Dynamics and Regulation of Extracellular Superoxide Production by Marine Microbes

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Reactive oxygen species (ROS) are key players in the biogeochemistry of the ocean, where they play a critical role in the degradation of carbon, cycling of metals, and health of biotic systems. ROS are, in fact, both detrimental and beneficial to life. For instance, at low concentrations the ROS superoxide mediates a number of essential physiological processes, including cell differentiation, signaling, and defense. At high concentrations, superoxide degrades essential biomolecules and initiates programmed cell death. Marine microbes, including bacteria, cyanobacteria and diatoms, have recently been shown to produce substantial levels of extracellular superoxide at rates that could greatly contribute to in situ superoxide fluxes within the ocean. Yet, little is known about the physiological basis for extracellular superoxide production in marine microbes and how this production is regulated as a function of species, ecological interactions, and surrounding environmental conditions.

Here we show that despite a wide variability in rates, extracellular superoxide production is ubiquitous throughout a diverse range of marine biota. We also show that extracellular superoxide production rates and steady-state concentrations predictably vary as a function of cell density and growth stage for *Roseobacter* and *Synechococcus* species – key organisms in the biogeochemistry of the ocean. Our results reveal tightly controlled regulation of superoxide at the cellular level and point to a role for superoxide in the growth of these organisms. Similar extracellular superoxide production patterns for a diverse range of Antarctic phytoplankton suggest that superoxide production is a key process underpinning the physiology of marine microbes that requires further interrogation.