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Chesapeake Bay hypoxia: Relative impacts of nitrogen entering from the land, the atmosphere, and the coastal ocean

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Very few studies of estuarine hypoxia have simultaneously examined the impacts of nutrients from the land, the atmosphere, and from the coastal ocean. However, all three nutrient sources can be important to estuarine oxygen dynamics, and can have important ramifications for managers, since in general inputs from the atmosphere and coastal ocean are more difficult to control at the local level.

In this study, the three-dimensional Estuarine-Carbon-Biogeochemistry model embedded in the Regional Ocean Modeling System is linked to a management-based watershed model, and is used to examine the relative impacts on Chesapeake Bay hypoxia resulting from nitrogen entering from rivers, the atmosphere and the coastal ocean. Model sensitivity experiments highlight that dissolved inorganic nitrogen (DIN) inputs from the atmosphere have roughly the same impact on hypoxia as the same gram for gram change in riverine DIN loading. DIN inputs at depth from the shelf have a similar overall impact on hypoxia as those from the atmosphere (~0.2 mg L-1), however the mechanisms driving these impacts are distinct. While atmospheric DIN impacts hypoxia primarily via the decomposition of autochthonous organic matter, coastal DIN impacts oxygen concentrations primarily via the decomposition of allochthonous organic matter entering the Bay from the continental shelf. The impacts of coastal and atmospheric DIN on estuarine hypoxia are greatest in the summer, and occur farther downstream (lower mesohaline) in wet years than in dry years (upper mesohaline). Integrated analyses of the relative contributions of all three DIN sources to summer bottom oxygen concentrations indicate that impacts of atmospheric deposition are largest in shallow near-shore regions, riverine DIN has dominant impacts in the largest tributaries and the oligohaline Bay, while coastal DIN fluxes are most influential in the polyhaline region. However, during the winter when estuarine circulation is strong and shelf DIN concentrations are relatively high, coastal DIN impacts bottom oxygen throughout the Bay. Overall, this research describes an integrated modeling approach for the Chesapeake riverine-estuarine-sea continuum that quantifies the impacts on hypoxia of multiple nutrient sources.

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