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On the Nutrient Concentrations in the Northern Japan Sea

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Abstract

High concentrations of phosphate, nitrate and silicate in the surface waters of the coastal region along Hokkaido Island in April were observed. Their concentrations increased with the distance from the island due to mixing between the nutrient-poor Tsushima warm current and the nutrient-rich northern cold water. The cold water extended far to the south and supplied rich nutrients to the warm current in April. These results were supported by the horizontal and vertical profiles of water temperature.

Introduction

It was generally believed that the Japanese coastal regions in the Japan Sea, where affected by the Tsushima warm current, have poor nutrients and, therefore, low primary production. However, investigation of nutrients in the northern Japan Sea in April in 1986 and 1987 revealed high concentrations in both years. Those of PO_4 and NO_3 in the surface waters were approximately 0.4-0.9 and 2-9 μM, respectively. The nutrient concentrations in the Tsushima current, which is a stream separate from the Kuroshio, are quite low because of low concentrations in the Kuroshio throughout the year (Japan Meteorological Agency ; 1986 and 1987). In this study, we investigated the origin of rich nutrients in the Tsushima current, which flows northward along the islands in the Japan Sea.

Methods

Water samples were collected with Niskin samplers on Oshoro Maru from the stations shown in Fig. 1 during the period 1 to 10 April in 1986 and 1987. After collection, the samples were kept frozen at -20°C until analyses in the laboratory. The concentrations of PO_4, NO_3 and SiO_2 were determined by a Technicon Autoanalyzer II.

Results and Discussion

The horizontal distribution of PO_4, NO_3 and water temperature in the surface

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waters from 138° to 140°50′E longitude and from 41°55′ to 43°N latitude in 1987 are shown in Figs. 1–3. Similar distributions were seen in 1986. Profiles of PO_4 and NO_3 were also comparable in both years. Concentrations increased with the distance from the island, furthermore, correlated with water temperature (Fig. 3). The highest values, 3.34 μM for PO_4 and 15.6 μM for NO_3, at station 4 were eliminated. The higher concentrations were generally observed in the cold water and the lower values were observed in the warm water. The relationships between temperature and PO_4 or NO_3 in the surface waters are shown in Fig. 4. These indicate a mixing process between two water masses. The concentration of SiO_2 at all stations was about 5 μM. However, the concentration profile in the surface waters did not indicate a correlation with water temperature. The reason for this is not known.

The vertical profiles of temperature along the 42°30′N latitude line are shown in Fig. 5. The profiles also indicate the presence of warm water from the northward Tsushima current along the coast, and cold water from the north cold water far from the coast. The water column from the surface to 400 m at station 10 originates in the Tsushima current. On the other hand, those at the other stations originate in the north cold water, as shown in the two characteristic profiles. Moreover, mixing between the warm and cold waters tends to occur, particularly in the surface layer from 0–50 m. The warm and cold waters and their mixing process reflect the concentrations of PO_4 and NO_3 in the surface layers, as shown in Figs. 6 and 7. Along the 41°20′, 41°55′ and 43°N latitude lines, the vertical profiles of temperature are nearly the same as that along the 42°30′ litude.

Generally, the water of the Japan Sea is divided into two water masses ; the one

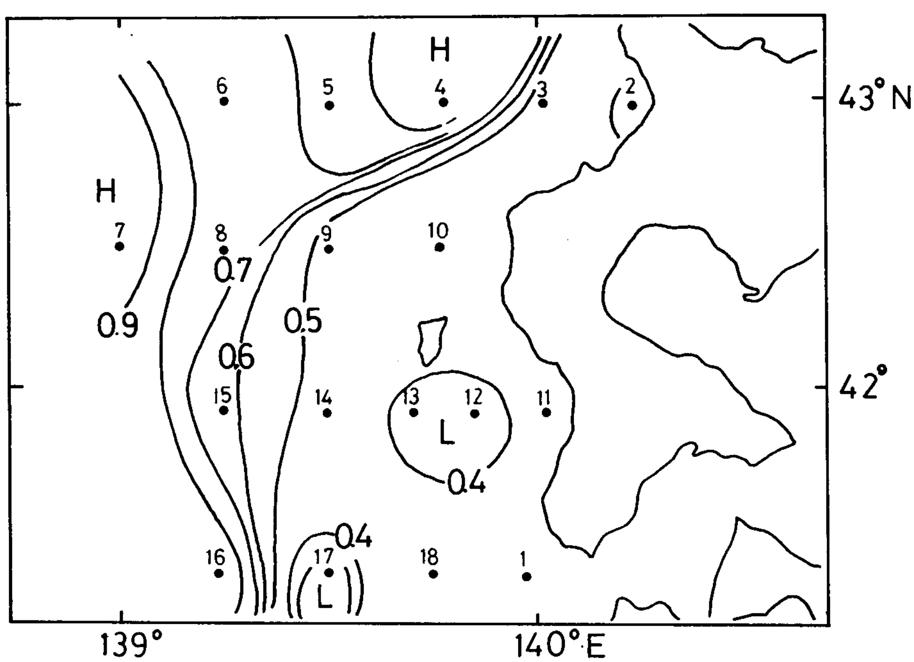

Fig. 1. Sampling stations and horizontal distribution of PO_4 (μM).

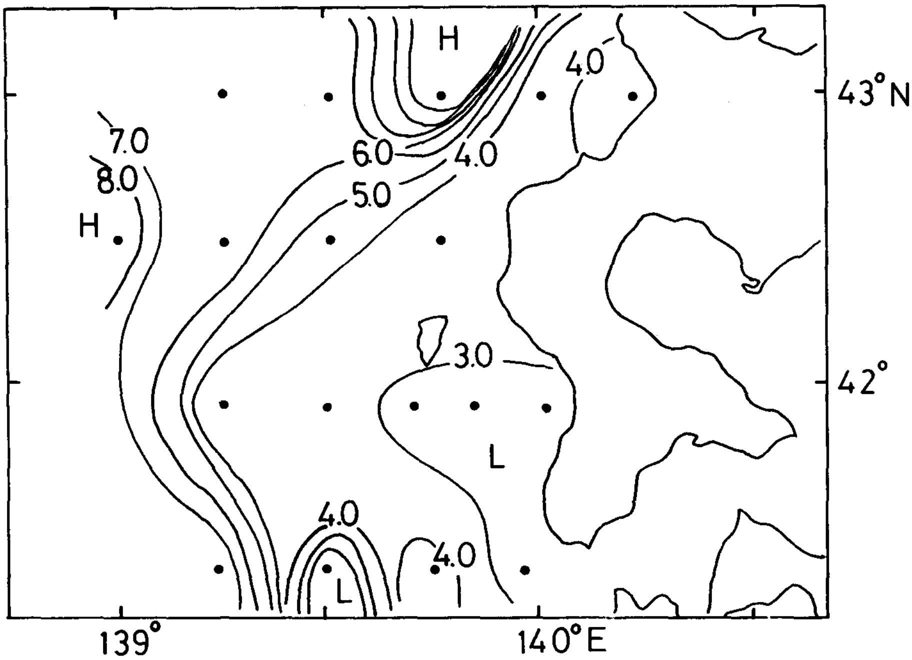

Fig. 2. Horizontal distribution of NO_3 (μM).

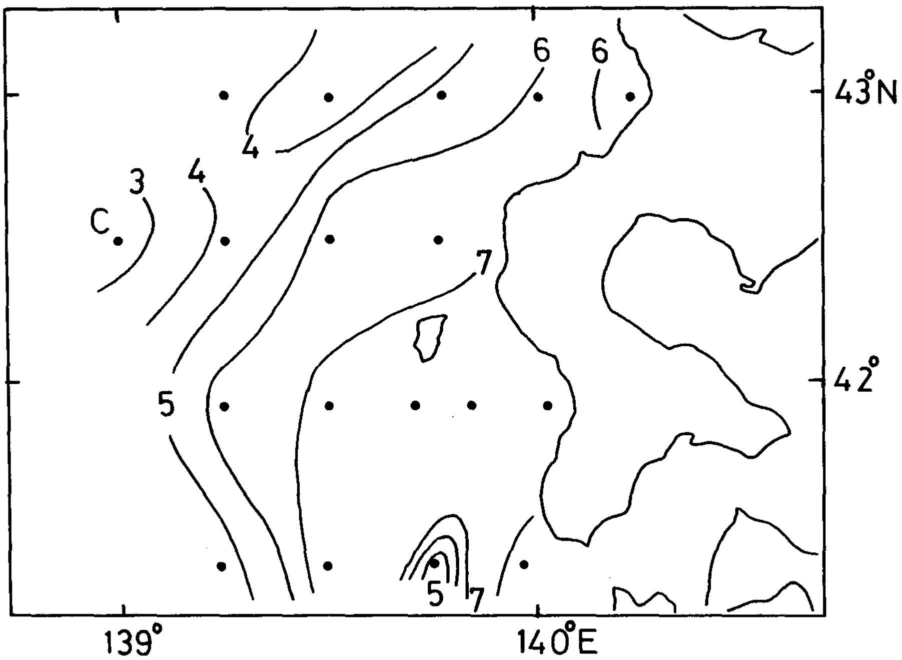

Fig. 3. Horizontal distribution of water temperature (°C).

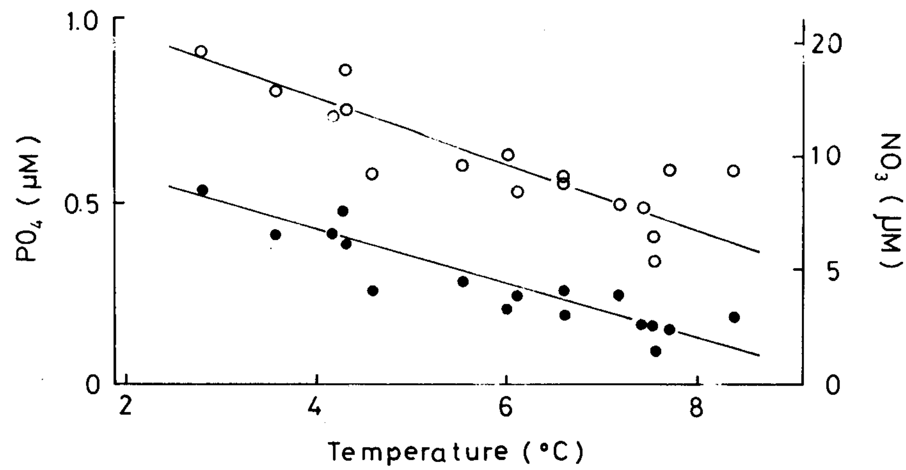

Fig. 4. Relationship between water temperature and PO_4 or NO_3.
○: NO_3; ●: PO_4.

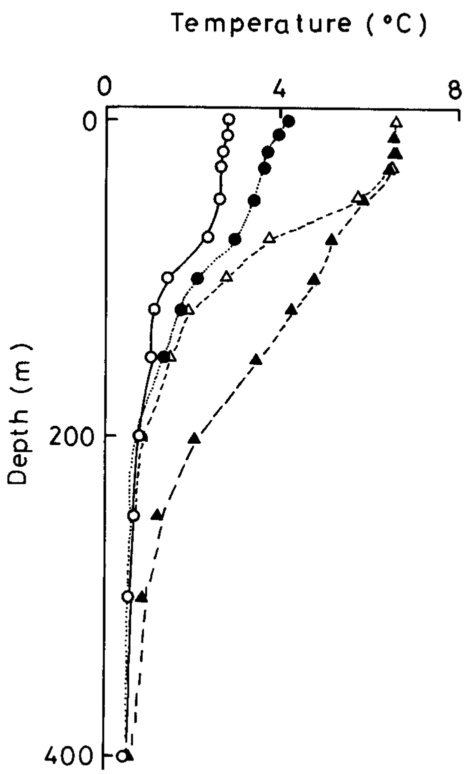

Fig. 5. Vertical distribution of water temperature.
○: St.7; ●: St.8; △: St.9; ▲: St.10.

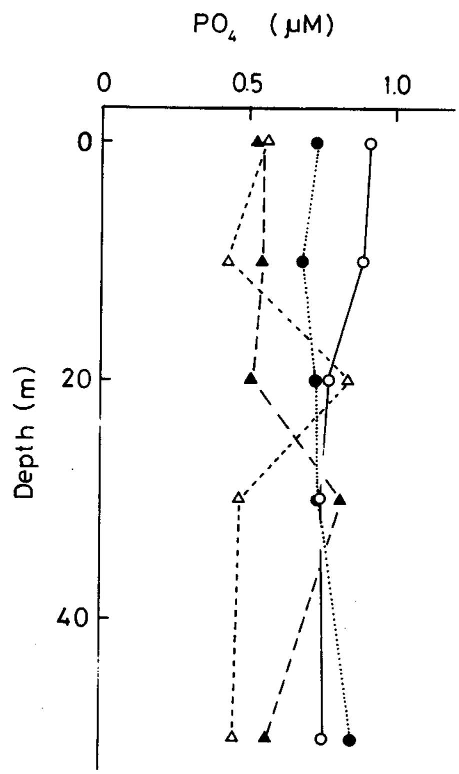

Fig. 6. Vertical distribution of PO_4. Symbols as in Fig. 5.

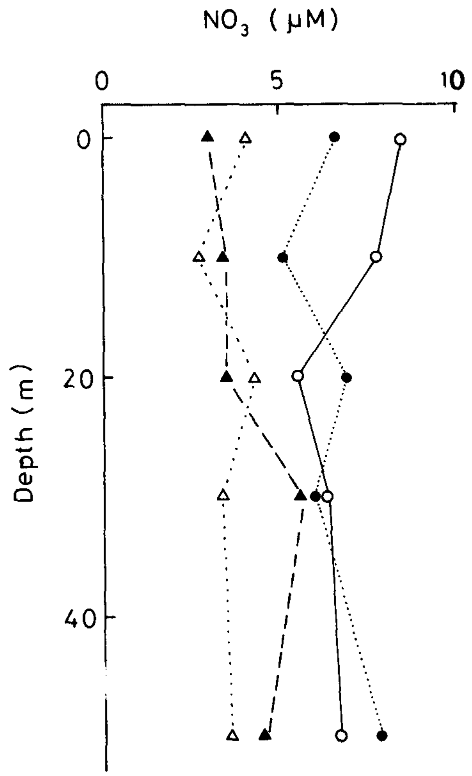

Fig. 7. Vertical distribution of NO_3.
Symbols as in Fig. 5.

along the Japan Islands is of relatively high temperature and salinity, and the other along the Korean Peninsula and Siberia is relatively low (Naganuma; 1977). The seasonal water mass transport of the Tsushima current into the Japan Sea is at a maximum from July to November and a minimum from February to April; the minimum mass transport is approximately 20% of the maximum (Yi; 1966, Okiyama; 1974). The Japan Meteorological Agency (1986 and 1987) reported seasonal observation results of nutrient concentrations in the Japan Sea. As an example, the nutrient concentrations in the warm surface waters are shown in Fig. 8 (Feb. 4-Mar. 11, 1985). They increase as the Tsushima current moves north, while water temperature and salinity decrease. On the contrary, extremely low concentrations were observed during the other seasons (May-Jun., Jul.-Aug. and Sept.-Oct.).

From the above results, we attribute the supply of rich nutrients from the cold water mass to the Tsushima current.

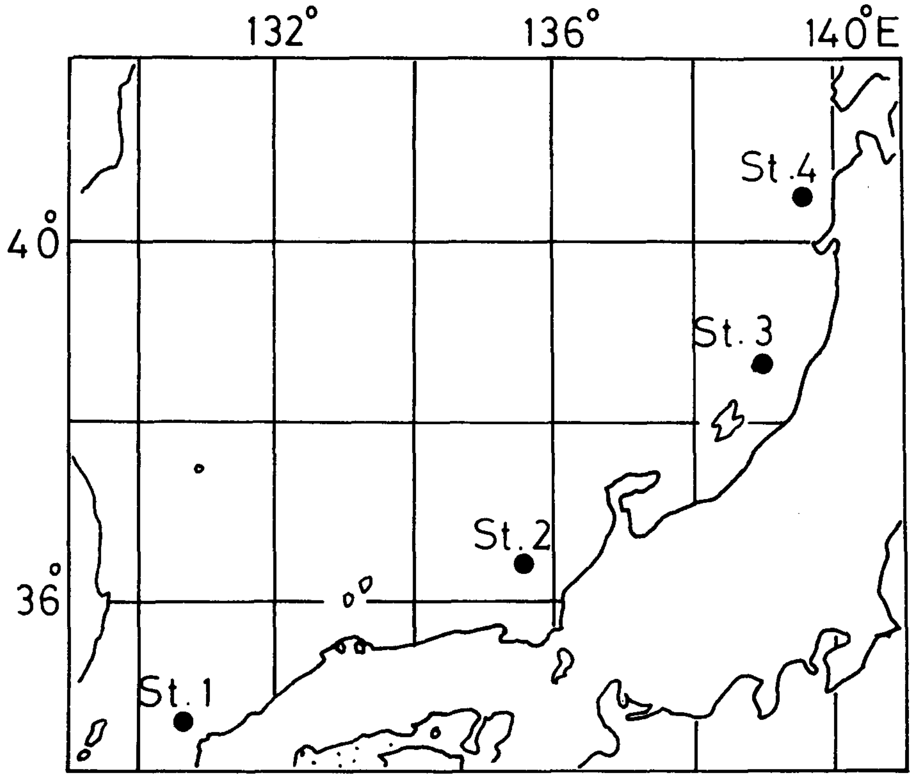

Fig. 8. Water temperature, salinity and concentrations of PO_4 and NO_3 along Honshu Ialand in the Japan Sea.

	St. 1	St. 2	St. 3	St. 4
1985.	Feb. 26	Feb. 4	Mar. 4	Mar. 5
	34°-30′N	36°-25′N	38°-40′N	40°-30′N
	130°-49′E	135°-28′E	139°-00′E	139°-33′E
Temp.°C	13.3	10.7	8.7	8.1
S‰	34.58	34.25	34.18	34.15
$PO_4\mu M$	0.07	0.46	0.40	0.40
$NO_3\mu M$	4.3	4.0	4.2	4.5

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