Dear Mr Peschel:

As requested, I have reviewed the documentation provided regarding various total nitrogen targets/thresholds for the restoration/protection of eelgrass and benthic resources in various estuaries in New England that have EPA-approved Total Maximum Daily Loads (TMDL) under the Clean Water Act. SMAST was involved in the majority of those projects and is cited heavily in their TN threshold analyses. As a result, I am quite familiar with the level of water quality modeling and water quality monitoring that were used to develop these protective nutrient targets for the eelgrass endpoint. The characteristics of those studies and data collection efforts supporting the development of the TN endpoints and TMDL reductions are stated below.

Background on SMAST Endpoint and TMDL Development

Virtually all of the studies were conducted to address the impacts on TN on saltwater "ponds" and embayments. The nitrogen sources to these systems were generally "non-point" (i.e., groundwater, septic, and surface runoff) with point sources limited to a only a few estuaries. These systems were not associated with major river systems, significant upland watersheds or substantial WWTPs. For these systems, the groundwater, groundwater fed streams and sediment components would have been primarily contributing dissolved inorganic nitrogen forms (i.e., nitrate from septic tanks or ammonium from sediment organic matter decay). TN loading to the estuaries was determined from individual parcel data coupled to nitrogen source strengths from local studies (watershed module) and directly measured stream nitrogen discharges and directly measured sediment nitrogen release.

The system data used to identify the protective TN targets and calibrate the embayment specific water quality models were collected during the growing season (typically May – September), as the critical period for management. The growing season was selected as the focus as it supports the poorest water and habitat quality of the year. Embayment specific hydrodynamic models were used to ensure that the impact of the external loading sources were properly considered, with respect to system transport, dilution (dispersion), flushing and boundary exchanges and freshwater volumetric inputs as they affect the distribution of TN concentrations throughout the system of interest. The forms of nitrogen present were typically composed of bioavailable or readily degradable plus more refractory forms (refractory is defined as not biologically available within its residence time in a basin). As the external loading sources to the watershed (e.g., septic tanks) did not vary seasonally for the most part, the TMDLs have only recommended annual average load reductions. If the sources had a major seasonal component (like riverine or WWTP inputs), this temporal variation was integrated into the water quality models to assess growing season impacts. This was relatively straightforward as most embayments had water exchanges on the order of weeks to a month.

The eelgrass TN thresholds developed by SMAST were fundamentally based on intra and intersystem comparisons of eelgrass and measured water quality (including TN, water clarity, salinity, depth) with tidally averaged TN from the validated numerical water quality modeling. However, the modeling of TN was a refinement and is not always critical to developing a threshold.

It is the comparison of TN levels across a variety of eelgrass sites (areas with healthy eelgrass and stable beds, areas with thinning beds, areas where eelgrass beds have been declining or have recently disappeared) that underpins threshold analysis for the eelgrass endpoint. This comparative approach is used for to develop a variety of threshold in aquatic systems and is generally accepted as the best available approach because it is based upon actual measurements of the constituent of interest (nitrogen) and the"health" of the selected endpoint (in this case eelgrass, but also benthic animals). The approach is both robust and verifiable and can be augmented by the use of indexes or models,

Regarding to the questions that you posed, please see my answers below:

Appropriate nitrogen concentrations for the protection of eelgrass resources;

For eelgrass, the protective growing season TN concentration identified by SMAST typically ranged 0.32-0.45 mg/l, as you have properly identified in the summary attachment. (Enclosure). For the Great Bay system, selecting a growing season average in the range of 0.32-0.35 mg/l should be protective of that resource based on our experiences with the nearby Massachusetts estuarine waters. But analysis of the Great Bay available data on water quality and eelgrass is needed to be sure. Also, the range in TN across the SMAST threshold analyses stems from differences between estuaries, particularly in terms of depth, tidal range, amount of inorganic material versus organic material in watercolumn and data on site specific temporal trends in eelgrass coverage. For example, eelgrass in shallow water can tolerate higher TN and turbidity levels than in adjacent sites in deeper water, etc.

Timing and Forms of Nitrogen to Regulate

I understand that the Great Bay system is relatively well flushed (relatively short residence time) and that the form of nitrogen likely includes components that are not biologically active during their short time in the estuary, for example bulk DOC/DON can be 100's of years old and typically makes up the majority of TN entering through the offshore boundary on incoming tides. Given that the point and non-point system loads to Great Bay Estuary can vary significantly seasonally the peak seasonal loads need to be used in the modeling and the model verified with growing season measured TN levels throughout the basins. The growing season loading needs to account for regeneration of nitrogen from the sediments, as this can be a significant input during summer. I suggest that the modeling also include bioactive nitrogen (DIN+PON) as it has been found to be more accurate in large basins, as it does not include bulk DON which is generally refractory. Having both the TN and bioactive N models should allow better targeting of N load reductions and over-management.

This system would have a higher particulate N loading than the systems evaluated by SMAST, given the large watershed that feeds into Great Bay and the Piscataqua River. Some particles would be expected to settle within the system. Therefore, it is recommended that the impact of sediment release of bioavailable forms of nitrogen be assessed. In some systems, this is significant, others less so. This would provide insight on the need to address the control of particulate forms of nitrogen from the watershed in runoff that could settle and create adverse impacts during the growing season. The model calibration for TN and bioactive N should also yield insight into the importance of summer sediment N release to the overall N load to the watercolumn.

Overall, it appears that a comparative analysis of key water quality metrics and eelgrass health/stability will support a site-specific TN threshold for Great Bay. Also, nitrogen modeling needs to provide distribution of TN and bioactive N throughout the system and allow validation using actual data to ensure proper N load reductions are developed.

Presently, I am not aware of any other papers or studies addressing the level of nitrogen that would be protective of eelgrass resources in the New England area. I hope you find this information helpful in completing your analyses of the Great Bay System.

Sincerely,

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