

TITLE: The Role of Topography in Coastal Upwelling and
Cross-Shelf Exchange. II: A Numerical Study

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ABSTRACT

Coastal topographic variations have been hypothesized to play a role in controlling upwelling centers and enhancing the cross-shelf exchange of water masses. In this study, a numerical model is used to verify these hypotheses and to assess the specific role of topography in the coastal region off California. Process-oriented experiments based on an idealized coastal model as well as a realistic simulation of the California current system are performed.

In the idealized model, several upwelling centers and a wavelike density front develop; each center is located on the downhill side of a topographic high. The velocity field contains a broad coastal jet meandering southward, with an anticyclonic eddy forming on its offshore side and a cyclonic eddy forming on its onshore side near a topographic high. The anticyclonic eddy, on the uphill side of a topographic high, enhances offshore transport of coastal water while the cyclonic eddy, on the downhill side of a topographic high, enhances onshore transport of deep ocean water. With relaxation of surface winds, the meandering jet becomes unstable to break the continuity of the alongshore flow by forming detached eddies and cold filaments from the upwelling centers. Sensitivity analyses show that the cross-shelf exchange of water masses is increased greatly, about 60 times, compared to the case without alongshore-varying topography.

In the California coastal model, cold filaments, meanders, and eddies are the dominant features along the upwelling fronts and appear more intense around capes or headlands, remarkably similar to satellite observations. Cross-shelf exchange of water masses is found to concentrate near topographic features and reaches about 15 Sv of water moving offshore near the locations of C. Blanco, Pt. St. George, C. Mendocino, Pt. Arena, and Pt. Reyes.

The results of these experiments reveals consistent agreement with theoretical results and indicates that bottom topography does indeed play a dominant role in enhancing cross-shelf exchanges and controlling their locations. A topographic index is introduced to identify the possible locations of strong cross-shelf exchange of water masses. Implications of the exchange of biogeochemical fluxes between continental shelves and deep ocean are discussed.