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Dynamic nutrient regime and phytoplankton response in the eastern equatorial Pacific Ocean over the past 25,000 years

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Fully and accurately reconstructing changes in productivity and carbon export and their controls is critical to determining the efficiency of the biological pump and its role in the global carbon cycle through time, particularly in modern CO_2 source regions like the eastern equatorial Pacific (EEP). Here we present new high-resolution records of sedimentary ^{230}Th normalized opal, bulk carbonate, and nannofossil carbonate fluxes and [^{231}Pa/^{230}Th]xs ratios from site MV1014-02-17JC (00° 10.8297' S, 85° 52.0042' W) in the Panama Basin with existing radiogenic isotope, trace metal, and stable isotope records from the same core and other nearby terrestrial and marine sites to generate a multi-proxy record of biological productivity, carbon export, and ocean-atmosphere variability for the EEP that spans the early Holocene to Last Glacial Maximum (LGM) (~9-25,000 years ago). We find that the nutrient regime of the deglacial EEP was very dynamic with variability dependent on the average position of the Intertropical Convergence Zone (ITCZ) and hydrography/circulation in the Southern Ocean, each of which played a role in controlling nutrient delivery to the EEP, upwelling strength, nutrient leakage, and windblown dust flux. Overall, the deglaciation was marked by a shift in phytoplankton community structure coincident with the transition from a more southerly displaced ITCZ at the LGM to a more northerly displaced ITCZ in the early Holocene. Lastly, we determine that common geochemical (xsBa) and biomarker (brassicasterol) proxies are likely not useful for reconstructing productivity in the EEP across this timeframe due to the combined effects of bottom water oxygenation, high sedimentation rates, and frequently fluctuating nutrient delivery. Our work suggests greater scrutiny is required in the interpretation of many common geochemical proxies of productivity and carbon export, and that in general, a multi-proxy approach is preferable, particularly in the EEP.