



Submillimeter life positions of bacteria, protists, and metazoans in laminated sediments of the Santa Barbara Basin

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ABSTRACT: To provide insights into the biogeochemistry of environments where steep chemical gradients place anaerobes, microaerophiles, and aerobes in close proximity, it might be necessary to survey biotic distributions on scales that are not possible using conventional ecological approaches. To overcome such limitations, we adapted sedimentological and cell biological methods to examine the life positions of microbes within sediments. This fluorescently labeled embedded core (FLEC) technique was used to survey the submillimeter distributions of eukaryotic nanobiota and meiofauna, plus co-occurring prokaryotes, inhabiting laminated sediments of the bathyal Santa Barbara Basin (SBB; 34° 13'N, 120° 02'W). Although SBB sediments were vertically structured on the scale of millimeters (i.e., as laminae), and microelectrode profiles suggested vertically distinct oxygenated and anoxic-sulfidic layers, the distributions of aerobes, microaerophiles, and sulfide-tolerant anaerobes were not concomitantly structured. Unprecedented associations were observed among microorganisms. For example, relatively deep in the sediments, where high sulfide concentrations were expected, flagellates were intimately associated with *Beggiatoa*. Ciliates were typically solitary, whereas flagellates were often aggregated in nearly monomorphotypic swarms of $>3 \times 10^4 \text{ mm}^{-3}$. Such aggregations could significantly affect geochemical pore-water processes at scales $<1 \mu\text{l}$. Our observations indicate that a mosaic of chemically heterogeneous microhabitats exist in both vertical and horizontal dimensions, suggesting that biogeochemical processes in the SBB are more complex than predictions based on standard biotic assessments and microelectrode profiling.

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