

II. PREVIOUS STUDIES RELATED TO NITROGEN MANAGEMENT

In most marine and estuarine systems, such as Great Pond, Green Pond, Bournes Pond and Little Pond in Falmouth, 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 eutrophication management approach via the reduction of nitrogen loads 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. 2003). The Oyster Pond system is structurally different than the more typical Falmouth salt pond estuarine systems mentioned above and has also been managed as a brackish water pond with highly restricted tidal exchange. As such it is necessary for the purpose of the MEP to adjust the eutrophication management approach in order to capture the unique characteristics of the Oyster Pond system

Until recently, the tools for predicting loads and concentrations tended to be generic in nature, and overlooked 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 Oyster Pond System.

The Town of Falmouth, Massachusetts, has long recognized the potential threat of nutrient over-enrichment of its coastal salt ponds and embayments. In the mid-1980's the Town enacted an innovative Nutrient Overlay By-law that tied watershed development to water quality within the adjacent embayment. The goal was to keep nitrogen concentrations in the receiving systems below thresholds that were projected to cause water quality shifts. A water quality monitoring program, Falmouth PondWatch, was established to provide on-going nutrient related embayment health information in support of the By-law. Oyster Pond was among the first three Ponds (Oyster Pond, Little Pond, Green Pond) to undergo water quality monitoring in the Town of Falmouth. These approaches were primarily initiated for planning as development within coastal watersheds progressed. Falmouth's Planning Department has continued to enhance its tools for gauging future nutrient effects from changing land-uses. The GIS database used in the present study is part of that continuing effort. Unfortunately, monitoring has documented that most regions within the Town's coastal ponds are currently showing water quality declines and are beyond the limits set by the By-law.

Given the brackish waters of Oyster Pond and the management need for targeting the nutrient which limits algal production, the MEP sought site-specific evidence of either nitrogen or phosphorus limitation in this system. Two lines of evidence were found, both of which indicate that Oyster Pond, like the other embayments of Cape Cod is nitrogen limited. A study conducted in June and July 2002, added nitrogen or phosphorus to surface water samples from Oyster Pond and followed chlorophyll a levels (as an indicator of phytoplankton growth) over 4 days. In the two experiments conducted, only the nitrogen enriched waters showed stimulation of phytoplankton (Weber et al. 2002). The second line of evidence is based upon the elemental ratio method (Redfield Ratio), where molar ratios of inorganic N/P less than 16 suggest that as nutrient uptake occurs to support algal growth (phytoplankton and macro-algae) nitrogen will

become depleted before phosphorus. In other words, addition of phosphorus would not stimulate algal growth, but nitrogen would. The Falmouth PondWatch Program has found that during summer samplings, 2000-2004, the geometric mean ratio of inorganic nitrogen to inorganic phosphorus (N/P) in samples from 0-3.25 m was 10 (s.d. 4, N=102). During this period the salinity of the surface waters averaged 2.1 ppt, range 1.6-2.8 ppt (Howes and Goehring unpublished data). A different study found a similarly low N/P ratio (~5) in September 2002 (Dixon et al. 2002). While this is only an approximate method, it is consistent with other studies concluding nitrogen limitation in estuaries throughout the region. These studies support the targeting of nitrogen as the key nutrient for management of the habitat quality of this estuarine system.

Data generated by the Falmouth PondWatch Program has also yielded clear indications of nutrient related impairment to the Oyster Pond system and has assisted the Town in the development of initial management options for improving the ecological health of the system. Specifically, the PondWatch Program water quality database for Oyster Pond assisted the Town of Falmouth in the design and permitting of the salinity control/fish ladder which separates Oyster Pond from the down gradient salt marsh lagoon. This control structure is what currently maintains the surface mixed waters between 2 – 4 ppt. The concept of salinity control as phase I of the management of the Oyster Pond System was to achieve a variety of resource management goals. The phase I management plan was devised by PondWatch working closely with the Oyster Pond Environmental Trust (OPET) and the Town of Falmouth (planning, engineering, conservation, natural resources, Herring Warden) and the Town's consulting engineers at Applied Coastal Research and Engineering. The management goals were to create a "stable" salinity environment for Oyster Pond and to improve the oxygen status of the bottom waters, which were typically hypoxic-anoxic below 3 meters during summer (Howes and Hart 1997). The option to increase the tidal flushing to create a high salinity environment was rejected due to (a) the difficulty in maintaining an open inlet, (b) the need for additional hard-structures to fix a new tidal inlet to Vineyard Sound, (c) the salinity history of the Pond which indicated that for most of the 1900's the surface waters were <5 ppt, and (d) the cost of creating and maintaining a 100's of meters long tidal channel from the Sound. Creating a freshwater pond by closing off of the tides was rejected due to the periodic overwash of salt waters during major storms (e.g. Hurricane Bob 1991). The phase I plan was also consistent with the uses of the Pond by local residents as determined from surveys. The phase I plan was implemented, initially by allowing sedimentation to restrict tidal flow in the Trunk River and between the Trunk River and Oyster Pond. By 1996 Oyster Pond salinity levels had dropped below 4 ppt and by 2000 the salinity levels were stabilized at ~2 ppt. The phase I results have been to restore the salinity of the pond to the historic levels, to maintain relatively stable salinity conditions, to restore the fish community, including the herring run, and to improve the oxygen conditions. The design and role in tidal hydrodynamics of the salinity control/fish weir are presented in detail in Section 5 and the salinity history, salinity levels and implications for Oyster Pond management are presented in Section 7, below. At present, phase I is nearly completed, needing only a channel maintenance program to keep the short channel between the Trunk River and the salt marsh Lagoon open. Phase II was slated to focus on watershed nitrogen management, which is also the purpose of the SMAST/DEP Massachusetts Estuaries Project Linked Watershed-Embayment Approach.

Oyster Pond has been the focus of a variety of scientific studies of which the most notable was by K.O. Emery, who provided a full analysis of the geomorphology, geology, chemistry and biology of the Pond in the early 1960's. This study was updated (and republished) in 1997 to include a nitrogen balance and to outline the anthropogenic alterations which affect the Pond ecosystem and set forward the path for Pond management and restoration (Howes and Hart

1997). More recently, Oyster Pond has been used by Boston University students for class projects (2001 and 2002). These data have been evaluated by the MEP Technical Team. Unfortunately, use of results from the series of studies based on watershed nitrogen loading rates is problematic, as the delineated watershed is very different from the present MEP watershed and earlier watersheds derived for this system (see Section 3). Similarly, the series of studies showing shallow (0.25-1.5 m below land surface) “groundwater” nitrogen concentrations collected 0-2 m from the pond edge could not be validated, as groundwater was defined as having a salinity of <2ppt and the pondwater itself in the upper basin (0.15m) was 1.7-2.3 in 2001-2002. However, some of the results of these studies have been incorporated as supporting information into the present MEP analysis, specifically as relates to nitrogen as the critical nutrient for management (as described above) and mapping of the various aquatic resources.

For the MEP modeling analysis, the data from the previous studies were evaluated relative to the needs of the Linked Watershed-Embayment Model. The PondWatch watercolumn nutrient data was deemed acceptable as these data met MEP protocols and the assays were conducted by the Coastal Systems Analytical Facility at SMAST, whose protocols have been reviewed by DEP and EPA. In addition, the prior hydrodynamic analysis was also included as it met with MEP methods and quality assurance procedures. In addition, K.O. Emery’s study was a valuable source of information related to the geology, geomorphology and history of Oyster Pond.