Enhancement of vertical mixing and upwelling by artificial mound in the shallow ocean

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An artificial mound was settled at the shallow ocean at 33 28 41 N and 129 25 29 E (north-northwest to Ikutsuki Island) for enhancing vertical mixing and consequently carrying the nutrients from the bottom to surface layer aiming at rich primary production. The depth of water at this site is about 80 m, and the height and horizontal length of the mound are 12 m and 60 m, respectively. In order to understand the flow characteristics near the mound, vertical shear was measured by two kinds of ADCPs; one was loaded on a moving boat and the other was settled at the sea bottom. Stratification was also measured regularly by a CTD.

Energy dissipation rate and diapycnal diffusivity were estimated from vertical shear and stratification, by using the Gregg and the Osborn models, respectively. Spatial and temporal distributions of diapycnal diffusivity were obtained from moving and fixed ADCPs, respectively. The estimated diapycnal diffusivity ranged from O (10^{-5}) to O (10^{-2}) m^2/s, with spatial and temporal variations. It was found that dissipation of kinetic energy occurs differently in the two flow regimes characterized by the Richardson number (hereafter Ri). In the large Ri regime, horizontal zones of high diffusivity appear at the middle depth. These may be caused by the density stratification, the distribution of which is not uniform. The effect of the artificial mound was not found at this regime. In the small Ri regime, on the other hand, the enhanced diapycnal diffusivity is distributed above the mound. This locally-enhanced diffusivity is considered to be resulted from the dissipation of internal waves generated from the mound. The temporal distribution of energy dissipation rate near the mound shows that the energy dissipation follows the current speed in the large Ri regime, while it does not in the small Ri regime.

In order to quantify the contribution of diapycnal diffusivity to the upwelling, simplified numerical simulations of nutrient diffusion were carried out by using the estimated vertical diffusivities. The result of the simulations show the more nutrients are transported upward near the mound in the small Ri regime than the large Ri regime by the association of the locally enhanced vertical flux and the effect of tidal advection.