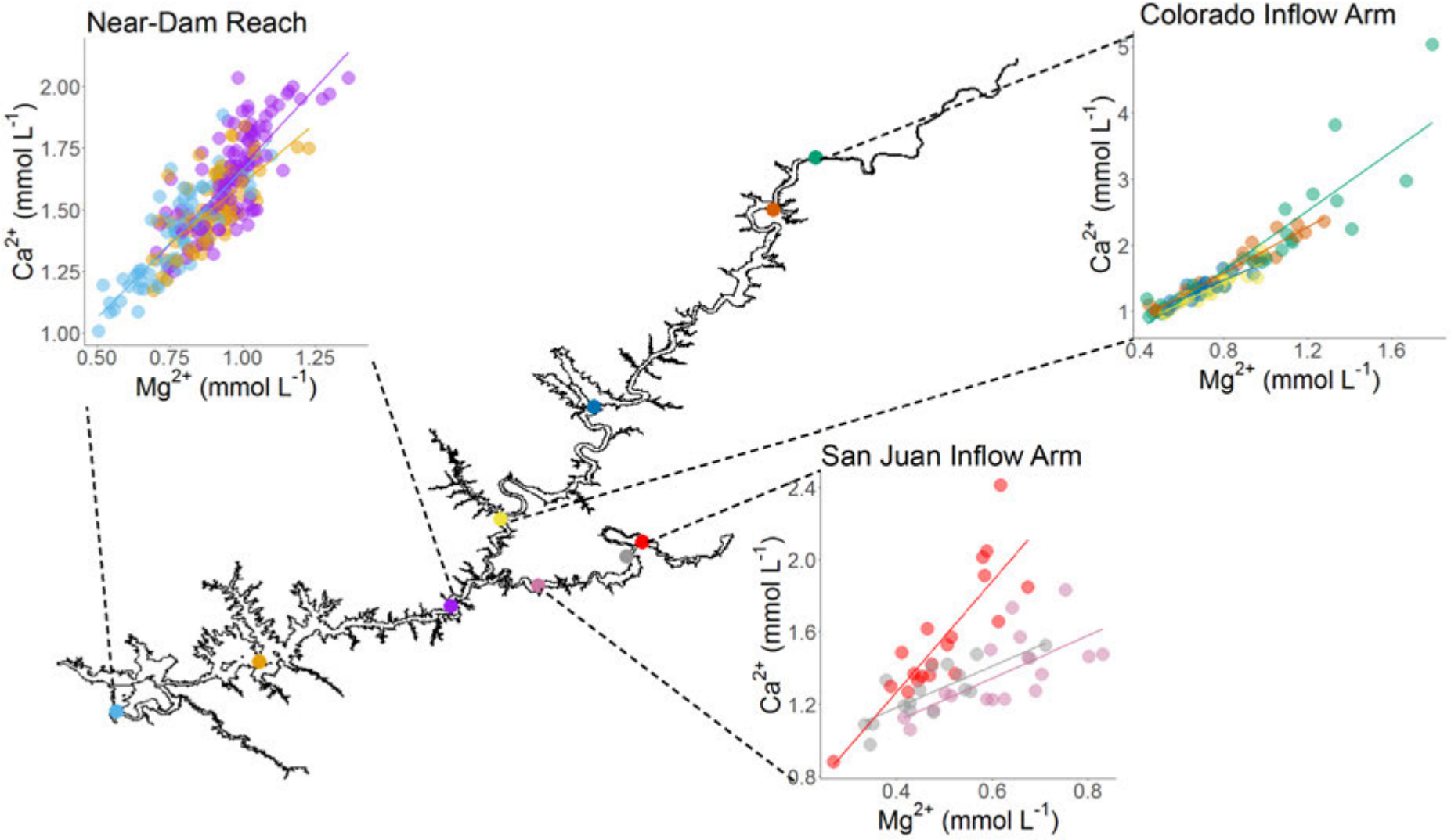
Biological Processes in the Reservoir



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Deemer et al. 2020 L&O

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ASLO

Limnol. Oceanogr. 9999, 2020, 1–17

doi: 10.1002/lno.11399

Calcite precipitation in Lake Powell reduces alkalinity and total salt loading to the Lower Colorado River Basin

Bridget R. Deemer ,[1]* Edward G. Stets,[2] Charles B. Yackulic[1]
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[2]U.S. Geological Survey, Water Mission Area, Boulder, Colorado

- Lake Powell reduces salt transport to the lower basin by an average of ~2000 metric tons of salt per day
- These salts can bind phosphate

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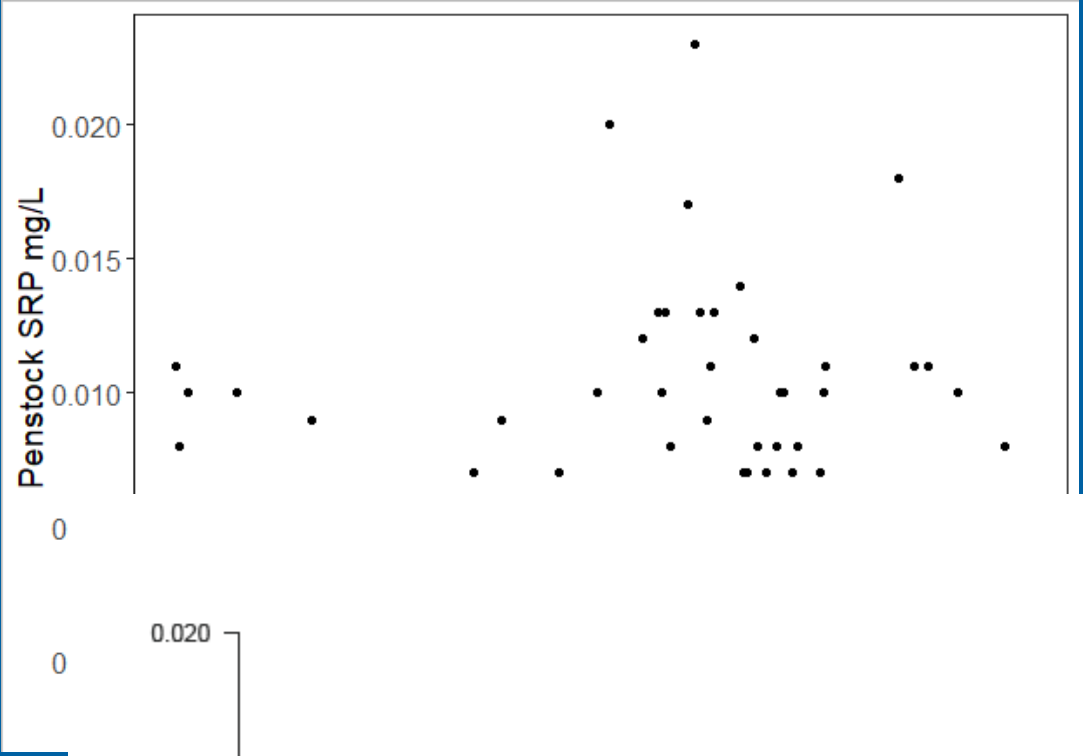
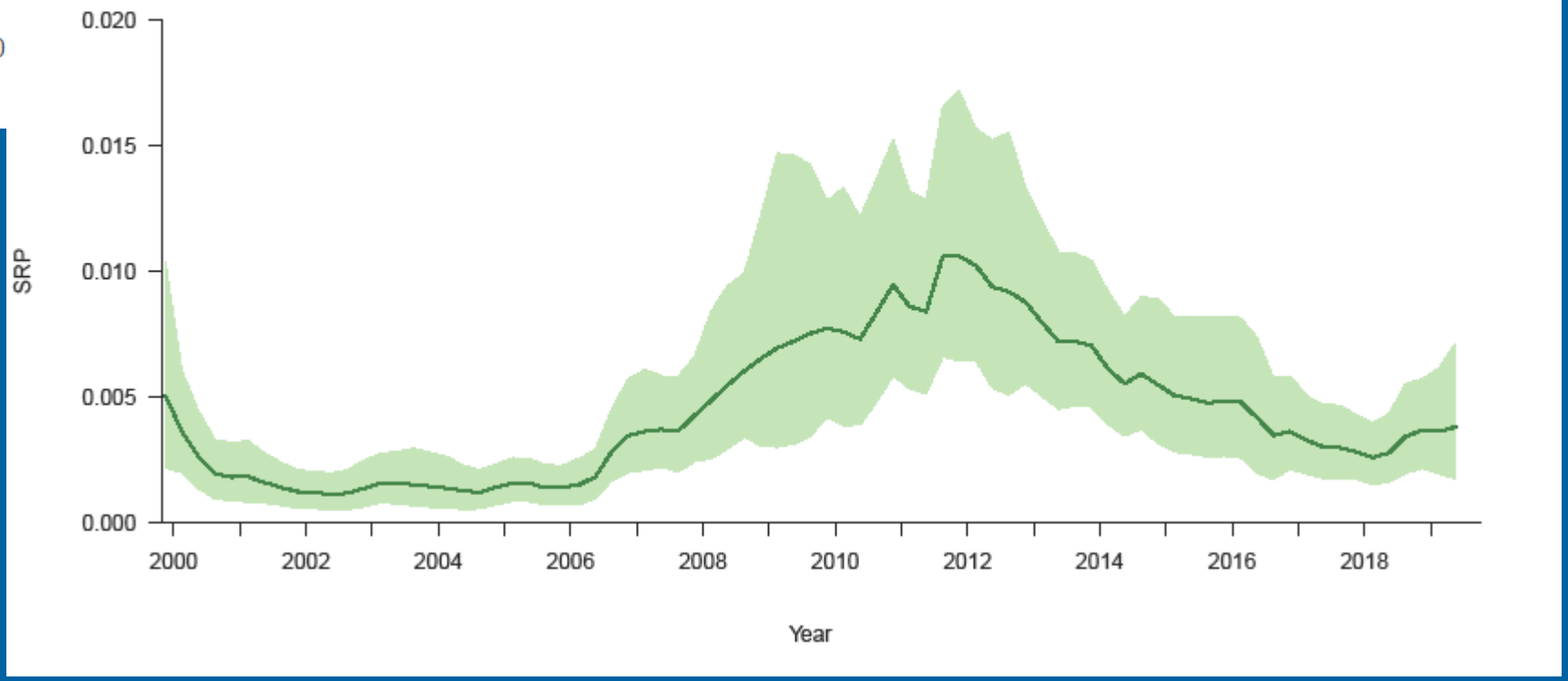
SRP is difficult to measure





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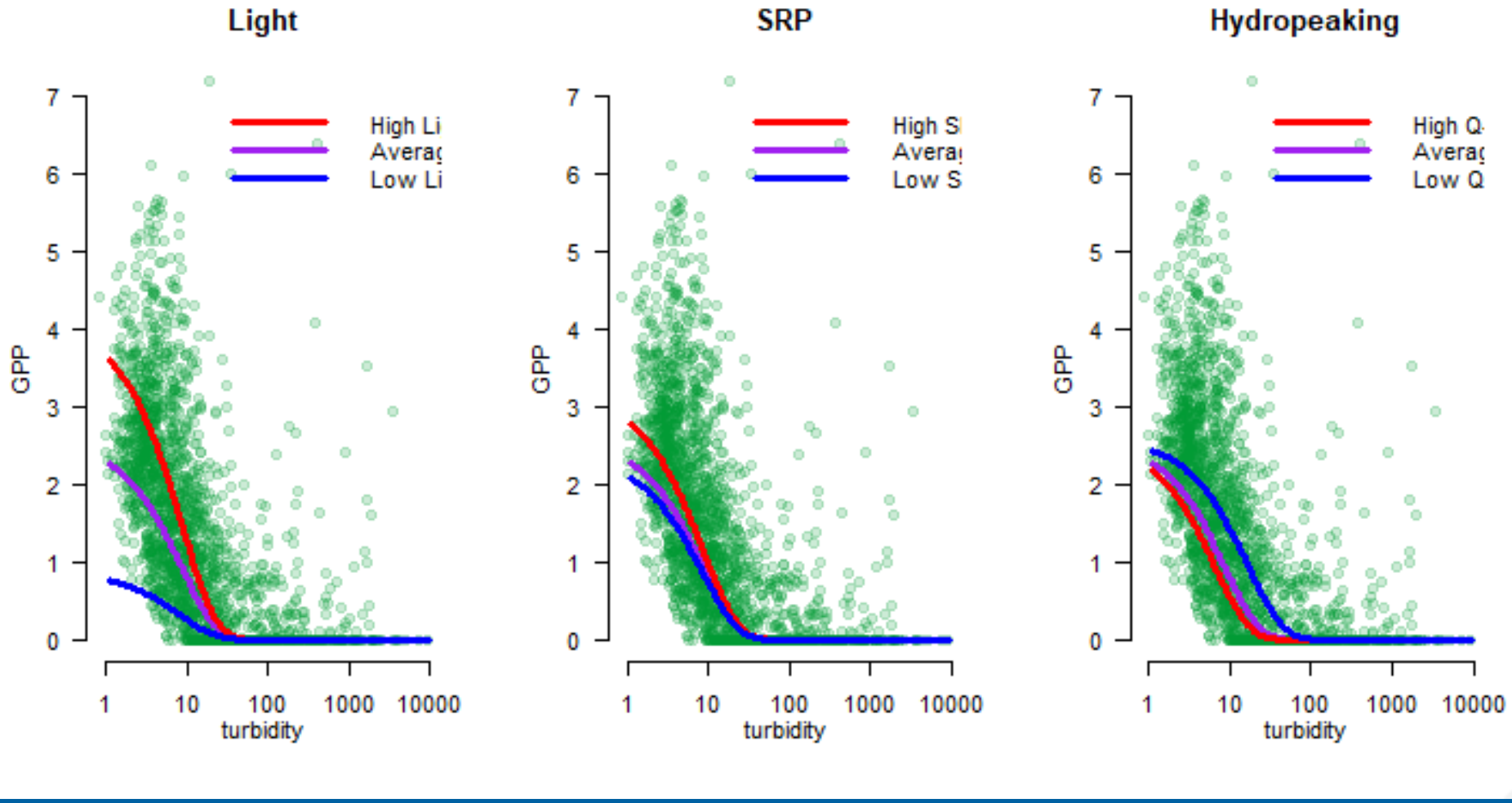
Less Hydropeaking= More GPP



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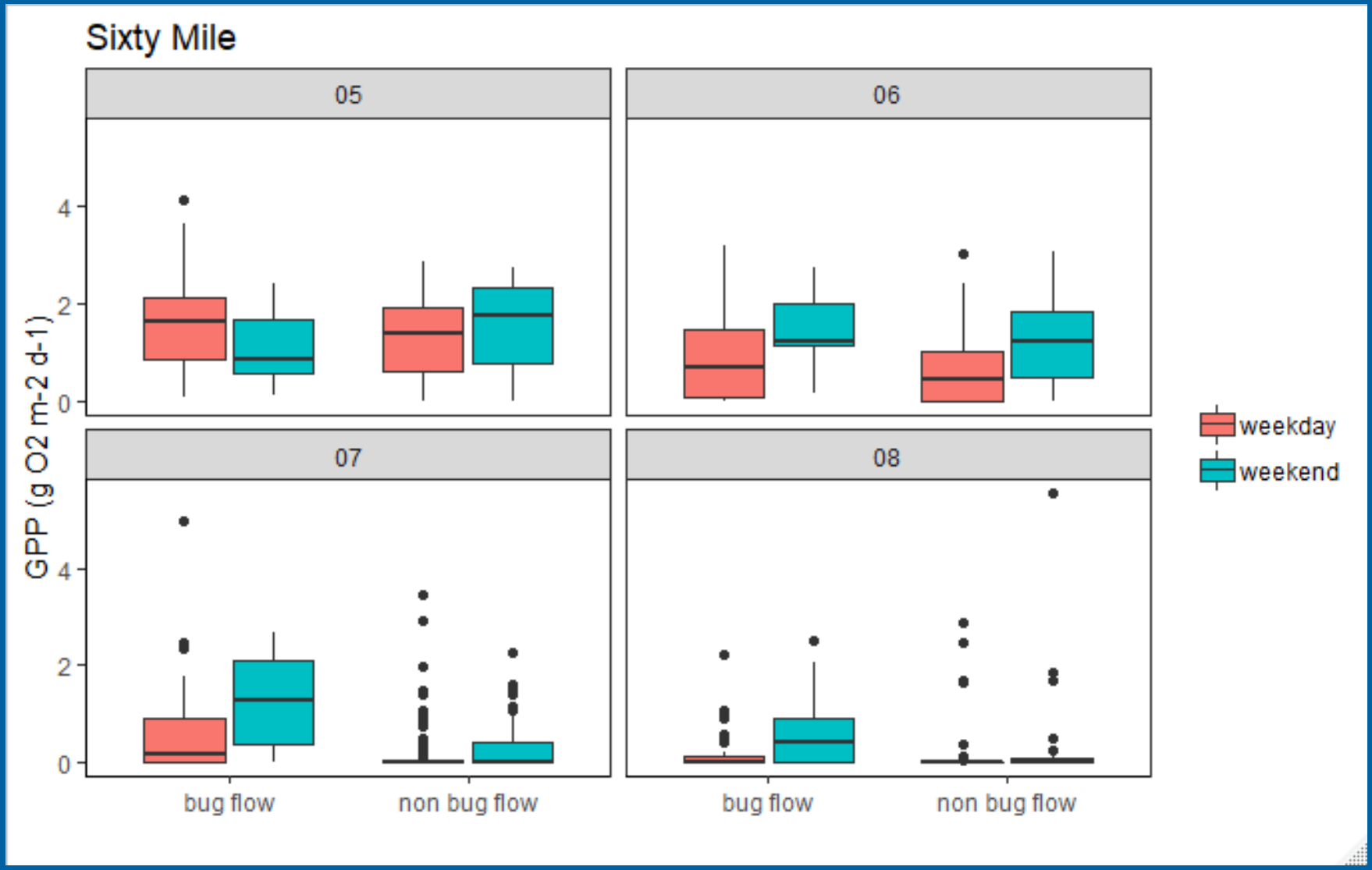
Weekday and Weekend GPP In Bugflow and Non-Bugflow Years



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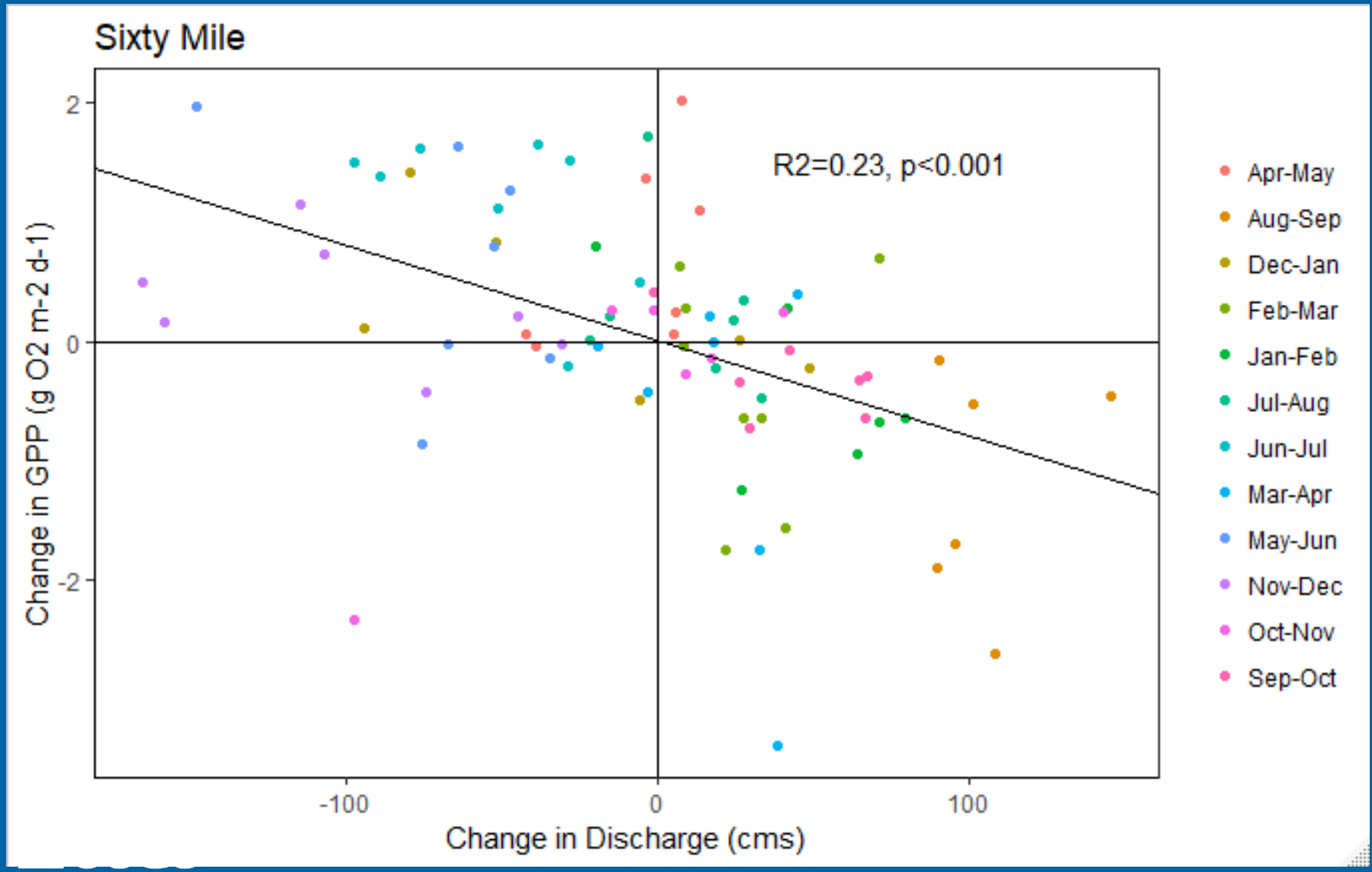
Low Water= Higher GPP at 60 Mile



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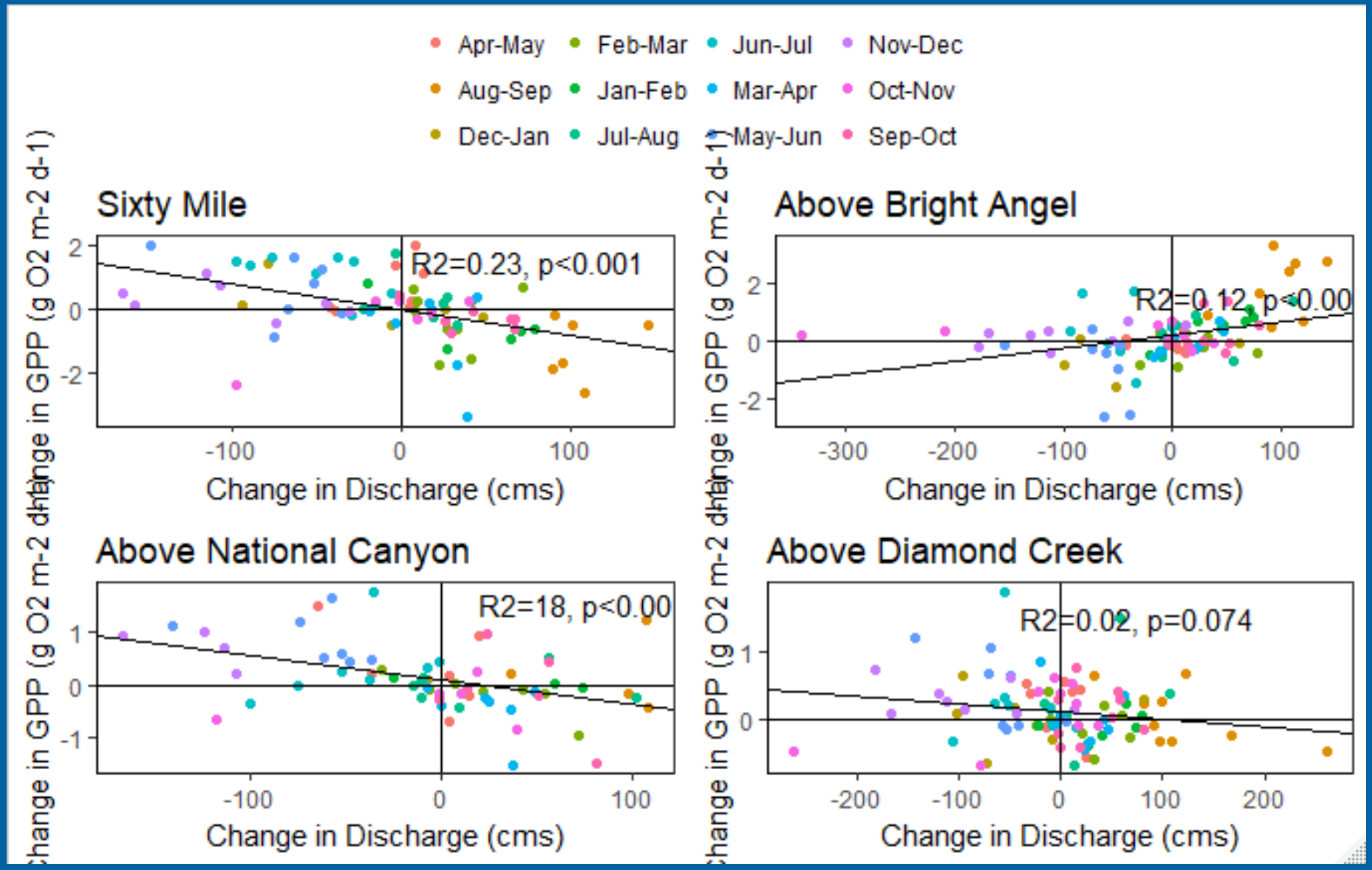
Many Factors Influencing GPP- Lack of Synchrony Through the River



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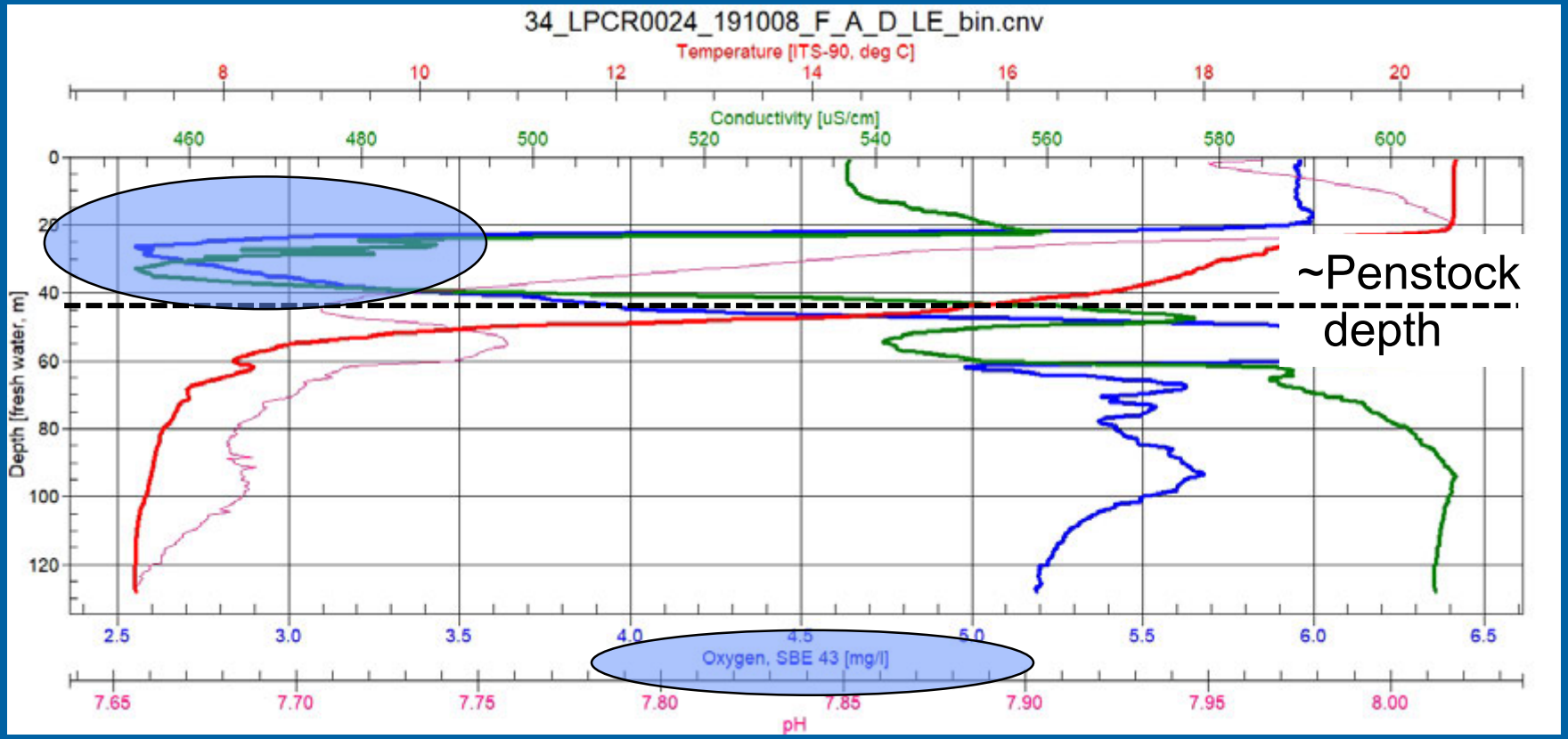
Challenges of Predicting Interflow Limnology & Biogeochemistry



Pocket of low dissolved oxygen water above penstocks (minimum DO = 2.6 mg/L)

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Project Information, Slide 6

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Acknowledgements

- Lake Powell Monitoring Group: Nick Voichick, David Goodenough, Robert Radtke, Kristin Lewis, and Keri Stout
- GPP modeling/data: Charles Yackulic, Bob Hall, Ted Kennedy, Jeff Muehlbauer, David Goodenough
- Logistics & Lab Support: Carol Fritzinger, Dave Foster, and Seth Felder, Amy Stephenson, Ann Marie Bringhurst
- Mass Balance Modeling: Ted Stets, Charles Yackulic

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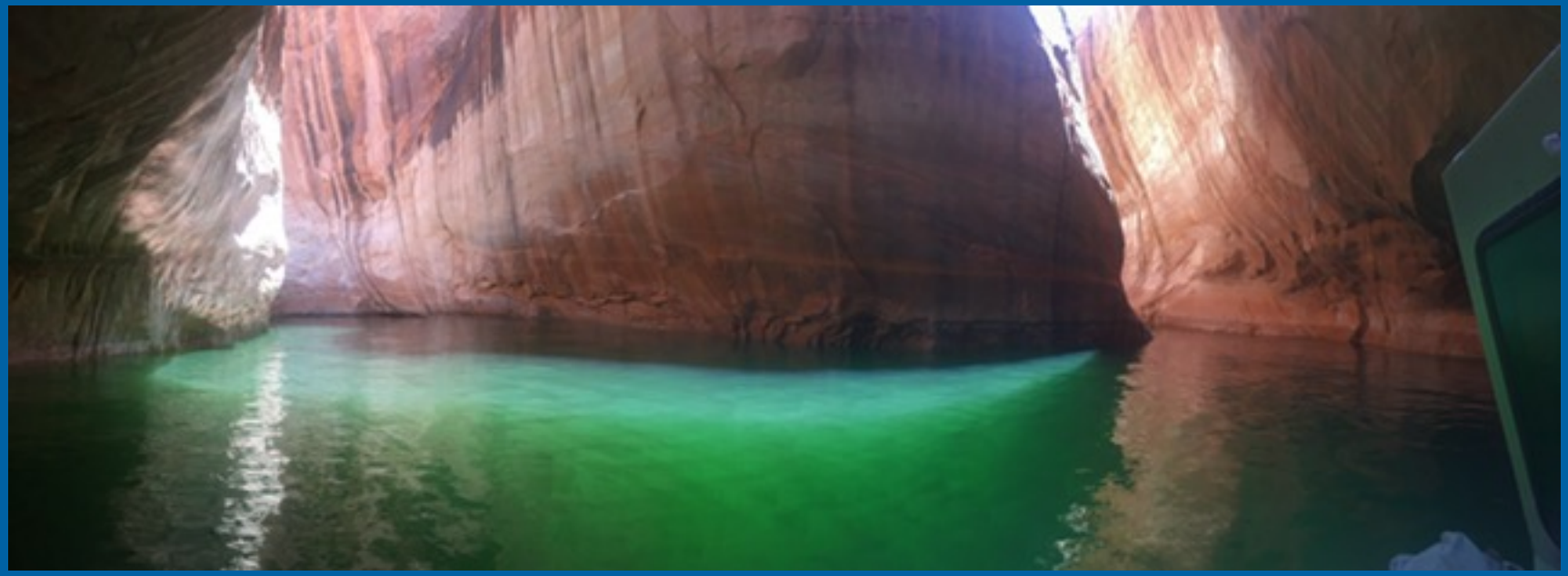
Questions



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