Technical Memorandum

FINAL

Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Update 2014

To:

Town of Nantucket
Marine and Natural Resources Department
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From:

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The Technical Memorandum on the 2014 Nantucket Water Quality Monitoring Program is organized consistent with previous SMAST water quality monitoring summaries (2010, 2012 and 2013) for direct comparison to data from the previous years of monitoring. However, the 2014 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 including it herein is unnecessarily redundant. The 2014 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

2. Trophic State: Water Quality/Eutrophication Status

3. Recommendations for Future Monitoring

As in previous years, the 2014 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, 2013), the approach utilized for the collection and analysis of 2014 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 while the Nantucket Natural Resources Department focused primarily on coordination, field sampling and data collection on physical parameters.

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

1. determine the present (2014) 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, and 2013, sampling in 2014 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 (2014), Table 1b (2013), Table 1c (2012) and Table 1d (2010). Samples collected in 2014 were obtained from the same sampling station locations and the same depths as in previous years to maximize cross comparability. 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 of previous years technical memoranda and are not being reproduced again herein.

The physical parameters measured in the estuaries during the 2014 sampling season included: total depth, Secchi depth (light penetration), temperature, conductivity/salinity (YSI meter), general weather, wind force and direction, dissolved oxygen levels and observations of moorings, birds, shell fishing and unusual events (fish kills, algal blooms, etc). Laboratory analyses for estuaries included: salinity, nitrate + nitrite, ammonium, dissolved organic nitrogen, particulate organic carbon and nitrogen, chlorophyll-*a* and pheophytin-*a* and orthophosphate. As in the summer of 2013, the water quality monitoring undertaken in 2014 was focused entirely on estuarine stations. In addition, 33 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. 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 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 2014 appears to have improved water quality for Nantucket Harbor and Hummock Pond and continuing change (+/- depending on the year and based on specific parameters such as CHLA, nutrients or eutrophication index) in Long Pond and Sesachacha Pond (see below).

Table 1a. 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 1b. 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 1c. 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 1d. 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**

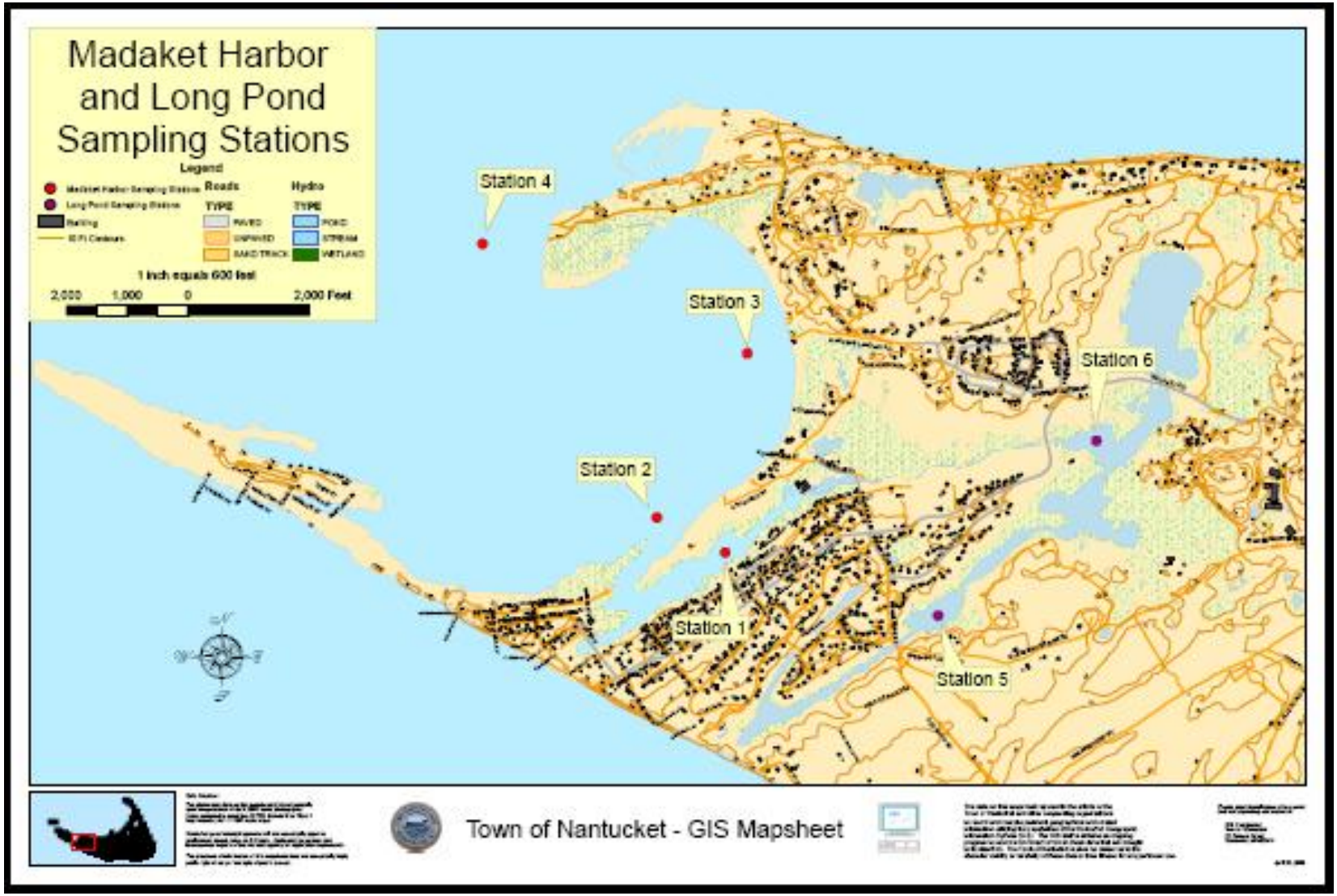

Figure 1. Madaket Harbor and Long Pond sampling stations 2010, 2012, 2013 and 2014.

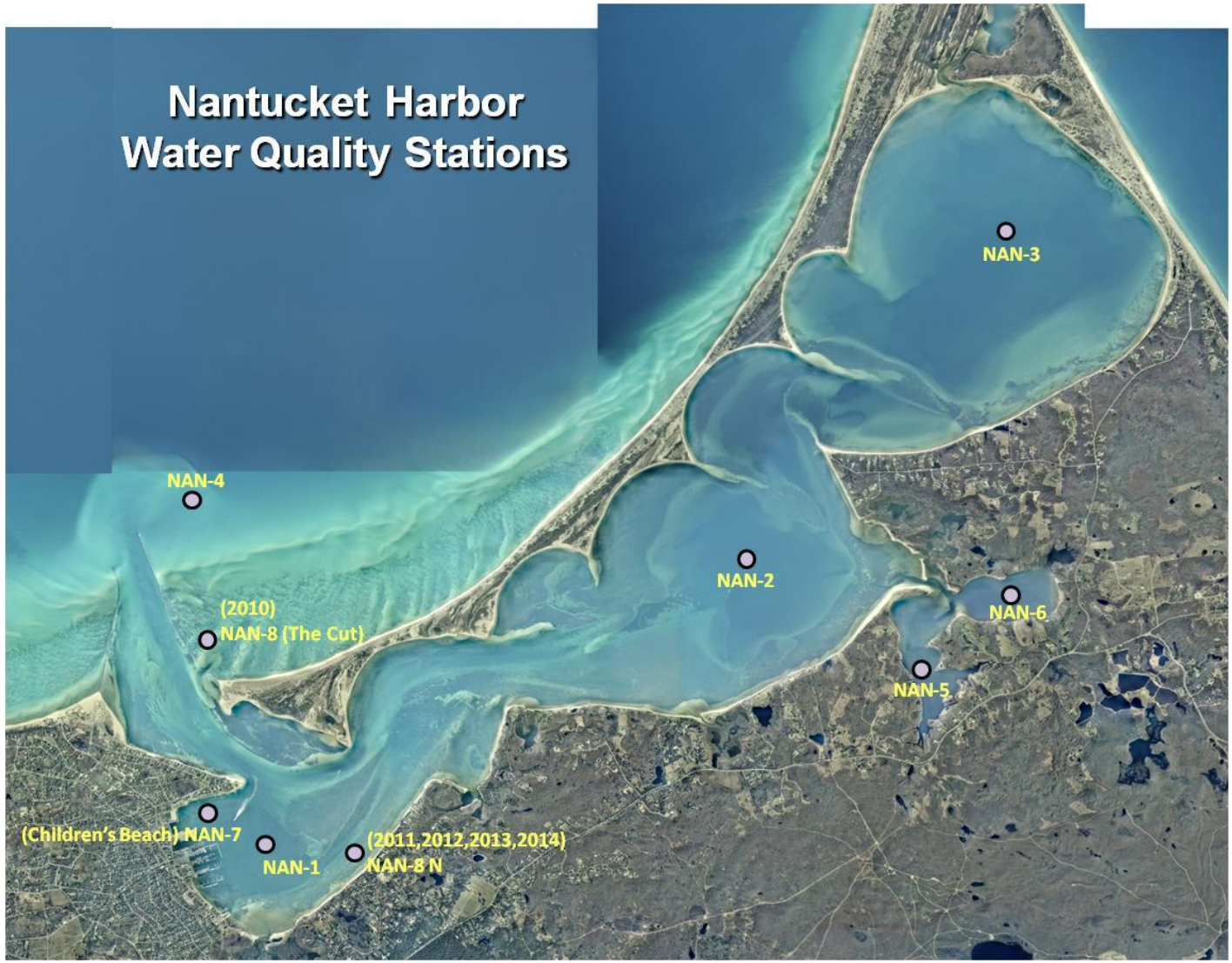

Figure 2. Nantucket Harbor sampling stations 2014. Station NAN-8 (the cut) was only sampled in 2010 and location changed in 2011 and 2012, 2013. Nantucket Harbor and Polpis Harbor each have nitrogen thresholds in the MassDEP/USEPA TMDL for this system.

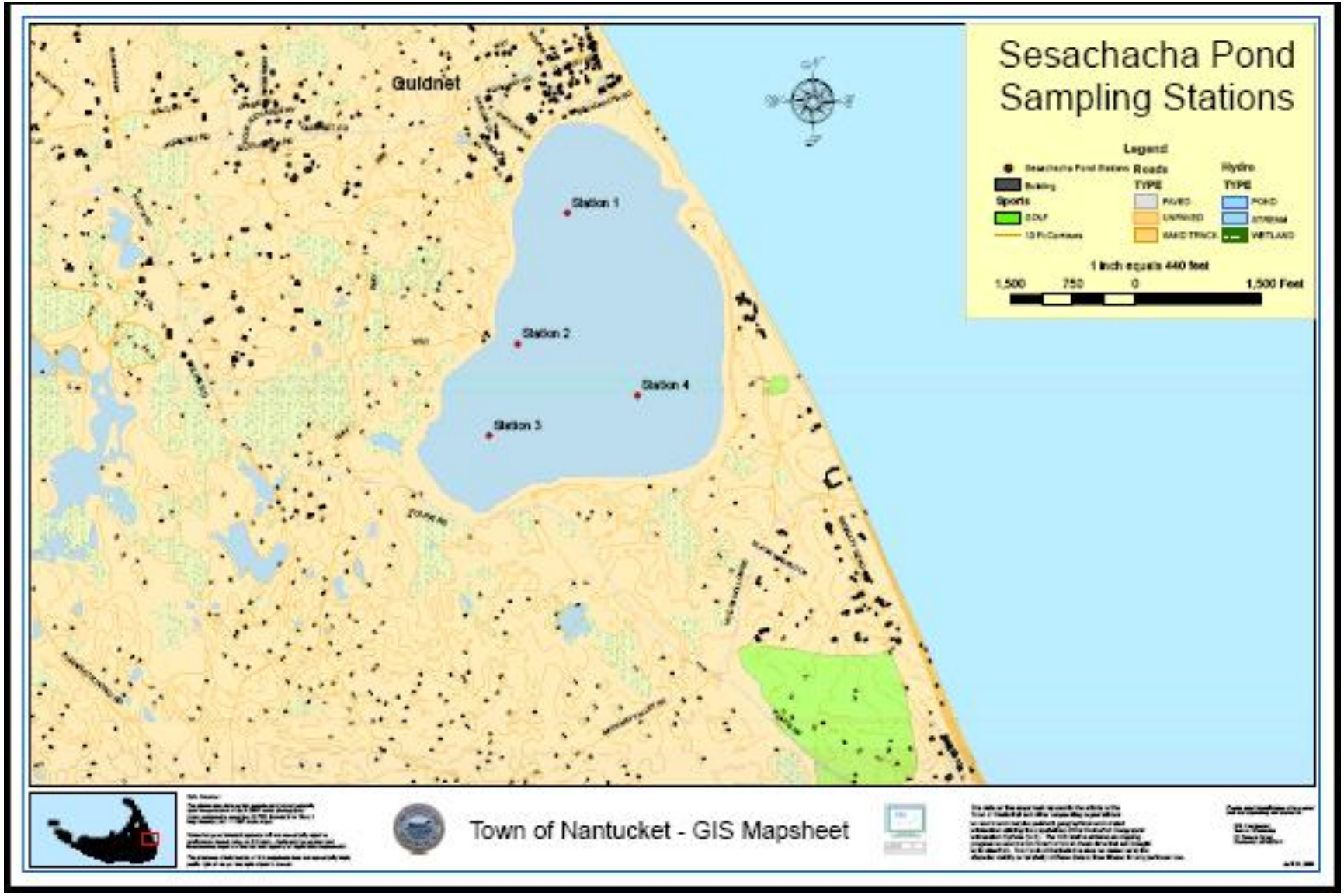

Figure 3. Sesachacha Pond sampling stations 2010, 2012, 2013, 2014.

Figure 4. Hummock Pond sampling stations 2010, 2012, 2013 and 2014. 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 and 2014.

Summary of 2014 Water Quality Results for Nantucket Sampling

While there were some localized areas of interest (Sesachacha and Long Ponds and Hummock Pond, see below), the overall trends in water quality observed in 2014 follow and expand the pattern observed in 2010, 2012 and 2013. Water samples collected from May through September in the estuarine systems indicate that organic nitrogen (dissolved + particulate) dominates the Total Nitrogen pool (79%-97% overall, 91%-95% 2014 alone), while bio-available nutrients in the form of nitrite and nitrate (NOx) and ammonium (NH_4) account for only 5%-21% (5%-9%, 2014) of the Total Nitrogen pool (Table 2a,b,c,d, Figure 12). 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 2014 (Table 2a), as noted in prior years as well (Table 2b,c,d). 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, Figure 6,7). The level of variation is common and underscores the need for multi-year monitoring to establish trends.

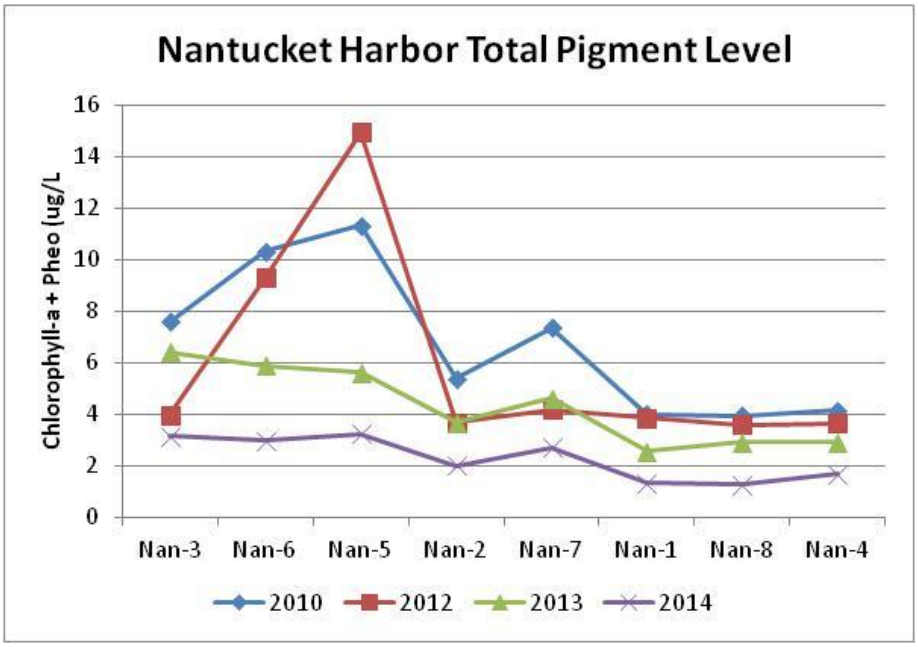

Figure 6. Average Chlorophyll-*a* (CHLA) concentrations by station in the well flushed Nantucket Harbor system during the summer 2014 sampling season. Stations Nan-5 and 6 are in Polpis Harbor the rest relate to the main basin. Note that 2014 levels were consistently lower than in prior years.

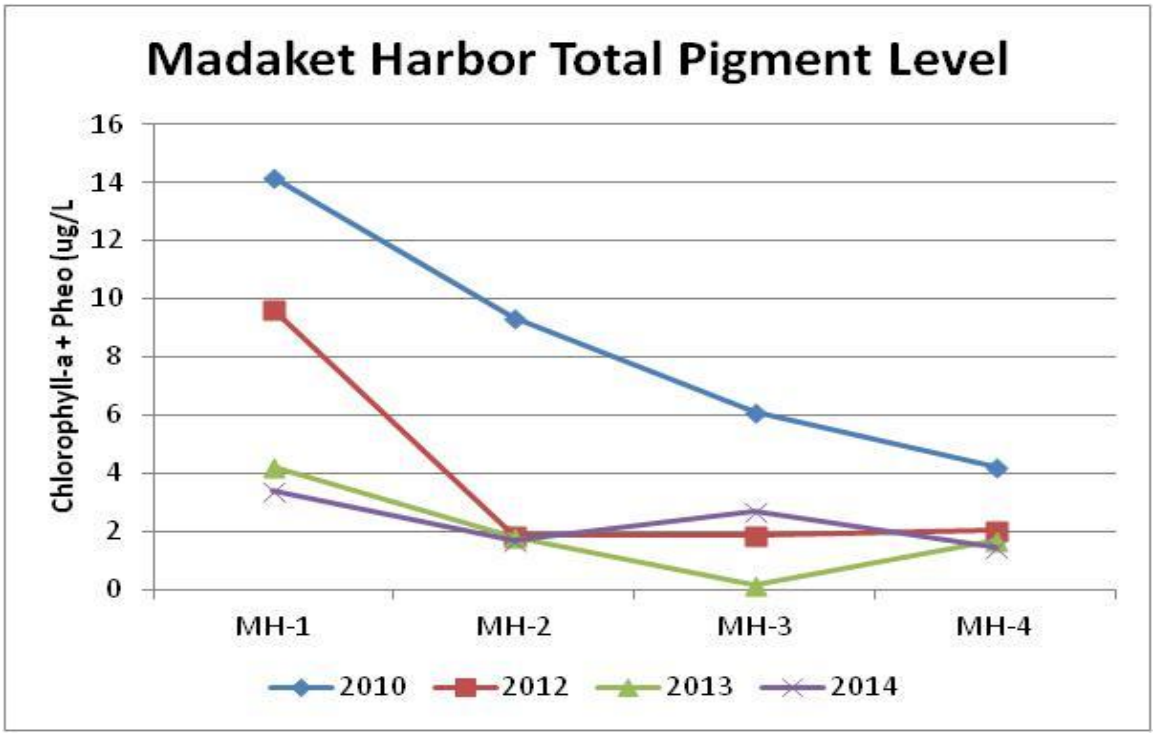

Figure 7. Average Chlorophyll-*a* (CHLA) concentrations by station in the well flushed Madaket Harbor system during the summer 2014 sampling season. Stations MH-2,3,4 are in the main open basin, MH-1 is the MEP sentinel station in Hither Creek. The 2010 blooms have not been as prevalent in recent years.

Both well flushed basins tended to have generally lower phytoplankton biomass (chlorophyll-*a*) in 2014 than previous years. This was most striking in Nantucket Harbor where average chlorophyll-*a* at each station was lower than in each of the prior years, while in Madaket Harbor the levels were in amongst the lowest. This is consistent with the higher water clarity as in these systems turbidity is primarily the result of organic particulate, e.g. phytoplankton. The parallel measurements of total nitrogen (TN) are generally consistent with the chlorophyll-*a* results, showing lower TN levels with lower chlorophyll-*a* levels (see below). This is particularly apparent in Nantucket Harbor and provides additional evidence that nitrogen is the eutrophying nutrient in these systems.

Where tidal flushing is more restricted in Long, Hummock and Miacomet Ponds (0.4-1.2 m) and in the improving Sesachacha Pond (2 meters), these moderate levels of water clarity are consistent with the chlorophyll-*a* concentrations that have a higher (2x-3x) average (compared to Nantucket and Madaket Harbors), 2.6 ug/L (max. 19.94 ug/L), 4.4 ug/L (max. 17.61 ug/L), 4.2 ug/L (max. 19.9 ug/L) and 3.0 ug/L (max. 7.9 ug/L), respectively (Table 2a, Figures 8,9,10,11). These general patterns were also observed in the monitoring results of the prior year (2013, 9 ug/L, 8-17 ug/L, 20 ug/L and <5 ug/L), however, it should be noted that the chlorophyll-*a* levels in Long Pond, Hummock Pond and Miacomet Pond appear to be lower when compared to 2013 average values. In Sesachacha Pond chlorophyll-*a* levels have risen slightly in 2014 compared to 2013

(maybe due to a less effective opening compared to the prior years of 2012 and 2013). 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 but do show variation (e.g. Sesachacha Pond 2014 > 2013). However, due to increased flushing with openings, Sesachacha Pond is much improved over its 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. These levels far exceed the recent monitoring results, 2010-2014, with station averages generally 3-8ug/L. These lower chlorophyll-*a* values are associated with lower TN levels, most likely the result of comparatively improved openings.

Long Pond also showed lower chlorophyll-*a* in 2013 and 2014 than prior years, a trend noted previously and possibly a result of activities at the landfill. However, Long Pond continues to be eutrophic and impaired. Miacomet Pond which is not open to tidal flows and has become very fresh, showed the highest chlorophyll-*a* levels of all the estuaries and levels indicative of eutrophic conditions for both fresh and salt water (>10 ug/L). Overall, 2014 supported slightly lower chlorophyll-*a* levels, likely for meteorological reasons, there was no clear inter-annual pattern.

Hummock Pond showed significantly lower total chlorophyll-*a* levels in summer 2014 than prior years. The 2014 results were the lowest levels measured over the 4 years of monitoring. While one year does not make a trend, nor are the results necessarily going to be repeated in 2015 there is a potential explanation. The Town and 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 and lowered TN levels in the pond and raised its salinity. The hydraulic gradient on opening was ~1.7 m, which provided a good head of water for opening the channel. 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 is the cause of the relatively low total chlorophyll-*a* and TN in Hummock Pond. Total chlorophyll-*a* was the lowest at each monitoring station in 2014 when compared to prior years. The opening protocol is being further refined 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	0.03	19.94	4.20
Sesachacha Pond	0.03	7.86	3.00
Long Pond	0.03	5.40	2.61
Hummock Pond	0.03	17.61	4.35

System	avg Total Pig (ug/L)	min Total Pig (ug/L)	max Total Pig (ug/L)
Miacomet Pond	9.29	2.46	31.52
Sesachacha Pond	6.27	1.44	13.21
Long Pond	7.23	3.68	21.27
Hummock Pond	7.16	2.18	26.40

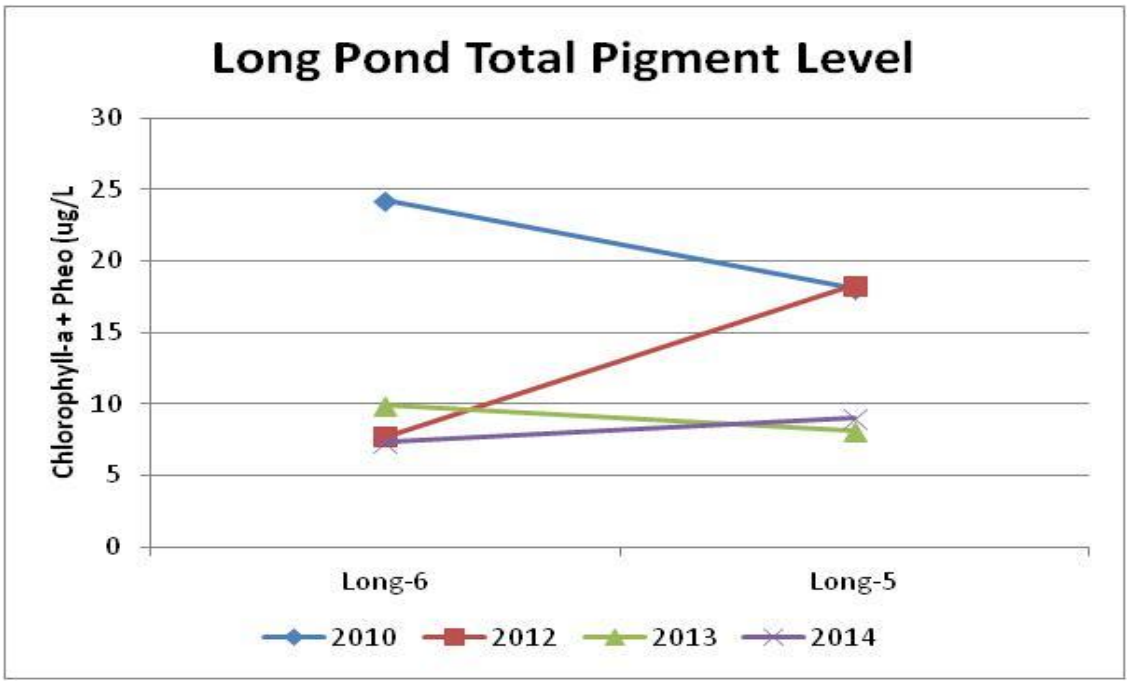

Figure 8. Average Chlorophyll-*a* (CHLA) concentrations by station in the Long Pond portion of the Madaket Harbor system during the summer 2014 sampling season compared to 2010, 2012 and 2013.

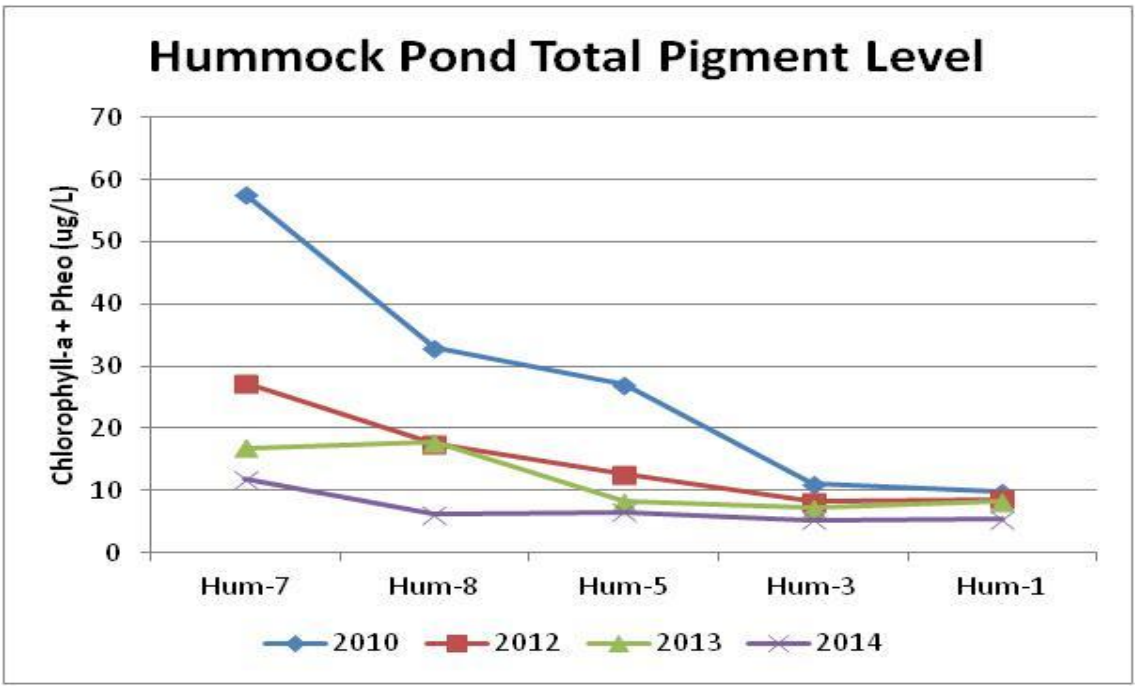

Figure 9. Average Chlorophyll-*a* (CHLA) concentrations by station in the seasonally opened Hummock Pond system during the summer 2014 sampling season compared to 2010, 2012 and 2013.

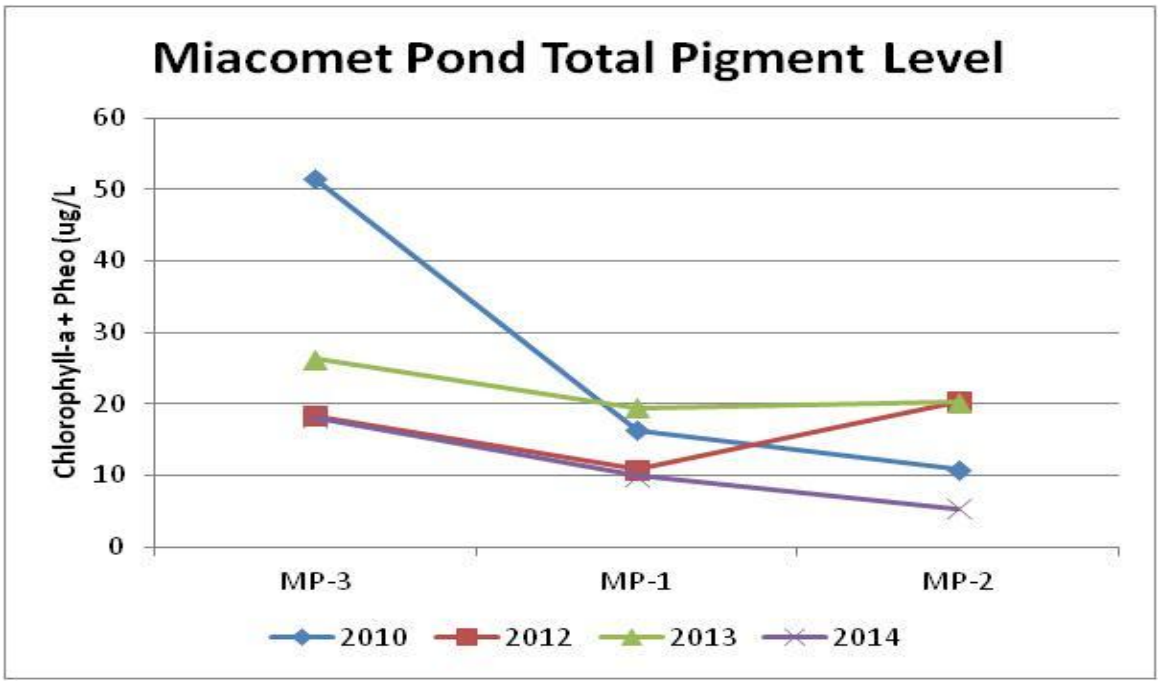

Figure 10. Average Chlorophyll-*a* (CHLA) concentrations by station in the Miacomet Pond system during the summer 2014 sampling season compared to 2010, 2012 and 2013. Miacomet Pond is not opened to the Atlantic Ocean.

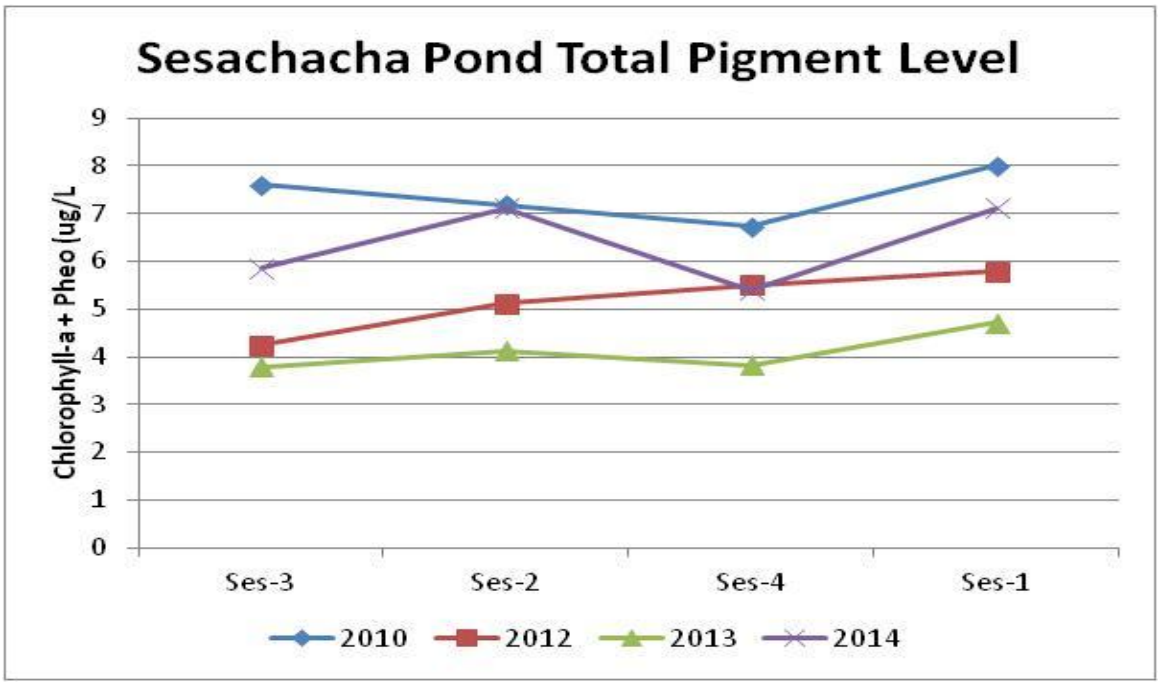

Figure 11. Average Chlorophyll-*a* (CHLA) concentrations by station in the seasonally opened Sesachacha Pond system during the summer 2014 sampling season compared to 2010, 2012 and 2013.

Average Total Nitrogen values in Hummock Pond followed the pattern in total chlorophyll-*a* being lower in 2014 than prior years [2013, 2012, 2010]: 0.715 [0.900, 0.923, 0.944] mg/L, further evidence of potential improvement through flushing. In contrast, Miacomet Pond which had no restoration activities showed similar TN levels throughout the 4 years of monitoring: 0.982 [0.962, 0.919, 0.886] mg/L. Both of these small estuaries only receive tidal water through periodic openings and are poorly flushed, in contrast to Nantucket and Madaket Harbors. However, TN values appear to be variable in both Long Pond 0.79-1.48 [0.795, 0.94,1.75] mg/L and in Sesachacha Pond 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 increase in TN maybe attributable to a less effective opening in 2014 compared to previous years. However, levels remain significantly lower than during the MEP assessment and suggest that the TMDL is being achieved or is close. Average TN levels in all 4 ponds are significantly higher than average values in the "offshore" stations NAN 4 and MH4 which average 0.277 [0.317, 0.344, 0.302] and 0.254 [0.278, 0.297, 0.285] mg/L, respectively (Tables 2a, 2b, 2c, Figures 1, 2).

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). This variation in TN levels at station 5 is change that the monitoring program must continue to follow closely. Station 6 continued to show a decrease in TN from 2013 to 2014. It is necessary to determine if the increase in TN levels at station 5 represents a real increase or merely a natural inter-annual variation. It is unusual for one station to increase and not the adjacent station. In this case it may be the result of poor mixing in Long Pond due to a change 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. This should be investigated. However, the long-term lowering of the TN levels, particularly at station 6, appears to follow Town activities at the landfill, as both 2014 and 2013 TN levels follow a downward trend and chlorophyll-*a* levels in Long Pond are significantly lower than in 2010 and generally similar to what was measured in 2013.

As in all previous years, in Sesachacha Pond, there is no noticeable nutrient or chlorophyll gradient among any of the 4 Stations (Figure 11 and 12, Tables 2a,b,c,d) 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 TN and chlorophyll-*a* concentrations in Sesachacha Pond where generally higher in 2014 compared to 2013. That there was a noticeable increase from 2013 to 2014 is good reason to continue regular monitoring of the system (primarily to determine the effectiveness of annual pond openings). However, TN levels remain at or below the nitrogen threshold in the TMDL, but the recent increase is a cause for concern, as the most likely cause relates to the success of the spring/summer opening.

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 Madaket Ditch), and is relatively poorly flushed, out to Station 2 in the Harbor with further decreases out to the off-shore Station 4. 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

(Figure 6 and 12, Table 2a). There is also a chlorophyll gradient with the highest concentrations at the 2 Polpis Stations (5 and 6), decreasing in the main Harbor and out to the off-shore Station 4 (Table 2).

Average 2014 [2013, 2012, 2010] TN level in Madaket Harbor (Stations 1-3, not including Station 4, offshore) was 0.390 [0.404, 0.485, 0.462] mg/L, compared to the off-shore Station 4 0.254 [0.278, 0.297, 0.285] mg/L.

Average TN in Nantucket Harbor (all Stations except Station 4, offshore) were quite low averaging 0.324 mg/L compared to 2010, 2012, 2013, with the offshore boundary station 4 averaging only 0.277 mg/L in 2014 (Tables 2a, 2b). It should be noted that the [2010] value includes station NAN-8 (the cut) whereas the 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). That may be a reason the 2014, 2013 and 2012 average TN concentration is slightly higher for station NAN-8N than the 2010 value. 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 2b). In spite of the high TN concentrations in these 6 streams and the likely high 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; Figure 2). 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 may be warranted to periodically sample streams discharging to this tributary sub-embayment. TN concentrations in East Polpis Harbor, 0.378 [0.401, 0.438, 0.484] mg/L and West Polpis Harbor 0.389 [0.385, 0.431, 0.419] , which is 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). TN levels remain above the nitrogen threshold for these basins, although total chlorophyll-*a* was relatively low in 2014 reflecting the “lower TN” in that year.

Relative to the 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 12). Based on average TN and chlorophyll-*a* values in Hummock Pond, water quality appears improved over prior years, but not enough to meet the nitrogen threshold. In Miacomet Pond, average TN values in 2014 were generally similar to 2013 (0.982 vs. 0.962) but chlorophyll-*a* levels appeared slightly lower than in 2013. These are very high TN levels for this basin. However, Miacomet Pond in 2014 likely had phytoplankton production (e.g. chlorophyll-*a*) controlled by phosphorus levels, as the salinity has declined to <0.5 ppt, due to the long time since basin was opened to the tides. At present, this pond appears to be shifting to a freshwater ecosystem.

In reviewing the 2014, 2013, 2012 and 2010 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.

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). 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 and 2014) 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. 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 and 8a). It should be noted that if there is a bias 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 oxygen did not generally change the bay health rank, although it did yield a change in the numerical value, the standard Index was used for assessment.

The Health Status of each site was based on the Index Score, which is 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 10-14 show the distribution of Health Status throughout each estuary based on each of the 4 years of monitoring (2010, 2012, 2013, 2014). Numerical results are color coded for ease of mapping. The colors of each triangle represent the Bay Health Index status of its 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 4 years of monitoring, although some improvement 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 4 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. Over the 4 years of monitoring Hither Creek (Station 1) has consistently supported the poorest “health” status within the Madaket Estuary (Table 7, 8, Figure 16). Hither Creek is clearly nitrogen enriched and showing continuing impairment based on a variety of parameters. However, over the past 4 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 –high water quality in 2014. The main basin of Madaket Harbor is showing relatively high water quality in each year with only a slight gradient on the ebbing tide from offshore of Hither Creek out to the Harbor entrance. The gradient was most significant in 2012 and 2013. 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 this is controlling 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 captured each year, than a shift in status. In contrast, the offshore sites (3 & 4) support high quality waters resulting from low nitrogen inputs and very high rates of water exchange. The 4 year upward trend in health index is possibly related to the reduced loading from the landfill to upper Long Pond and an improvement in the ebbing waters through Madaket Ditch. This trend needs to be reconciled with the variability observed at Station 5 and 6 in Long Pond and the mechanism for the large difference between the stations in 2014. If the improvement in Hither Creek continues it will meet the predictions of the MEP, and may offset the need for a fraction of the watershed sewering.

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 16). 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 this poor water quality water flowing into the head of Hither Creek during the ebb tide represents a localized input that contributes to creating the low water quality observed in Hither Creek as well. While there may be some small decline in nitrogen levels in the upper basin (Station 6) the level is still very high and results in poor clarity, algal blooms and nutrient related stress to aquatic resources. The lack of 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 show improving water quality at stations 5 and 6 in 2012, 2013 and 2014 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.

Nantucket Harbor

Nantucket Harbor is presently supporting the highest water quality of Nantucket's estuaries. The main basin is supporting high quality waters, with only a periodic small level of decline in uppermost basin of the main Harbor, Wauwinet basin (Figure 17). Wauwinet basin had the highest average total nitrogen values for the Harbor System in 2013 (0.415) consistent with its designation as the sentinel station for the main basin. In contrast the 2014 results show the main basin to be of high water quality throughout, consistent with the chlorophyll-*a* and TN levels in 2014 versus prior years. However, the enclosed sub-basin of Polpis Harbor (East and West) is showing moderate impairment and only moderate water quality. This designation stems both from both elevated nitrogen levels and consequent enhancement of phytoplankton, with summer averages of 10-15 ug/L typical. However, in 2014 Polpis Harbor, like the main basin, showed high water quality, but it is unlikely that this will be sustained, instead it may indicate a slight improvement that will show variation over time. While the Harbor 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 results showed a higher level 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 past 4 years have been stable at a moderate level of estuarine health (Figure 18). Additional higher level assessment of Sesachacha Pond initiated by the 2010 monitoring results is being written to document the level of improvement in nutrient related health of this system and the degree to which the pond meets conditions for habitat restoration documented in the 2006 MEP nitrogen threshold analysis for Sesachacha Pond. It appears that like other periodically opened pond, the quality of the opening (amount of water exchanged) controls the level of water quality in the following months.

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). There is a small gradient in water quality with moderate to poor conditions near the ocean and poor conditions in the uppermost basins (Figure 19). 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). All of the metrics are consistent with a nutrient impaired basin in both 2010 and 2012. 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 appear to support that tidal flushing was

improved as nutrient related health was highest in 2014 of the years monitored. This 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.

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. 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 20). 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. All of the metrics are consistent with a nutrient impaired basin. However, if the freshening of this basin continues, it may come into a new equilibrium as a purely 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). At some point it may be useful 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 presently controlling pond health.

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.

Recommendations for Future Monitoring

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, Madaket Harbor (stations 1&2) and Wauwinet basin in Nantucket Harbor should be considered for this analysis at some time in the future. 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 and 2013 appear to show a significant reduction

in TN over historical conditions and 2010. The TN pattern in 2014 suggests that there may be a restriction to mixing between station 5 and 6 which should be investigated and if possible managed.

Additionally, it should be noted that the stream stations discharging to Nantucket Harbor (specifically Polpis Harbor) were not sampled in 2012, 2013 or 2014. However, with increasing interest in lowering TN concentrations in Polpis Harbor to meet the MEP established TN threshold, it may be warranted to resume sampling in streams discharging to this tributary sub-embayment to gage the degree to which the loads these streams contribute affect the TN concentration at the sentinel station in Polpis Harbor.

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 to refine the opening protocol and gauge its effectiveness. This protocol still needs to be codified and further refined. This can only be done by monitoring several openings to relate opening metrics to subsequent water quality. Management should 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.

Table 2a. 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 2b. 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 2c. 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 2d. 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).

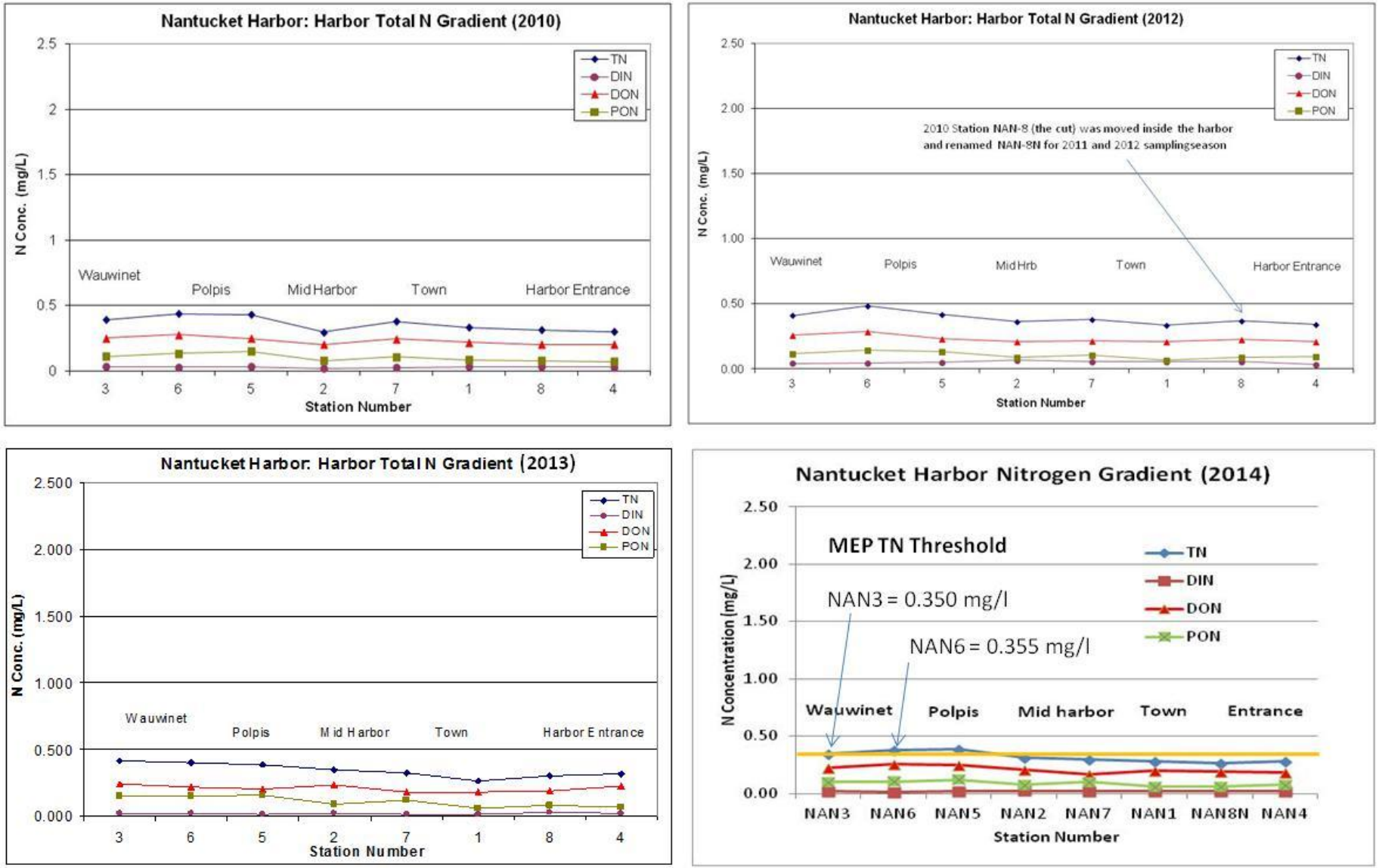

Figure 12. Comparison of nitrogen species (mg/L) in Nantucket Harbor in summers, 2010 (upper left); 2012 (upper right); 2013 (btm left); 2014 (btm right). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.

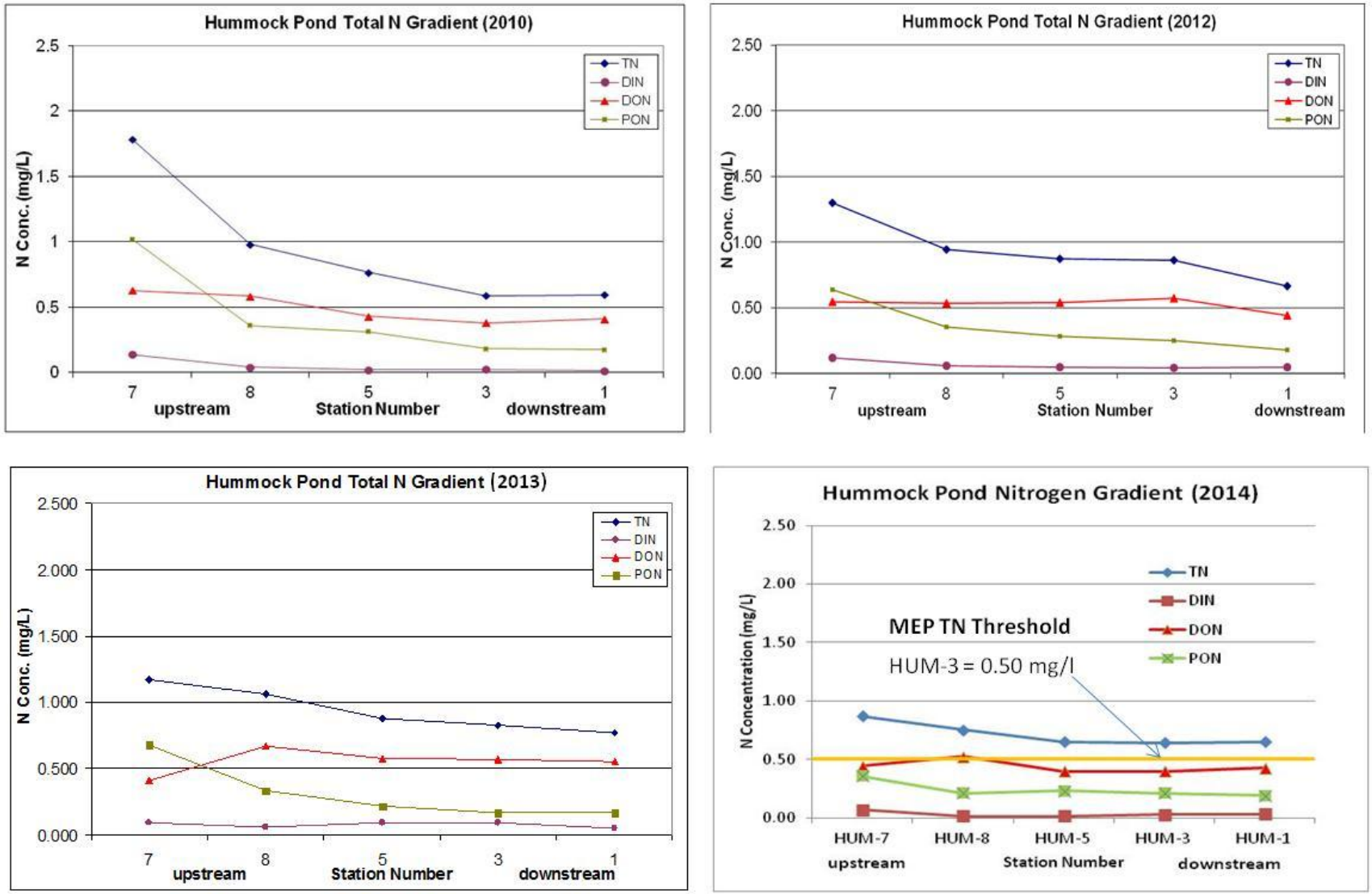

Figure 12 cont'd. Comparison of nitrogen species (mg/L) in Hummock Pond in summers, 2010 (upper left); 2012 (upper right); 2013 (btm left); 2014 (btm right). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.

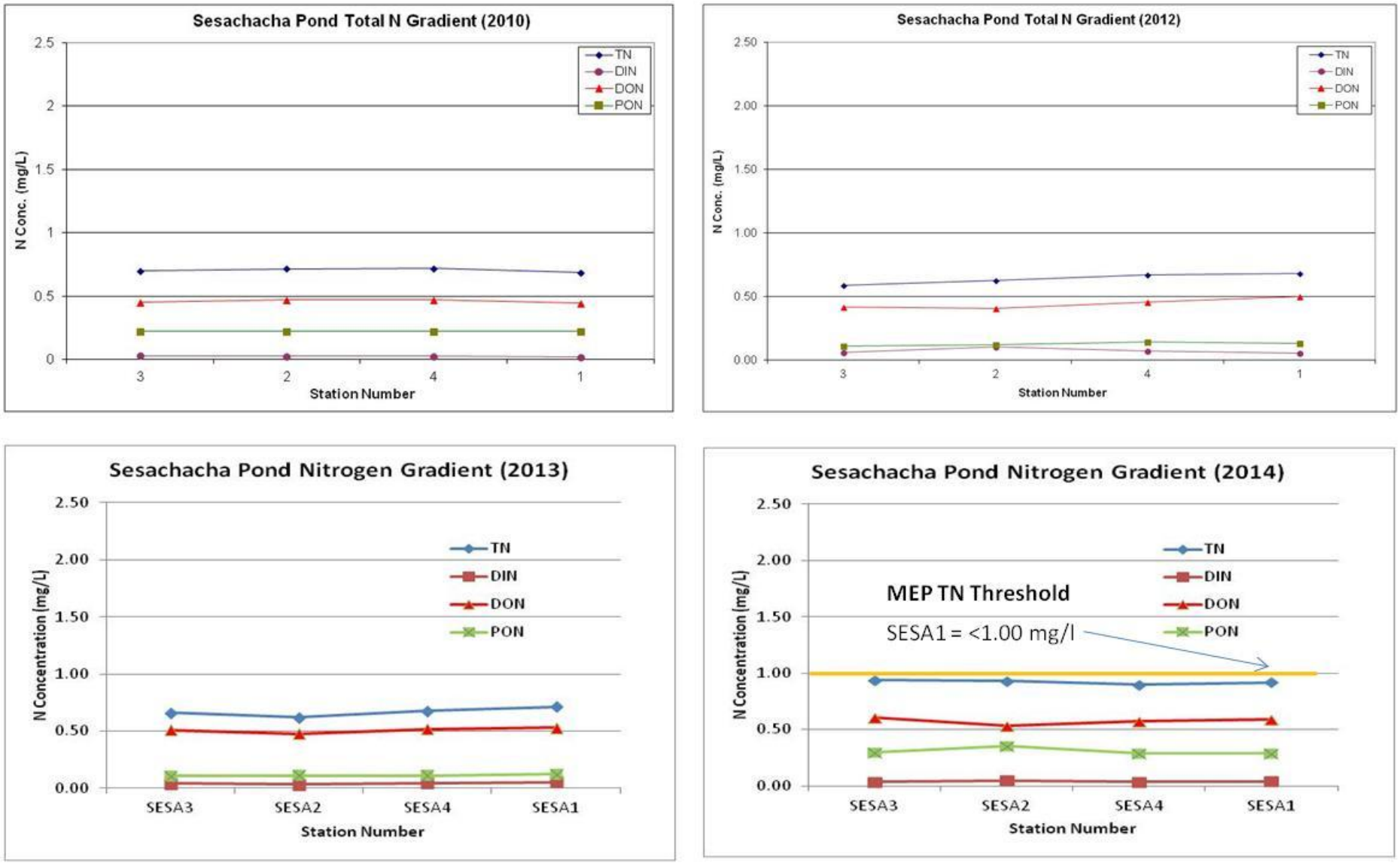

Figure 12 cont'd. Comparison of nitrogen species (mg/L) in Sesachacha Pond in summers, 2010 (upper left); 2012 (upper right); 2013 (btm left); 2014 (btm right). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph).

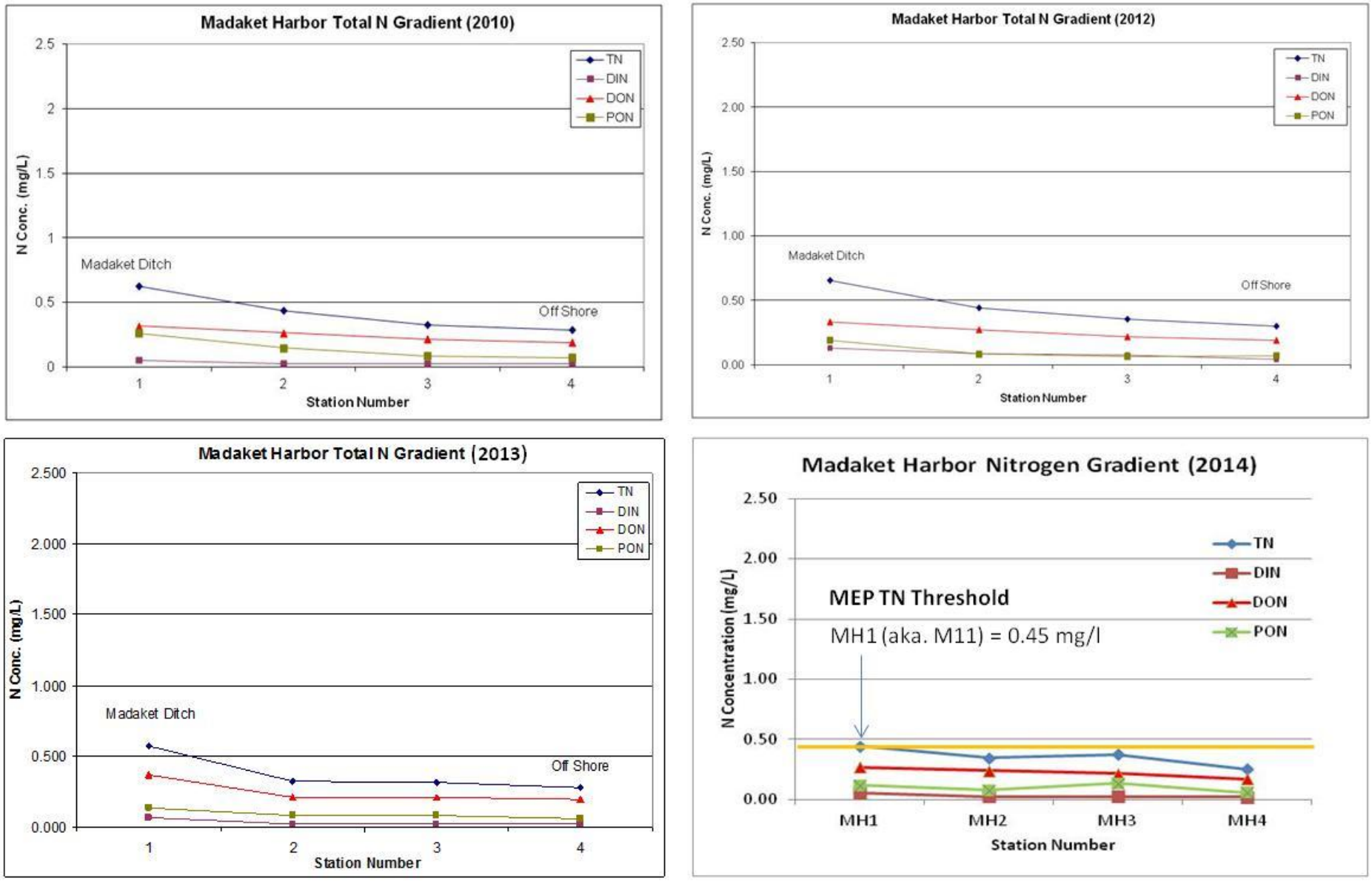

Figure 12 cont'd. Comparison of nitrogen species (mg/L) in Madaket Harbor in summers, 2010 (upper left); 2012 (upper right); 2013 (btm left); 2014 (btm right). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.

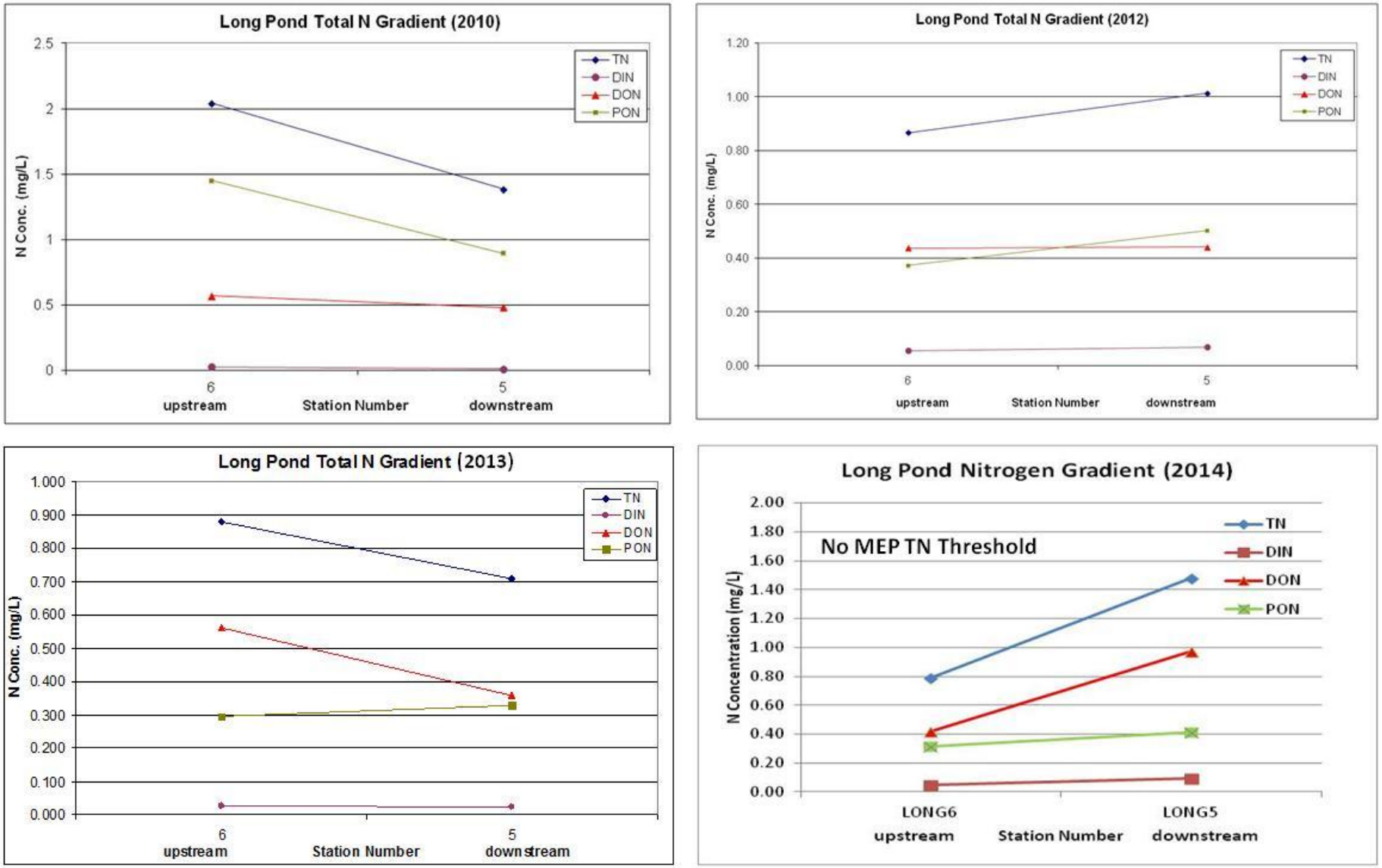

Figure 12 cont'd. Comparison of nitrogen species (mg/L) in Long Pond (Madaket Harbor System) in summers, 2010 (upper left); 2012 (upper right); 2013 (btm left); 2014 (btm right). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.

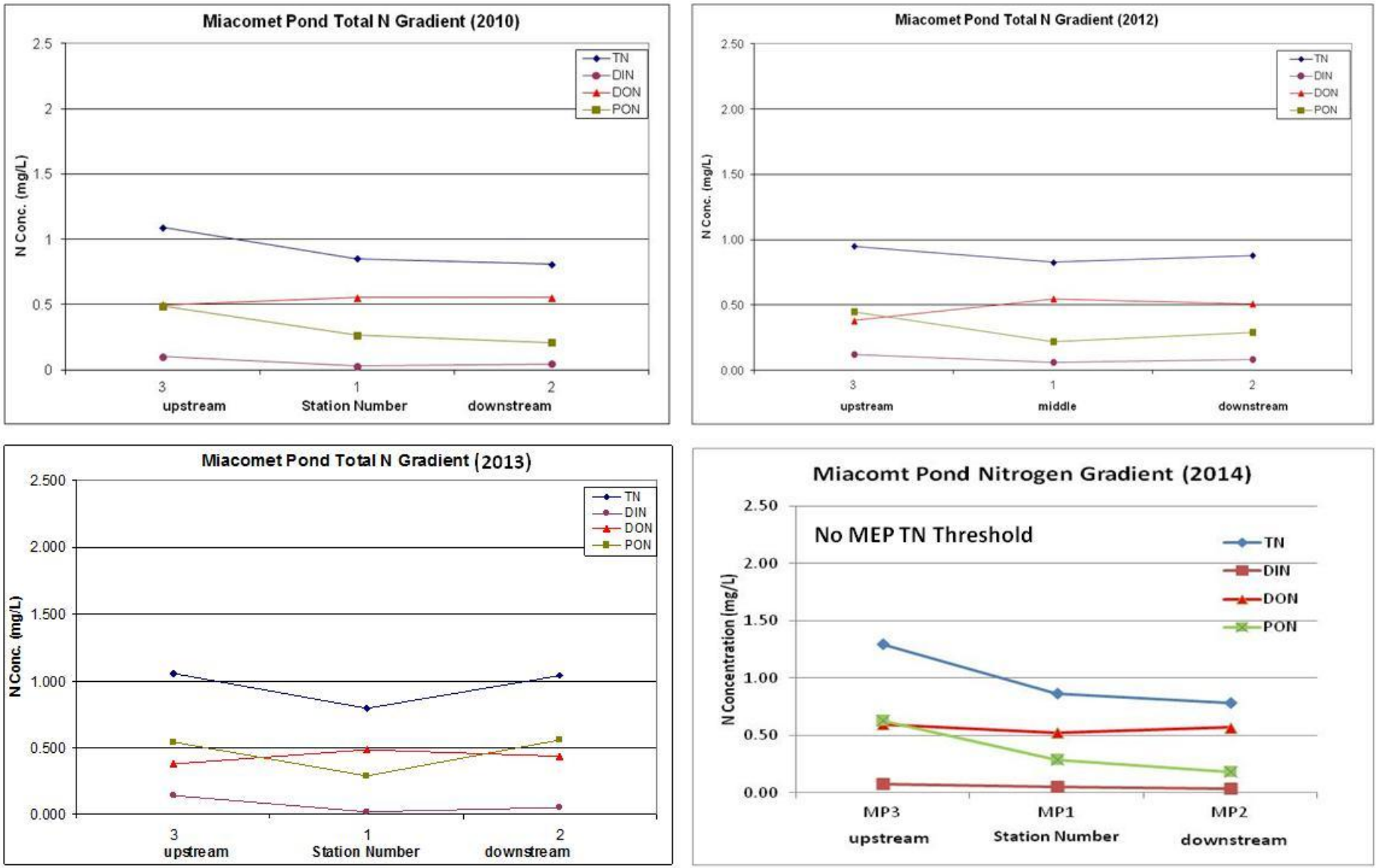

Figure 12 cont'd. Comparison of nitrogen species (mg/L) in Miacomet in summers, 2010 (upper left); 2012 (upper right); 2013 (btm left); 2014 (btm right). Total nitrogen is the sum of the inorganic and organic fractions (top line in each graph). All figures are to same scale.

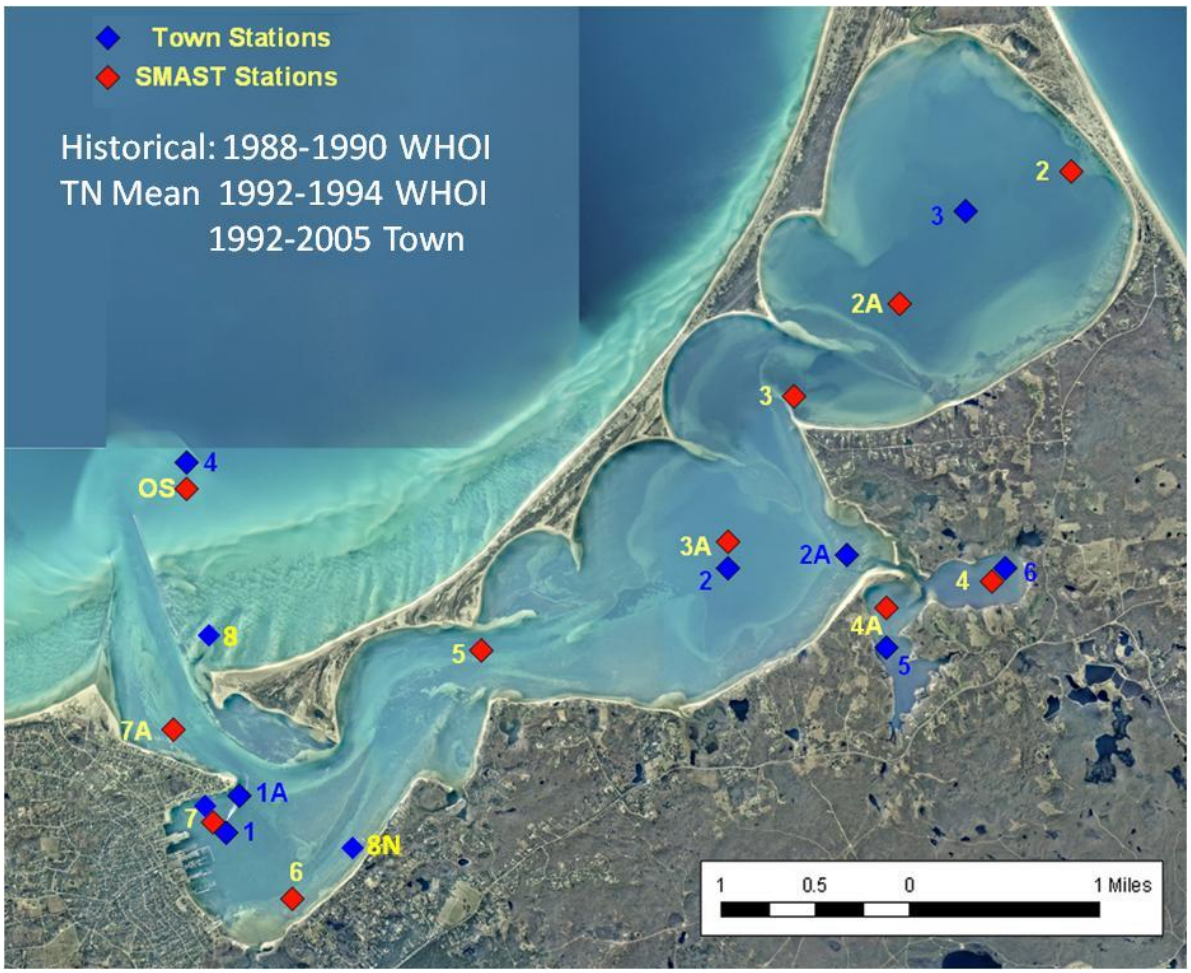

Figure 13. Estuarine water quality monitoring station locations in the Nantucket Harbor estuary system. Station labels correspond to those provided in Table 3 below. Red diamonds indicate locations of MEP monitoring stations. Blue diamonds are locations of Town sampling. Station 8 sampled in 2010, station 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)
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
Head of the Harbor - Lower	2A	0.339	0.070	NA	NS	NS	NS	NS
Pocomo Head	3	0.335	0.081	NA	NS	NS	NS	NS
Quaise Basin	3A+Town 2	0.336	0.112	2	0.297	0.364	0.345	0.314
East Polpis Harbor	4+Town 6	0.362	0.105	6	0.438	0.484	0.401	0.378
West Polpis Harbor	4A+Town 5	0.388	0.119	5	0.431	0.419	0.385	0.389
Abrams Point	5	0.335	0.060	NA	NS	NS	NS	NS
Monomoy	6	0.297	0.086	NA	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
Nantucket Sound	OS+Town 4	0.239	0.041	4	0.283	0.344[1]	0.317[1]	0.277

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.

[1] 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.

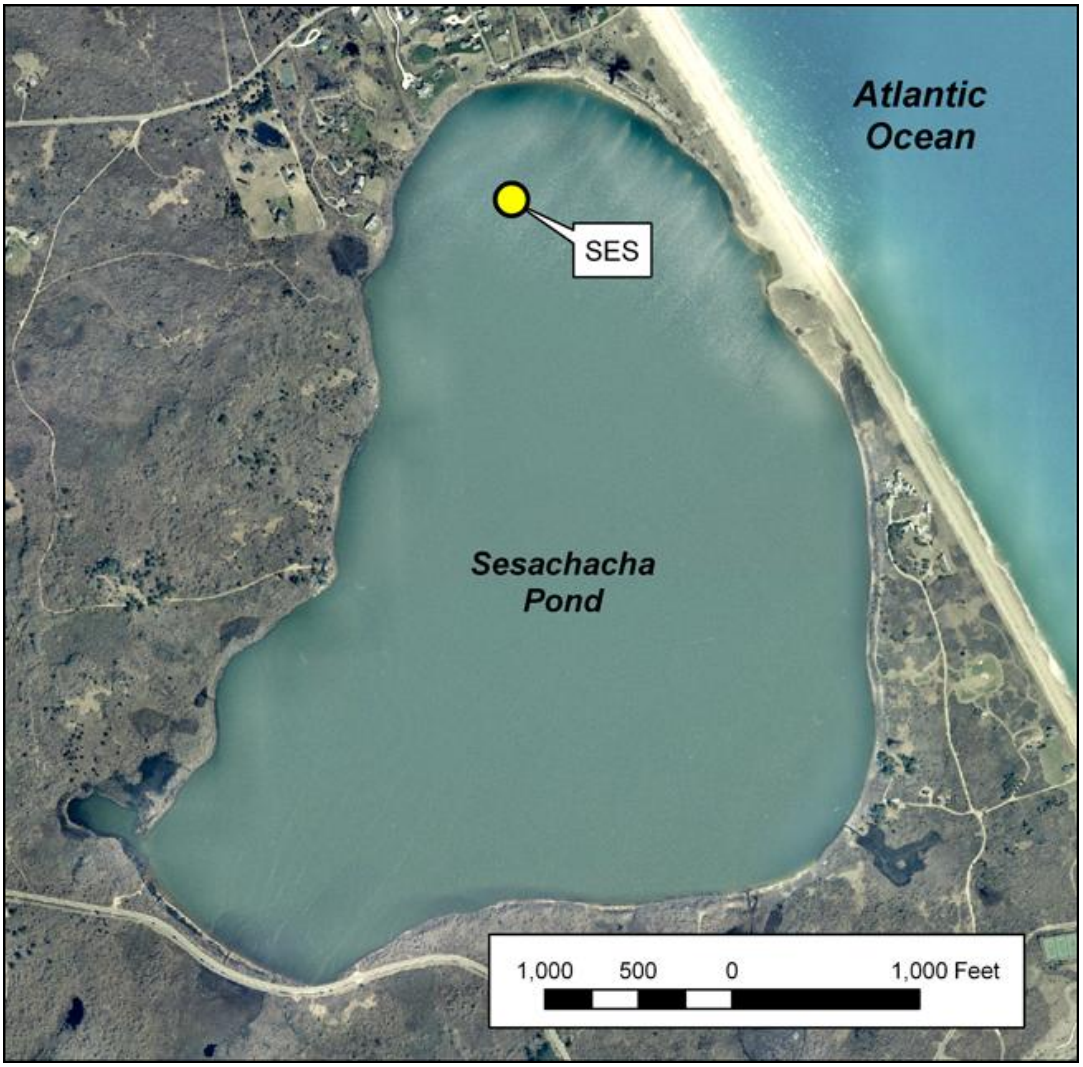

Figure 14. 2005 aerial photo showing MEP monitoring station location in Sesachacha Pond that was used in the water quality analysis for the Massachusetts Estuaries Project. Station SES corresponds to SESA-1 in Tables 2a,b and Station 1 in Figure 3.

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)
Sesachacha Pond	1.197	0.078	0.684 (0.704)	0.678 (0.639)	0.714 (0.669)	0.919 (0.922)

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 15. 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)
Madaket Harbor	MEP M1	0.336	0.098				
Madaket Harbor	Town 4			0.285	0.297	0.278	0.254
Madaket Harbor	MEP M2	0.395	0.083				
Madaket Harbor	Town 2			0.436	0.444	0.323	0.347
Madaket Harbor	MEP M3	0.415	0.090				
Madaket Harbor	Town 3			0.324	.356	0.314	0.376
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
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
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
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	2014	2013	2012	2010	2005/2007	
	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	TN (mg/L)	
	Mean	Mean	Mean	Mean	Mean	S.D.
HUM1	0.651	0.769	0.666	0.616	0.751**	0.374
HUM3	0.643	0.827	0.863	0.589	0.630**	0.388
HUM5	0.653	0.881	0.871	0.766	ND	ND
HUM7	0.873	1.170	1.301	1.786	1.283**	0.969
HUM8	0.755	1.064	0.944	0.983	ND	ND
MP1	0.864	0.792	0.828	0.854	0.842*	0.191
MP2	0.784	1.036	0.880	0.811	0.855*	0.213
MP3	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 and 2014. All values are mg/L.

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 7. 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 7a. 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 7b. 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 7c. 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	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 8. 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 8a. 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 8b. 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 8c. 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).

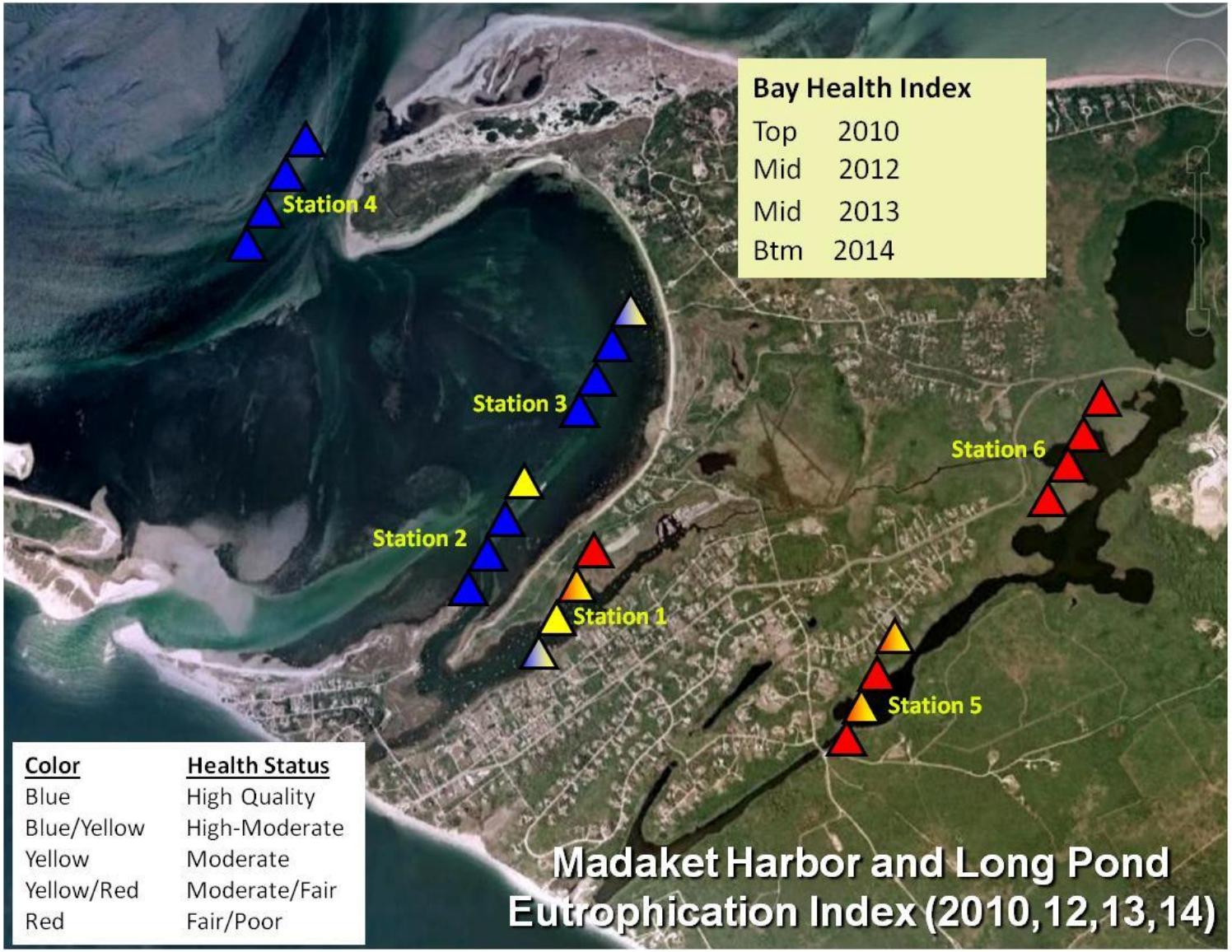

Figure 16. Madaket Harbor Eutrophication Index 2010 (top triangle) and 2014 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

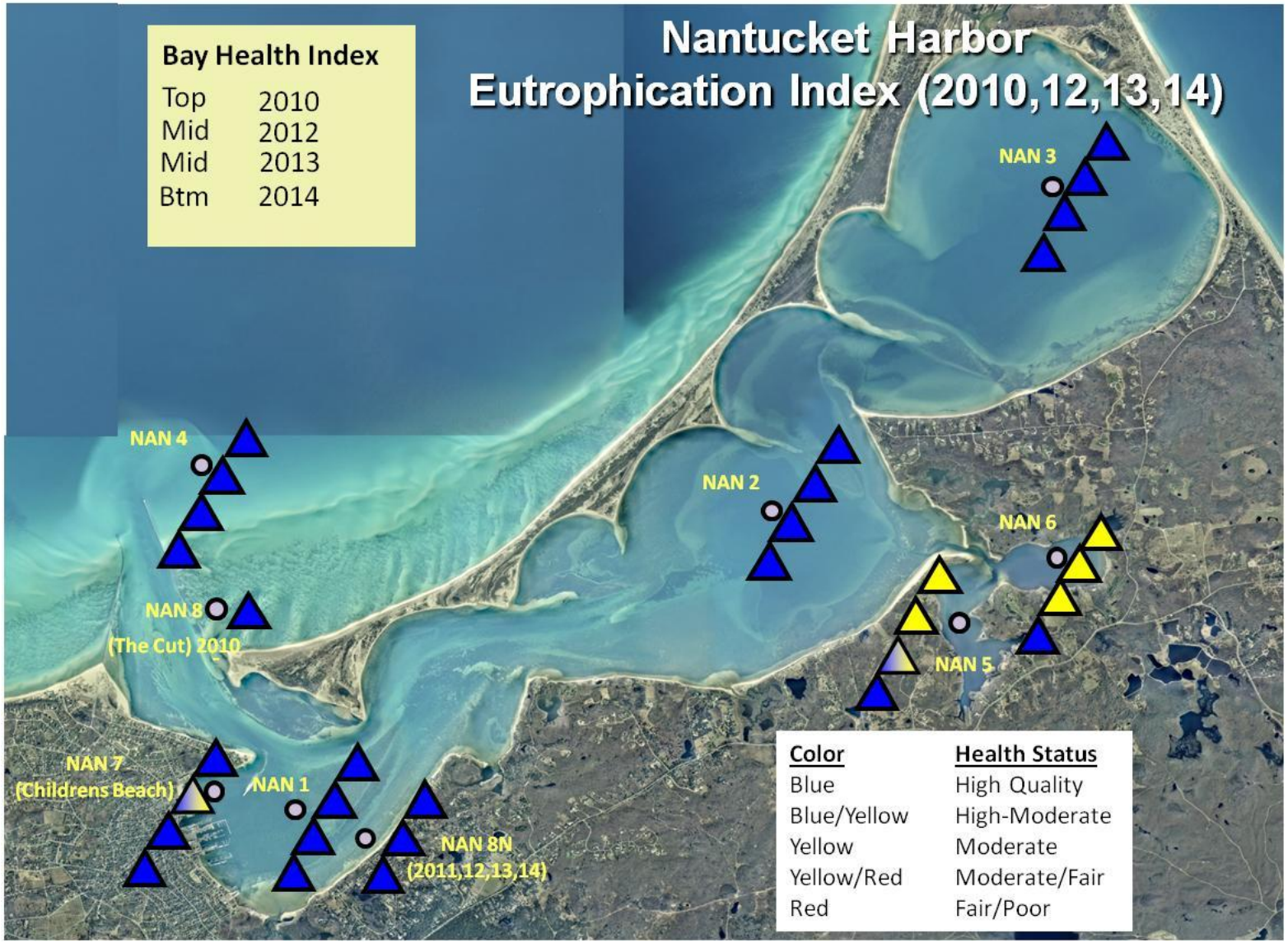

Figure 17. Nantucket Harbor Eutrophication Index 2010 (top triangle) and 2014 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

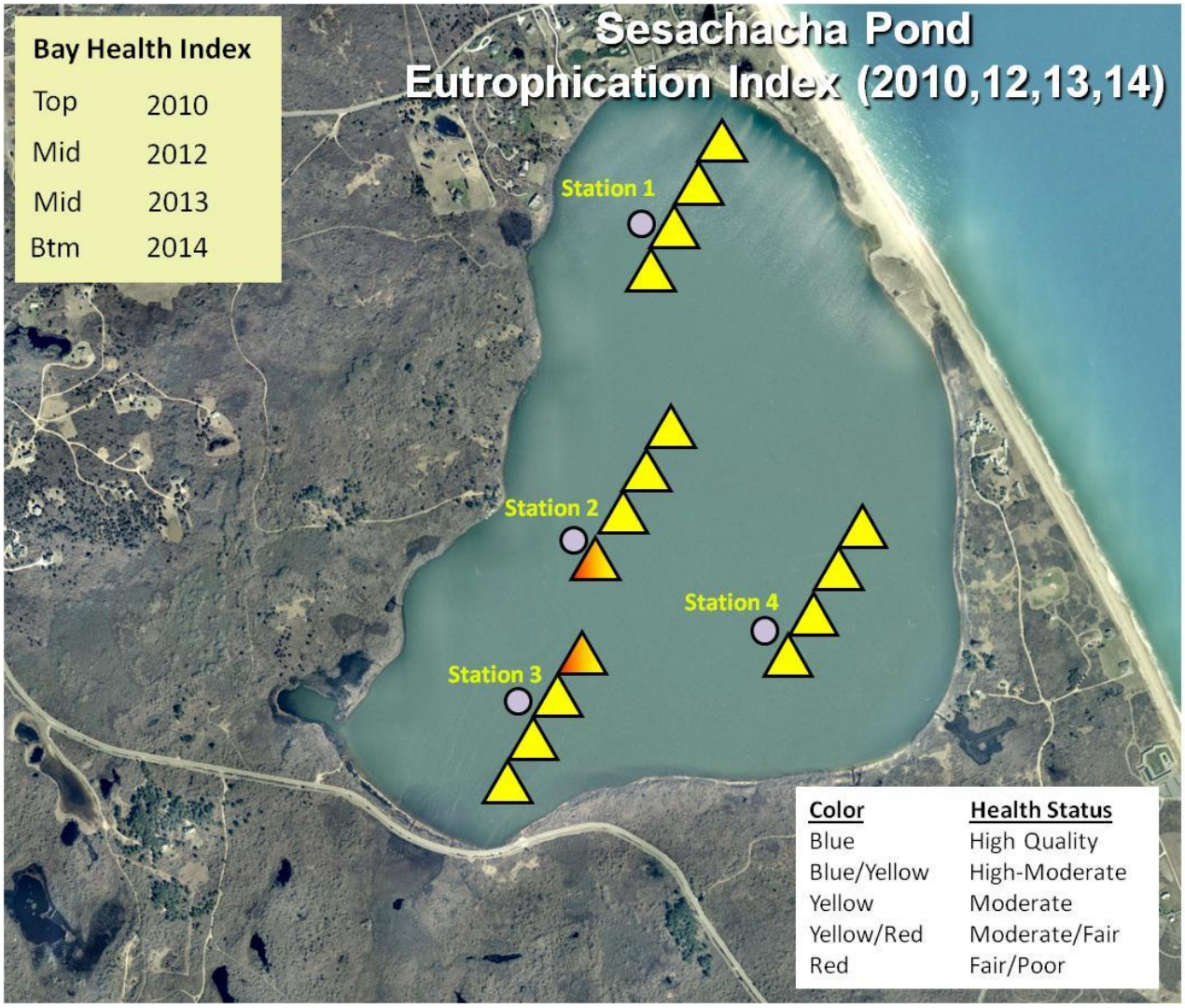

Figure 18. Sesachacha Pond Eutrophication Index 2010 (top triangle) and 2014 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

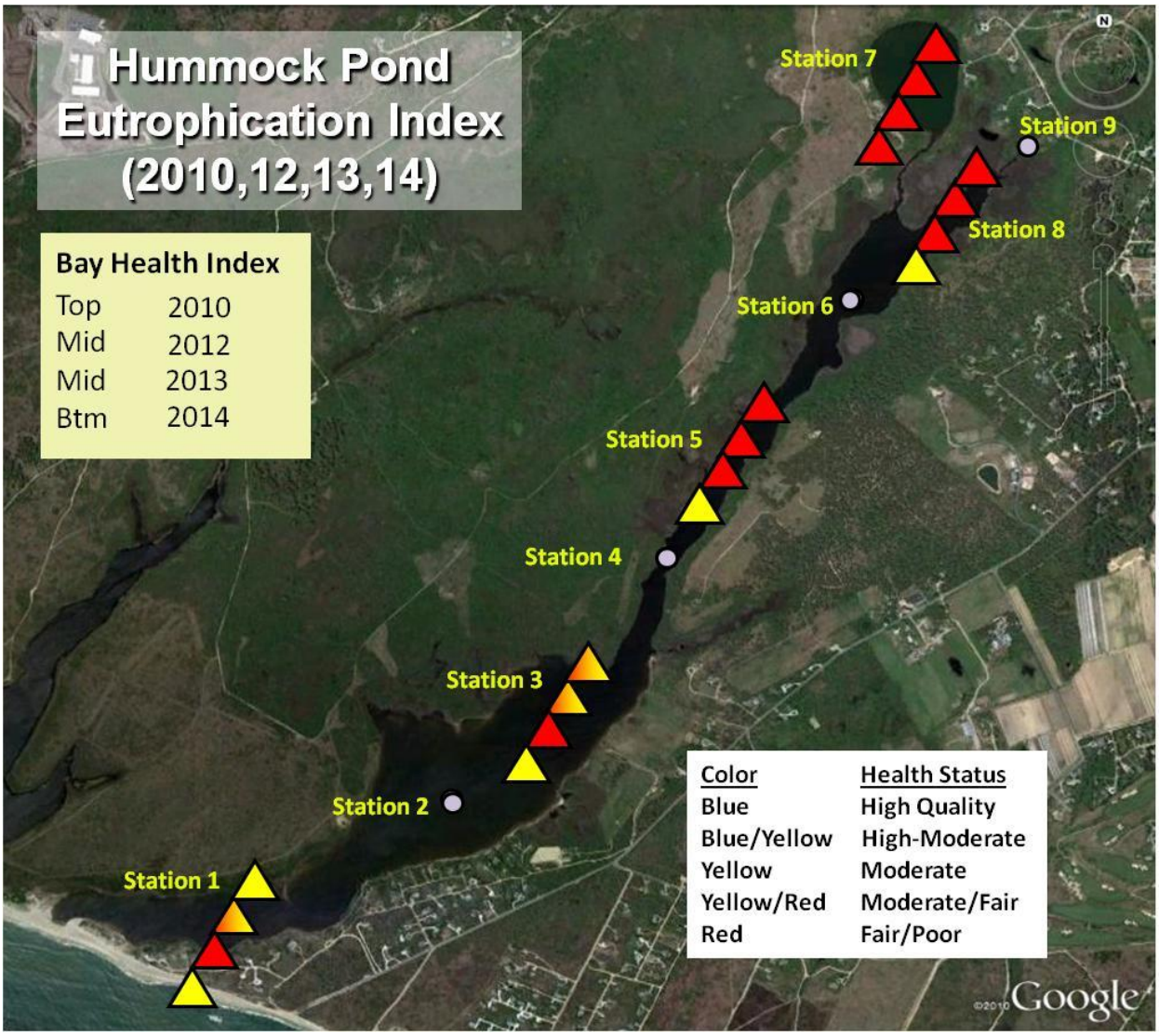

Figure 19. Hummock Pond Eutrophication Index 2010 (top triangle) and 2014 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

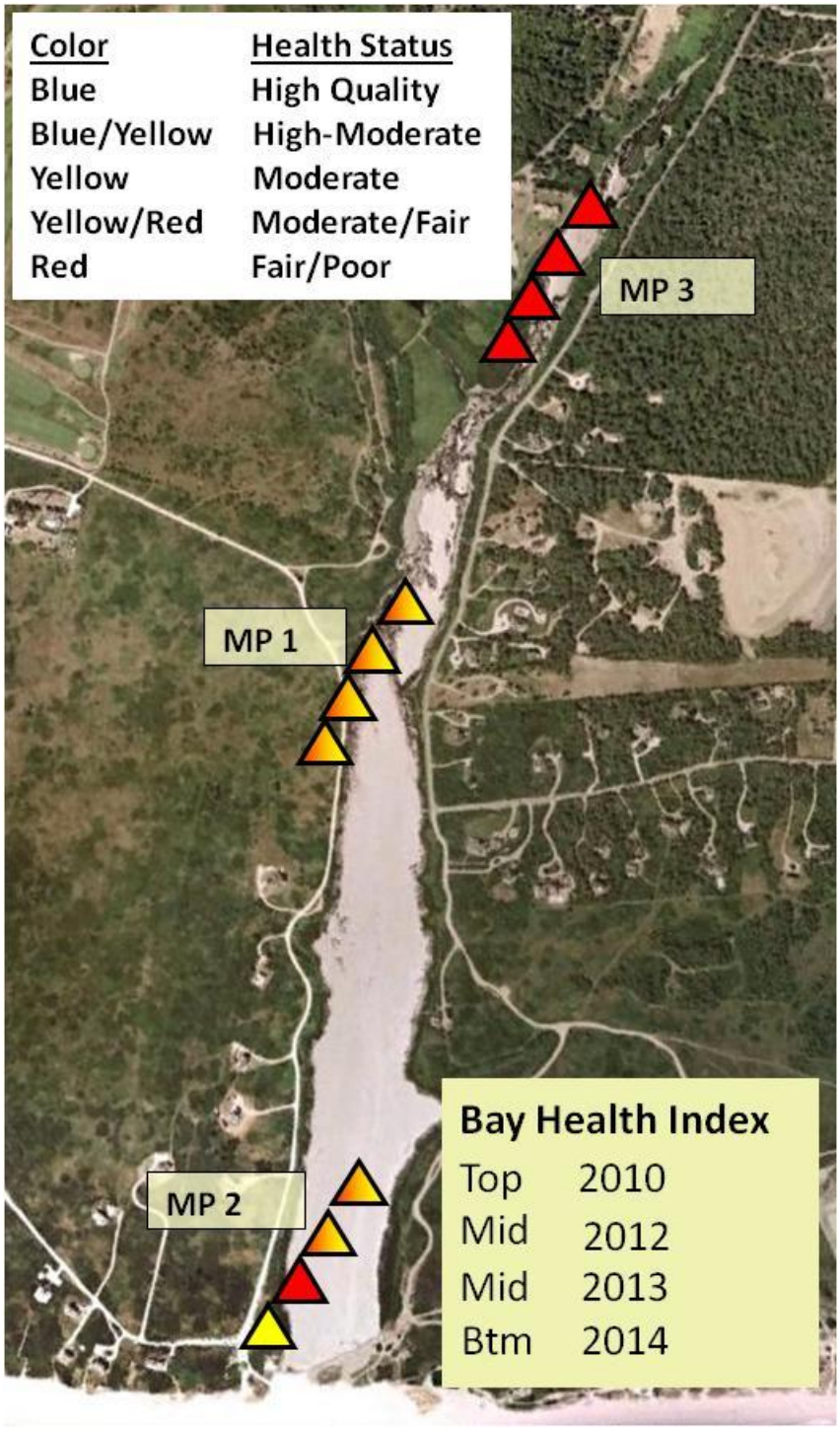

Figure 20. Miacomet Pond Eutrophication Index 2010 (top triangle) and 2014 (bottom triangle). Index was calculated with dissolved oxygen. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.