CIRCULATION AND MATERIAL TRANSPORT IN A PARTIALLY STRATIFIED ESTUARY: WINYAH BAY, SC

By

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ABSTRACT

The along-channel residual circulation pattern of Winyah Bay estuary is examined using stationary and shipborne current measurements. In the lower estuary, residual flow is directed seaward and landward in the channel and shoals, respectively, suggesting that the residual flow is tidally induced. In contrast, the upper and middle parts of the estuary exhibit a typical baroclinic residual circulation. The presence of bifurcated channels in the middle part of the estuary modifies the gravitational circulation: the near-bed landward-directed residual flow is stronger in the deeper main channel than the shallower western channel. This is due to the fact that the magnitude of residual flow scales with the water depth of the channel and it is confirmed by analytical modeling.

In a left curved section of the estuary, analysis of the transient momentum equation for lateral flows showed that the centrifugal forcing dominates over baroclinic pressure gradient. Thus counterclockwise and clockwise circulation (when looking up-estuary) patterns develop during ebb and flood, respectively. During flood, lateral current in the surface layer was directed toward the right, which transported sediments from the left shoal to the center of the channel. Lateral sediment fluxes averaged over a tidal cycle represents convergence of suspended sediments to the center of the channel, contributing to the development of the estuarine turbidity maximum at the location of maximum channel curvature. Tidal decomposition results showed that this convergence originated from oscillatory tidal component.

A protocol for the measurement of particulate organic carbon (POC) concentrations using optical and acoustic instruments was developed and applied for estimating the along-channel fluxes of POC in the estuary. The results showed that net POC fluxes were directed up-estuary in the channel during both low and high discharge periods. Only the residual fluxes during high discharge condition were directed to down-estuary in the surface layer. Our findings suggest that this import of suspended particles, including POC, contribute to the development of an estuarine turbidity maximum in the upper part of the estuary, and is attributed mainly to residual rather than tidal fluxes.