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Long-term Changes in Chesapeake Bay Water Quality: An Integrated Assessment of Dissolved Oxygen, Chlorophyll-a, and Water Clarity

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Abstract

To protect the health of aquatic living resources of Chesapeake Bay, the Chesapeake Bay Program partnership has developed a suite of recommended water quality (WQ) criteria subsequently, adopted into tidal states' WQ standards according to five designated uses (DUs). A multimetric attainment indicator approach was then developed to measure progress toward meeting the WQ standards. Over three decades of monitoring data of dissolved oxygen (DO), chlorophyll-a, and water clarity/underwater bay grasses were evaluated using the indicator approach for all 92 tidal management segments of the Bay. Results show that 40% of tidal water segment-DU-criterion combinations were estimated to meet their WQ criteria in the 2014-2016 assessment period, which marks the best 3-year status between the 1985-1987 and 2014-2016 assessment periods. Since the 1985-1987 period, the Baywide indicator has followed a nonlinear trajectory, consistent with impacts from extreme weather events and subsequent recoveries. Over the entire period (1985-2016), however, the Baywide indicator exhibited a positive and statistically significant trend ($p < 0.05$), indicating that the Bay's condition has been recovering since the 1980s. This improvement was statistically linked to the reduction of total nitrogen load from the watershed, suggesting responsiveness of the indicator to management actions. In further work, an analytical extension to the existing assessment framework was introduced to quantify the amount of impairment shown by the space-time exceedance of a specific criterion (referred to as "attainment deficit"), which can indicate how close a segment is to attainment if it is not currently attaining DO standards. This extended framework improved our understanding of the temporal patterns of DO attainment within each DU, salinity zone, and tidal system. Such insights are critical to the management and research community for understanding the dynamics of the Bay ecosystem and for further assessing the effectiveness of management initiatives aimed toward the Bay restoration.

Keywords

water quality standards, monitoring and assessment, ecosystem management, coastal restoration