Estimating internal tidal current in a tidally-energetic shallow estuary, Ariake Sea, Japan

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Coastal ocean mixing affects transfer of materials, heat and freshwater not within a local sea but also among ocean, land and atmosphere. It results largely from tides. Surface tides, which are propagating towards coastal sea from open-ocean, are mostly dissipated by local frictional processes at coastal boundaries while internal waves, especially ones at tidal frequencies, redistribute a certain fraction of the surface-tide energy for the coastal ocean mixing. Estimating such an internal-tide energy in the coastal ocean is therefore important to understand the coastal marine processes, although it is sometimes challenging in shallow areas because significant bottom boundary layer (BBL) makes it difficult to make a common assumption when we estimate internal-tide current velocity: surface (barotropic) tidal current is depth-independent and internal (baroclinic) tidal one is anomaly from it. In this study, we develop a method estimating internal tidal current in regions where surface tidal current forms a bottom boundary layer at significant part of the water column. We observed tidal currents using bottom-mounted acoustic Doppler current profilers for a fortnight cycle in highly stratified season in the Ariake Sea, a shallow estuary (mean depth is ~20 m) located on southwest of Japan. Surface tide in the sea is dominated by semidiurnal constituents and the semi-diurnal current speed reached ~0.8 m s^{-1} in spring tide, exhibiting a well-developed bottom boundary layer structure. Based on the bottom Ekman balance, we estimated vertical profile of tidally-averaged vertical eddy viscosity from the harmonic coefficients of the observed velocity. The estimated viscosity was fairly consistent with the estimate from simultaneous measurements of microstructure turbulence. We calculated semi-diurnal surface-tide current profile including the BBL component based on the bottom Ekman balance and the estimated eddy viscosity, and then obtained semi-diurnal internal tidal current by extracting the surface-tide velocity from net semi-diurnal velocity. The estimated internal-tide velocity was in-phase with vertical elevation of pycnocline, suggesting a propagating nature of semi-diurnal internal tide during the observational period.

Keywords: internal tide, shallow seas, vertical eddy viscosity, bottom boundary layer, Ariake Sea

