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# $^{15}N$ AND $^{13}C$ ABUNDANCES IN THE ANTARCTIC OCEAN WITH EMPHASIS ON BIOGEOCHEMICAL STRUCTURE OF FOOD WEB (EXTENDED ABSTRACT)*

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Stable isotopes of light elements undergo a fractionation in physico-chemical and biochemical processes occurring in the natural environments. In a recent decade, a considerable sum of data on the distribution and the variation of nitrogen and carbon isotopes has been accumulated in various kinds of systems involving terrestrial ecosystems, marine ecosystems, and laboratory culture systems.

Firstly, a biogeochemical framework that governs the distribution and the fractionations of nitrogen and carbon isotopes in a natural ecosystem was presented. Principal factors involved were: (1) isotopic compositions of substrate used for the growth of photosynthetic organisms, (2) kinetic isotope effects during the initial enzymatic reactions of the photosynthetic $CO_2$ fixation and the assimilation of inorganic nitrogeneous compounds, (3) the enrichment of $^{15}N$ and $^{13}C$ in feeding processes, and (4) isotope effects during the decomposition of organic matter.

Under the light of these considerations, stable isotope ratios of nitrogen and carbon for biogenic substances from the Antarctic Ocean were investigated to elucidate isotopic chemical structure of the Antarctic ecosystem.

Particulate organic matter (POM), net plankton (XX13 and GG54), zooplankton, and macrofauna were collected from the southern ocean Australian Sector during KH-83-4 cuirse of the R. V. HAKUHO MARU as part of the BIOMASS SIBEX I operation.

The $\delta^{15}N$ values of POM (phytoplankton) ranged from 0.4 to 0.5‰, and the $\delta^{13}C$ values extended from $-27.4$ to $-26.4$‰. These values were particularly low in marine ecosystems. High nitrate concentration and high $P_{CO_2}$ in the surface sea waters in the southern side of the polar front, and the low light intensity seemed to enhance the kinetic isotope fractionations of both nitrogen and carbon that preferred the depletion of $^{15}N$ and $^{13}C$ in the algal body. The sea water temperature seemed to be an another factor as the growth of the phytoplankton was restricted by the *in situ* temperature below 2°C. However, the $\delta^{15}N$ and $\delta^{13}C$ values of plankton involving particulate organic matter collected by a Whatman GF/C glass fiber filter (POM), settling particles collected by sediment traps, and net plankton samples were variable temporally and spatially. The fact seems to result from the algal blooming during the austral summer season. The

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mean fractionation factors of 1.029 and 1.006 were estimated for the photosynthetic carbon fixation ($HCO_3^-$-algal body) and for the assimilation of inorganic nitrogenous compounds (ammonium and nitrate) during an algal growth, respectively.

Enrichments of $^{15}N$ along the food chain were also confirmed for the Antarctic ecosystems. For instance the $\delta^{15}N$ values of the marine biota collected on 13 January, 1984 near Stn. 3 (150.5°E, 61.5°S) increased in the following order: POM collected by Whatman GF/F filteration (0.5‰) < *Euphausia superba* (young) (1.0‰) < *Salpa thompsoni* (1.8‰) < *Euphausia superba*, (adult) (3.1‰) < polychaeta sp. (4.8‰), *Sagitta maxima* (5.6‰) < *Notolepis coasti* (7.1‰) and *Electrona antarctica* (7.5‰). On the other hand, the $\delta^{13}C$ values of these materials did not increase in the same manner and the lowest value was found for *Euphausia superba* (−29.1‰), while *Notolepis coasti* exhibited the highest value (−25.8‰). Difference in lipid content among these animals was strongly suggested as one of the possible factors to make the $\delta^{13}C$ anomaly. On the basis of ecological knowledge, some organisms examined in the present study were picked as representatives of phytoplankton, zooplankton and fish. The $\delta^{15}N$ value of each group clearly indicated the enrichment of $^{15}N$ along the food chain (Table 1).

*Table 1. $\delta^{15}N$ and $\delta^{13}C$ values for various biogenic materials in the Antarctic Ocean.*

| | | $\delta^{15}N_{air}$ ‰ | $\delta^{13}C_{PDB}$ ‰ |
|---|---|---|---|
| Phytoplankton | | 0.5±0.1 | −26.9±0.7 |
| Net plankton | XX 13 | 1.4±1.1 | −29.6±3.9 |
| | GG 54 | 3.8±2.3 | −27.9±0.6 |
| Euphausiid | | 2.8±1.3 | −28.2±1.7 |
| Copepoda (mesopelagic) | | 9.2±0.8 | −29.1±0.4 |
| Pisces | | 8.3±1.8 | −25.4±1.9 |

Sedimentary organic nitrogen collected at Stn. 3B (61°26.1′S, 150°05.0′E, 3870m), Stn. 5 (65°04.1′S, 117°53.0′E, 2540m) and PI-2 (64°11.6′S, 135°41.3′E, 3160 m) exhibited different $^{15}N$ and $^{13}C$ abundances from phytoplankton. The $\delta^{15}N$ ranged from 4.9 to 5.5‰ with the average of 5.2 that could not be simply expected from the degradation of plankton in the euphotic zone. Furthermore, a very high $\delta^{13}C$ value of −20.5‰ was found for sediments from Stn. 3B, while −25.4‰ was obtained for other sediments. The high value has been never before found in the Antarctic Ocean. The sediment at Stn. 3B consisted mostly of siliceous ooze, an assembly of dead diatoms. The $\delta^{13}C$ value near −20‰ can only be understood when phytoplankton had grown under a limited supply of carbon dioxide, since coagulated algal mat gives a similarly high $\delta^{13}C$ value. A high pH of 9 is sometimes observed in the Antarctic fast ice where ice algae are blooming. This suggests a $CO_2$ diffusion limited condition for the algal growth. Ice algae were, thus, proposed to be the most probable candidate as a souce organic material in the sediment at Stn. 3B.

Sinking particles collected by sediment traps at Stn. 3B (61°33.6′S, 150°27.6′E) were also studied. The sampling was performed from December 10, 1983 to January 13, 1984 at five depths from 690m down to 3130m. All trap materials consisted mainly of diatom frustules and fecal pellets packed with the frustules. The $\delta^{15}N$ values of these materials were $-3.0$ to 0.9‰. The $\delta^{15}N$ and $\delta^{13}C$ values of the trap samples gave the similar profiles with depth. The $\delta^{15}N$ of the 690 m sample was $-0.5$‰ and increased to 0.9‰ at 1330 m (a maximum value) and then decreased to $-3.0$‰ at 3130 m. The $\delta^{13}C$ value was lowest for the 690 m samples ($-27.9$‰), the maximum ($-25.6$‰) at 1330 m, and then decreased to $-26.6$‰ below the maximum layer. An exact reason to account for the observed profile is yet unknown, but it might reflect the algal blooming in the euphotic layer. If so, we can say that the variation of the profiles should reflect a temporal variation of the algal growth in the euphotic zone. The maximum value observed at 1330 m supports this view and suggested that the main part of the sample consisted of diatom with a rapid growth rate during the algal blooming.

The Antarctic ecosystem, thus, seems to provide an isotopically ordered chemical system as a first order approximation and that the fluctuation of the isotopic abundances resutls mainly from the variation of $^{15}N$ and $^{13}C$ abundances in phytoplankton grown under different conditions during the austral summer season.

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