Wastewater Management Validation and Design Committee
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Originated 11 November 2008
Revised 17 November 2008

Subject: Summary Chapter VIII (Critical Nutrient Threshold Determination and Development of Water Quality Targets)

Massachusetts Estuaries Project: Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Final Report May 2006

Key Issues:

1. How will it be known if benthic habitats have achieved a reasonable level of health?
2. How will threshold nitrogen concentrations be directly related to successful eelgrass restoration?
3. What criteria will be utilized to judge the quality of benthic infaunal communities?

Tasks to be Undertaken to Address the Key Issues:

Task 1. Conduct a critical review of pertinent literature on estuaries to evaluate the direct cause and effect relationship between nitrogen concentration, dissolved oxygen levels and benthic health in well mixed and circulated estuaries, particularly as they pertain to the situation in Pleasant Bay as presented in the SMAST-MEP report.

Task 2. Evaluate the relative significance of the various ecological parameters that are most critical to the viability and propagation of *Zostera marina*. In that context, conduct a critical analysis of the data, assumptions and conclusions related to Zostera in Pleasant Bay as presented in the SMAST-MEP report.

The purpose of conducting these tasks is to assure and reinforce the assumption that eelgrass distribution within Pleasant Bay is the best measure of the impact of nitrogen concentrations on ecological health.

Expertise and Experience Required to Complete the Tasks:

1. Coastal and estuarine marine ecology.
2. Familiarity with benthos/sediment dependencies and relationships.

APPENDIX

Commentary:

On the face of it Chapter VIII of the SMAST-MEP Report seems to be a logical progression from the preceding chapters of that report. If one accepts the assumptions, assertions, and conclusions set forth in Chapter IV through VII, then Chapter VIII makes sense and seems to result in a valid determination. However, as we have seen and presented in this summary review, each of the preceding four chapters has sufficient deficiencies on its own as to undermine the validity of Chapter VIII. More specifically, Chapter VII, dealing with the assessment of habitat health in Pleasant Bay, constitutes the foundation for most of what follows in Chapter VIII. To briefly recapitulate the critical review of Chapter VII, the following key issues raise major questions regarding deficiencies in the analysis of habitat health in Pleasant Bay.

1. The codification of *Zostera marina* (eelgrass) as the sentinel species to evaluate the ecological health of Pleasant Bay.
2. The adequacy and significance of sample collection and analysis of benthic communities within Pleasant Bay by SMAST and MEP as an accurate assessment of the Bay's ecological health.
3. The relationship between nitrogen concentrations in Bay waters and the viability of Zostera.
4. The causal effect of nitrogen concentrations on dissolved oxygen and hypoxia of Bay waters.
5. The ecological impact of recreational boating and mooring density on turbidity and photosynthesis, and on biochemical oxygen demand in Pleasant Bay.

Therefore, taken together the totality of these deficiencies does not warrant confidence in the determinations and conclusions of Chapter VIII.

<u>Threshold Nitrogen Concentrations</u>

The SMAST-MEP report clearly states that eelgrass restoration is the primary nitrogen management goal within the Pleasant Bay system. The assumed inference is implicit: the major controlling parameter on the restricted distribution of eelgrass is the nutrient element nitrogen, and that increases in nitrogen concentrations result in degradation of habitat and decline in productivity by benthic plants. Nowhere in the entire report is this assumption evaluated or documented by direct evidence. The SMAST analysis appears to ignore other mechanisms that may cause the loss of eelgrass: disease, sand movement (due to storms or breaches, for example), and possible predators or grazers.

The northern sub-embayments of Pleasant Bay seem to have never harbored significant eelgrass habitats. Therefore, benthic interstitial microfauna communities were selected as an alternate proxy for evaluating habitat health. As we have seen in Chapter VII, benthic infaunal communities within these sub-embayments have not been compared qualitatively with comparable communities in other embayments, or even with earlier community analyses within Pleasant Bay. On what basis can they be judged to be impaired or degraded? No criteria for evaluating the quality of benthic infauna has been established; there is no measure of relative success for the benthic infauna. How can any reliable threshold for nitrogen concentration be established when no criteria have been established for what needs to be achieved?

Reviewer Questions:

p**.** 200, ¶ 4: Dissolved Oxygen. SMAST describes the high level of oxygen stress in the sub-embayments. *"These small enclosed basins tend to have higher nitrogen levels and high rates of sediment metabolism associated with their circulation and focus of watershed nitrogen loads."* Consequently, SMAST relates bio-activity stress due to low oxygen to elevated nitrogen levels. It is correct that septic nitrogen in the form of ammonia or urea consumes oxygen in their oxidation to nitrates, but is the oxygen stress totally related to increased septic nitrogen concentrations?

p. 201, ¶ 1: *"Salt marsh creeks (that do not empty at low tide) frequently become hypoxic in summer as a result of high organic matter loading associated with marshes. Even pristine salt marshes can exhibit this behavior."* Don't the sub-embayments, such as Meetinghouse and Arey's Ponds collect organic matter? Is it possible that the hypoxia in these "A ponds" is caused by similar mechanisms to those in the marshes?

p.202, ¶ 1: *"As for the oxygen and chlorophyll indicators and the distribution of sediment metabolism, the enclosed basins (Group A, above) are generally significantly to severely impaired relative to the benthic infaunal habitat quality."* It appears that to accept this premise that the impairment is related to low oxygen and chlorophyll, one must accept the fact that septic nitrogen is the primary cause of deplete oxygen. Is it possible that the same mechanisms that occur in marshes occur in the Group A sub-embayments?

p. 204, ¶ 1 and 2:
"the <u>restoration target</u> should reflect both recent pre-degradation habitat quality and be reasonably achievable." "The <u>threshold nitrogen level</u> for an embayment represents the tidally averaged water column concentration of nitrogen that will support the habitat quality being sought."

p. 204 , ¶ 5 :
"After the sentinel sub-system (or systems) is selected, the nitrogen level associated with high and stable habitat quality typically derived from a lower reach of the same system or an adjacent embayment is used as the nitrogen concentration target."
Is this a reasonable approach?

p. 205, ¶ 1: What is the support for the notion that dissolved organic nitrogen is non-reactive in the marine environment? What are the sources of dissolved organic nitrogen?

p. 205, ¶ 2: The nitrogen threshold of 0.16 mg bioactive nitrogen/liter was set based on a Dec. 2003 MEP Report for Bassing Harbor. What if it were 0.17? Or 0.18? How is the determination made? Note that the data in Chapter VII, Table VII-7, eelgrass areas declined from 246 to 114 acres between 1951 and 2000. Was the concentration of bioactive nitrogen less than 0.16 mg/liter during this 50 year period? Especially from 1951 to the early 1980s when the building boom occurred? Again, is bioactive nitrogen the only real culprit?

p. 205, ¶ 3: *"Ryder Cove represents a system capable of fully supporting eelgrass beds and stable high quality habitat based upon the 1951 – 2000 surveys. At present, this basin is transitioning from high to low habitat quality in response to increased nitrogen loading."* So… if Bassing Harbor has had high quality water column in terms of bioactive nitrogen until recently, why did the eelgrass population decline between 1951 and 1995? Are there other potential causes of eelgrass decline that are not included in the SMAST assessment?

p. 206, ¶ 1:
"Unfortunately, <u>total nitrogen within this system appears to be very high</u>. In fact, the <u>whole of lower Pleasant Bay appears to contain very high levels of total nitrogen</u>. Analysis of the composition of the watercolumn nitrogen pool within these embayments revealed that the concentrations of dissolved inorganic nitrogen (DIN) and particulate organic nitrogen (PON) were the same as for the Stage Harbor System. In fact, the level of these combined pools (DIN+PON) was lower in Bassing Harbor (0.133 mg N L-1) than in the Stage Harbor (0.158 mg N L-1) and the mouth of Oyster River (0.160 mg N L-1). Note that the mouth of the Oyster River exhibits a documented stable healthy eelgrass habitat (MEP 2003). It appears that the reason for the higher total nitrogen levels in the Pleasant Bay waters results from the accumulation of dissolved organic nitrogen. The bulk of dissolved organic nitrogen (DON) is relatively non-supportive of phytoplankton production in shallow estuaries, although some fraction is actively cycling. It is likely that the high background DON results from the relatively long residence time of Pleasant Bay waters relative to the smaller systems. This allows the accumulation of the less biologically active nitrogen forms, hence the higher background. Decomposition of phytoplankton, macroalgae and eelgrass release DON to estuarine waters as do salt marshes and surface freshwater inflows." (underlines added)
The quotation indicates that the <u>very high</u> total nitrogen levels in Pleasant Bay are not expected or well understood. The text "explains" the phenomenon using the phrases "It is likely" and "It appears" throughout. It seems that the explanation is a pure conjecture without any facts to back it up. Since the crux of this matter is about how much nitrogen is in Pleasant Bay, how it moves in and out of the bay and how it impacts the flora and fauna in the bay, it would seem important to have and understand the facts about the nitrogen levels in the bay.

p. 206, last ¶:
"moving into the mouth of The River (PBA-13) and the lowermost basin of Pochet (WMO-03) eelgrass coverage appears to have declined since 1951, although eelgrass is still present. This loss of beds indicates that the habitat quality has become impaired, but since eelgrass remains, the impairment is judged to be "moderate."
(see p.182, para. 2*: "….smaller eelgrass areas in Pochet and fringing shallow areas in The River and Meetinghouse Pond. …..However, it is clear from the 1951, 1995 and 2001 temporal sequence that the eelgrass areas in each basin, except Chatham Harbor,*

are declining in coverage. In The River and Pochet the eelgrass areas were always patchy and in the shallows. By the 2001 survey this pattern continues, but the beds appear to be declining, although they persist.")
Given the inferiority of the 1951 photos and the lack of any field verification, the thesis that eelgrass has been declining from 1951 to 2001 corresponding to an increasing rate of nitrogen introduction to the bay is lacking in credibility. Furthermore, the report does not present convincing evidence that 0.16 mg/L is a critical nitrogen level. Where is the body of scientific research showing the relationship between nitrogen concentration and eelgrass success?

p. 208, ¶ 2: *"While these systems [drowned kettle ponds] may not be supportive of eelgrass habitat, they are generally capable of supporting healthy benthic animal habitat. Infaunal animals are sensitive to the organic matter loading and resultant periodic oxygen depletions associated nitrogen overloading. Since these conditions typically occur at higher nitrogen loads than does the shading of the bottom by increased phytoplankton production (principal cause of eelgrass loss), the nitrogen threshold level for healthy benthic animal habitat is higher than for healthy eelgrass habitat."* How important, in relative terms, are "organic matter" and the "nitrogen concentrations" in supporting a healthy benthic habitat? SMAST appears to consider the loss of eelgrass to be solely attributed to bioactive nitrogen in the water column, and ignores other mechanisms that contribute to eelgrass loss!

p. 208, last ¶ :
After describing successful amphipod communities in the Orleans ponds where the bioactive nitrogen concentration varies apparently varies from 0.2 to 0.4 mg/l, the report concludes that 0.21mg/l should be established as the threshold concentration for benthic infauna. Why 0.21? Why not 0.28 or .030?

p. 209, final 2 sentences:
"Therefore restoration success will be gauged by reaching the target at the sentinel station and at the secondary stations for eelgrass (Ryders Cove) and infauna. Overall there are three primary(PBA-12, PBA-03 and CM-13.) and 8 secondary target stations within this System, the largest embayment on Cape Cod."
This states that both the sentinel station and the secondary station must meet targets. The targets are shown in Table VIII-2 which contains both Bioactive Nitrogen thresholds and Total Nitrogen Thresholds for all 8 secondary stations, 6 of which are in Orleans. This seems inconsistent with the statement on p. 204 i.e.,
"……to first identify a sentinel station within the embayment …….is selected such the restoration of the one site will necessarily bring the other regions of the system to acceptable habitat quality levels."

These multiplicity of requirements and seemingly conflicting statements need to be resolved.