Ecological Thresholds and Environmental Indicators of the Density of Zooplankton Exports from a Polymictic Reservoir Series

Dominic Ruggiero, Michael Grove, Courtney Richmond, Nathan Ruhl
Department of Biological Sciences, Rowan University, Glassboro NJ 08028

Background and Methods

- Construction of reservoirs alters ecological function of streams as reservoir zooplankton are exported downstream.
- Density (DZE), community composition (CCZE), and biomass of exports (BZE) may affect downstream consumers.
- Reservoirs connected in series are poorly understood.

- Weekly samples at outfall of four reservoirs during three summers.
- Zooplankton quantified via microscopy.
- 2019 Environmental data: mix of field and lab-based methods (22 drivers assessed).
- Statistical analyses: MLR, SLR, CVA, recursive partitioning, Kruskal-Wallis test, PCA.

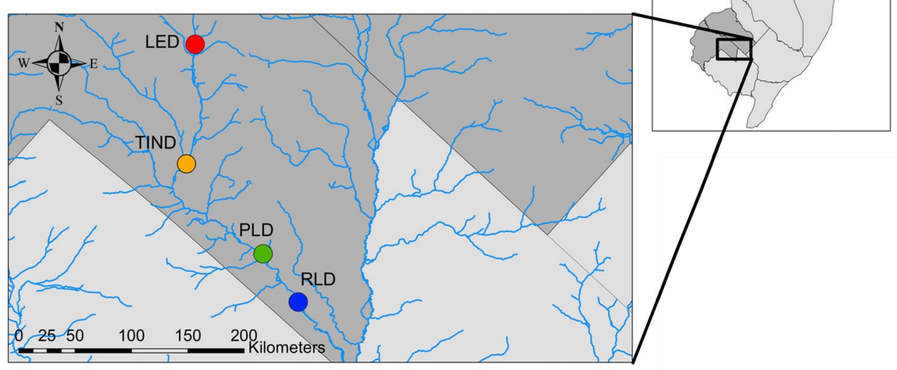

Figure 1: Map showing relative location of sampled lakes in Southern NJ.

Lake and Date are Correlated with the Density of Zooplankton Exports

Q1: Does DZE vary by date, year, or location?
Methods: Summer 2017-2019 zooplankton quantified.

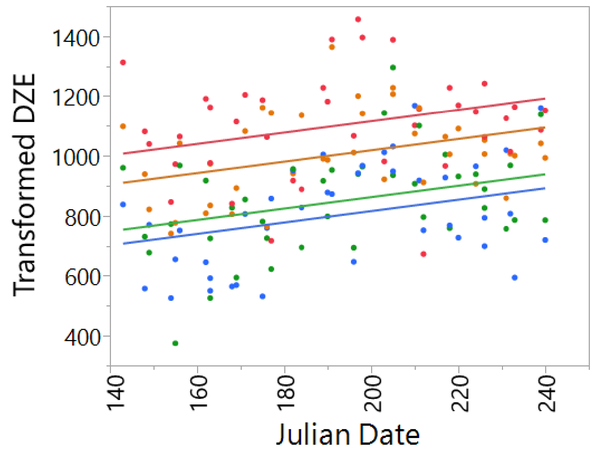

Figure 2: Multiple Linear Regression analysis of Box-Cox transformed DZE by Julian Date with color coding corresponding to lakes in Figure 1.

A1: Julian Date and lake are significantly correlated with density, year is not.

Conductivity is a Strong Indicator for Spatial and Seasonal Variation in the Density of Zooplankton Exports

Q2: What environmental factors predict temporal change in DZE?
Methods: VIF screening of 2019 environmental data.

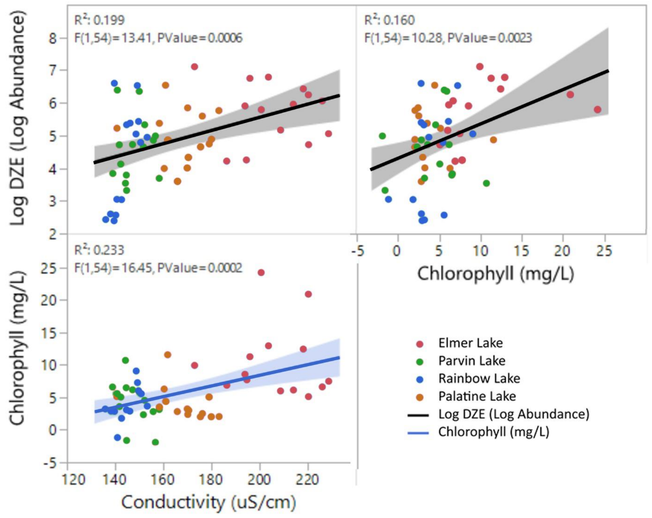

Figure 3: Simple Linear Regression analyses for chlorophyll, conductivity, and log-transformed DZE. Variables were obtained via VIF screening to control for multi-collinearity

A2: Conductivity and chlorophyll are positively associated with DZE.

Q3: What environmental factors define spatial variation in DZE?
Methods: Canonical Variate Analysis of log-transformed 2019 environmental and zooplankton density data.

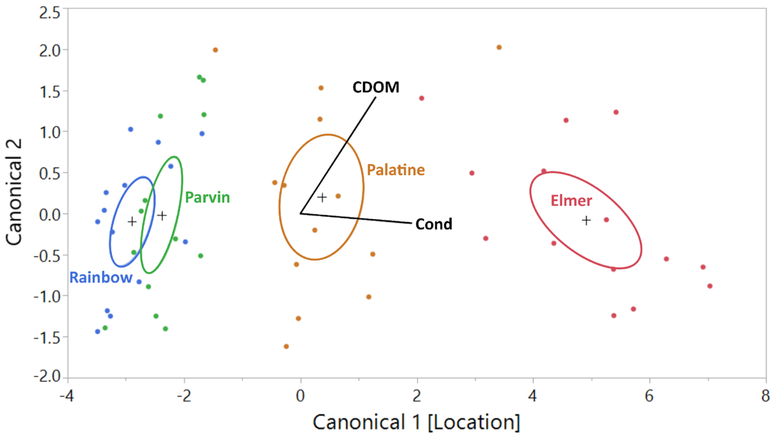

Figure 4: Canonical Variate Analysis of log-transformed DZE and Variance Inflation Factor-screened environmental variables.

A3: Lake axis strongly linked with conductivity. The remaining variation is best described by Colored Dissolved Organic Matter (CDOM).

Ecological Thresholds Affect the Density of Zooplankton Exports

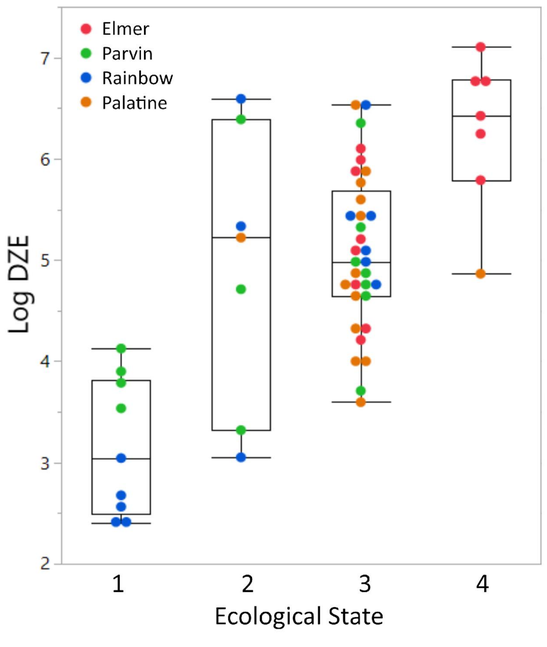

Figure 5: Boxplots of four ecological states identified via recursive partitioning. Kruskal-Wallis indicates state 1 is significantly different from the other 3 defined states.

Q4: Are there ecological thresholds in the Density of Zooplankton Exports (DZE)?

Methods: Kruskal-Wallis test based on recursive partitioning of 2019 data. Steel-Dwass for pairwise comparisons.

Q5: Do Q2/Q3 Environmental Drivers contribute to state 1?

Methods: PCA of lakes in the significant state from Figure 5.

A4: One significant ecological state exists, defined by an early-season date and low conductivity in two of the sample lakes.

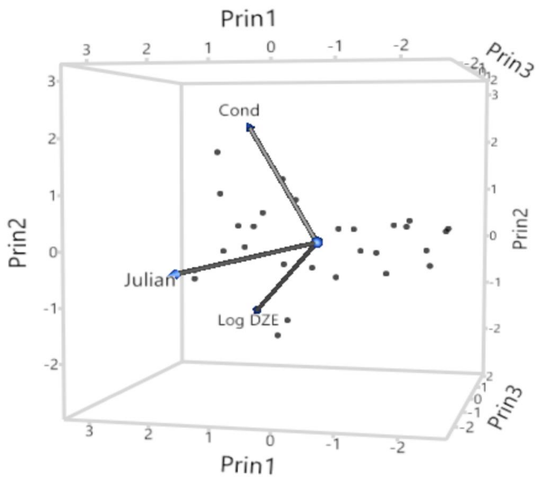

Figure 6: Principal Components Analysis showing divergence between early and late season measurements in ecological state 1.

Conclusions

- Density of zooplankton exports varies between connected reservoirs.
- Conductivity is the most reliable indicator of the density of zooplankton exports at a weekly timescale; conductivity is easy/cheap to measure.
- Ecological thresholds (as defined by the distinct ecological states) in the density of zooplankton exports are present.

Next Steps

- Explore alternatives to multiple linear regressions for Q1.
- Fine-tune simple linear regressions.
- Extend analysis to community composition of zooplankton exports.
- Assess conductivity as an environmental driver in our studies from 2017 and 2018
- Explore alternatives to recursive partitioning.