

## CHLOROPHYLL VARIABILITY, NUTRIENT INPUT, AND GRAZING: EVIDENCE FROM WHOLE-LAKE EXPERIMENTS<sup>1</sup>

STEPHEN R. CARPENTER, JAMES F. KITCHELL, KATHRYN L. COTTINGHAM,  
DANIEL E. SCHINDLER, DAVID L. CHRISTENSEN, DAVID M. POST, AND  
NICHOLAS VOICHICK  
*Center for Limnology, University of Wisconsin, Madison, Wisconsin 53706 USA*

**Abstract.** A Planktivore Lake with small herbivorous zooplankton and a Piscivore Lake with large grazers were monitored for 2 yr and then enriched for 2 yr with inorganic phosphorus and nitrogen. An unenriched lake with an undisturbed fish community served as a reference ecosystem. Added nutrients increased biomass of both phytoplankton and zooplankton. In the Planktivore Lake, phytoplankton were stimulated more than zooplankton. This situation was reversed in the Piscivore Lake. Time series models predicting chlorophyll from P input rate and crustacean length fit well for total chlorophyll and the edible fraction ( $<35\ \mu\text{m}$ ), but were less successful for the large fraction ( $>35\ \mu\text{m}$ ). A 1-mm change in mean crustacean length had about the same effect on chlorophyll as a decrease in P input rate of  $1\ \text{mg}\cdot\text{m}^{-3}\cdot\text{d}^{-1}$ . There was no evidence of interaction between grazer and P input effects. Although effects of grazers and P input are equal and additive, the range of mean crustacean lengths among lakes is  $\approx 1\ \text{mm}$ , while the range of P input rates is substantially  $>1\ \text{mg}\cdot\text{m}^{-3}\cdot\text{d}^{-1}$ . Therefore, the potential for increasing eutrophication by P input exceeds the potential for controlling eutrophication by food web manipulation. Nevertheless, biomanipulation can reduce chlorophyll concentration at P input rates of  $1.5\ \text{mg}\cdot\text{m}^{-3}\cdot\text{d}^{-1}$  or more; these rates characterize a large fraction of the world's stratified lakes.

**Key words:** Bayesian analysis; biomanipulation; cascading trophic interactions; chlorophyll; ecosystem; grazing; lake; phosphorus; time series analysis.