Abstract View

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Steady Coastal Upwelling Induced by an Along-Shore Current

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ABSTRACT

Studies of frictionally induced motions of continental shell water near a large-scale ocean current reveal the possibility of strong coastal upwelling whenever the straight coast lies to the left of the current direction in the Northern Hemisphere and to the right of it in the Southern Hemisphere. In a homogeneous ocean with linear dynamics, this is apparently a consequence of the adjustment necessitated by the presence of bottom friction over the continental shelf which causes reduction of the Coriolis acceleration and allows the development of an onshore flow near the bottom due to the unbalanced pressure gradient. As a result, a one-sided subsurface mass convergence is established. In a vertical section normal to the coast, viewed in the direction of the current, the streamlines thus form a clockwise gyre in the Northern Hemisphere and a counterclock-wise gyre in the Southern Hemisphere. In both cases, strong coastal upwelling appears. In the presence of a subsurface countercurrent offshore, the region of upwelling is displaced toward the shelf edge. Inshore sinking of coastal water occurs.

The analysis employs Fourier series expansions in distance away from the coast and depth from the sea surface. The final solution of the velocity field is expressed in terms of convergent infinite series. Numerical examples simulating major upwelling areas (Oregon, Peru and Gulf of Mexico Coast) are then worked out and discussed to illustrate the essential dynamics.