Insights into the activity and metabolic capabilities of planktonic marine archaea using NanoSIMS

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Archaeal cells comprise over 20% of the total microbial cells in marine waters, and likely play an important role in marine biogeochemical cycles [1]. Planktonic marine archaea are numerically dominated by two phylogenetic groups: Thaumarchaeota (a newly recognized phylum previously known as marine group I Crenarchaeota) and marine group II Euryarchaeota [1, 2]. Although ubiquitous, their activity and metabolic flexibility are still poorly described. In particular, although Thaumarchaeota are thought to live primarily chemoautotrophically, coupling ammonia oxidation to bicarbonate fixation, some evidence suggests that they may live heterotrophically or mixotrophically [3, 4, 5, 6]. In the current study, we investigate the carbon metabolic flexibility and growth rates of marine archaea in order to understand their potential role in C and N cycling in the oceans. We incubated coastal marine water at *in situ* temperature in the dark, with isotopically labeled substrates, in the presence and absence of antibiotics. Specifically, we used $H^{13}CO_3^-$ and ^{15}N- and ^{13}C-labeled amino acids to investigate autotrophy and heterotrophy, respectively, and $^{15}NH_4^+$ to observe overall anabolic activity. We measured the uptake of these substrates using both bulk and single-cell isotope analyses (Isotope Ratio Mass Spectrometry and Nanoscale Secondary Ion Mass Spectrometry (NanoSIMS), respectively). By combining NanoSIMS with fluorescence *in situ* hybridization (FISH-NanoSIMS) as well as microarrays (Chip-SIP), we are able to differentiate uptake by archaeal and bacterial cells, as well as different archaeal phylotypes. Our single-cell approach allows us to determine the contribution of individual phylotypes to overall community activity, as well as observe the distribution in activity levels within phylotypes.

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