Technical Memorandum

FINAL

Water Quality Monitoring and Assessment of the Martha's Vineyard Island-Wide Estuaries and Salt Ponds Summary 2016 (year 1 of 3)

To:

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From:

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The Technical Memorandum on the results of the summer 2016 Martha's Vineyard Island-wide Water Quality Monitoring Program is organized as follows:

1. Overview
   - Background
   - Need for a Monitoring Program
2. Summary of Sampling Approach for each of the estuaries and salt ponds of Martha's Vineyard. The following systems represent all the estuaries that will eventually be sampled under the unified monitoring program, however, a few were not sampled initially in year 1 of the program (specifically #8,10,12,13 from the list below):
   1. Lake Tashmoo (**Yes** - MEP Threshold)
   2. Lagoon Pond (**Yes** - MEP Threshold)
   3. Oak Bluffs Harbor (**Yes** - MEP Threshold)
   4. Farm Pond (**Yes** - MEP Threshold)
   5. Sengekontacket Pond (**Yes** - MEP Threshold)
   6. Cape Pogue / Pochet Pond (To Be Developed - MEP Threshold)
   7. Katama Bay/Edgartown Harbor (To Be Developed - MEP Threshold)
   8. Oyster Pond (To Be Developed - MEP Threshold)
   9. Edgartown Great Pond (**Yes** - MEP Threshold)
   10. Tisbury Great / Black Point Pond (**Yes** - MEP Threshold)
   11. Chilmark Pond (**Yes** - MEP Threshold)
   12. Menemsha / Squibnocket Ponds (Yes - MEP Threshold)
   13. James Pond (No - MEP Threshold)
3. Results of Sampling: Summary of Water Quality Results
   - Review of and comparison to historical data used in the MEP Reports
4. Trophic State: Water Quality/Eutrophication Status
5. Recommendations for Future Monitoring

Overview

Background: Coastal salt ponds and estuaries are among the most productive components of the coastal ocean. These circulation-restricted embayments support extensive and diverse plant and animal communities providing the foundation for many important commercial and recreational fisheries. The aesthetic value of these systems, as well as the freshwater ponds of a town, are important resources to both residents and the tourist industry alike. Maintaining high levels of water quality and ecological health in these aquatic systems (fresh and marine) is fundamental to the enjoyment and utilization of these valuable resources for all coastal communities.

Nutrient over-enrichment is the major ecological threat to water quality in the salt ponds and embayments across all the Towns of Martha's Vineyard, primarily via ecological degradation which results when nutrient loading exceeds the critical nutrient threshold i.e. the assimilative capacity (level at which additional nutrients begin to cause declines). Each aquatic system has its own specific threshold, based upon its configuration, mixing and flushing rates. Of the various forms of pollution that threaten coastal waters (nutrients, pathogens and toxics), nutrient inputs are the most ubiquitous, insidious and difficult to control. This is especially true for nutrients originating from non-point sources, such as nitrogen and phosphorous transported in the groundwater from on-site septic treatment systems, agriculture or even residential lawn fertilization. On-site septic treatment systems are the primary mechanism for waste disposal within the watersheds of nearly all the estuaries of Martha's Vineyard with the exception of Edgartown Great Pond. Edgartown Great Pond is in a somewhat different situation as the watershed to that system is partially sewered and wastewater is treated by a wastewater treatment facility. Nevertheless, the nutrient characteristics and ecological health of that system must be monitored given the wastewater treatment plant effluent does discharge to Edgartown Great Pond and the pond only has tidal flushing during its periodic openings to the Atlantic Ocean via managed breaching of the barrier beach. Additionally, Edgartown Great Pond does still support eelgrass habitat that is especially vulnerable to changes in nutrient concentrations and associated water clarity.

Since the primary nutrients, nitrogen and phosphorous, are natural components of estuarine and pond systems, it is important that management allow for the natural capacity of these systems to absorb watershed nutrient inputs. Through the coupling of monitoring data to the Massachusetts Estuaries Project (MEP) watershed loading analysis developed in collaboration with the Coastal Systems Program (CSP), the most cost-effective management strategies can be found to protect these valuable aquatic environments of Martha's Vineyard. Moreover, as nutrient load reduction strategies become implemented across the Island and in specific estuarine watersheds, maintaining the regular monitoring of nutrient related water quality is critical for assessing the extent to which a particular implementation approach is having its planned effect toward restoration and how much additional effort may be required.

Need for a Monitoring Program: Conserving and/or restoring the environmental health of coastal embayments and freshwater ponds is achievable, but only through proper management of the waters and watersheds of each. Managing environmental health requires a quantitative understanding of the biological and physical processes which control nutrient related water quality within a specific basin and the role of watershed inputs in the nutrient balance of the receiving waters. An essential step in managing these fresh and saltwater systems is to monitor their water quality. The results of a long-term monitoring effort are needed to determine the status and trend of each system's ecological health to assess the need for management actions. Nutrient impaired systems can be restored, but require that long-term water quality data be coupled with higher-end ecological data to support the development of quantitative site-specific management plans.

Water quality monitoring of the fresh and saltwater systems of Martha's Vineyard is focused on summer-time conditions, as the warmer months typically have the lowest water quality conditions, which are the target of resource management. The Martha's Vineyard Commission as well as the Towns of Martha's Vineyard have a long history of monitoring of the Island's aquatic systems to support the protection and management of the natural resources of the Island. Generally, water quality monitoring has been undertaken by the MVC Water Resources Planner or Town Shellfish or Natural Resources Departments. These past efforts have also supported nutrient related estuarine analyses by the Massachusetts Estuaries Project for restoration/protection of all the coastal systems of southeastern Massachusetts and specifically on the island of Martha's Vineyard. Over the past 8-10 years, the MEP has established the estuarine specific nitrogen thresholds for nearly all of the estuaries of Martha's Vineyard with the exception of James Pond, Oyster Pond, Katama Bay, Cape Pogue Bay and Pocha Pond. Field data collection has been completed under the umbrella of the MEP for future analysis of Oyster Pond, Katama Bay, Cape Pogue Bay and Pocha Pond. Modeling and threshold development is forthcoming assuming funds can be garnered from the Town.

Water quality monitoring programs, like the unified Island-wide program initiated in the summer of 2016 across all the coastal systems of Martha's Vineyard, are the most efficient way to maximize the value of the results. The efficiency is achieved by structuring the sampling and analysis program such that results can be cross compared to historic water quality monitoring data and that collected throughout the region. For example, a similar unified monitoring program was initiated in 2010 covering all of the estuaries on Nantucket Island. Both the Vineyard and Nantucket programs utilize exactly the same sampling and analytical protocols ensuring seamless cross comparability. 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 Martha's Vineyard Towns to directly benefit from lessons learned across the Island as well as throughout the wider region, be it Cape Cod or the Island of Nantucket.

Summary of Sampling Approach

Monitoring Project Team: To address the present nutrient related ecological health issues of the salt ponds and embayments across the Island of Martha's Vineyard and to provide necessary information with which to develop policies to protect and/or remediate these systems with regard to nutrient overloading, a long-term, unified monitoring effort was established for the summer 2016 and coordinated through the Martha's Vineyard Commission (MVC). This unified monitoring program builds on the multiple and diverse historic water quality monitoring efforts. These prior monitoring efforts were undertaken beginning as early as 2000 and continued through around 2007 to support the baseline water quality monitoring needs of the Massachusetts Estuaries Project (MEP). In 2016 the MVC determined that the need for consistent water quality monitoring required an Island-wide Water Quality Monitoring Program and that monitoring should be resumed with support from the Coastal Systems Program (CSP) at the University of Massachusetts-Dartmouth, School for Marine Science and Technology (SMAST). The CSP was responsible for the analysis of the prior water sampling results completed in the estuaries of Martha's Vineyard as part of the MEP nutrient thresholds development. To maintain consistency with water quality monitoring procedures and assays from all the previous years, water quality monitoring in 2016 was completed as a collaboration between the Martha's Vineyard Commission (MVC) and the Coastal Systems Program. The Martha's Vineyard Commission is serving as Project Leader and lead field organization and the Coastal Systems Program is providing laboratory services through the Coastal Systems Analytical Facility at SMAST. Coordination and oversight of the program is by the MVC Water Resources Planner (Ms. Sheri Caseau) with CSP-SMAST providing the technical oversight, analytical support and data interpretation.

While the Martha's Vineyard Commission and its Water Resources Planner have extensive experience in water sample collection and have an inventory of necessary sampling equipment, some equipping and training of volunteers & staff prior to sampling was warranted to ensure that sampling protocols are understood and properly implemented (primary focus on any new staff and new sampling locations). Training took place in the early summer in advance of the July 2016 sampling events. The Coastal Systems Program has also been responsible for the development and coordination of the majority of the estuarine and pond water quality monitoring across southeastern Massachusetts, Cape Cod and the Island of Nantucket as well as the analysis of all the samples collected and synthesis of the resulting water quality data. As such, the CSP is able to leverage this comprehensive water quality database on an as needed basis to further evaluate results obtained from the Martha's Vineyard Island-wide monitoring program. It should also be noted that The Coastal Systems Analytical Facility, in addition to conducting research quality assays of environmental samples, has been cleared for regulatory nutrient related water quality assays in Massachusetts estuaries. This required review of all laboratory protocols, inter-calibration studies and blind performance and evaluation (P&E) samples (most recently 2015). In addition, laboratory QA/QC procedures were brought to “certification” standards and various agencies have reviewed MEP water quality data results. This makes the Coastal Systems Analytical Facility uniquely qualified for the conduct of low level environmental nutrient assays in a regulatory setting (TMDL’s) and this level of analytical rigor is the basis for the Martha's Vineyard Island-wide Water Quality Monitoring Program.

CSP scientists focused primarily on the analysis of samples collected from the Island-wide effort, data analysis and program coordination while the Martha's Vineyard Commission focused primarily on field sampling and data collection on physical parameters. Both participated in the compilation of field and laboratory data to provide an ecological overview of water quality conditions within each of the systems for the benefit and use by all the Towns of Martha's Vineyard. The goals of the monitoring program were to:

(1) determine the present ecological health of each of the main salt ponds and estuaries across the Island of Martha's Vineyard,

(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 for proper nutrient and resource management, if needed, and to assess the success of implemented restoration alternatives,

(4) compliance monitoring to meet requirements of TMDLs as they are developed and as towns across the island move into implementation of restoration approaches,

(5) provide a mechanism to easily compare present water quality data to MEP established nutrient thresholds.

The latter points (3,4) are critical for restoration planning should an estuarine system be found to be impaired or trending toward impairment.

Water Quality Program Description: As was the case during historical sampling to develop the baseline water quality data sets in each estuary for the MEP, sampling took place during the warmer summer months (July, August) of 2016, the critical period for environmental management. Samples were collected in year 1 of the unified Island-wide Monitoring Program from 10 of 13 estuarine systems and 1 freshwater pond (Fresh Pond {aka. Wiggies Pond} watershed to Major's Cove in the Sengekontacket Estuary) as depicted in Figures 2-11 on dates ("events") as summarized in Table 1a and Table 1b. Sampling followed the general schedule presented in Table 1c.

The Martha's Vineyard Commission oversaw the sampling and all samplers who were involved were given refresher "training" by CSP staff to meet QA requirements. The physical parameters measured in the estuaries included: total depth, Secchi depth (light penetration), temperature, specific conductivity/salinity (YSI meter), general weather, wind speed and direction, dissolved oxygen levels and observations of moorings, birds, shellfishing 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. Estuarine sampling in 2016 was based on completion of four (4) sampling events in July and August (see Table 1a, 1b, 1c for summary) with the exception of two estuaries (Farm Pond and Oak Bluffs Harbor which were sampled once in August and once in September. The precise dates were selected based upon early morning mid-tides for tidal estuaries and simply in the early morning for salt ponds with no permanent inlet. Water samples were collected at 53 locations (3 stations in Fresh Pond {Wiggies Pond}) including sentinel stations established as part of the MEP nutrient threshold assessments. Sampling these stations generated a maximum of 61 samples per event (not including QA samples) when all systems were being sampled on a given date. It should be noted that while each system did receive the same number of sampling events (4), some estuaries are deeper than others and as such some stations were sampled at 2 depths (surface and bottom) and others at only one depth (surface or mid). QA samples were collected at ~10% of the stations for a given event. Data were compiled and reviewed by the CSP laboratory for accuracy and evaluated to discern any possible artifacts caused by improper sampling, holding or storage technique.

Table 1a. Sampling Schedule for 2016 Martha's Vineyard Island-Wide Water Quality Monitoring Program

Month	Cape Pogue Bay	Pochet Pond	Katama Bay	Edgartown Great Pond	Chilmark Pond	Fresh Pond	Farm Pond
Jan							
Feb							
Mar							
April							
May							
June							
July	July 13, 27	July 13	July 13, 27	July 7, 21	July 6, 20	July 12, 26	14, 28
August	Aug. 11, 25	Aug. 11, 25	Aug. 11, 25	Aug. 4, 18	Aug. 5, 18	Aug. 9, 30	Aug. 10
September							Sept. 22
October							
November							
December							
Totals	**4**	**3**	**4**	**4**	**4**	**4**	**4**

Table 1b. Sampling Schedule for 2016 Martha's Vineyard Island-Wide Water Quality Monitoring Program

Month	Oak Bluffs Harbor	Lake Tashmoo	Lagoon Pond	Sengekontacket Pond
Jan				
Feb				
Mar				
April				
May				
June				
July	July 14, 28	July 11, 25	July 11, 25	July 12, 26
August	Aug 10	Aug 8	Aug 8, 23	Aug 9, 30
September	Sept. 22			
October				
November				
December				
Total Events	**4**	**3**	**4**	**4**

Town	Embayment	Number of Stations	Sample Depths	Total Samples per Event	Total Samples per Summer
Edgartown	Sengekontacket Pond	SKT-2,3,4,5,6,7,8,9	6 mid, 1 surf,btm	8	32
Oak Bluffs					
Edgartown	Cape Pogue Bay	POG-2,3,4,5	4 mid	4	16
Edgartown	Pocha Pond	PCA-1,3	2 mid	2	8
Edgartown	Katama Bay	KAT-1,2,3,4,5,7	6 mid	6	24
Edgartown	Oyster Pond	OYS-1,2,3,4	4 mid	4	16
Egartown	Edgartown Great Pond	EGP-2,3,4,5,6,7,9,10,11	9 mid	9	36
Oak Bluffs	Wiggies Pond (aka. Fresh)	FRS-1,2,3	3 surf,3 btm	6	24
Oak Bluffs	Farm Pond	FRM-1,2,3	3 surf	3	12
Oak Bluffs	Oak Bluffs Harbor	MV-15,16,14	2 mid, 1 surf,btm	4	16
Oak Bluffs	Lagoon Pond	LGP-2,4,8,9	2 surf, 2 surf,btm	6	24
Tisbury					
Tisbury	Lake Tashmoo	MV-21,2,3,4, sentinel	4 mid, 1 surf,btm	6	24
West Tisbury	James Pond	JMS-1,3,4	3 mid	3	12
Chilmark	Menemsha Pond	MEN-2,3,5,6,7	5 surf,btm	10	40
Aquinnah					
Chilmark	Squibnocket Pond	SQB-1,3	2 surf,btm	4	16
Aquinnah					
Chilmark	Chilmark Pond	CHP-1,2,4,5,6,7,Upper	7 mid	7	28
Chilmark	Tisbury Great Pond	TGP-1,3A,4,5,6,7,8	6 surf, 1 surf,btm	8	32
West Tisbury					
Sub-Total				61	244
QA Samples @ 10%				25	
Grand Total					**269**

Table 1c – Summary of sampling by station for each estuarine / salt pond system. Systems in red were not included in year 1 of the monitoring program, but are slated for inclusion in out years.

Figure 1 - Estuaries of Martha's Vineyard that have already undergone a minimum of 3 years water quality monitoring by the MVC with support from the Coastal Systems Program. Most estuaries already have regulatory nitrogen thresholds developed by the Massachusetts Estuaries Project (MEP). The Island-wide water quality monitoring program builds on this historical baseline data. Year 1 of the Island-wide water quality monitoring program covers all the estuaries except: Oyster Pond, Tisbury Great Pond, James Pond and Menemsha/Squibnocket Ponds.

STATION LOCATION MAPS FOR ESTUARIES OF MARTHA'S VINEYARD

Figure 2 – Historic Sampling Points (yellow symbols) in Lake Tashmoo including MEP established sentinel station (new station between MV4 and MV5). Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

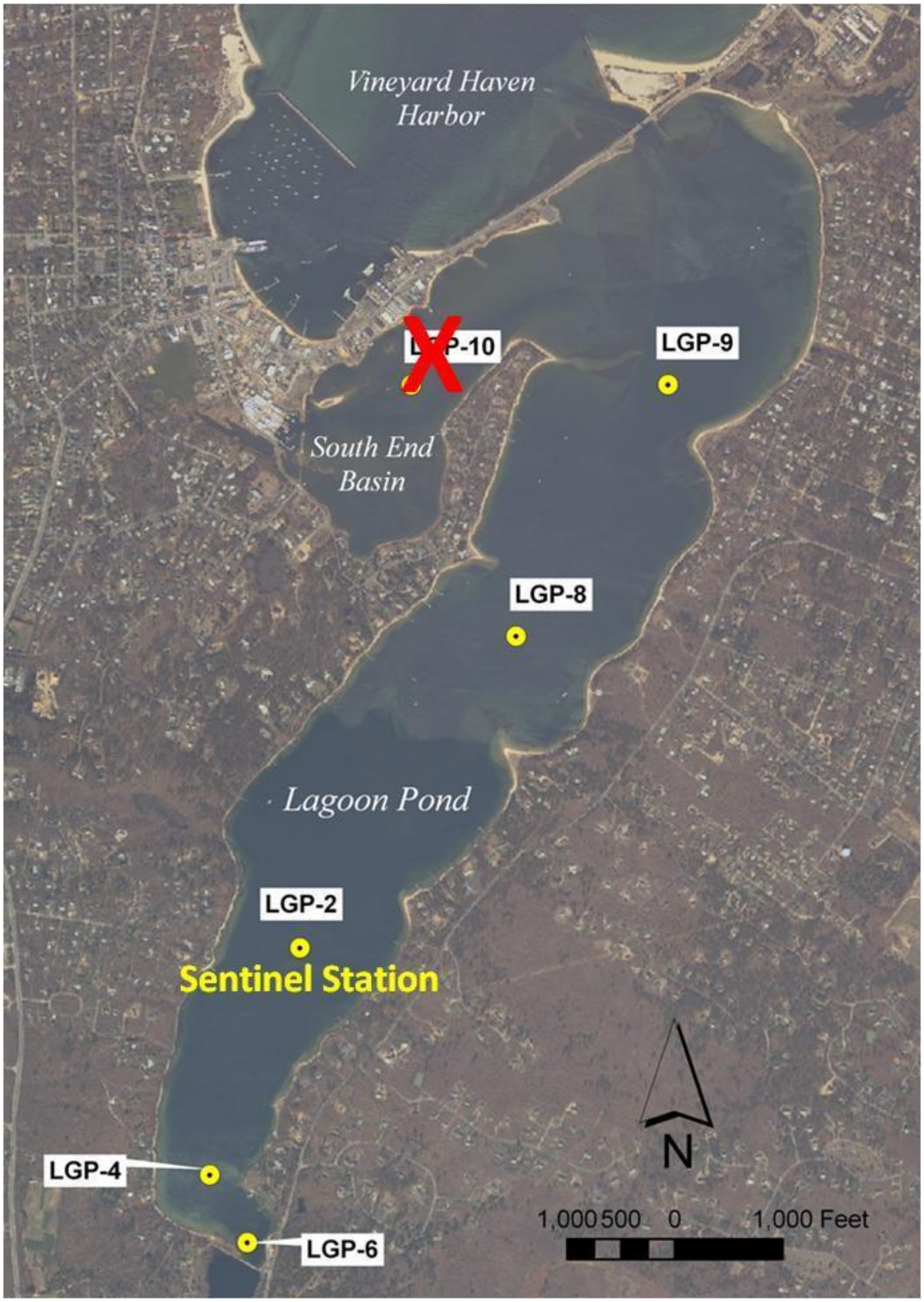

Figure 3 – Historic Sampling Points (yellow symbols) in Lagoon Pond including MEP established sentinel station LGP-2. Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

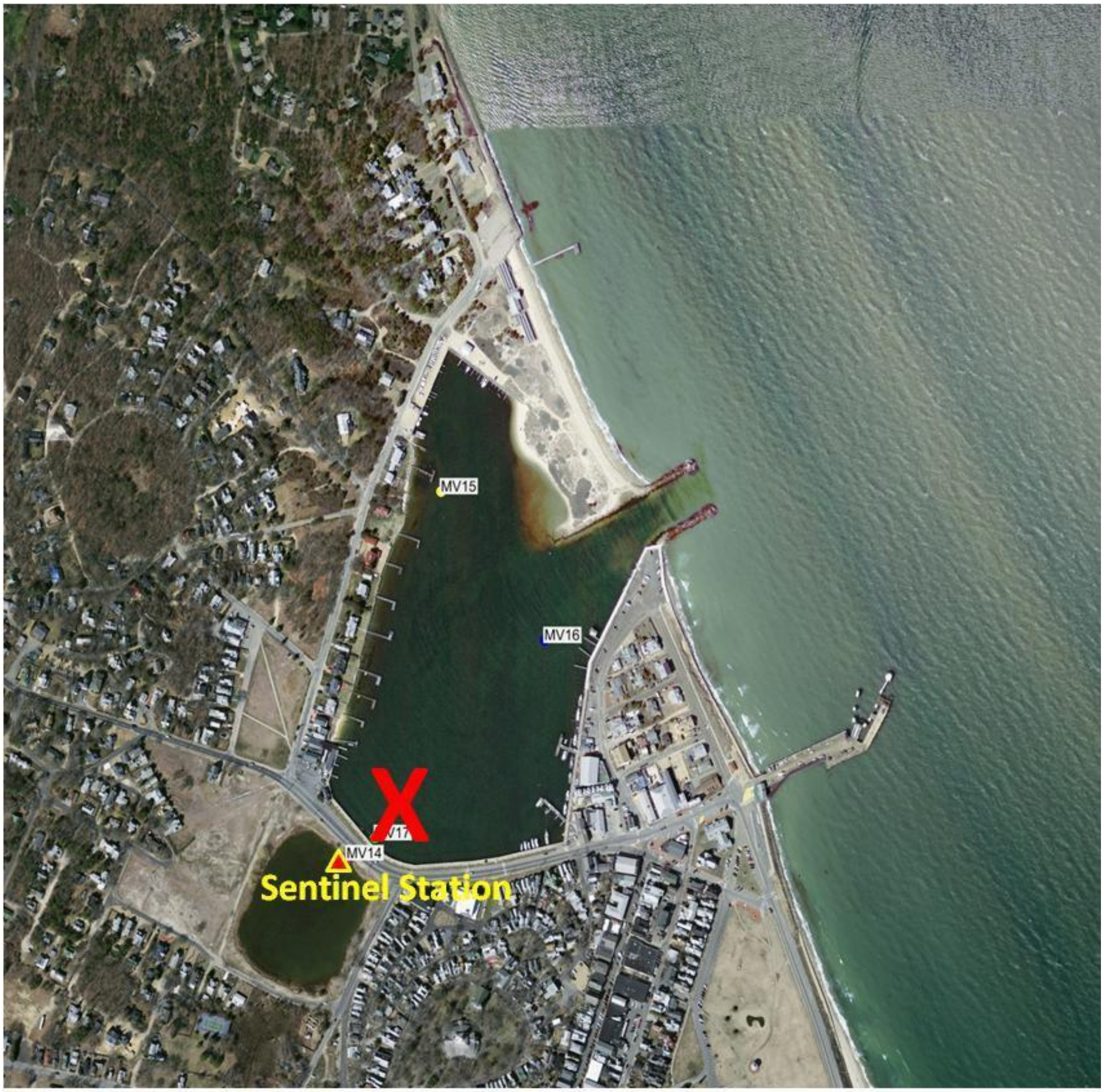

Figure 4 – Historic Sampling Points (white labels) in Oak Bluffs Harbor including MEP established sentinel station (MV-14) in Sunset Lake. Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

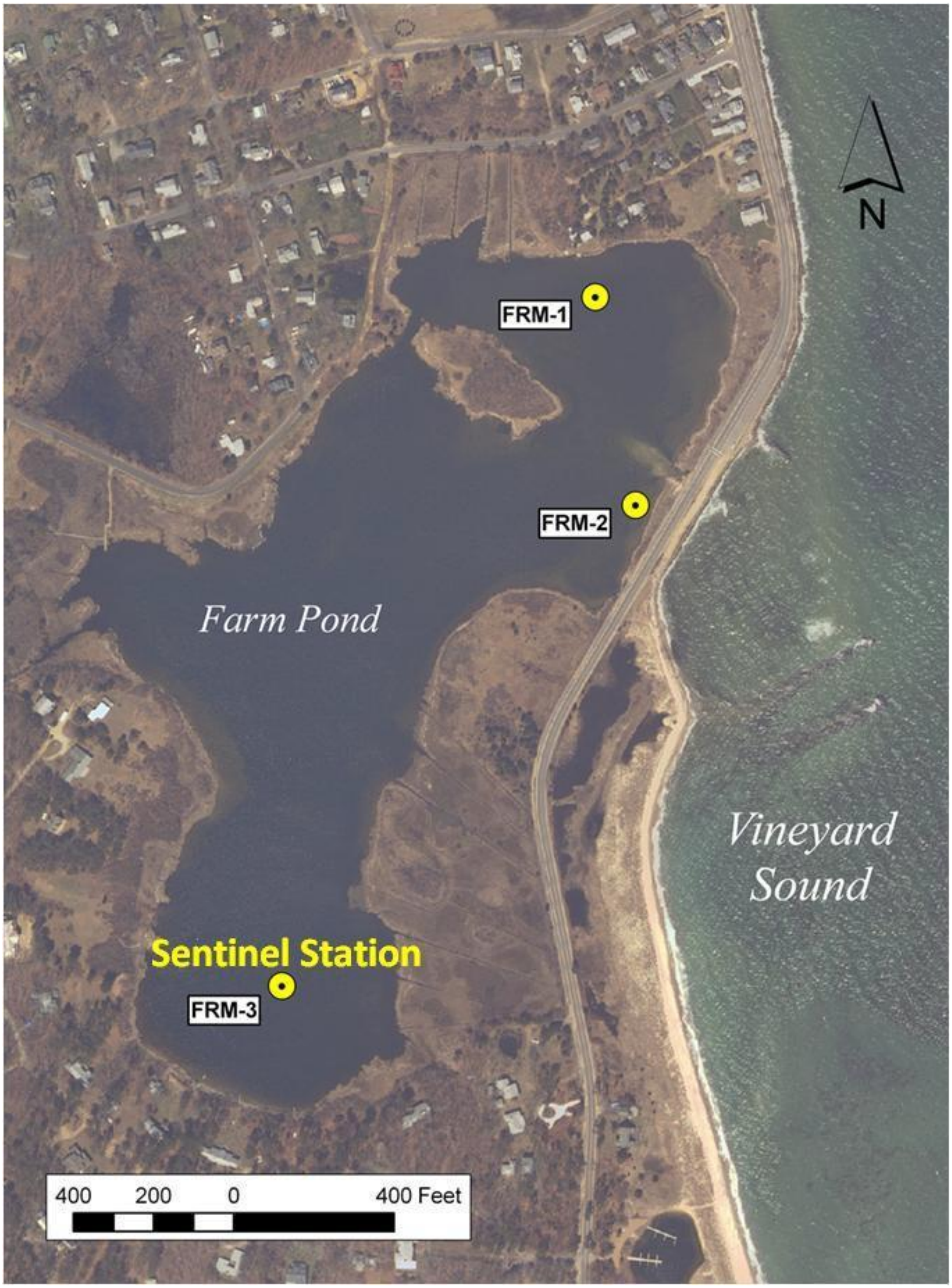

Figure 5 – Historic Sampling Points (yellow symbols) in Farm Pond including MEP established sentinel station FRM-3. Stations re-visited for 2016 sampling season.

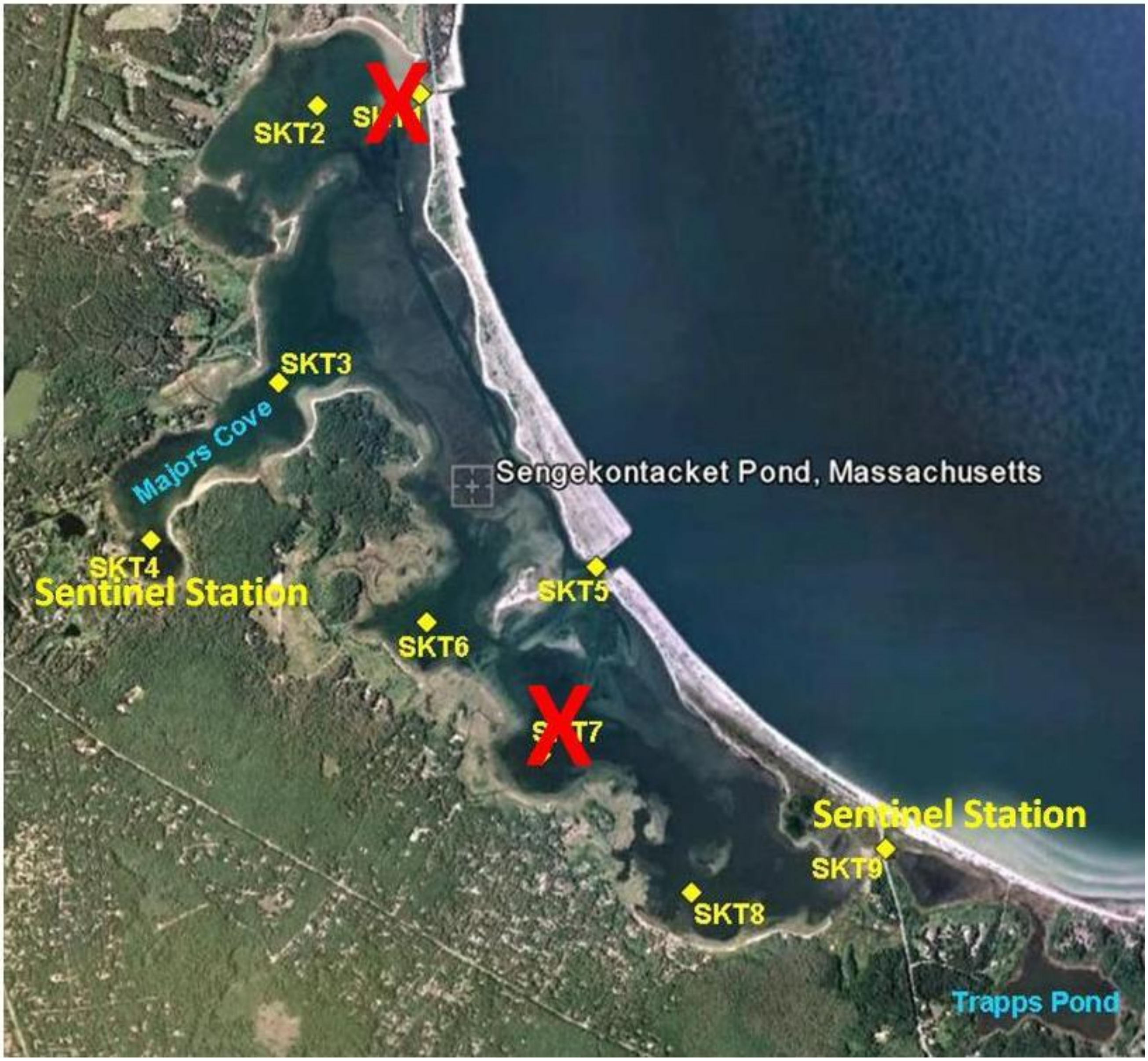

Figure 6a – Historic Sampling Points (yellow symbols) in Sengekontacket Pond including MEP established sentinel stations SKT-4 and SKT-9. Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

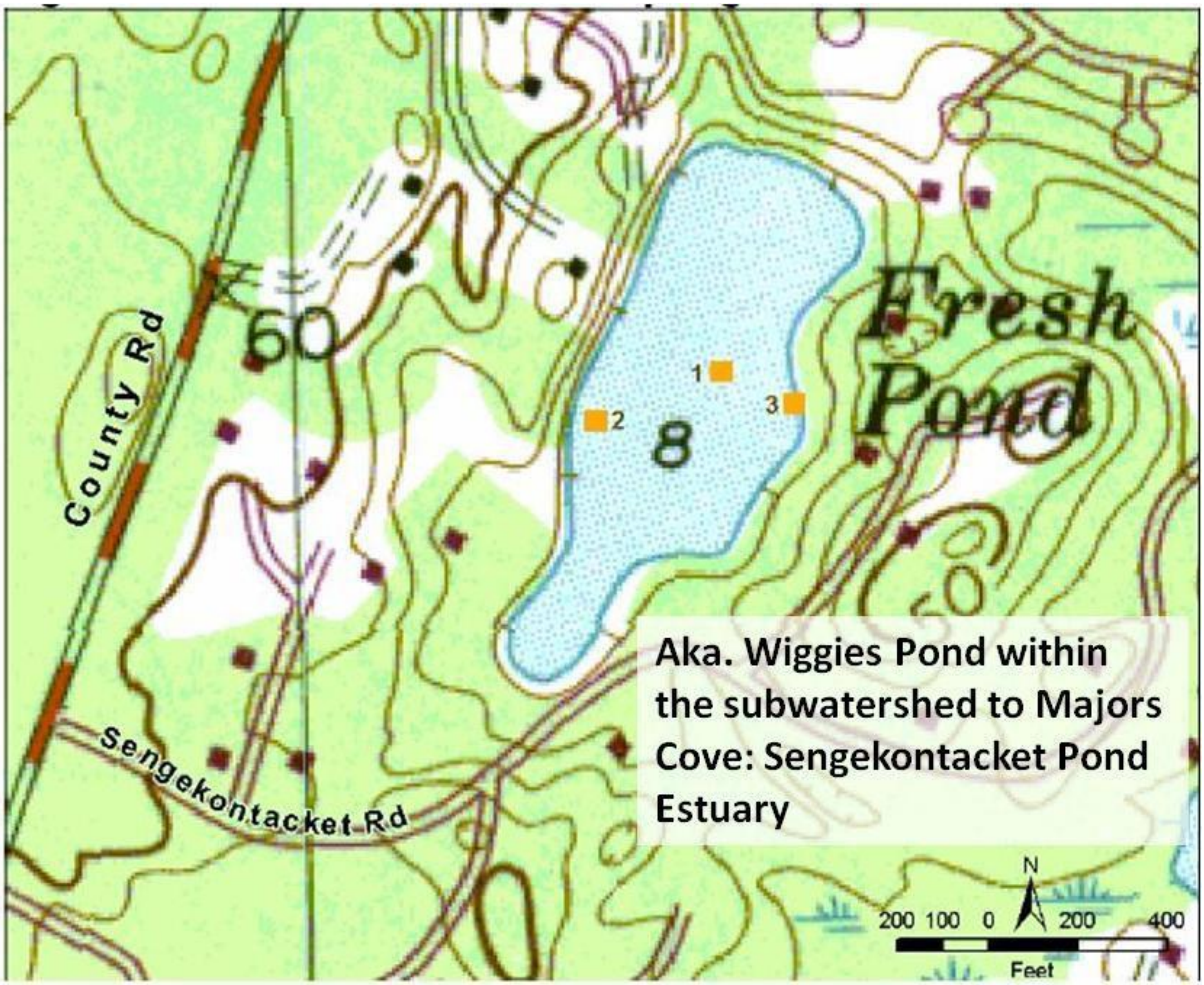

Figure 6b – Historic Sampling Points (yellow symbols) in Fresh Pond (aka. Wiggies Pond) within the subwatershed to Majors Cove located in the Sengekontacket Pond Estuary. Due to historic documented stratification, stations were sampled in 2016 at 2 depths each (surface and bottom). Stations 2 and 3 maybe re-oriented to run length wise across the pond for better spatial distribution.

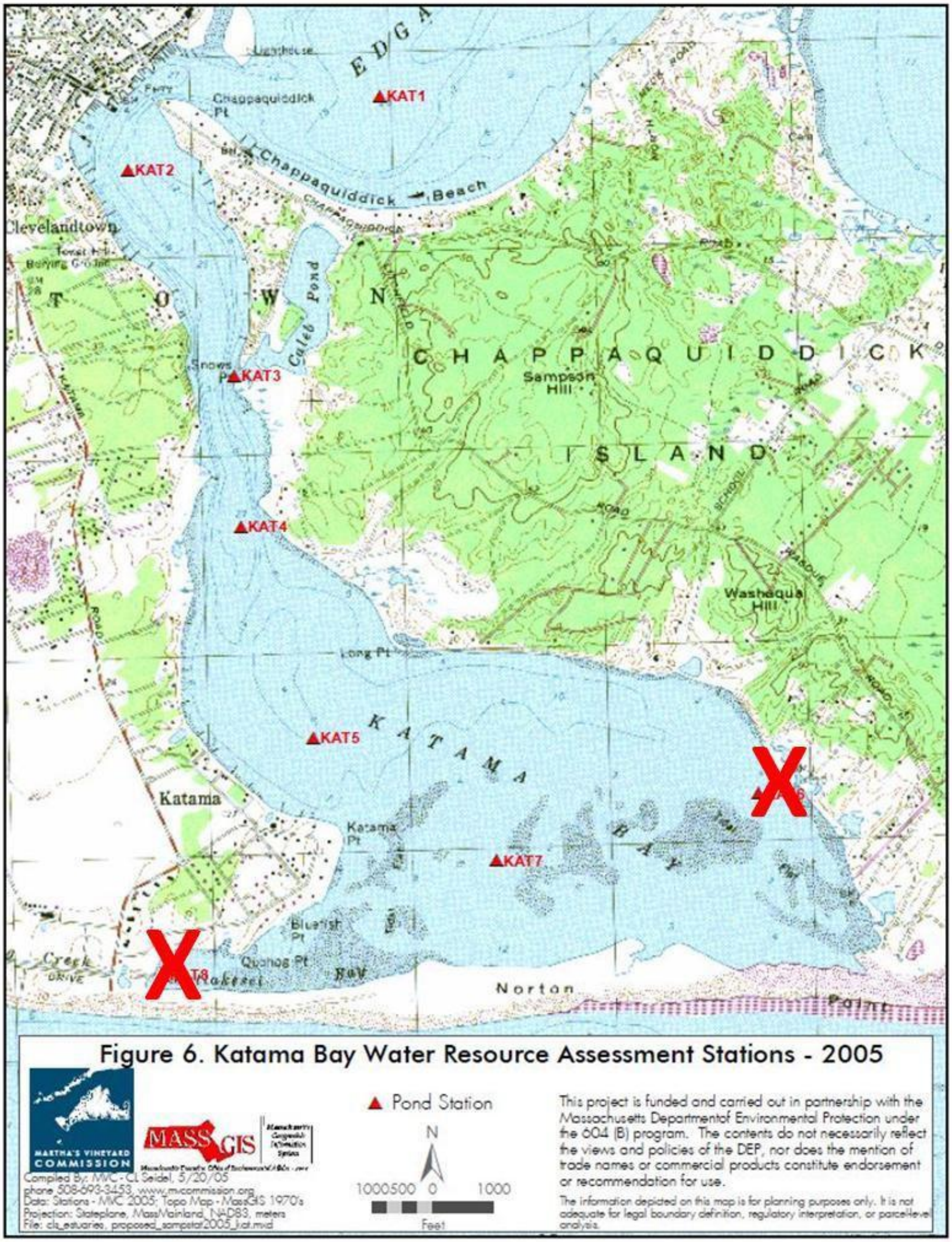

Figure 7 – Historic Sampling Points (red symbols) in Katama Bay. Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

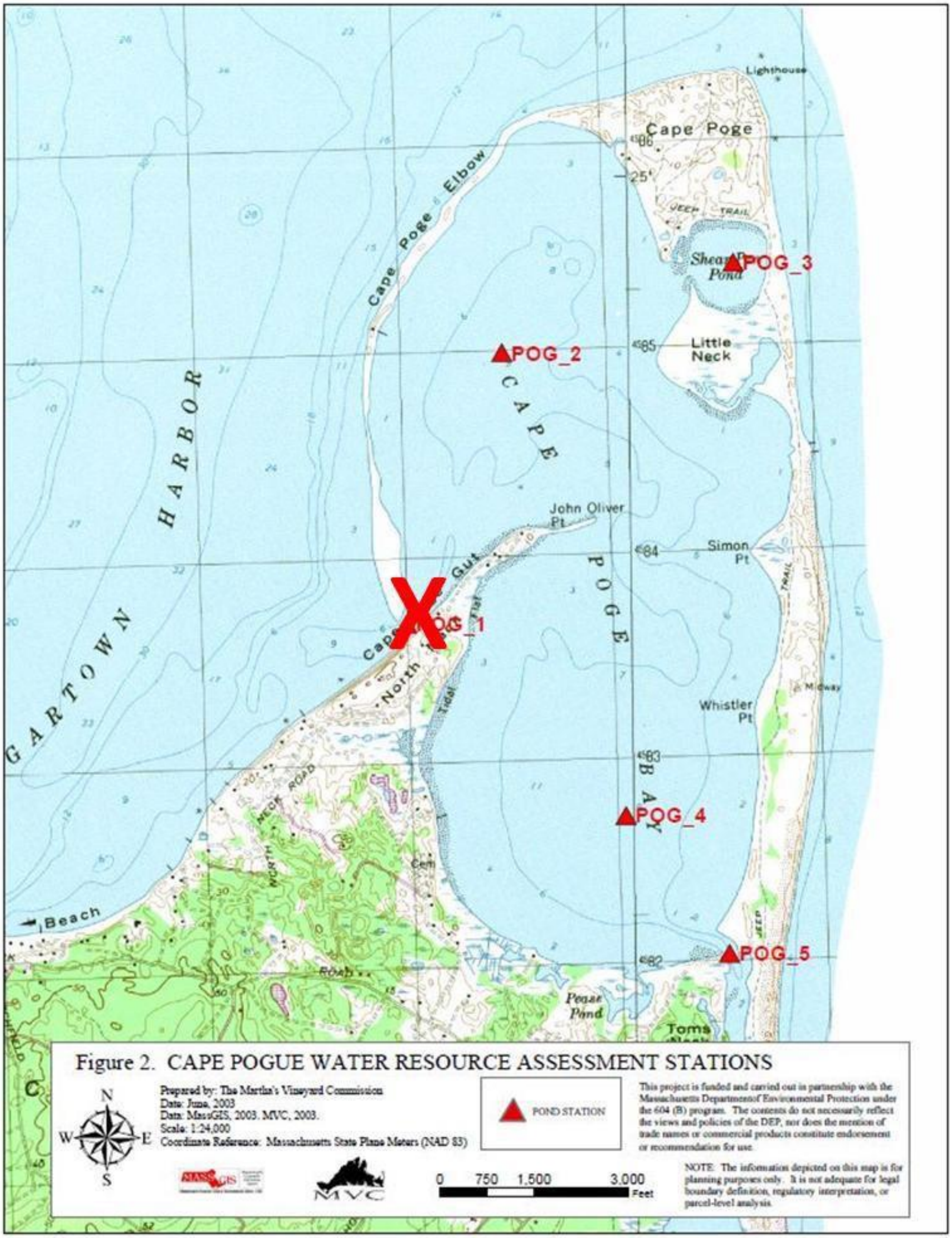

Figure 8 – Historic Sampling Points (red symbols) in Cape Pogue Bay. Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

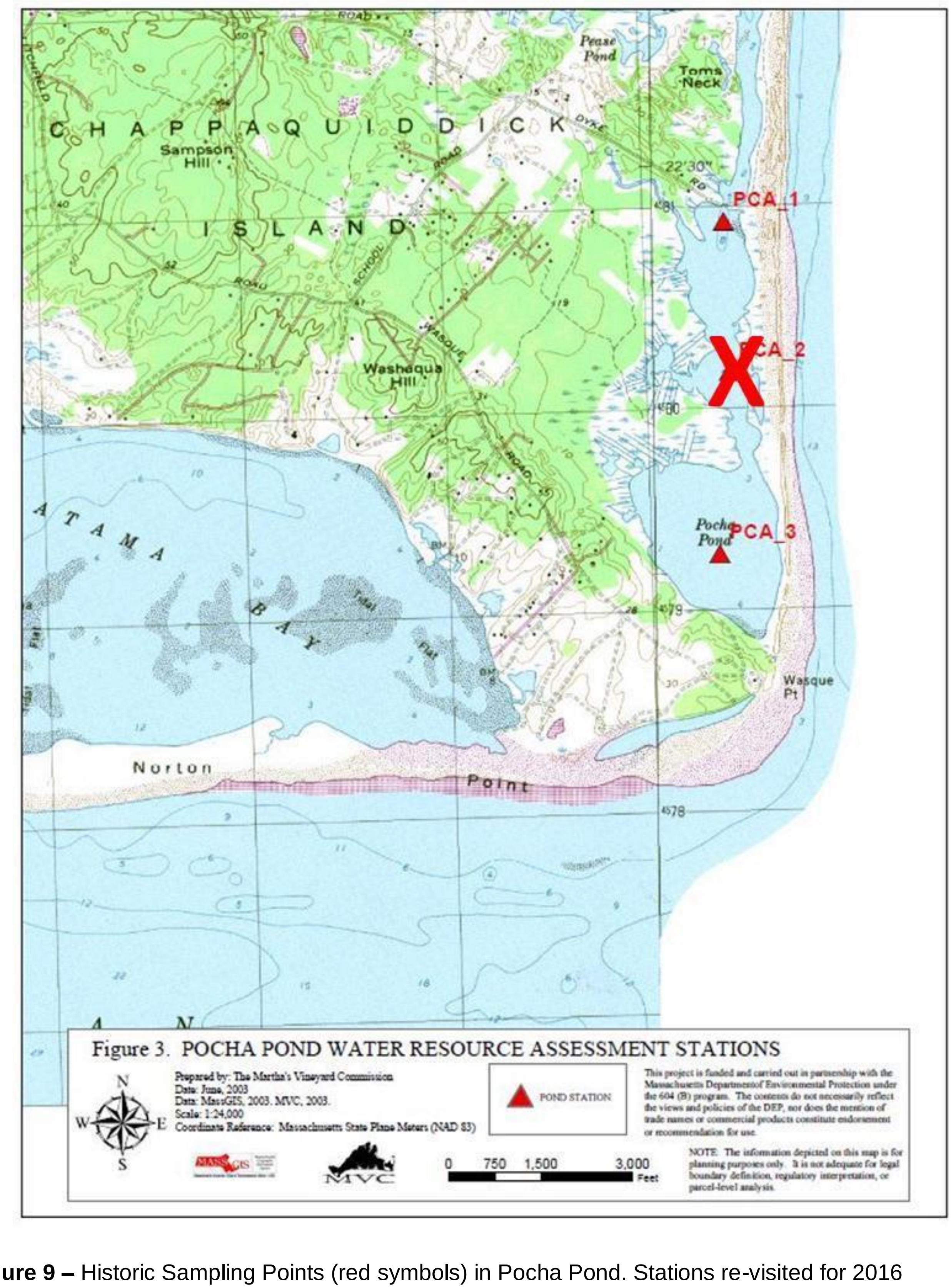

Figure 9 – Historic Sampling Points (red symbols) in Pocha Pond. Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

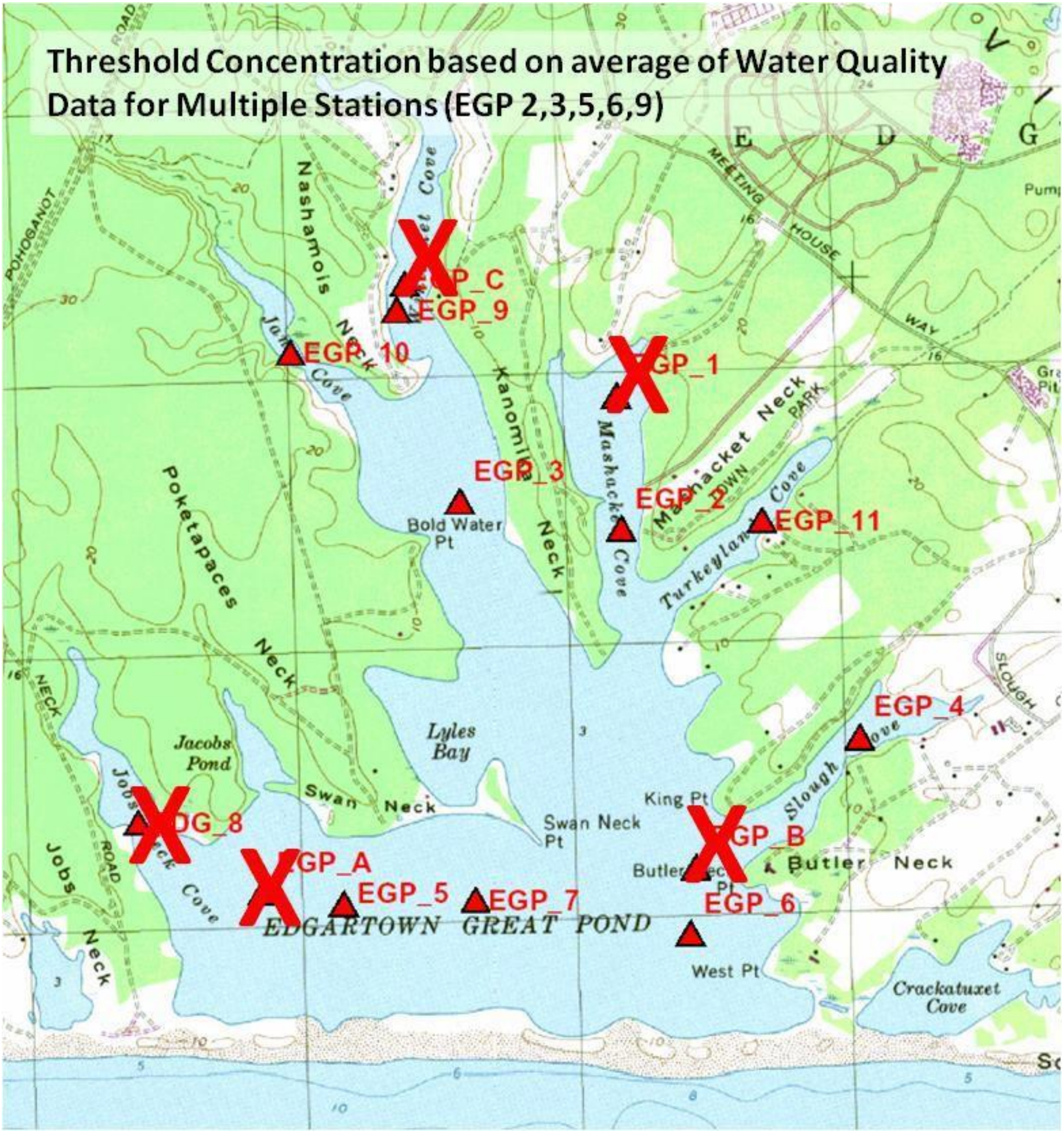

Figure 10 – Historic Sampling Points (red symbols) in Edgartown Great Pond including MEP established "sentinel station" (average of EGP 2,3,5,6,9). Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program.

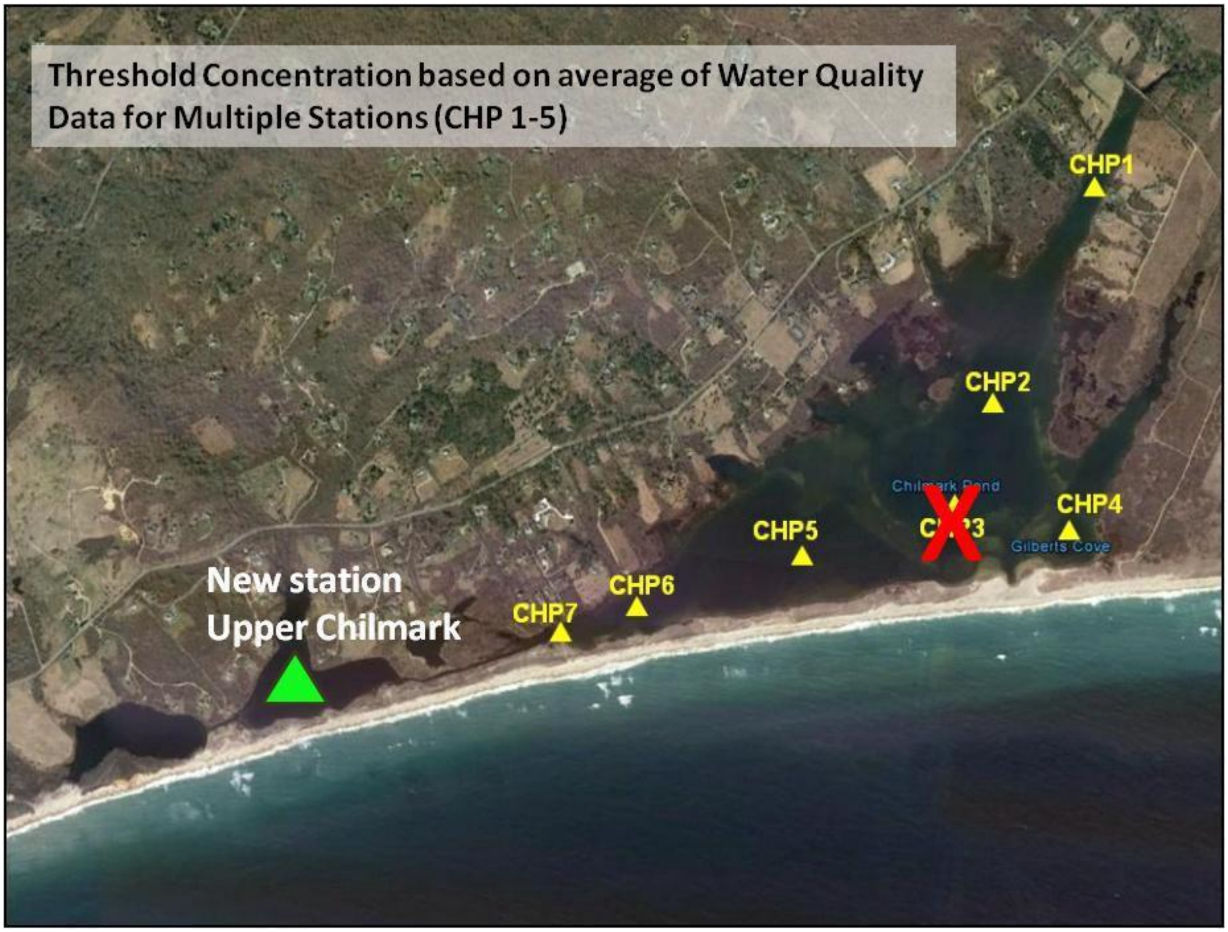

Figure 11 – Historic Sampling Points (yellow symbols) in Chilmark Pond including MEP established "sentinel station" (average of CHP 1-5). Stations re-visited for 2016 sampling season. Stations denoted by a red X are historic stations that are not being sampled under the unified Island-wide Monitoring Program.

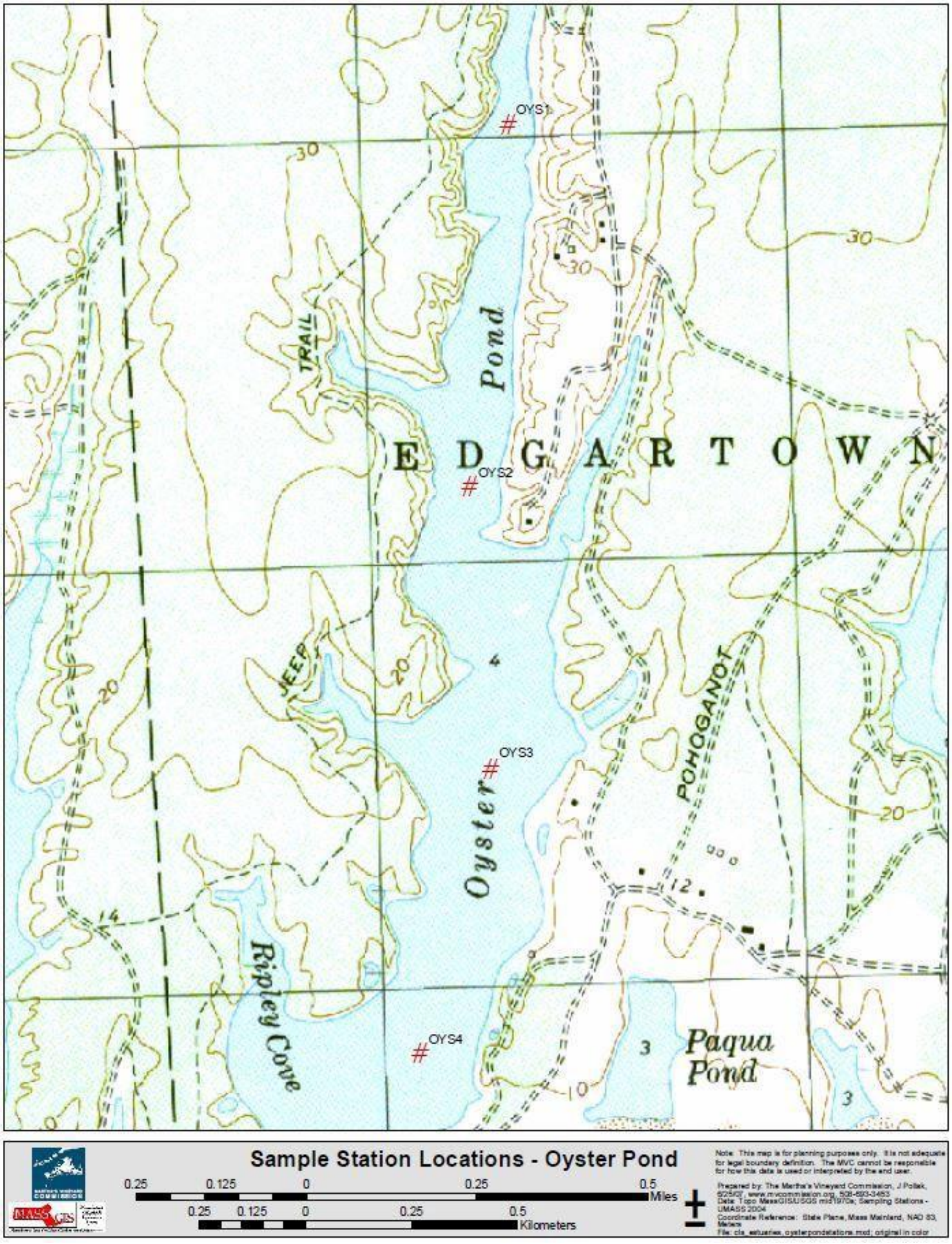

Figure 12 – Historic Sampling Points (red symbols) in Oyster Pond. Oyster Pond was not sampled in 2016 but will be included in the island-wide program as funding becomes available.

Figure 13 – Historic Sampling Points (red symbols) in Tisbury Great Pond including MEP established "sentinel station" (average of TGP 4,5,6) and TGP7. Stations denoted by a red X are historic stations that are not being sampled under the unified Island-wide Monitoring Program. Tisbury Great Pond was not sampled in 2016 but will be included in the island-wide program as funding becomes available.

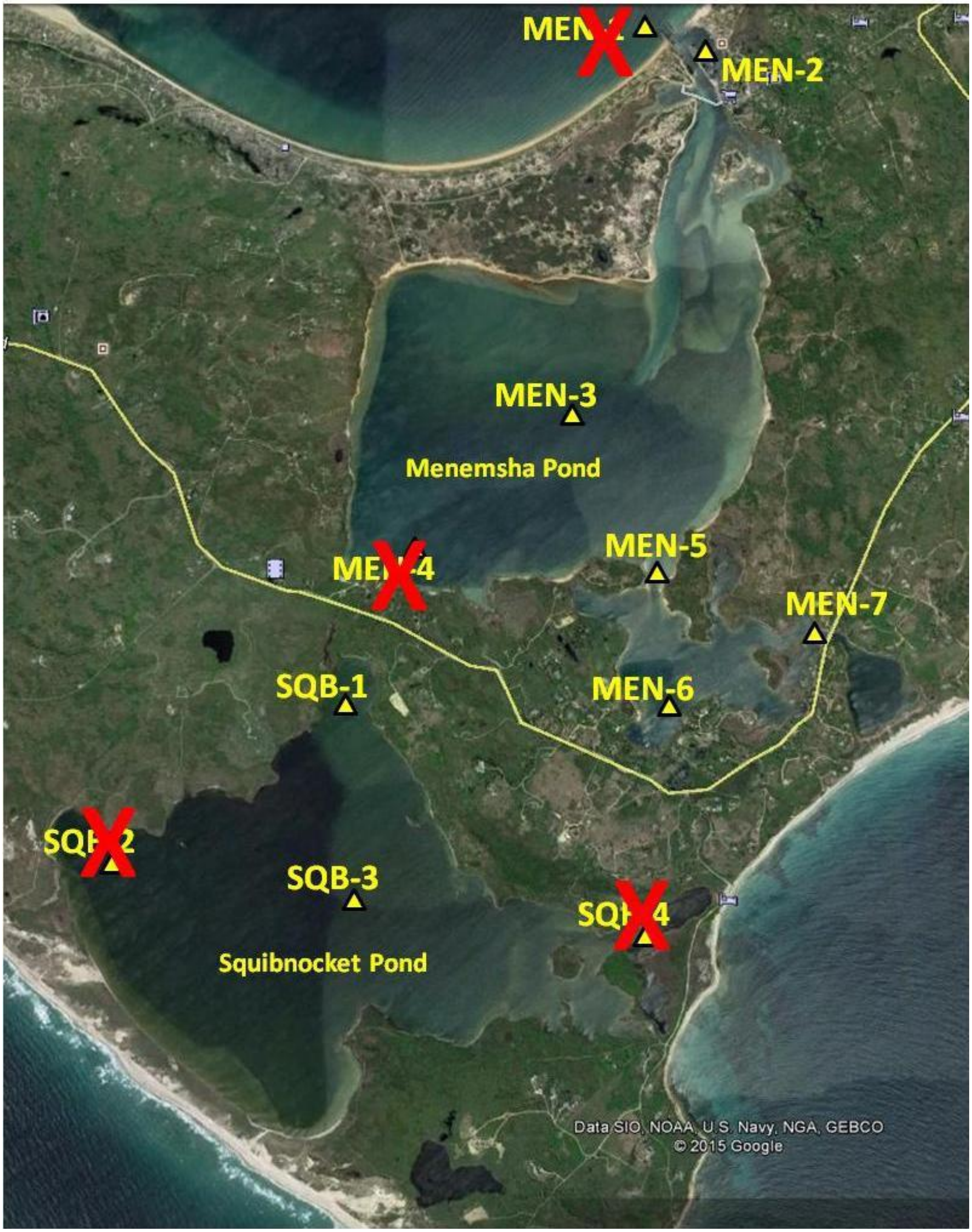

Figure 14 – Historic Sampling Points (yellow symbols) in Menemsha Pond and Squibnocket Pond including MEP established sentinel station. Stations denoted by a red X are historic stations that are not being sampled under the unified Island-wide Monitoring Program. Menemsha / Squibnocket Ponds were not sampled in 2016 but will be included in the island-wide program as funding becomes available.

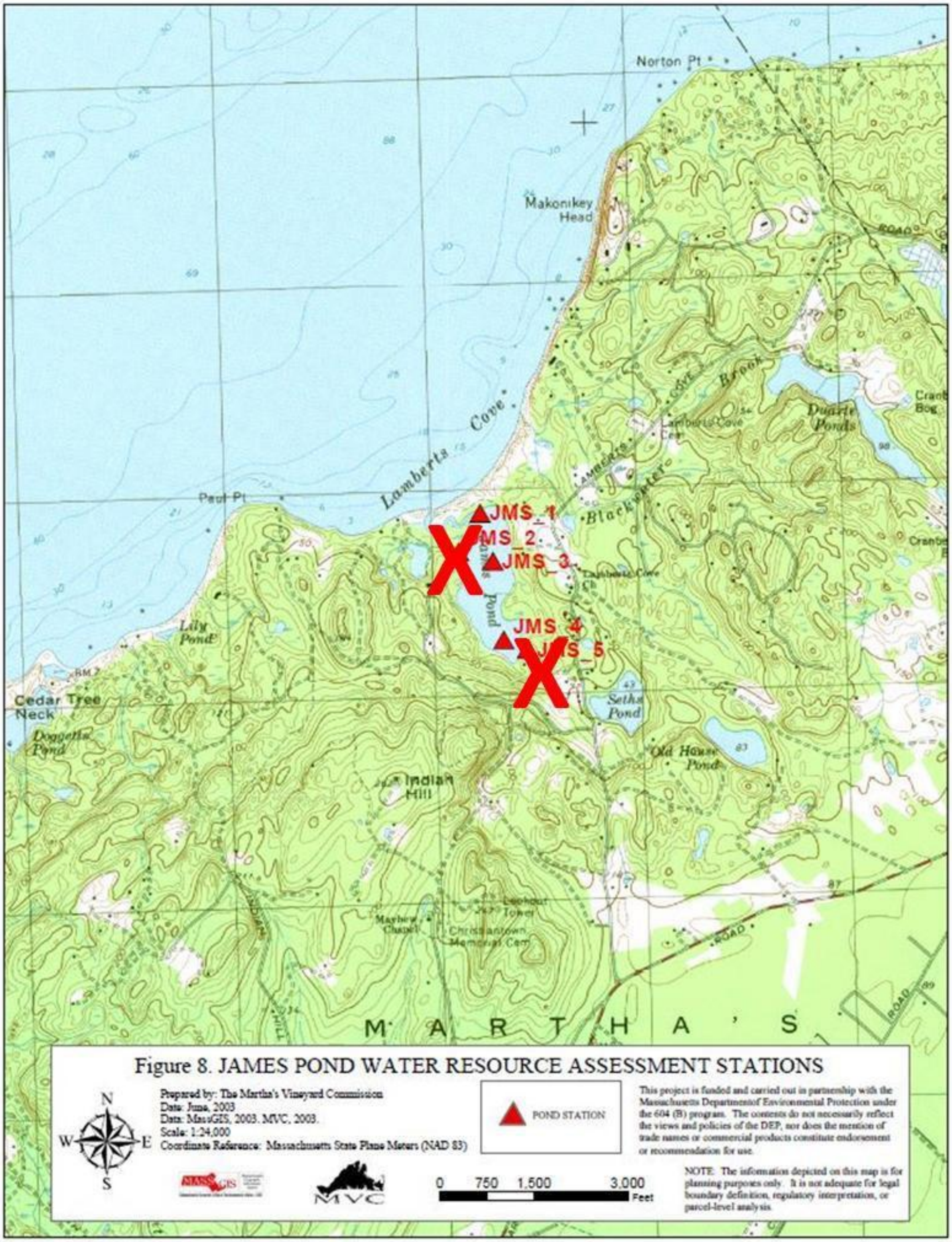

Figure 15 – Historic Sampling Points (red symbols) in James Pond. Stations denoted by a red X are historic stations that are no longer being sampled under the unified Island-wide Monitoring Program. James Pond was not sampled in 2016 but will be included in the island-wide program as funding becomes available..

Summary of 2016 Water Quality Results for Martha's Vineyard Island-wide Sampling

Water samples collected in July and August in the estuarine systems of Martha's Vineyard indicate that organic nitrogen (dissolved + particulate) dominates the Total Nitrogen pool (94%-98%) with the majority (57%-78%) of the TN pool comprised of dissolved organic nitrogen (DON) and the remainder (20%-40%) consisting of particulate organic nitrogen. Meanwhile, bio-available nutrients in the form of nitrite and nitrate (NOx) and ammonium (NH_4) account for only 1%-8% of the water-column Total Nitrogen pool (Table 2, Figure 17). This contrasts with the fact that virtually all of the nitrogen entering from the watershed is in bioavailable forms. These results 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 phytoplankton within their waters are effectively converting the bioavailable inorganic forms of nitrogen into organic forms (e.g. biomass). 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 and chlorophyll levels in the lower main basin of Lagoon Pond (LGP-9, average secchi depth 3.2m) and the Edgartown Harbor / channel into Katama Bay (KAT-2, average secchi depth 2.8m). Summary data is presented in Table 2 and Total Pigment concentrations are plotted in Figures 16a-16k. By comparison, in Chilmark Pond, which is only periodically opened to flushing with the Atlantic Ocean, average secchi depths were low across all the stations ranging from 0.72m to 1.18m and DON (60%) and PON (38%) accounted for almost all of the TN pool. The high proportion of TN as PON is consistent with the lower secchi depths and high Total Pigment concentrations (CHLA+Pheophytin = 10.38 ug/L average of all stations, 10 ug/L being indicative of impairment). As part of the analysis the role of nitrogen as the nutrient to be targeted for management was confirmed by evaluating the molar ratio of bioavailable nitrogen and phosphorus. This ratio, also called the Redfield Ratio, gives a general assessment of nitrogen versus phosphorus as the critical nutrient of eutrophication (nutrient impairment). Values much less than 16 (<10) indicate nitrogen additions will stimulate plant growth and much greater thant 16 (>22), that phosphorus may be the concern. For almost all of the estuaries assessed in 2016, N/P values were generally less than 6 and virtually always less than 8, indicating nitrogen as the nutrient to be managed. Only Edgartown Great Pond showed periodic high N/P ratios indicating that phosphorus may also be of concern. If this also occurs in 2017 monitoring it may be useful to conduct a more definitive analysis on N versus P stimulation of phytoplankton.

Consistent with the water clarity, corresponding Total Pigment levels (Chlorophyll-*a* + Pheophytin pigment concentrations) were lowest (2.0 - 3.25 ug/L) in well flushed systems such as lower Lagoon Pond, Katama Bay, Cape Pogue Bay and Oak Bluffs Harbor (Table 2). Where tidal flushing is more restricted as in Chilmark Pond, water clarity is relatively poor as shown by generally shallower Secchi Depth recordings and higher total pigment concentrations, 4.27 - 24.16 ug/L (Table 2). These general patterns are consistent with summer time results from other estuaries across Cape Cod and Nantucket and should be consistently monitored to be able to establish trends as towns across the island move into nutrient management to meet the MEP established nitrogen thresholds for restoration.

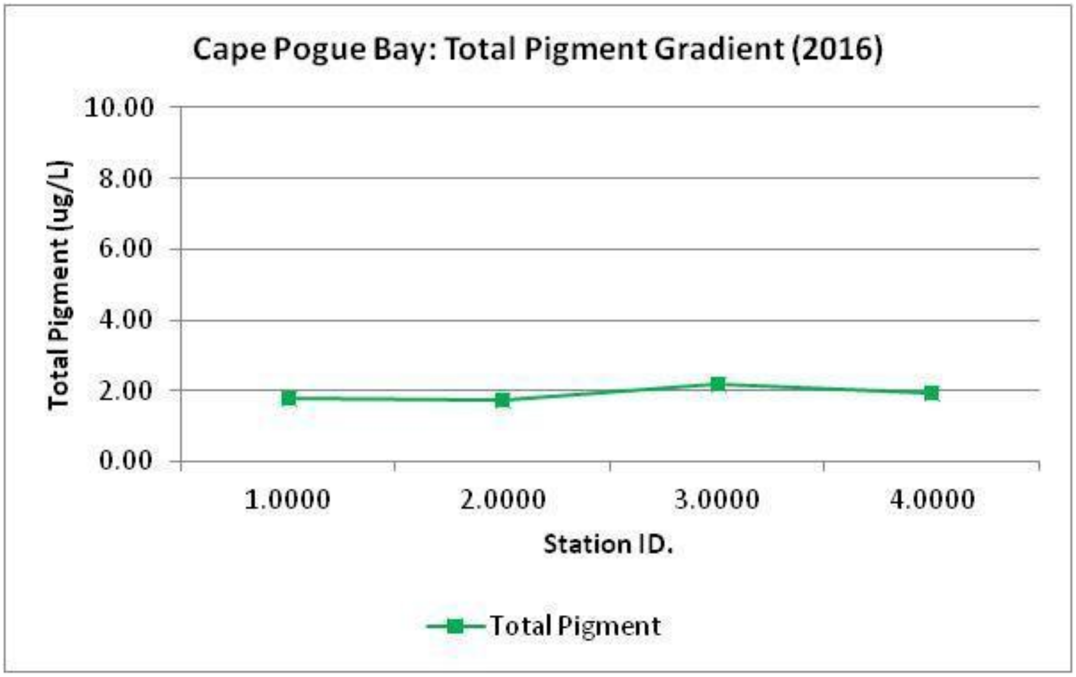

Figure 16a. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Cape Pogue Bay (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

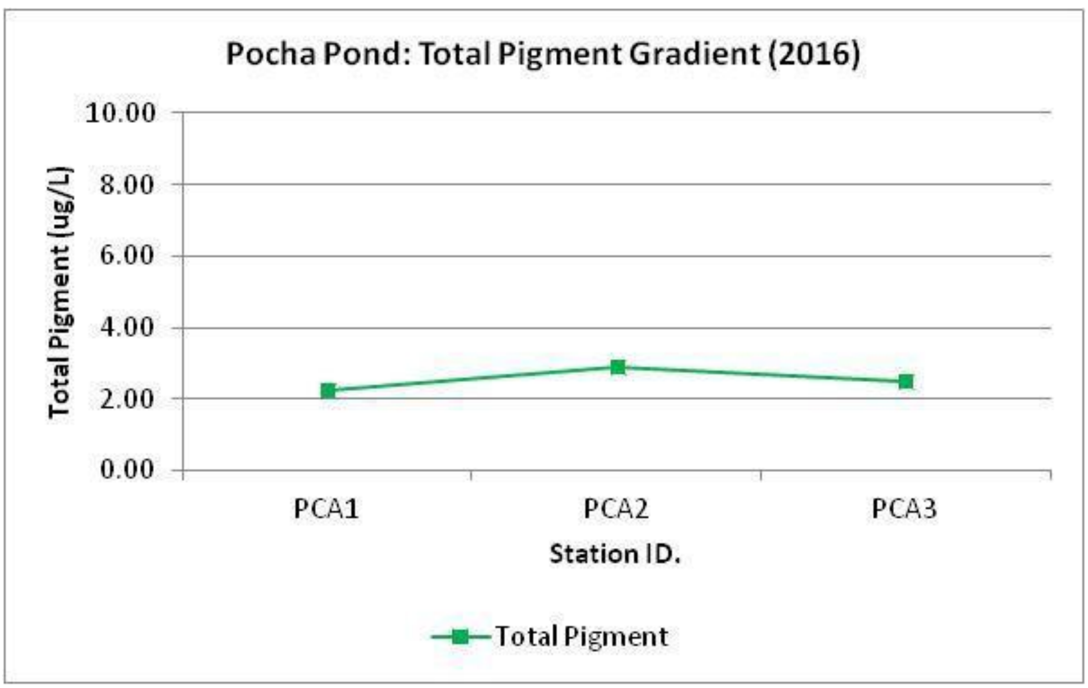

Figure 16b. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Pocha Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

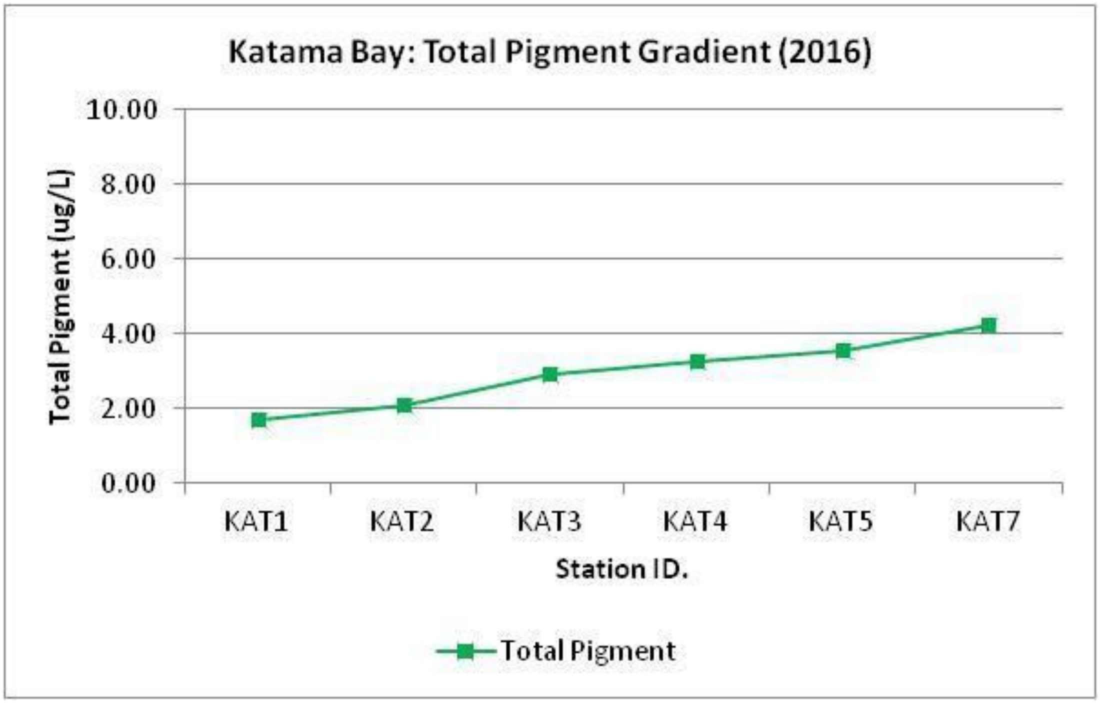

Figure 16c. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Katama Bay (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

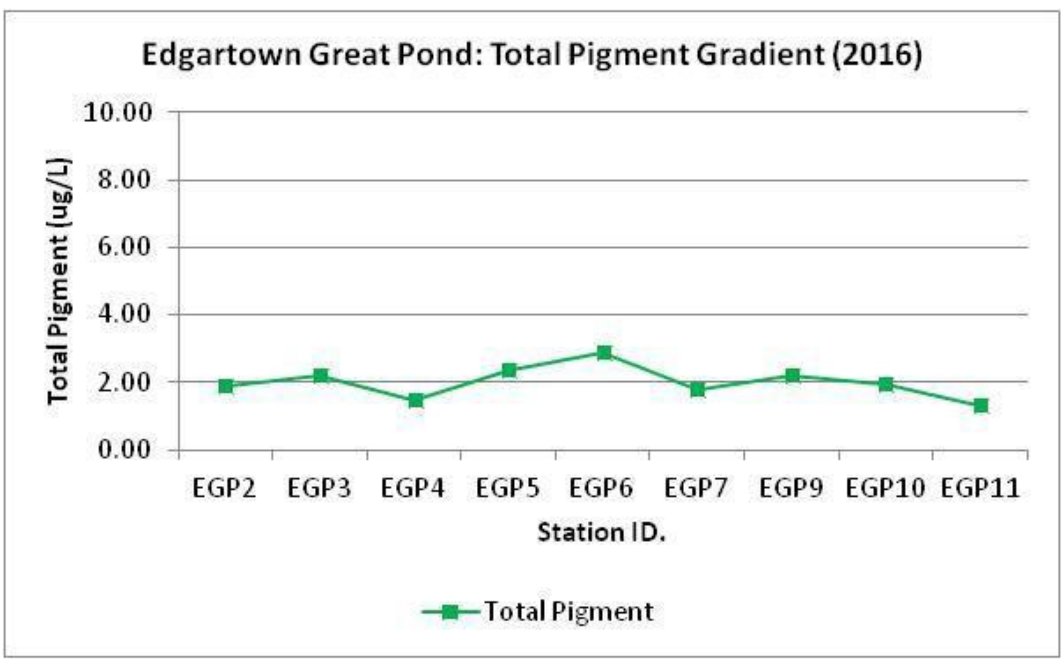

Figure 16d. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Edgartown Great Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

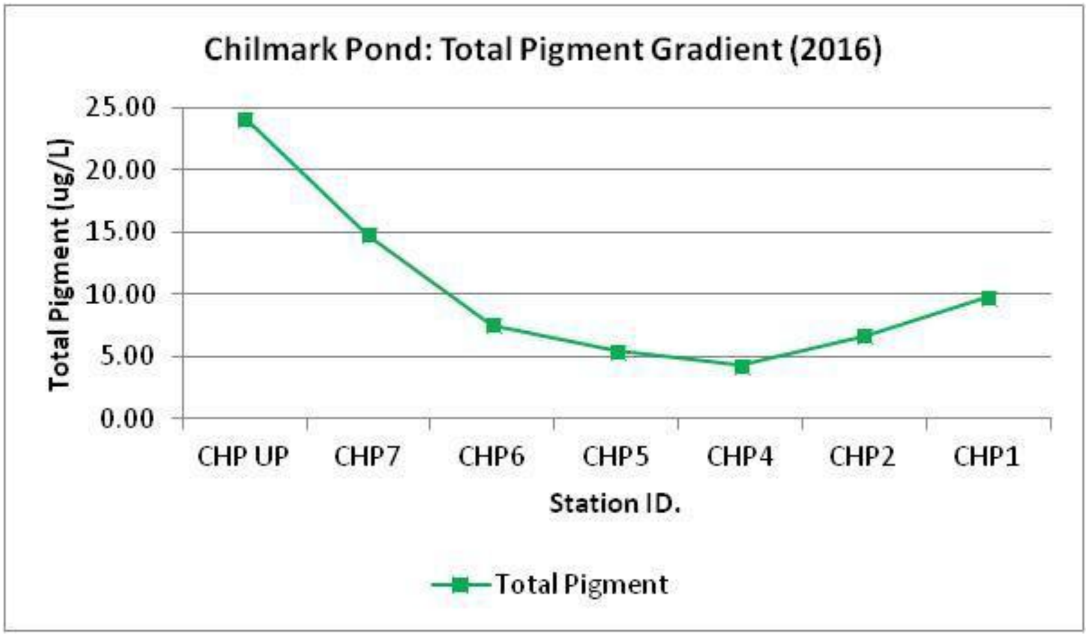

Figure 16e. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Chilmark Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

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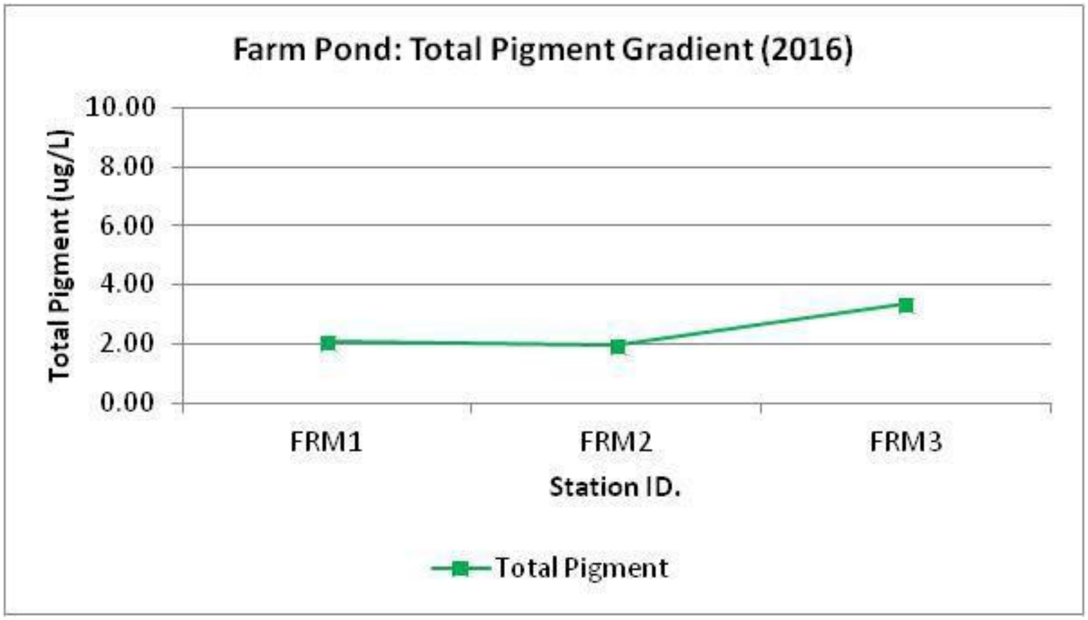


Figure 16f. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Farm Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

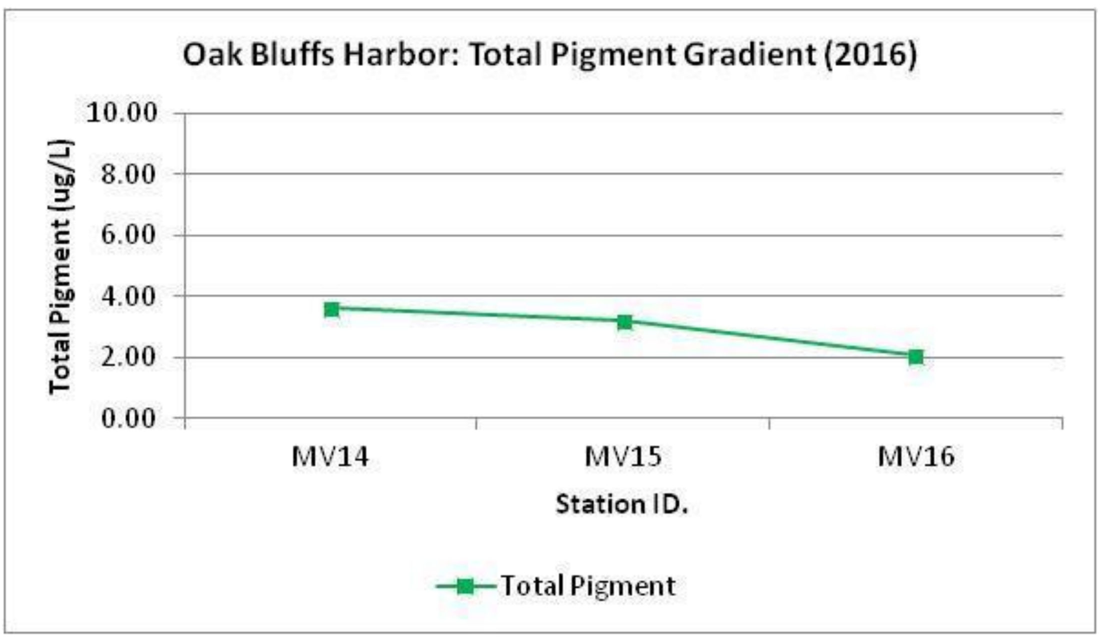


Figure 16g. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Oak Bluffs Harbor (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

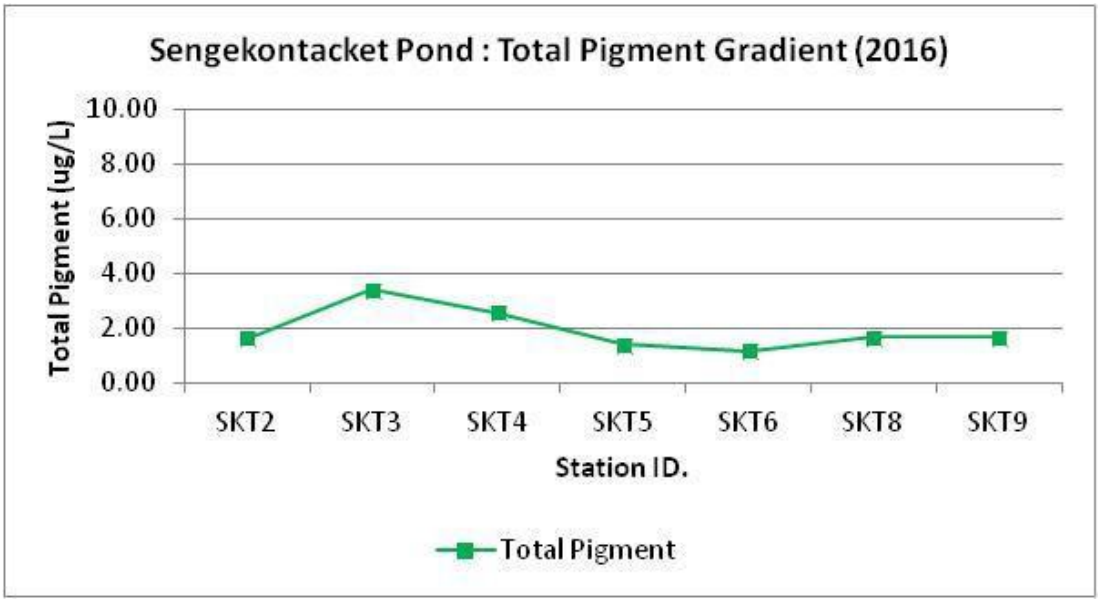


Figure 16h. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Sengekontacket Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

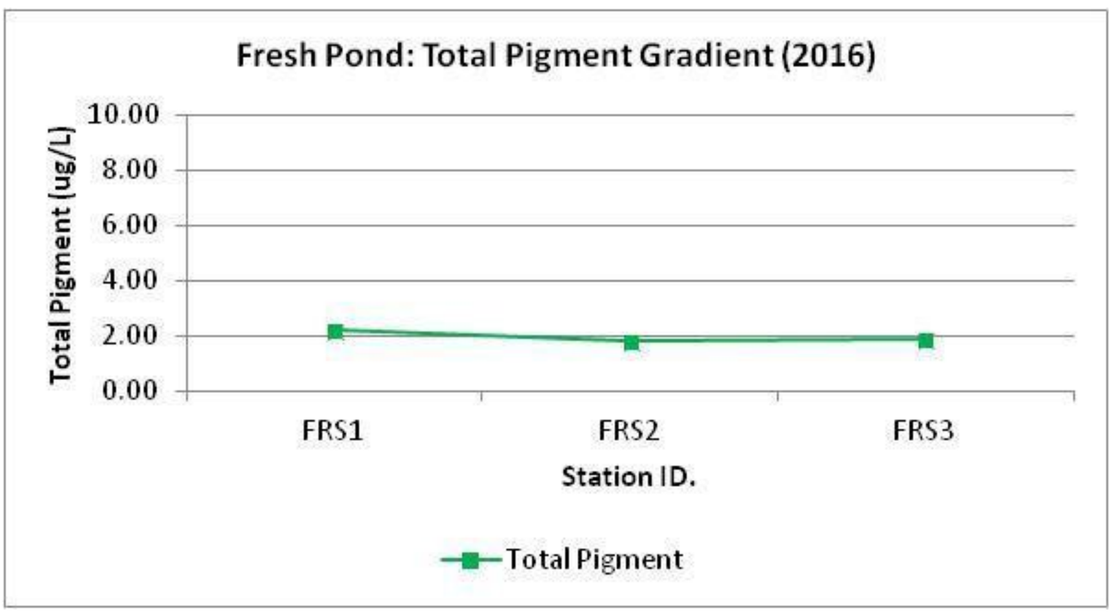


Figure 16i. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Fresh Pond located in the sub-watershed to Majors Cove, Sengekontacket Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

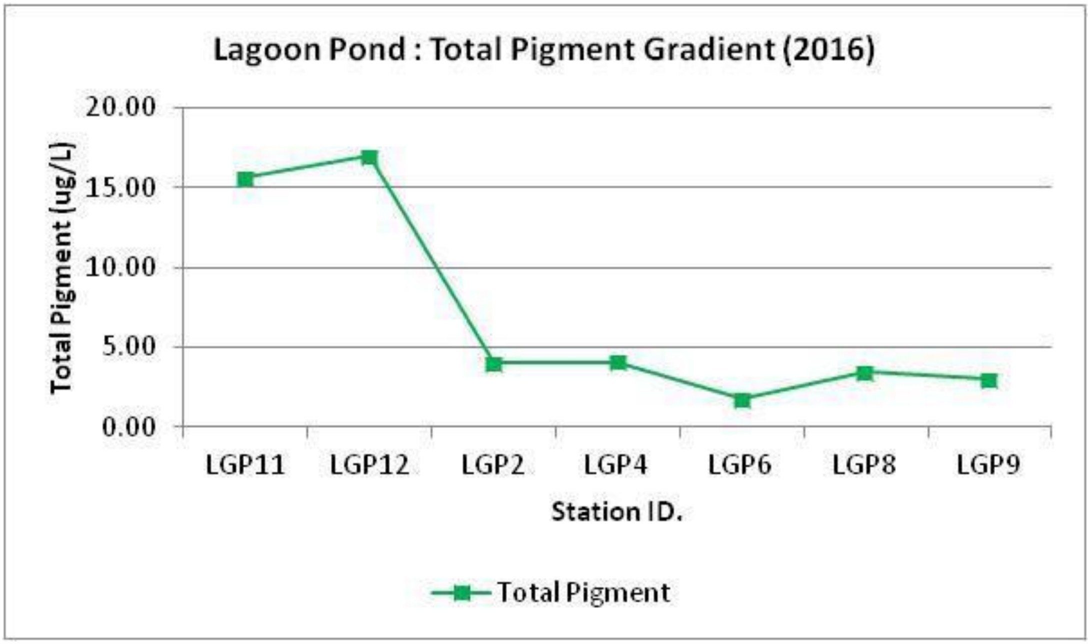


Figure 16j. Station averages of total pigment (chlorophyll a + pheophytin *a*) in Lagoon Pond (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

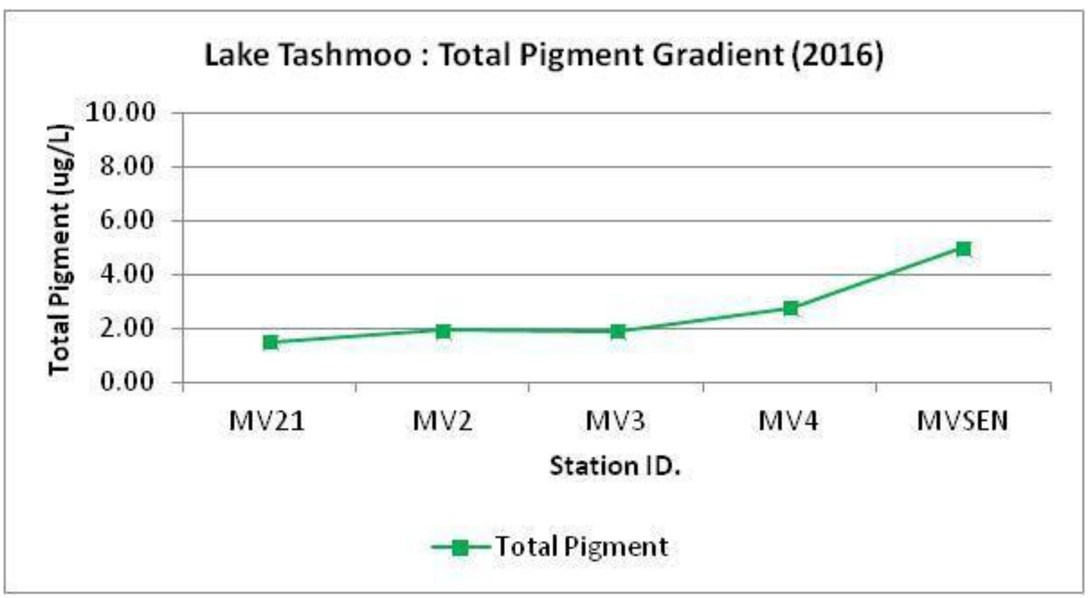


Figure 16k. Station averages of total pigment (chlorophyll a + pheophytin *a* in Lake Tashmoo (Summer 2016 sampling season). Levels greater than 10 ug/L typically indicate impaired habitat.

A general view of the status of each estuary can be derived from the average Total Nitrogen (TN) values. Averaging over entire estuaries is useful for comparing systems, but it should be noted that it ignores the nutrient gradients that occur in each system. In 2016 for Martha's Vineyard estuaries that exchange tidal waters year round via a fixed inlet varied from: Lake Tashmoo 0.359 mg/L, Lagoon Pond 0.396 mg/L, Oak Bluffs Harbor 0.397 mg/L, Katama Bay 0.404 mg/L, Sengekontacket Pond 0.430 mg/L, Pocha Pond 0.449 mg/L, Cape Pogue Bay 0.458 mg/L, Farm Pond 0.478 mg/L and Edgartown Great Pond 0.522 mg/L. By comparison, the average TN concentration in Chilmark Pond, which is only periodically open to flushing with Atlantic Ocean water when the barrier beach is breached, is 0.927 mg/L. The significantly higher concentration of total nitrogen in Chilmark Pond suggests that the frequency and efficacy of the annual openings in this system plays a major role in maintaining the ecological health of this great salt pond. As such, monitoring the water quality in this closed system as well as other closed systems such as Tisbury Great Pond is critical for properly managing the nitrogen concentration at the MEP established sentinel stations. Additionally, the importance of effective openings for managing closed salt ponds such as Chilmark Pond and Tisbury Great Pond would warrant consideration of monitoring openings in a specific manner in order to develop pond specific criteria to guide the timing of the openings and the most favorable conditions for maximizing effectiveness (e.g. wind strength and direction, tidal conditions, pond water levels).

Average TN levels in each of the estuaries are significantly higher than historical average TN values in the “offshore” or boundary stations such as MV6 located offshore from Lake Tashmoo (0.270), station offshore Pleasant Bay (0.232 mg/L) and station NTKS located in Nantucket Sound (0.290-0.294 mg/L). The higher levels within the estuaries compared to the offshore waters which enter on flood tide results from the nitrogen entering the estuarine waters from their watersheds. The level of increase depends largely on the rate of tidal exchange and the magnitude of the watershed loading. All TN values and plots are summarized and presented in Tables 2 and Figure17.

In reviewing the 2016 dissolved oxygen data, it does not appear that there is sufficient temporal sampling in one year of four summer time sampling events 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, building on the monitoring results. We have made some recommendations which we have noted at the end of the discussion section.

Comparison of the 2016 data with historical MEP baseline: At all sites, historical TN levels were compared to 2016 TN concentrations. The length of the historical water quality data record that was used as the baseline for the Massachusetts Estuaries Project (MEP) varied from 3-7 years. Historical data presented here are from the MEP Nitrogen Threshold Reports for: 1) Edgartown Great Pond, 2) Chilmark Pond, 3) Lake Tashmoo, 4) Lagoon Pond, 5) Oak Bluffs Harbor, 6) Farm Pond and 7) Sengekontacket Pond. It should be noted that Fresh Pond is truly freshwater, salinity $\leq$0.05 PSU, and is located within the subwatershed to Majors Cove in the Sengekontacket Pond system and this pond did not receive specific analysis under the MEP. Not all sites sampled historically were sampled in 2016 as the Island-wide Water quality monitoring was designed specifically to meet the needs of compliance monitoring than establishing a water quality baseline for modeling as completed by the MEP. Those stations that were sampled in 2016 are compared to the historical data in Tables 3 through 9. While Tisbury Great Pond was assessed under the MEP, water quality monitoring was not undertaken in 2016 due to limited funds and the Menemsha Pond and Squibnocket Pond system is currently being evaluated under the MEP for nitrogen threshold development and will likely be integrated into the monitoring program in the summer of 2017. Cape Pogue Bay, Pocha Pond and Katama Bay are likely to be evaluated by the MEP in 2017 and the 2016 water quality data will be utilized in that assessment. James Pond is not presently slated for MEP analysis, however, it will be integrated into the Island-wide water quality monitoring program for the summer 2017.

Edgartown Great Pond: The 2016 Edgartown Great Pond TN data generally compares well with historical data from the same sampling stations sampled by the MVC as part of the Island-wide Water Quality Monitoring Program (Figure 18, Table 3). Not all of the historical sites were sampled in 2016, specifically EGP-1,8,A,B,C. In general, TN levels in 2016 at all the stations sampled were slightly lower than the station averages from 2003 to 2006. This lowering of TN levels has been anticipated as the historic high nitrogen groundwater plume from discharge at the previous WWTF has been flushing out, lowering its load to the pond. In addition, the Town of Edgartown has modified the pond opening protocol over the past decade to increase the volumetric exchange that occurs with each opening, resulting in lower post-breach nitrogen levels in pond waters. The 2016 TN concentrations ranged from 0.469 mg/L - 0.552 mg/L whereas the historical TN data at the same stations ranged from 0.582 mg/L - 0.711 mg/L. The MEP TN threshold was set at 0.50 mg/L as an average of stations EGP-2,3,5,6,9. The historical average TN concentration at the time the MEP analysis was completed for those 5 stations was 0.597 mg/L. Based on the 2016 data, the average TN concentration for those same stations is 0.523 mg/L, still slightly above the 0.50 mg/L MEP threshold but lower than it was historically. The lowering of TN is consistent with observations of water clarity, eelgrass coverage and shellfish production in this Great Pond.

Chilmark Pond: The 2016 Chilmark Pond TN data generally shows an increase in Total Nitrogen concentration compared to the levels previously documented from the same sampling stations sampled by the MVC as part of the Island-wide Water Quality Monitoring Program (Figure 19, Table 4). TN levels in 2016 at all the stations sampled were high compared to the nitrogen threshold developed by the MEP. The 2016 TN concentrations ranged from 0.797 mg/L - 1.096 mg/L higher than the 0.704-0.769 mg/L range found in the historic data. Both data sets are significantly higher than the MEP TN threshold of 0.50 mg/L as an average of stations CHP-1,2,4,5, needed for restoration of pond habitats. This can be seen more clearly in the average TN concentration for those same stations historically and in 2016 of 0.744 mg/L and 0.877 mg/L, respectively. The high levels of TN in Chilmark Pond are consistent with the elevated levels of total pigment observed during the summer 2016 water quality monitoring. While it is not possible to confirm a trend with only the 2016 data, Chilmark Pond will be closely observed to determine if nitrogen levels are increasing due to increased inputs or reduced flushing as the program continues.

Lake Tashmoo: The 2016 Lake Tashmoo TN data generally compares well with historical data from the same sampling stations sampled by the MVC as part of the Island-wide Water Quality Monitoring Program (Figure 20, Table 5). Not all of the historical sites were sampled in 2016, specifically MV-1 and MV-5. In general, TN levels in 2016 at all the stations sampled were nearly the same (+/-) than the station averages from 2001 to 2007. The 2016 TN concentrations ranged from 0.273 mg/L - 0.355 mg/L whereas the historical TN data at the same stations ranged from 0.314 mg/L - 0.360 mg/L. The lowest TN concentration observed in 2016 (0.273 mg/L) was at station MV-21 closest to the inlet of the system and was slightly lower than the historical average at that station (0.314 mg/L) as determined by the MEP. It is not possible based on one year to determine if this is “real” or not, but in any case it does not reflect any substantive positive shift in the habitat health of the basin (both 0.273 and 0.314 mg/L indicate high quality waters). The MEP TN threshold was set at 0.36 mg/L at a sentinel station (MV-SEN) to be located between MW-4 and MV-5. As this is a new station sampled for the first time in 2016 there is no historical data at this location. Based on the 2016 data, the average TN concentration for the MEP established sentinel location is 0.482 mg/L, above the 0.36 mg/L MEP threshold and indicative of the need for some nitrogen management. The higher TN concentrations observed at MV-SEN in 2016 are consistent with the high total pigment concentrations measured at that location. Additionally, at the stations that had lower TN concentrations, total pigment levels were commensurately lower.

Lagoon Pond: The 2016 Lagoon Pond TN data generally compares well with historical data from the same sampling stations (Figure 21, Table 6). Not all of the historical sites were sampled in 2016, specifically LGP-10. In general, TN levels in 2016 at all the stations sampled were nearly the same (+/-) as station averages from 2002 to 2007. In 2016, TN concentrations at 3 out of 5 stations sampled (LGP-2,4,8) were slightly higher than the historical averages and slightly lower at 2 of 5 stations (LGP-6,9). The 2016 TN concentrations ranged from 0.317 mg/L - 0.460 mg/L whereas the historical TN data at the same stations ranged from 0.333 mg/L - 0.418 mg/L. The lowest TN concentration observed in 2016 (0.317 mg/L) was at station LGP-9 closest to the inlet of the system and was slightly lower than the historical average at that station (0.333 mg/L) as determined by the MEP. The MEP TN threshold was set at 0.35 mg/L at the sentinel station (LGP-2). Based on the 2016 data, the average TN concentration for the MEP established sentinel location is 0.432 mg/L, above the 0.35 mg/L MEP threshold. The MEP determined historical average for station LGP-2 was 0.360 mg/L indicating that TN concentrations still need to be managed in this system. The higher TN concentrations observed at LGP-2 and 4 in 2016 are consistent with the higher total pigment concentrations measured across the pond in 2016, however, it should be noted that in the lower tidal reaches total pigment was generally low with the exception of observed total pigment levels at LGP-11 and 12 which we between 15 ug/L and 17 ug/L, well over 10 ug/L which is a typical threshold for sign of impairment. Uppermost stations continue to show the effects of nitrogen enrichment.

Oak Bluffs Harbor: The 2016 Oak Bluffs Harbor TN data generally compares well with historical data from the same sampling stations sampled by the MVC as part of the Island-wide Water Quality Monitoring Program (Figure 22, Table 7). Not all of the historical sites were sampled in 2016, specifically MV-17. In general, TN levels in 2016 at all the stations sampled were nearly the same (+/-) as station averages from 2001 to 2007. In 2016, TN concentrations were slightly higher than the historical average at 2 of the 3 stations sampled (MV-14,15) and slightly lower at 1 of 3 stations (MV-16). The 2016 TN concentrations ranged from 0.306 mg/L - 0.463 mg/L whereas the historical TN data at the same stations ranged from 0.325 mg/L - 0.392 mg/L. The lowest TN concentration observed in 2016 (0.306 mg/L) was at station MV-16 closest to the inlet of the system and was slightly lower than (but not significantly different from) the historical average at that station (0.325 mg/L) as determined by the MEP. The MEP TN threshold was set at <0.45 mg/L at the sentinel station (MV-14 in Sunset Lake). Based on the 2016 data, the average TN concentration for the MEP established sentinel location is 0.463 mg/L, slightly above the 0.45 mg/L MEP threshold. The MEP determined historical average for station MV-14 was 0.392 mg/L suggesting that TN concentrations may have increased and still need to be managed in this system. This station will be the focus of trend analysis as more data becomes available. It is not clear if the increase, if "real", is the result of occlusion of the tidal channel or an increase in nitrogen inputs.

Farm Pond: The 2016 Farm Pond TN data generally compares well with historical data from the same sampling stations sampled by the MVC as part of the Island-wide Water Quality Monitoring Program (Figure 23, Table 8). All of the historical sites have been included in the island-wide program and were sampled in 2016. In general, TN levels in 2016 at the stations sampled were nearly the same or slightly lower than the station averages from 2002 to 2008. In 2016, TN concentrations were slightly lower than the historical average at 2 out of 3 stations sampled (FRM-1,2) and slightly higher at 1 of 3 stations (FRM-3, MEP sentinel station). The 2016 TN concentrations ranged from 0.427 mg/L - 0.544 mg/L whereas the historical TN data at the same stations ranged from 0.505 mg/L - 0.530 mg/L. The lowest TN concentration observed in 2016 (0.427 mg/L) was at station FRM-1 located at the end of the pond close to the inlet of the system and was slightly lower than the historical average at that station (0.516 mg/L) as determined by the MEP. The MEP TN threshold was set at 0.45 mg/L at the sentinel station (FRM-3). Based on the 2016 data, the average TN concentration for the MEP established sentinel location is 0.544 mg/L and remains significantly above the 0.45 mg/L MEP threshold. The MEP determined historical average TN concentration for station FRM-3 was 0.530 mg/L indicating that TN concentrations in 2016 were only slightly higher than the historical average and therefore nitrogen management is still needed in this system. The higher TN concentration observed at FRM-3 in 2016 is consistent with the slightly higher total pigment concentrations measured across the pond in 2016, however, it should be noted that total pigment was generally low and consistent with the observed TN concentrations.

Sengekontacket Pond: The 2016 Sengekontacket Pond TN data generally compares well with historical data from the same sampling stations sampled by the MVC as part of the Island-wide Water Quality Monitoring Program (Figure 24, Table 9). Most of the historical sites were sampled in 2016 with the exception of SKT-1 and SKT-7. In general, TN levels in 2016 at the stations sampled were generally higher than station averages from 2003 to 2009. In 2016, TN concentrations were higher than the historical average at 6 out of 7 stations (SKT-2,3,4,5,8,9). The 2016 TN concentrations ranged from 0.427 mg/L - 0.544 mg/L whereas the historical TN data at the same stations ranged from 0.299 mg/L - 0.545 mg/L. The lowest TN concentration observed in 2016 was at station SKT-6 located closest to the inlet of the system and was the same as the historical average at that station (0.299 mg/L vs 0.302 mg/L) as determined by the MEP. The MEP TN threshold was set at 0.35 mg/L at the sentinel stations (SKT-4 and SKT-9). Based on the 2016 data, the average TN concentration at the MEP established sentinel locations was 0.437 mg/L and 0.509 mg/L respectively, well above the 0.35 mg/L MEP threshold. The MEP determined historical average TN concentrations for stations SKT-4 and SKT-9 were 0.406 mg/L and 0.445 mg/L respectively, indicating that TN concentrations in 2016 were slightly higher than historically and therefore still need to be managed in this system. The higher TN concentration observed at SKT-4 in 2016 is consistent with the slightly higher total pigment concentrations measured at SKT-4 and SKT-3 (both associated with Majors Cove), however, it should be noted that total pigment was generally low and consistent with the TN concentrations measured in 2016.

Trophic State of the Estuaries of Martha's Vineyard

The Trophic State of an estuary is a quantitative indicator of its nutrient related ecological health and is based on concentrations of Nitrogen, 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 (unhealthy, deteriorated condition, high nutrient). The Trophic Health Index Score used here is a basic 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 of Martha's Vineyard, a trophic index score was calculated for each sampling location using the 2016 data (Table 10). It is important to understand that the Index is useful as a guide and provides a simple way to composite the multiple parameters related to nutrient related habitat health, but it is not comprehensive. For example in estuaries, such as those on Martha's Vineyard, 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. Therefore, there is always some uncertainty in the Index until several years of data are available. However, in the almost 100 estuaries where this Index has been used, it has been good in determining general nutrient related health and has been very useful in prioritizing systems for more detailed analysis (e.g. continuous DO recorders). It should be noted that the issue primarily relates to the key habitat metric of dissolved oxygen, as the other water quality parameters do not change as rapidly as dissolved oxygen and therefore the sampling program should adequately capture accurate concentration data. It should be noted that as more oxygen data from the monitoring program is available, the Index becomes more robust as has been found in MEP analysis of Cape Cod estuaries. Based upon the results it is possible to assess the nutrient related health of the basins within each of the 10 estuarine systems that were included in the Martha's Vineyard Island-wide Water Quality Monitoring Program for 2016.

The Health Status of each site was based on the Index Score, which is based on the numeric data collected during the sampling events (Tables 1c and 2). The ranges of Index scores that fall within a particular Health Status determination are given at the bottom of Table 10. Figures 25-34 show the distribution of Health Status throughout each estuary based on the 2016 monitoring program results. The colors of each triangle in the figures 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

Edgartown Great Pond: During summer 2016 Edgartown Great Pond supported relatively high water quality (High/Moderate) throughout all of its basins, with slightly lower (Moderate) water quality in only 1 tributary basin, Turkeyland Cove (Figure 25). Edgartown Great Pond appears to currently have only modest nutrient related impairments and is maintaining some high quality estuarine habitat. Throughout this salt pond, the Index was lowered primarily by water clarity, nitrogen level and degree of oxygen depletion. The relative uniformity of the status indicators is frequently seen in large salt ponds which only have periodic connection to offshore waters (e.g. no regular tidal exchange). In these settings salt ponds become similar to fresh ponds in their hydrodynamics and water quality indicators become relatively uniform throughout. This contrasts with tidal estuaries where watershed inputs are typically entering mainly in the inland most reaches with twice a day entry of high quality marine waters through the tidal inlet. This structure sets up water quality gradients within the estuary, typically with poor water quality in the inner tidal reaches grading to high water quality near the tidal inlet.

Chilmark Pond: The MVC Island-Wide Water Quality Monitoring Program supported a status assessment of Chilmark Pond based on 2016 data collection. The composite water quality index indicates that nutrient related water quality throughout Chilmark Pond (including the western most tributary basin) is impaired based on its moderate to poor summertime water quality (Figure 26). Key parameters (water clarity, nitrogen levels, oxygen depletion and phytoplankton biomass) are all consistent with a nutrient enriched basin, with poor clarity, periodic oxygen depletions and high phytoplankton biomass. As noted for Edgartown Great Pond, Chilmark Pond has relatively uniform water quality due to its only periodic tidal exchange. While it is not clear if nitrogen levels are increasing, it is likely that the current enrichment is due in large part to the only periodic tidal exchange during openings. An analysis of opening protocols coupled to estuarine response in Chilmark Pond may provide a means to partial improvement.

Lake Tashmoo: Lake Tashmoo is a classic simple estuary with a single tidal inlet, a linear basin to inland headwaters. As such it has highest quality waters near the tidal inlet with a slight decline in quality to the head water station (MVSEN, Figure 27). Lake Tashmoo was found to be impaired by nitrogen in the MEP analysis, based mainly on declines in eelgrass coverage and benthic animal communities, with some periodic DO depletions. The present analysis of water quality parameters is consistent with the MEP water quality assessment. There is modest nitrogen enrichment and some oxygen decline, but generally good water clarity and low phytoplankton biomass compared to other estuaries (e.g. Cape Cod and Buzzards Bay). These latter parameters are supporting the eelgrass beds that remain in the system. Eelgrass is typically associated with the highest quality waters and estuarine habitat, but as the coverage is declining and showing signs of stress (e.g. significant epiphytic growth), it appears that nitrogen is just above its threshold level, as was confirmed in the 2016 TN measurements.

Lagoon Pond: Lagoon Pond, like Lake Tashmoo, is a classic simple estuary with a single tidal inlet, a relatively linear basin to inland headwaters. Lagoon Pond has a headwater “stream” and pond with a direct discharge to the uppermost estuarine shore. As such its highest quality waters are near the tidal inlet, with a slight decline in quality to the head water station (LGP-6 Figure 28). The innermost shallow region of South End Basin is highly nitrogen enriched (LGP-11 and LGP-12) with low oxygen and phytoplankton blooms, in a restricted area with limited flushing. The deeper waters in the upper pond, nitrogen loading and flushing differences result in the entire upper pond showing slight nutrient related impairment (i.e. High-Moderate water quality). Similarly, Lagoon Pond was found to be impaired by nitrogen in the MEP analysis, based mainly on declines in eelgrass coverage and benthic animal communities, with some periodic DO depletions. The present analysis of water quality parameters is consistent with the MEP water quality assessment. Except for the innermost region of South End Basin, Lagoon Pond currently supports only moderate impaired water quality, consistent with its remaining eelgrass areas and benthic animal communities. The water quality impairment is primarily due to modest nitrogen enrichment and periodic oxygen declines, but generally good water clarity and low phytoplankton biomass compared to other estuaries (e.g. Cape Cod and Buzzards Bay). These latter parameters are supporting the eelgrass beds that remain in the system. Eelgrass is typically associated with the highest quality waters and estuarine habitat, but as the coverage is declining, it appears that nitrogen levels remain above the threshold level for high quality estuarine habitat, in the 2016 TN measurements.

Oak Bluffs Harbor: Oak Bluffs Harbor is a heavily altered coastal salt pond that has an engineered tidal inlet, which supports twice daily tidal exchange with the high quality waters of Vineyard Sound. The system consists of a main basin with a smaller basin (Sunset Lake) connected through a culvert. Given its small size and tidal exchange the main basin supports relatively high and uniform water quality, while enclosed Sunset Lake is showing some nutrient related impairment (Figure 29). The Sunset Lake moderate water quality (impairment) results from its elevated nitrogen levels, reduced water clarity and periodic oxygen depletion. Oak Bluffs Harbor was also found to be impaired by nitrogen in the MEP analysis, based mainly on declines in eelgrass coverage and benthic animal communities, with some periodic DO depletions. The present analysis of water quality parameters is consistent with the MEP water quality assessment. Sunset Lake is likely being impacted both by its local sub-watershed and it hydrodynamics, but a specific analysis needs to confirm if altering the tidal flows would be sufficient for its restoration. However, given its function as a harbor and its structure the main basin is currently supporting high water quality with some benthic animal impairment possibly due mainly to its structure and use.

Farm Pond: Farm Pond is a heavily altered coastal salt pond currently with a tidally restricted inlet. Coastal processes have damaged the culvert and it is slated to be replaced. The MEP determined that properly restoring tidal exchange with a new culver/channel structure would be sufficient to restore Farm Pond water and habitat quality, without additional actions. The 2016 water quality is similar to that assessed by the MEP. Due to the reduced tidal exchange, Farm Pond water quality parameters (Figure 30) are relatively uniformly distributed, with only a slightly higher quality waters in the upper basin near the restricted tidal culvert (i.e. it is operating like Chilmark Pond or Edgartown Great Pond). Water quality is presently moderate being impaired by elevated nitrogen levels with associated periodic oxygen declines and reduced clarity. Restoring monitoring in 2016 will provide an excellent baseline for assessing restoration success related to the future installation of the new tidal inlet.

Sengekontacket Pond: Sengekontacket Pond is permanently open coastal salt pond that has two engineered inlets that are periodically dredged to maintain tidal exchange with Nantucket Sound. Water quality within the Sengekontacket Pond System is heterogeneous, with high quality waters throughout the main basin and lower quality waters in its tributary basins. The main tributary basin of Majors Cove is less well flushed than the main basin, with a resulting slight decline in water quality due to nitrogen enrichment, lower water clarity and periodic oxygen depletion. The other major tributary basin, Trapps Pond, shows a greater reduction in water quality, being more nitrogen enriched, with lower clarity and greater oxygen depletion than Majors Cove (Figure 31, (SKT-9). The Trapps Pond monitoring station is located at the tidal culvert between the main basin and Trapps Pond and is only monitored on the ebbing tide so that Trapps Pond waters are being evaluated. However, it is likely that water from the uppermost tidal reach in this tributary basin is of even lower quality than the measured outflowing water.

Katama Bay: Katama Bay is functionally a large enclosed basin with a single tidal inlet. However, it is periodically altered by coastal processes that open a tidal inlet to the Atlantic Ocean through the southern barrier beach, such as happened within the last decade. As such the pond's tidal flushing can vary significantly between a 1 and 2 inlet system. During the 2016 monitoring effort, Katama Bay supported generally high quality waters throughout, with only the innermost region near the barrier beach showing only slightly lower quality waters (Figure 32). This slight impairment was due to lower clarity associated with elevated phytoplankton biomass and nitrogen and some oxygen depletion. The cause of this impairment is most likely associated with tidal flushing, the location being furthest from the entry of high quality water through the inlet coupled to nitrogen inputs from the western shore of the basin.

Cape Pogue Bay-Pocha Pond: One of the largest estuaries in the region is the Cape Pogue Bay-Pocha Pond System. This estuary has a single natural tidal inlet and tributary basins. The main basin and nearest the tidal inlet is Cape Pogue Bay. This basin has a small tributary basin to the east (Shear Pen Pond), which is a tidally connected salt pond and a large tributary basin to the south (Pocha Pond) which is a large basin connect through a long tidal channel. It appears that the basin was formed by coastal processes building a large barrier beach system to enclose the basin based on the geomorphology. Water quality within this large estuary appears to be primarily based on the physical structure and tidal exchange, primarily related to distance from the tidal inlet. Watershed nitrogen loading plays only a background role in this system. Overall there are high quality waters throughout the main basin (Cape Pogue Bay) and only slightly lower quality waters in the tributary basins (Figure 33-34). The main basin generally has low nitrogen and phytoplankton levels with high clarity and only modest oxygen depletions, in contrast the tributary basin of Shear Pen Pond, has elevated nitrogen and modest oxygen depletions. These conditions in salt ponds, like Shear Pen Pond, is typically associated with low tidal exchange. Nitrogen can become elevated for 2 reasons, (1) high nitrogen inputs, (2) low rates of output (e.g. flushing). To date the inlet to Shear Pen Pond has not been evaluated for any restrictions or occlusion, which would address this issue. The major tributary basin of Pocha Pond is generally showing high water quality with some impairment due to elevated nitrogen and periodic oxygen depletion, although at lower levels than Shear Pen Pond. However, it appears that water quality in both tributary basins is determined primarily by the amount of tidal exchange. Fortunately, the overall water quality of Cape Pogue Pond and Pocha Pond basins is currently relatively high.

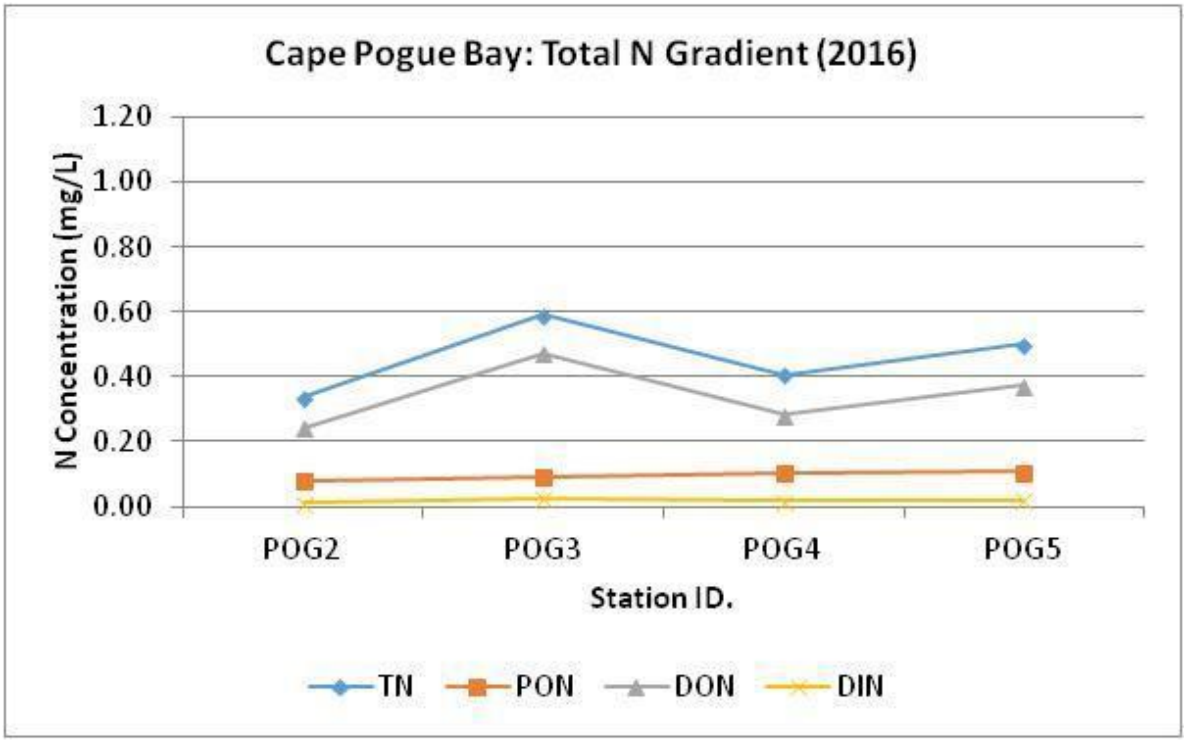
Recommendations for Future Monitoring

Due to the critical importance of dissolved oxygen to the ecological health of an estuarine basin, specific locations may need additional data in coming years to support more quantitative analysis for restoration. The few stations selected should collect high frequency data using automated sensors. This is only needed when the low frequency sampling of the monitoring program suggests that a problem may exist in a specific basin. At this point, the assessment of Lagoon Pond upper, Lake Tashmoo lower and Majors Cove would likely be improved (less uncertainty) by conducting 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. Specifically, continue doing Winkler Titrations on water samples where meter readings of D.O. are < 5mg/L. Winkler titration is a more accurate and precise method for quantifying dissolved oxygen concentrations. This prevents future decisions from being misled by oxygen meter data that was erroneously low due to a problem during field collection.

While more data is needed for developing many restoration alternatives for implementation, the 2016 Monitoring Program has brought forward a positive action that can be begun now. For the salt ponds that are only periodically breached to allow temporary tidal exchange it appears that an analysis of present opening protocols coupled to estuarine response may provide a means to achieve partial improvement in the short term. While opening analysis was performed for salt ponds during the Massachusetts Estuaries Project, it was not possible to determine the effectiveness through follow on changes in water quality. A recommendation to leverage the monitoring results is to track the opening efforts of the various groups conducting the openings and as possible collect a few samples at strategic times that capture the "opening success". Over time this will allow a data based evolution of the opening protocols to maximize their positive impacts on the ponds. CSP should be consulted in advance of collecting samples around openings and closings of beach breaches to insure the validity of the sampling.

Embayment	Sample ID	Secchi average (meters)	Secchi Depth % of WC	20% Low DO (mg/L)	20% Low DO (% Sat.)	Salinity (ppt)	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)	Chla/Phaeo Ratio	Avg. Total Pig (ug/L)
CAPE POGUE BAY	POG2	2.68	49%	5.04	72%	32.48	0.0108	0.0106	0.0012	0.0119	0.2433	0.2552	0.5023	0.0814	0.3247	0.3366	1.35	0.42	0.75	1.77
	POG3	2.25	45%	4.17	60%	32.63	0.0130	0.0220	0.0027	0.0247	0.4733	0.4980	0.5358	0.0929	0.5662	0.5908	1.00	0.74	0.56	1.74
	POG4	2.44	66%	4.66	68%	32.73	0.0119	0.0158	0.0015	0.0173	0.2834	0.3007	0.6006	0.1044	0.3879	0.4051	1.42	0.76	0.63	2.18
	POG5	1.82	93%	4.25	62%	32.65	0.0110	0.0160	0.0030	0.0190	0.3723	0.3913	0.6062	0.1078	0.4801	0.4991	1.05	0.91	0.53	1.96
POCHA POND	PCA1	1.07	100%	4.25	63%	32.58	0.0113	0.0200	0.0040	0.0239	0.3099	0.3338	0.6890	0.1170	0.4269	0.4509	1.30	0.94	0.58	2.24
	PCA2	1.80	72%	4.97	72%	33.50	0.0111	0.0040	0.0020	0.0059	0.2338	0.2397	0.9450	0.1444	0.3782	0.3841	2.15	0.76	0.74	2.91
	PCA3	1.48	87%	4.09	61%	32.58	0.0100	0.0205	0.0040	0.0245	0.3462	0.3707	0.8561	0.1405	0.4868	0.5112	1.56	0.94	0.61	2.50
KATAMA BAY	KAT1	3.03	35%	4.86	69%	32.43	0.0165	0.0132	0.0033	0.0164	0.2520	0.2684	0.4454	0.0828	0.3348	0.3513	1.23	0.49	0.73	1.72
	KAT2	2.81	60%	4.78	68%	32.43	0.0184	0.0145	0.0029	0.0174	0.2849	0.3023	0.4782	0.0834	0.3682	0.3857	1.33	0.74	0.64	2.07
	KAT3	1.16	100%	4.57	66%	32.08	0.0210	0.0127	0.0024	0.0151	0.2363	0.2514	0.6866	0.1247	0.3610	0.3761	2.16	0.76	0.72	2.93
	KAT4	2.00	18%	4.79	69%	32.33	0.0228	0.0195	0.0045	0.0240	0.2914	0.3155	0.6498	0.1165	0.4079	0.4319	2.07	1.20	0.63	3.28
	KAT5	1.80	63%	4.71	68%	32.15	0.0288	0.0150	0.0031	0.0181	0.2629	0.2809	0.7049	0.1402	0.4031	0.4211	2.38	1.20	0.66	3.57
	KAT7	1.28	94%	4.56	65%	32.08	0.0263	0.0118	0.0017	0.0135	0.2903	0.3038	0.8422	0.1553	0.4456	0.4591	3.03	1.20	0.71	4.23
EDGARTOWN GREAT POND	EGP2	2.38	92%	3.63	68%	21.63	0.0012	0.0338	0.0024	0.0362	0.3938	0.4300	0.6454	0.1223	0.5160	0.5522	1.64	0.27	0.83	1.91
	EGP3	2.63	78%	4.75	66%	21.50	0.0009	0.0222	0.0019	0.0242	0.3791	0.4033	0.6010	0.1118	0.4909	0.5151	2.03	0.17	0.91	2.19
	EGP4	1.75	100%	4.59	65%	21.50	0.0011	0.0390	0.0062	0.0453	0.3479	0.3931	0.6677	0.1028	0.4506	0.4959	1.23	0.24	0.80	1.47
	EGP5	2.23	100%	4.83	68%	22.85	0.0005	0.0274	0.0022	0.0295	0.3897	0.4192	0.7599	0.1249	0.5146	0.5441	2.09	0.24	0.84	2.33
	EGP6	2.28	100%	4.65	65%	22.43	0.0005	0.0206	0.0014	0.0220	0.3816	0.4036	0.7398	0.1311	0.5128	0.5347	2.66	0.19	0.87	2.85
	EGP7	2.66	100%	4.56	64%	22.78	0.0009	0.0329	0.0016	0.0345	0.3934	0.4279	0.6456	0.1126	0.5061	0.5406	1.60	0.19	0.86	1.80
	EGP9	1.88	100%	4.60	65%	20.78	0.0009	0.0203	0.0027	0.0230	0.3090	0.3319	0.8229	0.1366	0.4456	0.4686	1.85	0.34	0.84	2.19
	EGP10	1.80	100%	4.33	62%	21.08	0.0013	0.0231	0.0021	0.0253	0.3580	0.3833	0.7030	0.1152	0.4732	0.4984	1.73	0.22	0.87	1.95
	EGP11	1.60	100%	4.16	59%	21.40	0.0009	0.0494	0.0029	0.0523	0.3969	0.4492	0.5736	0.0994	0.4963	0.5486	1.10	0.23	0.82	1.33
CHILMARK POND	CHP UP	0.78	56%	6.46	79%	0.13	0.0326	0.0030	0.0024	0.0055	0.4145	0.4200	3.7003	0.6761	1.0907	1.0961	23.19	0.96	0.97	24.16
	CHP7	0.72	100%	2.78	36%	5.77	0.0174	0.0207	0.0042	0.0249	0.5248	0.5497	2.3354	0.4127	0.9375	0.9624	13.16	1.64	0.80	14.80
	CHP6	0.85	89%	4.98	65%	9.20	0.0168	0.0190	0.0032	0.0222	0.5525	0.5747	1.9863	0.3488	0.9013	0.9235	6.81	0.72	0.88	7.53
	CHP5	1.18	61%	5.28	69%	9.50	0.0064	0.0061	0.0019	0.0081	0.5672	0.5753	1.7618	0.2570	0.8223	0.8320	4.98	0.43	0.88	5.41
	CHP4	1.09	80%	5.50	71%	9.75	0.0108	0.0041	0.0020	0.0061	0.5918	0.5979	1.1489	0.1995	0.7913	0.7974	3.59	0.69	0.84	4.27
	CHP2	1.16	54%	5.13	67%	9.88	0.0215	0.0034	0.0023	0.0056	0.5609	0.5665	1.7785	0.2893	0.8502	0.8558	6.04	0.62	0.87	6.66
	CHP1	0.90	61%	4.91	64%	9.58	0.0059	0.0038	0.0024	0.0062	0.6427	0.6489	2.6034	0.3750	1.0178	1.0240	9.32	0.48	0.92	9.80
OAK BLUFFS HARBOR	MV14	0.90	100%	3.73	52%	30.50	0.0142	0.0096	0.0262	0.0358	0.2533	0.2891	0.9596	0.1742	0.4275	0.4633	2.48	1.14	0.69	3.62
	MV15	1.79	100%	4.56	63%	31.60	0.0176	0.0095	0.0126	0.0221	0.2713	0.2934	0.8708	0.1273	0.3987	0.4207	2.43	0.77	0.74	3.20
	MV16	2.81	78%	4.80	67%	31.81	0.0129	0.0132	0.0035	0.0167	0.2082	0.2249	0.5120	0.0810	0.2892	0.3059	1.45	0.62	0.69	2.08
FARM POND	FRM1	0.79	100%	4.30	62%	31.58	0.0153	0.0106	0.0060	0.0165	0.3033	0.3199	0.6457	0.1074	0.4108	0.4273	1.48	0.59	0.71	2.07
	FRM2	0.97	100%	3.42	48%	31.55	0.0149	0.0073	0.0038	0.0110	0.3407	0.3517	0.6054	0.1111	0.4518	0.4628	1.20	0.73	0.64	1.93
	FRM3	1.20	100%	2.84	42%	30.65	0.0613	0.0070	0.0036	0.0106	0.3615	0.3721	0.9738	0.1720	0.5334	0.5440	2.38	0.97	0.74	3.35
SENGEKONTACKET POND	SKT2	1.88	100%	4.25	61%	31.88	0.0135	0.0143	0.0022	0.0165	0.3474	0.3639	0.6014	0.0951	0.4425	0.4590	1.15	0.48	0.70	1.62
	SKT3	2.37	89%	3.93	57%	31.50	0.0115	0.0141	0.0027	0.0167	0.3804	0.3971	0.7691	0.1481	0.5285	0.5452	2.72	0.67	0.74	3.39
	SKT4	1.41	98%	3.82	55%	30.85	0.0151	0.0142	0.0041	0.0184	0.2883	0.3066	0.7281	0.1305	0.4188	0.4372	1.50	1.06	0.58	2.56
	SKT5	1.23	100%	4.59	65%	31.95	0.0112	0.0101	0.0016	0.0117	0.2286	0.2403	0.4614	0.0753	0.3039	0.3156	0.88	0.54	0.59	1.41
	SKT6	2.27	100%	4.44	63%	31.95	0.0135	0.0134	0.0022	0.0157	0.2150	0.2306	0.3810	0.0679	0.2828	0.2985	0.82	0.36	0.69	1.18
	SKT8	1.93	100%	4.28	62%	31.48	0.0040	0.0121	0.0017	0.0138	0.3192	0.3330	0.5876	0.1124	0.4316	0.4454	1.31	0.35	0.77	1.66
	SKT9	0.30	100%	3.48	51%	30.45	0.0085	0.0250	0.0045	0.0295	0.3899	0.4195	0.5468	0.0890	0.4789	0.5085	0.93	0.74	0.57	1.67
FRESH POND	FRS1	1.93	59%	5.44	68%	0.05	0.0016	0.0020	0.0041	0.0061	0.4076	0.4137	0.8022	0.1103	0.5179	0.5240	1.50	0.71	0.64	2.22
	FRS2	1.78	88%	5.48	69%	0.03	0.0026	0.0030	0.0033	0.0063	0.4127	0.4190	0.7497	0.1201	0.5328	0.5391	1.15	0.67	0.63	1.82
	FRS3	1.98	89%	5.50	69%	0.03	0.0049	0.0072	0.0049	0.0121	0.3999	0.4120	0.6857	0.0906	0.4905	0.5026	1.17	0.70	0.62	1.87
LAGOON POND	LGP11	0.93	78%	2.75	35%	26.48	0.0088	0.0280	0.3447	0.3727	0.4802	0.8528	5.6625	0.9640	1.4553	1.8279	8.16	7.46	0.64	15.61
	LGP12	0.23	89%	2.96	39%	23.58	0.0190	0.0344	0.2872	0.3216	0.5719	0.8935	5.8302	1.0202	1.5921	1.9136	11.00	5.96	0.66	16.97
	LGP2	2.73	31%	1.94	27%	31.75	0.0213	0.0119	0.0021	0.0141	0.2654	0.2795	0.9164	0.1526	0.4180	0.4320	3.28	0.72	0.79	4.00
	LGP4	2.69	36%	0.49	7%	31.48	0.0268	0.0111	0.0020	0.0131	0.2568	0.2698	1.2330	0.1904	0.4471	0.4602	3.07	0.98	0.73	4.05
	LGP6	2.19	42%	2.94	42%	31.20	0.0332	0.0196	0.0042	0.0238	0.3892	0.4130	0.5614	0.1060	0.3587	0.3858	1.27	0.49	0.72	1.75
	LGP8	2.88	48%	4.31	60%	31.38	0.0151	0.0117	0.0017	0.0134	0.2376	0.2510	0.9078	0.1360	0.3736	0.3870	3.02	0.45	0.81	3.47
	LGP9	3.20	59%	3.99	57%	31.65	0.0143	0.0097	0.0021	0.0119	0.2050	0.2169	0.6397	0.1005	0.3055	0.3174	2.29	0.70	0.70	2.99
LAKE TASHMOO	MV21	0.81	100%	5.13	71%	31.63	0.0126	0.0114	0.0028	0.0142	0.1910	0.2052	0.4163	0.0676	0.2586	0.2728	1.07	0.44	0.72	1.51
	MV2	2.80	93%	4.82	66%	31.60	0.0320	0.0125	0.0018	0.0142	0.2374	0.2516	0.4819	0.0844	0.3217	0.3360	1.47	0.46	0.77	1.94
	MV3	2.46	88%	4.66	65%	31.53	0.0153	0.0097	0.0021	0.0118	0.2308	0.2425	0.6889	0.1088	0.3396	0.3514	1.33	0.58	0.72	1.91
	MV4	2.60	84%	4.70	65%	31.68	0.0146	0.0125	0.0016	0.0140	0.2268	0.2408	0.7036	0.1138	0.3406	0.3546	1.97	0.79	0.71	2.75
	MVSEN	2.00	70%	4.38	62%	30.89	0.0173	0.0138	0.0046	0.0184	0.2386	0.2570	1.4494	0.2249	0.4636	0.4820	4.10	0.92	0.80	5.02

Table 2. Summary of Water Quality Parameters, 2016 Martha's Vineyard Island-wide Water Quality Monitoring Program. Values are Station Averages of all sampling events, July-Aug for estuarine and salt pond sites. Farm Pond and Oak Bluffs Harbor received 1 sampling event in August and 1 in September. All other systems were sampled twice in both July and August.



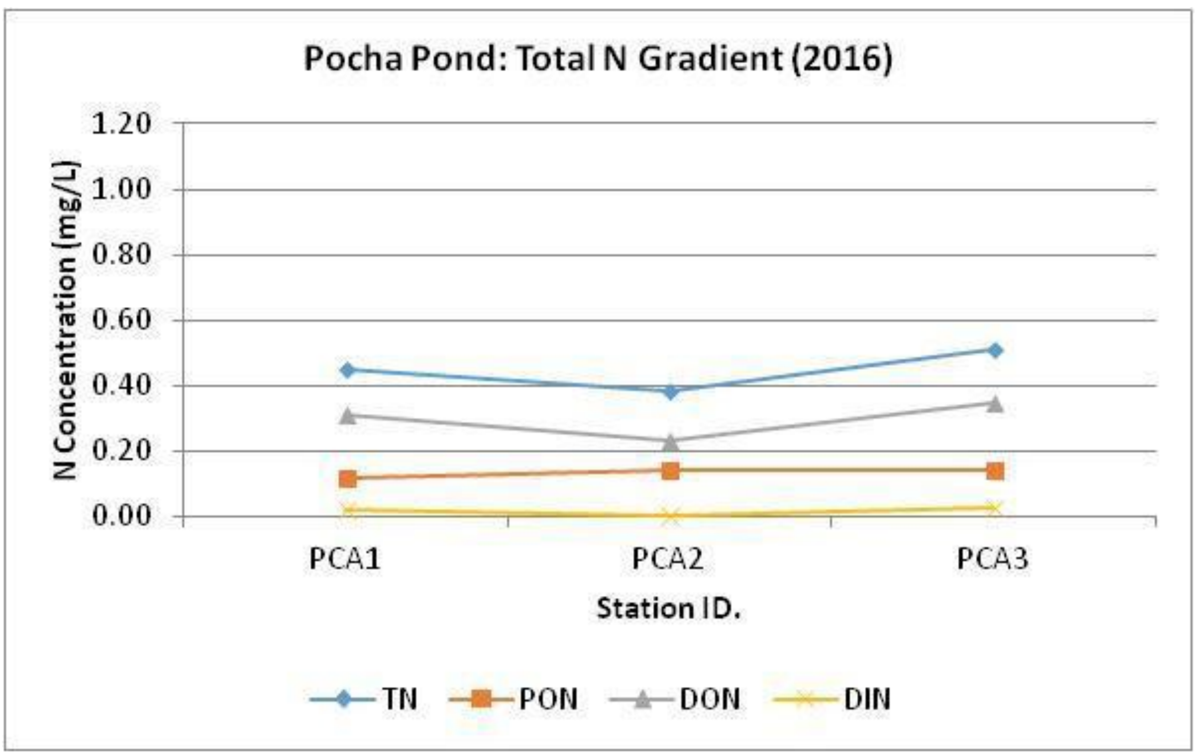
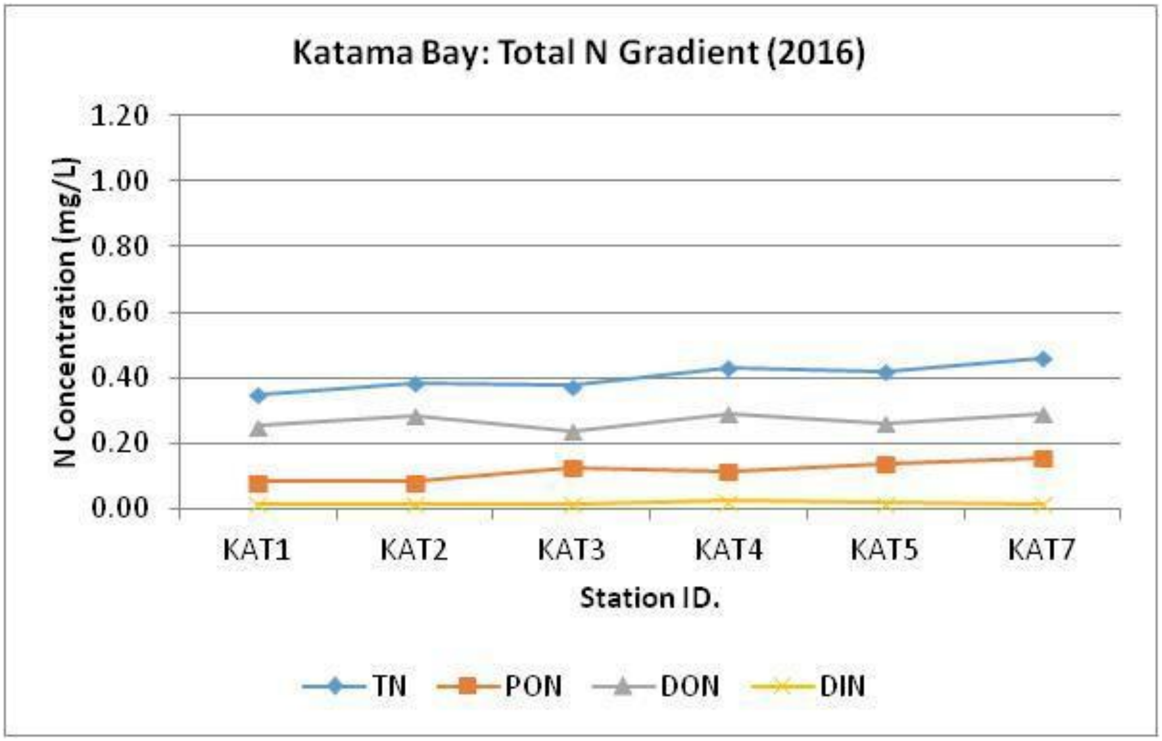


Figure 17. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season). Presently, no MEP Threshold set for Cape Pogue Bay or Pocha Pond.



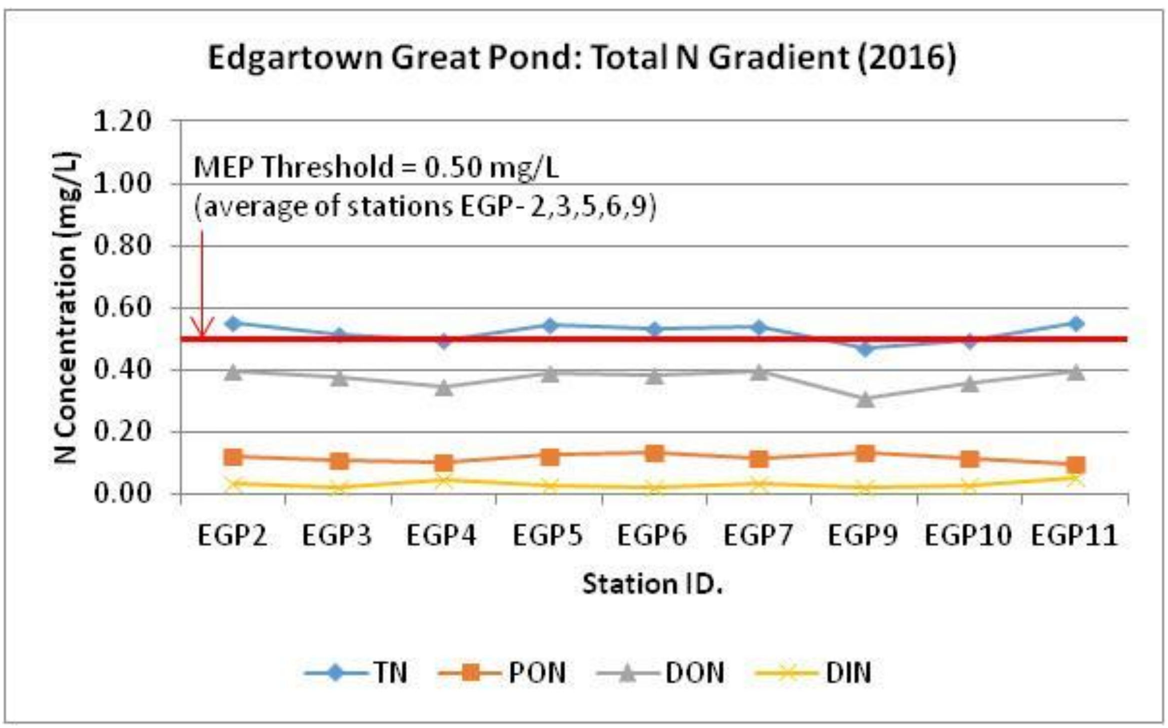


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season). Presently, no MEP Threshold set for Katama Bay.

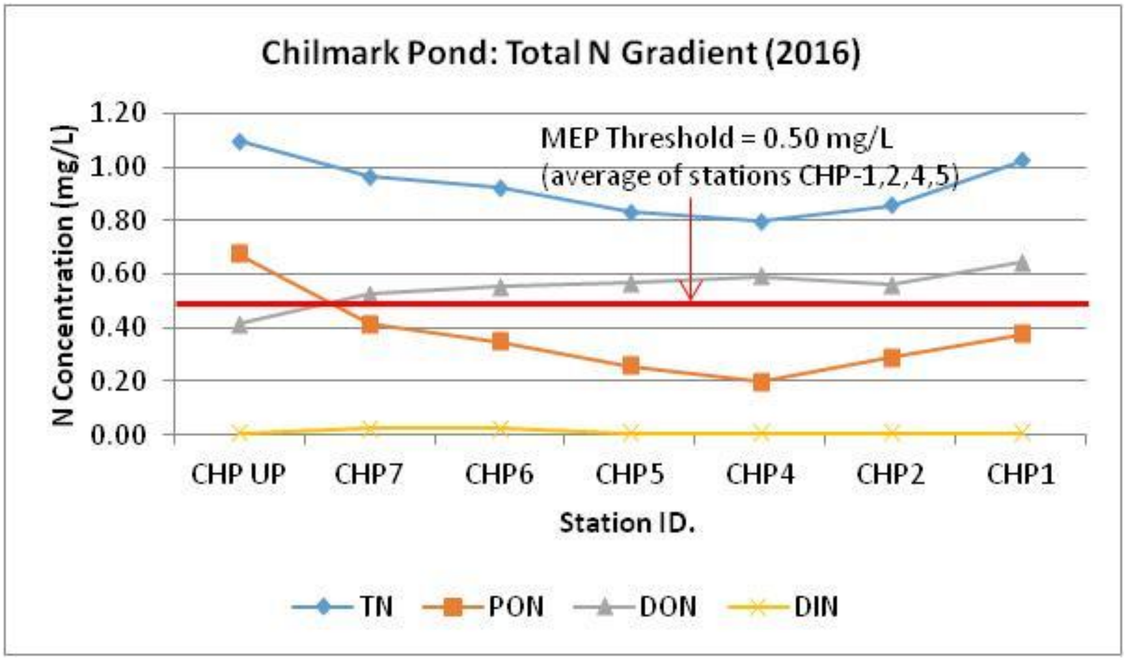


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

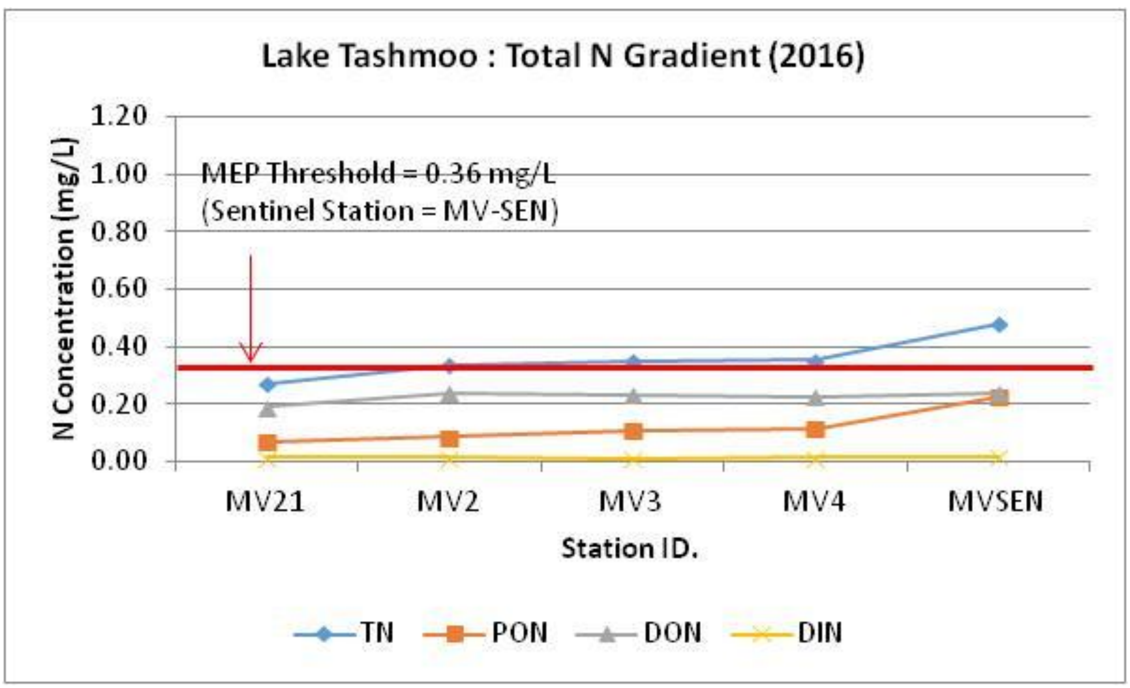


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

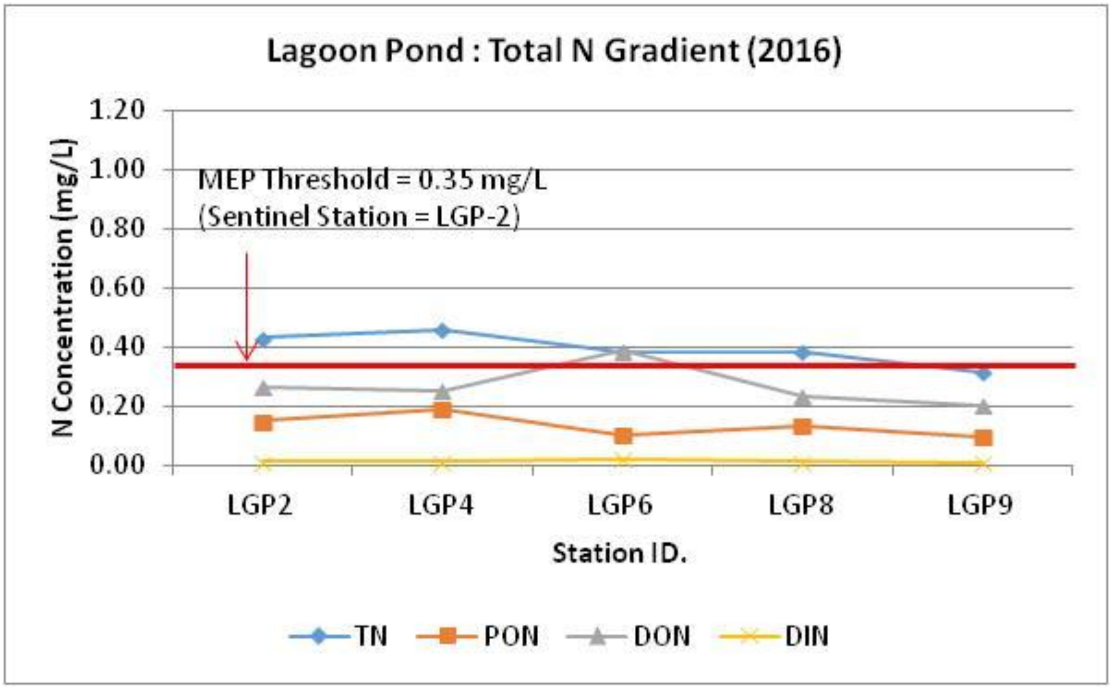


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

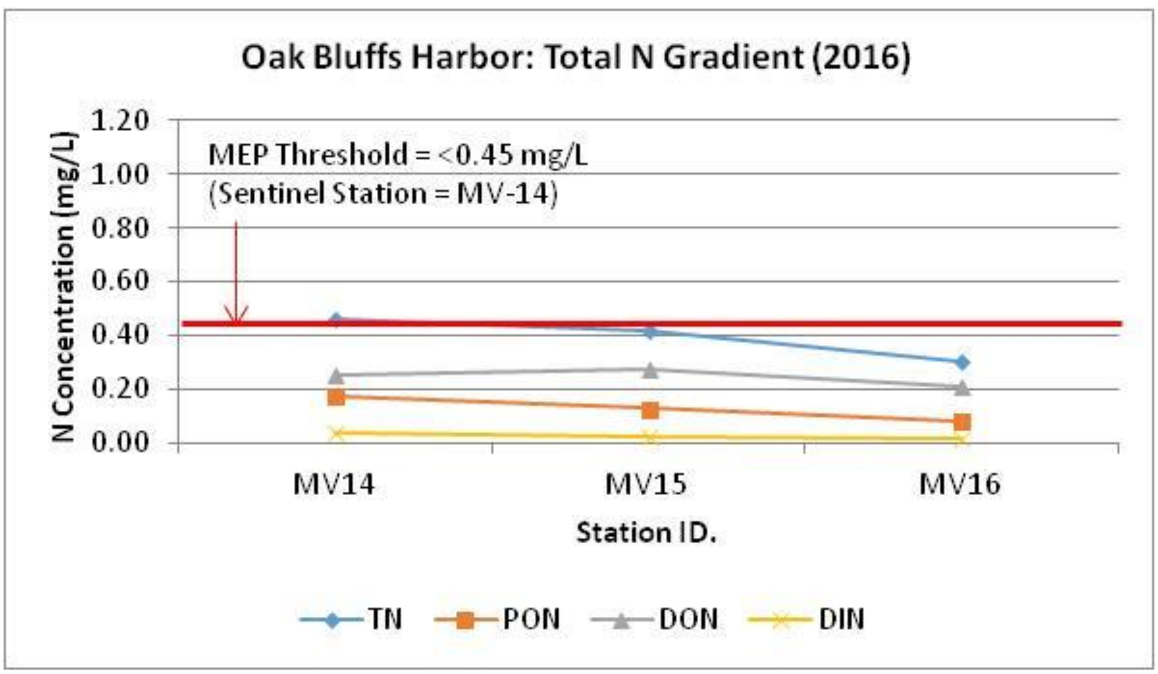


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

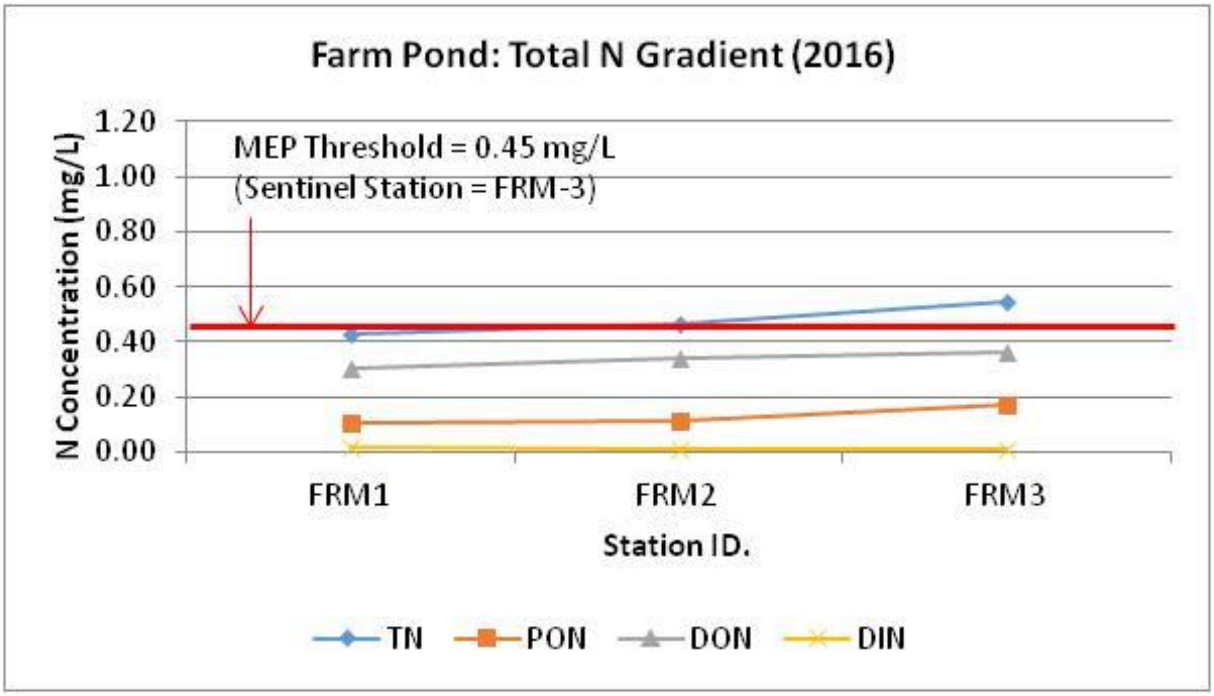


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

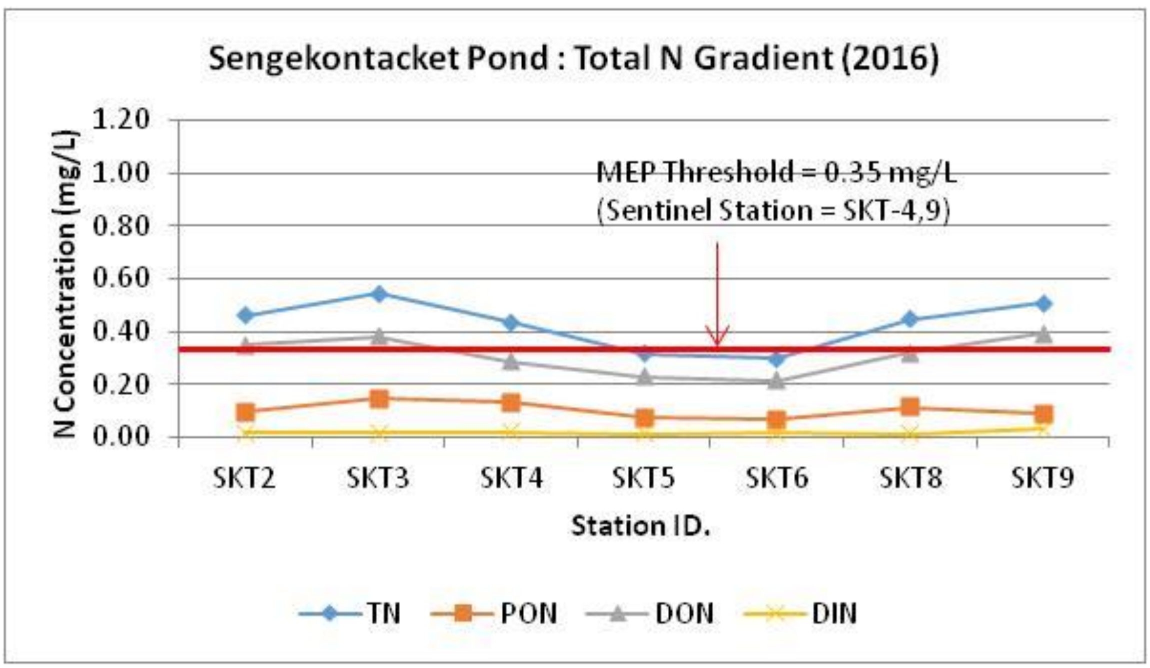


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

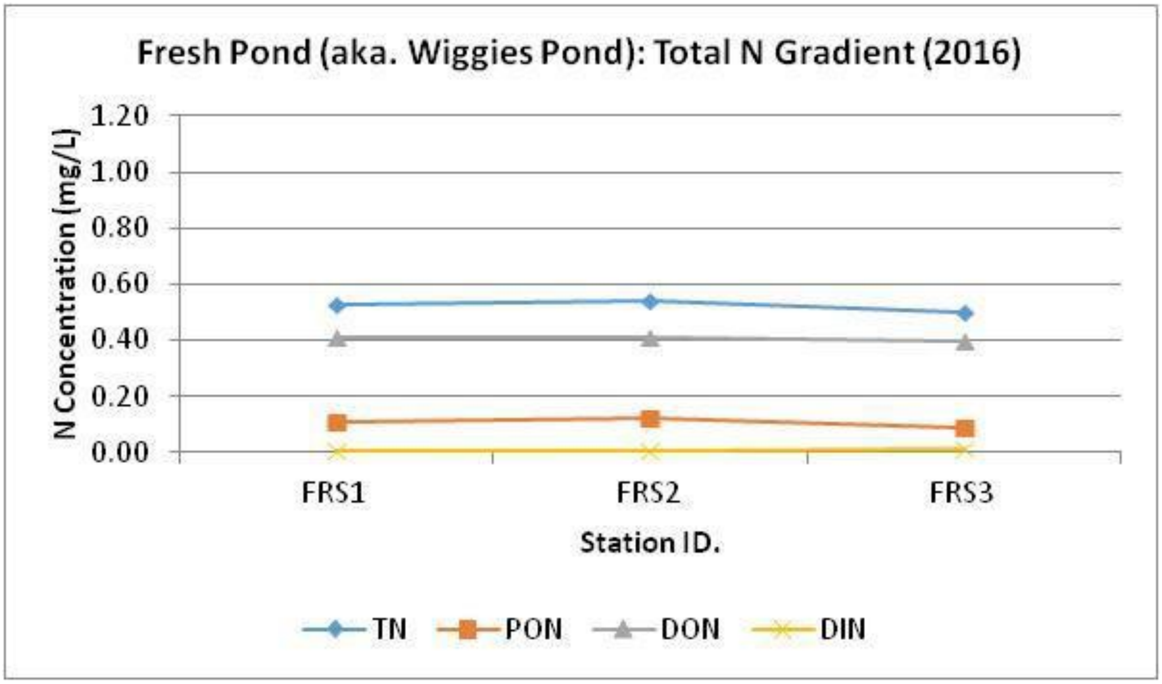


Figure 17 cont'd. Comparison of nitrogen species in the Martha's Vineyard estuaries and salt ponds (Summer 2016 sampling season).

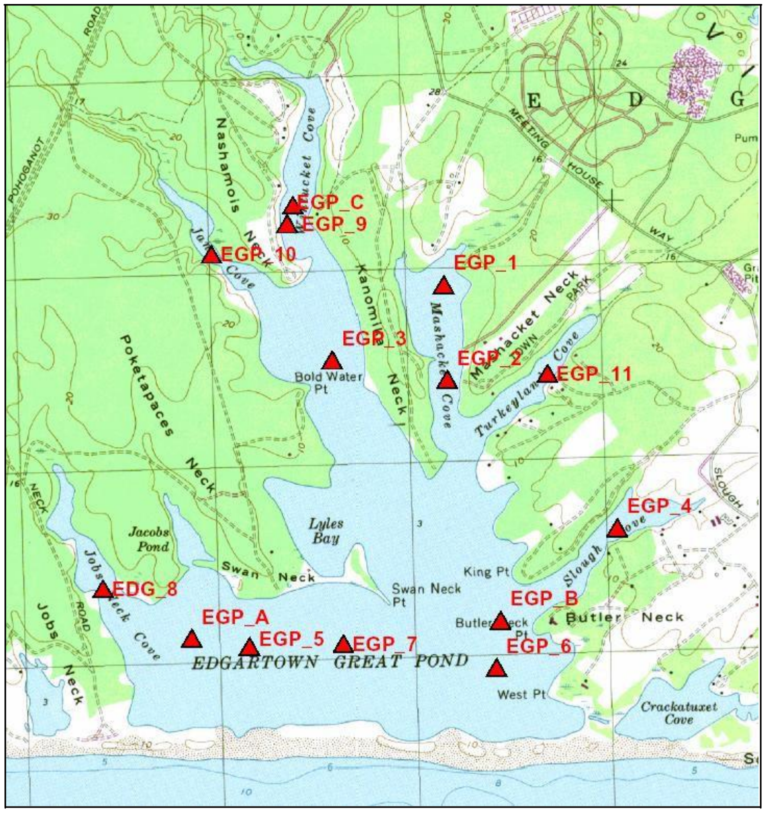


Figure 18. Estuarine water quality monitoring station locations in the Edgartown Great Pond estuary system. Station labels correspond to those provided in Table 3 below. Red diamonds indicate locations of MEP monitoring stations. Not all stations were included in the summer 2016 sampling effort. MEP "Sentinel station" (average of EGP 2,3,5,6,9). MEP TN threshold = 0.50 mg/L.

Sampling Station Location	MEP total nitrogen			MEP salinity			2016
	data mean (mg/L)	s.d. all data (mg/L)	N	data mean (ppt)	s.d. all data (ppt)	N	**Mean TN (mg/L)**
Jobs Neck Cove – EGP8	**0.583**	0.174	9	17.9	5.1	11	
Jane's Cove – EGP10	**0.582**	0.153	7	16.5	3.4	10	**0.498**
Wintucket Cove – EGP9	**0.597**	0.123	10	18.0	3.8	11	**0.469**
Upper Mash Cove – EGP1	**0.650**	0.170	9	18.9	4.6	14	
Lower Mash Cove – EGP2	**0.613**	0.159	9	18.2	5.6	14	**0.552**
Turkeyland Cove – EGP11	**0.639**	0.107	5	19.8	3.4	11	**0.549**
Upper Slough Cove – EGP4	**0.711**	0.193	10	16.2	4.6	32	**0.496**
Upper EGP Basin – EGP3	**0.587**	0.175	10	18.4	5.1	14	**0.515**
Lower EGP West – EGP5	**0.595**	0.187	11	20.9	4.6	14	**0.544**
Lower EGP East – EGP6	**0.591**	0.205	9	22.1	5.4	14	**0.535**
Lower EGP Mid - EGP7							**0.541**
Atlantic Ocean	**0.232**	0.044	17	32.3	0.6	5	

Table 3. MEP mean values of TN and salinity used in the development of the nutrient threshold for Edartown Great Pond. Measured nitrogen concentrations and salinities for Edgartown Great Pond. "Data mean" values are calculated as the average of the separate yearly means. TN data represented in this table were collected in 2003 through 2006 in Great Pond and 2002 through 2004 for salinity. The offshore Atlantic Ocean data (offshore Pleasant Bay Inlet) are from the summer of 2005.

Figure 19. MEP monitoring station location in Chilmark Pond that was used in the water quality analysis for the Massachusetts Estuaries Project. MEP established "sentinel station" (average of CHP 1-5). MEP TN Threshold = 0.50 mg/L or less.

Sampling Station Location	MEP Total Nitrogen			**2016**
	Mean (mg/L)	s.d. all data (mg/L)	N	**Mean TN (mg/L)**
Wades Cove Upper (CHP-1)	**0.757**	0.209	20	**1.024**
Chilmark Pond (CHP-2)	**0.733**	0.231	20	**0.856**
Gilberts Cove (CHP-4)	**0.769**	0.224	9	**0.797**
Chilmark Pond (CHP-5)	**0.753**	0.227	15	**0.832**
Chilmark Pond (CHP-6)	**0.704**	0.125	12	**0.924**
Chilmark Pond (CHP-7)	**0.808**	0.228	7	**0.962**
Chilmark Pond Upper (CHP-up)				**1.096**
Atlantic Ocean	**0.232**	0.044	17	

Table 4. Comparison of MEP mean values of TN with summer 2016 sampling effort (all values are mg/L) from Chilmark Pond. Measured nitrogen concentrations for Chilmark Pond. TN data represented in this table were collected from 2004 in Chilmark Pond. The offshore Atlantic Ocean data (offshore Pleasant Bay Inlet) are from the summer of 2005.

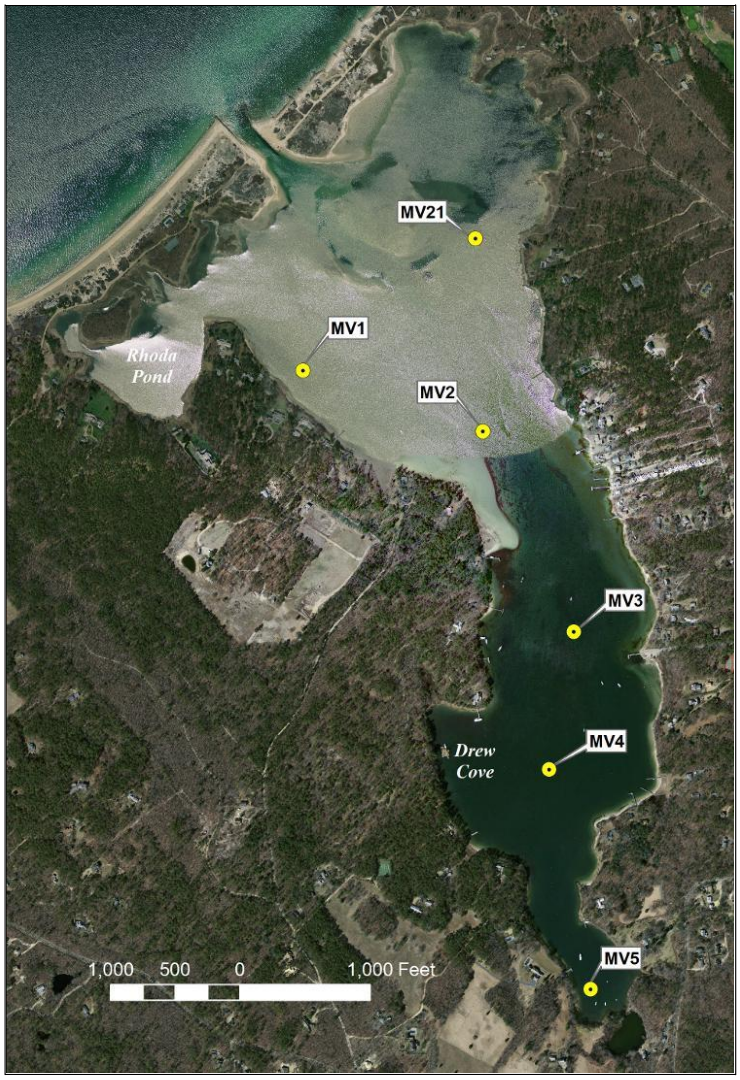


Figure 20. MEP monitoring station location in Lake Tashmoo that was used in the water quality analysis for the Massachusetts Estuaries Project. MEP established "sentinel station" between MV4 and MV5 (MV SEN, newly established station in 2016). MEP TN Threshold = 0.36 mg/L.

Sub-Embayment	Monitoring station	**Data Mean**	s.d. all data	N	model min	model max	model average	**2016 Mean TN (mg/L**
Lower Basin	MV21	**0.314**	0.047	29	0.279	0.327	0.300	**0.273**
Lower Basin	MV1	**0.306**	0.068	28	0.283	0.343	0.311	
Lower Basin	MV2	**0.301**	0.069	28	0.294	0.356	0.329	**0.336**
Mid-Upper Basin	MV3	**0.343**	0.071	38	0.356	0.379	0.369	**0.351**
Mid-Upper Basin	MV4	**0.360**	0.065	37	0.379	0.391	0.385	**0.355**
Upper Basin	MV5	**0.447**	0.087	37	0.418	0.428	0.423	
MEP Sentinel Station	MV-SEN							**0.482**
Offshore	MV6	**0.270**	0.065	60	-	-	-	

Table 5. MEP Measured data and modeled nitrogen concentrations for the Lake Tashmoo estuarine system. All concentrations are given in mg/L N. “Data mean” values are calculated as the average of all measurements. Data represented in this table were collected in the summers of 2001 through 2007.

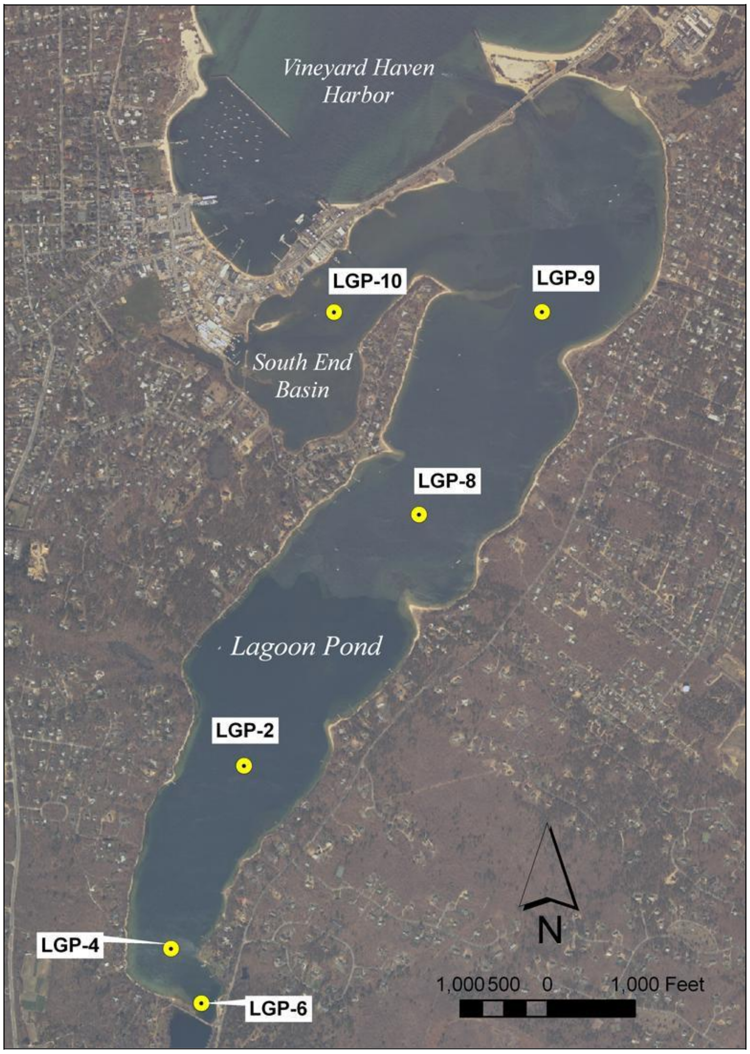


Figure 21. MEP monitoring station location in Lagoon Pond that was used in the water quality analysis for the Massachusetts Estuaries Project. MEP established "sentinel station" (LGP2). MEP TN Threshold = 0.35 mg/L.

Sub-Embayment	MEP monitoring station	**data mean**	s.d. all data	N	model min	model max	model average	**2016 Mean TN (mg/L)**
Lagoon Pond head at dike	LGP-6	**0.418**	0.071	23	0.408	0.424	0.413	**0.386**
Lagoon Pond Head	LGP-4	**0.384**	0.077	100	0.384	0.387	0.385	**0.460**
Lagoon Pond upper Basin	LGP-2	**0.360**	0.067	135	0.370	0.372	0.371	**0.432**
Lagoon Pond mid Basin	LGP-8	**0.359**	0.070	66	0.334	0.342	0.338	**0.387**
Lagoon Pond lower Basin	LGP-9	**0.333**	0.058	60	0.322	0.336	0.328	**0.317**
West Arm (South End Basin)	LGP-10	**0.386**	0.075	35	0.370	0.391	0.378	
Nantucket Sound	NTKS	**0.290**	0.052	48	-	-	-	

Table 6. Measured data and modeled Nitrogen concentrations for the Lagoon Pond estuarine system used in the MEP modeling and threshold development. All concentrations are given in mg/L N. “Data mean” values are calculated as the average of the separate yearly means. Data represented in this table were collected in the summers of 2002 through 2007.

Figure 22. Estuarine water quality monitoring station locations in the Oak Bluffs Harbor and Sunset Lake System used to establish the MEP water quality baseline. MEP TN threshold is <0.45 mg/L in Sunset Lake.

Monitoring station	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean	2006 mean	2007 mean	**mean**	s.d. all data	N	model min	model max	model average	**2016 Mean TN (mg/L)**
MV-14	0.382	--	0.390	0.411	0.386	0.413	0.350	**0.392**	0.047	35	0.367	0.422	0.392	**0.463**
MV-15	0.333	0.363	0.351	0.321	0.296	0.327	0.318	**0.329**	0.044	41	0.307	0.333	0.320	**0.421**
MV-16	0.338	0.363	0.320	0.389	0.273	0.324	0.302	**0.325**	0.066	63	0.294	0.328	0.313	**0.306**
MV-17	--	0.355	0.385	0.373	0.305	0.375	0.328	**0.351**	0.066	34	0.320	0.347	0.335	

Table 7. Comparison of MEP mean values of TN with summer 2016 data (all values are mg/L) from Oak Bluffs Harbor. Town of Oak Bluffs water quality monitoring data, and MEP modeled Nitrogen concentrations for the Oak Bluffs Harbor System. “Data mean” values are calculated as the average of the separate yearly means.

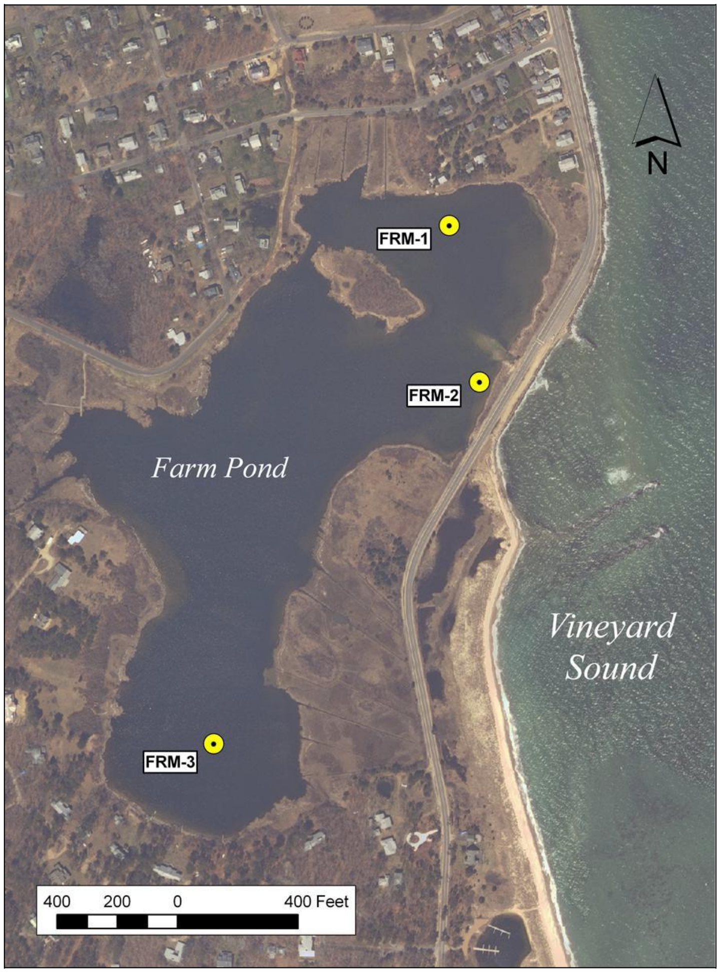


Figure 23. Estuarine water quality monitoring station locations in the Farm Pond System used to establish the MEP water quality baseline. MEP TN threshold is 0.45 mg/L at MEP "sentinel" station (FAM-3).

Sub-Embayment	MEP monitoring station	**data mean**	s.d. all data	N	model min	model max	model average	**2016 Mean TN (mg/L)**
North Basin	FAM-1	**0.516**	0.114	18	0.466	0.520	0.496	**0.427**
Mid Pond	FAM-2	**0.505**	0.135	16	0.440	0.507	0.480	**0.463**
South Basin	FAM-3	**0.530**	0.178	17	0.506	0.510	0.508	**0.544**
Nantucket Sound	NTKS	**0.294**	0.062	4	-	-	-	

Table 8. Comparison of MEP mean values of TN with summer 2016 data (all values are mg/L) from Farm Pond. Measured data and modeled Nitrogen concentrations for the Farm Pond estuarine system used in the model calibration. All concentrations are given in mg/L N. “Data mean” values are calculated as the average of the separate yearly means. Data represented in this table were collected in the summers of 2002 through 2008.

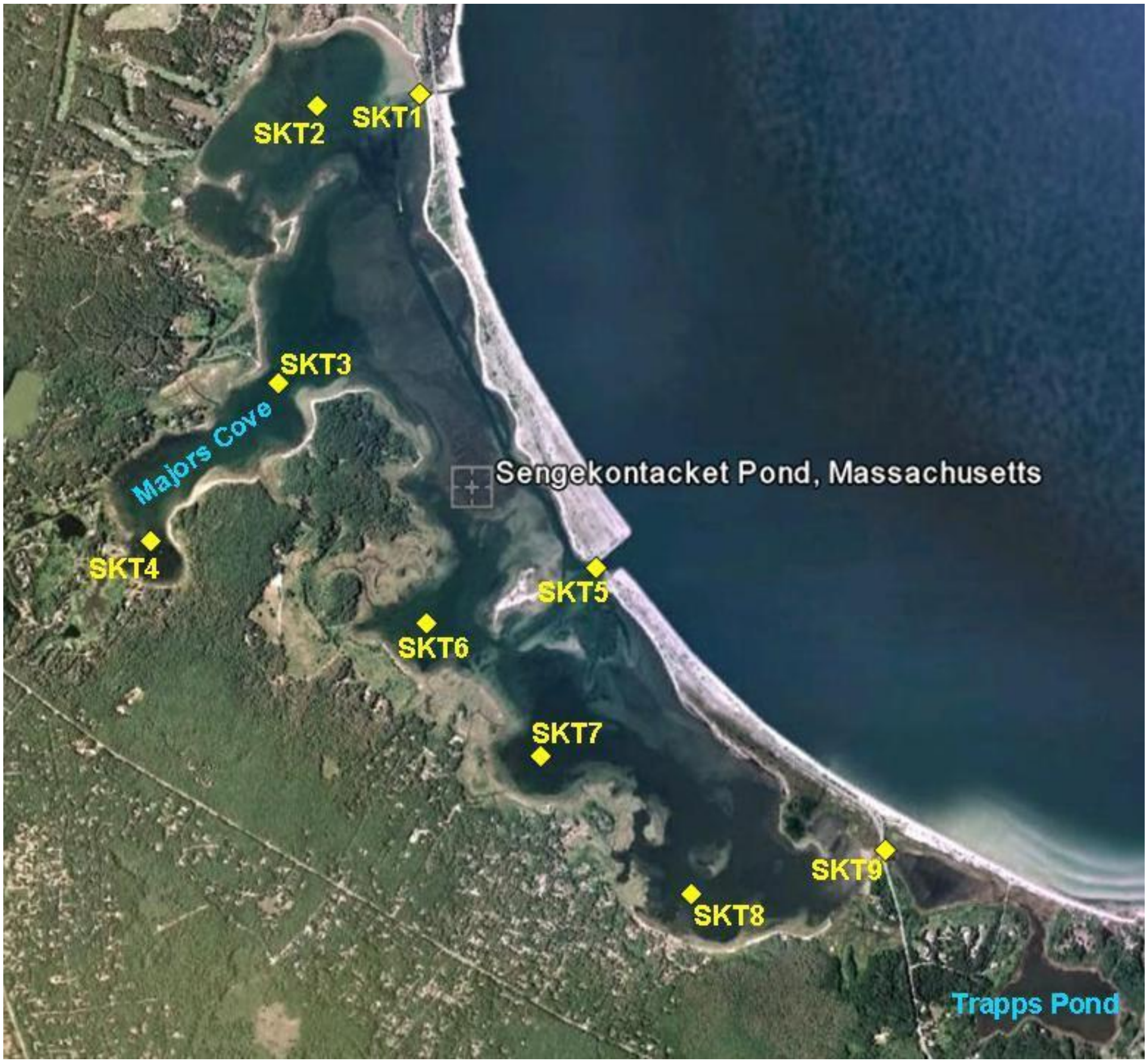


Figure 24. Estuarine water quality monitoring station locations in the Sengekontacket Pond System used to establish the MEP water quality baseline. MEP TN threshold is 0.35 mg/L at water quality monitoring stations SKT-4 and SKT-9, to restore eelgrass habitat within Majors Cove/Sengekontacket Pond and to improve eelgrass habitat within Trapps Pond. The approximate locations of the sentinel threshold stations for Sengekontacket Pond (SKT-4 and SKT-9) are shown. There is no baseline water quality station within Trapps Pond.

Sub-Embayment	Farm Neck Inlet	Farm Neck Basin	Majors Cove	Majors Cove	Main Inlet	Ocean Heights	Ocean Heights	Ocean Heights	Trapps Pond
Monitoring station	Skt-1	Skt-2	Skt-3	Skt-4	Skt-5	Skt-6	Skt-7	Skt-8	Skt-9
2003 mean	0.457	0.451	0.554	0.611	0.306	0.365	0.420	0.604	0.607
2004 mean	0.350	0.369	0.416	0.366	0.288	0.315	0.299	0.417	0.413
2005 mean	0.268	0.285	0.351	0.356	0.205	0.268	0.217	0.311	0.396
2006 mean	0.351	0.373	0.421	0.437	0.355	0.319	0.312	0.412	0.516
2007 mean	0.348	0.336	--	0.392	0.257	0.259	0.279	0.380	--
2008 mean	0.402	0.365	0.347	0.373	0.336	0.270	0.429	0.381	0.380
2009 mean	0.295	0.294	0.342	0.347	0.248	0.264	0.263	0.378	0.422
mean	**0.351**	**0.347**	**0.414**	**0.406**	**0.290**	**0.302**	**0.314**	**0.392**	**0.445**
s.d. all data	0.073	0.064	0.098	0.100	0.071	0.083	0.104	0.094	0.089
N	24	24	25	25	25	25	27	24	20
model min	0.295	0.312	0.340	0.370	0.294	0.300	0.299	0.323	0.331
model max	0.324	0.328	0.363	0.380	0.320	0.325	0.317	0.337	0.476
model average	0.308	0.320	0.351	0.375	0.299	0.308	0.306	0.331	0.382
2016 mean		**0.459**	**0.545**	**0.437**	**0.316**	**0.299**		**0.445**	**0.509**

Table 9. Comparison of MEP mean values of TN with summer 2016 data (all values are mg/L) from Sengekontacket Pond. Measured data and modeled Nitrogen concentrations for the Sengekontacket Pond estuarine system used in the model calibration. All concentrations are given in mg/L N. “Data mean” values are calculated as the average of the separate yearly means. Data represented in this table were collected in the summers of 2003 through 2009.

EMBAYMENT STATION	YEAR	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	2016 EUTROPHICATION RATING
POG2	2016	93.0	72.6	100.0	80.6	100.0	89.2	High
POG3	2016	82.1	50.9	75.4	7.6	100.0	63.2	High-Moderate
POG4	2016	87.1	66.3	90.9	57.2	100.0	80.3	High
POG5	2016	68.8	53.3	86.8	29.2	100.0	67.6	High-Moderate
PCA1	2016	35.9	56.0	76.7	44.7	100.0	62.7	High-Moderate
PCA2	2016	68.3	72.4	100.0	60.5	100.0	80.2	High
PCA3	2016	55.9	52.2	75.8	27.4	100.0	62.3	High-Moderate
KAT1	2016	100.0	67.7	93.0	76.5	100.0	87.4	High
KAT2	2016	95.9	65.7	90.5	64.1	100.0	83.2	High
KAT3	2016	41.1	60.9	96.7	66.7	100.0	73.1	High
KAT4	2016	74.8	66.5	76.5	50.6	92.7	72.2	High
KAT5	2016	68.3	64.9	89.0	52.2	85.5	72.0	High
KAT7	2016	47.2	59.6	100.0	39.0	71.4	63.5	High-Moderate
EGP2	2016	85.6	64.5	58.7	19.8	100.0	65.7	High-Moderate
EGP3	2016	91.7	62.1	76.3	26.3	100.0	71.3	High
EGP4	2016	66.5	59.0	49.0	37.6	100.0	62.4	High-Moderate
EGP5	2016	81.4	65.4	67.6	20.2	100.0	66.9	High-Moderate
EGP6	2016	82.8	60.5	80.5	20.6	100.0	68.9	High-Moderate
EGP7	2016	92.6	58.0	60.8	22.3	100.0	66.8	High-Moderate
EGP9	2016	70.8	60.6	78.5	39.0	100.0	69.8	High
EGP10	2016	68.3	54.0	74.4	31.2	100.0	65.6	High-Moderate
EGP11	2016	60.9	47.6	42.8	24.9	100.0	55.2	Moderate
CHP UP	2016	15.9	83.6	100.0	0.0	0.0	39.9	Moderate
CHP7	2016	11.0	0.0	75.0	0.0	0.0	17.2	Fair/Poor
CHP6	2016	21.6	59.8	80.0	0.0	23.5	37.0	Mod-Fair
CHP5	2016	41.8	67.1	100.0	0.0	51.1	52.0	Moderate
CHP4	2016	37.0	71.2	100.0	0.0	70.6	55.7	Moderate
CHP2	2016	41.0	64.0	100.0	0.0	33.8	47.7	Moderate
CHP1	2016	25.2	58.1	100.0	0.0	1.7	37.0	Moderate-Fair
MV14	2016	24.9	31.7	59.2	44.5	84.3	48.9	Moderate
MV15	2016	67.8	56.4	80.3	53.6	94.6	70.5	High
MV16	2016	96.0	62.7	92.3	95.8	100.0	89.3	High
FRM1	2016	17.1	54.2	92.8	49.7	100.0	62.8	High-Moderate
FRM2	2016	29.7	23.6	100.0	37.2	100.0	58.1	Moderate
FRM3	2016	42.9	6.4	100.0	15.4	90.7	51.1	Moderate

Table 10. 2016 Trophic Health Index Scores and status for water quality monitoring stations in Martha's Vineyard 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 STATION	YEAR	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	2016 EUTROPHICATION RATING
SKT2	2016	70.8	51.4	92.9	39.9	100.0	71.0	High
SKT3	2016	85.3	42.8	92.3	16.7	89.7	65.4	High-Moderate
SKT4	2016	53.2	39.9	88.2	47.2	100.0	65.7	High-Moderate
SKT5	2016	44.8	60.4	100.0	89.2	100.0	78.9	High
SKT6	2016	82.6	55.7	95.1	98.7	100.0	86.4	High
SKT8	2016	72.7	54.2	100.0	43.2	100.0	74.0	High
SKT9	2016	0.0	29.3	67.6	29.6	100.0	45.3	Moderate
FRS1	2016	72.6	65.3	100.0	19.3	100.0	71.4	High
FRS2	2016	67.6	66.8	100.0	15.6	100.0	70.0	High
FRS3	2016	74.0	66.8	100.0	26.5	100.0	73.5	High
LGP11	2016	26.9	0.0	0.0	0.0	0.0	5.4	Fair/Poor
LGP12	2016	0.0	0.0	0.0	0.0	0.0	0.0	Fair/Poor
LGP2	2016	94.0	0.0	99.8	47.4	76.2	63.5	High-Moderate
LGP4	2016	93.2	0.0	100.0	38.6	75.0	61.4	High-Moderate
LGP6	2016	80.5	6.0	76.9	67.5	100.0	66.2	High-Moderate
LGP8	2016	97.5	50.8	100.0	62.2	88.0	79.7	High
LGP9	2016	100.0	43.5	100.0	88.6	100.0	86.4	High
MV21	2016	18.8	70.0	99.3	100.0	100.0	77.6	High
MV2	2016	95.7	62.6	99.3	81.8	100.0	87.9	High
MV3	2016	87.7	59.5	100.0	74.7	100.0	84.4	High
MV4	2016	91.1	60.4	99.9	74.3	100.0	85.2	High
MVSEN	2016	74.8	53.1	88.1	33.8	57.3	61.4	High-Moderate

Table 10 cont'd. 2016 Trophic Health Index Scores and status for water quality monitoring stations in Martha's Vineyard 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).

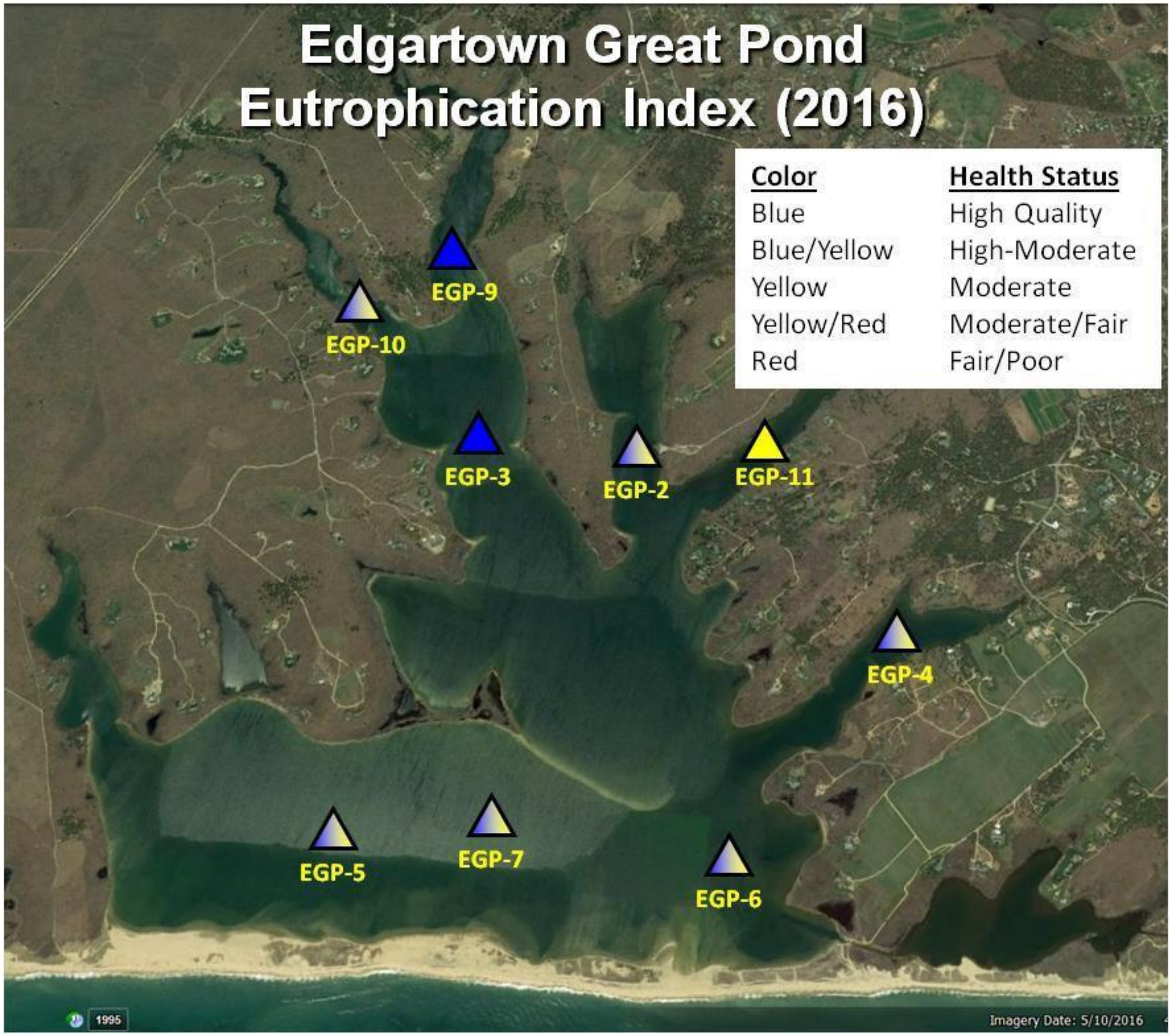


Figure 25. Edgartown Great Pond Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

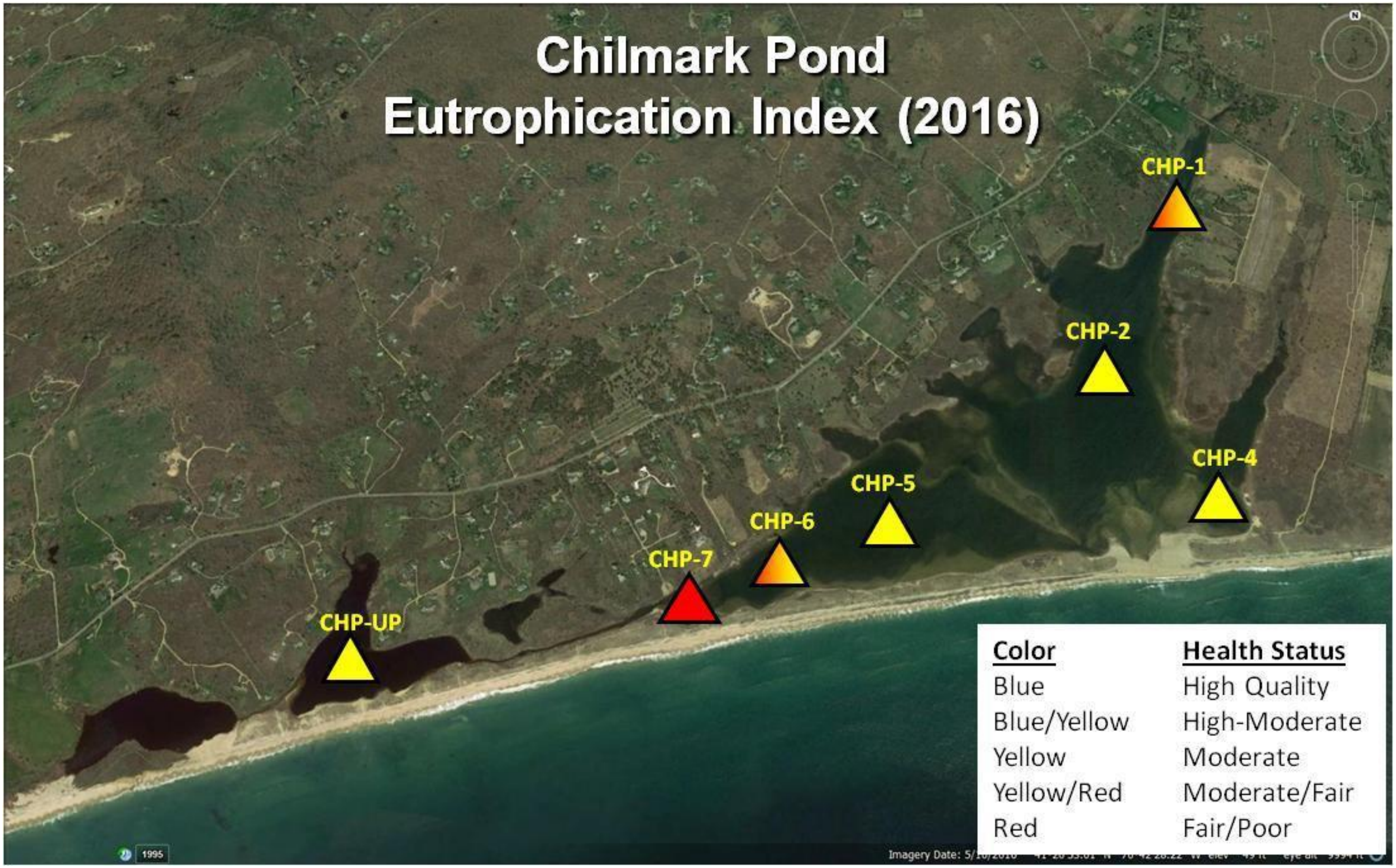


Figure 26. Chilmark Pond Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

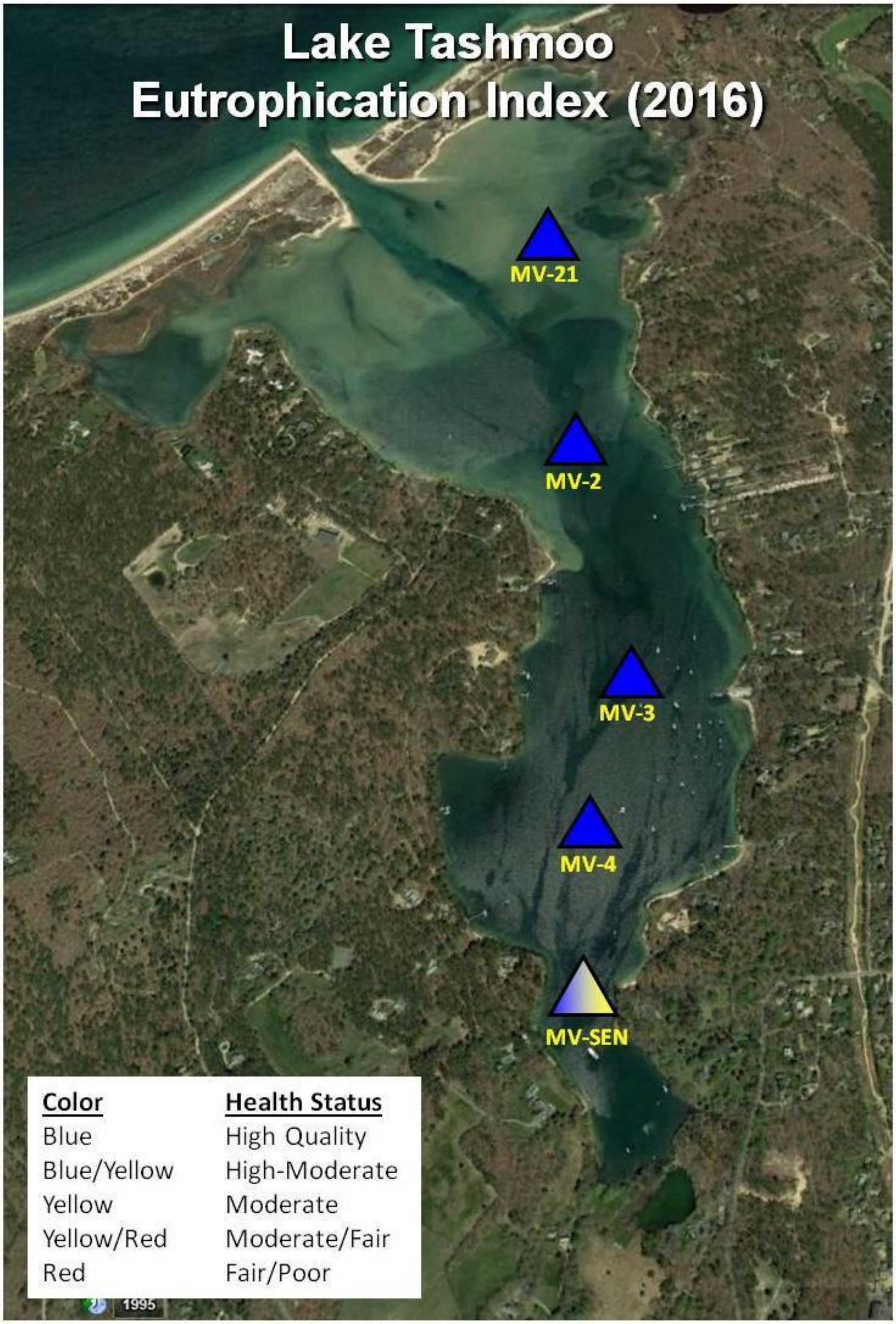


Figure 27. Lake Tashmoo Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality

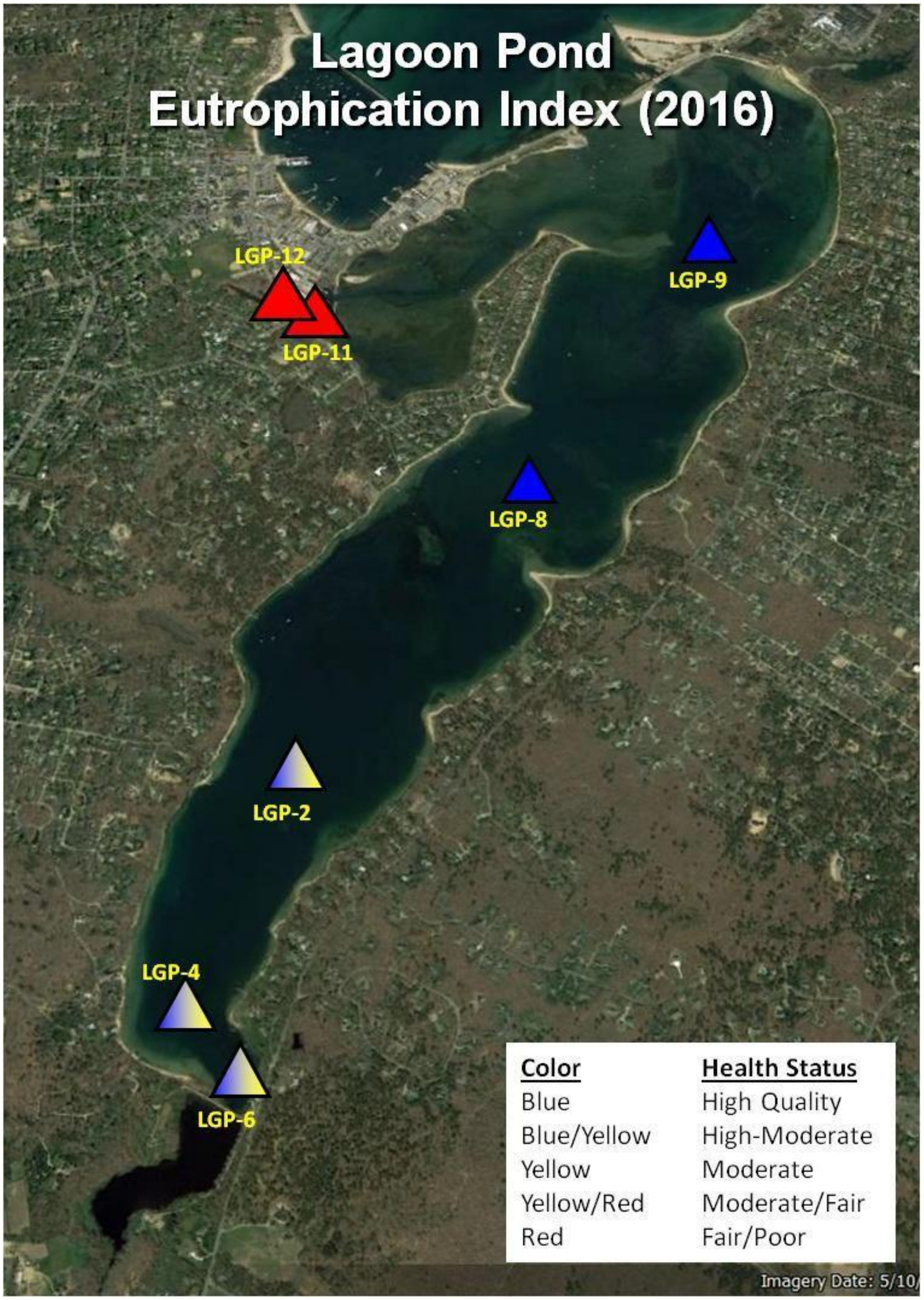


Figure 28. **Lagoon** Pond Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality

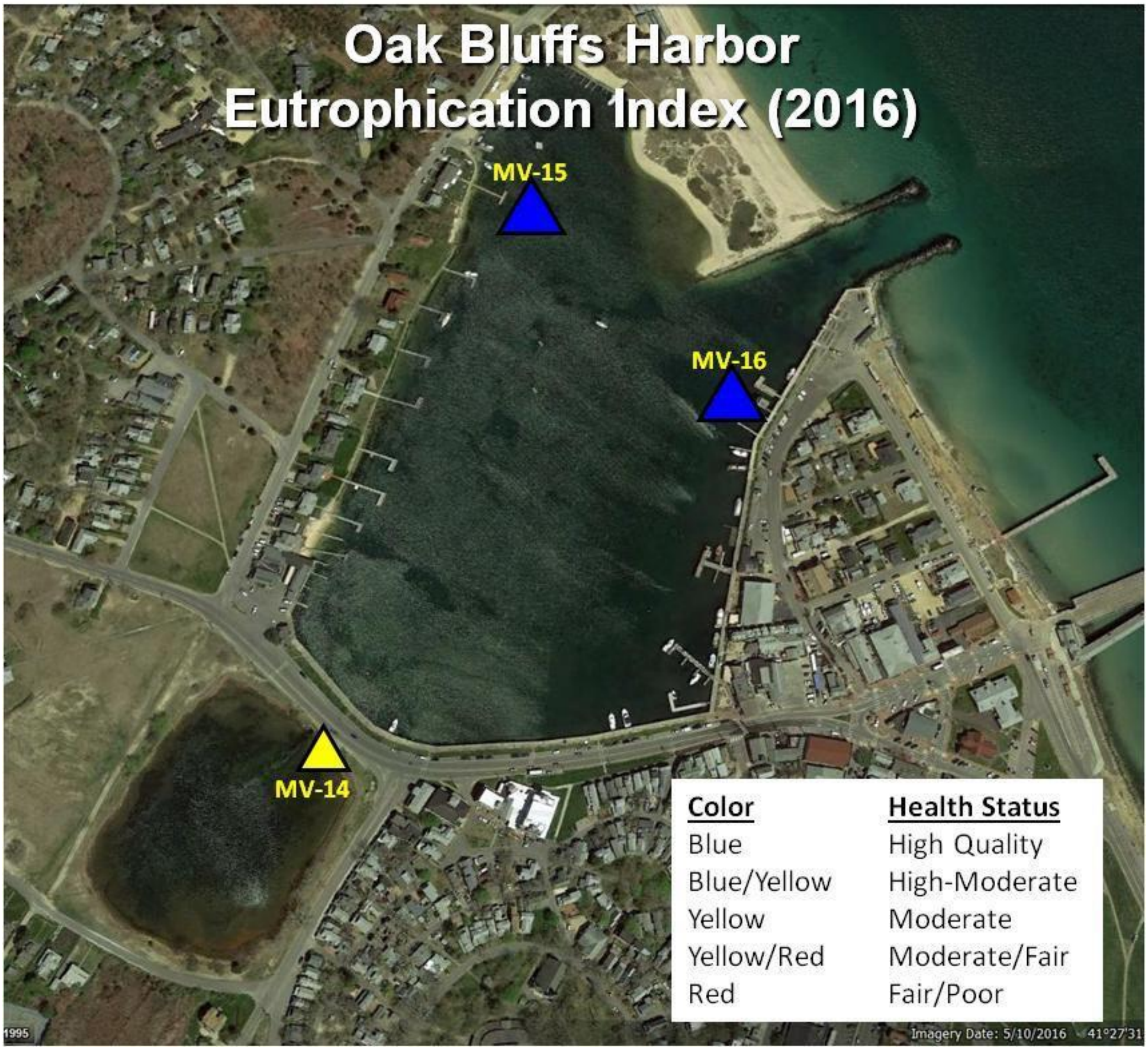


Figure 29. Oak Bluffs Harbor Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

Figure 30. Farm Pond Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

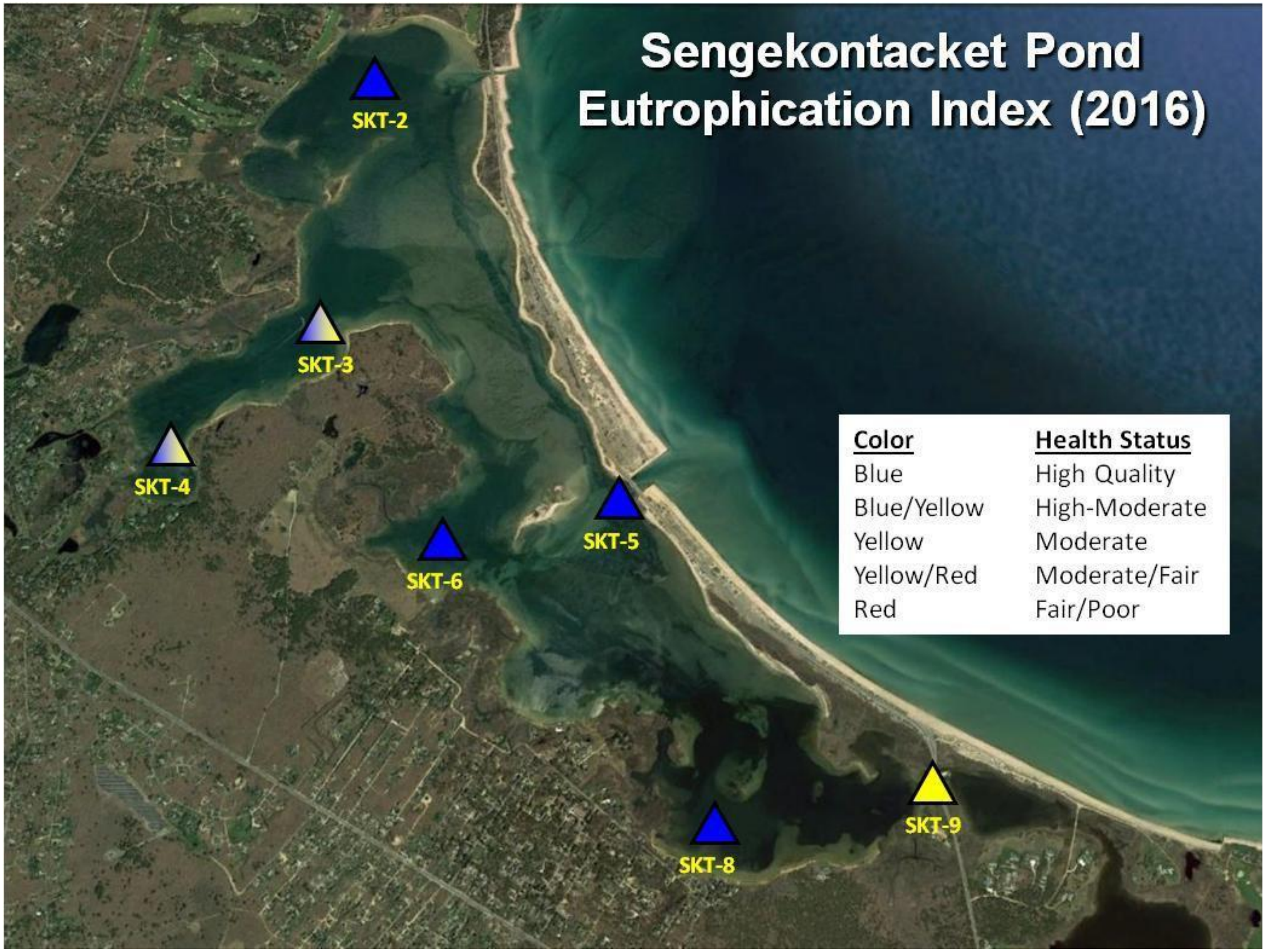


Figure 31. Sengekontacket Pond Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

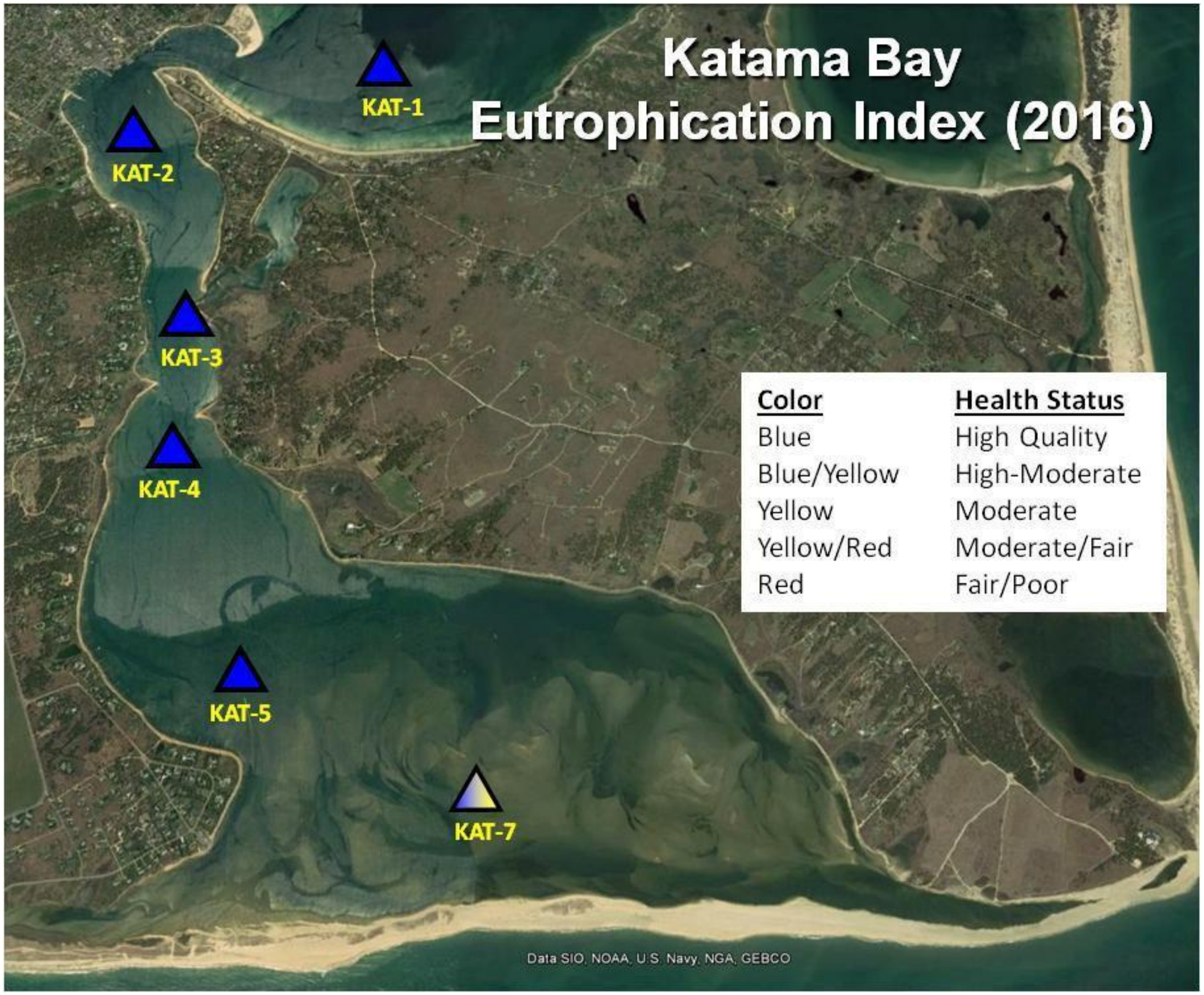


Figure 32. Katama Bay Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

Figure 33. Cape Pogue Bay Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.

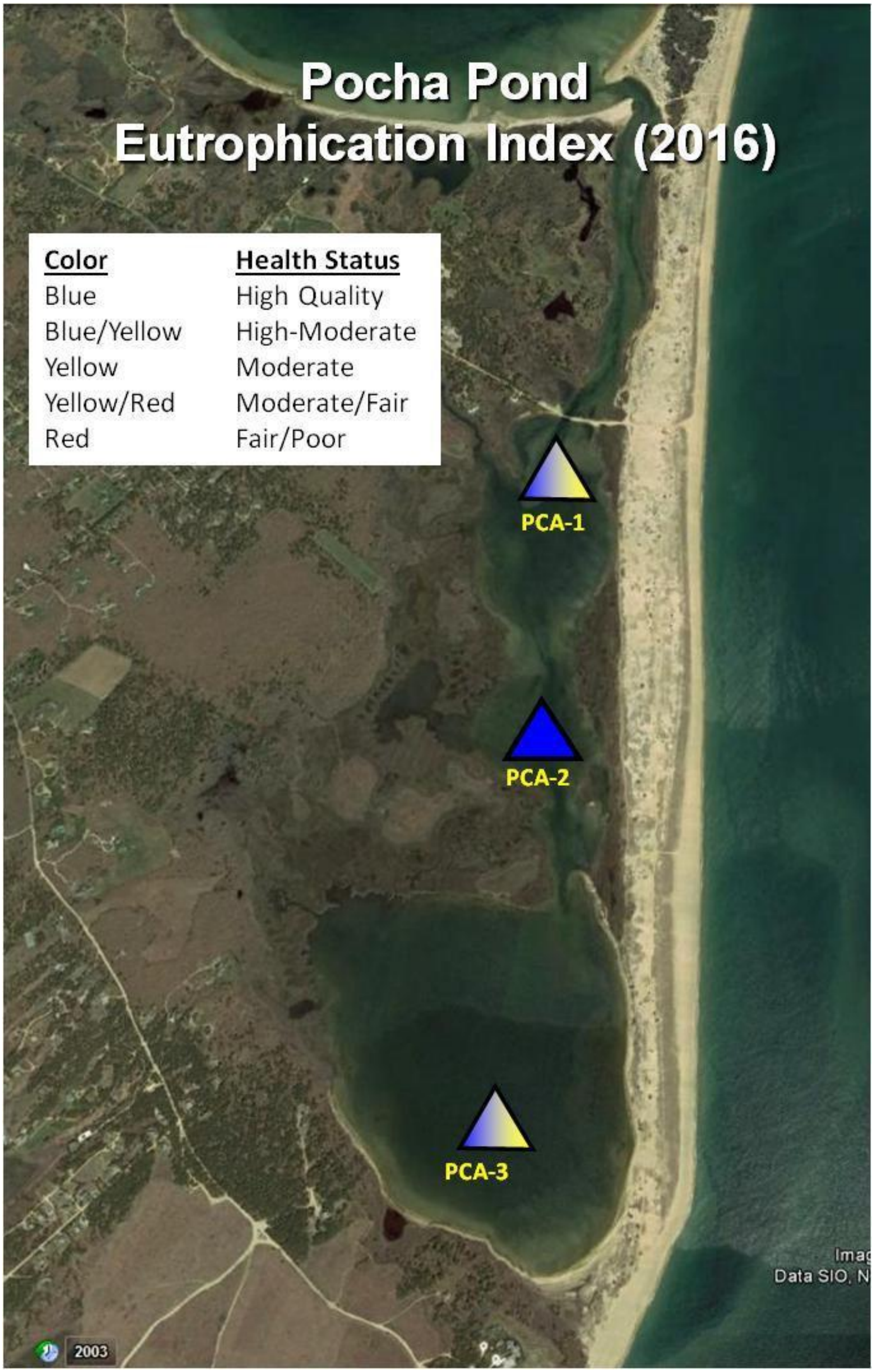


Figure 34. Pocha Pond Eutrophication Index 2016. Colors indicate High (Blue), Moderate (Yellow), Fair/Poor (Red) nutrient related water quality.