Hummock Pond
Annual Report
2006

Prepared for:
Marine and Coastal Resource Department
34 Washington Street
Nantucket, MA 02554

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March 2007

Introduction:

Hummock pond is a eutrophic coastal pond located on the southwest side of Nantucket Island. Hummock is approximately 2.3 miles long, running north to south with an average depth of 6ft. The watershed to pond ratio at an average is 15:1. The pond is approximately 142 acres in size with a surface drainage basin of approximately 2,227 acres and a groundwater drainage basin of approximately 2,000 acres. Hummock Pond accumulates water during the winter and generally floods in the spring. Flooded conditions of Hummock Pond can reach Millbrook Swamp and Madaket Road. During flooded conditions, the surface area of the pond increases from 140 acres to approximately 425 acres (Kortman and Knoecklein 1994). Hummock Pond is opened to the sea twice per year to alleviate flooded conditions and to enhance marine fisheries. In addition, pond openings decrease nutrient concentrations and remove organic matter that accumulates in the pond from the bordering wetlands.

The surface drainage basin extends north and east of the head of Hummock. The basin encompasses Maxy's Pond, Crooked Lane, and one third of Sunset Hill. The surface divide extends south to Academy Hill School, "Five Corners", part of Prospect Cemetery, and encompasses Burnt Swamp. The surface divide then follows the configuration of the pond to Cisco Beach extending just north of Hummock Pond Road (Horsley, Witten and Heggemen 1990).The groundwater drainage basin starts north of Rams Pasture and follows in a northward direction reaching Capaum Pond. The divide stretches east to West Chester Street encompassing "No Bottom Pond" and to the southwest through Burnt Swamp, Rotten Pumpkin Pond, and Larrabee Swamp and to Cisco Beach. There are two soil types in the watershed that determine permeability and eroding capability. The northern section is classified as "Medisaprists-Barryland Variant association", consisting of organic mucky deposits, combined with outwash soils that are poorly drained. The southern section is classified as "Evesboro association" defined by gently sloping sandy soils that drain rapidly.

Accelerated eutrophication of the pond in recent years has lead to harmful blue-green algae blooms, and macro algae blooms. Dense mats of *Enteromorpho intestinalis* in '02, and '03 impeded navigation and raised concerns of local residents, as to the health of the pond. Because of this a more in depth and recent study was required. George Knoecklein of Northeast Aquatic Research, LLC, a limnological consultant for the Nantucket Marine and Coastal Resources Department, who had done previous studies on the pond was hired to complete a two year evaluation. In corroboration with Marine Dept. personnel Tracy Curley, and Keith Conant, Knoecklein investigated nutrient loading aspects, water quality, and the effectiveness of pond openings with respects to mitigating the ponds current problems. Copies of this report, Hummock Pond 2005 Monitoring Report, by Dr. Knoecklein can be obtained at the Nantucket Marine Department, 34 Washington St.

The School for Marine Science and Technology (SMAST), which is heading up the Massachusetts Estuaries Project for the Department of Environmental Protection will also be performing studies on the pond. Preliminary investigations have already begun with help from Marine Department personnel. A more intensive study will begin in the summer of 2007 with the goal of providing the Town of Nantucket a Total Maximum Daily Load (TMDL) scenario, similar to the reports done for Nantucket Harbor, Sesachacha Pond, and the Madaket Harbor / Long Pond system.

Methods:

Hummock Pond was monitored from April to November this year. Physical parameters include, temperature, dissolved oxygen, salinity, secchi disk depth, and water depth. Chemical parameters include nutrient concentrations of inorganic and organic components, Nitrate (NO_3), Ammonia (NH_3), Kjeldhal Nitrogen (TKN), Total Nitrogen (TN), and Total Phosphorous (TP). In 2004 9 sampling sites were established for the Knoecklein study. Sites 1-6 remained the same, with a re-ordering of site 7, and the creation of sites 8, and 9. In 2006 sites 1, 3, 6, 7, and 8 were measured for physical parameters, additional water samples were collected for chemical constituents at sites 1, 3, and 7. The water samples are processed by Envirotech Laboratories located in Sandwich, MA for the as for mentioned nutrient constituents.

Hummock water quality sampling stations are as follow: **Site 1:** is located at the foot of Hummock Pond. This site is closest to the ocean and generally remains brackish throughout the year. The average depth is approximately 9ft. The bottom sediment is sand. **Site 3:** is northward in a wider section of the pond. The water depth is approximately 6ft. The bottom sediment is sand and mud. **Site 6:** is located at the base of the northern bay. The average depth at this site is 4 ft., and the bottom is mud and detritus. **Site 7:** is located in the north head of hummock which is connected to the main body of the pond by a small winding tributary. The average depth at this site is 12 ft., and the bottom is a flocculent muddy surface approximately 6” deep covering a mud bottom. **Site 8:** is located at the northeast headwater of the northern bay, where there is an inlet from a sub-watershed to the northeast. The average depth is 4 ft., and the bottom is detritus, and flocculent mud. These locations are designated on **Map #1.**

Water Quality Monitoring Results:

Appendix A: contains all physical and chemical water quality data. **Appendix B:** contains the averages of A with corresponding charts. **Appendix C:** contains average monthly rainfall for 2006, as collected by the Nantucket Water Company.

Temperature and Dissolved Oxygen:

Temperature and dissolved oxygen are often closely related, and inversely proportional. The solubility of oxygen in water is very dependant on the temperature, and will decrease as temperature rises. Dissolved oxygen (D.O.) is also affected by nutrients, and the biological oxygen demand (BOD) of decaying plant or animal matter. As nutrients increase, phytoplankton and macro algae increase proportionately. These plants have a relatively short life cycle, and when they die and sink to the bottom, they are consumed by bacteria. These bacteria consume oxygen, and may lead to anoxic events. When this occurs, nutrients are released from the sediments, and a process known as "internal recycling" begins. The process of eutrophication may occur naturally, but at Hummock Pond it is accelerated by anthropogenic uses.

The temperature in Hummock Pond follows a well defined cyclical seasonal pattern, which is shown by the bell curve graph in figure 1. The pond is relatively isothermic because of its shallow condition and elongated shape, which allows it to be well mixed by wind driven waves. However because it is so long there are some differences between the foot and the head. These differences are also affected by surface water runoff, groundwater intrusion, and salinity gradients. The isolation of the northern head, its depth, and its kettle shape create the greatest variances. July and August are typically the months where temperatures reach their highest points. Fortunately in 2006 the main body of the pond stayed around 24ºC, or 75ºF (Appendix A). This may decrease the solubility of oxygen in the water column, however it would not normally create an anoxic condition. The highest recorded temperatures occurred in the northern reaches of the pond at Sites 7, and 8, just under 77ºF in July. For the most part there was limited stratification, with very subtle effects from a mild turnover during the winter, due to limited ice formation.

Dissolved oxygen (D.O.) concentrations are at maximum in the winter, due to cooler water temperatures. The main body of the pond experiences lower dissolved oxygen concentrations during the summer months where the concentrations typically range between 4 mg/l and 6 mg/l. The lowest dissolved oxygen readings taken, coincide with the highest temperature recordings taken in July and August (Appendix A). Periods of hypoxia occurred at the bottom at Site 1 in July where 2.67 mg/l and 2.62 mg/l were recorded at 9 and 11 feet. Anoxic conditions were also recorded during this month at Sites 6, and 7. The lowest recorded reading was taken at Site 7, on the bottom at 0.06 mg/l. The month of August showed similar recordings, with low D.O. conditions existing at Sites 6, 7, and 8. It is during these anoxic events that nutrients are released from sediments on the bottom, further exacerbating enriched conditions. As a coincidence a blue-green algae bloom was seen traveling down the connector from the north head during the August sampling round. The algae bloom concentration increased in the direction of the north head, from which it was emanating. With the onset of Fall, D.O. conditions began to improve with declining temperatures. However there were some low recordings at Sites 1, and 3 following the opening 10/25, but were primarily related to salinity gradients. Site 7 also continued to show anoxic, and hypoxic conditions in October (0.19 mg/l), and November (2.62 mg/l) on the bottom as a result of the nutrient enriched conditions.

Figure 1: Average Temperature 2006

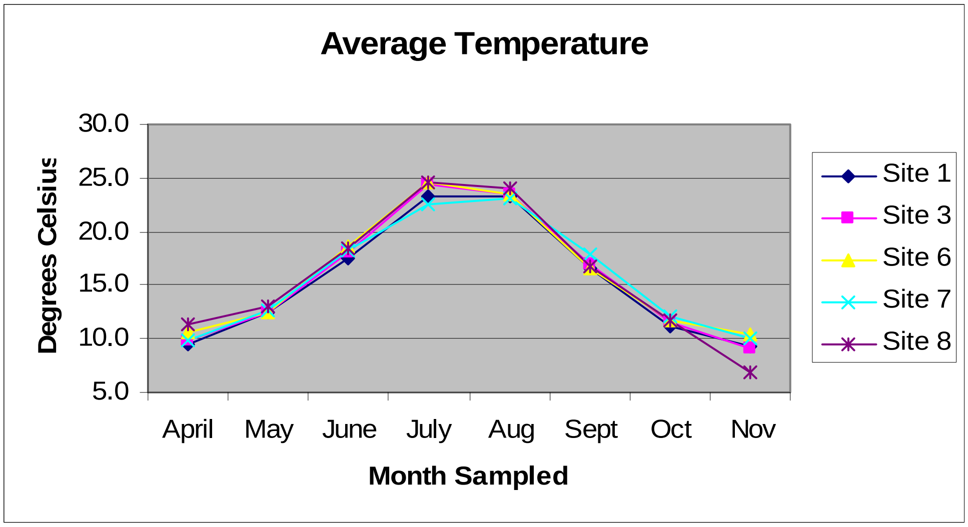
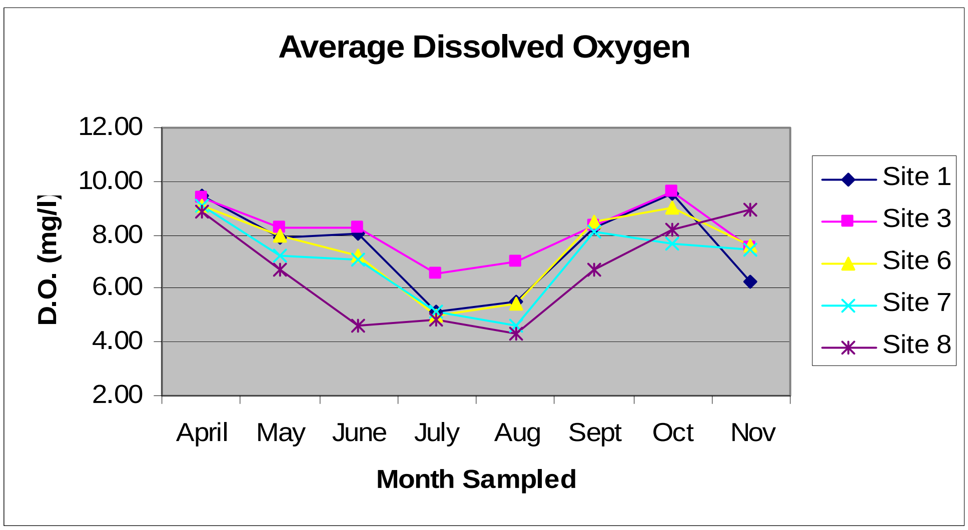


Figure 2: Average Dissolved Oxygen 2006



Salinity:

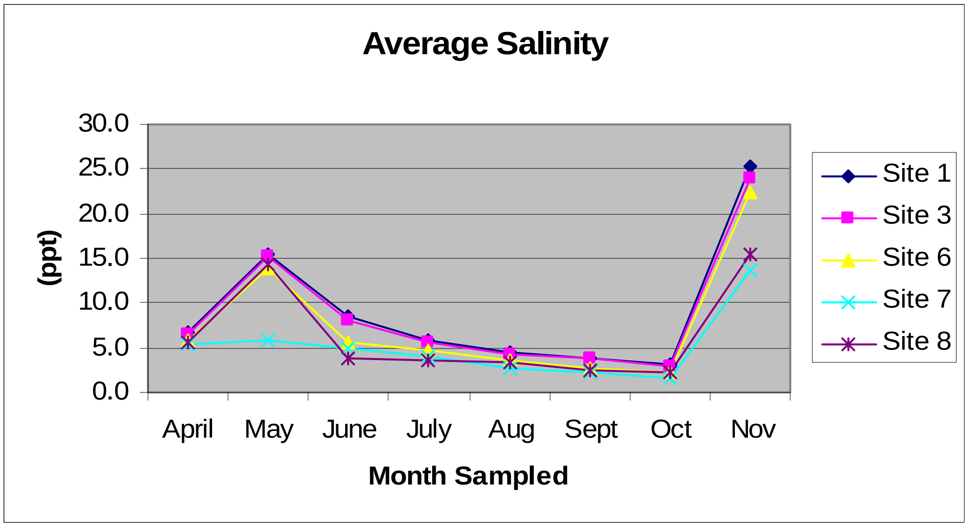
Hummock Pond has been designated to be maintained as a brackish water pond for fisheries migrations, mitigation of water quality and flood control by mechanically breaching the natural barrier beach to the ocean in the spring and fall. The 2006 spring opening occurred 4/24, and remained opened until 5/4, the fall opening occurred 10/25 and remained open until 10/29. Spring openings typically last longer than fall openings because of head waters accumulated during winter and spring precipitation. However, if a spring opening is not met for at least a week then water quality usually declines throughout the summer. During the spring opening, the ocean typically fills approximately half the pond (site 1 to site 5). Groundwater and surface water fill the head of the pond (site 6 to site 7, and 8). After an opening, mixing slows down and a salinity gradient develops in the pond forming a wedge. The foot of the pond retains the highest salinity while the head continues to become fresh from the constant input of groundwater. Hummock pond, located in the outwash plains, cannot maintain saline conditions due to the physical configuration of the pond, with respect to its watershed.

Hummock contained an average salinity of (6 ppt) in April prior to the spring pond opening. The pond increased in average salinity to 10ppt after the opening. There were of course differences between the foot and the North head, prior to, and after the opening (Appendix A). These differences were greatest (8.7 ppt) following the closure, as the pond began to seek equilibrium with a well defined salt wedge. The length of time the pond remains open to the ocean usually determines the initial salinity change in the pond. Salinity decreased throughout the summer as the pond filled with groundwater; this was quickened this year by the high amount of precipitation accumulated over the summer. Signs of freshening occurred first at Site 7 in May, and then Site 8 in June, as freshwater inputs from the northern watershed drive the freshening of the pond. The lowest salinity reading taken on the pond was at Site 8 on the surface in June, at (0.4 ppt).

The average pond salinity was 2.5 ppt in October prior to the fall opening. When the pond closed on 10/29, it closed on a high tide with a storm surge; after approximately 8 tidal exchanges. The result of this was an extremely high salinity throughout the pond. Bottom measurements at the foot and the head were recorded at 27.9 ppt for Site 1, and 17.1 ppt for Site 7. Top to bottom differences were as much as 8 ppt (Site 7). Salinity in the pond has not been to this level since the year 2000, where in May, Site 1 was measured at 31.5 ppt at the bottom.

This extensive flushing should help to reduce nutrient levels in the pond, temporarily alleviating eutrophic conditions. If this is true, then water quality conditions for the summer of ’07 should be good, or at least better, and the pond should exhibit mesotrophic conditions. Blue-green algae blooms, and nuisance macro algae growth should also be minimized. However if this is not the case, then another form of remediation must be met in order to restore the ponds water quality. The success of openings can not be guaranteed, and the exportation of the nutrients which cause the problem, is not necessarily the best strategy. In fact the opening of a coastal pond to the ocean is very disruptive to the ecological community within. Following the last opening several dead yellow perch were seen floating on the surface; the benthic community was not sampled. Hopefully though, the openings will be beneficial to the herring population recovery; a species which has received a no fishing prohibition by the Division of Marine Fisheries until 2009.

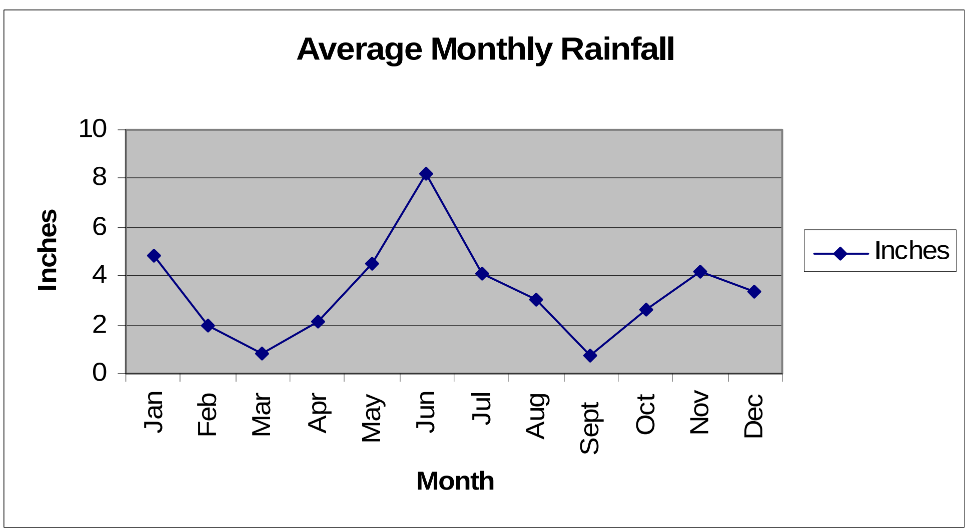
Figure 3: Average Salinity 2006



Rainfall:

Average rainfall was collected by the Nantucket Water Company, and shows considerable precipitation throughout the summer. As previously discussed rainfall directly affects volume and salinity in the ponds. It also affects the amount of nutrients that are carried in groundwater flow from watersheds to their associated water bodies. As anthropogenic uses increase, rainfall becomes an important factor in determining water quality.

Figure 4: Average Monthly Rainfall 2006

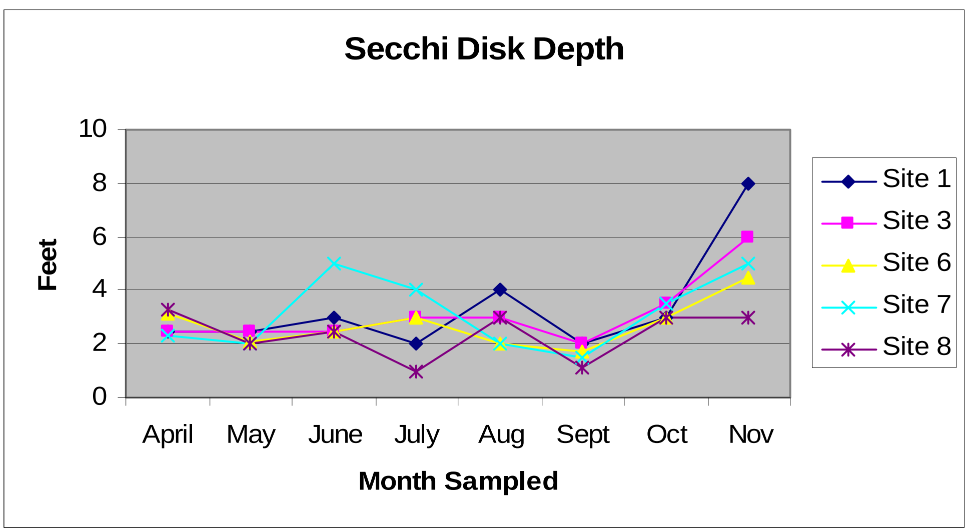


Secchi Disk Depth:

Secchi disk depth recordings are a quick helpful test in measuring water clarity. Water transparency will indicate the amount of phytoplankton, algae, and nutrients available in the water column. The disc measures one half the visible light penetrating the water column. When you combine this information with the bathymetry of any given water body, you can roughly define submerged aquatic vegetation boundaries. Because of Hummock Pond's average depth, bathymetry, and poor water quality, it has a relative high abundance of submerged aquatic vegetation. Secchi disk depth recordings reflect this condition. The salinity appears to be too low to effectively wipe out phragmities, and too low to support eel grass. Because of this however, the pond does support an abundant and diverse population of pond weeds. However, with nutrient levels as high as they are, Hummock has had problematic episodes of nuisance vegetation, and had deleterious phytoplankton blooms of blue-green algae which may dominate ecosystem.

Secchi disk depth recordings were low, (2.5 ft average) for most of the sampling period, indicating a high level of phytoplankton production. Also in some shallow Sites, 3, 6, and 8 pond weeds were so thick they interfered with disk readings. Site 7 experienced one its high readings in June at 5 ft. This may have been the result of a shift in phytoplankton communities as a result of the freshening of the pond due to high levels of precipitation in and around that time period; 8.23" in June. A total 16.08" of rain was recorded between the months of May to July, uncommonly high for this time period. The lowest secchi disk recording, (1 ft.) was taken at Site 8 in July. The highest recording was taken at Site1, and measured to 8ft. This was undoubtedly due to the high volume of exchange with ocean water during the fall opening, which improved secchi disk depths at all locations (with the exception of Site 8, due to pond weeds).

Figure 5: Secchi Disk Depth 2006

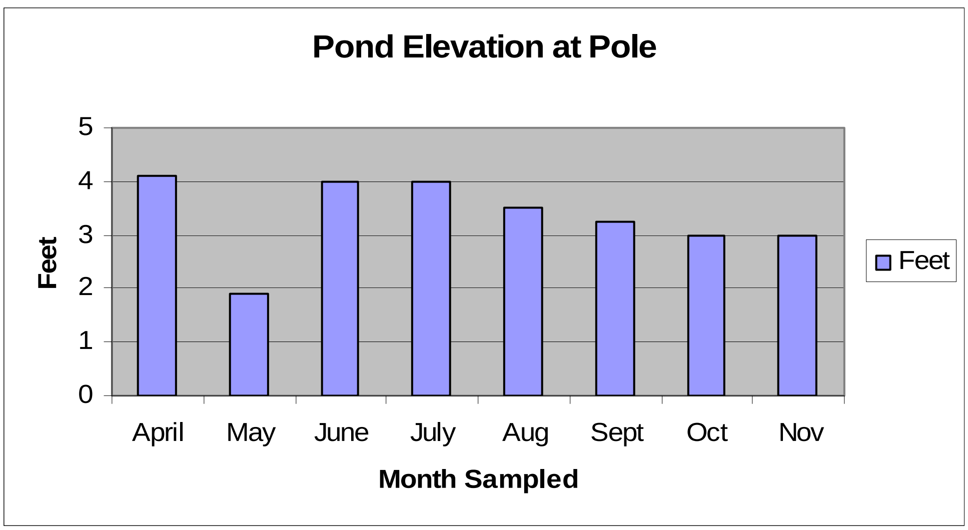


Pond Elevation:

Pond elevations were recorded on a pole between Sites 3, and 4 on the east side of the pond, at an abandoned floating dock location. The pole was chosen in 2004 for the 2 year Knoecklein (Northeast Aquatic Research) study. It was used in cross reference with topographical contours to measure pond volume with respects to mean sea level (MSL) elevation. With many years of data an average pond volume may be acquired with the use of the elevation at the pole. The 2005 report showed that the ponds surface area was 142 acres when the pole elevation was 3 ft., and this appears to be the average volume. The study also showed that when the pole was at 4ft., the pond was approximately 8 ft. above MSL. At 5 ft. the pond would be at a somewhat flooded condition, with a surface area coverage of 267 acres.

When the pond was opened in April, it was just over 4ft. (Appendix B, and Figure 6). The pond closed on a low tide, but was soon filled with fresh groundwater from all the precipitation in May, June and July. As precipitation dropped off in August and September so did elevation at the pole, approximately 3 ft. The pole elevation combined with salinity also shows how the pond was emptied, and filled back to the same elevation following the fall opening. This 3 ft. mark, that the pole was at in October and November, puts the pond at approximately 6 ft. above mean sea level.

Figure 6: Pond Elevation at Pole 2006



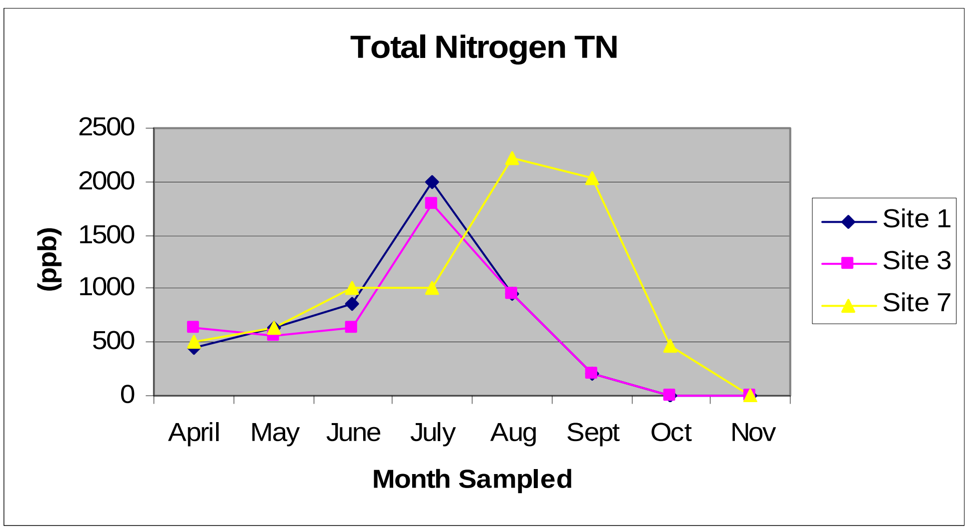
Nutrients:

Nitrogen:

Nitrogen is the limiting nutrient in marine ecosystems, the quantity of which will dictate the health of any particular water body. Because Hummock is opened to the ocean it maintains a brackish water system for much of the year. Nitrogen which is accumulating in Hummock Pond has more of an effect toward the foot of the pond than the head, because of the ponds shape, fresh water recharge, and the varying saline conditions. Total nitrogen includes both organic and inorganic components. Ammonia or NH3 was the only constituent in 2006 where the detectable limit was required to be lowered during lab analysis in order to approximate actual levels occurring in Hummock pond. The Department of Environmental Protection for Massachusetts uses some standard classifications based on nitrogen thresholds to describe the health of many marine ecosystems. Hummock is now classified as an impaired, or eutrophic water body. Total nitrogen above 700 ppb is considered eutrophic. These standards can be found in the Estuaries Project Interim Report 2003.

Total nitrogen reached exceedingly high levels in July at Sites 1 and 3, where 2,000 ppb and 1,800 ppb TN were recorded from those sample sites respectively. Figure 7 shows an increasing trend for much of the summer, with a peak concentration of 2,220 ppb TN at Site 7 in August. During the months of July and August there were anoxic dissolved oxygen levels recorded at Site 7. This undoubtedly led to a release of nutrients from the sediments. Ammonia levels were also high in August for Site 7, (Appendix B), this presence was also probably the result of the anoxic events. Total nitrogen was below eutrophic conditions for the last three months sampled at Sites 1, and 3, and the last two months at Site 7. The large exchange that occurred in the fall opening will be expected to decrease nitrogen levels for the summer of 2007, as long as pond temperatures remain cool, and anoxic events are avoided. If this is not the case then other means of controlling nitrogen levels must be met in order to ensure the future health of the pond.

Figure 7: Total Nitrogen 2007

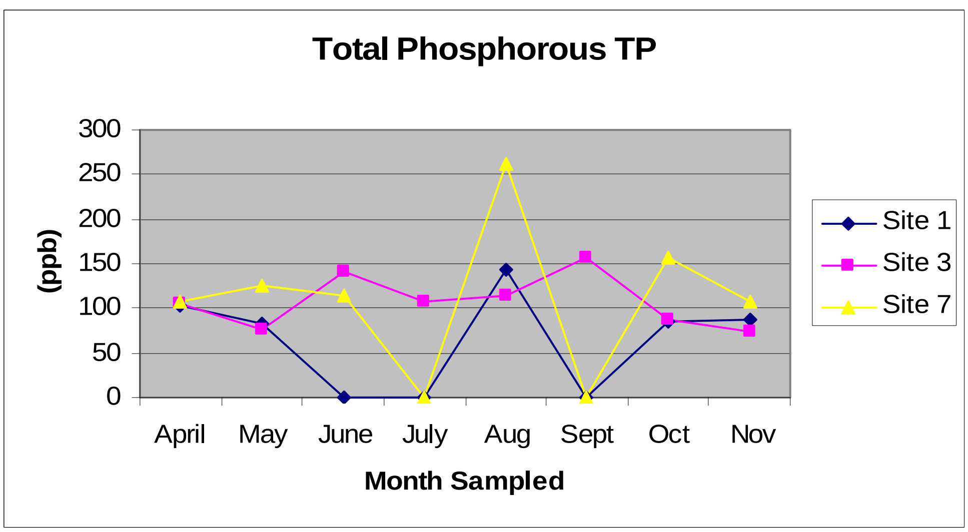


Total Phosphorus:

Hummock pond is predominantly a fresh water system because of its elongated shape, watershed area, and fresh water inputs on its northern end. The foot of the pond does remain brackish for much of the year though, and this does create some interesting dynamics. Total phosphorous (TP), is predominantly the limiting nutrient for plant growth in a fresh water system. However there is most likely a flip flopping of nutrient limiting conditions, and associated phytoplankton species; based on nitrogen phosphorous ratios. This is usually the case in most coastal ponds that are opened to the ocean, and as previously discussed when this pond is transformed into a marine system, nitrogen becomes the limiting nutrient. Total phosphorous levels at or between 15-25 ppb, would be indicative of a mesotrophic system with good to fair water quality. Phoshorous levels rising above 50 ppb indicate eutrophic conditions.

The majority of water samples taken at Hummock for the summer of 2006 indicate eutrophic conditions with respects to phosphorous. All samples taken at Site 3 are above the impaired level. Some are twice the eutrophic limit and two samples taken in June, and September at Site 3 are three times that magnitude; showing 142 ppb and 156 ppb (Appendix B). Site 1, the area with the most saline conditions showed the lowest average TP for 2006. However the initial readings at Sites 1 were high, with a spike in August to 143 ppb. Coincidentally July and August exhibited periods of hypoxia and anoxia at different locations in Hummock. This would result in a release of phosphorous from bottom sediments. Indications of this can be seen in figure 8, from the physical presence of the blue-green algae bloom witnessed in the north head, and its connector in August. The TP sampled at Site 7 at that time was the highest recorded for the 2006 sampling period, 262 ppb TP. Prior to and following the August sampling, TP had dropped below a reportable limit at both Sites 3, and 7. It may be conjectured that at these times, July and September, all the available TP in the system was being used up by the phytoplankton community that had evolved from the freshening of the pond, and the availability of TP. This would in turn help create the anoxic period in August, that resulted in a massive release of Phosphorous from the sediments; which in turn created a hyper-eutrophic state. TP values remained high for the last two months of the sampling period, October and November; despite the opening of the pond, decreasing water temperatures, and increasing dissolved oxygen in the water column.

Figure 8: Total Phosphorous 2006

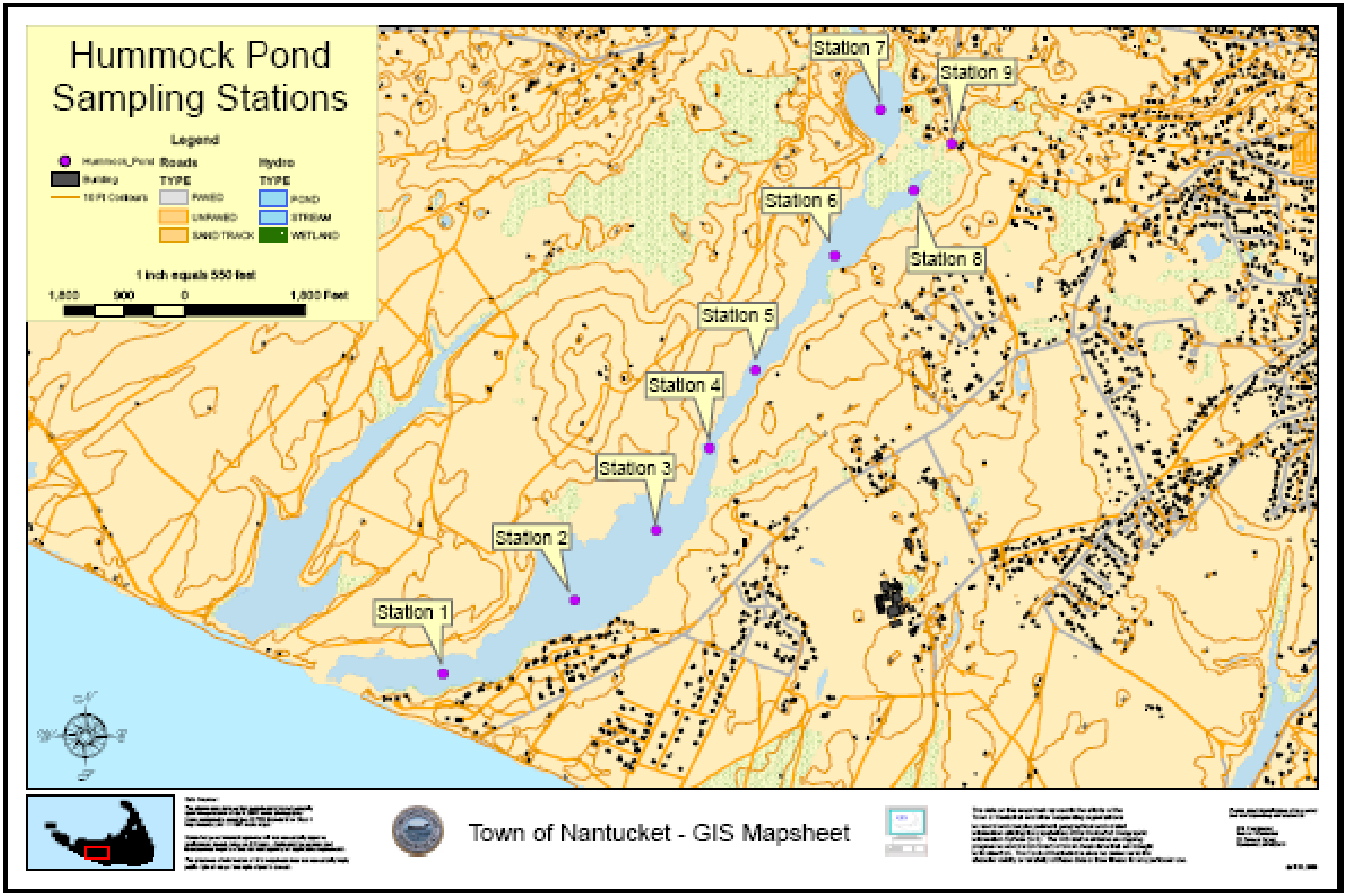


Conclusions:

The summary of results from the 2006 sampling period reveal that elevated levels of nutrients are occurring throughout Hummock pond. The highest concentrations of which are occurring in the northern head, which then affect lower portions of the pond.

Nutrients are entering the pond from atmospheric deposition, septic and fertilizer inputs from the watershed, and internal recycling during anoxic events. The opening of the pond to flush nutrients does not appear to be a working solution, and the mitigation of nutrients in the form of sewer installation or changes in anthropogenic uses will not be resolved in the near future. In Knoecklein's 2005 report on Hummock, aeration is suggested as a possible solution to destratify the north head of Hummock to eliminate the recycling of nutrients during anoxic events. Also suggested is, the mechanical harvesting of weeds, a process that will have to be repeated as necessary. Both options should be considered, however the only long term solution is to mitigate nutrients in the watershed before they reach the pond.

The School for Marine Science and Technology (SMAST), is currently conducting some preliminary nutrient studies of the pond in cooperation with the Nantucket Marine Department. These studies will evolve into a more thorough Total Maximum Daily Load (TMDL) scenario, in accordance with the Massachusetts Estuaries Project, overseen by the Department of Environmental Protection. The comprehensive waste water treatment plan being evaluated by Earth Tech and the Nantucket Department of Public Works will also help come up with solutions to mitigate nutrient enrichment in Hummock. Until then, the opening of Hummock Pond, which may not definitively improve water quality will continue. Opening Hummock Pond for flood control and marine fisheries also needs as much attention as water quality monitoring. Their benefits and effectiveness need to be gauged quantitatively against their potential negative effects.



Hummock Pond
Sampling Stations
Legend
Hummock_Pond
Building
10 Ft Contours
Roads
TYPE
PAVED
UNPAVED
SAND TRACK
Hydro
TYPE
POND
STREAM
WETLAND
1 inch equals 550 feet
1,800 900 0 1,800 Feet
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7
Station 8
Station 9
Town of Nantucket - GIS Mapsheet

Appendix A

Hummock Pond
2006
Physical and Chemical Data

Site 1: Foot of Pond
Site 3: Middle of Pond / Top of Main Body
Site 6: Northen Bay
Site 7: North Head
Site 8: North East Cove of Northern Bay

Temperature (º C)

Site 1	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	10.1	12.5	17.7	23.9	23.5	16.6	11.1	7.2
3	9.7	12.5	17.6	23.8	23.5	16.6	11.1	7.1
6	9.4	12.4	17.5	23.3	23.3	16.6	11.1	11.4
9	9.1	12.4	17.4	22.7	22.9	16.6	11.1	11.8
11	8.9		17.3	22.4	22.8	16.6	11.1	

Site 3	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	10.3	12.5	18.1	24.5	23.6	16.9	11.5	8.2
3	10.2	12.5	18.1	24.5	23.6	17	11.5	8.2
6	9.6	12.4	18	24.4	23.3	17	11.5	8.2
7	9.5		17.9	24.3	23.3	17	11.6	11.5

Site 6	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	10.8	12.8	19.3	24.7	23.3	16.5	11.8	9.1
3	10.7	12.3	18.8	24.7	23.3	16.5	11.8	10.3
6	10.5		17.9	24.5	23.7	16.5	11.7	11.6

Site 7	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	10.6	12.9	19	24.8	23.7	17.8	12	8.1
3	10.5	12.8	18.9	24.6	23.5	17.8	12.1	10.6
6	10.3	12.5	18.7	24.6	23.2	17.8	12.1	10.4
9	9.7	12.3	17.7	23.2	23.1	17.8	12.1	10.3
12	9.3	12.3	17.5	19.8	22.3	18	12.3	10.7
13	9.1		17.4	18.5				

Site 8	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	11.6	13.6	18.2	24.9	24.1	16.7	11.7	6.1
3	11.5	12.4	18.9	24.4	23.8	16.7	11.7	7.8
5	11.1		18.4	24.3		16.7		

Dissolved Oxygen (mg/l)

Site 1	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	9.49	8.04	8.44	7.02	6.3	8.41	9.63	9.58
3	9.44	8.01	8.26	6.99	6.26	8.42	9.61	9.53
6	9.53	8.01	8.06	6.45	5.5	8.34	9.68	3.42
9	9.41	7.64	7.56	2.67	4.71	8.41	9.71	2.42
11	9.36		7.76	2.62	4.62	7.62	9.19	

Site 3	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	9.54	8.31	8.34	6.83	8.16	8.65	9.71	9.16
3	9.53	8.29	8.3	6.75	8.1	8.54	9.59	9.14
6	9.22	8.12	8.29	6.62	6.03	8.55	9.64	9.09
7	9.21		8.01	5.99	5.84	7.74	9.54	2.65

Site 6	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	9.19	8.27	8.53	7.26	6.88	8.57	9.11	8.48
3	9.25	7.61	8.13	7.2	6.64	8.54	9.08	8.31
6	8.72		4.92	0.49	2.75	8.45	8.95	6.11

Site 7	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	9.86	8.56	9.15	8.98	7.6	8.88	9.59	10.81
3	9.84	8.59	9.06	8.97	5.39	8.77	9.49	8.96
6	9.74	7.82	9.28	8.94	5.24	8.73	9.5	7.52
9	9.36	6.65	7.48	3.79	4.57	8.78	9.48	7.25
12	7.91	4.36	3.93	0.09	0.14	5.58	0.19	2.62
13	7.69		3.67	0.06				

Site 8	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	8.59	6.76	3.09	4.99	5.53	7.54	8.41	9.46
3	8.64	6.68	7.4	5.72	3.08	7.57	7.95	8.48
5	9.27		3.44	3.78		5.06		

Salinity (ppt)

Site 1	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	6.7	15.5	8.5	5.8	4.4	3.8	3.1	23
3	6.7	15.5	8.5	5.8	4.4	3.8	3.1	22.8
6	6.7	15.5	8.5	5.8	4.4	3.8	3.1	27.6
9	6.7	15.5	8.5	5.9	4.4	3.8	3.1	27.9
11	6.7		8.5	5.9	4.4	3.8	3.1	

Site 3	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	6.5	15.3	8.1	5.7	4.1	3.7	3	23
3	6.5	15.3	8.1	5.7	4.1	3.7	3	23
6	6.5	15.3	8.2	5.7	4.3	3.7	3	23
7	6.5		8.1	5.7	4.3	3.7	3	27

Site 6	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	5.7	12.2	3.8	4.8	3.3	2.7	2.3	20.7
3	5.7	15.6	5	4.8	3.3	2.7	2.3	22.1
6	6.2		7.8	4.8	4.1	2.7	2.3	24.5

Site 7	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	5.3	4.8	4.7	3.4	2.6	2.2	1.6	9
3	5.3	4.8	4.7	3.4	2.6	2.2	1.6	12.7
6	5.3	5.1	4.9	3.4	2.6	2.2	1.6	14.2
9	5.3	7.1	4.9	4.1	2.6	2.2	1.6	15.5
12	5.3	7.4	4.9	4.9	2.7	2.2	1.6	17.1
13	5.3		4.9	4.9				

Site 8	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
0	5.5	13.5	0.4	2.2	3	2.4	2.2	13.5
3	5.5	15.1	5	4	3.5	2.4	2.2	17.2
5	5.5		5.9	4.6		2.5		

Secchi Disk Depth (ft.)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Site 1	2.5	2.5	3	2	4	2	3	8
Site 3	2.5	2.5	2.5	3	3	2	3.5	6
Site 6	3.1	2.1	2.5	3	2	1.75	3	4.5
Site 7	2.3	2	5	4	2	1.5	3.5	5
Site 8	3.3	2	2.5	1	3	1.1	3	3

Pond Elevation at Pole (ft.)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Feet	4.1	1.9	4	4	3.5	3.25	3	3

Nitrate (NO_3 ppb)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Site 1	20	BRL	20	BRL	BRL	60	10	<10
Site 3	<10	BRL	BRL	10	BRL	BRL	BRL	<10
Site 7	20	BRL	230	10	120	BRL	10	<10

Ammonia (NH_3 ppb)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Site 1	65	23	ND	ND	170	100	90	70
Site 3	44	48	ND	ND	140	130	70	70
Site 7	47	47	20	ND	640	150	100	170

Kjeldhal Nitrogen (TKN ppb)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Site 1	420	630	840	2,000	980	140	BRL	<100
Site 3	630	560	630	1,800	950	200	BRL	<100
Site 7	490	630	770	1,000	2,100	2,040	450	<100

Total Nitrogen (TN ppb)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Site 1	440	630	860	2,000	960	200	<100	<100
Site 3	630	560	630	1,800	950	200	<100	<100
Site 7	510	630	1,000	1,000	2,220	2,040	460	<100

Total Phosphorous (TP ppb)

	4/12/2006	5/11/2006	6/13/2006	7/11/2006	8/22/2006	9/12/2006	10/24/2006	11/6/2006
Site 1	103	83	BRL	BRL	143	BRL	86	87
Site 3	105	76	142	108	115	156	87	75
Site 7	108	126	114	BRL	262	BRL	156	107

BRL = Below Reportable Limit
ND = Not Detected / Below Detectable Limit

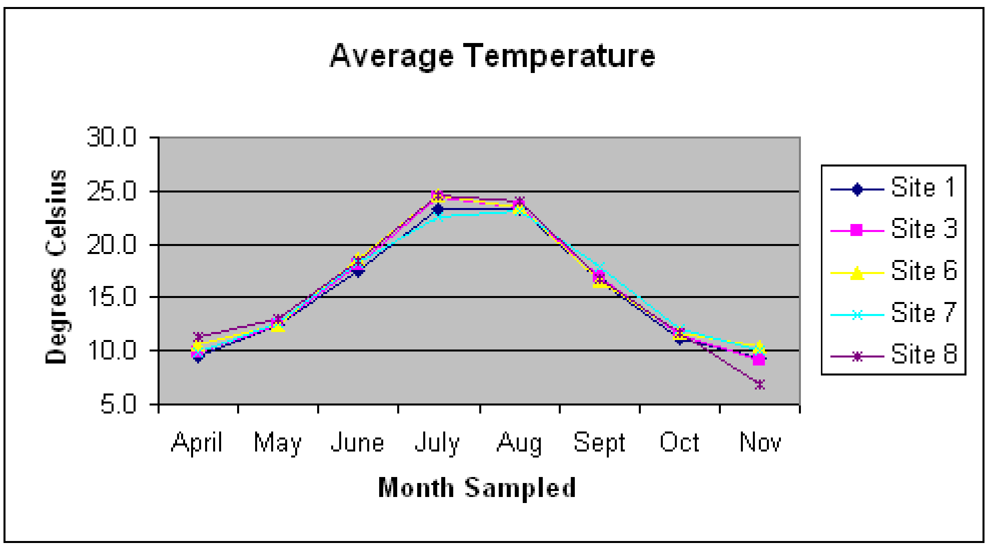
Appendix B

Hummock Pond 2006
Average Physical and Chemical Data with Charts

Site 1: Foot of Pond
Site 3: Middle of Pond / Top of Main Body
Site 6: Nothern Bay
Site 7: North Head
Site 8: North East Cove of Northern Bay

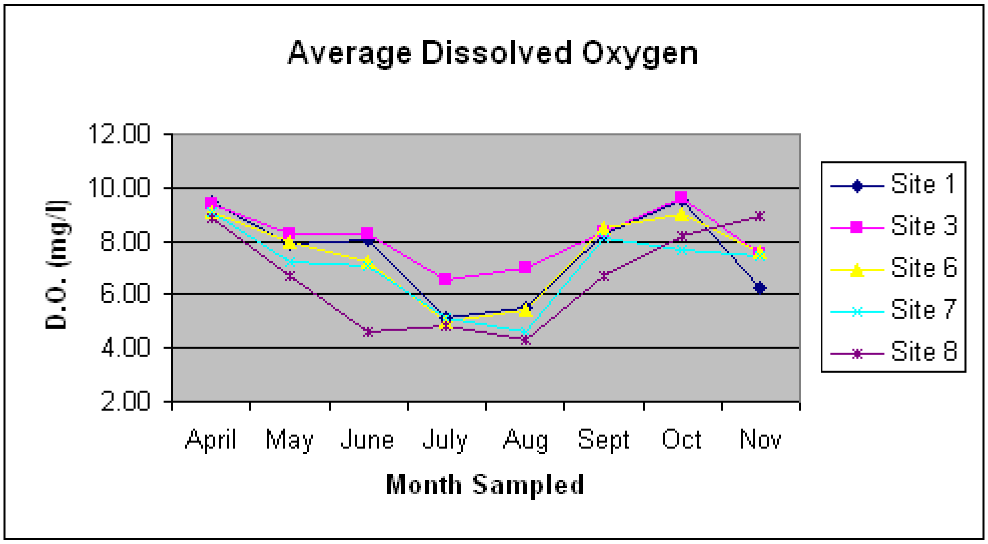
Temperature (º C)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	9.4	12.5	17.5	23.2	23.2	16.6	11.1	9.4
Site 3	9.9	12.5	18.0	24.4	23.5	17.0	11.5	9.0
Site 6	10.7	12.6	18.7	24.6	23.4	16.5	11.8	10.3
Site 7	9.9	12.6	18.2	22.6	23.2	17.8	12.1	10.0
Site 8	11.4	13.0	18.5	24.5	24.0	16.7	11.7	7.0



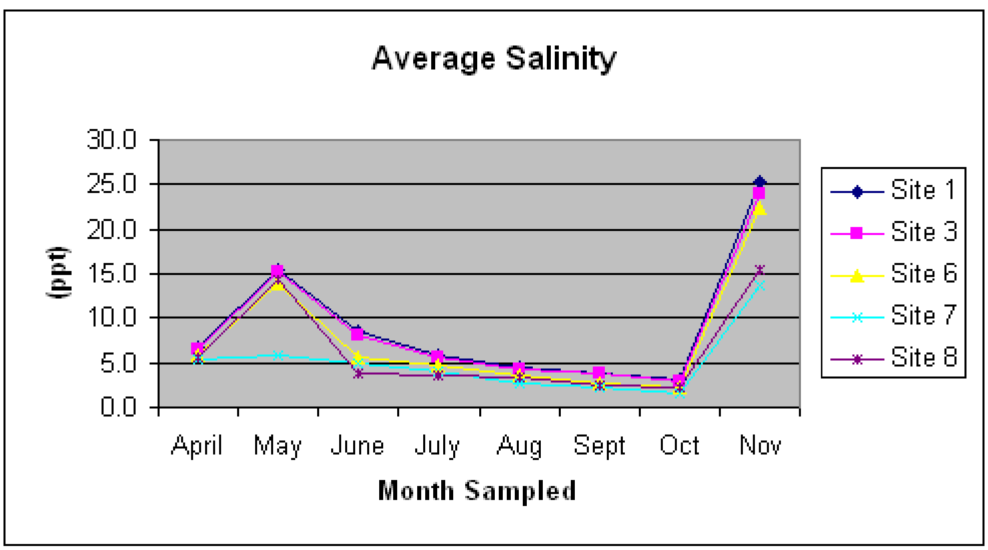
Dissolved Oxygen (mg/l)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	9.45	7.93	8.02	5.15	5.48	8.24	9.56	6.24
Site 3	9.38	8.24	8.24	6.55	7.03	8.37	9.62	7.51
Site 6	9.05	7.94	7.19	4.98	5.42	8.52	9.05	7.63
Site 7	9.07	7.20	7.10	5.14	4.59	8.15	7.65	7.43
Site 8	8.83	6.72	4.64	4.83	4.31	6.72	8.18	8.97



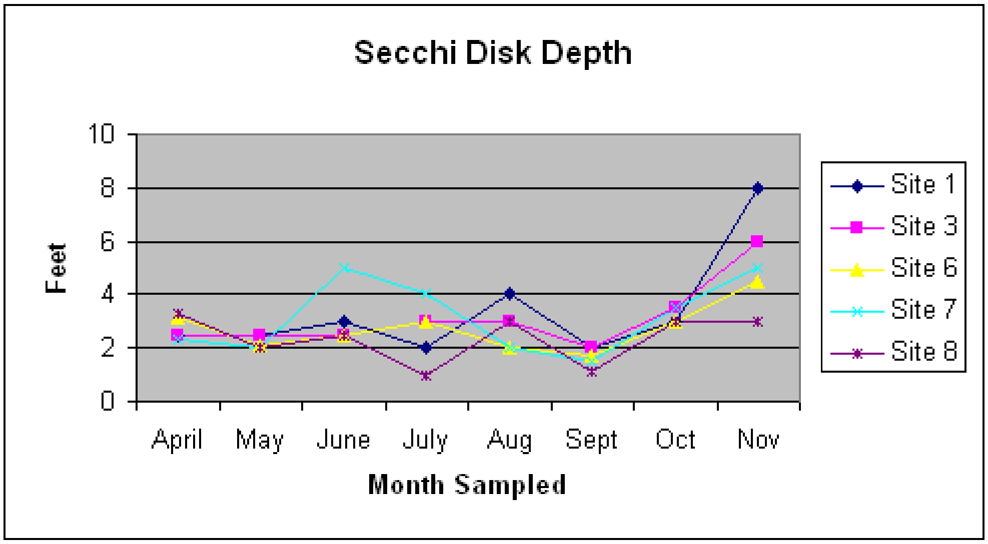
Salinity (ppt)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	6.7	15.5	8.5	5.8	4.4	3.8	3.1	25.3
Site 3	6.5	15.3	8.1	5.7	4.2	3.7	3.0	24.0
Site 6	5.9	13.9	5.5	4.8	3.6	2.7	2.3	22.4
Site 7	5.3	5.8	4.8	4.0	2.6	2.2	1.6	13.7
Site 8	5.5	14.3	3.8	3.6	3.3	2.4	2.2	15.4



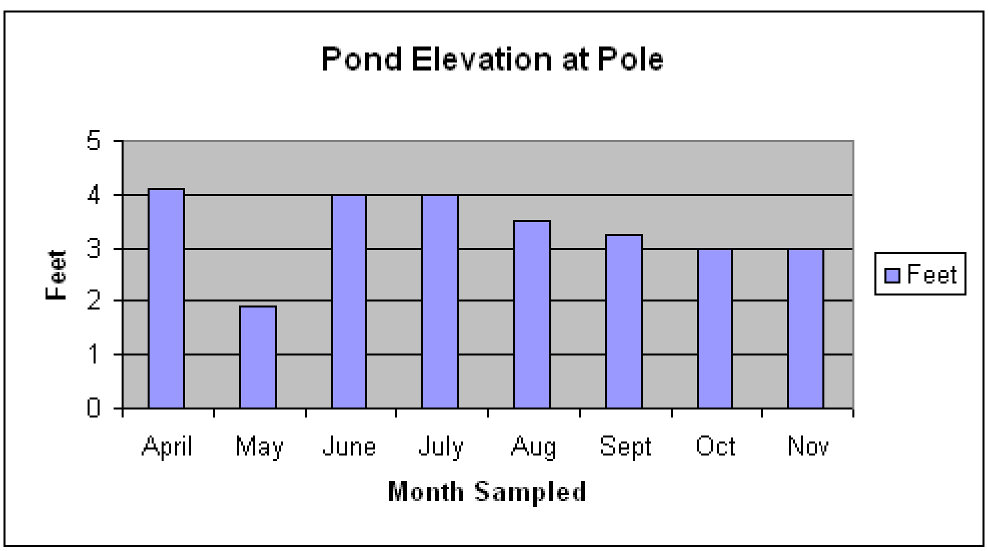
Secchi Disk Depth (ft.)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	2.5	2.5	3	2	4	2	3	8
Site 3	2.5	2.5	2.5	3	3	2	3.5	6
Site 6	3.1	2.1	2.5	3	2	1.75	3	4.5
Site 7	2.3	2	5	4	2	1.5	3.5	5
Site 8	3.3	2	2.5	1	3	1.1	3	3



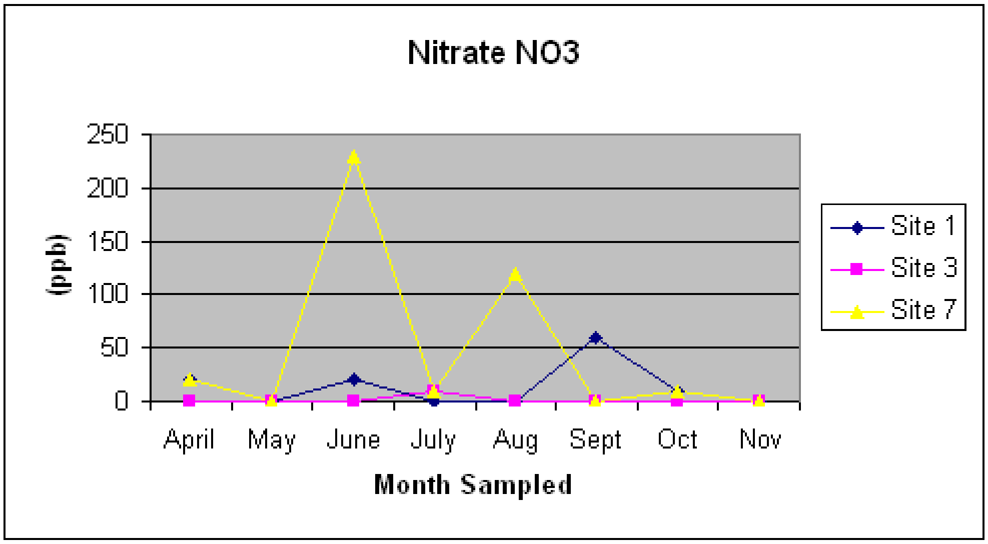
Pond Elevation at Pole (ft.)

	April	May	June	July	Aug	Sept	Oct	Nov
Feet	4.1	1.9	4	4	3.5	3.25	3	3



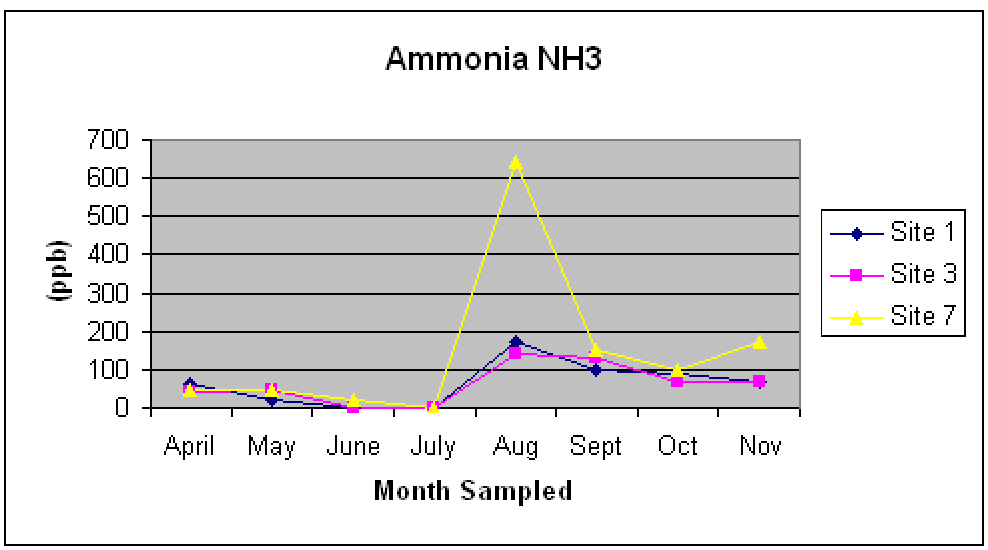
Nitrate (NO3 ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	20	BRL	20	BRL	BRL	60	10	<10
Site 3	<10	BRL	BRL	10	BRL	BRL	BRL	<10
Site 7	20	BRL	230	10	120	BRL	10	<10



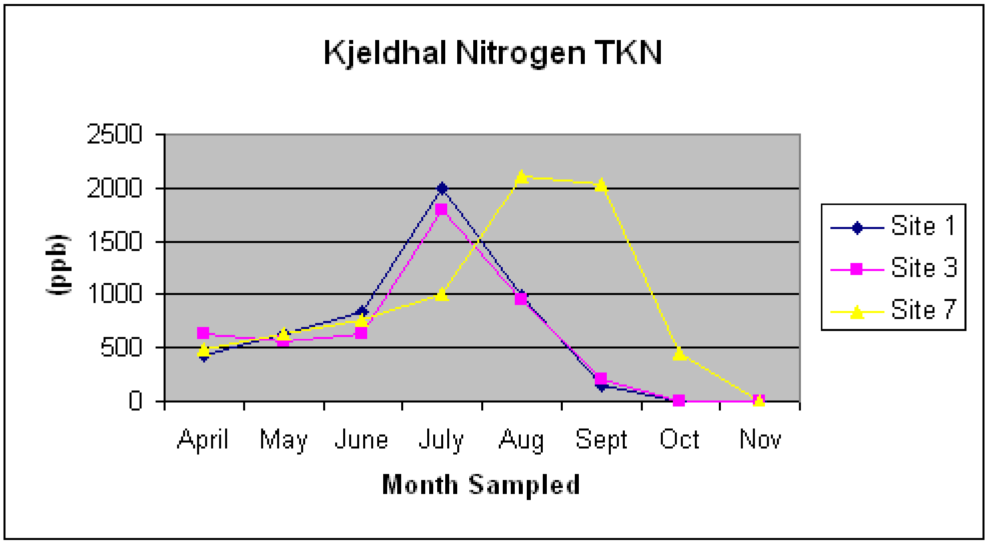
Ammonia (NH3 ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	65	23	ND	ND	170	100	90	70
Site 3	44	48	ND	ND	140	130	70	70
Site 7	47	47	20	ND	640	150	100	170



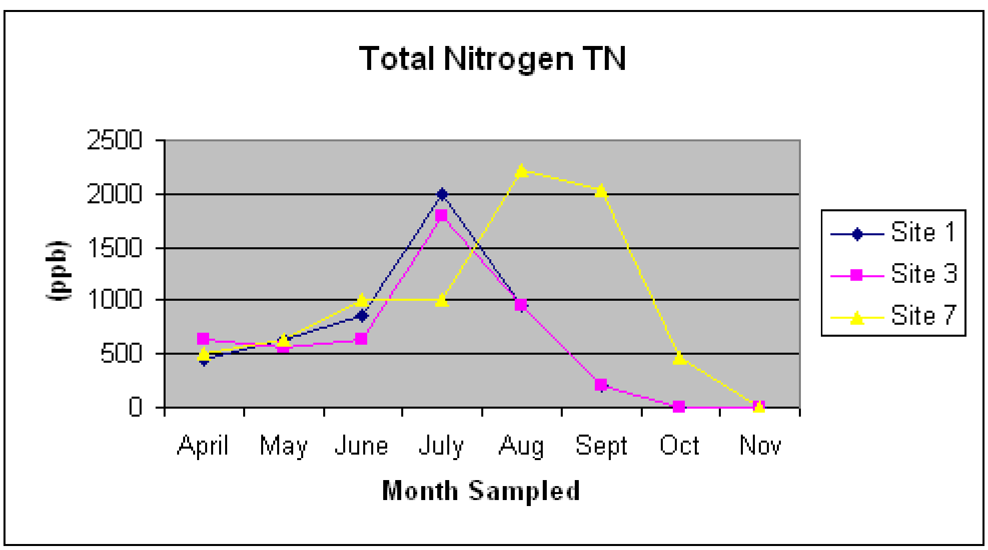
Kjeldhal Nitrogen (TKN ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	420	630	840	2,000	980	140	BRL	<100
Site 3	630	560	630	1,800	950	200	BRL	<100
Site 7	490	630	770	1,000	2,100	2,040	450	<100



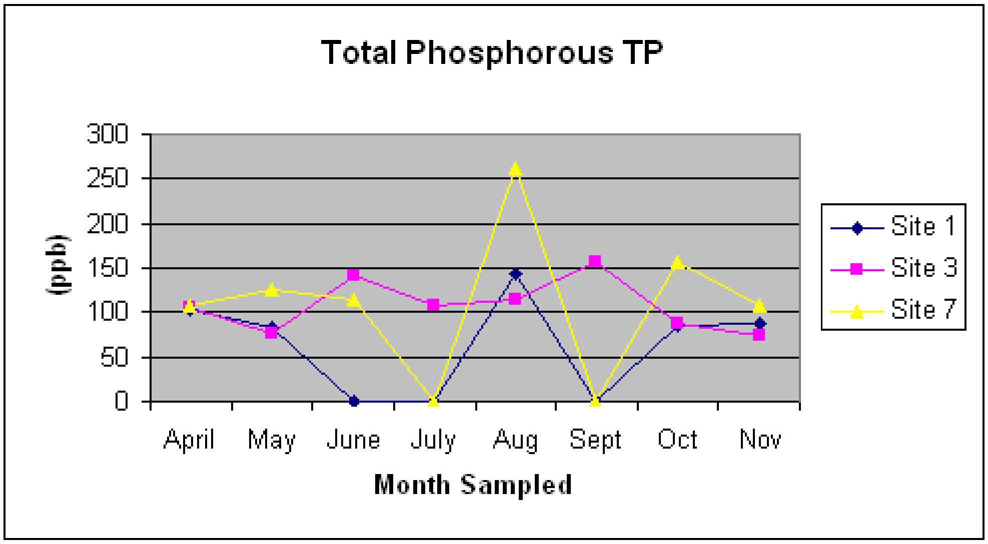
Total Nitrogen (TN ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	440	630	860	2,000	960	200	<100	<100
Site 3	630	560	630	1,800	950	200	<100	<100
Site 7	510	630	1,000	1,000	2,220	2,040	460	<100



Total Phosphorous (TP ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	103	83	BRL	BRL	143	BRL	86	87
Site 3	105	76	142	108	115	156	87	75
Site 7	108	126	114	BRL	262	BRL	156	107

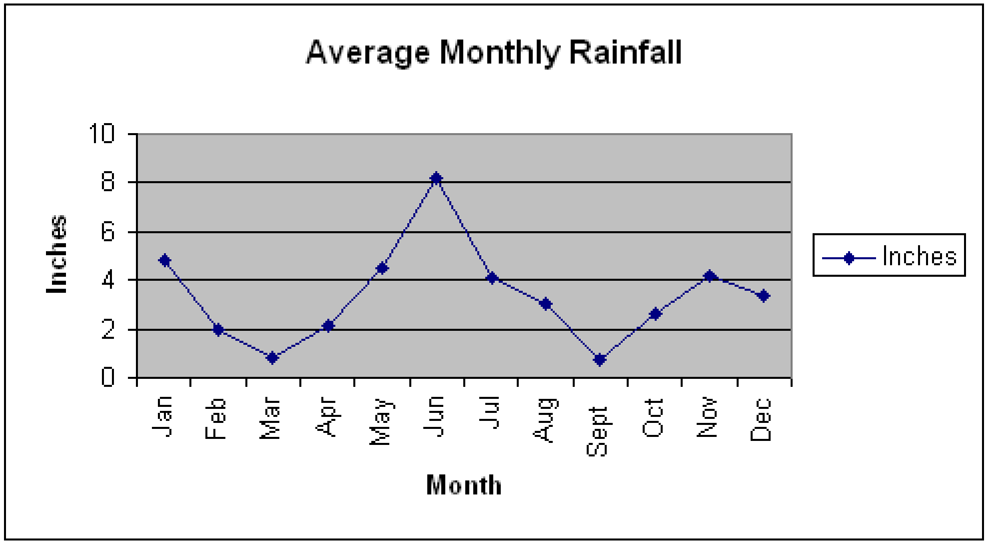


BRL = Below Reportable Limit
ND = Not Detected / Below Detectable Limit

Appendix C

Average Monthly Rainfall
2006

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Inches	4.86	1.98	0.85	2.13	4.5	8.23	4.07	3.05	0.76	2.6	4.19	3.32



Total Rainfall: 40.54 "