

II. PREVIOUS STUDIES RELATED TO NITROGEN MANAGEMENT

Nutrient additions to aquatic systems cause shifts in a series of biological processes that can result in impaired nutrient related habitat quality. Effects include excessive plankton and macrophyte growth, which in turn lead to reduced water clarity, organic matter enrichment of waters and sediments with the concomitant increased rates of oxygen consumption and periodic depletion of dissolved oxygen, especially in bottom waters, and the limitation of the growth of desirable species such as eelgrass. Even without changes to water clarity and bottom water dissolved oxygen, the increased organic matter deposition to the sediments generally results in a decline in habitat quality for benthic infaunal communities (animals living in the sediments). This habitat change causes a shift in infaunal communities from high diversity deep burrowing forms (which include economically important species), to low diversity shallow dwelling organisms. This shift alone causes significant degradation of the resource and a loss of productivity to both the local shellfisherman and to the sport-fishery and offshore finfishery, which are dependant upon these highly productive estuarine systems as a habitat and food resource during migration or during different phases of their life cycles. This process is generally termed “eutrophication” and in embayment systems, unlike in shallow lakes and pond, it is not a necessarily a part of the natural evolution of a system.

In most marine and estuarine systems, such as the Three Bays system, the limiting nutrient, and thus the nutrient of primary concern, is nitrogen. In large part, if nitrogen addition is controlled, then eutrophication is controlled. This approach has been formalized through the development of tools for predicting nitrogen loads from watersheds and the concentrations of water column nitrogen that may result. Additional development of the approach generated specific guidelines as to what is to be considered acceptable water column nitrogen concentrations to achieve desired water quality goals (e.g., see Cape Cod Commission 1991, 1998; Howes et al. 2002).

These tools for predicting loads and concentrations tend to be generic in nature, and overlook some of the specifics for any given water body. The present Massachusetts Estuaries Project (MEP) study focuses on linking water quality model predictions, based upon watershed nitrogen loading and embayment recycling and system hydrodynamics, to actual measured values for specific nutrient species. The linked watershed-embayment model is built using embayment specific measurements, thus enabling calibration of the prediction process for specific conditions in each of the coastal embayments of southeastern Massachusetts, including the Three Bays System. As the MEP approach requires substantial amounts of site specific data collection, part of the program is to review previous data collection and modeling efforts. These reviews are both for purposes of “data mining” and to gather additional information on an estuary’s habitat quality or unique features.

Numerous studies relating to nitrogen loading, hydrodynamics and habitat health have been conducted within the Three Bays System over the past 10 years. In the late 1980’s and early 1990’s local concern over the health of the sub-embayments to the Three Bays system, particularly in the upper reaches, focused upon closures of shellfish beds. Field measurements by the Town of Barnstable in the mid/late 1990’s indicted that the greater issue of habitat degradation from nitrogen enrichment was occurring particularly in the region of Prince’s Cove. This concern about nutrient related habitat declines resulted in a nitrogen loading and flushing analysis by the Cape Cod Commission under the Cape Cod Coastal Embayment Project (Eichner et al. 1998). In that study the major sub-watersheds to the Three Bays system were delineated based upon available water table measurements, a land-use nitrogen loading model

was implemented to determine nitrogen inputs to bay waters and a box model was used to evaluate flushing rates of the estuary's sub-basins. The box model incorporated both August and October salinity data and the results of a dye study in Prince's Cove. Although the approach yields only approximations, the results clearly supported the concept that nitrogen inputs to the Three Bays system were impacting the water quality system-wide, with greatest degradation in the upper regions of Prince's Cove and Warren's Cove. Further, the landuse analysis indicated that on-site septic disposal of wastewater was the major single source of watershed nitrogen to bay waters. While the overall results of this study have held true, the box model is insufficient to simulate changes in nitrogen within the estuary under different management alternatives. In addition, as quantitative surveys of embayment nitrogen levels were not yet available, the model could not be validated. In addition, as the landuse model did not account for nitrogen attenuation by the surface freshwater ecosystems within the watershed (no data available), it over estimated the role of nitrogen sources in upper (inland most) sub-watersheds compared to the direct groundwater watersheds to the estuary. While base data from this earlier study was incorporated by the MEP, direct use of the modeling results was problematic. Since the landuse model was based upon the 1996 watershed delineations from well data, rather than the MEP's USGS West Cape Model (see Chapter III), the contributing areas are slightly different. Due to the difference in watershed areas and the MEP's update and refinements to the watershed nitrogen loading model (eg. to incorporate attenuation and new nitrogen source information), the results from the MEP are different and supercede those of this earlier study.

At this same time (1996) a group of private citizens formed a non-profit NGO, Three Bays Preservation, to address environmental problems within the Three Bays System. Three Bays Preservation initially focused upon dredging the tidal inlet between Cotuit Bay and Nantucket Sound, with a small amount of dredging in West Bay. As part of this process a 2-D hydrodynamic model was used to evaluate the effects of dredging on water circulation and flushing of the Three Bays system. The model is similar to that used by MEP, but it appears that the model did not calibrate and therefore the effort was revisited by MEP. In addition, as the earlier model focused on the effects of dredging on circulation, the model needed to be redeveloped with appropriate grid spacing to support the MEP water quality modeling effort. After permitting, the dredging effort was carried out with the Town of Barnstable in the winters of 1998-99 (187,000 cu yd), 1999-00 (24,700 cu yd), 2001 (15,000 cu yd) and 2002 (9,000 cu yd). The dredged sand was used to nourish Dead Neck for barrier beach stabilization.

Despite these dredging activities, it was clear that inlet maintenance was not sufficient to redress the nitrogen related declines observed throughout large portions of the Three Bays System. In 1999 Three Bays Preservation established a nitrogen related water quality monitoring program throughout the Three Bays system to support restoration efforts. The Three Bays Water Quality Monitoring Program was provided technical assistance by the Coastal Systems Program at SMAST-UMD and over the past several years the program has been incorporated into Barnstable's Town-wide embayment monitoring program. To date water column sampling has been conducted throughout the system on 6-8 dates per summer, June-August. Initial results of the Three Bays Water Quality Monitoring Program (Howes and Hampson 2000) indicated that:

- (a) "some areas within the Estuary are presently showing nutrient related water quality declines and there is a wide variation in habitat quality within the Three Bays System. In general the quality of habitat in the Three Bays system shifts from high quality near the inlets to Nantucket Sound to poor quality (eutrophic) in the inner reaches. Prince's's Cove, and the region of the mouth of the Marstons Mill River through the narrows to

North Bay are showing poor nutrient related environmental health. However, the loss of eel grass beds from most of the Three Bays system proper indicates that the system has undergone nutrient loading related shifts”;

- (b) “the effects of watershed nutrient inputs can be seen in diminished water transparency, increased chlorophyll and nitrogen levels in the upper system and North Bay.
- (c) “the Three Bays Estuary appears to be nitrogen limited, i.e. additions of nitrogen will increase algal production”;
- (d) “the organic matter within the Three Bays Estuary appears to be produced by phytoplankton supported by inputs of watershed nitrogen and recycled nitrogen within the Bays, as opposed to entering the system in surface water flows”;

This effort provides the quantitative watercolumn nitrogen data (1999-2004) required for the implementation of the MEP’s Linked Watershed-Embayment Approach used in the present study. In addition, there have been a variety of smaller studies relating to bacterial contamination (see MEP Bacterial Technical Report for Prince’s Cove 2005) and macroalgal management conducted by Three Bays Preservation.

The MEP has incorporated all appropriate data from all previous studies to enhance the determination of nitrogen thresholds for the Three Bays System and to reduce costs to the Town of Barnstable.