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Carbon and nitrogen isotope composition of organic matters in the Arctic food webs

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Abstract: During the last decade, the isotope compositions of carbon and nitrogen have been used to describe the behavior of organic matter in sea water. As both elements are bioactive, the isotope composition can provide insight into primary production,decomposition and the food chain. The nitrogen isotope ratio in particulate matters is considered an especially good tracer for new production. However this isotope cannot be directly applied without taking in account both the variation in source materials and isotopic fractionations arising from chemical or biochemical reactions.

Here, we focus the C and N trophodynamics in the Arctic,especially the western Canadian continental shelf which has a strong input from the Mackenzie River. The Beaufort sea ecosystem shows a relatively high ^{15}N content when compared with other oceans. We assign this difference to terrestrial organic matters which appears to be an important source to the ecosystem and sediments. Implications of this to the regional particle dynamics will be discussed.

The direct determination of carbon and nitrogen isotope abundances in the various components of marine ecosystem have neen used,in recent years, to clarify nutrient dynamics. Carbon isotope ratios in marine organic matter are essentially governed by the isotope discrimination associated with primary production in the euphotic layer. Previous work has shown that the $\delta^{13}C$ values for most plankton range between −19 to −21 ‰, except for polar seas. In the Antarctic Ocean, low $\delta^{13}C$ (up to −28 ‰) values are widely observed and have been attributed to the cold water temperature. Low $\delta^{13}C$ values have also been measured in plankton from Bering Sea (MCCONNAUGHEY and MCROY, 1979) and the western Beaufort Sea (SAUPE *et al.*, 1989). Three factors are thought to control ^{13}C distribution; variation of isotope fractioation with water temperature, physiological discrimination by marine plants, and variations in pCO_2 in surfac water. However, the relationship between $\delta^{13}C$ and the environmental conditions has still poorly defined.

From this point of view, carbon isotopic distribution in the Arctic requires further study. The Arctic Ocean differs fundamentally from the Antarctic Ocean. First, the interior Arctic Ocean surface is covered by permanent ice which limits the CO_2 exchange. Second, the Arctic Ocean has extensive continental shelves which are seasonally covered by ice and receive large inputs of land-derived matter may play an important role in the material cycle in the Arctic Ocean especially over the shelves.

The nitrogen isotope ratio in marine organic matter is controlled mainly by the balance between nitrogen fixation, denitification and supply of nitrate from the deep ocean. The $\delta^{15}N$ of the organic matter can provide a good proxy of the various proce-

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sses which produce the balance, and previous studies have traced the movement of nitrogen between marine plankton, suspended particles and sediment trap particles. The $\delta^{15}N$ of pelagic plankton varied from -2 to 10 ‰ in the North pacific (MINAGAWA and WADA, 1986). This wide variation suggests that $\delta^{15}N$ of marine organic matter provides a sensitive indicator of the nitrogen source and metabolisms in ocean ecosystems. Overall fractionation factors have been measured for nitrogen fixation (1.002: MINAGAWA and WADA 1986) and for nitrate uptake (1.006: Wada, 1980). these results suggest that new production should be characterized by relatively lower delta values in primary producers. In contrast, ^{15}N enrichment along the food chain (MINAGAWA and WADA, 1984) will be reflected in the Particulate organic matters which sinks from the euphotic zone into deeper water. Denitrification, which occurs for example in the oxygen minimum layer of the eastern tropical Pacific Ocean (CLINE and KAPLAN, 1976; LIU and KAPLAN, 1989; SAINO and HATTORI, 1989) also tends to increase the $\delta^{15}N$. Except for this region, the $\delta^{15}N$ of pelagic plankton falls in the range of 6 to 7 ‰, which is almost the same range measured for nitrate in surface water.

The nitrogen isotope abundances and distridutions in Arctic marine ecosystems are poorly. The shelves receive some terrestrial nitrate (e.g., MACDONAL DA *et al.*, 1987) and have new production of perhaps 20-60 gC m^{-2} yr^{-1} (ANDERSON *et al.*, 1990). Incontrast, the productivity of the Arctic interior ocean appears to be very low (SUBBA RAO and PLATT, 1984; MACDONALD and CARMACK, 1991). The lack of new production there may therefore result in higher ^{15}N abundane in recycled nitrogen when compared to marginal or other seas.

In recent investigations of material budgets in the Canadian Beaufort Sea (NOGAPB. 6 project), we have attempted to identify the carbon and nitrogen ispotope ratios of organic matters in the Arctic shelf ecosystem. The first detailed analyses of $\delta^{15}N$ and $\delta^{13}C$ have been made for plankton, fish, sediments and sediment trap particles. Since detailed results of this study will be published in elsewhere, we describe the results only briefly here.

The $\delta^{13}C$ of zooplankton and trap particles was found to be near -23 ‰ and -25 ‰, respectively, indicating slightly lower ^{13}C content compared to plankton in other seas. On the other hand, sediments from the Mackenzie River estuary and the Mackenzie Shelf 150 km away from the coast show in their isotopic composition a substantial addition of land-delived organic material, for which the $\delta^{13}C$ is -28 ‰. Therefore, we believe that significant quantities of terrestrial organic carbon is added into the carbon cycle in this ecosystem and that it alters the $\delta^{13}C$ of both plankton and sinking particles. The temperature effect, which produces low $\delta^{13}C$, is relatively unimportant for the Beaufort sea.

The $\delta^{15}N$ of plankton, fish and trap particles varied from 7 to 12 ‰, which is within the normal range found for other oceans. However, if we subtract the $\delta^{15}N$ dilution caused by mixing with terrestial organic matter (about 1 ‰), the results indicate a significant enrichment of ^{15}N. Further, the $\delta^{15}N$ of sediment samples also shows relative enrichment of ^{15}N compared to $\delta^{13}C$ - $\delta^{15}N$ relationships reported for other seas. These results suggest that the nitrogen isotope in the Beaufort Sea are defined by a balance between selective fixation of ^{14}N into are sediment and the addition of river-delived terrestrial nitrogen which is ^{14}N rich.

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