Factors controlling the flux of organic carbon to the bathypelagic zone of the ocean

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Multiple linear regression between mean annual satellite-derived estimates of export production and settling fluxes measured with deep (>2000m) moored sediment traps at 68 diverse oceanic sites reveals that the fraction of the flux of organic carbon exported from the euphotic zone that reaches the bathypelagic zone of the ocean is directly related to the accompanying flux of calcium carbonate and inversely related to seasonality. Similar statistical relationships also show a strong inverse relationship with the mean annual f-ratio and a strong positive relationship with mean annual SST. In contrast, the transfer efficiency of organic carbon to the deep sea is essentially unaffected by the accompanying flux of biogenic opal, while the flux of lithogenic material is generally too low at open ocean sites to have a significant impact. These statistical correlations suggest that the ballasting effect of carbonate minerals, and possibly a "packaging" factor statistically related to carbonate production (e.g. hydrodynamic fecal pellets in carbonate-dominated regions versus loose aggregates in opal-dominated regions), may be important factors promoting the transfer of organic carbon to the deep sea. The negative correlation with seasonality and f-ratio and positive correlation with SST are tentatively interpreted as reflecting the effect of the biodegradability of the exported organic matter. Organic matter exported from cold, highly seasonal regions with high f-ratios, which are often dominated by diatoms, may be more labile and prone to degradation in the mesopelagic zone than organic matter exported from warm, carbonate-dominated regions with low f-ratios, where complex food webs and the microbial loop more effectively process organic matter before export. We thus postulate that higher mesopelagic respiration in cold regions results from the settling of more biodegradable organic matter in the form of loose aggregates. In warm, carbonate-dominated regions, higher transfer efficiency through the mesopelagic zone would reflect the export of more refractory organic matter packaged into more hydrodynamic fecal pellets. As a result, low latitude productive regions (e.g. Arabian Sea, equatorial upwelling regions) are the most efficient open ocean sites at transferring organic carbon from the base of the euphotic zone to bathypelagic depths. The resulting algorithm appears globally applicable and is able to explain > 80% of the variability in the transfer efficiency of organic carbon to the deep sea. Comparing the new algorithm to Martin's equation suggests that the exponent of the latter algorithm (b) must be adjusted systematically between oceanic regions proposed to accurately predict carbon fluxes at depth > 2000m. In high latitude productive oceanic regions, $b < -1$; in low latitude productive oceanic regions, $b > -0.7$; and in low latitude oligotrophic and mesotrophic regions, $-1.0 > b > -0.7$, close to Martin's original value of -0.86.