Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain

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The stable isotope ^{15}N is widely used an indicator of trophic level, and has been incorporated into ecosystem models in order to understand nitrogen cycling and trophic transfer. However, such studies typically consider only the average enrichment per trophic level. We present a recently developed model of the dynamic fractionation of the stable isotope ^{15}N in lower-trophic ecosystems of the North Pacific. The model accounts for the dynamics of trophic transfer from nutrients (nitrate and ammonium) to phytoplankton, and to two idealized zooplankton compartments representing herbivores and carnivores, respectively. The d^{15}N signal of herbivores tracks that of phytoplankton, with a nearly constant offset, i.e., enrichment by a nearly constant factor. However, the modeled d^{15}N difference between carnivores and herbivores varies seasonally, and depends on the mortality rate (turnover time or effective lifespan) of the carnivores. Seasonal variations of modeled d^{15}N signals differ with trophic level because carnivores integrate the signal from their ^{15}N uptake over longer timescales compared to herbivores. Thus, the model reproduces the lower observed variability of d^{15}N for carnivorous zooplankton (chaetognaths) and the more variable d^{15}N for largely herbivorous zooplankton (copepods). Our results imply that for interpreting observed d^{15}N values, it is important to consider not only the average enrichment per trophic level, but also the dynamics of ^{15}N fractionation and the timing of observations, e.g. to avoid unrealistic estimates of trophic linkages based on seasonally biased observations.

Keywords: nutrients, predation, zooplankton, production, transfer efficiency