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首页 | 关于本刊 | 影响因子及获奖 | 投稿须知 | 订阅指南 | 广告业务 | 学术会议 | 专辑与专题 | 优秀论文

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太平洋中西部海域浮游植物营养盐的潜在限制

Potential nutrient limitation of phytoplankton growth in the Western and Central Pacific Ocean

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中文摘要:

2009年8月至9月期间在太平洋西部N1站和中部N2站进行现场营养盐加富培养实验。结果显示:N1站,浮游植物生物量对N或者P添加都有较强的响应,其中N+P+Si组和N+P组浮游植物长势迅速,叶绿素a从初始的0.03 μg/L分别达到2.12 μg/L和1.83 μg/L,同时P先于N和Si之前被耗尽;说明N1站为N、P共同限制,P是首要限制因子。而N2站,浮游植物生物量仅对N、P共同添加有明显响应,N先于P和Si被浮游植物消耗殆尽。利用培养过程中营养盐比值变化推断,N1站浮游植物以低于Redfield ratio (16N∶1P)吸收N和P;而N2站浮游植物以高于Redfield ratio (16N∶1P)吸收N和P。这可能解释了太平洋西部的寡营养盐海域为潜在P限制,而在太平洋中部海域则为潜在N限制。

English Summary:

An increase in N_2 fixation by diazotrophic organism due to increased stratification driven by climate changes, may decrease phosphate concentrations and result in P limitation in the oligotrophic upper ocean, which challenges the traditional view that nitrogen is generally the primary nutrient limiting phytoplankton productivity in oceanic waters. Which nutrient, N or P, is the most limiting nutrient for phytoplankton growth in the oligotrophic Pacific Ocean has been on debate over recent years. More studies on nutrient limitation are apparently needed to resolve this debate in the Pacific Ocean. In August and September of 2009, nutrient enrichment bioassays were conducted at two representative stations, N1 (160.58°E, 21.61°N) in the western Pacific Ocean with extremely low nutrient (below detect limit) and Chl a concentrations, and N2 (154.12°W, 10.12°N) in the eastern Pacific Ocean with shallower nutricline due to the influence of equatorial currents, in order to examine the spatial variability in the potential limiting nutrient for phytoplankton growth in the Pacific Ocean. Nutrients were added in 5 combinations in bioassays: control (no addition), NO_3+PO_4 (N+P); NO_3+SiO_4 (N+Si), PO_4+SiO_4 (P+Si), and NO_3+PO_4+SiO_4 (N+P+Si). The limiting nutrient was judged based on the response of algal biomass and nutrient depletion among treatments. Phytoplankton exhibited different response to nutrient additions at two study sites. Phytoplankton biomass increased dramatically in response to both N and P additions at station N1 where the concentrations of Chl a increased from 0.03 μg/L at the beginning to 2.12 μg/L and 1.83 μg/L in N+P+Si and N+P treatments at the end of incubation, respectively. However, the maximum Chl a concentration achieved in N+Si treatment was slight higher than that in and P+Si treatment. Furthermore, P was depleted before N and Si in the N+P and N+P+Si treatments at station N1. In contrast, algal biomass was significantly stimulated only when both N and P were added at station N2, where the concentrations of Chl a increased profoundly from 0.10 μg/L to 0.34 μg/L and 0.40 μg/L at the end in N+P+Si and N+P treatments, respectively, while they was not stimulated in the N+Si and P+Si treatments Furthermore, N always disappeared before P and Si in N+P, N+Si and N+P+Si treatments. These results showed that the limiting nutrient varied spatially during summer in the Pacific Ocean. N and P co-limitation occurred at both stations, with P being the primary limiting nutrient at N1 and N at N2. In addition, changes in the N∶P ratios during the incubation demonstrated distinct patterns, likely due to difference in the phytoplankton composition. N∶P ratios rose from 15.7 at the beginning to 59.2 at the end of the incubation at N1, while N∶P ratios decreased from 15.3 to 0.06 at N2. This implied that the uptake ratio of N∶P was lower than the Redfield ratio (16N∶1P) at N1, but higher than the Redfield ratio at N2. This might explain why P was the primary limiting nutrient in the western Pacific Ocean but N in the central Pacific Ocean. It is speculated that P limitation possibly is associated with N_2 fixation in the oligotrophic western Pacific Ocean.

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