Spatiotemporal patterns of carbon remineralization and bio-irrigation in sediments of Casco Bay Estuary, Gulf of Maine

Green, Mark A., Jeanne D. Gulnick, Nathaniel Dowse, Patience Chapman

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ABSTRACT: We measured the seasonal and spatial rates of organic matter decomposition and pore-water irrigation at four subtidal stations in Casco Bay estuary, Gulf of Maine. Organic carbon decomposition and associated flux from sediments showed strong seasonal fluctuations, with averaged highs of 44.9 (±4.9) mmol dissolved inorganic carbon (DIC) m^{-2} d^{-1} during August and lows of 8.6 (±1.6) mmol DIC m^{-2} d^{-1} during January. Apparent activation energies ($E_{a\text{-}app}$) ranged from 61 (±5.5) to 83 (±14.5) kJ mol^{-1} in the 0-1 and 2-3 cm layers of sediments, respectively, which reflects a decrease in carbon reactivity with depth. Spatial differences in surface $E_{a\text{-}app}$ correlate with C:N ratios in pore water, with lowest $E_{a\text{-}app}$ levels at stations with lowest C: N; ratios, which is consistent with the remineralization of recently formed organic matter. In addition, there was a significant time-dependent change in the transport mechanism between sediments and overlying water. Br_2 tracer experiments, comparison of flux estimates, and diagenetic transport-reaction models all independently showed that transport increases significantly because of the activities of benthos during spring, summer, and fall, when rates are ~3 times higher than simple diffusion alone. Biologically enhanced transport resulted from the high density of benthos (>1.0 mm, ~7,000 m^{-2}), with the nephtyid polychaete *Aglaophamus neotenus* and the spionid polychaete *Prionospio steenstrupi* being most abundant. The polychaete *Owenia fusiformis* and the burrowing, deposit-feeding amphipod *Casco bigelowi* were also important. These results further confirm the importance of understanding seasonal variability in both carbon degradation and the influence of benthic organisms in controlling material exchange between sediments and water in estuarine systems.