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Massachusetts Department of Environmental Protection

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Chilmark Pond Embayment System, Chilmark, Massachusetts

Summary of Major Findings

The Massachusetts Estuaries Project (MEP) Nitrogen Threshold Report presents the results generated from the implementation of the MEP's Linked Watershed-Embayment Modeling Approach to the Chilmark Pond embayment system. Analyses of the Chilmark Pond embayment system were performed to assist the Town of Chilmark with up-coming nitrogen management decisions associated with the current and future wastewater planning efforts of the Town, as well as wetland restoration, management of anadromous fish runs and shell fisheries as well as the development of open-space management programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Town of Chilmark resource planning and decision-making process. The primary products of the MEP effort are:

(1) a current quantitative assessment of the nutrient related health of the Tisbury Great Pond embayment,

(2) identification of all nitrogen sources (and respective N loads) to embayment waters,

(3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters,

(4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and

(5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management alternatives (to be developed by the Town) for the restoration of the Chilmark Pond embayment system.

Application of MEP Approach: The Linked Model was applied to the Chilmark Pond embayment system by using site-specific data collected by the MEP and water quality data from the Water Quality Monitoring Program conducted primarily by the Martha's Vineyard Commission and with field support from the Town of Chilmark. The water quality monitoring program was conducted with technical guidance from the Coastal Systems Program at SMAST. Evaluation of upland nitrogen loading was conducted by the MEP and data was provided by the Planning Department in the Town of Chilmark as well as the Martha's Vineyard Commission. The watersheds utilized in the MEP assessment are largely based on delineations created and used by the Martha's Vineyard Commission (MVC). Details of those watershed delineations are provided in the full report. These watershed delineations and the land-use data were used to determine watershed nitrogen loads within the Chilmark Pond embayment system and each of the systems sub-embayments as appropriate. Water quality within an embayment is the integration of nitrogen loads with the site-specific estuarine circulation. Therefore, water quality modeling of this occasionally tidal estuary included a thorough evaluation of the hydrodynamics of the estuarine system.

MEP Nitrogen Thresholds Analysis: The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The nitrogen thresholds developed by the MEP for Chilmark Pond were used to determine the amount of total nitrogen mass loading reduction required for restoration of eelgrass and infaunal habitats in the Pond. Watershed nitrogen loads were sequentially lowered, using reductions in septic effluent discharges only, in concert with modifications to the pond opening schedule until the nitrogen levels reached the threshold level at the sentinel stations chosen for the Chilmark Pond system. It is important to note that load reductions can be produced by reduction of any or all sources, increasing flushing of the system with clean open ocean water or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment.

The Massachusetts Estuaries Project's thresholds analysis, as presented in the Draft MEP report provides the site-specific nitrogen reduction guidelines for nitrogen management of the Chilmark Pond embayment system. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in nitrogen loading reduction to the embayment.

Summary of Major Findings: The Chilmark Pond Embayment System is a complex coastal open water embayment comprised of a large central basin (Chilmark Pond East) and multiple sub-embayments (Wades Cove, Gilberts Cove). The western basin, Upper Chilmark Pond is currently fresh to slightly brackish and has been functionally separated from the estuary by coastal processes. The main basin and its tributary coves are maintained as an estuary by the periodic breaching of the barrier beach with a single temporary inlet. The estuary only occasionally receives tidal waters from the Atlantic Ocean into its main basin based on a schedule of openings set by the Town. As such, the Chilmark Pond estuary is particularly vulnerable to the effects of nutrient enrichment from the watershed, due to its very limited tidal exchange and that circulation is mainly through wind driven mixing in the small tributary sub-embayments. In particular, the Chilmark Pond Estuary is eutrophying from nitrogen enriched groundwater and surface water flows and runoff from its watershed.

The Chilmark Pond Estuary is beyond its ability to assimilate nitrogen without further impairment. The system is showing a moderate level of nitrogen enrichment, no eelgrass habitat and moderately/significantly impaired benthic animal habitats, regions of periodic moderate oxygen depletion and phytoplankton blooms. All lines of evidence support an

assessment of habitat impairment. Since there is no record of eelgrass in this estuary in recent decades, the impairment of concern is that of benthic animal habitat (Table VIII-1). These findings indicate that nitrogen management of this system will be for restoration rather than for protection or maintenance of an unimpaired system. It should be noted that nitrogen management includes both source reduction and in the case of a tidally restricted embayment, enhanced tidal flushing.

The measured levels of oxygen depletion and enhanced chlorophyll-a levels follows the spatial pattern of total nitrogen levels in this system (Chapter VI), and the parallel variation in these water quality parameters is consistent with watershed based nitrogen enrichment and only periodic tidal flows. The spatial pattern indicated that the magnitude of oxygen depletion, enhancement of chlorophyll-a levels and total nitrogen concentrations were consistent with the absence of eelgrass and the moderate impairment of benthic animal communities.

Given moderate levels of watershed nitrogen loading and limited periodic tidal exchange and the nitrogen, chlorophyll and oxygen levels within the pond basins (2000-2012), it can be concluded that Chilmark Pond is not presently supportive of eelgrass beds. Further, based upon the past decade and analysis of historic information, the MEP Technical Team concluded that Chilmark Pond Estuary has not supported eelgrass habitat for at least 50 years. Given that the pond's water quality is controlled in significant part by the amount of induced tidal flushing, it is likely that the Pond has had negligible eelgrass habitat for the past century. As eelgrass habitat could not be documented to exist, either historically or presently, within the Chilmark Pond Estuary, the threshold analysis for this system is necessarily focused on restoration/protection of infaunal animal habitat.

Overall, the infauna survey indicated that most sub-basins comprising the Chilmark Pond Embayment System are presently beyond their ability to tolerate additional nitrogen inputs without further impairment. Consistent with the observed periodic oxygen depletions and large phytoplankton blooms occurring in the main depositional basins, with little drift macroalgal accumulation, the benthic animal communities are showing moderate to significant impairment. The impairment is consistent with organic enrichment resulting from increased nitrogen loading from a combination of watershed inputs and only periodic tidal flushing. The Benthic survey did not reveal any areas of severe degradation. Each of the estuarine basins, specifically Lower Chilmark Pond (east), Wades Cove and Gilberts Cove are showing moderate-significant levels of impairment related to their elevated chlorophyll-a levels and moderate periodic oxygen depletions. While the numbers of individuals remain high throughout the system, the community numbers of species and their diversity and Evenness are low and indicative of a community under ecological stress.

Nitrogen enrichment of the Chilmark Pond Estuary stems from the combination of watershed nitrogen load and the absence of tidal exchange with offshore waters except during "dredged' openings by the Town. More frequent or prolonged openings has the same effect of lowering nitrogen loads, relative to relieving nitrogen related habitat impairments. Following the MEP protocol, since eelgrass has not been documented in the Chilmark Pond Estuary, restoration of impaired infaunal habitat is the restoration goal. Infaunal animal habitat is a critical resource to the Chilmark Pond Estuary and estuaries in general. Since there are no unimpaired infaunal animal habitat areas remaining in the Chilmark Pond Estuary, comparisons to the soft bottom basins of other nearby estuarine systems were relied upon for setting the nitrogen threshold for healthy infaunal habitat at a nitrogen level of TN <0.5 mg TN L^{-1}. Present TN levels within throughout the Chilmark Pond Estuary during summer are ~0.74 mg TN L^{-1}, consistent with the observed lack of eelgrass beds and impaired benthic animal habitat. Based upon comparisons

to other systems, the current TN level within the Chilmark Pond Estuary, the periodic oxygen depletions and phytoplankton blooms, it appears that a water column nitrogen threshold for the Chilmark Pond Estuary of 0.50 mg TN L^{-1} is required for restoration. All habitat metrics indicate a moderate to moderate/significant level of habitat impairment. While the TN level is significantly above the threshold (0.74 vs. 0.5 mg TN L^{-1}) the system is still supporting a productive if clearly impaired benthic animal community.

To restore benthic habitat, load reduction focused on lowering average TN level at the sentinel station within the main basin to 0.50 mg/L during the summer months, when benthic regeneration and algae production is greatest. This goal was achieved by reducing the watershed loading to the pond and assuming the pond is breached three times a year. Watershed loading was reduced from present conditions until the combined time averaged TN concentration would remain below 0.50 mg/L during a 120-day period during the summer months. The threshold modeling assumptions include a successful spring breach, which remains open for 8 days and lowers the average pond TN concentration to 0.33 mg/L. The Pond is also allowed to be closed for 120 days, which allows the time for the water level in the pond to rise to support subsequent breaching of the pond. A 30% septic reduction from present conditions was required along with the successful spring breach to achieve the threshold requirements. All other watershed sources, including agricultural loads, were not reduced for this threshold modeling scenario.