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Dissolved organic matter quality influences heterotrophic alkaline phosphatase activity in the California Current Ecosystem

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Alkaline phosphatase (AP) activity (APA) is typically interpreted as a marker for phosphorus (P) stress in marine microbial communities. However, high APA values have been measured in many regions that are replete with phosphate (Pi). This “APA enigma” has been attributed to bacterial acquisition of carbon (C), rather than Pi. Yet, these dynamics are not fully understood. To address the APA enigma, total dissolved P (TDP) and APA measurements were taken together for the first time in the California Current Ecosystem (CCE) Long Term Ecological Research (LTER) upwelling region, at two stations during the summer of 2021. While Pi concentrations increased from the surface to 150m at both the onshore (0.12-1.8μM) and offshore (0.012-1.16μM) stations, cell-normalized APA also increased, confirming the presence of the APA enigma. Where bacterial production was lowest, a significant majority of DOC was phosphorylated compared to where bacterial production was greater ($p < 0.05$). Furthermore, APA increased as the quality of dissolved organic matter (C:P ratio) decreased. These results suggest that microbial upregulation of APs at depth may be necessary in order to access phosphorylated DOC that is less bioavailable. These results also help to reframe our understanding of APA as a P stress indicator. Rather than relying on APA alone as an indicator of P stress, we offer an alternative metric based on APA as a fraction of the ambient Pi pool. Using this metric to analyze previously published observations from a wide range of marine environments, we propose that a system is P stressed when more than 80% of the Pi pool is generated by APA.