WAVE-FORCED POREWATER MIXING AND NUTRIENT FLUX IN A CORAL REEF FRAMEWORK

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ABSTRACT

Surface waves passing over coral reef flats should induce an oscillatory motion of framework interstitial waters and, in the presence of a downward increase in porewater nutrient concentrations, may enhance through dispersion the flux of interstitial nutrients to the overlying waters and marine organisms at the reef surface. These processes were examined through the use of a cross-reef array of well point-samplers, and electronic recording of hydraulic head variations on and within the framework of a small patch reef, Checker Reef, located in central Kaneohe Bay, Oahu, Hawaii. Spectral analyses of the head time series allowed the development of two hydrological models of wave-induced chemical flux, macroscopic dispersion and megadispersion, and allowed the comparison to fluxes driven only by molecular diffusion. Wave-induced pressure head was usually measured at 1 and 2 m framework depth, although it was measured in detail over the upper meter of the fore-reef framework. Spectral analysis of the time series of pressure head variations yielded relationships between wave-frequency and (1) the spectral variance of the mean normalized amplitude, and (2) the cross-spectral phase and coherence between the mean-normalized amplitude and the net head. At sediment depths of 2 m, waves with periods >2-20 s were not detected, although internal waves with periods of around 30-60 s were still present. The ranges of the calculated mean fluxes due to macroscopic dispersion for February, 1992, were 1-10 μmoles PO_4 m^{-2} d^{-1}, 1-73 μmoles NO_3+NO_2 m^{-2} d^{-1}, 6-41 μmoles NH_4 m^{-2} d^{-1}, and 10-198 μmoles Si m^{-2} d^{-1}. The mean fluxes for February 1992 by wave-driven megadispersion were 140-1540 μmoles PO_4 m^{-2} d^{-1}, 60-27220 μmoles NO_3+NO_2 m^{-2} d^{-1}, 640-15560 μmoles NH_4 m^{-2} d^{-1}, and 1780-70170 μmoles Si m^{-2} d^{-1}. The close agreement between the megadispersive fluxes and flux estimates by previous researchers using independent techniques suggests that wave-induced flux by megadispersion was the controlling mechanism driving nutrient fluxes through the framework pore space. The large difference between the modelled megadispersive flux and observed benthic chamber-derived fluxes indicated substantial (90%) autotrophic consumption of interstitial nutrients within the upper few centimeters of the framework, and at rates similar to that of the overlying reef autotrophs.