Nantucket Island Ponds and Their Water Quality

Chapter 4

Pest House Pond - 2015

4.0 Introduction

This chapter presents a summary and discussion of the physical, chemical and biological data collected from Pest House Pond by the Nantucket Land Council, Inc. during 2015.

4.1 Results

Pest House Pond was sampled on July 21st and September 8th 2015. Whereas access to the pond is quite difficult, the pond was sampled at the concrete pipe located at the west end of the pond that drains brackish water during the falling tide and brings saltwater into the pond on the rising tide.

There were no temperature data collected on either sampling date and dissolved oxygen and percent saturation data only were collected on July 21st.

4.1.1 Physical characteristics

General. Pest House Pond is located along the south-east shore of Nantucket Harbor, has a surface area of ~0.75 acres and is very shallow with the average depth of ~2 feet or less. It would appear from the aerial view provided in Figure 4.1 that the pond originally was about twice its current size.

Figure 4.1

The pond has no surface inlets and receives input from ground water, precipitation and surface runoff from the relatively small surrounding watershed.

4.1.2 Chemical characteristics

Specific conductance. A single conductance value of 28,390 $\mu S \cdot cm^{-1}$ was collected on the July 21st sampling date. This is a high value but expected for a body of water that receives saltwater input during the rising tide.

pH. A single pH value of 8.79 was recorded on the July 21st sampling date. This is an elevated value for mid-summer pH and suggests that there are high levels of productivity occurring in the pond that result in an imbalance between respiration and photosynthesis.

Dissolved oxygen concentration-percent saturation. A single set of dissolved oxygen concentration (8.80 $mg \cdot L^{-1}$) and percent saturation (95.2 %) readings was collected on July 21st. Although the water temperature of the pond was not recorded at the time these oxygen data were collected, the

concentration and saturation values seem normal for mid-summer conditions where the surface temperature is about 25°C.

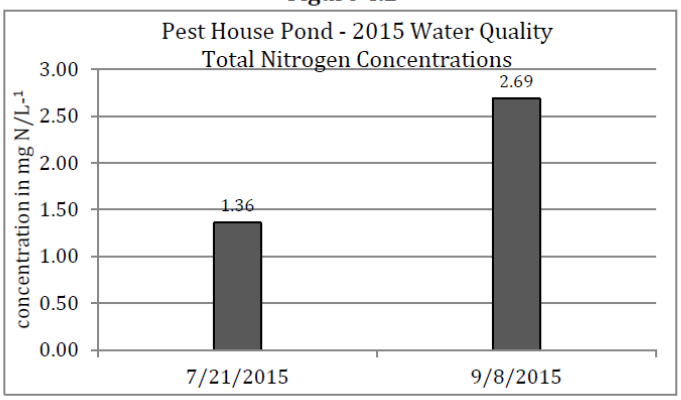
4.1.3 Plant Nutrients

Nitrogen. Nitrate-nitrogen was not detectable in Pest House Pond on either sampling date which is not unusual since this form of nitrogen is taken up by phytoplankton during the process of photosynthesis.

Measureable levels of **ammonia-nitrogen** occurred in the water column on both sampling dates, 0.030 mg $N{\cdot}L^{-1}$ on July 21st and 0.470 mg $N{\cdot}L^{-1}$ on September 8th. Whereas Pest House Pond is extremely shallow, it is not unusual that warm mid-summer conditions would lead to a build-up of **ammonia-nitrogen** since this is the first nitrogen product of organic decomposition by bacteria of material accumulated on the pond bottom.

The 2015 **total nitrogen** (**TN**) concentrations measured in Pest House Pond are shown in Figure 4.2.

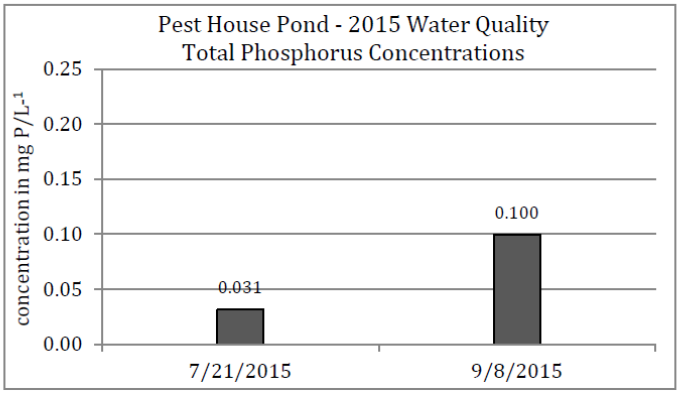
Figure 4.2



On July 21st, the **TN** concentration was 1.36 mg $N{\cdot}L^{-1}$, and by September 8th, the concentration had doubled to 2.69 mg $N{\cdot}L^{-1}$. These values are moderate-to-high and indicative of large amounts of organic nitrogen in the system in the form of phytoplankton and seston (other organisms and non-living matter).

Phosphorus. The **total phosphorus** (**TP**) concentrations measured in Pest House Pond during 2015 are shown in Figure 4.3.

Figure 4.3



On July 21st, the **TP** concentration was 0.031 mg $P{\cdot}L^{-1}$, while the concentration measured on September 8th was 0.100 mg P·L-1. While the September value is considered high, it would not be unusual to measure this level if a phytoplankton bloom was in progress at the time of sampling, which appears to have been the case and will be discussed in the next section of this report.

4.1.4 Phytoplankton

Description of the assemblage. A total of 27 taxa were identified in the 2015 July and September phytoplankton samples and all of the major algal groups were represented (Table 4.1).

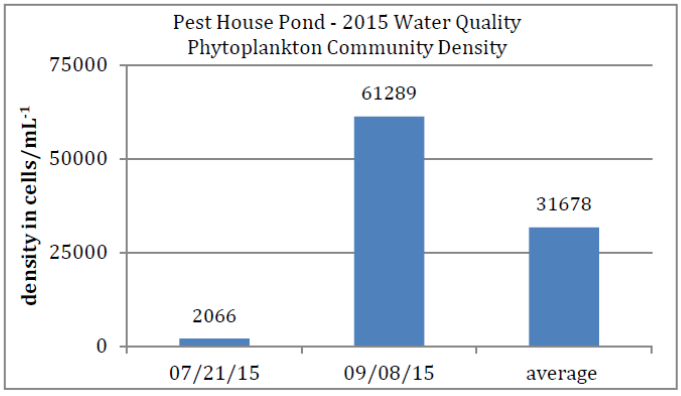
Table 4.1

Cyanophyta	**Chrysophyta (Bacillariophyceae)**	**Chrysophyta (Chrysophyceae)**
A. flos aquae	Cymbella sp.	Ochromonas sp.
Aphanizomenon flos aquae	Gomphonema spp.	Synura uvella
Oscillatoria sp.	Navicula spp.	**Euglenophyta**
Chlorophyta	Nitzschia sp.	Peranema sp.
Monoraphidium contortum	Planothidium sp.	Phacus sp.
Pyramimonas tetrarhyncus	Rhoicosphenia curvata	**Pyrrhophyta (Cryptophyceae)**
Schroederia Judayi	Stauroneis sp.	Cryptomonas erosa
Chrysophyta (Bacillariophyceae)	Surirella sp.	C. ovata
Achnanthes sp.	Synedra acus	**Pyrrhophyta (Dinophyceae)**
Cocconeis sp.	S. fulgens	Peridinium cinctum
Cyclotella sp.	Tabellaria fenestrata	

There were 23 taxa identified in the pond's phytoplankton community on July 21st and 17 taxa present on September 8th; community richness for the 2015 samples was calculated to be 20.0 (±4.2) taxa.

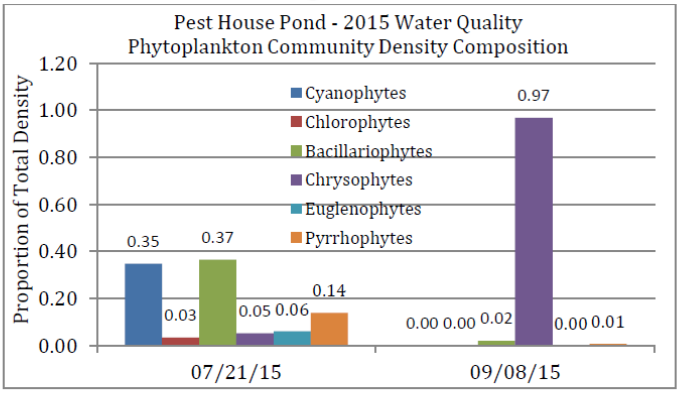
Density. Phytoplankton community density in Pest House Pond was 2,066 cells·mL^{-1} on July 21st and 61,289 cells·mL^{-1} on September 8th; average density was 31,678 cells·mL^{-1} for both dates (Figure 4.4).

Figure 4.4



The July 21st phytoplankton assemblage was comprised primarily of Bacillariophytes (diatoms) with 37 percent of the density and Cyanophytes (Blue-green algae) with 35 percent of the density (Figure 4.5).

Figure 4.5

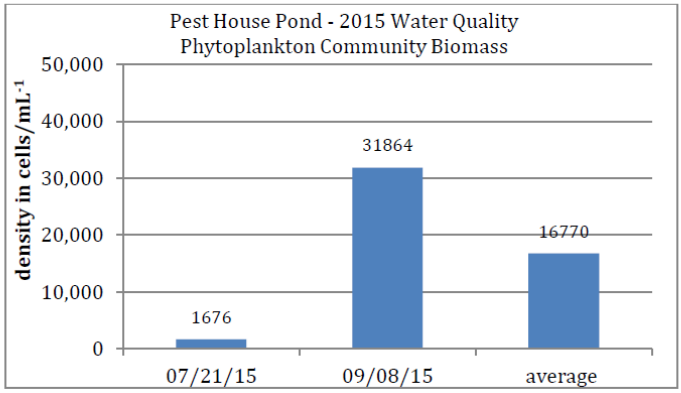


By September 8th, the density characteristic of the assemblage had completely changed and was comprised almost exclusively (97 percent) of Chrysophytes, which are cold-water, flagellated cells (Figure 4.5)

Biomass. Cell biovolume also was used to evaluate phytoplankton taxon biomass, or productivity, since cell counts and conversion into density does not account for the significant size difference among the various phytoplankton taxa that occur in the pond. It is quite common for size differences among different types of phytoplankton of several orders of magnitude.

The phytoplankton community biomass documented in Pest House Pond during July and September 2015 is presented in Figure 4.6.

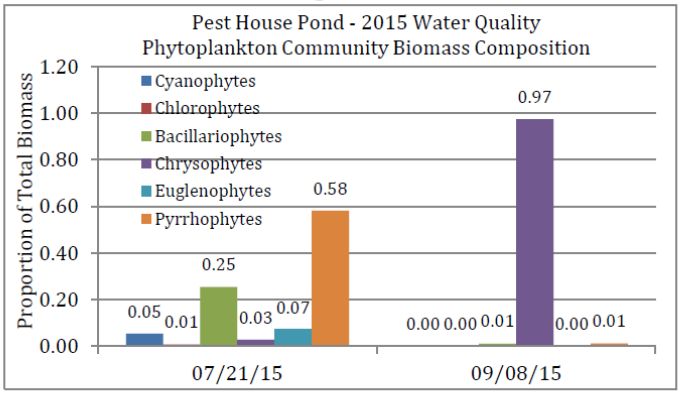
Figure 4.6



The biomass in the pond was 1,676 mg·m^{-3} on July 21st and 31,864 mg·m^{-3} on September 8th, which is an average of 16,770 mg·m^{-3} for both sampling dates (Figure 4.6).

With respect to biomass, the July phytoplankton assemblage was comprised primarily of Pyrrhophytes (58 percent) and Bacillariophytes (25 percent)(Figure 4.7).

Figure 4.7



By September 8th, the biomass composition of the phytoplankton community had changed dramatically and In September, the community was almost entirely comprised of Chrysophytes (97 percent).

Dominance. A ranking of phytoplankton taxa dominance in Pest House Pond on the 2015 sampling dates is summarized in Table 4.2.

Table 4.2

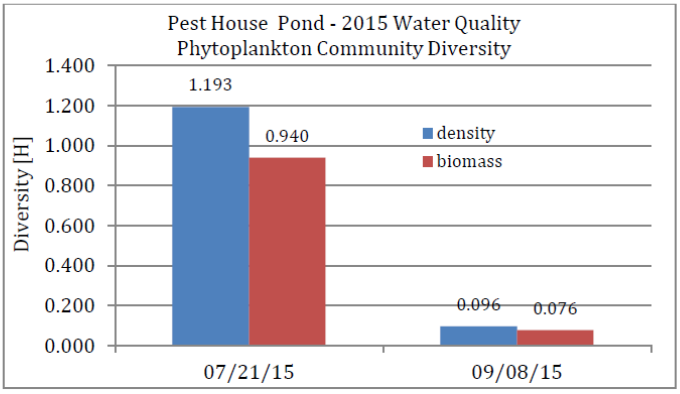
Sampling Date	Taxon (Major Group)	Biomass Rank	% of Total Biomass
7/21/15	*Cryptomonas ovata* (Chrysophyte)	1	31
	Peridinium cinctum (Pyrrhophyte)	2	27
	Phacus sp. (Euglenophyte)	3	7
	Surirella sp. (Chrysophyte)	4	5
9/8/15	*Synura uvella* (Chrysophyte)	1	97

Taxa are considered dominant in the community if they comprise at least 5 percent of the total community biomass. There were 4 dominant taxa in the phytoplankton community on July 21st and 1 dominant taxon in the community on September 8th (Table 4.2).

Diversity. Phytoplankton diversity in Pest House Pond was measured using the Shannon-Wiener function[1] which calculates diversity, **[H]**, using number of taxa and the portion of individuals among the taxa on each sampling date. An increase in either factor will increase the value of the diversity index. Calculated values that approach 1.0 indicate conditions of maximum diversity in the distribution of the population.

Diversity in Pest House Pond was calculated using both density and biomass in the equation. The results of the diversity calculations are presented in Figure 4-8.

Figure 4.8



Using density as the primary variable, diversity calculated for Pest House Pond was 1.193 and 0.096 in July and September, respectively. With biomass, the diversity values were 0.940 and 0.076 during July and September, respectively. Regardless of which variable is used to calculate diversity, the most noteworthy feature is the drastic decline in diversity between July and September.

Cyanophytes. As a major phytoplankton group, the Cyanophytes were identified in both the July and September samples collected in Pest House Pond. A total of 3 taxa were identified including *Anabaena flos aquae*, *Aphanizomenon flos aquae*, and *Oscillatoria* sp. Two of these species, *Anabaena flos aquae*, and *Aphanizomenon flos aquae* are known to produce algal toxins with a range of effects including liver, nerve, skin and gastrointestinal disorders. While there is no evidence that the genera documented in Pest House Pond produce any algal toxins, recreational users of the pond should be aware that Cyanobacteria can be present during the mid-summer periods.

[1] $H = -\sum_{i=1}^{s} (p_i)\,(log_2)(p_i)$, in units of information per individual per unit volume or area, where p_i is the proportion of the total samples belonging to the *i*th species and S is the number of species.

Chlorophyll *a*. The chlorophyll ***a*** concentrations measured in Pest House Pond were 1.8 µg·L^{-1} on July 21st and 28.0 µg·L^{-1} on September 8th, indicating a normal concentration in July and a concentration that indicates an algal bloom in progress on September 8th.

4.1.5 Trophic Status

'Trophic' means nutrition or growth. The trophic state of ponds refers to biological production, plant and animal, that occurs in the pond and the level of production is determined by several factors but primarily phosphorus supply to the pond and by the volume and residence time of water in the pond. Many different indicators are used to describe trophic state such as phosphorus, water clarity, chlorophyll, rooted plant growth and dissolved oxygen.

The reader is referred to Chapter 1 for a more thorough explanation of trophic status and the process of calculating this important indicator of lake and pond productivity.

Sufficient water quality data were collected from Pest House Pond during 2015 to calculate the Carlson Trophic State Index (TSI) using chlorophyll a and total phosphorus. Average values were calculated for each variable for the July and September sampling dates. The average values then were substituted into equations to calculate the TSI values for each variable. The stepwise calculation and results of the analysis are as follows:

Chlorophyll *a*
Average mid-summer chlorophyll *a* = 14.90 µg/L^{-1}
Chlorophyll *a* TSI = 9.81*[ln (14.90)] + 30.6
TSI = (9.81)(2.70) + 30.6
TSI = 57.1

Total phosphorus
Average mid-summer total phosphorus = 65.45 µg/L^{-1}
Total phosphorus TSI = 14.42*[ln (65.45)] + 4.15
TSI = (14.42)(4.18) + 4.15
TSI = 64.4

Both TSI indices were situated well within the eutrophic range of values as shown in Table 4.4 below. Given that the period between sampling dates was about 6 weeks in duration (late July to early September), it is likely that the key parameters used to calculate trophic state (total phosphorus and chlorophyll a) were well within the eutrophic range of values for a greater duration during the growing season.

Table 4.3

Trophic State Index	Chlorophyll (µg L^{-1})	TP (µg L^{-1})	Secchi Depth	Trophic Class
< 30 - 40	0.0 – 2.6	0.0 - 12	> 8 - 4	Oligotrophic
40 - 50	2.6 – 7.3	12 - 24	4 - 2	Mesotrophic
50 - 70	7.3 - 56	24 - 96	2 – 0.5	Eutrophic
70 – 100+	56 – 155+	96 – 384+	0.5 - <0.25	Hyper-eutrophic

4.2 Summary

Based upon the data collected during 2015, Pest House Pond exhibits water quality similar to other Island ponds studied by the Nantucket Land Council. The pond has high productivity characterized as eutrophic based upon the numerical analysis of 2 separate water quality variables that were sampled. Many of the Island ponds probably are very similar due to their extremely shallow nature and the highly

enriched organic material contained in the sediments from aquatic vegetation that has decomposed and accumulated in that region. Nutrients such as nitrogen and phosphorus that are trapped in these bottom sediments are subject to being released into the water column at various times during the mid-summer growing season when mixing of the water column occurs due to sufficient winds blowing across the Island that generate water currents throughout the pond.

4.3 Literature Cited

Carlson, R. E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Carlson, R. E. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22(2): 361-369.