A stoichiometric analysis of the zooplankton–phytoplankton interaction in marine and freshwater ecosystems

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In the 35 years since A. C. Redfield's classic paper[1], the use of elemental ratios has become widespread in marine and freshwater phytoplankton studies[2,3]. But nutrient ratios have only recently been studied elsewhere in pelagic ecosystems, such as the producer–consumer interface[4,5]. Here we report the results of the first study, to our knowledge, of N:P ratios in pelagic producers and consumers (phytoplankton and zooplankton) in lacustrine and marine habitats. The N:P ratio of phytoplankton was higher in lakes than in marine sites; however, N:P ratios were higher in marine zooplankton than in freshwater zooplankton. The elemental imbalance of the phytoplankton–zooplankton interaction ($N:P_{food}$–$N:P_{consumers}$) in lakes was positive and exceeded the negative imbalance in marine sites; thus P-deficient food may limit zooplankton growth in lakes but not in oceans. Stoichiometric calculations[6] indicated that consumer-driven nutrient recycling ratios in lakes may be 4–6 times higher than in marine systems. Consistent with this difference, phytoplankton P-limitation was more prevalent in lakes than in marine sites. Thus, the ecological stoichiometry of the zooplankton–phytoplankton interaction differs qualitatively in freshwater and marine ecosystems.