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"Expanding the Role of Microorganisms in the Production of Superoxide within Marine Systems: Implications for Coral Bleaching"

Abstract: 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 beneficial and detrimental to life. For instance, at low concentrations, the ROS superoxide (O2-) mediates a number of essential physiological processes, including cell signaling, cell differentiation, defense, and nutrient acquisition. At high concentrations, however, superoxide degrades essential biomolecules and initiates programmed cell death (apoptosis). ROS production in the ocean has historically been attributed to primarily photochemical reactions and more recently phytoplankton activity, and thus ROS formation has been considered fundamentally constrained by light. Here, we will discuss new findings revealing that biogenic superoxide production rates below the photic zone (in the dark) within marine and freshwater systems are much higher than predicted, and are at times even higher than surface (i.e., sunlit) production rates. Further, even within sunlit waters, 'dark' biogenic superoxide production is a dominant contributor to total ROS fluxes. This production is attributed to the activity of both heterotrophic bacteria and phytoplankton that is decoupled from photosynthesis and may in fact be required for cell proliferation. This dark biogenic production is also observed in coral reef ecosystems, where light and thermal stress induced superoxide production by the algal symbiont Symbiodinium has been implicated in coral bleaching. By coupling in situ measurements of superoxide production from corals during a natural bleaching event with laboratory incubations of coral larvae and its symbionts, we find that the patterns of superoxide production are not, in fact, consistent with Symbiodinium as the primary source of superoxide within the coral holobiont. It is becoming increasingly clear that superoxide has a complex yet integral role in organismal and ecosystem functioning, and the consequences of this production have far reaching implications for marine biogeochemistry.