Abstract View

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Three-Layer Circulations in Estuaries and Harbors

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ABSTRACT

A theory is developed for the three-layer circulation in an overmixed estuary (finite fresh-water influx) or harbor (zero fresh-water influx) accompanying a two-layer structure in the large body of water outside. A determinate act of algebraic equations is derived for the general case and the form of the equations shows that for zero fresh-water influx the discharge q_1 from a harbor is proportional to the square root of the density difference between the two outside fluids.

The problem is solved completely when there is a uniform depth H of the fluids inside and outside the harbor, when the fresh-water influx is zero, and when the two layers of fluid outside the harbor are of equal thicknesses. The solution shows that the outflowing layer of water has a thickness $d=H/2$ and a flux $q_1=HW(H\Delta b_0)^{1/2}/8$, where W is the width at the constriction and Δb_0 the buoyancy difference between the two outside layers of water.

A laboratory model reproduced the three-layer circulation of the theory. The outflowing fluid was quite turbulent and this made the observation of the layer thickness uncertain but it appeared to be close to the value $d=H/2$ of the theory.