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Aggregation and fragmentation of sedimenting particles in marine environments

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Marine particles can be broadly divided into the categories of suspended or sinking particulate matter. Sinking particles form an important link in the biological pump by mediating transport of surface-derived organic carbon out of the upper ocean to the ocean interior and seafloor. These large particles typically arise either from coagulation of smaller, suspended particles or from the production of feeding webs and fecal pellets by zooplankton. Coagulation of small particles to form larger particles occurs primarily in surface waters as aggregation is dependent on physical shear stress, particle concentration, and adhesion. The abundance of these sinking detrital aggregates, known as marine snow, decreases rapidly between the base of the mixed layer and 1000 m indicating that important removal processes are occurring in the mesopelagic zone. Several mechanisms of marine snow removal have been suggested including abiotic physical fragmentation by wind-induced shear stress or convective overturn. However, the strength of marine snow aggregates is typically at least an order of magnitude greater than energy dissipation rates generated in surface waters even during storm events. Recently a novel biotic mechanism of fragmentation has been described: the disruption of marine snow by swimming macrozooplankton, specifically euphausiids. As macrozooplankton migrators traverse the mesopelagic their swimming and feeding can disrupt particles. This releases interstitial nutrients, alters the surface area available for microbial colonization, and reduces particle sinking rates. Such fragmentation processes are likely to be important in eutrophic regions where macrozooplankton and marine snow are abundant and sedimentation is high. This balance between marine snow aggregation and degradation is critical both in determining carbon sedimentation patterns and food web structure for organisms reliant on this particle rain.