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Steady Wind-driven Upwelling in the Presence of a Baroclinic Coastally Trapped Jet

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ABSTRACT

The usual two-layer model for steady wind-driven upwelling along a uniform coastline is extended to incorporate the effects of an upper-layer jet trapped against the coast. The characteristic width of the jet is the internal deformation radius, so the jet Rossby number in the governing equations for the upper layer is order of unity, and the nonlinear term involving cross-stream shear must be retained. It is shown, however, that the equations can be reduced to a manageable form when the upper-layer thickness and equilibrium displacement of the interface are both much less than the total depth. Explicit solutions are obtained for equilibrium jet profiles for which the interface is either exponential, which corresponds to a frictionless jet with uniform potential vorticity, or parabolic. It is also shown that solutions should be obtainable when the jet profile can be expressed as an arbitrary polynomial in the offshore coordinate. The principal differences between our results and the usual ones for the no-jet case are that upwelling is reduced at the coast and amplified offshore. The differences are due to a reduction in the divergence of the on-offshore velocities within an internal Rossby radius of the coast and to increased divergence farther offshore. These changes in divergence are the result of the equilibrium displacement of the interface through the continuity equation and of advection of mean flow momentum by wind-induced offshore motion through the cross-stream shear.

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