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Nutrient control of phytoplanktonic biomass in atoll lagoons and Pacific ocean waters: Studies with factorial enrichment bioassays

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Abstract

Although the atolls of the Tuamotu archipelago (Central South Pacific) are located in an oligotrophic oceanic area, some of their lagoons have experienced exceptionally harmful phytoplanktonic blooms in the last 30 years. Twenty-four differential enrichment bioassays were conducted on 10 atoll lagoons and 5 ocean sites at two different times of the year in order to determine, among other factors, which nutrients may control phytoplanktonic crop. Complete factorial (2^3) design with N, P and Si and fractional factorial (2^{8-3}) design with N, P, Si, chelator, Fe, Mo, Mn and vitamins were performed. In vivo fluorescence (IVF) was used to follow the growth of phytoplankton. Although this method is imperfect, we argue that the large increases in fluorescence, observed in response to some spikes, indicate biomass shifts. Nitrogen, phosphorus and sometimes silicate effects were significant. The nitrogen effect was greatest in 17 out of 24 samples. In the smallest lagoon, the phosphorus effect was higher than the nitrogen effect. In the six other samples N and P effects were similar. Silicate spikes resulted in a significant effect for only seven samples. Vitamins, Mo, Mn, iron and chelators had little or no effect. In 20 bioassays there was also a synergistic effect when N and P were added simultaneously. This synergistic effect was present in five bioassays when N, P, and Si were added simultaneously. The season or origin (lagoon or ocean) had little influence on these effects. On average fluorescence attained by samples supplemented with N alone was six times that of controls (unspiked). The highest responses were observed with combined N + P or N + P + Si spikes. Combined N + P fertilization produced an in vivo fluorescence ranging from 5 to 85 times the fluorescence attained by controls. This synergy is consistent with the view that both N and P are in relatively short supply. Ocean waters appeared to be nitrogen depleted. Phosphorus limitation increased in small lagoons with low advective ocean waters and a large ratio of immersed surfaces to water volume. Atoll lagoons and ocean waters from the Tuamotu archipelago appear to be highly susceptible to eutrophication with the addition of both nitrogen and phosphorus.

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