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Plankton networks driving carbon export in the oligotrophic ocean

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The biological carbon pump is the process by which CO_2 is transformed to organic carbon via photosynthesis, exported through sinking particles, and finally sequestered in the deep ocean. While the intensity of the pump correlates with plankton community composition, the underlying ecosystem structure driving the process remains largely uncharacterized. Here we use environmental and metagenomic data gathered during the *Tara* Oceans expedition to improve our understanding of carbon export in the oligotrophic ocean. We show that specific plankton communities, from the surface and deep chlorophyll maximum, correlate with carbon export at 150 m and highlight unexpected taxa such as Radiolaria and alveolate parasites, as well as *Synechococcus* and their phages, as lineages most strongly associated with carbon export in the subtropical, nutrient-depleted, oligotrophic ocean. Additionally, we show that the relative abundance of a few bacterial and viral genes can predict a significant fraction of the variability in carbon export in these regions.

Marine planktonic photosynthetic organisms are responsible for approximately 50% of Earth's primary production and fuel the global ocean biological carbon pump[1]. The intensity of the pump is correlated with plankton community composition[2,3], and controlled by the relative rates of primary production and carbon remineralization[4]. About 10% of this newly produced organic carbon in the surface ocean is exported through gravitational sinking of particles. Finally, after multiple transformations, a fraction of the exported material reaches the deep ocean where it is sequestered over thousand-year timescales[5].

Like most biological systems, marine ecosystems in the sunlit upper layer of the ocean (denoted as the euphotic zone) are complex[6,7], characterized by a wide range of biotic and abiotic interactions[8–10] and in constant balance between carbon production, transfer to higher trophic levels, remineralization, and export to the deep layers[11]. The marine ecosystem structure and its taxonomic and functional composition probably evolved to comply with this loss of energy by modifying organism turnover times and by the establishment of complex feedbacks between them[6] and the substrates they can exploit for metabolism[12]. Decades of ground-breaking research have focused on identifying independently the key players involved in the biological carbon pump. Among autotrophs, diatoms are commonly attributed to being important in carbon flux because of their large size and fast sinking rates[13–15], while small autotrophic picoplankton may contribute directly through subduction of surface water[16] or indirectly by aggregating with larger settling particles or consumption by organisms at higher trophic levels[17]. Among heterotrophs, zooplankton such as crustaceans impact carbon flux via production of fast-sinking fecal pellets while migrating hundreds of meters in the water column[18,19]. These observations, focusing on just a few components of the marine ecosystem, highlight that carbon export results from multiple biotic interactions and that a better understanding of the mechanisms involved in its regulation requires an analysis of the entire planktonic ecosystem.

Advanced sequencing technologies offer the opportunity to simultaneously survey whole planktonic communities and associated

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