Stoichiometry of Ammonia Oxidation and C and P Fluxes by Marine Archaea

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Archaeal ammonia oxidizers (AOA) are among the most abundant cells in the ocean [1] and play crucial roles in the global nitrogen (N) cycle, generating energy from the conversion of ammonia to nitrite, and in the global carbon (C) cycle, assimilating inorganic carbon into biomass [2]. Given the small biovolume of the cell [2], high phosphate uptake affinity in combination with access to the dissolved organic phosphorous (DOP) pool [3] may offer AOA a competitive advantage in regions of the ocean subject to P limitation. To determine the kinetics and C-N-P stoichiometry of AOA production, we measured cell specific uptake rates of C and P as well as nitrite production for two strains of *Nitrosopumilus maritimus* grown over a range of phosphate concentrations (0.1 to 1.6 µM) via a parallel radiotracer labeling approach (33P-labeled phosphate and 14C-labeled bicarbonate). We found that for 1 mole of NH4 respired, N. maritimus fixed 0.2-1 mol C and assimilated 1-3 mmol P. The aquarium isolate *N. maritimus SCM1* assimilated bicarbonate and phosphate at a higher ratio (270-1110) than the environmental strain *N. maritimus NAOA6* (20-140), and the assimilation ratio in both strains typically decreased at higher growth rates. Furthermore, the environmental strain was more responsive to changes in [P] and achieved a much higher specific affinity for phosphate. The estimated cellular budgets do not distinguish AOA from marine bacteria and measured uptake kinetics suggest that strains of *N. maritimus* could compete for P in oligotrophic ocean environments [4]. DOP production by AOA accounted for 1-3% of P uptake and translated to production rates of 10-170 zmol (10^-21 mol) DOP cell-1 d-1. Based on an estimated 10^28 AOA cells in the ocean [1], this scales up to a rate of roughly 10-100 pmol DOP L-1 y-1 in the global ocean.

[1] Karner *et al.* (2001) *Nature* **409**, 507–10. [2] Könneke *et al.* (2005) *Nature* **437**, 543-546. [3] Metcalf *et al.* (2012) *Science* **337**, 1104–7. [4] Tanaka *et al.* (2003) *Limnol Oceanogr* **48**, 1150-60.