MICROBIAL NITRIFICATION IN THE MARINE EUPHOTIC ZONE: RATES AND RELATIONSHIPS WITH NITRITE DISTRIBUTIONS, RECYCLED PRODUCTION AND NITROUS OXIDE GENERATION

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ABSTRACT

Concerns are mounting that rising levels of carbon dioxide and other greenhouse gases in the atmosphere will lead to global warming and global environmental change. At the same time, there is growing evidence that chlorofluorocarbons and other trace gases are depleting Earth's protective stratospheric ozone layer. Microbial nitrification, the biologically mediated oxidation of ammonium to nitrite to nitrate, plays a key role in both of these issues (1) nitrification may complicate measurements of new production, resulting in inaccurate estimates of the amount of carbon dioxide that can be removed from the atmosphere by the ocean's natural biological pump, and (2) nitrification may produce nitrous oxide as a by-product, a trace greenhouse gas that also depletes ozone.

In this study I have utilized sensitive chemical and radioisotopic techniques to measure relevant nitrogen compounds and to estimate in situ nitrification rates. This work has been carried out during the regular cruises of the Hawaii Ocean Time-series (HOT) project to the oligotrophic Station ALOHA in the subequatorial North Pacific Ocean. The study has focused on the lower euphotic zone, which is characterized by an accumulation of nitrite (the primary nitrite maximum or PNM). The goals of the study were to assess the role of nitrification in the recycling of nitrogen within the euphotic zone of a well-characterized oligotrophic site, to investigate the influence of nitrification on the structure and variability of nitrite distributions and to examine the relationship between nitrification and the production of nitrous oxide.

Nitrification rates in the euphotic zone were found to be highly variable, ranging from <2 to 123 μmol m^{-3} d^{-1}. Nitrate production via nitrification within the euphotic zone was several times greater than the estimated eddy-diffusive flux of nitrate into the euphotic zone from below, indicating that nitrate-based production cannot be equated with new production at Station ALOHA.

Chemiluminescent nitrite measurements revealed that the PNM exhibits a double-peaked structure, with a large upper maximum at a depth of 126±18 m and a lower maximum of lesser magnitude at 149±15 m. The vertical distributions of nitrogenous compounds and nitrification rates suggest that the upper peak of the PNM is produced through the incomplete assimilatory reduction of nitrate by phytoplankton, while the lower peak is maintained through the differential photoinhibition of nitrifying bacteria. This vertical separation of nitrite-producing processes and the observed vertical nitrite profiles were successfully recreated using a light-dependent model.

Water column profiles of nitrous oxide showed significant supersaturation, even within the surface mixed layer. A mass balance of nitrous oxide within the euphotic zone, based on measured concentrations and nitrification rates, suggests that in situ production of nitrous oxide, rather than a flux from below the euphotic zone, is the dominant term in supporting the sea-air flux of this trace gas at Station ALOHA. However, much of this in situ nitrous oxide generation appears to be fueled by a process other than nitrification which remains uncharacterized.