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Transport of Nutrients from Deeper Waters in the North Pacific Subarctic Sea

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Abstract

Transport of nitrate, phosphate and silicate from deeper waters to surface waters is described. The ratio of NO_3/PO_4 for both 180° and 155° W longitude is about 16 throughout observed water columns which is in good agreement with that of phytoplankton. The ratio of SiO_2/PO_4 at a depth of less than 200 m on both of these lines is approximately 30, however, at greater than 200 m the ratio is more than 30. This indicates that opal or silicate minerals from the atmosphere appear to dissolve in deeper waters. Deep waters having a high SiO_2/PO_4 ratio play an important role in the high productivity of diatoms.

Introduction

It is well known that the North Pacific Subarctic Sea has high primary productivity. Chemical substances, especially nutrients, as well as physical conditions are very important factors concerning any increase in primary productivity. Deep waters in the North Pacific Ocean move upward with a velocity of 4-5 m/y[1]. Deep waters of the North Pacific Ocean have higher nutrient concentrations than those of the Atlantic Ocean.

Vertical sections of nutrients for the North Pacific Ocean have been reported 20 years ago[2], however, accurate analytical methods for determining nutrient concentrations had not yet been established and there has also been no discussion relevant to ratios of NO_3/PO_4 and SiO_2/PO_4. In terms of oceanographic structure in the northern part of the North Pacific, it was reported that the North Pacific is more suitable for primary production than the South Pacific[3].

Herin the transport of nutrients from deeper waters to surface waters and the ratios of SiO_2/PO_4 and NO_3/PO_4 are discussed.

Methods

Water samples were taken with rosset samplers from the stations shown in Fig. 1 during a period from June to August, 1984. All samples were frozen immediately on board and subsequently analyzed in the laboratory. Nitrate, nitrite, phosphate and silicate were determined by an autoanalyzer. Nitrite will not be further

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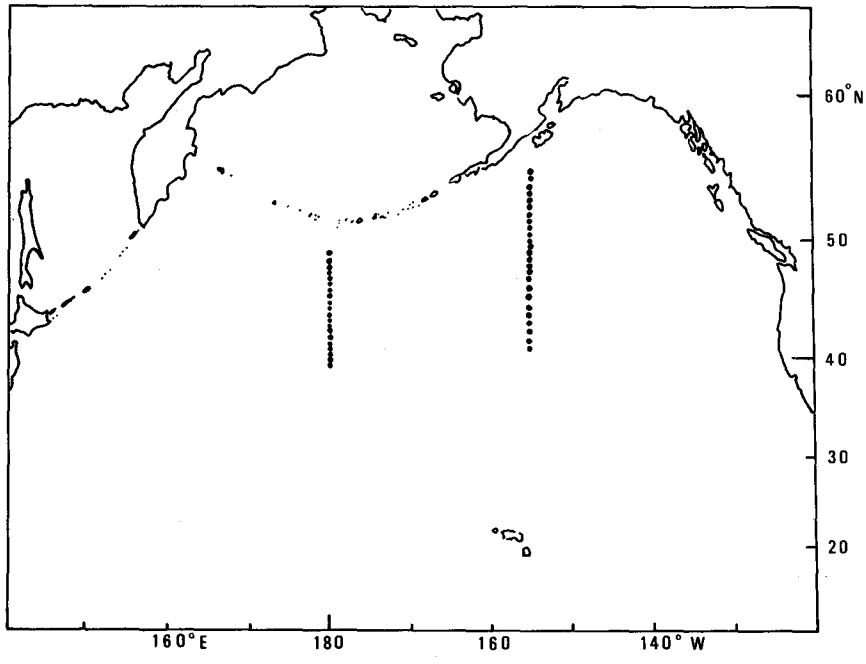

Fig. 1. Sampling stations.

discussed because the nitrite concentrations were negligible, less than 1 μM, and also, nitrite is an intermediate product of nitrification of ammonia or denitrification of nitrate.

Results and discussion

The vertical sections of salinity, nitrate, phosphate, silicate and σ_t at both 180° and 155° W longitude lines are shown in Figs. 2-4 respectively. Water of the same salinity and σ_t becomes shallower from south to north. This is particularly obvious at 155° W longitude. At 40° N on 180° longitude, water containing 20 μM of nitrate, 2 μM of phosphate and 40 μM of silicate at a depth of 400 m is transported to a depth of about 100 m at 49° N. Also, 155° W longitude has nearly the same vertical profiles as 180° longitude. These results show that nutrients are transported from deeper waters to surface layers.

The vertical distributions of silicate at some stations on both lines are shown in Fig. 5. Comparison of silicate concentrations at an equal depth near 40° and 50° N shows that silicate at near 40° N is less concentrated than that at near 50° N.

The silicate and nitrate concentrations are plotted against phosphate as shown in Figs. 6 and 7 at 45-55° N on 180° and 155° W longitude respectively because at these latitudes there is a considerable transport of nutrients. In Figs. 6 and 7, the data at a depth of greater than 200 m are plotted with open circles. The nitrate plots against phosphate both show nearly straight lines. The ratio of NO_3/PO_4 for both lines is about 16 which is in good agreement with the ratio for phytoplankton.

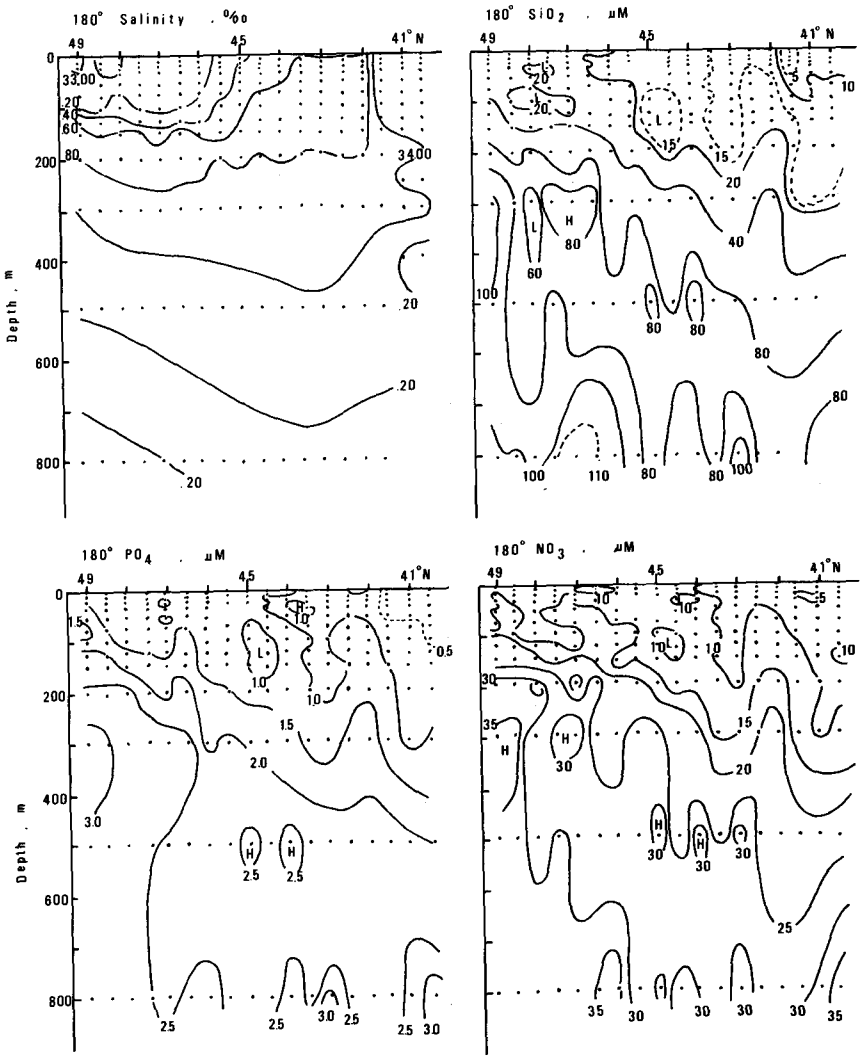

Fig. 2. Vertical sections of salinity, nitrate, phosphate and silicate on 180° longitude line.

The silicate plots against phosphate at a depth of greater than 200 m, however, are above the straight lines which are drawn with plots for a depth of less than 200 m. The ratio of SiO_2/PO_4 at a depth of greater than 200 m for both lines is about 30.

Nitrate plots against phosphate are on the lines. Thus, nitrate does not appear to be added to deeper waters. Silicate plots against phosphate at a depth of greater than 200 m depth, however, are above the lines (Fig. 6). This implies that silicate is added to deeper waters. It is well known that the dissolution rate of particulate silicate is very slow. Thus, opal or silicate minerals from the atmosphere would dissolve as they sink into deeper waters.

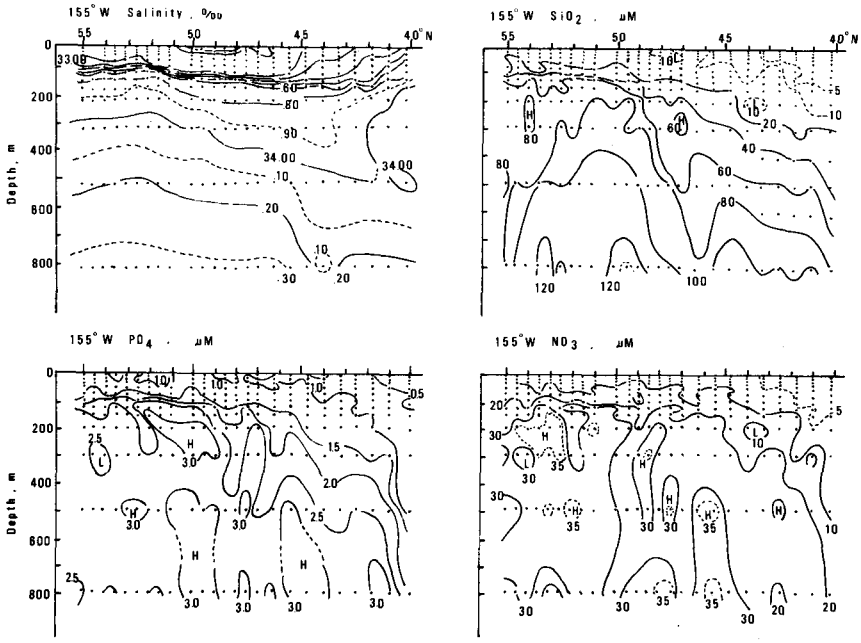

Fig. 3. Vertical sections of salinity, nitrate, phosphate and silicate on 155°W longitude line.

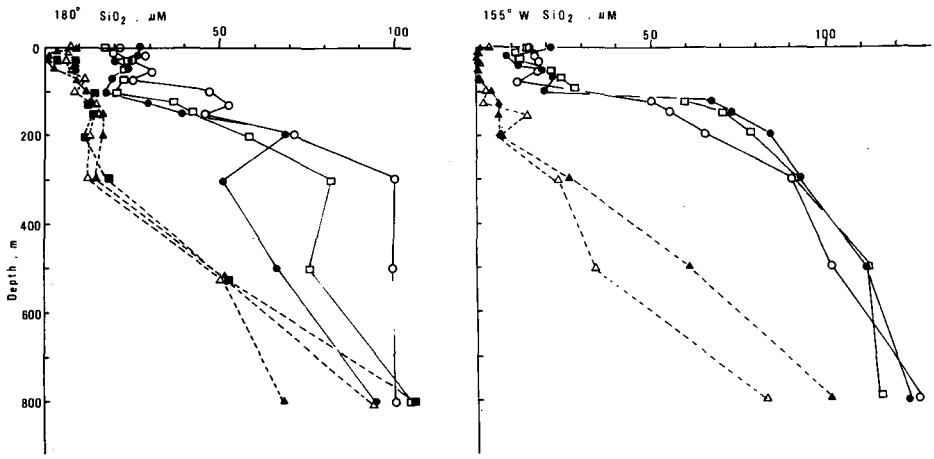

Fig. 5. Vertical distributions of silicate on 180° and 155°W longitude lines.
● : 49°-00 ; □ : 48°-30 ; ○ : 48°-00 ; ▲ : 41°-30 ; △ : 40°-57 ; ■ : 40°-30 N on 180° line
● : 51°-00 ; □ : 50°-00 ; ○ : 49°-00 ; ▲ : 40°-59 ; △ : 40°-07 N on 155°W line

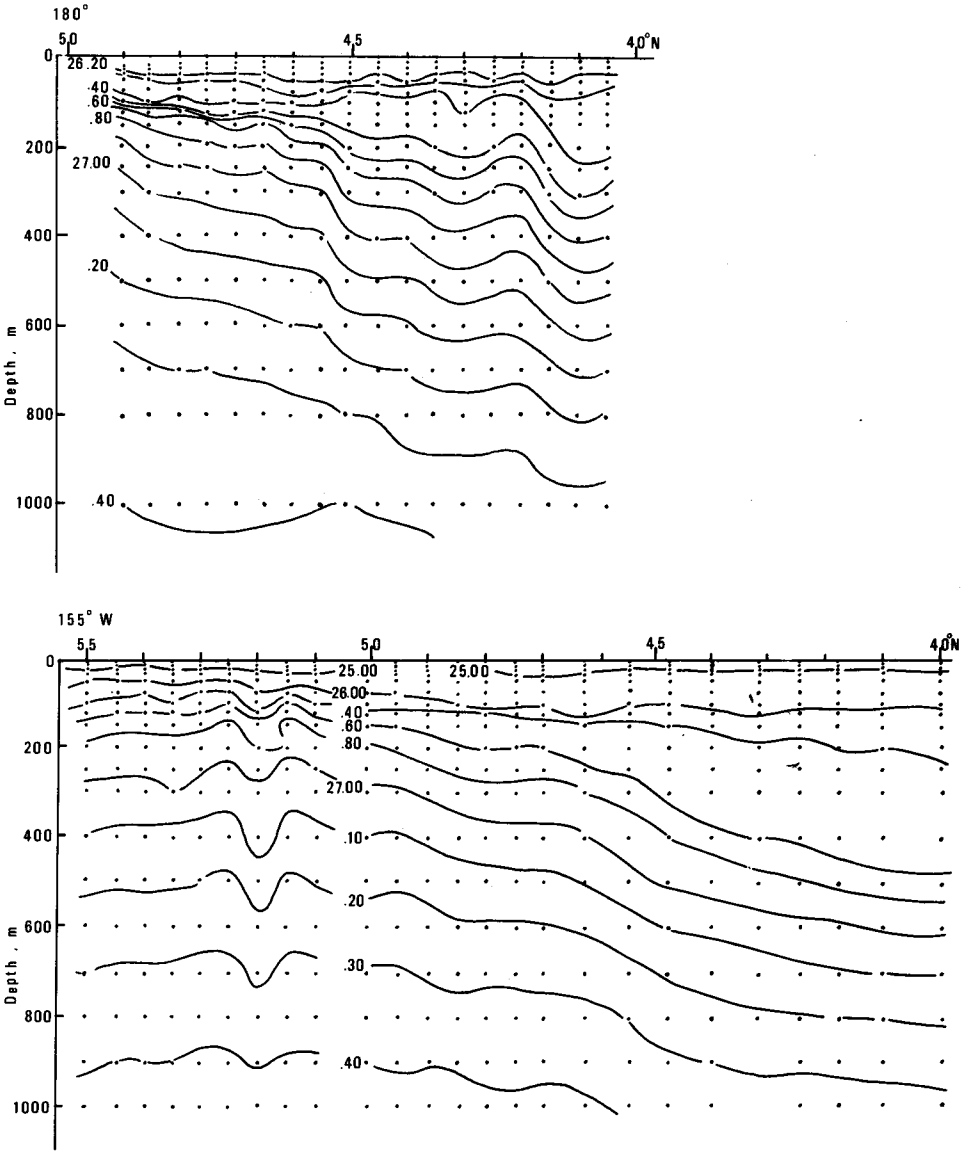

Fig. 4. Vertical sections of σ_t on 180° and 155°W longitude lines.

Although both nitrate and silicate content in surface waters is low when compared to phosphate (Fig. 6 and 7), deeper waters having high SiO_2/PO_4 ratios supply silicate to surface waters. Thus, the North Pacific Subarctic Sea has a high silicate concentration which yields a high diatom content.

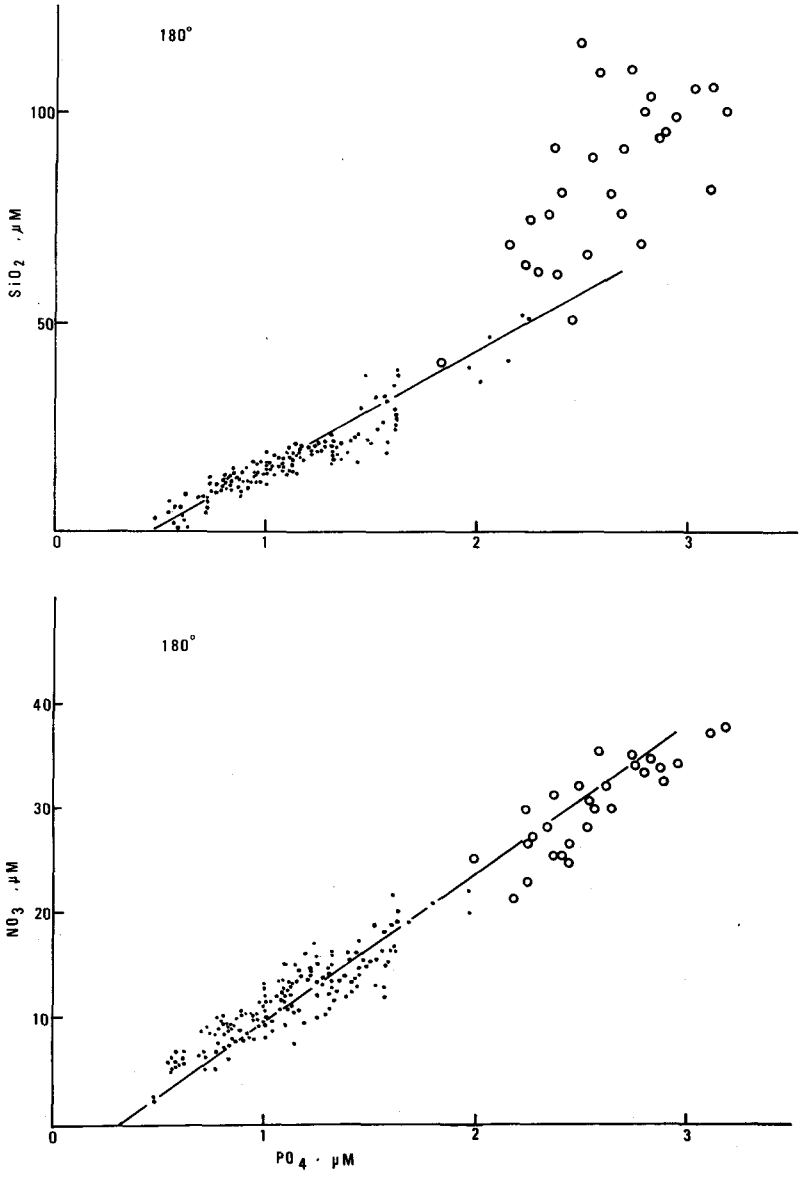

Fig. 6. Plots of silicate and nitrate against phosphate on 180° longitude line
○ : below 200 m

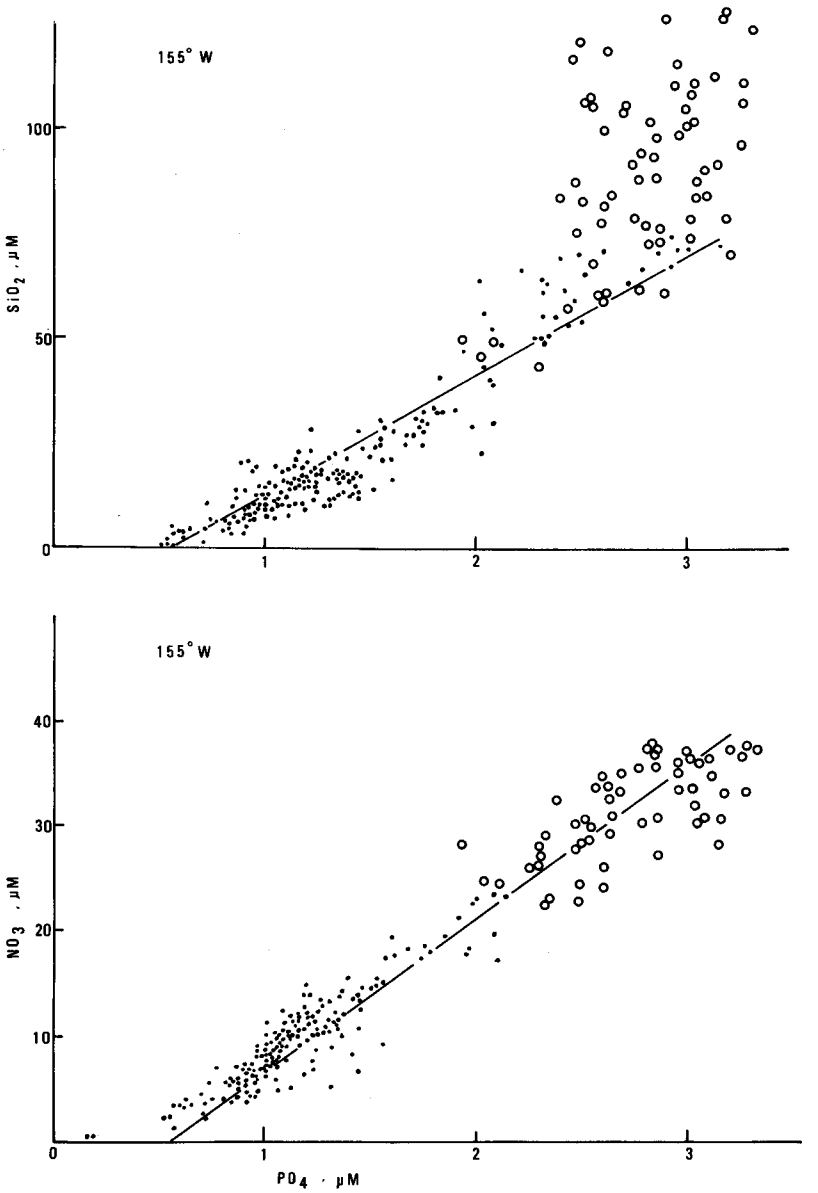

Fig. 7. Plots of silicate and nitrate against phosphate on 155°W longitude line
○ : below 200 m

Acknowledgements

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References

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