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Tidal prism modeling of phytoplankton and nitrogen concentrations in Narragansett Bay and its sub-embayments

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ABSTRACT

A tidal prism model was developed to calculate temporal changes in the spatially averaged concentration of three state variables: phytoplankton, dissolved inorganic nitrogen, and detritus. Our main objective was to develop a model to help us understand the causes of phytoplankton and nutrient responses to temporal changes in nutrient loading and environmental factors. The physical part of the model includes water volume, water depth, tidal forcing, exchanges at the seaward boundary, freshwater inflow, detritus settling to the bottom, and the effects of seawater on salinity (for calibration). The chemical part of the model considers concentration, transformation, recycling, and bottom fluxes of inorganic nitrogen. The biological part examines phytoplankton growth under the effects of nitrogen, temperature, and light limitations, and phytoplankton mortality (including grazing). Also included are the organic carbon storages and flows in phytoplankton and detritus, which are related to nitrogen using the carbon to nitrogen ratio. This single box model is formulated on a spread sheet and it can quickly simulate behavior in well-mixed systems over extended periods of time. It identifies the effects of parameter values on the state variables using a time increment of one tidal cycle. The model was calibrated for Narragansett Bay, RI, USA, and simulated for the bay and two nested sub-systems, Greenwich Bay and Greenwich Cove over a four-year period. Comparison with field observations verified that the model performed reasonably when checked against weekly and monthly data.