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Spatial and Temporal Variability in the Concentration and Turnover of the Inorganic Phosphate and Adenosine-5'-triphosphate pools in the North Pacific Subtropical Gyre

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The microbial community's utilization of inorganic phosphate (Pi) and adenosine-5'-triphosphate (ATP) as a function of the Pi pool concentration was studied over a multi-year period at Station ALOHA (22.75˚N, 158˚W) in the North Pacific Subtropical Gyre (NPSG). Additionally, the spatial variability in these same properties was investigated along an east-west transect from California to Hawaii in the Fall of 2014. We used radiotracer techniques to determine the turnover times of the Pi or ATP pools respectively, and assessed the net production of dissolved organic phosphorus, and Pi hydrolysis rate from ATP.

Pi concentrations in the upper water column at Station ALOHA are temporally highly dynamic, with periods of <10 nM-P to near 200 nM-P recorded within the top 50 m over the past decades of observations. During the California to Hawaii transect Pi concentrations showed a similarly large range (<10 to >200 nM-P), emphasizing the spatially and temporally mosaic nature of the upper ocean of this large biome. The Pi-pool turnover time ranged from a few hours to several weeks, and was strongly correlated with measured Pi pool concentrations (r2=0.8; n=30 Station ALOHA; n=15 transect). The calculated Pi uptake rates at Station ALOHA averaged 3.7±1.3 nM-P d-1 (n=30), reflecting the typically low maximum Pi uptake rates of the Prochlorococcus dominated community and the predominantly non-limiting Pi conditions. The Pi uptake rates along the transect were more variable than Station ALOHA (averaging 9.2±4.7 nM=P d-1, n=15), possibly due to a more diverse planktonic community structure, including stations with elevated concentrations of chlorophyll and primary productivity.

The turnover time of the dissolved ATP pool was typically substantially shorter than for the Pi-pool (2-5 days at Station ALOHA; 0.3-2.5 days along the transect), likely reflecting its low nanomolar to picomolar ambient pool concentrations. However, at stations with the lowest SRP concentrations the Pi pool turned over more rapidly than the dissolved ATP pool. Furthermore, larger plankton size classes (<0.6 and <2 μm) tended to have longer turnover times for ATP relative to Pi. This suggests that microbial utilization of these two phosphorus pools are independent of one another and that ATP predominantly is processed by the smallest microbial components of this ecosystem. Net production rates of DOP were approximately 1-2% h-1, with no net DOP production measureable at stations with the lowest Pi concentrations. ATP hydrolysis routinely exceeded the Pi taken up by the microbial community, resulting in a net release of Pi into the ambient seawater. This net release ranged from >80% to 5% of the total ATP hydrolysis and positively correlated with the Pi pool turnover time along the transect (r2=0.7; n=15). These results indicate that during Pi limiting conditions regenerated P is rapidly consumed, and that Pi limitation occurs locally and transiently but appear not to be the predominant condition in the upper water column of the NPSG.