SYNOPSIS OF WMV&DC FINAL REPORT ON ITS PEER REVIEW OF THE SMAST/MEP PLEASANT BAY REPORT[1]

Prepared December 31, 2009 by

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The Orleans' Citizens Peer Review Panel

SUMMARY

The major findings of the Orleans' Wastewater Management Validation and Design Committee (WMV&DC) are summarized below. Some of these findings are based on the Committee's analytical work and others are based on the analysis of the Committee's consultant, The Woods Hole Group (WHG).

Data in the SMAST/MEP[2] Pleasant Bay report and water quality data collected from 2000 to 2008 by the Pleasant Bay Resource Management Alliance indicate that nitrogen levels in most of the Orleans portion of Pleasant Bay have been dropping for 22 years. Nitrogen levels in Little Pleasant Bay and Meetinghouse Pond have been dropping since 2000 when water quality monitoring first began. SMAST information contained in the MEP Report for Pleasant Bay indicates that nitrogen levels in most of the System have been decreasing since 1987. Nitrogen levels in Pah Wah Pond have also decreased in the recent two years. These water bodies make up approximately 80% of the Orleans Pleasant Bay estuary. Nitrogen levels in most of these waters now meet or are below the DEP maximum specifications. Sewering of the watersheds surrounding these areas may not be necessary.

Nitrogen levels in Arey's and Lonnie's Ponds have been slowly rising since the year 2000. The Committee does not know why. In Arey's Pond the measured benthic flux nitrogen (that is the nitrogen that comes from the muddy sediment in the bottom of the pond) is seven times greater than the septic system nitrogen level. It is therefore not clear that sewering will reduce the nitrogen levels in Arey's and Lonnie's Ponds to improve water quality. The Committee believes that the cause of the rising nitrogen in these two ponds needs to be better understood to determine the most effective remediation strategy.

The restoration of eelgrass habitat is stated by the MA DEP as the primary basis for required remediation of nitrogen in Pleasant Bay. Yet there is no reliable basis for asserting that there has been a significant decline in eelgrass distribution or habitat quality over the past several decades. Moreover, the WMV&DC and its consultant WHG have found no historical basis for the MEP to claim that benthic animal habitat has been degraded as a result of increased septic nitrogen in the tidal ponds in northern Little Pleasant Bay over the past several decades.

1 Full report available Online at: http://www.town.orleans.ma.us at Boards & Committees under Validation

2 SMAST is the School of Marine Science and Technology at the University of Massachusetts, Dartmouth.

MEP is the Massachusetts Estuary Project of the Massachusetts Department of Environmental Protection.

Thus, the SMAST/MEP nitrogen specification for restoration of eelgrass and benthic animal habitats in Pleasant Bay lacks empirical supporting evidence and appears to be totally arbitrary.

The WHG pointed out that the SMAST/MEP report failed to present a nitrogen mass balance analysis for Pleasant Bay. A total nitrogen mass balance calculation by the WMV&DC using data only from the MEP Pleasant Bay Report shows that the outputs of total nitrogen from the Bay exceed the inputs into the Bay on a daily basis by more than 5 metric tonnes (20 to 25%). The TMDLs (total maximum daily loads, of nitrogen) for Pleasant Bay require the towns of Chatham, Harwich, Brewster and Orleans to eliminate 46 kilograms per day of septic nitrogen when a mass balance shows more than 100 times that amount is lost daily and unaccounted for.

FINDINGS CONCERNING NITROGEN INPUTS

Septic Discharge. In early 2009, the Committee conducted a simple analysis using a survey of property owners in the Arey's Pond watershed. The Committee concluded that the nitrogen contribution from septic systems is approximately 70 percent of the values calculated by the Cape Cod Commission. The nitrogen input from septic systems is based on the equivalent number of year-round residents. Furthermore SMAST, the Cape Cod Commission, and DEP determined that the average resident generates approximately 2.7 kilograms of nitrogen per year which is discharged into the local residential septic system. Thus, it is important to have an estimate of the occupancy in each property on a full year basis. Orleans has a large senior population and a large percentage of seasonal homes.

The Committee's sample analysis of the Arey's Pond watershed shows in Table 1 that the fulltime equivalent residency occupancy is 1.28 full time equivalent occupants, or about 62 percent of the value used by SMAST. While this survey indicates that for the Arey's Pond area, occupancy is much lower than the value assumed by SMAST, it is likely that the occupancy in other watersheds may also be lower than 2.05. This finding will have a significant impact on the computations by the SMAST linked model simulation of the Pleasant Bay System.

Table 1

Type Housing	Occupancy	Percent	Avg. Occupancy
Year-round	2.46	30	**0.74**
Seasonal	0.77	70	**0.54**
Total/Average		100	**1.28**

Benthic Flux. During warm summer months, nitrogen is introduced into the water column from the sediments, particularly in the tidal ponds, such as Meetinghouse and Arey's Ponds. Generally this form of nitrogen is collected in the sediments from nitrogen in the watercolumn during the cold winter months and released in the summer. The Woods Hole Group reported that procedures used by SMAST overestimated the benthic flux values and that the actual values perhaps should be only about 70 percent of those used by SMAST in their analysis.

SMAST estimates of nitrogen inputs into the Arey's Pond watershed are shown in the center column of Table 2. Alternate estimates prepared by the WMV&DC are shown in the right column. For this particular watershed, the estimated nitrogen input is only 64 to 66 percent of the SMAST amount. As shown in Table 2, the septic and benthic flux sources are the largest nitrogen sources.

Table 2

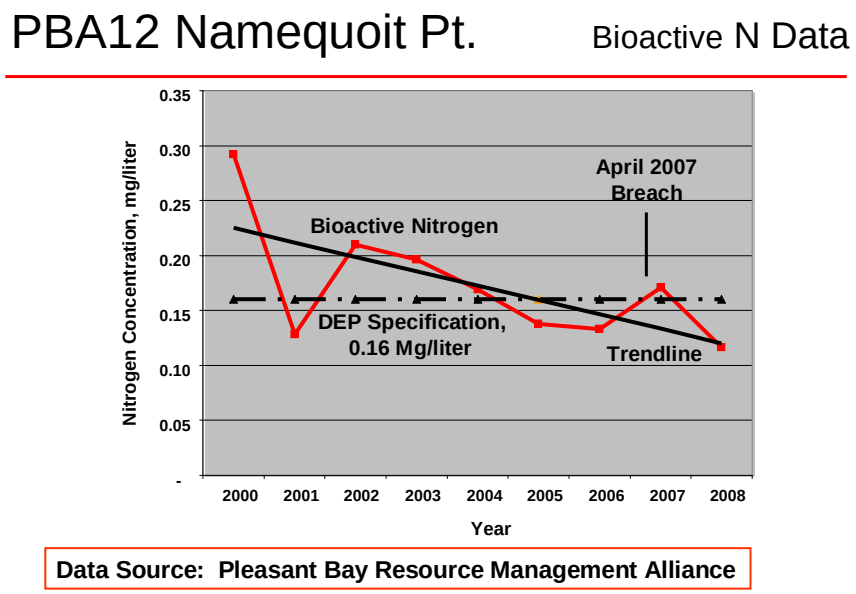
Source	Arey's Pond SMAST Est. (kg per day)	Alternate-Estimate (kg per day)
Natural Background	**0.47**	**Not Avail.**
Land Use	**0.53**	**0.34**
Septic Systems	**0.78**	**0.42 to 0.58**
Atmospheric Deposition	**0.18**	**0.13**
Total Input	**1.96**	**0.89 to 1.05**
Benthic Flux	**6.00**	**4.20**
Total Load	**7.96**	**5.09 to 5.27**
Ratio Benthic to Septic	**7.69**	**7.24 to 10.00**

FINDINGS CONCERNING NITROGEN CONCENTRATIONS

The Pleasant Bay Resource Management Alliance has collected numerous water quality samples for SMAST in each year beginning in 2000 and continuing through 2008. The WMV&DC has analyzed the resulting data and the results suggest that nitrogen concentrations in a large part of Pleasant Bay and contiguous tidal ponds are decreasing, not increasing as previously suggested to the public. In fact, some of the sampling stations have met, or in the near future will meet, the DEP water quality specifications.

The sentinel station to observe water quality with respect to the health of eelgrass is PBA12, located just off Namequoit Point in Little Pleasant Bay. The DEP specification of 0.16 parts per million (ppm) of bioactive nitrogen has been achieved yearly since 2004, as shown in Figure 1. Note: the DEP specification of 0.16 ppm is only approximate and may be higher.

Figure 1

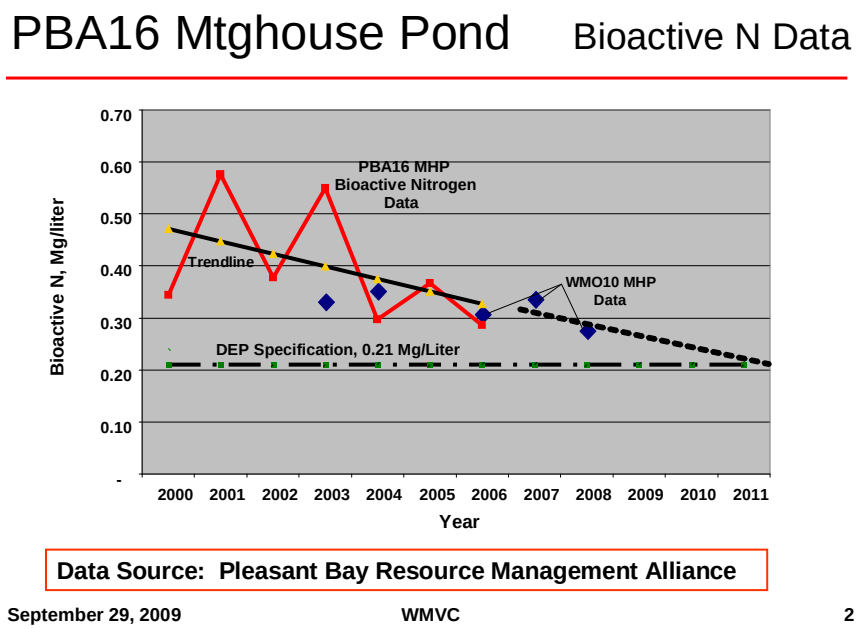


The bioactive nitrogen concentrations are shown in the zig-zag line, and the statistical trend is shown in the sloping straight line. The trend line still decreases even if one uses only the data prior to the April 2007 breach opposite Allen Point. The DEP specification is also shown. Note that the source of the data is the Pleasant Bay Resource Management Alliance.

SMAST modeling of Pleasant Bay using tidal conditions as they were in 1986 and into 1987 prior to the breach occurring at Chatham Light is described in Chapter IX of the MEP Pleasant Bay report. The model output data estimates the bioactive nitrogen concentration at Namequoit Point in 1987 prior to the Chatham Light breach to be 0.279 ppm. Assuming that the 1987 septic and fertilizer nitrogen loads were 50% of the corresponding 2005 loads, the Namequoit Point bioactive nitrogen level in 1987 was approximately 0.26 ppm (59% above the DEP specification) compared with the current, 2008 level of 0.12 ppm (26% below the DEP

specification). It is clear from the modeling information that bioactive nitrogen and total nitrogen have been decreasing in most areas of Pleasant Bay since the breach opposite the Chatham lighthouse in1987. It is also clear from the same modeling information that, if the inlet configuration were to return to the pre-1987 condition, even with the elimination of all septic nitrogen from Pleasant Bay watersheds, the Namequoit Point bioactive nitrogen concentration would be approximately 0.23 ppm (45% above the DEP specification). As a result, attainment of zero septic nitrogen with the pre-1987 inlet conditions would likely make the DEP specification unachievable without applying some alternative technology to improve water quality.

Figure 2

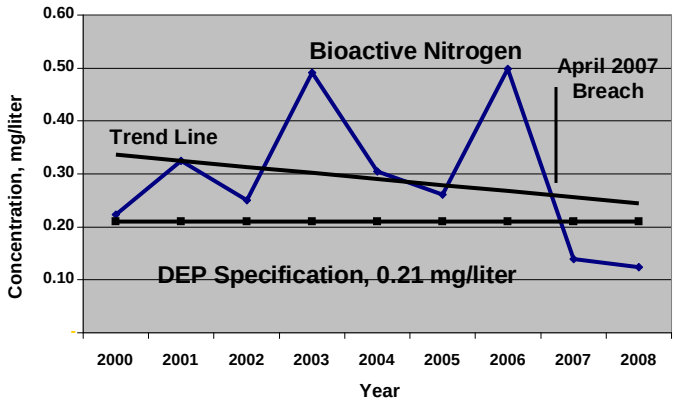


Data for Meetinghouse and Paw Wah Ponds also show declining concentrations of bioactive nitrogen. Data for Meetinghouse Pond are presented in Figure 2. The April 2007 Breach in the Nauset Spit opposite Allen Point has not had a dramatic effect on the water quality of Meetinghouse Pond, which has been continuing to improve. In 2008 the concentrations of bioactive nitrogen was approaching the DEP threshold specification of 0.21 ppm bioactive nitrogen.

Nitrogen concentrations for Pah Wah Pond are shown in Figure 3. The impact of the 2007 breach was evidently significant, as the bioactive nitrogen concentrations dropped to less than 0.15 ppm, compared to the DEP threshold of 0.21 ppm. This reflects improved flushing by the waters in Little Pleasant Bay (see PBA12 data).

Figure 3

PBA11 Pah Wah Pond Bioactive N Data



Data Source: Pleasant Bay Resource Management Alliance

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In contrast to the situation in Meetinghouse and Paw Wah Ponds, data collected for Lonnie's and Arey's Ponds show modest increases in bioactive nitrogen concentrations from 2000 to 2008 (Lonnie's Pond) or to 2006 (Arey's Pond). Since there are no reasons to expect septic loading and tidal flushing to be significantly different among these four ponds, the reasons for the increases in Arey's and Lonnie's Ponds are not clearly understood.

FINDINGS CONCERNING BENTHIC HEALTH

The fundamental driving force for the remediation of groundwater in Orleans that is discharged into Pleasant Bay is the health of benthic or bottom-dwelling organisms within the Bay. It has been asserted, and it is widely assumed, that habitat health within the Bay has declined significantly over the past several decades as a consequence of increasing contamination by septic effluent within the groundwater. However, the WMV&DC has not been able to validate the conclusion that Pleasant Bay has suffered major or even significant environmental degradation resulting in the decline of benthic health or habitat quality over any period during the past 58 years.

The major benthic communities in Pleasant Bay that are believed to have been impacted most significantly by septic effluent are the eelgrass meadows that are widespread and abundant in the major lagoons, and the interstitial infauna that live within the mud on the bottom of the semi-isolated tidal ponds in the northernmost portion of the Bay system. The shellfish communities, which are the richest resource within the Bay, seem not to have been affected adversely.

Eelgrass Health. The assumption that presumed declines in eelgrass distribution are the result of increasing levels of nitrogen within the Bay is unfounded in fact. The WMV&DC and the Woods Hole Group have found that numerous other environmental variables may be detrimental to eelgrass viability. Most notable among these detriments within Pleasant Bay are burial by storm and over-wash deposits, commercial shellfish harvesting, and infection by wasting disease.

The two major findings by the WMV&DC concerning eelgrass health are:

- There is no reliable basis for asserting that there has been a significant decline in eelgrass distribution or habitat quality within the major embayments of Pleasant Bay over the past several decades.
- There is no rational ecologic basis for ranking the relative impacts of the various potential causes of environmental stress on eelgrass, and claiming that the likely cause of presumed declines in areal distribution is septic effluent.

Benthic Infauna. The tidal ponds are relatively impaired with their central bottoms approximating quasi "dead zones". The WMV&DC does not know if this impairment is the consequence of septic effluent, other influences, or intrinsically natural. There is no basis for believing that the tidal ponds are recipients of higher levels of nutrients than other parts of the Bay system, and their flushing rates are comparable with the major lagoons. The tidal ponds may not be amenable to remediation, nor responsive to nitrogen reduction.

The major findings of the WMV&DC concerning the health of benthic fauna are:

- The major lagoonal embayments within Pleasant Bay are essentially healthy benthonic habitats with good water quality, and rich and diverse faunal communities.
- The central deeper bottoms of the tidal ponds are stressed habitats with poor water quality, characterized by low oxygen and high suspended sediment.

- Whether the stressed benthonic habitats in the tidal ponds are reflective of man-induced degradation or natural causes is an unresolved question.

Nutrient Related Health. There is little evidence of significant documented declines in eelgrass distribution since1995. Nevertheless, the Massachusetts DEP has used eelgrass distributions as the basis for establishing permissible threshold levels for nitrogen concentrations in various parts of Pleasant Bay, and these constitute the basis for establishing acceptable TMDLs of nitrogen discharges into Orleans' groundwater.

Neither the WMV&DC nor the Woods Hole Group has been able to document an empirical foundation for establishing an optimal or critical threshold for nitrogen concentrations in marine embayments comparable with Pleasant Bay.

FINDINGS CONCERNING THE SMAST LINKED MODEL

As a result of the analyses by the WMV&DC and the Woods Hole Group (WHG) several major concerns regarding the SMAST linked model's reliability to simulate nitrogen behavior in Pleasant Bay have been identified. The following are of primary concern:

- Inability to calibrate the model to accommodate the complexities of the estuarine system of Pleasant Bay.
- Lack of a bona fide nitrogen mass balance in the MEP Pleasant Bay Report (i.e. an accounting for all the nitrogen inputs and outputs showing that Nitrogen Inputs minus Nitrogen Outputs equals zero over some time period).
- Failure to consider significant pathways of nitrogen loss from the Pleasant Bay system.

The calibration problems are considered in detail in the Final Report of the WMV&DC[3], and will not be elaborated here. To briefly summarize, the WMV&DC found that these problems indicate that the SMAST linked model is unlikely to provide a reliable basis for simulating the behavior of nitrogen in Pleasant Bay.

Lack of Nitrogen Mass Balance. The WHG pointed out the lack of a bona fide nitrogen mass balance in the MEP Pleasant Bay Report as a cause for concern. A basic scientific principle is the law of conservation of mass. This principle requires that, over some period of time (i.e. a day or a year), if the nitrogen concentration in the system does not change, the quantity of nitrogen going into the water column must equal the quantity of nitrogen leaving the water column.

Each day approximately 23,300 kg of nitrogen enters Pleasant Bay. This includes 89 kg of septic nitrogen (less than 0.4%) plus nitrogen from fertilizer and all other sources. Of the 23,300 kg, more than 99% is from natural sources (i.e. rainfall and Atlantic Ocean tidal waters). Using the SMAST model, the only loss pathway identified is tidal flow leaving the bay and passing into the Atlantic Ocean. This output of nitrogen is roughly 28,400 kg per day. So, according to the data in the MEP Pleasant Bay Report, roughly 5,100 kg per day more nitrogen

[3] Full report available Online at: http://www.town.orleans.ma.us at Boards & Committees under Validation

leaves Pleasant Bay waters than goes into Pleasant Bay waters. The system can not lose 5,100 kg per day. This is a huge number; more than 20% of all the nitrogen loads going into the Bay daily.

Nitrogen Losses Not Considered by SMAST. Of further concern regarding the lack of a mass balance by SMAST is the omission of significant nitrogen loss pathways in the SMAST analysis. In other words, SMAST failed to include all the pathways by which nitrogen leaves the Pleasant Bay system. Nitrogen loss pathways omitted by SMAST include the following:

- Microbial denitrification, adsorption and other natural processes that consume nitrogen within the groundwater.
- Denitrification (conversion to inert nitrogen gas) at the sediment-water interface within the Bay.
- Removal by burial of materials containing nitrogen in the sediment on the bottom of the Bay.

These three nitrogen loss pathways are all net overstatements of the nitrogen inputs to the water column in Pleasant Bay. By their omission, the quantity of nitrogen going into the water has been overstated.

The Wastewater Management Validation & Design Committee has identified several biases in the SMAST nitrogen inputs and omission by SMAST of three important nitrogen loss pathways (outputs). Each is significant in its own right and each is an overstatement of the nitrogen loadings to Pleasant Bay.

These findings mean that the nitrogen loadings and nitrogen outputs from the Pleasant Bay system used by SMAST are highly unlikely to be representative of the actual nitrogen sources and losses in Pleasant Bay. Since the SMAST loadings were those used to calibrate the SMAST linked embayment model, the calibration is highly unlikely to be valid and the use of the model for simulation of nitrogen is unlikely to be valid.

FINDINGS CONCERNING THE 2007 BREACH

The breach in the barrier beach opposite Allen Point in Chatham on 19 April 2007 occurred after the SMAST/MEP report was written and published in 2006. The findings of the WMV&DC are not dependent on the breach remaining open and stationary. Water quality has been improving since 1987, and it should continue to improve due to the greater tidal range and better flushing of Pleasant Bay by clean Atlantic Ocean water. The water quality in most areas is now meeting very stringent DEP specifications. The future of the breach can not be predicted precisely, but historical studies have shown that it probably will not close, but likely migrate slowly south over the next fifty to eighty years.

ORLEANS' CITIZENS PEER REVIEW PANEL

Biographical Sketches

Paul Ammann, Chairman: Mr. Ammann holds B.S. and M.S. degrees in Chemical Engineering from the Massachusetts Institute of Technology. He worked in industry approximately 25 years, and subsequently as a consultant, and was a licensed professional engineer in the Commonwealth of Massachusetts until his retirement.
In positions with major companies and as a consultant he has been responsible for conceptualizing, designing, testing, and implementing technologies involving pollution control; hazardous waste handling and remediation; and metallurgical and chemical processes. As a consultant, he has concentrated his work in the environmental area to include the analysis of policies, technologies, and costs associated with the cleanup of hazardous waste sites. He has assisted companies in structuring research and development efforts, and aided policymakers in assessing the cost implications of various regulatory scenarios. Mr. Ammann also has worked with companies and their legal counsel and legal committees in connection with settlement and litigation matters at Superfund sites.

Ed Daly, Vice Chairman: Mr. Daly, a missile guidance engineer, holds a B.S. in Electrical Engineering and a M.S. in Electrical and Electronic Engineering from Northeastern University and is a graduate of the Raytheon Executive Management Program. Prior to retiring to Cape Cod, Mr. Daly served as the major program manager for Raytheon's Saudi Arabian program in which position he was responsible for deployment of Hawk and Patriot missile air defense systems, including all supporting logistics facilities for training, maintenance depots, housing bases for employees, a major medical facility, and a desalination plant on the Red Sea. Earlier in his career, Mr. Daly served as Raytheon Laboratory manager for the design of the Patriot missile, including oversight of the flight test program at White Sands Missile Range in New Mexico, and as a missile guidance engineer for AVCO where he was responsible for the design of telemetry equipment for the Minuteman and Titan ICBM missiles. He holds two registered U.S. patents and has been published in several professional journals.

Jeffrey Eagles: Mr. Eagles retired to Cape Cod in 2000 following 20 years of service in the semiconductor industry with the BOC Group, a multinational industrial gas company, where he marketed, and managed the sale and servicing of gases, vacuum pumps, and a range of chemical processing equipment used to convert highly toxic gases to safe byproducts. In addition to BOC assignments in the U.S., Mr. Eagles also lived and worked in Taiwan, Japan, and the United Kingdom during that period. Prior to joining BOC, Mr. Eagles served as project control manager for a Raytheon Company petrochemical plant construction project in Alberta, Can. As a commissioned Naval Officer during the 1970s, Mr. Eagles served in Admiral H.G. Rickover's headquarters engineering organization, where he was responsible for environmental and waste treatment aspects related to radioactive materials generated on U.S. Navy submarines, surface ships; and shipyards and land-based facilities, including two commercial electrical power generated plants. Mr. Eagles earned a B.S in Chemical Engineering from Tufts University and an S.M. in Hydrogeochemical Engineering from Harvard University, School of Engineering and Applied Science. He also holds an M.B.A. from Harvard University.

Greg Horne: Dr. Horne received his Ph.D. in geology from Columbia University in 1968. He joined the faculty of Wesleyan University in 1970, and two years later initiated one of the first undergraduate programs in environmental sciences in the United States at Wesleyan as an outgrowth of the university's traditional geology department. Over the next 30 years, Dr. Horne spearheaded the development of that program with a primary focus on coastal marine science. As an adjunct of that work, he developed and implemented a vigorous research program on the Connecticut River estuary, the largest estuary in New England, and served as director of the Essex Marine Laboratory in Essex, Conn. Dr. Horne also collaborated with colleagues at the West Indies Laboratory at St. Croix, USVI, on the ecology of Caribbean coral reefs. He served for 20 years as an officer on the Board of Control of the Connecticut Experiment Station in New Haven, Conn., that state's major environmental facility. He has published the results of his research with the Connecticut River estuary and Long Island Sound in peer-reviewed scientific journals on the topics of tidal circulation; estuarine hydraulics; sediment transport; coastal erosion; salt marsh evolution; sea level change; and Quaternary coastal development. Dr. Horne retired to the Cape in 2000, and has since focused his interests on the health of Pleasant Bay.