Town and County of Nantucket
Board of Selectmen • County Commissioners

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C. Elizabeth Gibson
Town & County Manager

AGENDA FOR THE MEETING OF THE
BOARD OF SELECTMEN
FEBRUARY 10, 2016 - 6:00 PM
PUBLIC SAFETY FACILITY COMMUNITY ROOM
4 FAIRGROUNDS ROAD
NANTUCKET, MASSACHUSETTS

I. CALL TO ORDER

II. BOARD ACCEPTANCE OF AGENDA

III. ANNOUNCEMENTS

1. The Board of Selectmen Meeting is Being Video/Audio Recorded.

IV. APPROVAL OF MINUTES, WARRANTS AND PENDING CONTRACTS

1. Approval of Pending Contracts for February 10, 2016 - as Set Forth on the Spreadsheet Identified as Exhibit 1, Which Exhibit is Incorporated Herein by Reference.

V. WORKSHOP - WATER QUALITY

1. Review of 2015 Water Quality Testing Results (Town's Water Quality Testing Contractor -- SMAST).

2. Review of 2015 Nantucket Harbor Eel Grass Study (Natural Resources Department).

3. Review of Harbor Water Quality Initiatives (Town Administration).

4. Review of Proposed Sewer Project for 2016 Annual Town Meeting:

   a) Overview of Comprehensive Wastewater Management Plan (Woodard & Curran).

   b) Overview of Financing/Funding (Finance Director).

   c) Septic System Utilization (Public Health Director).

d) Review of Public Outreach (Town Manager).

5. Public Input (Questions, Comments, Concerns).

VI. OFFICIAL BUSINESS

1. Town Manager: Request for Approval of Conflict of Interest Disclosure in Connection with Sewer Project and Pursuant to MGL Chapter 268A, section 19.

VII. ADJOURNMENT

Board of Selectmen Agenda Protocol:

- *Roberts Rules: The Board of Selectmen follows Roberts Rules of Order to govern its meetings as per the Town Code and Charter.*

- *Public Comment: For bringing matters of public interest to the attention of the Board. The Board welcomes concise statements on matters that are within the purview of the Board of Selectmen. At the Board's discretion, matters raised under Public Comment may be directed to Town Administration or may be placed on a future agenda, allowing all viewpoints to be represented before the Board takes action. Except in emergencies, the Board will not normally take any other action on Public Comment. Any personal remarks or interrogation or any matter that appears on the regular agenda are not appropriate for Public Comment.*

  Public Comment is not to be used to present charges or complaints against any specifically named individual, public or private; instead, all such charges or complaints should be presented in writing to the Town Manager who can then give notice and an opportunity to be heard to the named individual as per MGL Ch. 39, s 23B.

- *New Business: For topics not reasonably anticipated 48 hours in advance of the meeting.*

- *Public Participation: The Board welcomes valuable input from the public at appropriate times during the meeting with recognition by the Chair. For appropriate agenda items, the Chair will introduce the item and take public input. Individual Selectmen may have questions on the clarity of information presented. The Board will hear any staff input and then deliberate on a course of action.*

- *Selectmen Report and Comment: Individual Selectmen may have matters to bring to the attention of the Board. If the matter contemplates action by the Board, Selectmen will consult with the Chair and/or Town Manager in advance and provide any needed information by the Thursday before the meeting. Otherwise, except in emergencies, the Board will not normally take action on Selectmen Comment.*

EXHIBIT 1
AGREEMENTS TO BE EXECUTED BY TOWN MANAGER
UNLESS RESOLUTION OF DISAPPROVAL BY BOARD OF SELECTMEN
February 10, 2016

Type of Agreement/Description	Department	With	Amount	Other Information	Source of Funding
Service Agreement	Various Town Departments	Inquirer & Mirror	1st year: $14/column inch; $7.50/column inch for warrants	2 year contract with renewal option for advertising all legally required notices	Various Department Budgets

University of Massachusetts-Dartmouth

School for Marine Science & Technology (SMAST)

Coastal Systems Program

Summary of 2015 Island-wide Water Quality Monitoring of Estuaries and Salt Ponds

Technical Team

Dr. Brian Howes, Director

Dr. Roland Samimy, Sr. Research Manager

Ms. Sara Sampieri, Technical Associate

with

Jeff Carlson & Kaitlyn Shaw, Nantucket Natural Resources

February 10, 2016

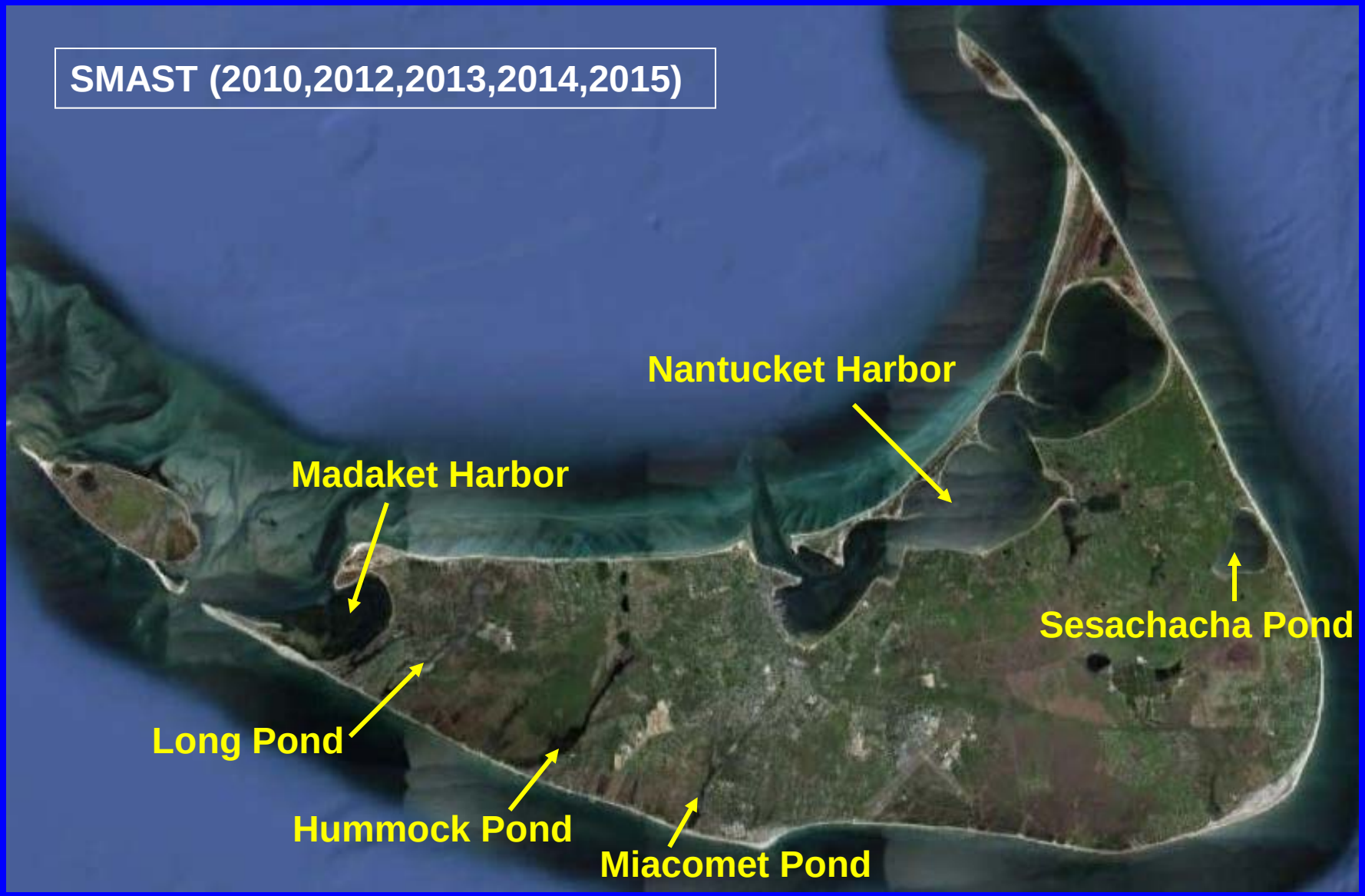
Major Anthropogenic Problem Facing Nantucket Estuaries

Habitat Degradation:

→increased <u>nitrogen loading</u> to estuaries, resulting in wholesale decline in estuarine habitats from shifting land-use.

→all of Nantucket's estuaries are currently showing some level of nitrogen impairment (moderate to high).

Water Quality Monitoring and Assessment
Nantucket Island-Wide Estuaries and Salt Ponds



Town of Nantucket Water Quality Monitoring Program

Goals:

-- to assess the current nutrient related water quality of each estuary within the Town of Nantucket

-- to track short & long-term changes in embayment health

-- to yield site specific validation of the effectiveness of Nitrogen Management Alternatives and for TMDL compliance

ESTUARINE SAMPLING

1. Ammonia (NH4)
2. Nitrate / Nitrite (NO3+NO2)
3. Dissolved Organic Nitrogen (DON)
4. Particulate Organic Nitrogen (PON)
5. Particulate Organic Carbon (POC)
6. Phosphate (PO4)
7. Chlorophyll-*a* and Pheophytin-*a*

FRESHWATER STREAM SAMPLING

(Polpis Harbor + Nantucket Harbor, 2010 only, resumed for 2015)

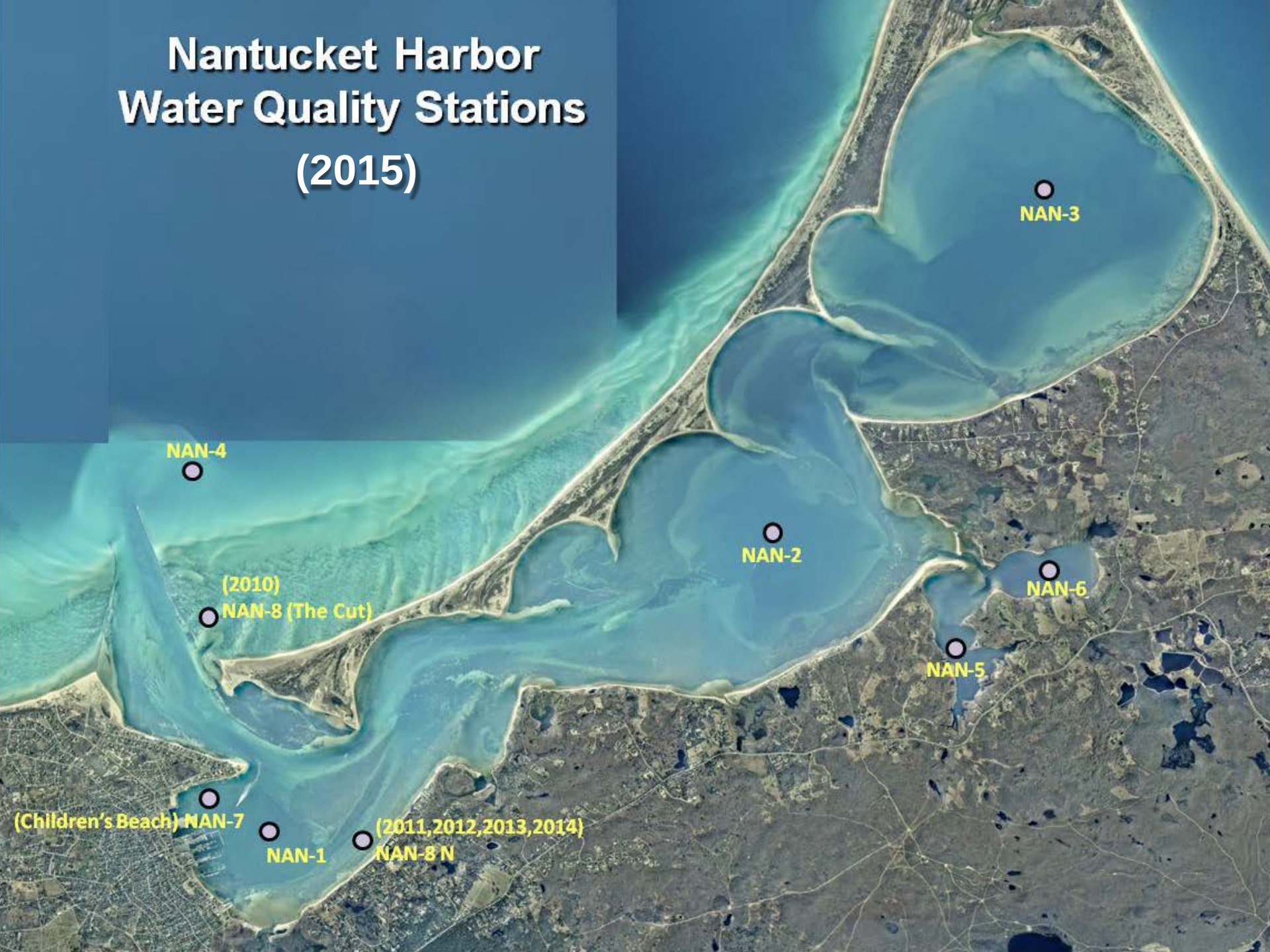
1. Ammonia (NH4)
2. Nitrate / Nitrite (NO3+NO2)
3. Dissolved Organic Nitrogen (DON)
4. Particulate Organic Nitrogen (PON)
5. Particulate Organic Carbon (POC)
6. Phosphate (PO4)
7. Total Phosphorus (TP)

2015 Water Quality Monitoring Program Sampling Schedule

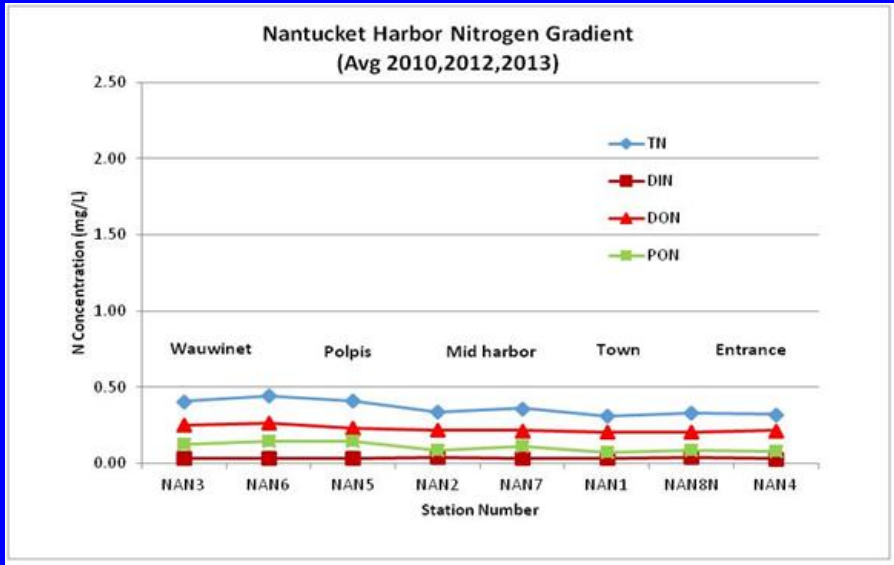
Month	Nantucket Harbor	Madaket Harbor	Long Pond	Sesachacha Pond	Miacomet Pond	Hummock Pond	Polpis Streams	Oyster Sites
Jan								
Feb								
Mar								
April								
May	May 7		May 12	May 11	May 11	May 12, 27		
June	June 9, 22	June 8	June 17	June 15	June 15	June 17	June 8	June 9
July	July 8, 20	July 6	July 13	July 15	July 15	July 13	July 6	July 6
August	Aug 4,19	Aug 5	Aug 17	Aug 10	Aug 10	Aug 12	Aug 3, 31	Aug 3
September	Sept 1	Sept 3	Sept 14	Sept 10	Sept 10	Sept 9		Sept 2
October								
November								
December								
Total Events	**8**	**4**	**5**	**5**	**5**	**6**	**4**	**4**

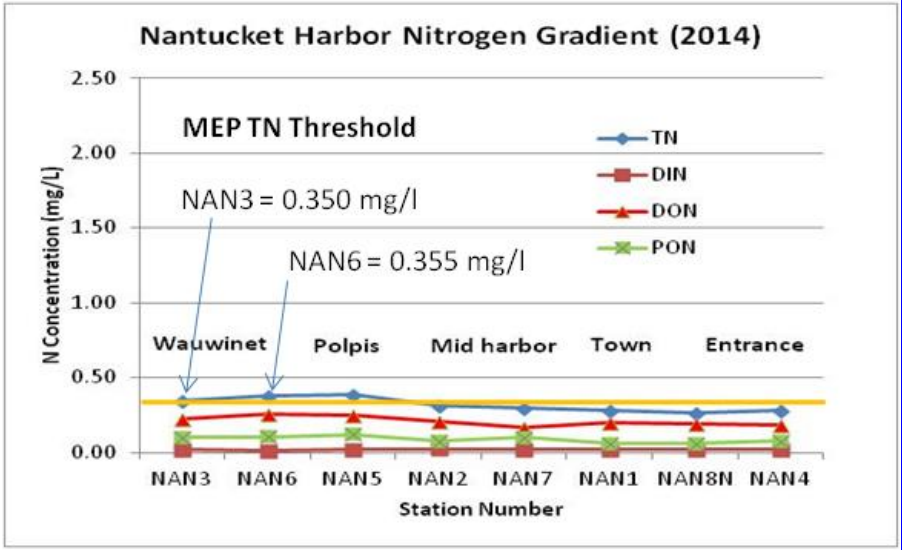
Sampling undertaken during warmer summer/fall months (May-Sept.)
(critical period for environmental management)

Nantucket Harbor Water Quality Stations (2015)



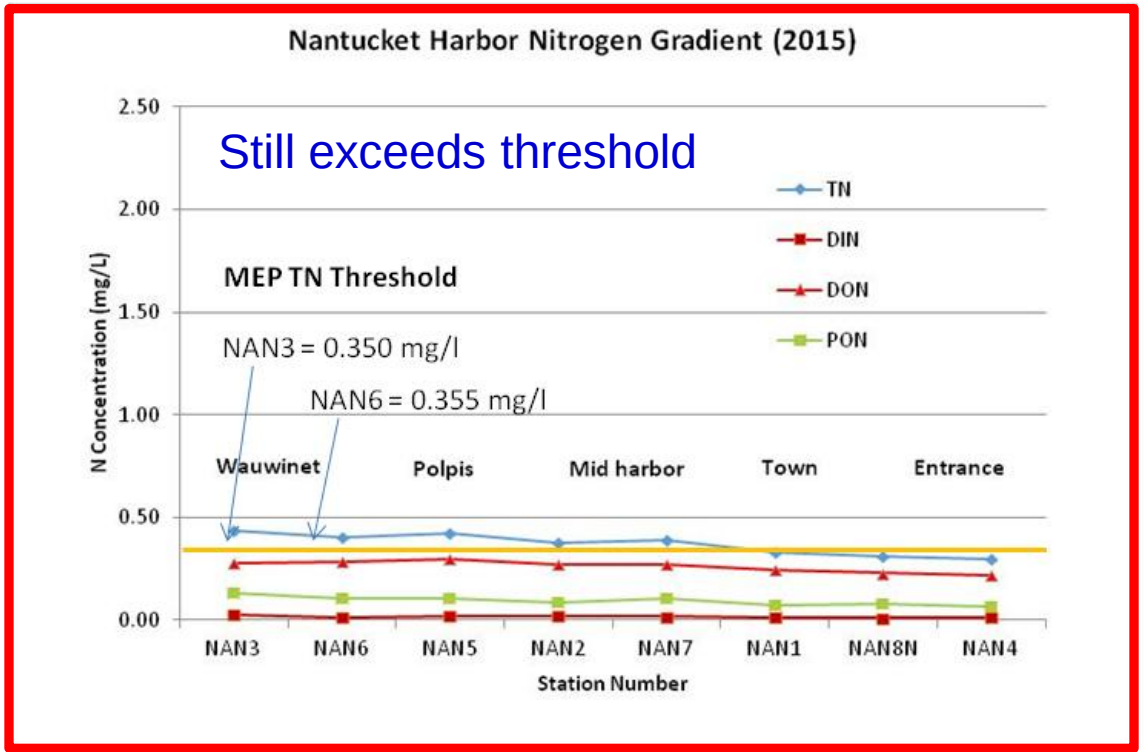
N-Concentrations Nantucket Harbor (2010-15)



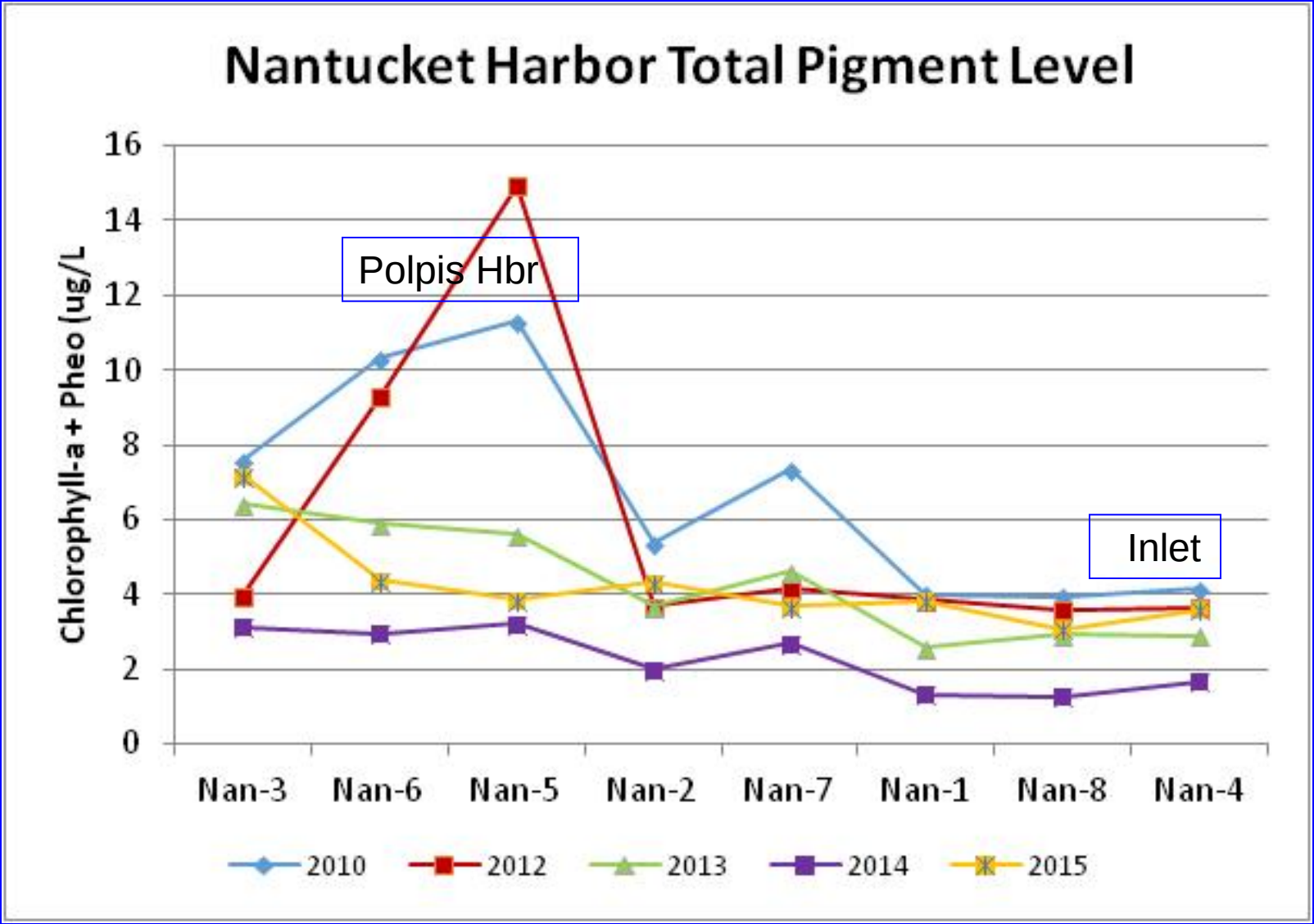


Averages based on all events (May-Oct.)

<u>2015</u>
<u>NAN3=0.436</u>
<u>NAN6=0.404</u>



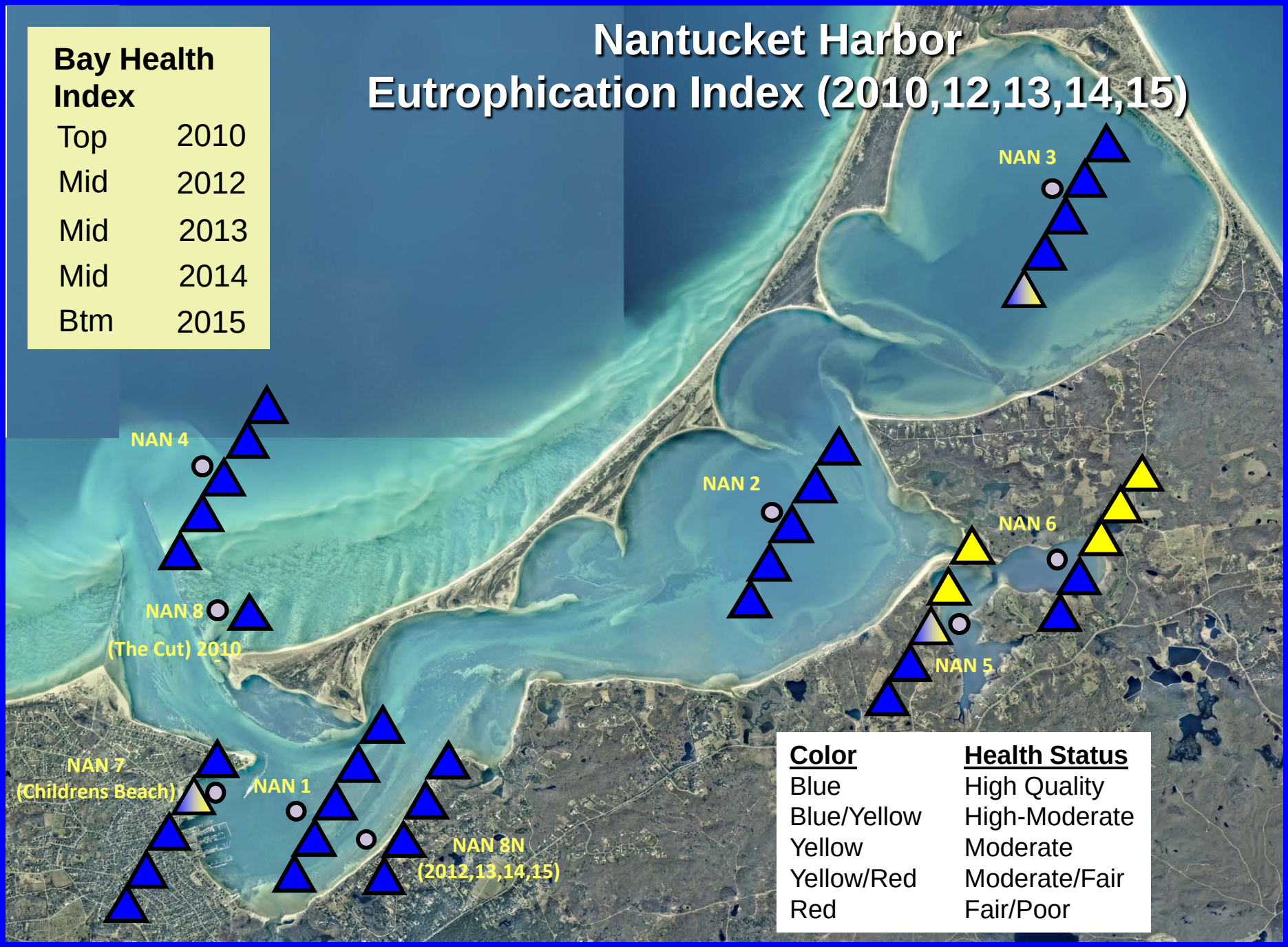
Total Pigment (chla+pheophytin) Nantucket Harbor Stations



Nantucket Harbor
Avg. Annual TN Concentrations (2010-2015)

Sub-Embayment	Monitoring Station	Historical MEP Mean TN (mg/L)	s.d.	2010 Town ID	2010 Mean TN (mg/L)	2012 Mean TN (mg/L)	2013 Mean TN (mg/L)	2014 Mean TN (mg/L)	2015 Mean TN (mg/L)
Head of the Harbor - Upper	2	0.408	0.188	NA	NS	NS	NS		
Head of the Harbor - Mid	Town 3	0.401	0.115	3	0.392	0.411	0.415	0.345	0.436
Head of the Harbor - Lower	2A	0.339	0.070	NA	NS	NS	NS	NS	NS
Pocomo Head	3	0.335	0.081	NA	NS	NS	NS	NS	NS
Quaise Basin	3A+Town 2	0.336	0.112	2	0.297	0.364	0.345	0.314	0.374
East Polpis Harbor	4+Town 6	0.362	0.105	6	0.438	0.484	0.401	0.378	0.404
West Polpis Harbor	4A+Town 5	0.388	0.119	5	0.431	0.419	0.385	0.389	0.422
Abrams Point	5	0.335	0.060	NA	NS	NS	NS	NS	NS
Monomoy	6	0.297	0.086	NA	NS	NS	NS	NS	NS
Mooring Area	7+Town 1, 1A	0.326	0.106	1, 7	0.332, 0.377	0.335, 0.379	0.323, 0.323	0.294, 0.284	0.39, 0.33
Nantucket Sound	OS+Town 4	0.239	0.041	4	0.283	0.344[1]	0.317[1]	0.277	0.297

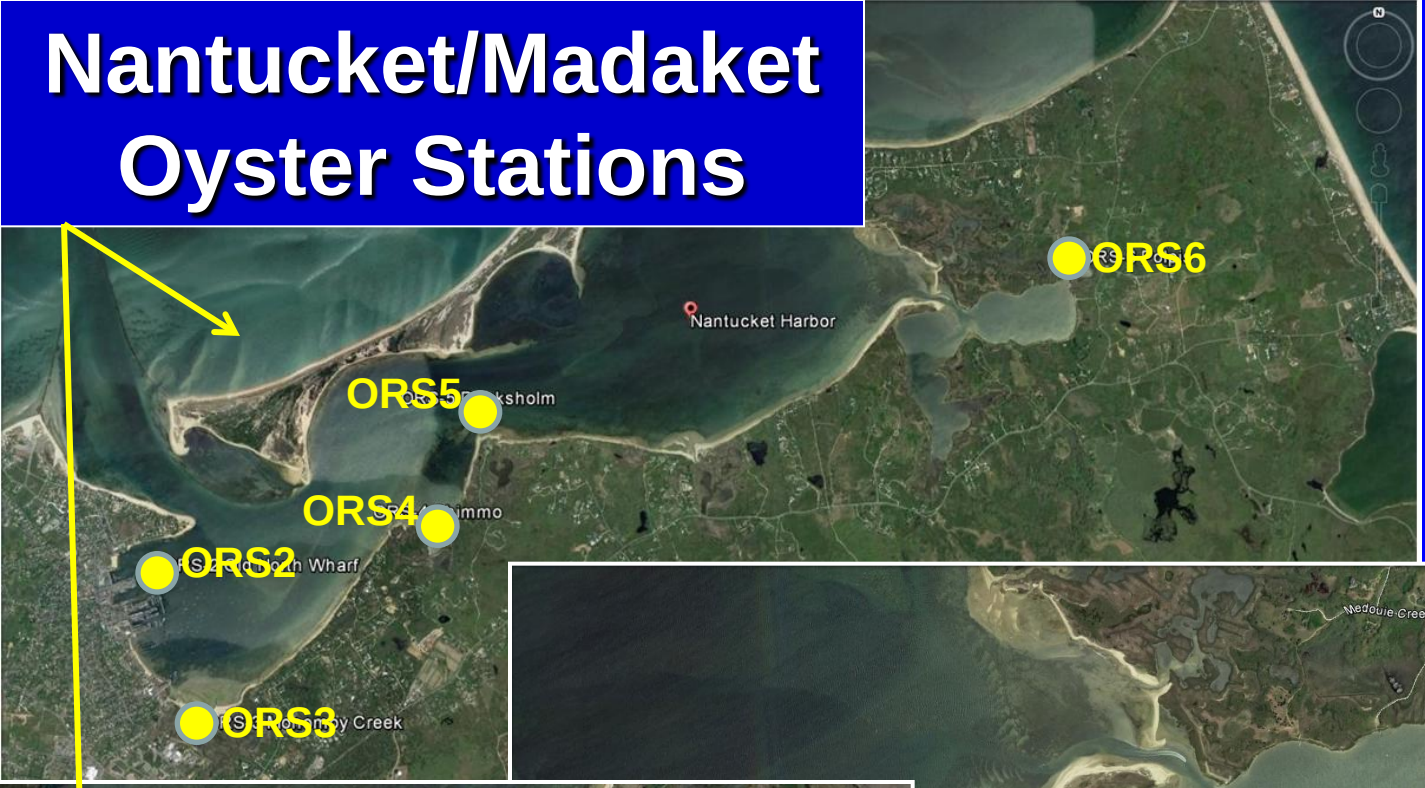
Nantucket Harbor Eutrophication Index (2010,12,13,14,15)



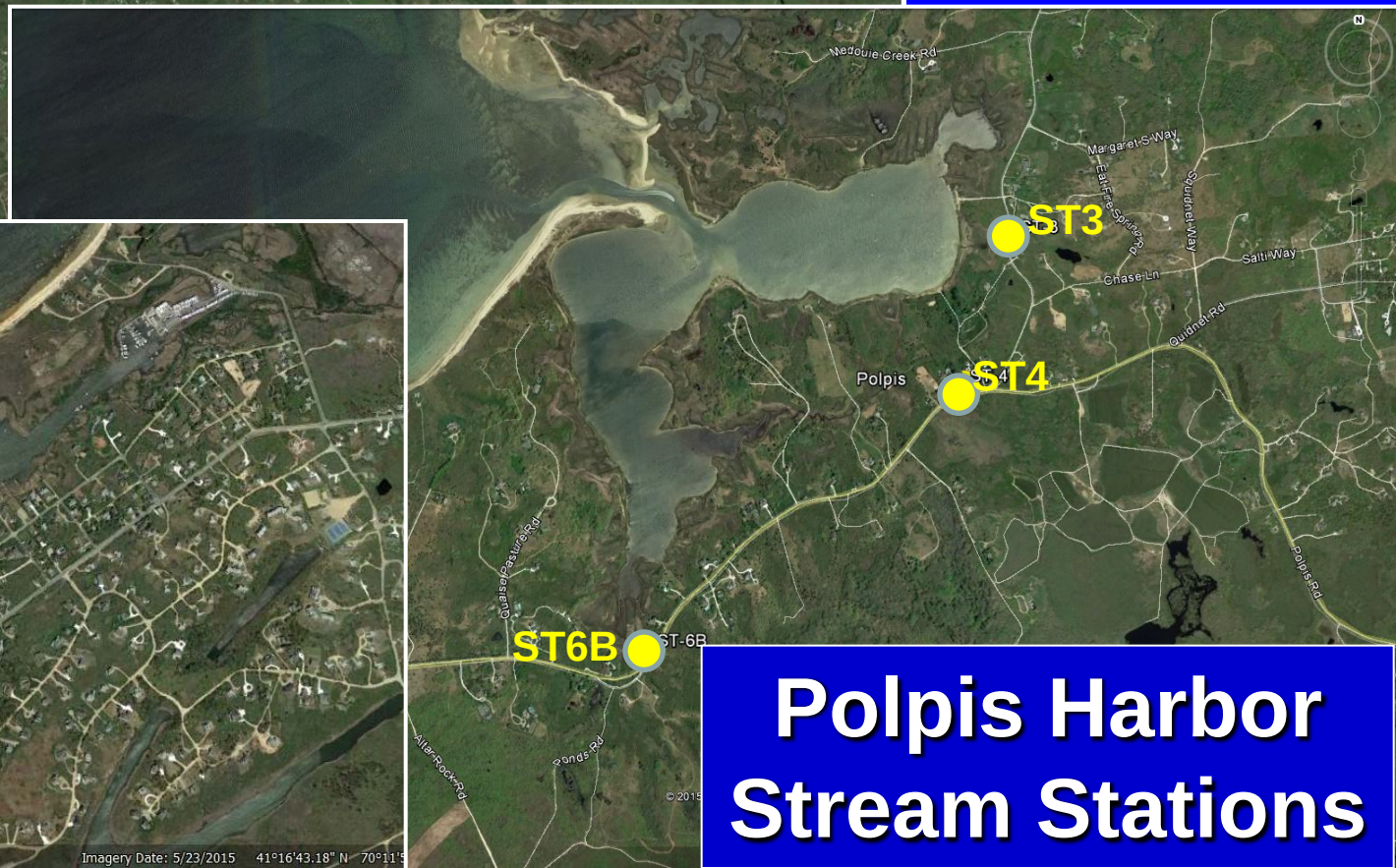
Bay Health Index	
Top	2010
Mid	2012
Mid	2013
Mid	2014
Btm	2015

Color	Health Status
Blue	High Quality
Blue/Yellow	High-Moderate
Yellow	Moderate
Yellow/Red	Moderate/Fair
Red	Fair/Poor

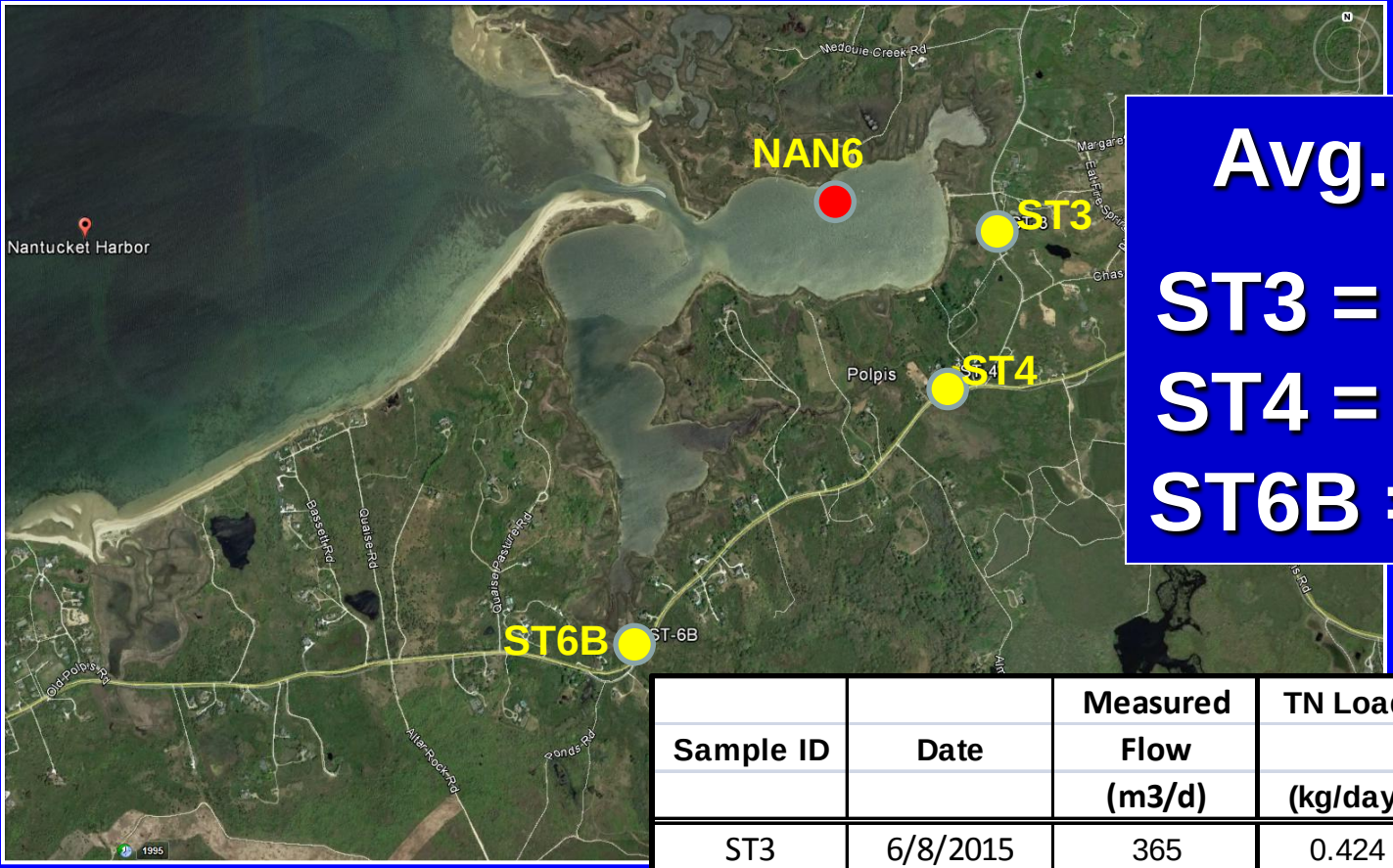
Nantucket/Madaket Oyster Stations



New Stations for Summer 2015 Sampling Season



Polpis Harbor Stream Stations



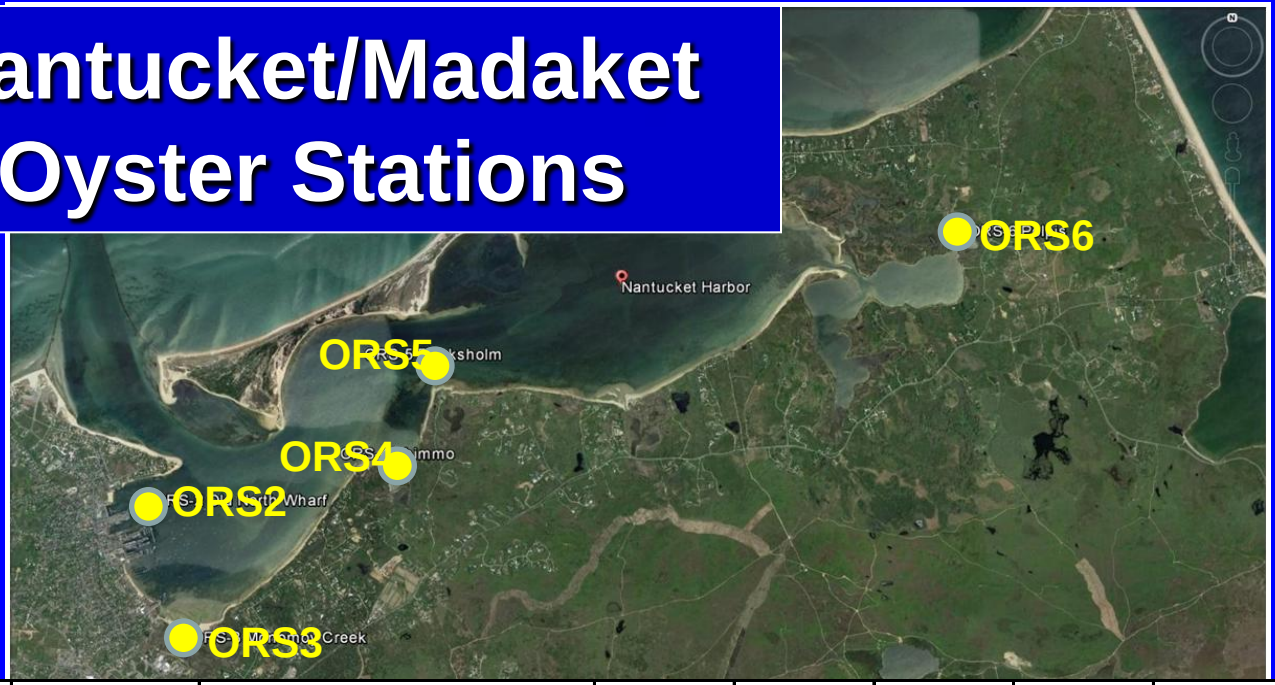
Avg. TN Conc.

ST3 = 1.038 mg/L
ST4 = 1.060 mg/L
ST6B = 1.10 mg/L

Sample ID	Date	Measured Flow (m3/d)	TN Load (kg/day)	TN Load (kg/month)	Representative Month
ST3	6/8/2015	365	0.424	12.7	June
ST3	7/6/2015	248	0.385	11.9	July
ST3	8/3/2015	127	0.119	3.7	August
ST3	8/31/2015	40	0.020	0.6	September
ST4	6/8/2015	2040	2.020	60.6	June
ST4	7/6/2015	1771	1.739	53.9	July
ST4	8/3/2015	0	0.000	0.0	August
ST4	8/31/2015	208	0.213	6.4	September
ST6B	6/8/2015	696	0.586	17.6	June
ST6B	7/6/2015	805	1.450	44.9	July
ST6B	8/3/2015	187	0.151	4.7	August
ST6B	8/31/2015	87	0.082	2.5	September

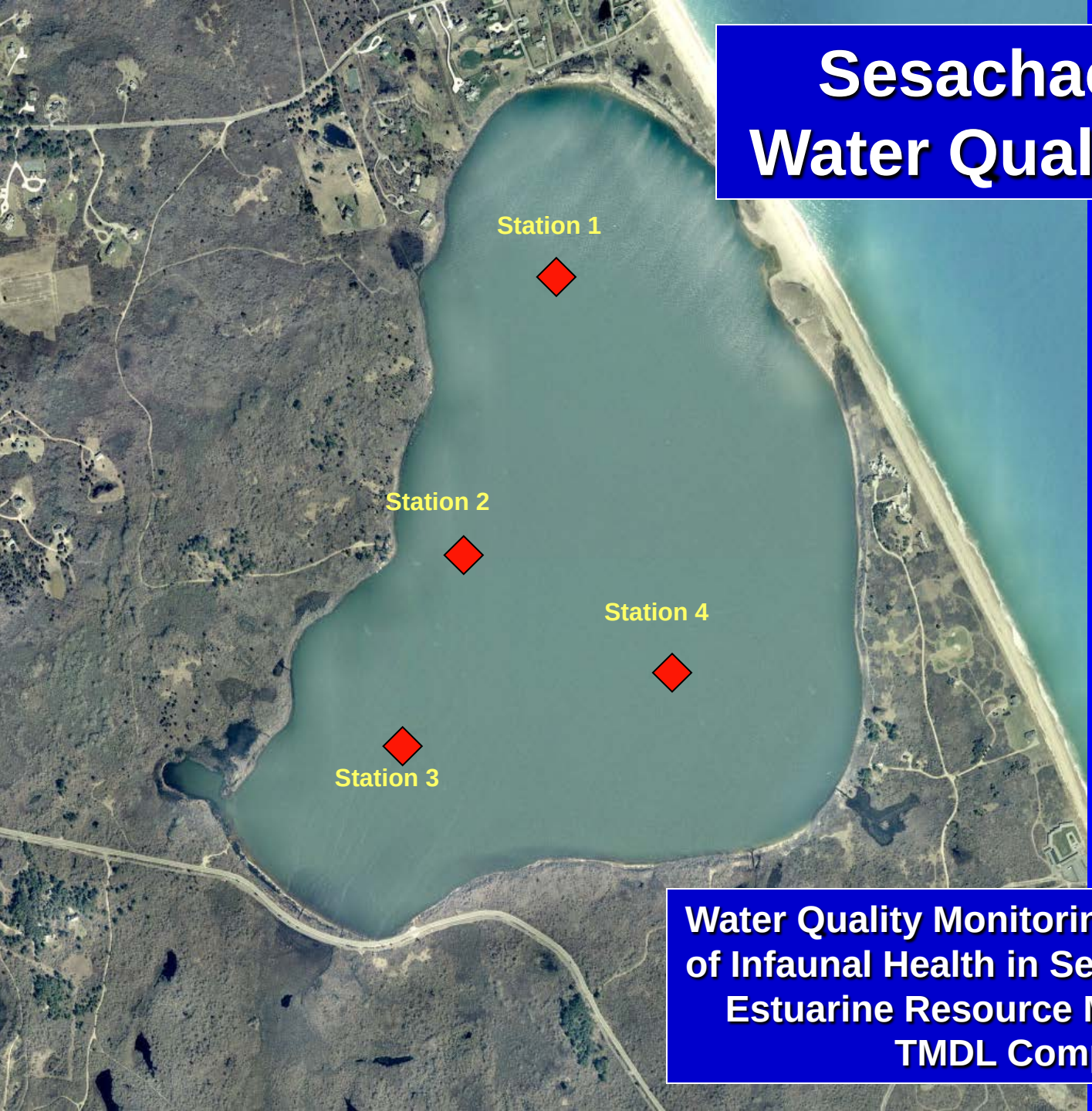
Polpis Stream Stations

Nantucket/Madaket Oyster Stations



Sample ID	Date	Embayment	Avg. PO4 (mg/L)	Avg. NH4 (mg/L)	Avg. Nox (mg/L)	Avg. DON (mg/L)	Avg. PON (mg/L)	Avg. TN (mg/L)	Avg. Total Pig (ug/L)
ORS1	6/9/2015	MADAKET	0.037	0.015	0.005	0.287	0.119	0.426	7.536
ORS1	7/6/2015	MADAKET HITHER CREEK	0.025	0.000	0.014	0.373	0.231	0.618	11.009
ORS2	6/9/2015	OLD NORTH WHARF	0.014	0.019	0.000	0.200	0.090	0.309	5.057
ORS2	7/6/2015	OLD NORTH WHARF	0.016	0.004	0.007	0.287	0.086	0.384	3.186
ORS2	8/3/2015	OLD NORTH WHARF	0.019	0.017	0.011	0.254	0.059	0.341	2.467
ORS2	9/2/2014	OLD NORTH WHARF	0.026	0.020	0.001	0.225	0.072	0.318	3.463
ORS3	6/9/2015	MONOMOY CREEKS	0.024	0.014	0.036	0.294	0.077	0.421	3.983
ORS3	7/6/2015	MONOMOY CREEKS	0.028	0.029	0.047	0.429	0.082	0.587	2.703
ORS4	8/3/2015	PIMENYS POINT	0.012	0.015	0.002	0.369	0.064	0.449	2.102
ORS4	9/2/2014	SHIMMO	0.026	0.056	0.003	0.214	0.109	0.382	5.188
ORS5	8/3/2015	DUCKS HOLM	0.009	0.012	0.003	0.460	0.063	0.537	1.753
ORS5	9/2/2014	DUCKS HOLM	0.014	0.013	0.000	0.302	0.089	0.404	3.501
ORS6	8/3/2015	POLPIS	0.020	0.013	0.000	0.533	0.112	0.658	4.204
ORS6	9/2/2014	POLPIS	0.035	0.050	0.000	0.299	0.094	0.443	4.147

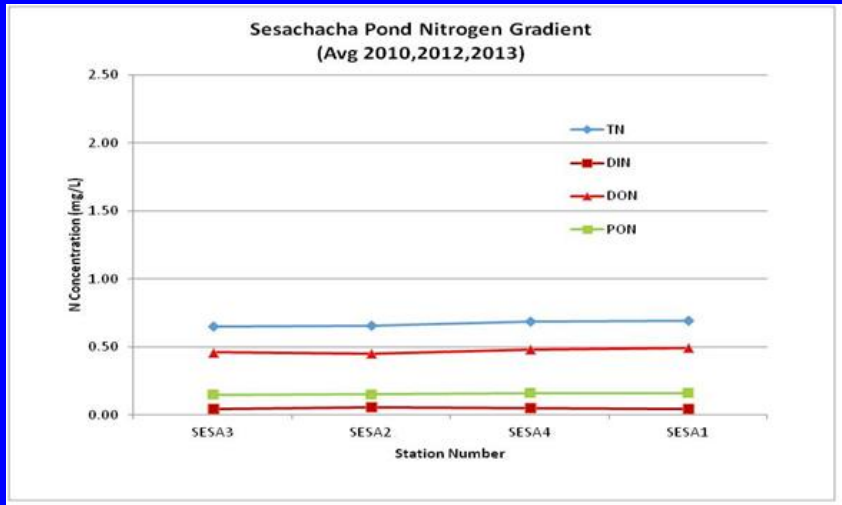
Sesachacha Pond Water Quality Stations

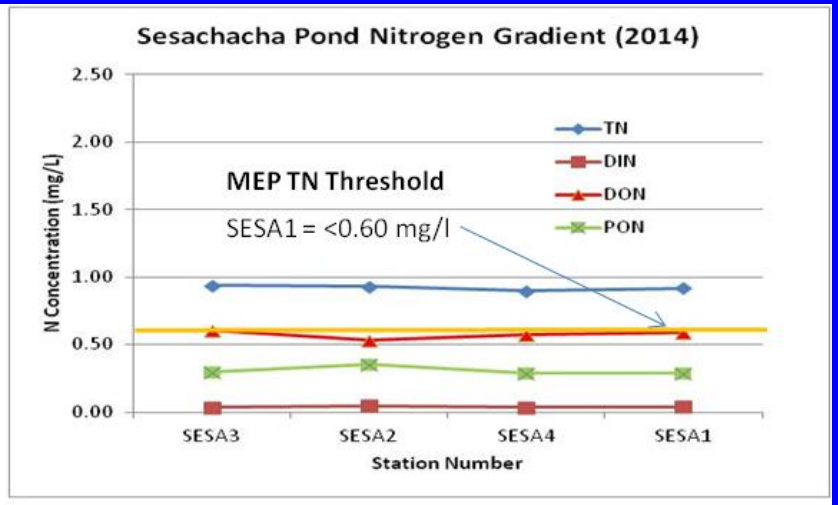


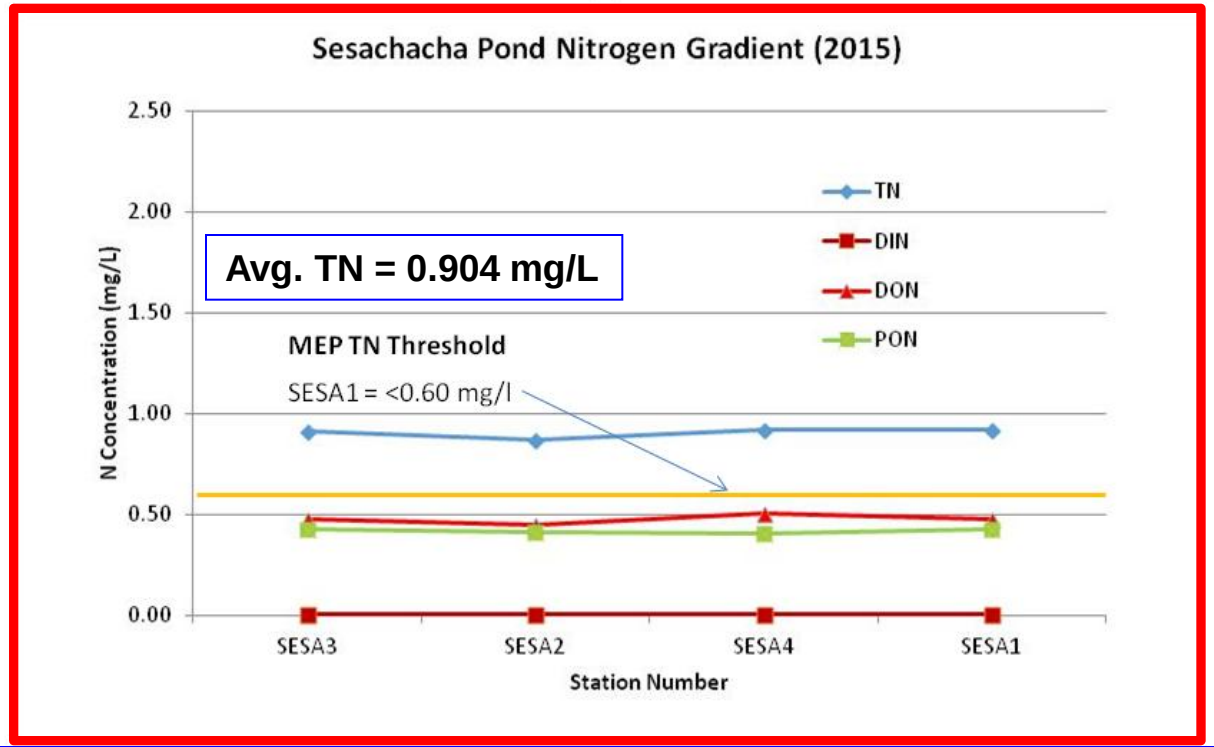
Water Quality Monitoring and Assessment of Infaunal Health in Sesachacha Pond for Estuarine Resource Management and TMDL Compliance

N-Concentrations Sesachacha Pond (2010-15)

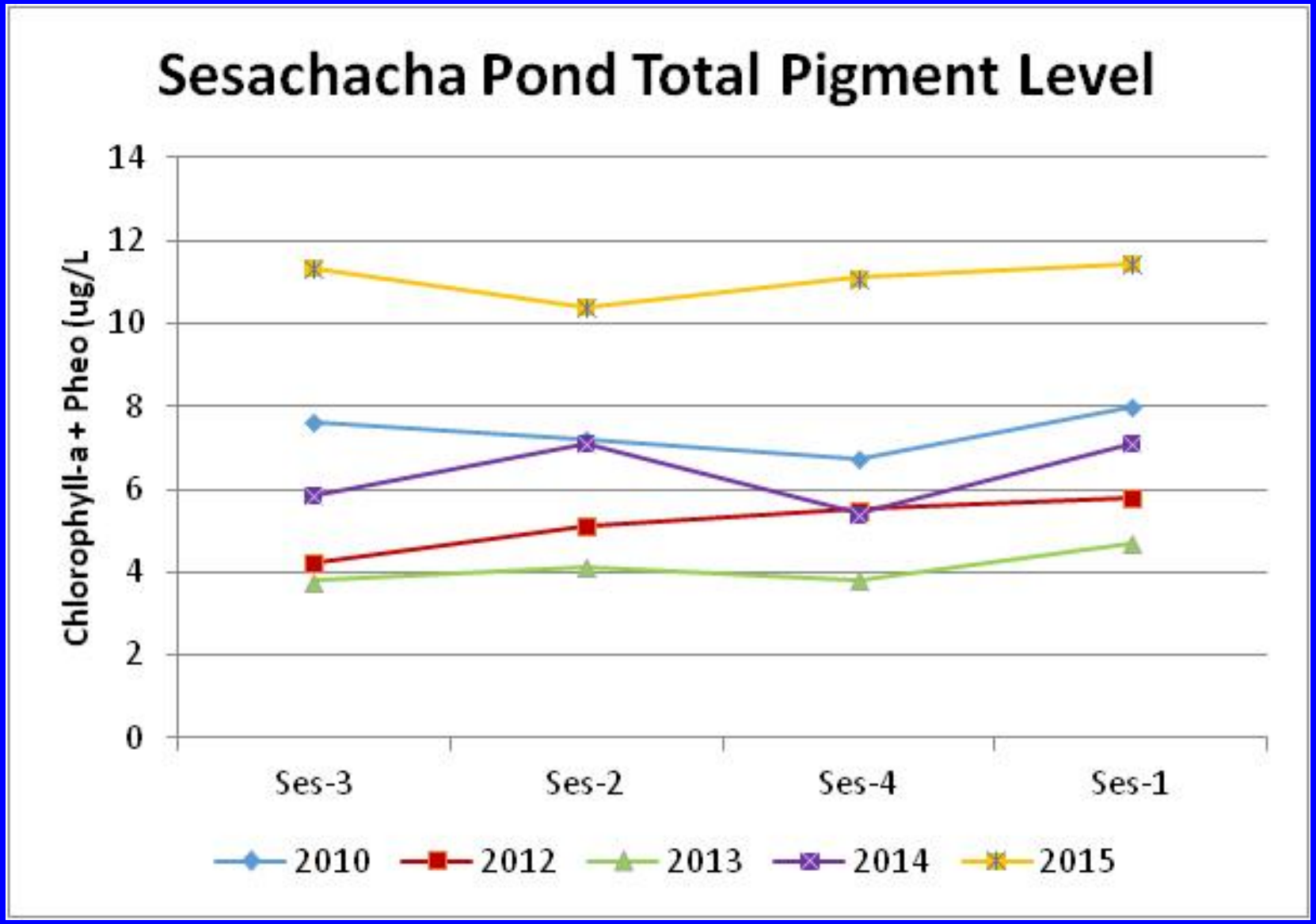
NO noticeable nutrient gradient across the pond

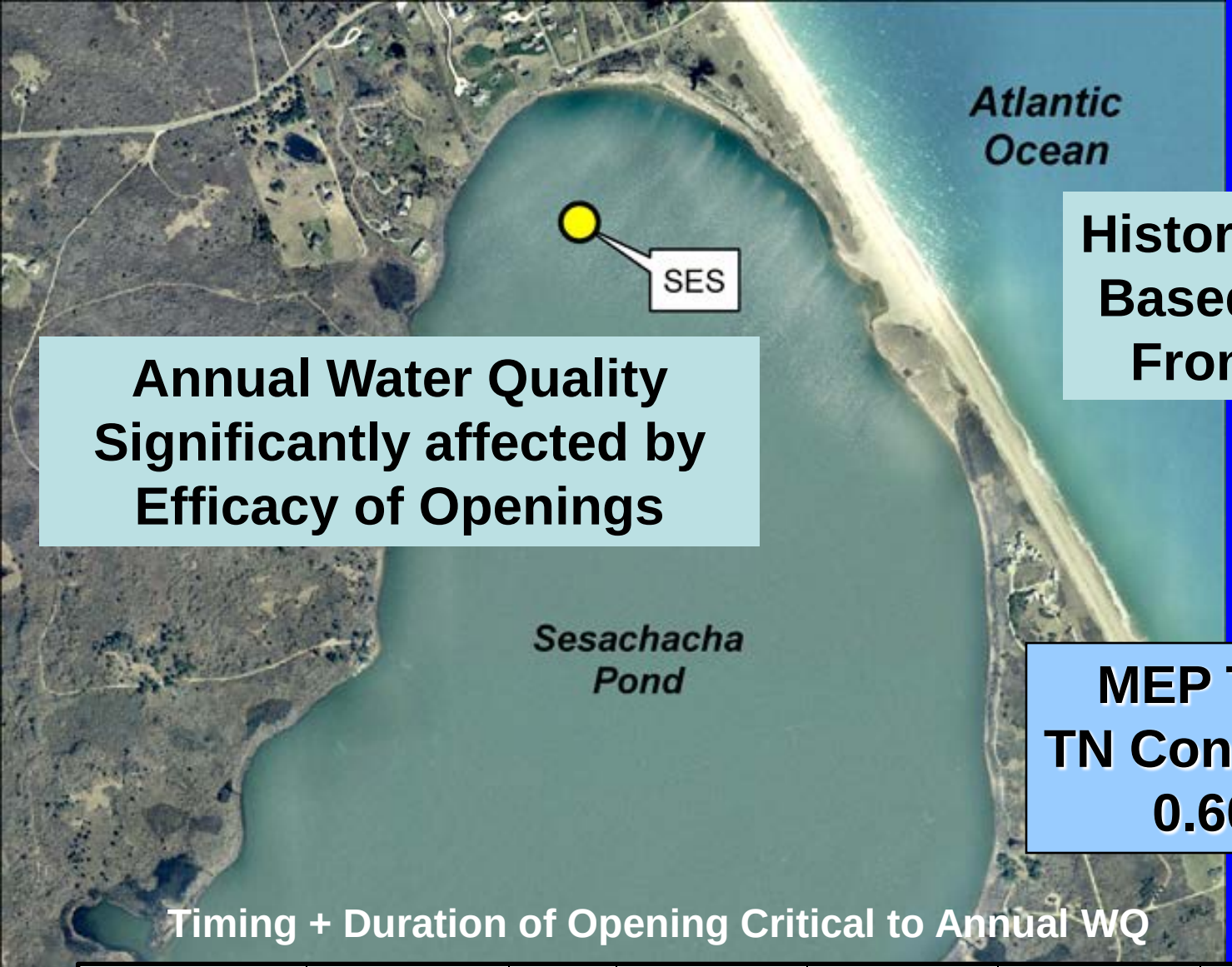






Sesachacha Pond (phytoplankton) Summer Averages (2010,12,13,14,15)





Historical MEP Data Based on samples From 1992-2005

Annual Water Quality Significantly affected by Efficacy of Openings

MEP Threshold TN Concentration = 0.600 mg/L

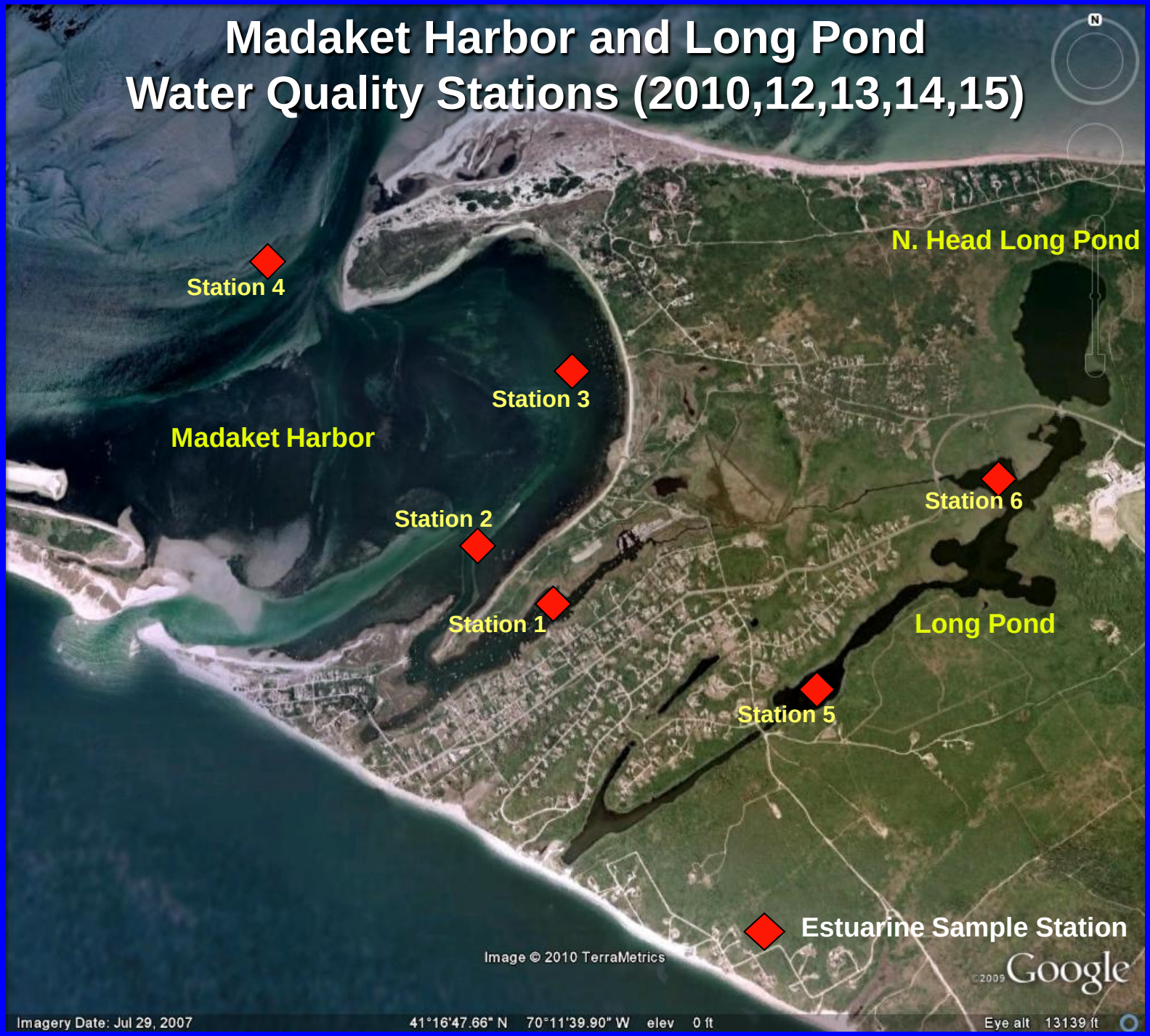
Timing + Duration of Opening Critical to Annual WQ

Sampling Station Location	Historical MEP Mean TN (mg/L)	s.d.	2010 Mean TN (mg/L)	2012 Mean TN (mg/L)	2013 Mean TN (mg/L)	2014 Mean TN (mg/L)	2015 Mean TN (mg/L)
Sesachacha Pond	1.197	0.078	0.684 (0.704)	0.678 (0.639)	0.714 (0.669)	0.919 (0.922)	0.918 (0.904)

Sesachacha Pond (2010-15)

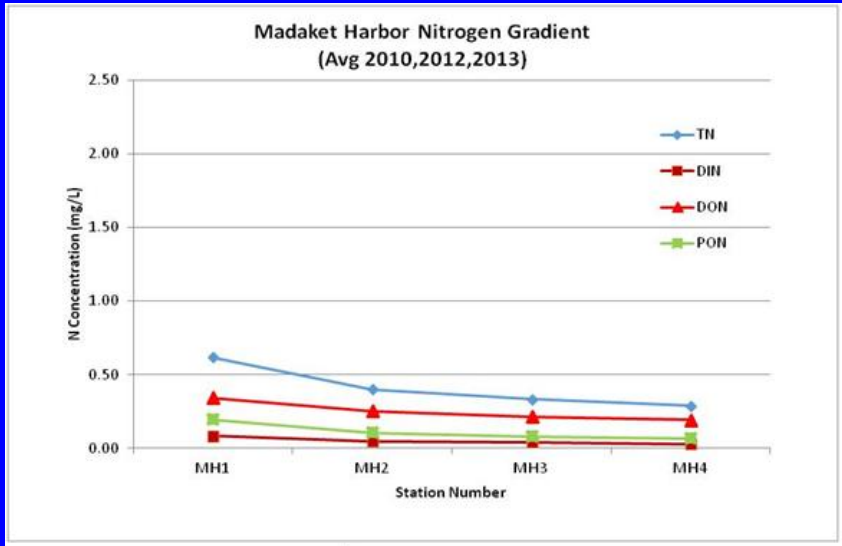
- **Water quality very sensitive to efficacy of openings (tidal flushing);**
- TN levels dropped significantly (2010-2013), but **<u>2014 to 2015 monitoring shows levels returning to historic TN levels</u>**
- Increased TN and chlorophyll a levels in 2014 and 2015 likely due to less effective openings
- If openings can be managed to 2012 & 2013 openings, Sesachacha Pond should sustain improvement and meet its designated TMDL.

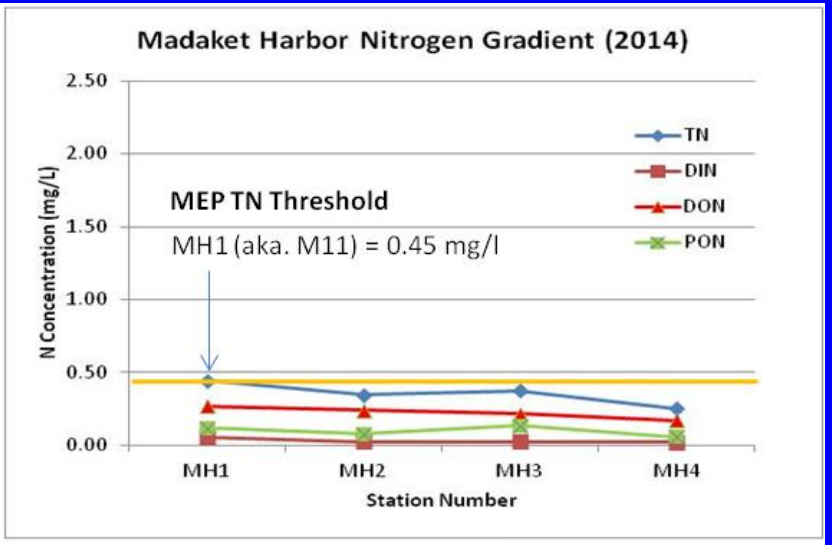
Madaket Harbor and Long Pond Water Quality Stations (2010,12,13,14,15)

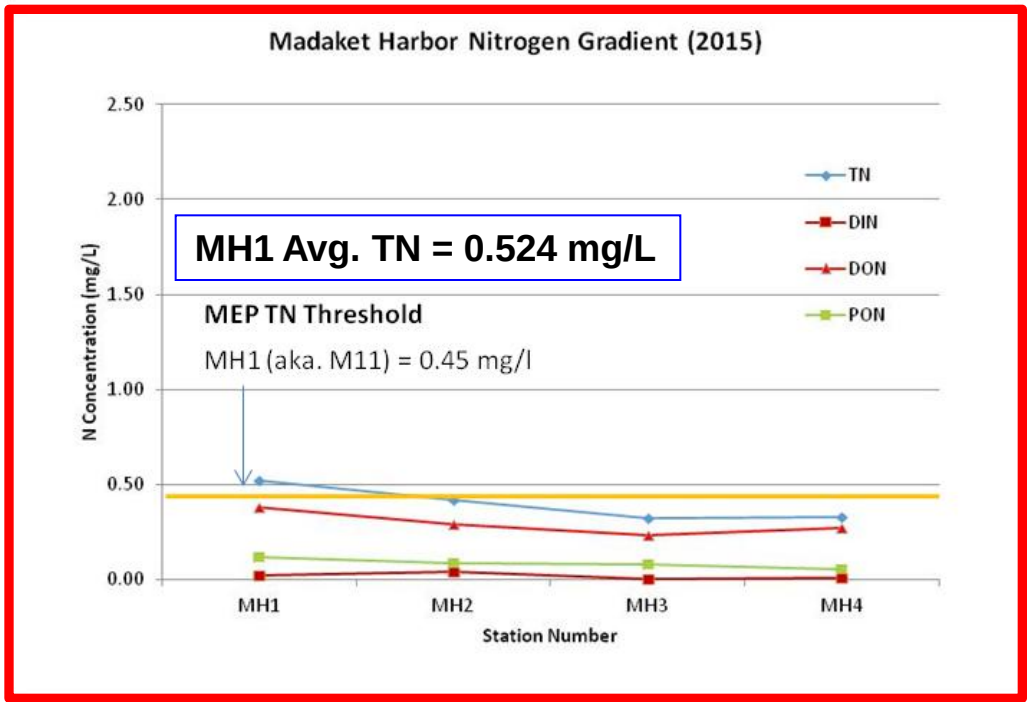


N Concentrations Madaket Harbor (2010-14)

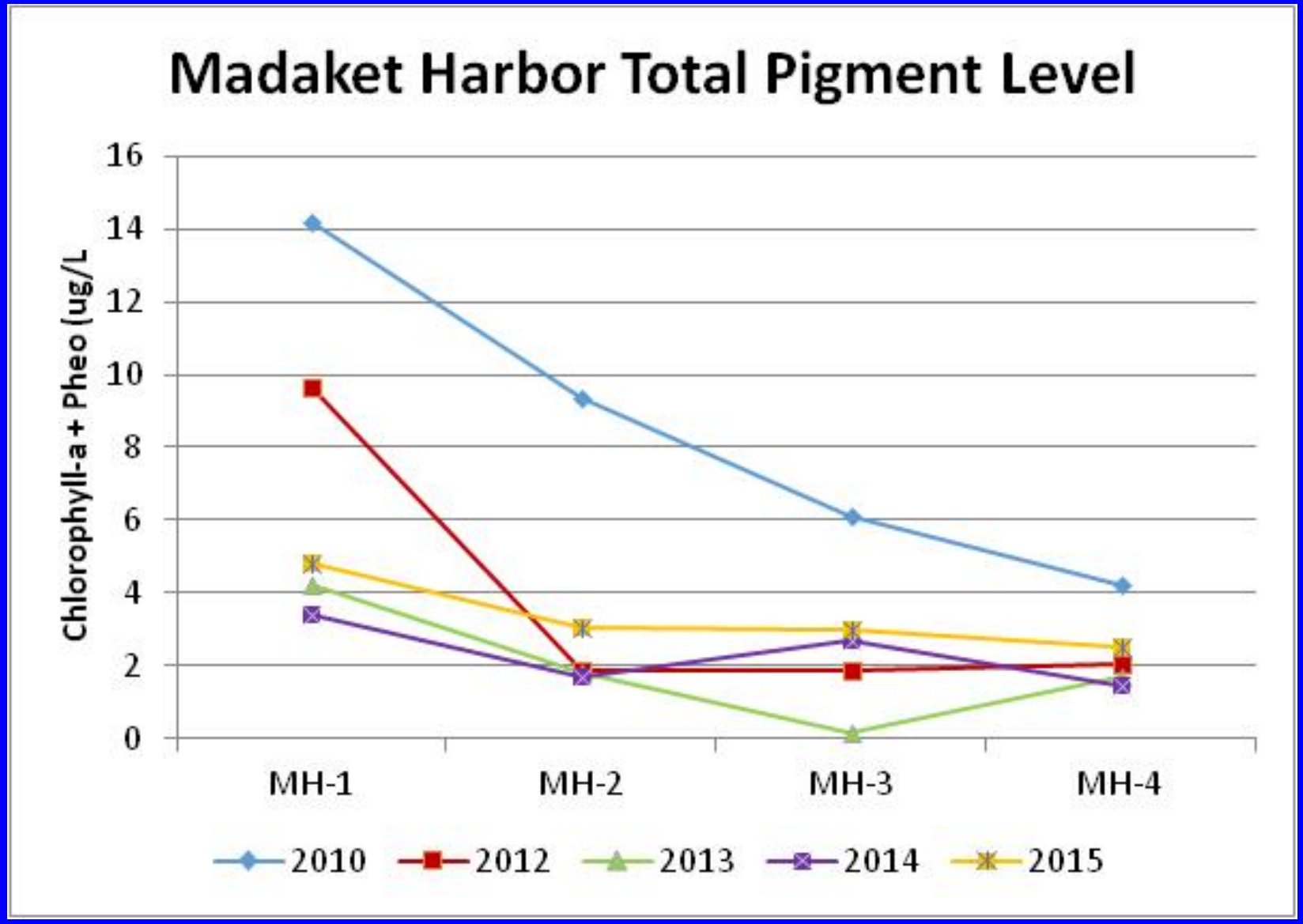
SLIGHT nutrient gradient across the Harbor



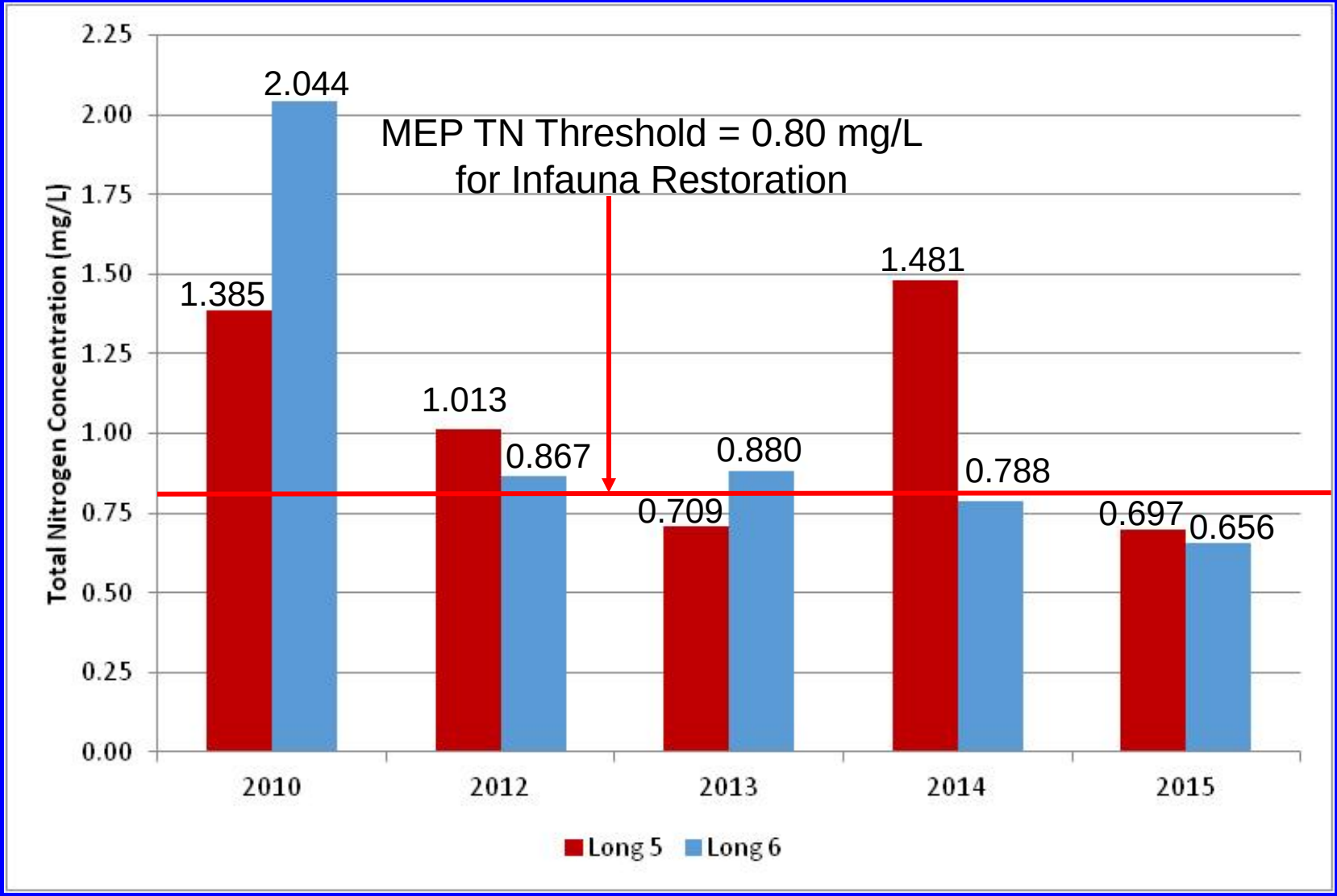




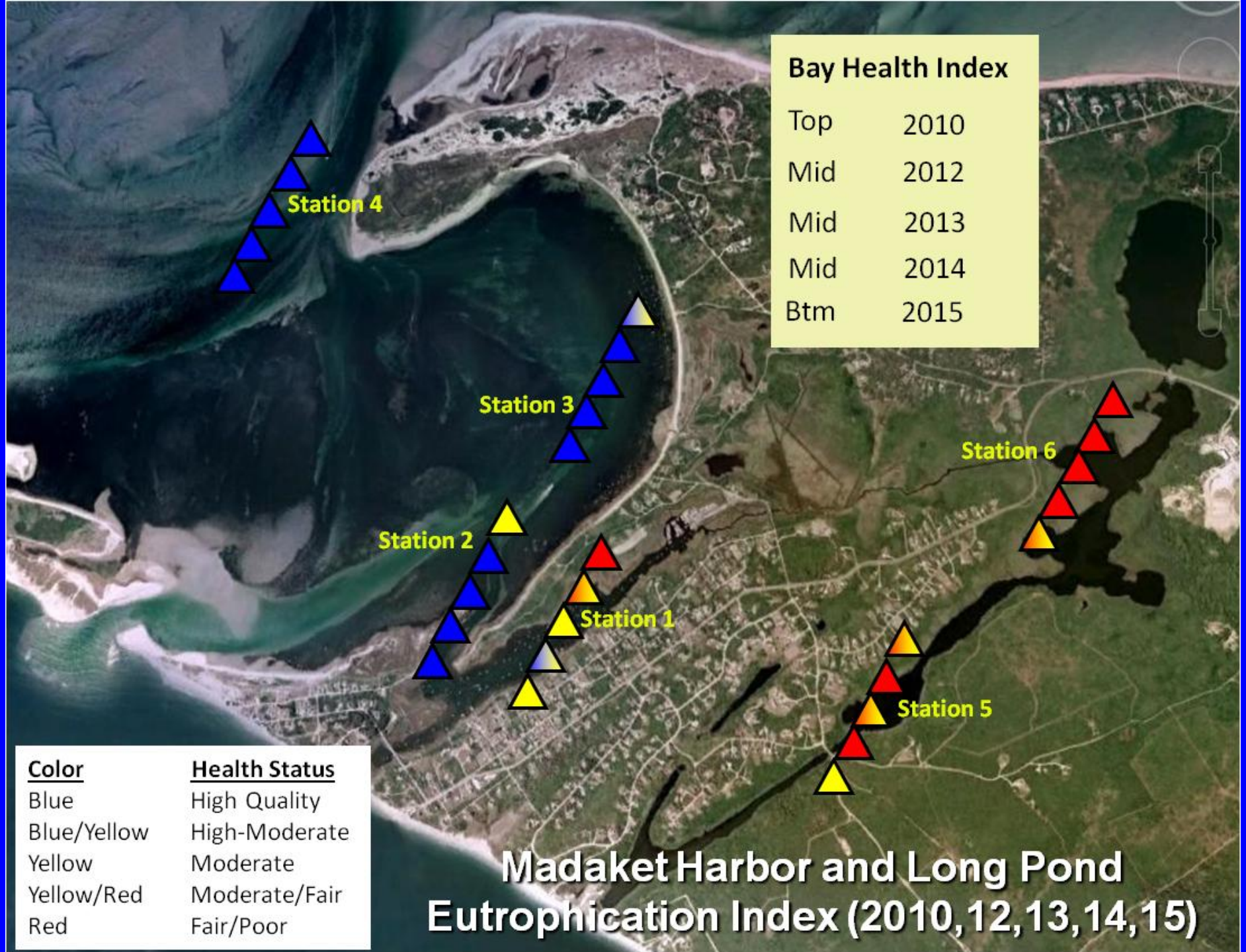
Madaket Harbor (phytoplankton) Summer avg. chlorophyll (2010,12,13,14,15)



Total Nitrogen Long Pond Stations



Long Pond showed significantly lower TN levels (~60%) in 2015 versus 2010.

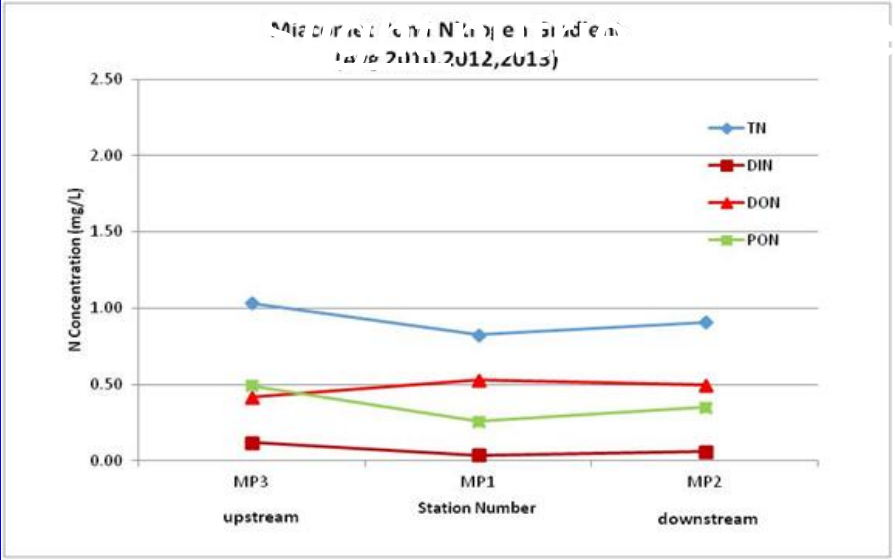

Bay Health Index
Top 2010
Mid 2012
Mid 2013
Mid 2014
Btm 2015
Station 4
Station 3
Station 2
Station 1
Station 6
Station 5
Color
Blue
Blue/Yellow
Yellow
Yellow/Red
Red
Health Status
High Quality
High-Moderate
Moderate
Moderate/Fair
Fair/Poor
Madaket Harbor and Long Pond
Eutrophication Index (2010,12,13,14,15)

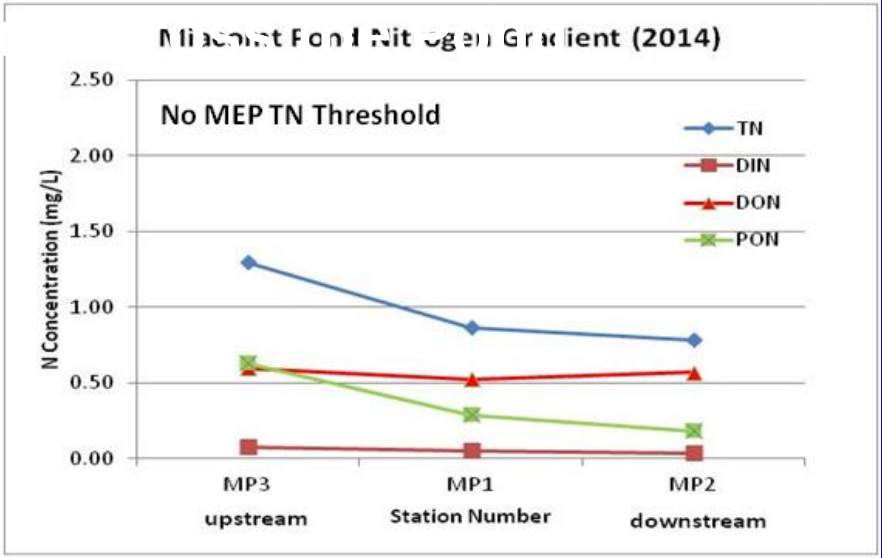
Miacomet Pond Water Quality Stations (2010,12,13,14,15)

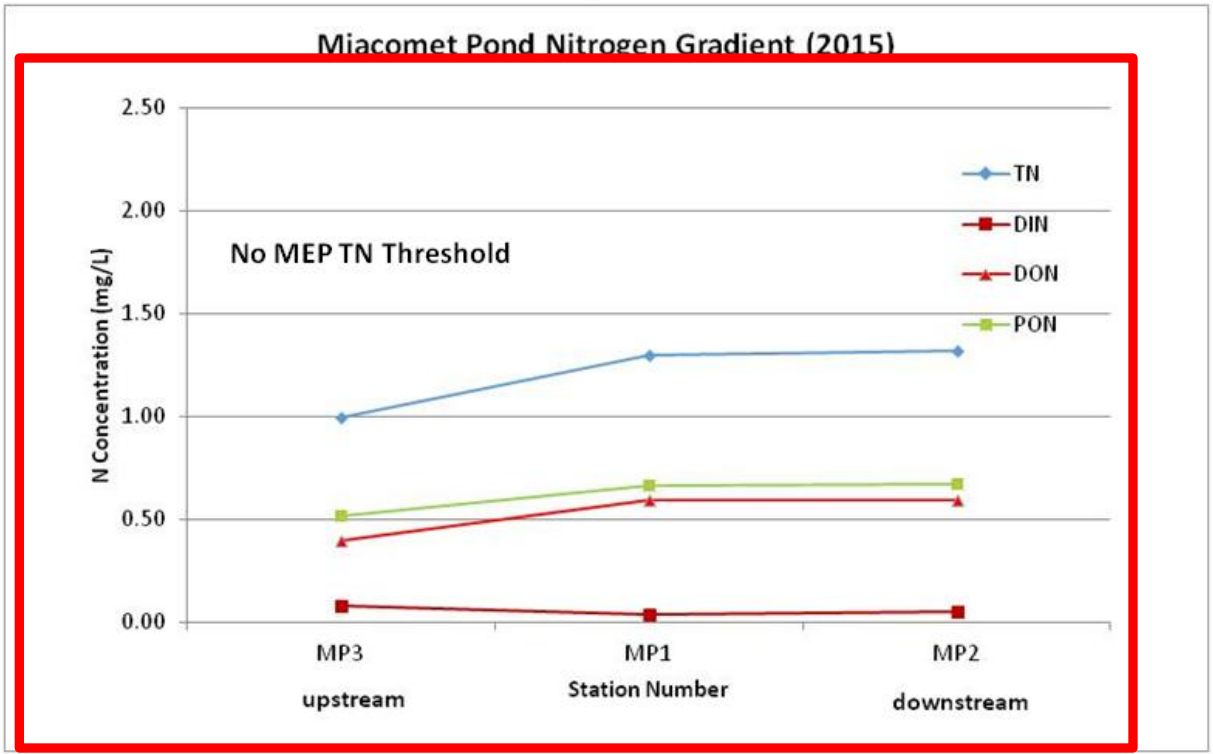
Monitoring shows significant impairment, now almost freshwater

NO MEP Analysis for Miacomet Pond

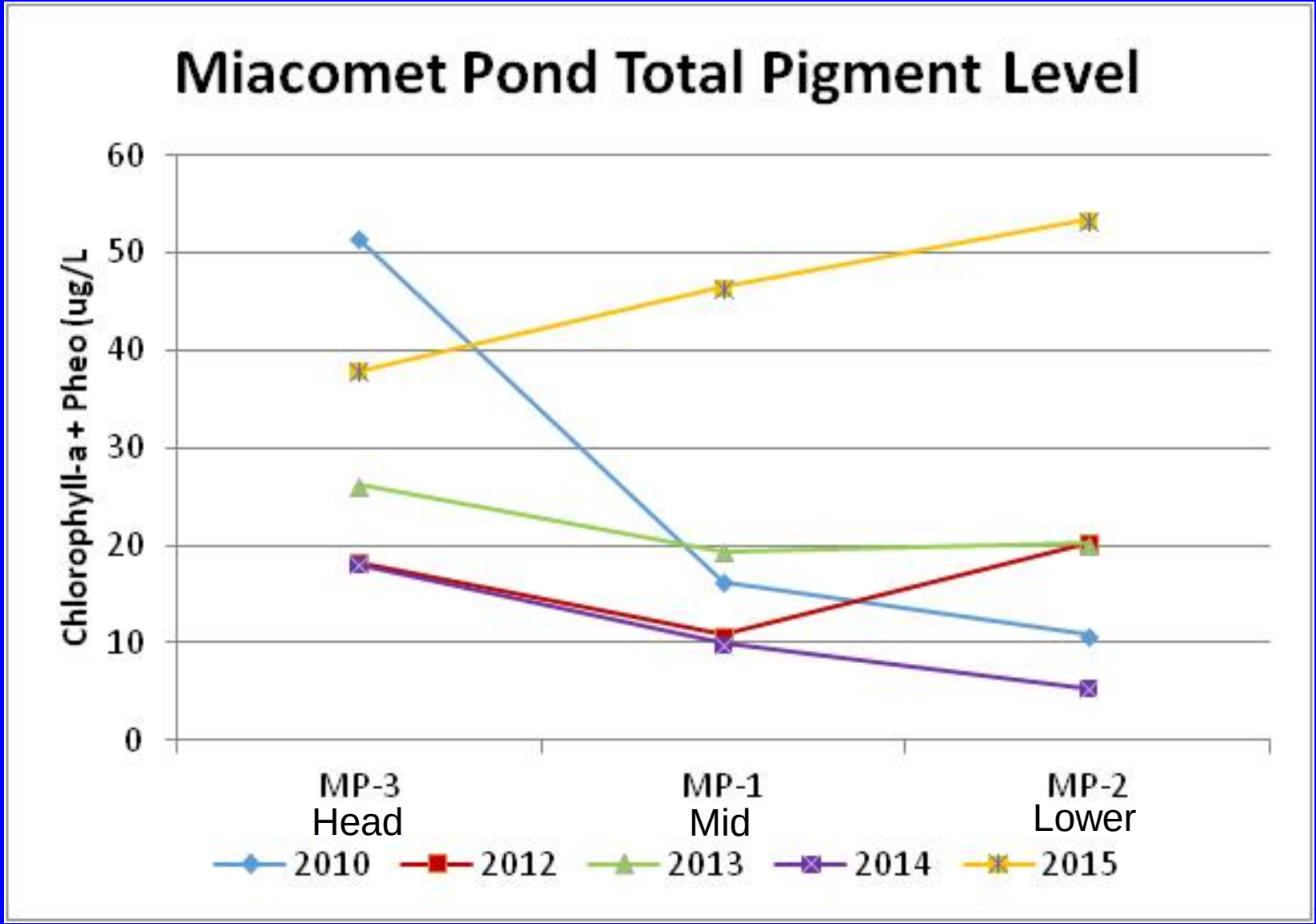
N Concentrations Miacomet Pond (2010-15)



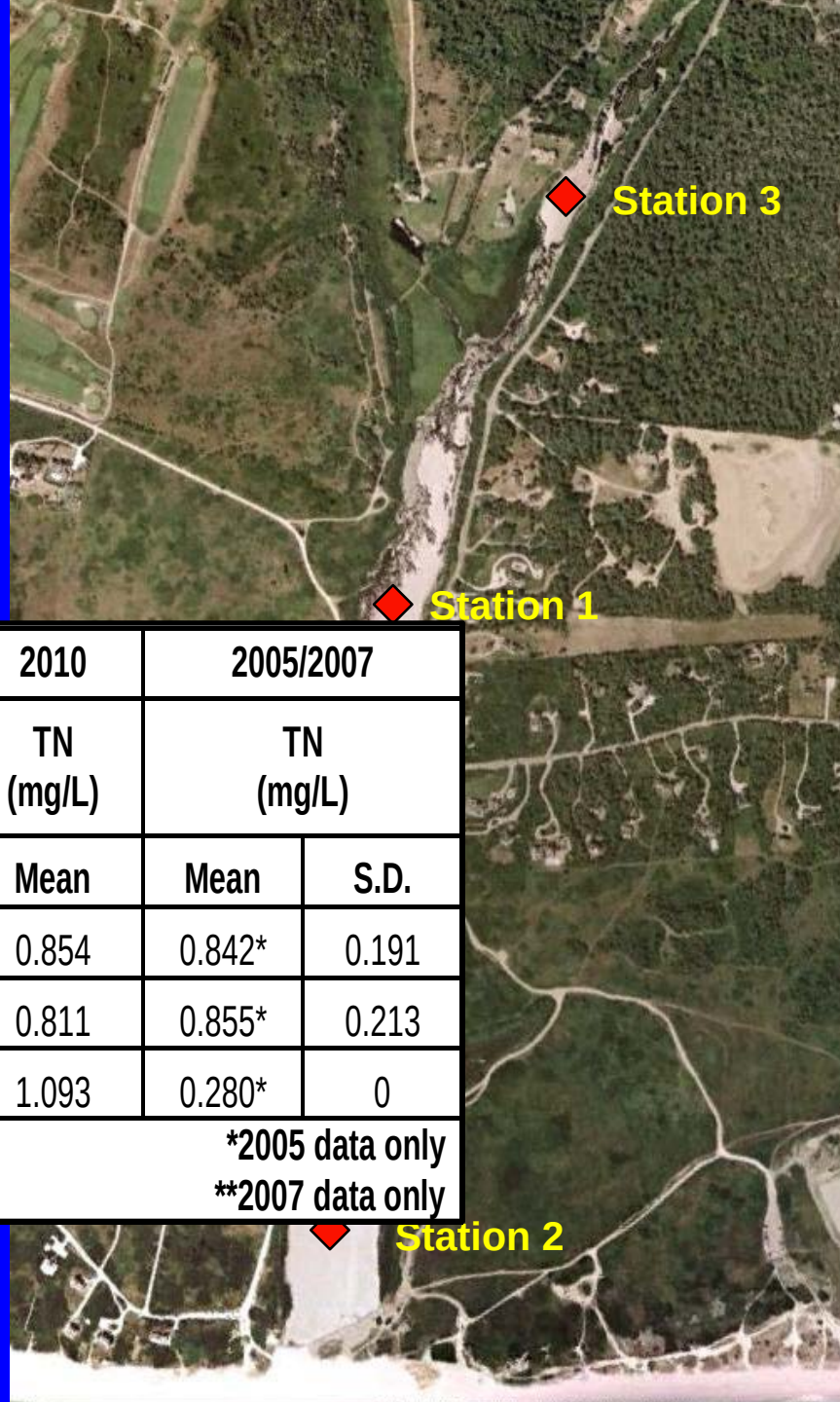




Total Pigment (chla+pheophytin) Miacomet Pond (2010,12,13,14,15)



Miacomet Pond Water Quality Stations (2010,12,13,14,15)



Miacomet Pond Station ID's	2015	2014	2013	2012	2010	2005/2007	
	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	
	Mean	Mean	Mean	Mean	Mean	Mean	S.D.
MP1	1.297	0.864	0.792	0.828	0.854	0.842*	0.191
MP2	1.318	0.784	1.036	0.880	0.811	0.855*	0.213
MP3	0.992	1.297	1.058	0.950	1.093	0.280*	0

*2005 data only
**2007 data only

Miacomet Pond Nitrogen / Phosphorous Ratios

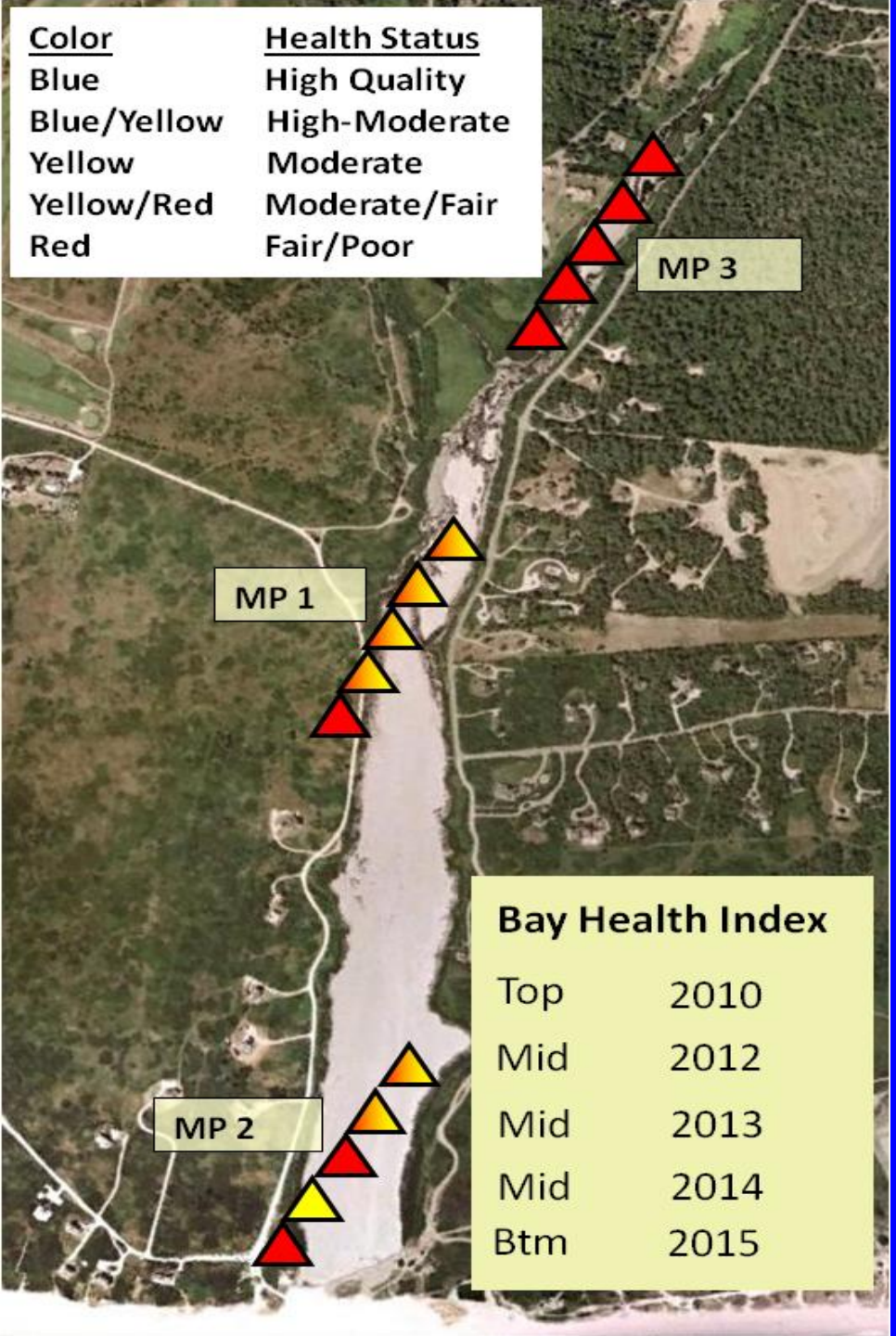
Phosphorous Sampling Initiated in 2015

Redfield Ratios (C:N:P, 106:16:1)

Station Id	DIN/DIP inorganic	TN/TP total
MP-3	10.2	16.1
MP-1	10.3	34.3
MP-2	13.1	32.3

N/P ratios significantly greater than 20 indicate that P additions will likely result in increased eutrophication

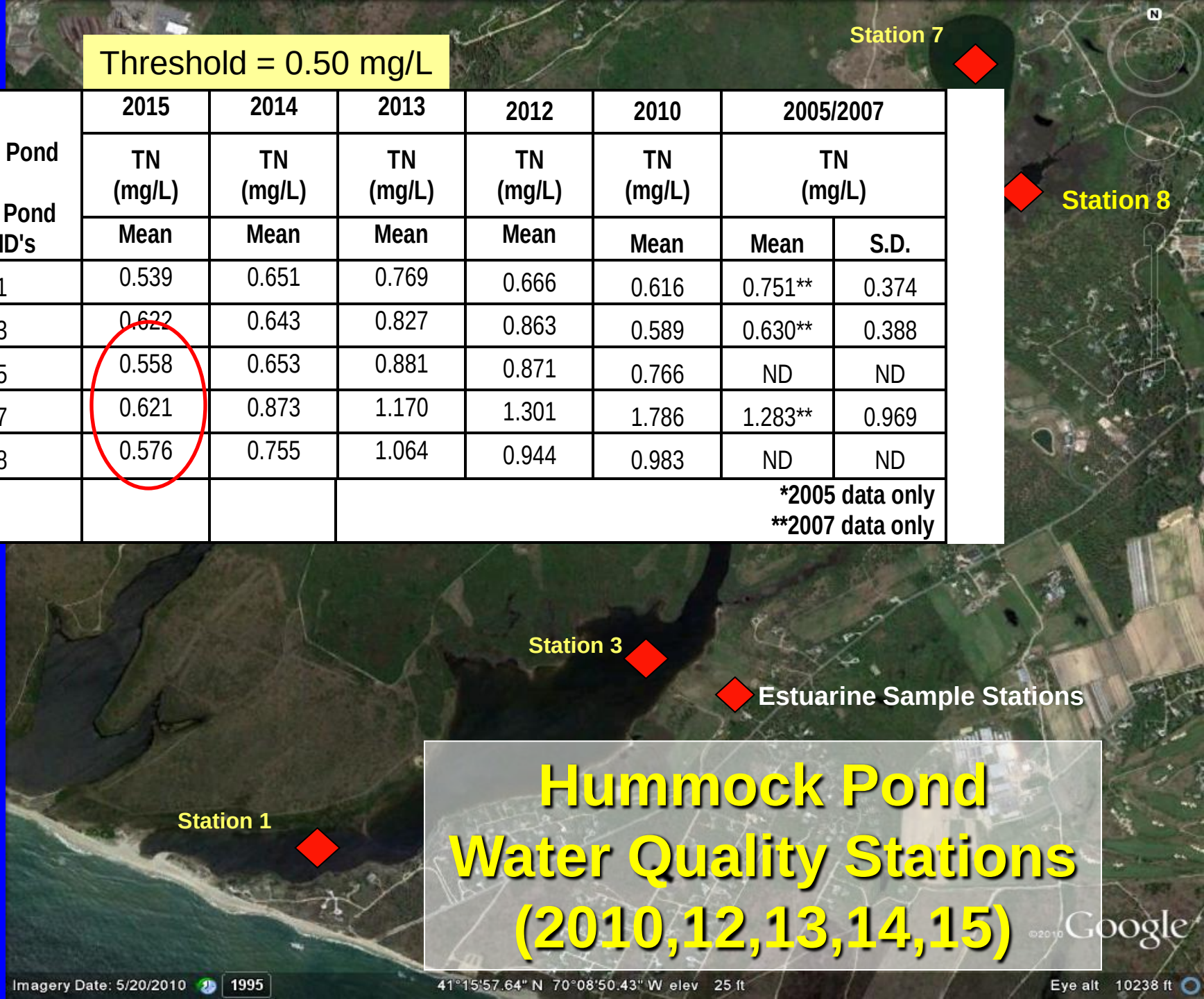
Miacomet Pond Eutrophication Index (2010,12,13,14,15)



Relatively Consistent slow increase in Habitat Impairment over the 5 years of Monitoring

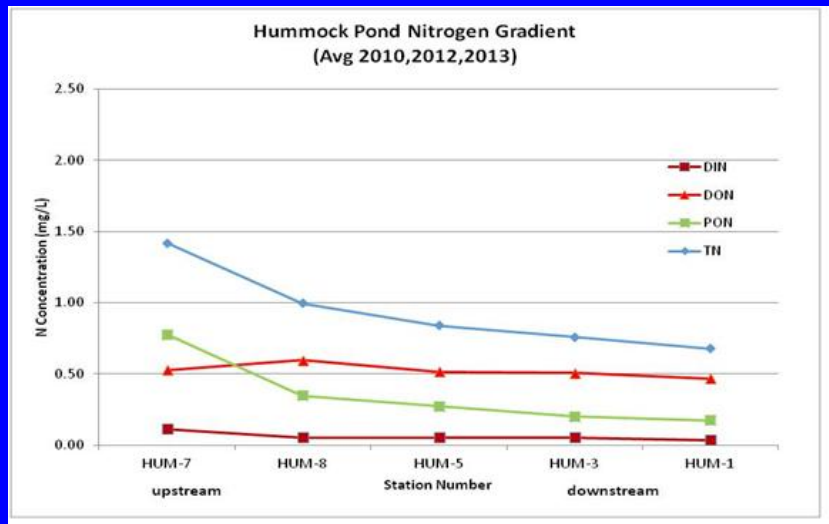
Threshold = 0.50 mg/L

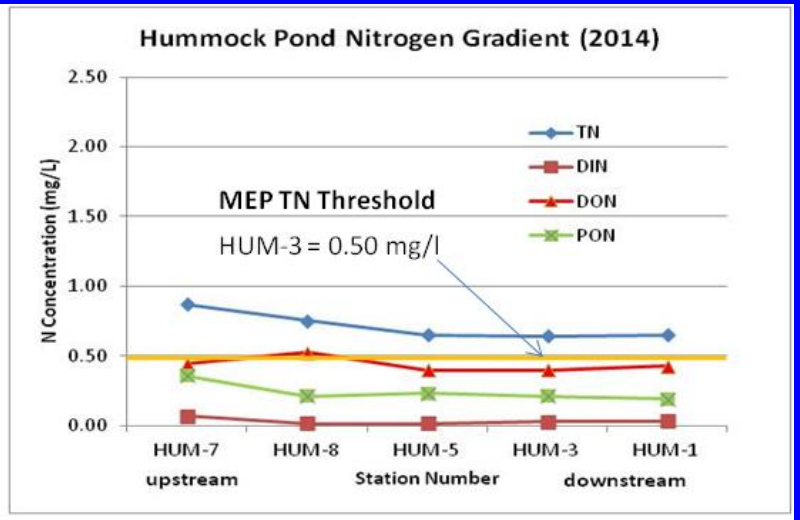
Hummock Pond and Miacomet Pond Station ID's	2015	2014	2013	2012	2010	2005/2007	
	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	
	Mean	Mean	Mean	Mean	Mean	Mean	S.D.
HUM1	0.539	0.651	0.769	0.666	0.616	0.751**	0.374
HUM3	0.622	0.643	0.827	0.863	0.589	0.630**	0.388
HUM5	0.558	0.653	0.881	0.871	0.766	ND	ND
HUM7	0.621	0.873	1.170	1.301	1.786	1.283**	0.969
HUM8	0.576	0.755	1.064	0.944	0.983	ND	ND
							*2005 data only **2007 data only

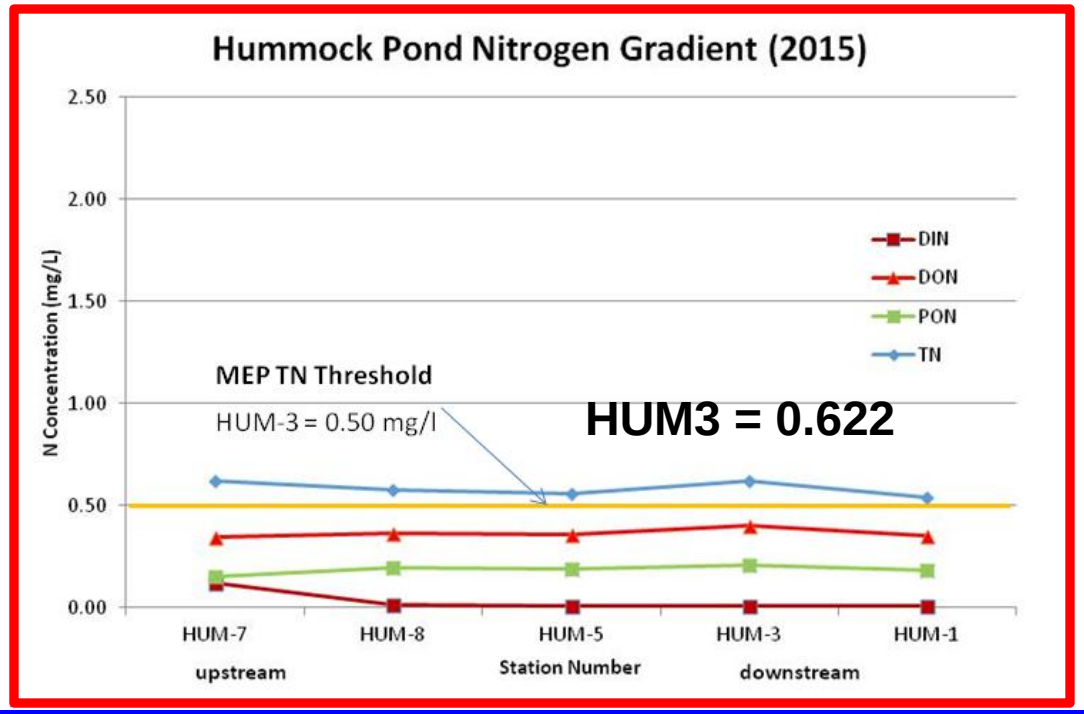


N Concentrations Hummock Pond (2010-15)

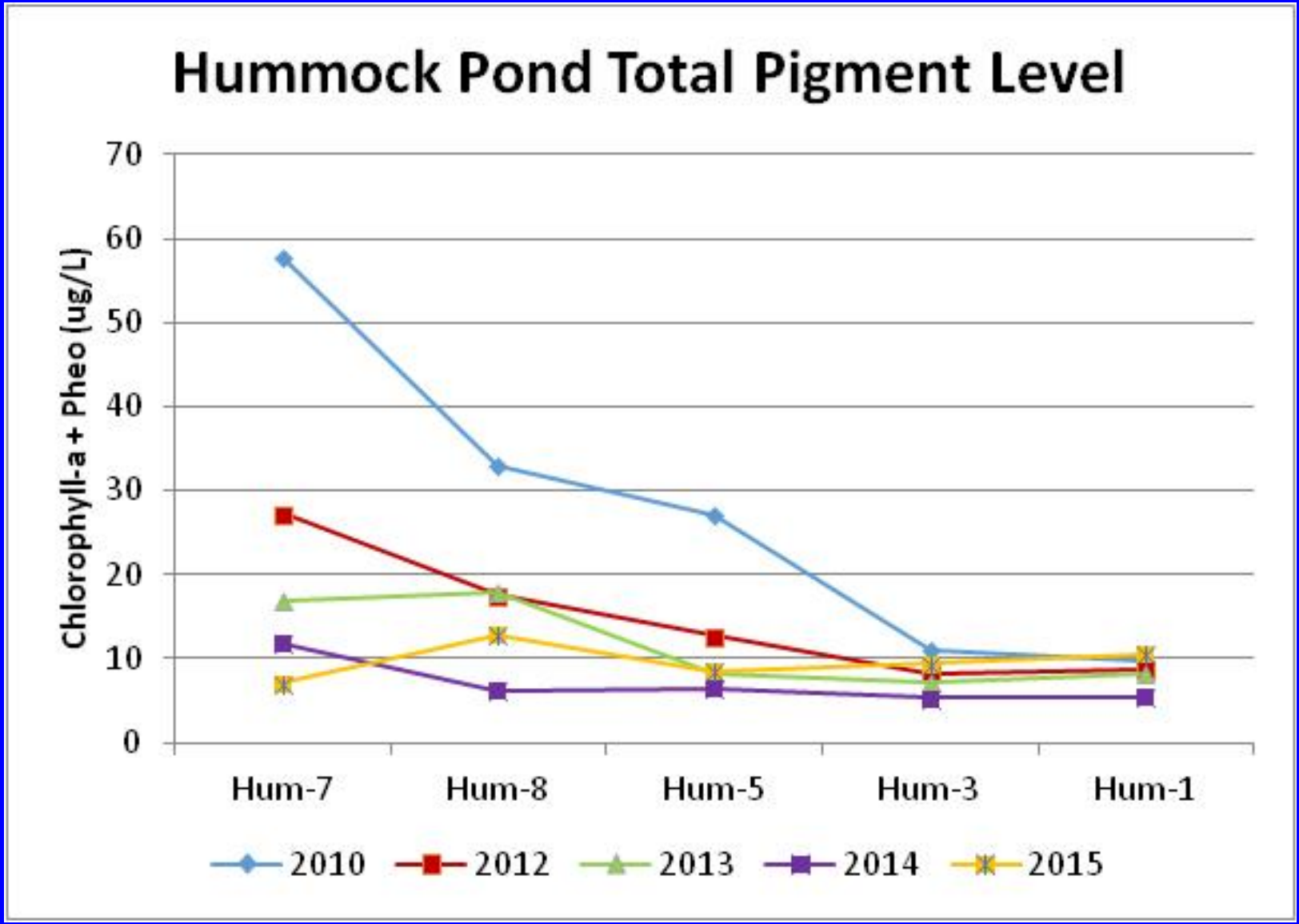
Clear nutrient gradient across the Pond

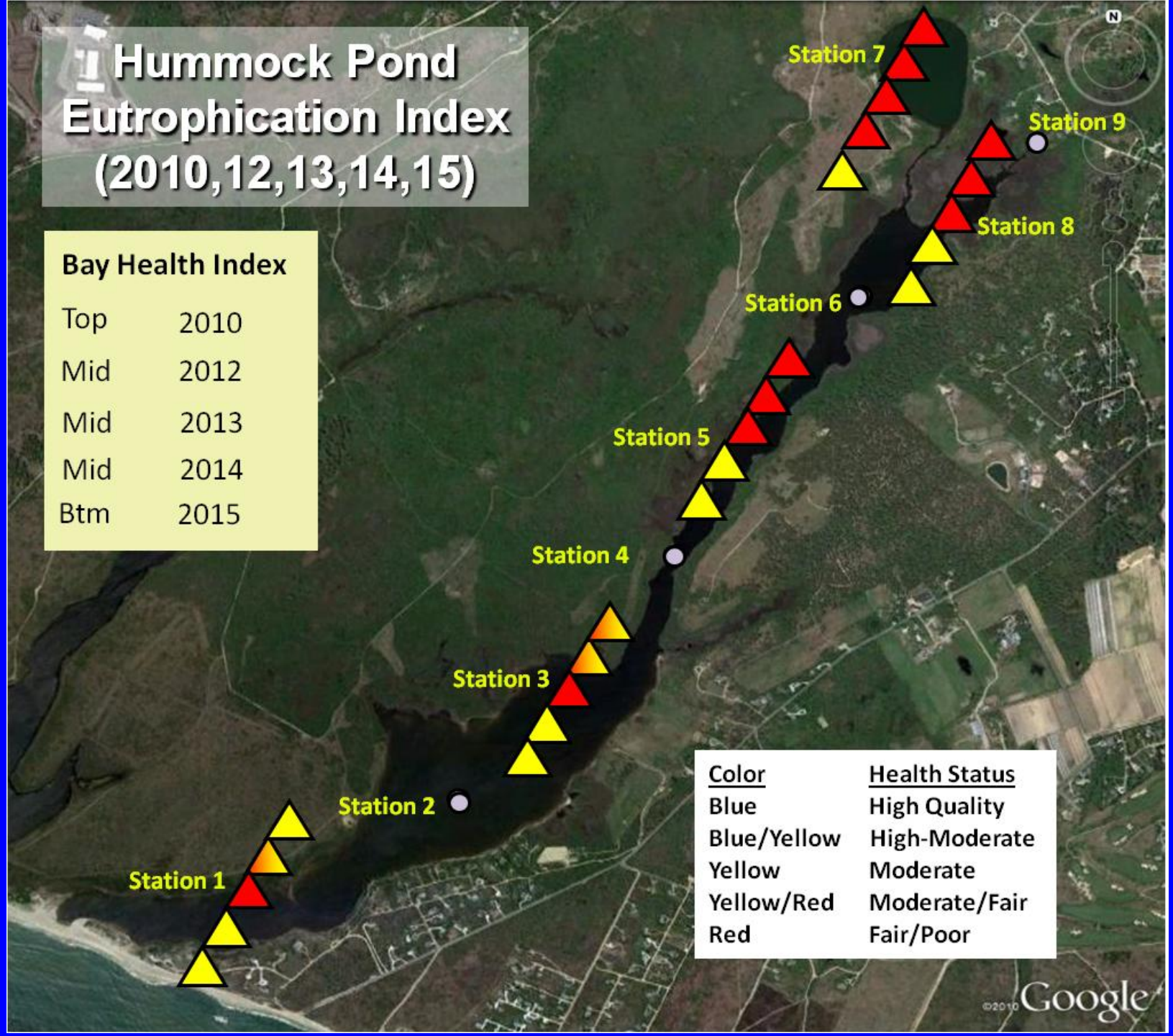






Total Pigment (chla+pheophytin) Hummock Pond (2010,12,13,14,15)




Hummock Pond
Eutrophication Index
(2010,12,13,14,15)
Bay Health Index
Top 2010
Mid 2012
Mid 2013
Mid 2014
Btm 2015
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7
Station 8
Station 9
Color | Health Status
Blue | High Quality
Blue/Yellow | High-Moderate
Yellow | Moderate
Yellow/Red | Moderate/Fair
Red | Fair/Poor
©2010 Google

Key Points for Consideration

1. Nantucket Harbor: TN Concentrations in Head of Harbor is approaching, but Polpis Harbor currently *exceeds* TMDL Threshold (management required)
2. Madaket Harbor: TN Concentrations in Hither Creek is approaching, but Long Pond *exceeds* TMDL Threshold (management required)
3. Sesachacha Pond: TN Concentration is significantly lower with new breaches (2010-2013), but *exceeds* TMDL Threshold
4. Hummock and Miacomet Ponds: Strong TN Gradient, High TN & Total Pigment, *indicates impairment* – MEP Analysis completed on Hummock, TN Threshold *exceeded*.
5. New experimental breaching protocol applied (2014 and 2015) is significantly lowering TN levels.

Recommendations

1. Continue Water Quality Monitoring for TMDL Compliance and to allow for interannual variation,
2. Formalize efforts to link pond opening success to water quality (Sesachacha and Hummock Ponds),
3. Dissolved Oxygen should be assessed using high frequency automated sensors when monitoring suggests a problem in a specific basin, e.g. Polpis Harbor, Madaket Harbor (station 2) and lower Miacomet Pond.
4. Continue monitoring stream loads to Polpis Harbor and consider BMPs up-gradient stream site (ST- 4)

Recommendations

5. Conduct detailed analysis of Long Pond for nitrogen entering from the land fill, the monitoring results from 2012 and 2013 appear to show a significant reduction in TN over historical conditions and 2010 but 2014 higher than 2012 and 2013. <u>2015 much better than 2014.</u>

6. Miacomet Pond highly impaired and declining. "Special Study" to create nitrogen and phosphorus budgets and nutrient limitation analysis to develop a long-term Management Plan for this system is warranted.

Town of Nantucket
Water Quality Monitoring

2015

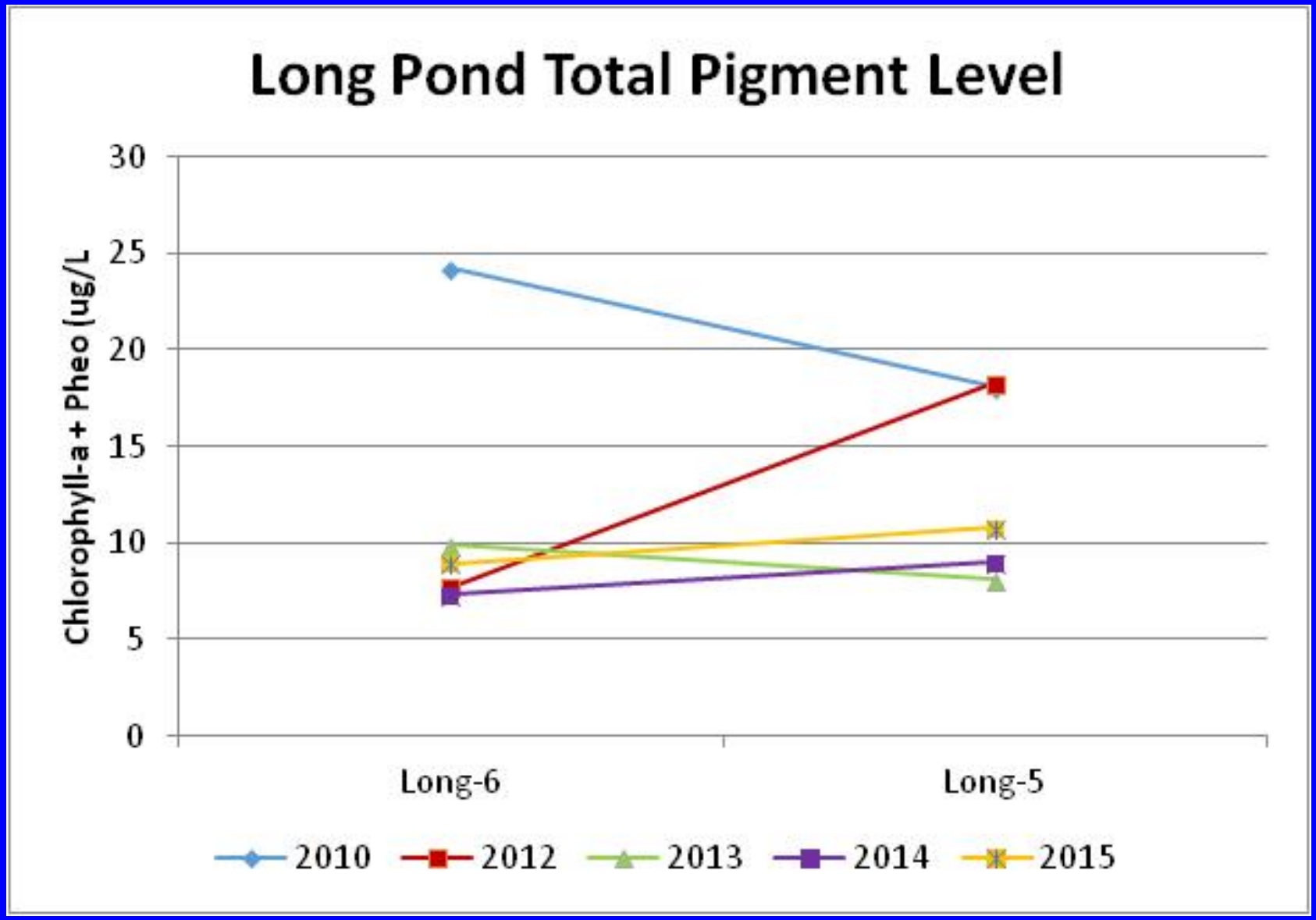
Questions & Discussion

THANK YOU

Coastal Systems Program
SMAST

Coastal Systems Program
SMAST

Total Pigment (chla+pheophytin) Long Pond (2010,12,13,14,15)

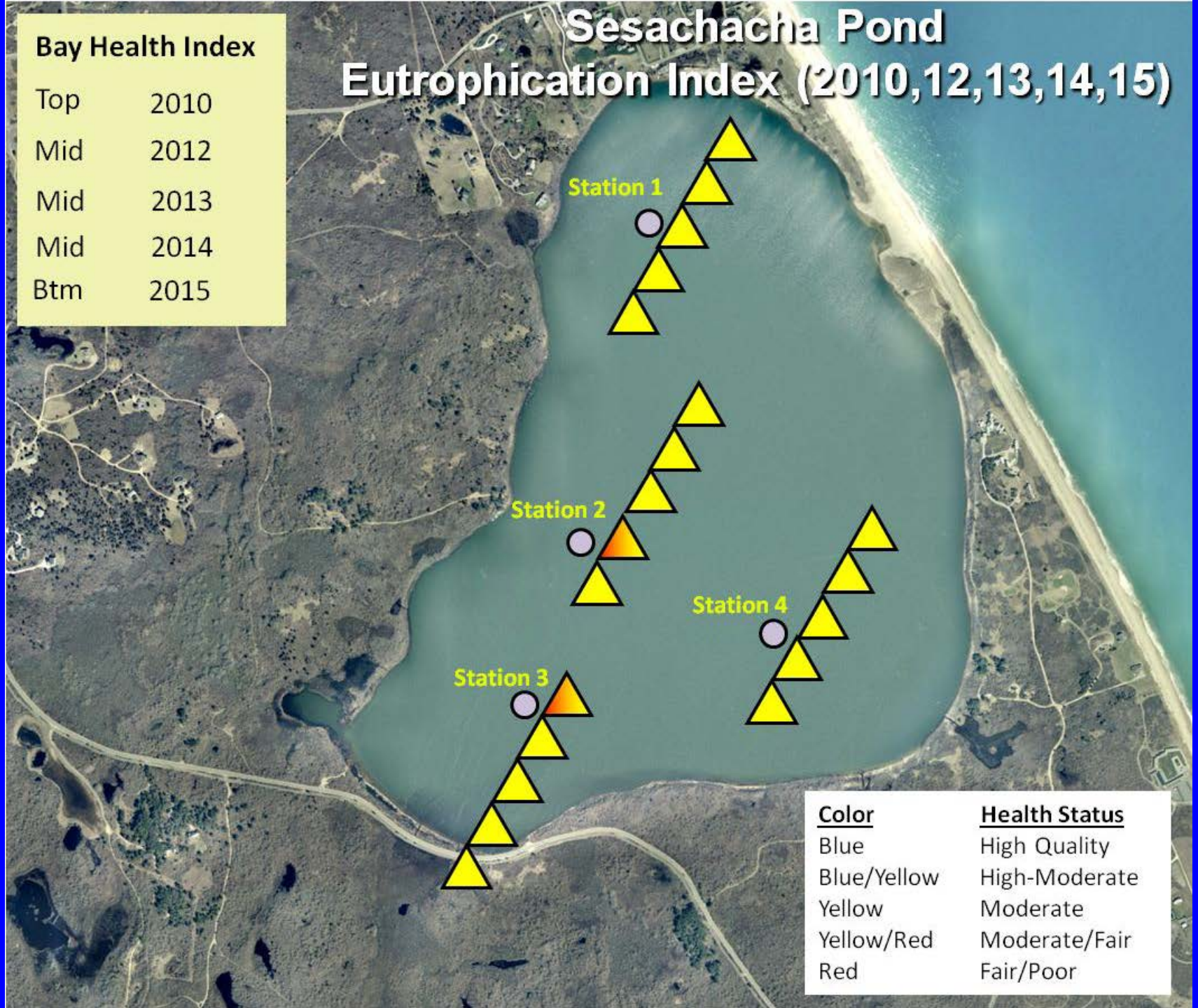


Embayment Nutrient Related Health:

Degradation of Estuaries and Bays by nutrient enrichment is primarily through Nitrogen from surrounding watersheds.

<u>Over-Fertilization results in declining health:</u>

- *Phytoplankton Blooms and turbid waters*
- *Loss of **eelgrass beds***
- *Declining **benthic animal populations**, fish & shellfish*
- *Low Oxygen in bay waters, fish kills, possibly odors*
- *Macro-algal accumulations*
- *At highest levels → loss of aesthetics*


Sesachacha Pond
Eutrophication Index (2010,12,13,14,15)
Bay Health Index
Top 2010
Mid 2012
Mid 2013
Mid 2014
Btm 2015
Station 1
Station 2
Station 3
Station 4
Color
Health Status
Blue
High Quality
Blue/Yellow
High-Moderate
Yellow
Moderate
Yellow/Red
Moderate/Fair
Red
Fair/Poor

EMBAYMENT	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	No DO EUTRO Index	Health Status
HUM1	37.7	100.0	15.7	0.0	38.3	Moderate
HUM3	37.2	100.0	0.0	5.1	35.6	Moderate-Fair
HUM5	34.3	100.0	11.3	12.8	39.6	Moderate
HUM7	62.7	7.1	23.3	28.7	30.4	Moderate-Fair
HUM8	35.7	94.8	8.9	0.0	34.9	Moderate-Fair
LONG5	22.0	93.1	0.0	9.2	31.1	Moderate-Fair
LONG6	16.7	100.0	0.0	0.0	29.2	Fair-Poor
MH1	63.3	74.5	24.2	60.6	55.6	Moderate
MH2	81.4	52.4	61.2	98.1	73.3	High
MH3	80.0	100.0	83.3	99.9	90.8	High
MH4	99.0	100.0	82.2	100.0	95.3	High
MP1	19.0	56.6	0.0	0.0	18.9	Fair-Poor
MP2	17.9	42.1	0.0	0.0	15.0	Fair-Poor
MP3	24.5	25.8	0.0	0.0	12.6	Fair-Poor
NAN1	97.1	100.0	83.5	79.5	90.0	High
NAN2	92.0	86.6	68.7	69.6	79.2	High
NAN3	60.1	77.1	49.3	14.7	50.3	Moderate
NAN4	100.0	100.0	97.4	85.2	95.6	High
NAN5	67.6	85.7	52.2	79.2	71.2	High
NAN6	74.8	97.5	56.9	68.4	74.4	High
NAN7	68.7	96.4	61.7	83.1	77.5	High
NAN8N	79.7	100.0	89.3	97.8	91.7	High
ORS1	100.0	91.5	22.6	6.3	55.1	Moderate
ORS2	48.0	85.2	83.1	86.2	75.6	High
ORS3	0.0	34.6	40.4	91.0	41.5	Moderate
ORS4	0.0	57.4	60.6	83.8	50.4	Moderate
ORS5	21.6	99.9	35.8	100.0	64.3	High-Moderate
ORS6	0.0	64.6	19.0	72.5	39.0	Moderate
SESA1	25.5	100.0	0.0	0.0	31.4	Moderate-Fair
SESA2	9.6	100.0	0.0	0.0	27.4	Fair-Poor
SESA3	9.6	100.0	0.0	0.0	27.4	Fair-Poor
SESA4	7.8	100.0	0.0	0.0	26.9	Fair-Poor

High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39; Fair-Poor = <31

Eutrophication Index WITHOUT DO Factored in

2015

Eutrophication Index With DO Factored in 2015

EMBAYMENT	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	2015 EUTRO Index	Health Status
HUM1	37.7	81.3	100.0	15.7	0.0	46.9	moderate
HUM3	37.2	73.6	100.0	0.0	5.1	43.2	moderate
HUM5	34.3	79.2	100.0	11.3	12.8	47.5	moderate
HUM7	62.7	81.4	7.1	23.3	28.7	40.6	moderate
HUM8	35.7	67.8	94.8	8.9	0.0	41.5	moderate
LONG5	22.0	82.4	93.1	0.0	9.2	41.4	moderate
LONG6	16.7	70.4	100.0	0.0	0.0	37.4	moderate/fair
MH1	63.3	51.7	74.5	24.2	60.6	54.9	moderate
MH2	81.4	72.2	52.4	61.2	98.1	73.1	High
MH3	80.0	89.5	100.0	83.3	99.9	90.5	High
MH4	99.0	98.5	100.0	82.2	100.0	95.9	Highe
MP1	19.0	75.1	56.6	0.0	0.0	30.1	Fair-Poor
MP2	17.9	79.8	42.1	0.0	0.0	28.0	Fair-Poor
MP3	24.5	95.0	25.8	0.0	0.0	29.1	Fair-Poor
NAN1	97.1	96.4	100.0	83.5	79.5	91.3	High
NAN2	92.0	89.1	86.6	68.7	69.6	81.2	High
NAN3	60.1	93.7	77.1	49.3	14.7	61.6	Moderate
NAN4	100.0	94.3	100.0	97.4	85.2	95.4	High
NAN5	67.6	79.2	85.7	52.2	79.2	72.8	High
NAN6	74.8	84.8	97.5	56.9	68.4	76.5	High
NAN7	68.7	91.8	96.4	61.7	83.1	80.4	High
NAN8N	79.7	83.5	100.0	89.3	97.8	90.1	High
ORS1	100.0	26.4	91.5	22.6	6.3	49.3	Moderate
ORS2	48.0	49.5	85.2	83.1	86.2	70.4	High
ORS3	0.0	33.8	34.6	40.4	91.0	40.0	Moderate
ORS4	0.0	35.0	57.4	60.6	83.8	47.4	Moderate
ORS5	21.6	56.5	99.9	35.8	100.0	62.8	High-Moderate
ORS6	0.0	53.3	64.6	19.0	72.5	41.9	Moderate
SESA1	25.5	88.1	100.0	0.0	0.0	42.7	Moderate
SESA2	9.6	88.5	100.0	0.0	0.0	39.6	Moderate
SESA3	9.6	98.4	100.0	0.0	0.0	41.6	Moderate
SESA4	7.8	93.5	100.0	0.0	0.0	40.3	Moderate

High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39; Fair-Poor = <31

EMBAYMENT	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	No DO EUTRO Index	Health Status
HUM1	51.3	62.7	0.0	50.0	41.0	Moderate
HUM3	34.8	68.2	0.0	53.3	39.1	Moderate
HUM5	36.5	91.7	0.0	35.3	40.9	Moderate
HUM7	28.1	29.3	0.0	0.0	14.3	Fair-Poor
HUM8	17.1	91.7	0.0	39.2	37.0	Moderate-Fair
LONG5	13.4	18.4	0.0	8.9	10.2	Fair-Poor
LONG6	11.8	43.7	0.0	25.7	20.3	Fair-Poor
MH1	66.1	39.4	56.9	88.8	62.8	High-Moderate
MH2	88.7	72.7	82.0	100.0	85.8	High
MH3	82.5	76.7	69.8	100.0	82.2	High
MH4	92.6	83.8	100.0	100.0	94.1	High
MP1	51.8	42.2	0.0	0.6	23.6	Fair-Poor
MP2	70.6	58.6	0.0	52.3	45.4	Moderate
MP3	23.1	26.1	0.0	0.0	12.3	Fair-Poor
NAN1	100.0	86.9	100.0	100.0	96.7	High
NAN2	100.0	76.2	95.3	100.0	92.9	High
NAN3	100.0	83.7	80.6	96.6	90.2	High
NAN4	100.0	89.5	100.0	100.0	97.4	High
NAN5	78.8	87.6	63.3	94.0	80.9	High
NAN6	85.6	97.5	65.9	100.0	87.3	High
NAN7	67.9	79.1	100.0	100.0	86.8	High
NAN8N	77.6	91.2	100.0	100.0	92.2	High
SESA1	41.5	54.0	0.0	28.3	30.9	Moderate-Fair
SESA2	44.6	46.0	0.0	28.3	29.7	Fair-Poor
SESA3	42.5	56.0	0.0	44.5	35.8	Moderate-Fair
SESA4	44.3	55.1	0.0	51.1	37.6	Moderate-Fair

High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39;
Fair-Poor = <31

Eutrophication Index WITHOUT DO Factored in

2014

Eutrophication Index With DO Factored in 2014

EMBAYMENT	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	2014 EUTRO Index	Health Status
HUM1	51.3	74.7	62.7	0.0	50.0	47.7	Moderate
HUM3	34.8	78.3	68.2	0.0	53.3	46.9	Moderate
HUM5	36.5	73.8	91.7	0.0	35.3	47.5	Moderate
HUM7	28.1	81.0	29.3	0.0	0.0	27.7	Fair-Poor
HUM8	17.1	66.6	91.7	0.0	39.2	42.9	Moderate
LONG5	13.4	34.4	18.4	0.0	8.9	15.0	Fair-Poor
LONG6	11.8	67.6	43.7	0.0	25.7	29.7	Fair-Poor
MH1	66.1	67.6	39.4	56.9	88.8	63.7	High-Moderate
MH2	88.7	65.1	72.7	82.0	100.0	81.7	High
MH3	82.5	65.1	76.7	69.8	100.0	78.8	High
MH4	92.6	77.8	83.8	100.0	100.0	90.8	High
MP1	51.8	55.8	42.2	0.0	0.6	30.1	Moderate-Fair
MP2	70.6	70.1	58.6	0.0	52.3	50.3	Moderate
MP3	23.1	46.0	26.1	0.0	0.0	19.0	Fair-Poor
NAN1	100.0	81.3	86.9	100.0	100.0	93.7	High
NAN2	100.0	73.4	76.2	95.3	100.0	89.0	High
NAN3	100.0	77.5	83.7	80.6	96.6	87.7	High
NAN4	100.0	87.6	89.5	100.0	100.0	95.4	High
NAN5	78.8	68.0	87.6	63.3	94.0	78.4	High
NAN6	85.6	69.4	97.5	65.9	100.0	83.7	High
NAN7	67.9	74.0	79.1	100.0	100.0	84.2	High
NAN8N	77.6	75.7	91.2	100.0	100.0	88.9	High
SESA1	41.5	75.9	54.0	0.0	28.3	39.9	Moderate
SESA2	44.6	69.8	46.0	0.0	28.3	37.7	Moderate-Fair
SESA3	42.5	76.8	56.0	0.0	44.5	44.0	Moderate
SESA4	44.3	73.3	55.1	0.0	51.1	44.8	Moderate

High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39;
Fair-Poor = <31

Sta ID	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	No DO EUTRO Index	Health Status
HUM-1	29.6	47.1	0.0	16.9	23.4	Fair-Poor
HUM-3	30.2	18.9	0.0	26.8	19.0	Fair-Poor
HUM-5	0.0	20.1	0.0	15.8	9.0	Fair-Poor
HUM-7	0.8	19.8	0.0	0.0	5.2	Fair-Poor
HUM-8	0.0	36.3	0.0	20.1	14.1	Fair-Poor
LONG-5	11.2	81.0	0.0	17.3	27.4	Fair-Poor
LONG-6	9.3	74.8	0.0	1.1	21.3	Fair-Poor
MH1	64.5	33.4	22.0	71.2	47.8	Moderate
MH2	69.3	75.1	91.8	100.0	84.0	High
MH3	73.6	86.5	93.0	100.0	88.3	High
MH4	99.0	79.3	100.0	100.0	94.6	High
MP1	31.0	83.7	0.0	0.0	28.7	Fair-Poor
MP2	41.9	44.1	0.0	0.0	21.5	Fair-Poor
MP3	27.3	0.0	0.0	0.0	6.8	Fair-Poor
NAN1	100.0	88.4	100.0	100.0	97.1	High
NAN2	97.3	75.7	82.0	83.1	84.5	High
NAN3	89.9	84.1	54.8	36.9	66.4	High-Moderate
NAN4	100.0	81.4	93.1	100.0	93.6	High
NAN5	70.7	91.3	64.3	48.0	68.6	High-Moderate
NAN6	76.1	72.4	61.9	44.2	63.6	High-Moderate
NAN7	70.0	90.9	88.6	64.4	78.4	High
NAN8	78.6	64.2	100.0	100.0	85.7	High
SES 1	78.9	40.3	0.0	62.4	45.4	Moderate
SES 2	86.4	61.6	2.8	73.5	56.1	Moderate
SES 3	88.0	52.5	0.0	80.7	55.3	Moderate
SES 4	92.1	47.9	0.0	79.9	55.0	Moderate

Eutrophication Index WITHOUT DO Factored in

2013

Eutrophication Index With DO Factored in 2013

Sta ID	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	2013 EUTRO Index	Health Status
HUM-1	29.6	56.8	47.1	0.0	16.9	30.1	Fair-Poor
HUM-3	30.2	42.1	18.9	0.0	26.8	23.6	Fair-Poor
HUM-5	0.0	15.8	20.1	0.0	15.8	10.3	Fair-Poor
HUM-7	0.8	12.2	19.8	0.0	0.0	6.6	Fair-Poor
HUM-8	0.0	0.0	36.3	0.0	20.1	11.3	Fair-Poor
LONG-5	11.2	77.9	81.0	0.0	17.3	37.5	Moderate-Fair
LONG-6	9.3	25.0	74.8	0.0	1.1	22.0	Fair-Poor
MH1	64.5	52.5	33.4	22.0	71.2	48.7	Moderate
MH2	69.3	75.4	75.1	91.8	100.0	82.3	High
MH3	73.6	75.4	86.5	93.0	100.0	85.7	High
MH4	99.0	88.1	79.3	100.0	100.0	93.3	High
MP1	31.0	62.2	83.7	0.0	0.0	35.4	Moderate-Fair
MP2	41.9	30.5	44.1	0.0	0.0	23.3	Fair-Poor
MP3	27.3	56.2	0.0	0.0	0.0	16.7	Fair-Poor
NAN1	100.0	75.7	88.4	100.0	100.0	92.8	High
NAN2	97.3	68.2	75.7	82.0	83.1	81.3	High
NAN3	89.9	28.4	84.1	54.8	36.9	58.8	Moderate
NAN4	100.0	88.6	81.4	93.1	100.0	92.6	High
NAN5	70.7	42.6	91.3	64.3	48.0	63.4	High-Moderate
NAN6	76.1	20.5	72.4	61.9	44.2	55.0	Moderate
NAN7	70.0	73.8	90.9	88.6	64.4	77.5	High
NAN8	78.6	72.3	64.2	100.0	100.0	83.0	High
SES 1	78.9	83.6	40.3	0.0	62.4	53.0	Moderate
SES 2	86.4	70.2	61.6	2.8	73.5	58.9	Moderate
SES 3	88.0	77.5	52.5	0.0	80.7	59.7	Moderate
SES 4	92.1	79.3	47.9	0.0	79.9	59.8	Moderate

Water Quality Station Averages 2015

2015 Sample ID	Seccchi Depth (meters)	Secchi Depth as % of WC	20% Low Field DO (mg/L)	20% Low DO Sat (%)	Salinity ppt	PO4 (mg/L)	TP (mg/L)	NH4 (mg/L)	Nox (mg/L)	DIN (mg/L)	DON (mg/L)	TDN (mg/L)	POC (mg/L)	PON (mg/L)	TON (mg/L)	TN (mg/L)	Total Pig (ug/L)
HUM1	1.50	48%	7.13	83%	7.43	0.009	--	0.004	0.003	0.007	0.350	0.357	1.097	0.182	0.532	0.539	10.50
HUM3	1.50	61%	6.82	75%	7.11	0.012	--	0.005	0.006	0.011	0.402	0.413	1.236	0.209	0.610	0.622	9.41
HUM5	1.00	57%	6.87	79%	5.45	0.019	--	0.005	0.003	0.008	0.359	0.366	1.206	0.192	0.550	0.558	8.58
HUM7	1.30	49%	5.65	87%	3.33	0.101	--	0.089	0.030	0.119	0.349	0.468	0.996	0.154	0.502	0.621	7.07
HUM8	0.70	90%	7.13	95%	3.90	0.059	--	0.005	0.011	0.016	0.366	0.381	1.230	0.195	0.560	0.576	12.82
LONG5	0.70	86%	6.60	85%	16.02	0.020	--	0.012	0.004	0.016	0.378	0.395	2.025	0.302	0.681	0.697	8.95
LONG6	0.60	76%	5.78	73%	16.01	0.025	--	0.006	0.002	0.008	0.369	0.377	1.619	0.280	0.649	0.656	10.78
MH1	1.80	77%	4.88	68%	29.28	0.021	--	0.019	0.006	0.025	0.379	0.404	0.652	0.120	0.499	0.524	4.82
MH2	1.78	100%	5.56	78%	31.76	0.010	--	0.012	0.030	0.042	0.289	0.331	0.482	0.088	0.376	0.418	3.07
MH3	2.40	97%	6.57	90%	32.00	0.010	--	0.005	0.001	0.006	0.236	0.242	0.461	0.082	0.318	0.324	3.00
MH4	2.90	63%	6.70	91%	32.13	0.015	--	0.006	0.002	0.008	0.269	0.277	0.301	0.051	0.321	0.328	2.54
MP1	0.90	50%	6.94	83%	0.10	0.008	0.084	0.025	0.013	0.038	0.592	0.630	3.870	0.666	1.259	1.297	46.52
MP2	0.70	32%	6.10	82%	0.11	0.009	0.090	0.042	0.011	0.053	0.593	0.646	3.726	0.671	1.264	1.318	53.40
MP3	1.40	54%	7.91	91%	0.10	0.017	0.136	0.021	0.057	0.077	0.396	0.473	2.878	0.518	0.914	0.992	37.91
NAN1	ND	62%	6.29	88%	32.13	0.024	--	0.010	0.002	0.012	0.246	0.258	0.437	0.072	0.318	0.330	3.84
NAN2	2.65	49%	5.95	85%	32.25	0.019	--	0.018	0.001	0.019	0.272	0.291	0.474	0.084	0.355	0.374	4.33
NAN3	1.45	27%	5.89	86%	32.37	0.026	--	0.022	0.002	0.024	0.278	0.302	0.716	0.134	0.412	0.436	7.16
NAN4	3.80	65%	6.58	91%	32.14	0.019	--	0.010	0.001	0.011	0.219	0.230	0.357	0.066	0.286	0.297	3.58
NAN5	1.65	85%	5.32	76%	31.92	0.021	--	0.018	0.001	0.019	0.296	0.316	0.578	0.107	0.403	0.422	3.86
NAN6	1.95	73%	5.64	81%	31.94	0.019	--	0.014	0.001	0.015	0.282	0.297	0.555	0.107	0.389	0.404	4.39
NAN7	1.45	76%	6.20	86%	32.00	0.019	--	0.013	0.002	0.015	0.270	0.285	0.628	0.105	0.375	0.390	3.68
NAN8N	1.00	96%	5.65	81%	31.97	0.016	--	0.007	0.002	0.009	0.227	0.236	0.435	0.077	0.304	0.313	3.08
SESA1	0.60	20%	7.06	88%	11.26	0.202	--	0.006	0.003	0.008	0.479	0.487	3.193	0.431	0.910	0.918	11.45
SESA2	0.60	14%	6.55	82%	11.27	0.202	--	0.003	0.002	0.005	0.448	0.454	3.100	0.417	0.865	0.870	10.39
SESA3	0.60	20%	6.73	89%	11.27	0.211	--	0.003	0.002	0.006	0.476	0.481	3.146	0.429	0.904	0.910	11.33
SESA4	0.60	20%	6.62	87%	11.27	0.210	--	0.003	0.003	0.007	0.507	0.514	3.028	0.405	0.912	0.919	11.10

Water Quality Station Averages 2014

Sample ID	Seccchi Depth (meters)	Secchi Depth as % of WC	20% Low DO (mg/L)	20% Low Sat (%)	Salinity ppt	PO4 (mg/L)	NH4 (mg/L)	Nox (mg/L)	DIN (mg/L)	DON (mg/L)	TDN (mg/L)	POC (mg/L)	PON (mg/L)	TON (mg/L)	TN (mg/L)	Total Pig (ug/L)
HUM1	1.37	56%	8.41	73%	6.12	0.012	0.029	0.004	0.033	0.428	0.461	1.230	0.191	0.618	0.651	5.480
HUM3	1.05	61%	8.35	75%	5.72	0.012	0.023	0.006	0.029	0.402	0.431	1.329	0.212	0.614	0.643	5.262
HUM5	1.08	58%	8.38	73%	4.75	0.014	0.014	0.003	0.017	0.401	0.418	9.925	0.235	0.636	0.653	6.534
HUM7	0.94	41%	8.44	77%	2.65	0.047	0.054	0.020	0.071	0.444	0.515	2.400	0.358	0.801	0.873	11.875
HUM8	0.79	35%	8.36	69%	3.62	0.030	0.014	0.003	0.017	0.526	0.543	1.417	0.212	0.738	0.755	6.240
LONG5	0.75	75%	7.62	53%	14.12	0.032	0.080	0.012	0.092	0.975	1.066	2.354	0.415	1.390	1.481	8.988
LONG6	0.73	75%	7.69	69%	15.06	0.014	0.040	0.011	0.051	0.420	0.472	1.841	0.316	0.737	0.788	7.342
MH1	1.74	86%	7.14	69%	28.03	0.019	0.046	0.010	0.057	0.270	0.326	0.616	0.119	0.389	0.445	3.431
MH2	2.50	100%	7.14	68%	31.01	0.010	0.024	0.002	0.026	0.243	0.269	0.433	0.079	0.321	0.347	1.674
MH3	2.26	91%	7.24	68%	31.40	0.011	0.023	0.001	0.024	0.217	0.241	0.891	0.135	0.352	0.376	2.701
MH4	2.66	57%	7.38	75%	31.53	0.012	0.016	0.007	0.020	0.174	0.194	0.340	0.059	0.233	0.254	1.489
MP1	1.38	85%	8.41	63%	0.13	0.018	0.050	0.003	0.053	0.522	0.575	1.967	0.289	0.811	0.864	9.932
MP2	1.87	63%	8.51	71%	0.12	0.009	0.035	0.002	0.036	0.568	0.604	1.170	0.180	0.748	0.784	5.326
MP3	0.87	65%	8.46	58%	0.10	0.049	0.038	0.038	0.077	0.594	0.671	4.437	0.626	1.220	1.297	18.068
NAN1	3.35	64%	7.23	77%	31.36	0.015	0.017	0.002	0.019	0.201	0.220	0.380	0.063	0.265	0.284	1.311
NAN2	3.06	52%	7.17	73%	31.42	0.017	0.021	0.003	0.024	0.210	0.234	0.493	0.080	0.290	0.314	1.977
NAN3	3.10	51%	6.98	75%	31.42	0.016	0.020	0.001	0.020	0.225	0.245	0.631	0.100	0.325	0.345	3.125
NAN4	3.00	56%	7.27	81%	31.49	0.017	0.017	0.001	0.018	0.180	0.198	0.439	0.079	0.259	0.277	1.659
NAN5	2.13	90%	7.10	69%	30.99	0.016	0.016	0.003	0.019	0.248	0.267	0.756	0.122	0.370	0.389	3.223
NAN6	2.38	85%	7.09	70%	31.08	0.016	0.013	0.002	0.015	0.258	0.272	0.626	0.105	0.363	0.378	2.963
NAN7	1.79	80%	7.26	73%	31.23	0.020	0.022	0.001	0.023	0.168	0.190	0.656	0.104	0.271	0.294	2.691
NAN8N	2.09	99%	7.16	74%	31.29	0.016	0.015	0.002	0.017	0.188	0.205	0.356	0.062	0.250	0.267	1.267
SESA1	1.17	24%	7.87	74%	12.26	0.105	0.033	0.007	0.040	0.590	0.630	1.794	0.288	0.878	0.919	7.112
SESA2	1.23	24%	7.86	70%	12.23	0.111	0.038	0.010	0.049	0.531	0.579	2.154	0.352	0.883	0.931	7.116
SESA3	1.19	32%	7.86	75%	12.23	0.106	0.030	0.009	0.039	0.603	0.642	1.871	0.296	0.899	0.938	5.852
SESA4	1.22	32%	7.83	72%	12.25	0.108	0.030	0.009	0.039	0.572	0.611	1.808	0.290	0.862	0.902	5.407

Water Quality Station Averages 2013

2013 Station I.D.	Depth m	Secchi Depth m	Secchi Depth %WC	20% Low DO mg/L	20% Low DO %Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	N0x mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	T-Pig ug/L
HUM-1	2.6	1.0	0.4	5.86	63%	0.9	0.029	0.030	0.018	0.047	0.554	0.169	0.722	0.769	8.2
HUM-3	2.4	1.0	0.4	5.20	56%	0.8	0.034	0.075	0.016	0.091	0.571	0.165	0.736	0.827	7.2
HUM-5	2.2	0.6	0.3	4.20	45%	0.5	0.073	0.063	0.026	0.088	0.575	0.217	0.793	0.881	8.3
HUM-7	3.5	0.6	0.2	4.08	44%	0.5	0.061	0.077	0.012	0.089	0.408	0.674	1.081	1.170	16.9
HUM-8	2.2	0.6	0.3	3.32	36%	0.4	0.079	0.042	0.018	0.061	0.672	0.331	1.004	1.064	7.9
LONG-5	1.1	0.7	0.7	5.87	75%	11.9	0.009	0.015	0.008	0.022	0.358	0.328	0.686	0.709	8.1
LONG-6	1.0	0.7	0.7	3.82	49%	12.7	0.005	0.017	0.008	0.025	0.561	0.294	0.855	0.880	9.9
MH1	2.2	1.7	0.8	4.36	61%	25.7	0.019	0.047	0.019	0.065	0.374	0.134	0.508	0.573	4.2
MH2	1.9	1.8	1.0	5.25	74%	30.6	0.012	0.021	0.004	0.025	0.215	0.083	0.298	0.323	1.8
MH3	2.0	2.0	1.0	5.25	74%	31.0	0.011	0.014	0.005	0.019	0.209	0.087	0.295	0.314	2.2
MH4	4.5	3.0	0.7	5.82	82%	31.3	0.013	0.015	0.007	0.023	0.194	0.062	0.256	0.278	1.7
MP1	1.9	1.0	0.6	5.46	66%	0.2	0.009	0.015	0.006	0.020	0.481	0.290	0.771	0.792	19.5
MP2	3.1	1.2	0.4	4.22	51%	0.3	0.014	0.029	0.022	0.051	0.429	0.555	0.985	1.036	20.2
MP3	1.6	0.9	0.6	5.20	63%	0.1	0.049	0.036	0.104	0.143	0.378	0.540	0.917	1.058	26.2
NAN1	5.5	3.2	0.6	5.10	74%	31.2	0.014	0.015	0.003	0.018	0.182	0.062	0.244	0.262	2.6
NAN2	6.0	2.9	0.5	4.80	70%	31.1	0.014	0.019	0.006	0.024	0.231	0.090	0.321	0.345	3.7
NAN3	6.2	2.6	0.4	3.48	50%	30.9	0.019	0.016	0.004	0.020	0.241	0.154	0.395	0.415	6.4
NAN4	4.9	3.1	0.6	5.66	82%	31.3	0.016	0.017	0.004	0.021	0.226	0.070	0.295	0.317	2.9
NAN5	2.3	1.9	0.8	3.90	57%	30.1	0.018	0.012	0.005	0.017	0.208	0.159	0.368	0.385	5.6
NAN6	2.7	2.0	0.8	3.26	47%	30.5	0.016	0.023	0.004	0.026	0.221	0.153	0.374	0.401	5.9
NAN7	2.5	1.9	0.8	5.02	73%	31.1	0.013	0.013	0.004	0.017	0.183	0.122	0.305	0.323	4.6
NAN8	3.2	2.1	0.9	4.96	72%	31.1	0.013	0.028	0.004	0.032	0.189	0.084	0.272	0.304	2.9
SES 1	4.9	2.1	0.4	5.83	79%	17.1	0.044	0.045	0.011	0.055	0.533	0.125	0.658	0.714	4.7
SES 2	4.3	2.4	0.6	5.2	71%	17.0	0.043	0.025	0.008	0.034	0.477	0.110	0.587	0.621	4.1
SES 3	4.5	2.5	0.6	5.6	75%	17.0	0.046	0.031	0.011	0.042	0.512	0.109	0.621	0.663	3.8
SES 4	3.9	2.6	0.7	5.6	76%	17.0	0.040	0.034	0.013	0.046	0.518	0.111	0.630	0.677	3.8

Water Quality Station Averages 2012

Station I.D.	Secchi Depth m	Secchi Depth %WC	20% Low DO mg/L	20% Low DO %Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	N0x mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	T-Pig ug/L
HUM-1	1.0	44%	6.27	79%	7.6	0.020	0.044	0.006	0.050	0.439	0.178	0.616	0.666	8.7
HUM-3	1.2	58%	6.20	79%	7.0	0.029	0.039	0.003	0.042	0.573	0.249	0.822	0.863	8.3
HUM-5	0.8	44%	6.56	82%	6.3	0.030	0.043	0.004	0.047	0.540	0.283	0.824	0.871	12.7
HUM-7	0.7	21%	5.76	70%	4.8	0.011	0.085	0.031	0.117	0.546	0.638	1.184	1.301	27.2
HUM-8	0.6	53%	6.51	81%	6.0	0.030	0.054	0.005	0.058	0.534	0.352	0.885	0.944	17.5
LONG-5	0.6	58%	5.49	71%	16.8	0.067	0.063	0.007	0.069	0.441	0.503	0.944	1.013	18.3
LONG-6	0.5	51%	5.13	67%	18.6	0.027	0.049	0.008	0.057	0.437	0.373	0.810	0.867	7.7
MH1	1.7	70%	6.88	98%	26.8	0.026	0.115	0.015	0.131	0.332	0.192	0.525	0.655	9.6
MH2	2.3	100%	8.16	115%	30.9	0.015	0.078	0.010	0.088	0.272	0.084	0.356	0.444	1.8
MH3	2.4	100%	7.55	104%	31.6	0.018	0.063	0.011	0.074	0.217	0.065	0.282	0.356	1.8
MH4	3.7	90%	8.35	119%	31.6	0.019	0.032	0.009	0.041	0.189	0.068	0.257	0.297	2.0
MP1	1.5	97%	7.14	79%	0.3	0.007	0.057	0.004	0.061	0.546	0.221	0.767	0.828	10.8
MP2	1.5	67%	7.24	80%	0.4	0.005	0.070	0.012	0.082	0.509	0.290	0.799	0.880	20.3
MP3	1.0	81%	7.64	92%	0.1	0.045	0.109	0.011	0.120	0.381	0.450	0.830	0.950	18.3
NAN1	3.5	73%	5.22	74%	31.6	0.020	0.045	0.011	0.056	0.210	0.070	0.279	0.335	3.8
NAN2	2.9	62%	5.91	85%	31.6	0.022	0.057	0.009	0.066	0.213	0.091	0.304	0.364	3.7
NAN3	2.4	40%	5.86	87%	31.8	0.027	0.035	0.008	0.044	0.261	0.117	0.371	0.411	4.0
NAN4	2.9	63%	6.29	90%	31.6	0.017	0.031	0.007	0.038	0.212	0.094	0.306	0.344	3.6
NAN5	1.7	76%	5.96	83%	31.5	0.019	0.046	0.007	0.053	0.233	0.133	0.366	0.419	14.9
NAN6	2.1	76%	5.50	77%	31.5	0.019	0.042	0.006	0.048	0.289	0.147	0.436	0.484	6.3
NAN7	2.0	80%	6.10	86%	31.5	0.021	0.049	0.008	0.057	0.217	0.105	0.323	0.379	4.2
NAN8	1.9	100%	5.20	74%	31.5	0.017	0.050	0.006	0.057	0.225	0.090	0.315	0.371	3.6
SES 1	2.3	51%	5.49	77%	24.7	0.064	0.042	0.010	0.051	0.497	0.130	0.627	0.678	5.8
SES 2	2.5	52%	"	"	24.7	0.065	0.087	0.014	0.101	0.405	0.120	0.525	0.627	5.1
SES 3	2.8	87%	"	"	24.7	0.063	0.053	0.007	0.060	0.417	0.107	0.524	0.584	4.2
SES 4	2.7	77%	"	"	24.8	0.062	0.060	0.010	0.070	0.456	0.142	0.599	0.668	4.5

Water Quality Station Averages 2010

Station ID	Secchi Depth (m)	Secchi Depth as % WC	20% Low D.O. (mg/L)	20% Low % Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	NOX mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	Total Pig (ug/L)
HUM1	1.4	54.4%	4.81	56.0%	7.3	0.013	0.021	0.002	0.023	0.425	0.168	0.592	0.616	12.30
HUM3	1.3	61.5%	4.99	59.8%	6.4	0.012	0.022	0.003	0.025	0.380	0.184	0.564	0.589	11.04
HUM5	0.9	44.2%	4.65	56.1%	5.3	0.015	0.020	0.003	0.023	0.430	0.313	0.743	0.766	27.03
HUM7	0.9	23.4%	3.89	45.0%	4.0	0.284	0.070	0.069	0.139	0.628	1.020	1.647	1.786	67.66
HUM8	0.7	51.0%	4.80	56.5%	4.4	0.025	0.031	0.008	0.039	0.584	0.360	0.944	0.983	33.02
LONG5	0.6	48.5%	4.77	62.9%	16.0	0.071	0.009	0.002	0.011	0.480	0.894	1.374	1.385	18.08
LONG6	0.6	48.8%	4.76	62.9%	15.9	0.028	0.022	0.003	0.026	0.567	1.452	2.019	2.044	24.21
MH1	1.6	67.1%	3.00	40.1%	26.8	0.024	0.045	0.005	0.050	0.316	0.260	0.576	0.626	14.20
MH2	1.9	93.9%	3.52	47.9%	29.7	0.014	0.024	0.003	0.027	0.264	0.145	0.409	0.436	9.37
MH3	2.3	100.0%	4.39	55.5%	30.8	0.011	0.024	0.002	0.026	0.213	0.084	0.297	0.324	6.14
MH4	3.8	58.3%	4.27	55.6%	31.1	0.015	0.024	0.002	0.026	0.190	0.069	0.259	0.285	4.21
MP1	1.5	86.3%	5.43	54.0%	0.7	0.003	0.030	0.002	0.032	0.557	0.265	0.822	0.854	16.29
MP2	1.9	58.5%	5.70	62.8%	0.6	0.002	0.044	0.002	0.046	0.554	0.210	0.764	0.811	11.50
MP3	1.3	83.1%	4.93	56.6%	0.1	0.031	0.048	0.056	0.104	0.499	0.490	0.990	1.093	51.52
NAN1	4.5	84.8%	3.57	48.2%	31.0	0.016	0.027	0.003	0.030	0.218	0.084	0.302	0.332	4.00
NAN2	3.4	62.8%	3.45	47.4%	31.0	0.018	0.016	0.003	0.019	0.201	0.077	0.278	0.297	5.36
NAN3	2.8	49.2%	3.72	52.4%	30.9	0.022	0.027	0.003	0.030	0.251	0.111	0.362	0.392	7.58
NAN4	3.7	84.5%	3.89	52.2%	29.8	0.015	0.027	0.002	0.029	0.203	0.070	0.273	0.302	4.15
NAN5	2.0	98.0%	3.18	44.3%	30.4	0.017	0.027	0.007	0.034	0.248	0.149	0.397	0.431	11.31
NAN6	2.2	88.7%	3.26	45.7%	30.5	0.016	0.024	0.004	0.028	0.277	0.133	0.410	0.438	10.31
NAN7	2.1	92.5%	3.60	49.8%	30.9	0.016	0.023	0.003	0.026	0.244	0.106	0.351	0.377	7.35
NAN8	2.4	100.8%	3.65	50.0%	31.1	0.018	0.031	0.002	0.033	0.204	0.076	0.280	0.313	3.93
SESA1	1.6	32.9%	4.82	56.4%	11.9	0.051	0.018	0.003	0.021	0.441	0.222	0.663	0.684	8.00
SESA2	1.4	28.6%	4.83	56.4%	11.9	0.045	0.024	0.003	0.027	0.469	0.219	0.688	0.715	7.19
SESA3	1.5	36.6%	4.83	56.2%	11.9	0.049	0.021	0.006	0.028	0.449	0.223	0.672	0.700	7.61
SESA4	1.5	38.7%	4.83	56.4%	11.9	0.046	0.024	0.003	0.027	0.470	0.221	0.691	0.718	6.73
82 WAUWINET	ND	ND	ND	ND	18.2	0.071	0.122	0.004	0.126	0.611	0.108	0.719	0.845	40.70
STREAM1	ND	ND	ND	ND	0.3	0.077	0.081	0.021	0.102	1.419	0.258	1.677	1.779	2.64
STREAM4	ND	ND	ND	ND	<0.1	0.163	0.039	0.008	0.048	1.092	0.061	1.153	1.200	1.18
STREAM6B	ND	ND	ND	ND	<0.1	0.006	0.059	0.004	0.064	1.701	0.374	2.076	2.139	16.37
STREAM6C	ND	ND	ND	ND	<0.1	0.132	0.097	0.003	0.100	0.375	0.156	0.532	0.632	7.41
STREAM8	ND	ND	ND	ND	3.3	0.015	0.045	0.005	0.050	0.398	0.118	0.516	0.565	5.29

Secchi as % of WC is the % of the water column above the secchi depth, values of 100% means that the Secchi was at or below the bottom.
Lowest 20% of D.O. records for a site over the project period.

HUM = Hummock Pond, Long = Long Pond, MH = Madaket Harbor, MP = Miacomet Pond, NAN = Nantucket Harbor, SESA = Sesachacha Pond

Sesachacha Pond Conclusions

2014 showed slightly higher levels possibly due to ineffective spring 2014 breaching

The monitoring data suggest pond not fully restored, based on 2012 observed moderate impairment to the benthic animal community.

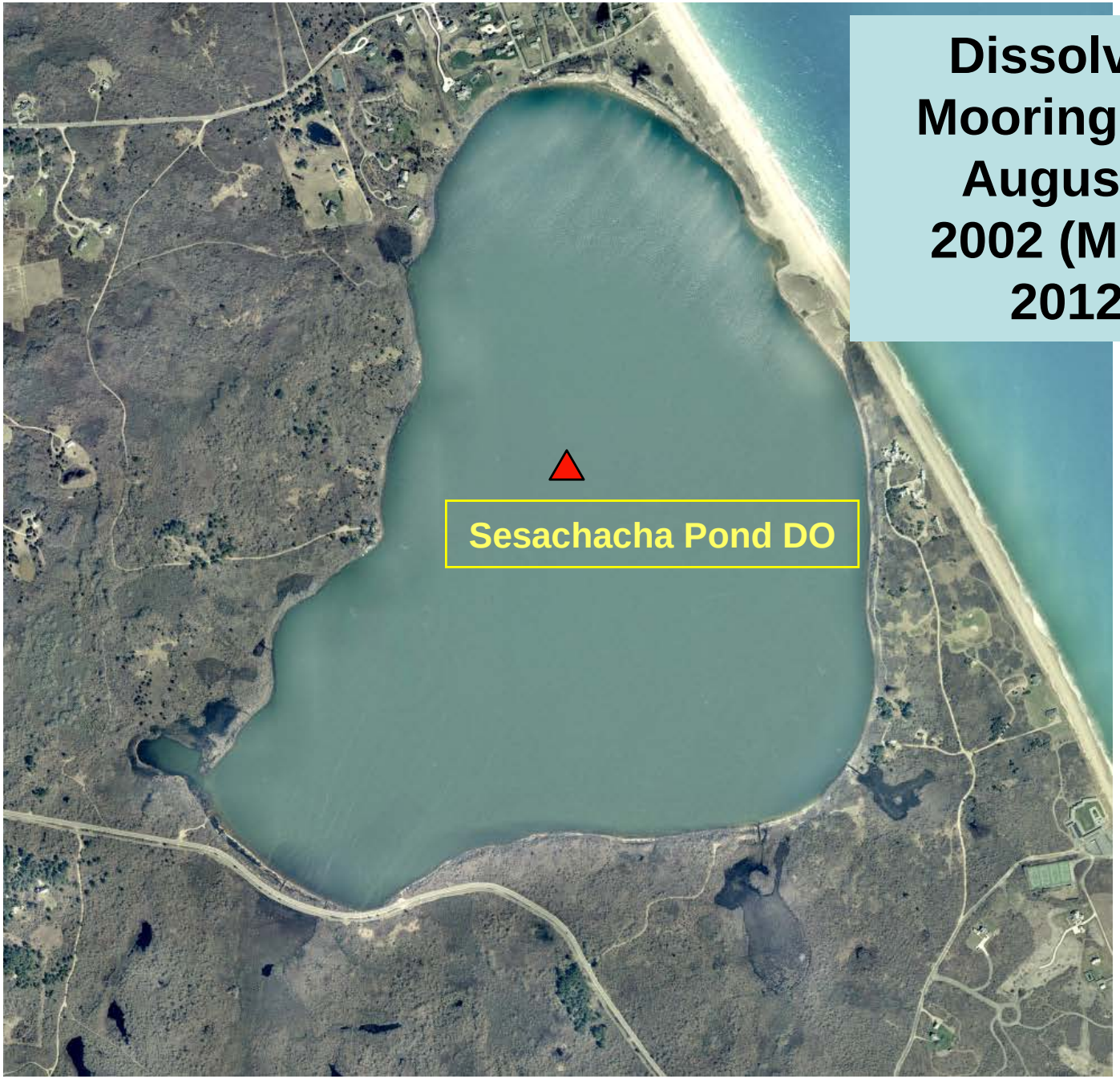
Benthic community likely to continue improving as the DO and organic matter loading related stress decreases.

The benthic animal habitat is consistent with water quality improvements, hypoxia common in 2002 not seen in 2012

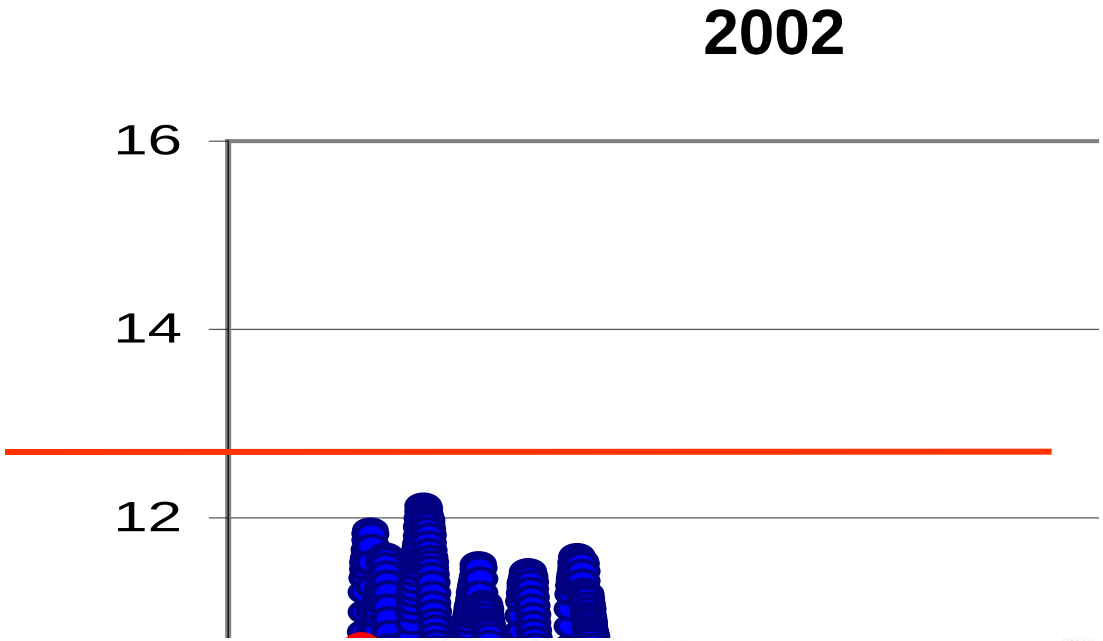
CHLA levels = moderate to high quality waters.

If the periodic openings can be managed at the level of the 2012 and 2013 openings, it is likely that Sesachacha Pond will continue to improve and meet its designated TMDL.

Dissolved Oxygen Mooring Deployment August - October 2002 (MEP) 67 Days 2012 57 Days

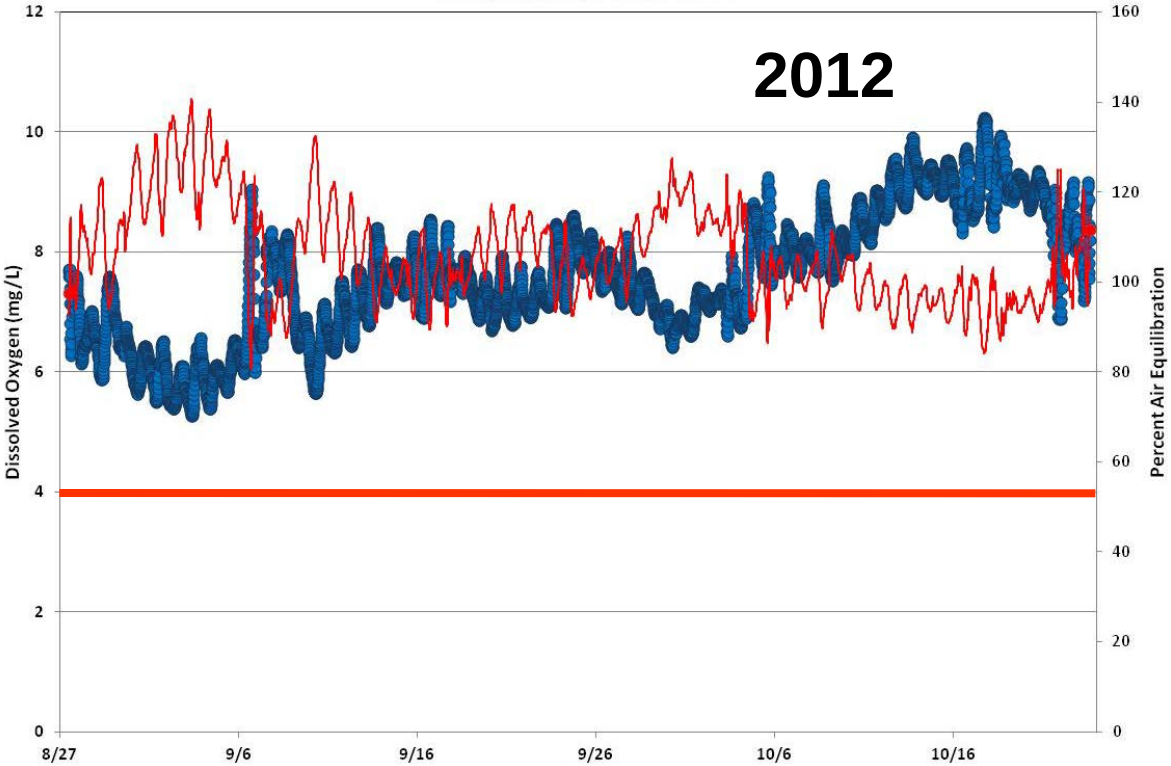


Sesachacha Pond Dissolved Oxygen (bottom water)



Stress to Infaunal Animals

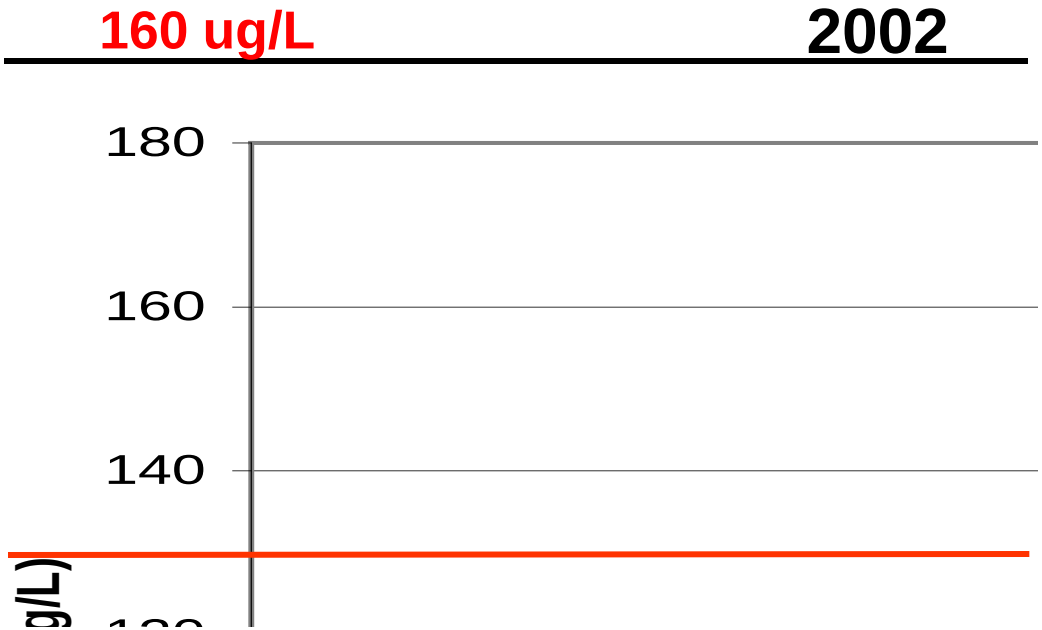
<4.0 mg/L 10% of Deployment



Stress to Infaunal Animals

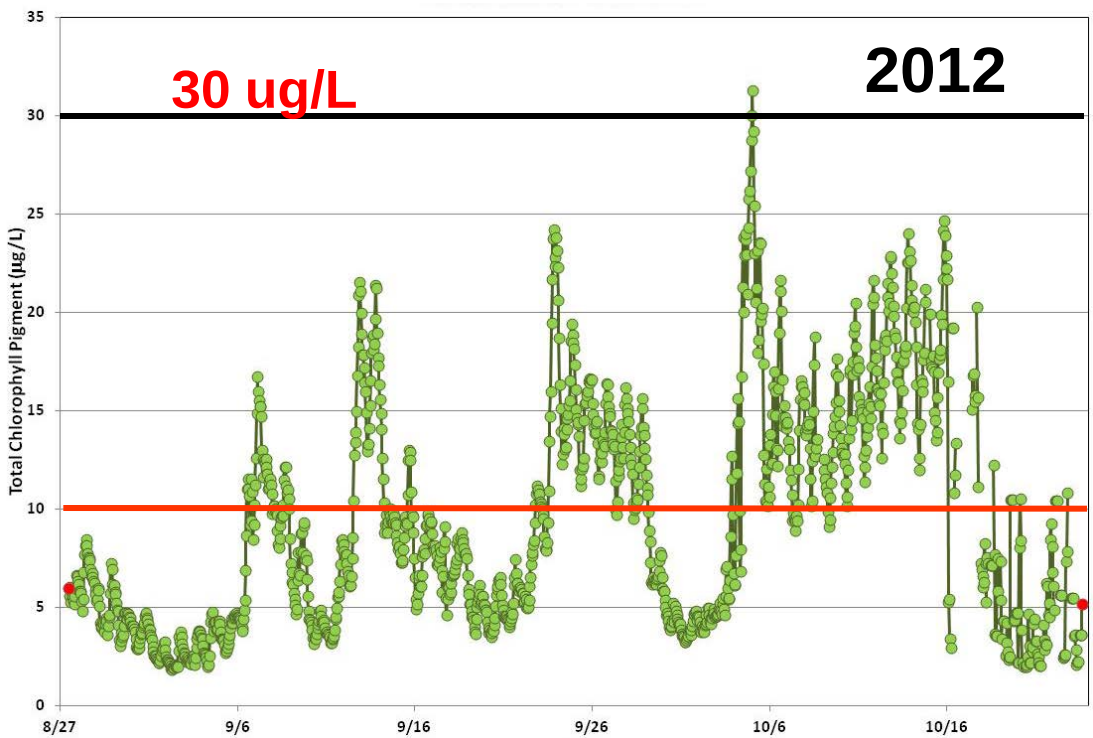
<4.0 mg/L 0% of Deployment

Sesachacha Pond Chlorophyll-*a* (bottom water)



>10.0 mg/L 90% of Deployment

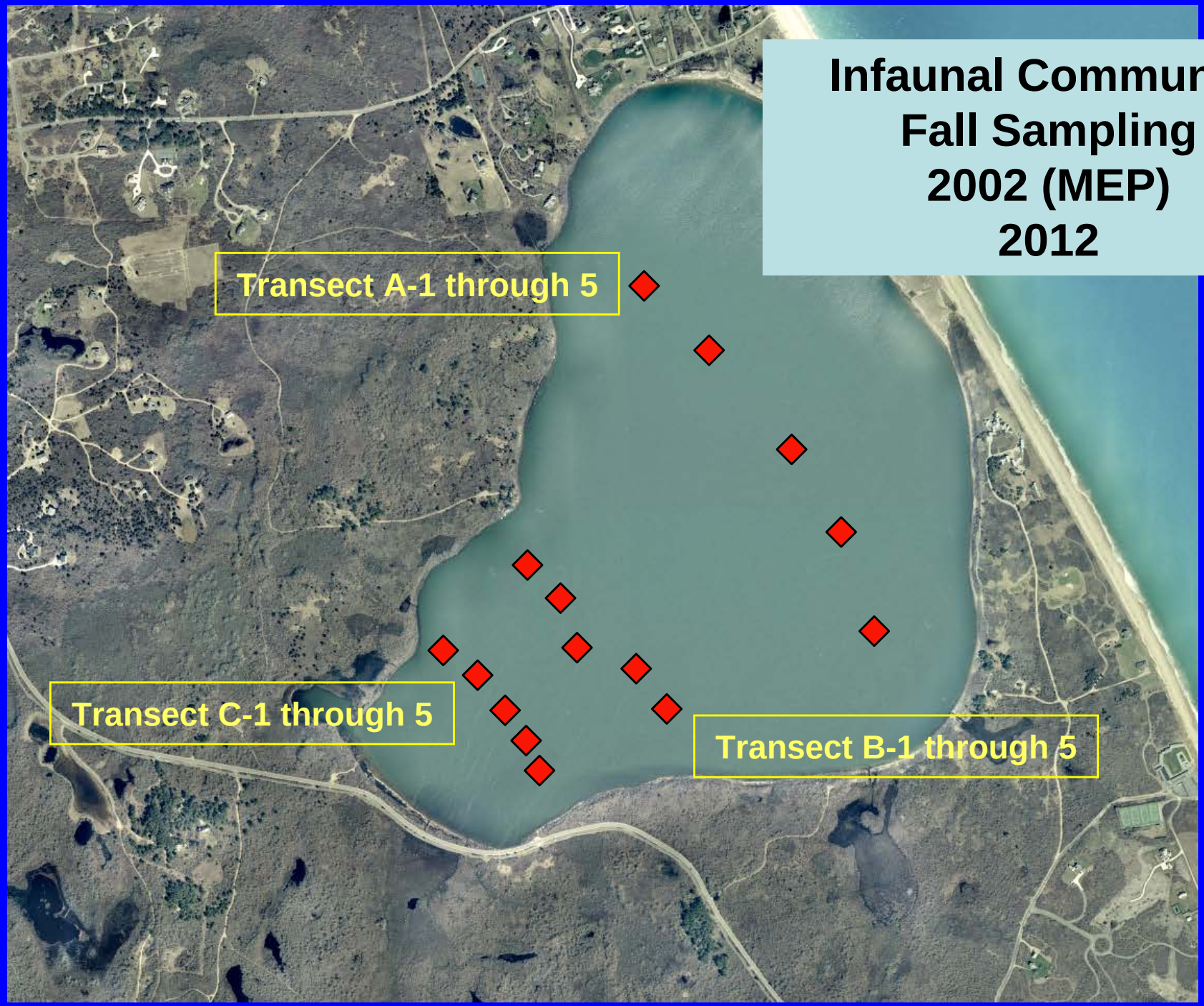
Stress to Infaunal Animals



Stress to Infaunal Animals

>10.0 mg/L 38% of Deployment

Infaunal Community
Fall Sampling
2002 (MEP)
2012



Assessment of Benthic Habitat Health (2002-2012)

Location	Total Actual Species	Total Actual Individuals	Species Calculated @75 Indiv.	Weiner Diversity (H')	Evenness (E)	Stations [a] I.D.
Sesachacha Pond 2002						
East Transect [A]	5.0	420	3.1	0.39	0.15	A-1 thru A-5
West Outer [B]	3.0	45	NA	1.32	0.90	B-1 thru B-5
West Nearshore [C]	3.8	210	3.6	1.27	0.65	C-1 thru C-5
Sesachacha Pond 2012						
East Transect [A]	5.4	88	NA	1.76	0.77	A-1 thru A-5
West Outer [B]	4.6	155	NA	1.44	0.83	B-1 thru B-5
West Nearshore [C]	6.0	342	6.5	1.48	0.54	C-1 thru C-5

a - stations refer to 2002 and 2012 location maps below.

High Quality Habitat = 20-25 species; >300 individuals

2015 Eelgrass Mapping Results

Kaitlyn Shaw

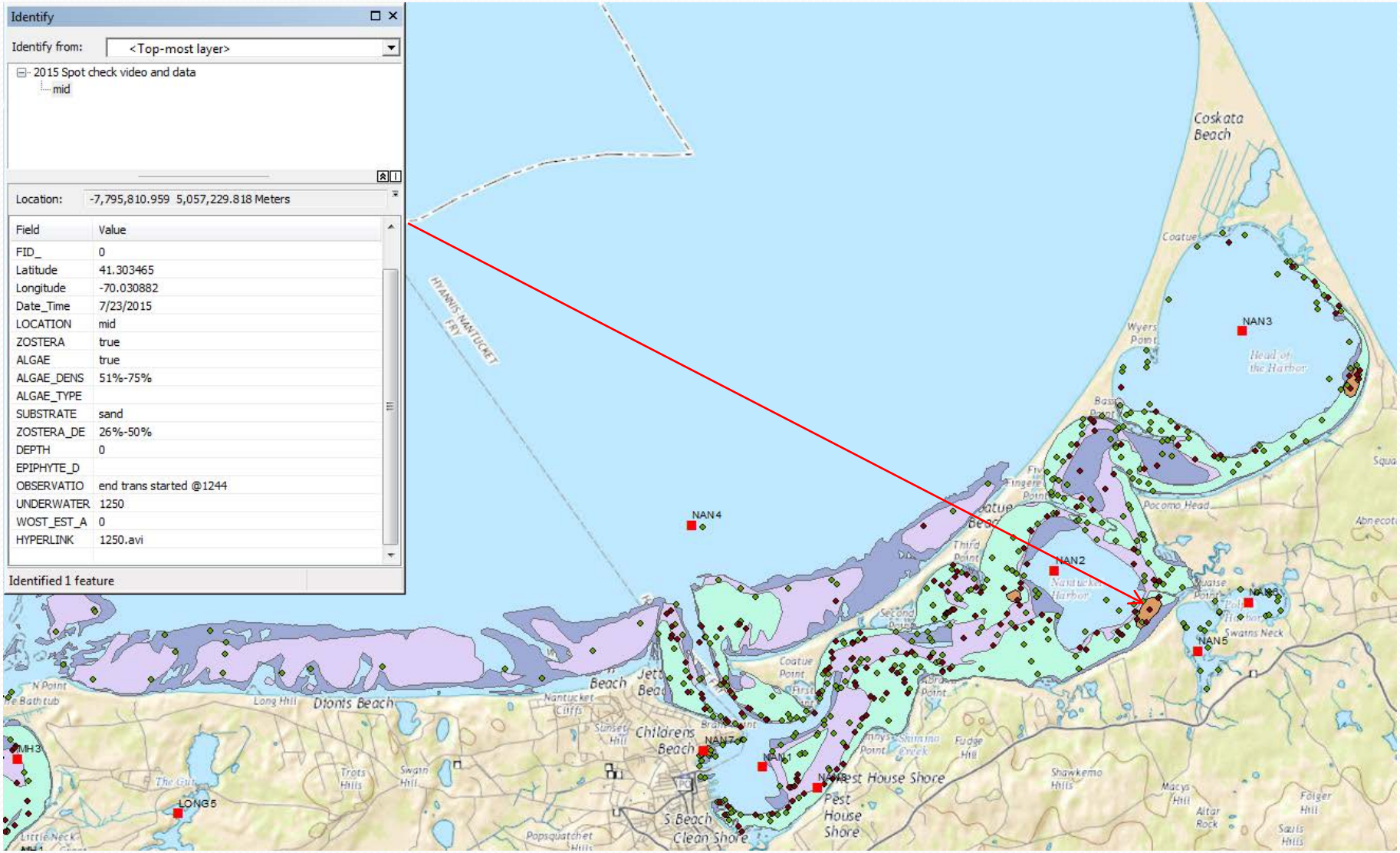
What does healthy habitat look like?

Eelgrass Survey Methods:

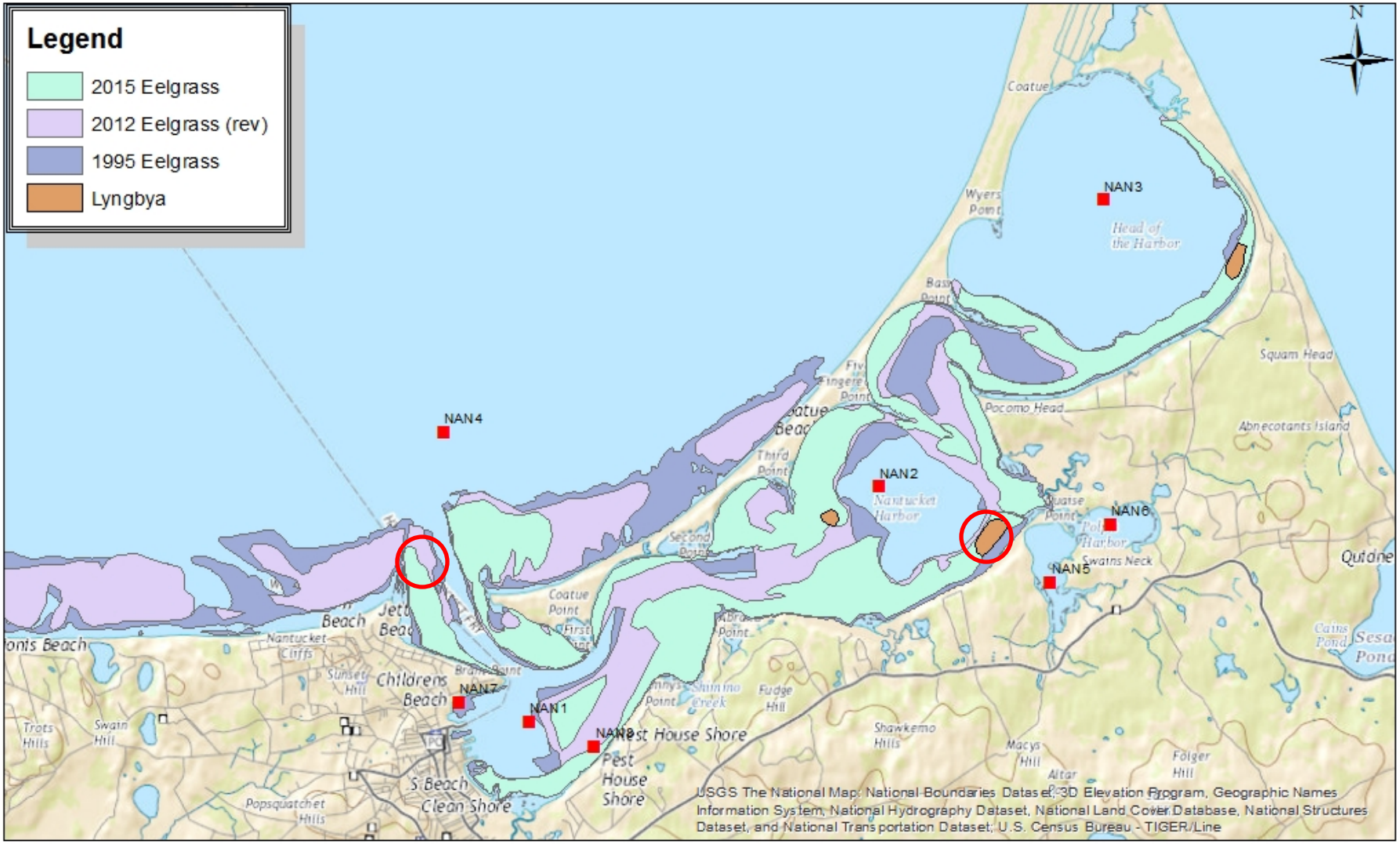
Geovantage Aerial Survey

Groundtruthing Video Survey

ArcMap data


Identify
Identify from: <Top-most layer>
2015 Spot check video and data
mid
Location: -7,795,810.959 5,057,229.818 Meters
Field Value
FID_ 0
Latitude 41.303465
Longitude -70.030882
Date_Time 7/23/2015
LOCATION mid
ZOSTERA true
ALGAE true
ALGAE_DENS 51%-75%
ALGAE_TYPE
SUBSTRATE sand
ZOSTERA_DE 26%-50%
DEPTH 0
EPIPHYTE_D
OBSERVATIO end trans started @1244
UNDERWATER 1250
WOST_EST_A 0
HYPERLINK 1250.avi
Identified 1 feature
Coskata Beach
NAN3
NAN4
NAN2
NAN5
LONG5
Dionts Beach
Childrens Beach
Pest House Shore
S. Beach Clean Shore

Nantucket Harbor Eelgrass Distribution



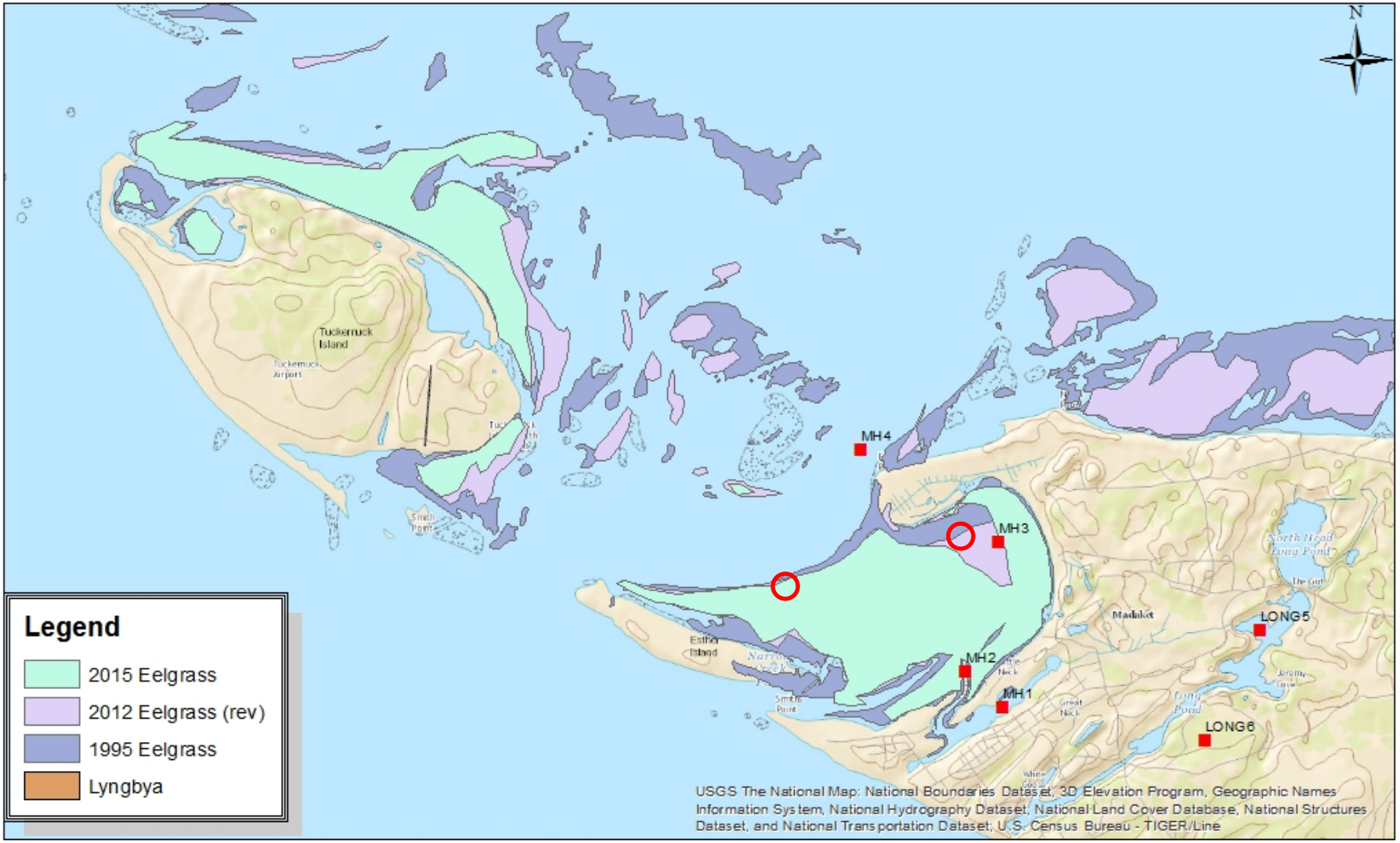
Data Source: Charlie Costello aerial eelgrass mapping survey, 1995-2015.
Data has been field verified using underwater video during the summer of 2015.

0 0.35 0.7 1.4 2.1 2.8 Miles

CH:01
West Jetty
07/20/15
14:01:27
0.0KMH

Wauwinet

Madaket Harbor & Tuckernuck Eelgrass Distribution



Data Source: Charlie Costello aerial eelgrass mapping survey, 1995-2015.
Data has been field verified using underwater video during the summer of 2015.

0 0.25 0.5 1 1.5 2 Miles

Outer Madaket Harbor

North Madaket Harbor

Survey findings:

- Town region 30% decline since ‘95.
- First through third bend 40% decline since ‘95.
- Head of Harbor 32% decline since ‘95.

Recommendations (Costello)

- Use 2015 maps as a high definition baseline for further 'loss calculations'

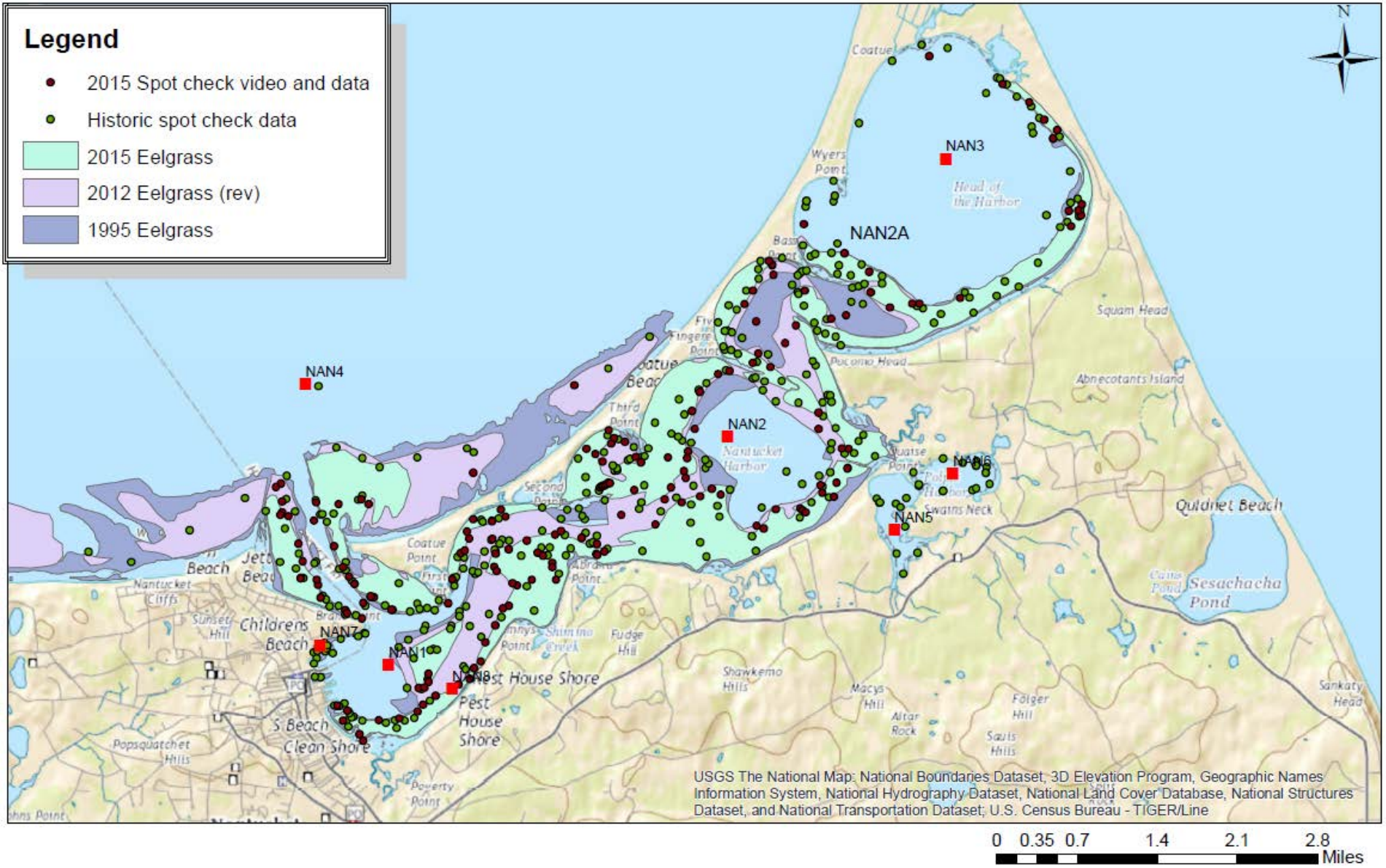
- Conduct aerial surveys every 2-3 years to assess changes in eelgrass distribution and health.

Natural Resources Action Items

- Develop permanent geo-referenced ‘sentinel’ eelgrass monitoring transects.
- Develop a Standard Operating Procedure for the assessment of eelgrass beds and associated impacts of coastal activities on bed health.
- Monitor and assess eelgrass health bi-monthly during spring/ summer.
- Provide visual underwater representations of the impacts of coastal activities, when possible.

Thank you & Questions

Nantucket Harbor Eelgrass Distribution



TOWN OF NANTUCKET NATURAL RESOURCES DEPARTMENT

KAITLYN SHAW, WATER RESOURCE SPECIALIST KSHAW@NANTUCKET-MA.GOV
2 BATHING BEACH ROAD 508-228-7230

MEMO
02/02/2016
To: Libby Gibson, Town Manager
Roberto Santamaria, Director of Public Health
Kara Buzanoski, Director of Public Works
Gregg Tivnan, Assistant Town Manager
Jeff Carlson, Natural Resource Coordinator
From: Kaitlyn Shaw, Water Resources Specialist

Nantucket Island-wide Water Quality Summary 2015

Embayment	Level of Water Quality supported	Concerns
Nantucket Harbor	High to Moderate	Eelgrass loss affecting suitable scallop habitat, Head of Harbor exhibiting high total nitrogen and an algae bloom in June
Madaket Harbor	High to Moderate	Inputs to Hither Creek from Long pond via Madaket ditch
Hummock Pond	Moderate	High total nitrogen & total pigments, blue-green algae bloom
Sesachacha Pond	Moderate	Nutrient levels dependent on success of pond opening, blue-green algae bloom
Long Pond	Moderate to Fair	High total nitrogen & inputs from landfill
Miacomet Pond	Fair to Poor	High total nitrogen, total phosphorous & total pigments, algae bloom

Nantucket Harbor (Figure 1): Total nitrogen (TN) concentrations in the Head of Harbor were approaching TMDL concentrations (0.350 mg/L) in 2014 however concentrations in 2015 have surpassed 0.40 mg/L indicating a recent decline in water quality. Three out of five Nantucket Harbor sites are currently *exceeding* the TMDL TN threshold (0.35 mg/L) (management required).

Polpis Harbor currently *exceeds* TMDL threshold (0.355 mg/L). The 2015 technical memo states, "that a relatively large TN load can be introduced to Polpis Harbor from the stream sites on a monthly basis. It is important to note that the large loads presented would actually be the lowest loads of the year as precipitation during the summer is typically much lower than in the winter and spring". Given this finding, further investigation into the Polpis Harbor stream contributions is warranted (management required).

Madaket Harbor (Figure 2): TN concentrations in Hither Creek were approaching TMDL concentrations (0.450 mg/L) in 2014 however 2015 concentrations *exceeded* 0.50 mg/L (management required).

Long Pond (Figure 2): TN concentrations continue to exceed the TMDL threshold (0.450 mg/L), however this year Long Pond exhibited the lowest TN values in over 5 years. Improving water quality is potentially due to management activities at the landfill. The high nutrient levels and degraded water

quality in Long pond likely affect the water quality via exchange through Madaket ditch (management required).

Sesachacha Pond (Figure 3): TN concentrations are significantly lower with successful openings (> 4days) (2010-2013), but *exceed* the TMDL threshold (0.60 mg/L). 2014 showed high TN levels associated with a less successful spring pond opening, followed by even higher TN levels at three out of four sites in 2015 following the 4 day spring opening. Blue-green algae blooms present.

Hummock Pond (Figure 4): Strong total nitrogen gradient from upper pond to opened region. High total nitrogen and total pigments indicate impairment, total nitrogen threshold (0.50 mg/l) *exceeded*. Water quality is improving due to successful pond openings. Blue-green algae blooms present.

Miacomet Pond (Figure 5): Strong TN gradient, high TN & total pigment, *indicates impairment* Currently, no MEP report. We began measuring total phosphorous (TP) due to the low salinity of this water body. Blue-green algae blooms present.

Recommendations (from Technical memo)

- Dissolved oxygen (DO) data should be collected using high frequency automated sensors when our current sampling program suggests a problem in a specific basin.
- Consider DO mooring deployment in Polpis Harbor, Madaket Harbor (station 2) and lower Miacomet Pond.
- Pond opening monitoring should be continued to expand understanding of Sesachacha and Hummock Pond opening success.
- Conduct analysis of Long Pond for nitrogen and organic matter entering from the land fill. The monitoring results from 2012 and 2013 appear to show a significant reduction in total nitrogen over 2010 and historical conditions, but 2014 exhibited higher total nitrogen levels.
- Nitrogen and phosphorus budgets should be developed for Miacomet Pond and a quantitative analysis of N versus P as the driving nutrient of eutrophication. This information will support management actions for managing the pond in its variable salinity state.
- Take into consideration variability, due to seasonal temperature differences, presence & severity of phytoplankton blooms and rainfall information.

Natural Resources Action Items

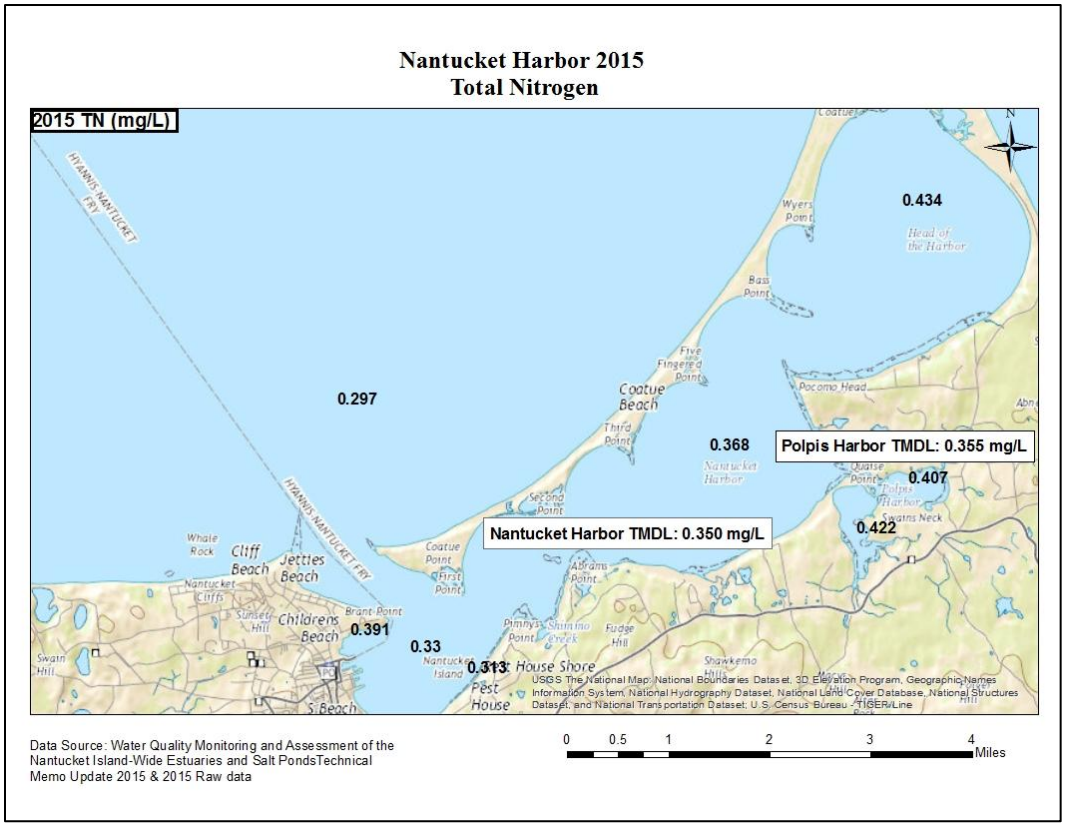
- A proposal is being submitted to the GHYC & NLC Nantucket Marine Resources Grant Program to deploy DO sensors in Polpis Harbor and Wauwinet, and to develop a static monitoring station at Brant Point.
- Conduct pre and post pond opening water quality sampling events and video monitoring of catadromous/ anadromous fish runs during Sesachacha and Hummock pond openings.
- Developed blue-green algae bloom detection and monitoring program, to be distributed during first annual 'Nantucket Research Collaborative' meeting (planned for Spring 2016).
- Re-initiate participation in the phytoplankton monitoring network (PMN) for early detection of harmful algal blooms (HAB) in Nantucket and Madaket Harbors.
- Continue to monitor stream flows and nutrient loads to Polpis Harbor, address potential BMP's for Cranberry irrigation practices.
- Obtain funding for Miacomet Pond report, due to declining water quality and lack of formal management document.

Definitions

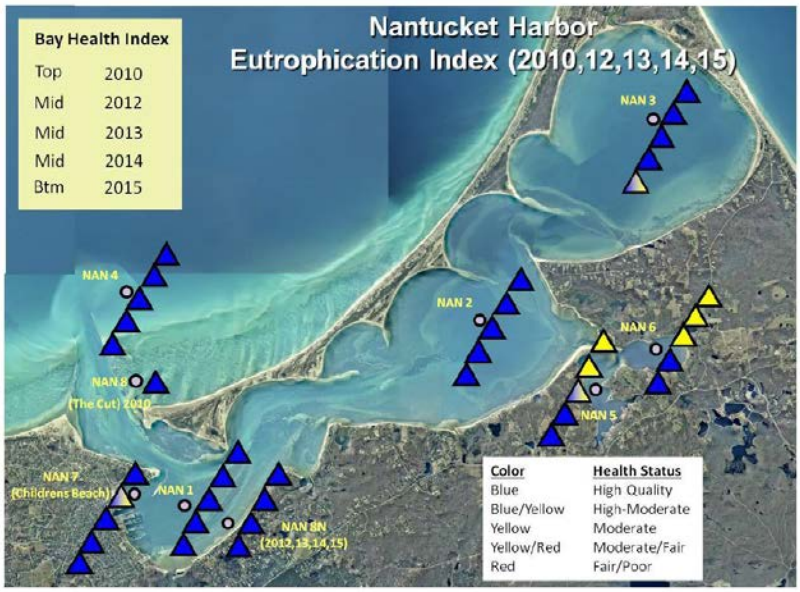
Eutrophication: The process by which excess nutrients in the form of nitrogen and phosphorous enter an estuary (semi-enclosed coastal water body) & cause algae blooms which cloud the water, leading to low light levels & low dissolved oxygen. Eelgrass does not like low light levels and can decline in response to these conditions. Shellfish and fish require oxygen to survive, if dissolved oxygen levels decrease due to excess nutrient input we will lose important economic shellfish resources.

TMDL: Total maximum daily load. Under section 303(d) of the Clean Water Act, states are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by the state. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. We speak of TMDL's for Total Nitrogen (TN) because nitrogen causes eutrophication. Currently four of five Nantucket water bodies have TMDL goals set for total nitrogen and Miacomet and Gibbs have TMDL's for mercury in fish tissue.

Eutrophication Index: The Trophic State of an estuary is a quantitative indicator of its nutrient related ecological health and is based on concentrations of inorganic and organic Nitrogen, water clarity (Secchi Depth), lowest measured concentrations of Dissolved Oxygen (average of lowest 20% of measurements), and Chlorophyll-a pigments (surrogate for phytoplankton biomass). Trophic health scales generally range from Oligotrophic (healthy-low nutrient) to Mesotrophic (showing signs of deterioration of health due to nutrient enrichment) to Eutrophic (habitats impaired and degraded, high nutrient and organic matter). The Trophic Health Index Score used here is a standard numerical scale based on criteria for open water embayments and uses the above mentioned measured parameters to create a habitat quality scale (Howes et al. 1999, http://www.savebuzzardsbay.org).

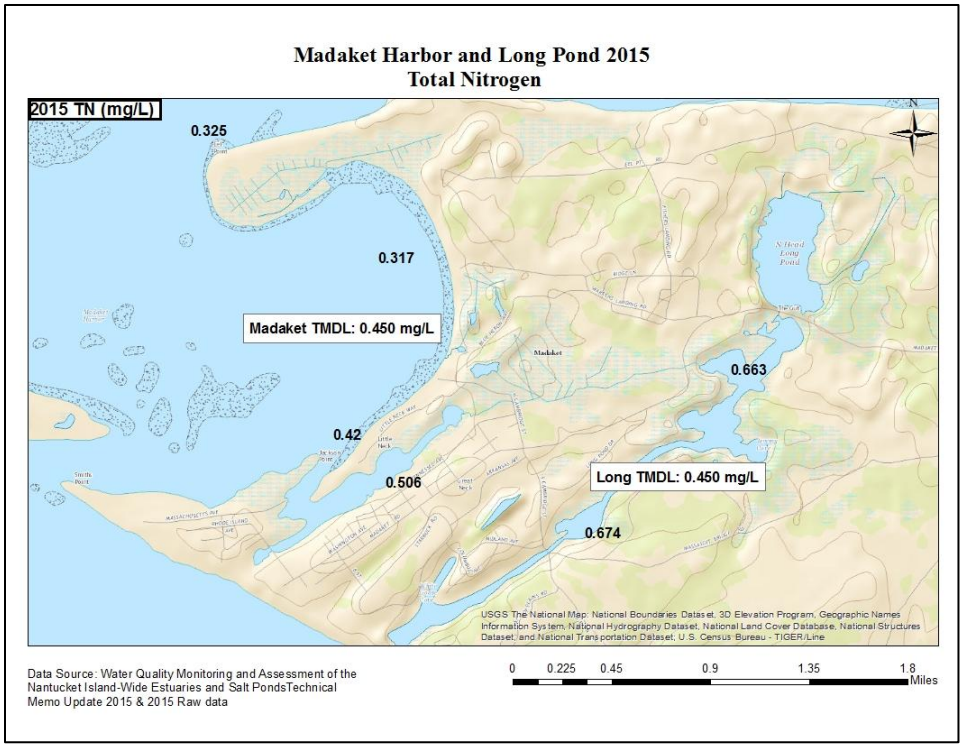


Source: Nantucket NRD.

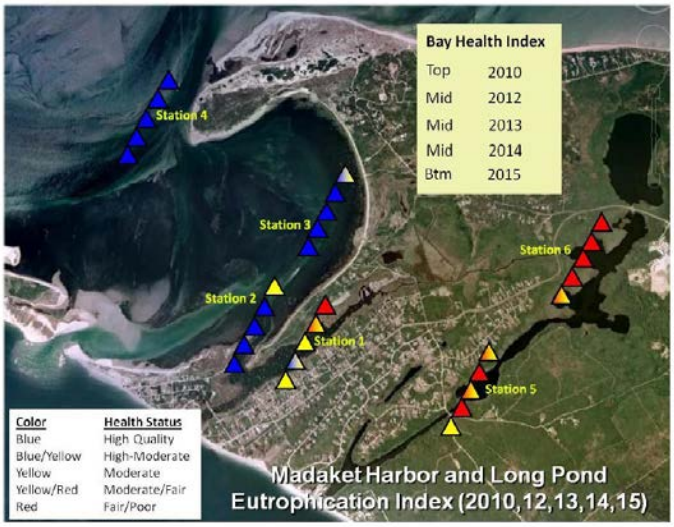


Source: Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Technical Memo Update 2015.

Figure 1. Nantucket Harbor: High quality habitat should be supported however eelgrass is currently in decline. Three out of five harbor sites TN values are above the TMDL (0.35 mg/L). Head of Harbor is experiencing higher than usual nitrogen. Polpis Harbor water quality improving, yet still above TMDL threshold (0.355 mg/L).

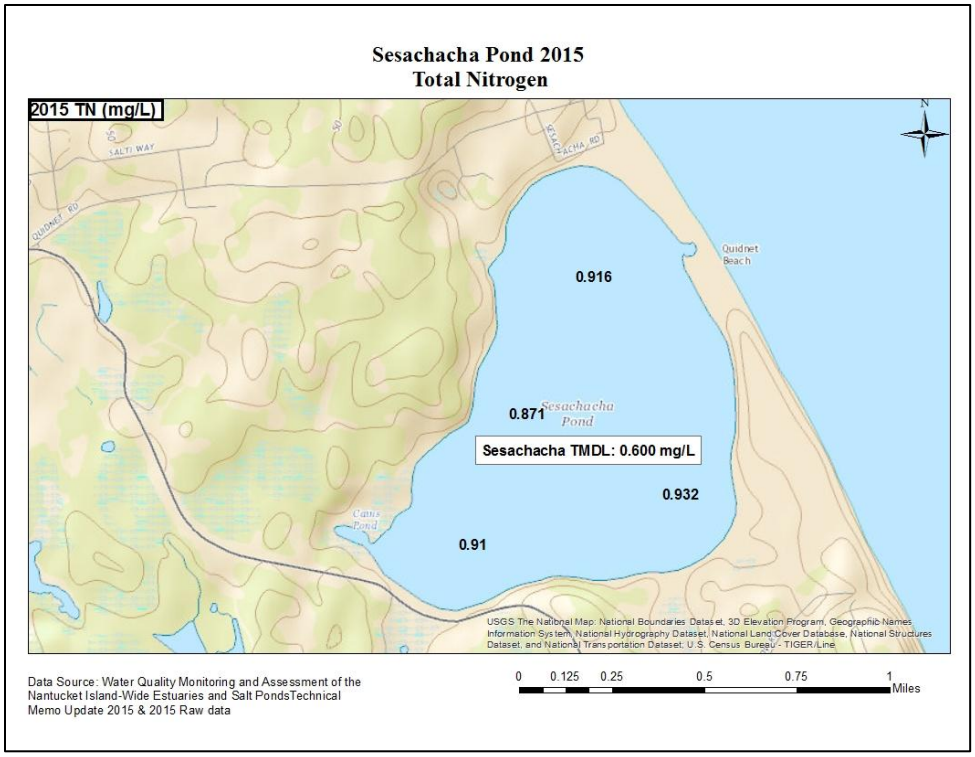


Source: Nantucket NRD.

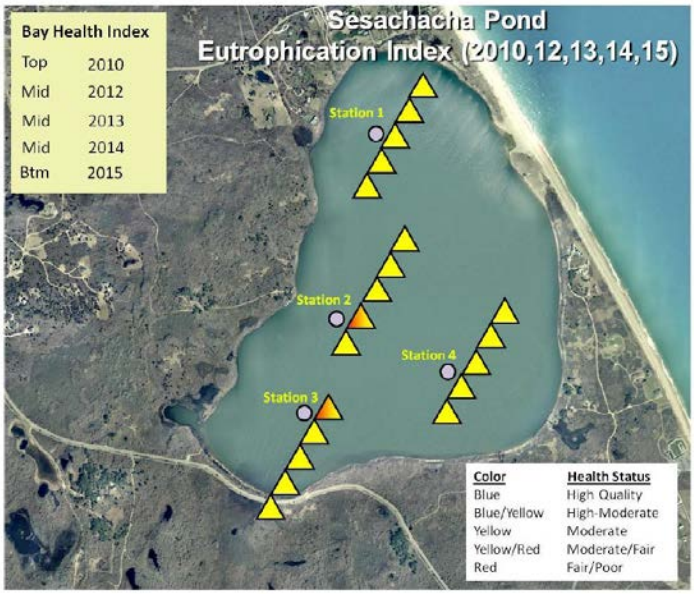


Source: Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Technical Memo Update 2015.

Figure 2. Madaket Harbor: High quality habitat, with two out of three sites surpassing the Madaket TMDL (0.45 mg/L). Hither creek: Moderate quality. Long Pond: Moderate to Fair quality, with TN values surpassing the TMDL (0.45 mg/L).

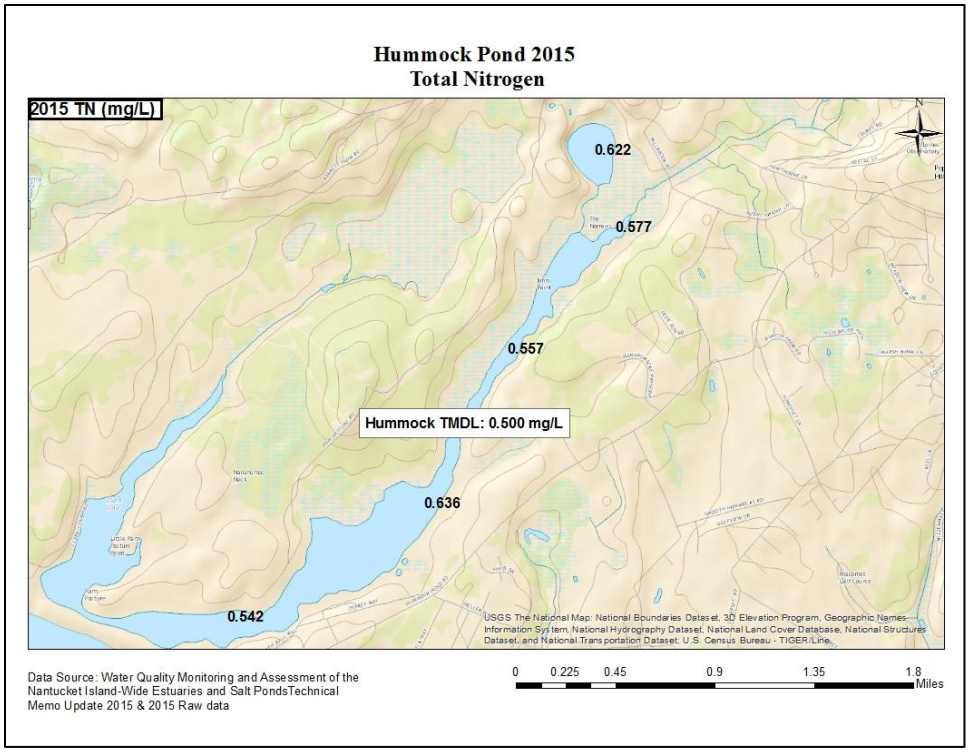


Source: Nantucket NRD.

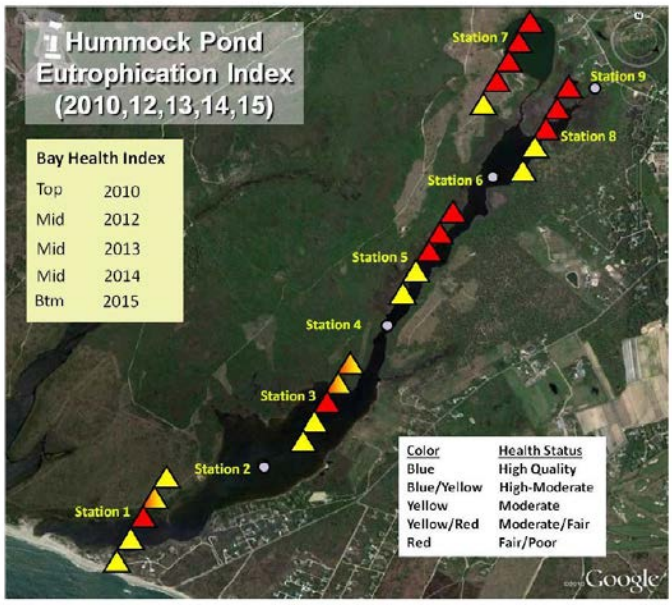


Source: Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Technical Memo Update 2015.

Figure 3. Sesachacha: Moderate to fair water quality. Water quality is significantly affected by the success of pond openings (>4 days). All site TN values surpass TMDL (0.60 mg/L).

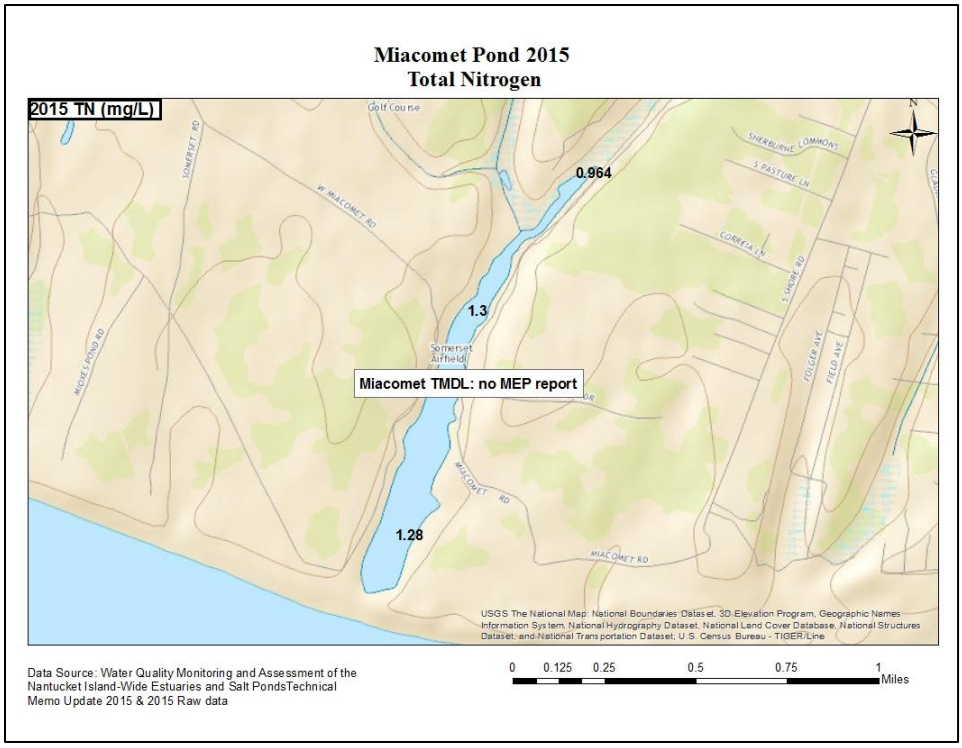


Source: Nantucket NRD.

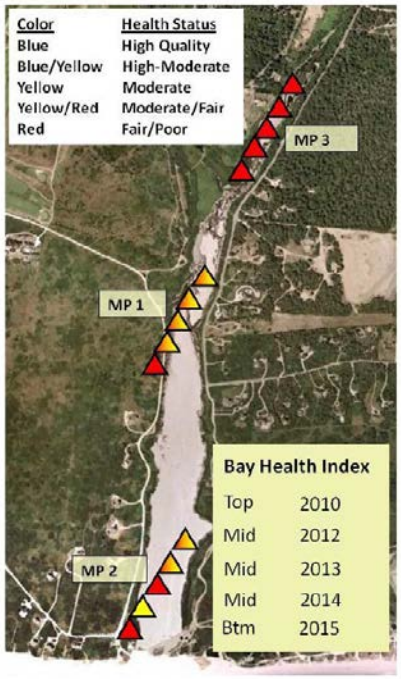


Source: Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Technical Memo Update 2015.

Figure 4. Hummock Pond: Moderate water quality, with all sites TN surpassing TMDL (0.50 mg/L).

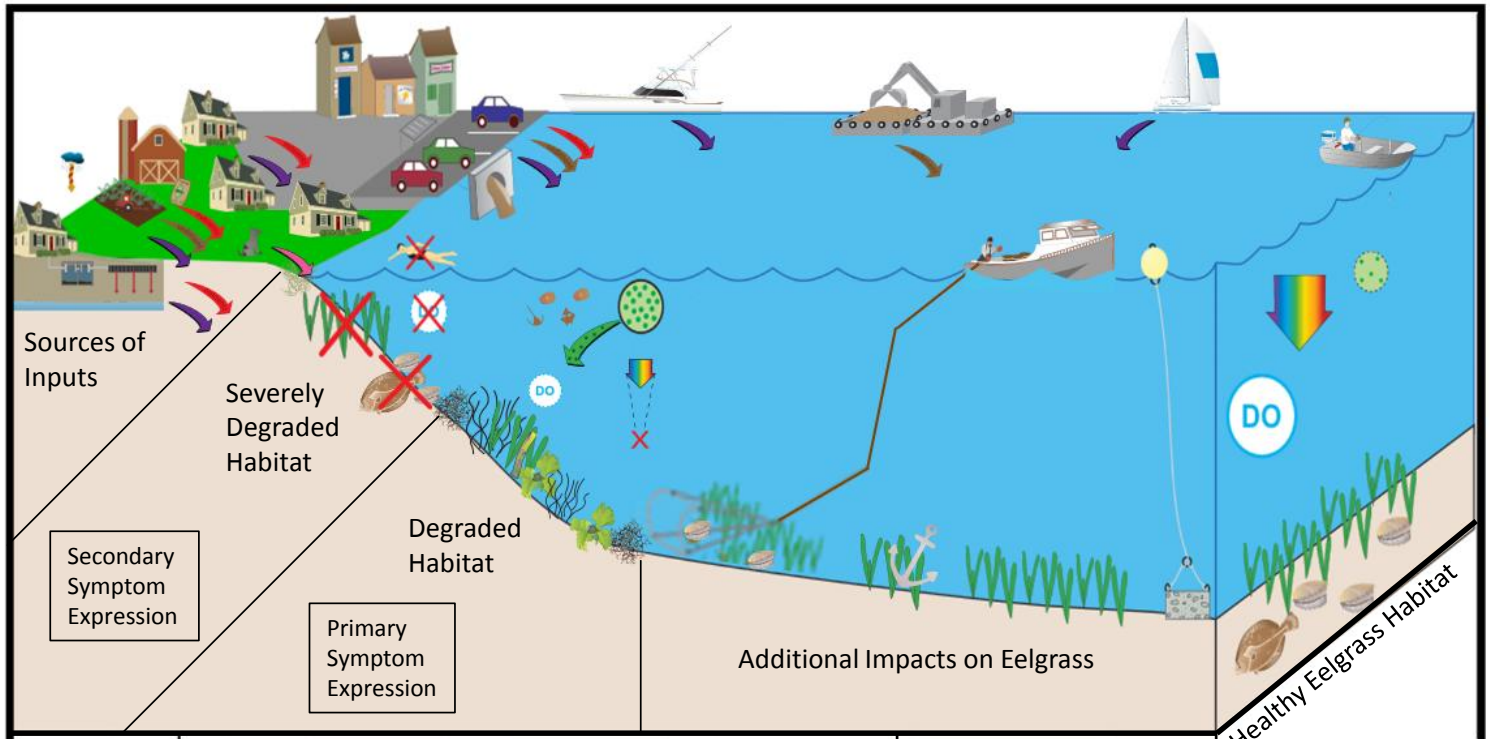


Source: Nantucket NRD.



Source: Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Technical Memo Update 2015.

Figure 5. Miacomet Pond: Moderate to poor water quality (from an estuarine standpoint). No MEP report for this water body, TN values are very high. We are currently investigating the freshwater nutrient dynamics (ie. phosphate) of this system.



EUTROPHICATION & IMPACTS ON EELGRASS

Sources

Atmospheric Deposition

Wastewater

Fertilizers

Impervious surfaces (road/ roof/ asphalt)

Natural (streams/ wetlands)

Inputs

Nutrients

Chemicals

Sediment

Bacteria

Primary Symptoms

Phytoplankton blooms, high chlorophyll

Sinking and decay of algae

Macroalgae blooms

Microalgae blooms

Harmful algal blooms

Secondary Symptoms

Lower light available for photosynthesis

Low or no dissolved oxygen

Loss of eelgrass

Shellfish and fish contamination or die-off

Beach closures due to bacterial contamination

Impacts on eelgrass

- Nutrient inputs (shading/ competition)
- Chemical inputs (toxicity)
- Sediment inputs (shading)
- Fishing (physical disruption)
- Anchoring (physical disruption)
- Boating (physical disruption)
- Dock construction (shading/ physical disruption)
- Natural (wasting disease)

Healthy eelgrass

- Low nutrient inputs
- Low- no chemical inputs
- Low- no sediment input
- High light penetration
- Less phytoplankton, lower chlorophyll
- Less sinking and decay of algae
- Higher dissolved oxygen
- Healthy habitat for scallops and fish

Diagram created by Kaitlyn Shaw using Ian.umces.edu online diagram creator.

Technical Memorandum

FINAL

Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Update 2015

To:

Town of Nantucket
Marine and Natural Resources Department
2 Bathing Beach Road
Nantucket, MA 02554

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From:

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January 7, 2016

The Technical Memorandum on the 2015 Nantucket Water Quality Monitoring Program is organized consistent with previous SMAST water quality monitoring summaries (2010, 2012, 2013, and 2014) for direct comparison to data from the previous years of monitoring. However, the 2015 summary does not include an overview of the program or the summary of the sampling approach as neither of those two sections have changed from previous years and it is included by reference.. The 2015 summary is focused specifically on the following:

1. Results of Sampling: Summary of Water Quality Results

    Nantucket Harbor
    Madaket Harbor
    Long Pond
    Hummock Pond
    Miacomet Pond
    Sesachacha Pond
    Polpis Harbor Streams
    Oyster Aquaculture Sites

2. Trophic State: Water Quality/Eutrophication Status

3. Recommendations for Future Monitoring

As in previous years, the 2015 water quality monitoring of Nantucket's fresh and saltwater systems was focused on summer-time conditions, as the warmer months typically have the lowest water quality conditions, which are the target of resource management. As in previous years (2010, 2012-2014), the approach utilized for the collection and analysis of 2015 water samples from each of the estuaries of Nantucket remains the same. This consistency is intended to maximize the value of the results by making the data perfectly cross comparable to water quality monitoring data collected across the Island of Nantucket from previous years and more broadly throughout the region (Cape Cod, Martha's Vineyard). In this manner, inter-ecosystem comparisons can be made to better assess system health/impairment and function and formulate appropriate nutrient management strategies. This allows individual towns such as Nantucket to directly benefit from lessons learned throughout the wider region.

As in past years, UMD-SMAST Coastal Systems Program (CSP) scientists focused primarily on the analysis of samples collected from the field effort and data analysis and program coordination with the Nantucket Natural Resources Department who’s primary focus was on coordination of field efforts, field sampling and data collection on physical parameters and water quality improvement efforts.

The goals of the monitoring program remain unchanged from previous years, primarily to:

1. determine the present (2015) ecological health of each of the main salt ponds and estuaries within the Town of Nantucket,

2. gauge (as historical data allows) the decline or recovery of various salt ponds and embayments over the long-term (also part of TMDL compliance), and
3. provide the foundation (and context) for detailed quantitative measures to derive and assess potential alternatives for nutrient and resource management, as appropriate.

This latter point (3) is critical for restoration planning should a system be found to be impaired or trending toward impairment and is also is required to develop cost-effective targeted solutions.

As was the case in 2010, 2012, 2013, and 2014 sampling efforts, 2015 sampling took place during the summer/early fall months (May-September). Samples were collected from 6 estuarine systems (Figures 1, 2, 3, 4 and 5) on multiple dates ("events") following the schedule presented in Table 1a (2015), Table 1b (2014), Table 1c (2013), Table 1d (2012), and Table 1e (2010). Samples collected in 2015 were obtained from the same sampling station locations and the same depths as in previous years to maximize cross comparability and to gauge temporal changes. It should be noted that the Town of Nantucket did undertake water quality monitoring in 2011, however, those samples were analyzed by a lab other than the Coastal Systems Analytical Facility at the UMASS School for Marine Science and Technology. The 2011 water quality data is presented in tabular form in Appendix A in Annual Technical Memoranda (2012, 2013) and are not being reproduced again herein.

The physical parameters measured in the estuaries during the 2015 sampling season included: total depth, Secchi depth (light penetration), temperature, conductivity/salinity (YSI meter), general weather (rain, cloudiness, etc), wind force and direction, dissolved oxygen levels and observations of moorings, birds, shell fishing and unusual events (fish kills, algal blooms, etc). Laboratory analyses of estuarine waters included: salinity, nitrate + nitrite, ammonium, dissolved organic nitrogen, particulate organic carbon and nitrogen, chlorophyll-*a* and pheophytin-*a* and orthophosphate. Similar to the summer of 2014, the water quality monitoring undertaken in 2015 was focused mostly on estuarine stations with an additional 3 stream locations. In 2015, 32 field duplicates were taken as part of the field sampling protocol for QA analysis. Data were compiled and reviewed by the laboratory for accuracy and evaluated to discern any possible artifacts caused by improper sampling technique, physical disturbance, etc. In addition, some samples were rerun to confirm prior results.

The Town of Nantucket has been working for decades to protect and more recently restore its estuaries and their aquatic resources. At present, activities to lower nitrogen enrichment and its negative impacts to water quality are underway associated with Nantucket Harbor (jetties and sewers), Long Pond (landfill), Sesachacha Pond (openings), Hummock Pond (refined opening protocol). All estuaries should also benefit from the recent fertilizer application by-law. As a result, it is anticipated that the monitoring data will begin reflecting these activities. As noted below, summer 2015 appears to have sustained high water quality for most Nantucket Harbor stations though some did show a possible slight decrease in water quality. Hummock Pond water quality in the summer of 2015 showed improvement, most likely due to newly implemented opening protocol resulting in significantly more effective openings and continuing trend

toward improved conditions in Long Pond and decline in Miacomet Pond seen in the chlorophyll a pigments, nitrogen and eutrophication index (see below). This analysis revealed that the significant improvement in Sesachacha Pond seen previously has diminished and the Pond has declined in nitrogen related water quality over the past 2 years (2014, 2015) possibly due to the inlet openings. If so, this recent decline should be readily reversible.

Table 1a. Sampling Schedule for 2015 Nantucket Water Quality Monitoring Program

Month	Nantucket Harbor	Madaket Harbor	Long Pond	Sesachacha Pond	Miacomet Pond	Hummock Pond	Polpis Streams	Oyster Sites
Jan								
Feb								
Mar								
April								
May	May 7		May 12	May 11	May 11	May 12, 27		
June	June 9, 22	June 8	June 17	June 15	June 15	June 17	June 8	June 9
July	July 8, 20	July 6	July 13	July 15	July 15	July 13	July 6	July 6
August	Aug 4,19	Aug 5	Aug 17	Aug 10	Aug 10	Aug 12	Aug 3, 31	Aug 3
September	Sept 1	Sept 3	Sept 14	Sept 10	Sept 10	Sept 9		Sept 2
October								
November								
December								
Total Events	**8**	**4**	**5**	**5**	**5**	**6**	**4**	**4**

Table 1b. Sampling Schedule for 2014 Nantucket Water Quality Monitoring Program

Month	Nantucket Harbor	Madaket Harbor	Long Pond	Sesachacha Pond	Miacomet Pond	Hummock Pond
Jan						
Feb						
Mar						
April						
May	May 6		May 14	May 20	May 14	May 7, 19
June	June 4, 17	June 19	June 11	June 12	June11	June 10
July	July 1, 17	July 2	July 23	July 30	July 30	July 23
August	Aug 4, 14	Aug 18	Aug 21	Aug 19	Aug 19	Aug 21
September	Sept 2, 15*	Sept 15	Sept 4	Sept 4	Sept 18	Sept 18
October						
November						
December						
Total Events	**8**	**4**	**5**	**5**	**5**	**6**

Note: * The September 15 sampling of Nantucket Harbor only involved one station (NAN-4).

Table 1c. Sampling Schedule for 2013 Nantucket Water Quality Monitoring Program

Month	Nantucket Harbor	Madaket Harbor	Long Pond	Sesachacha Pond	Miacomet Pond	Hummock Pond
Jan						
Feb						
Mar						
April						
May		May 28		May 22	May 22	May 21
June	June 13, 25	June 12	June 4,26	June 5	June 5	June 6
July	July 17, 30	July 16	July 10	July 9	July 9	July 2
August	Aug 13, 28	Aug 12	Aug 21	Aug 21	Aug 6	Aug 14
September	Sept 9	Sept 10	Sept 24	Sept 19	Sept 24	Sept 18
October						
November						
December						
Total Events	**7**	**5**	**5**	**5**	**5**	**5**

Table 1d. Sampling Schedule for 2012 Nantucket Water Quality Monitoring Program

Month	Nantucket Harbor	Madaket Harbor	Long Pond	Sesachacha Pond	Miacomet Pond	Hummock Pond
Jan						
Feb						
Mar						
April						
May	May 29					
June	June 7, 28	June 12	June 25	June 20	June 20	June 27
July	July 9, 26	July 11	July 24	July 19	July 19	July 31
August	Aug 7, 22	Aug 8	Aug 21	Aug 23	Aug 23	Aug 24
September	Sept 6	Sept 7	Sept 25	Sept 25	Sept 27	Sept 26
October						
November						
December						
Total Events	**8**	**4**	**4**	**4**	**4**	**4**

Table 1e. Sampling Schedule for 2010 Nantucket Water Quality Monitoring Program

Month	Nantucket Harbor	Madaket Harbor	Long Pond	Sesachacha Pond	Miacomet Pond	Hummock Pond	Streams
Jan							
Feb							
Mar							
April							
May	May 18	May 20	May 19	May 26	May 26	May 25	
June	June 2, 17	June 3, 15	June 17	June 24	June 24	June 29	June 28
July	July 1, 15, 30	July 16, 27	July 29	July 26	July 26	July 28	
August	Aug. 13	Aug. 12, 30	Aug. 11	Aug. 26	Aug. 26	Aug. 27	
September	Sept. 1, 14	Sept. 13	Sept. 15	Sept. 23	Sept. 23	Sept. 28	
October	Oct. 21						
November							
December							
Totals	**10**	**8**	**5**	**5**	**5**	**5**	**1**

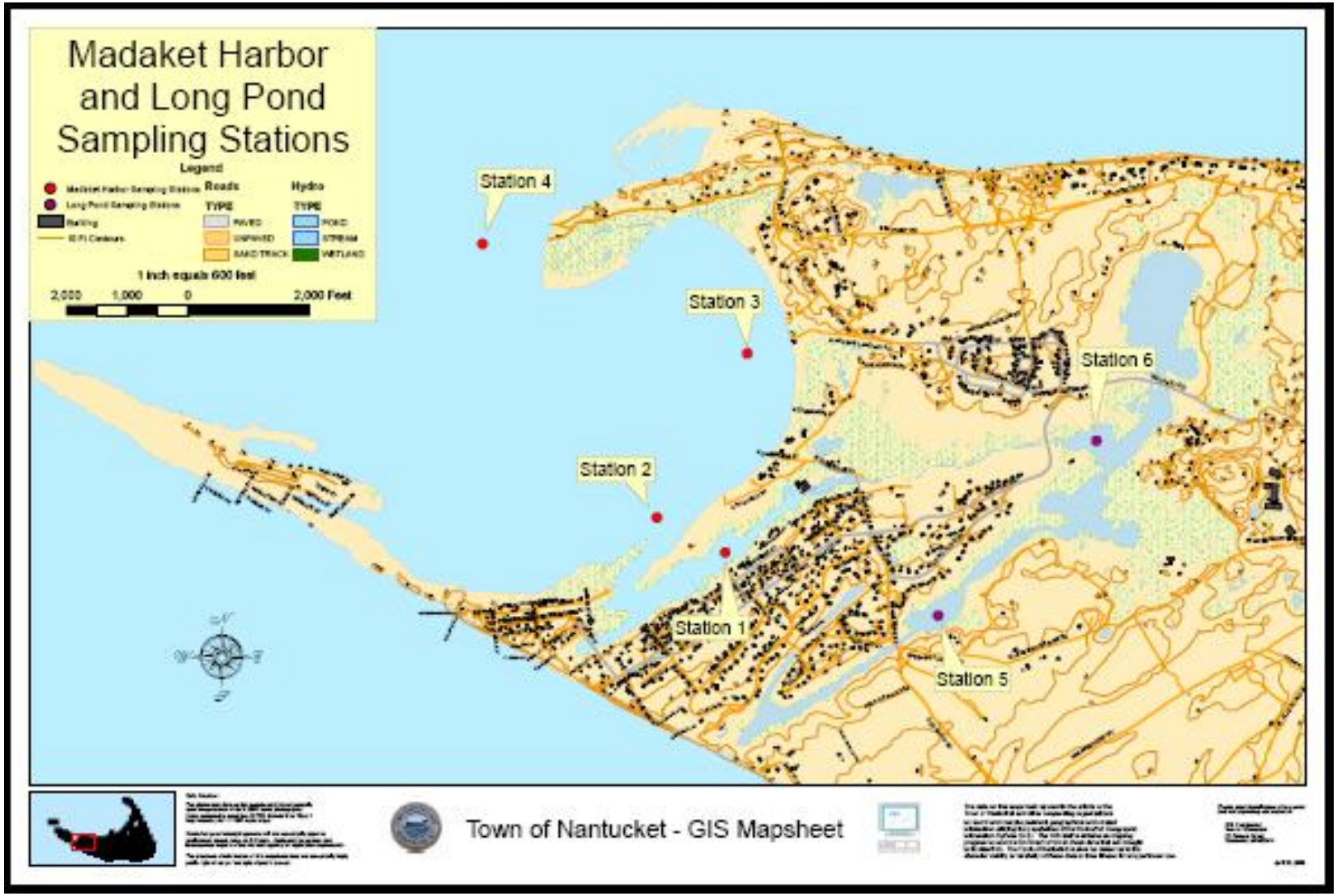

Figure 1. Madaket Harbor and Long Pond sampling stations 2010, 2012, 2013, 2014, and 2015.

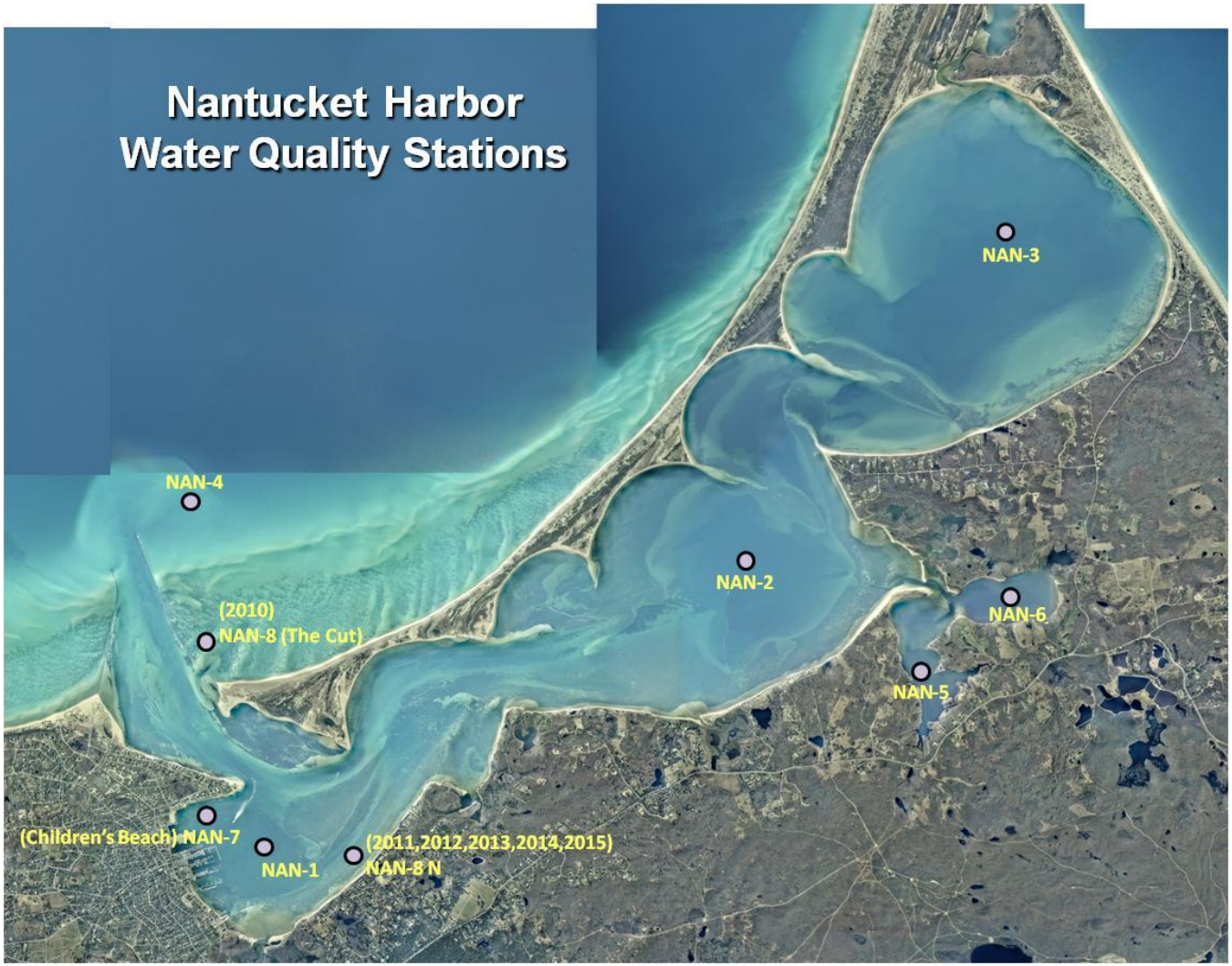

Figure 2. Nantucket Harbor sampling stations 2015. Station NAN-8 (the cut) was only sampled in 2010 and location changed in 2011 - 2015. Nantucket Harbor and Polpis Harbor each have nitrogen thresholds in the MassDEP/USEPA TMDL for this system.

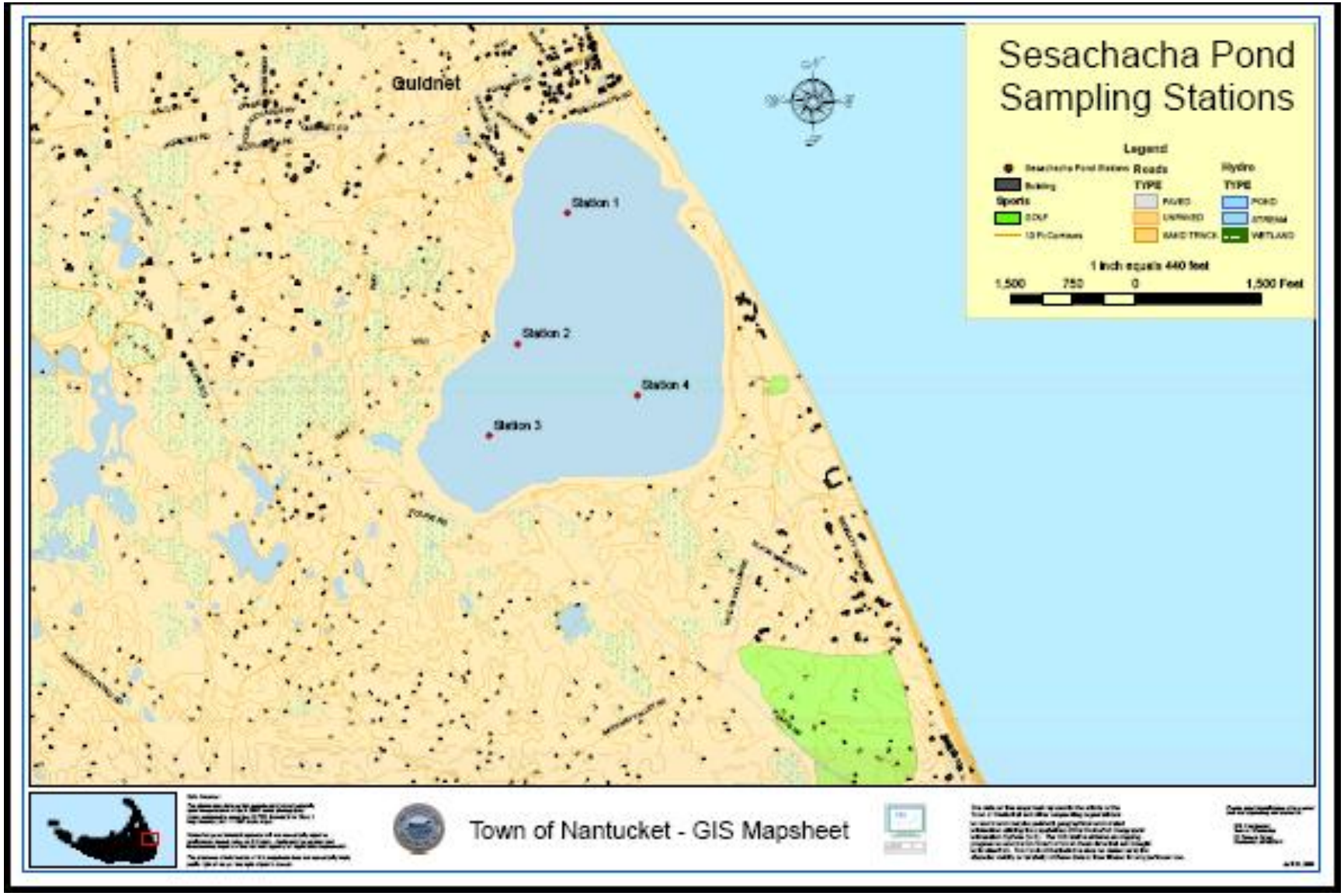

Figure 3. Sesachacha Pond sampling stations 2010, 2012, 2013, 2014, 2015.

Figure 4. Hummock Pond sampling stations 2010, 2012, 2013, 2014, 2015. Station 7 is in Head of Hummock, a kettle pond connected by an artificial channel to the estuary and a configuration that maintains a salinity gradient from Station 7 to Station 8.

Figure 5. Miacomet Pond sampling stations 2010, 2012, 2013, 2014, and 2015.

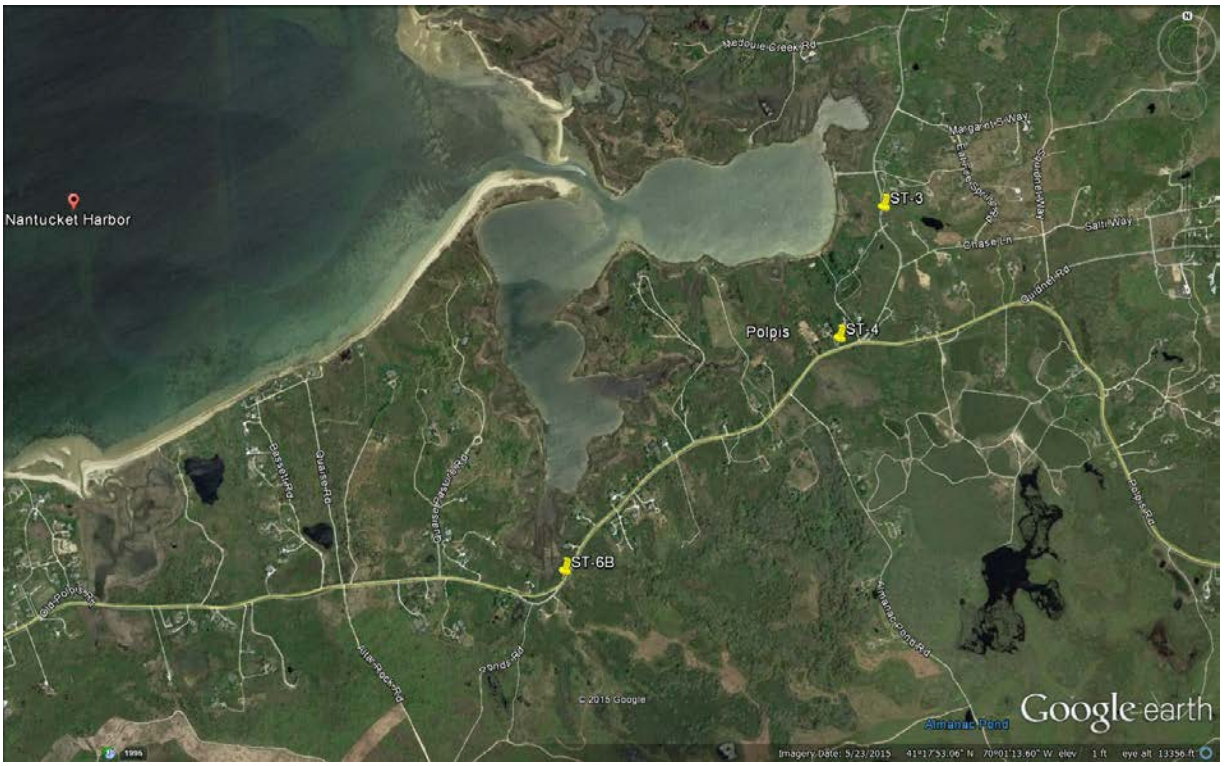

Figure 6. Polpis Harbor Stream Sampling locations (ST-3,4,6B) 2015. Water samples from mid depth in water exiting culverts.

Figure 7a. Oyster Aquaculture Sampling locations Nantucket Harbor (ORS-2,3,4,5,6) and Madaket Harbor (ORS-1) 2015. Sites are associated with possible oyster aquaculture areas.

Figure 7b. Oyster Aquaculture Sampling location Madaket Harbor (ORS-1) 2015. Site is associated with possible oyster aquaculture areas.

Summary of 2015 Water Quality Results for Nantucket Sampling

While there were some localized areas of interest (Hummock Pond {+}, Miacomet Pond {-}, Long Pond {+}[1], see below), the overall trends in water quality observed in 2015 follow and expand the pattern observed in 2010, 2012, 2013, 2014. Water samples collected from May through September in the estuarine systems indicate that organic nitrogen (dissolved + particulate) still dominates the Total Nitrogen pool (96% in 2015 alone), while bio-available nutrients in the form of nitrite and nitrate (NOx) and ammonium (NH_4) account for only 4% of Total Nitrogen pool in 2015 (Table 2a,b,c,d,e Figure 14). The observed distribution of the nitrogen fractions comprising total nitrogen are typical for estuarine systems throughout New England, where nitrogen is the nutrient responsible for eutrophication and therefore the nutrient critical for management.

The predominance of organic nitrogen in the Total Nitrogen (TN) pool in these systems would indicate that they are effectively converting the bioavailable inorganic forms of nitrogen into organic forms (e.g. phytoplankton). Where tidal flushing is effective, much of this particulate matter along with dissolved nutrients is washed out of the system resulting in good water clarity as evidenced by the greater Secchi depth readings in the main basins of Nantucket Harbor and Madaket Harbor in 2015 (Table 2a), as noted in prior years as well (Table 2b,c,d,e). Consistent with the water clarity, corresponding chlorophyll-*a* pigment concentrations were lowest (2-4 ug/L) in these well flushed systems (Table 2a,b,c,d,e, Figure 8,9). The level of variation is common and underscores the need for multi-year monitoring to establish trends.

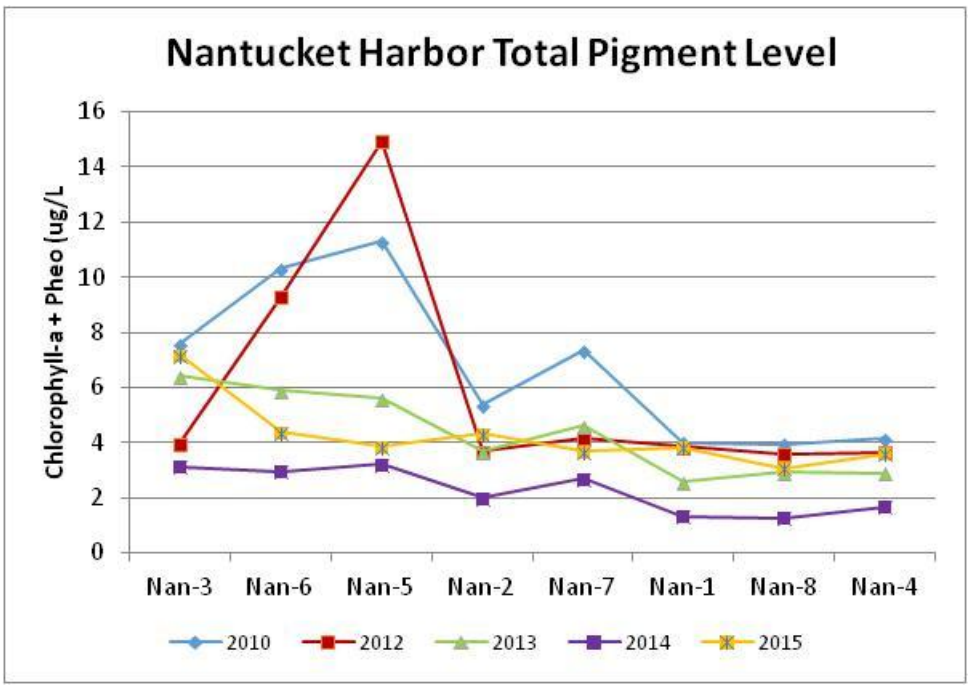

Figure 8. Average Chlorophyll-*a* (CHLA) concentrations by station in the well flushed Nantucket Harbor system during the summer 2015 sampling season. Stations Nan-5

[1] {+} indicates improved conditions in 2015; {-} indicates declining conditions in 2015.

and 6 are in Polpis Harbor the rest relate to the main basin. Note that 2015 levels were about average within the upper basins and relatively constant throughout the Harbor at a level consistent with low-moderate nitrogen enrichment.

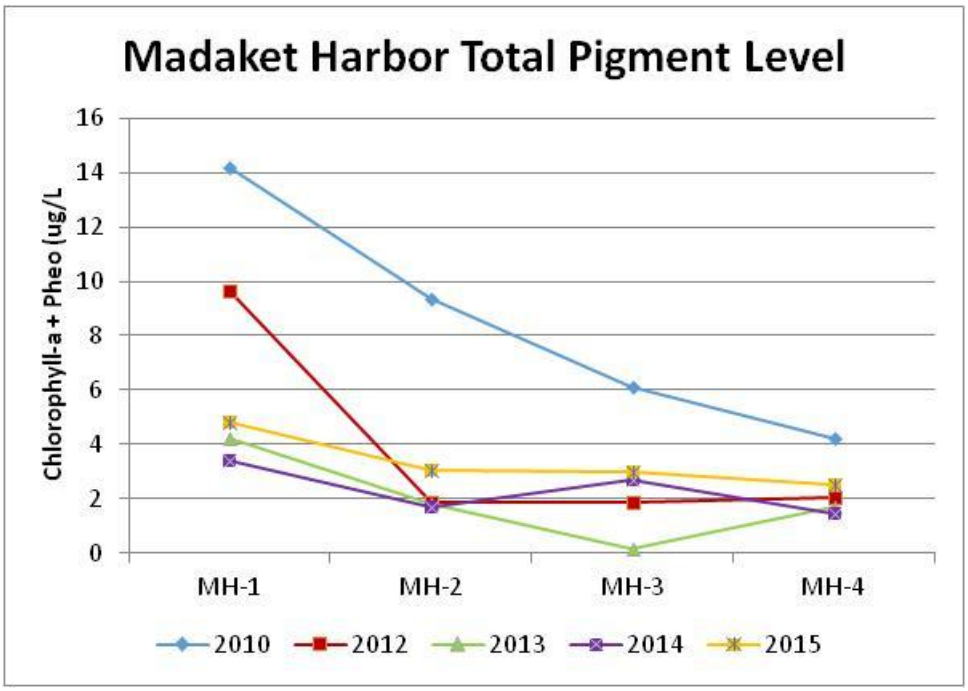

Figure 9. Average Chlorophyll-*a* (CHLA) concentrations by station in the well flushed Madaket Harbor system during the summer 2015 sampling season. Stations MH-2,3,4 are in the main open basin, MH-1 is the MEP sentinel station in Hither Creek. The 2010 blooms have not been as prevalent in recent years but 2015 total pigment levels were slightly higher than in 2014, similar to the lower reaches of Nantucket Harbor.

While Nantucket Harbor and Madaket Harbor are both well flushed basins, they tended to have slightly higher phytoplankton biomass (chlorophyll-*a*) in 2015 compared to 2014. This was most striking in Nantucket Harbor where average chlorophyll-*a* at station 3 was high compared to prior years. In Madaket Harbor the levels were also higher than all years but 2010. This is consistent with the lower water clarity observed in 2015 (Nantucket Harbor station 3 secchi depth 2014 = 3.1 m, 2015 = 1.45 m, Madaket Harbor MH-2 secchi 2.5 meters in 2014, 2.2 in 2015) as turbidity is primarily the result of organic particulates, e.g. phytoplankton. The parallel measurements of total nitrogen (TN) are generally consistent with the chlorophyll-*a* results, showing higher TN levels with higher chlorophyll-*a* levels (see below). This is particularly apparent in Nantucket Harbor (station 3) and provides additional evidence that nitrogen is the eutrophying nutrient in these systems.

Where tidal flushing is more restricted in Long, Hummock, Miacomet and Sesachacha Ponds, the moderate levels of water clarity were consistent with the chlorophyll-*a* concentrations that have a higher (2x-3x) average (compared to Nantucket and Madaket Harbors), 5.7 ug/L (max. 11.37 ug/L), 4.6 ug/L (max. 16.6 ug/L), 37.96 ug/L (max. 158.6 ug/L) and 6.74 ug/L (max. 10.74 ug/L), respectively (Table 2a, Figures 10, 11,12,13). These general patterns were also observed in the monitoring results of the prior year (2014, 2.6 ug/L, 4.4 ug/L, 4.2 ug/L and 3.0 ug/L). However, it should be noted that the

chlorophyll-*a* levels in Long Pond, Hummock Pond, Miacomet Pond and Sesachacha Pond all appear to be higher when compared to 2014 average values. In Sesachacha Pond chlorophyll-*a* levels have risen slightly in 2015 compared to 2014 (maybe due to a less effective opening compared to the prior years of 2012, 2013 and 2014). Additionally, total pigment values (chlorophyll-a + pheophytin) were significantly higher in Miacomet Pond in 2015 compared to 2014 (45.9 ug/L vs. 11.1 ug/L). While generally all the sampling dates for Miacomet Pond showed elevated levels for total pigment in 2015, consistent with other estuaries, one date had exceptionally high values at all stations indicating that sampling likely occurred during a strong bloom event. The multi-year results clearly show that 2010 was a poor water quality year as was also seen in the open basins, e.g. Madaket Harbor. Over the past 4 years, chlorophyll-*a* levels in Long Pond, Hummock Pond, Miacomet Pond and Sesachacha Pond have dropped compared to historic levels and 2010 but do show variation (e.g. all ponds higher in 2015 compared to 2014). However, Sesachacha Pond showed much improved water quality compared to its long term status during the MEP assessment that indicated chlorophyll-*a* levels generally >20 ug/L, frequently >60 ug/L and blooms as high as 100 ug/L. It appears that Sesachacha Pond quality is tightly linked to the success of its periodic openings, which significantly improved conditions in 2012 and 2013, but has recently showed declines in 2014 and 2015. This was clearly seen in 2014 as well as 2015 though in 2015 TN levels appeared higher than in 2014 with an associated increase in total pigment levels (potentially related to a less effective opening in 2015 compared to 2014). The temporal data indicate that Sesachacha Pond can be significantly restored by improved pond openings and that recent openings need to be re-examined relative to the recent increase in nitrogen enrichment and associated water quality metrics (chlorophyll, dissolved oxygen).

After a significant drop in chlorophyll-*a* in 2013 (versus 2010, 2012) Long Pond has maintained its phytoplankton levels at a high/moderate level 2013-2015. This decline was noted previously and is possibly a result of activities at the landfill leading to declining nitrogen inputs. However, Long Pond continues to be eutrophic and impaired. In contrast, Miacomet Pond which is not open to tidal flows and has become very fresh (avg. salinity 0.10 ppt), showed a large increase in chlorophyll-*a* levels in 2015 and showed the highest levels since the monitoring program began and the highest of all Nantucket's estuaries. Miacomet Pond is clearly supporting eutrophic conditions for both fresh and salt water (>35 ug/L total pigment). Moreover the phytoplankton bloom was pond-wide and persisted throughout the sampling period.

Hummock Pond showed significantly lower total chlorophyll-*a* levels in summer 2015 than prior years (2010,2012,2013) although slightly higher compared to 2014. The 2014 results were the lowest levels measured over the 2010-2015 monitoring period and while 2015 was slightly higher than 2014, chlorophyll levels in 2015 were still moderate-high as a metric of eutrophication. While two years (2014 and 2015) only represent the beginning of a restoration trend, the lower levels in those two years is consistent with an improved opening protocol developed in 2014 for the Hummock Pond openings. The Town and the Nantucket Land Council entered into a project to refine the opening protocol for Hummock Pond to maximize the amount of tidal flushing achieved by the openings. The April 2014 opening of Hummock Pond was moderately successful followed by a more effective opening in October 2014 which lowered TN levels in the pond and raised its salinity. It is possible that the combination of the good opening and the meteorological conditions that appear to have supported higher water quality in most

of the estuaries in summer 2014 was the cause of the relatively low total chlorophyll-*a* and TN in Hummock Pond in 2014. Total chlorophyll-*a* was the lowest at each monitoring station in 2014 when compared to prior years. In April 2015, Hummock Pond was opened and water levels and water quality were monitored before and after the opening. The April 2015 opening did appear to be a more effective opening compared to the October 2014 opening thereby contributing to the enhanced water quality observed during the summer 2015. Average TN levels in the summer of 2015 were moderately lower than in summer 2014 (0.583 mg/L and 0.715 mg/L respectively) though average total pigment in 2015 was slightly higher than in 2014 (9.68 ug/L and 7.08 ug/L respectively). It is possible that the slightly higher total pigment values observed in 2015 despite slightly lower TN values is the result of the warmer conditions experienced during the summer of 2015. Also, it is clear that the pond has not reached equilibrium with its new hydrodynamic conditions, such that further improvements are anticipated if the new opening protocol is continued. The opening protocol will be further refined as more data is gathered from future openings and the water quality monitoring will allow evaluation of this revised management tool.

System	min CHLA (ug/L)	max CHLA (ug/L)	avg CHLA (ug/L)
Miacomet Pond	2.80	204.83	41.26
Sesachacha Pond	3.08	11.23	6.79
Long Pond	2.56	11.37	5.44
Hummock Pond	1.00	19.71	4.50

System	min Total Pig (ug/L)	max Total Pig (ug/L)	avg Total Pig (ug/L)
Miacomet Pond	9.55	204.86	48.71
Sesachacha Pond	6.56	18.79	11.10
Long Pond	4.40	19.54	9.30
Hummock Pond	2.92	43.41	9.24

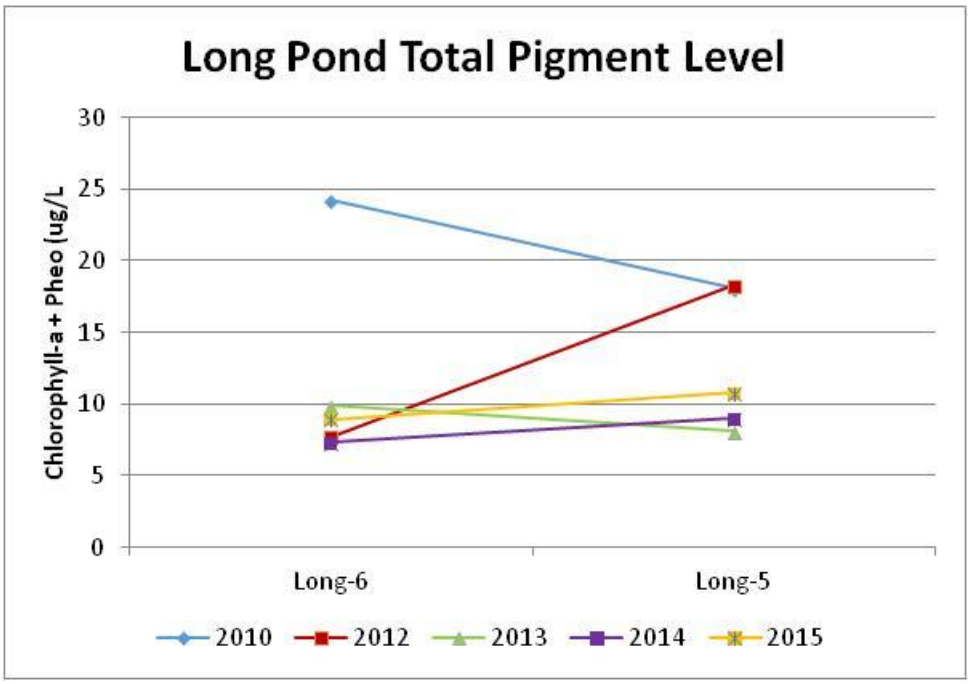

Figure 10. Average Chlorophyll-*a* (CHLA) concentrations by station in the Long Pond portion of the Madaket Harbor system during the summer 2015 sampling season compared to 2010, 2012, 2013, and 2014.

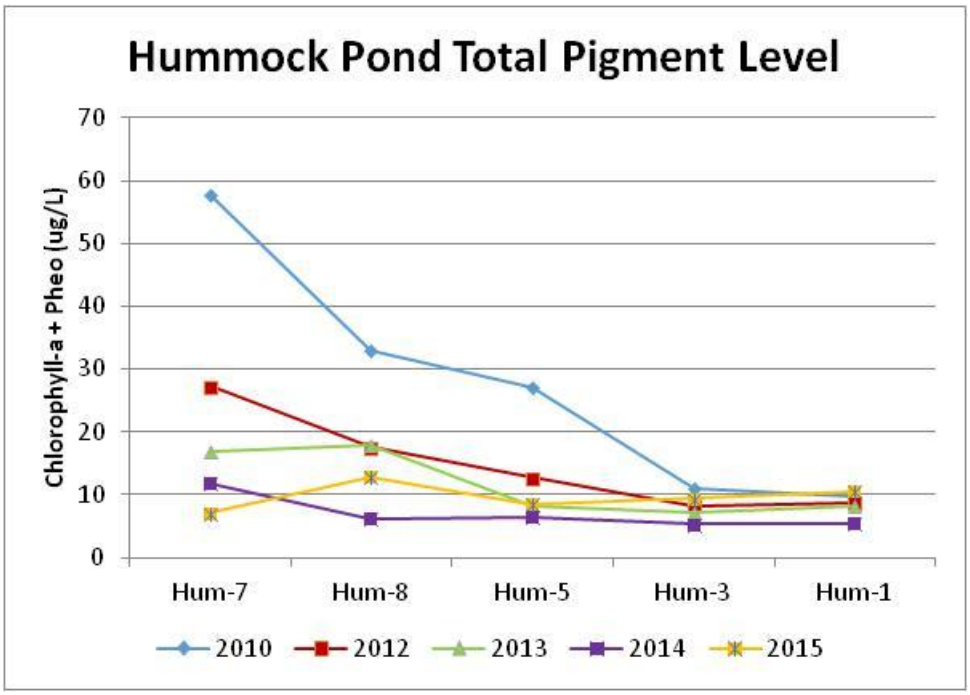

Figure 11. Average Chlorophyll-*a* (CHLA) concentrations by station in the seasonally opened Hummock Pond system during the summer 2015 sampling season compared to 2010, 2012, 2013, and 2014.

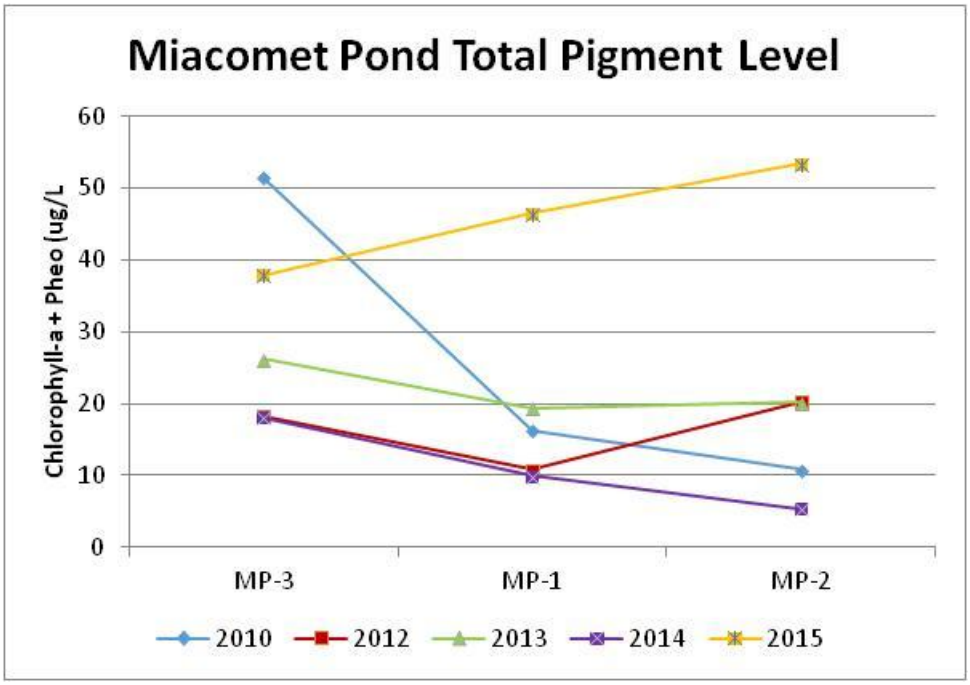

Figure 12. Average Chlorophyll-*a* (CHLA) concentrations by station in the Miacomet Pond system during the summer 2014 sampling season compared to 2010, 2012, 2013, and 2014 Miacomet Pond is not opened to the Atlantic Ocean.

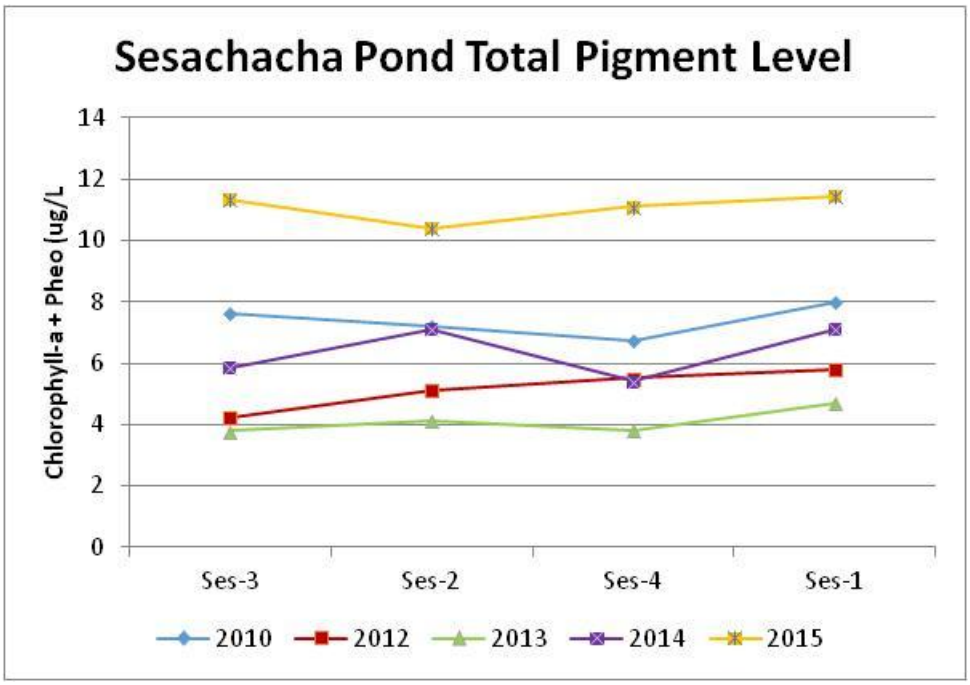

Figure 13. Average Chlorophyll-*a* (CHLA) concentrations by station in the seasonally opened Sesachacha Pond system during the summer 2015 sampling season compared to 2010, 2012, 2013, and 2014.

Average Total Nitrogen values in Hummock Pond were lower in 2015 even though total pigment appeared slightly higher than in 2014. Total nitrogen averaged 0.583 mg/L in 2015 whereas in prior years [2014, 2013, 2012, 2010] average TN values where [0.715, 0.900, 0.923, 0.944] mg/L respectively. This temporal trend is consistent with the timing of improved flushing observed in 2014 and 2015 openings, as is the decline from 2014 to 2015 which is expected from a system in transition. In contrast, Miacomet Pond which had no restoration activities or openings showed higher TN levels in 2015 compared to the previous 4 years of monitoring: 1.202 mg/L compared to [0.982, 0.962, 0.919, 0.886] mg/L respectively. These high levels of TN are consistent with small estuaries that only receive tidal water through periodic openings (Hummock Pond) or overwash during storm events (Miacomet Pond) and are poorly flushed. The effect of flushing is clearly seen by comparing TN and pigment levels in Nantucket's well flushed estuaries (Nantucket and Madaket Harbors) to these "closed" poorly flushed estuaries.

Total Nitrogen values appear to be temporally variable in both Long Pond 0.656-0.697 [1.14, 0.795, 0.94,1.75] mg/L and in Sesachacha Pond 0.904 [0.922, 0.669, 0.704, 0.639] mg/L. Like Hummock and Miacomet Ponds, Long Pond and Sesachacha Ponds are also poorly flushed. In the case of Sesachacha Pond, the TN levels also appear to be related to the success of the periodic openings. The similar TN levels in 2015 as compared to 2014 likely relate to similar opening characteristics and are higher than the prior 2 years which had better openings. It is worth noting that the high historic levels and 2010 levels were under less robust opening conditions, prior to the Town's new awareness of the importance openings as a pond management tool. It should be noted that TN levels in 2015 (and 2014) remain significantly lower than during the MEP assessment and suggest that achieving the TMDL may be possible by refined openings,

saving infrastructure costs. Average TN levels in all 4 ponds are significantly higher than average values in the “offshore” stations NAN 4 and MH4 which average 0.297 [0.277, 0.317, 0.344, 0.302] and 0.328 [0.254, 0.278, 0.297, 0.285] mg/L, respectively (Tables 2a, 2b, 2c, 2d, 2e, Figures 1, 2). It should be noted that the average offshore TN concentration for station MH4 is 0.295 mg/L if the 8/5/2015 sampling date (TN concentration = 0.427 mg/L) is not included in the calculation. It is possible that sample data for that one sampling date is aberrant, which is supported by statistical analysis of the complete data set (2010-2015).

Long Pond showed significantly lower TN levels (~40%) in 2012 versus 2010. Levels at Station 5 declined from 2012 to 2013 and held steady or improved in 2013, however there was an increase in average TN levels from 2013 to 2014 at station 5 (1.48 mg/L in 2014 vs. ~0.70 mg/L in 2013). TN concentrations at station 5 declined again in 2015 to 0.656 mg/L from 1.48 mg/L in 2014. This variation in TN levels at station 5 needs to be tracked closely by the monitoring program, as MEP modeling suggests that conditions will improve as the landfill process continues. Station 6 continued to show a decrease in TN concentrations. Station 6 TN concentrations in 2015 dropped to 0.697 mg/L from 0.788 mg/L in 2014. Based on the lower TN concentrations observed in 2015, it is possible that the increase in TN levels at station 5 from 2013 to 2014 represented a natural inter-annual variation. While it is unusual for one station to increase and not the adjacent station, in this case it may be the result of poor horizontal mixing in Long Pond due to a changes in tidal action through Madaket Ditch. Although it has been observed previously, mixing even if through only dispersion should not allow the large difference in TN levels. Continued monitoring of station 5 is warranted. The long-term lowering of the TN levels, particularly at station 6, appears to follow Town activities at the landfill, as 2015, 2014 and 2013 TN levels follow a downward trend and chlorophyll-*a* levels in Long Pond are significantly lower than in 2010 and 2012 and generally similar to what was measured in 2013 and 2014. The monitoring program will be assessing potential causes of the large temporal variations in the lower basin of Long Pond (Station 5).

As in all previous years, in Sesachacha Pond, there is no noticeable nutrient or chlorophyll gradient among any of the 4 Stations (Figure 13 and 14, Tables 2a,b,c,d,e) because of the closed nature of the pond and the shape of its basin, it's mixing is more like a freshwater lake than an estuary. However, it should be noted that while TN and chlorophyll-*a* concentrations in Sesachacha Pond where generally higher in 2014 compared to 2013, TN levels in 2015 remained high and very similar to 2014 (0.904 mg/L and 0.922 mg/L respectively). Total pigment in 2015 was higher than what was observed in 2014 (11.07 ug/L and 6.37 ug/L respectively), however, the higher pigment levels in 2015 were generally observed across all the estuaries of Nantucket indicating the higher levels likely meteorologically related. It should be noted that the average temperature May-September 2015 (22.6 degrees Celsius) was highest when compared to 2010-2014 (22.5, 19.8, 22.3, 19.6, 19.3 degrees Celsius respectively). That there was a noticeable increase from 2013 to 2014 and consistency between 2014 and 2015 is good reason to continue regular monitoring of the system, particularly to determine changes in the effectiveness of annual pond openings that are the likely driver for increased or decreased water quality in a given year. However, TN levels are now above the nitrogen threshold in the TMDL, and the 2014 and 2015 increase is a cause for concern, particularly after a few years of much lower TN levels (~0.6 mg/L).

Consistent with previous years monitoring results, Madaket Harbor shows a clear nitrogen gradient (and associated metrics) from Station 1 in Hither Creek (which receives discharge from Long Pond via Madaket Ditch), and is relatively poorly flushed, out to Station 2 in the Harbor, with further decreases out to the off-shore Station 4 (Figure 9 and 14, Table 2a). Similarly, in Nantucket Harbor, there is a very small nutrient gradient from Wauwinet at the Head of the Harbor and the more enclosed Polpis stations out to the entrance at Stations 8 and 4. There is also a chlorophyll gradient with the highest concentrations at the 2 Polpis Stations (5 and 6) and Wauwinet basin, decreasing in the main Harbor and out to the off-shore Station 4.

Average 2015 [2014, 2013, 2012, 2010] TN level in Madaket Harbor (Stations 1-3, not including Station 4, offshore) was 0.422 [0.390, 0.404, 0.485, 0.462] mg/L, compared to the off-shore Station 4 0.328 [0.254, 0.278, 0.297, 0.285] mg/L. As mentioned above, the best estimate of the offshore TN concentration for station MH4 is 0.295 mg/L.

Average TN in Nantucket Harbor (all Stations except Station 4, offshore) were quite low averaging 0.381 mg/L compared to 2010, 2012, 2013, 2014, with the offshore boundary station 4 averaging only 0.297 mg/L in 2015 (Tables 2a, 2b). It should be noted that the 2010 value includes station NAN-8 (the cut) whereas the 2015, 2014, 2013 and 2012 value includes station NAN-8N which was relocated into the Town Basin within the Harbor (refer to Figure 2 for station location). TN concentrations in the 6 streams adjacent to Nantucket Harbor in 2010 ranged from 0.565 mg/L in Stream 8 to 2.139 mg/L in Stream 6B (Table 2e). In spite of the high TN concentrations in these 6 streams and the TN loads that these streams contribute to the Harbor, tidal flushing and dilution with lower concentration Harbor waters seems to be an effective mechanism to keep TN levels in the main body of the Harbor relatively low (Table 2a,b,c,d; Figure 2). A subset of streams sampled in 2010 where sampled again in 2015 and the results are discussed below. It should be noted that the stream stations were not sampled in 2012, 2013 or 2014, however, with increasing interest in lowering TN concentrations in Polpis Harbor, it was warranted to periodically sample streams discharging to this tributary sub-embayment. TN concentrations in East Polpis Harbor, 0.404 [0.378, 0.401, 0.438, 0.484] mg/L and West Polpis Harbor 0.422 [0.389, 0.385, 0.431, 0.419] , which are fed by the high TN levels in Streams 4, 6B and 6C, are somewhat higher than the levels in the main Harbor, but still significantly lower than the levels in the streams themselves (Table 2, Figure 2). It should be noted that these two stations in Polpis Harbor (NAN-5 {Polpis west} and NAN-6 {Polpis east}) do show an increased TN concentration compared to levels observed in 2014. TN levels remain above the nitrogen threshold for these basins, although total chlorophyll-*a* was still relatively low in 2015. Total pigment at Stations NAN-5 and NAN-6 were slightly higher in 2015 compared to 2014 reflecting the slightly higher TN in that year and warm summer conditions in 2015. Overall, TN concentrations in Nantucket Harbor were slightly higher in 2015 (0.381 mg/L) compared to summer 2014 (0.324 mg/L). As such it is important to continue summer water quality monitoring and watershed based nutrient management. However a full evaluation of the streams would be to add stream volumetric flow to the stream sampling such that nitrogen load to the harbor could be monitored, as load is associated with the harbor TN levels.

Relative to the 2015, 2014, 2013, 2012 and 2010 data sets, results indicate that within Long, Hummock and Miacomet ponds, there is a general gradient of nutrient (N and inorganic P) and chlorophyll concentrations from high levels in the upper, more enclosed

and poorly flushed reaches of the estuaries to lower concentrations closer to the outlets where flushing is more effective (Figure 14), although the gradient appears to be a bit flatter in 2015 for both Hummock Pond and Long Pond. Based on average TN values in Hummock Pond, water quality in 2015 appears improved over prior years, but not enough to meet the nitrogen threshold needed for restoration. In Miacomet Pond, while average TN values in 2014 were generally similar to 2013 (0.982 mg/L vs. 0.962 mg/L), TN values in 2015 were even higher (1.202 mg/L) and chlorophyll-*a* levels were also significantly higher than in 2014 and 2013. These are very high TN levels for this basin. However, Miacomet Pond in 2015 as in 2014 likely had phytoplankton production (e.g. chlorophyll-*a*) also controlled by phosphorus levels, as the salinity has declined to ~0.1 ppt, due to the extended time since this basin was opened to the tides. As TP and PO4 samples were collected in parallel with the nitrogen fractions in the 2015 surveys of Miacomet Pond, it was possible to assess nitrogen versus phosphorus significant to eutrophication from the N to P ratios as well as Carbon to Nitrogen (C/N) ratios. These field ratios are compared to the idealized Redfield Ratios (C:N:P, 106:16:1) to get a first approximation of the degree to which N or P maybe structuring the pond. Interestingly, C/N ratios remain relative consistent from the head to the lowest basin of the pond closest to the ocean (MP3 - MP1 - MP2, C/N ratio 6.5, 6.8, 6.5 respectively, Redfield C/N ratio is 6.62). This supports the contention that phytoplankton comprise almost all of the particulate matter in the pond. The nutrient data showed significant variation between the pond basins, with N/P ratios lower at the head and increasing to the middle and lower portions (MP3 - MP1 - MP2, N/P ratio 16.9, 36.9, 34.4 respectively, Redfield N/P ratio is 16). Ratios significantly greater than 16 indicate that phosphorus additions likely result in increased eutrophication and that Phosphorus should be a focus of pond management. This is the case in the middle and lower pond. The upper pond appears to be sensitive to both nitrogen and phosphorus, such that overall both nutrient need to be monitored and considered for management of Miacomet Pond.

More specifically, use of Redfield ratio information in freshwater is greatly enhanced when nutrient ratios are examined together with controlled biotests (bottle tests, mesocosms) with different levels of P and N amendments to natural phytoplankton community. These types of biotests were employed by the Coastal Systems Program for an assessment of Oyster Pond in Falmouth specifically to better determine the degree of N or P limitation in that coastal salt pond for nutrient management purposes. Comparison of algal biotest results and chemical nutrient concentrations in lakes has suggested that a mass N:P ratio above 17-20 indicates P limitation, a ratio below 10 indicates N limitation and values between 10 and 17 indicate that either of the nutrients may be limiting." (Petri Ekholm, Finnish Environment Institute, 2008). That there is a clear difference between the N/P ratios in the upper part of the pond versus the lower part of the pond and considering the N/P ratio at the uppermost station is ~16 and the lower station is significantly >16 (see table below) suggests that the upper portion of Miacomet could be either N limited or P limited while the middle and lower portions of the system are likely P limited. A more detailed examination of N and P cycling is warranted to ascertain which is playing a bigger role in the nutrient cycling of the pond system as a whole. At present, this pond appears to be shifting from a eutrophic brackish water system to a eutrophic freshwater ecosystem and should potentially be managed as such, taking into consideration which nutrient is dominant (N vs. P). However, management must include that periodic overwash from storms could upset the ecological balance of this system if it were managed purely as a freshwater system.

Station Id	N/P organic	PC/PN particulate	DIN/DIP inorganic	TN/TP total
MP-3	16.9	6.5	10.2	16.1
MP-1	36.9	6.8	10.3	34.3
MP-2	34.4	6.5	13.1	32.3

Unlike previous sampling years (2012, 2013, 2014), stream sampling and flow measurement was added to the 2015 monitoring program in Nantucket Harbor, particularly due to the interest in achieving the MEP TN threshold in Polpis Harbor (NAN-6 is considered the MEP sentinel station and with a TN threshold concentration of 0.355 mg/L for restoration). Samples collected from 3 stream stations (ST3, ST4, ST6B) discharging to Polpis Harbor showed high TN concentrations (1.218, 1.060, 1.10 mg/L respectively, based on data presented in Table 2). It should be noted that the average TN concentration for station ST3 is 1.038 mg/L if the 8/31/2015 sampling date (TN concentration = 0.499 mg/L) is included in the calculation. It is possible that sample data for that one sampling date is abnormally low compared to the results from the three other sampling dates at that station (0.939-1.554 mg/L). As such, the 8/31/2015 sample result was not utilized to calculate summer average TN concentration for station 3. Interestingly, stream sampling site ST4 and ST6B were sampled once (June) in 2010 and showed TN concentrations of 1.200 and 2.139 mg/L respectively. The 2010 concentrations are consistent with the high concentrations observed in 2015 and as such, warrants continued monitoring of stream nutrient concentrations and stream flow discharging to Polpis Harbor specifically. Management of these flows and nutrient loads may help to achieve the MEP TN threshold for Polpis Harbor at the sentinel station (NAN-6).

In addition to nutrient sampling, the Town of Nantucket staff measured the velocity of water flowing at each sampling location at the time water quality samples were being collected during the summer 2015 field season. While the CSP scientists are unaware of how the velocity and cross-sectional measurements were made, the town provided the critical stream flow values (m^3/d) to be coupled with the parallel measurements of total nitrogen concentration data to calculate TN load from these streams to Polipis Harbor in summer 2015. The flow determined for each sampling day was then used to determine load for a representative month. The flows and loads are provided below:

Sample ID	Date	Measured Flow (m3/d)	TN Load (kg/day)	TN Load (kg/month)	Representative Month
ST3	6/8/2015	365	0.424	12.7	June
ST3	7/6/2015	248	0.385	11.9	July
ST3	8/3/2015	127	0.119	3.7	August
ST3	8/31/2015	40	0.020	0.6	September
ST4	6/8/2015	2040	2.020	60.6	June
ST4	7/6/2015	1771	1.739	53.9	July
ST4	8/3/2015	0	0.000	0.0	August
ST4	8/31/2015	208	0.213	6.4	September
ST6B	6/8/2015	696	0.586	17.6	June
ST6B	7/6/2015	805	1.450	44.9	July
ST6B	8/3/2015	187	0.151	4.7	August
ST6B	8/31/2015	87	0.082	2.5	September

Combining the high TN concentrations with relatively large flows measured at ST4 and ST6B, it becomes clear that a relatively large TN load can be introduced to Polpis Harbor from the stream sites on a monthly basis. It is important to note that the large loads presented would actually be the lowest loads of the year as precipitation during the summer is typically much lower than in the winter and spring. Given this first approximation of the TN loads entering Polpis Harbor via streams, it would clearly be worth continuing measuring flow and nitrogen sampling in coming years of monitoring.

Additional estuarine stations (ORS-2,3,4,5,6) were added to the sampling stations in Nantucket Harbor and Madaket Harbor (ORS-1) specifically to monitor water quality in the vicinity of potential sites for oyster aquaculture. These stations have never previously been sampled so it is not possible to compare 2015 results to past years water quality, however, 2015 results can serve as the beginning of establishing a baseline for gauging changes in future years. Station concentrations are generally consistent with the water quality from nearby long term monitoring stations. In the future a detailed interpretation of the data collected at these stations will be possible once more data becomes available. Three stations sampled (ORS-1,5,6) are in addition to the stations identified prior to the summer 2015 sampling (e.g. Madaket, DucksHolm, Polpis). Additional analysis will be useful as additional data/information becomes available.

As noted about past years monitoring results, in reviewing the multi-year monitoring dissolved oxygen data, it does not appear that there is sufficient temporal sampling in any one year to capture the critical minimum oxygen levels. Therefore, while assessment of the oxygen levels in each estuary was performed, it will be necessary to conduct a multi-year composite analysis once sufficient data has been collected. It is also possible to strengthen the dissolved oxygen data base in specific estuarine basins as each years monitoring results are assessed through the deployment of continuously recording DO sensors. However this should only be performed on an “as needed basis” rather than as part of the long-term monitoring program. We have made some recommendations which we have noted at the end of the discussion section.

Table 2. Summary of Stream Water Quality Parameters (ST3,ST4,ST6B) and stations associated with potential oyster aquaculture locations (ORS1,2,3,4,5,6), **2015** Nantucket Sampling Program.

Sample ID	Date	Embayment	Avg. PO4 (mg/L)	Avg. NH4 (mg/L)	Avg. Nox (mg/L)	Avg. DIN (mg/L)	Avg. DON (mg/L)	Avg. TDN (mg/L)	Avg. POC (mg/L)	Avg. PON (mg/L)	Avg. TON (mg/L)	Avg. TN (mg/L)	Avg. Chla (ug/L)	Avg. Phaeo (ug/L)	Avg. Total Pig (ug/L)
ST3	6/8/2015	ND	0.011	0.012	0.056	0.068	0.369	0.437	9.117	0.724	1.093	1.160	2.334	4.934	7.267
ST3	7/6/2015	STREAMS TO POLPIS	0.012	0.007	0.052	0.059	0.369	0.429	19.465	1.126	1.495	1.554	0.884	2.088	2.971
ST3	8/3/2015	STREAMS TO POLPIS	0.021	0.004	0.049	0.052	0.330	0.382	10.349	0.557	0.886	0.939	0.025	0.757	0.782
ST3	8/31/2015	STREAMS TO POLPIS	0.010	0.010	0.050	0.059	0.229	0.289	4.055	0.211	0.440	0.499	0.476	5.067	5.543
ST4	6/8/2015	ND	0.037	0.010	0.001	0.011	0.942	0.953	0.539	0.037	0.979	0.990	0.612	1.536	2.148
ST4	7/6/2015	STREAMS TO POLPIS	0.044	0.010	0.000	0.010	0.935	0.945	0.454	0.037	0.972	0.982	0.261	0.652	0.913
ST4	8/3/2015	STREAMS TO POLPIS	0.168	0.026	0.002	0.028	0.975	1.003	4.852	0.243	1.218	1.246	0.109	0.482	0.591
ST4	8/31/2015	STREAMS TO POLPIS	0.077	0.020	0.001	0.021	0.905	0.926	1.596	0.098	1.003	1.024	1.104	1.266	2.370
ST6B	6/8/2015	STREAMS TO POLPIS	0.024	0.011	0.000	0.011	0.649	0.660	3.694	0.182	0.831	0.842	1.310	2.059	3.369
ST6B	7/6/2015	STREAMS TO POLPIS	0.166	0.007	0.001	0.007	0.790	0.797	22.908	1.003	1.793	1.801	0.329	0.745	1.074
ST6B	8/3/2015	STREAMS TO POLPIS	0.012	0.014	0.001	0.015	0.322	0.337	11.321	0.469	0.791	0.806	0.200	0.519	0.719
ST6B	8/31/2015	STREAMS TO POLPIS	0.026	0.077	0.014	0.091	0.411	0.502	9.627	0.443	0.854	0.945	3.178	7.018	10.196

Sample ID	Date	Embayment	Avg. PO4 (mg/L)	Avg. NH4 (mg/L)	Avg. Nox (mg/L)	Avg. DIN (mg/L)	Avg. DON (mg/L)	Avg. TDN (mg/L)	Avg. POC (mg/L)	Avg. PON (mg/L)	Avg. TON (mg/L)	Avg. TN (mg/L)	Avg. Chla (ug/L)	Avg. Phaeo (ug/L)	Avg. Total Pig (ug/L)
ORS1	6/9/2015	MADAKET	0.037	0.015	0.005	0.020	0.287	0.307	0.849	0.119	0.406	0.426	3.376	4.160	7.536
ORS1	7/6/2015	MADAKET HITHER CREEK	0.025	0.000	0.014	0.014	0.373	0.388	1.072	0.231	0.604	0.618	6.118	4.891	11.009
ORS2	6/9/2015	OLD NORTH WHARF	0.014	0.019	0.000	0.019	0.200	0.219	0.563	0.090	0.290	0.309	2.855	2.202	5.057
ORS2	7/6/2015	OLD NORTH WHARF	0.016	0.004	0.007	0.011	0.287	0.298	0.532	0.086	0.373	0.384	1.733	1.453	3.186
ORS2	8/3/2015	OLD NORTH WHARF	0.019	0.017	0.011	0.028	0.254	0.282	0.350	0.059	0.313	0.341	0.661	1.806	2.467
ORS2	9/2/2014	OLD NORTH WHARF	0.026	0.020	0.001	0.021	0.225	0.246	0.407	0.072	0.297	0.318	1.523	1.940	3.463
ORS3	6/9/2015	MONOMOY CREEKS	0.024	0.014	0.036	0.050	0.294	0.344	0.473	0.077	0.371	0.421	1.563	2.419	3.983
ORS3	7/6/2015	MONOMOY CREEKS	0.028	0.029	0.047	0.076	0.429	0.504	0.522	0.082	0.511	0.587	1.212	1.491	2.703
ORS4	8/3/2015	PIMENYS POINT	0.012	0.015	0.002	0.016	0.369	0.385	0.373	0.064	0.433	0.449	0.909	1.193	2.102
ORS4	9/2/2014	SHIMMO	0.026	0.056	0.003	0.059	0.214	0.273	0.596	0.109	0.323	0.382	2.712	2.476	5.188
ORS5	8/3/2015	DUCKS HOLM	0.009	0.012	0.003	0.015	0.460	0.475	0.351	0.063	0.522	0.537	0.904	0.849	1.753
ORS5	9/2/2014	DUCKS HOLM	0.014	0.013	0.000	0.013	0.302	0.315	0.493	0.089	0.391	0.404	1.237	2.264	3.501
ORS6	8/3/2015	POLPIS	0.020	0.013	0.000	0.013	0.533	0.546	0.683	0.112	0.645	0.658	1.589	2.614	4.204
ORS6	9/2/2014	POLPIS	0.035	0.050	0.000	0.050	0.299	0.349	0.561	0.094	0.393	0.443	1.451	2.696	4.147

Trophic State of the Estuaries of Nantucket Island

The Trophic State of an estuary is a quantitative indicator of its nutrient related ecological health and is based on concentrations of inorganic and organic Nitrogen, water clarity (Secchi Depth), lowest measured concentrations of Dissolved Oxygen (average of lowest 20% of measurements), and Chlorophyll-*a* pigments (surrogate for phytoplankton biomass/blooms). Trophic health scales generally range from Oligotrophic (healthy-low nutrient) to Mesotrophic (showing signs of deterioration of health due to nutrient enrichment) to Eutrophic (habitats impaired and degraded, high nutrient and organic matter). The Trophic Health Index Score used here is a standard numerical scale based on criteria for open water embayments and uses the above mentioned measured parameters to create a habitat quality scale (Howes et al. 1999, http://www.savebuzzardsbay.org). For the estuaries within the Town of Nantucket, a trophic index score was calculated for each sampling location for each year (2010, 2012, 2013, 2014 and 2015) using the summer monitoring data. The Index scores were calculated in 2 ways, one which included the low dissolved oxygen for each year in the index ("with DO", Table 7) and one which excluded the oxygen metric ("without DO", Table 8). The reason for this dual approach is that in some estuaries, such as those on Nantucket, there are only periodic depletions in bottom water dissolved oxygen, generally related to meteorological events acting on nutrient enriched basins. While these short-term depletions have important ecological consequences, they are difficult to capture in programs that sample 4 or 5 dates per summer. In these cases, inclusion of the oxygen can bias the Index upwards (i.e. higher quality) because of the greater probability of capturing high versus low oxygen events. This bias was found in the previous analysis of the 2010 dataset, as well as for other estuaries in s.e. Massachusetts. However, this is not always the case and there was no substantive difference between the "with DO" and "without DO" Index scores based on the 2013 and 2014 data, although the analysis is presented for informational purposes herein (Tables 7a,b and 8a,b). It should be noted that to the extent the bias exists in a given year, it relates only to the oxygen data, the other water quality parameters do not change as rapidly as dissolved oxygen and therefore the sampling program adequately captures accurate concentrations of nutrient related metrics (DO changes by the hour). Given that inclusion of oxygen data did not generally change the bay health rank, it did yield a change in the numerical value.

For the present analysis the standard Index was used for assessment and the Health Status was determined for each site based on the data collected during the sampling events. The ranges of Index scores that fall within a particular Health Status determination are given at the bottom of both Tables 7 and 8 with the Index values and description for each monitoring station. Figures 18-22 show the distribution of Health Status throughout each estuary based on each of the 5 years of monitoring (2010, 2012, 2013, 2014, 2015). Numerical results are color coded for ease of interpretation. The colors of each triangle represent the Bay Health Index status of each site and follow the designation scheme below:

Color	Health Status
Blue	High Quality
Blue/Yellow	High-Moderate
Yellow	Moderate
Yellow/Red	Moderate/Fair
Red	Fair/Poor

The integrated water quality scores, as represented by the Index were generally consistent between all 5 years of monitoring, although change at some sites was observed. This relative stability is typical as nutrient related health does not generally change rapidly unless a significant alteration has occurred to the watershed nitrogen loading or to tidal flushing of a basin (e.g. Hummock Pond). However, 2 systems do appear to show a potential shift in nitrogen related health over the past 5 years, Hither Creek and lower Hummock Pond (see below). Based upon the results it is possible to assess the nutrient related health of the basins within each of the 5 estuarine systems within the Nantucket Water Quality Monitoring Program. The following assessments rely mainly on the Index "with DO" scores as it appears to accurately represent current conditions:

Madaket Harbor

Madaket Harbor main basin is supporting a high level of nutrient related water quality. It has been the more enclosed basins of Hither Creek and Long Pond with their reduced tidal flushing that have nitrogen impairment problems. Water quality generally changes gradually, unless there has been a major change in loading or flushing. Within the Madaket Harbor/Long Pond watershed there has been a significant change in the nitrogen sourced at the Town Landfill. The Landfill has recently been undergoing management actions that reduce nitrogen loading to the groundwater, hence to upper Long Pond. It appears that the long-term gradual improvement within the upper portions of this complex estuary is consistent with a lowering of nitrogen loading. Over the 5 years of monitoring, Hither Creek (Station 1), which receives discharge from Long Pond via Madaket Ditch, has consistently supported the poorest “health” status within the Madaket Estuary (Table 7, 8, Figure 18). Hither Creek is clearly nitrogen enriched and showing continuing impairment based on a variety of parameters. However, over the past 5 years the Index indicates that this basin has improved slightly each year, going from fair-poor water quality and improving in a step-wise manner to moderate water quality in 2014 and 2015. The main basin of Madaket Harbor is showing relatively high water quality in each year but also shows a possible improvement from 2010 to 2012 and has been stable at high water quality in more recent samplings. It appears that Station 2, near the outlet to Hither Creek is receiving low quality waters on the ebb tide from Hither Creek and that can modify water quality at this nearshore location. The inter-annual difference at this site likely stems from the degree that the poor water quality plume from Hither Creek was sufficient to shift its status in previous years. In contrast, the offshore sites (3 & 4) support high quality waters resulting from low nitrogen inputs and very high rates of water exchange. The 5 year positive trend in health index is at least partially the result of the reduced loading from the landfill to upper Long Pond and an improvement in the ebbing waters through Madaket Ditch. This trend

is consistent with the upper basin feeding Madaket Ditch, although the lower Long Pond Station (#5) has varied from year to year without a clear trend. The cause of this inter-annual variation and the mechanism for the large difference between the 2 Long Pond stations in needs further analysis. If the improvement in Hither Creek continues, it is possible that the TMDL for Madaket Harbor may be met, and may reduce some of the need for other nitrogen management actions. However, it will not be sufficient to meet the TMDL for Long Pond (see below).

Long Pond

Long Pond is a large tributary basin to Madaket Harbor, which receives tidal flow through the artificial connection of Madaket Ditch. Given the structure of the basin and its watershed, Long Pond operates semi-independently from Madaket Harbor (Figure 18). Unlike Madaket Harbor which is marine, Long Pond is a brackish water system resulting from groundwater inflows and its restricted tidal exchange. Long Pond's Bay Health scores for both stations (5 & 6) in the 4 years of monitoring (2010, 2012, 2013, 2014) clearly indicate poor nutrient related water quality. It is nearly certain that the water quality of Hither Creek is partially dependent on the nitrogen load from Long Pond via Madaket Ditch during the ebb tide. However, the Town's management of the Landfill, which should reduce the nitrogen load from this source is temporally consistent with improvements in the water quality Index for Long Pond and the lower TN levels. TN levels in 2015 were almost half that of historical/2010-11 measurements. While continued monitoring will determine the level of improvement, it does appear that there a reduction in N loading may be occurring with beneficial effects. However, even if TN levels stabilize at 2015 levels, the TN is still high and results in poor clarity, algal blooms and nutrient related stress to aquatic resources. It should be noted that the lack of major change in the Health Index for Long Pond results in part from the relative coarseness of the Index, where sometimes large index score changes are required to change the Index value. The analysis of key metrics (Chlorophyll-*a*, water clarity-Secchi and total nitrogen) individually do show improving water quality at stations 5 and 6 in 2012, 2013,2014 and 2015 compared to 2010 and in the MEP threshold analysis (see analysis and figures above). The issue is that presently there has not been a large enough shift to bring metrics above Health Index thresholds to change the rating significantly. Results from the 2016 should help to determine the level of improvement expected in coming years.

Nantucket Harbor

Nantucket Harbor with Madaket Harbor are presently supporting the highest water quality of Nantucket's estuaries. The main basin of Nantucket Harbor is supporting high quality waters, with only a periodic small level of decline in the uppermost basin, Wauwinet basin (Figure 19). Wauwinet basin (station 3) had the highest average total nitrogen values for the Harbor System in 2013 (0.415 mg/L) and 2015 (0.436 mg/L) consistent with its designation as the surrogate for the sentinel station for the main basin and its documented past eelgrass loss. It should be noted that in summer 2016, SMAST station 2A (the official MEP sentinel station for which the nitrogen threshold was established, refer to Figure 15) will be added to the monitoring along with station 3 in order to meet TMDL compliance monitoring criteria. Summer 2015 showed similar water quality in this basin as 2010 and 2012, contrasting with the 2014 results which showed improved chlorophyll-*a* and TN levels versus prior years. The main driver of the 2015 water quality was a phytoplankton bloom in the upper Harbor, which was relatively large for Nantucket Harbor but only moderate for more enriched estuaries in the region. It is

unclear if this will become more commonplace in the future and should be monitored. However, other activities associated with the Harbor (additional sewer hookups, jetty improvement and oyster aquaculture) may offset any underlying trend. A similar pattern was seen in the enclosed sub-basins of Polpis Harbor (East and West) which continue showing moderate impairment and moderate nitrogen enrichment, although appear to have improved over historic conditions. As in Wauwinet, Polpis Harbor showed TN levels similar to 2010 and 2012 which were higher than 2013 and 2014. This variation makes continued monitoring essential to clarify any trends in water quality. However, unlike Wauwinet, Polpis did not show a phytoplankton bloom and supported only moderate-low phytoplankton biomass in 2015 (~4 ug/L) and appears to have attained moderate-high water quality status. While the overall Nantucket Harbor System is generally supporting high quality waters, the variability in the index in Wauwinet and Polpis should be monitored to ascertain the long-term health of these basins and that efforts to restore these basins by the Town continue to move forward to meet the MassDEP TMDL for this system. Overall, Nantucket Harbor appears to be relatively stable from year to year and even with high index scores the higher level metrics support the contention that it is still above its TMDL threshold, as also for Polpis Harbor.

Sesachacha Pond

Sesachacha Pond is a closed coastal salt pond that has its water quality managed by periodically breaching the barrier beach to open the basin to tidal exchange with the adjacent Atlantic Ocean waters. This management action serves to flush out nutrients and organic matter on the ebb tides and receive saline waters on the flood tides. Sesachacha Pond was evaluated under the Massachusetts Estuaries Project and a nitrogen threshold (0.60 mg/L) was established for restoration of this system. Additionally, the MEP analysis recommended an additional mid-summertime opening as part of the pond management strategy to enhance flushing of the pond and improve water quality to reach the threshold. The water quality monitoring program in 2010, 2012 and 2013 showed that the pond nitrogen levels were converging on the 0.60 mg/L total nitrogen threshold established by the MEP. Total nitrogen (TN) levels dropped significantly from historical levels of 1.20 mg/L to ~0.68 mg/L in 2010 and 2012 and 0.67 mg/L in 2013, with associated improvements in the levels of water clarity and chlorophyll-*a*. The monitoring data suggest that the pond may still be reaching a new balance, as the limited 3 years of data (2010, 2012 and 2013) show virtually the same TN concentrations in each year. In contrast the 2014 and 2015 results showed a partial return to historic levels of TN, ~0.9 mg/L, which may relate to the quality of the pre-summer opening. Given the prior 3 years, it appears that a solid opening program has the capability to improve the water quality metrics pond-wide to levels near the TMDL nitrogen threshold. Using the Index alone, changes in water quality in Sesachacha Pond over the 2010-2013 period were stabilizing at moderate level of estuarine health, with the past 2 seasons seeing a significant trend toward poor water quality conditions (Figure 20). Additional higher level assessment of Sesachacha Pond initiated by the 2010 monitoring results has been conducted which confirms that the pond was improving by 2013, but was impaired in 2014 consistent with the monitoring results. The 2015 data underscores the reversal of improvement with phytoplankton biomass (as chlorophyll) averaging >10 ug/L at all stations over the summer, indicative of a significant nitrogen enrichment. The high chlorophyll values are consistent with the high TN values in 2014 and 2015. It appears that like other periodically opened ponds, the quality of the opening (amount of water exchanged) controls the level of water quality in the following months. Fortunately, the data indicate that attaining pond openings of the

quality of 2012 and 2013 (done under Town supervision) in the future may be sufficient to attain the TMDL for this system. A closer examination of the opening protocol and the linkage to resultant water quality is needed for management of this system.

Hummock Pond

Hummock Pond is a closed coastal salt pond that is only periodically opened to the ocean to flush out nutrients and organic matter on the ebb tide and receive saline waters on the flood tide. Creating sustained openings that are sufficient to allow exchange of tidal waters for more than 4-5 days has been difficult for this system due to its location on the coast and the large amount of sand migration in the coastal zone which can rapidly reseal the inlet.

Hummock Pond is opened at a sufficient frequency to sustain salinity levels in the 4-8 ppt range, with only small inter-annual differences (2012 slightly higher than 2010). The pond supports a small but clear salinity gradient from Station 1 nearest the ocean to Station 7 in the uppermost basin (Head of Hummock). The present non-tidal state and watershed nutrient inputs have resulted in moderate to poor nutrient related water quality throughout the pond, with poor water quality conditions the present norm (2005-2007, 2010, 2012, 2013, 2014, 2015). There is a small gradient in water quality with moderate to poor conditions near the ocean and poor conditions in the uppermost basins (Figure 21). This gradient stems from the periodic openings and over-wash events. The uppermost basin, Station 7, is approaching fresh/brackish conditions and is currently supporting mainly freshwater plant and animal habitats. This basin is particularly eutrophic with phytoplankton blooms exceeding 70 ug/L (offshore waters are ~2 ug/L). This basin appears to have been artificially connected to the adjacent estuary and is the recipient of much of the freshwater inflow. It is one of the most highly eutrophic basins within the Town of Nantucket. Due to the restricted tidal exchange even the lower basin of Hummock Pond supports moderate to high average chlorophyll levels ~10 ug/L (2010, 2012, 2015). All of the metrics are consistent with a nutrient impaired basin in all years. It should be noted that the lower third of the Hummock Pond Estuary is currently supporting impaired benthic animal habitat even though conditions are the "best" in the overall impaired system.

Given previous studies of Hummock Pond it appeared that its nutrient related health was significantly related to the success of its periodic openings. As a result, the Town and Nantucket Land Council undertook an analysis to refine the opening protocol and gauge its effectiveness. The April 2013 opening was the first “experimental” opening and it appeared to result in significant loss of TN and inflow of salt water. The individual metrics and the Health Index for summer 2014 and 2015 appear to support that tidal flushing was improved as nutrient related health was highest in 2014 and 2015 of the years monitored. It also appears that the continued successful inlet openings from April 2014 into 2015 have resulted in additional improvements in water quality from 2014 to 2015, with 2015 showing the lowest TN levels in records back to 2005, although it is still above its threshold value to support high quality habitat. This opening program and associated monitoring around the openings and in the summer should be continued to set metrics for a “successful” opening, to produce a simplified assessment protocol for opening success and to document and further refine the opening protocol for the Town’s on-going program. To date this joint effort has resulted in significant benefits to Hummock Pond water quality and associated natural resources at low cost to the Town.

Miacomet Pond

Miacomet Pond is a closed coastal salt pond that is seldom (once in the past ten years) opened to the ocean to flush out nutrients and organic matter on the ebb tide and receive saline waters on the flood tide. As a result of the lack of tidal flow and groundwater inputs the pond is presently freshwater, with salinity levels in each of the 4 years of monitoring of <0.6 ppt, reaching a low of 0.1 ppt in 2015. The present non-tidal state and watershed nutrient inputs has resulted in a decline in nutrient related water quality throughout the pond for both nitrogen and phosphorus, with poor water quality conditions the present norm (Figure 22). This can be seen, for example, in the high chlorophyll levels (2010: 12-50 ug/L); 2012: 10-20 ug/L; 2013: 20-26 ug/L; 2014: 23-70 ug/L) several times the levels found in the high quality basins of Nantucket and Madaket Harbors with 2015 continuing the trend (38-53 ug/L) and supporting the highest chlorophyll a levels throughout the pond of the years measured (as opposed to at a single station). All of the metrics are consistent with a nutrient impaired basin. However, as the freshening of this basin has continued, it likely will have to be managed as a transitional freshwater system and will need to be reassessed as such. As salt ponds freshen and become fresh ponds the nutrient causing eutrophication can shift to phosphorus from nitrogen or become both nitrogen and phosphorus (seasonally varying nutrient limitation). Since Miacomet Pond may have storm overwash in the future, it may be necessary for management to create both a nitrogen and a phosphorus budget for this system and to conduct short-term incubations to determine which nutrient is controlling pond health under present and varying salinity conditions.

It will be difficult for Miacomet Pond to maintain itself as a purely freshwater system as storm overwash and rising sea level will tend to periodically cause seawater intrusion into its lower basin. An analysis of future conditions for Miacomet Pond as sea level rises may be in order in the near future, as remediation is considered. But at present the system is a highly nutrient impaired aquatic system with poor water quality.

Recommendations for Future Monitoring

As mentioned in previous years summaries of estuarine water quality across Nantucket, due to the critical importance of dissolved oxygen to the ecological health of an estuarine basin, additional data should be collected using high frequency automated sensors when the low frequency sampling of the monitoring program suggests that a problem may exist in a specific basin. At this point, Polpis Harbor and Wauwinet basin in Nantucket Harbor should be considered for this analysis at some time in the future (e.g. summer 2016). It may also be timely to complete a higher level assessment of Miacomet Pond as that large salt pond has been showing consistently poor water quality and low trophic status indicative of an impaired habitat and is becoming a freshwater basin. However, procedural steps should also be implemented to strengthen the oxygen data base from the on-going monitoring program.

Approaches to address these 2 issues are:

1) Deploying in situ oxygen meters (sondes) on the bottom of specific estuaries at several strategic locations for the summer months when periodic hypoxic or anoxic events in bottom waters can occur.

2) Long Pond is approaching the time when a detailed analysis of nitrogen entering from the land fill should be conducted, particularly how the land fill remediation is projected to improve water quality in the adjacent estuary. The monitoring results from 2012 - 2015 appear to show a significant reduction in TN over historical conditions and 2010. The TN pattern in 2014 suggested that there may be a restriction to mixing between station 5 and 6 which should be investigated and if possible managed. Additionally, the TN data in 2015 showed a continuing decrease in TN levels with a significant drop from 2014 at both stations in the pond (station 5 {1.481 dropped to 0.697}, station 6 {0.788 dropped to 0.656}).

Additionally, it should be noted that the stream stations discharging to Nantucket Harbor (specifically Polpis Harbor) which were not sampled in 2012, 2013 or 2014 were sampled in 2015. With increasing interest in lowering TN concentrations in Polpis Harbor to meet the MEP established TN threshold, it is appropriate to extend stream sampling into the 2016 sampling season given the high concentrations of total nitrogen observed in 2015 that are discharging to this tributary sub-embayment. The utility of these data would be greatly enhanced if sampling was paired with flow measurements to allow determination of both the concentration of stream water and the nitrogen load discharged to the Harbor from each streams watershed and to gage the degree to which the loads these streams contribute to the TN concentration at the sentinel station in Polpis Harbor. While concentrations are high at stations 3, 4 and 6b (1.218, 1.060, 1.184 mg/L respectively) loads may be moderate depending on the flow rate at each stream sampling point.

Miacomet continues to show poor and worsening trophic conditions, high TN concentrations at stations 1, 2, and 3 (1.297, 1.318, 0.992 respectively) and extremely high total pigment (CHLA + pheophytin) in 2015. In light of yet another year of decreasing water quality in Miacomet Pond, nitrogen and phosphorus budgets should be developed for Miacomet Pond and a quantitative analysis of N versus P as the driving nutrient of eutrophication. This information will support management actions for managing the pond in its variable salinity state.

Hummock Pond appears to have its nutrient related health significantly controlled by the success of its periodic openings. As a result, the Town and Nantucket Land Council undertook an analysis of openings in 2013-2014 to refine the opening protocol and gauge its effectiveness. Critical elements of the protocol were described in a technical memorandum developed by the Coastal Systems Program which summarized two openings that were monitored to gauge effectiveness. The opening protocol should be formalized and rigorously implemented as monitoring clearly showed that if specific conditions are taken into consideration during a given opening, the ensuing opening will tend to be effective thereby having a clear positive impact on water quality in Hummock Pond and indeed Hummock Pond water quality has significantly improved under the revised opening protocol by the Town. Management should continue to focus on how to create the most efficient openings, and evaluate the need for a mid-summer opening in this system. The new opening program and associated monitoring around the openings and in the summer should be continued to set metrics for a “successful” opening and document and further refine the opening protocol for the Town’s on-going program. Additionally, it is critical to carefully document conditions during a given opening (pond water levels before during and after the opening, water quality, wind direction, wave conditions {size and direction}, tidal state {spring vs. neap}, size of opening {depth and width} and duration of opening) in order to continue building up a quantitative basis for

refining openings and maximizing the improvement of water quality in Hummock Pond. Similarly, the opening protocol should be implemented for openings of Sesachacha Pond as monitoring has indicated that water quality improved in Sesachacha Pond (2010-2013) compared to historical MEP mean (1992-2005) and that is most likely directly related to the effectiveness of openings as loads into the pond are low and not necessarily decreasing. However, this trend toward restoration has reversed with TN levels in 2014 and 2015 (0.919 and 0.918 mg/L respectively) rising compared to levels in 2010,12,13 (0.684, 0.678, 0.714 mg/L respectively). Details of the openings in 2014 and 2015 should be compiled and compared to the openings completed in 2010, 2012 and 2013 in order to ascertain the difference between openings and future openings in 2016 should be monitored to continue building up the database of what constitutes an effective opening in both Sesachacha Pond and Hummock Pond. The data base will serve to strengthen and refine the Ponds Opening Protocol.

Acknowledgements

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Table 2a. Summary of Water Quality Parameters, **2015** Nantucket Sampling Program. Values are Station Averages of all sampling events, May-September for sampling sites. It should be noted that TP was only evaluated in Miacomet Pond because of the expected low salinity values in that closed pond and the possibility that the system maybe phosphorous limited rather than nitrogen limited. Further study should investigate the possibility and TP paired with salinity should continue to be monitored during the summer 2016 field season.

2015 Sample ID	Seccchi Depth (meters)	Secchi Depth as % of WC	20% Low Field DO (mg/L)	20% Low DO Sat (%)	Salinity ppt	PO4 (mg/L)	TP (mg/L)	NH4 (mg/L)	Nox (mg/L)	DIN (mg/L)	DON (mg/L)	TDN (mg/L)	POC (mg/L)	PON (mg/L)	TON (mg/L)	TN (mg/L)	Total Pig (ug/L)
HUM1	1.50	48%	7.13	83%	7.43	0.009	--	0.004	0.003	0.007	0.350	0.357	1.097	0.182	0.532	0.539	10.50
HUM3	1.50	61%	6.82	75%	7.11	0.012	--	0.005	0.006	0.011	0.402	0.413	1.236	0.209	0.610	0.622	9.41
HUM5	1.00	57%	6.87	79%	5.45	0.019	--	0.005	0.003	0.008	0.359	0.366	1.206	0.192	0.550	0.558	8.58
HUM7	1.30	49%	5.65	87%	3.33	0.101	--	0.089	0.030	0.119	0.349	0.468	0.996	0.154	0.502	0.621	7.07
HUM8	0.70	90%	7.13	95%	3.90	0.059	--	0.005	0.011	0.016	0.366	0.381	1.230	0.195	0.560	0.576	12.82
LONG5	0.70	86%	6.60	85%	16.02	0.020	--	0.012	0.004	0.016	0.378	0.395	2.025	0.302	0.681	0.697	8.95
LONG6	0.60	76%	5.78	73%	16.01	0.025	--	0.006	0.002	0.008	0.369	0.377	1.619	0.280	0.649	0.656	10.78
MH1	1.80	77%	4.88	68%	29.28	0.021	--	0.019	0.006	0.025	0.379	0.404	0.652	0.120	0.499	0.524	4.82
MH2	1.78	100%	5.56	78%	31.76	0.010	--	0.012	0.030	0.042	0.289	0.331	0.482	0.088	0.376	0.418	3.07
MH3	2.40	97%	6.57	90%	32.00	0.010	--	0.005	0.001	0.006	0.236	0.242	0.461	0.082	0.318	0.324	3.00
MH4	2.90	63%	6.70	91%	32.13	0.015	--	0.006	0.002	0.008	0.269	0.277	0.301	0.051	0.321	0.328	2.54
MP1	0.90	50%	6.94	83%	0.10	0.008	0.084	0.025	0.013	0.038	0.592	0.630	3.870	0.666	1.259	1.297	46.52
MP2	0.70	32%	6.10	82%	0.11	0.009	0.090	0.042	0.011	0.053	0.593	0.646	3.726	0.671	1.264	1.318	53.40
MP3	1.40	54%	7.91	91%	0.10	0.017	0.136	0.021	0.057	0.077	0.396	0.473	2.878	0.518	0.914	0.992	37.91
NAN1	ND	62%	6.29	88%	32.13	0.024	--	0.010	0.002	0.012	0.246	0.258	0.437	0.072	0.318	0.330	3.84
NAN2	2.65	49%	5.95	85%	32.25	0.019	--	0.018	0.001	0.019	0.272	0.291	0.474	0.084	0.355	0.374	4.33
NAN3	1.45	27%	5.89	86%	32.37	0.026	--	0.022	0.002	0.024	0.278	0.302	0.716	0.134	0.412	0.436	7.16
NAN4	3.80	65%	6.58	91%	32.14	0.019	--	0.010	0.001	0.011	0.219	0.230	0.357	0.066	0.286	0.297	3.58
NAN5	1.65	85%	5.32	76%	31.92	0.021	--	0.018	0.001	0.019	0.296	0.316	0.578	0.107	0.403	0.422	3.86
NAN6	1.95	73%	5.64	81%	31.94	0.019	--	0.014	0.001	0.015	0.282	0.297	0.555	0.107	0.389	0.404	4.39
NAN7	1.45	76%	6.20	86%	32.00	0.019	--	0.013	0.002	0.015	0.270	0.285	0.628	0.105	0.375	0.390	3.68
NAN8N	1.00	96%	5.65	81%	31.97	0.016	--	0.007	0.002	0.009	0.227	0.236	0.435	0.077	0.304	0.313	3.08
SESA1	0.60	20%	7.06	88%	11.26	0.202	--	0.006	0.003	0.008	0.479	0.487	3.193	0.431	0.910	0.918	11.45
SESA2	0.60	14%	6.55	82%	11.27	0.202	--	0.003	0.002	0.005	0.448	0.454	3.100	0.417	0.865	0.870	10.39
SESA3	0.60	20%	6.73	89%	11.27	0.211	--	0.003	0.002	0.006	0.476	0.481	3.146	0.429	0.904	0.910	11.33
SESA4	0.60	20%	6.62	87%	11.27	0.210	--	0.003	0.003	0.007	0.507	0.514	3.028	0.405	0.912	0.919	11.10

Table 2b. Summary of Water Quality Parameters, **2014** Nantucket Sampling Program. Values are Station Averages of all sampling events, May-September for sampling sites.

Sample ID	Seccchi Depth (meters)	Secchi Depth as % of WC	20% Low DO (mg/L)	20% Low Sat (%)	Salinity ppt	PO4 (mg/L)	NH4 (mg/L)	Nox (mg/L)	DIN (mg/L)	DON (mg/L)	TDN (mg/L)	POC (mg/L)	PON (mg/L)	TON (mg/L)	TN (mg/L)	Total Pig (ug/L)
HUM1	1.37	56%	8.41	73%	6.12	0.012	0.029	0.004	0.033	0.428	0.461	1.230	0.191	0.618	0.651	5.480
HUM3	1.05	61%	8.35	75%	5.72	0.012	0.023	0.006	0.029	0.402	0.431	1.329	0.212	0.614	0.643	5.262
HUM5	1.08	58%	8.38	73%	4.75	0.014	0.014	0.003	0.017	0.401	0.418	9.925	0.235	0.636	0.653	6.534
HUM7	0.94	41%	8.44	77%	2.65	0.047	0.054	0.020	0.071	0.444	0.515	2.400	0.358	0.801	0.873	11.875
HUM8	0.79	35%	8.36	69%	3.62	0.030	0.014	0.003	0.017	0.526	0.543	1.417	0.212	0.738	0.755	6.240
LONG5	0.75	75%	7.62	53%	14.12	0.032	0.080	0.012	0.092	0.975	1.066	2.354	0.415	1.390	1.481	8.988
LONG6	0.73	75%	7.69	69%	15.06	0.014	0.040	0.011	0.051	0.420	0.472	1.841	0.316	0.737	0.788	7.342
MH1	1.74	86%	7.14	69%	28.03	0.019	0.046	0.010	0.057	0.270	0.326	0.616	0.119	0.389	0.445	3.431
MH2	2.50	100%	7.14	68%	31.01	0.010	0.024	0.002	0.026	0.243	0.269	0.433	0.079	0.321	0.347	1.674
MH3	2.26	91%	7.24	68%	31.40	0.011	0.023	0.001	0.024	0.217	0.241	0.891	0.135	0.352	0.376	2.701
MH4	2.66	57%	7.38	75%	31.53	0.012	0.016	0.007	0.020	0.174	0.194	0.340	0.059	0.233	0.254	1.489
MP1	1.38	85%	8.41	63%	0.13	0.018	0.050	0.003	0.053	0.522	0.575	1.967	0.289	0.811	0.864	9.932
MP2	1.87	63%	8.51	71%	0.12	0.009	0.035	0.002	0.036	0.568	0.604	1.170	0.180	0.748	0.784	5.326
MP3	0.87	65%	8.46	58%	0.10	0.049	0.038	0.038	0.077	0.594	0.671	4.437	0.626	1.220	1.297	18.068
NAN1	3.35	64%	7.23	77%	31.36	0.015	0.017	0.002	0.019	0.201	0.220	0.380	0.063	0.265	0.284	1.311
NAN2	3.06	52%	7.17	73%	31.42	0.017	0.021	0.003	0.024	0.210	0.234	0.493	0.080	0.290	0.314	1.977
NAN3	3.10	51%	6.98	75%	31.42	0.016	0.020	0.001	0.020	0.225	0.245	0.631	0.100	0.325	0.345	3.125
NAN4	3.00	56%	7.27	81%	31.49	0.017	0.017	0.001	0.018	0.180	0.198	0.439	0.079	0.259	0.277	1.659
NAN5	2.13	90%	7.10	69%	30.99	0.016	0.016	0.003	0.019	0.248	0.267	0.756	0.122	0.370	0.389	3.223
NAN6	2.38	85%	7.09	70%	31.08	0.016	0.013	0.002	0.015	0.258	0.272	0.626	0.105	0.363	0.378	2.963
NAN7	1.79	80%	7.26	73%	31.23	0.020	0.022	0.001	0.023	0.168	0.190	0.656	0.104	0.271	0.294	2.691
NAN8N	2.09	99%	7.16	74%	31.29	0.016	0.015	0.002	0.017	0.188	0.205	0.356	0.062	0.250	0.267	1.267
SESA1	1.17	24%	7.87	74%	12.26	0.105	0.033	0.007	0.040	0.590	0.630	1.794	0.288	0.878	0.919	7.112
SESA2	1.23	24%	7.86	70%	12.23	0.111	0.038	0.010	0.049	0.531	0.579	2.154	0.352	0.883	0.931	7.116
SESA3	1.19	32%	7.86	75%	12.23	0.106	0.030	0.009	0.039	0.603	0.642	1.871	0.296	0.899	0.938	5.852
SESA4	1.22	32%	7.83	72%	12.25	0.108	0.030	0.009	0.039	0.572	0.611	1.808	0.290	0.862	0.902	5.407

Table 2c. Summary of Water Quality Parameters, 2013 Nantucket Sampling Program. Values are Station Averages of all sampling events, May-October for estuarine and harbor sites.

2013 Station I.D.	Depth m	Secchi Depth m	Secchi Depth %WC	20% Low DO mg/L	20% Low DO %Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	N0x mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	T-Pig ug/L
HUM-1	2.6	1.0	0.4	5.86	63%	0.9	0.029	0.030	0.018	0.047	0.554	0.169	0.722	0.769	8.2
HUM-3	2.4	1.0	0.4	5.20	56%	0.8	0.034	0.075	0.016	0.091	0.571	0.165	0.736	0.827	7.2
HUM-5	2.2	0.6	0.3	4.20	45%	0.5	0.073	0.063	0.026	0.088	0.575	0.217	0.793	0.881	8.3
HUM-7	3.5	0.6	0.2	4.08	44%	0.5	0.061	0.077	0.012	0.089	0.408	0.674	1.081	1.170	16.9
HUM-8	2.2	0.6	0.3	3.32	36%	0.4	0.079	0.042	0.018	0.061	0.672	0.331	1.004	1.064	7.9
LONG-5	1.1	0.7	0.7	5.87	75%	11.9	0.009	0.015	0.008	0.022	0.358	0.328	0.686	0.709	8.1
LONG-6	1.0	0.7	0.7	3.82	49%	12.7	0.005	0.017	0.008	0.025	0.561	0.294	0.855	0.880	9.9
MH1	2.2	1.7	0.8	4.36	61%	25.7	0.019	0.047	0.019	0.065	0.374	0.134	0.508	0.573	4.2
MH2	1.9	1.8	1.0	5.25	74%	30.6	0.012	0.021	0.004	0.025	0.215	0.083	0.298	0.323	1.8
MH3	2.0	2.0	1.0	5.25	74%	31.0	0.011	0.014	0.005	0.019	0.209	0.087	0.295	0.314	2.2
MH4	4.5	3.0	0.7	5.82	82%	31.3	0.013	0.015	0.007	0.023	0.194	0.062	0.256	0.278	1.7
MP1	1.9	1.0	0.6	5.46	66%	0.2	0.009	0.015	0.006	0.020	0.481	0.290	0.771	0.792	19.5
MP2	3.1	1.2	0.4	4.22	51%	0.3	0.014	0.029	0.022	0.051	0.429	0.555	0.985	1.036	20.2
MP3	1.6	0.9	0.6	5.20	63%	0.1	0.049	0.036	0.104	0.143	0.378	0.540	0.917	1.058	26.2
NAN1	5.5	3.2	0.6	5.10	74%	31.2	0.014	0.015	0.003	0.018	0.182	0.062	0.244	0.262	2.6
NAN2	6.0	2.9	0.5	4.80	70%	31.1	0.014	0.019	0.006	0.024	0.231	0.090	0.321	0.345	3.7
NAN3	6.2	2.6	0.4	3.48	50%	30.9	0.019	0.016	0.004	0.020	0.241	0.154	0.395	0.415	6.4
NAN4	4.9	3.1	0.6	5.66	82%	31.3	0.016	0.017	0.004	0.021	0.226	0.070	0.295	0.317	2.9
NAN5	2.3	1.9	0.8	3.90	57%	30.1	0.018	0.012	0.005	0.017	0.208	0.159	0.368	0.385	5.6
NAN6	2.7	2.0	0.8	3.26	47%	30.5	0.016	0.023	0.004	0.026	0.221	0.153	0.374	0.401	5.9
NAN7	2.5	1.9	0.8	5.02	73%	31.1	0.013	0.013	0.004	0.017	0.183	0.122	0.305	0.323	4.6
NAN8	3.2	2.1	0.9	4.96	72%	31.1	0.013	0.028	0.004	0.032	0.189	0.084	0.272	0.304	2.9
SES 1	4.9	2.1	0.4	5.83	79%	17.1	0.044	0.045	0.011	0.055	0.533	0.125	0.658	0.714	4.7
SES 2	4.3	2.4	0.6	5.2	71%	17.0	0.043	0.025	0.008	0.034	0.477	0.110	0.587	0.621	4.1
SES 3	4.5	2.5	0.6	5.6	75%	17.0	0.046	0.031	0.011	0.042	0.512	0.109	0.621	0.663	3.8
SES 4	3.9	2.6	0.7	5.6	76%	17.0	0.040	0.034	0.013	0.046	0.518	0.111	0.630	0.677	3.8

Table 2d. Summary of Water Quality Parameters, 2012 Nantucket Sampling Program. Values are Station Averages of all sampling events, May-October for estuarine and harbor sites. Stream sites were sampled once in June (see Table 1b).

Station I.D.	Secchi Depth m	Secchi Depth %WC	20% Low DO mg/L	20% Low DO %Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	N0x mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	T-Pig ug/L
HUM-1	1.0	44%	6.27	79%	7.6	0.020	0.044	0.006	0.050	0.439	0.178	0.616	0.666	8.7
HUM-3	1.2	58%	6.20	79%	7.0	0.029	0.039	0.003	0.042	0.573	0.249	0.822	0.863	8.3
HUM-5	0.8	44%	6.56	82%	6.3	0.030	0.043	0.004	0.047	0.540	0.283	0.824	0.871	12.7
HUM-7	0.7	21%	5.76	70%	4.8	0.011	0.085	0.031	0.117	0.546	0.638	1.184	1.301	27.2
HUM-8	0.6	53%	6.51	81%	6.0	0.030	0.054	0.005	0.058	0.534	0.352	0.885	0.944	17.5
LONG-5	0.6	58%	5.49	71%	16.8	0.067	0.063	0.007	0.069	0.441	0.503	0.944	1.013	18.3
LONG-6	0.5	51%	5.13	67%	18.6	0.027	0.049	0.008	0.057	0.437	0.373	0.810	0.867	7.7
MH1	1.7	70%	6.88	98%	26.8	0.026	0.115	0.015	0.131	0.332	0.192	0.525	0.655	9.6
MH2	2.3	100%	8.16	115%	30.9	0.015	0.078	0.010	0.088	0.272	0.084	0.356	0.444	1.8
MH3	2.4	100%	7.55	104%	31.6	0.018	0.063	0.011	0.074	0.217	0.065	0.282	0.356	1.8
MH4	3.7	90%	8.35	119%	31.6	0.019	0.032	0.009	0.041	0.189	0.068	0.257	0.297	2.0
MP1	1.5	97%	7.14	79%	0.3	0.007	0.057	0.004	0.061	0.546	0.221	0.767	0.828	10.8
MP2	1.5	67%	7.24	80%	0.4	0.005	0.070	0.012	0.082	0.509	0.290	0.799	0.880	20.3
MP3	1.0	81%	7.64	92%	0.1	0.045	0.109	0.011	0.120	0.381	0.450	0.830	0.950	18.3
NAN1	3.5	73%	5.22	74%	31.6	0.020	0.045	0.011	0.056	0.210	0.070	0.279	0.335	3.8
NAN2	2.9	62%	5.91	85%	31.6	0.022	0.057	0.009	0.066	0.213	0.091	0.304	0.364	3.7
NAN3	2.4	40%	5.86	87%	31.8	0.027	0.035	0.008	0.044	0.261	0.117	0.371	0.411	4.0
NAN4	2.9	63%	6.29	90%	31.6	0.017	0.031	0.007	0.038	0.212	0.094	0.306	0.344	3.6
NAN5	1.7	76%	5.96	83%	31.5	0.019	0.046	0.007	0.053	0.233	0.133	0.366	0.419	14.9
NAN6	2.1	76%	5.50	77%	31.5	0.019	0.042	0.006	0.048	0.289	0.147	0.436	0.484	6.3
NAN7	2.0	80%	6.10	86%	31.5	0.021	0.049	0.008	0.057	0.217	0.105	0.323	0.379	4.2
NAN8	1.9	100%	5.20	74%	31.5	0.017	0.050	0.006	0.057	0.225	0.090	0.315	0.371	3.6
SES 1	2.3	51%	5.49	77%	24.7	0.064	0.042	0.010	0.051	0.497	0.130	0.627	0.678	5.8
SES 2	2.5	52%	"	"	24.7	0.065	0.087	0.014	0.101	0.405	0.120	0.525	0.627	5.1
SES 3	2.8	87%	"	"	24.7	0.063	0.053	0.007	0.060	0.417	0.107	0.524	0.584	4.2
SES 4	2.7	77%	"	"	24.8	0.062	0.060	0.010	0.070	0.456	0.142	0.599	0.668	4.5

Station ID	Secchi Depth (m)	Secchi Depth as % WC	20% Low D.O. (mg/L)	20% Low % Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	NOX mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	Total Pig (ug/L)
HUM1	1.4	54.4%	4.81	56.0%	7.3	0.013	0.021	0.002	0.023	0.425	0.168	0.592	0.616	12.30
HUM3	1.3	61.5%	4.99	59.8%	6.4	0.012	0.022	0.003	0.025	0.380	0.184	0.564	0.589	11.04
HUM5	0.9	44.2%	4.65	56.1%	5.3	0.015	0.020	0.003	0.023	0.430	0.313	0.743	0.766	27.03
HUM7	0.9	23.4%	3.89	45.0%	4.0	0.284	0.070	0.069	0.139	0.628	1.020	1.647	1.786	67.66
HUM8	0.7	51.0%	4.80	56.5%	4.4	0.025	0.031	0.008	0.039	0.584	0.360	0.944	0.983	33.02
LONG5	0.6	48.5%	4.77	62.9%	16.0	0.071	0.009	0.002	0.011	0.480	0.894	1.374	1.385	18.08
LONG6	0.6	48.8%	4.76	62.9%	15.9	0.028	0.022	0.003	0.026	0.567	1.452	2.019	2.044	24.21
MH1	1.6	67.1%	3.00	40.1%	26.8	0.024	0.045	0.005	0.050	0.316	0.260	0.576	0.626	14.20
MH2	1.9	93.9%	3.52	47.9%	29.7	0.014	0.024	0.003	0.027	0.264	0.145	0.409	0.436	9.37
MH3	2.3	100.0%	4.39	55.5%	30.8	0.011	0.024	0.002	0.026	0.213	0.084	0.297	0.324	6.14
MH4	3.8	58.3%	4.27	55.6%	31.1	0.015	0.024	0.002	0.026	0.190	0.069	0.259	0.285	4.21
MP1	1.5	86.3%	5.43	54.0%	0.7	0.003	0.030	0.002	0.032	0.557	0.265	0.822	0.854	16.29
MP2	1.9	58.5%	5.70	62.8%	0.6	0.002	0.044	0.002	0.046	0.554	0.210	0.764	0.811	11.50
MP3	1.3	83.1%	4.93	56.6%	0.1	0.031	0.048	0.056	0.104	0.499	0.490	0.990	1.093	51.52
NAN1	4.5	84.8%	3.57	48.2%	31.0	0.016	0.027	0.003	0.030	0.218	0.084	0.302	0.332	4.00
NAN2	3.4	62.8%	3.45	47.4%	31.0	0.018	0.016	0.003	0.019	0.201	0.077	0.278	0.297	5.36
NAN3	2.8	49.2%	3.72	52.4%	30.9	0.022	0.027	0.003	0.030	0.251	0.111	0.362	0.392	7.58
NAN4	3.7	84.5%	3.89	52.2%	29.8	0.015	0.027	0.002	0.029	0.203	0.070	0.273	0.283	4.15
NAN5	2.0	98.0%	3.18	44.3%	30.4	0.017	0.027	0.007	0.034	0.248	0.149	0.397	0.431	11.31
NAN6	2.2	88.7%	3.26	45.7%	30.5	0.016	0.024	0.004	0.028	0.277	0.133	0.410	0.438	10.31
NAN7	2.1	92.5%	3.60	49.8%	30.9	0.016	0.023	0.003	0.026	0.244	0.106	0.351	0.377	7.35
NAN8	2.4	100.8%	3.65	50.0%	31.1	0.018	0.031	0.002	0.033	0.204	0.076	0.280	0.313	3.93
SESA1	1.6	32.9%	4.82	56.4%	11.9	0.051	0.018	0.003	0.021	0.441	0.222	0.663	0.684	8.00
SESA2	1.4	28.6%	4.83	56.4%	11.9	0.045	0.024	0.003	0.027	0.469	0.219	0.688	0.715	7.19
SESA3	1.5	36.6%	4.83	56.2%	11.9	0.049	0.021	0.006	0.028	0.449	0.223	0.672	0.700	7.61
SESA4	1.5	38.7%	4.83	56.4%	11.9	0.046	0.024	0.003	0.027	0.470	0.221	0.691	0.718	6.73
82 WAUWINET	ND	ND	ND	ND	18.2	0.071	0.122	0.004	0.126	0.611	0.108	0.719	0.845	40.70
STREAM1	ND	ND	ND	ND	0.3	0.077	0.081	0.021	0.102	1.419	0.258	1.677	1.779	2.64
STREAM4	ND	ND	ND	ND	<0.1	0.163	0.039	0.008	0.048	1.092	0.061	1.153	1.200	1.18
STREAM6B	ND	ND	ND	ND	<0.1	0.006	0.059	0.004	0.064	1.701	0.374	2.076	2.139	16.37
STREAM6C	ND	ND	ND	ND	<0.1	0.132	0.097	0.003	0.100	0.375	0.156	0.532	0.632	7.41
STREAM8	ND	ND	ND	ND	3.3	0.015	0.045	0.005	0.050	0.398	0.118	0.516	0.565	5.29

Secchi as % of WC is the % of the water column above the secchi depth, values of 100% means that the Secchi was at or below the bottom.
Lowest 20% of D.O. records for a site over the project period.

HUM = Hummock Pond, Long = Long Pond, MH = Madaket Harbor, MP = Miacomet Pond, NAN = Nantucket Harbor, SESA = Sesachacha Pond

Table 2e. Summary of Water Quality Parameters, 2010 Nantucket Sampling Program. Values are Station Averages of all sampling events, May-October for estuarine and harbor sites. Stream sites were sampled once in June (see Table 1a).

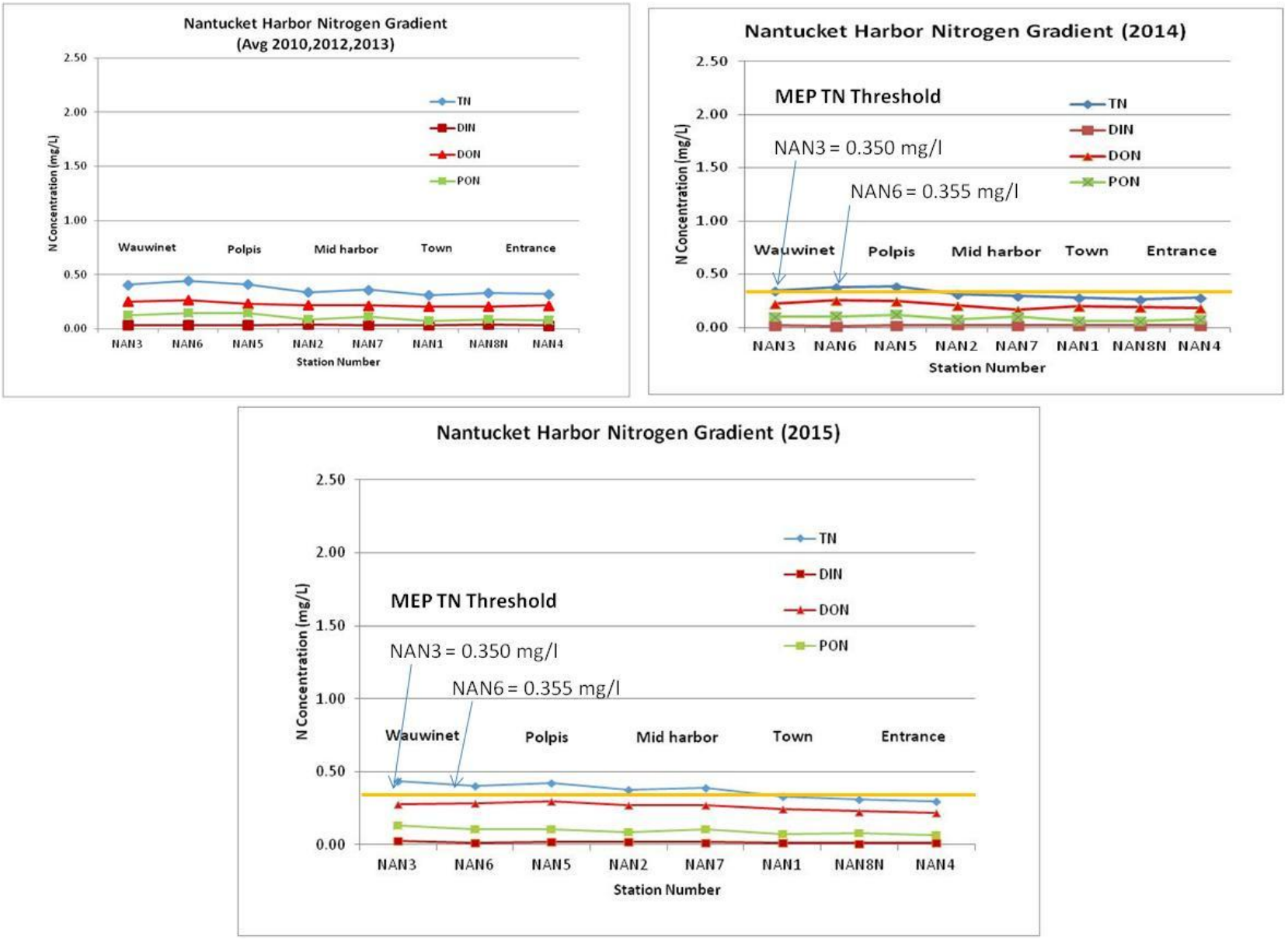
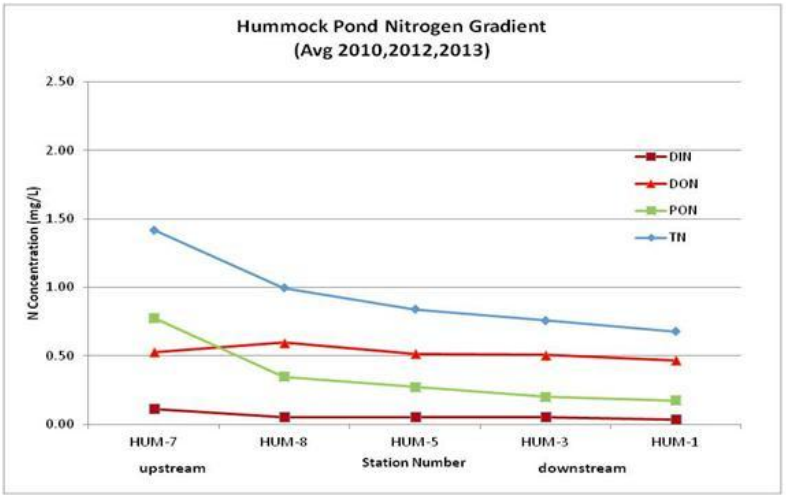
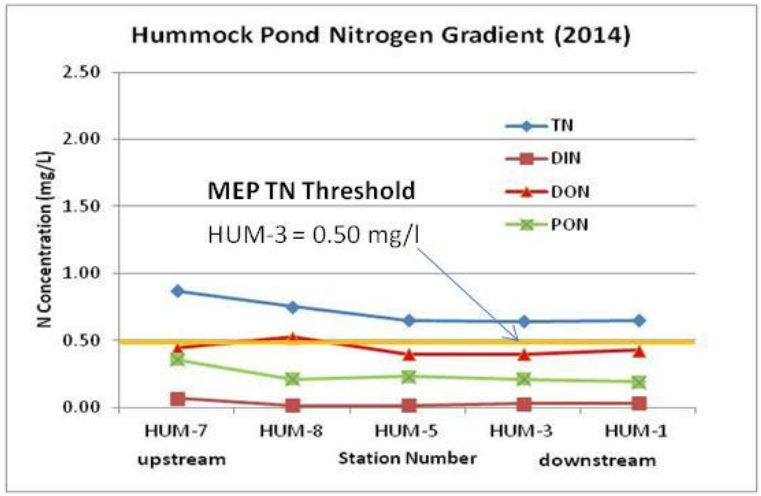


Figure 14. Comparison of nitrogen species (mg/L) in Nantucket Harbor in summers, 2010-2013 avg. (upper left); 2014 (upper right); 2015 (bottom) Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.





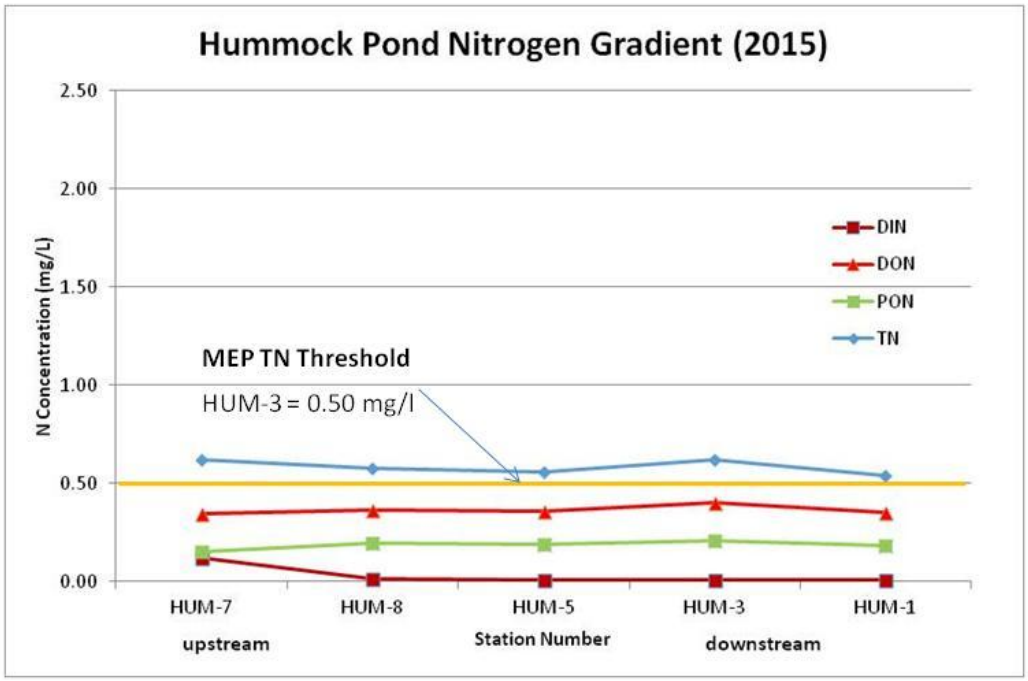
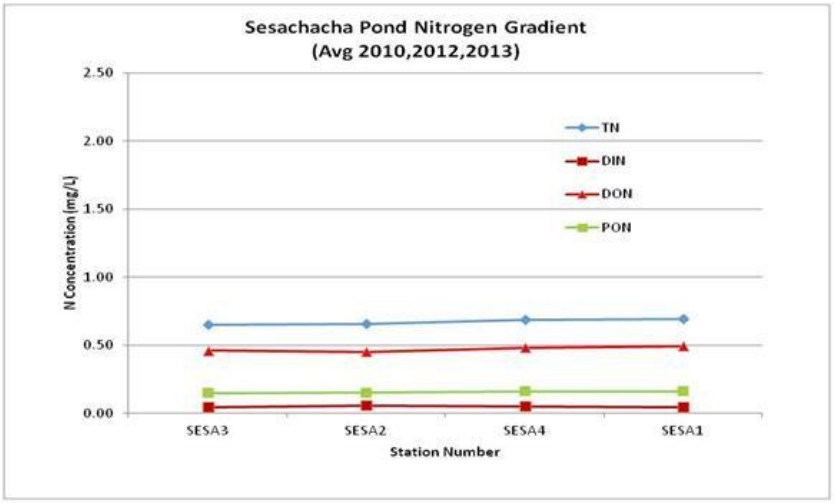
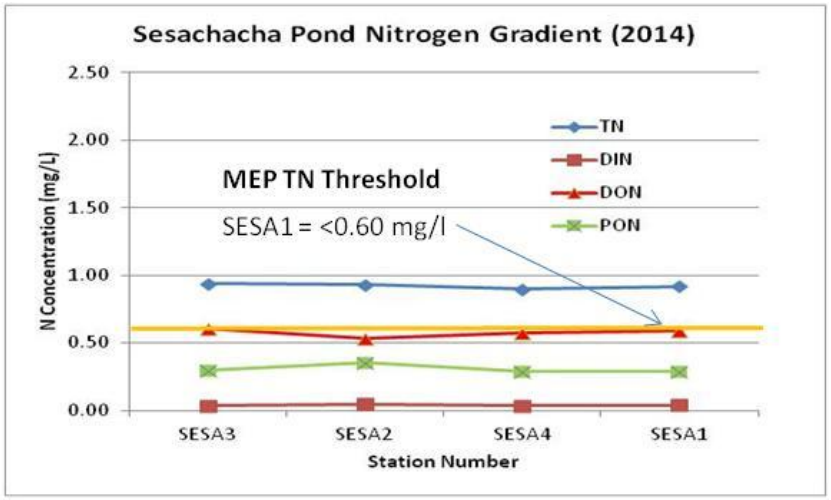


Figure 14 cont'd. Comparison of nitrogen species (mg/L) in Hummock Pond in summers, 2010-2013 avg. (upper left); 2014 (upper right); 2015 (bottom). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.





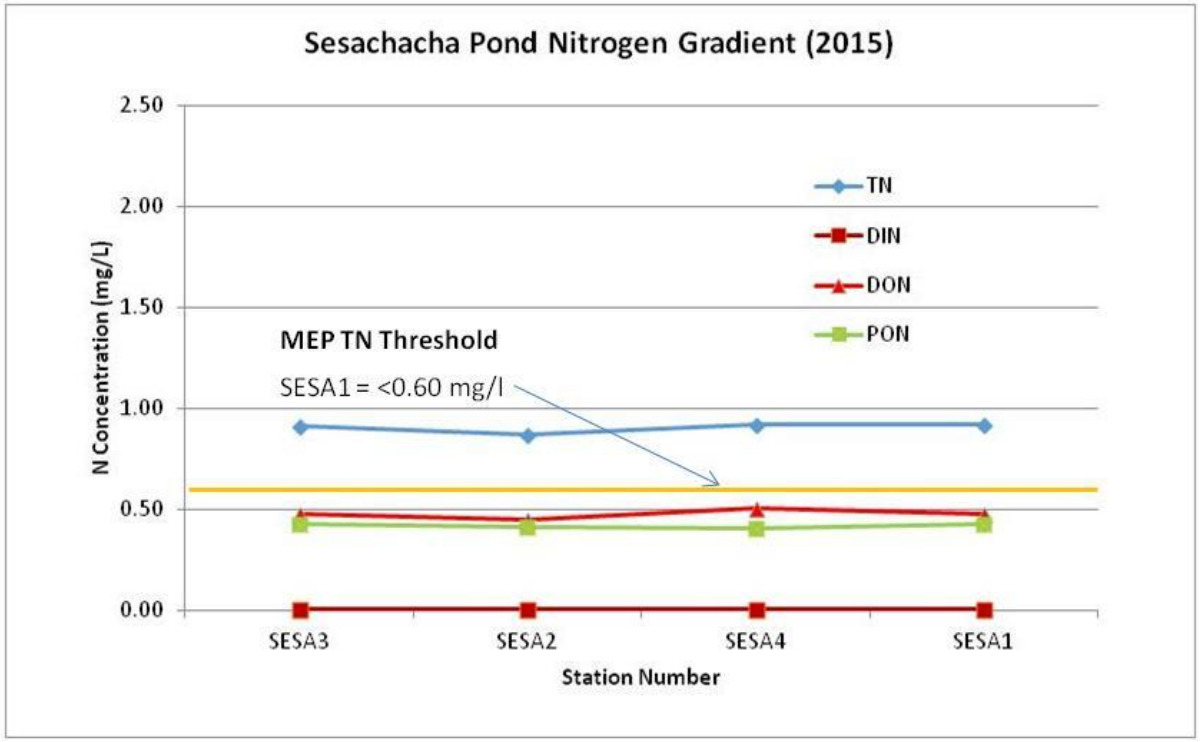
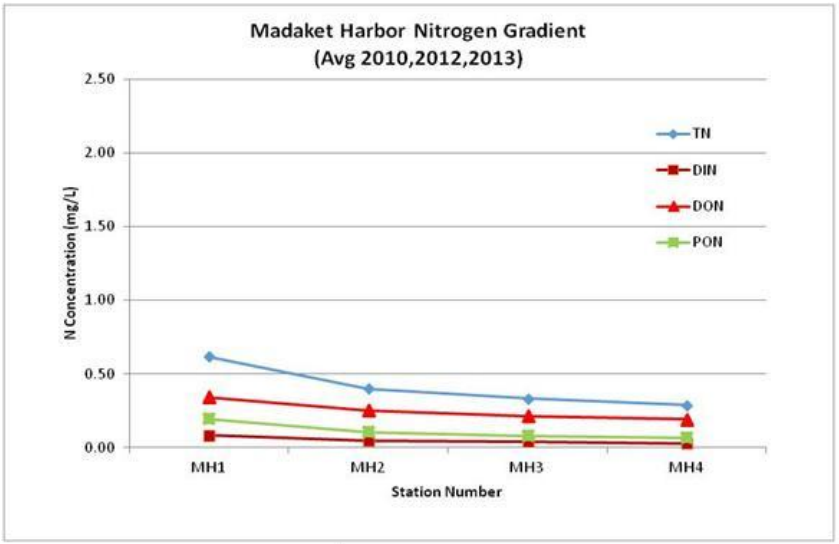
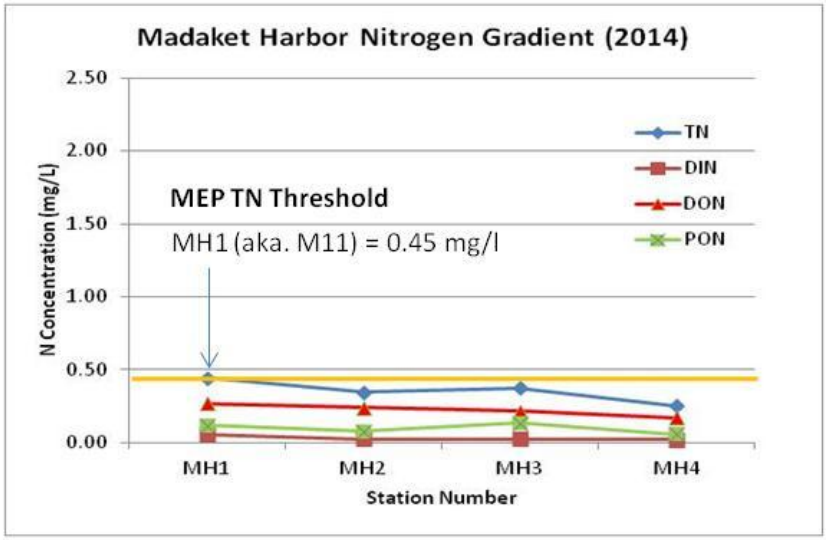


Figure 14 cont'd. Comparison of nitrogen species (mg/L) in Sesachacha Pond in summers, 2010-2013 avg. (upper left); 2014 (upper right); 2015 (bottom). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph).





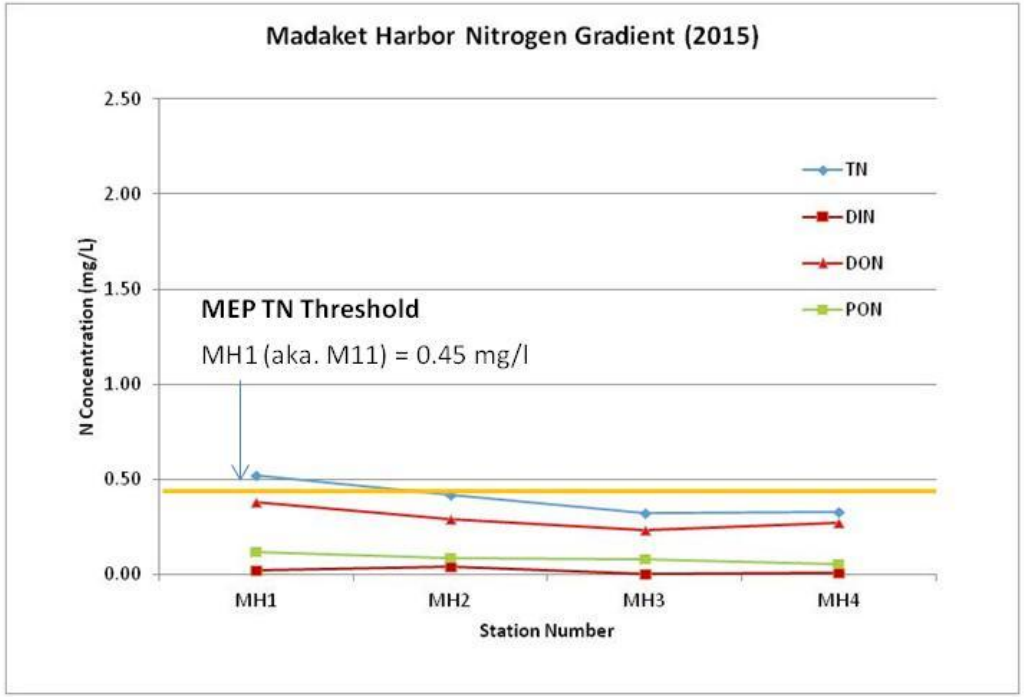
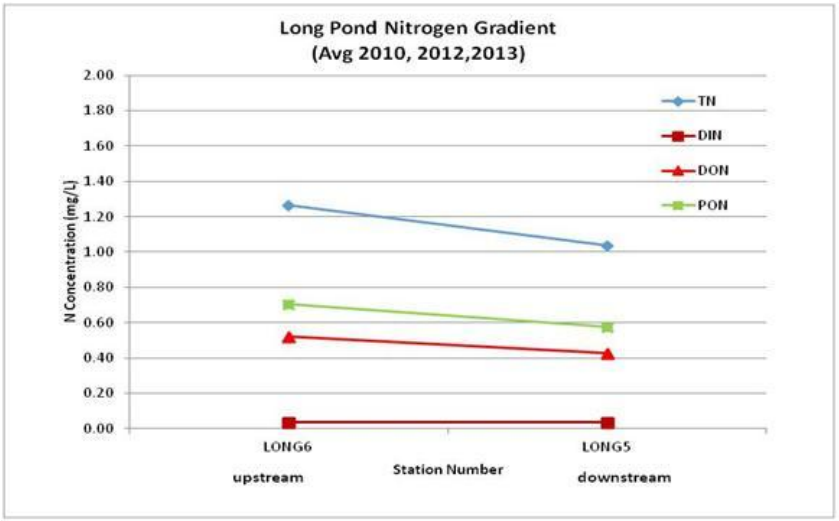
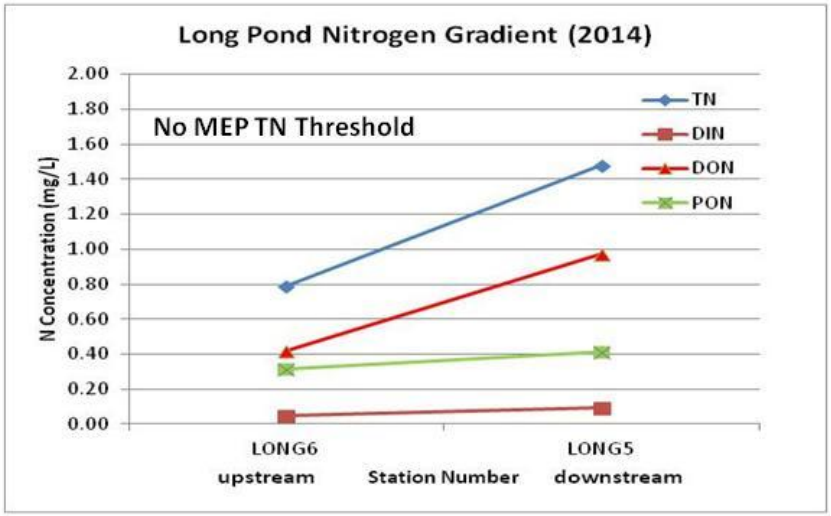


Figure 14 cont'd. Comparison of nitrogen species (mg/L) in Madaket Harbor in summers, 2010-2013 avg. (upper left); 2014 (upper right); 2015 (bottom). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.





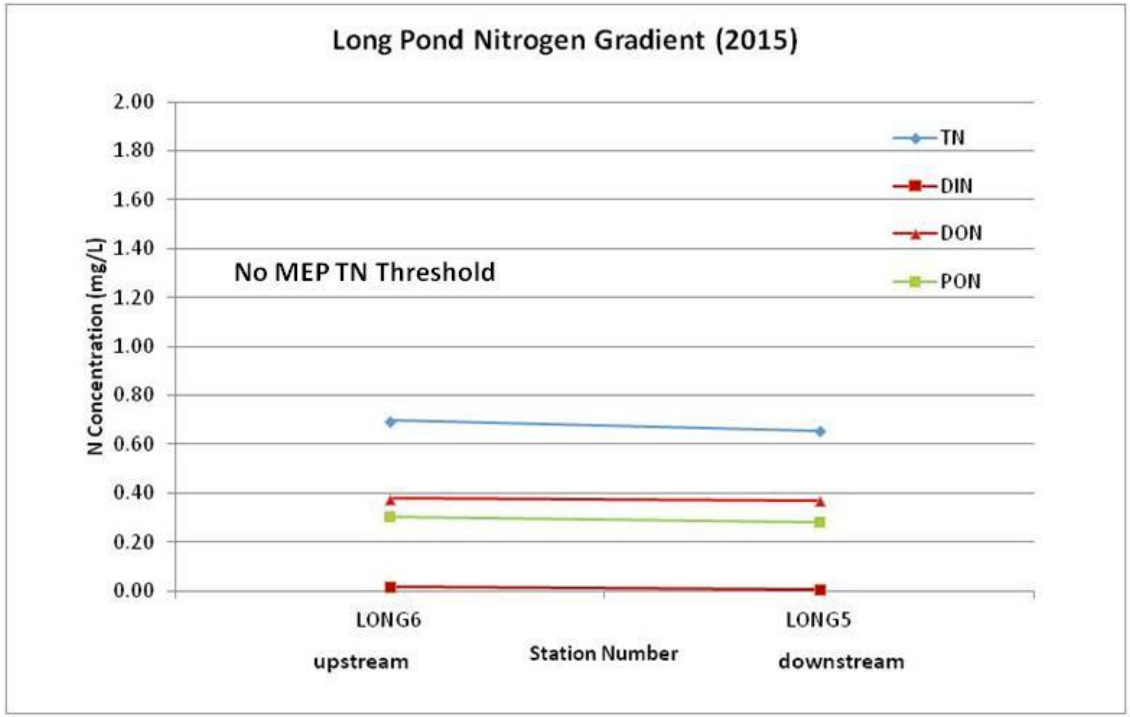
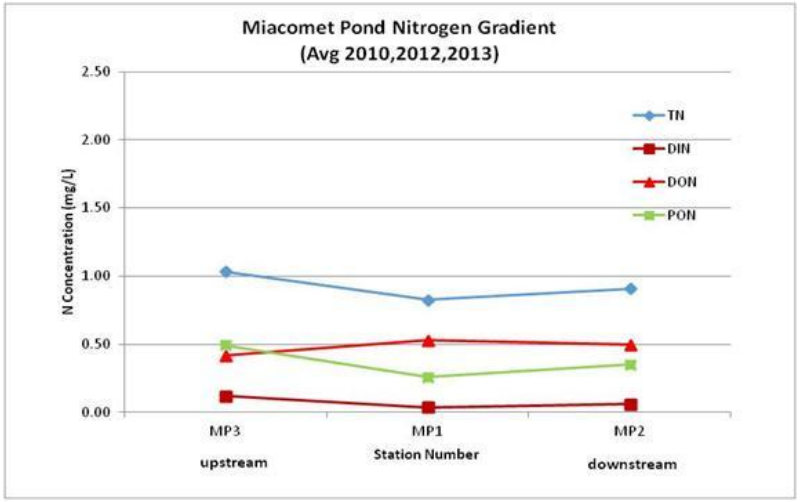
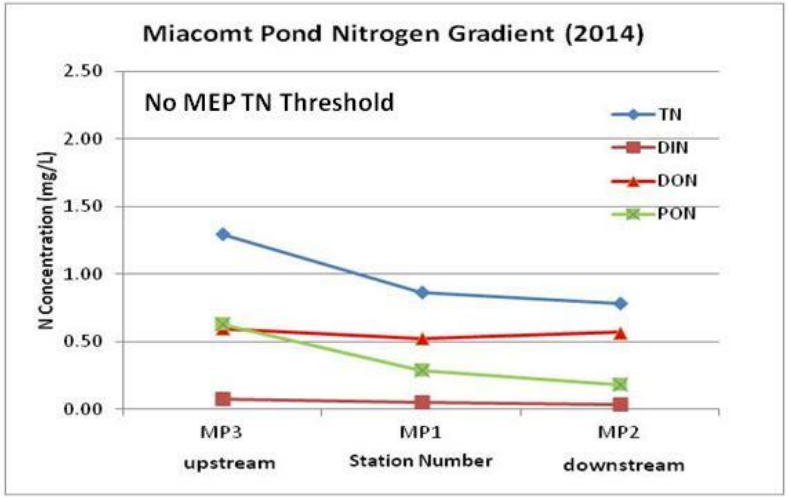


Figure 14 cont'd. Comparison of nitrogen species (mg/L) in Long Pond (Madaket Harbor System) in summers, 2010-2013 avg. (upper left); 2014 (upper right); 2015 (bottom) Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.





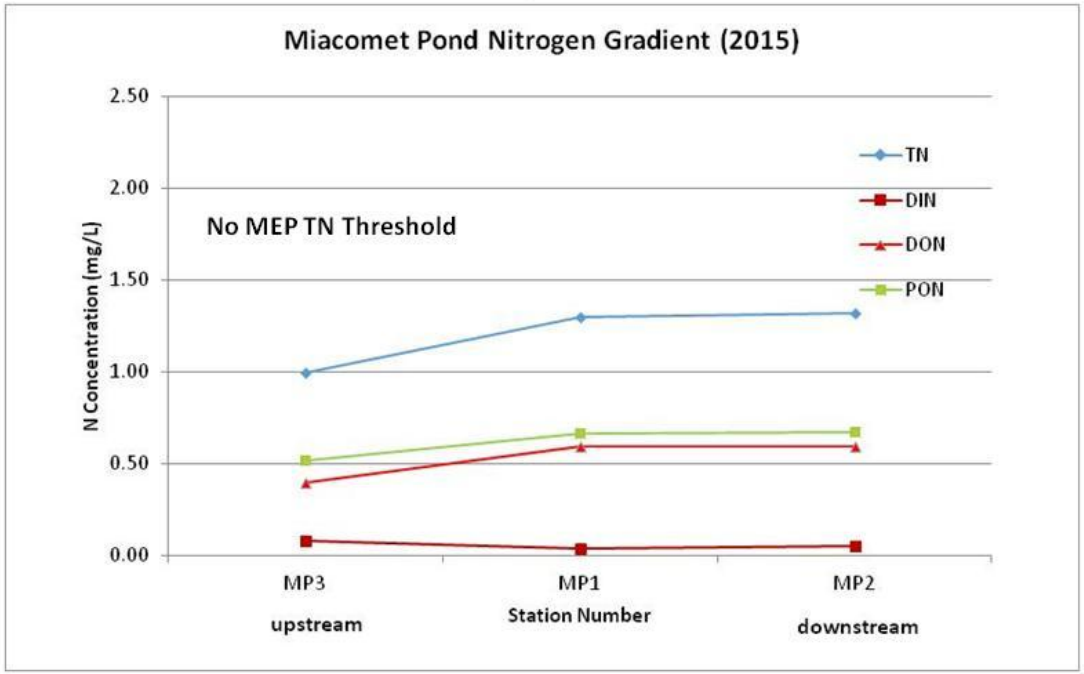


Figure 14 cont'd. Comparison of nitrogen species (mg/L) in Miacomet in summers, 2010-2013 avg. (upper left); 2014 (upper right); 2015 (bottom). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.

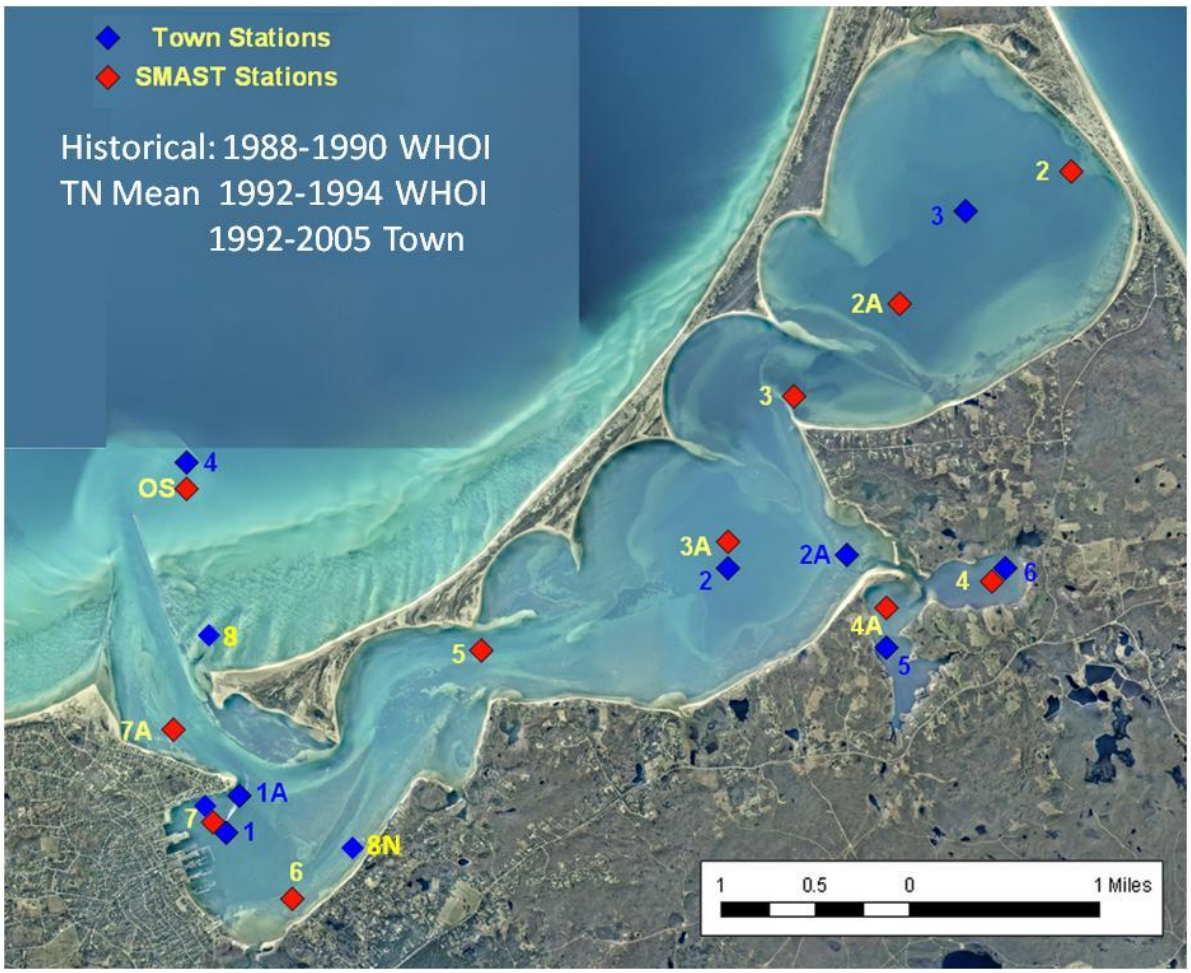


Figure 15. Estuarine water quality monitoring station locations in the Nantucket Harbor estuary system. Station labels correspond to those provided in Table 3 below. Red diamonds indicate locations of MEP monitoring stations. Blue diamonds are locations of Town sampling. Station 8 sampled in 2010, station 8N sampled in 2011 and 2012.

Sub-Embayment	Monitoring Station	Historical MEP Mean TN (mg/L)	s.d.	2010 Town ID	2010 Mean TN (mg/L)	2012 Mean TN (mg/L)	2013 Mean TN (mg/L)	2014 Mean TN (mg/L)	2015 Mean TN (mg/L)
Head of the Harbor - Upper	2	0.408	0.188	NA	NS	NS	NS		
Head of the Harbor - Mid	Town 3	0.401	0.115	3	0.392	0.411	0.415	0.345	0.436
Head of the Harbor - Lower	2A	0.339	0.070	NA	NS	NS	NS	NS	NS
Pocomo Head	3	0.335	0.081	NA	NS	NS	NS	NS	NS
Quaise Basin	3A+Town 2	0.336	0.112	2	0.297	0.364	0.345	0.314	0.374
East Polpis Harbor	4+Town 6	0.362	0.105	6	0.438	0.484	0.401	0.378	0.404
West Polpis Harbor	4A+Town 5	0.388	0.119	5	0.431	0.419	0.385	0.389	0.422
Abrams Point	5	0.335	0.060	NA	NS	NS	NS	NS	NS
Monomoy	6	0.297	0.086	NA	NS	NS	NS	NS	NS
Mooring Area	7+Town 1, 1A	0.326	0.106	1, 7	0.332, 0.377	0.335, 0.379	0.323, 0.323	0.294, 0.284	0.39, 0.33
Nantucket Sound	OS+Town 4	0.239	0.041	4	0.283	0.344[2]	0.317[1]	0.277	0.297

Table 3. Comparison of MEP mean TN with Town data (values mg/L) from Nantucket Harbor. MEP data collected in the summers of 1988 - 1990 and 1992 - 1994 by the Woods Hole Oceanographic Institution, and between 1992 and 2005 by the Town of Nantucket Marine Department and by the Nantucket Marine and Coastal Resources Department in summers 2010, 2012, 2013 and 2014.

[2] It is almost certain that this does not represent the TN level in the inflow to Nantucket Harbor on the flood tide, but rather the 2012 data is influenced by mixing with TN enriched out-flowing waters. An attempt to control for this issue was implemented in the 2013 monitoring program.

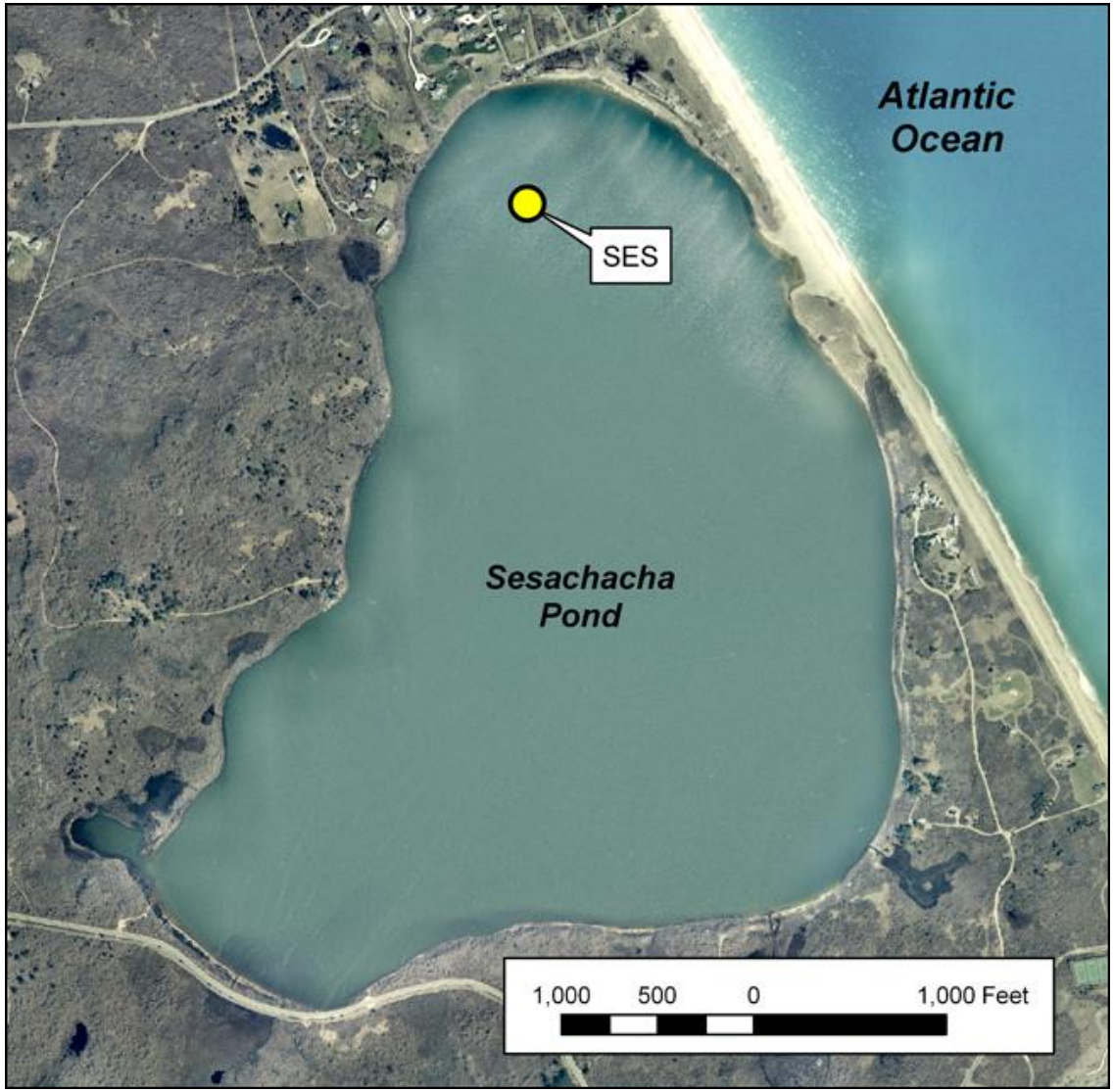


Figure 16. 2005 aerial photo showing MEP monitoring station location in Sesachacha Pond that was used in the water quality analysis for the Massachusetts Estuaries Project. Station SES corresponds to SESA-1 in Tables 2a,b and Station 1 in Figure 3.

Sampling Station Location	Historical MEP Mean TN (mg/L)	s.d.	2010 Mean TN (mg/L)	2012 Mean TN (mg/L)	2013 Mean TN (mg/L)	2014 Mean TN (mg/L)	2015 Mean TN (mg/L)
Sesachacha Pond	1.197	0.078	0.684 (0.704)	0.678 (0.639)	0.714 (0.669)	0.919 (0.922)	0.918 (0.904)

Table 4. Comparison of MEP mean values of TN with Town TN data (all values are mg/L) from Sesachacha Pond. MEP data were collected in the summers of 1992 through 2005. Town data were collected in the summers of 2010, 2012, 2013 and 2014 by the Town of Nantucket Marine and Coastal Resources Department. Values in 2010, 2012, 2013 and 2014 represent the average at Station 1, with the average of stations 1-4 in ( ).

Figure 17. Estuarine water quality monitoring station locations in the Madaket Harbor and Long Pond Systems.

Sub-Embayment	Monitoring Station	Historical MEP Mean TN (mg/L)	s.d.	2010 Mean TN (mg/L)	2012 Mean TN (mg/L)	2013 Mean TN (mg/L)	2014 Mean TN (mg/L)	2015 Mean TN (mg/L)
Madaket Harbor	MEP M1	0.336	0.098					
Madaket Harbor	Town 4			0.285	0.297	0.278	0.254	0.328
Madaket Harbor	MEP M2	0.395	0.083					
Madaket Harbor	Town 2			0.436	0.444	0.323	0.347	0.418
Madaket Harbor	MEP M3	0.415	0.090					
Madaket Harbor	Town 3			0.324	.356	0.314	0.376	0.324
Hither Creek	MEP M4	0.581	0.193					
Hither Creek	MEP M5	0.780	0.178					
Madaket Harbor	MEP M6	0.347	0.067					
Madaket Harbor	MEP M10	0.422	0.127					
Hither Creek	MEP M11+Town 1	0.620	0.215	0.626	0.655	0.573	0.445	0.524
Long Pond	MEP LOPO1	1.058	0.404					
Long Pond	MEP LOPO2+Town 5	0.971	0.369	1.385	1.013	0.709	1.481	0.697
Long Pond	MEP LOPO3	0.924	0.234					
Long Pond	MEP LOPO4+Town 6	0.894	0.278	2.044	0.867	0.880	0.788	0.656
North Head Long P.	MEP LOPO5	0.954	0.271					

Table 5. Comparison of MEP mean values of TN with Town TN data (all values are mg/L) from Madaket Harbor and Long Pond. MEP data were collected by SMAST in the summers of 2002 through 2004. Town data were collected in the summers of 2010, 2012, 2013 and 2014 by the Town of Nantucket Marine and Coastal Resources Department.

Hummock Pond and Miacomet Pond Station ID's	2015	2014	2013	2012	2010	2005/2007	
	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	
	Mean	Mean	Mean	Mean	Mean	Mean	S.D.
HUM1	0.539	0.651	0.769	0.666	0.616	0.751**	0.374
HUM3	0.622	0.643	0.827	0.863	0.589	0.630**	0.388
HUM5	0.558	0.653	0.881	0.871	0.766	ND	ND
HUM7	0.621	0.873	1.170	1.301	1.786	1.283**	0.969
HUM8	0.576	0.755	1.064	0.944	0.983	ND	ND
MP1	1.297	0.864	0.792	0.828	0.854	0.842*	0.191
MP2	1.318	0.784	1.036	0.880	0.811	0.855*	0.213
MP3	0.992	1.297	1.058	0.950	1.093	0.280*	0
							***2005 data only** ****2007 data only**

Table 6. Comparison of TN concentrations collected in 2005 (Miacomet Pond) and 2007 (Hummock Pond) by Nantucket Marine and Coastal Resources Department with Town TN data collected at both sites the summer of 2010, 2012, 2013, 2014 and 2015. All values are mg/L.

EMBAYMENT	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	2015 EUTRO Index	Health Status
HUM1	37.7	81.3	100.0	15.7	0.0	46.9	moderate
HUM3	37.2	73.6	100.0	0.0	5.1	43.2	moderate
HUM5	34.3	79.2	100.0	11.3	12.8	47.5	moderate
HUM7	62.7	81.4	7.1	23.3	28.7	40.6	moderate
HUM8	35.7	67.8	94.8	8.9	0.0	41.5	moderate
LONG5	22.0	82.4	93.1	0.0	9.2	41.4	moderate
LONG6	16.7	70.4	100.0	0.0	0.0	37.4	moderate/fair
MH1	63.3	51.7	74.5	24.2	60.6	54.9	moderate
MH2	81.4	72.2	52.4	61.2	98.1	73.1	High
MH3	80.0	89.5	100.0	83.3	99.9	90.5	High
MH4	99.0	98.5	100.0	82.2	100.0	95.9	Highe
MP1	19.0	75.1	56.6	0.0	0.0	30.1	Fair-Poor
MP2	17.9	79.8	42.1	0.0	0.0	28.0	Fair-Poor
MP3	24.5	95.0	25.8	0.0	0.0	29.1	Fair-Poor
NAN1	97.1	96.4	100.0	83.5	79.5	91.3	High
NAN2	92.0	89.1	86.6	68.7	69.6	81.2	High
NAN3	60.1	93.7	77.1	49.3	14.7	61.6	Moderate
NAN4	100.0	94.3	100.0	97.4	85.2	95.4	High
NAN5	67.6	79.2	85.7	52.2	79.2	72.8	High
NAN6	74.8	84.8	97.5	56.9	68.4	76.5	High
NAN7	68.7	91.8	96.4	61.7	83.1	80.4	High
NAN8N	79.7	83.5	100.0	89.3	97.8	90.1	High
ORS1	100.0	26.4	91.5	22.6	6.3	49.3	Moderate
ORS2	48.0	49.5	85.2	83.1	86.2	70.4	High
ORS3	0.0	33.8	34.6	40.4	91.0	40.0	Moderate
ORS4	0.0	35.0	57.4	60.6	83.8	47.4	Moderate
ORS5	21.6	56.5	99.9	35.8	100.0	62.8	High-Moderate
ORS6	0.0	53.3	64.6	19.0	72.5	41.9	Moderate
SESA1	25.5	88.1	100.0	0.0	0.0	42.7	Moderate
SESA2	9.6	88.5	100.0	0.0	0.0	39.6	Moderate
SESA3	9.6	98.4	100.0	0.0	0.0	41.6	Moderate
SESA4	7.8	93.5	100.0	0.0	0.0	40.3	Moderate
High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39; Fair-Poor = <31							

Table 7. 2015 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *with* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

EMBAYMENT	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	2014 EUTRO Index	Health Status
HUM1	51.3	74.7	62.7	0.0	50.0	47.7	Moderate
HUM3	34.8	78.3	68.2	0.0	53.3	46.9	Moderate
HUM5	36.5	73.8	91.7	0.0	35.3	47.5	Moderate
HUM7	28.1	81.0	29.3	0.0	0.0	27.7	Fair-Poor
HUM8	17.1	66.6	91.7	0.0	39.2	42.9	Moderate
LONG5	13.4	34.4	18.4	0.0	8.9	15.0	Fair-Poor
LONG6	11.8	67.6	43.7	0.0	25.7	29.7	Fair-Poor
MH1	66.1	67.6	39.4	56.9	88.8	63.7	High-Moderate
MH2	88.7	65.1	72.7	82.0	100.0	81.7	High
MH3	82.5	65.1	76.7	69.8	100.0	78.8	High
MH4	92.6	77.8	83.8	100.0	100.0	90.8	High
MP1	51.8	55.8	42.2	0.0	0.6	30.1	Moderate-Fair
MP2	70.6	70.1	58.6	0.0	52.3	50.3	Moderate
MP3	23.1	46.0	26.1	0.0	0.0	19.0	Fair-Poor
NAN1	100.0	81.3	86.9	100.0	100.0	93.7	High
NAN2	100.0	73.4	76.2	95.3	100.0	89.0	High
NAN3	100.0	77.5	83.7	80.6	96.6	87.7	High
NAN4	100.0	87.6	89.5	100.0	100.0	95.4	High
NAN5	78.8	68.0	87.6	63.3	94.0	78.4	High
NAN6	85.6	69.4	97.5	65.9	100.0	83.7	High
NAN7	67.9	74.0	79.1	100.0	100.0	84.2	High
NAN8N	77.6	75.7	91.2	100.0	100.0	88.9	High
SESA1	41.5	75.9	54.0	0.0	28.3	39.9	Moderate
SESA2	44.6	69.8	46.0	0.0	28.3	37.7	Moderate-Fair
SESA3	42.5	76.8	56.0	0.0	44.5	44.0	Moderate
SESA4	44.3	73.3	55.1	0.0	51.1	44.8	Moderate
High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39; Fair-Poor = <31							

Table 7a. 2014 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *with* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

Sta ID	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	2013 EUTRO Index	Health Status
HUM-1	29.6	56.8	47.1	0.0	16.9	30.1	Fair-Poor
HUM-3	30.2	42.1	18.9	0.0	26.8	23.6	Fair-Poor
HUM-5	0.0	15.8	20.1	0.0	15.8	10.3	Fair-Poor
HUM-7	0.8	12.2	19.8	0.0	0.0	6.6	Fair-Poor
HUM-8	0.0	0.0	36.3	0.0	20.1	11.3	Fair-Poor
LONG-5	11.2	77.9	81.0	0.0	17.3	37.5	Moderate-Fair
LONG-6	9.3	25.0	74.8	0.0	1.1	22.0	Fair-Poor
MH1	64.5	52.5	33.4	22.0	71.2	48.7	Moderate
MH2	69.3	75.4	75.1	91.8	100.0	82.3	High
MH3	73.6	75.4	86.5	93.0	100.0	85.7	High
MH4	99.0	88.1	79.3	100.0	100.0	93.3	High
MP1	31.0	62.2	83.7	0.0	0.0	35.4	Moderate-Fair
MP2	41.9	30.5	44.1	0.0	0.0	23.3	Fair-Poor
MP3	27.3	56.2	0.0	0.0	0.0	16.7	Fair-Poor
NAN1	100.0	75.7	88.4	100.0	100.0	92.8	High
NAN2	97.3	68.2	75.7	82.0	83.1	81.3	High
NAN3	89.9	28.4	84.1	54.8	36.9	58.8	Moderate
NAN4	100.0	88.6	81.4	93.1	100.0	92.6	High
NAN5	70.7	42.6	91.3	64.3	48.0	63.4	High-Moderate
NAN6	76.1	20.5	72.4	61.9	44.2	55.0	Moderate
NAN7	70.0	73.8	90.9	88.6	64.4	77.5	High
NAN8	78.6	72.3	64.2	100.0	100.0	83.0	High
SES 1	78.9	83.6	40.3	0.0	62.4	53.0	Moderate
SES 2	86.4	70.2	61.6	2.8	73.5	58.9	Moderate
SES 3	88.0	77.5	52.5	0.0	80.7	59.7	Moderate
SES 4	92.1	79.3	47.9	0.0	79.9	59.8	Moderate

Table 7b. 2013 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *with* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

Station ID	Year	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	Health Status
HUM-1	2012	30.8	84.2	45.0	0.0	12.0	34.4	Moderate-Fair
HUM-3	2012	41.0	83.4	52.8	0.0	16.0	38.6	Moderate-Fair
HUM-5	2012	17.5	89.3	47.3	0.0	0.0	30.8	Fair-Poor
HUM-7	2012	11.3	69.5	7.9	0.0	0.0	17.7	Fair-Poor
HUM-8	2012	1.0	87.1	38.0	0.0	0.0	25.2	Fair-Poor
LONG-5	2012	0.0	70.9	30.4	0.0	0.0	20.3	Fair-Poor
LONG-6	2012	0.0	64.1	39.3	0.0	21.9	25.1	Fair-Poor
MH1	2012	65.3	100.0	3.0	17.6	3.1	37.8	Moderate-Fair
MH2	2012	83.2	100.0	20.1	68.4	100.0	74.3	High
MH3	2012	84.8	100.0	27.7	99.0	100.0	82.3	High
MH4	2012	100.0	100.0	53.8	100.0	100.0	90.8	High
MP1	2012	55.3	84.6	36.2	0.0	0.0	35.2	Moderate-Fair
MP2	2012	55.4	85.3	23.2	0.0	0.0	32.8	Moderate-Fair
MP3	2012	31.0	100.0	6.7	0.0	0.0	27.5	Fair-Poor
NAN1	2012	100.0	76.4	40.2	100.0	79.4	79.2	High
NAN2	2012	98.9	92.6	32.5	89.4	83.0	79.3	High
NAN3	2012	85.2	96.0	50.7	63.0	76.7	74.3	High
NAN4	2012	98.5	99.8	57.2	88.3	84.0	85.5	High
NAN5	2012	65.1	90.5	42.3	64.9	0.0	52.6	Moderate
NAN6	2012	79.2	80.8	46.5	41.9	38.5	57.4	Moderate
NAN7	2012	75.0	95.0	39.4	81.3	72.6	72.7	High-Moderate
NAN8	2012	71.4	76.1	39.3	84.7	85.1	71.3	High
SES 1	2012	84.2	80.4	43.6	0.0	45.4	50.7	Moderate
SES 2	2012	88.9	80.4	14.1	17.4	55.7	51.3	Moderate
SES 3	2012	95.4	80.4	36.7	17.8	71.3	60.3	Moderate
SES 4	2012	93.6	80.4	30.2	0.3	66.2	54.2	Moderate
High Quality = >69; High/Moderate = 61-69; Moderate = 39-61; Moderate/Fair = 31-39; Fair/Poor = <31								

Table 7c. 2012 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *with* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

ID	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	Health Status
HUM1	54.0	41.6	100.0	4.3	2.4	40.4	Moderate
HUM3	48.5	49.6	75.2	8.2	0.0	36.3	Moderate-Fair
HUM5	25.9	41.7	77.7	0.0	0.0	29.0	Fair-Poor
HUM7	22.4	14.5	0.4	0.0	0.0	7.4	Fair-Poor
HUM8	12.2	42.6	55.2	0.0	0.0	22.0	Fair-Poor
LONG5	0.6	55.8	100.0	0.0	0.0	31.3	Moderate-Fair
LONG6	4.6	55.8	73.9	0.0	0.0	26.8	Fair-Poor
MH1	59.0	0.3	44.5	5.4	0.0	21.8	Fair-Poor
MH2	72.8	22.3	70.7	50.3	5.4	44.3	Moderate
MH3	83.3	40.5	72.7	92.1	40.5	65.8	High-Moderate
MH4	100.0	40.5	72.4	100.0	71.8	77.0	High
MP1	54.8	37.1	63.7	0.0	0.0	31.1	Moderate-Fair
MP2	70.3	55.6	47.9	0.0	0.0	34.8	Moderate-Fair
MP3	47.1	42.8	12.9	0.0	0.0	20.6	Fair-Poor
NAN1	100.0	23.0	66.7	90.1	76.1	71.2	High
NAN2	100.0	20.9	87.2	100.0	51.8	72.0	High
NAN3	95.5	33.4	66.4	66.3	23.0	56.9	Moderate
NAN4	100.0	32.8	68.0	100.0	73.0	74.8	High
NAN5	74.8	12.5	62.1	54.1	0.0	40.7	Moderate
NAN6	81.7	16.6	69.8	49.9	0.0	43.6	Moderate
NAN7	78.1	27.1	72.3	70.4	25.6	54.7	Moderate
NAN8	86.7	27.5	62.3	100.0	77.6	70.8	High
SESA1	62.1	42.3	82.2	0.0	18.5	41.0	Moderate
SESA2	54.3	42.3	71.4	0.0	27.4	39.1	Moderate
SESA3	55.9	42.0	70.2	0.0	22.7	38.2	Moderate-Fair
SESA4	54.8	42.5	71.3	0.0	32.9	40.3	Moderate
High Quality = >69; High/Moderate = 61-69; Moderate = 39-61; Moderate/Fair = 31-39; Fair/Poor = <31							

Table 7d. 2010 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *with* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

EMBAYMENT	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	No DO EUTRO Index	Health Status
HUM1	37.7	100.0	15.7	0.0	38.3	Moderate
HUM3	37.2	100.0	0.0	5.1	35.6	Moderate-Fair
HUM5	34.3	100.0	11.3	12.8	39.6	Moderate
HUM7	62.7	7.1	23.3	28.7	30.4	Moderate-Fair
HUM8	35.7	94.8	8.9	0.0	34.9	Moderate-Fair
LONG5	22.0	93.1	0.0	9.2	31.1	Moderate-Fair
LONG6	16.7	100.0	0.0	0.0	29.2	Fair-Poor
MH1	63.3	74.5	24.2	60.6	55.6	Moderate
MH2	81.4	52.4	61.2	98.1	73.3	High
MH3	80.0	100.0	83.3	99.9	90.8	High
MH4	99.0	100.0	82.2	100.0	95.3	High
MP1	19.0	56.6	0.0	0.0	18.9	Fair-Poor
MP2	17.9	42.1	0.0	0.0	15.0	Fair-Poor
MP3	24.5	25.8	0.0	0.0	12.6	Fair-Poor
NAN1	97.1	100.0	83.5	79.5	90.0	High
NAN2	92.0	86.6	68.7	69.6	79.2	High
NAN3	60.1	77.1	49.3	14.7	50.3	Moderate
NAN4	100.0	100.0	97.4	85.2	95.6	High
NAN5	67.6	85.7	52.2	79.2	71.2	High
NAN6	74.8	97.5	56.9	68.4	74.4	High
NAN7	68.7	96.4	61.7	83.1	77.5	High
NAN8N	79.7	100.0	89.3	97.8	91.7	High
ORS1	100.0	91.5	22.6	6.3	55.1	Moderate
ORS2	48.0	85.2	83.1	86.2	75.6	High
ORS3	0.0	34.6	40.4	91.0	41.5	Moderate
ORS4	0.0	57.4	60.6	83.8	50.4	Moderate
ORS5	21.6	99.9	35.8	100.0	64.3	High-Moderate
ORS6	0.0	64.6	19.0	72.5	39.0	Moderate
SESA1	25.5	100.0	0.0	0.0	31.4	Moderate-Fair
SESA2	9.6	100.0	0.0	0.0	27.4	Fair-Poor
SESA3	9.6	100.0	0.0	0.0	27.4	Fair-Poor
SESA4	7.8	100.0	0.0	0.0	26.9	Fair-Poor
High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39; Fair-Poor = <31						

Table 8. 2015 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *without* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

EMBAYMENT	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	No DO EUTRO Index	Health Status
HUM1	51.3	62.7	0.0	50.0	41.0	Moderate
HUM3	34.8	68.2	0.0	53.3	39.1	Moderate
HUM5	36.5	91.7	0.0	35.3	40.9	Moderate
HUM7	28.1	29.3	0.0	0.0	14.3	Fair-Poor
HUM8	17.1	91.7	0.0	39.2	37.0	Moderate-Fair
LONG5	13.4	18.4	0.0	8.9	10.2	Fair-Poor
LONG6	11.8	43.7	0.0	25.7	20.3	Fair-Poor
MH1	66.1	39.4	56.9	88.8	62.8	High-Moderate
MH2	88.7	72.7	82.0	100.0	85.8	High
MH3	82.5	76.7	69.8	100.0	82.2	High
MH4	92.6	83.8	100.0	100.0	94.1	High
MP1	51.8	42.2	0.0	0.6	23.6	Fair-Poor
MP2	70.6	58.6	0.0	52.3	45.4	Moderate
MP3	23.1	26.1	0.0	0.0	12.3	Fair-Poor
NAN1	100.0	86.9	100.0	100.0	96.7	High
NAN2	100.0	76.2	95.3	100.0	92.9	High
NAN3	100.0	83.7	80.6	96.6	90.2	High
NAN4	100.0	89.5	100.0	100.0	97.4	High
NAN5	78.8	87.6	63.3	94.0	80.9	High
NAN6	85.6	97.5	65.9	100.0	87.3	High
NAN7	67.9	79.1	100.0	100.0	86.8	High
NAN8N	77.6	91.2	100.0	100.0	92.2	High
SESA1	41.5	54.0	0.0	28.3	30.9	Moderate-Fair
SESA2	44.6	46.0	0.0	28.3	29.7	Fair-Poor
SESA3	42.5	56.0	0.0	44.5	35.8	Moderate-Fair
SESA4	44.3	55.1	0.0	51.1	37.6	Moderate-Fair
High Quality = >69; High-Moderate = 61-69; Moderate = 39-61; Moderate-Fair = 31-39; Fair-Poor = <31						

Table 8a. 2014 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *without* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

Sta ID	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	No DO EUTRO Index	Health Status
HUM-1	29.6	47.1	0.0	16.9	23.4	Fair-Poor
HUM-3	30.2	18.9	0.0	26.8	19.0	Fair-Poor
HUM-5	0.0	20.1	0.0	15.8	9.0	Fair-Poor
HUM-7	0.8	19.8	0.0	0.0	5.2	Fair-Poor
HUM-8	0.0	36.3	0.0	20.1	14.1	Fair-Poor
LONG-5	11.2	81.0	0.0	17.3	27.4	Fair-Poor
LONG-6	9.3	74.8	0.0	1.1	21.3	Fair-Poor
MH1	64.5	33.4	22.0	71.2	47.8	Moderate
MH2	69.3	75.1	91.8	100.0	84.0	High
MH3	73.6	86.5	93.0	100.0	88.3	High
MH4	99.0	79.3	100.0	100.0	94.6	High
MP1	31.0	83.7	0.0	0.0	28.7	Fair-Poor
MP2	41.9	44.1	0.0	0.0	21.5	Fair-Poor
MP3	27.3	0.0	0.0	0.0	6.8	Fair-Poor
NAN1	100.0	88.4	100.0	100.0	97.1	High
NAN2	97.3	75.7	82.0	83.1	84.5	High
NAN3	89.9	84.1	54.8	36.9	66.4	High-Moderate
NAN4	100.0	81.4	93.1	100.0	93.6	High
NAN5	70.7	91.3	64.3	48.0	68.6	High-Moderate
NAN6	76.1	72.4	61.9	44.2	63.6	High-Moderate
NAN7	70.0	90.9	88.6	64.4	78.4	High
NAN8	78.6	64.2	100.0	100.0	85.7	High
SES 1	78.9	40.3	0.0	62.4	45.4	Moderate
SES 2	86.4	61.6	2.8	73.5	56.1	Moderate
SES 3	88.0	52.5	0.0	80.7	55.3	Moderate
SES 4	92.1	47.9	0.0	79.9	55.0	Moderate

Table 8b. 2013 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *without* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

Station ID	Year	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	Health Status
HUM-1	2012	30.8	45.0	0.0	12.0	22.0	Fair-Poor
HUM-3	2012	41.0	52.8	0.0	16.0	27.4	Fair-Poor
HUM-5	2012	17.5	47.3	0.0	0.0	16.2	Fair-Poor
HUM-7	2012	11.3	7.9	0.0	0.0	4.8	Fair-Poor
HUM-8	2012	1.0	38.0	0.0	0.0	9.7	Fair-Poor
LONG-5	2012	0.0	30.4	0.0	0.0	7.6	Fair-Poor
LONG-6	2012	0.0	39.3	0.0	21.9	15.3	Fair-Poor
MH1	2012	65.3	3.0	17.6	3.1	22.3	Fair-Poor
MH2	2012	83.2	20.1	68.4	100.0	67.9	High-Moderate
MH3	2012	84.8	27.7	99.0	100.0	77.9	High
MH4	2012	100.0	53.8	100.0	100.0	88.4	High
MP1	2012	55.3	36.2	0.0	0.0	22.9	Fair-Poor
MP2	2012	55.4	23.2	0.0	0.0	19.7	Fair-Poor
MP3	2012	31.0	6.7	0.0	0.0	9.4	Fair-Poor
NAN1	2012	100.0	40.2	100.0	79.4	79.9	High
NAN2	2012	98.9	32.5	89.4	83.0	76.0	High
NAN3	2012	85.2	50.7	63.0	76.7	68.9	High-Moderate
NAN4	2012	98.5	57.2	88.3	84.0	82.0	High
NAN5	2012	65.1	42.3	64.9	0.0	43.1	Moderate
NAN6	2012	79.2	46.5	41.9	38.5	51.5	Moderate
NAN7	2012	75.0	39.4	81.3	72.6	67.1	High-Moderate
NAN8	2012	71.4	39.3	84.7	85.1	70.1	High
SES 1	2012	84.2	43.6	0.0	45.4	43.3	Moderate
SES 2	2012	88.9	14.1	17.4	55.7	44.1	Moderate
SES 3	2012	95.4	36.7	17.8	71.3	55.3	Moderate
SES 4	2012	93.6	30.2	0.3	66.2	47.6	Moderate
High Quality = >69; High/Moderate = 61-69; Moderate = 39-61; Moderate/Fair = 31-39; Fair/Poor = <31							

Table 8c. 2012 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *without* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

ID	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	Health Status
HUM1	54.0	100.0	4.3	2.4	40.1	Moderate
HUM3	48.5	75.2	8.2	0.0	33.0	Moderate-Fair
HUM5	25.9	77.7	0.0	0.0	25.9	Fair-Poor
HUM7	22.4	0.4	0.0	0.0	5.7	Fair-Poor
HUM8	12.2	55.2	0.0	0.0	16.9	Fair-Poor
LONG5	0.6	100.0	0.0	0.0	25.2	Fair-Poor
LONG6	4.6	73.9	0.0	0.0	19.6	Fair-Poor
MH1	59.0	44.5	5.4	0.0	27.2	Fair-Poor
MH2	72.8	70.7	50.3	5.4	49.8	Moderate
MH3	83.3	72.7	92.1	40.5	72.1	High
MH4	100.0	72.4	100.0	71.8	86.1	High
MP1	54.8	63.7	0.0	0.0	29.6	Fair-Poor
MP2	70.3	47.9	0.0	0.0	29.6	Fair-Poor
MP3	47.1	12.9	0.0	0.0	15.0	Fair-Poor
NAN1	100.0	66.7	90.1	76.1	83.3	High
NAN2	100.0	87.2	100.0	51.8	84.7	High
NAN3	95.5	66.4	66.3	23.0	62.8	High-Moderate
NAN4	100.0	68.0	100.0	73.0	85.3	High
NAN5	74.8	62.1	54.1	0.0	47.8	Moderate
NAN6	81.7	69.8	49.9	0.0	50.4	Moderate
NAN7	78.1	72.3	70.4	25.6	61.6	High-Moderate
NAN8	86.7	62.3	100.0	77.6	81.7	High
SESA1	62.1	82.2	0.0	18.5	40.7	Moderate
SESA2	54.3	71.4	0.0	27.4	38.3	Moderate-Fair
SESA3	55.9	70.2	0.0	22.7	37.2	Moderate-Fair
SESA4	54.8	71.3	0.0	32.9	39.8	Moderate
High Quality = >69; High/Moderate = 61-69; Moderate = 39-61; Moderate/Fair = 31-39; Fair/Poor = <31						

Table 8d. 2010 Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated *without* Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

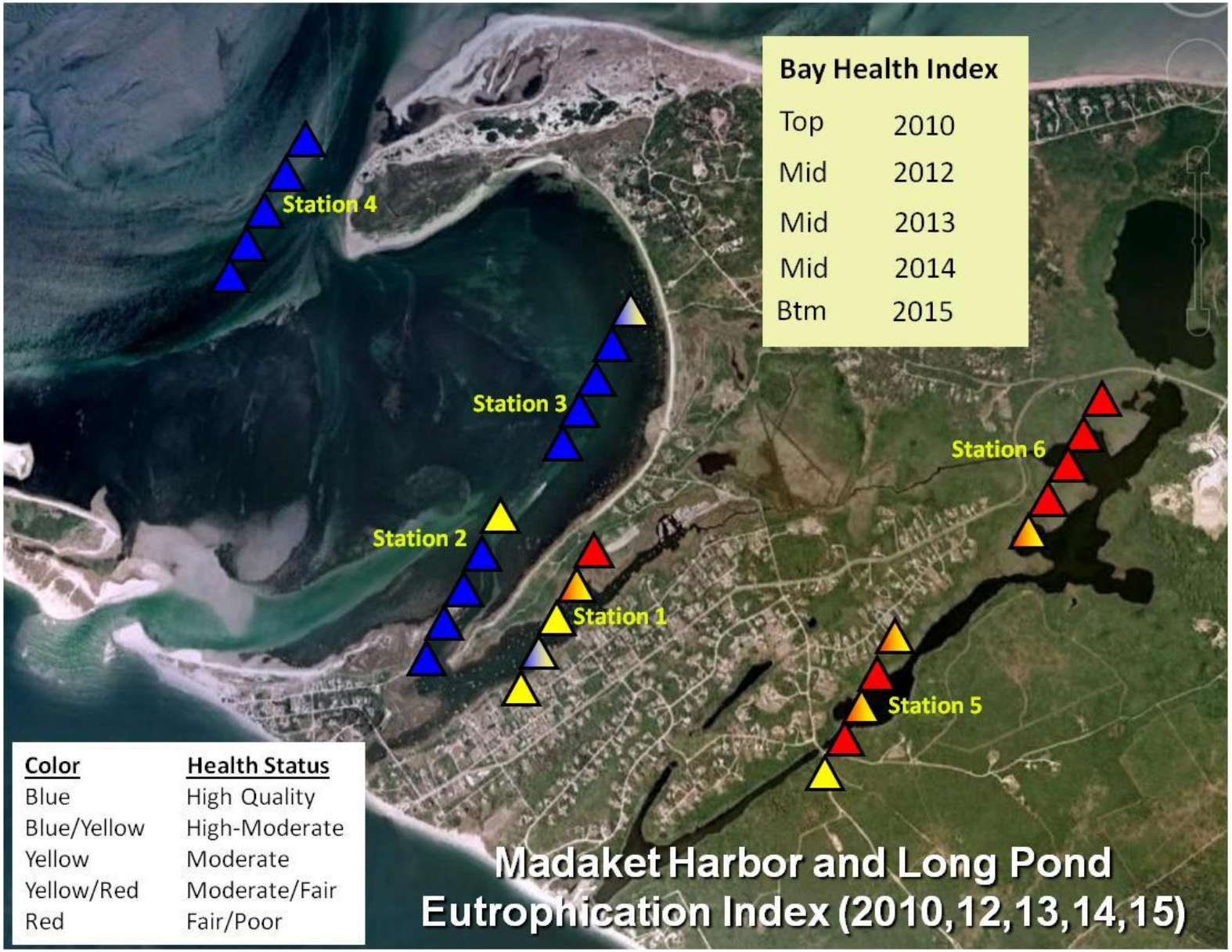


Figure 18. Madaket Harbor Eutrophication Index 2010 (top triangle) and 2015 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

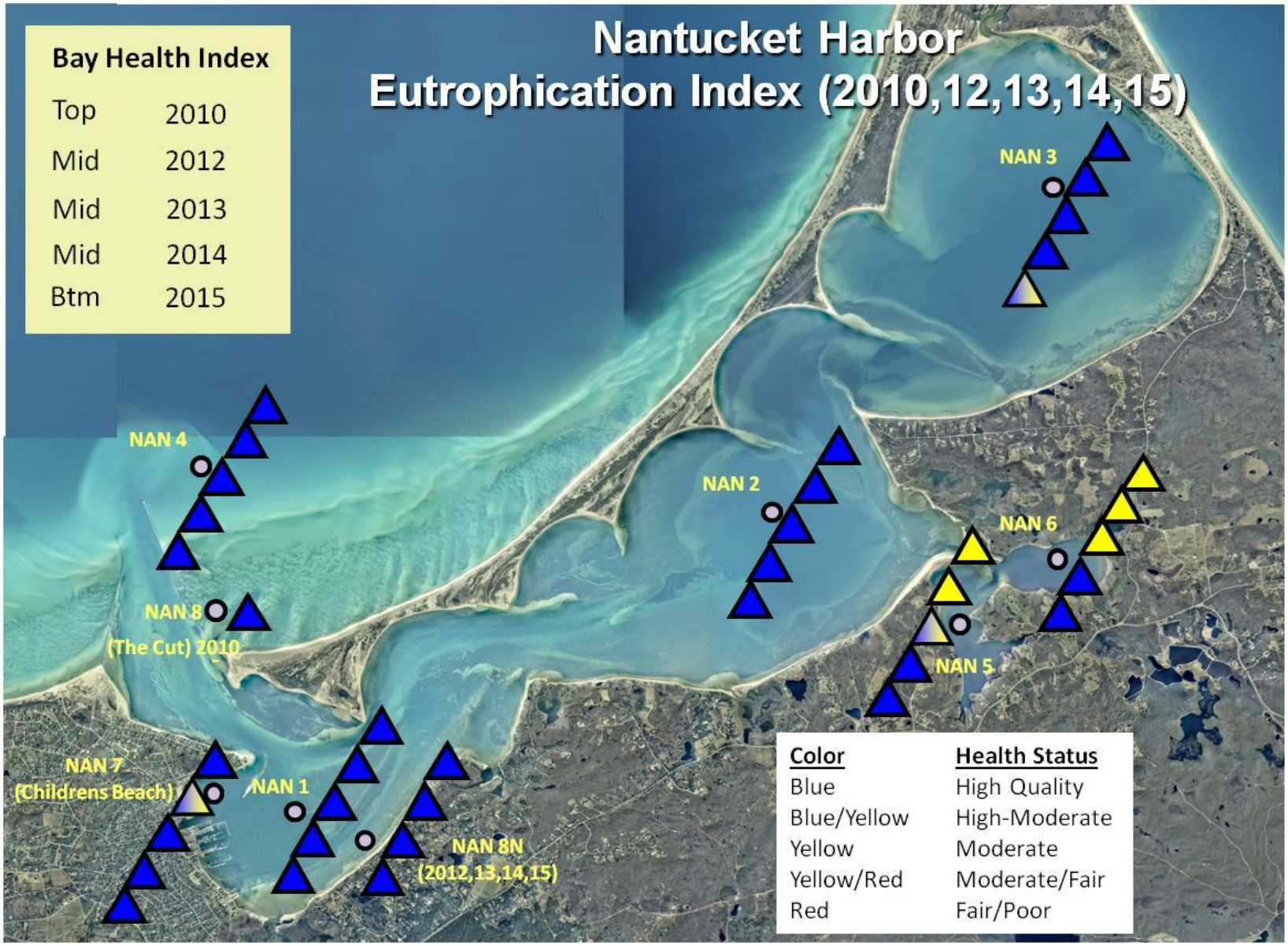


Figure 19. Nantucket Harbor Eutrophication Index 2010 (top triangle) and 2015 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

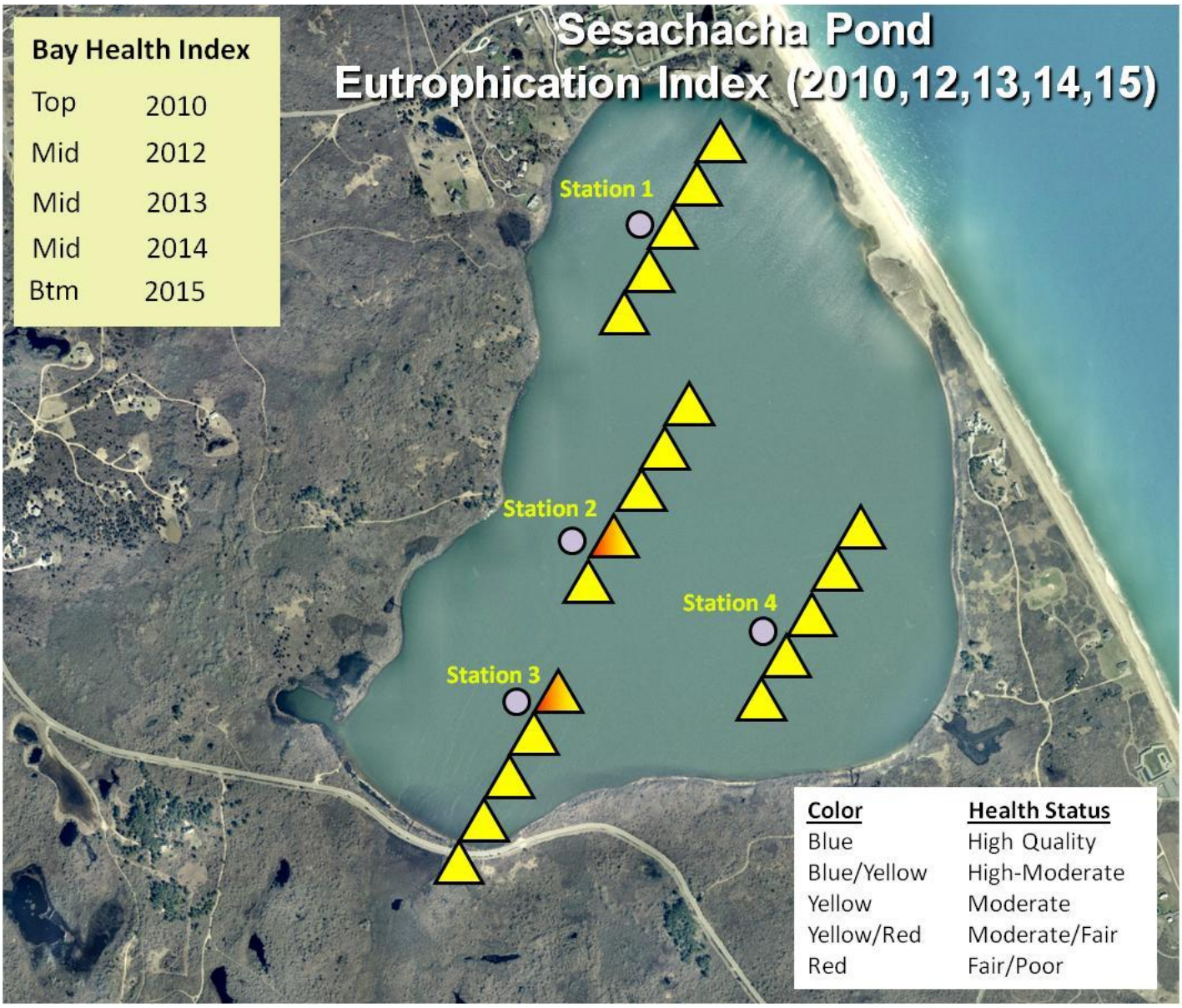


Figure 20. Sesachacha Pond Eutrophication Index 2010 (top triangle) and 2015 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

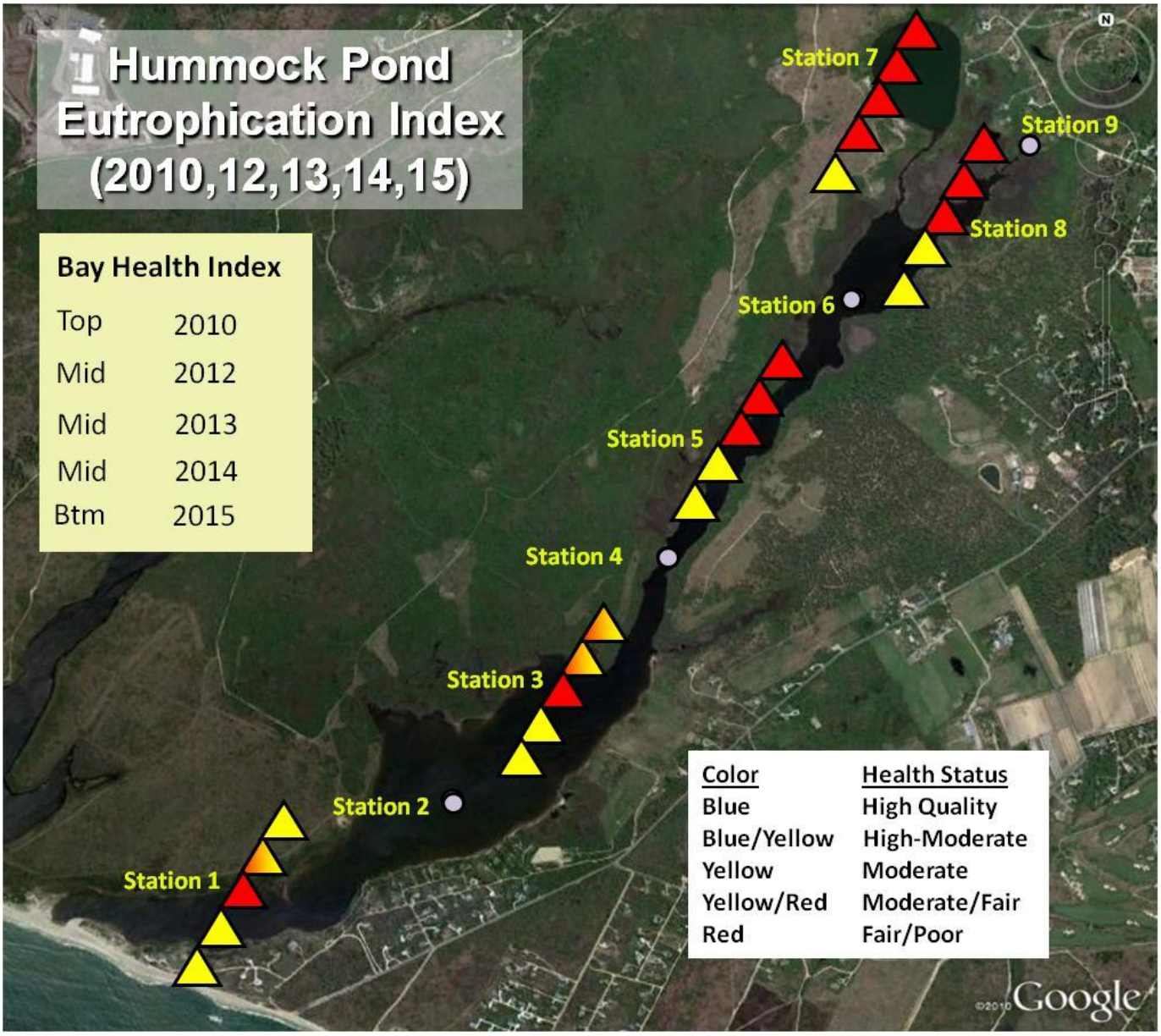


Figure 21. Hummock Pond Eutrophication Index 2010 (top triangle) and 2015 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

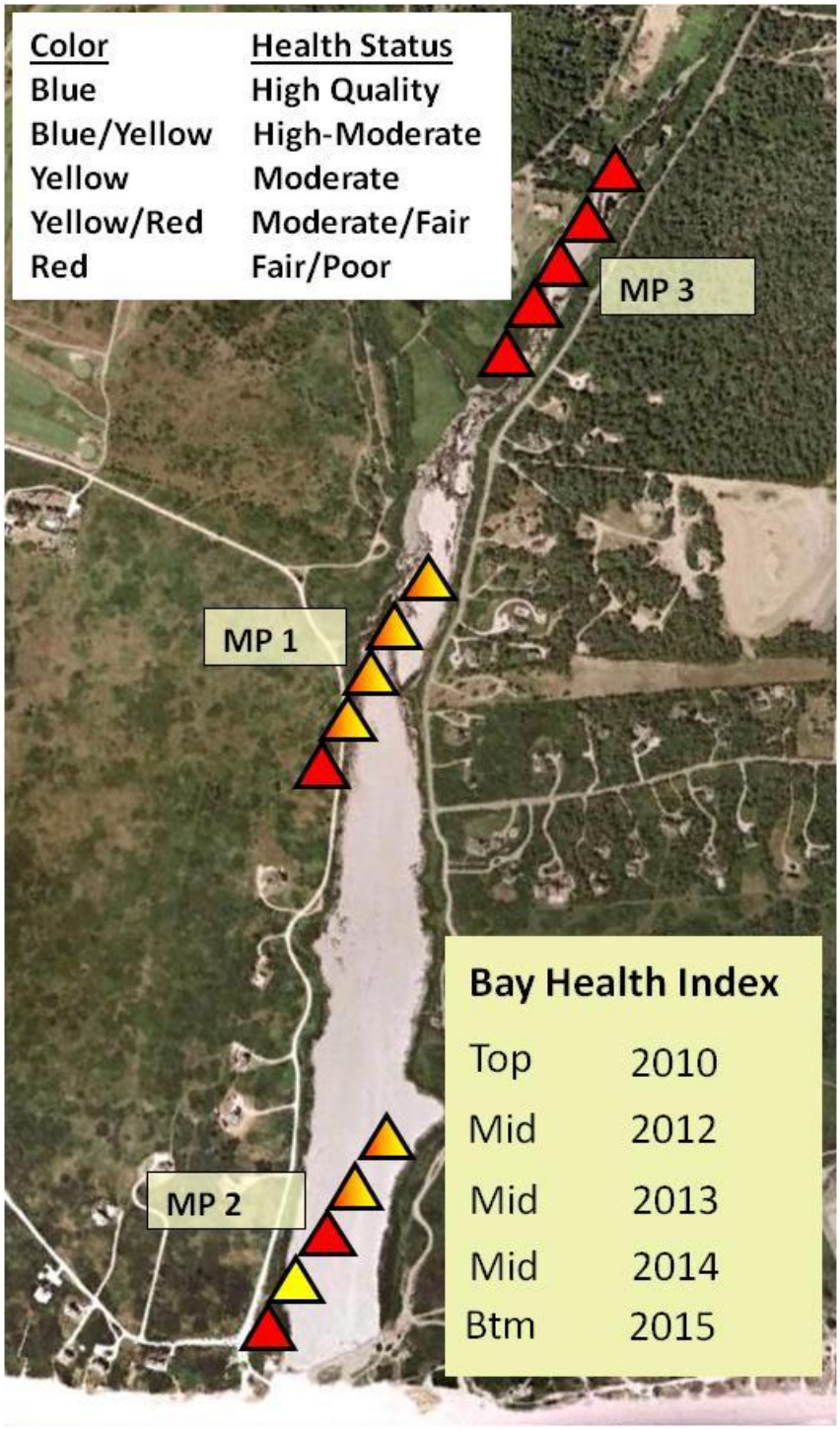


Figure 22. Miacomet Pond Eutrophication Index 2010 (top triangle) and 2015 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

TOWN OF NANTUCKET NATURAL RESOURCES DEPARTMENT

KAITLYN SHAW, WATER RESOURCE SPECIALIST
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508-228-7230

MEMO
02/02/2016
To: Libby Gibson, Town Manager
Roberto Santamaria, Director of Public Health
Kara Buzanoski, Director of Public Works
Karen Beattie, Conservation Foundation
Gregg Tivnan, Assistant Town Manager
Jeff Carlson, Natural Resource Coordinator
From: Kaitlyn Shaw, Water Resources Specialist

Nantucket Island-wide Eelgrass Mapping Update

Due to mounting concerns regarding eelgrass loss on Nantucket, Dr. Charles Costello was hired in 2015 to "Map and Characterize the Present and Historical Distribution of Eelgrass (Zostera Marina) in Nantucket and Madaket Harbors and Tuckernuck Island, MA". The study established high precision baseline data on the current distribution, abundance and characteristics of eelgrass (Zostera marina) in Nantucket and Madaket Harbors and Tuckernuck Island. This data will be used to:

- Serve as a baseline for future assessments of eelgrass distribution changes.
- Determine the level of monitoring needed in the future.
- Establish long-term 'sentinel' eelgrass monitoring sites.
- Determine the status and trends of eelgrass distribution and abundance in order to conduct environmental assessments and track regulatory compliance intended to protect and enhance the health and condition of eelgrass and its associated shellfish resources.

The aerial survey was conducted using protocols developed by the Division of Watershed Management, Massachusetts Department of Environmental Protection (Costello and Kenworthy 2011). Digital imagery was acquired through a contract with GeoVantage Corporation (Peabody, MA, USA). Field verification of digital image signatures (ground truthing) was conducted in the summer of 2015 to develop a quantitative understanding of the eelgrass signatures on the imagery and gather surface level data where the presence or extent of eelgrass habitat is not apparent in the imagery. The outer edges of seagrass polygons were determined utilizing underwater video camera transects. A differential global positioning system (DGPS) was used to mark video data points of the outer bed edges which were entered into the GIS database. This database is searchable in ArcGIS and provides geo-referenced underwater video clips throughout Nantucket Harbor, Madaket Harbor and Tuckernuck.

Recommendations (Costello)

- Use 2015 maps as a high definition baseline for further 'loss calculations'
- Conduct aerial surveys every 2-3 years to assess changes in eelgrass distribution and health.

Natural Resources Action Items

- Develop permanent geo-referenced 'sentinel' eelgrass monitoring transects.
- Develop a Standard Operating Procedure for the assessment of eelgrass beds and associated impacts of coastal activities on bed health.
- Monitor and assess eelgrass health bi-monthly during spring/ summer.
- Provide visual underwater representations of the impacts of coastal activities, when possible.

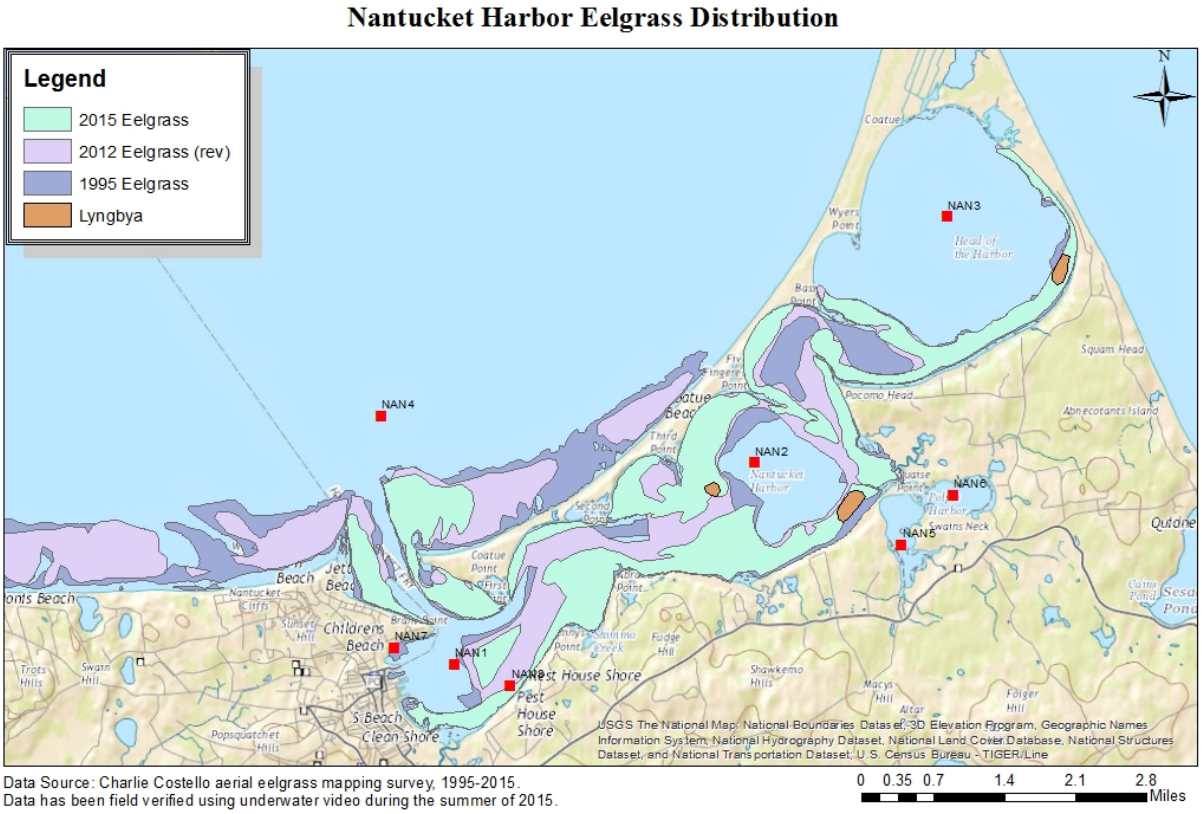


Figure 1. Nantucket Harbor 1995, 2012 and 2015 eelgrass and *Lyngbya* distribution.

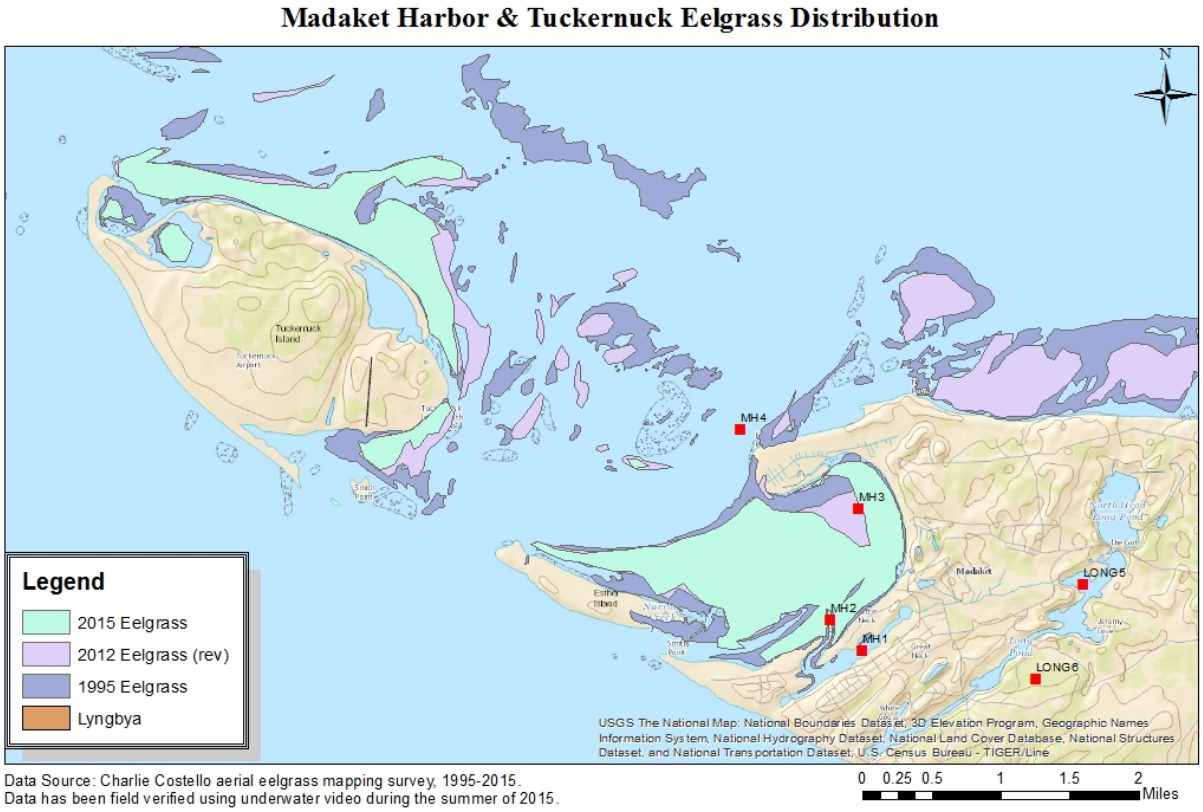


Figure 2. Madaket Harbor and Tuckernuck 1995, 2012 and 2015 eelgrass and *Lyngbya* distribution.

Harbor Water Quality Action Update
*02/10/16 BOS Meeting (update shown in **bold**) as of 01/14/16 and subsequent to most recent update (June, 2015)*

<u>In Progress:</u>

1. Amendments to Shellfish Regulations (NRD; BOS):

-- establish "Habitat Sensitive Area(s)" with language that allows the Town the ability to close off to moorings, boat traffic and shellfishing – as circumstances require

-- increase dredge restrictions on commercial scallop boats

-- Public Hearing, March 4

-- DONE!

2. Mooring Field/Anchorage Area (Marine):

-- presentation given on March 4 by Harbormaster

-- need to reach clarity on when we have reached capacity & where boats are supposed to go

-- active discussions occurring with Race Week and Boston Pops organizers; need direction from BOS at some point: seek to have events held at different dates?

-- re-alignment of the Anchorage (Hussey Shoal to be more defined with buoys)

-- increased enforcement of where boats are being moored/anchored

-- buoys (red) installed to define Hussey Shoal & delineate where there is "No Anchoring"

-- Notice to Mariners issued; harbor charts showing the area available "On Demand" now

3. Mooring Regulations (Marine):

-- proposed regs reviewed with SHAB, other interested parties; changes include:

-- changes to fees

-- phase out of helix moorings

-- public hearing scheduled for 4/22/15

-- amendments adopted by Board 4/22/15

-- DONE!

4. Amendments to Septic System Regulations (these are being developed and will require legal and technical review) (NRD; BOH):

-- concept is to require Innovative-Alternative systems when current systems have failed

-- New regulations (regulation 64) adopted by BOH in August, 2015 and implemented September 1, 2015; 175 letters to the Hummock Pond Watershed property owners sent out; all but 3 complied within the given timeframe; the Nantucket Harbor Watershed letters are still within their enforcement timeline, but so far we have about 60% compliance. This is expected as compliance in NHW requires engineering and an

installation of an I/A system. George Heufelder of Barnstable County is currently working on getting a new type of I/A system approved by DEP that will significantly bring the cost of an I/A down (approximately 70% cheaper). However, this technology is still about 1-2 years away from being fully approved. In the meantime, we will be moving forward with Madaket watershed letters in the coming months.

-- Septic system education flyer/website info being updated (multi-party effort): Currently working with the Nantucket Pond Coalition, and Land Council to develop and distribute to septic system owners across the island.

5. Stormwater Drainage Outfall Pipes (NRD; DPW):

-- catch basins marked to educate people not to dump anything– DONE!

-- (2) of private outfall pipes in Monomoy area being discussed with ConCom on 4/1/15 (voluntary removal vs enforcement order)

-- letters been sent by certified mail to owners; Natural Resources been in subsequent contact with the owners who are aware of need to address the matter (ConCom approval will be required for corrective action)

-- pipes have been capped and/or confirmed to be no longer in use

6. Green Crab Removal/Reduction (NRD):

-- private party contacted and arrangements being made – DONE!

-- program expected to continue in 2016

7. Fertilizer Regulations (NRD):

-- better tracking methodology for field compliance checks & increased field compliance checks being implemented this year (scannable license card)

-- seasonal enforcement position funded for FY 16 (pending 2015 ATM approval)

-- working on increasing education/outreach as to BMPs (live-streaming program idea)

-- evaluating changing the application ratios in the BMPs w/goal to issue revised BMPs

-- $100/license fee implemented for 2015

-- annual training held (and taped) on 3/17/15; doing 2 more classes by 4/15/15; 240 attendees

-- in process of preparing flyer (Fact Sheet) to be mailed to homeowners in Watershed areas **- DONE**

- in process of compiling list of licensed landscapers to be posted on Town website

-- review screenshot of Natural Resources webpage re fertilizer regs

-- discuss idea of inviting landscapers to BOS (workshop?) mtg to hear input and/or sending a questionnaire to them

-- 295 licenses issued as of 5/21/15; list of licensed landscapers on Town website

-- additional fertilizer regs class to be held in June; as well as an abbreviated class for homeowners

-- January 6, 2016 BOS meeting:

-- additional seasonal position will begin inspection/enforcement by April 15, 2016

-- seek Town Counsel opinion on ways to strengthen enforcement and/or compliance/ban certain levels of fertilizer – see attached

-- Admin meeting with former members of "Article 68 Work Group"; interested landscapers to discuss compliance/education (Roberto & Jeff) Met with landscapers at the January 17, 2016 BOH meeting to discuss the fertilizer regulations. We are currently trying to implement a fertilizer advisory group to inform any decisions regarding the fertilizer regulation. An open hearing is scheduled for the February 18 BOH hearing to discuss enforcement issues.

8. Eel Grass Survey (NRD):

-- eel grass survey (aerial mapping and ground truthing) to be overseen by NRD with DMF in 2015 (funded thru gift from NLC and GHYC – soon to be presented to BOS)

-- survey complete; final report to be presented to BOS 2/10/16

9. Other

-- Water Quality testing

-- 2015 water quality testing contract – in process of being finalized; SMAST only bidder

-- 2014 Water Quality testing report out – presentation given on 5/14/15; video available on-line; complete report on-line

-- UMass Boston Seafloor Mapping Project – presentation on 5/14/15 (not directly related to water quality but fyi)

-- 2015 test results scheduled for presentation to BOS 2/10/16

-- 2016 – test locations added pursuant to Surfside WWTF Groundwater Discharge permit

-- CWMP update complete

-- acceptance requested of BOS 6/3/15

-- SPWG recommendations re: funding options to be discussed with BOS 6/17/15

-- throughout fall 2015 BOS discuss projects to be put forward/staff work on funding sources/cost projections; projects to be finalized 1/20/16 with public outreach to begin

-- Water Quality webpage being developed – can we show to BOS?

<u>Still Evaluating/Reviewing/Researching/Discussing (not in any particular order):</u>

1. Possibility of a phased-in ban of pre-1999 2-stroke engines (this is referenced in the Harbor Action Plan) – very difficult to do this, a lot to work out; looking into rebate program?

2. Reviewing the possibility of restricting or banning use of surfactants (referenced in Harbor Action Plan and Shellfish Management Plan); still being researched; Boat Basin been contacted, will increase oversight

-- advisory signage placed at Town Pier with dock worker education from Natural Resources

-- reviewing ways in which to better educate/enforce BOH Gray Water regulations/Town bylaw

Is your landscaper licensed to apply fertilizer on Nantucket?

Photo courtesy of Jeff Carlson

Under the Board of Health Local Regulation 75.00, commercial landscapers must be licensed to apply fertilizer.

Did you know?

•If lawns were considered a crop, they would be the fifth largest in the United States.

•Mulching grass clippings into lawns reduces or eliminates the need to fertilize.

What is the purpose of these regulations?

•To protect Nantucket's economically important scallop fishery habitat.

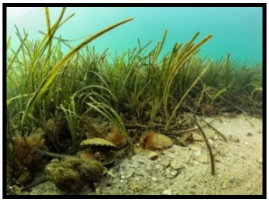
How will these regulations be enforced?

•Ask your landscaper to see their license.

How does fertilizer overuse affect our harbors and ponds?

Nutrients from fertilizers, septic systems, yard and animal waste cause **eutrophication**.

Eutrophication is when excess nutrients in the form of nitrogen and phosphorous enter the harbor & cause algae blooms which cloud the water and lead to low light levels & dissolved oxygen.



Healthy habitat

Loss of important shellfish habitat can occur, due to high nutrient levels.

Degraded habitat

Photos courtesy of Tom Montgomery

YOU can make a difference!

•Ask to see your landscaper's license.

•Visit the Town of Nantucket Natural Resources Dept. Fertilizer program webpage to choose a licensed landscaper.

•Ask your landscaper to perform a soil test for nutrient content. It can cost as little as $25 and can save you money in fertilizer costs.

•Consider choosing native vegetation. Using native plants can minimize the need for additional fertilizer and water.

•Discuss the benefits of using mulched grass clippings with your landscaper.

•Only irrigate when necessary.

- •Excess nutrients are carried to the harbors through water.
- • If the forecast calls for rain, turn off your irrigation system and do not fertilize.
- •Discuss installing a timed irrigation system.

Questions?

Town of Nantucket
Natural Resources Dept.
2 Bathing Beach Rd.
Nantucket, MA
508-228-7230

Libby Gibson

From: Gregg J. Corbo [GCorbo@k-plaw.com]
Sent: Thursday, February 04, 2016 10:29 AM
To: Libby Gibson
Cc: Kara Buzanoski; Roberto Santamaria; Jeff Carlson; John Giorgio
Subject: FW: Nantucket Fertilizer Regulations

Dear Libby:

You have requested an opinion concerning the Town's authority to regulate the sale and use of fertilizer on the Island. While the Board of Health has enacted a comprehensive fertilizer regulation, there is evidence to suggest that more stringent controls are needed. You have, therefore, asked whether the regulations can be amended to ban certain types of fertilizers or certain levels of fertilizer. You have also asked whether the regulations can be amended to add provisions for enforcement on private property and for more stringent enforcement against landscapers who violate the regulations. For the detailed reasons set forth below, it is my opinion that the regulations can be amended if the amendments are part of a plan and recommendation from the Nantucket Planning and Economic Development Commission.

Notwithstanding the broad regulatory authority of the Board of Health, in 2012, the Legislature delegated to the Department of Agriculture comprehensive authority to regulate all aspects of the manufacture, distribution and use of fertilizer in the Commonwealth. See Chapter 262 of the Acts of 2012 (the "Fertilizer Act"). The Massachusetts Attorney General has interpreted this statute as preempting any local regulation on the subject, except those specifically enumerated in the Fertilizer Act. Those exemptions include local regulations that were in existence prior to July 31, 2012 and any regulation adopted in conjunction with a plan and recommendation of the Nantucket Planning and Economic Development Commission (the "Commission"). In 2013, the Fertilizer Act was amended to provide that "any ordinance or by-law relative to nutrient management or establishing fertilizer guidelines enacted or adopted by a city or adopted by a town between July 31, 2012 and July 31, 2013 shall be enforceable by that city or town" See, Section 157 of Chapter 38 of the Acts of 2013.

It is my understanding that the Board of Health's regulation was adopted on or about June 13, 2012 (See, Section 10) and that it had an effective date of January 1, 2013. Therefore, it is my opinion that the Regulations remain enforceable in the Town. It is my further opinion, however, that the regulations can only be amended if the amendment is part of a plan and recommendation of the Commission and it complies with additional requirements of the Fertilizer Act. More specifically, pursuant to Chapter 561 of the Acts of 1973, "the commission shall be responsible for the preparation of comprehensive plans for the physical, social and economic development of [the] county and town and shall make recommendations for action to implement said plans to the responsible county and town agencies." Therefore, it is my opinion that, if supported by scientific studies, the Commission may recommend additional restrictions on the use of fertilizer as part of a comprehensive plan for the development of the county and town, and that the Board of Health may execute that recommendation by enacting an amendment to the regulations. Provided, however, that such regulations cannot be less stringent than the regulations of the Department of Agriculture and they must be enacted in conjunction with the University of Massachusetts Amherst Extension to ensure that they are consistent with the program's published information, as required by the Fertilizer Act.

In enacting amendments to the regulations, I recommend that you review recent regulations enacted by the Department of Agriculture to ensure that the Town's regulations will be at least as stringent. Those regulations can be found at 330 CMR 31.00. Otherwise, it is my opinion that, in enacting additions to the regulations, the Board of Health will have broad authority to enact regulations that are reasonably related to the goals set forth by the Commission. That authority, however, will have to be exercised so as not to intrude upon certain constitutional protections enjoyed by private property owners and businesses. In this regard, we will be happy to work with you to develop a regulation that balances the Town's needs for effective enforcement and the constitutional rights of property owners and residents.

Please do not hesitate to contact me if you have any further questions in this regard.

Very truly yours,

Gregg J. Corbo, Esq.
KOPELMAN AND PAIGE, P.C.
101 Arch Street, 12th Floor
Boston, MA 02110
O: (617) 556 0007
F: (617) 654 1735
gcorbo@k-plaw.com
www.k-plaw.com

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NANTUCKET WASTEWATER PLAN UPDATE

4 Fairgrounds Road Community Room
Board of Selectmen
Wednesday, February 10,2016 6:00 pm

Agenda

- Current Status of Overall Wastewater Planning
  - Comprehensive Wastewater Management Plan (CWMP) Update
  - Surfside WWTF Improvements Project
  - Sewer Extension Implementation Plan
    - Nantucket Harbor Shimmo
    - PLUS
  - Estimated Project Costs and Capital Cost Recovery Plan
    - Betterments
    - Property Taxes
  - April 2016 Annual Town Meeting Actions

Comprehensive Wastewater Management Plan Update

- Incorporates Massachusetts Estuaries Program Results Into Recommended Plan
  - Nitrogen Reduction to Meet Total Maximum Daily Loads (TMDLs)
- Ranks “Areas of Need”
- Septage Management Solutions
  - Board of Health Local Regulations
- Full Use of Surfside WWTF Permit - Flows
  - Madaket WWTF Eliminated
- 20-Year Planning Document

Adaptive Management Plan to Meet Nitrogen Reductions

Structured Nitrogen Reducing Solutions

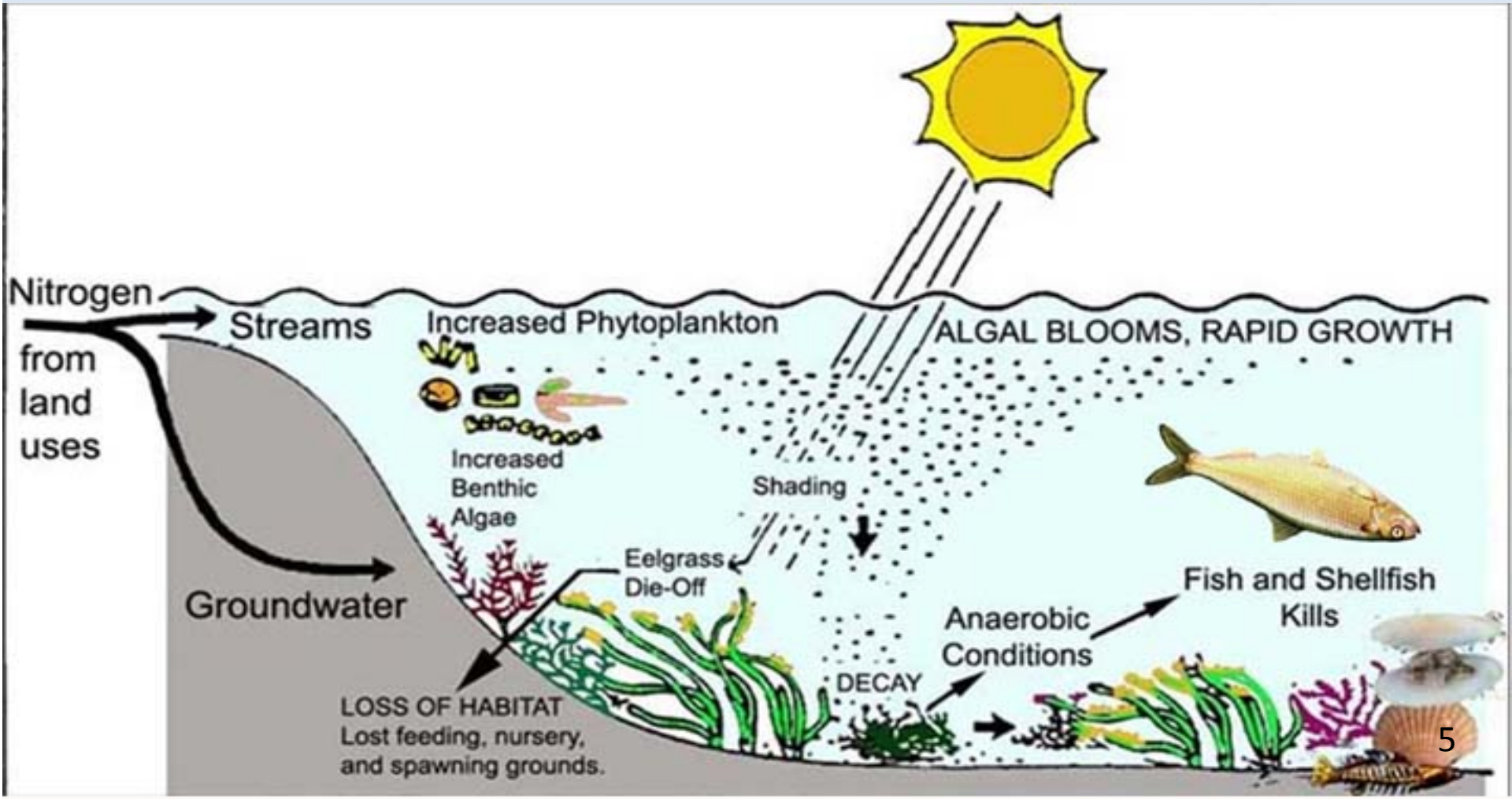
- Address all Needs Areas With a Plan Defined as a Structured, Iterative Process and Adapt As Necessary
  - Sewer Expansion
- Aim to Reduce Nutrient Loading Over Time – Water Quality Monitoring Program
  - Start With Plans That Give the Town the Biggest Bang for its Buck
- Add or Reduce Solutions as Needed to Meet Established Thresholds
  - Hummock Pond Breach – Jetties Reconstruction
  - Sesachacha Pond Breach

Adaptive Management Plan to Meet Nitrogen Reductions

Non-Structured Nitrogen Reducing Solutions

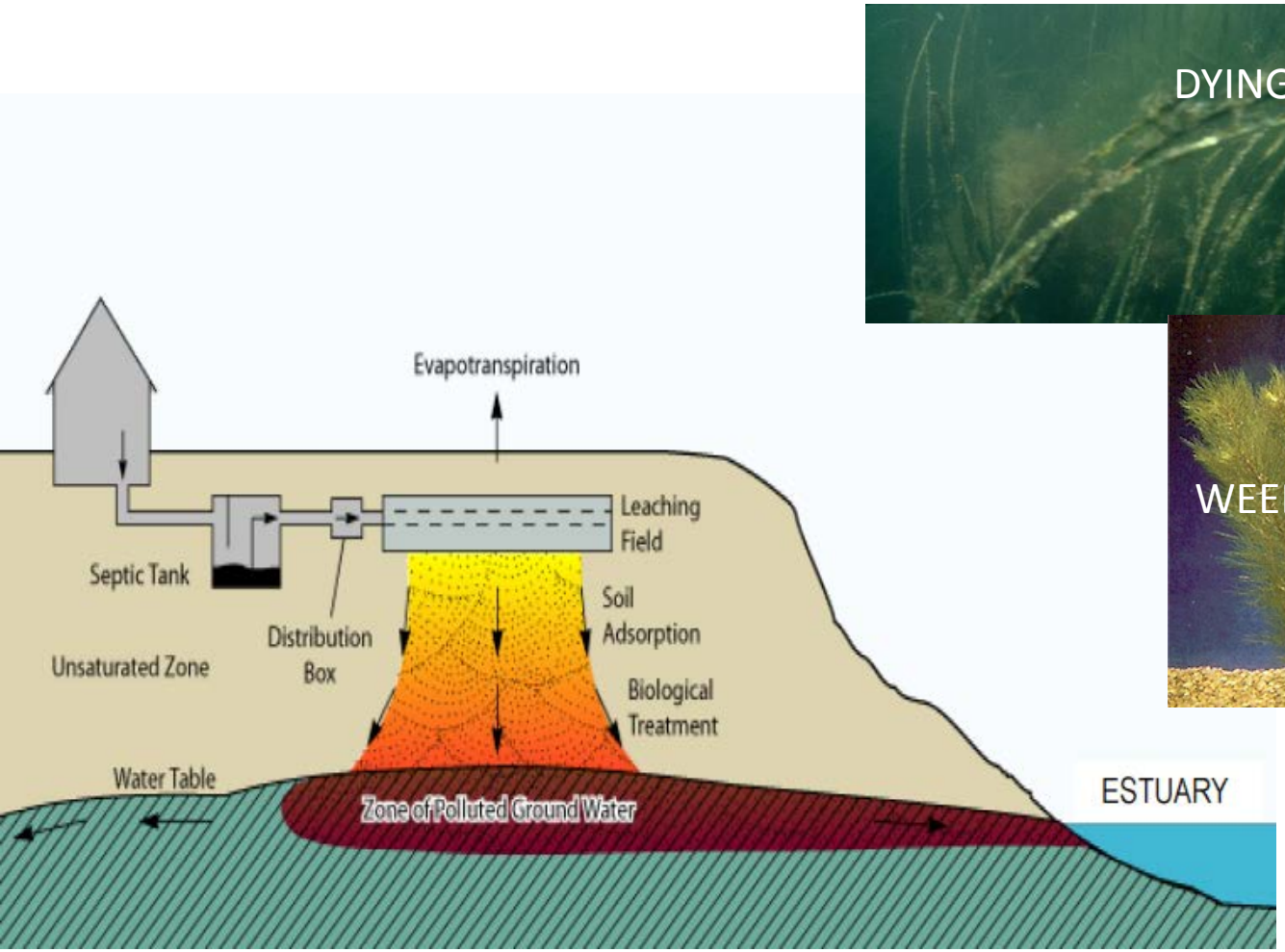
- Septage Management Plan
  - Pumping Incentive
  - Innovative/Alternative Systems
- Fertilizer Management
  - Education and Enforcement of Local Regulations
- Stormwater Management
  - Island-wide
  - Known Direct Discharges

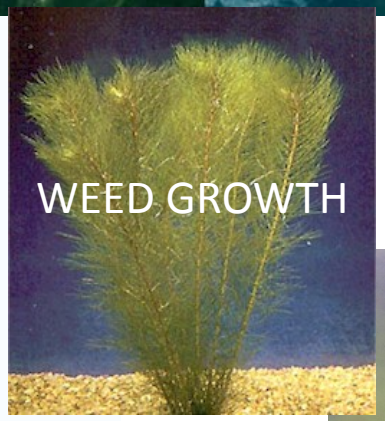
Nitrogen Pollution From Land Uses

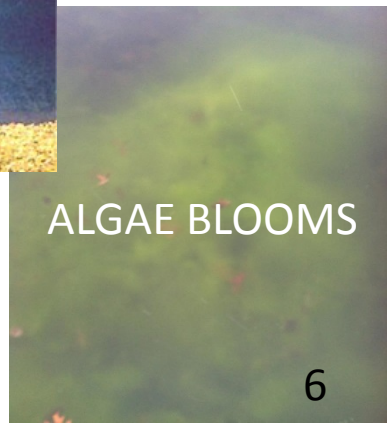


Modified from U.S. Fish and Wildlife Circular, Restore Chesapeake Bay, Feb. 1990

Septic Systems and Nitrogen Pollution Impacts

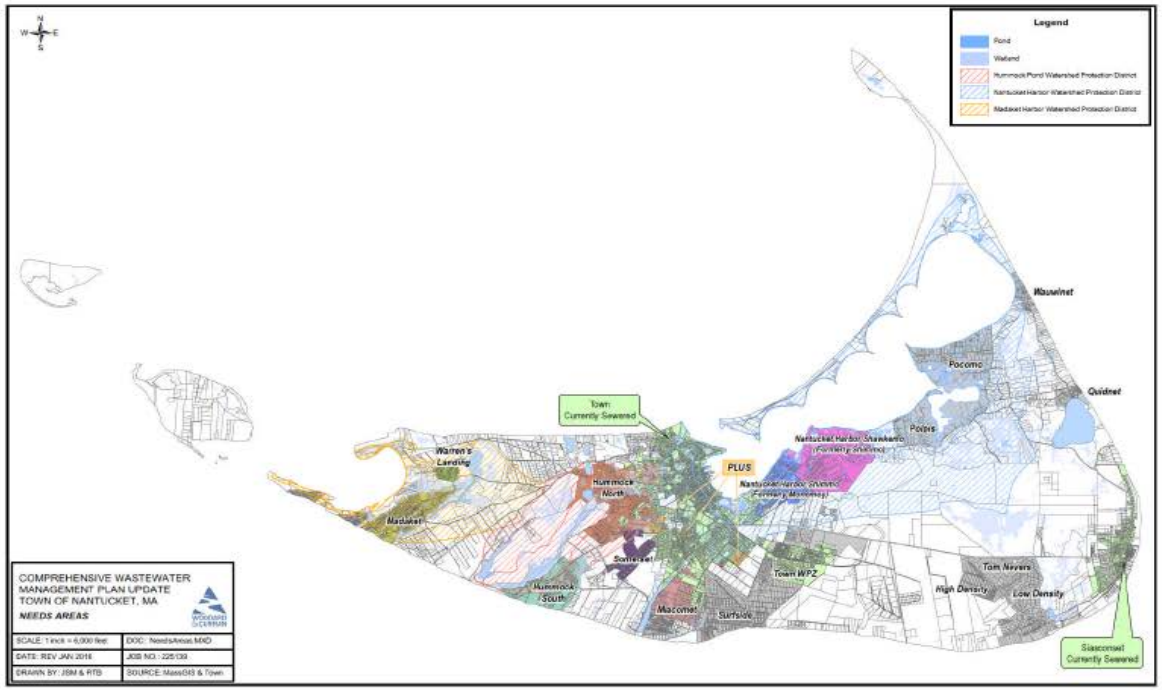






Comprehensive Wastewater Management Plan Update Final Recommended Plan

Town of Nantucket CWMP Update



AREAS RECOMMENDED FOR SEWER SERVICE

MADAKET

Drivers:
- Draft TMDL – Water Quality
- Madaket Harbor Watershed
- Small, Dense Lots
- Severe Soils
- Severe Groundwater
- Inability to Meet Title 5
- Inability to Meet Local BOH Regs
- Private Water Supply

Recommendation:
Municipal Sewer at Surfside WWTF

HUMMOCK POND SOUTH

Drivers:
- Pending TMDL – Water Quality
- Hummock Pond Watershed
- Small, Dense Lots
- Severe Soils
- Inability to Meet Title 5
- Inability to Meet Local BOH Regs
- Private Water Supply

Recommendation:
Municipal Sewer at Surfside WWTF

WARRENS LANDING

Drivers:
- Draft TMDL – Water Quality
- Madaket Harbor Watershed
  - GW Flow Towards Hither Creek Water Quality
- Small, Dense Lots

Recommendation:
Municipal Sewer at Surfside WWTF

MIACOMET

Drivers:
- Water Quality
- Small, Dense Lots
- Severe Soil and Groundwater Conditions

Recommendation:
Municipal Sewer at Surfside WWTF

HUMMOCK POND NORTH

Drivers:
- Pending TMDL – Water Quality
- Hummock Pond Watershed
  - Head of Hummock

Recommendation:
Municipal Sewer at Surfside WWTF

NANTUCKET HARBOR / SHIMMO

Drivers:
- TMDL – Water Quality
- Nantucket Harbor Watershed
  - Polpis Harbor TMDL
- Severe Soil and Groundwater Conditions

Recommendation:
Municipal Sewer at Surfside WWTF

NANTUCKET HARBOR / SHAWKEMO

Drivers:
- TMDL – Water Quality
- Nantucket Harbor Watershed
  - Polpis Harbor TMDL
- Severe Soil and Groundwater Conditions

Recommendation:
Municipal Sewer at Surfside WWTF

SOMERSET

Drivers:
- Small, Dense Lots
- Severe Soil and Groundwater Conditions
- Inability to Meet Title 5
- Private Water Supply

Recommendation:
Municipal Sewer at Surfside WWTF

AREAS RECOMMENDED FOR SEPTAGE MANAGEMENT PLAN

Polpis, Pocomo, Wauwinet, Quidnet, Surfside, Tom Nevers High Density, Tom Nevers Low Density

SPECIAL AREAS RECOMMENDED FOR SEWER

TOWN WPZ

Drivers:
- Town's Wellhead Protection

Recommendation:
Municipal Sewer at Surfside WWTF IF IMPACTED

TOWN SEWER DISTRICT UNSEWERED & PLUS - Drivers:
- TMDL – Water Quality
- Nantucket Harbor Watershed
  - Polpis Harbor TMDL

Recommendation:
Municipal Sewer at Surfside WWTF

CWMP 2004 Versus CWMP Update

	2004 CWMP		CWMP Update	
	Design Flows with 2nd Dwellings		Average Daily Flow	
Need / Study Area	Winter	Summer	Winter	Summer
Madaket	169,516	293,007	91,850	158,800
WarrensLanding	27,497	47,562	18,500	32,000
HummockPondSouth			38,200	66,070
HummockPondNorth			56,730	97,980
Somerset	63,139	108,794	51,630	89,030
Monomoy	69,936	120,551	48,890	84,550
Shimmo	57,107	98,675	35,940	62,150
Town Sewer District Build Out			358,569	612,704
Total Flows	387,195	668,589	**700,309**	**1,203,284**

Surfside WWTF Improvements Project Update

- MassDEP Approved Expansion Up to 4.0 MGD
  - Will Support All Needs Areas From CWMP Update
  - No Additional Discharge Beds Needed
  - Groundwater Discharge Permit – Monitors Water Quality Testing at TMDL Locations
- MassDEP Approved State Revolving Fund (SRF) Loan at Zero Percent Interest – 20 Years
- Highest and Best Use of Surfside WWTF
  - Madaket WWTF Eliminated
- Final Improvements Project Out to Bid Summer 2016
  - $8.8M 2015 ATM Approved Project - Currently Under Design

Aerial View of Surfside WWTF

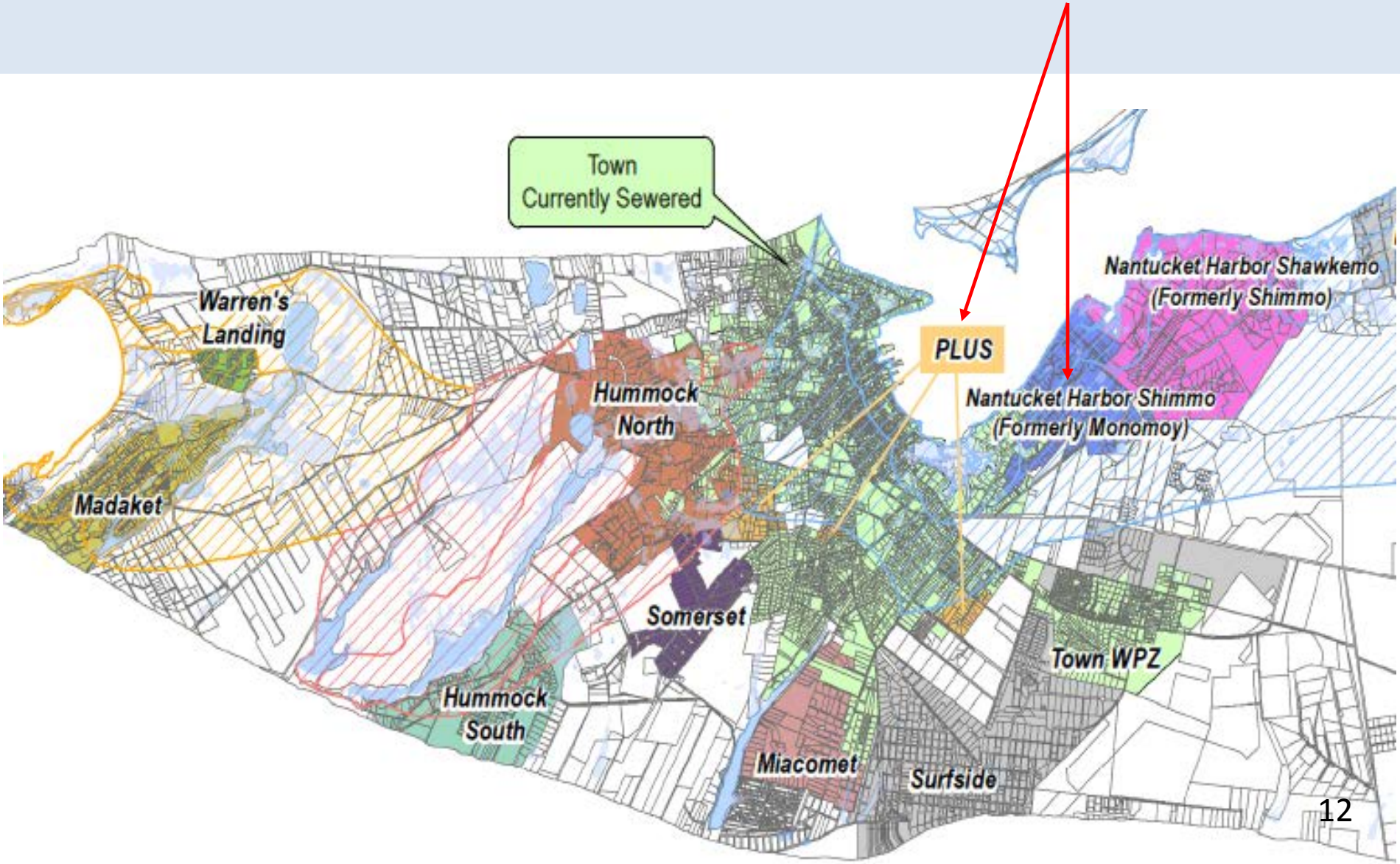
Google earth

feet 3000
km 1

April 2, 2016 ATM Sewer Implementation Plan Design & Construction of "Nantucket Harbor Shimmo" and "PLUS"

- Phase 1 - Nantucket Harbor Shimmo (Formerly Called Monomoy)
  - If Approved – Construction Starts 2017
- Phase 2 - PLUS (Larger Neighborhood In-fill Areas Within or Adjacent to the Existing Town Sewer District)
  - If Approved – Construction Starts 2019

2016 Annual Town Meeting Sewer Locations



Estimated Project Costs

- Phase 1 – 2017 Cost Escalation
  - Nantucket Harbor Shimmo (Formerly Called Monomoy)
  - Design - $2,782,916.
  - Construction - $25,046,246.
- Phase 2 – 2019 Cost Escalation
  - PLUS (Larger Neighborhood In-fill Areas Within or Adjacent to the Existing Town Sewer District)
  - Design - $1,309,821.
  - Construction – $11,788,385.

Capital Recovery Plan

- SRF Loan at Zero Percent Interest
  - Paid Over 20 Years
  - Can Extend to 30-Years at Current Interest Rate
- Costs to be Apportioned
- Betterments
  - 60 Percent to Property Owner
- Taxpayers
  - 40 Percent

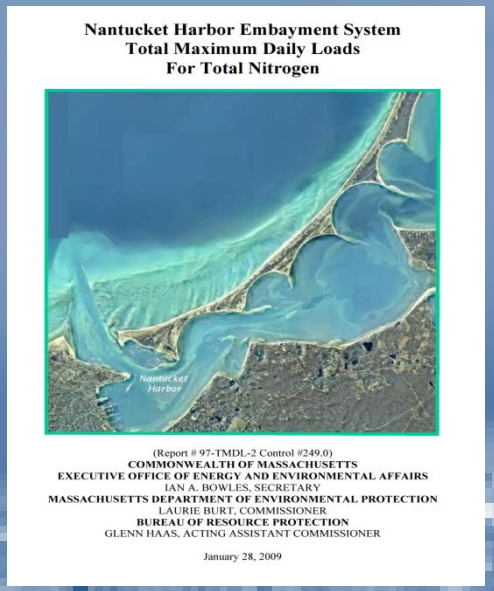
Betterment Policy Recommendations

- Approve Policy Establishing Uniform Unit Method Termed “Sewer Equivalent Unit (SEU)”
- I SEU Equal to 1-3 Bedroom Single Family Home
- Additional SEUs 3+ Bedrooms – 1/3 SEU
- Non-Residential Based on SEU
- Fair and Equitable Policy to Distribute Project Cost

2016 Annual Town Meeting

- Two Warrant Articles:
  - "Nantucket Harbor Shimmo" and "PLUS"
    - Adding Needs Areas Parcels to Town Sewer District
    - Approve Design and Construction
- 2016 ATM Follow Up
  - Ballot Questions on April 12, 2016

Board of Selectmen Wastewater Plan Update QUESTIONS & ANSWERS



Nantucket Harbor Embayment System
Total Maximum Daily Loads
For Total Nitrogen

(Report # 97-TMDL-2 Control #249.0)
COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
IAN A. BOWLES, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
LAURIE BURT, COMMISSIONER
BUREAU OF RESOURCE PROTECTION
GLENN HAAS, ACTING ASSISTANT COMMISSIONER

January 28, 2009

Back-Up Slides

Conceptual Sewer System Layout

Conceptual Sewer System Layout
Nantucket Harbor Shimmo

Town of Nantucket
Sewer Project Impacts
February 10, 2016

			Nantucket Harbor - Shimmo	PLUS Parcels	Totals
Estimated Cost of Project			27,829,162.00	13,098,206.00	40,927,368.00
Estimated number of connections			212.00	190.00	402.00
Estimated Number of Potential Connections			130.00	88.00	218.00
Allocate Betterment % equally	y				
Allocate tax rate % equally	y				
Allocation % to Betterment		60%			
Allocation % to Tax Rate		40%			
Total Betterment			16,697,497.20	7,858,923.60	24,556,420.80
Total to Tax Rate			11,131,664.80	5,239,282.40	16,370,947.20
Total to Sewer Rate					
Estimated Betterment Cost (Uniform Unit Method)			48,823.09	28,269.51	
Estimated Annual Betterment Impact			$2,540.56	$1,272.13	
State Revolving Fund Eligible			y	y	
Interest Rate					
Interest on Non SRF Eligible portion			3.50%	3.50%	
Amortization of debt # of years					
Betterment Years			20.00	20.00	
Tax Impact per $100,000 of Value					
Residential			2.79	1.32	4.11
Open Space			2.68	1.26	3.94
Commercial			4.93	2.32	7.26
Industrial			4.93	2.32	7.26
Personal			4.93	2.32	7.26
Tax Bill Impact					
Average Residential Value					
	$1,784,378		49.87	23.47	73.34
Average Residential Value - Year Round					
	$1,144,544		31.99	15.06	47.04

(BOS Letterhead)
Wastewater Project Update
February 2016
Frequently Asked Questions
As of 2/10/16

1. What are voters being asked to vote on, for sewer projects, at the April 2, 2016 Annual Town Meeting?

At the Town Meeting, voters will be asked to approve funding for one sewer project with two phases as well as to add the parcels to be sewered by the project into the Town Sewer District. The sewer project includes the following Needs Areas from the Comprehensive Wastewater Management Plan Update http://www.nantucket-ma.gov/259/Wastewater-Action-Plan

*Phase 1 of 1 -- Nantucket Harbor Shimmo (formerly known as "Monomoy")**
Phase 2 of 1 -- "Plus" parcels (various areas that are within or directly abut the Town Sewer District that had been left out of the District in error at some point in time) (nothing to do with the "PLUS" department)
**(See map attached on the last page of this Handout that details these geographic areas)*

There are two warrant articles relating to this project: one article will require Town Meeting approval to add all of the properties in the above areas into the Town Sewer District. The Town Sewer District is the area served by the Surfside Wastewater Treatment Facility. The other article seeks approval to borrow the funds needed to design and construct the project (this article will require further approval at the April 12, 2016 Annual Town Election (if approved at the Town Meeting).

**NOTE: Phase 1 of 1 above is called "Monomoy" in all previous documents, maps and reports and has been renamed "Nantucket Harbor Shimmo" to more accurately reflect the geographic area that it encompasses, which includes Brewster Road to the southwest to Gardner Road on the northeast and Kelley Road to the south across to Nantucket Harbor.*

2. How much is this project going to cost?

Nantucket Harbor Shimmo (Phase 1)

Design	*$2,782,916*
Construction	*$25,046,246*
Total	*$27,829,162*

"Plus" (Phase 2)

Design	*$1,309,821*
Construction	*$11,788,385*
Total	*$13,098,206*

Total both Phases combined: $40,927,368

3. How is this project proposed to be paid?

The Commonwealth of Massachusetts has a State Revolving Fund (SRF) Loan Program that provides a low (or zero percent) interest loan to Commonwealth municipalities for eligible water quality projects that are primarily for nutrient reduction. The two-phased sewer project on the 2016 Annual Town Meeting Warrant is a proposed nutrient removal project for Nantucket and Polpis

Harbors as a solution to the "Total Maximum Daily Loads" (TMDL) which have been issued in these locations and this qualifies the Town for the zero percent loan program. TMDL is a regulatory term in the U.S. Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards (more detail on this in Question 15). All SRF loans cover the construction costs, but do not cover any design costs -- these must be paid by the Town. The Town has applied for and received approval of its application for SRF monies for the construction portion of the project on the Town Meeting Warrant. Eligible project costs would be funded through the SRF loan with loan payments over 20, and possibly 30 years. The non-eligible costs of design are paid by the Town. The capital cost recovery of all costs is proposed to be paid through a combination of betterment assessments and the general tax base (all taxpayers).

The betterments would be assessed to all properties that will be "bettered" or directly benefit from the extension of municipal sewer. The Town is proposing to issue betterments under Massachusetts General Laws Chapters 80 and 83, which allow the Town to construct and maintain sewers for public health and convenience and assess the cost of such to those receiving the benefit. The Board of Selectmen is proposing a "60-40" cost share, with the "bettered" properties to cover 60% of the cost and the general tax base to cover 40%. The Board of Selectmen is authorized, by law, to assess betterments for projects such as these; the general tax base share requires Town Meeting approval and approval by ballot question.

Comment [lg1]: Should we explain that the betterment assessment % is to be approved by town Meeting?

4. What is a betterment?

"A betterment or special assessment is a special property tax that is permitted where real property within a limited and determinable area receives a special benefit or advantage, other than the general advantage to the community, from the construction of a public improvement." Definition from: "Massachusetts Department of Revenue Division of Local Services, Betterments and Special Assessments".

In Nantucket's case the public sewer proposed for the Needs Areas listed above will be assessed upon the parcels, both developed and undeveloped. For these projects, the betterment assessment is proposed to be based on Uniform Unit Method. EXPLAIN.

5. How are betterments paid?

Betterments are generally paid in a lump sum at the time of the bill or the property owner can opt to make equal payments for up to 30 years. Betterments are included on the property tax bill. The property owner has the option to declare the term which can be any number of years at no more than 2% of the cost to borrow.

6. Is there any savings to the property owner if a lump sum payment is made?

Yes, if the betterment is paid in full within 30 days of the commitment, there are no interest charges due.

7. What is the betterment cost?

The estimated betterment cost for 1 Sewer Equivalent Unit (SEU) is WHAT. All single family xx 3? 4? bedroom residential lots (approximately xx% in Nantucket Harbor Shimmo and xx% in Plus) will be assigned 1 SEU. The final betterment cost will be determined after construction is completed (2018 for Nantucket Harbor Shimmo and 2019 for Plus ??) and will be based on actual documented project costs. The final betterment value cannot exceed the value voted at the hearing at which estimated betterments are approved. Betterments are assessed against and run with the property and not against the individual.

Comment [lg2]: Who has these numbers?

Comment [lg3]: So do we estimate high & hope the actual costs are lower?

8. I own a property in one of the two areas proposed for sewer. What will this project cost me?

1. ***Betterment cost*** *– Use range based on which Needs Area?*
2. ***House connection*** *– Includes costs of permitting and installing your house connection to the sewer pipe in the road (also includes decommissioning of your septic system; landscaping; property restoration)*
3. *Sewer connection fee -- $2,000, the Town's standard charge for a connection to the sewer line to cover administrative costs.*
4. ***Sewer User Fee*** *- Annual cost of maintaining the Town sewer system currently this fee is approximately $XX per year.*
5. ***Privilege Fee*** *– A fee established as of April 24, 2005 (??) intended to offset the costs of upgrades to the Surfside wastewater treatment facility made in WHEN as a result of additional users*
6. ***Capacity Utilization Fee*** *– Per the Town's Sewer Regulations, this fee applies to properties that were not Needs Areas in the original 2004 CWMP. For this project, the CUF would apply to the Plus parcels.*

SAMPLE COST SCENARIOS

Scenario 1
Property in Nantucket Harbor Shimmo – (3 Bedrooms)
-- Betterment = what (assessed once project is complete and properties can be connected)
-- House Connection = what range (paid privately to contractor)
-- Annual Sewer Use Fee= once connection is complete)
-- Town Sewer Connection Fee = $2000
-- Privilege Fee = what

Property in Plus Area – (3 Bedrooms)
Same as above only add the Capacity Utilization Fee & what is that?

Scenario 2
SAME AS ABOVE BUT WITH 6 BRs??

Scenario 3
SAME BUT IN PLUS WITH 3 BRS

Scenario 4
SAME BUT COMMERCIAL BUILDING IN PLUS

Need a # I have a main house and a cottage on my property – do I have to pay two betterments?
Yes. Each dwelling unit is subject to the betterment.

Need a # How many dwelling units are there on the island and how many are currently connected to sewer? And, how many additional properties would be connected with this project?

There are approximately 11,000 dwelling units on the island. Slightly more than half (5,825) are

Comment [lg4]: ??

Comment [lg5]: Is this right??

Comment [lg6]: Is there a better way to show this?

DRAFT

connected to sewer. An additional 350 properties would become connected to sewer (Nantucket Harbor Shimmo -- 170 properties; Plus -- 180 properties).

9. I live on a private road. Will the Town be taking my road and/or maintaining it once the sewer has been installed?

The Town will require easements for the installation of sewer lines in private roads. We would hope to obtain the necessary easements voluntarily rather than have to acquire them through the eminent domain taking process. The Town does not intend to take any of the affected private roads; or, maintain them going forward. The Town will resurface the affected roads but will not change the type of road (for example, dirt roads will remain dirt, paved roads will remain paved – the Town will not pave any roads that are currently dirt as part of this project).

Comment [lg7]: ??

10. What if I cannot afford to pay the betterment? Is there a program in place to help?

There is a way to help defray the betterment costs to elderly property owners under Mass General Laws. If the Town adopts Massachusetts General Law, Chapter 80, Section 13B (on the 2016 Annual Town Meeting Warrant), then a deferral may be approved as long as the elderly homeowner has been approved for deferral with the Assessor under Massachusetts General Law Chapter 59, Section 5, forty-first A.

11. Are properties mandated to connect to the sewer once it is operational?

Local Board of Health Regulation 69.00 mandates that parcels located in defined nitrogen sensitive areas (Nantucket Harbor Watershed, Hummock Pond Watershed, Madaket Harbor Watershed), once sewer is operational and available for connection, must connect within 6 months. All other areas have 2 years to connect from the date of notification that the sewer is available. Properties failing to connect within the required timeframe are subject to a $100/day fine. Nantucket Harbor Shimmo and Plus are located within the Nantucket Harbor Watershed and are considered nitrogen sensitive areas.

12. If I recently replaced or repaired my septic system, do I still have to connect when sewer becomes available, and pay a betterment?

Yes; however, we have not yet started the design of the proposed sewer extensions, which will take upwards of a year and then construction is not planned to start with the first phase (Nantucket Harbor Shimmo) until 2017 and second phase (Plus) in 2019. With construction expected to take about 2 years, sewer won't be operational in the first phase until approximately 2019. This affords any property owner who has already replaced a system at least 3-4 years of additional use.

Comment [lg8]: Per phase??

The cost of a new conventional septic system is estimated at between $10,000 - $25,000. The cost of a new Innovative/Alternative (I/A) system is estimated at between $30,000 - $70,000. The estimated life of septic systems is approximately 20 years (with proper maintenance). Once a septic user is connected to sewer the future costs of septic system replacement, repair or upgrade are eliminated.

13. Is there any way to find out what my betterment cost will be?

The Town will be putting information on its website so that an individual homeowner may calculate their betterment.

Comment [lg9]: When?

14. Is there any means to lower the betterment costs?

The Town has worked diligently to research all possible avenues to arrive at a fair and equitable way to recover the capital costs for these substantial water quality improvements. First, the zero percent loan (versus even a low-interest two percent loan) will save the Town millions of dollars over the life of these loans. Secondly, while there are several perspectives on "who should

pay", the problem is an Island problem that affects all residents. The properties in the areas to be sewered are currently the major cause of nitrogen pollutants to the Island's water resources. Properties which will ultimately be sewered will realize an increase to property valuation as a result of the sewer. After much discussion, the Board of Selectmen has determined that the "60-40 split" is the fairest way to pay for the project. Inclusion in the state's zero percent loan program will save the Town and the taxpayers and those who will be assessed betterments, millions of dollars over the course of the payback period (estimated savings approximately $15,000,000.)

Comment [lg10]: ?? right?? Or??

Comment [lg11]: Can someone explain why here?

Comment [lg12]: Should we show the calculation on this?

15. How were the areas for sewer extension determined?

The areas recommended for sewer extension are from the Town's Comprehensive Wastewater Management Plan (CWMP) Update Report completed in 2014. Nantucket began its Comprehensive Wastewater Management Planning (CWMP) in 2000. The initial CWMP was completed in 2004 and included a Town-wide wastewater management plan that identified areas of the Island that were not long-term sustainable with on-site wastewater (septic) systems. Criteria reviewed at that time concluded that data contained in Board of Health records for Title 5 failures, major repairs, multiple system pumping, soils and groundwater conditions and potential impacts of on-site systems to environmental resources, showed multiple areas needed to eliminate septic systems as the primary wastewater systems. When we began the CWMP in 2000, there was no knowledge of the issues that would be encountered in future years due to nitrogen enrichment to the water resources. The 2004 CWMP recommendations were made based on the criteria described above. The Commonwealth of Massachusetts then introduced the Massachusetts Estuaries Program ("MEP"), which examined nitrogen pollution in 89 estuaries (harbors, ponds, creeks, embayments) in southeastern Massachusetts, the Cape and Islands from various sources. Nantucket alone had six areas studied in the MEP including: 1) Nantucket Harbor; 2) Polpis Harbor; 3) Sesachacha Pond; 4) Madaket Harbor; 5) Long Pond; and 6) Hummock Pond.

Nantucket's MEP reports have identified nitrogen as the largest contributor of pollution to the water resources examined in the MEP reports. Once the MEP reports were complete on Island, the state mandated that Nantucket update its 2004 CWMP to include solutions to the nitrogen pollution in the areas identified in the MEP reports. The Clean Water Act, both federal and state versions, mandates that the polluting of the waters of the Commonwealth, be eliminated and/or reduced. The standard which the state has established to measure nitrogen loads is through the issuance of a Total Maximum Daily Load (TMDL), which is a regulatory term in the U.S. Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. The state has issued TMDLs for Nantucket Harbor, Polpis Harbor, Sesachacha Pond, Madaket Harbor/Long Pond and one is pending in Hummock Pond. In 2012, we initiated an update to the CWMP. The Update, as required, provides a long-term solution to reduce nitrogen pollution to our water resources in order to meet the established TMDLs and was completed and approved by the state in 2014. The CWMP Update provides recommendations to meet the state mandate (TMDL) with a 20-year plan. The articles on 2016 Annual Town Meeting are among the initial steps in implementing these recommendations. The MEP Reports and TMDLs can be reviewed on the Town's website at http://www.nantucket-ma.gov/132/Water-Quality-Initiative.

16. Did the Needs Areas change from the 2004 CWMP in the CWMP Update?

Yes, there were several changes as a result of the additional data provided by the MEP Reports, as well as a comprehensive review of updated Board of Health records. The 2004 CWMP identified five Needs Areas:

a. *Madaket*
b. *Nantucket Harbor Shimmo (formerly called "Monomoy")*

c. *Nantucket Harbor Shawkemo (formerly called Shimmo)*
d. *Somerset*
e. *Warren's Landing*

The 2014 CWMP Update identified four additional Needs Areas due to the MEP Reports:

a. *Hummock Pond North*
b. *Hummock Pond South*
c. *Miacomet*
d. *Plus (larger neighborhood in-fill areas within or adjacent to the existing Town Sewer District)*

The CWMP Update also researched and identified a large number of parcels already located within the Town Sewer District (TSD) that are not yet connected to the existing sewer. The Town is working through the Board of Health and Board of Health Regulation 69.00 which regulates and mandates connections to the public sewer, to get these parcels connected. Successful implementation of this effort will reduce a significant amount of nutrient pollution from leaching into Nantucket Harbor.

17. Is there a priority as to how the Needs Areas are sewered?

There are multiple reasons why one Needs Area is proposed for sewer before another. One is based on actual "need" and where the area is located and its contribution to the nutrient pollution. Nantucket Harbor Shimmo is located directly on Nantucket Harbor and is shown to have a large impact on the pollution to the Harbor. The MEP studies examined the septic system contribution to the pollution and based on the science and studies, removing the septic systems from this area, in coordination with other efforts such as the Jetties reconstruction, fertilizer reduction and managing stormwater runoff -- will all reduce the nitrogen pollution to the Harbor and work together to meet the TMDL. The Plus area is tributary to the Nantucket Harbor Watershed and again, is a direct influence to the nitrogen pollution. The priority of sewering these areas is directed toward meeting the TMDLs issued for Nantucket Harbor.

Other reasons for setting priorities are more technical. For example, in the Somerset and Madaket/Warren's Landing Needs Areas, the sewer infrastructure needed in order to travel to the Surfside WWTF is located within the Somerset Needs Area. The Somerset Needs Area is located partially within a MEP area, but on its own would be prioritized below that of Madaket/Warren's Landing criteria-wise, however, it makes technical sense to sewer Somerset as a priority as it will provide the necessary physical infrastructure transmission for Madaket/Warren's Landing.

There are also funding priorities and how the Town qualifies for the zero percent state loan that will change priorities. Phasing several areas together, as was done with the project before 2016 Annual Town Meeting. One area itself did not meet the state requirements for the state loan, but phasing two together helped meet the requirements.

There are many reasons to set priorities with some more evident than others.

18. Will sewers allow for increased development in the designated areas?

There is a certain amount of new growth that may happen as a result of sewers, but the Town addressed many of these concerns with revised zoning in recent years. Projected flows to the Surfside Wastewater Treatment Facility are based on a complete buildout of all the Needs Areas tributary to Surfside. The availability of sewer will not allow more development that zoning allows.

19. Instead of sewering, why can't septic users switch to tight tanks?

Tight tank usage is governed by the Massachusetts Title 5, at 310 CMR 15.000, specifically at 15.260.Tight tanks are similar to septic tanks, except that they have no outlet and must be pumped out at regular, frequent intervals. Title 5 strongly discourages the use of tight tanks, but they are allowed in situations where an existing system has failed and there is no other feasible alternative. Tight tanks are not allowed for new construction or increases in design flow. According to the Regulation at 15.260, "Approval of a tight tank may be granted only to eliminate a failed on-site system when no other feasible alternative to upgrade the system in accordance with 310 CMR 15.201 through15.293 exists".

The Town worked with MassDEP in establishing areas where no feasible alternative exists and those areas where tight tanks are allowed are clearly defined in Local Regulation 49.00, Madaket Tight Tank Policy. A tight tank is considered a "last resort". There are but a few of these areas on Island. The Board of Health is the local jurisdiction, with MassDEP approval.

20. Aren't there other means to meet the TMDLs that could allow the Town to delay or not proceed with the sewer projects?

No. These projects are not optional. Other means to reduce the TMDLs will not be enough. Other means include: fertilizer reduction -- landscapers and property owners must significantly reduce the use of fertilizers but even so nitrogen from septic systems must also be removed/reduced; rehabilitation of the Jetties (this may increase tidal flow/currents in Nantucket Harbor but models show that it is not enough on its own to have a substantial impact), stormwater management – some projects have been completed, one is in progress, more are planned but again, this is only one component to a whole approach. Other options which have been explored include tight tanks (see above) and package treatment plants (small wastewater treatment systems that treat the wastewater of a small area of properties). Package plants are not viable because there is not enough room to fit them into any one area. While they are small, treating flows of 15,000 gallons per day and up, they would require land, infrastructure and maintenance. The Town of Falmouth is currently operating a pilot program for a new method of nitrogen removal in a certain area with certain soil and topography characteristics – many towns, including us, are monitoring the program with interest; however, it will take a number of years for the technology to be proven, accepted, and permittable. We do not have that time to wait.

If the Town does not take action that will bring its TMDLs into compliance, we can expect the state to mandate changes – on the state's schedule; and, without the benefit of zero percent loans. The Town must take action on its own, beginning now. Clean water is essential to the Island's economy and quality of life.

Additionally, the zero percent loan program currently expires in 2019. Any delays in this project could result in loss of the zero percent loan which would add millions of dollars (estimated $15,000,000) to the project cost.

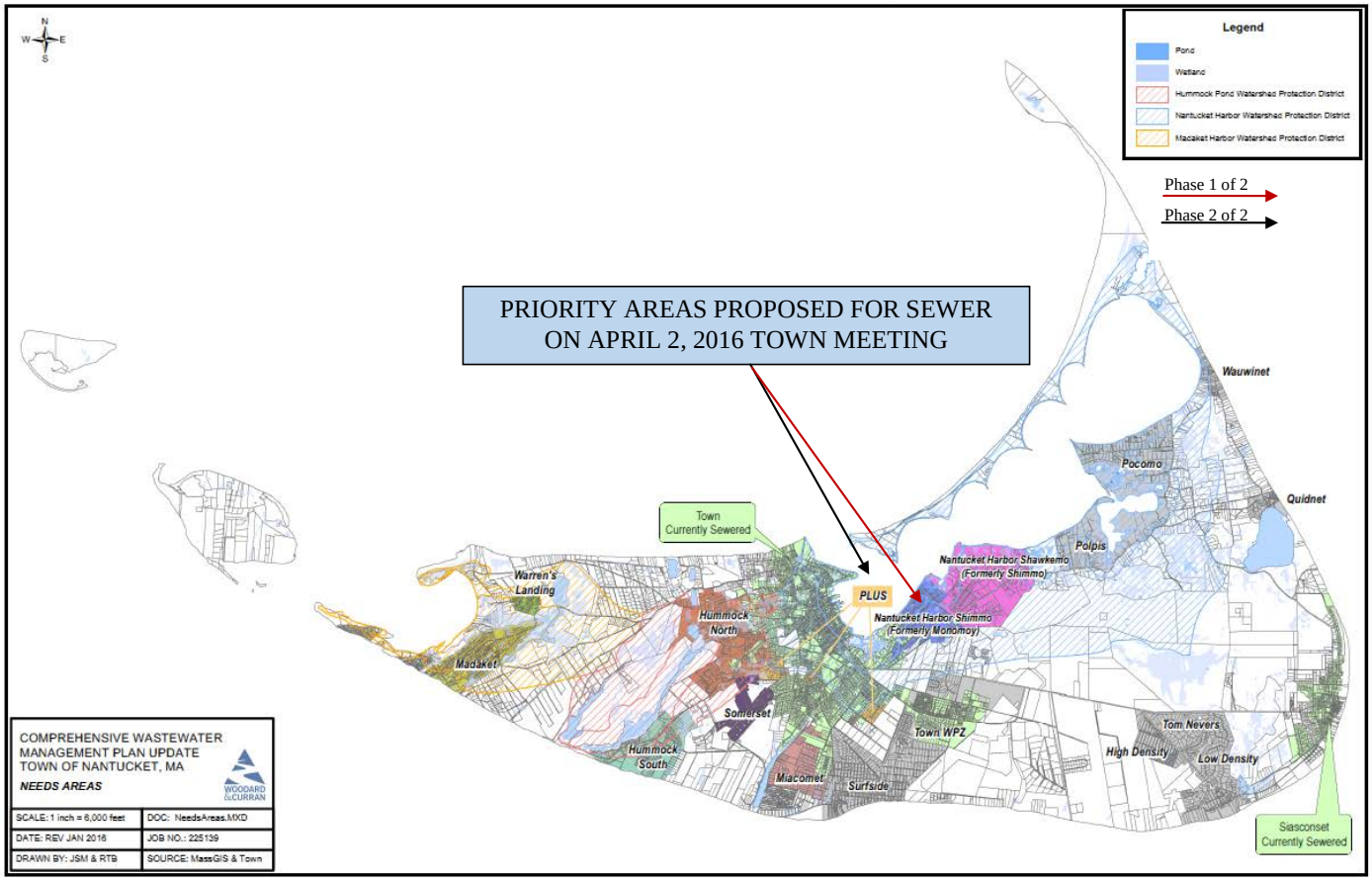
21. How many more projects are there and where are they?

The complete list of projects is contained in the CWMP Update. The next likely projects are Somerset and Madaket/Warren's Landing Needs Areas.

Comment [lg14]: Move this comment closer to the beginning?

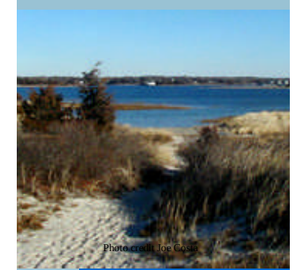
Comment [lg15]: What else should we say here? Should we attach the CIP page from the CWMP update?

DRAFT


Legend
Pond
Wetland
Hummock Pond Watershed Protection District
Nantucket Harbor Watershed Protection District
Madaket Harbor Watershed Protection District
Phase 1 of 2
Phase 2 of 2
PRIORITY AREAS PROPOSED FOR SEWER
ON APRIL 2, 2016 TOWN MEETING
Wauwinet
Pocomo
Quidnet
Polpis
Town
Currently Sewered
Nantucket Harbor Shawkemo
(Formerly Shimmo)
PLUS
Nantucket Harbor Shimmo
(Formerly Monomoy)
Warren's
Landing
Hummock
North
Madaket
Somerset
Hummock
South
Miacomet
Surfside
Town WPZ
Tom Nevers
High Density
Low Density
Siasconset
Currently Sewered
COMPREHENSIVE WASTEWATER
MANAGEMENT PLAN UPDATE
TOWN OF NANTUCKET, MA
NEEDS AREAS
WOODARD &CURRAN
SCALE: 1 inch = 6,000 feet
DOC: NeedsAreas.MXD
DATE: REV JAN 2016
JOB NO.: 225139
DRAWN BY: JSM & RTB
SOURCE: MassGIS & Town

Volume 1

February 2016



TOWN OF NANTUCKET BOARD OF SELECTMEN

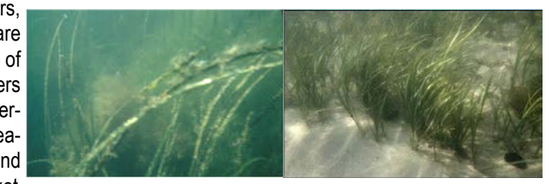
Wastewater Plan Update

Nantucket Wastewater Management Plan Update

Comprehensive Wastewater Management Plan (CWMP) Update Complete

The CWMP Update is complete and the Town now has a state approved 20-year wastewater plan. The major goal of the CWMP Update was to measure how clean our waters are and develop a solution to address water quality Island-wide.

We can tell how healthy our harbors, streams, ponds, creeks and estuaries are by the creatures that live there. Decades of studies by scientists looked at our waters and their environments in order to determine how healthy they are and what creatures and plants depend on the waters and their habitats. One example, in Nantucket and Polpis Harbors, are scallops that depend on eelgrass to thrive. If eelgrass is dying because of pollution in the water, then the scallops cannot survive. If the scallops cannot survive, then the scalloping industry will not survive. It is a domino effect.

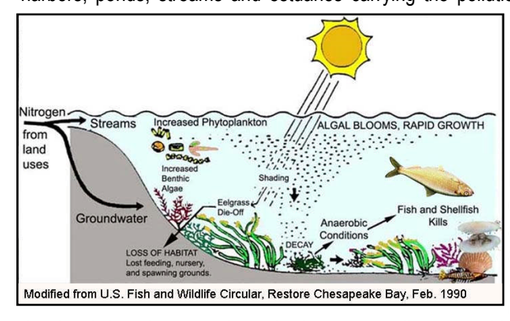


In nitrogen enriched waters, eelgrass is increasingly covered by algae ;left: healthy eel grass (right). Photo credit: Joe Costa.

Polluting of our water resources impacts us all. Nantucket depends on its water resources for drinking water, public health, tourism, fishing, boating, swimming, recreation, livelihoods and sole source sustainability. These water resources help make Nantucket unique and special.

This newsletter is the first of a series of public outreach efforts to help you understand what this pollution is, what is causing it, how we can control it, at what cost, and how we can all play a part to help. The CWMP Update examined the science and engineering and developed a plan to end this pollution. We are moving forward to implement this plan and need your support. ***The Board of Selectmen and Town Administration are committed to preserving and protecting Nantucket's water resources.***

WHAT IS CAUSING THE POLLUTION? A major cause is nitrogen. Nitrogen is in our septic systems, fertilizers and stormwater. All of these drain into our groundwater, which then flows into our harbors, ponds, streams and estuaries carrying the pollution with it. One cause and effect of too much nitrogen is that it produces excessive algae blooms, which limits sunlight through the water and kills off eel grass in the Harbors, which is impacting scalloping, as well as many other environmental resources.



Modified from U.S. Fish and Wildlife Circular, Restore Chesapeake Bay, Feb. 1990

Nitrogen pollution reduces the quality of our waters, which will impact recreational uses, the environment, public health and potentially our drinking water. Overuse of fertilizer, roadway and rooftop runoff from storms and septic systems that leach into the ground are the largest contributors to this pollution that as a community we CAN control. Plans to eliminate or lessen these impacts to our environment are contained in the CWMP Update.

TOWN OF NANTUCKET
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MARCH 2016

WHAT'S NEXT?

The Board of Selectmen will be holding workshop meetings on the Wastewater Plan on Wednesday, February 10, 2016 and Wednesday, March 9, 2016 at 6:00 PM in the first floor Community Room of the Public Safety Facility, 4 Fairgrounds Road. The meetings will be broadcast live on NCTV18 and can also be viewed online at http://nantucket-ma.gov/363/Video-On-Demand

All are welcome and encouraged to attend.

COMMENT / QUESTION CORNER

Comments and/or questions for the Wastewater Plan Update can be sent to:

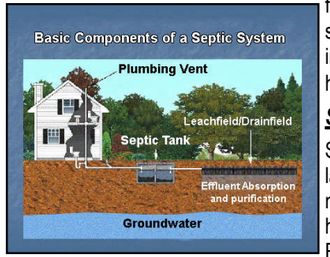
Sewerproject@nantucket-ma.gov

Answers and/or comments will appear in future volumes of this newsletter and/or addressed at Board of Selectmen meetings.

We're on the web at www.nantucket-ma.gov/259/Wastewater-Action-Plan

HOW CAN WE STOP THE POLLUTION?

The CWMP Update outlines plans to extend sewer, manage/reduce fertilizer use and contain stormwater where possible in order to stop the flow of harmful nutrients.



Sewer

Septic systems are the largest contributor to the nitrogen pollution that we have the ability to control. Removing septic systems eliminates the pollutants from entering the groundwater and thus provides protection of our water resources in multiple ways. Removing wastewater from entering the groundwater eliminates risk to nearby drinking water supplies, protects the public health from potential contamination, protects pollution from environmental areas nearby, as well as protects our water resources from pollution by nutrients like nitrogen.

We can extend municipal sewer in areas determined to be at risk with resource pollution. We have room to treat additional wastewater at the Surfside Wastewater Treatment Facility (WWTF). The WWTF is able to discharge thoroughly cleaned water to the ground in the existing sand beds. This is a "*highest and best use"* of a facility we currently own and operate, so it makes sound financial sense to use it to its full capacity. The Town received approval from the MassDEP to sewer all areas from the CWMP Update Report shown as needing an off site wastewater solution. The map below shows the nine geographic areas (colored and labeled) proposed for future sewer. Gray areas stay on septic.

Fertilizer

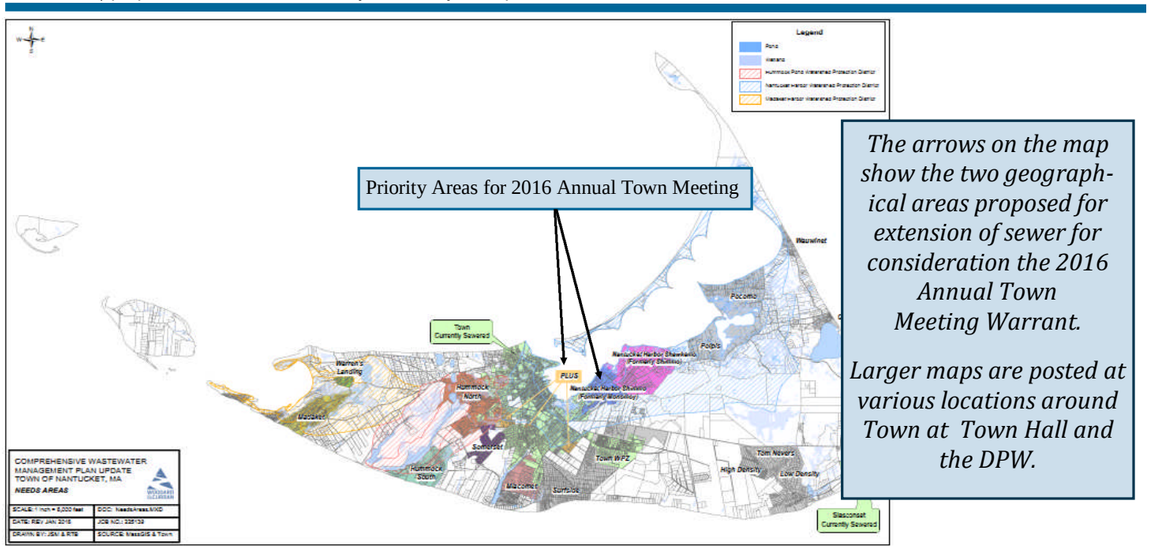
The Town developed and implemented fertilizer regulations, Board of Health Local Regulation 75.00, to manage fertilizer use Island wide. The Natural Resources Department took the lead with implementing the regulations, working to develop and complete educational sessions, as well as bringing the process of licensing the landscapers to fruition. All of this work is ongoing and being enforced, specifically in areas where the science is telling us that overuse is impacting our water resources. Continuing to reduce fertilizer overuse by incorporating the guidelines developed in the Town's *Best Management Practices for Landscape Fertilizer Use on Nantucket* will contribute towards eliminating another source of excessive nitrogen pollution from our waters.

> *"The purpose of the BEST MANAGEMENT PRACTICES FOR NANTUCKET [BMP] is to provide science based guidelines for fertilizer use and other landscape practices that, when followed, reduce the loss of soil nutrients from excessive, incorrectly timed, or inappropriate fertilizers. On Nantucket, lost nutrients find their way rapidly to the coastal waters, harbors, ponds, and streams where they may cause contamination that is harmful to aquatic organisms as well as to human health and welfare."*
>
> *Excerpt from*
> Best Management Practices for Landscape Fertilizer Use on Nantucket Island
>
> Prepared by the Article 68 Work Group
>
> 2010–2012

Stormwater

Work with stormwater is ongoing, especially in the Town area along Nantucket Harbor. The DPW regularly sweeps streets and cleans catch basins to keep runoff from entering the water resources. Town drainage projects include addressing runoff into the water that happens with undersized pipes and existing outfall pipes that contribute to pollution.

Managing wastewater, fertilizer use, as well as stormwater, reduces the pollutants going in to our waters.



The arrows on the map show the two geographical areas proposed for extension of sewer for consideration the 2016 Annual Town Meeting Warrant.

Larger maps are posted at various locations around Town at Town Hall and the DPW.

DESIGN / CONSTRUCTION COST ESTIMATES

Nantucket Harbor Shimmo (2017 Costs)

Design - $2,782,916
Construction - $25,046,246

PLUS (2019 Costs)

Design - $1,309,821
Construction - $11,788,385

IF 2016 ANNUAL TOWN MEETING APPROVES THE SEWER PROJECTS, WHAT WILL THE COST IMPACT BE?

The Town studied various ways to cover the costs of bringing sewer to all of the areas determined to be removed from traditional septic systems. We took all of this information and worked to develop scenarios for funding and public acceptance. A Sewer Planning Work Group (SPWG) was formed and worked diligently to provide the Board with a report detailing its work in recommending a variety of items, including how to distribute costs fairly and equitably. With the SPWG information, we further refined the funding options and arrived at a plan to apportion costs between the proposed sewer user and the general tax base. Overall costs include design, (which is NOT eligible for State Revolving Fund (SRF) funds) and construction. If the 2016 Annual Town Meeting approves the sewer extension projects, we will apply for the construction costs under a zero percent state loan program with a 20-year pay back. Under new state legislation, we can extend the payback an additional 10 years at a low interest rate, currently at 2 percent. The Town will then be able to finance the cost to the property owner under a Betterment Program, with payments made over 20 or 30 years. With an interest rate of zero percent, the Town is able to maintain the lowest possible end user costs. While we understand that these costs are high, our goal is to provide a mechanism to repay individual costs at the lowest possible terms.

The two Needs Areas proposed for sewer extension at the 2016 Annual Town Meeting are shown on the map on page 2 and in the box above. The current schedule for sewering proposes Nantucket Harbor Shimmo (formerly shown as "Monomoy" and encompassing Brewster Road to the southwest to Gardner Road on the northeast and Kelley Road to the south to the Harbor) as the first area constructed with a planned start date in 2017. PLUS (larger neighborhood in-fill areas within or adjacent to the existing Town Sewer District) is proposed to follow in 2019. The April 2016 Annual Town Meeting will ask voters to approve moving forward with this plan.

Estimated planning costs shown in the box above include both project design and construction costs. Once the Town begins the design process, these estimates will be refined, with more accurate costs arrived at during the actual project bidding.

Capital costs apportioned to the property owner can be paid by the assessment of betterments. A betterment is a special property tax typically used by municipalities to recover the cost of a public improvement, such as sewer. The method under which betterment assessments will be made is under discussion now and will be explained in upcoming public meetings and publication of materials to the public and affected property owners in advance of the 2016 Annual Town Meeting. The Board is further refining how much to assess property owners receiving sewer and how much goes on the general tax base. The betterment is typically assessed when the sewer is operational, but in some cases an *Estimated Betterment* is assessed when the project is at 50 percent completion in order to cover borrowing costs to the Town. There is a 20-30 year pay back term on betterments, which the Town can set up as payment plans with each property owner on the same schedule as property taxes. The property owner can also can choose to pay all at once.

The Board of Selectmen is planning to hold public meetings to explain all cost information in greater detail.

WHAT IF WE CHOOSE TO DO NOTHING?

The science and engineering is telling us that several factors are contributing to polluting our water resources. There are many reports, which conclude that excessive nutrients, mainly nitrogen, from multiple sources are polluting our waters. ***But, more importantly, we are SEEING the impacts***! With algae blooms, red tides, reduction of fish/ shellfish/eelgrass/plant life historically found in our waters, we can see that there are issues. What we cannot see until it is too late, is how this pollution has the potential to impact our drinking water, the fishing/shellfishing industry, the public health, our tourism, all of which can eventually impact our property values, not to mention the impact on Nantucket's unique attributes.

The Massachusetts Department of Environmental Protection, (MassDEP) under the jurisdiction of the Environmental Protection Agency (EPA), is mandating that Nantucket eliminate the pollution of water resources and restore water quality to established standards. Both agencies approved the CWMP Update Plan and will work with the Town as it voluntarily works to achieve restoration of the waters.

The sewer plan is a major piece of the restoration process, along with stormwater management and fertilizer reduction. These are the items that we, as Nantucket residents, can control. Every individual contribution counts!

> ***If the Town chooses NOT to do anything, MassDEP will issue orders, and together with fines, will mandate restoration under its terms and conditions.***

DISCLOSURE BY NON-ELECTED MUNICIPAL EMPLOYEE OF FINANCIAL INTEREST AND DETERMINATION BY APPOINTING AUTHORITY AS REQUIRED BY G. L. c. 268A, § 19

	MUNICIPAL EMPLOYEE INFORMATION
Name:	C Elizabeth Gibson
Title or Position:	Town Manager
Municipal Agency:	Town of Nantucket
Agency Address:	16 Broad Street, Nantucket, MA 02554
Office Phone:	508-228-7255
Office E-mail:	lgibson@nantucket-ma.gov
	My duties require me to participate in a particular matter, and I may not participate because of a financial interest that I am disclosing here. I request a determination from my appointing authority about how I should proceed.
	PARTICULAR MATTER
Particular matter E.g., a judicial or other proceeding, application, submission, request for a ruling or other determination, contract, claim, controversy, charge, accusation, arrest, decision, determination, or finding.	My home is identified as one of the parcels in a Needs Area contained within the Town's Comprehensive Wastewater Management Plan that may be the subject of a Town Meeting warrant article for an appropriation in the next 12 months. If the article is approved, at some point, a sewer line will constructed in front of my home and I will likely be assessed a betterment.
Your required participation in the particular matter: E.g., approval, disapproval, decision, recommendation, rendering advice, investigation, other.	Preparation of warrant articles, motions, communications, follow-up if approved. Any decisions I might make or tasks I might be responsible for concerning the warrant articles, motions, or any follow-up that might be required will be made without any regard for my personal financial interest, in accordance with any applicable laws and regulations and in the best interests of the Town.
	FINANCIAL INTEREST IN THE PARTICULAR MATTER
Write an X by all that apply.	__X_ I have a financial interest in the matter. ___ My immediate family member has a financial interest in the matter. ___ My business partner has a financial interest in the matter. ___ I am an officer, director, trustee, partner or employee of a business organization, and the business organization has a financial interest in the matter.

	___ I am negotiating or have made an arrangement concerning future employment with a person or organization, and the person or organization has a financial interest in the matter.
Financial interest in the matter	I will be assessed a sewer betterment. I do not know how much but several thousand dollars or more is anticipated.
Employee signature:	C. Christian
Date:	2/4/16

DETERMINATION BY APPOINTING OFFICIAL

	APPOINTING AUTHORITY INFORMATION
Name of Appointing Authority:	Board of Selectmen
Title or Position:	Chief Elected Officials
Agency/Department:	Town of Nantucket
Agency Address:	16 Broad Street, Nantucket, MA 02554
Office Phone:	508-228-7255
Office E-mail	rdecosta@nantucket-ma.gov
	DETERMINATION
Determination by appointing authority:	As appointing official, as required by G.L. c. 268A, § 19, I have reviewed the particular matter and the financial interest identified above by a municipal employee. I have determined that the financial interest is not so substantial as to be deemed likely to affect the integrity of the services which the municipality may expect from the employee.
Appointing Authority signature:	
Date:	
Comment:	

Attach additional pages if necessary.

The appointing authority shall keep this Disclosure and Determination as a public record.

Form revised February, 2012