

Background on Water Column Parameters Shown in the Graphs:

There are key chemical and physical measures that are indicators of the condition of a tidal water body. When collected over time, these parameters can identify the trophic state of the system. Trophic state is a description of the amount of productivity in the system. Nitrogen is the nutrient that drives the growth of plant material in coastal pond systems. Productivity is important to the yield of natural resources such as bay scallops and quahogs from a pond. However, there can be too much of a "good thing" when the pond produces too much biomass that robs the water column of dissolved oxygen and in extreme cases produce large rafts of decaying algae that causes odors and fish kills. This condition is often described as being eutrophic.

The measures include **chlorophyll pigment** that is 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 light penetration through the water column. The more fine particles like phytoplankton in the water column the lower the light penetration and the shallower the extinction depth. The amount of **dissolved oxygen** is a key 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 in all forms indicates whether a system is over-productive and if the nitrogen input from the watershed is excessive. There are many other approaches to characterize the condition of a pond including population studies of the benthic organisms (quahogs, worms etc.), distribution and amount of aquatic plants and fish population. The parameters evaluated here are those that determine the viability of the aquatic plant and animal communities. In evaluating the data presented for each pond, the rating system devised by the Buzzard's Bay Program is helpful. Our goals should be to avoid zero point ratings and to maintain average ratings above a 60% score. The ratings are summarized in Table 1. Seasonal variation is the rule and year-to-year changes in water quality, in response to weather and even changes in the Gulf Stream may be substantial.

Table 1: Buzzard's Bay Eutrophication Index

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 reviewing the charts, we suggest that you apply a desirable goal for these water bodies as follows:

- ❖ maintain ratings that are above 60% of the perfect score value for DO saturation and Secchi depth and
- ❖ less than 60% of the zero score value for pigments, DIN and TON for the growing season.

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 rating system will be refined specifically for each pond during the Massachusetts Estuaries Project study of these systems.

CHILMARK POND:

This pond is very different in terms of circulation than most tidal ponds in that it is cut open to the sea periodically, remains tidal from as little as a few days to as many as a month or more and then the inlet closes and the pond gradually freshens as it receives stream and groundwater input that refills it. When the pond is open to the ocean, tidal circulation replaces the water in the pond system every 15 days. When the pond is closed to the ocean, the exchange time ranges from 60 days to well over 100 days. This allows the nitrogen to be circulated repeatedly into producing new generations of phytoplankton and building up large amounts of organic matter. The implications for salinity and water quality are enormous.

The area covered by water varies with the height of the Ponds that depends on the state of the inlet through the barrier beach. The area of the ponds during an open pond was determined (Wilcox, 2001) from aerial photographs (3/25/98 flight with scale at 1 inch is 1042 feet) using planimeter. The Upper Pond measured 33.1 acres (1.44 million square feet) and the Lower Pond was 145.5 acres (6.34 million square feet) at low water. When the Lower Pond is at its highest (about 5 feet NGVD), a large area of wetlands is flooded (Long Point, Allen Point and the area around Gilbert's Cove). The wetland area was measured by planimeter from aerial photos (1998) at 79.8 acres that brings the Lower Pond (including the connecting channel to the Upper Pond) to a total surface area of 241 acres when it is at its highest stage. The Upper Pond at that stage approaches 35 to 40 acres. The Upper Pond is exclusively a fresh water body except during extreme storm conditions. The Lower Pond is brackish for most of the time and may develop salinity near the Atlantic Ocean during the unusual times when the inlet remains open for extended periods of time.

The Pond contains some small oyster beds located along the barrier beach on the south side. It has a herring population of unknown size. The Upper Pond provides suitable spawning habitat. The excessive productivity in the system makes it unsuitable for eelgrass. In fact, the eelgrass beds probably died out a very long time ago.

During 2004, the Pond was opened to the ocean on July 8 and remained tidal until near the end of August. Water quality was improved over 2003 as a result of the long period of tidal flow. Salinity values remained between 21 and 28 parts per thousand from July through the last sampling round in early September.

In the charts, you will note the following:

- Dissolved inorganic nitrogen values were at acceptable concentrations throughout the sampling period. This is in marked contrast to the 2003 values.
- Despite the lower DIN values, during the sampling period TON at all stations is very close to or exceeds the zero point limit for tidal ponds. The outlet from the upper fresh Pond (CHP7) is over this limit during the sampling period. High TON is a reflection of the limited tidal exchange that the south-shore great ponds experience.
- Pigments associated with chlorophyll-bearing phytoplankton in the water column are elevated in the western half of the Pond during a most of the sampling period. The eastern sampling stations (CHP1 and 3) have acceptable values. Station 7, at the point where the fresh water discharge from the western (Upper) pond enters the eastern (Lower) pond is well above the zero point value through most of the summer. The pattern of high chlorophyll in the western half and lower values in the eastern half is a result of the summer opening providing exchange that dominates the eastern half of the system.
- Dissolved oxygen saturation below the surface at Stations CHP3 and CHP5 was generally above 80% throughout the sampling period. The values from CHP5 are very near the surface due to the Pond being open and at a low level during the sampling.
- Secchi readings were difficult to obtain due to the shallow water depths while the Pond was open to the ocean. Secchi depth readings at station CHP6 were improved over 2003 probably as a result of better tidal circulation.

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Edgartown Great Pond:

This pond is very different in terms of circulation than most tidal ponds in that it is cut open to the sea periodically, remains tidal from as little as a few days to as many as a month or more and then the inlet closes and the pond gradually freshens as it receives stream and groundwater input that refills it. When the pond is open to the ocean, tidal circulation replaces the water in the pond system every 13 days. When the pond is closed to the ocean, the exchange time ranges from 60 days to well over 100 days. This allows the nitrogen to be circulated repeatedly into producing new generations of phytoplankton and building up large amounts of organic matter. The implications for salinity and water quality are enormous.

The area of the system varies from the closed-inlet situation where the Pond fills with groundwater and reaches 895 acres to the tidal condition where it covers only 462 acres. The Pond contains oyster beds that have recently stabilized after a significant decline due to the oyster disease dermo. There are also widely varying numbers of soft-shelled clams and blue claw crabs.

During 2004, the inlet to the ocean was open from April 3 to April 14 and again from June 11 to June 24. The Pond did not refill enough to allow another opening until November.

In the charts, you will note the following:

- ❖ During 2004, the Total Organic Nitrogen was at or above the desirable target of less than 0.4 milligrams per liter. The Cove stations generally have more TON than the stations in or near the main body of the Pond. The values recorded were higher than those measured in 2003 probably due to less tidal circulation during July and August.
- ❖ The variation between Cove stations and mid-Pond stations is even more dramatic for dissolved inorganic nitrogen (DIN) reflecting the increased dominance of fresh groundwater input toward the head of each Cove. The mid-Pond stations are generally at the desirable target of 6 micromoles per liter. In 2003, the Cove stations were well above that level before the June inlet but declined to low levels after the inlet closed. This phenomenon may have developed due to the below average rainfall in July and August.

- ❖ Total pigment concentration was at or below the desired goal of 6 micrograms per liter at all stations by the end of the sampling period. Stations 4, 9 and 10 exceeded the desirable target during the period from mid-July to early August.
- ❖ Secchi extinction depth is lower in a cove station like EGP11 in Turkeyland Cove or EGP8 in Job's Neck Cove than in a more central station like EGP2 at the southern end of Mashacket Cove. In the more central stations, the extinction depth was near to the desirable goal of 1.8 meters or more throughout the sampling period. In the Coves, the depth was less than desirable but above the zero point value.
- ❖ The dissolved oxygen saturation in the deeper water declined following the closing of the inlet in late June. The saturation values were generally at or above 70%.

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Farm Pond:

Farm Pond is a 33-acre tidal pond. The watershed is dense but largely seasonal residential with on-site wastewater disposal. The northern and northwestern parts of the watershed are high density.

The tidal signal is severely reduced in transit through the culvert beneath Beach Road. An approximate 2-foot tide range in Nantucket Sound is reduced to 0.31 feet within the Pond (Wilcox and Dripps, 1999 unpublished). The volume of the Pond at mid-tide was determined to be 4.465 million cubic feet and the tidal prism to be 0.44 cubic feet (Wilcox and Dripps, unpublished). The estimated time for 95% tidal exchange is 15 days. This figure could be significantly reduced by enlarging the culvert, adding a second one or replacing it with bridge or large box culvert.

The Pond now contains a significant eelgrass bed throughout the entire Pond. This reflects an increase in coverage over that mapped in 1998. The eelgrass is heavily coated with epiphytes and is at some risk (Hemps and Wilcox, 1998). It probably continues to thrive mainly because the Pond is so shallow (most is less than 4 feet deep).

The Pond may have a limited herring population. It also contains quahogs and soft-shelled clams.

In the charts, you will note the following:

- Total Organic Nitrogen concentrations in the water column are above acceptable levels throughout the sampling period. We hypothesize that the eelgrass continues to thrive because the Pond is so shallow that sunlight can

penetrate through the water column and through the slime growing on the leaf blades.

- Dissolved inorganic nitrogen concentrations are low through the sampling period.
- Chlorophyll and other pigments are too high periodically during the sampling period.
- Dissolved oxygen saturation is generally at or above the desirable level during the sampling period.
- The Pond is so shallow that Secchi extinction depths could not be obtained.

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Lagoon Pond:

The Lagoon Pond is fully tidal with a tide range of 1.75 feet. The Pond averages about 9 feet in depth although the West Arm probably is less than half that on average. The estimated flushing time to remove and exchange 95% of the pond water with Vineyard Sound water is 8.8 days. However, the Lagoon has a series of deep-water basins that are separated by sand bars and appear to be isolated from the main circulation pattern. This is supported by an accumulation of organic matter and deep-water anoxia in the southern most of these basins. The implications for tidal flushing are not clear.

The watershed of the Pond is approximately 3916 acres in area containing residential and some significant wastewater sources including the high school. Sewage collection along Beach Road has removed a source of nitrogen from the West Arm of the Lagoon. The MVC estimates that the Lagoon has reached its nitrogen-loading limit. Eelgrass beds declined in area by over 50% between a survey in 1995 and a follow-up in 2001.

In the charts, you will note the following:

- ❖ During 2004, the Total Organic Nitrogen exceeded the zero point value (0.38 milligrams per liter) at least once at all stations over the course of the summer. TON was highest toward the portions of the Pond removed from the vigorous tidal flow at the inlet particularly Station 4 at the south end of the Pond and station 10 in the West Arm. Except for the August sampling round, stations 8 and 9 are close to the values found in Vineyard Sound.
- ❖ Dissolved inorganic nitrogen was at or better than the desirable target of 6 micromoles per liter over the course of the sampling period.
- ❖ Total pigment concentration was very variable from well above the zero point value of 10 parts per billion to well below that value. This variation reflects the onset and decline of phytoplankton blooms in the Pond. Stations 2 and 4 at the south end of the Pond once again displayed the highest concentrations.
- ❖ Secchi extinction data is only available for early August when the visibility was well above the zero point value and better than the desirable target of 2 meters.
- ❖ The dissolved oxygen saturation in the deep water is also only available for the early August sampling. At that time the saturation was at or above 60%.

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Oak Bluffs Harbor:

The Harbor is a 30-acre tidal water body connected to Nantucket Sound by an inlet fixed by stone jetties. The Harbor is an important mooring area and a point for passenger ferries to unload during the summer months. Sunset Lake, a 5-acre tidal water, drains into the Harbor by a 3-foot by 10-foot box culvert under Lake Avenue. The Harbor receives road runoff from a stormwater collection system that includes a large impervious area. The watershed was recently sewered removing a large nitrogen source from wastewater. Residual nitrogen still moving from the groundwater into the system may have influenced water quality in 2003. A considerable area of the watershed includes moderate density residential and will not be sewerized.

The tide range recorded in 2001 averaged 1.9 feet in the Harbor and 1.84 feet in Sunset Lake (Taylor, 2003). The Harbor and Sunset Lake have a mean depth of 2.6 meters. Old water is flushed out and replaced by new, Sound water (95%) over a period of 6.5 days.

In the charts, you will note the following:

- Total Organic Nitrogen concentrations in the water column are higher than desirable throughout the study and reach or exceed the zero-point value at OBH1 on two dates and OBH3 once. OBH1 is collected from the outlet from Sunset Lake.
- Dissolved inorganic nitrogen concentrations are highest in Sunset Lake (OBH1) and at the inner end of the Harbor (OBH2). DIN is above desirable concentrations throughout July but only on July 27 does it exceed the 10 micromole per liter limit for tidal ponds.
- Chlorophyll and other pigments vary widely reflecting growth and decline of algal blooms. The concentrations are higher than desirable during the

sampling period and exceed the zero point value at during three of the five sampling runs.

- Dissolved oxygen saturation data and Secchi readings are collected by the School of Marine Science personnel and are not available at this time.

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Pocha Pond:

Pocha Pond is a 115-acre tidal water body that is connected with Edgartown Outer Harbor and Nantucket Sound by way of a narrow elongate water body (the Lagoon) and Cape Poge Pond. The Pond is fringed by salt marsh that is particularly extensive on the inland side (300 acres, Gaines 1998). At one time, it was a fresh water body that was separated from the northern half of the Lagoon by a dike where herring access was provided.

The Pond watershed is low density residential on average but higher density in the area known as the Enos lots and toward the Wasque end of the Pond. A horse farm including hayland and pastureland is also within the watershed. The Trustees of reservations, the MV Land Bank and Sheriff's Meadow Foundation own substantial open space within the watershed.

Bottom sediment in the majority of the system is highly organic muck, becoming sandier toward East Beach, the north-to-south barrier beach that separates the Pond from Nantucket Sound. The Pond is less than 2 meters in depth throughout and probably averages somewhat less than 3 feet. The Pond produces some blue mussels and limited amounts of soft-shelled clams and quahogs. The Lagoon is deeper and with more vigorous tidal flow produces bay scallops.

In the charts, you will note the following:

- ❖ Total Organic Nitrogen concentrations are higher than the desirable goal of 0.38 milligrams per liter or less. Concentrations at PCA 2 and 3 are higher than desirable reflecting excess productivity.
- ❖ Dissolved Inorganic Nitrogen concentrations are within the acceptable range although variable. The concentrations on August 25 are somewhat higher than desirable levels.
- ❖ Total Pigment concentrations are acceptable at all stations throughout the sampling period.
- ❖ Secchi readings could only be collected at station PCA1, as the rest of the Pond is too shallow. The depth when the disk was seen on the bottom is also shown providing a minimum reading. The extinction depths are acceptable at PCA1 throughout the period.
- ❖ Dissolved oxygen saturation values are mostly over or near 80% (with the exception of the July 7 values) throughout the sampling period.

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Cape Poge Pond:

Cape Poge Pond is a 1520-acre tidal pond that is a highly productive source of bay scallops for the Town of Edgartown. It is connected to Pocha Pond by way of a 95-acre water body called the Lagoon (Gaines, 1998).

The Pond has a tide range of about 2 to 2.25 feet (Wilcox, 2000, unpublished data). Gaines reports that about 1/3 of the pond is over 2 meters in depth and 2/3 less than 2 meters.

The Pond has extensive eelgrass beds in the water where sunlight penetration is good. Some decline was noted in the eelgrass bed area over the period from 2000 to 2002. The cause is not clear. Cape Poge also produces soft-shelled clams and quahogs.

The watershed for the system as a whole (including the Lagoon and Pocha Pond) is about 1480 acres of upland, 350 acres of barrier beach and 468 acres of salt marsh (Gaines, 1998) and includes low and moderate density residential development.

In the charts, you will note the following:

- ❖ Total Organic Nitrogen concentrations during 2004 are near the cutoff for eelgrass health at 0.38 milligrams per liter. The TON concentration generally increases from the inlet (POG1) to the Pocha Pond outlet (POG5). The TON value at POG2 on August 25 is significantly higher than all other results and may indicate an error in collection or analysis or other aberrant result. In general, TON values are near the desirable goal.

- ❖ Inorganic nitrogen (DIN) is higher at the outlet from Pocha Pond and in Shear Pen Pond where confined water bodies are more influenced by the addition of DIN from groundwater or precipitation. DIN in general is low.
- ❖ Chlorophyll pigments concentrations are very good throughout the sampling period at all stations with the exception of POG4 on July 26.
- ❖ Secchi extinction depths are typically well over 2 meters throughout the sampling period indicating good light penetration. Lower values are found in the southern half of the Pond (POG4) further from the source of Nantucket Sound water.
- ❖ Dissolved oxygen saturation in the deep water is above 80% throughout the sampling period in the main body of the Pond. Saturation in Shear Pen Pond is lower reflecting the reduced tidal exchange resulting from the shoal channel connecting it to the main Pond.

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Sengekontacket Pond:

The watershed of Sengekontacket Pond is 4472 acres in the Towns of Oak Bluffs, West Tisbury and Edgartown. The watershed is largely residential but also includes a portion of the Vineyard Golf Club and much of the Farm Neck Golf Club. The area around Trapp's Pond is a sub-watershed to Sengekontacket and receives groundwater from the outskirts of Edgartown including part of the Edgartown Golf Club and the Upper Main Street and Vineyard Haven Road commercial area.

Sengekontacket physical character:

Sengekontacket Pond is a shallow, 700-acre coastal salt pond and is connected by a culvert to Trapp's Pond a 44-acre tidal water body. Old flood tidal flat sand deposits that formed before the inlets were fixed by jetties occupy a large portion of the pond causing the average depth of the Pond to be 0.9 meters or 3 feet.

Sengekontacket is vigorously circulated by the tides that average 2 feet in range and produce a flushing rate of about 2.33 days for removal of 95% of the old pond water to the Sound.

Trapp's Pond has restricted tidal exchange due to the culvert under Beach Road. The tide range in Trapp's Pond averages 0.55 feet.

Sengekontacket Pond is an important source of bay scallops, quahogs and soft-shelled clams to the Towns of Oak Bluffs and Edgartown. There is a large population of blue crabs associated with the area around the culvert under beach Road that connects to Trapp's Pond. The eelgrass in Sengekontacket was largely lost during the late 1980's and early 1990's. The exact cause is not known although the pattern of the remaining eelgrass (found only in Trapp's Pond and in the western end of Majors Cove) implies that wasting disease may have been the cause. This disease is caused by a slime net organism and was the cause of a major die-off in the northeast during the 1930's. Eelgrass is a crucial component of the estuarine habitat that is of key importance to shellfish and juvenile finfish. The MV Commission with funding support from the Friends of

Sengekontacket and the Farm Neck Foundation have conducted trial restoration projects using seed from the plants growing in Trapp's Pond.

In the charts, you will note the following:

- Dissolved inorganic nitrogen values are below guidance levels throughout the sampling period. The DIN concentration approaches the guidance value at SKT2 located off the Farm Neck Golf Club as it did in 2003.
- TON concentrations exceed the guidance limit at all sampling stations at times during the sampling period except SKT6 near the inlet.
- Pigment concentration are below the guidance specification for most stations during the sampling period with the exception of one round off the Boulevard Town landing (SKT8) and at SKT4 in Major's Cove in late July.
- The dissolved oxygen saturation in the deep water is acceptable during the sampling period.
- Because the Pond is shallow Secchi extinction depths are difficult to acquire. Depth readings to the bottom indicate that during 2004, light penetration was adequate.

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Tisbury Great Pond:

This pond is very different in terms of circulation than most tidal ponds in that it is cut open to the sea periodically, remains tidal from as little as a few days to as many as a month or more and then the inlet closes and the pond gradually freshens as it receives stream and groundwater input that refills it. When the pond is open to the ocean, tidal circulation replaces the water in the pond system every 12.6 days. When the pond is closed to the ocean, the exchange time ranges from 60 days to well over 100 days. This allows the nitrogen to be circulated repeatedly into producing new generations of phytoplankton and building up large amounts of organic matter in the water column. The implications for salinity and water quality are enormous.

Including Black Point Pond and the channel connecting it to the Great Pond, the Pond covers about 800 acres in area at high pond. The elevation of the Pond may drop from this level by over 4 feet when it is connected to the ocean. The Pond area at this time is approximately 663 acres in area.

The tide range in the Pond averages about 0.6 feet. The large watershed contributes an enormous amount of fresh water that adds to the outflow to the ocean and aids in keeping the Pond open to the ocean longer than either Edgartown Great or Chilmark Ponds. In 2004, the Pond was opened to the ocean in mid-April for a total of 33 days and again on August 2 when it remained open through the September 7 sampling and continuing on through the fall for a total of 121 days.

The Pond contains oyster beds that have recently declined due to the oyster disease, dermo. The Pond also produces soft-shelled clams and a large but variable blue crab population.

In the charts, you will note the following:

- ❖ During the sampling period, Total Organic Nitrogen generally decreases at all stations following the early August inlet. TON concentrations are above acceptable levels for most of the sampling period and exceed the zero point value during early to mid-August at stations TGP13 and 14.
- ❖ Dissolved Inorganic Nitrogen values are higher in the Coves (TGP10 and TGP14) nearer to the sources of fresh water discharge and lower in the main basin (TGP13). While the Pond is open, the DIN concentration at TGP10 steadily rises. This is a result of the increased input of fresh water at this station indicated by lower surface salinity (1.5 to 10 parts per thousand over the period). Fresh water input to the Pond carries nitrogen with it from the watershed.
- ❖ Chlorophyll pigments increase to levels that were well above the zero point value following the May-June inlet but drop steadily after the early August inlet as tidal circulation carries some of the phytoplankton out to sea. In general, chlorophyll concentrations are above the desirable target of 6 parts per billion.
- ❖ The Secchi extinction depth reached a low point of 1 meter at station TGP12 just before the August inlet. Following that opening, the readings increase to 1.2 meters on August 18 and 1.6 meters by September 7.
- ❖ The dissolved oxygen saturation in the deeper water at both station TGP12 and 14 reaches 60% during the late July to mid-August time period. A saturation of 60% is the desired minimum value and when saturation hits 40% animals living in the Pond are stressed. When this happens during daytime measurement, it is likely that overnight the saturation values were lower. Without more data it is not clear whether the lower oxygen readings extended over a longer period. This phenomenon occurs where the deeper water is isolated from the air overnight and the oxygen in the water is gradually used up. The saturation at TGP13 remained at good levels probably due to wind circulation mixing the water column.

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Tashmoo Pond:

Tashmoo Pond is a 270-acre tidal pond situated on the north shore of Martha's Vineyard. It has a mean depth of 1.3 meters (4.25 feet) but reaches maximum depth in excess of 12 feet below mean sea level. The tide range is 0.61 meters (2.0 feet) (MVC, 2003). The Pond is flushed through a man-made channel to Vineyard Sound that is stabilized by stone groins. Approximately 3.2 days are required to exchange 95% of the water in the system with Vineyard Sound.

The Pond was a fresh water body called lake Tashmoo (and still is by many) with a narrow meandering channel emptying into Vineyard Sound. Today, the tide flows through an inlet fixed by jetties that were created during a Corps of Engineers dredging project that turned the Lake to an estuarine water body.

Tashmoo pond includes a large seasonal mooring field. It is a limited source of bay scallops to the Town of Tisbury and also produces some soft-shelled clams and quahogs. There is a herring run into the Upper Pond that is fresh water.

In the charts, you will note the following:

- Dissolved Inorganic Nitrogen concentrations at all stations are generally at acceptable concentrations. Station TSH4 is the outlet from Upper Tashmoo Pond, a fresh water system that carries with it nitrogen from the surrounding watershed.
- The TON concentration is elevated above Vineyard Sound values at all stations. The TON values are mostly above the desired target of 0.4 milligrams per liter throughout the sampling period.
- The concentration is higher toward the south end of the pond (TSH2S and 3) where tidal circulation is less vigorous and the fresh water input in the

- form of springs and the Upper Pond discharge are more important. The values at these south end stations are too high for desirable water quality.
- School of Marine Science personnel collected Field data for this Pond and we do not have dissolved oxygen and Secchi data.

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