Abstract View

Volume 9, Issue 5 (September 1979)

Journal of Physical Oceanography
Article: pp. 962–974 | Abstract | PDF (907K)

Tidally Induced Residual Currents in Estuaries of Variable Breadth and Depth

John P. Ianniello

Marine Sciences Institute, University of Connecticut, Groton 06340

(Manuscript received October 6, 1978, in final form May 24, 1979)

DOI: 10.1175/1520-0485(1979)009<0962:TIRCIE>2.0.CO;2

ABSTRACT

Analytic solutions are derived for the longitudinal and cross-channel Eulerian and Lagrangian residual currents induced in narrow tidal channels of variable breadth and depth, but rectangular cross section, by the nonlinear interactions of the first-order tides. The solutions are shown to be valid as long as the system is weakly nonlinear such that $g\eta_0\sigma^{-2}\Delta x^{-2} \ll 1$, and as long as breadth variations are sufficiently gradual that $fb_0\sigma^{-1}\Delta x^{-1} \ll \eta_0$ is a typical tidal amplitude. g is the acceleration of gravity, σ the tidal frequency, Δx the length scale over which the breadth changes, f the Coriolis parameter and b_0 the channel width.

Results are given for channels with exponentially decreasing breadth and depth profiles and for a channel with a constriction in the breadth profile. These results indicate that significant differences from the residual currents in constant breadth and depth channels occur for all three types, but especially for the constricted channel. For this channel a strong two-layer structure with a divergence in the surface water and a convergence in the bottom water, centered at the constriction, is generated for both the Eulerian and Lagrangian currents. This two-layer flow reinforces any two-layer density-induced circulation seaward of the constriction and opposes it landward of the constriction. The existence of a two-layer flow has important implications for the estuarine circulation; further-more, since such a two-layer flow will not appear in depth-averaged models of the residual currents induced in narrow tidal channels, it may confound attempts to verify such models from measurements.