# Tisbury Great Pond: On-going Resource Assessment

**Tisbury Great Pond, Chilmark and West Tisbury**
**2002**

**Richard Karney, MV Shellfish Group**
**William M. Wilcox, Martha's Vineyard Commission**

**FINAL REPORT July 2003**

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**Acknowledgments:** The Pond Sewers, Mary Jane Pease, George Manter and Kent Healy made this project possible by their willingness to try to manipulate the salinity outside the normal timing of openings. George Manter generously provided a boat and his time to carry out the sampling program. Dr. Roxanna Smolowitz, Marine Biological Laboratory, identified presence of the *dermo* disease organism. Kathy Krogslund, University of Washington Marine Chemistry Lab and Dr. Brian Howes, University of Mass. School of Marine Science provided water chemistry analyses. The Tisbury Great Pond Riparian Association, the Edey Foundation and Mass. DEM provided financial support for the field, lab and evaluation efforts.

**Project Scope:** The proposed study was to continue to collect water quality data that will qualify the pond for entry into the Commonwealth's Estuaries Program and to assess the feasibility of suppressing the oyster disease, *dermo (Perkinsus marinus)*, by reducing the salinity in the Pond during the growing season. The program consisted of placing caged, cultured and wild oysters into both Tisbury Great and Edgartown Great Ponds, which were regularly sampled for determination of the level of infection and mortality over the course of the season. Dr. Roxanna Smolowitz, Marine Biological Lab, analyzed samples for presence and degree of infection with dermo.

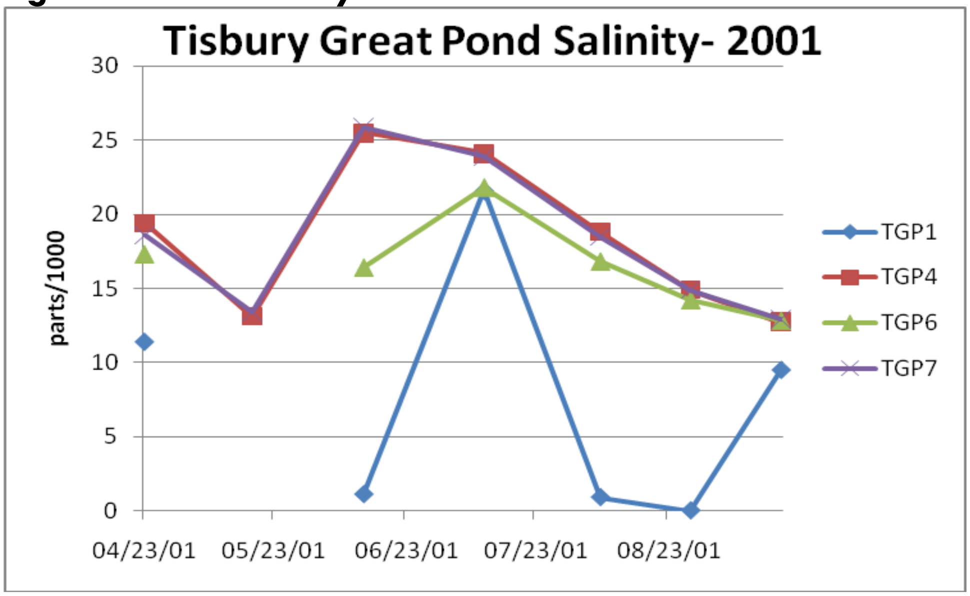
During the initial stages of harvest in fall 2002, it became apparent that there was a substantial die–off of the wild oyster population. It seems likely that this was brought on by the mild 2001-02 winter weather and that the cause was *Perkinsus.*

Water Quality sample stations that have been regularly sampled since 1995 were sampled 6 times from April 30 to September 5 to determine the concentration of nutrients, the salinity, dissolved oxygen content and the transparency of the water column. See Figure 1 for locations. The plan was to have a relatively short duration opening to the pond in the spring and to attempt to hold off opening the pond again until the salinity reached 10 parts per thousand. This salinity level has been reported to result in suppression of the parasitic organism in the Chesapeake and elsewhere.

**FIGURE 1: Sampling Station Locations**

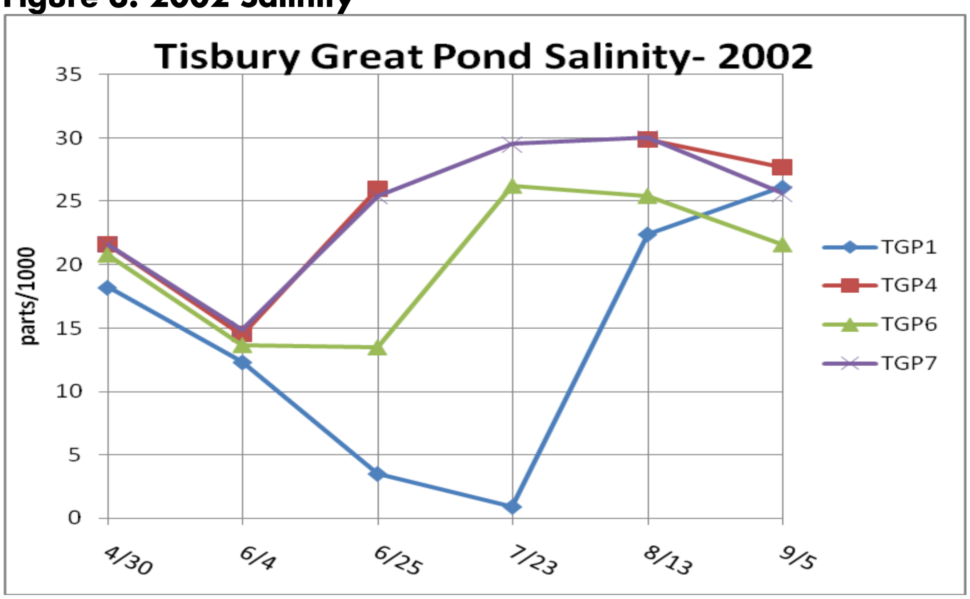

**Program Results:** The spring opening persisted from late February for about 6 weeks. The summer opening was cut through the barrier beach on June 22 when the pond was somewhat lower than usual (about 5 inches). It was expected that the lower initial head might shorten the lifetime of the inlet. In fact, the inlet persisted through July and August and closed in early September. This indicates the predominance during 2002 of factors other than the initial discharge of water when the barrier was cut (particularly wind, precipitation and waves on the south shore) in determining the lifetime of an inlet. The lifetime of the inlet dictates the salinity in the pond and sets the framework for overall water quality by determining the ratio of fresh, watershed water to Atlantic Ocean water in the pond. Both 2001 (Figure 2) and 2002 (Figure 3) salinity results are presented.

**Figure 2: 2001 Salinity**



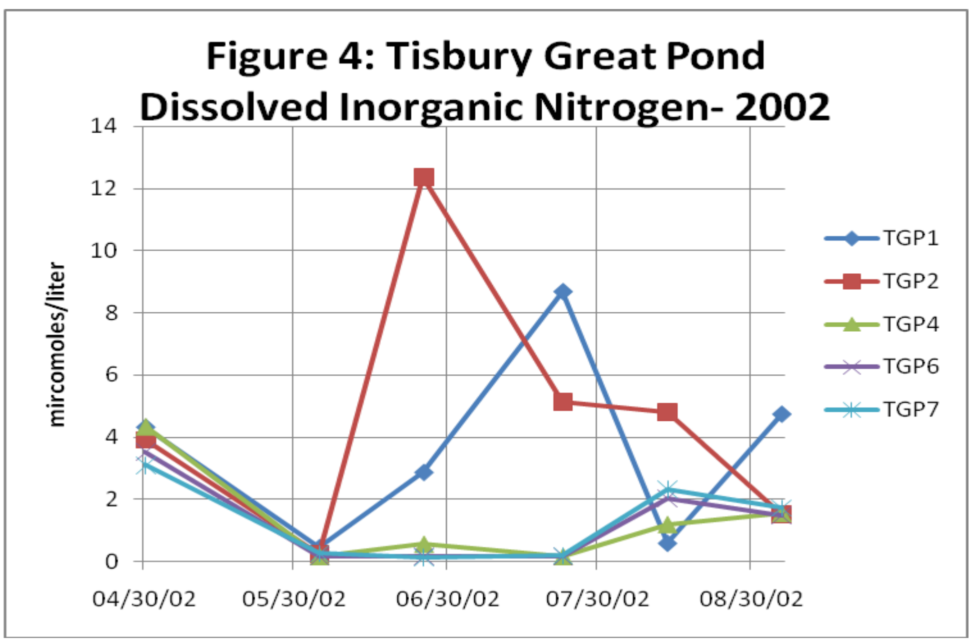

In the main basin (stations 4 and 7) during 2002, the long-lived summer inlet caused salinity levels that were over 20 parts per thousand on June 25 and 25 to 30 ppt in late July, mid-August and early September. As a result of the opening cycle, the Pond never freshened up as much as was desired. There is a significant difference from 2001 when the pond closed during July and began to freshen up during August and early September.

**Figure 3: 2002 Salinity**

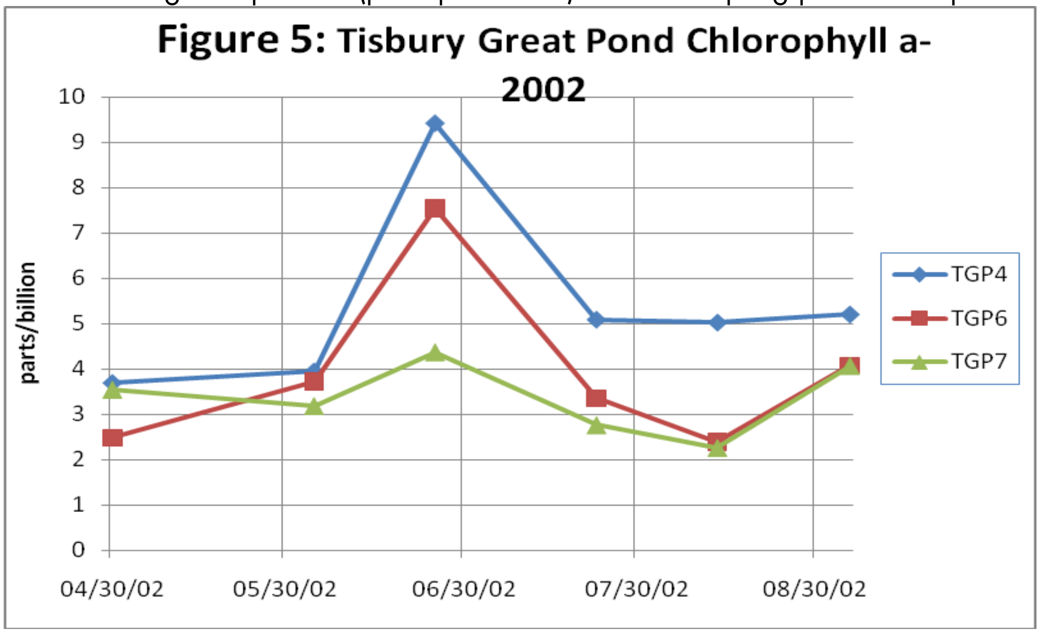


**Water Quality:** The stations set up for water quality sampling include stations highly influenced by the stream input from Mill Brook (station 1) and the Tiasquam (Station 2), a transitional station (4), a station in the basin that is strongly influenced by the opening (7) and a station in Deep Bottom cove with a bar that can be influenced by groundwater discharge when the pond is closed and by the tides when it is open (6). See Figure 1 for station locations. In addition to location in the system, another fundamental influence on water column chemistry in the system is the inlet through the barrier beach to the Atlantic Ocean. The cut through the beach causes the pond level to be lowered which leads to increased discharge of groundwater and a movement of fresh water from the upper reaches of the coves into the main basin of the pond. Movement of groundwater into the system carries with it dissolved nitrogen from land use nearby in the watershed. As nitrogen is an essential nutrient, when added to the water column it leads to an increase in phytoplankton as reflected by particulate carbon and chlorophyll.

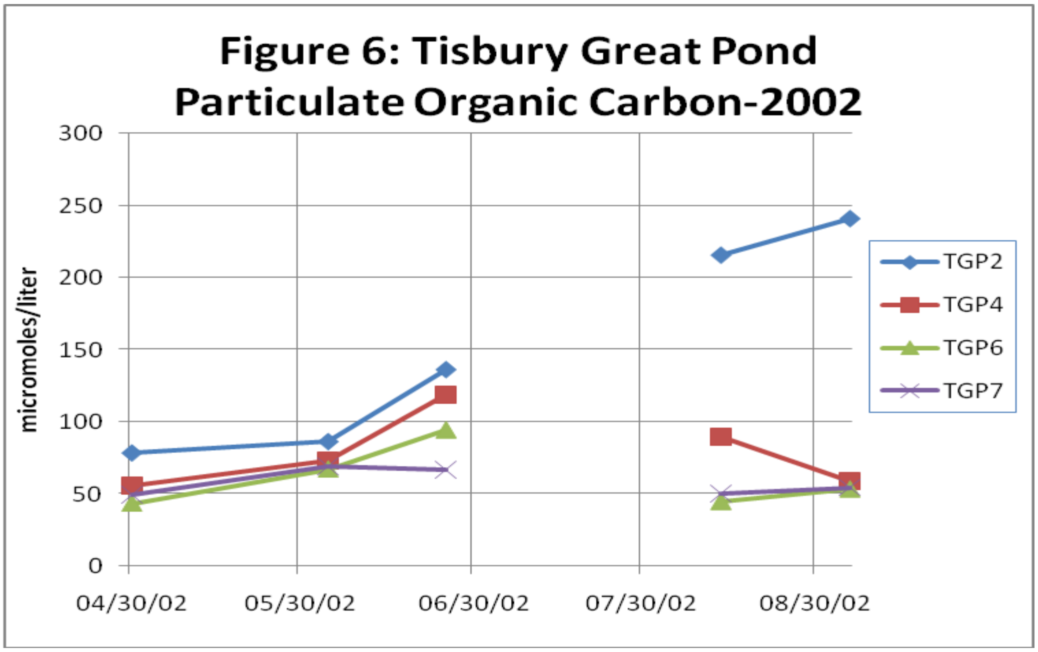
In Figure 4, the dissolved inorganic nitrogen cycle is strongly influenced by the timing of openings through the barrier beach. When an inlet is cut and the pond lowered, DIN increases at all stations. Openings were cut in late May and early October 2001 and in late February and on June 22 in 2002. The June opening remained open until mid-November. Each of these events is followed by an increase in DIN and particulate carbon.



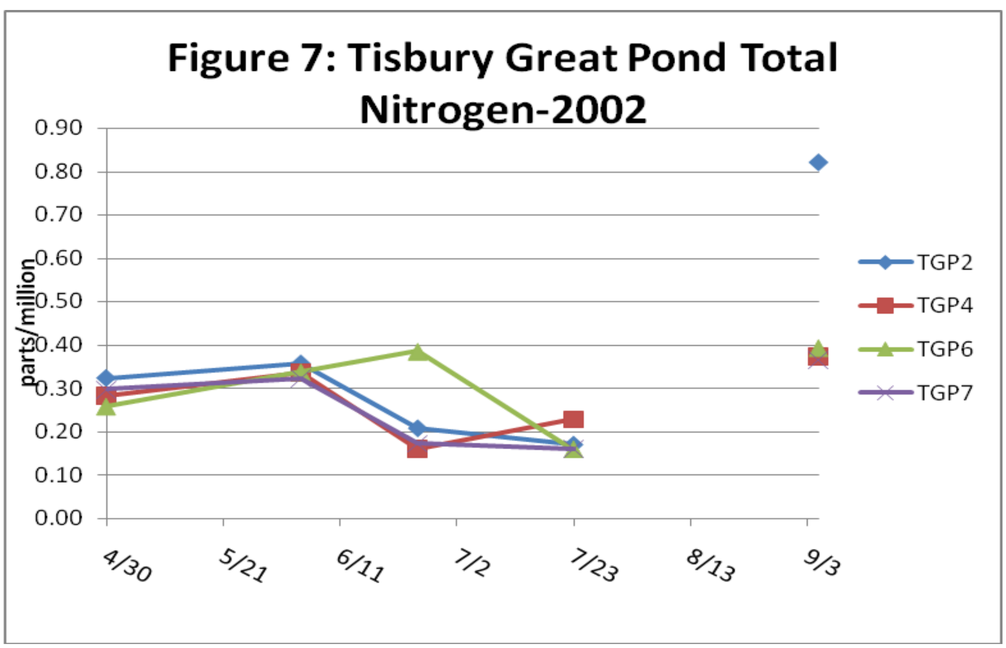

The physical presence of small particles in the water column intercepts and reflects sunlight reducing its penetration. Less light reaching the bottom causes stress in rooted plants like eelgrass and widgeon grass and may eliminate these important plants from the deeper portions of the pond. During 2002, the Secchi extinction depth ranged from just below to just above two meters at Stations 4, 6 and 7 (Figure 7). This is a good condition and contrasts with 2001, when the Secchi depth was less than 2 meters for most of the summer and reached a low of 1.4 meters on June 13 and 1.5 meters on August 28. The improved transparency of the water column is reflected by the lower concentration of chlorophyll in the water column. Chlorophyll *a* is a measure of the amount of chlorophyll bearing phytoplankton in the water column. As is seen in Figure 5, chlorophyll was less than 5 micrograms per liter (parts per billion) for the sampling period except for June 25.



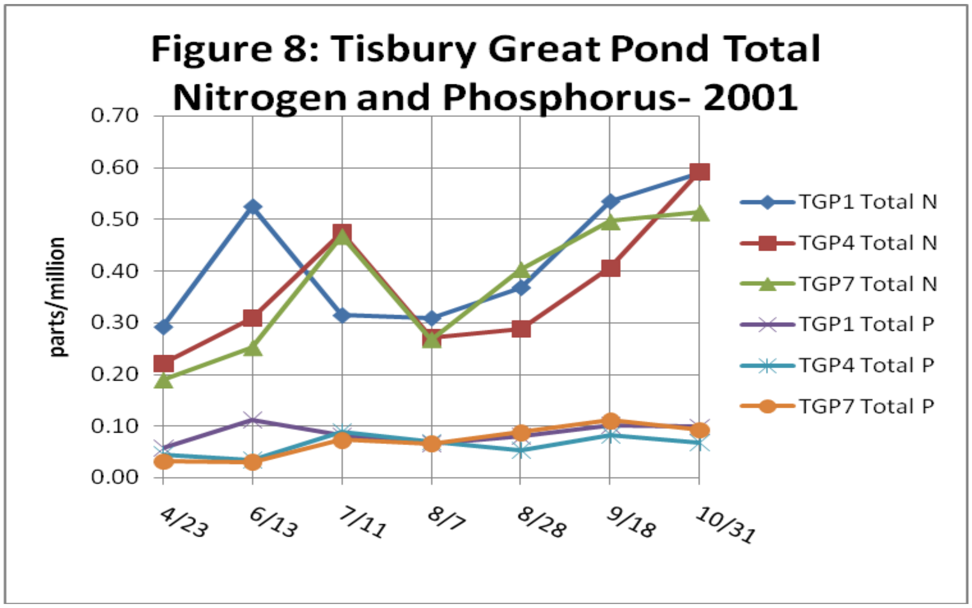

In Figure 6, particulates are higher at station TGP2 in the Tiasquam outlet than at stations further to the south and closer to the inlet. This pattern is similar to the chlorophyll *a* pattern reflecting the availability of nutrients to stimulate primary production and add more phytoplankton to the water column. The higher the particulates in the water column the less sunlight can penetrate and plants on the bottom are stressed. In addition, particulates demand oxygen from the water column for overnight respiration while living and when they die and decay.



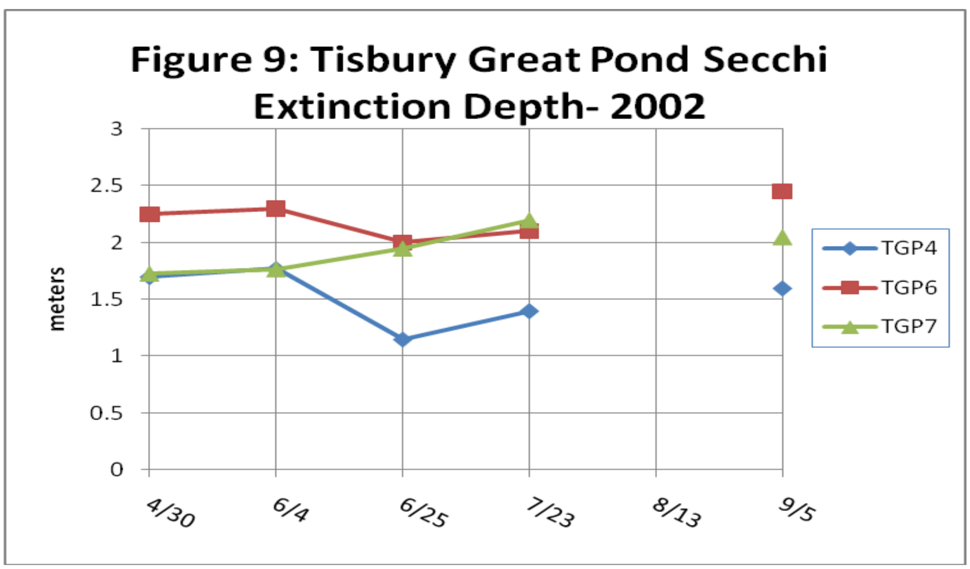

Inorganic nitrogen reaching the Pond from the groundwater and the streams is quickly converted to biomass in the form of phytoplankton and algae. The nitrogen in the water column from all sources dissolved inorganic, organic and particulate make up total nitrogen. Total nitrogen concentration was low throughout the Pond during 2002 (Figure 7). This results from the tidal flushing that continued throughout the summer. Total nitrogen concentration has been found to correlate inversely with eelgrass health- when the TN is above about 0.5 ppm eelgrass is stressed or is not found in the system.



By comparison, 2001 saw higher and more variable total nitrogen concentration as seen in Figure 8. TN concentration builds after the early June inlet that lasted about 25 days. As the Pond refills with fresh water after the inlet closed, nitrogen entering with it is incorporated into plant material and breakdown products that add to the total nitrogen found.

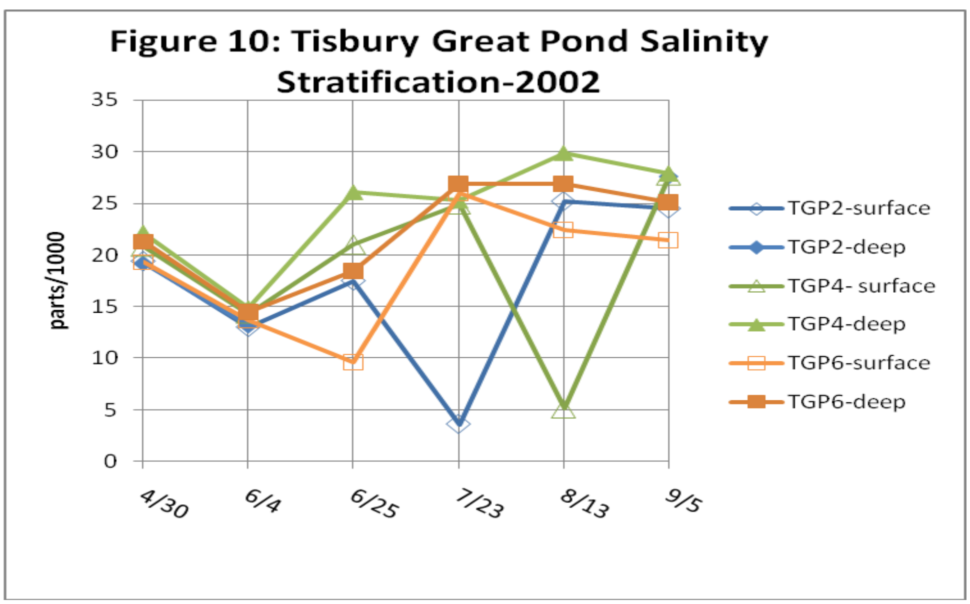



The Secchi extinction depth indicates the depth that sunlight penetrates the water column. It is lower at higher concentrations of chlorophyll, particulate carbon and total nitrogen. In Figure 9, extinction is deeper toward the south end of the Pond (TGP7) and in Deep Bottom (TGP6) than it is off Flat Point Farm at station TGP4. The pattern is similar to but inverse to the particulate carbon concentration pattern. No readings could be collected at TGP 1 or 2 as the water is too shallow at both locations.



**Stratification in the System:**
Stratification is a term applied to the water column where the water density is lowest at the surface and highest at the bottom due to a strong gradient in temperature and/or salinity. A stratified water column is stable because the denser (heavier) water is at the bottom where it is isolated from the air by the overlying, less-dense water. Water column stratification creates a potential for water trapped at the bottom to become anoxic under the right conditions. The deeper water receives a steady rain of dying phytoplankton from the surface. This organic matter requires oxygen to decay and diminishes the amount found in the water column. Add to this the demand for oxygen from photosynthetic rooted plants, algae and phytoplankton during the night and the potential develops for early morning oxygen depletion. This potential problem can be resolved by wind mixing which is a major circulation factor in the pond when it is closed.

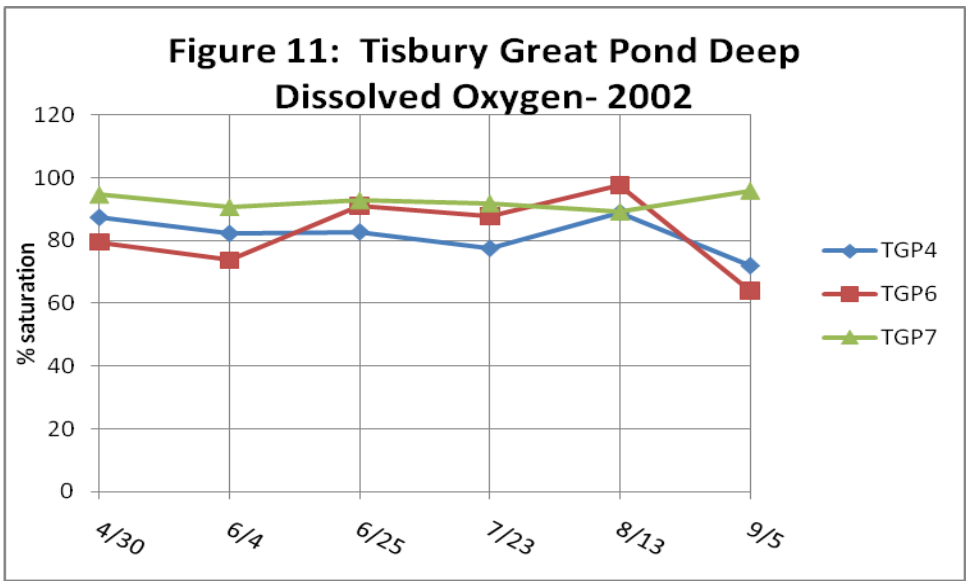
Typically, when the pond is opened, a large volume of fresh water is discharged from the watershed causing the water column at the heads of the coves to become relatively fresh as stream and groundwater discharge dominate. See Figure 10 where, the greater the separation between the surface and bottom salinity, the stronger the stratification. Once tidal exchange is initiated, saline water enters the system and, due to its higher density, may result in a stratified water column at locations midway up the coves such as Station 4 (see Figure 1). In 2001, the spread between surface and deep salinity is minimal on 5/18 but grows through 8/7 where it is a 10 ppt difference. In 2002 (Figure 10), the spread is minimal through 6/4 and all stations have similar salinity. By 6/25 immediately after the inlet was cut the surface and deep salinity curves separate and only come together on 7/23. At that point, the pond becomes well mixed and the salinity values at top and bottom are very much the same. This uniformity stems both from the persistence of the tidal phase caused by an active inlet and from the lack of normal precipitation during July and August (less than one inch). On August 13, some stratification has redeveloped particularly at station TGP2 but it does not persist.



Stratification can be enhanced when the wind is moderate out of the south and piles up the fresh water trying to exit the pond at the surface. Eventually, the salty wedge of water makes its way up to the stations further up in the coves such as TGP1 and 2.

Oxygen is necessary for the animals in the system. Those that are mobile can move out of the low oxygen water to areas where it is available. Those that are not able to move will be stressed or killed depending on the duration and severity of the oxygen depletion. During the study period, no harmful oxygen depletion occurred. Hypoxia is defined as occurring when there is less than 2 milligrams per liter (mg/l) of dissolved oxygen in the water column, which translates to about 25% saturation of dissolved oxygen. The limit for fish and other invertebrates is around 4 to 5 mg/l, which would be 40 to 60% saturation.

In 2002, stratification was not as well developed and the deep, dissolved oxygen readings at Stations 4, 6 and 7 remained above 75 percent until the September 5 survey (see Figure 11).




During 2001, on June 13 at station 7, the salinity at the surface was 16.2 PPT and 28.4 PPT (parts per thousand) at the bottom indicating a stratified water column. Dissolved oxygen decreased from 122 % (supersaturated) at the surface to 68.7% at the bottom. By July 11 2001, the salinity gradient had decreased to range from 19.7 PPT at the surface to 25.3 at the bottom and the dissolved oxygen saturations were near 100% top to bottom. In Deep Bottom the salinity driven stratification did not break up until after the July 11 sampling and, on that date, dissolved oxygen saturation was 69%. Dissolved oxygen in this range at the bottom is acceptable. Stratification extending further into the summer could have undesirable consequences. For example, on August 7, 2001 at station 1, the salinity at the surface was 0.9 PPT and 17.4 PPT at ½ meter depth indication a strong stratification. Dissolved oxygen dropped from 80% at the surface to 55% in the bottom water.

**Dermo Evaluation:**
*Dermo (Perkinsus marinus)* is a parasite that impacts young oysters and often kills them before they reach harvest size. The disease has been prevalent in the Chesapeake for a long period of time where researchers have found that it is suppressed both by very cold winter weather and by the presence of fresh water of salinity less than 10 parts per thousand during the growing season. The disease developed in Edgartown Great Pond in the mid 1990's and only in the last few years in Tisbury great Pond. Recent experience in Edgartown Great Pond has been that only about 50 % of the native oysters in that pond survive to harvest size.

**2001 Program:** Oyster samples were placed into Tisbury and Edgartown Great Ponds during the third week of June 2001. Oysters were collected in the wild, separated into 7 bags containing 40 oysters each. Test plots with oysters native to the two ponds were set at one location in each pond. In Tisbury Great Pond, these cages were placed at the mouth of Tiah's Cove. For comparison, nine bags of oysters native to Edgartown Great Pond were placed at the mouth of Slough Cove in that pond where the *dermo* problem has been entrenched for a long period of time. These samples of wild oysters were expected to be infected with dermo at the same rate and intensity as the wild population in general in the two ponds. In addition, cultured oysters, free of the disease, were placed in seven bags of 40 animals each at these two test sites (Edgartown and Tisbury Great Pond) and also on the Chilmark side of Tisbury Great Pond.

The mild winter preceding the summer sampling for presence of this disease set the stage for extensive infection. Dermo is suppressed by cold winters and salinity at 10 ppt or less during the summer growing season. The winter of 2000-2001 was not a cold one while the 2001-2002 winter was significantly more severe. Salinity levels during both the summer of 2001 and 2002 did not reach the desired level of 10 ppt where dermo is suppressed.

In the initial 2001 sample, the cultured oysters had no disease, the Tisbury Great Pond wild sample had 4% infected and the Edgartown Great Pond wild sample had 74% infected.

In Tisbury Great Pond, the percent infected in the wild group rose to 50% in August 2001, 42% in September and declined to 4% in October. The disease-free, cultured sample on the West Tisbury side was 21% infected by August 2001, 75% infected in September and 4% infected in October. The pace of infection of the cultured oysters was very similar in Edgartown Great Pond. By the October 2001 sample round, cumulatively 100% of both the wild and the initially disease-free samples were infected in all test sites with the exception of the Chilmark-side cultured, disease-free animals.

**NOTE:** ***The percentages reported are not cumulative but the percent of each batch of animals taken for analyses.***

On the Chilmark side of the Pond, the infection rate of the initially disease-free oysters was slower, reaching 4% in August, jumping to 72% in September and declining to zero infection in October. Total, cumulative infection in 2001 was 76% by the last sample.

**2002 Program:** Surviving animals from the 2001 project were left in place over the winter to provide a basis for following the course of the disease during 2002. Samples were collected on July 19 and August 7. At that time, on the West Tisbury side, all of the wild animals and those that were initially disease-free (the cultured oysters) were positive for dermo. On the Chilmark side, the disease free animals were nearly two thirds infected.

**Table 1**
Results of Dermo Evaluation: Dr. Roxanna Smolowitz, Marine Biological Laboratory

| Location | Shell Height mm | Average weight (grams) | % positive | Weighed prevalence | Weighed intensity |
|---|---|---|---|---|---|
| Tisbury Great Pond (Tiah's cove/ West Tisbury side-cultured) | 54.9 | 16.4 | 100% | 2.3 | 2.3 |
| Tisbury Great Pond W. Tisbury side/wild | 82.6 | 56.9 | 100% | 3.0 | 3.0 |
| Tisbury Great Pond Chilmark side –cultured | 63.3 | 25.0 | 66% | 1.7 | 2.6 |
| Edgartown Great Pond (mouth of Slough Cove-wild) | 84.6 | 76.6 | 84% | 2.2 | 2.9 |
| Edgartown Great Pond (mouth of Slough Cove-cultured) | 61.9 | 23.8 | 84% | 2.4 | 2.6 |
| Edgartown Great Pond Last Years Set (natural spawn) | 45 | 9.93 | 64% | 1.1 | 1.8 |
| ***Results from two batches*** | **7/19 &** | **8/07/02** | | | |

***Weighed Prevalence*** *is the total of the intensities from each positive animal divided by the total number of animals examined in the sample*
***Intensity*** *is the total of the intensities from each positive animal divided by the total number of positive animals in the sample.*

**Conclusions:**
In 2001, we concluded that "... it would be difficult but possible for pond managers to adjust the timing and duration of the cut through the barrier beach and, thereby, lower the salinity to 10 PPT in the Pond over the course of several months. However, natural variables such as wind direction and speed that cannot be accurately predicted more

than a few days in advance may have great influence over the inlet lifetime." In 2002, it was clear that natural variables were the operative force in the lifetime of that summer inlet. Cutting the early summer inlet while the pond is lower than the usual level where a cut is made will probably lead to a shorter duration inlet in some years. Periodic reduction in the level of diseased oysters by this method may offer some boost to overall production.

The long-lived inlet during summer 2002 probably also contributed to a lack of stratification and moderate to high levels of dissolved oxygen. The lack of rainfall in July and August probably reduced the input of nitrogen to the system when compared to an average year and lead to lower phytoplankton productivity. Total nitrogen concentrations were substantially lower in 2002 compared to those during 2001. This would be a direct result of the long lasting summer inlet and tidal flushing.

During the course of the study, phytoplankton populations were lower than in 2001 and were not increased beyond those levels found during 1995 when no attempt was made to manipulate the salinity. This is indicated by chlorophyll *a,* particulate nitrogen and particulate carbon. It is likely that this resulted primarily from the extended lifetime of the inlet bringing Atlantic Ocean water into the system. Lower productivity may also have been caused by very low rainfall in July and August that would reduce nitrogen input to the pond.

The infection rate with dermo for initially disease-free oysters is strongly affected by the proximity of an infected resident population. In both Great Ponds, the parasite had reached nearly all disease-free animals in proximity to infected, wild animals by the end of the summer.

Although in the first year, the infection-rate of the disease-free oysters introduced into the contaminated portion of the ponds was nearly 100%, the mortality rate of these animals was lower when compared to the resident, wild-oyster population.

From the data collected in 2001, it appears that the infection will reach well over half of disease-free animals placed where there is a source of infection nearby. By the second year, the infection rate for initially disease free animals will be 100 percent if there are infected animals nearby. Where there are no resident, infected wild oysters, the second year infection rate is well over half of the initially disease-free animals.

It appears likely that disease-free animals infected the first year will die the following year roughly in proportion to the die out found in Edgartown Great Pond (29.5%). Mortality is a function of the intensity of the infection, which builds over time, rather than the presence of the *dermo* parasite.

Over time, the infection rate of wild populations in Tisbury Great Pond at the beginning of the growing season may rise until it is well in excess of half the total resident population based on the historical progression and observation of the disease in Edgartown Great Pond.

**Recommendations:**
The potential for manipulating the salinity in the system appears to be limited however the potential benefit from low salinity by suppressing the dermo disease warrants continued attempts at reducing the lifetime of the early summer inlet. The possible adverse water quality that might develop in the Pond with no tidal circulation during the July through September period must be considered.

The sample collection program from the system has set the stage for taking the study to the next level- the Commonwealth's Estuaries Project. This course of study will bring experts and powerful computerized modeling tools to bear on the most difficult water quality questions in a pond like Tisbury Great Pond. I see these important questions as including:

- Circulation and exchange between the main basin and the cove stations particularly Town Cove.
- Appropriate timing of inlets through the barrier beach to cause the fewest water quality impacts.
- The nutrient budgets for the system and the options to reduce those we can control: septic systems and fertilizer applications in the watershed.