IS2.5 - Autonomous measurements of phytoplankton electron transport, carbon fixation and growth in oceanic waters

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Marine phytoplankton account for approximately half of global primary productivity and play a critical role in driving oceanic CO_2 sequestration. Over the past several decades, advances in ship-based instrumentation and remote sensing have provided new approaches to estimate various aspects of photosynthetic process in oceanic waters, yet quantifying the phytoplankton productivity on ecologically-relevant time and space scales remains challenging. Over the past several years, we have conducted sea-going research to quantify photosynthetic electron transport rates (ETR), carbon fixation rates and photosynthetic pigment quotas. Results from the Subarctic Pacific and Arctic Ocean provide insight into the regulatory mechanisms used by phytoplankton to maximize productivity in response to a range of environmental fluctuations, including variable irradiance regimes and macro and micro-nutrient limitation. In the Subarctic Pacific, results from ^{14}C incubations and Fast Repetition Rate Fluorometer (FRRF) measurements show highly variable ETR : C-fixation rates, indicative of significant physiological regulation of photosynthetic electron sinks. Much of this regulation appears to function as a protective mechanism under high light and nutrient (iron) limiting conditions. Variability in ETR : C-fixation can be empirically related to FRRF-based estimates of non-photochemical quenching (NQP), providing a potential means of deriving carbon fixation rates from autonomous FRRF data. Variability in phytoplankton C : Chl ratios, assessed using particulate absorption and backscatter measurements, also provide information on the light and nutrient-dependent regulation of cellular physiology. Deviations in C:Chl ratio can be used as index of nutrient stress, with derived growth rates used, alongside carbon biomass estimates, to quantify net primary productivity. Comparisons of these optically-derived NPP estimates with standard ^{14}C incubations show significant promise in this approach.