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The Propagation of Gravity Currents along Continental Shelves

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ABSTRACT

An analytical method for computing the speed at which the nose of a light (rotating) intrusion advances along a continental shelf is proposed. The nonlinear model includes two active layer; the intrusion itself, which occupies the entire shelf (and extends beyond the shelf break), and the heavy fluid situated both ahead of the intrusion and in the deep ocean. The section of the intrusion which extends beyond the shelf break overlies an infinitely deep ocean. Friction is neglected but the motions near the intrusion's leading edge are not constrained to be quasi-geostrophic nor are they constrained to be hydrostatic.

Solutions for steadily propagating currents are constructed analytically by taking into account the flow-forces behind and ahead of the nose, and considering the conservation of energy and potential vorticity. This procedure leads to a set of algebraic equation which are solved analytically using a perturbation scheme in ϵ, the ratio between the internal deformation radius and the shelf width.

It is found that all the heavy fluid ahead of the intrusion is *trapped* and cannot be removed from the shelf. Namely, it is pushed ahead of the intrusion's leading edge as the gravity current is advancing behind. Unlike intrusions without a shelf, which can never reach a truly steady propagation rate (in an infinitely deep ocean), the intrusion in question propagates *steadily* when $\epsilon \to 0$. Under such conditions, the propagation rate is given by $(2g'D)^{1/2}$, where g' is the "reduced gravity" and D is the intrusion depth at the shelf break [note that $D \gtrsim H$, where H is the (uniform) shelf depth, so that at the shelf break the intrusion is deeper than the shelf].

Possible applications of this theory to various oceanic situations, such as the Skagerrak outflow, are mentioned.

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