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Responses of estuarine salinity and transport processes to potential future sea-level rise in the Chesapeake Bay

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Abstract

Understanding the changes of hydrodynamics in estuaries with respect to magnitudes of sea-level rise is important to understanding the changes of biogeochemical processes that are coupled tightly with the physical processes. Based on the 21st century sea-level rise scenarios projected by the U.S. Climate Change Science Program (CCSP, 2009), the Chesapeake Bay was chosen as a prototype to study the responses of the estuary to potential future sea-level rise. The numerical model results show that the average salt content, salt intrusion length, and stratification will increase as sea level rises. The changes of these parameters have obvious seasonal and inter-annual variations. Both the salt content and stratification show more increase in spring (following the high-flow periods) and wet years than in autumn (following the low-flow periods) and dry years. The salt intrusion length has larger increase and greater standard deviation in autumn

than in spring. The transport time scales are used to illustrate the variations of transport processes as sea level rises, and results indicate that (1) the exchange flow would be strengthened but the downstream transport of fresh water would be slower; (2) the residence time of the Bay would increase due to the increased volume and change of circulation; (3) the vertical transport time (reference to water surface) has more pronounced increase and the volume of water mass with different age groups increases with different rates. As a result, the retention time of dissolved substances in the Bay would increase. Although the increased tidal currents would strengthen the vertical mixing, the increased stratification would weaken the vertical exchange. The increase of vertical transport time is due to the impact of stratification changes, which overwhelms the impact of tidal changes. As the bottom dissolved oxygen (DO) supply is predominated by the vertical exchanges in the Chesapeake Bay, the increased upstream transport time has a weak impact on hypoxia conditions in the middle and upper portions of the Bay. The weakened vertical exchange would result in less DO supply from the surface to the bottom layer.

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Keywords

sea-level rise; salinity; stratification; transport process; time scale; Chesapeake Bay

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