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Ocean metabolism and dissolved organic matter: How do small dissolved molecules persist in the ocean?

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The ocean reservoir of dissolved organic matter (DOM) is among the largest global reservoirs (∼700 Pg C) of reactive organic carbon. Marine primary production (∼50 Pg C/yr) by photosynthetic microalgae and cyanobacteria is the major source of organic matter to the ocean and the principal substrate supporting marine food webs. The direct release of DOM from phytoplankton and other organisms as well as a variety of other processes, such as predation and viral lysis, contribute to the ocean DOM reservoir. Continental runoff and atmospheric deposition are relatively minor sources of DOM to the ocean, but some components of this material appear to be resistant to decomposition and to have a long residence time in the ocean. Concentrations of DOM are highest in surface waters and decrease with depth, a pattern that reflects the sources and diagenesis of DOM in the upper ocean. Most (70-80%) marine DOM exists as small molecules of low molecular weight (<1 kDalton). Surprisingly, high-molecular-weight (>1 kDalton) DOM is relatively enriched in major biochemicals, such as combined neutral sugars and amino acids, and is more bioavailable than low-molecular-weight DOM. The observed relationships among the size, composition, and reactivity of DOM have led to the size-reactivity continuum model, which postulates that diagenetic processes lead to the production of smaller molecules that are structurally altered and resistant to microbial degradation. The radiocarbon content of these small dissolved molecules also indicates these are the most highly aged components of DOM. Chemical signatures of bacteria are abundant in DOM and increase during diagenesis, indicating bacteria are an important source of slowly cycling biochemicals. Recent analyses of DOM isolates by ultrahigh-resolution mass spectrometry have revealed an incredibly diverse mixture of molecules. Carboxyl-rich alicyclic molecules are abundant in DOM, and they appear to be derived from diagenetically-altered terpenoids, such as sterols and hopanoids. Thermally-altered molecules, including black carbon, also appear to be important components of DOM, but their origins are unclear. We are rapidly acquiring novel information about the composition and molecular identity of DOM, and novel insights about the origins, transformations and fates this vast reservoir of DOM are emerging. This presentation will review and synthesize this information for comparison with non-living organic matter in other systems.