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Understanding the efficient biological carbon pump in the South Pacific oxygen minimum zone

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The biological pump sequesters carbon in the ocean interior through the production of organic particles in surface waters, followed by their sinking and remineralization at depth. Carbon dioxide released at depths greater than 1000m is sequestered for centuries before returning to the surface, so the proportion of particulate organic carbon (POC) that reaches 1000m before remineralizing is a key determinant of total ocean carbon storage. Multiple lines of evidence show that oxygen minimum zones (OMZs) are regions of slow particle flux attenuation and efficient carbon transfer to depth, but the impact of anoxia on particle transformations is not well understood. Here, we examine two mechanisms that may explain efficient POC transfer through an OMZ, and leverage the distinct imprint they leave in particle size specta to distinguish between them: (i) slower remineralization during the transition from aerobic to anaerobic respiration increases the relative abundance of small particles compared to oxygenated waters, since remineralization preferentially removes slow-sinking particles; (ii) reduced particle disaggregation due to the exclusion of zooplankton from the OMZ preserves large particles over depth, increasing their abundance relative to oxygenated waters. We used a size-resolved particle flux model (PRiSM) that simulates sinking, remineralization, and disaggregation of particles, to test the balance of these two mechanisms needed to explain observations from the Eastern Tropical South Pacific (ETSP) OMZ. When constrained by thorium-based POC flux estimates and size spectra measured by Underwater Vision Profilers, our model detects distinct impacts of anoxia on particle remineralization and disaggregation. The two processes slow down in different portions of the OMZ, and together explain efficient particle transfer to depth. These insights will help predict how carbon storage by the biological pump responds to ocean warming and deoxygenation.