Development of a marine ecosystem model including nitrite

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Nitrite is an intermediate product during nitrification and denitrification. Few marine ecosystem models including nitrite have been developed. However, many phytoplankton species have been observed to assimilate and release significant amounts of nitrite, although those processes are not well understood. The lack of these processes may cause uncertainty about predictions of primary production. As nitrite is a precursor of nitrous oxide (N_2O), which is a significant anthropogenic greenhouse gas and a stratospheric ozone destroyer, a marine ecosystem model including nitrite is also necessary for development of a marine N_2O model as a base model. In this study, a 1D marine ecosystem model including nitrite was developed, in order to understand the nitrite production and consumption processes quantitatively and to develop the relevant equations. We applied this model to the JAMSTEC time-series subarctic and subtropical sites (K2 and S1) in the western north Pacific. The nitrite concentrations observed at the highly productive K2 site during 20 cruises from 2004 to 2014 were relatively high (0.0-1.0 μM), and with maxima observed around σ_θ=26.4 kg/m^3 throughout the year. The nitrite concentrations observed at the less productive S1 site during 19 cruises from 2010 to 2014 were relatively low (0.0-0.5 μM) with maxima observed around σ_θ=25.0 kg/m^3 throughout the year. Nitrification rates determined by ^{15}N-labeling during the cruises in June 2013 and in July 2014 were 0-34 nmolN/L/day in at K2, and 0-11 nmolN/L/day at S1. Maximum rates were observed around σ_θ=26.4 kg/m^3 at K2 and σ_θ=25.1 at S1, consistent with the density at which nitrite was maximal. These results suggest that active production and remineralization cause nitrite accumulate at K2 more than at S1. Our model was validated with observed nitrate, ammonium, nitrite, and chlorophyll *a* concentrations and nitrification rates at K2 and S1. The model successfully simulated the higher nutrient and chlorophyll *a* concentrations and nitrification rates at K2 compared with S1, and also represented the subsurface maxima of nitrite and ammonium concentrations and nitrification rate. Case studies were conducted to test different formulations for the equations in this model. In the case without photoinhibition of nitrification, the simulated densities of nitrite, ammonium, and nitrification maxima are much shallower than observed at both stations. Surface nitrification rates could be measured at K2 because nitrate is not depleted at the surface, and the rates were not detected at depths sallower than 40 m. However, simulated surface nitrification rates were 6-13 nmolN/L/day in the case without photoinhibition of nitrification. These results suggest that our previous model, which did not include photoinhibition of nitrification, may underestimate the nitrite and ammonium concentrations in the euphotic layer and the regeneration rate. In this presentation, we will also show the differences in densities of nitrification and nitrite maxima and regeneration rate as obtained using the different equations for nitrification as applied in various existing marine ecosystem models.

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