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A photosynthetic strategy for coping in a high light, low nutrient environment

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In the open ocean, high irradiances and low nutrient availability present a challenge to photosynthetic organisms, who must simultaneously maintain high photosynthetic efficiency while preventing photodamage resulting from a scarcity of electron acceptors downstream of photosystem (PS) II. Here we present results of a study in the Atlantic and Pacific Oceans that identifies a photosynthetic process that preserves PSII activity by diverting electrons from PSI-mediated carbon assimilation to oxygen via a propyl gallate-sensitive oxidase. This process stabilizes diel photochemical efficiency of PSII (ΦPSII) and inorganic carbon fixation, despite midday photoinhibition, by maintaining oxidized PSII reaction centers. Moreover, we show that carbon fixation saturates at low irradiances even though PSII electron flow is not saturated at maximum midday surface irradiances. This disparity is consistent with the activity of an oxidase that serves as a terminal electron acceptor, maintaining PSII electron flow even when carbon fixation has saturated and the total number of functional reaction centers decreases due to photoinhibition (reflected in lower midday F_v/F_m values). This phenomenon is less apparent in coastal phytoplankton populations, suggesting that it is a strategy particularly distinctive of phytoplankton in the oligotrophic ocean. Spatial variability in photosynthetic electron flow characteristics could explain biogeographical differences in productivity throughout the ocean, and should be represented in models that use empirical measurements from a limited number of ocean sites to estimate the productivity of the entire ocean. (This study is published in: KRM Mackey, A Paytan, AR Grossman, & S Bailey. 2008. Limnology and Oceanography 53: 900-913.)