Martha's Vineyard Coastal Pond Water Quality Survey- Summer 2008 and 2009

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2008 to 2010

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PREPARED FOR:

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Executive Summary:
The primary goal of this project was to improve our water quality database for Oyster and Tisbury Great Ponds by collecting more detailed data on water quality response to the opening of these managed systems to tidal exchange. Neither system had a normal tidal phase, Oyster Pond having a shorter than usual inlet and Tisbury Great Pond a much longer than average one. The information collected will be utilized by the Commonwealth's Massachusetts Estuaries Project to better calibrate the water quality model for this system. More detailed guidance for interpreting the data is provided in the text on page 12 as well as an explanation of the use of the Buzzard's Bay rating scores.

Both Ponds are barrier beach systems that, without the excavation of regular openings to the Ocean, would go through wide swings from nearly fresh to marine as a result of storm action breaking through the beach and opening the Pond. Wide swings in salinity would prevent the system from developing into a mature equilibrium within either extreme. Pond managers open the ponds 3 or 4 times over the year, producing salinity that varies from 10 to 28 parts per thousand, suited to oysters, blue crabs and alewives. Typically the ponds remain tidal for 5 to 15 days. About 10 days are needed to exchange 95% of the nutrient enriched pond water for Atlantic Ocean water. During July 2008, the Oyster Pond opening only remained open for two days that was inadequate for substantial tidal flushing. In general, water quality was in the Marginal category over the summer sampling period (see page 12 for definition of terms). A total of 30 samples, including 6 blind duplicate samples to assess data accuracy, were collected over the period from July through September. During 2009, Tisbury Great Pond remained open from April 9 through September 5. The resulting water quality was Acceptable. During 2009, 55 samples, including 7 blind duplicate samples, were collected from April through October.

Table 1 shows the number of pond systems that have been sampled over the years. In order to qualify for Massachusetts Estuaries Project entry, three years of sampling are required. Analyses for all samples were by a laboratory under the supervision of Dr. Brian Howes either at Woods Hole Oceanographic (1995 through 1997) or at the UMass Center for Marine Science and Technology. Funding for the testing programs came from a large number of sources including the Edey Foundation, DEP 604(b), the Riparian Owners of Tisbury Great Pond, the Great Pond Foundation, the Friends of Sengekontacket, the Wampanoag Tribe of Aquinnah, the Lagoon Pond Association, the DEM Clean Lakes Program, Tisbury Waterways, MV Shellfish Group, MV Commission and the Towns of Edgartown, Tisbury and Oak Bluffs Shellfish Departments. The actual sampling was assisted by numerous student interns, the Town Shellfish Wardens, in particular Dave Grunden, Oak Bluffs, and Paul Bagnall, Edgartown and volunteers who provided valuable assistance without which this dataset would not be as substantial as it is.

Table 1: Pond Systems Sampled Showing Number of Stations and Number of Sample Rounds in Parentheses

Pond System	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cape Poge/Pocha									8	8	8	2 (3)			
Katama Bay											9	9	9		3 (2)
Sengekontacket	9	12	5 (2)						9	9	9	9	9 (2)	9	9
Farm									3	3	3	3			3 (2)
Oak Bluffs Harbor							4		4 (3)	4	5 (6)	5	5		
Lagoon	8	12			8 (2)			7		6	6 (6)	5	6		
Tashmoo							5		6	8	7 (6)	7	6		
James									5 (2)		5	6	6		
Menemsha	9				10 (2)				10						
Squibnocket	4				4 (2)				4						
Chilmark Pond					8 (3)	10 (2)			7	7	7 (3)				
Tisbury Great Pond	5		4		6	4	5	5	6	6	6 (3)	6 (3)	7		7 (7)
Oyster Pond	3		3								4	4	4	4 (6)	
Edgartown Great Pond	6		6			6(3)	6	6	7	10		7 (1)	8	6	6 (5)

NOTES:

Number in parentheses is the number of sampling rounds if other than 4 rounds were collected.

Light shaded entries indicate SMAST sampling program.

Entries with white Font were funded by the 604-B program.

Record shown is not complete for Menemsha and Squibnocket sampled by Wampanoag Tribe. There are additional years with analyses.

Pond System Descriptions:

Oyster Pond:

Oyster Pond is a 200-acre south shore pond, separated by a barrier beach from the Atlantic Ocean. The watershed contributing groundwater is near 3,000 acres in area. Typically, it is only tidal for relatively short periods of time following a cut through the barrier beach. During the drain down period the pond drops approximately 4 feet before becoming tidal for a period ranging from less than one week up to a month. During the drain down, the water near the north end of the system becomes very fresh from groundwater discharge that is focused at the head of the pond. This can set up a strong horizontal salinity gradient and, under the right wind conditions, vertical stratification can become well established.

Water quality samples were collected from a number of Vineyard Ponds including Oyster Pond in 1995 (Wilcox, 1999). Data indicate that during that time, the northern end of the Pond was phosphorus limited (dissolved inorganic nitrogen to orthophosphate ratio well over 16). Over the same time frame, the sampling station in the middle of the north-south length of the Pond was generally nitrogen limited. At this station, specific conductivity rose to 25 to 30 milli-Seimens from mid-July to mid-August in response to a June inlet to the ocean and then declined to about 15 mS as the inlet closed and the system freshened. Chlorophyll pigment content, indicating the amount of phytoplankton in the water column, was always less than 6 micrograms per liter.

During 2005, the total organic nitrogen concentration averaged between 0.42 and 0.46 parts per million, above the desired target for eelgrass health of 0.38 ppm but within recently suggested limits of 0.5 ppm for habitat quality in Edgartown Great Pond (Brian Howes et al, Massachusetts Estuaries Project, 2007). Chlorophyll pigments were also elevated above the desired goal, varying from 7.2 to 7.5 parts per billion (ppb) in the southern half of the system and up to 16.2 ppb at the northernmost station indicating abundant chlorophyll bearing microscopic plankton. Dissolved inorganic nitrogen showed a similar pattern, ranging from 0.6 to 1.3 micromoles per liter at the south end up to 3.2 at the northern station. The ratio of inorganic nitrogen to phosphorus shows a nitrogen limitation in the southern half of the system at all times, whether open to the ocean or not. The stations at the northern half of the system are variable, being phosphorus limited when that end of the pond is fresh and nitrogen limited when it is more saline as indicated by the ratio of the inorganic nitrogen to orthophosphate. Water quality during 2005 was near the Undesirable rating depending on station location and timing relative to the inlet to the ocean closing.

In 2006, Total Organic Nitrogen averaged 0.49 milligrams per liter (ppm) across all sampling stations over the course of the sampling period. This exceeds the target goal of around 0.4 ppm for eelgrass, meets the 0.5 ppm guidance for Edgartown Great Pond (MEP Draft 2007) and is below the zero score value of 0.6 ppm as in the Buzzard's Bay water quality rating system. During the same time period, the average value for total pigments (chlorophyll plus phaeo-pigments) was 7.99 micrograms per liter (ppb). The pigment concentration was lowest at the sample station furthest south and highest to the north. The concentrations exceeded the target of

6 ppb at all stations on all dates except for August 1. During the sampling period, water quality fell into the Marginal category.

The Pond was tidal in the spring of 2007 well before the sampling program but was closed to the Atlantic throughout the sampling period. This resulted in moderate horizontal (from station to station) as well as vertical stratification at stations OYS 2 and 3 during the first half of the sampling program. The vertical stratification remained in place during early August but decreased over the sampling program as the system was closed to the Ocean. The lack of tidal exchange and flushing is directly related to poor water quality. Parameters exceeded the maximum goal for both Total Organic Nitrogen and Total Pigments. Water quality was Undesirable over the time period of the sampling program.

During 2008, sampling was scheduled around an opening on July 10. Summer openings are often less successful than the spring openings as the reduced freshwater recharge often fails to raise the pond as high. Less head is a factor in the lifetime of the inlets through the barrier beach in the south shore great ponds. Sample stations are numbered 1 to 4 from north to south in this system (see Figure A2, Appendix 2, page 53). From a simplistic perspective, station 1 represents the freshest part of the estuary, station 2 is transition and 3 and 4 have a greater likelihood of being more marine when the system is open to the ocean. However, typically the system becomes fairly well mixed by wind after it has been closed to the ocean for a short period of time. For example, stratification that formed with the July 10 opening had dissipated by the August 12 sampling round. Water quality during 2008 was Marginal despite the brief tidal exchange.

Tisbury Great Pond:
Tisbury Great Pond is a south shore coastal salt pond similar to Oyster Pond with the exception of two substantial streams that flow into the northern Coves and a much larger watershed (approaching 11,000 acres). The Tiasquam and the Mill Brook contribute an estimated 200 to 400 million cubic feet per year depending on preceding and current year precipitation (Healy, personal communication). These figures are being updated and refined by the Massachusetts Estuaries Project.

The Pond has been productive in oysters, blue claw crabs and occasionally soft shell clams in the past. The oyster disease dermo had decimated the crop and the 2006/2007 harvest was the first in two years. Efforts are underway to restock the Pond with disease resistant oysters and a substantial crop was in the Pond by 2009. The soft shell clams often do not reach marketable size in significant numbers possibly due to salinity variations and or the high water temperatures that develop in the shallows of the tidal flats. The Pond also has a small herring run. Based on field observations, there is no eelgrass in the Pond at this time.

As a result large watershed, fresh water influx from both groundwater and streams is able to raise the pond when it is closed to the ocean by outpacing seepage loss through the barrier beach to the ocean. The excess inflow allows pond managers to bring the Pond to significantly higher elevation prior to opening the system to the ocean compared to managers of the other ponds.

Compare the starting elevation of about 4.5 feet for Oyster Pond and near 5.6 feet for Tisbury Great Pond. The outrush of water cuts a deep channel through the beach and pushes the sand far offshore. It appears that, at least in part because of this, the pond has longer duration openings (often 40 to 60% of the year for the 3 openings). Once open to the ocean the initial tide range is 12 inches or less that declines as the channel through the beach shoals. Circulation in the system is sluggish except for the area near the inlet through the barrier beach.

MVC personnel have sampled the Pond since 1995 using the same procedures and lab to obtain the same parameters as for the other ponds. Due to the changing tidal connection, the parameters measured vary widely. Typically when the Pond is first opened to the sea all coves become fresher. As the salt wedge works its way into the system, strong stratification often develops and may persist for several days at station TGP4 and sometimes at TGP3 and TGP6. Typically dissolved organic nitrogen concentration is high at the stations nearer to the stream inflow (TGP1 and TGP2) and total organic nitrogen averages from 0.4 milligrams per liter (mg/l or ppm) at the higher quality areas to over 1 mg/l at the poorer quality stations. In addition, inorganic nitrogen can be high in the coves particularly as they freshen.

Samples collected from this system will be labeled with the identifier "TGP" and include the following:

- TGP1 At the pier on the west side of Town Cove where there is significant influence from the Mill Brook inflow.
- TGP2 This identifier was assigned to a blind duplicate sample
- TGP3 Pear Tree Cove just below the junction with Muddy Cove
- TGP4 Mid Pond just south of Pear Tree Cove
- TGP5 Tiah's Cove north of first sand bar restriction
- TGP6 Mid way into Deep Bottom Cove
- TGP7 North of the usual location of the inlet through the barrier beach
- TGP8 At the outlet from Black Point Pond

See Figure A1 in Appendix 2, page 51, for locations.

During 2006, three sample rounds indicate that Total Organic Nitrogen concentration remained below 0.5 ppm. This value would be very near the suggested goal for Total Nitrogen of 0.5 ppm in Edgartown Great Pond (Howes et al, 2007). Total pigment concentration was generally at or below the 10 parts per billion (micrograms per liter or ppb) zero-score level identified by the Buzzard's Bay Project (see page 11 for discussion). For the calendar 2006 year, the system was cut open to the ocean 5 times and remained tidal for approximately 25% of the year. Openings were made on May 22 that remained open for about 1 month and from August 22 to September 9. Overall water quality was acceptable during the sampling period.

During 2007, except for Station 4, Total Organic Nitrogen concentration was at or below the 0.6 ppm zero-score value. Total pigment concentration often exceeded the 10 ppb zero-score concentration particularly in the northern Cove stations 1 through 4. Concentrations were lower at stations in the main body of the Pond and in Deep Bottom Cove (6 through 8). This may reflect the success of system openings to the ocean that resulted in a tidal system 47% of the time between January 1 and August 1. This period included an opening cut on July 19 for only a few days. Overall water quality was marginal during the sampling period.

During 2008, the system was opened prior to the start date for this project and either remained open or did not have enough head to reopen through the fall. Samples were not collected.

In 2009 the Pond was opened on April 9 and remained tidal until September 5, a period of 149 days. This was one of the longest lasting openings to the system since records have been kept starting in 1993 (Healy, personal communication). Water quality was acceptable.

Methodology:
The Sampling and Analysis Plan was revised and samples were collected, handled and processed accordingly (MVC, 2008 see Appendix 2). Samples were collected from a water depth of 8 to 12 inches unless otherwise noted. Field parameters were measured with an YSI-85 meter included dissolved oxygen saturation, specific conductivity, temperature and salinity. These parameters were collected at regular intervals of 0.5 or 1.0 meter depending on depth to the bottom. The deep reading was typically collected at approximately 0.5 meters above the sediment surface. A depth-sounding device was used to determine total depth before data collection with the YSI meter to avoid inadvertent contact with the sediment stirring up a silt and organic-matter cloud. Water column transparency was measured with a standard 8-inch diameter Secchi disk with black and white quadrants. Extinction depth was measured over the shaded side of the boat both on the way down and on the return. Station locations were fixed with a Trimble Pathfinder or Geo-XH GPS unit and by means of landmarks (often distinctive houses or piers) on shore and distance estimates to the shore.

Samples were collected in 1-liter dark HDPE bottles and placed in a cooler on ice. Upon returning from the sampling round, samples were filtered for particulate organic matter and chlorophyll pigment analyses following methods outlined in the SMAST QA Plan. They were typically shipped out the same day by MV Fast Ferry or transferred directly to the SMAST boat that was sampling on the Vineyard for the return trip to the lab. Sample collection, handling and processing and field data collection are more fully described in Appendix 2.

Lab and field data was evaluated for five parameters considered to provide insights into pond water quality. These include dissolved oxygen saturation, Secchi depth, Dissolved Inorganic Nitrogen (DIN), Total Organic Nitrogen (TON) and total pigment concentration (chlorophyll and phaeopigment).

Sample station locations are shown in Figures A1 and A2 included in the Sampling Plan in Appendix 2, pages 52 and 54.

Water Quality Framework:
The term "eutrophication" is generally associated with an increase in productivity (the cycling of carbon into living matter) and high concentrations of nutrients (Wetzel, 1983). The term was devised to indicate the extreme end of a range of conditions in lakes from clear and unproductive

to excessively productive on the eutrophic end. Eutrophication in marine waters is characterized by a number of conditions that are undesirable from the human use perspective. These include excess microscopic phytoplankton, sometimes abundant larger aquatic plants (wrack algae), low oxygen levels in the water sometimes to the point of causing a die off of animals, a reduction in the number of species living in the system with a shift from filter feeders (scallops and clams) to detritus feeders like snails and, under extreme conditions, burrowing worms. The eutrophic state can develop under natural conditions where nutrients released from the surrounding uplands enter the pond in quantities that are not flushed out quickly enough and stimulate excessive productivity. The process is hastened by man made nutrients that are released in concentrations far in excess of the natural processes. These nutrients are released from development in the watershed by runoff of stormwater, erosion of soil from farmland, disposal of sewage by septic systems or by treatment facilities and by fertilizers applied to farmland and landscaping. The nutrients are also added from outside the watershed by acid rain that is contaminated through the stack emissions of power plants, manufacturing processes and auto exhaust.

One nutrient that all of these activities release and which is required for plant growth is nitrogen. The other major nutrients required for growth of phytoplankton and algae include phosphorus, carbon, hydrogen and oxygen. Generally, the last three are sufficiently available in coastal waters so that they do not hinder growth of these aquatic plants. In phytoplankton, nitrogen and phosphorus are required in the approximate ratio of 16 to 1 (Redfield, 1963). While other less important nutrients may also affect growth rates, these two are of primary importance and, by their availability alone, usually determine the amount of growth of biomass in the system. In ocean waters, nitrogen is the deficient nutrient and phosphorus is usually present in sufficient quantities for growth of phytoplankton (Valiela, 1995). For this reason, marine waters are often described as being nitrogen limited. This means, if nitrogen is added to the water, phytoplankton can reproduce to take advantage of the supply and the amount of organisms in the water column can increase until once again limited by availability of nitrogen or another necessary nutrient.

While some increase in the phytoplankton population is not necessarily a problem, with enough nutrients, the population can explode. High populations of phytoplankton (often called an algae bloom) cloud the water reducing light transmission. In large numbers, overnight oxygen uptake by these living organisms or the die off and decay of phytoplankton can reduce oxygen levels to the point where other organisms are stressed or killed. This may have occurred in Edgartown Great Pond in 1993, when the oyster population died out following a late summer algae bloom. In James Pond in 2003, a 5 acre raft of windblown algae accumulated in the northeast corner of the system in August following an inlet and generating strong odors and low dissolved oxygen saturation.

Reduced light penetration limits the vigor of eelgrass that requires sunlight, as does any green plant. Eelgrass is an important component of the ecosystem providing cover for bait fish, scallops, tautog, blue crabs and eels as well as food and a substrate for the growth of a myriad of aquatic plants and animals. It also acts as a sediment stabilizer through its dense root system. While the available light level limits the potential success of eelgrass, both phytoplankton and large macro-algae (wrack algae) are typically limited by the availability of nutrients rather than light (Valiela, 1995). In coastal salt ponds, common wrack algae include *Ulva*, *Enteromorpha* and *Cladophora*. The differing growth limitations set up a situation where, as nutrients are added to the system, phytoplankton and wrack algae increase, reduce the light penetrating to the bottom and cause a decline of eelgrass which may eventually be replaced entirely by macro-algae. The wrack algae however do not fill the role that eelgrass plays as a key component of the shallow, marine habitats. The macro-algae also tend to break loose late in the season or after a storm and gather into large mats which may smother desirable, filter feeding shellfish such as clams, scallops and oysters, encourage detritus (debris) feeders such as snails and, when severe, anoxia (lack of oxygen), aquatic animal die off and odors.

Nutrient stimulation of phytoplankton blooms also reduces available light to the eelgrass beds at the bottom particularly where the water depth is 2 or more meters. Nutrients also increase the growth of single cell and chain algae (e. g. diatoms) that grow on the surface of the eelgrass blades further blocking the sun light. Reduced light may stress the eelgrass making it more susceptible to wasting disease or may just reduce its vigor and lead to thinning of the eelgrass and eventual loss of entire beds over time.

Numerous studies of coastal ponds by researchers have concluded that nitrogen loading from shoreline development may have adverse impacts on these waters. Waquoit Bay, Cape Cod, has been thoroughly studied over 30 years (Valiela et al 1990). It is a coastal pond with a fixed inlet through a barrier beach. As residential land use increased in the recharge area, the pond has steadily lost formerly extensive eelgrass beds. The loss was attributed primarily to nutrient loading from septic systems in the watershed (Kennish, 1996).

In many situations, the addition of nitrogen to our coastal ponds will lead to undesirable consequences if it exceeds a threshold known as the loading limit. Interim loading limits have been determined by the MV Commission but establishing final limits is the goal of the Massachusetts Estuaries Project. We should be very concerned at what the future nitrogen loading of the recharge area may do to our ponds. Once the recharge area is built out, it will take 20 years or more for the system to reach equilibrium and for the full effect of the nitrogen loading to appear in the pond to which the recharge area contributes groundwater. If the "effect" on the pond is undesirable, changes made to reduce nitrogen loading further back in the recharge area will take another 20 years or more to reach the pond and reverse the negative impacts. For this reason, we need to make every effort to anticipate possible impacts with a conservative limit on nitrogen loading within the watershed recharge area.

Water Column Parameters:

There are key chemical and physical measures that are indicators of the condition of a water body under study. When collected over time, these measures can identify the trophic state of the system. The trophic state of a coastal pond is a descriptive term that indicates the amount of biomass production in the system. The most familiar trophic state is the eutrophic condition that indicates excessive biomass production. Field and lab data are included in Appendix 1.

The measures discussed here include **chlorophyll pigment(s)** that are an indicator of the microscopic algae population in the water column. The depth at which the Secchi disk can no longer be seen is the **extinction depth** and indicates the amount of light penetration through the water column. The amount of **dissolved oxygen** is a fundamental necessity for the animals living in a pond. It is affected by the algae population but also by the amount of organic matter that is decaying in the pond. The amount of **nitrogen** in the water column indicates whether a system is over- productive and if the nitrogen input from the watershed is excessive.

Although there are many other approaches to characterizing the condition of a pond including population studies of the benthic organisms, distribution and amount of aquatic plants and fish population, these parameters have not yet been evaluated. In examining the data presented for each pond, the rating system devised by the Buzzard's Bay Program (Costa et al, 1996) is helpful. The ratings are summarized in Table 1. The lab analyses data is included in spreadsheet form in Appendix 1.

Table 2: Buzzard's Bay Eutrophication Index (Costa et al, 1996)

Parameter	Zero Score	Perfect Score
Oxygen Saturation (lowest 1/3 observed)	40% saturation or less	90% saturation or more
Transparency (Secchi disk)	0.6 meters or less	3 meters or more
Phytoplankton **pigments**	10 parts per billion or more	3 ppb or less
Dissolved inorganic nitrogen (DIN)	10 micromolar (0.14 ppm) or more	1 micromolar or less
Total organic nitrogen (TON)	0.6 ppm or more	0.28 ppm or less

In the discussion that follows, "Undesirable" water quality means that most parameters at most stations are at unacceptable levels during much of the sampling period. "Marginal" water quality means that at some stations, parameters are at acceptable levels at some times and unacceptable at others. "Acceptable" means that the parameters are generally at or better than the undesirable levels. "Good" water quality means that the system is most always at acceptable levels. These labels are for public outreach purposes and not meant to be precise descriptions of the systems and it should be kept in mind that these parameters will vary from year to year.

In reviewing the charts, we suggest that you use the following ***desirable*** goals for water quality:

- ❖ Maintain ratings that are over 60% of the perfect score value for Dissolved Oxygen saturation (i.e. over 54%) and Secchi depth (over 1.8 meters) **and**
- ❖ Less than 60% of the zero score value for pigments, DIN (less than 6 micromoles/liter) and TON (0.38 parts per million) for the growing season.

NOTE ON NITROGEN INDICATORS:
In the recently released Massachusetts Estuaries Project Edgartown Great Pond, Total Nitrogen (TN) is used as an indicator of system quality rather than Total Organic Nitrogen (TON). The recommended target Total Nitrogen concentration to maintain acceptable quality habitat in Edgartown Great Pond is at or below 0.5 milligrams per liter (Howes et al, 2007). This concentration would score low on the Buzzard's Bay rating system. In this report, we continue to use TON as the standard not only for consistency with previous reports but also because TON comprises well over 90% of TN. The addition of dissolved inorganic nitrogen to TON adds very little to the rating system at sample stations where the salinity is over 10 parts per thousand.

CAVEAT: The application of any rating system to such a diverse group of ponds is prone to misinterpretation. The caveat to the text that follows is that these ratings will change as the amount of specific information we have increases. The ratings may also change from year to year depending on weather, the temperature of the offshore water and other factors not known at this time. The rating system will be refined specifically for each pond during the Massachusetts Estuaries Project study of these systems.

Oyster Pond:

Oyster Pond is a south shore great pond that is breached to the Atlantic 2 to 4 times each year as are the others (Edgartown Great, Tisbury Great and Chilmark ponds). It may remain tidal from a few days to a few months depending on the wind direction and velocity as it determines wave action along the south shore. The Pond is approximately 200 acres in area. It is believed to be a drowned, post-glacial erosional valley, cut by sediment sapping by springs fed by melting glacial ice and a meltwater lake located in Vineyard Sound. It is elongate in the north-south direction and the northern portion is separated into two basins by subsurface sand bars that bisect the Pond. Sample stations are shown in Figure A2 in Appendix 2 on page 53.

In 2008, the goal was to sample around an opening to the pond to assess the changes in nitrogen, chlorophyll, salinity and other water quality parameters. This data when combined with a pond level dataset will allow Massachusetts Estuaries Program scientists to model the response of the system to drain down and tidal exchange.

The opening was made just after the beginning of a neap tidal cycle that has been found from an examination of Edgartown Great Pond data to produce a short-lived tidal opening to the ocean (Wilcox, 2009). It is difficult at times to get excavation equipment out in a timely fashion and the opening to the ocean closed about 2 days after it was cut.

A Global water WL-15 water level logger was placed in the Pond at the southeast corner in about 4 feet of water following sample collection on July 8. The gauge was set to record the water level over the pressure transducer at 10 minute intervals. The record from this dataset is plotted in Figure 1. The vertical markers are for mid-night of the date indicated. The Pond opening was cut through the barrier beach at approximately 11:00 on July 10. From this record, it appears that only 4 high tides can clearly be identified indicating that, after the drain down, the pond experienced two days of tidal exchange.

Without a bathymetric survey it is not clear exactly what portion of the total pond volume was removed. An approximation of the depth distribution indicates the average depth to be about 6.5 feet at high pond (high pond average depth for Edgartown Great Pond averages 4 feet as per Gaines, 1993 and Tisbury Great Pond 8.1 feet, as per Fugro-McClelland, Inc. (1992). The drain down volume is near 54% of the starting pond volume and is estimated to be 24 million cubic feet. With an average total nitrogen content of 0.5 milligrams per liter (see Figure 5), the discharge carried with it about 340 kilograms of nitrogen.

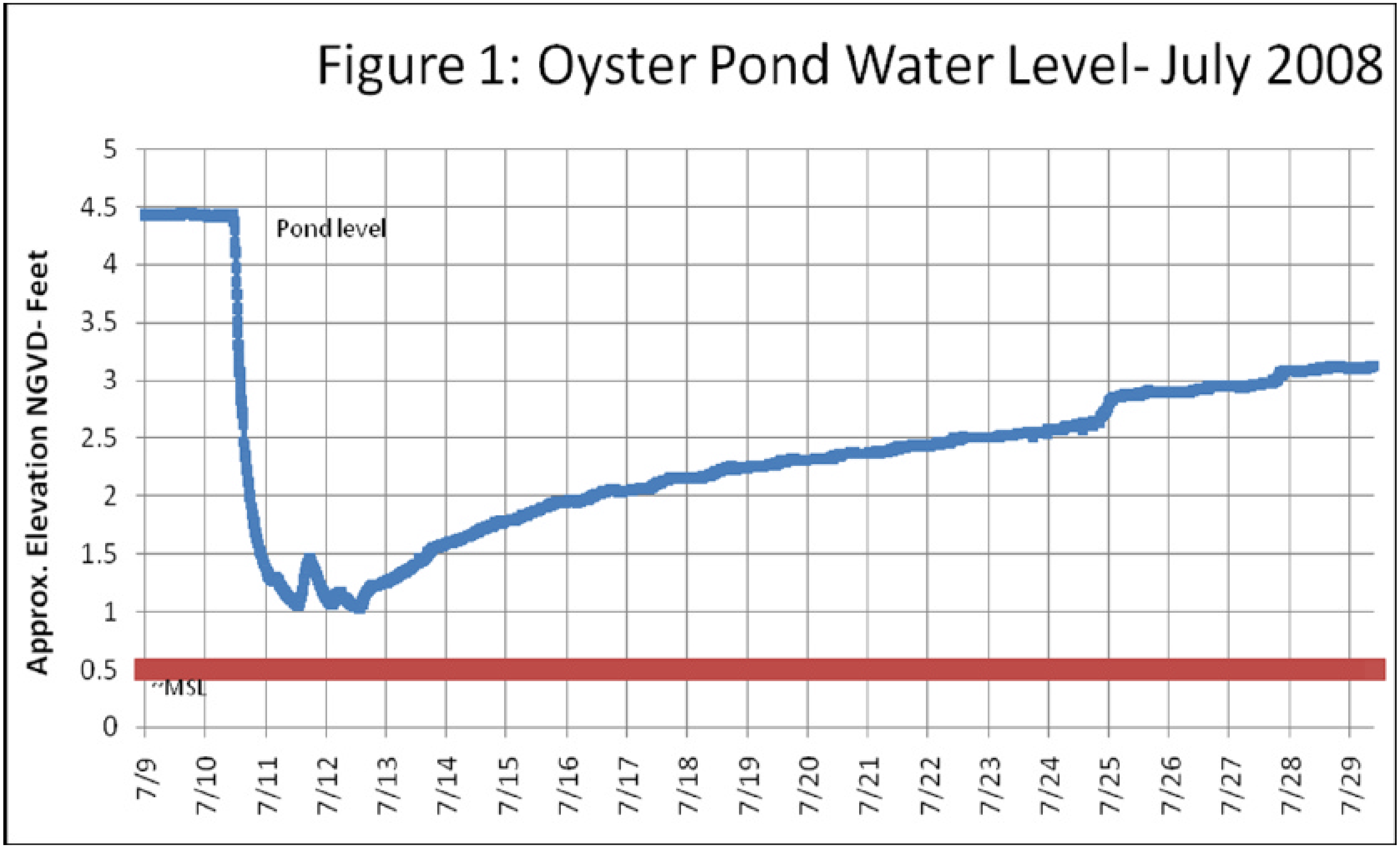


Figure 1: Oyster Pond Water Level- July 2008
Approx. Elevation NGVD- Feet
Pond level
~MSL
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
7/9
7/10
7/11
7/12
7/13
7/14
7/15
7/16
7/17
7/18
7/19
7/20
7/21
7/22
7/23
7/24
7/25
7/26
7/27
7/28
7/29

Following closure, Pond level continued to rise gradually from 1.5 feet to finish at about 3.85 feet NGVD on September 9. The rise was at an average daily rate of 0.04 feet per day over the 58 day period. Factors controlling the rate of rise include direct rainfall on the pond, runoff, groundwater inflow, evaporative loss and seepage loss through the barrier beach. A rainfall event recorded in Edgartown (Lovewell, personal communication) deposited 0.27 inches by the morning of July 24 and another 2.47 inches by the morning of July 25. There is a clear response in the pond level during the evening of July 24. The pond level increases from 2.6 feet to 2.9 feet or a net rise of 3.6 inches reflecting direct precipitation plus runoff and on-going groundwater input. The fact that a rainfall of about 2.74 inches contributed to a 3.6 inch water level increase over that 2 day period indicates that direct rainfall plus runoff increased pond level at a rate that exceeded the negative factors (seepage and evaporative loss) by about 0.86 inches. Over the course of the project, the rainfall record was as shown in Table 3.

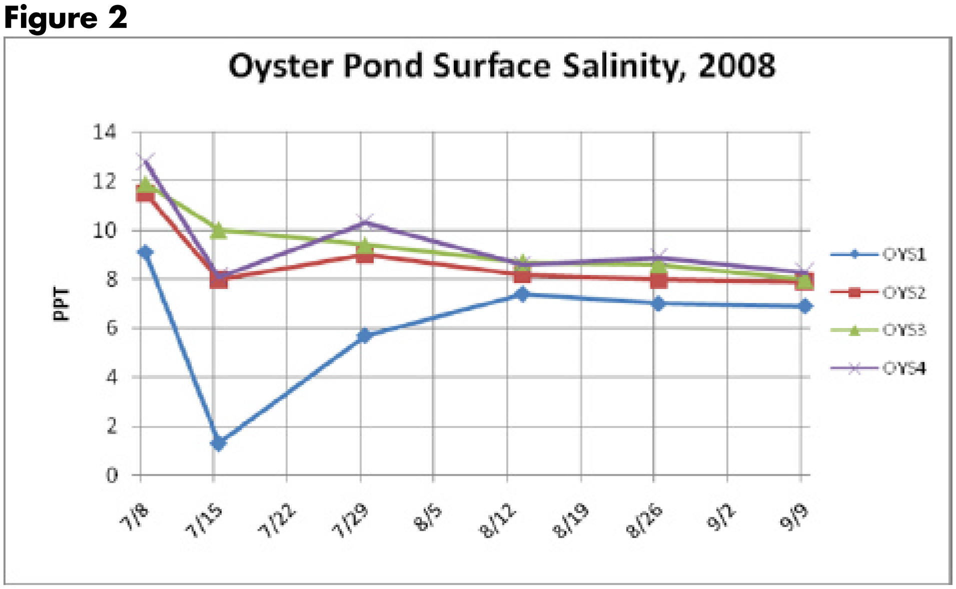
Table 3: Precipitation Record During the Study Period

Month	Precipitation- inches	Average Precipitation- inches
July 2008	4.15	2.63
August 2008	1.73	4.43
September 1 to 9 2008	0.88	NA

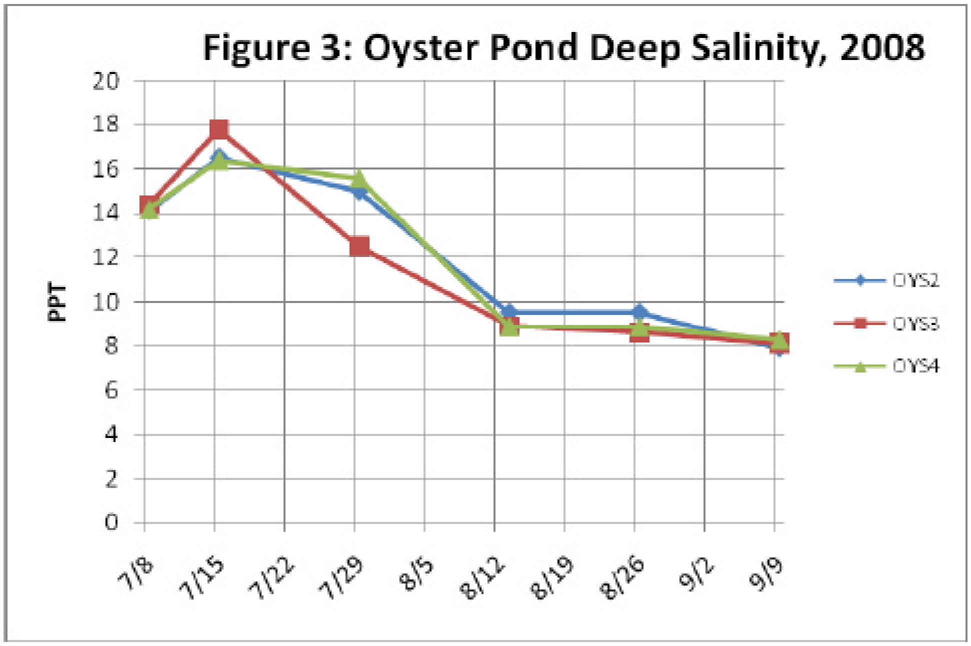
Source: Mark Lovewell, National Weather service Observer

Surface water salinity shows some horizontal stratification with station OYS1 at the northern end furthest from the inlet being the freshest and station OYS4 at the south end being saltiest. Salinity decreased initially following the opening due to an influx of fresh water from standing water in fringing wetlands at the north end of the Pond and from increased groundwater input into a lowered discharge elevation that was suddenly 3.5 feet lower than it had been. The salinity in Figure 2 decreases by 2 to 5 PPT at stations 2, 3 and 4 and by 8 PPT at station OYS1 at the northern end of the system. Fresh water tends to float in a brackish pond until wind mixing raises the salinity and samples collected at 8 to 12 inches are more influenced by fresh water than are deeper samples.

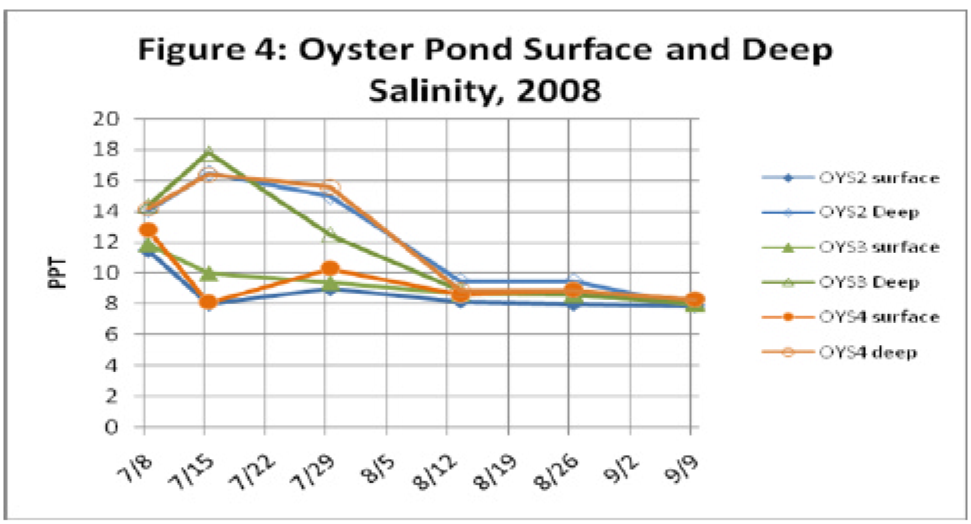
Figure 2



In the deeper water, the salinity increases in response to tidal influx resulting in elevated readings in the July 15 data. The increase was on the order of 2 to 4 PPT at stations OYS 3 and 4. The readings in Figure 3 were taken from 2.5 or 3.0 meters depth.



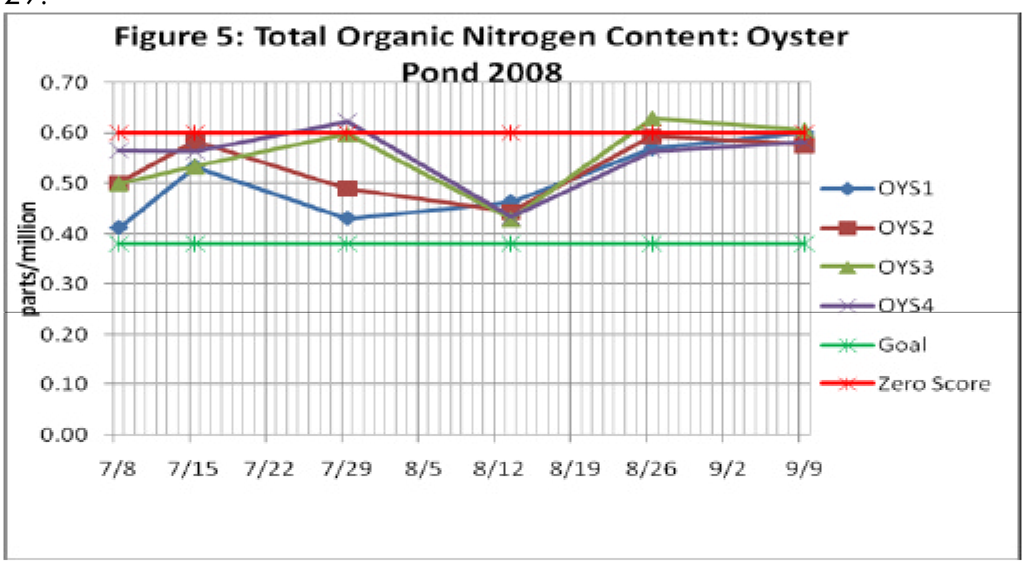
The result of the opposing salinity trends in the surface and at depth is the creation of strong salinity stratification that can be seen in Figure 4 by the divergence of surface salinity (solid markers) from deep salinity (open markers). The salinity difference was initially about 2 PPT on July 8 but increased to 6 to 8 PPT by July 15. The system did not return to a 2 PPT gradient until August 12.



The presence of a stratified water column can isolate the deeper, saltier (and heavier) water from the surface and from oxygen leading to anoxia. This condition was not found during 2008 as illustrated by station OYS3 that had the strongest vertical salinity gradient from 10 PPT at the surface to near 18 PPT at 3 meters. Despite this, the dissolved oxygen saturation was 73%.

The salinity record is somewhat of an inverse proxy for the nitrogen content of the Pond in that nitrogen concentration is very low in the ocean where the salinity is high and much higher in the fresh groundwater that discharges into the system. Water quality samples are collected at a depth about 8 to 12 inches below the surface. The analyses reported are those found in the lower salinity water at each station.

In Figure 5, depending on location, the opening either produces an increase in total organic nitrogen by July 15 or starts an upward trend that continues to the July 29 sample round. Total organic nitrogen at stations OYS1 and 2 follows an upturn by July 15 followed by a decrease to the July 29 round. Stations OYS3 and 4 toward the southern end of the Pond don't respond as strongly on July 15 but the nitrogen concentration at these stations continues to increase to July 29.



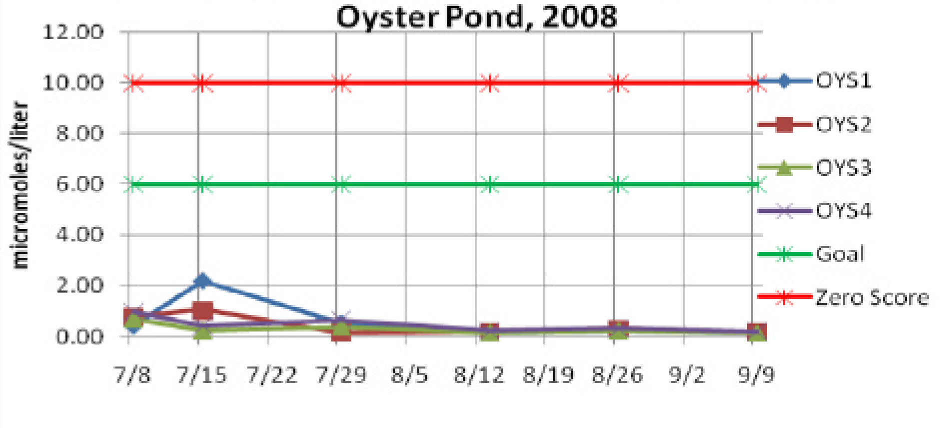
It is not clear exactly how the timing of the nitrogen peak developed at different times depending on location in the Pond. Clearly lowering the Pond increases groundwater discharge into the system carrying nitrogen. This is supported by decreasing surface salinity between July 8 and 15 at all stations (Figure 2) and corresponding increase in total organic nitrogen in Figure 5). Wind direction may have played a role in the timing of the peak nitrogen occurrence as described below for salinity. The addition of 2.74 inches of rainfall on July 24 and 25 with a nitrogen concentration that is around 1 ppm may have also played a role in this pattern. The response to this rain clearly shows up in the pond water level record in Figure 1.

By July 29, the salinity has increased significantly at station OYS1 and by about 10% at station OYS2 as the influx of saltwater from the opening works its way into the system (Figure 2). The salinity at station OYS3 continues to decline. Station OYS4, very near to the barrier beach does not follow this pattern.

An examination of the MV Coastal Observatory wind record indicates that the average wind direction between the 8th of July and the 15th was 205 degrees (south-southwest) and between the 15th and the 29th it was 195 degrees. This wind direction would push surface water to the north confining it near the two northern stations. The wind was however out of the north for 6 hours from late the 27th through early on the 28th followed by a few hours of southeast and it is possible this drove surface water to the south carrying nitrogen with it.

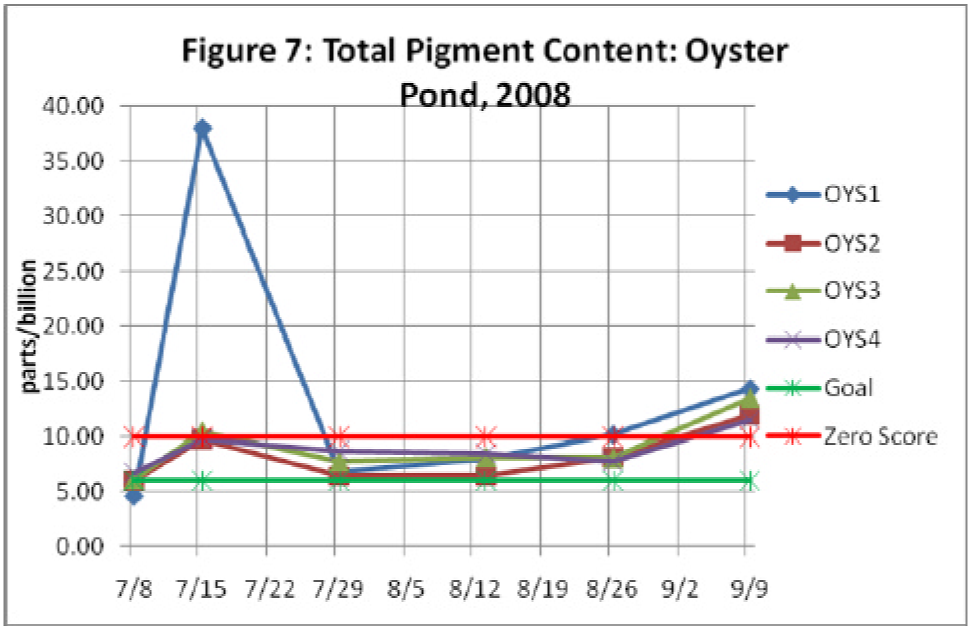
The average concentration of total organic nitrogen (TON) exceeded the high water quality goal of 0.38 ppm and even exceeded the goal suggested for Edgartown Great Pond for total nitrogen (Howes et al, 2007) of 0.5 ppm. Interestingly the average concentration increases from 0.5 at station OYS1 at the north end to 0.56 ppm at station OYS4 at the south end. The average at the other two stations is intermediate between the north and south stations. This is somewhat surprising as the freshest water expected to have higher nitrogen concentration was found at station OYS1 at the north end but on average this location had the lowest TON concentration. Dissolved inorganic nitrogen follows the pattern described for TON, spiking at stations OYS1 and 2 on July 15 but not until July 29 at stations OYS3 and 4. DIN is quickly taken up by phytoplankton and concentrations are very low well below the goal of 6 micro-moles per liter.

Figure 6: Dissolved Inorganic Nitrogen Content: Oyster Pond, 2008



Ratios of nitrogen to phosphorus are indicators of whether the growth of phytoplankton in the system is limited by the availability of either of these nutrients. The break point between phosphorus limited and nitrogen limited was found to be a ratio of 16 with lower ratios indicating nitrogen limited and higher phosphorus limited (Redfield, 1958). The ratio of total nitrogen to total phosphorus has been found to indicate strong nitrogen limitation if it is less than 20:1 and strong phosphorus limitation if greater (Smith, 2006). At stations OYS3 and OYS4 the ratio averages 29 and 30.5 over the sampling period indicating the system was phosphorus limited. At station OYS1 at the north end of the Pond, the average was 22.5 indicating it was less clearly phosphorus limited by late August and early September.

Chlorophyll bearing phytoplankton spike at all stations on July 15 when they are at or exceed the "Zero Score" concentration. For most of the sampling period however,they are at acceptable concentrations. The average concentration at stations OYS2, 3 and 4 ranges between 8.1 and 9 parts per billion over the sampling period. The station 1 average is increased to 13.7 ppb by a very high reading on July 15.



Dissolved and particulate organic nitrogen are components of total organic nitrogen and show a similar pattern of increasing from north to south (station OYS1 to 4). The particulates follow the pattern of total pigment in Figure 7 spiking on July 15 declining through August before rising late in the month and into September. Average particulate organic carbon peaks at station OYS3 and OYS4 has a higher average concentration than either OYS1 or 2, however the range is only 10 micromoles per liter.

Tisbury Great Pond:

Tisbury Great Pond is a complex coastal system in that it has substantial fresh water stream inputs at the north end (Stations 1 and 2), a mixing zone in the middle (Station 4) and coves where exchange may be limited (Stations 3, 5 and 6). See Figure A1 page 51 in Appendix 2. It is opened to the ocean 3 to 4 times each year and all combined, it is often tidal for more than half the year. The system is 660 acres in area when tidal and, when closed to the ocean, freshwater input enlarges the system to 800 acres as it fills with water. It receives drainage from Black Point Pond a 50 to 60 acre system (acreage included above) through a channel (station 8).

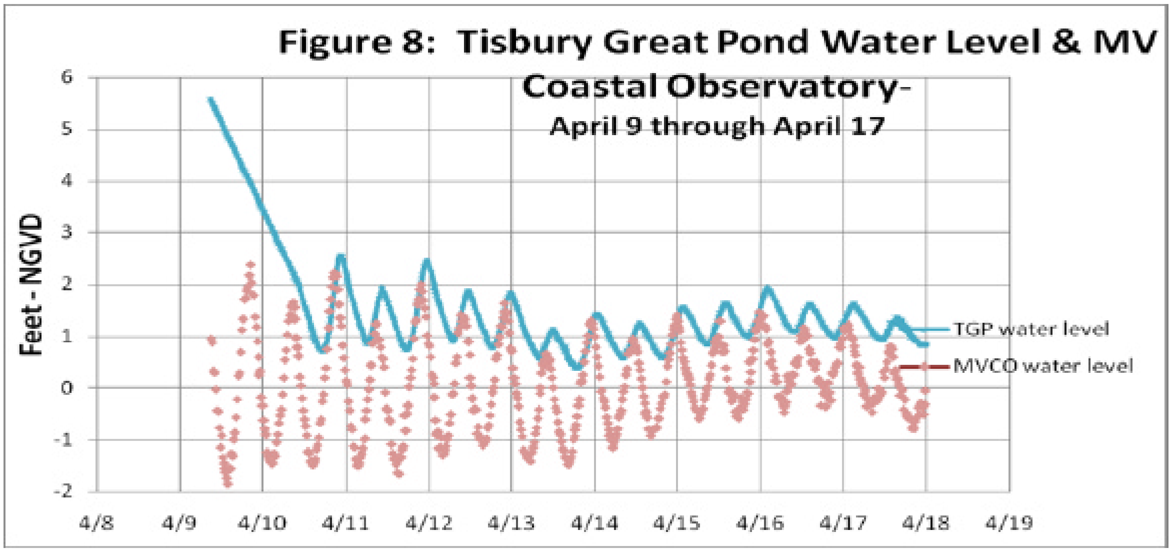
Exchange with the Ocean:
Tisbury Great Pond attained an elevation of 5.57 feet NGVD (Kent Healy, personal communication) in April before it was opened to the Atlantic on April 9, 2009, by means of a trench excavated across the barrier beach. A steel stake was positioned in the Pond in Tiah's Cove on March 26 and was utilized to record the elevation of the water before and after the drain down that dropped the pond level from 5.57 feet to 0.7 feet that came on a low tide. A Global Water WL15 gauge was attached to the stake on April 10 and the record was corrected to NGVD by means of measurement of water level from the top of the stake.

A hypsographic curve was prepared after Fugro-McClelland (1992). From this, pond volume can be estimated at high pond and under tidal conditions. The drop in Pond level of 4.87 feet represents a discharge of approximately 133 million cubic feet of water or 48% of the initial volume at 5.57 feet elevation. At an initial total nitrogen concentration of 0.3 milligrams per liter, the discharge removed 1100 kilograms of nitrogen that is about 10% of the annual watershed nitrogen load.

During the first week, the tide range averaged 0.99 feet on the ebb tide and 0.96 on the flood, the difference may be accounted for by the elevation of the Pond above MSL. The approximate tidal prism at the low pond elevation for a 1 foot tide is 24.7 million cubic feet or, over the course of the day, about 17.4% of the pond volume while tidal. This implies a 6 day period for tidal exchange to equal pond volume. The 1 foot tide range persists long enough to deliver a volume of new Atlantic Ocean water equal to the initial, pre-opening pond volume.

The ebb tide required 7 hours and 14 minutes on average while the flood tide required 5 hours and 10 minutes. The tide curve for two periods is shown in Figures 9 and 10. The tide stage in the pond lagged behind the offshore tide as indicated for Job's Pond by 2.5 to 3.5 hours in part due to the higher elevation of the Pond that leads to a long ebb outflow extending beyond the point where the offshore tide has turned to flood (www.capetides.com). This timing also reduces the tide range in the Pond.

In general the tide range decreased within days of the initiation of tidal conditions (Figure 8 and Table 4) although periodically the range would increase (Figure 9 circa May 7 and June 20 near the Full and New moons). In Figure 8, the water level at the WHOI offshore coastal observatory is plotted with the level of Tisbury Great Pond. The datum used for the MVCO data is arbitrary as this gauge is not tied in to a datum. There is a clear lag between the times of high and low tides in the Pond compared to offshore. The lag between the offshore high tide and the in-pond high tide for the record shown in Figure 8 was 1 hour and 48 minutes on average. During that lag, the offshore water level dropped 0.65 feet reducing the head that drives water into the Pond. The lag between the low tides averaged 2 hours and 38 minutes and the offshore water level rises 0.84 feet on average over that time. The lag produces a situation where the pond cannot develop a full tide range because while it is still ebbing, the offshore water level has already been rising for 2.5 hours. When the pond is flooding, the driving force begins to wane nearly 2 hours before the Great Pond reaches a high tide and has lowered the head that drives water into the Pond.



In Figure 9, the phases of the moon are shown schematically with the occurrence of spring tides (new and full moons) indicated by the plot at elevation 5 and the neap tides by the plot at elevation 3 with a 48 hour buildup and decline also shown. The average pond level itself rises and falls coincident with the spring tides (rising to higher elevations) and the neap tides (falling to lower elevations). While tidal, the Pond level is generally between 1.0 and 2.5 feet NGVD although immediately after the inlet, the low tide dropped to less than 1.0 feet. On the south shore of the Vineyard, NGVD does not coincide with Mean Sea Level but is about 0.6 feet lower (i.e. MSL is about at elevation + 0.6 NGVD). The Pond elevation only rarely reaches as low as MSL but tends to range between 1 and 2 feet above mean sea level.

With the Pond standing above MSL, the offshore 2 foot plus tide range is dampened to 1 foot or less. The flood tide is generally short and fast while the ebb outflow is prolonged as is seen in Table 4.

Table 4: Tidal Conditions Over Selected Periods

Date	Flood tide range- feet	Flood duration- hours	Ebb tide range- feet	Ebb duration- hours	Lunar phases
4/10 to 4/11	1.47	4:45	1.45	7:20	Full
4/10 to 4/17	0.957	5:10	0.986	7:14	Full waning
4/17 to 4/24	0.48	5:34	0.4	6:55	Last quarter to New
6/5 to 7/7	0.500	4:50	0.503	7:32	Full to Full
7/7 to 7/20	0.217	4:50	0.209	7:35	Full to New

It is clear from the data in Table 4 that the tide range begins to decrease shortly after the opening and continues to decrease. The variation in average tide ranges for the different periods shown in Table 4 is believed to be the result of shoaling reducing tidal exchange and narrowing the tide range. From April 10th to the 17th, early in the ponds tidal phase, the drop in pond level during ebb tide is more than the rise on the flood tide. This may result from the pond still standing higher than the equilibrium level with the Atlantic combined with spring freshwater input that exits the system prolonging the ebb tide so that it is 2 hours and 4 minutes longer than the flood tide.

As the inlet across the barrier beach adjusts its channel, the tide range is half what it was initially (Table 4, 4/17 to 4/24 compared to 4/10 to 4/17). Ebb tide is still significantly longer than the flood tide but the duration of the flood tide increases while the ebb tide period decreases. During this period, flood tide rise is more than the ebb tide drop. This at least in part contributes to the average elevation of the Pond increasing from less than 1.5 feet to near 2 feet (see Figure 9). This time period coincides with the onset of Spring tidal conditions (new moon occurs at 12:11 on the 24th). Spring tide conditions bring a widening tide range with a higher high tide and a lower low tide that brings more water into the Pond on the flood.

Through July 20, the average elevation of the Pond follows a pattern of rising up nearer to 2 feet as the new or full moon develops and dropping down from there to a lower level during the onset of lunar quarter moons (Figure 9). Often the onset of spring tides coincides with an increase in the tide range as on May 9 when the average range was 1.1 feet while on May 7 (and the week preceding) it was 0.5 feet.

In July and continuing through August, the tide range is significantly reduced as the overall pond level rises to near 2 feet NGVD. The elevated average condition probably develops as the channel capacity is further reduced by shoaling either within the channel itself or in the shoals on the pond side of the barrier beach. The presence of shoals reduces channel capacity and increases frictional loss of velocity leading to a condition where the amount of ebb tide outflow that can occur before the onset of offshore high tide is reduced. The combination of flood water and freshwater entering the Pond does not fully exit the system and results in an increase in average elevation. The higher pond average elevation further reduces the amount of the offshore high tide that can enter the Pond.

Beginning in July and continuing until the pond closed to the ocean on September 5 the tide range was reduced (see Figure 10). The new moon occurs on July 22 and August 20 preceding spikes in average pond elevation centered on July 24 and August 23. Nearly 2 inches of rain fell on the 22nd and 23rd of July that raised the pond level. No clear pattern of wind velocity or persistent direction is apparent in the MV Coastal Observatory records for the date. Wind at the MV Coastal Observatory in the 3 days preceding August 23 was consistently out of the south at speeds from 10 to 20 mph that may have contributed to the spike in pond level by driving water ashore. The spike in pond elevation centered on August 29 is related to tropical storm Danny that dropped over 3 inches of rain and the coincident storm surge.

From June 5 to July 20 the average tide range was 0.42 feet. From July 20 to September 5 when the Pond closed, the tide range averaged 0.29 feet. Ebb tide dominated in duration lasting 8.25 hours while flood tide averaged 4.5 hours. On August 24 and 25 when the average Pond elevation was declining the ebb tide averaged 9.33 hours and the pond dropped 0.52 feet on the ebb compared to a flood tide that averaged 3.33 hours and had a range of 0.29 feet. The Pond closed with the onset of a full moon on September 4.

A tide range of 0.4 feet exchanges approximately 10 million cubic feet per day or 7% of the pond volume. This indicates a 14 day time to exchange a volume of water equal to the pond volume.

From closure on September 5, the Pond rose 3 feet over the last 30 days of the record. This represents an increase in volume of about 113.8 million cubic feet in total or 3.8 million cubic feet per day. Fugro-McClelland (1992) estimated the average annual daily inflow at 3.1 million cubic feet and Healy (2009) estimated the average annual freshwater flow into the pond at 1.95 million cubic feet per day.

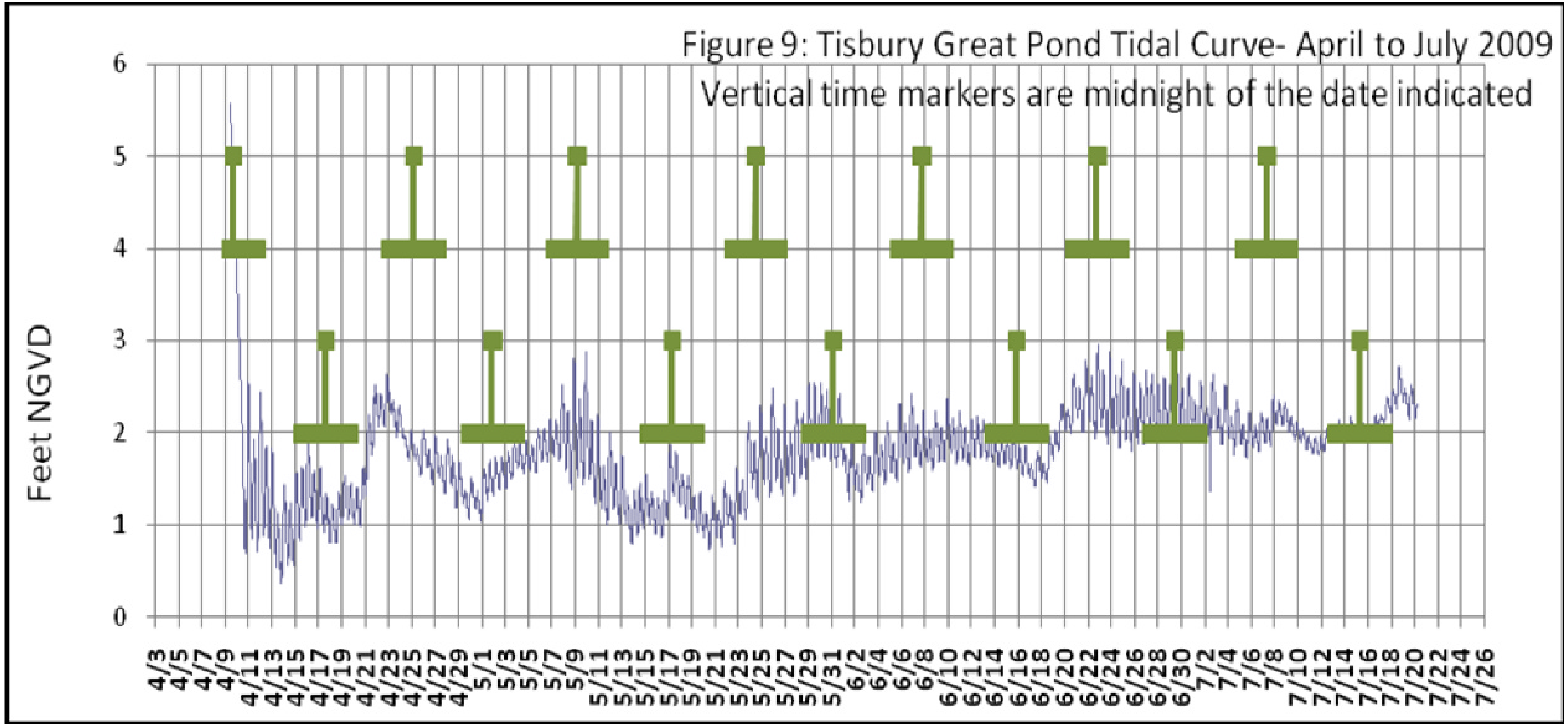
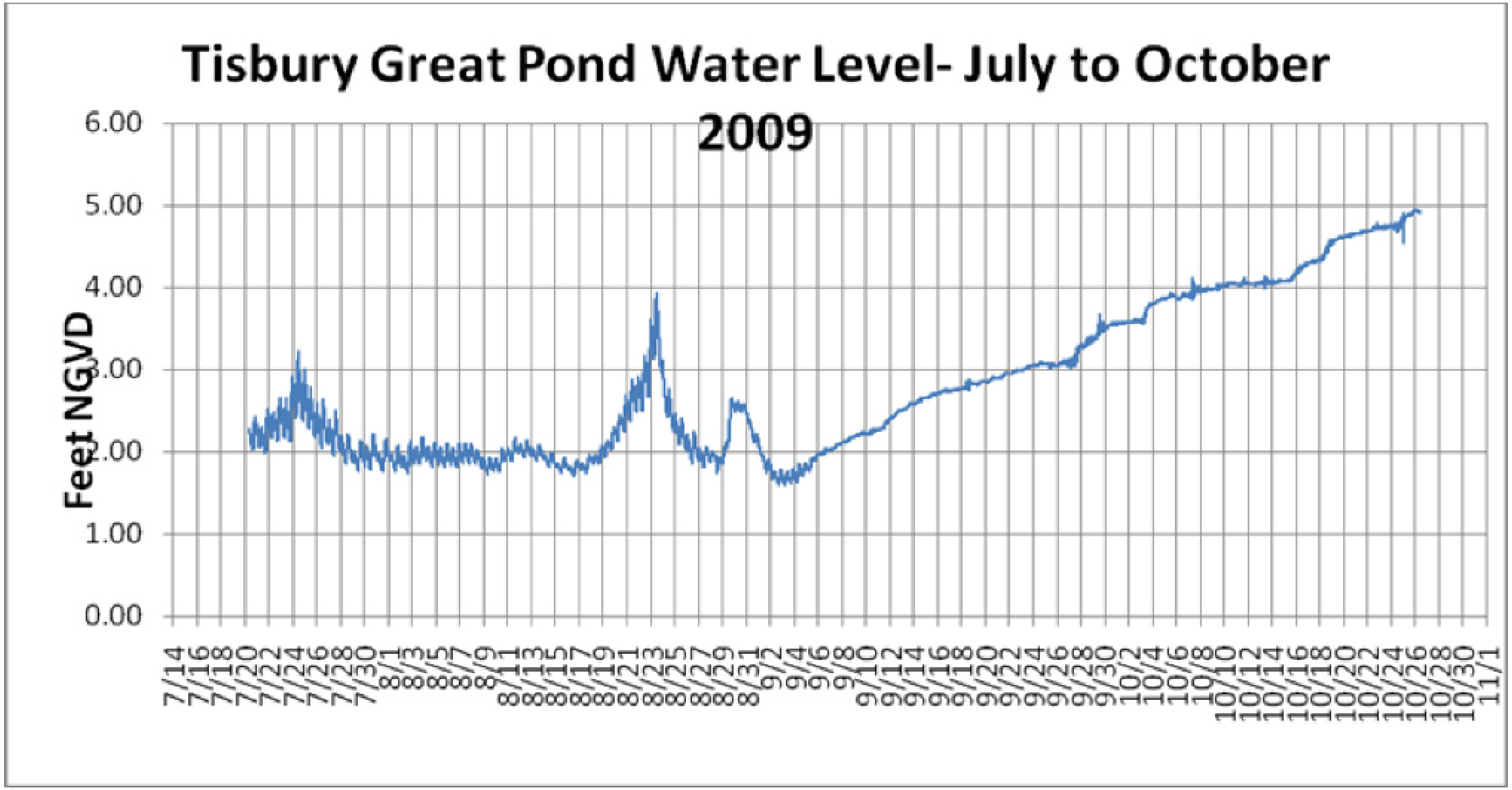


Figure 9: Tisbury Great Pond Tidal Curve- April to July 2009
Vertical time markers are midnight of the date indicated

In this chart, the onset of the Lunar Phases is signified by the green chart line that is elevated above the bar that covers a 96 hour period. Spring tides associated with the Full and New moon phases are plotted at 5 feet elevation while the Neap tidal phases of last and first quarter moon are plotted at 3 feet. This plot is meant to be visual and there is no significance to the elevations at which the phases are plotted. Spring tides are typically marked by a higher stand of the high tide and a lower stand of the low tide producing a greater tide range. Neap tide ranges are smaller and are marked by a lower high tide level and a higher low tide.


Tisbury Great Pond Water Level- July to October 2009
Feet NGVD
6.00
5.00
4.00
3.00
2.00
1.00
0.00
7/14
7/16
7/18
7/20
7/22
7/24
7/26
7/28
7/30
8/1
8/3
8/5
8/7
8/9
8/11
8/13
8/15
8/17
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9/24
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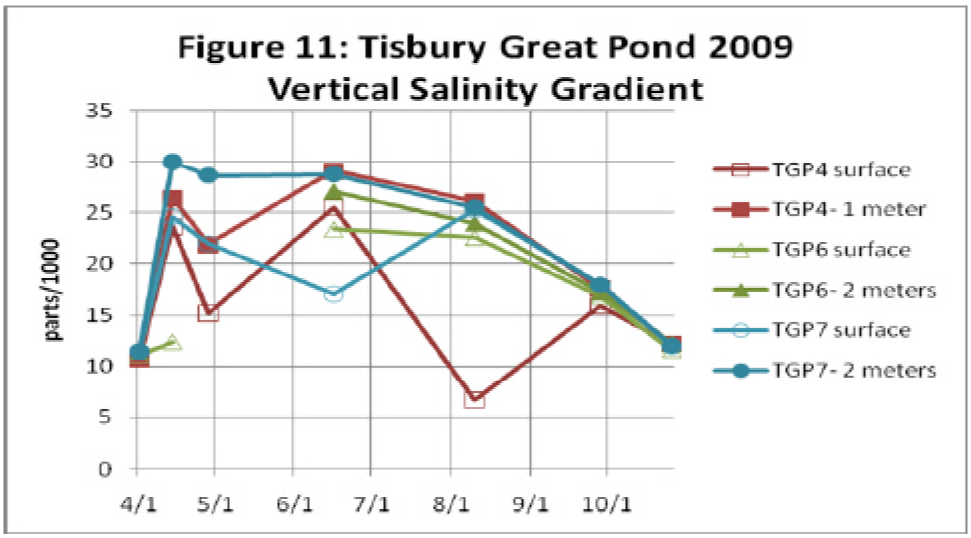
10/8
10/10
10/12
10/14
10/16
10/18
10/20
10/22
10/24
10/26
10/28
10/30
11/1

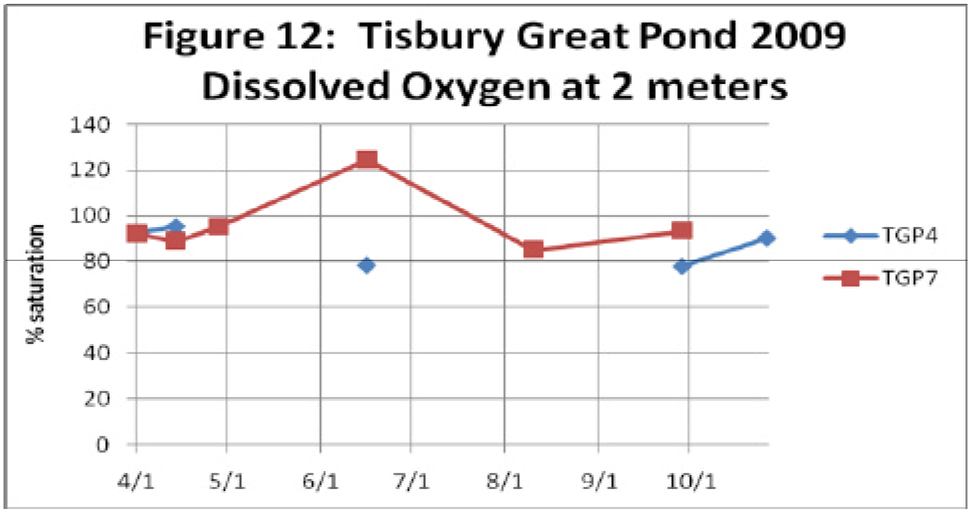
With the considerable input of fresh water from streams and groundwater, stratification can develop during when the pond is opened to the ocean due to the density difference between the fresh input and the saline water that enters from the Atlantic Ocean. A strongly stratified system can develop anoxia in the deeper water as it is isolated from the air.

During 2008, stratification was limited early during the opening cycle but became strong at station TGP4 on August 10 when the salinity was 20 PPT higher at depth than at the surface. In 2009, stratification as indicated by salinity occurred during mid-June at station TGP7 and early August at station TGP4 as is seen in Figure 11. There is little stratification in Deep Bottom (TGP6) but the record is hampered by missing data when the pond was too shoal to access this station. The lack of persistent stratification probably relates to both wind and tidal circulation. After the Pond closed on September 5, the salinity rapidly becomes uniform both around the Pond as well as vertically. Field data for Tisbury Great Pond can be found in Appendix 1.



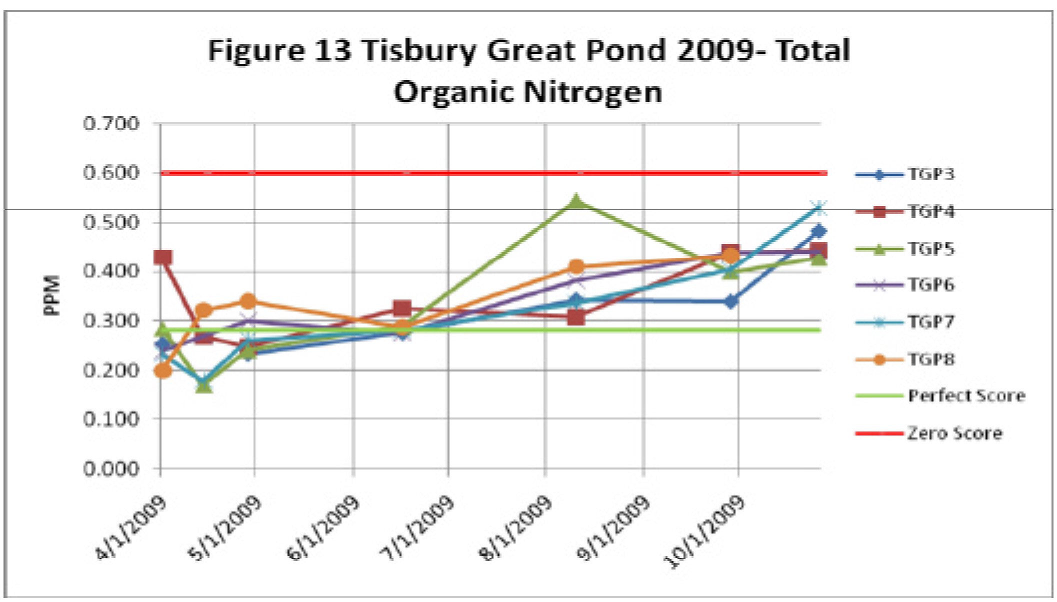
The Secchi extinction depth was general good for the south shore great ponds where excess phytoplankton often limits visibility in the water column. The average of all readings over the entire study period was 1.98 meters. On April 1, the extinction depth was 2.65 meters at station TGP 4 and 3.5 meters at station TGP7. At all other stations, the disk was visible on the bottom. In general, the extinction depth decreased over the course of the summer but few readings could be collected as the Pond was too shallow. On August 10 at TGP5 the extinction depth was down to 1 meter but in mid-pond it was 2.1 meters.

The dissolved oxygen saturation at depth remained generally at or above 80% (see Figure 12) indicating that despite some stratification low oxygen levels were not found during the morning sampling period. Lower levels are expected overnight but any low values did not persist.



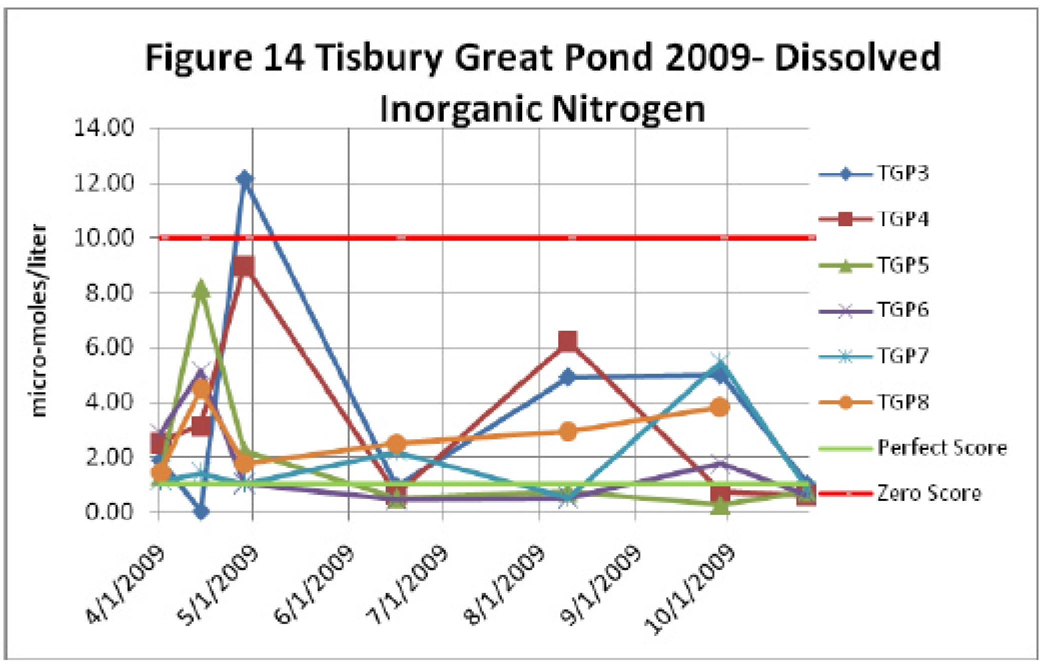
The duration of tidal conditions during summer 2009 set the stage for low nitrogen concentration in the water column by exchanging higher nitrogen pond water for low nitrogen Atlantic Ocean water. The average total organic nitrogen ranged from a low of 0.32 parts per million at station TGP7 to 0.40 at station TGP1. As a result the average nitrogen concentration met the total nitrogen goal of 0.5 ppm proposed by the Massachusetts Estuaries Project for Edgartown Great Pond over the course of the summer months.

An upward trend in organic nitrogen concentration began following the June 16 sampling round (Figure 13) and coincides with the average pond elevation moving up from less than 2 feet NGVD to more than 2 feet (see Figure 9). This may result from a change in the overall flushing as the channel outlet through the barrier beach narrows allowing less "old" water to escape the system leading to a gradual build up in nitrogen. June 16 was the pivot date from which salinity at station TGP4 and TGP6 began to decrease as is seen in Figure 11.



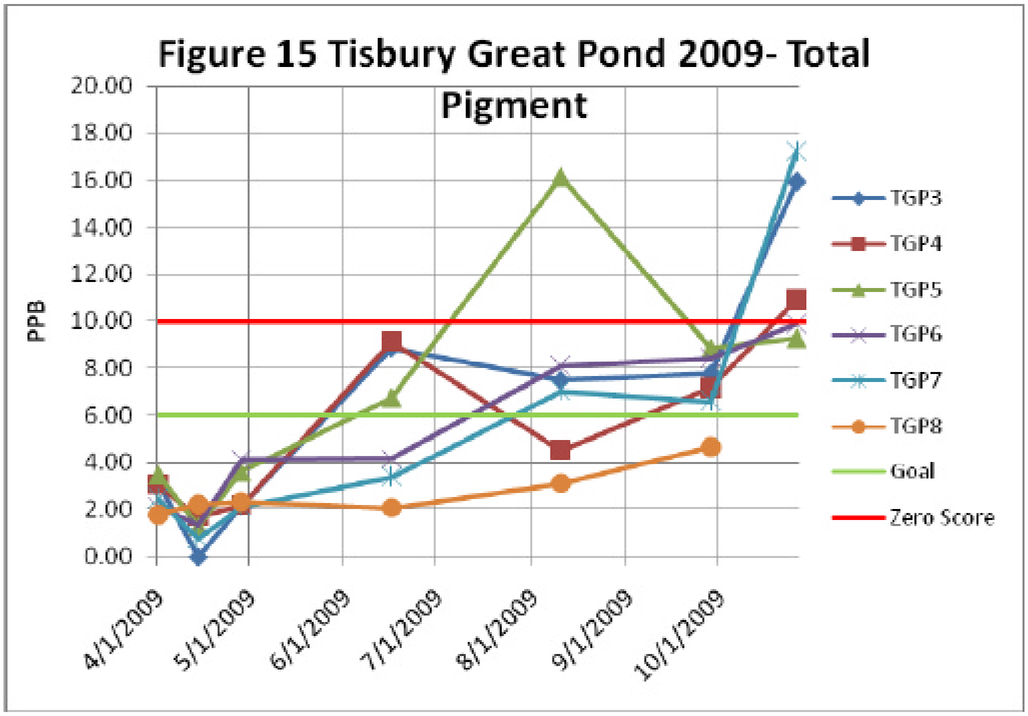
The ratio of total nitrogen to total phosphorus indicates the system is limited by nitrogen if less than 22:1 and by phosphorus if greater than 22:1. The limitation is on the growth of phytoplankton that require these nutrients to grow and multiply. Station TGP1 was nitrogen limited throughout the sampling varyinbg from a ratio of 7 to 20. At TGP4 the indications are an alternation between nitrogen and phosphorus as the limiting nutrient particularly before and after the inlet was cut open. The June through September data indicates a nitrogen limited system. At TGP6, the water column was phsophorus limited until the early August and late September sampling rounds. At station TGP7, the system was predominantly limited by nitrogen although the late April and mid-June samples indicate phosphorus limitation.

Dissolved inorganic nitrogen is in such demand that it is typically at very low concentrations in our coastal ponds. In general, the stations furthest north, nearer to fresh water inputs and further from the inlet, show higher concentrations. These include TGP3 and TGP4. All stations show a spike following the pond opening as the lower pond draws in more fresh groundwater increasing the water column nitrogen content. The spike occurs at cove stations TGP5, 6 and 8 on the April 14 sampling round but doesn't peak until the April 28 round at TGP3 and 4 in the central part of the Pond. In general, the dissolved inorganic nitrogen remains at acceptable levels throughout the pond during the sampling program.



Nitrogen entering the Pond from rain, stream flow and groundwater discharge is quickly converted into biomass in the form off phytoplankton. Measuring the chlorophyll content in the water column is a good indicator of the amount of microscopic biomass. The greater the biomass the less light can penetrate to allow rooted plants like eelgrass to grow and the greater the demand for oxygen that can stress or kill aquatic animals.

During 2009, total pigment concentration increased throughout the sampling period to coincide with the onset of the growing season. At most stations, the concentration was at acceptable levels until the pond closed in early September. By the time of the late October sampling round, the concentration at most stations exceeded the zero score value of 10 parts per billion.



Quality Control:

In addition to those checks of lab accuracy that are run internally, we provided the lab with a number of blind duplicate samples to evaluate their ability to provided reproducible results and our ability to process the samples uniformly. Blind duplicate samples are drawn from the same sample bottle as another sample but identified with a different sample station number. The lab runs both sets of samples as if they were from two distinct locations. The results are then compared by means of statistical analysis to determine how closely the results for each parameter are to each other. The statistical metric applied to the data was the relative percent difference or RPD. The formula used was:

$$RPD == \frac{(X_1 - X_2)100}{(X_1 + X_2)/2}$$

Ideally the two results (X_1 and X_2) are the same and the RPD is zero. In practical application, this is not the case and results that are within 30% of each other are acceptable for field duplicates. The variation in results is more likely to be a higher percentage for parameters such as nitrate, nitrite ammonium or phaeophytin that are typically found at concentrations of less than a few micromoles. For these parameters, a very small difference in the lab reported concentration could amount to a substantial percentage difference.

Table 5 summarizes the RPD analysis. The averages of the absolute value of14 duplicate samples are shown. The RPD for all parameters in both years (except ammonium in 2009) fall within the 30% RPD. The analytes that show larger RPD values are those that are found in very small concentrations such as ammonium and ortho-phosphorus. The analytes that when combined make up the most important indicators of pond water quality (total pigments, total organic nitrogen and total nitrogen) include chlorophyll, particulate nitrogen and dissolved organic nitrogen are all well below the maximum desired RPD. Appendix 1 (at the end of the field data tables) includes the RPD results for each sample round over the course of the sampling season.

Table 5: Average of Relative Percent Difference from Blind Duplicate Samples

Parameters	**Relative percent difference averaged Oyster Pond 2008**	**Relative percent difference averaged Tisbury Great Pond 2009**
Silicate	4.46 %	NA %
Ortho-phosphate	16.27 %	15.92 %
Ammonium	29.18 %	45.87 %
Nitrate + nitrite	9.47 %	10.07 %
Dissolved organic nitrogen	10.45 %	10.53 %
Particulate carbon	3.32 %	6.56 %
Particulate nitrogen	5.49 %	12.23%
Chlorophyll pigments	12.04 %	6.42 %

Samples were collected during the planned time namely before, during and after an inlet across the barrier beach to the ocean. The order of data collection was carried out as planned. Samples were processed and shipped on the same day as they were collected via Fast Ferry to New Bedford where they were picked up by SMAST personnel and taken to the lab for processing.

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APPENDIX 1

LAB AND FIELD DATA

Sample Station Maps are found in Appendix 2

Oyster Pond
2008

Funded by DEP 604B
Analyses by U of Mass SMAST

Sample ID		Depth	Date	Sal (ppt)	SiO4 (uM)	PO4 (uM)	NH4 (uM)	NOX (uM)	DIN (uM)	DON (uM)	TSS mg/L	POC (uM)	PON (uM)	C/N Ratio	TON (uM)	TN (uM)	Total Pigments (ug/L)
OYS	1	M	7/8/2008	9.3	87.25	0.1	0.29	0.15	0.44	17.92	NA	88.12	11.50	7.66	29.42	29.86	4.63
OYS	1	M	7/15/2008	1.7	125.36	1.0	1.10	1.11	2.20	17.90	NA	129.83	20.23	6.42	38.12	40.33	37.99
OYS	1	M	7/29/2008	4.6	95.72	0.05	0.45	0.07	0.52	16.41	NA	105.29	14.36	7.33	30.76	31.28	6.86
OYS	1	M	8/13/2008	6.7	88.78	0.2	0.05	0.11	0.16	19.47	NA	100.91	13.59	7.43	33.06	33.23	8.05
OYS	1	M	8/26/2008	7.0	94.14	0.4	0.11	0.11	0.22	22.16	NA	145.98	18.51	7.89	40.67	40.89	10.18
OYS	1	M	9/9/2008	6.8	83.11	0.3	0.05	0.10	0.15	22.54	NA	153.83	20.36	7.55	42.91	43.05	14.35
AVG	OYS1			6.02					0.61	19.40		120.66	16.42				13.68
OYS	2	M	7/8/2008	12.0	71.15	0.1	0.56	0.23	0.79	19.71	15.90	116.86	16.06	7.28	35.77	36.57	6.00
OYS	2	M	7/15/2008	10.8	102.61	0.05	0.83	0.22	1.05	20.40	14.60	147.02	21.26	6.92	41.66	42.70	9.77
OYS	2	M	7/29/2008	6.0	100.25	0.05	0.11	0.05	0.16	16.99	9.75	125.06	17.93	6.98	34.92	35.07	6.43
OYS	2	M	8/13/2008	8.9	87.59	0.05	0.05	0.15	0.20	22.01	7.33	63.90	9.65	6.62	31.66	31.86	6.44
OYS	2	M	8/26/2008	7.5	93.11	0.4	0.20	0.12	0.32	23.86	14.20	138.24	18.52	7.46	42.38	42.70	8.12
OYS	2	M	9/9/2008	7.4	83.26	0.2	0.05	0.12	0.17	22.40	5.80	132.07	18.78	7.03	41.18	41.34	11.98
AVG	OYS2			8.77					0.45	20.89		120.52	17.03				8.13
OYS	3	M	7/8/2008	12.6	71.44	0.05	0.47	0.24	0.71	18.89	18.45	123.08	16.79	7.33	35.68	36.40	6.13
OYS	3	M	7/15/2008	11.7	98.58	0.05	0.05	0.21	0.26	18.07	6.20	153.84	20.04	7.68	38.11	38.37	10.46
OYS	3	M	7/29/2008	9.1	100.69	0.05	0.28	0.14	0.41	21.64	15.30	152.78	21.10	7.24	42.73	43.15	7.75
OYS	3	M	8/13/2008	8.7	92.03	0.05	0.05	0.13	0.18	21.23	6.98	58.08	9.41	6.17	30.64	30.82	8.14
OYS	3	M	8/26/2008	8.9	88.83	0.4	0.11	0.15	0.26	24.55	15.40	151.71	20.41	7.43	44.96	45.21	8.05
OYS	3	M	9/9/2008	7.5	80.45	0.1	0.05	0.11	0.16	22.51	5.75	144.08	20.75	6.94	43.26	43.43	13.43
AVG	OYS3			9.75					0.33	21.15		130.59	18.08				8.99
OYS	4	M	7/8/2008	13.5	69.92	0.05	0.70	0.27	0.97	20.13	20.40	150.31	20.29	7.41	40.41	41.38	6.66
OYS	4	M	7/15/2008	8.4	112.71	0.05	0.23	0.20	0.43	22.04	6.40	129.45	18.25	7.09	40.29	40.72	9.74
OYS	4	M	7/29/2008	10.1	97.15	0.05	0.49	0.18	0.66	23.70	16.20	152.06	20.85	7.29	44.56	45.22	8.63
OYS	4	M	8/13/2008	8.3	84.44	0.05	0.05	0.17	0.22	23.40	5.74	51.02	7.63	6.69	31.03	31.25	8.43
OYS	4	M	8/26/2008	7.3	84.20	0.4	0.20	0.10	0.30	20.64	16.65	144.71	19.72	7.34	40.37	40.67	7.71
OYS	4	M	9/9/2008	7.9	81.54	0.2	0.05	0.13	0.18	24.12	11.44	117.16	17.43	6.72	41.55	41.73	11.46
AVG	OYS4			9.25					0.46	22.34		124.12	17.36				8.77

Tisbury Great Pond

2009

Key

NS = No Sample Taken

ND = No Data Available

< value estimate

Sample ID	Sta No	Depth	Date	Salinity PPT	silica (uM)	PO4 (uM)	NH4 (uM)	NOX (uM)	DIN (uM)	DON (uM)	TSS mg/L	POC (uM)	PON (uM)	C/N Ratio	TON (uM)	TN (uM)	Pigments (ug/L)
TGP	TGP1		4/1/2009	10.9	32.96	0.10	0.6	2.44	3.02	11.83	NA	51.95	6.32	8.21	18.16	21.18	3.32
TGP	TGP1		4/14/2009	NES	107.51	2.41	2.2	10.33	12.50	11.49	NA	406.16	28.86	14.07	40.36	52.86	20.22
TGP	TGP1		4/28/2009	0.2	72.08	2.60	1.7	8.82	10.48	17.24	NA	110.33	8.40	13.14	25.63	36.11	5.54
TGP	TGP1		6/16/2009	7.0	90.90	0.60	0.2	4.98	5.17	12.39	NA	55.31	5.15	10.74	17.55	22.72	7.82
TGP	TGP1		8/10/2009	NES	97.41	1.09	0.7	6.40	7.13	14.95	NA	118.21	16.00	7.39	30.95	38.08	21.18
TGP	TGP1		9/28/2009	9.2	111.72	0.30	2.2	10.73	12.92	20.28	NA	111.66	16.81	6.64	37.09	50.00	12.73
TGP	TGP1		10/26/2009	9.1	81.26	0.41	0.4	2.24	2.64	20.16	NA	92.75	11.93	7.78	32.09	34.72	12.57
AVERAGE																	
TGP	TGP3		4/1/2009	11.4	23.91	0.10	0.4	1.49	1.87	12.56	NA	40.02	5.57	7.18	18.13	20.00	3.18
TGP	TGP3		4/14/2009	NS	NS	NS	NS	NS	NS	NS	NA	56.07	5.11	10.98	ND	ND	ND
TGP	TGP3		4/28/2009	4.6	101.10	0.10	3.7	8.42	12.15	8.46	NA	57.62	8.16	7.06	16.62	28.77	2.17
TGP	TGP3		6/16/2009	21.9	38.30	0.10	0.1	0.81	0.91	11.53	NA	57.62	8.16	7.06	19.69	20.60	8.89
TGP	TGP3		8/10/2009	4.8	107.00	0.67	0.5	4.39	4.89	14.34	NA	78.73	10.10	7.80	24.43	29.32	7.50
TGP	TGP3		9/28/2009	7.5	100.44	0.40	0.4	4.53	4.96	14.90	NA	76.76	9.31	8.25	24.21	29.17	7.79
TGP	TGP3		10/26/2009	12.8	50.75	0.20	0.2	0.76	0.97	20.15	NA	92.00	14.29	6.44	34.44	35.41	15.94
AVERAGE																	
TGP	TGP4		4/1/2009	11.5	29.57	0.10	1.1	1.47	2.53	24.55	7.18	40.67	6.13	6.63	30.69	33.22	3.05
TGP	TGP4		4/14/2009	23.6	39.51	0.20	1.6	1.51	3.14	11.42	22.04	77.19	7.77	9.94	19.19	22.32	1.70
TGP	TGP4	on foot	4/28/2009	11.8	78.75	0.10	3.5	5.49	8.99	10.99	4.33	44.61	6.69	6.67	17.67	26.66	2.17
TGP	TGP4		6/16/2009	23.3	39.83	0.10	0.05	0.57	0.62	14.36	2.37	61.49	8.94	6.88	23.30	23.92	9.15
TGP	TGP4		8/10/2009	5.9	109.05	0.76	0.4	5.84	6.21	13.74	NA	70.57	8.28	8.52	22.03	28.23	4.54
TGP	TGP4		9/28/2009	15.9	81.88	0.25	0.2	0.47	0.71	18.82	NA	88.58	12.54	7.06	31.36	32.07	7.16
TGP	TGP4		10/26/2009	12.7	53.21	0.20	0.1	0.48	0.59	20.19	NA	76.66	11.51	6.66	31.70	32.29	10.94
AVERAGE																	

Sample ID	Sta No	Depth	Date	Salinity PPT	silica (uM)	PO4 (uM)	NH4 (uM)	NOX (uM)	DIN (uM)	DON (uM)	TSS mg/L	POC (uM)	PON (uM)	C/N Ratio	TON (uM)	TN (uM)	Pigments (ug/L)
TGP	TGP5		4/1/2009	11.6	22.38	0.05	0.4	0.91	1.29	11.88	NA	51.85	8.45	6.14	20.33	21.62	3.46
TGP	TGP5	channel outflow	4/14/2009	4.4	105.41	0.15	2.4	5.76	8.17	9.18	NA	37.58	2.96	12.70	12.13	20.30	1.27
TGP	TGP5	sample inside bar	4/28/2009	15.5	47.13	0.10	1.6	0.66	2.22	11.76	NA	40.35	5.43	7.43	17.20	19.42	3.59
TGP	TGP5		6/17/2009	14.6	66.70	0.05	0.05	0.44	0.49	12.17	NA	60.30	8.44	7.15	20.61	21.10	6.74
TGP	TGP5		8/10/2009	12.9	105.62	0.15	0.2	0.53	0.70	19.01	NA	133.88	19.82	6.75	38.83	39.53	16.13
TGP	TGP5		9/28/2009	16.2	86.44	0.10	0.2	0.09	0.24	17.70	NA	77.01	10.84	7.11	28.53	28.78	8.82
TGP	TGP5		10/26/2009	11.7	52.50	0.15	0.2	0.51	0.71	20.41	NA	70.49	10.11	6.97	30.52	31.23	9.27
AVERAGE																	
TGP	TGP6		4/1/2009	11.9	24.81	0.05	1.5	1.36	2.86	13.08	6.27	25.40	3.99	6.36	17.07	19.93	2.10
TGP	TGP6	just inside bar on foot	4/14/2009	14.8	63.78	0.15	2.3	2.82	5.13	14.93	3.49	32.06	4.24	7.55	19.18	24.31	1.33
TGP	TGP6	sample inside bar	4/28/2009	23.3	29.99	0.20	0.8	0.22	1.02	14.06	8.68	53.46	7.40	7.22	21.46	22.48	4.11
TGP	TGP6		6/17/2009	23.6	51.88	0.05	0.2	0.25	0.44	14.44	2.13	30.07	5.19	5.80	19.63	20.07	4.15
TGP	TGP6		8/10/2009	22.6	40.94	0.62	0.2	0.33	0.51	17.82	NA	70.80	9.43	7.51	27.25	27.76	8.13
TGP	TGP6		9/28/2009	17.4	63.88	0.30	1.4	0.42	1.77	18.90	NA	77.45	12.49	6.20	31.39	33.16	8.45
TGP	TGP6		10/26/2009	12.4	50.19	0.20	0.1	0.48	0.59	21.85	NA	66.50	9.62	6.91	31.47	32.06	9.91
AVERAGE																	
TGP	TGP7		4/1/2009	12.2	26.50	0.05	0.1	0.99	1.13	11.55	7.13	30.33	5.05	6.01	16.60	17.73	2.48
TGP	TGP7		4/14/2009	25.0	27.67	0.20	0.8	0.66	1.42	9.39	3.70	32.76	3.38	9.70	12.77	14.18	0.77
TGP	TGP7		4/28/2009	22.3	34.81	0.15	0.4	0.63	1.02	12.93	10.31	36.66	5.72	6.41	18.65	19.67	2.11
TGP	TGP7		6/17/2009	20.3	49.62	0.05	1.8	0.42	2.18	13.99	1.97	34.12	6.06	5.63	20.05	22.23	3.40
TGP	TGP7		8/10/2009	25.4	44.54	0.62	0.3	0.24	0.51	16.00	NA	75.72	8.00	9.46	24.00	24.51	7.05
TGP	TGP7		9/28/2009	18.4	67.47	0.52	5.0	0.51	5.46	20.96	NA	53.75	7.93	6.78	28.89	34.35	6.60
TGP	TGP7		10/26/2009	12.7	49.52	0.20	0.3	0.48	0.78	21.18	NA	130.30	16.69	7.81	37.87	38.65	17.24
AVERAGE																	
TGP	TGP8		4/1/2009	11.7	26.82	0.05	0.2	1.19	1.42	11.24	NA	30.67	2.96	10.36	14.20	15.62	1.76
TGP	TGP8		4/14/2009	9.9	18.36	0.05	2.6	1.84	4.47	16.89	NA	60.68	6.09	9.96	22.98	27.45	2.21
TGP	TGP8		4/28/2009	9.8	14.92	0.05	1.2	0.57	1.77	17.70	NA	51.19	6.53	7.84	24.23	26.00	2.31
TGP	TGP8		6/16/2009	9.0	11.38	0.05	1.9	0.62	2.48	16.87	NA	31.12	3.64	8.55	20.51	22.99	2.06
TGP	TGP8		8/10/2009	14.8	18.68	0.25	2.1	0.78	2.92	24.52	NA	38.11	4.77	7.99	29.30	32.21	3.10
TGP	TGP8		9/28/2009	16.7	47.08	0.40	3.2	0.56	3.81	25.49	NA	39.47	5.39	7.32	30.88	34.69	4.66
			10/26/2009														
AVERAGE																	

OYSTER POND FIELD DATA **2008** Stations 1 to 4

		Pond level			SURFACE				1METER				3.0 Meters			
Date	Station #	tide stage	Total D.	Secchi	DO %	Sp. Cond.	Temp	Salinity	DO %	Sp. Cond.	Temp	Salinity	DO %	Sp. Cond.	Temp	Salinity
7/8/2008	1	CLOSED	2	1.6	110.7	15.65	26.8	9.1	111.7	16.16	27	9.4				
7/15/2008		CLOSED	1.25		114.8	2.446	23.6	1.3	114	15.45	27	9				
7/29/2008		CLOSED	1.8	1.5	109.8	8.91	26.3	5.7	97.7	15.6	27.6	9.1				
8/13/2008		CLOSED	1.9	1.3	105.6	12.94	24.4	7.4	103.2	14.86	25.6	8.6				
8/26/2008		CLOSED	1.6	1.1	101.8	12.13	23.7	7	94.9	13.85	24.6	8				
9/9/2008		CLOSED	1.75	1.2	104.2	12.08	24	6.9	104	12.38	24.2	7.1				
				1.34												
7/8/2008	2	CLOSED	3.75	1.5	114.4	19.44	26.8	11.5	114.5	19.47	26.7	11.5	96.7	23.34	26.6	14.1
7/15/2008		CLOSED	3.25	1.3	118.9	14.26	26.9	8	120.1	20.59	27.7	12.3	66	26.96	26.4	16.5
7/29/2008		CLOSED	3.3	1.4	104.9	15.22	26.7	9	100.8	18.8	27.1	11.1	79	25.35	27.2	15
8/13/2008		CLOSED	3.4	1.6	100.3	14.17	24	8.2	100	14.54	24.1	8.4	93.9	16.22	25.3	9.5
8/26/2008		CLOSED	3.4	1.1	97.2	13.86	23.8	8	96.5	13.89	23.8	8	72.5	16.14	24.5	9.5
9/9/2008		CLOSED	3.6	1.5	100.6	13.65	24	7.9	99.1	13.63	24	7.9	93.8	13.74	24	7.9
				1.4												
7/8/2008	3	CLOSED	4	1.4	109.7	20.05	26.8	11.9	110.2	20.13	26.5	12	87.9	23.38	26.4	14.4
7/15/2008		CLOSED	3.4	1.4	115.6	18.03	26.9	10	116.8	20.12	27.3	11.9	72.8	28.92	25.9	17.8
7/29/2008		CLOSED	3.8	1.4	99	16.08	26.1	9.4	99.9	17.66	26.2	10.3				12.5
8/13/2008		CLOSED	4.2	1.7	100.9	15.02	24.2	8.7	99.5	15.03	24.1	8.7	95.1	15.29	23.9	8.9
8/26/2008		CLOSED	3.9	1.2	97.5	14.83	23.8	8.6	97	14.81	23.8	8.6	92	14.86	23.8	8.6
9/9/2008		CLOSED	4	1.5	94.8	13.9	23.8	8	95.2	13.88	23.8	8	95.6	13.91	23.7	8.1
				1.433333												
7/8/2008	4	CLOSED	3.5	1.4	112.6	21.41	26.7	12.8	111.6	21.34	26.5	12.8	71.4	23.43	26	14.2
7/15/2008		CLOSED	3	1.4	110.8	14.01	25.2	8.1	108	19.42	26.6	11.5				16.4
7/29/2008		CLOSED	3.3	1.6	106	17.55	26	10.3	105	17.84	25.6	10.5	89.6	25.63	27.1	15.6
8/13/2008		CLOSED	3.7	1.6	98.4	14.85	23.7	8.6	98.1	14.94	23.8	8.7	84.4	15.23	23.6	8.9
8/26/2008		CLOSED	3.3	1.1	94	15.28	23.3	8.9	93.8	15.21	23.3	8.9	93.9	15.28	23.4	8.9
9/9/2008		CLOSED	3	1.5	92.5	14.33	23	8.3	90.8	14.32	23	8.3				8.3
				1.43												

TISBURY GREAT POND FIELD DATA Stations 1 to 8 NOTE- NO STATION 2

2009 Date	Station #	Pond level tide stage	Total D.	Secchi	Notes	SURFACE DO %	Sp. Cond.	Temp	Salinity	1METER DO %	Sp. Cond.	Temp	Salinity	2.0 METERS DO %	Sp. Cond.	Temp	Salinity
4/1	tgp1	CLOSED	1.4		11:35	84.1	17.52	9	10.3	88.8	12.56	9.1	10.6				
4/14		open	0.25		11:00	78.7	0.289	13.6	0.1								
4/28		open	0.5		7:50	66.7	0.16	12.8	0.1								
6/16		open	0.33		11:25	144.7	19.08	21.3	14.8								
8/10		open	0.4		11:35	143.5	28.5	25.9	20								
9/28		CLOSED	0.6		7:50	71.6	2.88	15.9	5.8								
10/26		CLOSED	1.3		7:30	77.8	4.28	9.8	2.3	83.5	21.2	12.8	12.7				
4/1	tgp3		1.6		10:30	93.9	18.14	8.4	10.7	92.3	18.52	8.6	11				
4/14																	
4/28			0.65		11:00	96.4	8.57	16.6	4.8								
6/16			0.75		11:10	87.8	40.37	20.8	25.9								
8/10			0.75		11:15	113	10.08	24.7	5.8								
9/28			1.15		10:30	89.7	12.65	17.9	7.4	58.7	28.4	18.5	17.6				
10/26			1.6		10:30	89.7	20.31	12.5	12.2	89.1	20.37	12.6	12.2				
4/1	tgp4		2.7	2.65	10:15	94.7	17.71	8.1	10.7	93.5	18.19	8.1	10.7	92.6	18.83	8.4	11.4
4/14			1.95			84	37.76	8.9	23.6	94.2	41.54	7.6	26.4	95.3			
4/28	ON FOOT		1		11:15	93.1	20.39	17.2	15.2				21.9				
6/16			1.65		11:00	89.8	39.78	20.5	25.5	93.1	44.87	20.5	29.1	78.6			
8/10			1.4		10:45	93.2	12.9	24.2	6.7	86.4	40.84	24.2	26.1				
9/28			2.2	1.38	10:15	77.6	25.92	18.7	15.9	86.1	28.42	18.2	17.6	78.1	28.59	18.2	17.7
10/26			2.15		10:20	93.1	20.45	12.5	12.2	91.6	20.41	12.6	12.2	90.4	20.99	12.9	12.6

2009		Pond level				SURFACE				1METER				2.0 METERS			
Date	**Station #**	**tide stage**	**Total D.**	**Secchi**	**Notes**	**DO %**	**Sp. Cond.**	**Temp**	**Salinity**	**DO %**	**Sp. Cond.**	**Temp**	**Salinity**	**DO %**	**Sp. Cond.**	**Temp**	**Salinity**
4/1	tgp5		2.42		8:45	96.6	18.61	8.9	11	96	18.83	9.2	11.1	89.9	18.99	8.8	11.3
4/14	CHANNEL SAMPLE- TOO SHALLOW- EBB OUTFLOW				9:00	81.4	5.2	7.1	3.5								
4/28	Inside sample- sluggish flood		>1		9:05	95.9	25.39	17.6	15.4								
6/16			1.5		8:40	92.4	28.64	18.1	17.7	98.9	33.06	20.8	20.9				
8/10			1.6	1	13:50	130.3	21.8	26.4	12.8	107.4	29.45	27.1	18.2				
9/28			2.3	1.6	9:45	85.6	25.72	18.3	15.8	82.2	26.25	18	16.1	78.1	27.14	18.1	16.7
10/26			2.7	1.82	8:30	94	18.46	12.5	11	92.9	19.45	13.3	11.6	88.3	20.15	13.3	12.1
4/1	tgp6		2.8		9:50	96	18.84	7.3	11.1	94.6	19.07	7.6	11.3				11.5
4/14	inside sample too shallow	wave driven flood	>1.5		9:45	92.1	20.19	7.7	12.4								
4/28	meter failed		>1														
6/16			2.2		9:45	91.8	36.91	19.3	23.4	96.5	40.37	21.1	25.9	96.8	42.19	21.7	27.1
8/10			4.5	1.9	14:40	118.5	35.86	25.7	22.6	115.4	35.93	25.6	22.7	151.5	38	26.6	24
9/28			2.7	1.8	9:00	84.3	27.5	18.2	16.9	84	27.53	18.2	17	80.4	27.97	18	17.3
10/26			3.5	2.15	8:55	96.7	19.38	12.1	11.6	94.4	19.7	12.5	11.8	91.1	20.48	13.1	12.3
4/1	tgp7		3.6	3.5	9:15	95	19.45	7.7	11.5	93.5	19.44	7.7	11.5				11.5
4/14			2.07		9:20	94.5	39	7.5	24.6	94.5	41.01	7.3	26	92.3	46.87	6.7	30
4/28			2.3		9:25	94.8	34.85	14.9	22	91.3	35.29	14.8	22.1	89.1	44.43	12.9	28.7
6/16			2.3		9:00	96.4	32.17	17.1	17.1	92.2	40.1	18.5	25.7	95.3	44.46	19.5	28.8
8/10		ebb	2.4	2.1	14:05	126.2	39.62	24.1	25.3	124.3	39.63	24.1	25.3	124.6	39.92	24	25.5
9/28			1.4		9:30	85.3	29	17.8	18					85.2	29.01	17.8	18
10/26			3.3	1.85	9:15	95.4	20.11	12.4	12	93	20.13	12.4	12	93.7	20.15	12.5	12.1
4/1	tgp8		0.7		9:25	90.9	18.54	6.9	10.9								
4/14		slight ebb	0.5		11:30	100.7	16.58	9.8	9.7								
4/28			0.5		7:30	87.6	16.46	13.7	9.7								
6/16			0.5		11:45	110.2	20.29	21.1	12.2								
8/10			0.5		15:50	151	24.41	27.9	14.8								
9/28			0.6		7:35	77.5	28.55	17	17.7								
10/26	NA																
			Average	1.98													

Relative Percent Difference Data- 2008 and 2009

		silica	PO4	NH4	NOX	DIN	DON	POC	PON	Pigments	CHl-a	Phaeo
Oyster Pond Absolute Values												
7/8/08	OYS	3.44	0.00	17.69	2.38	11.39	4.23	0.60	2.31	1.60	0.52	106.12
7/15/08	OYS	1.21	0.00	141.78	8.89	93.15	16.83	6.15	5.94	15.83	15.86	0.00
7/29/08	OYS	0.81	0.00	87.24	5.99	60.05	9.52	0.44	3.88	25.54	31.15	170.47
8/13/08	OYS	4.04	0.00	0.00	20.98	15.64	19.34	0.21	7.52	31.90	32.01	0.00
8/26/08	OYS	1.28	11.75	0.00	7.23	2.81	4.12	0.35	4.62	11.54	19.71	16.29
9/9/08	OYS	3.96	40.00	0.00	14.60	9.91	20.71	6.96	7.37	6.31	6.32	0.00
9/10/08	EGP	18.77	8.70	3.29	15.77	1.26	5.71	6.77	2.22	1.35	37.11	36.17
11/12/08	EGP	3.51	0.00	5.86	6.08	5.94	2.51	1.62	1.92	1.36	5.71	11.70
12/3/08	EGP	3.17	85.97	6.75	3.34	5.68	11.10	6.84	13.66	12.95	13.33	11.50
Average RPD Values		4.46	16.27	29.18	9.47	22.87	10.45	3.32	5.49	12.04	17.97	39.14
Tisbury Great pond Absolute Values												
4/1/2009	TGP		0.00	0.00	20.98	15.64	19.34	0.21	7.52	31.90	32.01	0.00
4/14/2009	TGP		11.75	0.00	7.23	2.81	4.12	0.35	4.62	11.54	19.71	16.29
4/28/2009	TGP		40.00	0.00	14.60	9.91	20.71	6.96	7.37	6.31	6.32	0.00
6/17/2009	TGP		8.70	3.29	15.77	1.26	5.71	6.77	2.22	1.35	37.11	36.17
8/10/2009	TGP		0.00	5.86	6.08	5.94	2.51	1.62	1.92	1.36	5.71	11.70
9/28/2009	TGP		85.97	6.75	3.34	5.68	11.10	6.84	13.66	12.95	13.33	11.50
10/26/2009	TGP		16.27	29.18	9.47	22.87	10.45					
Average RPD Values			23.24	6.44	11.07	9.16	10.56	3.79	6.22	10.90	19.03	12.61

APPENDIX 2

SAMPLING AND ANALYSIS PLAN

Sampling and Analysis Plan

Final- July 10, 2008

FOR: Coastal Pond Water Quality Assessment/ Island Basin

Prepared By: William M. Wilcox, Martha's Vineyard Commission

Submitted to: Massachusetts Department of Environmental Protection

Project: 604(b) # 2008-03/604

Funded by: Funded partially by federal Funds from the Environmental Protection Agency to the Massachusetts Department of Environmental Protection under Section 604(b) Water Quality Management Planning Grant

Start Date: July 1, 2008

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1.0 Background and Overview of Sampling and Analysis Plan:

The proposed project will obtain data necessary to prepare two coastal salt ponds for nutrient modeling by the Estuaries Project. The fundamental requirement is three years of high-quality water chemistry and field data. The south shore coastal ponds are not continuously tidal. Their barrier beaches are breached by pond managers typically in the spring and depending on the lifetime of the tidal condition, in late fall and possibly winter. This complicates the modeling required for the Massachusetts Estuaries Project that typically uses a hydrodynamic circulation model that is only accurate when the systems are tidal. We propose to collect data from Tisbury Great and Oyster Ponds to allow the preparation of a mass balance model to capture the evolving water quality conditions after an inlet has closed and the ponds begin to refill with stream and ground water.

Samples and field data will be collected from 12 sample stations during 6 sample rounds before, during and after a breach to the ocean. The data will be incorporated into a report and converted to an internet-ready format as was the previous sampling data for placement on the Martha's Vineyard Commission's website (2004, 2005 are up and 2006 will be by July 31, 2008). All lab analyses will be performed at the University of Massachusetts School of Marine Science and Technology under their laboratory SOP and Quality Assurance Plan procedures. This document is intended to provide specific details of the sampling locations, sample collection, handling and shipping procedures as well as the use of field equipment for collection of temperature, dissolved oxygen, specific conductivity and GPS locations. <u>Additional details are provided in the Massachusetts Estuaries Project (MEP) QAPP, approved 13 June 2003 in Appendix B-1 (Field Protocols and Data Sheets).</u>

Sampling rounds will be scheduled at one to two-week intervals during the falling tide or at dead-low water if the system is open and during the morning hours. The state of the tide will be the prime determining factor in timing sample collection however afternoon sampling will only occur when samples must be acquired and low tide is late in the afternoon. Sampling would begin when pond managers indicate a breach is planned. Sample stations will be located in the field with Global Positioning System (GPS, see detail below) and on-shore landmarks such that the same stations can be acquired for each round. Final locations will be decided in consultation with SMAST personnel to assure that the data is sufficient for numerical modeling. On station, an YSI 85 meter (see detail below) will be used to collect vertical profile data at no greater than 1 meter intervals. The Secchi disk will be used to determine light penetration on site. Standard data sheets will be used for this information as well as to record weather conditions and the presence of any unusual natural phenomena such as jellyfish, rafts of algae, large numbers of waterfowl etc. Water samples will be collected at a depth of 6 to 12 inches (15 centimeters) below the surface. Where a deep sample is collected, sample collection depth will be 0.5 meters above the bottom sediment. Samples will be immediately placed in a cooler on ice during the sample collection process.

Samples will be processed prior to shipping to provide dissolved nutrient samples (nitrate, nitrite, ammonium, organic nitrogen, silica and ortho-phosphate), chlorophyll *a*, particulate carbon and nitrogen and, for a sub-set of sites, total phosphorus samples. Total Suspended Solids (TSS) samples will be collected and shipped to the SMAST Lab in lab-clean, 1-liter HDPE bottles for filtration and processing as per their procedures. The samples will be shipped on ice with an accompanying Chain of Custody by the Fast Ferry to New Bedford where SMAST personnel will pick them up at the pier for analysis. Oversight of sample collection, processing, handling and shipping will be the responsibility of William M. Wilcox, Water Resource Planner, Martha's Vineyard Commission. All chemical laboratory analyses will be performed at the School for Marine Science & Technology (SMAST, Dr. Brian Howes and Roland Samimy, 508-910-6352). Dr. Brian Howes will be the laboratory leader.

2.0 Data to Be Collected:

Lab methodology is contained within the SMAST Laboratory SOP and Quality Assurance Plan, Section B.1 (Review of Nitrogen Related Water Quality Monitoring Data). Sample collection and processing methodology is described in detail in Sections 3.0, 5.0 and 6.0.

2.1 Lab analyses planned are identical to those from previous years to allow direct comparability. Total Suspended Solids is added to the list that includes:

Nitrate + Nitrite Silicate Ortho-phosphate (dissolved reactive P)
Total phosphorus Particulate carbon particulate nitrogen Dissolved organic nitrogen Ammonium chlorophyll *a* & pheophytin Specific conductance Total Suspended Solids

Not all will analytes will be tested for all stations. See Summary Table page 12 for breakdown by sample station.

2.2 Blind Duplicate Samples:

To assess lab performance and provide confidence in the results, a blind duplicate sample will be sent along to the lab for analysis with each batch of 20 samples. The blind sample will be drawn from, handled and processed as the source sample and numbered in sequence with the actual samples. A logbook will be kept identifying the actual source of each blind sample to allow comparison of the results. Additional details are provided in the MEP QAPP Section B.1.1 (Data Quality Objectives).

2.3 In the field, vertical profile data will be collected at no greater than 1-meter intervals including:

Dissolved oxygen saturation
Temperature
Specific conductivity
Salinity

The deepest data record at each site will be collected at a distance of 0.5 meters or less from the bottom. A Secchi extinction depth will be determined at each station using a standard 8-inch, black and white quadrant disk.

3.0 Sample Collection:

3.1 Schedule: All sampling will be completed between 1 July 2008 and 30 June 2009. The extended period is required because the focus of the sampling program will be on water quality changes associated with cutting an inlet through the barrier beach in each pond. The inlet cutting process is dependent on attaining sufficient pond level elevation which cannot be predicted. This sampling schedule is designed to cover a long enough time frame to include the usual period when an inlet is cut through the beach, the tidal period and the refilling process that occurs after the pond inlet closes and to provide flexibility to substitute dates to focus sample acquisition during the time when the Ponds shift from tidal to closed. Once an inlet is cut in a given pond, sampling will proceed at a one to two week interval and be complete in approximately two to three months.

3.2 Personnel: Samples and field data will be collected by MVC personnel under the direction of William Wilcox and/or SMAST personnel under the direction of Roland Samimy. William Wilcox has prepared and carried out water quality assessments involving in excess of 1500 samples in the coastal ponds of Martha's Vineyard since 1995 including a 604(b) sampling project in Chilmark Pond completed in 2001, 604(b) funded studies in 2003, 2004, 2005 and 2006 and a DEM Lakes and Ponds sampling project in Lagoon Pond (Oak Bluffs, 2002). All of these projects were conducted in close association with Dr. Brian Howes both at Woods Hole Oceanographic Institute and at SMAST. All personnel will be trained by William Wilcox or, in the case of SMAST personnel, by Dr. Brian Howes to assure that the sample collection and handling procedures are followed. All personnel will be provided with a copy of the relevant pages from this document that describe the methodology to be followed.

William Wilcox, (MV Commission) or Roland Samimy (or staff directly under his supervision SMAST) will collect the samples from Katama Bay, Oyster Pond, James Pond, and Tisbury Great Pond.

3.3 Materials: One liter HDPE bottles for initial sample acquisition and for particulate, TSS and chlorophyll *a* samples and 60 milliliter dissolved nutrient and total phosphorus sample bottles will be provided by the SMAST lab. Carbon-clean glass fiber filters for particulate analysis and nitro-cellulose filters for chlorophyll *a* analysis will also be provided by SMAST. Cellulose acetate filters required by SMAST for preparing dissolved nutrient samples will be purchased direct from GeoTech Environmental Equipment, Inc. in Denver, Colorado or provided by SMAST. Dissolved oxygen membrane replacement kits are provided by YSI. Conductivity calibration standards will be NIST certified reagent grade solutions.

3.4 Deep samples: At this time, we anticipate sampling from deep within the water column of these ponds only a few times over the course of the sampling period. The decision regarding deep sampling will be made on-station based on the presence of either a well-developed thermocline or a deep-water oxygen deficiency (below 40% saturation). If samples are collected toward the bottom of the water column, a Niskin sampler will be used to collect discrete samples at 0.5 to 1.0 meters above the bottom at any locations. Possible locations include station OYS3 in Oyster Pond and TGP5, TGP6 and TGP7 in Tisbury Great Pond. The Niskin sampler will be rinsed with distilled water prior to use for field sampling. Sample collection depth will be determined using a depth sounder to avoid stirring the bottom. Sample collection for deep stations will occur prior to use of the Secchi disk to avoid stirring the bottom or mixing a possible stratified layer near the bottom. The sampler will be armed, triggered and the sample discharged to an HDPE 1-liter bottle following manufacturer's instructions. Analyses performed on deep samples will be the same as those for the surface samples. In addition to the analytes listed in the summary table, total phosphorus will be run on all deep samples.

4.0 Ponds to be sampled:

The sampling program will be carried out on Tisbury Great and Oyster Ponds. All ponds will be sampled from a boat. The sample station locations shown in Figures 1 and 2 are approximate until they are refined with GPS in the field to obtain exact locations. The location of most stations is meant to coincide with sample sites used in previous studies. However, most of these earlier stations were located without benefit of GPS and for those stations, this study will utilize USGS maps or other paper maps within reports to identify and duplicate previous stations. All stations identified will be sampled for the parameters outlined in items 2.1 and 2.3. Lab analyses from the 2005 604(b) funded project are available and are briefly reviewed along with the field results are discussed in 4.5 below.

4.1 Tisbury Great Pond

Tisbury Great Pond is a south coastal salt pond similar to Oyster Pond with the exception of two substantial streams that flow into the northern Coves. The Tiasquam and the Mill Brook contribute an estimated 200 to 400 million cubic feet per year (Healy, personal communication). These figures are being updated and refined by the Massachusetts Estuaries Project.

The Pond has been productive in oysters and occasionally soft shell clams in the past. The oyster disease dermo has decimated the crop and the 2006/2007 harvest was the first in two years. The soft shell clams rarely reach marketable size in significant numbers possibly due to the salinity variations and or the high water temperatures that develop in the shallows of the tidal flats. The Pond also has a small herring run. At this time there is no eelgrass in the Pond.

The watershed is estimated to be nearly 11,000 acres in extent. As a result, pond managers are able to raise the pond significantly higher due to the large freshwater influx from streams and groundwater than are the managers of the other ponds. It appears that, at least in part because of this, the pond has longer duration openings (often 40 to 60% of the year).

MVC personnel have sampled the Pond since 1995 using the same procedures and lab to obtain the same parameters as for the other ponds. Due to the changing tidal connection, the parameters measured vary widely. Typically when the Pond is first opened to the sea all coves become fresher. As the salt wedge works its way into the system, strong stratification often develops and may persist for several days at station TGP3 and sometimes at TGP4. Typically dissolved organic nitrogen concentration is high and total organic nitrogen averages from 0.4 mg/l at the higher quality areas to over 1 mg/l at the poorer quality stations. In addition, inorganic nitrogen can be high in the coves particularly as they freshen.
Samples collected from this system will be labeled with the identifier "TGP" and include the following:

- TGP1 At the pier on the west side of Town Cove where there is significant influence from the Mill Brook inflow.

- TGP2 In the mouth of the Tiasquam River discharge.
- TGP3 Mid Pond just south of Pear Tree Cove
- TGP4 Mid way into Deep Bottom Cove
- TGP5 North of the usual location of the inlet through the barrier beach
- TGP6 At the outlet from Black Point Pond
- TGP7 Pear Tree Cove just below the junction with Muddy Cove
- TGP8 Tiah's Cove north of first sand bar restriction

Figure 1 Tisbury Great Pond Sampling Stations

4.2 Oyster Pond:

Oyster Pond is a south shore great pond that is breached to the Atlantic 2 to 4 times each year. It may remain tidal from a few days to a few months depending on the weather as it affects wave action along the south shore. The Pond is approximately 190 acres in area. It is elongate in the north-south direction and the northern portion is separated into two basins by subsurface bars that extend into the Pond from subaerial sand spits.

Water quality samples were collected in 1995 from the Pond. Data indicate that during that time, the northern end of the Pond was phosphorus limited (dissolved inorganic nitrogen to orthophosphate ratio well over 16). Over the same time frame, the sampling station in the middle of the north-south length of the Pond was generally nitrogen limited. At this station, specific conductivity rose to 25 to 30 milli-Seimens from mid-July to mid-August in response to a June inlet to the ocean and then declined to about 15 mS as the inlet closed and the system freshened. Chlorophyll pigment content was always less than 6 micrograms per liter.

Samples collected from this system will be labeled with the identifier "OYS" and are shown in Figure 2. The stations are located as follows:

- **At the northern end just south of the wetlands: OYS-1**
- **At the mid-point of the north-south length of the Pond: OYS-2**
- **Middle of the southern basin: OYS-3**
- **Deep area just north of the inlet location: OYS-4**

Figure 2 Oyster Pond Sampling Stations

4.5 Data from 2005 and 2006

Tisbury Great Pond and Oyster Pond were sampled under the previous 604(b) grant (2007-01/604). The lab analyses results have been processed into a draft report now in review. The 2007 data is not available at this time.

Tisbury Great Pond

Tisbury Great Pond was sampled three times during 2005, in mid-July, mid-August and early September. The focus was on the southern stations, 4, 6 and 7. The Pond was weakly tidal during July through early September but closed after the early September sampling round. Salinity was between 23 and 28 PPT during the sampling period. Secchi extinction depth dropped over the sampling period and was less than 1 meter during the early September round. Dissolved oxygen saturation declined to less than 60% in the deeper water by the last sampling round.

Total organic nitrogen was less than 0.4 mg/l during mid-July but increased dramatically by the mid-August round to over 0.6 mg/l. This coincided with a significant increase in chlorophyll pigments to well over 10 ppb by the mid-August round. Pigment concentration then declined to less than 5 ppb by early September. Initially, particulate carbon content followed a similar pattern but then continued to increase into September perhaps reflecting a shift in phytoplankton to non-chlorophyll types. Dissolved inorganic nitrogen was below 1.1 micromole per liter throughout the sampling.

In 2006, Tisbury Great Pond was opened to the ocean on August 22 and closed by September 2. It sampled three times during August- the 3rd, the 21st and the 28th (non-604b project). The total organic nitrogen averaged a high of 0.51 mg/l at the northern end of Town Cove at station 1 and 0.43 mg/l at station 7 near the middle of the southern basin. Chlorophyll content averaged 8.3 ppb at the northern end of the Pond and 6.4 in the middle of the southern basin. Secchi extinction depth dropped off to less than 1 meter at station 4 during late August. In the southern basin, water clarity was better with a late August value of 1.5 meters. Dissolved oxygen saturation in the deeper water dropped below 40% in at August at station 4.

Oyster Pond **was sampled four times in 2005. The pond is elongate in the north-south direction away from the portion of the barrier beach where the inlet to the ocean is cut. The pond is divided by shoals into several basins that vary in their salinity due to proximity to or isolation from the saltwater. During the sampling rounds, total organic nitrogen was initially below 0.4 ppm while the system was still connected to the ocean and tidal. After the inlet closed, TON increased to over 0.6 ppm. Chlorophyll pigment concentration increased during the sampling period from around 5 ppb in early July to 10 to 15 ppb in mid-August. Dissolved inorganic nitrogen was highest at the northern end (OYS1) and decreased toward the ocean.**

Strong vertical salinity stratification was seen at stations OYS2, 3 and 4 during the July sampling rounds but breaking up by the early August sampling round. The surface water was between 5 and 15 PPT while the deeper water was between 25 and 30 PPT. As a result, dissolved oxygen saturation was lower in the deeper water and was below 40% at stations OYS2 and 3 at 3 meters depth by the mid-August sampling round. Secchi extinction depths were about 1 meter throughout the sampling period.

During 2006, Oyster Pond was open to the ocean during the July 18 sample round and closed by the August 1 sampling round. Total organic nitrogen ranged from 0.44 mg/l at the stations nearer to the beach (station 7) and up to 0.51 toward the north end of the Pond (station 1). TON peaked during the August 28 sampling round at all stations and declined during the September 12 round. Chlorophyll content followed a similar pattern, highest to the north end and lowest near the beach and peaking during the August 28 sampling round. Average total pigment content varied from 10.4 ppb at the northern station (1) and 5.99 ppb at the southern station (4).

The Secchi extinction depth varied from about 1.25 meters to 1.75 meters over the course of the sampling program at stations 2, 3 and 4. Dissolved oxygen saturation in the deeper water declined during the month of August following the termination of the tidal condition. Saturation reached a low of less than 60% during the September 12 sampling round at station 3. However at station 4 nearer to the inlet saturation remained near 90% in the deeper water through the September 12 sampling.

Summary Table of Ponds and Parameters to be Analyzed:

Pond	Station numbers	Dissolved parameters	Particulate parameters	Chlorophyll and pheophytin	Total P	TSS	Field data
Tisbury Great Pond	**TGP1-8**	**X**	**X**	**X**	**1, 4, 6 & 7**	**4, 6 & 7**	**X**
Oyster Pond	**OYS1-4**	**X**	**X**	**X**	**1, 3 & 4**	**2, 3 & 4**	**X**

NOTE: X signifies all stations will be analyzed for the parameters indicated

Dissolved parameters**: nitrate, nitrite, ammonium, silicate, orthophosphate and organic nitrogen**

Particulate parameters**: particulate carbon and nitrogen**

Total P: Total phosphorus- **this analysis will be performed on samples from selected stations as identified**

Field parameters: **Dissolved oxygen (saturation and milligrams per liter), temperature, specific conductivity, salinity and Secchi depth.**

Maximum Holding time:

Nitrate + nitrite 28 days if frozen to -20 degrees C

Total phosphorus	28 days when acidified and stored at 4 degrees C
Particulate carbon & nitrogen & TSS	24 hours at 4 degrees C when unfiltered and 28 days when filtered and stored in dessicator
Ammonium, Total Dissolved nitrogen & Ortho-phosphate	24 hours at 4 degrees C
Chlorophyll a	24 hours unfiltered at 4 degrees C

5.0 Massachusetts Estuaries Project

Field Sampling Protocol: Nutrients
Water Quality Program

5.1 Nutrient Sample Collection Overview (MEP QAPP Appendix B-1, H)

The goal of the Water Quality Monitoring Program is to provide needed data with which to evaluate overall water quality conditions in nearshore waters and harbors. These waters are most likely to be impacted by excessive nutrient loading originating from local land use. Because of the value of this data, it is very important that measurements are made using the protocol provided and that collections occur during the last three hours of an outgoing tide. Through training sessions, hands-on instruction and sampling tips, we will provide you with the information necessary to ensure efficiency and accuracy in the measurements. Please call (Roland Samimy 508-910-6314) if you have any questions and note any problems on the data sheet.

In addition to nutrient sample collection and filtering, the following measurements need to be taken at each station: dissolved oxygen (percent saturation and milligrams per liter), water temperature, salinity, water clarity (Secchi disk) and total depth. Samples collected for nutrients will be analyzed at the SMAST laboratory for:

Ammonium Nitrate+Nitrite Particulate Organic Nitrogen
Ortho-Phosphate (dissolved reactive P) Chlorophyll a & pheophytin
Particulate Organic Carbon Dissolved Organic Nitrogen Total Phosphorus (as needed)
Specific Conductance Silicate

5.2 ARRIVING ON STATION:

The on-shore landmarks will be used to approximate sample station location. If there is any uncertainty, the GPS will be used to obtain location. It is anticipated that, for many stations, proximity to shore and landmarks and small size of the embayment will permit return to station location without the use of GPS. These are expected to include those stations in Tisbury Great Pond and Oyster Pond where the station is central in a cove or a long, narrow segment of the pond with good landmarks. All stations will be located by GPS so that future sampling programs can easily return to them. The boat will be anchored so that it remains in a fixed position while samples are collected and profile readings taken. The boat should approach the sample location at headway speed to minimize sediment disturbance for all sample stations but particularly for shallow stations (anticipated water depth less than 1 meter).

5.3 Order of data collection on station:

In order to avoid bottom disturbance, the following data collection order will be followed:

• Determine approximate depth with Solinst depth sounder or from amount of anchor line required.

• Collect meter data in vertical profile using depth information to collect data to within 0.5 meters of the bottom.

• Collect water samples.

• Use Secchi disk to determine light penetration and to determine exact depth.

5.4 GENERAL INFORMATION AND WEATHER CONDITIONS (MEP QAPP Appendix B-1, H)

The following parameters will be recorded on the data sheet:
***Time of nearest low tide from tide table and whether the tide is ebbing (approaching low) or flooding (approaching high)**
***Wave conditions - see Beaufort scale**
***Wind direction - the direction the wind is coming from**
***Weather conditions**
***Rainfall in last 24 hours.**
*** Any unusual natural or man-made conditions.**
***Fill out each field data sheet with the pond, station number, time, cloud cover and wind direction and speed and wave height if it has changed from the previous station.**
Data sheet sample is in Appendix A.

5.5 SECCHI DEPTH/TOTAL DEPTH (MEP QAPP Appendix B-1, H) **These readings should be taken over the shaded side of the boat and without the aid of polarizing sunglasses.**

Step 1. Lower Secchi disk into water slowly from shady side of a boat, dock or pier until it just disappears from view. Raise and lower slightly to insure the proper average depth of disappearance.

Step 2. Read depth on tape where it intersects the water surface, record on data sheet. *Note: Sometimes the Secchi disk will hit the bottom before it disappears — in this case write "visible on bottom" or "vis/btm" on disk depth on data sheet.*

Step 3. Lower Secchi disk slowly until it touches bottom, record station total depth.

5.6 Field Data Collection with YSI-85 Multi-parameter Meter:

The meter is calibrated each day on shore before starting the sampling. Calibration is described in Appendix B. Once calibrated, the meter should be left on throughout the course of the sampling day. If turned off, it must be re-calibrated for Dissolved Oxygen prior to proceeding with data collection. The meter provides readings of four parameters with six pieces of information: dissolved oxygen percent saturation, dissolved oxygen milligrams per liter, conductivity, specific conductivity, salinity and temperature. When arriving on station, once the boat is secured with the anchor, remove the probe from its protective housing and place it into the surface water to allow it to equilibrate with the surface water temperature. Water depth will initially be determined

with a Solinst depth-sounding device to avoid disturbance of the sediment. After meter readings and water sample collection, the Secchi readings will be taken and the marked cable used to determine the exact depth.

The meter data should be collected in the same order as listed above at each depth interval. Record the data on the field data sheets. The meter cable is marked in one-meter intervals. At each depth, the probe should be moved in an up and down manner over a distance of several inches to circulate pond water over the probe. Wait to record data until the reading for each parameter has stabilized. Data should be collected at the surface (at a depth of 6 inches) and then at one-meter intervals to the bottom reading at less than one-half meter above the sediment. Use the Solinst depth-sounder information to avoid hitting the bottom with the probe. If the water depth is one meter or less, readings should be taken at the surface and at one-half meter and near the bottom.
When the data collection is completed, retrieve the probe and insert it in the protective housing. Do not shut the meter off until the last station readings are completed.

<u>5.7 NUTRIENT SAMPLE COLLECTION PROTOCOL (MEP QAPP Appendix B-1, H)</u>

Sample collection should proceed in the up-current or up-wind direction from the meter readings and only after any suspended bottom sediments have settled. You will perform each of these steps at each station in your embayment beginning in the inner portion and moving outward (toward the inlet). Samples are collected by Sampling Pole or Niskin Bottle. A surface sample will be collected at every station at 15 cm below the surface at pre-selected depths where required with the bottom sample 50 cm above sediment surface (be sure not to hit the bottom).

<u>COLLECTION (MEP QAPP Appendix B-1, H)</u>

MAKE SURE **ICE** IS IN COOLER

1. a) Label one 1 liter nutrient (white) bottle and one 1 liter chlorophyll (brown) bottle with station I.D., date, depth, and time of collection).

b) ***Lower sampling pole with the 1-liter nutrient (white) sample bottle to 15 cm below the surface and pull stopper, bring to surface, shake and dump to rinse bottle; replace stoppers then repeat. If a sample is collected for dissolved oxygen Winkler analysis, that sample will be collected first.***

c) Immediately cap nutrient (white) bottle, put in cooler, and shut cooler lid.

d) Use the water in the oxygen bottle to determine water temperature with thermometer.

e) Lower sampling pole again with 1 liter brown Chlorophyll bottle to 15 cm below surface, pull stopper, bring to surface, cap and put in cooler. Shut cooler.

******PUT NUTRIENT AND CHLOROPHYLL SAMPLES IN COOLER IMMEDIATELY*****

2. Take Secchi depth and total station depth.

3. If a bottom sample is required, repeat ***a*** through ***e*** at a depth of 30cm above the bottom. If water is >3 meters (depth of sampling pole) a Niskin Sampler should be used.
4. Move to next station, repeat.
Note**: Surface samples can be taken by hand or with the sampling pole. If taking samples by hand you must hold the open bottle in an inverted vertical position while submerging to the desired depth and then tip upright to fill.**

6.0 Sample Processing
Samples will be prepared for dissolved nutrient analyses by filtration. This process will be done by MVC personnel prior to shipping as described in item 6.1. Processing for particulate and chlorophyll *a* analyses will either be done by MVC personnel or by SMAST lab personnel as described in items 6.2 and 6.3 below. Total Suspended Solids samples will be processed by SMAST personnel at their Lab.

6.1 On station (preferable) or back on shore
FILTERING: Dissolved Nutrient Analyses (MEP QAPP Appendix B-1, H)
Samples for dissolved nutrient analyses will be filtered through a 0.22-micron cellulose acetate filter 47 millimeters in diameter into a 60 cc acid-washed plastic bottle.
• TO BE DONE AS SOON AS POSSIBLE AFTER COLLECTION,
• Filtered samples are to be shipped in the small white 60 cc plastic bottle (these bottles are acid leached),
• Write label directly on plastic bottle with provided permanent marker (date, time, station, depth, embayment name)

Procedure (MEP QAPP Appendix B-1, H):
1. Remove white 1 liter sample bottle from cooler, one station bottle at a time.
2. Label a 60cc bottle with identical station information:
   a. Embayment abbreviation name
   b. Station ID
   c. Sample Depth (in meters)
   d. Date (mo/dy/yr)
3. Filter sample water to prepare dissolved sample
   a. Place filter (using provided forceps) in clear plastic filter holder. (white filter, not the blue paper).
   b. Shake 1-liter nutrient (white) sample bottle (in case of particulate settling) and fill 60cc syringe with water from bottle by removing plunger and pouring in, replace plunger.
   c. Attach filter (cup side up) to syringe (most filter holders have an arrow drawn on side indicating the direction of flow) and push through and discard the first approx. 30 cc of water through the filter.
   d. Push next 20 cc – 30 cc of water through the filter into the small 60 cc sample bottle, replace cap, shake and discard water.
   e. Now refill syringe, **attach to filter** (cup side up) and collect all water through the filter into the now rinsed bottle until bottle is full to shoulder, **taking care that no**

unfiltered water drips into sample, Fill bottle to top leaving only a small (2-3 ml) bubble, cap and put on ice.

f. Cap 1-liter nutrient (white) sample bottle with the remaining water, check label and put on ice. The bottle must be at least ¾ full to be used for analysis.

g. Remove used white filter paper and discard.

Repeat steps a) through g) for each 1 liter nutrient (white) sample bottle.

The samples must remain in the dark and cold. Keep cooler lid closed.

6.2 Filtering: Particulate Analyses (by MVC personnel or by SMAST lab personnel) Note: a Three-port vacuum filtration unit is used for Particulate and chlorophyll filtrations. Rinse forceps tip with a squirt of distilled water between handling used filters and between handling used filters and extracting and placing new filters.

3. Remove white 1 liter sample bottle from cooler, one station bottle at a time.
4. Apply label tape to a 47 mm, plastic, lab-cleaned petri dish and print on label tape the identical station information:
   a. Embayment abbreviation name
   b. Station ID
   c. Sample Depth (in meters)
   d. Date (mo/dy/yr)
   Note: The label tape should be of sufficient length to extend across the bottom of the plastic petri and up onto the top, tying the two pieces together.
5. Place pre-combusted 25 mm Glass Fiber Filter (using provided forceps) in vacuum unit holder.

Secure pre-rinsed funnel housing onto vacuum unit filter housing and turn funnel to engage.

6. Shake 1-liter nutrient (white) sample bottle (in case of particulate settling) and fill 250 cc pre-rinsed (distilled water) graduated cylinder with water from bottle. Attempt to filter at least 250 milli liters of sample but judge the amount that will probably be accommodated through the filter based on the difficulty of filtration of the dissolved nutrient sample. As the sample drains down the funnel, rinse the inside of the funnel with distilled water from a squirt bottle. Note the amount filtered on the petri dish.
7. The filter will be removed using forceps and placed into the petri dish and folded in half using the forceps rinsed in distilled water.

8. If shipping immediately to the lab, seal the petri dish and refrigerate. If the sample will not be shipped for 24 hours, leave the petri cracked open and place in a 60 degree C drying oven over night.

9. After first sample is filtered, graduated cylinders and funnel housing will be rinsed with distilled water and second sample water before proceeding to filter the second sample.

6.3 Filtering: Chlorophyll *a* Analyses (by MVC personnel or by SMAST lab personnel)
Note: Rinse forceps with a squirt of distilled water as described for Particulate Analyses above. Throughout processing, the sample must remain in the dark. Green lights may be used.
10. Remove brown 1 liter sample bottle from cooler, one station bottle at a time.
11. Apply label tape to a 47 mm, plastic, lab-cleaned petri dish and print on label tape the identical station information:

a. Embayment abbreviation name
b. Station ID
c. Sample Depth (in meters)
d. Date (mo/dy/yr)

Note: The label tape should be of sufficient length to extend across the bottom of the plastic petri and up onto the top, tying the two pieces together.

12. Place a 47 mm, 0.22*u*M nitrocellulose filter (using distilled-rinsed forceps) in vacuum unit holder. Secure pre-rinsed funnel housing onto vacuum unit filter housing and turn funnel to engage.
13. Shake 1-liter nutrient (brown) sample bottle (in case of particulate settling) and fill 250 cc pre-rinsed (distilled water) graduated cylinder to the 250 mark with water from bottle. Attempt to filter at least 250 milli liters of sample but judge the amount that will probably be accommodated through the filter based on the difficulty of filtration of the dissolved nutrient sample. As the sample drains down the funnel, squirt three drops of saturated magnesium carbonate solution onto the last 10 ml of sample and then rinse the inside of the funnel with distilled water from a squirt bottle. Take care that the sample does not run dry before the magnesium carbonate is added. Note the amount filtered on the petri dish label tape.
14. The filter will be removed using forceps and placed into the petri dish and folded in half and in quarters using the forceps.
15. If shipping immediately to the lab, seal the petri dish and freeze making sure that the sample remains in the dark during storage and transport.
16. Rinse equipment as for particulate analyses in item 8 above.

6.4 Total Suspended Solids Analysis by SMAST lab personnel
Total Suspended Solids or TSS is a measure of the amount of suspended particulate material per unit volume of water and is expressed as mg/L or µg/L of retained on a standard GFF glass fiber filter. Samples will be collected in lab-clean 1-liter HDPE bottles provided by SMAST at the stations indicated in the summary Table on page 16. The samples will be collected at the surface as described for nutrient samples in Section 5.7 and put on ice until shipped to the Lab. The SMAST Lab will perform sample analyses.

1. Equipment

Convection oven (60 °C)

Muffle furnace (485 °C)

Vacuum filtration setup with filtering towers for 2.5 cm glass fiber filters.

Graduated cylinders (500 mL)

Plastic petri dishes (45 cm)

2. Consumable Supplies

GFF glass fiber filters (2.5 cm)

Deionized water

3. Procedure

3.1 *Preparation of Samples*

1. Pre-combust 2.5 cm glass fiber filters at 485 °C for 4 hrs.

2. Pre-weigh each filter to 4 decimal places, place in labeled petri dish and record weight. Vacuum filter a known volume of water sample (in graduated cylinders) through the combusted filter until sufficient organic material accumulates on the filter without clogging it. If a filter gets clogged with particulates, scrape the filter to let the remaining water run out, rinse the funnel, and start over.

** **Be sure that samples are very well shaken before pouring****

3. Dry filters in petri dishes in the drying oven at 60°C overnight. You will want enough for all your samples, 3 blanks, and a few extra in case the sample clogs a filter.
4. Cool in glass dessicator for about 15 minutes before weighing (until cool to touch).
5. Weigh each filter to 4 decimal places and record.
6. Be sure to include date, ID, volume filtered on the label, and make it clear that these are TSS.
7. Between samples, rinse funnel with DI and rinse the graduated cylinder with 2 rinses of the next sample.
8. After all your samples have been filtered, make three blanks by rinsing the filtration funnels with DI.

3.2 Data Calculations

TSS = (weight of filter full –weight of filter empty)/volume filtered

3.3 Quality Assurance/Quality Control

Field duplicates are collected for 5% of the sample set.

3.4 References

Standard Methods for the Examination of Water and Wastewater, 17th edition, 1989. P 2-75.

6.5 SHIPPING and Handling:

SMAST will be notified at least 24 hours before a sampling round to assure that personnel can pick up samples and that the lab is able to handle the projected analysis load. Before actual shipment, William Wilcox will notify SMAST, MVC (contact Roland Samimy at 508.910.6314) that samples will be in transit. Samples will be shipped by William Wilcox either on the Fast Ferry to the New Bedford dock for pick up by SMAST personnel. If ferry schedules are not workable in terms of sample

collection and holding times, samples may be shipped by Cape Air flight to New Bedford Airport. The Cape Air schedule to New Bedford airport is not yet available however, samples will be shipped the same day as collection to arrive within 8 hours of collection in the case of morning sampling and the following morning within 12 hours of collection in the case of afternoon sampling. Samples collected by SMAST personnel will be carried back to the lab by those personnel on their boat. Samples collected by William Wilcox may be shipped back to SMAST by SMAST personnel where scheduling permits the transfer of samples to SMAST personnel.

After collection, samples will be kept continuously on ice or in refrigeration. (No other sample preservatives will be used).
Samples will be shipped in heavy-duty Styrofoam coolers with ice or cold packs adequate to maintain cold internal temperatures. All shipments will be accompanied by a Chain of Custody (sample in Appendix A). COC will be copied before shipping to maintain an in-house copy. Samples will be collected always on the ebb tide or at dead low water and in the morning unless the need for a sampling round requires afternoon sampling.

7.0 YSI 85 METER Dissolved Oxygen Confirmation:
In order to assure the Quality of the dissolved oxygen data collected in the field with the meter, bi-weekly samples will be collected for Winkler method analyses. Dissolved oxygen as recorded by the meter will be checked for a subset of 10 percent of the samples to be collected during that week. The samples will be collected as follows:

7.1 Dissolved Oxygen WATER SAMPLE ANALYSIS (MEP QAPP Appendix B-1, J)

First: **Fill glass O2 reagent bottle from blue oxygen kit:**

Step 1. Remove glass stopper.

Step 2. Lower rubber tube from oxygen bottle on pole to the bottom of the glass reagent bottle from the blue oxygen kit.

Step 3. Drain ¾ of the poles plastic oxygen (0.5 liter) bottle through the glass bottle, overflowing the glass bottle.

Step 4. Gently tap glass bottle to insure that no bubbles stick to sides.

Step 5. As volume reaches ¾ of the 0.5 liter plastic bottle, slowly remove the rubber tube from the glass bottle and then carefully insert glass stopper so as not to trap any bubbles. Dropping glass stopper in from above works best.

Step 6. Set sample aside in the shade for now.

Next: Put thermometer in the salinity/temperature bottle on pole, let stabilize, record this as "water temperature". Remove thermometer and cap the salinity bottle and set it aside till after the dissolved oxygen is tested.

Now: Continue the dissolved oxygen analysis instruction below….

7.2 DISSOLVED OXYGEN (MEP QAPP Appendix B-1, J)

i. Open Reagent packet #1 (use the scissors in your kit);

ii. Open Reagent packet #2
iii. Remove glass stopper from glass oxygen reagent bottle;
iv. Pour Reagent #1 into bottle and then add reagent packet #2 to bottle.
v. Replace glass stopper, careful not to trap bubbles.
vi. Shake bottle vigorously holding bottle and stopper (some reagent may stick to bottom of bottle…this is O.K.).
vii. Let stand 2 minutes, shake again.

After a total of 5 minutes (when the chemical floc has settled the second time and there is a clear division), open Reagent packet #3, remove glass stopper, add powder to bottle, replace stopper (no bubbles), shake vigorously until water in bottle becomes clear (no #3 particles). *THE SAMPLE IS FIXED NOW AND WILL BE TRANSPORTED TO THE LABORATORY– IN THE ICE CHEST AND DARK.*

8.0 Data Review

The lab data will be reviewed by Dr. Brian Howes to assure that the data meets SMAST Quality Assurance requirements. At this stage, the source identity of blind duplicate samples will reside solely with William Wilcox at the Martha's Vineyard Commission.

The resulting data will then be evaluated by William Wilcox to compare blind duplicate results with their source samples to assess the accuracy of the lab analyses. The goal of this screening is to determine that there are no obvious errors in the lab analyses. When completed, Jo-Ann Taylor, QA Officer, will examine this review, to assure that the blind duplicates are appropriately attributed to the matching stations and to determine precision based on the coefficient of variation (Relative Percent Difference or RPD). This evaluation rather than Relative Standard Deviation will be used due to the limited number of repetitions available from the sampling program. RPD will be determined using this formula:

$$RPD == \frac{(X1 - X2)100}{(X1 + X2)/2}$$

In addition, both Jo-Ann Taylor and William Wilcox will independently screen the entire data set to assure that sample identification numbers and sampling dates are correct; to seek out decimal point errors; and to identify questionable data on the basis of values outside the expected range from previous surveys at those locations.

Lab results will be scrutinized both for each station over the course of the sampling program and for all stations within the pond during each sampling round. The data will be compared to identify suspicious outliers that will be assessed first by examining the lab accuracy for that date and then by considering the setting at the sample site to determine any unique conditions that might cause the observed results. Possible causative factors for data outliers are anticipated to include: proximity to a fresh water discharge; location within a poorly circulated recess of the estuary; recent rainfall; handling or collection errors; and lab error as indicated by blind duplicate results for that date.

These evaluations will be included in the Final Report.
The data will be graphed to display the trend through the sampling period and to compare the data collected in 2008 with previous years. Ratios of inorganic nitrogen and silica to orthophosphate will be calculated to determine limiting nutrient(s).

APPENDIX A
Field Data Sheet
Chain of Custody

MV COMMISSION Field Data Sheet

Station # ___________
Time: ______________
Date: ______________
Wind Dir: __________
Wind Speed: ________
Rain Last 24 Hours:Y N
Cloud Cover: _____%
Wave height (Beaufort scale):

Secchi Disk Depth: Shaded Side of Boat or Pier

Depth Down: _____
Depth Up: _______
Total Depth to Bottom: ______
METER READINGS: The Meter(s) in Use Are: ________________________________

Depths:

DO % SAT. ______ ______ ______ ______ ____
Cond. ______ ______ ______ ______ _____
Sp. Cond. ______ ______ ______ ______ ______
Sal. ______ ______ ______ ______ ______
Temp. ______ ______ ______ ______ ______
PH ______ ______ ______ ______ ______
Turb. ______ ______ ______ ______ ______

Observations: E.g. floating weed, debris, oil, jellyfish or other animals, rafts of waterfowl, presence and distance to overnight boats, current direction, speed etc.

Samples Taken: Indicate bottle number if different than Station number. For deeper samples indicate depth.

	Nutrient	POC	Bacteria	Phyto.	Chlor.A	Other
SURFACE	______	______	______	_____	______	____
DEEP(show depth)	______	______	______	_____	______	_____

Device used for deep sample_______________________
Other Notes: ____
Pond Watchers Identity:____

CHAIN OF CUSTODY

Laboratory samples Are Shipped to: ________________________________

FROM: Martha's Vineyard Commission
P.O. Box 1447
Oak Bluffs, MA 02557
508.693.3453

CONTACT:

Project Name: **Number:**

Project Site: Samples Collected By: __________________

Special Notes: ____

____

NUMBER OF SAMPLES ENCLOSED:

Dissolved Tot. P ____________
Particulate ________________
Chlorophyll ________________
Other ________________

Check Analyses Required for Each Sample

Sample ID	NH4	NOx	PO4	TDN	HCN	TSS	CHLA	TP	Sal.	PH	Alk.	SiO2	Cond.
_____													
_____													
_____													
_____													
_____													
_____													
_____													
_____													

Collected By: ______________ **Date:** ________________ **Time:** __________

Received By: ______________ **Date:** ________________ **Time:** __________

Received By: ______________ **Date:** ________________ **Time:** __________

Received By: ______________ **Date:** ________________ **Time:** __________

APPENDIX B:

Equipment to be Used and Calibration of Same

GPS Station Location:
A Trimble Geo-XH Global Positioning System will be used to locate all sample stations. Location measurements will proceed only with at least 5 satellites available to assure accuracy. The goal will be a minimum of six satellites using the High Precision setting. Station locations will be corrected with the download data available at the National Geodetic Survey CORS site (continuously operating reference system). Corrected station locations are expected to be accurate within 3 meters and probably within 1 meter.

YSI85 Field Meter:
The YSI-85 model field monitoring equipment will be maintained and checked as per manufacturers' instruction. The probe is a non-detachable, combination sensor that reads conductivity, dissolved oxygen and temperature. As suggested, the probe and its storage cell will be rinsed with clean tap water after each use.

Equipment Calibration and Frequency
The preparation and expiration dates of standard solutions will be clearly marked on each of the containers to be used in calibration. It will be the responsibility of William Wilcox to check the calibration status of any meter prior to using the instrument and to check its calibration periodically during use. A log documenting problems experienced with the instruments and corrective measures taken will be maintained by the Sampling Coordinator.

All equipment to be utilized during the field analysis and laboratory analysis will be checked, prior to its use, to see that it is in operating condition. This includes checking the manufacturer's operating manuals and the instructions with each instrument to ensure that all maintenance items are being observed.

William Wilcox will assume responsibility for quality control checks and calibration of field measurement equipment. The laboratory manager will assume responsibility for all lab quality control checks, maintenance and calibration of laboratory equipment as per the SMAST SOP and QA Plan.

The meter will be auto-calibrated for dissolved oxygen before each sampling event following manufacturers recommended procedures. The accuracy of dissolved oxygen readings will be checked by collection of samples for Winkler method DO determination at two-week intervals.

The accuracy of the instrument will be checked with a standard conductivity solution each week and the instrument will be calibrated by two-point calibration using lab standard solutions should the instrument error reading of the standard solution exceed 5 percent. Any deviation from these recommendations due to specific peculiarities with certain instruments will be documented in the field logbooks and the monitoring program of the grant work plan. Instruments will be left on for the duration of the sampling round, at station and en route. All standards will be traceable to a nationally recognized standard and documented in field logbooks. A monthly two-point calibration will be performed for the dissolved oxygen probe. Temperature will be calibrated quarterly, by validating the temperature in a known temperature water bath.

AUTO-CALIBRATION OF DISSOLVED OXYGEN PROBE

The probe is equipped with a polargraphic Clark-type sensor. A new dissolved oxygen membrane will be installed at the beginning of the field season and at 8-week intervals as per the manufacturer's recommendations outlined below.

1. Before departing from the shore, turn the meter on by pressing the ON/OFF button, and then press MODE button until dissolved oxygen is displayed in mg/l or %. Allow the readings of dissolved oxygen and temperature to stabilize for 15 minutes.
2. The meter has two buttons with arrows; one pointing up and the other pointing down. Push both buttons simultaneously. The screen will read "0", press "enter" if at sea level to set altitude. If above sea level, use the arrow keys to set the altitude in units of 100 feet (i.e. 12 is 1200 feet). For work on all coastal ponds the altitude will be set at zero. When correct altitude is shown, press ENTER.
3. The YSI 85 will now display CAL in the lower left of the display screen. The calibration value should be displayed in the lower right of the screen and the current % reading shows in the main display of the screen. This reading should be within the range of 99 to 101 percent. When the current reading display is stable, press ENTER button. The display will then read SAVE and return automatically to the Normal Operation Mode.

CALIBRATION OF CONDUCTIVITY METER

1. Turn the instrument on and allow it to go through its self-test procedure.

2. Select a calibration standard appropriate to the expected conductivity in the pond to be sampled:

a. For seawater a 50 mS/cm will be used.

b. For fresh water, a 1mS/cm standard will be used.

c. For brackish water, a 10mS/cm standard will be used.

3. Place at least three inches of calibration fluid in a clean glass beaker.

4. Use the MODE button to advance the display to conductivity.

5. Insert the probe deep enough into the standard solution so the oval hole on the side of the probe is completely covered. Suspend the probe ¼ inch from the bottom of the beaker. Do not rest it on the bottom of the beaker.

6. Allow at least 60 seconds for the temperature reading to stabilize.

7. Move the probe vigorously from side to side to dislodge any air bubbles from the electrodes.

8. Press the UP and DOWN arrows simultaneously. The CAL symbol will appear.

9. Use the UP or DOWN arrow buttons to adjust the reading on the display to match the value of the calibration standard.

10. Once the display reads the exact value of the calibration solution, press the ENTER button once. The display screen will then read SAVE indicating the calibration has been accepted.

The YSI 85 is designed to retain its last conductivity calibration permanently. Before each use, the instrument will be checked against the appropriate standard and corrected as needed to maintain accuracy within +/- 5 percent.

DISSOLVED OXYGEN MEMBRANE CAP REPLACEMENT

The membrane cap will be replaced annually at the beginning of field season and again at 8-week intervals or as needed based on inspection of the membrane for defects.

1. Unscrew and remove the probe sensor guard.
2. Unscrew and remove the old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare the KCl electrolyte according to the directions provided by the manufacturer with the solution .
5. Hold the membrane cap and fill at least ½ full with electrolyte solution.

6. Screw the membrane cap onto the probe moderately tight. A small amount of electrolyte should overflow.
7. Screw the probe sensor guard on moderately tight.

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