

Modeling *Cladophora* Growth: A Review of the Aure-Canale Framework

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Introduction

To address the problem of excessive growth of filamentous algae in the Great Lakes in the 1970s, a three-year study was conducted. Specific objectives of the study were: 1) to identify environmental factors mediating the growth of *Cladophora*, 2) to develop mathematical algorithms describing these relationships, 3) to incorporate these algorithms into a mechanistic model, 4) to test the model in a demonstration program, and 5) to apply the model to determine target levels of limiting nutrients. Field work for this study focused on Harbor Beach, Lake Huron, where *Cladophora* was locally abundant due to the discharge of nutrients from a municipal wastewater treatment plant. Presented below is a summary of the results of this study. The details of this effort, as well as the results of other earlier research on filamentous algae in the Great Lakes, are available in a special issue of the Journal of Great Lakes Research (Volume 8(1), 1982).

Model Overview

Model Conceptual Framework

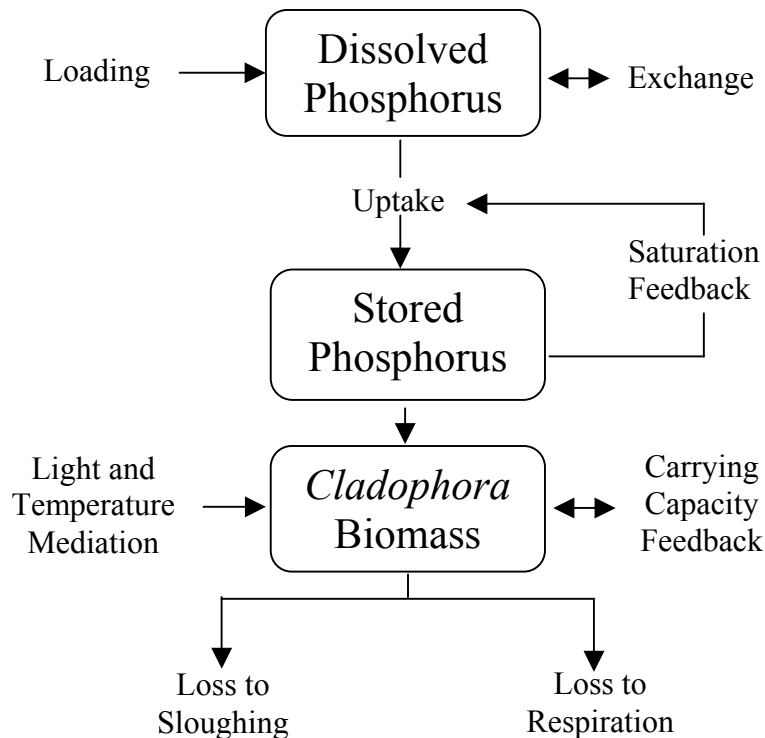


Fig. 1. Conceptual framework of model to simulate phosphorus dynamics and *Cladophora* biomass.

The model takes a mass balance approach, in which two major phosphorus pools (dissolved phosphorus and phosphorus stored in *Cladophora*) and *Cladophora* biomass are calculated by simulating the gain and loss processes for each of these state variables. For dissolved P, the gain processes include loading and mass transport within the lake, while the loss processes are uptake by *Cladophora* and mass transport. For *Cladophora* P content, P uptake is the main gain mechanism while dilution through growth is the loss process. This portion of the model accounts for the feedback between *Cladophora* P content and P uptake (Fig. 2). P uptake is modeled as a function of dissolved P, stored P and temperature. For *Cladophora* biomass, growth is the gain processes, while losses result from respiration and sloughing. Growth is modeled as a function of light, temperature, stored P, and carrying capacity.

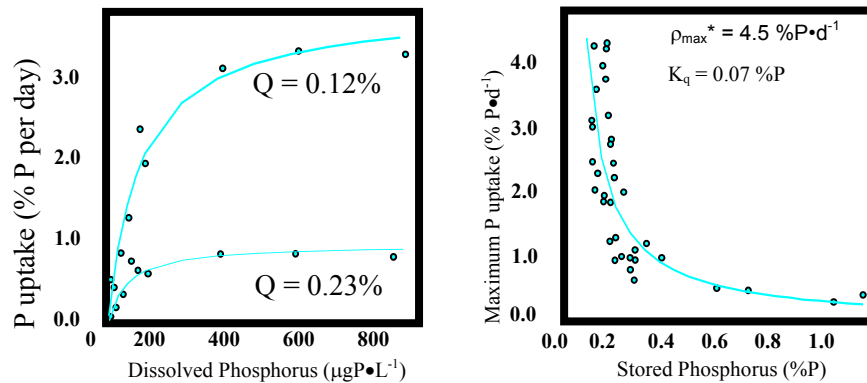


Fig. 2. Plots illustrating opposite effects of dissolved P and stored P on P uptake.

Laboratory experiments were conducted to determine the relationships between the state variables and forcing factors. The results of these experiments were then used to parameterize the various algorithms used in the model (Figs. 3, 4, 5). Sloughing proved to be the most difficult process to model, and there remains a need to better understand the mechanisms that influence the timing and magnitude of sloughing.

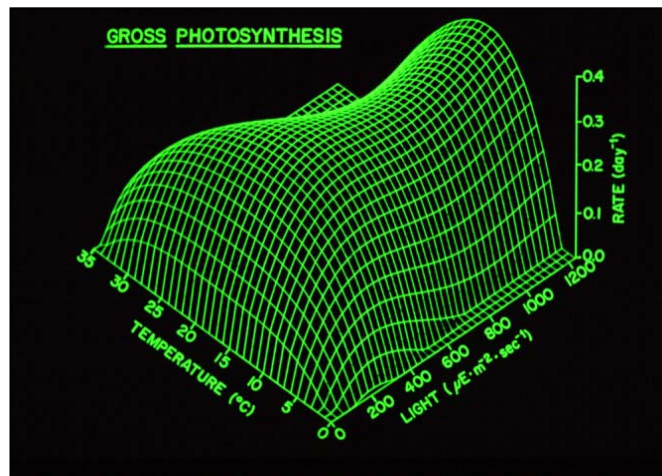


Fig. 3. The interactive effect of temperature and light on *Cladophora* photosynthetic rate.

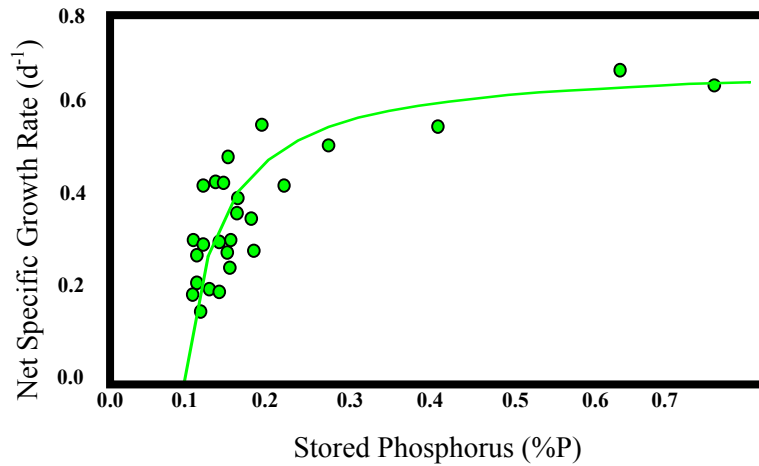


Fig. 4. *Cladophora* growth rate as a function of *Cladophora* P content.

Model Verification

By improving P removal at the wastewater treatment plant and monitoring phosphorus concentrations and *Cladophora* biomass in the lake, it was possible to compare model simulations of dissolved P, stored P and *Cladophora* biomass with in-lake measurements, and to determine the efficacy of P removal as a *Cladophora* management strategy.

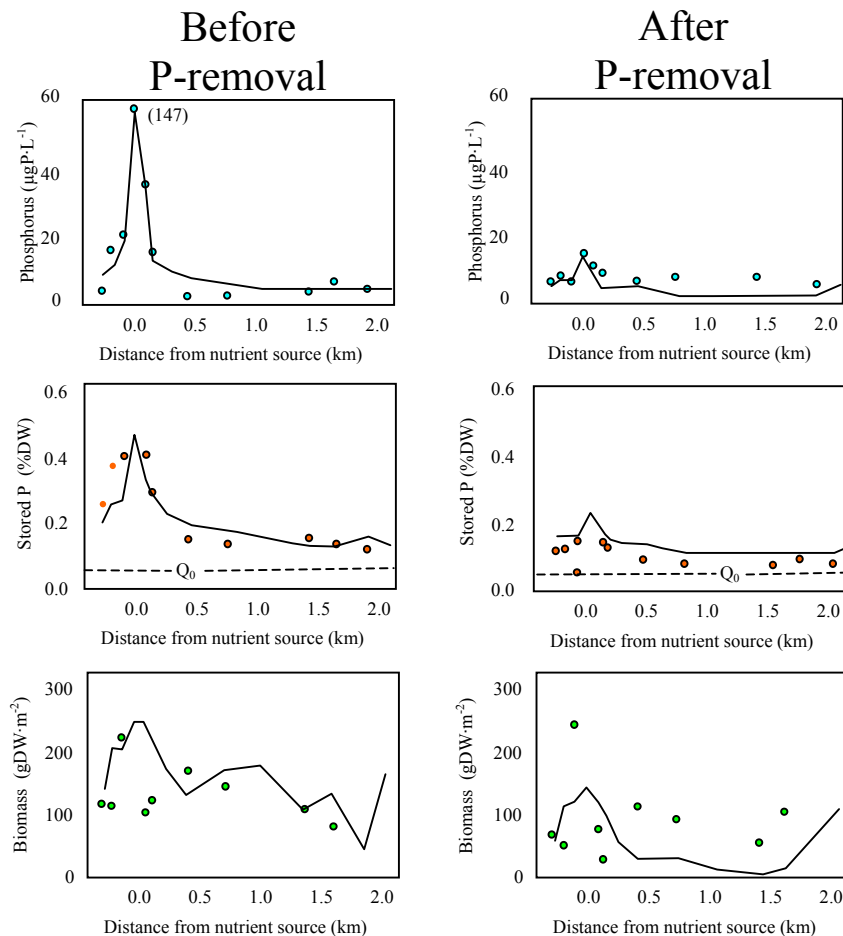


Fig. 5. Comparison of model results (lines) and in-lake measurements (symbols) before and after P removal.

In general, model results agreed well with field observations (Fig. 5). A reduction in P loading from 1.35 kg day^{-1} to 0.20 kg day^{-1} resulted in significant reductions in *Cladophora* production and standing crop density (Fig. 6), and in areal distribution (Fig. 7).

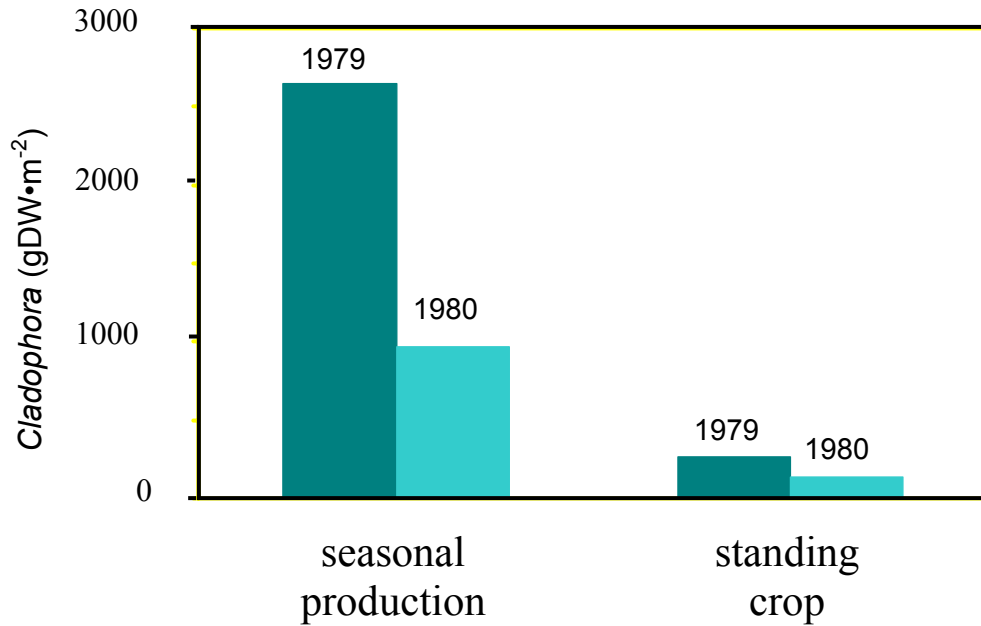


Fig. 6. Changes in *Cladophora* production and standing crop following a reduction of phosphorus input from a wastewater treatment plant.

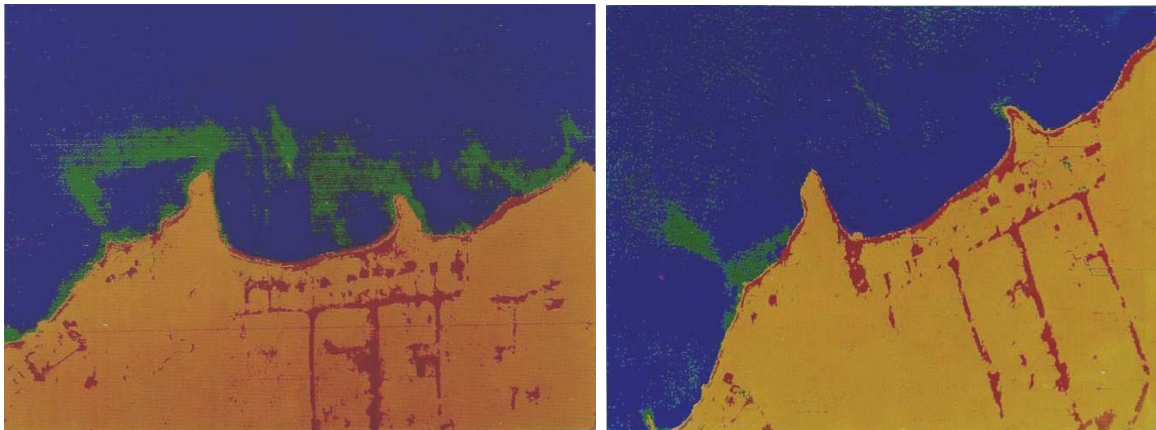


Fig. 7. Areal coverage of *Cladophora* on July 21, 1979 and August 4, 1980. *Cladophora* = green; water = blue; land = yellow and red. For details of remote imagery, see Lekan and Coney (1982).

Future Applications

The work conducted in Lake Huron demonstrated the utility of the *Cladophora*-phosphorus model for simulating *Cladophora* dynamics and designing management strategies. Since this research was carried out, a number of changes have occurred in the Great Lakes. Most notably, the nearshore benthic environment in which *Cladophora* and other filamentous algae grow is now inhabited by dreissenid mussels. It is evident that filtration of particulate material by dreissenids has resulted in increased water clarity, and may also be altering nutrient supply to the nearshore benthos (Hecky et al. 2004). The model described above may be used to assess the potential effect of these and other changes, such as temperature change, on *Cladophora* growth and abundance.

Literature Cited

- Hecky, R.E., R.E.H. Smith, D.R. Barton, S.J. Guildford, W.D. Taylor, M.N. Charlton, and T. Howell. 2004. The nearshore phosphorus shunt: a consequence of ecosystem engineering by dreissenids in the Laurentian Great Lakes. *Can. J. Fish. Aquat. Sci.* 61:1285-1293.
- Lekan, J.F., and T.A. Coney. 1982. The use of remote sensing to map the areal distribution of *Cladophora glomerata* at a site in Lake Huron. *J. Great Lakes Res.* 8:144-152.

