CYCLING OF ORGANIC MATTER BY BACTERIOPLANKTON IN PELAGIC MARINE ECOSYSTEMS: MICROENVIRONMENTAL CONSIDERATIONS

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INTRODUCTION

Recently developed methods for measuring production rates of heterotrophic bacteria have shown that the bacterioplankton is a major route for the flux of material and energy in marine ecosystems (Hagström et al., 1979; Fuhrman and Azam, 1980, 1982; Williams, 1981). Even conservative estimates (Fuhrman and Azam, 1980, 1982) show that the measured bacterial productivity corresponds to 10-50% of the primary productivity.

The discovery that bacteria utilize a large fraction of primary productivity is in apparent contradiction with the conventional wisdom that dissolved organic matter (DOM) is too dilute to support significant bacterial growth (Stevenson, 1978). Bacteria, however, can only utilize DOM; particulate organic matter (POM), as well as dissolved polymers, must first be hydrolyzed to small molecules, generally monomers. Fuhrman and Azam (1982) used microautoradiography and size-fractionation to show that free-living bacteria (rather than those attached to POM) are responsible for most of the bacterial secondary productivity.

Concentrations of most DOM components in seawater range from 10^{-12}M to 10^{-8}M (Mopper and Lindroth, 1982; Ammerman and Azam, 1981; Mopper et al., 1980. DOM is, however, produced at a discrete loci in seawater. High DOM concentrations are expected near a phytoplankter that is exuding organic matter or is autolyzing. Loss of intracellular pools of the prey damaged during predation (Lampert, 1978; Copping and Lorenzen, 1980) may also create microzones rich in DOM. Organic detritus colonized by bacteria is also expected to be a

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source of DOM, and high concentrations may exist in close proximity to such particles. These considerations raise questions regarding the nature of coupling between DOM production and its utilization by bacteria.

This paper will discuss whether new DOM is utilized at high concentrations by bacteria within the production microzone or whether much of it diffuses into the (exceedingly dilute) bulk-phase before being utilized by bacteria. We propose a conceptual model of bacterial cycling of organic matter which takes into account the possibility of microenvironmental nutrient gradients and the ability of bacteria to respond to them to maximize nutrient uptake.

SOURCES AND MODE OF DOM PRODUCTION

Figure 1 shows the main sources and mechanisms which introduce DOM into seawater. Most DOM comes from phytoplankton [via exudation, autolysis, and sloppy-feeding (cellular pool spillage during zooplankton feeding)], zooplankton (via excretion), and organic particles (via depolymerization). These processes channel about one-half of the primary productivity into the DOM pool (Williams, 1981). Bacteria can directly utilize some DOM components such as sugars and amino acids ("utilizable DOM"; UDOM). Some other components are utilizable after chemical modification (e.g. dissolved proteins and polysaccharides are hydrolyzed before uptake). The above distinction is important in considering the spatial and temporal coupling between

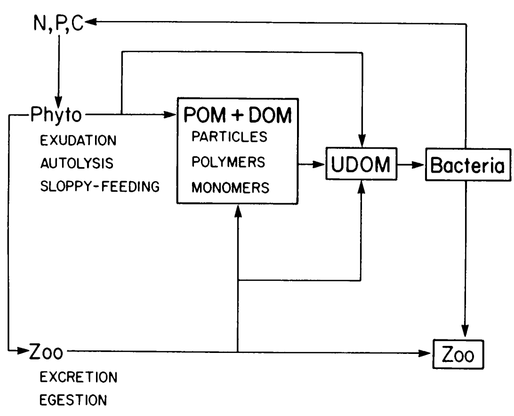

Fig. 1. Sources and pathways of utilizable dissolved organic matter (UDOM) in seawater. DOM = dissolved organic matter; POM = particulate organic matter; sloppy-feeding = spillage of algal cell contents during feeding by zooplankton; phyto = phytoplankton; zoo = zooplankton; N, P, C = inorganic nitrogen, phosphorus, and carbon, respectively.