

## Memorandum

To George Meservey, Director of Planning & Community Development  
Michael Domenica, PE, Program Manager

CC Betsy Shreve, AICP, AECOM Project Director  
Sia Karplus, Science Wares, Inc.  
Paula Winchell, AECOM

Subject **Town of Orleans, MA  
Water Quality and Wastewater Planning  
Task Number 4.e.7 and 8 – Adaptive Management Plan - Final Technical  
Memorandum on MEP Model Update and Implementation Analysis**

Project Number 60476644

From Thomas Parece, P.E., AECOM Project Manager

Date 05/16/16

### 1. Background

The *Linked Watershed-Embayment Model* is the foundation of the MEP Reports prepared for over fifty embayments throughout southeastern Massachusetts, including Pleasant Bay, Nauset Harbor and Rock Harbor Creek. To provide a realistic picture of these complex ecological systems, the MEP model accounts for a number of features. Factors that impact nutrient loading to estuaries are a key aspect of accurate modeling. The MEP model accounts for land-based nutrient sources, attenuation, recycling and regeneration within sediment. Circulation, basin structure and depths as well as tidal hydrodynamics are also part of the model. Incorporating the interactions among these physical attributes of the estuary allows accurate prediction of the spatial distribution of nitrogen impacts. Model outputs are also validated using site specific data for salinity, total nitrogen and tides. The original MEP model was set up, calibrated and verified using field data from 2001 through 2004. Storms and other events over the past decade have altered the inlets along Orleans's south coast, and changed the circulation patterns within both the Pleasant Bay and Nauset Harbor estuaries.

To better represent the impacts of nitrogen removal from different sub-embayments of the main estuarine systems in Orleans, the model should be based on updated bathymetry, accurate tide regimes, boundary conditions, salinity and nitrogen concentrations. Sediment cores as well as benthic infauna analysis are also needed to fully update the MEP Reports for these estuaries.

As documented in Technical Memorandum 4.a.1: *Baseline Monitoring*, Orleans maintains an ongoing program for water quality monitoring. In addition, several special studies have been recently completed relating to MEP model boundary conditions, bathymetry, sediment analysis and inlet dynamics in Nauset Harbor. In order to review and coordinate these programs and determine whether there are any data gaps for the purpose of implementing a program for an update of the MEP model, two workshops were held on April 1, 2016 and April 11, 2016. The purpose of this Technical Memorandum (TM) is to document the results of these workshops and provide an integrated work plan for monitoring, modeling and the analytical services needed to support the implementation of the Orleans water quality and wastewater program for the next 5 years.

## 2. Overview of Adaptive Management Planning Workshops

The goal of these workshops was to develop an integrated work plan for monitoring, modeling and analytical services that supports the planning and implementation of the Orleans water quality and wastewater program for the next five years. This work plan is to include a scope, schedule, responsible parties and budget based on a gap analysis that compares existing programs with the regulatory and planning requirements needed by Orleans going forward.

Workshop agendas and a list of attendees are provided in Appendix A. The April 1, 2016 schedule included an overview of Orleans's water quality and wastewater planning program, and presentations on the broad range of water quality monitoring programs in Orleans. Representatives from the Orleans Board of Selectmen (BOS), Town Staff, Orleans Water Quality Task Force (OWQTF), Orleans Water Quality Advisory Panel (OWQAP), Pleasant Bay Alliance (PBA), AECOM and the University of Massachusetts School for Marine Science and Technology (SMAST) presented details of their monitoring programs. Appendix B provides copies of the PowerPoint presentations that were made. Robust discussion followed each presentation to address the following questions:

- Are modifications to existing monitoring programs needed?
- Is additional information needed to supplement current programs?

Prior to the April 11, 2016 workshop, a summary of the findings from the first workshop was provided to attendees. These "key takeaways" are included as Appendix C. The second workshop provided time to thoroughly review these recommendations in order to finalize a list of action items and responsible parties. In addition, it was determined that SMAST would provide a detailed Scope of Work, schedule and budget for all analytical work required to continue water quality monitoring in Orleans as well as update the MEP Reports for Pleasant Bay and Nauset Harbor.

## 3. Workshop Outcomes

The following action items were agreed upon at the April 11, 2016 workshop. The Town entity listed below each item is responsible to either continue to perform tasks as described below, or provide a Scope of Work, schedule and budget to accomplish new tasks.

### A. Continue to use volunteers for data collection

- Use of volunteers is approved by regulators (MassDEP and USEPA);
- Volunteers are well-trained to follow approved Quality Assurance Program Plan (QAPP) and samples are of high quality; and
- More volunteers are needed.

Appendix D includes a detailed description of the water quality monitoring programs organized by OWQTF for Nauset Harbor, Rock Harbor Creek and Namskaket and Little Namskaket Creek.

RESPONSIBLE PARTY: OWQTF

### B. Do not change protocols, sampling frequency or methods

- SONDES (dataloggers) are expensive and not recommended by SMAST for long-term waterbody monitoring for TMDL purposes. May be applicable for some short term project-specific monitoring;

- Sample collection during July and August is sufficient for long-term waterbody monitoring;
- Winter sampling is not necessary for TMDL purposes; and
- Demonstration project sampling (shellfish and Floating Constructed Wetlands) may benefit from winter sampling as well as continuous monitoring using SONDES.

RESPONSIBLE PARTY: OWQTF

#### C. Water Quality Data Base Consolidation

Salt and fresh water databases from various groups need to be consolidated into a unified data management system. The overall consistency and quality of the data needs to be confirmed. A program for on-going quality control and addition of information to the data base needs to be developed.

The following data sets or information currently exist:

- SMAST (from Town monitoring programs);
- APCC;
- Provincetown Center for Coastal Studies (PCCS),
- USGS;
- Consulting reports (various); and
- Designation of database manager, QA/QA and IT protocols must be developed.

RESPONSIBLE PARTY: Orleans BOS (hire a firm to perform this consolidation)

#### D. Pleasant Bay MEP Report (and linked model) should be updated, using:

- Current watershed delineation;
- Nutrient data from existing 28 monitoring stations;
- Station at Strong Island measured at flood tide to establish boundary condition;
- One new station to capture breach;
- Tide gauges at all locations, including a gauge at the new station at the breach;
- New field and desktop studies of:
  - Benthic cores (64 stations);
  - Infauna survey;
  - Measured natural attenuation at strategic locations; and

- Review existing eelgrass data.
- Updated land and water use, impervious surfaces, roadway and rooftop areas;
- High quality bathymetry data with corresponding side scan sonar and benthic grab samples have been recently collected by Cape Cod National Seashore/Provincetown Center for Coastal Studies (CCNS/PCCS). Additional Acoustic Doppler Current Profiler (ADCP) data as needed; and
- Significant variability can exist during the tide cycle and during the lunar month. Marine samples are appropriately collected at mid-ebb tide for average tides (neither spring nor neap). The following should also be undertaken:
  - For one of the sampling events, sampling should be conducted at fixed stations during the entire tide cycle, to provide information on variability.

The MEP Report update for Pleasant Bay should include the following:

- Model calibrated to BioN as well as TN (as was done in the 2006 MEP Report);
- Total nitrogen (TN) is calculated based on adding the measurements of the different nitrogen species. Actual analyses of total nitrogen should also be conducted as an independent check of the TN values derived using summation estimates. One issue that was raised at the workshop is that the laboratory methods based on perchlorate digestion do not accurately measure particulate organic nitrogen because digestion is incomplete. Dr. Candace Oviatt at the University of Rhode Island Graduate School of Oceanography has developed a methodology that addresses the issue of incomplete digestion. Her method, that seems to result in complete particulate digestion, involves a hot water bath process instead of autoclaving. This modification to the perchlorate method, in which a sample digests for a longer period at lower temperatures, enables full digestion of particulates (Costa 2013 and personal communication);
- Salinity analyzed to provide quantitative information on tidal flushing at different sites;
- Trend regressions before and after the 2007 break that is matched at the time of the break; and
- Mass balance calculations should be prepared for the different sub-areas of Pleasant Bay with estimates of such factors as:
  - Stormwater loading;
  - Groundwater loading;
  - Atmospheric loading;
  - Tidal flushing; and
  - Benthic deposition or regeneration.

These mass balance calculations would characterize the nitrogen loading in different sections of Pleasant Bay to assist in trend analysis as well as targeting areas for different solutions.

RESPONSIBLE PARTY: Orleans BOS (coordinate with SMAST to approve a Scope of Work, budget and timeframe to accomplish this update)

E. Nauset Harbor MEP Report to provide a nitrogen-removal estimate for restoring water quality should be updated, using:

- 15 monitoring stations that need to be reinstated in Town Cove/Mill Pond from original MEP Report;
- TN calculated as the sum of different N species and also derived as a separate laboratory value for comparison. See explanation under item #8.
- Tide gauges at inlet to confirm dampening;
- CCNS/PCCS tide data for Nauset Marsh; and
- Model rerun to evaluate level of impairment, nutrient thresholds.

RESPONSIBLE PARTY: Orleans BOS (coordinate with SMAST to approve a Scope of Work, budget and timeframe to accomplish this update). Workshop goal is to have these items completed in the Summer of 2016.

F. Rock Harbor Creek Water Quality Standards Evaluation

Complete information assessment to determine the need and feasibility of a Use Attainability Assessment (UAA) for Rock Harbor Creek water quality standards adjustment.

To be completed after development of Amended CWMP that will provide information needed for scope of a UAA required by DEP/EPA.

RESPONSIBLE PARTY: Orleans BOS (hire a firm to perform this assessment)

G. Namskaket Marsh Watershed Management Plan, including:

- Vegetation Survey update (completed)
- Confirm hydraulic design and proper settings for stop logs at the Bike Trail culvert.
- Develop Watershed Management Plan including, working with Brewster:
  - Land use plan update for the watershed upgradient from the Bike Trail (consistent with RESET plan)
  - Stormwater management plan for Route 6a area, including Eel Pond
  - Pond Remediation Plan for Eel Pond.
- Review monitoring data, confirm monitoring plan, and confirm MEP model nitrogen projections

RESPONSIBLE PARTIES: Conservation Commission and Orleans BOS

H. Cedar Pond

- Plan is on track for Cedar Pond Management
  - Environmental Impact Report (EIR) is the next step;

- As part of EIR, clear thresholds for Adaptive Management will be established; and
- Monitoring should continue.

RESPONSIBLE PARTY: Orleans BOS (hire a firm to file Environmental Impact Report (EIR))

#### I. Freshwater Ponds Management Plan

The goal is to update and provide an implementation plan for water quality remediation and management of the Town's freshwater ponds.

- Aggregate data sets and establish a database;
- Establish ownership of data;
- Analyze data and identify data gaps;
- Update pond trophic status assessment and identify priority ponds for remedial action; and
- Prepare Action Plan/Pond Management Plan including scope of work, timeframe and required funding.

RESPONSIBLE PARTIES: OWQTF and Orleans BOS (hire a firm to perform this consolidation)

#### 4. Recommended Action Plan

- A. Updating the MEP model for Pleasant Bay and Nauset Harbor was identified in the workshops as a top priority. As detailed in Section 3: Workshop Outcomes, the first step in accomplishing this program is to develop a Scope of Work, budget and timeline with SMAST. This Scope of Work should be checked against this TM to ensure all the items recommended are either included or explicitly decided against.

The following specific items must be addressed:

- Advisability of revising the assumption used for septic nitrogen load value as part of updating the land and water use analysis;
- Need to update watershed boundaries and land use (using data that was collected for amendment of CWMP);
- Adequacy of recently-completed bathymetric and tide surveys in Pleasant Bay and Town Cove from CCNS/PCCS;
- Number and locations of monitoring stations needed in Nauset Harbor;
- Number of years of data needed from additional monitoring stations in Nauset Harbor; and
- Need and locations of additional stations to acquire tide data on elevation, velocity and ranges.

- B. To accomplish the other action items enumerated in Section 3: Workshop Outcomes, the responsible party should coordinate efforts with appropriate technical consultants.

**5. References**

Costa A, Larson E, Stamieszkin K. 2013. Quality Assurance Project Plan (QAPP) for Water Quality Monitoring in Cape Cod Bay 2011-2012. Boston: Massachusetts Water Resources Authority. Report 2013-09. 90 p.

**Appendix A**

**AMP – Water Quality Monitoring and Modeling Workshop - April 1, 2016**

**Agenda and a List of Attendees**

## Orleans Water Quality and Wastewater Planning

### AMP - Water Quality Monitoring and Modeling Workshop

#### Goals and Agenda [Revised]

**Date:** Friday April 1, 2016

**Time:** 8:30 AM - Noon

**Location:** Orleans Town Hall, Nauset Room

**Goal:** To develop an integrated work plan for monitoring, modeling and analytical services that supports the planning and implementation of the Orleans water quality and wastewater program for the next 5 years. The result will be a Technical Memorandum by AECOM to be included in ACWMP and Orleans program budgets for FY 2017 – 2021.

**Objective:** To develop a five-year work plan, including the scope, schedule, responsible parties and budget, for monitoring, modeling and analytical services that is based on a “gap analyses”. The gap analysis will compare the detailed scopes of work of existing programs being performed by various agencies and parties, including volunteer efforts, in the Pleasant Bay, Nauset and Rock Harbor Creek watersheds with the regulatory, planning, design and compliance monitoring/modeling requirements needed to implement the Orleans water quality and wastewater program.

#### Workshop Agenda:

**1. Introduction and Overview of the Orleans WQ and Wastewater Management Program (8:30-9:00)**

- a. MEP/TMDL requirements
- b. Ponds Program
- c. The Consensus Plan Projects and Project Goals
- d. Program Schedule

**2. Summary Presentations on Historic and Existing Water Quality Analytical Programs (9:00-12:00)**

The following presenters will provide 10 minute summaries of the particular monitoring, modeling or special studies in which they have been involved, followed by 5 minutes for questions/recommendations specific to their particular monitoring effort:

- A. Baseline, On-Going Estuarine Monitoring (60 min total)
  - Pleasant Bay – Bob Duncanson
  - Nauset System – Carolyn Kennedy
  - Rock Harbor Creek – Carolyn Kennedy
  - Little Namskaket and Namskaket Creek watersheds – Carolyn Kennedy
- B. Freshwater Ponds (Ed Eichner) (15 min)
- C. Cedar Pond Studies (Brian Howes) (15 min)
- D. MEP Modeling and Analyses (Brian Howes) (15 min)
- E. Non-Traditional Project Monitoring (Sia Karplus, Jim Begley) (15 min)
- F. Special Studies (Howes and others) (20 min)
  - Nauset inlet boundary study
  - Pleasant Bay eelgrass study
  - Pleasant Bay barrier breach
  - Sediment studies
- G. Other (10 min)

Each presentation should include:

- Purpose of the program
- Locations, parameters, frequency, monitoring times and seasons, duration of program
- Source and status of QAPP
- Laboratory arrangements
- Staff resources, e.g. volunteers, paid staff
- Analyses and documentation of results (cite links, reports, etc)
- Data base location and management
- Budgets, if any
- Other important information

After each presentation, the group will discuss:

- How existing programs should be modified (locations, parameters, etc.)?
- What additional information is needed to supplement the existing program?
- How additional needs will be addressed: Who, what, when, where, QAPP, cost for each.

H. Summary of Key Monitoring Recommendations (30 min)

### 3. Preparing the Work Plan (12:00-12:30)

- a. Work Plan Outline (Technical Memorandum)
- b. Action list
- c. Lead author and reviewers
- d. Schedule

**Workshop Attendees:**

George Meservey, Orleans Town Planner  
Tom Parese, AECOM Technical Services, Inc.  
Sia Karplus, Science Wares  
Brian Howes, SMAST  
Amy Costa, PCCS  
Bob Duncanson, Town of Chatham  
Carole Ridley, Pleasant Bay Alliance  
Sandy Bayne, Town of Eastham  
Carolyn Kennedy, Orleans Water Quality Task Force  
Judy Scanlon/Suzanne Phillips, Orleans Shellfish and Waterways  
Tom Cambareri, Cape Cod Commission  
Brian Dudley, DEP  
Mike Domenica, Orleans Wastewater Consultant

Water Quality Monitoring and Modeling  
Workshops  
April 1, 2016

<u>Name</u>	<u>Affiliation</u>	<u>Email</u>
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Amy Costa	CCS	acosta@coastalstudies.org
Stacy Keenleyside		

## Orleans Water Quality Advisory Panel

### AMP – Water Quality Monitoring and Modeling Workshop

#### Agenda

**Date:** Wednesday, April 11, 2016

**Time:** 10:00 AM

**Location:** Orleans Town Hall, Nauset Room

1. Non-Traditional Project Monitoring – Aquaculture/Shellfish and PRBs
2. Preparing the Work Plan
  - a. April 1, 2016 AMP Workshop - Key Takeaways
  - b. April 11, 2016 AMP Workshop - Key Takeaways
  - c. Action Items
  - d. Schedule

Sign In

<u>Name</u>	<u>Affiliation</u>	<u>Email</u>
Suzanne Phillips	Shellfish Waterways	stornp gma
BRIAN DUDLEY	MASS DEP	brian.dud state.ma
Jeff Eagles	DWA	jeyacce
Audrey Bayne	Earth and	pandyba
Judy Scanlon	Orleans WQTF	nohnac
Cardyn Kennedy	WQTF	
Brian Howes	SMASST-UMASS	bhowes@
Ed Eichner	SMASST/CSP	eichner@
Ed Daly	Orleans Peab Punc	eddalys
TOM PASCARE	SECOM	TOM.PASCARE@
ALAN MCLENNEN	BOS	alanbaats
Mike Domanica	WRA	mdomanica@
Paula Winchell	AELOM	paula.winc

**Appendix B**

**AMP – Water Quality Monitoring and Modeling Workshop - April 1, 2016**

**Presentation**



Town of

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Massachusetts

## Water Quality and Wastewater Planning

### AMP - Water Quality Monitoring and Modeling Workshop

April 1, 2016

#### Agenda

- ❖ Introduction and Overview
- ❖ Summary Presentations on Water Quality Analytical Programs
- ❖ Preparing the Work Plan





# Introduction and Overview

## Massachusetts Estuaries Project (MEP) Total Maximum Daily Load (TMDL) Requirements Nauset Harbor MEP Report (2012)

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Nauset Harbor estuary system.

Sub-embayments	Present Watershed Load <sup>1</sup> (kg/day)	Target Threshold Watershed Load <sup>2</sup> (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net <sup>3</sup> (kg/day)	TMDL <sup>4</sup> (kg/day)	Percent watershed reductions needed to achieve threshold load levels
<b>SYSTEMS</b>						
Nauset Marsh	10.729	10.729	11.252	46.838	68.819	0.0%
Salt Pond	5.014	1.196	0.299	14.201	15.696	-76.1%
Woods Cove	0.745	0.745	0.241	4.657	5.643	0.0%
Mill Pond	4.932	4.932	1.068	3.219	9.219	0.0%
Rachel Cove	0.178	0.178	0.162	0.000	0.340	0.0%
Town Cove	31.595	11.968	5.230	41.520	58.718	-62.1%
<b>System Total</b>	<b>53.192</b>	<b>29.748</b>	<b>18.252</b>	<b>110.436</b>	<b>158.435</b>	<b>-44.1%</b>

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.  
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.  
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).  
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.



## Massachusetts Estuaries Project (MEP) Total Maximum Daily Load (TMDL) Requirements

### Pleasant Bay MEP Report (2006)

Table VIII-4. Comparison of sub-embayment **total watershed loads** (including septic, runoff, and fertilizer) used for modeling of present and threshold loading under one possible restoration scenario of the Pleasant Bay system. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Meetinghouse Pond	6,197	1,058	-82.9%
The River – upper	2,773	1,737	-37.4%
The River – lower	3,879	2,444	-37.0%
Lonnies Pond	2,441	1,626	-33.4%
Arceys Pond	1,304	0,915	-29.8%
Namequoit River	2,737	1,732	-36.7%
Paw Wah Pond	1,860	0,728	-60.9%
Pochet Neck	8,422	4,123	-51.0%
Little Pleasant Bay	7,496	5,240	-30.1%
Quanset Pond	1,781	1,079	-39.4%
Tar Kiln Stream	6,123	5,225	-14.7%
Round Cove	4,225	2,960	-29.9%
The Horseshoe	0,638	0,638	0.0%
Muddy Creek – upper	9,981	4,814	-53.9%
Muddy Creek – lower	8,477	2,137	-74.9%
Pleasant Bay	23,159	16,621	-28.2%
Pleasant Bay/Chatham Harbor Channel	-	-	-
Bassing Harbor - Ryder Cove	9,819	4,466	-54.5%
Bassing Harbor - Frost Fish Creek	2,904	0,704	-75.8%
Bassing Harbor - Crows Pond	4,219	4,219	0.0%
Bassing Harbor	1,668	1,668	0.0%
Chatham Harbor	17,099	17,099	0.0%
TOTAL - Pleasant Bay System	127,203	81,032	-36.3%

Sub-embayment	Target Watershed Load <sup>1</sup> (kg/day)	Atmospheric Deposition (kg/day)	Benthic Input <sup>2</sup> (kg/day)	TMDL <sup>3</sup> (kg/day)
Meetinghouse Pond	1.06	0.58	7.86	10
The River – upper	1.74	0.29	4.10	6
The River – lower	2.44	2.24	8.52	13
Lonnies Pond	1.63	0.23	1.30	3
Arceys Pond	0.92	0.18	4.93	6
Namequoit River	1.73	0.52	12.23	14
Paw Wah Pond	0.73	0.08	2.67	3
Pochet Neck	4.12	1.77	0	6
Little Pleasant Bay	5.88	24.09	35.22	65
Quanset Pond	1.08	0.17	4.79	6
Round Cove	2.96	0.17	6.74	10
Muddy Creek – upper	4.61	0.16	2.70	7
Muddy Creek – lower	2.14	0.21	0	2
Pleasant Bay	21.85	37.01	96.17	155
Ryder Cove	4.47	1.30	6.71	12
Frost Fish Creek	0.70	0.10	0	1
Crows Pond	4.22	1.39	0.61	6
Bassing Harbor	1.67	1.07	0	3
Chatham Harbor	17.10	14.15	0	31
System Total	81.25	85.71	194.55	359



## MEP Updates Recommended

- ❖ MEP modeling based on data from 2003/2004
- ❖ MEP Report provides reasonable planning-level estimates for nitrogen-removal targets
- ❖ Updating MEP model will enable refinement of nitrogen-removal targets
  - Current water quality data is available
  - Hydrodynamic conditions have changed in both systems
  - Special Studies recommended to confirm system health (based on water quality data) in certain sub-embayments



## Freshwater Ponds Program

- ❖ 63 freshwater lakes and ponds in Orleans; 25 with surface area > 1 acre
- ❖ Comprehensive Wastewater Management Plan (CWMP, 2010), selected the following freshwater ponds for further evaluation:
  - Bakers Pond, Bolands Pond, Cedar Pond, Crystal Lake, Ice House Pond, Pilgrim Lake, Sarah's Pond and Shoal Pond
  - Summary of evaluation in CWMP Table 3-4
- ❖ Water quality monitoring has continued

TABLE 3-4  
POND TROPHIC STATUS, IMPAIRED USES AND  
WASTEWATER MANAGEMENT PRIORITIES

WATER BODY	TROPHIC STATUS	IMPAIRED USES	WASTEWATER MANAGEMENT PRIORITY
Bakers Pond	Oligotrophic	None	Second priority
Bolands Pond	Eutrophic	Aquatic life support Contact recreation	First priority
Cedar Pond	Eutrophic	Aquatic life support Contact recreation	Defer for MEP studies
Crystal Lake	Oligo-mesotrophic	Aquatic life support	First priority
Ice House Pond	Oligo-mesotrophic	None	Second priority
Pilgrim Lake	Mesotrophic	Aquatic life support	First priority
Sarah's Pond	Mesotrophic	Aquatic life support Contact recreation	No need
Shoal Pond	Eutrophic	Aquatic life support Contact recreation	Second priority



## Freshwater Ponds Program (cont.)

### Next Step: Ponds Management Plan

- ❖ Fiscal Year 2017
  - Update trophic status using ongoing monitoring data
  - Integrate stormwater and fertilizer information
- ❖ Fiscal Year 2018
  - Implementation of specific remediation measures



## Consensus Plan Project and Goals - Hybrid Approach

- ❖ Maximize the use of non-traditional (NT) technologies, including:
  - Permeable Reactive Barriers
  - Floating Constructed Wetlands
  - Shellfish
- ❖ Collection and treatment in two areas where NT technologies cannot meet nitrogen-removal and other goals
  - Downtown Orleans
  - Meetinghouse Pond subwatershed
- ❖ Demonstration projects needed to validate nitrogen-removal efficacy and other parameters
- ❖ Adaptive Management to incorporate findings of demonstrations into future planning and implementation decisions



## Program Schedule - Key Activities / Dates

- ❖ FCW / PRB Subcommittee Workshop – April 6, 2016
- ❖ Shellfish / Aquaculture – April 2016
- ❖ OWQAP – April 20, 2016
- ❖ Town Meeting – May 9, 2016





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## Summary Presentations on Water Quality Analytical Programs



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- A. Non-Traditional Project Monitoring
- B. Freshwater Ponds
- C. Cedar Pond Studies
- D. MEP Modeling and Analysis



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## E. Non-Traditional Project Monitoring

### Shellfish Demonstration Monitoring

#### Key Water Quality Monitoring Parameters

- ❖ Baseline water quality conditions
- ❖ Assessment of operation and maintenance requirements
- ❖ Population survival and size classes by length for one year of growth
- ❖ Useful modifications to gear design
- ❖ Density of area covered by shellfish
- ❖ Recommendations on the type of shellfish grown and whether there should be a mix of species
- ❖ Review of environmental conditions of site for shellfish growth
- ❖ Assessment of abutter compatibility and use conflicts



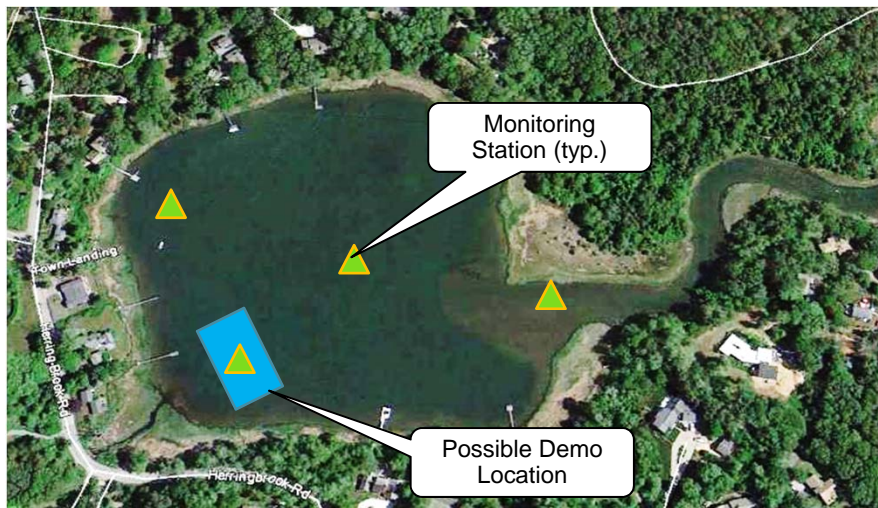
## Shellfish Demonstration Monitoring (cont.)

### Key Baseline Water Quality Conditions

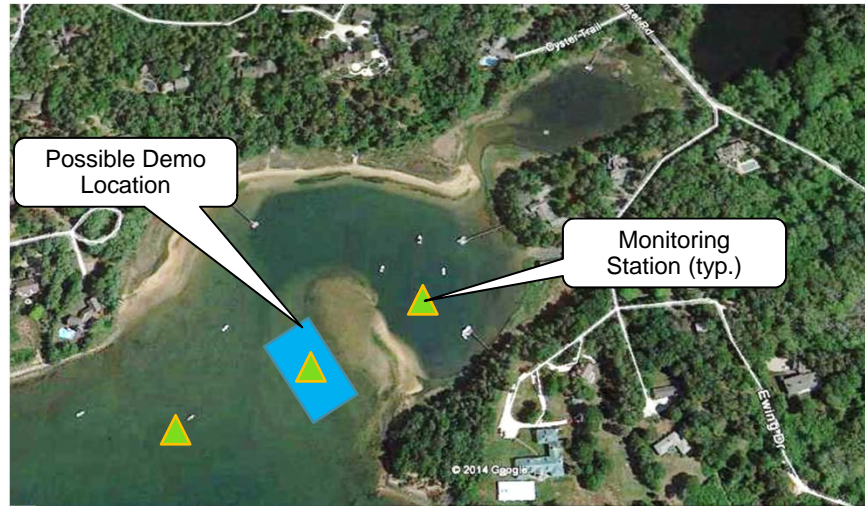
- ❖ Total Nitrogen
- ❖ Particulate Organic Nitrogen
- ❖ Particulate Organic Carbon
- ❖ Chlorophyll-a
- ❖ Water clarity (Secchi)
- ❖ Total Suspended Solids
- ❖ Sediment cycling/benthic flux
- ❖ Number and location of sampling stations depend on size of installation



## Shellfish Demonstration Monitoring Lonnie's Pond



## Shellfish Demonstration Monitoring Quanset Pond



## Floating Wetland Demonstration Monitoring

### In-Situ Water Quality Analysis

- ❖ Monitoring stations located landward and seaward of installation
- ❖ Dataloggers: water quality and current data in 15-minute intervals (temperature, DO, turbidity, chlorophyll and salinity)
- ❖ Paired Grab Samples: weekly water quality measurements 4/15 – 9/30; monthly sampling 10/1 – 4/14 (nitrogen species, soluble reactive phosphorus, total suspended solids, and chlorophyll-a)
- ❖ Discrete probe measurements taken with grab samples (temperature, conductivity, salinity, DO, and pH)
- ❖ Seasonal (4X/year) water quality samples (nutrient and physical chemical measurements) at each inflow, as well as a minimum of three stormwater samples



## Floating Wetland Demonstration Monitoring (cont.)

- ❖ Laboratory Analysis
- ❖ Aboveground biomass of vegetation on the FCW
  - Estimate of net primary production
  - Estimate of nutrient uptake
- ❖ Biofilm uptake using an array of pucks
  - Assess removal of nutrients by FCW mat material

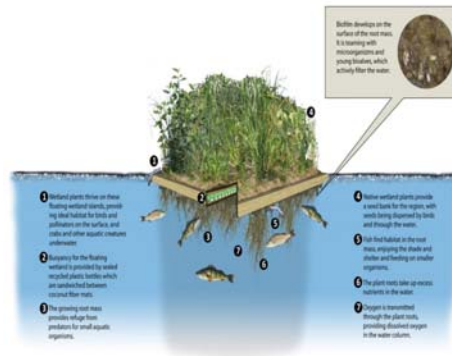
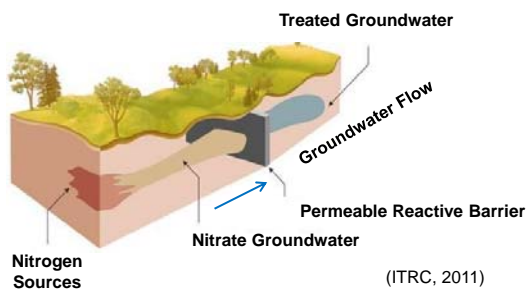


Figure 1: FCW Schematic and Installation



## PRB Overview

- ❖ A PRB Consists of a Zone of Reactive Material Installed in the Path of a Dissolved Contaminant (e.g. nitrate) Plume
- ❖ Denitrification - Biological Process by Bacteria Ubiquitous in the Environment
  - Nitrate converted to inert nitrogen gas ( $N_2$ )
  - Requires anoxic (low oxygen conditions)



(ITRC, 2011)



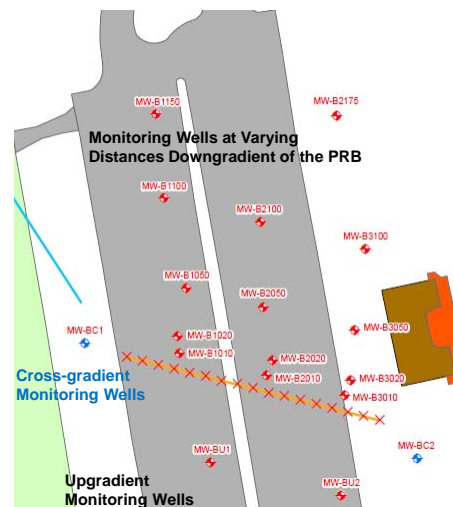
## PRB Demonstration Test Monitoring Overview

- ❖ PRB Demonstration Testing will Include Extensive Groundwater Sampling and Analysis Program
- ❖ Performance Monitoring
  - Evaluate Changing Nitrogen Concentrations and Load Reduction
  - Assess Size of Reactive Zone (Distance Downgradient of PRB)
  - Evaluate Migration of Carbon Substrate
- ❖ Evaluate Secondary Water Quality Impacts
- ❖ Engineering Design Optimization
- ❖ Monitoring Wells Located Upgradient and Downgradient of the PRB
- ❖ Similar to Other In-situ Biological Treatment Technologies



## PRB Demonstration Test Monitoring Overview

- ❖ 50 to 200 feet long
  - Dimensions easily adjusted
- ❖ Monitoring Parameters
  - Total Nitrogen
  - Nitrate
  - Nitrite
  - Ammonia
  - Dissolved Metals
  - Sulfate
  - Dissolved Organic Carbon
  - Methane
  - Dissolved Oxygen
  - pH
  - Oxidation-Reduction Potential





Town of

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Massachusetts

F. Special Studies  
G. Other  
H. Summary of Key Monitoring  
Recommendations



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Massachusetts

Preparing the Work Plan



Town of

*Orleans*  
Massachusetts

Thank You

## Estuarine Restoration and Management

# Overview of MEP Linked Watershed-Embayment Modeling Approach

for

Orleans Water Quality Monitoring  
and Modeling Workshop

April 1, 2016

*B.L. Howes, Director – Coastal Systems Program  
R.I. Samimy, Coastal Systems Program  
E. Eichner, Coastal Systems Program  
School for Marine Science and Technology  
University of Massachusetts – Dartmouth*



## Linked Watershed-Embayment Management Modeling Approach used for MEP

### Key Aspects:

- ✓ Site-specific Data-driven Approach with numerous validation steps
- ✓ Not a “push button model” but an “Approach” consisting of a series of models linked by scientists, conducting necessary reality checks and sub-routines;
- ✓ Watershed N Loading Module distributed to Municipalities to support management planning

## Linked Watershed-Embayment Model

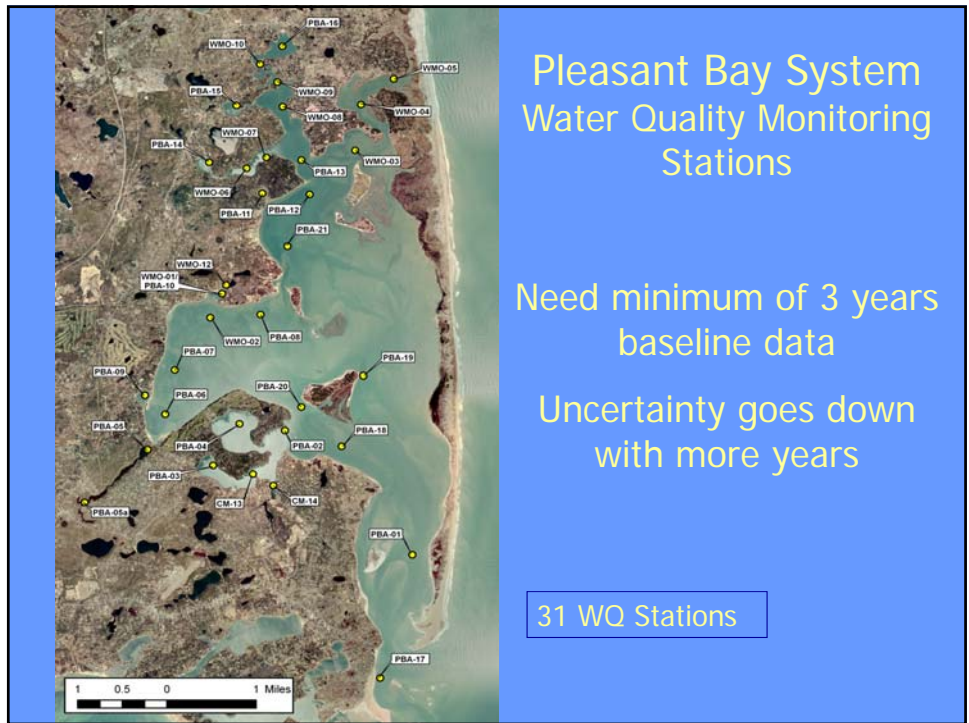
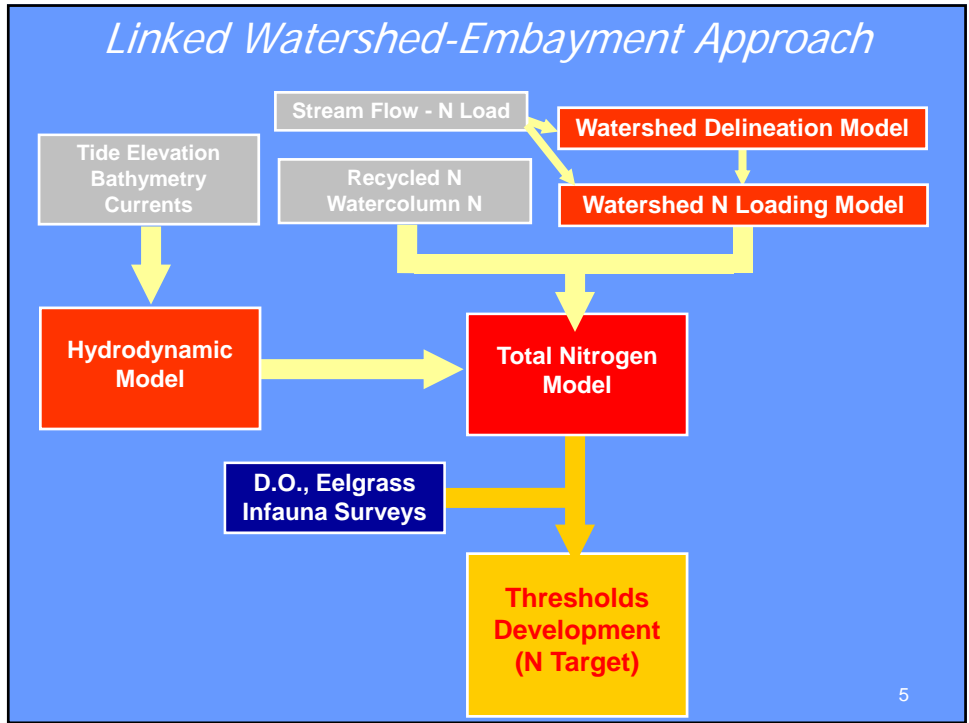
- **Nitrogen Loading Model**
  - Watershed delineation and transport time
  - Land-use inputs: natural and anthropogenic
  - Natural attenuation of nitrogen
- **Hydrodynamic Model**
  - Flushing characteristics
  - Dispersion
- **Water Quality Model**
  - Nitrogen species, salinity
  - Recycled nitrogen
- **Site-Specific Critical N Loads (Thresholds)**
  - Benthic animals, eelgrass, macroalgae, D.O., etc.

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## Background: MEP Management Modeling Approach

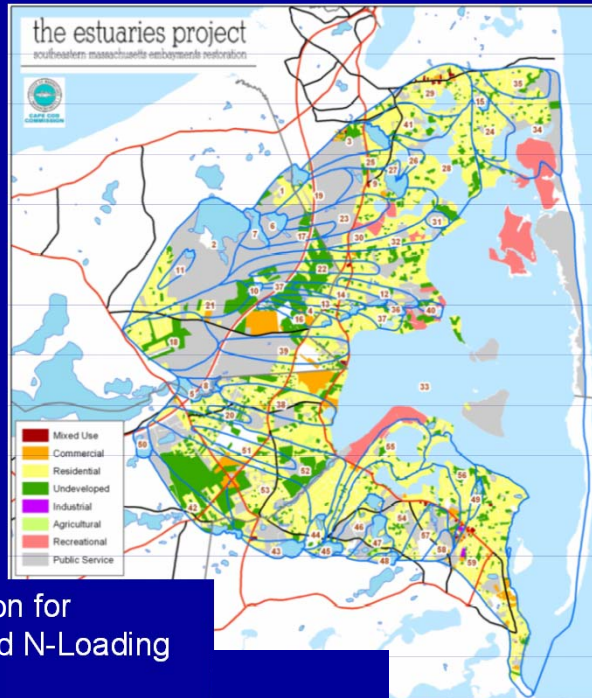
Comparison of key model components used for Nitrogen Management Actions, 2001			
Parameter	MEP Model	BBP Model	CCC Model
	Basis	Basis	Basis
<b>Embayment Model Parameters:</b>			
Numerical Circulation Model	Whole System	No	No
Flushing	Whole System	Upper 1/3 Residence Time	Upper 1/3 Residence Time
Corroboration Hydrodynamics	Key Basins	No	No
N Recycling /Regeneration	Whole System	No	No
Loading Calibration	System Salinity	No	No
Corroboration Embayment Nitrogen Level	Whole System	No	No
<b>Embayment Ecological Parameters:</b>			
Eelgrass/Algae Distribution	Temporal Trend	No	No
Benthic Comm.	Indicators	No	No
Oxygen Levels	July-Aug.	No	No

4



Existing watersheds are usable

Land-use and Water-use should be updated

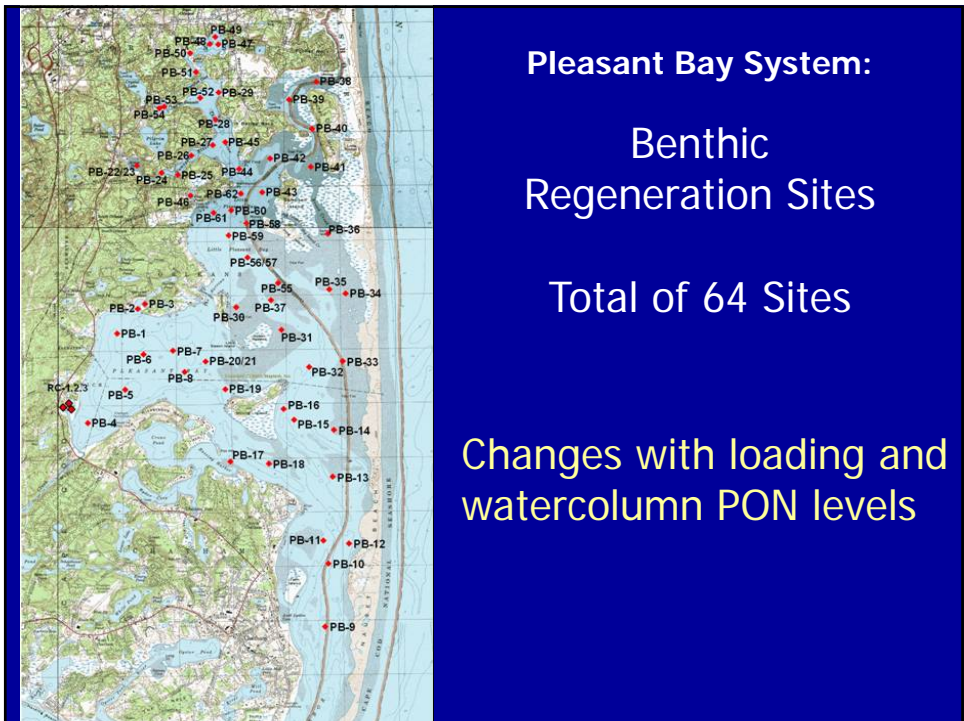
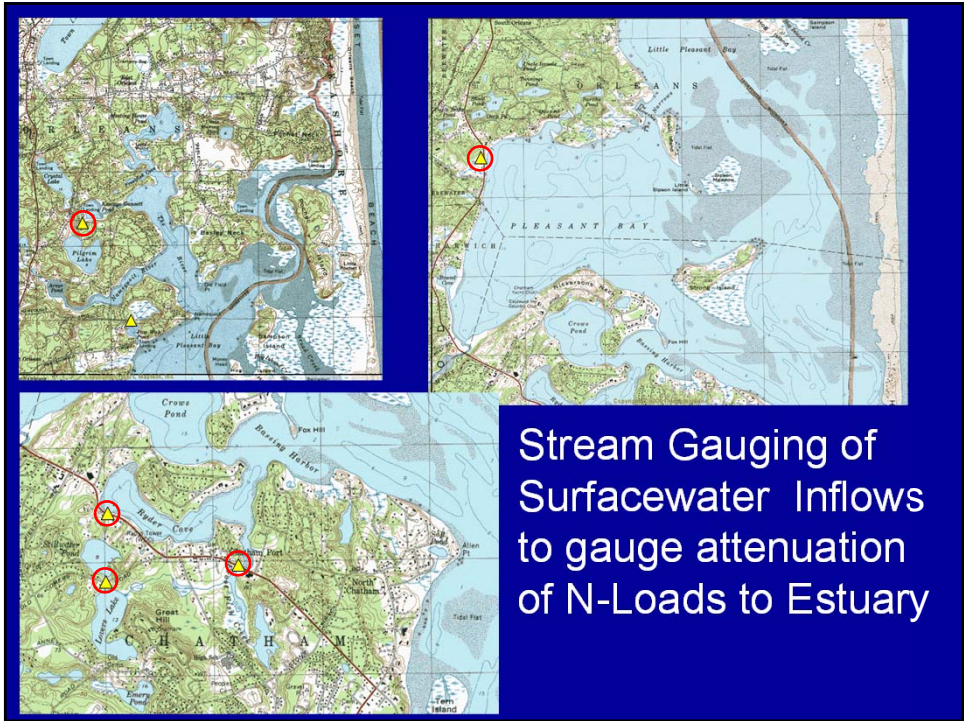


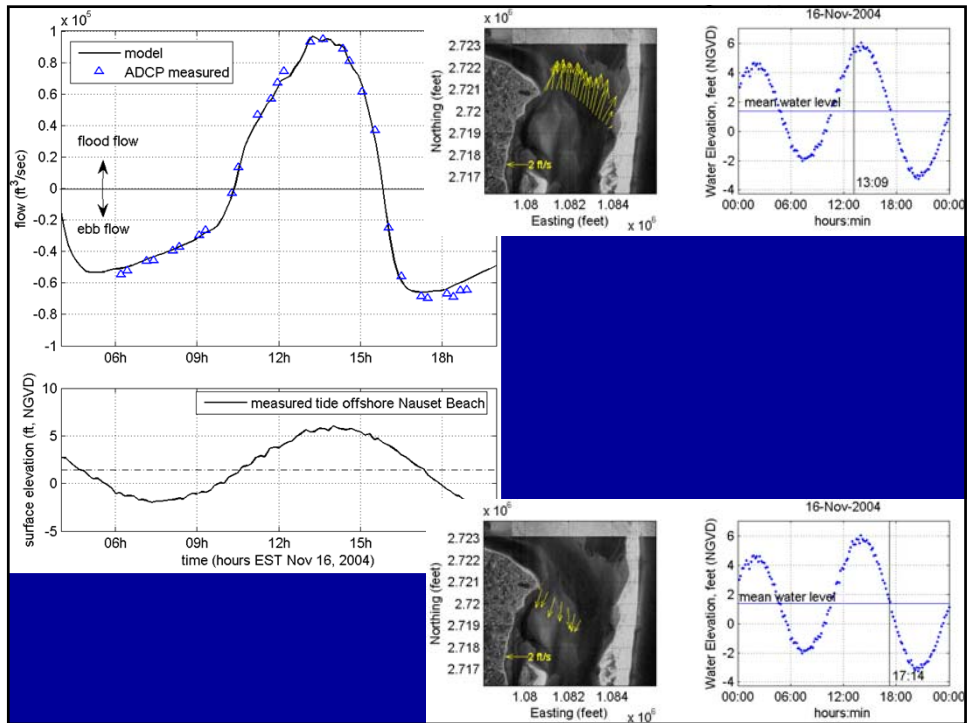
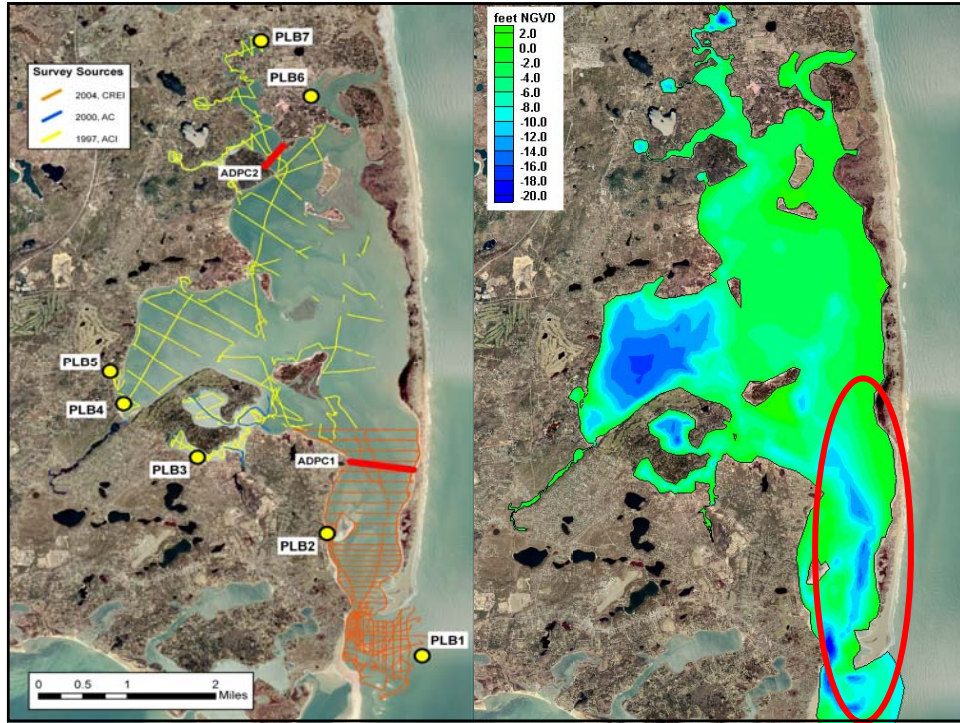
Watershed Delineation for Landuse Analysis and N-Loading Model

## Background: MEP Management Modeling Approach

Comparison of key model components used for Nitrogen Management Actions, 2001

Parameter	MEP Model	BBP Model	CCC Model
	Basis	Basis	Basis
<b>Watershed Land-Use N Loading Parameters:</b>			
Septic Systems	Water-Use; census check	Census	Census
Lawns <sup>a</sup>	Survey; 20% Leaching	50%-30% Leach; Full Applications	50%-30% Leach; Full Applications
Impervious <sup>b</sup>	0.75 mg/L; GIS	0.75 mg/L; general metrics	0.75 mg/L; GIS
Roadway <sup>d</sup>	1.5 mg/L; GIS	1.5 mg/L; general metric	1.5 mg/L; GIS
Natural Areas	Yes	Since 2000	Yes
Attenuation * Groundwater	0%	0% pre-2000; 30% post-2000	0%
Attenuation Surface Aquatic	30%-50%; data	0% pre-2000** 30% post-2000; Assumed	0%***, some data
Watershed Input	Spatially Distributed	Bulk Load	Bulk Load
N Loading Corroboration <sup>e</sup>	Yes	No	No





# *Massachusetts Estuaries Project for Estuarine Restoration*

## *MEP Habitat Assessment & Nitrogen Threshold Analysis*



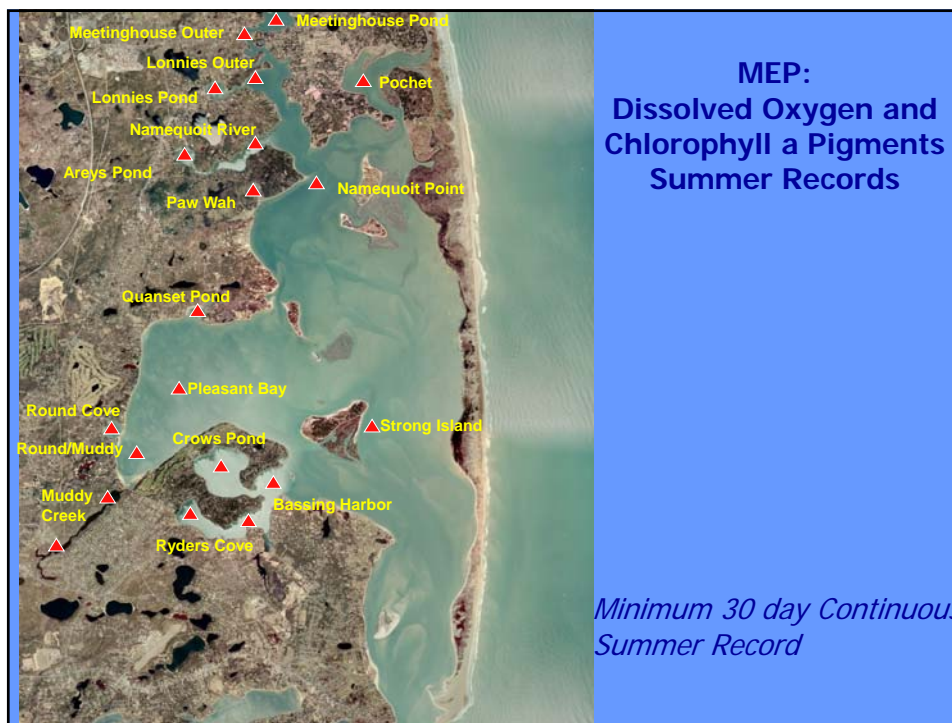
## **Embayment-Specific Critical Nitrogen Loading Thresholds**

### Primary Components:

- 1) Dissolved Oxygen Record (summer, bottom water)
- 2) Eelgrass & Macroalgae (distribution & abundance)
- 3) Benthic Animal Communities (habitat quality)
- 4) Water Quality Long-term Records

## Summary Habitat Assessment Pleasant Bay Pre-2007 Breach

Sub-Embayment	Nutrient related Health Indicator					
	D.O.	Chl a	Macro-algae	Eelgrass	Infaunal Animals	Overall
Meetinghouse Pond & Outlet	SI/SD <sup>1,2</sup>	SI/MI	MI <sup>3</sup>	--	SI	<b>SI</b>
Lonnies Pond	SI <sup>2</sup>	MI	MI	--	SI	<b>SI/MI</b>
Areys Pond & Outlet	SD <sup>1</sup>	SI	SI/SD <sup>13</sup>	--	SD <sup>9</sup>	<b>SD/SI</b>
The River	MI/SI <sup>3</sup>	MI	MI/SI	MI	SI	<b>MI</b>
Paw Wah Pond	SD <sup>1</sup>	SI	SI	--	SD <sup>10</sup>	<b>SD</b>
Quanset Pond	SI	SI	-- <sup>c</sup>	--	SD <sup>9</sup>	<b>SI</b>
Round Cove	MI <sup>4</sup>	SI	-- <sup>c</sup>	--	SI	<b>SI/MI</b>
Muddy Creek Upper	SD <sup>1</sup>	SI/SD	-- <sup>c</sup>	--	SD <sup>9</sup>	<b>SD</b>
Muddy Creek Lower	SI/SD <sup>1</sup>	SI/MI	-- <sup>c</sup>	SI	SI	<b>SI</b>
Bassing Hbr: Ryders Cove		SI	MI	MI <sup>7</sup>	MI	<b>MI</b>
Bassing Hbr: Crows Pond		MI	MI	MI <sup>7</sup>	H/MI	<b>MI</b>
Bassing Hbr: Lower Basin		MI/H	-- <sup>c</sup>	H/MI	MI	<b>H/MI</b>
Bassing Hbr: Frost Fish Crk		SI	SI	--	SI	<b>SI</b>
Pochet	H/MI <sup>3a</sup>	H	-- <sup>c</sup>	--	H/MI	<b>H</b>
Little Pleasant Bay	MI <sup>3</sup>	H	-- <sup>c</sup>	MI <sup>7</sup>	MI	<b>MI</b>
Pleasant Bay	MI/SI	MI	-- <sup>c</sup>	MI/SI	MI-SI	<b>MI</b>
Chatham Harbor	H <sup>b</sup>	H <sup>b</sup>	-- <sup>c</sup>	H	H	<b>H</b>



### MEP Habitat Assessment: Eelgrass Distribution

Lower Pleasant Bay



1995



2001

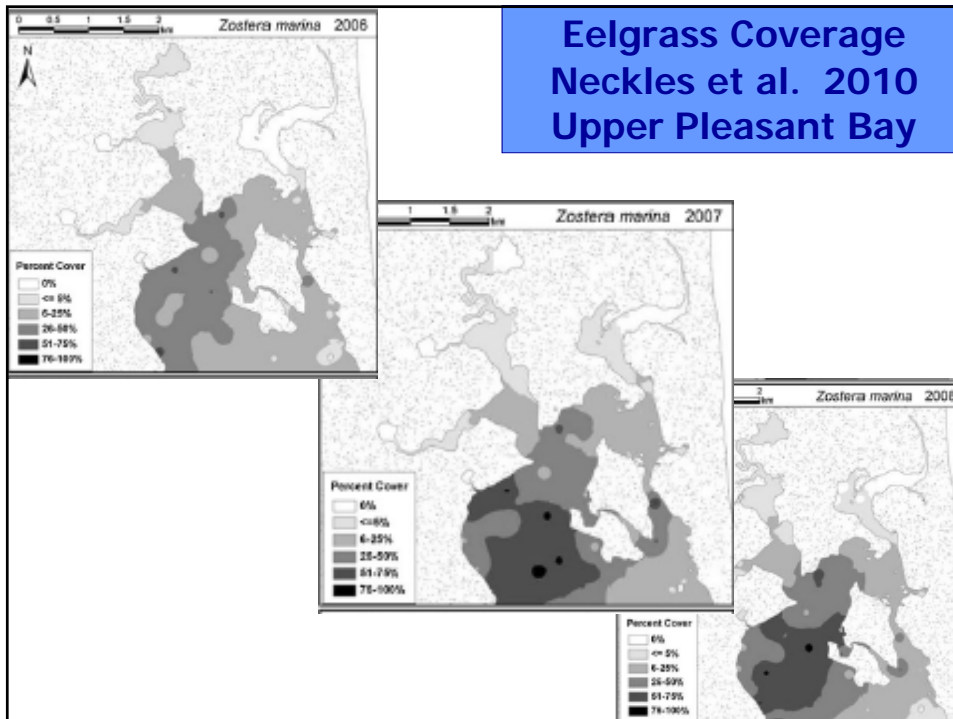
Eelgrass bed distribution within Pleasant Bay between two time periods

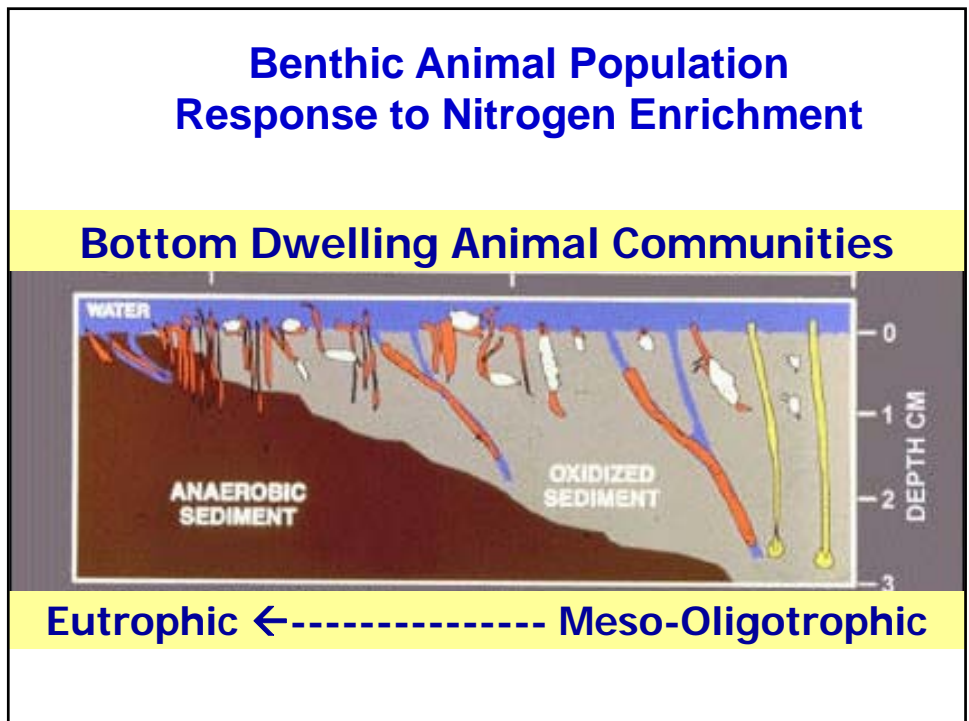
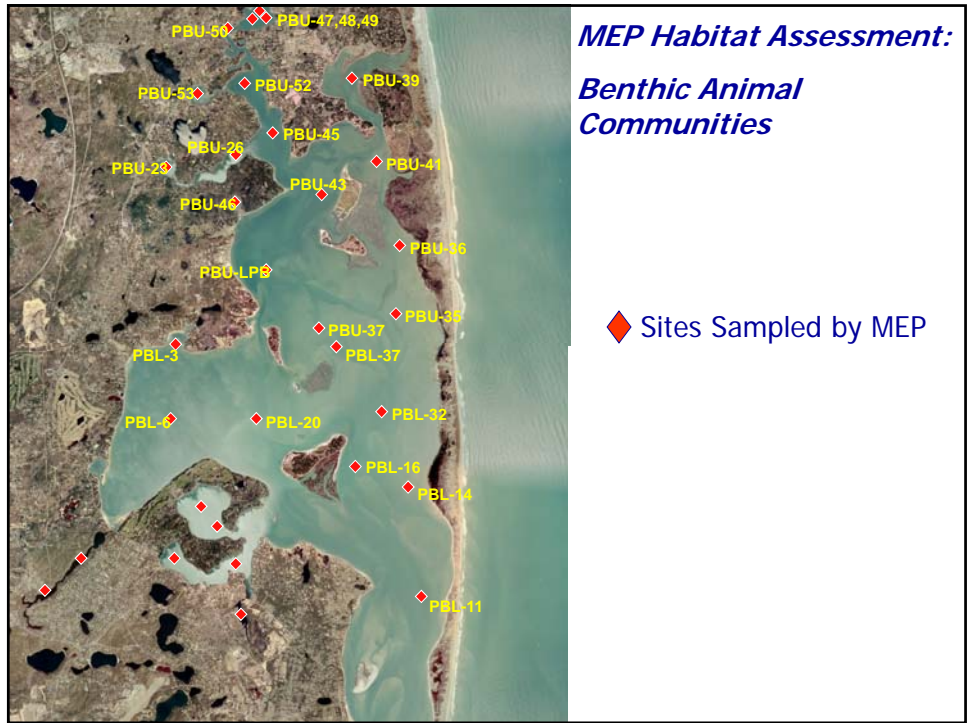
Coverages:

1995

2001

Area of Loss  
deeper water





## Linked Watershed-Embayment Approach Nitrogen Loading Thresholds

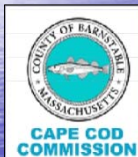
### MEP Site-Specific Critical N Loads

- Distribution of Nitrogen within each embayment relative to:  
benthic animal communities, eelgrass, macroalgae, Dissolved Oxygen, nutrient related water quality parameters
- Water quality modeling to achieve target nitrogen levels in embayment

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## *Massachusetts Estuaries Project for Estuarine Restoration*

### *Technical Questions & Discussion*



Phil Detjens  
Tom Cambareri



Brian Howes  
Roland Samimy  
David Schlezinger  
David White  
Dale Toner



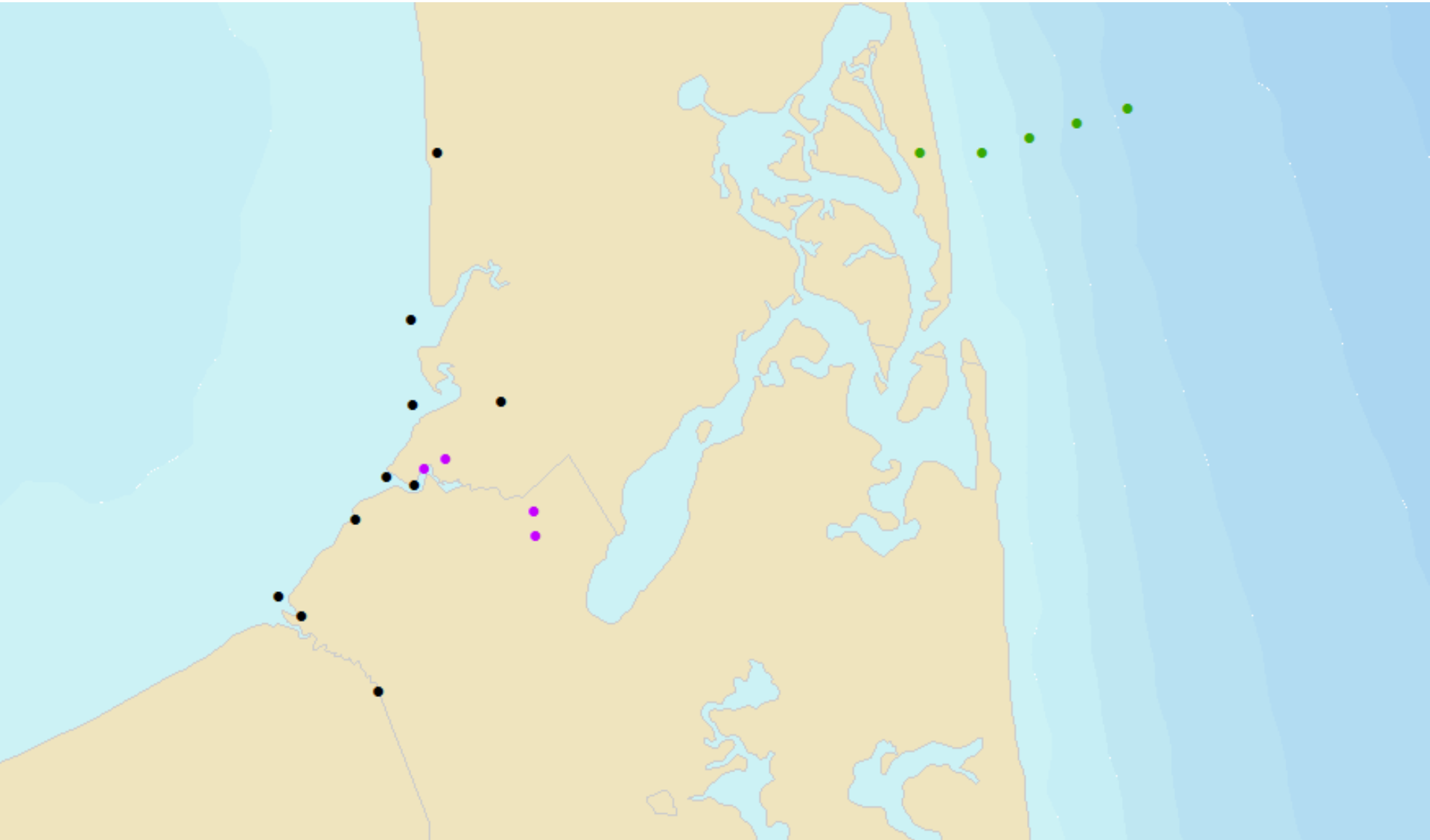
Ed Eichner  
Sara Sampieri  
Jen Benson  
Mike Bartlett  
Interns TNC



John Ramsey  
Sean Kelley  
Trey Ruthven  
Liz Hunt

22

- Regular WQ monitoring station (2006 – present; May-October)
- Cedar Pond WQ project station (2012 – present; April-November)
- Nauset Inlet WQ stations (2014; July-September)



Type of measurement	Parameter
Core Hydrographic Data	Temperature Salinity Depth of sensor
Optional Hydrographic Data	Dissolved oxygen pH PAR Chlorophyll fluorescence Secchi disk depth Total water depth Current weather (including Beaufort Scale and wind direction)
Water Chemistry	Nitrate + nitrite Ammonium Total nitrogen Ortho-phosphate Total phosphorus Silicate Turbidity Extracted chlorophyll Extracted pheophytin

# Benthic Habitat Mapping Stations: Nauset Marsh: 2014-2016

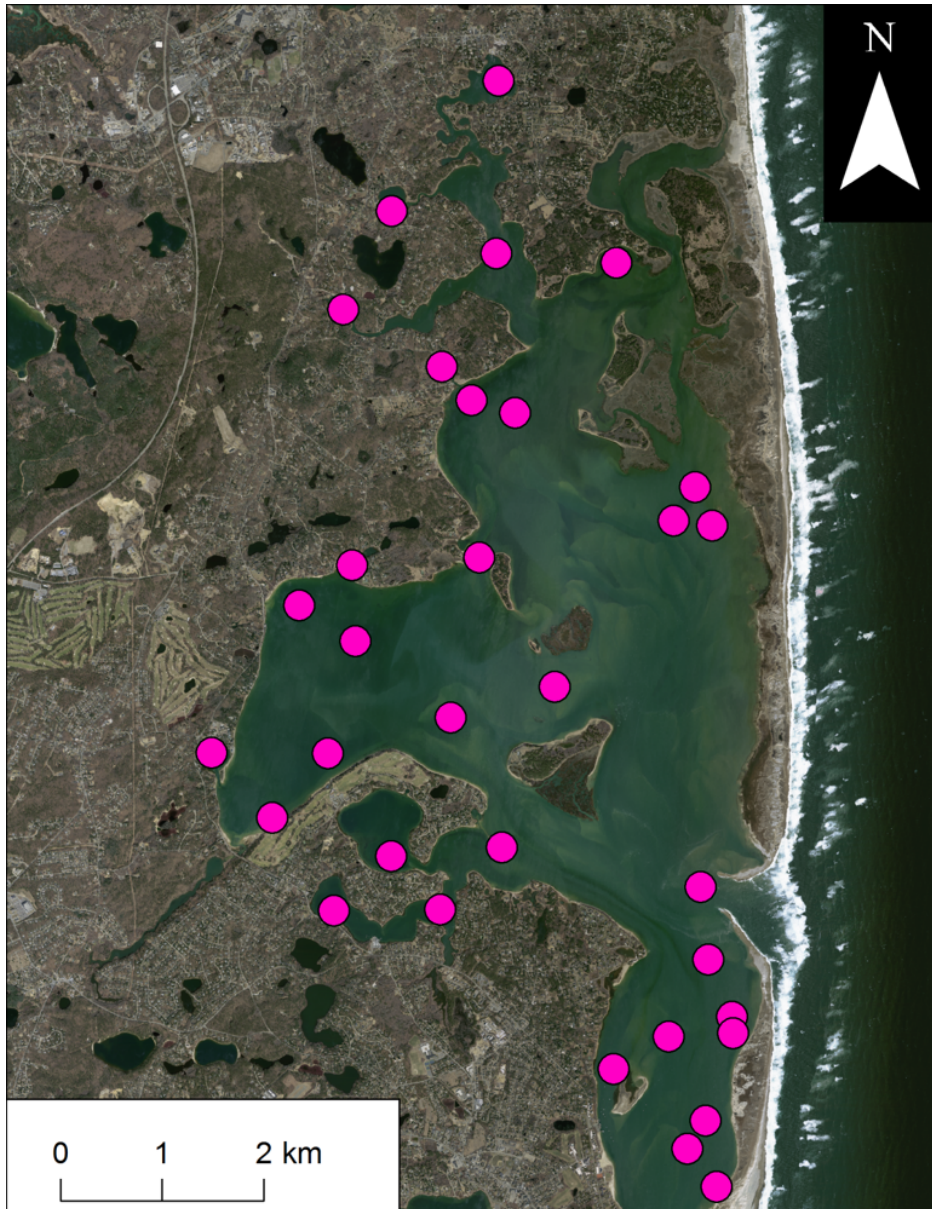
Center for Coastal Studies and Cape Cod National Seashore



- Bathymetry
- Sidescan Sonar Imagery
- Bottom Grab Samples
  - grain size
  - macro-fauna
- Tidal Cycles

# Benthic Habitat Mapping Stations: Pleasant Bay

Center for Coastal Studies, Cape Cod National Seashore, Friends of Pleasant Bay

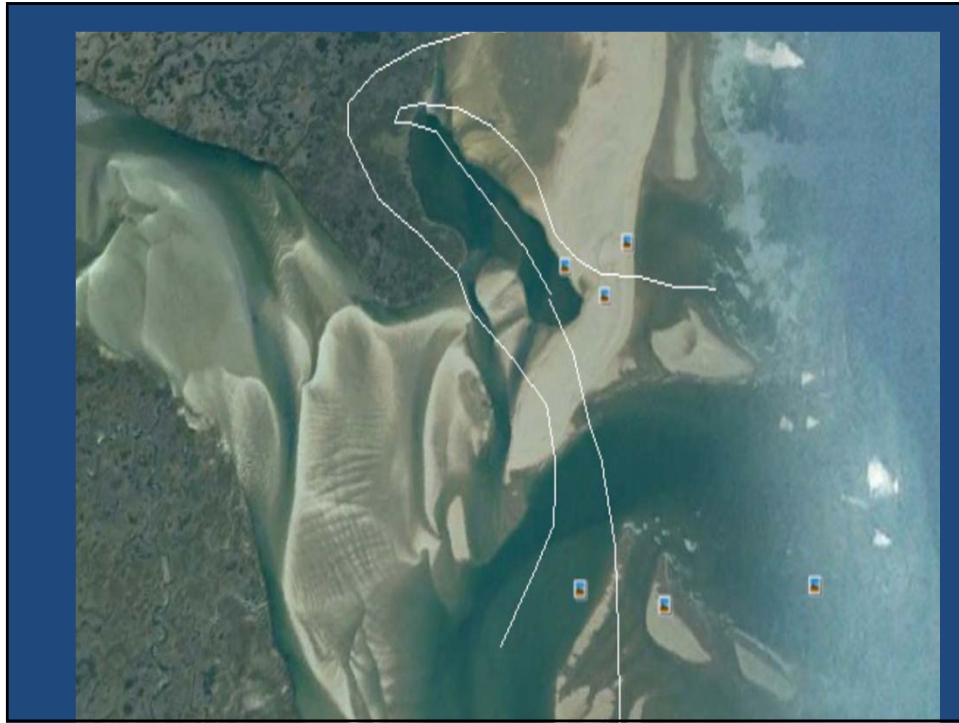


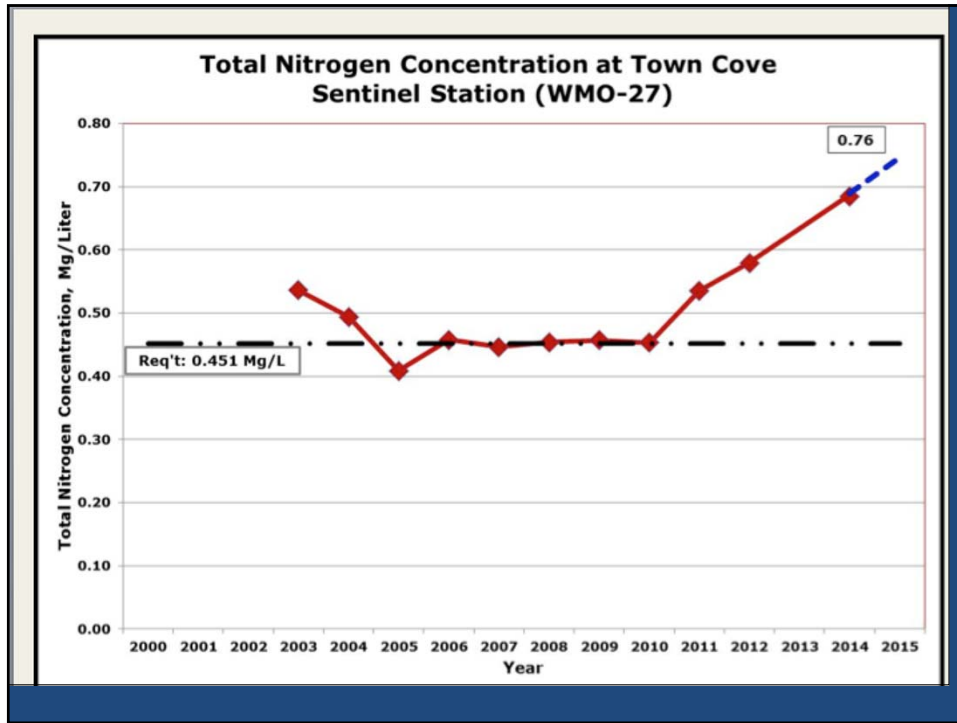
- Bathymetry
- Sidescan Sonar Imagery
- Bottom Grab Samples
  - grain size
  - macro-fauna
- Tidal Cycles
  
- Subset of stations
  - Fish trawls
  - Scallop drags
  - Fixed gear

# How can we proceed faster to restore water quality ?

- Ed Daly
- 11 April 2016







What do we want ?

Restore Water Quality in Town Cove

## What have we been doing?

- **Designing a Hybrid that is based on obsolete nitrogen data**
- **Problem: It will fail to restore water quality in Town Cove**

## Where are we now?

- We have a Hybrid System design concept based on 2001-2005 data
- We know Nauset Inlet has changed the Cove
- The Hybrid does not work

## What do we need ?

- How much Nitrogen to remove to restore water quality.

## Summary: Town Cove

- Total Nitrogen levels now are 40-50% higher than those values that are being used for the Hybrid concept
- Designing and building the current Hybrid concept will therefore not meet water quality requirements.

## Proposed Approach Today

- Increase Monitoring Sites
- Collect Data for 3 Years
- Update the MEP Model
- Determine New Nitrogen Removal
  
- SMAST Proposal to be Requested

## Dilemma

- Wait 3-6 years to obtain correct nitrogen removal levels and then start design

Versus

- Start design now of a system that will not restore water quality

## Request SMAST Help

- SMAST has the tools and experience in Town Cove
- 13 years of data since 2001-2005
- WHG Dredging Study
- PCCS Study
- National Seashore
- Orleans Plume Study

## Provide a Science Supported Placeholder

- Orleans would request a six month study by SMAST
- SMAST would provide a Placeholder nitrogen removal estimate :
  - Use data available now
  - Use SMAST assumptions where data not available
  - Use latest loading quantities

## What do we need?

- We need new nitrogen removal estimates
- So we can design a system that will work to restore water quality
- Designers need these estimates before starting design effort

## Benefits

- Citizens will support an SMAST based placeholder
- Engineers can design a system that will restore water quality

**Appendix C**

**AMP – Water Quality Monitoring and Modeling Workshop - April 1, 2016**

**Key Takeaways**

**Draft for Discussion at the April 11, 2016 AMP – Water Quality Monitoring and Modeling Workshop**

1. Volunteers for data collection:
  - a. Use of volunteers is approved by regulators (MassDEP and USEPA);
  - b. Volunteers are well-trained to follow approved QAPP and samples are of high quality; and
  - c. More volunteers are needed.
2. SONDES (dataloggers) are expensive and not recommended by SMAST for long-term waterbody monitoring for TMDL purposes. Maybe applicable for some short term project specific monitoring.
3. Sample collection during July and August is sufficient for long-term waterbody monitoring.
4. Winter sampling is not necessary for TMDL purposes (though PRB and/or Shellfish may want winter sampling where FCW dormant in winter).
5. Data consolidation from various groups is necessary:
  - a. SMAST;
  - b. APCC;
  - c. Center for Coastal Studies; and
  - d. Others.
6. Freshwater ponds needs:
  - a. Aggregate data sets;
  - b. Analyze data;
  - c. Identify gaps; and
  - d. Prepare Action Plan / Pond Management Plan.
7. Namskaket remediation should be completed.
  - a. Monitoring locations in Namskaket need to be identified.
8. Needs assessment should be completed for Rock Harbor reclassification.
9. Cedar Pond should continue to be monitored, and clear thresholds for Adaptive Management established.

**Draft for Discussion at the April 11, 2016 AMP – Water Quality Monitoring and Modeling Workshop**

10. Pleasant Bay MEP Report (and linked model) should be updated, including:
- a. Land and water use, impervious surfaces, roadway and rooftop areas might be beneficial to add; also natural attenuation has to be measured;
  - b. Tide gauges at all locations, add gauge at breach;
  - c. Boundary station at Strong Island measured at flood tide to establish condition;
  - d. Bathymetry and new ADCP data;
  - e. Use nutrient data from existing 28 monitoring stations but capture breach with a new station;
  - f. Calibrate to BioN as well as TN (as was done in 2006 MEP Report);
  - g. Keep current watershed delineation;
  - h. Evaluate bathymetry from CCS;
  - i. Include field studies of:
    - i. Benthic cores (64 stations);
    - ii. Infauna surveys; and
    - iii. Review existing eelgrass data.
  - j. Mass balance calculations should be prepared for the different sub-areas with estimates of such factors as:
    - i. Stormwater loading;
    - ii. Groundwater loading;
    - iii. Atmospheric loading;
    - iv. Tidal flushing; and
    - v. Benthic deposition or regeneration.

These mass balances would characterize the relative situation of the different sub-areas and would help in targeting solutions.

**NOTE: SMAST is developing a Scope of Work that details this update**

**Draft for Discussion at the April 11, 2016 AMP – Water Quality Monitoring and Modeling Workshop**

11. Nauset Harbor MEP Report should be updated, including:
  - a. Tide gauges at inlet to confirm dampening;
  - b. Reinstate 15 monitoring stations in Town Cove/Mill Pond; and
  - c. Model rerun to evaluate level of impairment, nutrient thresholds.

**NOTE: SMAST is developing a Scope of Work that details this update**

12. Dredging the breaks (mostly the south break, which appears to be shoaling) should be considered to increase tidal flushing.
13. Salinity is measured but it should be analyzed to provide quantitative information on tidal flushing at the different sites.
14. Significant variability can exist during the tide cycle and during the lunar month. Marine samples are generally collected at mid-ebb tide for average tides, i.e. neither spring nor neap which is good, however, the following should also be undertaken:
  - a. For one of the sampling events, sampling should be conducted at fixed stations during the entire tide cycle, to provide information on variability; and
  - b. Modeling should be conducted to provide a different assessment.
15. The important variable relative to loading is total nitrogen, which includes inorganic and bio-available nitrogen, but also nitrogen in phytoplankton. Dissolved inorganic nitrogen (DIN) gives a measure of how much food is available after consumption by algae. Total nitrogen is calculated based on measurements of the different nitrogen species. Actual analyses of total nitrogen should also be conducted, to check the summation estimates and also because it could replace the analyses of the nitrogen species in some cases, for example for the tidal variability sampling noted above.
16. Water quality modeling is done using the RMA-4 model through simulation of total nitrogen. RMA-4 only simulates first order decay, which does not cover all the decay and transformation processes of the nitrogen cycle and it does not simulate algae. Benthic loadings (positive or negative) are specified based on measurements. This approach is adequate. However, it is limited in its predictive ability, since benthic loading will change as nutrient loadings are reduced. Also, RMA-4 is a relatively old model, which does not reflect the state of the art. Therefore upgrading to RMA-11 should be considered. RMA-11 can simulate the nitrogen cycle. It is 3-dimensional model, but it can be used in 2-D mode using velocities calculated by RMA-2 (as is currently done with RMA-4).
17. Trend regressions before and after the 2007 break should be forced to match at the time of the break.

**Appendix D**  
**Water Quality Monitoring Programs for**  
**Namskaket and Little Namskaket Creek**  
**Rock Harbor Creek**  
**Nauset Harbor**

## Namskaket Creek and Little Namskaket Creek Monitoring

**Purpose:** Establish water quality conditions for preparation of Mass Estuaries Project report; establishment of TMDLs for development of Orleans Comprehensive Wastewater Management Plan

**Locations:**

**Namskaket Creek**

Years sampled	Station #	Site Description
2001-2015	WMO 22	Mouth of creek
2001-2004	WMO 23	Mid marsh
2001-2003	WMO 24	Bog side of stream leaving radio tower bog (FW outflow)
2001-2003	WMO 45	Bog side of stream leaving Hurleys Bog (FW outflow)



## Little Namskaket Creek

Years sampled	Station #	Site Description
2001-2015	WMO 19	Mouth of creek
2001-2004	WMO 20	Mid marsh
2001-2003	WMO 21	Headwaters to marsh at Roadway



**Parameters:** Current weather conditions, wind force and direction, visible water conditions, Secchi disk transparency, depth at station, sample depth, field DO and saturation, field temp at sample depth

**Frequency:** Currently five times, two weeks apart in July, August, and Sept on early morning outgoing tide

**Duration:** 2001-2015; ongoing

**Source and status of QAPP:** SMAST

**Lab arrangements:** SMAST

**Staff resources:** Director of Planning Dept,; Marine and Fresh Water Quality Task Force and recruited volunteers

**Analyses:** **SMAST lab** --Salinity, conductivity, PO<sub>4</sub>, NH<sub>4</sub>, No<sub>x</sub>, DIN, DON, TDN, POC, PON, C/N ratio, TON, TN, Chl a, Phaeo, pigment ratio, total pigments

**Documentation of results:**

Yearly spreadsheet report

*Linked Watershed Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Namskaket Marsh Estuarine System, Orleans, MA.* MEP, Draft report June 2007

**Staff resources:** Director of Planning Dept,; Marine and Fresh Water Quality Task Force, and recruited volunteers

**Analyses and documentation of results:** SMAST

**Database location:** SMAST

**Budget:** Town, \$1,000/station/year plus equipment replacement as needed

**Resources:**

*Linked Watershed Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Namskaket Marsh Estuarine System, Orleans, MA.* MEP, December 2008.

*Summary of 2004 Monitoring Results Namskaket Creek, Orleans, MA and Proposed future work.* USGS, Weiskel, February 2005.

*Update on USGS Monitoring Activities, Namskaket Creek, Orleans, MA .* USGS, April 2011

*Stability of Wetland Plant Communities in Upper Namskaket Marsh, Town of Orleans, MA.* SMAST, January 2016.

**Presenter:** Carolyn Kennedy, Chair, Marine and Fresh Water Quality Task Force

## Rock Harbor Creek Monitoring

**Purpose:** Establish water quality conditions for preparation of Mass Estuaries Project report on Rock Harbor; establishment of TMDLs for Town development of Comprehensive Wastewater Management Plan

### Locations:

Years sampled	Station #	Site Description
2001-2004	<b>WMO 14</b>	Cape Cod Bay offshore, 100 Ft past last tree in channel
<b>2001-2015</b>	<b>WMO 15</b>	<b>Rock Harbor, outer marina dock/Town Landing</b>
2001-2004	<b>WMO 16</b>	Rock Harbor - mid
2001-2003	<b>WMO 17</b>	Upper Rock Harbor in marsh channel
2001-2003, 2005, 2012	<b>WMO 18</b>	Cedar Pond outlet; headwaters to Rock Harbor

**Parameters:** Current weather conditions, wind force and direction, visible water conditions, Secchi disk transparency, depth at station, sample depth, field DO and saturation, field temp at sample depth

**Frequency:** Currently five times, two weeks apart in July, August, and Sept on early morning outgoing tide

**Duration:** 2001-2015; ongoing

**Source and status of QAPP:** SMAST

**Lab arrangements:** SMAST

**Staff resources:** Director of Planning Dept,; Marine and Fresh Water Quality Task Force, and recruited volunteers

**Analyses:** **SMAST lab** --Salinity, conductivity, PO<sub>4</sub>, NH<sub>4</sub>, NO<sub>x</sub>, DIN, DON, TDN, POC, PON, C/N ratio, TON, TN, Chl a, Phaeo, pigment ratio, total pigments

### Documentation of results:

Yearly spreadsheet report in Town computer files

*Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Orleans, MA . , SMAST, 2007.*

**Database location:** SMAST

**Budget:** Town, \$1,000/station/year plus equipment replacement as needed

**Studies related to Rock Harbor and Cedar Pond:**

**2003 :** *Cedar Pond Restoration of Herring Run*, Orleans Water Quality Task Force

**2007:** *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Orleans, MA.* This MEP for Rock Harbor documented the groundwater basin and land use patterns in the watershed.

**2007:** *Review and Interpretation of Orleans Freshwater Pond Volunteer Monitoring Data*, documents the anoxia in the bottom waters of the pond while “the shallowest waters on average are supersaturated, which is usually indicative of extensive algal photosynthesis.” (pg 66) The study recommends further analysis as part of the Massachusetts Estuaries Project.

**2010:** *Rock Harbor Creek, Restoration Feasibility Study*, Applied Coastal Research and Engineering. Documents the hydraulics and elevation of the creek from Rock Harbor to Cedar Pond.

**2011:** *Cormorant population studies*, Orleans Marine and Fresh Water Quality Task Force, 2011, 2012, 2015.

**2013:** *Cedar Pond Management Plan*, SMAST/UMASS Dartmouth.

**2013:** *Documentation of Atlantic White Cedars* adjacent to Cedar Pond, Orleans Marine and Fresh Water Quality Task Force.

**2014:** *CSP/SMAST Technical Memorandum: Board Height Recommendation for Cedar Pond Outlet: Task 1 of Cedar Pond Adaptive Management and Monitoring Program.*

**Roadway Water Quality Improvements surrounding Cedar Pond:**

2008: MASS-DOT installed leaching basins along Route 6 adjacent to north side of Cedar Pond.

2011: Stormwater drains along Locust Road (south side of Cedar Pond) were remediated with infiltration basins to eliminate direct roadway discharge and its associated nutrients from flowing into Cedar Pond.

**Presenter:** Carolyn Kennedy, Chair, Marine and Fresh Water Quality Task Force



## Nauset/Town Cove Estuary System

**Purpose:** Establish water quality conditions for preparation of Mass Estuaries Project report on Nauset Estuary; establishment of TMDLs for Town development of Comprehensive Wastewater Management Plan. See Executive Summary for *Linked Watershed* report noted below.

**Locations:** Map on page 3.

			2015	2016	
Yrs sampled			Orleans	Shared	
<b>2001 descriptions and locations</b>					
<b>NAUSET INLET SYSTEM:</b>			<b>NAUSET INLET SYSTEM:</b>		
<b>Town Cove</b>			2001 Site Descriptions		
2001-2005	Boat	Bay	WMO-25		Head of TC: Go to Buoy then go 100 feet out toward channel
2001-2004	Boat	Bay	WMO-26		3 houses "up" from Nauset Marine
2001-2015	Boat	Bay	WMO-27		Green Channel Marker #13 to shellfish grant side
2001-2003	Boat	Bay	WMO-28		20 feet south of Red Channel Marker #8
2001-2004	Boat	Bay	WMO-29		Red Channel Marker #6, near tiny marsh island (past Rachels Cove)
2001-2004	Boat	Bay	WMO-30		100 yards off Stony Island
2001-2003	Boat	Bay	WMO-31		Woods Cove - Center
2001-2004	Boat	Bay	WMO-32		Channel off Southern large marsh Island, near Inlet
<b>Mill Pond</b>					
2001-2004	Boat	Bay	WMO-33		Outer Mill Pond, outside "Dike" (also called: Roberts Cove)
2001-2015	Boat	Bay	WMO-34		Mill Pond Main Inner Basin, inside "Dike"
2001-2004	Boat	Bay	WMO-35		Little Cove (Innermost Basin of Mill Pond)
<b>Upper Nauset System</b>					
2001-2004	Boat	Bay	WMO-36		Marsh Channel to Salt Pond Bay off Town Landing
2001-2003	Boat	Bay	WMO-37		Salt Pond Bay - Central Basin (south of Salt Pond) Large Rock on Shore
2001-2015	Boat	Bay	WMO-38		Salt Pond - Basin (Visitors Center)
2001-2004	Kayak	Bay	WMO-39		Nauset Bay - Basin (off from greenhead fly boxes-as far as can get up bay)
2001-2004	Boat	Bay	WMO-40		Central Marsh Channel - Adjacent Tall Pole in edge of Marsh
2001-2003	Boat	Bay	WMO-41		Outside Nauset Harbor "Ocean Station"
					2015 Orleans stations
					2016 proposed additions for Orleans samplers
					2016 proposed additions for Eastham samplers
rev 3/29/2016					
CLK					

**Parameters:** Current weather conditions, wind force and direction, visible water conditions, Secchi disk transparency, depth at station, sample depth, field DO and saturation, field temp at sample depth,

**Frequency:** Currently five times, two weeks apart in July, August, and Sept on early morning outgoing tide

**Duration:** 2001 (15 stations) to 2015 (3 stations); see chart above.

**Source and status of QAPP:** SMAST

**Lab arrangements:** SMAST

**Staff resources:** Director of Planning Dept, Harbormaster for deployment of station buoys; Marine and Fresh Water Quality Task Force, and recruited volunteers

**Analyses:** **SMAST lab** --Salinity, conductivity, PO<sub>4</sub>, NH<sub>4</sub>, No<sub>x</sub>, DIN, DON, TDN, POC, PON, C/N ratio, TON, TN, Chl a, Phaeo, pigment ratio, total pigments

**Documentation of results:**

Yearly spreadsheet report in Town computer files

*Linked Watershed-Embayment Approach to Determine Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, MA.* SMAST. Rev. May 2012

**Database location:** SMAST

**Budget:** Town, \$1,000/station/year plus equipment replacement as needed

**Resources:**

*Linked Watershed-Embayment Approach to Determine Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, MA.* SMAST. Rev. May 2012

*Nauset Estuary Dredging Feasibility Assessment, Woods Hole Group, February 2016*

**Other:** Future planning must take into consideration volunteer and boat availability.

**Presenter:** Carolyn Kennedy, Chair, Marine and Fresh Water Quality Task Force

