

# LIMNOLOGY AND OCEANOGRAPHY

January 1988  
Volume 33  
Number 1

---

*Limnol. Oceanogr.*, 33(1), 1988, 1-14  
© 1988, by the American Society of Limnology and Oceanography, Inc.

## Zooplankton-mediated transitions between N- and P-limited algal growth<sup>1</sup>

*James J. Elser,<sup>2</sup> Monica M. Elser,<sup>3</sup> Neil A. MacKay, and Stephen R. Carpenter<sup>4</sup>*  
Department of Biological Sciences, University of Notre Dame, Notre Dame, Indiana 46556

### *Abstract*

Limitation of algal growth by nitrogen and phosphorus was assessed in three north-temperate lakes with physiological bioassays and nutrient enrichment experiments. In addition, mesocosm experiments were performed in the three lakes to examine the effects of nutrient enrichment and zooplankton biomass and size on algal nutrient status. In situ indicators of N and P availability were inversely related in magnitude and transitions between N and P limitation were abrupt. Physiological bioassay results did not indicate simultaneous limitation by N and P. However, limited responses to single-nutrient enrichment and pronounced responses to simultaneous N and P addition in enrichment experiments suggested that potential limitation by the secondary nutrient was usually in close proximity to limitation by the primary nutrient. Transitions between N and P limitation closely accompanied major shifts in the zooplankton community. The importance of the zooplankton community in regulating the relative degree of N or P limitation was confirmed by the mesocosm experiments, which demonstrated that transitions between algal N or P limitation could be induced by manipulations of zooplankton biomass or size. This result supports a hierarchical view of the function of planktonic systems, in which biotic interactions structure the response of the algal community to a given nutrient load.