

Nitrate isotope distributions in the subarctic and subtropical North Pacific

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Nitrogen isotopic composition of nitrate ($\delta^{15}\text{N}_{\text{Nitrate}}$) is widely used as a tracer of ocean-internal nitrogen cycling (consumption and regeneration) and ocean-external nitrogen inputs and losses (N_2 -fixation; fixation of N_2 gas into bioavailable nitrogen such as ammonia by diazotrophs, and denitrification; microbial respiration using nitrate as an electron acceptor). When the phytoplankton assimilates nitrate, nitrogen isotopes are fractionated. A $\delta^{15}\text{N}_{\text{Nitrate}}$ value increases, in conjunction with nitrate depletion, due to an isotopic effect during nitrate assimilation by phytoplankton. When denitrification occurs in the water column, a $\delta^{15}\text{N}_{\text{Nitrate}}$ value extremely increases due to a strong isotopic effect. N_2 -fixation produces fixed nitrogen with a $\delta^{15}\text{N}$ value of $\sim 0\%$, as nitrogen fixers take up N_2 gas with little isotopic effect. This fixed nitrogen with low $\delta^{15}\text{N}$ value is eventually converted into low- $\delta^{15}\text{N}_{\text{Nitrate}}$ through degradation of nitrogenous organic compounds called remineralization and subsequent nitrification. Those signatures of $\delta^{15}\text{N}_{\text{Nitrate}}$ in the euphotic zone are conserved in nitrogenous organic compounds and transfers to the sinking particles and deep-sea sediments. Here we determined $\delta^{15}\text{N}_{\text{Nitrate}}$ and $\delta^{18}\text{O}_{\text{Nitrate}}$ along 47°N in the subarctic North Pacific and 149°E in the western North Pacific. In the western subarctic gyre, known as High Nutrient, Low Chlorophyll (HNLC) region, the $\delta^{15}\text{N}_{\text{Nitrate}}$ and the differences between $\delta^{15}\text{N}_{\text{Nitrate}}$ and $\delta^{18}\text{O}_{\text{Nitrate}}$, or $\Delta(15-18)$, in the intermediate and deep waters were significantly lower than the surrounding area. Between the western subarctic gyre and the Alaskan gyre, there was an observed 0.4% increase in $\delta^{15}\text{N}_{\text{Nitrate}}$ and a 0.6% increase in $\Delta(15-18)$ associated with a $7.2 \mu\text{M}$ decrease in the nitrate concentration at the surface. These results suggest that the ^{15}N -depleted nitrate is generated by nitrified nitrate from remineralization of organic matter synthesized by partial consumption of surface nitrate pool, and the ^{15}N enrichment toward the east is affected by the increase in utilization of surface nitrate pool. Assuming Rayleigh distillation kinetics, the increase in utilization between the western subarctic gyre and the Alaskan gyre, going from 29% to 85% utilization, corresponded to a change in $\delta^{15}\text{N}$ of organic matter from 2.6% to 4.9% . This study also revealed that the ^{15}N -depleted nitrate in the surface water of the western subtropical gyre is generated by N_2 -fixation, whereas the ^{15}N -enriched nitrate in the intermediate water at the western margin of North America is generated by water-column denitrification. The $\delta^{15}\text{N}$ sediment record in the western subarctic North Pacific is expected to reflect the past changes in the HNLC region, but may also be controlled by water-column denitrification and N_2 -fixation.

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