Spatiotemporal variation in carbon and nitrogen stable isotope ratios of suspended and settling particles in coral reefs

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Particulate organic matter (POM) is an important carrier of energy and nutrients in oligotrophic aquatic environments such as coral reefs. Major nutrient elements including carbon, nitrogen, phosphorus, silicon, and iron can be transported in the form of sestonic POM by coastal currents from open ocean to coral reefs, where they are captured by particle-feeding organisms, or settle down and are consumed by deposit feeders and microorganisms. Concomitantly, coral reefs produce a variety of POM such as coral mucus and plant detritus, and export them back to the outer ocean. POM also provides a means of material exchange between different habitats within the ecosystem, such as coral-covered reef slope, algal pavement, back-reef lagoon, and seagrass meadows. Elucidating the dynamics of suspended and settling POM is essential to understand functioning, stability, and resilience of the coral reef ecosystem. In this study, we evaluated the variability of the concentration and the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopic compositions of POM in various locations and different seasons at two coral reefs (Shiraho and Itona coasts) of Ishigaki Island, southwest Japan. Depositional flux of POM to several different habitats within the reefs was also estimated using sediment traps. The concentration of POM in the outer ocean was low (<5 μ mol POC L^{-1}) with $\delta^{13}C$ ranging from −24‰ to −19‰ and $\delta^{15}N$ from +3‰ to +5‰. The concentration of POM was elevated in the reef system, especially around seagrass meadows (up to 50 μmol POC L^{-1}). Suspended and settling POM collected within coral-covered habitats showed typically higher $\delta^{13}C$ (−18‰ to −12‰) and slightly lower $\delta^{15}N$ (0‰ to +5‰) than the offshore POM, reflecting contribution of autochthonous organic matter. Suspended POM collected in the nighttime at coral-covered areas sometimes showed much higher $\delta^{15}N$ (+7‰ to +9‰) indicating an accumulation of zooplankton in the water column. The $\delta^{13}C$ and the $\delta^{15}N$ of POM collected in bare sanded backreef lagoon were usually in the midst of POM collected in the offshore and the coral covered areas. The $\delta^{13}C$ of POM in the overlying water of seagrass meadows was even higher than that in the coral-covered habitats, occasionally exceeding −10‰. Both the sinking flux of POM and the $\delta^{13}C$ of sinking POM were generally higher in summer than in winter. Endmember $\delta^{13}C$ and $\delta^{15}N$ values of source organisms including hermatypic corals, zooxanthellae, seagrasses, seagrass epiphytes, and macroalgae as well as some particle- and deposit-feeding organisms have been separately determined. Comparison of POM and these endmembers suggested that contributions of these internal and external (offshore) sources to the POM pool at particular habitats varied depending on location of the habitats, season, tidal cycle, and diurnal cycle. Using these data, we discuss potential importance of nutritional linkage by the transport of POM between the outer ocean and corals and between different habitats such as corals and seagrass meadows.

Keywords: particulate organic matter, coral reefs, seagrass beds, sinking flux, provenance analysis

