Flows and phosphorus: the influence of Lake Powell on primary production dynamics in the Colorado River

Glen Canyon Dam Adaptive Management Program
Annual Reporting Meeting, January 20, 2021
Bridget R Deemer
Project Information

- 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.
Project Title: Lake Powell Water Quality Monitoring Program

Project Elements:
- 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
- Improving Access to Historical Dataset

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

Funding Amount and Source: $212,955 for CY 2020, 5 Year Interagency Agreement R18PG00108 (ends Dec 31, 2022)

Cooperators: Bureau of Reclamation, National Park Service
Conceptual model (1)
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
Oxygen Data for Modeling GPP

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

Appling & Yackulic et al. 2018 JGR Biogeosciences
Management Change in Recent Years: Bug Flows

- “Give bugs the weekends off”
- Weekend stable low flows May-August
- Eggs laid on weekends never dry
Increased Light Intensity at Depth

M. Yard- Unpublished Data

Unpublished data, subject to change, do not cite.
Do Bug Flows Enhance GPP?

- During clear-water times of tributary quiescence, changes in discharge are a more important control on turbidity.
- Do the low and steady flows in May and June of 2018 and 2019 lead to clearer water and higher rates of GPP?
Study Design

4 YSI Is
7 MiniDOTs
11 reaches
120-400km downstream

Unpublished data, subject to change, do not cite.
Sensor Maintenance
Modeling Controls on GPP

- Used YSI data to interpolate discharge and turbidity at MiniDOT sites
- Compare GPP estimates from one “weekend” and 4 “weekdays”
- Mixed effects models to quantify the role of depth, turbidity, month, site, weekend

Unpublished data, subject to change, do not cite.
Weekend Flows Support Higher GPP

Weekend GPP is ~145% of Weekday GPP Across all Reaches
Much of This Effect Is Turbidity Driven

45% whole river increase in GPP on weekends

Unpublished data, subject to change, do not cite.

Deemer, Yackulic and others, unpublished
Both Fines and Sand Drive Turbidity Reductions

- ~10% reduction in water depth
- ~22% reduction in discharge
- ~30% reduction in turbidity
Conceptual model
Phosphorus - building block of all life

Redfield Ratio:

$106C : 16N : 1P$

$166C : 22N : 1P$
SRP is difficult to measure
N:P Ratios In Dam Outflows

Unpublished data, subject to change, do not cite.
Dam SRP concentrations are related to aquatic insect drift in Glen Canyon

Korman et al. 2020

Yackulic and Deemer unpublished
Rainbow trout recruitment models fit for 2017 annual reporting meeting

Out of sample R2: 0.85
Out of sample R2: -0.33

Model using SRP and existing rainbow trout population size as covariates previously outperformed model used in LTEMP EIS.

Yackulic, preliminary data, do not cite
We Can Detect Changes in SRP Within Lake Powell Water Column

Average gradient of 0.002 mg/L SRP per 10 m drop below penstock

Unpublished data, subject to change, do not cite.
Disconnect Between SRP and GPP in Glen Canyon

[Graph showing the relationship between Glen Canyon GPP (g O₂ m⁻² d⁻¹) and Dam SRP (mg/L) for different seasons: fall, monsoon, spring, and winter.]

Yackulic and Deemer, unpublished

Unpublished data, subject to change, do not cite.
Next Work Plan: Role of Macrophytes vs Diatoms in Glen Canyon GPP

- Hypothesis 1: SRP is disconnected from Glen Canyon GPP because macrophytes are accessing different (sediment) P pool
- Hypothesis 2: SRP does predict diatom (labile) GPP production
- Research Question: Is GPP by macrophytes and diatoms additive? Or is there a shading effect?
Dam Management Can Influence Both Light and P

Water withdrawal height effects SRP especially during spring

Discharge effects turbidity during times of tributary quiescence
Lake Powell Database

- Transfer from formerly maintained Microsoft Access database to a SQL Server Database is nearly complete

- Goals:
  - Write a data paper describing and publishing the updated dataset
  - Make data download linked to visualizations that are publicly available
Seabird Profile at LPCR0024 on 10/8/2019 10:00:00 AM

Depth: 27.0
Dissolved Oxygen: 2.566
Penstock Depth: 44.14 m

USGS

Hensleigh, Voichick, Deemer, unpublished
Acknowledgements

- GPP modeling/data: Charles Yackulic, Bob Hall, Ted Kennedy, Jeff Muehlbauer, Mike Dodrill, Maite Arroite, Mike Yard, David Topping, Nick Voichick, Tom Gushue, David Goodenough
- Glen Canyon GPP: Kim Dibble, Tom Sabol, David Goodenough
- Lake Powell Monitoring Group: Nick Voichick, James Hensleigh, Robert Radtke, Jeff Arnold, and Jeremiah Drewel
- Logistics & Lab Support: Carol Fritzinger, Dave Foster, Seth Felder, Amy Stephenson, and Ann Marie Bringhurst
Questions