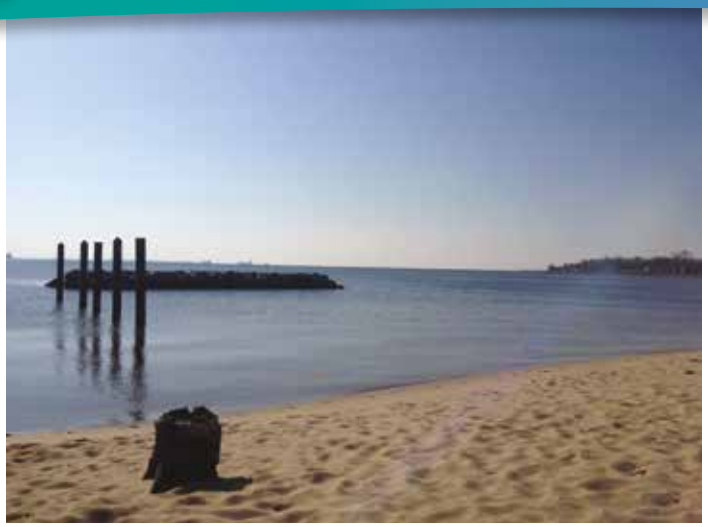
Executive Summary

WERF

Can the models used to establish TMDLs be relied upon to predict dissolved oxygen sags?

Can TMDL Models Reproduce the Nutrient Loading-Hypoxia Relationship? (U4R09)



The researchers constructed a long-term time series of nutrient loading for the Chesapeake Bay (1950-present) from nutrient loading observations, as well as proxies for other non-tidal rivers, long-term records of point sources, and proxies for changes in atmospheric loading.

The Central Issue

Anthropogenic nutrient enrichment of estuaries is a problem dramatically transforming coastal ecosystems worldwide. Despite significant public and private sector resources dedicated to curbing point and non-point sources of nutrient loading, many of the symptoms of eutrophication, such as low bottom water dissolved oxygen and loss of sea grasses, have not abated. Recently, studies have suggested that many eutrophied estuaries have exhibited a totally unexpected response to nutrient reduction: hypoxic volume has continued to increase while nutrient loading has plateaued or decreased.

Context and Background

Whether current state-of-the-art eutrophication models can detect or even forecast regime shifts or time lags is unknown because they have not been run over long enough time scales to detect these changes. However, these models are being used to determine Total Maximum Daily Loads (TMDLs) and to forecast the impact of TMDLs on water quality that would occur over long time periods.

This research sought to calibrate a 55-year watershed simulation in the Chesapeake Bay watershed using several models. The model output was then compared to 2-D and 3-D water distance kriging interpolations to simulate changing physical controls on hypoxia formation, and to explore biogeochemical controls on hypoxia formation.

Findings and Conclusions

Essentially, the researchers found that there is good agreement between models and measurable results, except in the wet months (July). They also found a significant phase shift in stream flows in the Chesapeake Bay area around 1972. After 1972, stream flows increased dramatically towards a wetter hydrology, apparently due to climate. The model behaved differently than the observed data indicated which suggests that lag times are occurring in multiple directions depending on stream flow.

Management and Policy Implications

Dischargers and regulatory agencies need to know whether TMDL models can make reliable long-term forecasts that correctly predict time lags. Based on the findings and recommendations from this research, regulatory agencies may want to evaluate the agreement between modeled and observed hypoxic volume in future TMDL re-evaluations. The researchers recommend that, at a minimum, general statements be included in TMDLs acknowledging that responses may not be immediate and could take years to be realized.

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Can TMDL Models Reproduce the Nutrient Loading-Hypoxia Relationship?

Related WERF Research

Project Title	Research Focus
Modeling Guidance for Developing Site-Specific Nutrient Goals (LINK1T11)	Presents guidance and tools for the use of models to set waterbody-specific nutrient goals, including Numeric Nutrient Criteria and allowable nutrient loadings. Identifies and assesses the relevant models and provides a selection process and guidance for how to apply these models at the local level.
Linking BMP Systems Performance to Receiving Water Protection: BMP Performance Algorithms (SWC1R06bmp)	Develops, adopts, and adapts treatment BMP algorithms for estimating and assessing the performance of distributed and regional BMPs.
BMP SELECT Model Version 2.0 and User's Guide (SWC1R06c)	Provides a planning level spreadsheet tool that enables stormwater managers to examine the effectiveness of alternative best management practice (BMP) scenarios for controlling stormwater pollution and the whole life cost associated with each scenario.
Linking Receiving Water Impacts to Sources and to Water Quality Management Decisions (WERF3C10)	Captures the state of the knowledge on nutrients and lays out a framework for addressing nitrogen control. The framework includes establishing water quality impacts, linking these impacts to nutrients, quantifying major nitrogen sources, evaluating the costs and benefits of available nitrogen controls, estimating receiving water responses to controls, and assessing water quality for potential improvements.
Technical Approaches for Setting Site-Specific Nutrient Criteria (99WSM3)	Provides methods to derive nutrient criteria for surface waters based on local factors, such as water quality requirements or designated uses.

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