

Stoichiometry of Dissolved Organic Matter at the Land-Ocean Interface of the North Sea

Wiebke Freund^{1*}, Thorsten Dittmar^{1,2}, Tina Sanders⁴, Philipp Böning¹, Michael Seidel¹

¹ Institute for Chemistry and Biology of the Marine Environment (ICBM), School of Mathematics and Science, Carl von Ossietzky Universität Oldenburg, Oldenburg, Germany

² Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg (HIFMB), Oldenburg, Germany

³ Institute of Coastal Environmental Chemistry/Department Inorganic Environmental Chemistry, Helmholtz-Zentrum Hereon, Geesthacht, Germany

⁴ Institute of Carbon Cycles, Helmholtz-Zentrum Hereon, Geesthacht, Germany

Dissolved organic matter (DOM) is a major oceanic carbon pool containing nitrogen (DON), phosphorus (DOP), and sulfur (DOS), which influence nutrient cycling and carbon dynamics. Lateral transport of DOM is a key pathway linking coastal production and sedimentary processes to the open ocean, yet the role of coastal seas in altering DOM stoichiometry and exporting recalcitrant fractions remains poorly understood. We combined elemental stoichiometry analyses with ultrahigh-resolution mass spectrometry of solid-phase-extracted DOM to trace sources and transformations across the southern North Sea, from river plumes and intertidal porewaters to offshore waters. The DOM composition reflected distinct endmembers: heteroatom-depleted terrestrial DOM nearshore, N- and P-rich, biologically fresh DOM in productive coastal zones; S-rich DOM from intertidal sediments; and low-heteroatom, marine DOM offshore. DOS showed strong nearshore enrichment from porewater outwelling, with high S/C ratios indicating abiotic sulfurization. Stoichiometric and molecular patterns revealed that the Wadden Sea acts as a biogeochemical reactor, contributing to the formation and export of both labile and recalcitrant DOM. DOM is laterally transported across the shelf to the North Atlantic Ocean, where labile fractions fuel food webs, and refractory DOM probably contributes to the long-term deep-ocean carbon pool.