Carbon-nitrogen coupling and algal-bacterial interactions during an experimental bloom: Modeling a 13C tracer experiment

Van den Meersche, Karel, Jack J. Middelburg, Karline Soetaert, Pieter van Rijswijk, Henricus T. S. Boschker, Carlo H. R. Heip

Limnol. Oceanogr., 49(3), 2004, 862-878 | DOI: 10.4319/lo.2004.49.3.0862

ABSTRACT: We tracked flows of carbon and nitrogen during an experimental phytoplankton bloom in a natural estuarine assemblage in Randers Fjord, Denmark. We used ^{13}C-labeled dissolved inorganic carbon to trace the transfer of carbon from phytoplankton to bacteria. Ecosystem development was followed over a period of 9 d through changes in the stocks of inorganic nutrients, pigments, particulate organic carbon and nitrogen, dissolved organic carbon (DOC), and algal and bacterial polar-lipid-derived fatty acids (PLFA). We quantified the incorporation of ^{13}C in phytoplankton and bacterial biomass by carbon isotope analysis of specific PLFA. A dynamic model based on unbalanced algal growth and balanced growth of bacteria and zooplankton adequately reproduced the observations and provided an integral view of carbon and nitrogen dynamics. There were three phases with distinct carbon and nitrogen dynamics. During the first period, nutrients were replete, an algal bloom was observed, and carbon and nitrogen uptake occurred at a constant ratio. Because there was little algal exudation of DOC, transfer of ^{13}C from phytoplankton to bacteria was delayed by 1 d, compared with the labeling of phytoplankton. In the second phase, the exhaustion of dissolved inorganic nitrogen resulted in decoupling of carbon and nitrogen flows caused by unbalanced algal growth and the exudation of carbon-rich dissolved organic matter by phytoplankton. During the final, nutrient-depleted phase, carbon and nitrogen cycling were dominated by the microbial loop and there was accumulation of DOC. The main source (60%) of DOC was exudation by phytoplankton growing under nitrogen limitation. Heterotrophic processes were the main source of dissolved organic nitrogen (94%). Most of the carbon exudated by algae was respired by the bacteria and did not pass to higher trophic levels. The dynamic model successfully reproduced the evolution of trophic pathways during the transition from nutrient-replete to -depleted conditions, which indicates that simple models provide a powerful tool to study the response of pelagic ecosystems to external forcings.

Article Links

Download Full-text PDF

Return to Table of Contents