Ultimate colimitation of oceanic primary production

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Abstract

Elucidating the long-term biogeochemical controls and feedbacks on primary production in the global ocean is crucial to understand how marine ecosystems were altered by past changes in nutrient supplies due to geological and biological processes, and how they will respond to global environmental changes, as nutrients are increasingly supplied to the surface ocean due to anthropogenic activities. Originally, the debate about the ultimate limitation (i.e. the nutrient limitation over long timescales) of oceanic primary production was focused on nitrogen and phosphorus; but recent studies propose that iron might be the ultimate limiting nutrient in the global ocean.

We build a simple model of the global oceanic cycles of nitrogen, phosphorus, and iron to address the unresolved issue of which nutrient controls primary production in the global ocean over long timescales. Our model predicts that the nutrient that limits the growth of nitrogen fixers is generally the ultimate limiting nutrient. It also predicts ultimate colimitation of oceanic primary production by iron and phosphorus, which is of special interest as previous studies have restricted ultimate limitation of oceanic primary production to a single nutrient. Thus past changes in iron and phosphorus supplies should have had major effects on oceanic ecosystems over geological times. Secondly, our results suggest that the anthropogenic increase in the supplies of these two key nutrients might further affect oceanic ecosystems at large spatial and temporal scales.

Keywords: global biogeochemical cycles, primary production, ocean, nutrient limitation, iron cycle, phosphorus cycle, nitrogen cycle

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