THE EFFECTS OF CORAL-ROUGHNESS ON MASS TRANSFER

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Abstract

The uptake of nutrients (nitrogen and phosphorus compounds) into coral reef communities is proposed to be limited by diffusion through a depleted boundary layer between the water and the organisms, or what is termed "mass transfer limitation". Theory from the engineering literature indicates that increased surface roughness should increase mass transfer; thus in this project the effects of coral-roughness on mass transfer were investigated experimentally using the dissolution of gypsum (plaster-of-paris) in fresh water from coral-shaped surfaces. The dissolution rate was measured as an increasing concentration of calcium ions over time in a flume of constant volume. The technique was first applied to a flat, smooth surface of gypsum over a wide range of temperatures and ionic strength. Stanton numbers (St_m, a dimensionless number giving the ratio of uptake rate per unit area to the rate of advection of the substance past the uptake surface) of experimental smooth surfaces ranged from 2.6-3.5 $\times 10^{-5}$ and were within 15% of engineering literature values. Stanton numbers for coral-shaped surfaces ranged from 70 $\times 10^{-5}$ at 0.03 m s^{-1} to 17 $\times 10^{-5}$ at velocities up to 0.50 m s^{-1}, and were in general 9 ± 1 times that of smooth surfaces. The results are compared (using St_m) with flume studies on experimental coral communities, and engineering literature. The relationship between mass transfer, friction and roughness of coral-shaped gypsum surfaces can be predicted from correlations of heat transfer from sand-roughened pipes. Results presented provide confirmation of Bilger and Atkinson's (1992) model of nutrient uptake being mass-transfer limited and can be used to predict nutrient-uptake into living coral reef communities.