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Nutrients and zooplankton as multiple stressors of phytoplankton communities: Evidence from size structure

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Abstract

Anthropogenic alterations of nutrient inputs and food-web structure are two of the primary stressors affecting lake phytoplankton. This paper explores the independent and interactive effects of nutrients and food-web structure (as indexed by zooplankton size) on phytoplankton size structure by fitting time-series models to data from three lakes where both factors have been manipulated. I assessed phytoplankton size structure using three different approaches: small and large size classes, normalized size spectra, and average phytoplankton size. Increased phosphorus loading and increased zooplankton size had positive effects on large phytoplankton, slope of size spectra, and mean phytoplankton size, but negative effects on the relative abundance of small phytoplankton. The absolute abundance of small phytoplankton was increased by increased nutrients and decreased by increased zooplankton size. There was some evidence for nutrient × zooplankton interactions, particularly from interlake comparisons which revealed that phytoplankton size structure responded to enrichment in qualitatively similar but quantitatively different ways in lakes with different food webs. Specifically, small phytoplankton increased more strongly with enrichment in lakes with many planktivores and few large zooplankton, while large phytoplankton increased more in lakes with few planktivores and many large zooplankton. Thus, food-web structure may influence the extent to which small vs. large phytoplankton respond to nutrient enrichment. Overall, size structure was an excellent descriptor of shifts in phytoplankton communities following manipulation of nutrient inputs and food-web structure. Size spectra and size classes were highly effective approaches for summarizing size structure; average phytoplankton size was somewhat less effective.