

Near Surface Nutrient and Phytoplankton Distribution in the Drake Passage during Early December

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Summary. Nutrient concentrations and phytoplankton species composition in near surface samples were studied along a S-N gradient in the Drake Passage in early December 1984. Nitrate concentrations were much lower than usually previously reported from circum-Antarctic waters. Comparison of dissolved nutrient concentrations with growth requirements of Antarctic plankton algae suggests potential limitation of at least some species by nitrate or silicate. The taxonomic composition of the phytoplankton in our samples seemed to be partially controlled by competition for limiting nutrients.

Introduction

Antarctic waters are famous for their high concentrations of inorganic nutrients (Holm-Hansen et al. 1977; El Sayed et al. 1983; Hayes et al. 1984). Only Si is considered to be potentially limiting for phytoplankton growth in some regions of the Antarctic Ocean (Jacques 1983). As long as nutrients are in non-limiting supply no influence of temporal and spatial nutrient variability on phytoplankton species composition can be expected. Here we report on the occurrence of unusually low nitrate concentrations along a S-N transect through the Drake Passage. Comparison of observed phytoplankton species composition with nutrient competition experiments performed during the same cruise (Sommer 1986) indicates, that nitrate might actually have been less than the demand for non-limited growth.

Methods

The analysis covers 24 near surface samples taken from 4 to 6 December 1984 along a transect performed by *RV Polarstern* from S 62°30', W 58°22'04" (end of Bransfield Strait) to S 56°45', W 61°50'20" (Drake Passage, just north of the Antarctic Convergence; Fig. 1) from 4 to 6 December 1984. Samples were taken from the seawater pump (intake at 10 m depth) at intervals of 15 latitudinal minutes and numbered consecutively from 1 to 24. Subsamples for nutrient analyses were im-

mediately filtered (0,1 µm pore-size) and deep frozen. The storage time was about 5 months. Analyses of soluble reactive phosphorus, nitrate, nitrite, ammonium and soluble reactive silicate were performed according to oceanographic standard methods (Strickland and Parsons 1972) with a Technicon-autoanalyzer. Nitrite and ammonium were found nearly undetectable. Samples for cell counts were fixed by glutaraldehyde and 250 ml were filtered on a 0.45 µm membrane filter, which was made transparent for microscopy by immersion oil. Biomass was estimated as cell volume (no correction for vacuoles) after approximation to standard geometric solids.

Results

Soluble reactive phosphorus concentrations (Fig. 2) were consistently high (1.35 to 2.2 µM) and well within the range reported in literature data. Silicate concentration

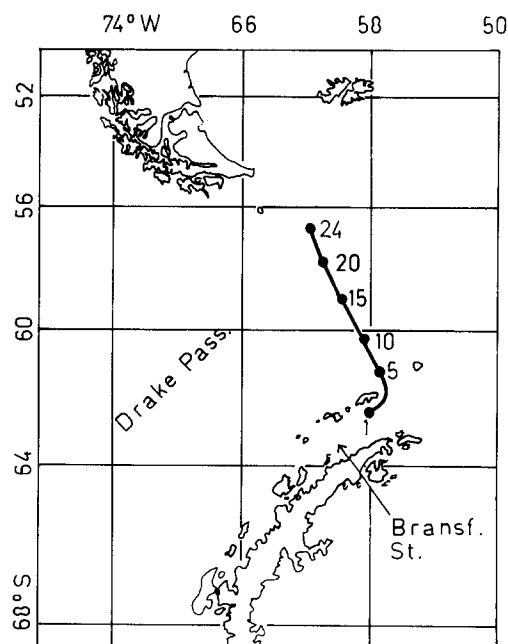


Fig. 1. Location of the transect sampled from 4 to 6 December

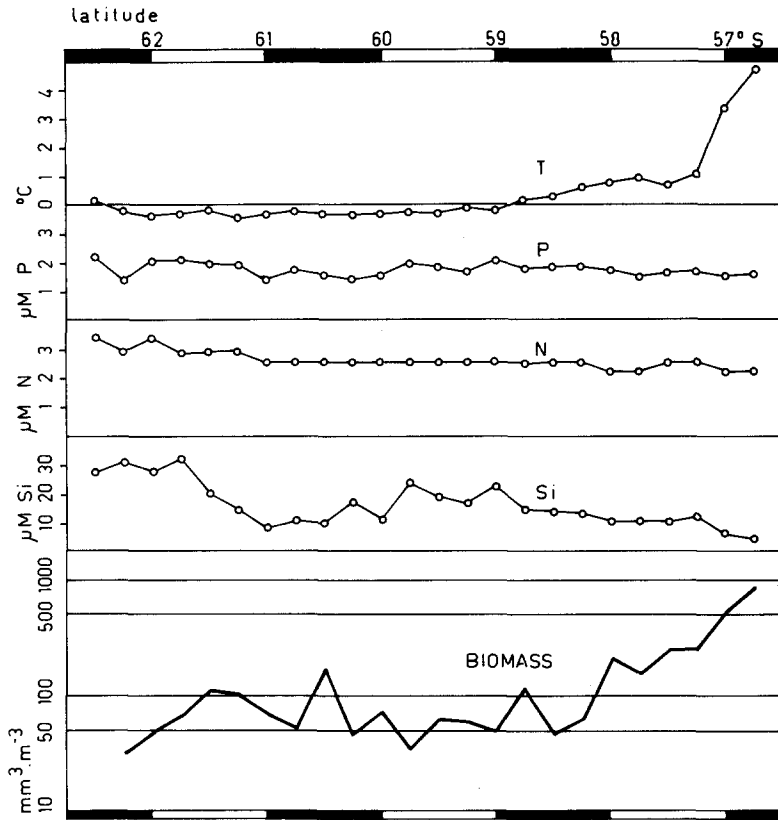


Fig. 2. Water temperature, soluble reactive phosphorus, nitrate, soluble reactive silicate, and total phytoplankton biomass along the Drake Passage transect

showed more pronounced fluctuations. High values were found more often to the south (up to 32 μM), the lowest values were encountered near the Convergence (4.3 μM). None of them were atypical. Nitrate, however, was found at concentrations from 2.2 to 3.35 μM , which is 5 to 10 times less than the usual values. Reanalysis of all samples with freshly composed reagents and standards confirmed the low nitrate concentrations. It can be excluded that our findings are caused by the method ap-

plied, since there is no methodological difference to previous authors. To our surprise the low nitrate concentrations did not coincide with high phytoplankton biomass levels. Unfortunately we do not know, whether there had been a nitrate depleting bloom in the sampled water body prior to our study.

Phytoplankton was dominated by diatoms throughout the entire transect; the only important non-diatomaceous algae were cryptophycean flagellates. Together,

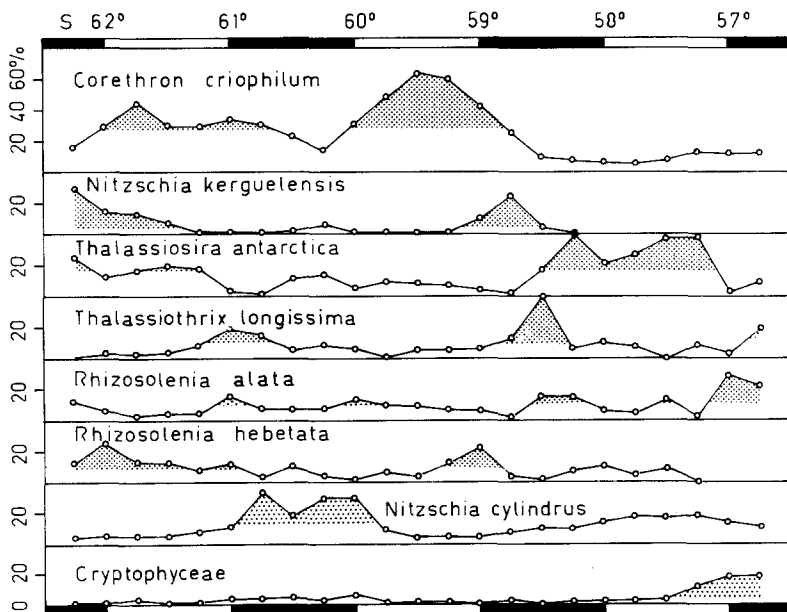


Fig. 3. Percent contribution of most important species to total phytoplankton biomass. Shaded area: relative abundance above mean

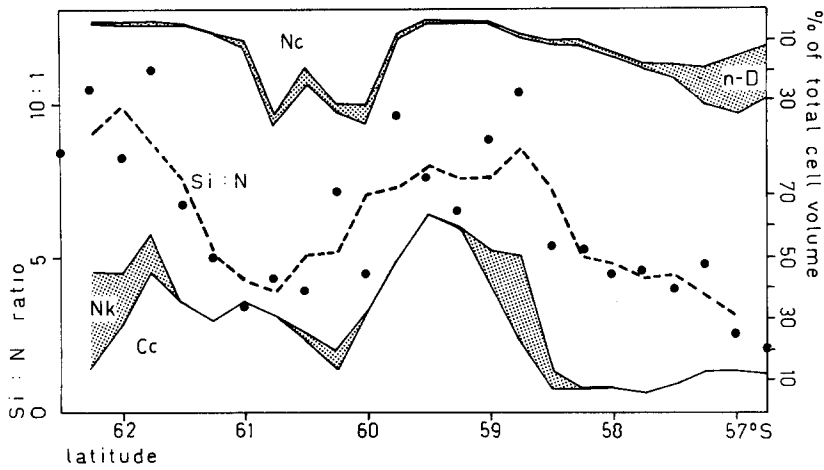


Fig. 4. Atomic Si : N ratios (full circles: Actual data broken line: smoothed by calculating the running mean between three consecutive values) compared to the cumulated relative abundances of *Corethron criophilum* (Co) and *Nitzschia kerguelensis* (Nk) and compared to the cumulated relative abundances of *Nitzschia cylindrus* (Nc) and all non-diatomaceous algae (n-D) plotted downwards

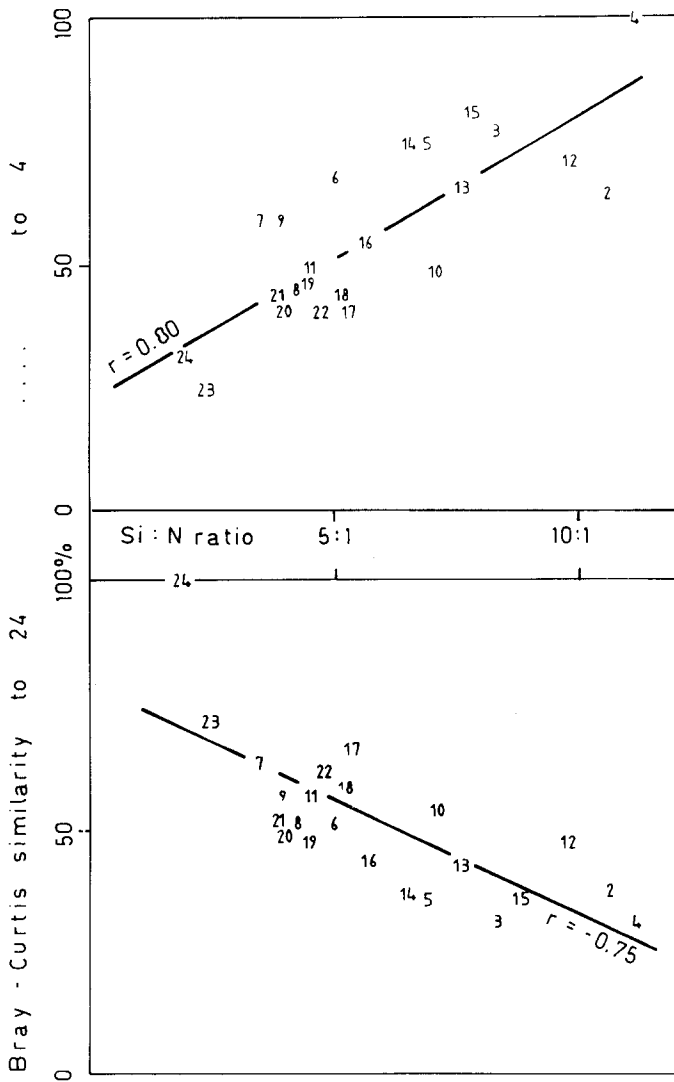


Fig. 5. Taxonomic similarity (Bray-Curtis index) of all stations with station 4 (highest Si : N ratio) and station 24 (lowest Si : N ratio) plotted against Si : N ratios

the 8 species shown in Fig. 3 always comprised >90% of total phytoplankton biomass. In general, change of taxonomic composition along the transect was rather gradual, as indicated by Bray and Curtis (1957) indices of taxonomic similarity of >70% between adjacent stations. Only between stations 22 and 23 the similarity was 49.7%. This discontinuity in taxonomic composition coincides with the Antarctic Convergence, from where already Hart (1934) had reported conspicuous species shifts in response to decreasing silicate concentrations.

Discussion

During the same cruise Monod-type (1950) kinetics of Si and N-limited growth have been established experimentally for several species (Sommer 1986). The observed nitrate concentrations were lower than the half saturation constant of one of them (*Nitzschia cylindrus*, $k_n = 4.1 \mu\text{M}$); even the highest silicate concentrations were less than the half saturation constants of two species (*Corethron criophilum*, $k_{\text{Si}} = 59.6 \mu\text{M}$; *Nitzschia kerguelensis*, $k_{\text{Si}} = 89.4 \mu\text{M}$).

Current competition theory (Tilman 1982) predicts that the outcome of competition between species with different demands for different nutrients is controlled by the supply ratio of the potentially limiting nutrients. Semicontinuous culture competition experiments performed with natural phytoplankton from the Drake Passage showed that in the absence of Si-limitation *Corethron criophilum* was the superior competitor for nitrate at low and medium dilution rates (0.1 and 0.25 d^{-1}) and *Nitzschia kerguelensis* was the superior N-competitor at high dilution rates (0.5 d^{-1}). Conversely, they were the worst competitors for silicate. *Thalassiosira subtilis* (low dilution rate) and *Nitzschia cylindrus* (medium and high dilution rates) were the superior competitors for Si, but poor competitors for nitrate. Figure 4 shows, that the combined abundances of C.

criophilum and *N. kerguelensis* roughly followed the ambient atomic Si:N ratios, whereas the combined relative abundances of *N. cylindrus* and all non-siliceous algae exhibit the opposite pattern (*Thalassiosira subtilis* was scarce in all samples).

A further test for the assumption that competition for nutrients was partly responsible for the observed species composition uses the following rationale: If resource ratios control species composition, samples with similar Si:N ratios should be more similar in species composition than samples with dissimilar Si:N ratios. Bray-Curtis similarity indices between all samples and the sample 4 (highest Si:N ratio) show a positive correlation to Si:N ratios; similarity indices of all samples with sample 24 (lowest Si:N ratio) show a negative correlation to Si:N ratios (Fig. 5).

In conclusion, the results presented here are not inconsistent with the assumption that in our situation competition for limiting nutrients had some influence on phytoplankton species composition. According to the existing literature, this seems to be an exceptional situation. Present knowledge, however, does not permit to judge whether it is a recurring, though short-lasting, seasonal pattern or an extremely rare event.

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