

Investigating vertical mixing in estuarine pycnocline: a case study in the Ariake Sea, Japan

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Turbulent mixing controls coastal environment and primary production through transportation of heat, freshwater, and various materials. Vertical mixing in pycnocline plays a key role in occurrence of major environmental problems in semi-enclosed seas and estuaries, such as bottom hypoxia and red tides, although it is not fully understood. For better understanding and prediction of coastal mixing processes, we investigate pycnocline mixing in a tidally-energetic shallow (~20 m) estuary, the Ariake Sea, Japan, where stratification is maintained almost throughout a year by large amounts of freshwater inputs from major rivers. We collected more than 5,000 microstructure turbulence profiles (~530-hour measurements) in several stations in the central area of the sea during 24-cruises conducted in various seasons over 2002-2012, and examined Turbulent kinetic energy (TKE) dissipation rate in the shear- and buoyancy-frequency space. TKE dissipation rates in pycnocline exhibited a broad variability, $O(10^{-9}) - O(10^{-5}) \text{ W kg}^{-1}$, while most of them fell into a range where the gradient Richardson number is larger than a critical value, i.e., $Ri_g > 1/4$. In stratified seasons, we frequently observed high-vertical wavenumber internal tides in the pycnocline around the microstructure stations from separately-conducted mooring observations using acoustic Doppler current profilers. The large variability in the mixing around pycnocline is therefore likely to be originated from internal wave breaking and shear instability. We found an ordered structure of mean dissipation rate where it correlates positively with vertical shear, which gives a clue to improving a “background” vertical diffusion parameterization in numerical ocean models.

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