Nantucket Island Ponds and Their Water Quality

Chapter 4

Washing Pond - 2014

4.0 Introduction

This chapter presents a summary and discussion of the physical, chemical and biological data collected from Washing Pond by Nantucket Land Council staff during 2014.

4.1 Results

Washing Pond was sampled on August 26th and September 15th 2014. The maximum water depth located in the pond was 14.1 feet (169 inches) on August 26th at a sampling location in the approximate center of the pond; the maximum water depth detected on September 15th was 14.2 feet (170 inches).

Following the collection of temperature and dissolved oxygen profile data on August 26th, an integrate sample was collected from the surface down to 8 feet of depth for the chemistry and phytoplankton samples; a grab sample was collected at the 12-foot depth for water chemistry.

The depth of collection on September 15th was 0-6 feet for the integrate sample and 12 feet for the grab sample. There were no other water samples collected from the pond on either sampling date.

4.1.1 Physical characteristics

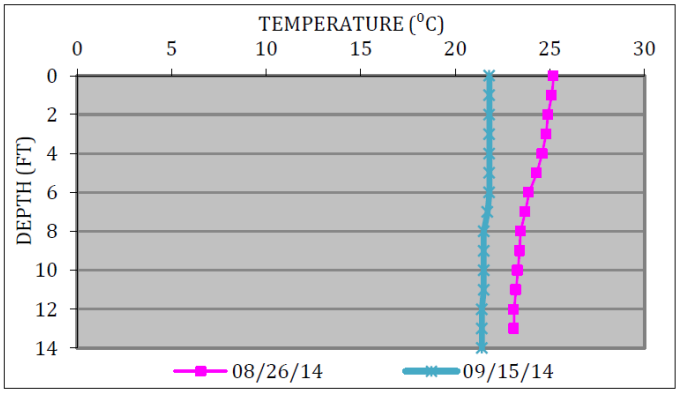
General. Washing Pond is rectangular in shape with a middle bugle giving it the appearance of an ellipse with its axis oriented in a north-south direction (Figure 3.1). The surface area of the pond is about 8 acres. There are no permanent streams flowing into the pond, and there is no outlet located along the shoreline.

Figure 4.1 Aerial view of Washing Pond (from *Google*™ earth)

Washing Pond has a moderate total depth of 14 feet and is situated in a basin of low elevation which should provide some limited protection from wind blowing across the Island and mixing of the water column.

Temperature. Temperature profile data were collected on both 2014 sampling excursions to Washing Pond. The profile data collected on both sampling dates are presented in Figure 4.2 and show that the pond was isothermal (the same temperature) from the surface to the bottom. The average temperature of the pond was 24.0°C on August 26th and 21.6°C on September 15th.

Figure 4.2 Temperature profiles collected at Washing Pond, August-September 2014.



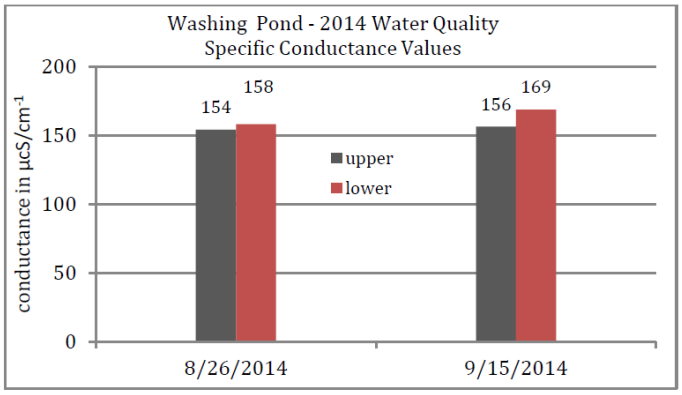
Transparency. The Secchi depth transparency measured at Washing Pond was 6.1 feet (73 inches) on August 26th and 4.9 feet (59 inches) on September 15th. Water color was recorded as 'cloudy green' on August 26th which could be an indication of an algal bloom in progress.

Water color on September 15th was recorded as 'brown', which either could be indicative of diatoms(algae) in the water column or 'staining' of the water by humic and fulvic acids leaching into the water from vegetation in the surrounding watershed.

4.1.2 Chemical characteristics

Specific conductance. Figure 4.3 presents the conductance values measured at Washing Pond on August 26th and September 15th.

Figure 4.3 Specific conductance measured in Washing Pond, August-September 2014.



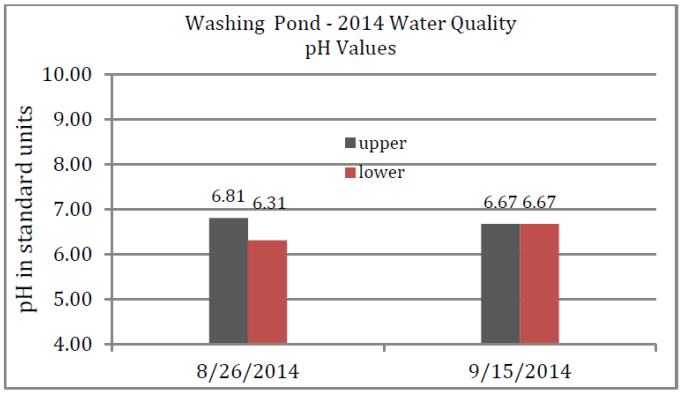
The conductance results for the integrate and grab samples on each sampling date essentially were the same, 154 and 158 µS·cm^{-1} in the *upper* and *lower* regions of the pond, respectively, on August 26th, and 156 and 169 µS·cm^{-1} in the *upper* and *lower* regions of the pond, respectively, on September 15th.

These values measured at Washing Pond are within the range of specific conductance values expected in ponds considered to be fresh water.

pH. As shown in Figure 4.4, Washing Pond was very close to neutral pH (7.0) on both sampling dates and there was little, if any, difference between the pH in different regions of the Pond.

The results for the integrate and grab samples collected on both sampling dates are as follows: 6.81 s.u. and 6.31 s.u. in the *upper* and *lower* regions of the pond, respectively, on August 26th, and 6.67 s.u. in the upper and lower regions on September 15th.

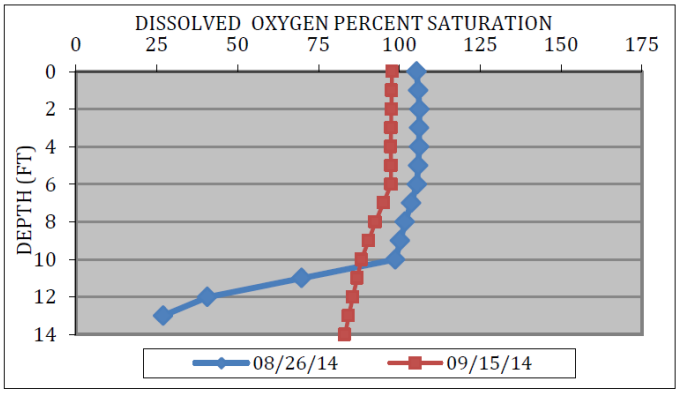
Figure 4.4 pH measured in Washing Pond, August-September 2014.



Dissolved oxygen concentration-percent saturation. The maximum concentration of dissolved oxygen that can occur in water, in general, is a function of water temperature. Higher concentrations of dissolved oxygen occur in low water temperatures than at high temperature. Dissolved oxygen levels in water often are reported in 'percent saturation' since the calculation corrects for temperature and removes bias from the oxygen concentration readings.

The oxygen saturation patterns in Washing Pond during August and September 2014 are shown in Figure 4.5.

Figure 4.5 Dissolved oxygen saturation profiles in Washing Pond, August-September 2014.



The data collected on August 26th show oxygen saturation values around 100 percent from the pond surface down to a depth of 10 feet; below that depth, the saturation values decline rapidly toward the bottom sediment (Figure 4.5). These conditions indicate a period of relative calm on the Island with little or no wind to promote mixing of the water column. Calm conditions can result in an oxygen saturation deficit in the lower region due to the decomposition of organic matter in this region.

4.1.3 Plant Nutrients

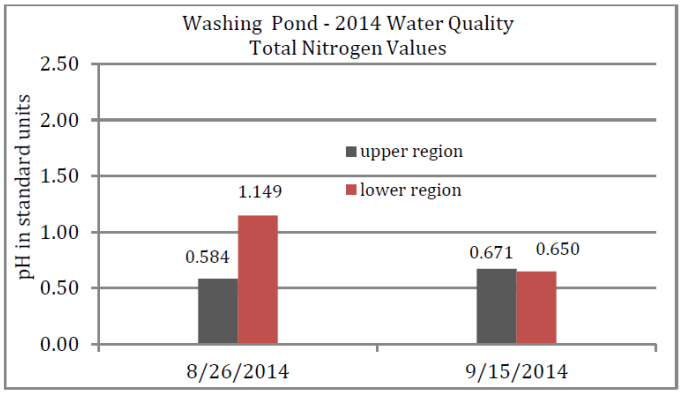
Nitrogen. Nitrate-nitrogen was detectable in Washing Pond on August 26th and the concentration was 0.028 mg $N \cdot L^{-1}$ in samples collected from the *upper* and *lower* regions of the pond. When the pond was

sampled on September 15th, **nitrate-nitrogen** was below the limit of detection (0.005 mg $N \cdot L^{-1}$) in both regions of the pond. Low (undetectable) **nitrate-nitrogen** levels is not an unusual phenomenon in fresh-water systems since this form of nitrogen is readily taken up by phytoplankton for metabolism when it is available in the water column.

And although there were measureable levels of **ammonia-nitrogen** in the water column on both sampling dates, the levels were low, which also is not unusual since this form of nitrogen is available for uptake by phytoplankton. The levels of **ammonia-nitrogen** measured in Washing Pond were as follows: 0.021 and 0.071 mg $N \cdot L^{-1}$ in the *upper* and *lower* regions, respectively, on August 26th, and 0.020 and 0.016 mg $N \cdot L^{-1}$ in the *upper* and *lower* regions, respectively, on September 15th.

The **total nitrogen** (**TN**) concentrations measured in Washing Pond during August and September 2014 are presented in Figure 4.6.

Figure 4.6 Total nitrogen concentrations measured in Washing Pond, August-September 2014.



On August 26th, the **TN** concentration measured in the *upper* region of the pond (0.584 mg $N \cdot L^{-1}$) was about one-half the concentration measured in the *lower* region of the pond (1.149 mg $N \cdot L^{-1}$).

Based upon the dissolved oxygen profile collected on August 26th and presented earlier in this chapter, it would appear that the pond experienced a calm period (with little or no wind) which allowed a saturation gradient to develop with low dissolved oxygen levels near the bottom of the pond. These conditions could promote the internal loading of nitrogen from the bottom sediments into the *lower* water column and would explain the discrepancy in the *upper* and *lower* concentration differences of **TN** on that date.

However, the total phosphorus (**TP**) data collected from Washing Pond on August 26th (see below) do not support the same internal loading scenario described here for **TN**, perhaps because **TP** generally is less available in fresh water lakes and ponds and would be more readily taken up by phytoplankton when available in the water column.

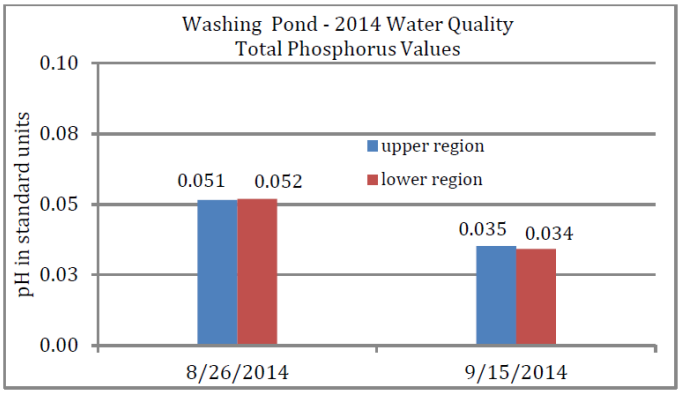
The same oxygen saturation differences in the profile data were not apparent on September 15th (see Figure 4.4) and it is noteworthy that **TN** concentrations in the *upper* and *lower* regions were very similar at 0.671 and 0.650 mg $N \cdot L^{-1}$, respectively, which would be expected under conditions of sufficient mixing of the pond.

Furthermore, the **TN** concentrations measured in Washing Pond during 2014 are similar to **TN** values measured in other Nantucket Island ponds during previous studies conducted by this report author. For example, the September 2012 **TN** value in *Hummock Pond* averaged 0.60 mg $N \cdot L^{-1}$ (Sutherland, 2013), while

the September 2013 **TN** concentration in *Head of Hummock Pond* averaged 1.16 mg N·L^{-1} (Sutherland and Mackinnon, 2014).

Phosphorus. The **total phosphorus** (**TP**) concentrations measured in Washing Pond during August-September 2014 are shown in Figure 4.7. On August 26th, **TP** concentrations were the same in the upper and lower regions of the pond at 0.051 and 0.052 mg P·L^{-1}, respectively. **TP** concentrations on September 15th were reduced from August levels, but also the same values in both *upper* and *lower* regions of the pond at 0.035 and 0.034 mg P·L^{-1}, respectively.

Figure 4.7 Total phosphorus concentrations measured in Washing Pond, August-September 2014.



As a comparison to Washing Pond, average **TP** levels were 0.085 mg P·L^{-1} in *Hummock Pond* during September 2012 and 0.252 mg P·L^{-1} in *Head of Hummock Pond* during 2013.

4.1.4 Phytoplankton

Description of the assemblage. A total of 47 taxa were identified in the August 26th and September 15th phytoplankton samples collected from Washing Pond and all of the major algal groups were represented in the samples (Table 4.1).

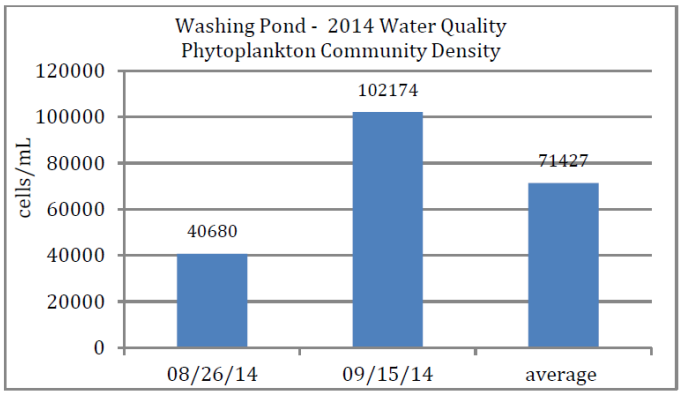
Table 4.1 Major groups and taxa of phytoplankton identified in Washing Pond, August-September 2014.

Cyanophytes	**Chlorophytes**	**Chrysophytes (Bacillariophyceae)**
Aphanizomenon flos aquae	*Kirchneriella lunaris*	*Rhoicosphenia curvata*
Chroococcus dispersus	*Micrasterias radiata*	*Stauroneis* sp.
C. limneticus	*Monoraphidium contortum*	*Synedra acus*
Gomphosphaeria lacustris compacta	*Oocystis pusilla*	*S. ulna*
Merismopedia glauca	*O. pusilla*	**Chrysophytes (Chrysophyceae)**
Microcystis aeruginosa	*Pandorina morum*	*Dinobyron bavaricum*
Woronichinia naegeliana	*Quadrigula lacustris*	*D. divergens*
Chloromonadophytes	*Staurastrum natator* var. *crassum*	*Mallomonas* sp.
Gonyostomum semen	*Tetraedron minimum*	*Ochromonas* sp.
Chlorophytes	**Chrysophytes (Bacillariophyceae)**	**Euglenophytes**
Ankistrodesmus falcatus	*Achnanthes* sp.	*Peranema* sp.
A. convolutus	*Aulacoseria granulata*	*Phacus* sp.
Chlamydomonas sp.	*Cocconeis* sp.	*Trachelomonas* sp.
Closteriopsis longissimi	*Cyclotella* sp.	**Pyrrhophytes (Cryptophytes)**
Closterium sp.	*Gomphonema* spp.	*Cryptomonas ovata*
Coelastrum cambricum	*Navicula* spp.	**Pyrrhophytes (Dinophytes)**
Cosmarium spp.	*Nitzschia* sp.	*Peridinium cinctum*
Eudorina elegans	*Pinnularia* sp.	
Golenkinia radiata	*Planothidium* sp.	

The were 37 taxa identified in the pond's phytoplankton community on August 26th and 28 taxa on September 15th; community richness was calculated for the 2 sampling periods and was 32.5 (±6.4) taxa.

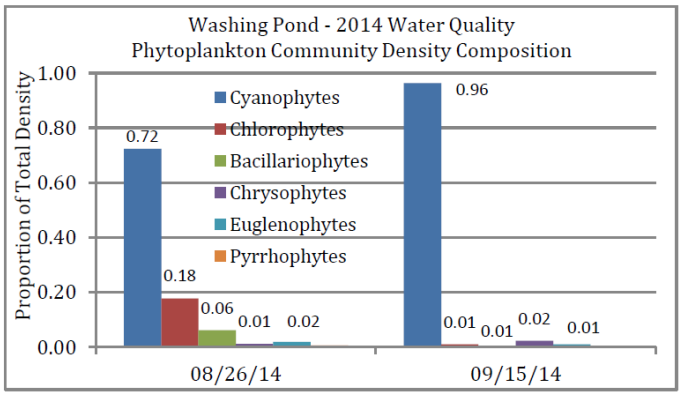
Density. The phytoplankton community density in Washing Pond was 40,680 cells·mL^{-1} on August 26th and 102,174 cells·mL^{-1} on September 15th, average density was 71,427 cells·mL^{-1} for both dates (Figure 4.8).

Figure 4.8 Phytoplankton community density in Washing Pond, August-September 2014.



The August 26th phytoplankton assemblage in Washing Pond was comprised primarily of Cyanophytes (Blue-green algae) with 72 percent of the community density and Chlorophytes (green algae) with 18 percent of the community density (Figure 4.9).

Figure 4.9 Density composition of the phytoplankton community in Washing Pond, August-September 2014.



The other 4 major groups of phytoplankton, the Bacillariophytes (diatoms), the Chrysophytes, the Euglenophytes and the Pyrrhophytes, made up the remaining 10 percent of the phytoplankton community.

The relative importance of the Chlorophytes was greatly diminished by September 15th and the Cyanophytes totally dominated the phytoplankton community with 96 percent of the total density. The other 4 phytoplankton classes comprised the remaining 4 percent of the community density on September 15th.

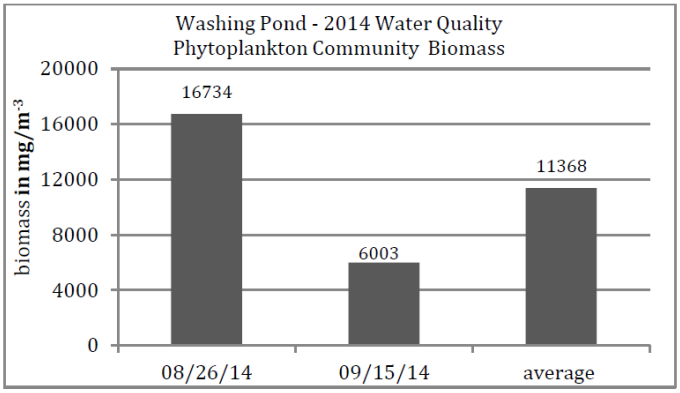
The conditions that existed in Washing Pond on September 15th with regard to phytoplankton density in the water column and the dominance of the Cyanophytes on that sampling date suggest that an algal 'bloom' was in progress.

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 Washing Pond during August and September 2014 is presented in Figure 4.10.

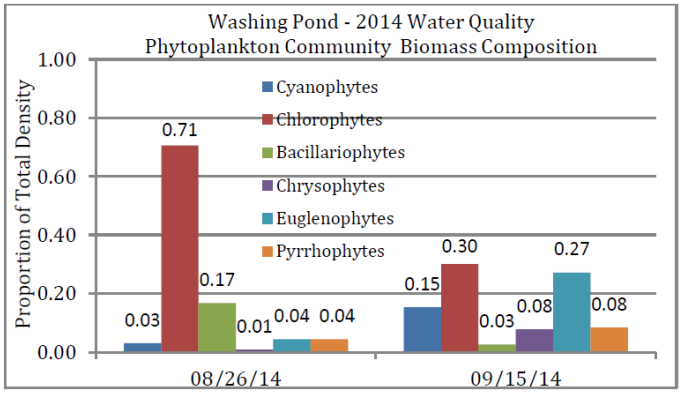
Figure 4.10 Phytoplankton community biomass in Washing Pond, August-September 2014.



The biomass in Washing Pond was 16,734 mg·m^{-3} on August 26th and 6003 mg·m^{-3} on September 15th, and averaged 11,369 mg·m^{-3} for both sampling dates (Figure 4.10).

In terms of biomass, the August 26th phytoplankton assemblage in Washing Pond included primarily the Chlorophytes (green algae) with 71 percent of the community density and the Bacillariophytes (diatoms) which comprised 17 percent of the community (Figure 4.11).

Figure 4.11 Biomass composition of the phytoplankton community in Washing Pond, August-September 2014.



By September 15th, the biomass composition of the phytoplankton community had changed dramatically. There were 5 major groups of algae that were important components of the assemblage including the Chlorophytes (30 percent), the Euglenophytes (27 percent), the Cyanophytes (15 percent), the Chrysophytes (8 percent) and the Pyrrhophytes (8 percent).

The misleading nature of density as a reliable community descriptor is evident when reviewing the September 15th Washing Pond cell biomass values and noting the substantial size difference between the Cyanophyte *Microcystis aeruginosa* cells (3.0 mg·m^{-3}) and the Chlorophyte *Staurastrum natator* cells (4000.0 mg·m^{-3}). Although *M. aeruginosa* comprised 92 percent of the phytoplankton density on September 15th with

94,000 cells, *S. natator* comprised 30 percent of the community biomass with only 90 cells. These differences in relative biomass (the size of individual cells) can explain how small numbers of cells with an exceptionally large biovolume can make a particular taxon a dominant member in the phytoplankton community.

Dominance. A ranking of phytoplankton taxa dominance in Washing Pond on the 2014 sampling dates is summarized in Table 4.2. 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 August 26th and 7 dominant taxa in the community on September 15th (Table 3.2). As discussed above, the green algae and the diatoms comprised a major portion of the community in August and in September, the greens, euglenoids and Blue-greens were the major components of the community.

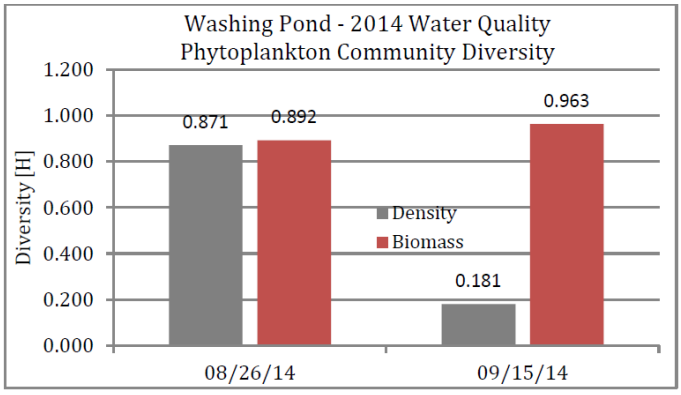
Table 4.2 Rank of phytoplankton taxa dominance, using biomass, in Washing Pond, August-September 2014.

Sampling Date	Taxon (Major Group)	Biomass Rank	% of Total Biomass
8/26/14	*Staurastrum natator* var. *crassum* (Chlorophyte)	1	47
	Aulacoseria granulata (Bacillariophyte)	2	14
	Closterium sp. (Chlorophytes)	3	6
	Gonyostomum semen (Chloromonadophyte)	4	6
9/15/14	*Staurastrum natator* var. *crassum* (Chlorophyte)	1	30
	Trachelomonas sp. (Euglenophyte)	2	16
	Aphanizomenon flos aquae (Cyanophye)	3	11
	Phacus sp. (Euglenophyta)	4	11
	Coelastrum cambricum (Chlorophyte)	4	6
	Mallomonas sp. (Chrysophyte)	6	6
	Microcystis aeruginosa (Cyanophyte)	7	5

Diversity. Phytoplankton diversity in Washing 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 Washing Pond was calculated using both density and biomass in the equation. The results of the diversity calculations are presented in Figure 4-12.

Figure 4.12 Summary of diversity calculation for Washing Pond, August-September 2014.



[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.

Using density as the primary variable. the diversity calculated for Washing Pond was 0.871 and 0.181 in August and September, respectively. With biomass, the diversity vales were 0.892 and 0.963 during August and September, respectively. The data presented for September 2014 in Figure 4-12 highlight the discrepancy that can occur when evaluating phytoplankton community dynamics using either density (0.181) or biomass (0.963) as the metric for comparison.

Cyanophytes. As a major phytoplankton group, the Cyanophytes were identified in both the August and September samples collected in Washing Pond. A total of 6 taxa were identified including *Aphanizomenon flos aquae*, *Chroococcus dispersus*, *C. limneticus*, *Gomphosphaeria lacustris compacta*, *Microcystis aeruginosa* and *Woronichinia naegeliana*. Three of these genera, *Aphanizomenon*, *Microcystis*, and *Woronichinia*, 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 Washing Pond produce any algal toxins, recreational users of the pond should be aware that Cyanobacteria can be present during the mid-summer periods.

Chlorophyll *a*. The chlorophyll ***a*** concentrations measured in Washing Pond were 5.02 µg·L^{-1} on August 26th and 10.86 µg·L^{-1} on September 15th, indicating a low level of algal productivity in the pond on both occasions.

In comparison to Washing Pond, chlorophyll ***a*** levels measured in Nantucket Island ponds during recent years include 6.98 µg·L^{-1} in *Hummock Pond* during September 2012 and an average of 143.93 µg·L^{-1} in *Head of Hummock Pond* during September 2013.

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 Washing Pond during 2014 to calculate the Carlson Trophic State Index (TSI) using all three variables. Average values were calculated for each variable (chlorophyll ***a***, total phosphorus, Secchi depth) for the 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* = 7.94 µg/L^{-1}
Chlorophyll *a* TSI = 9.81*[ln (7.94)] + 30.6
TSI = (9.81)(2.07) + 30.6
TSI = 50.9

Total phosphorus
Average mid-summer total phosphorus = 43.37 µg/L^{-1}
Total phosphorus TSI = 14.42*[ln (43.37)] + 4.15
TSI = (14.42)(3.77) + 4.15
TSI = 58.5

Secchi depth
Average mid-summer Secchi depth = 1.68 m
Secchi TSI = 60 – [14.41*[ln (1.68)]
TSI = 60 – (14.41)(0.52)
TSI = 52.5

The TSI of 50.9 calculated for chlorophyll ***a*** was just above the mesotrophic-eutrophic threshold of 50 (see Table 4.3 below), while the TSI calculated for total phosphorus (58.5) was in the middle of the eutrophic region. The average 2014 Secchi depth (1.68 meters) resulted in a calculated TSI value of 52.5, just above the mesotrophic-eutrophic threshold of 50. The TSI values calculated from all 3 independent variables for Washing Pond during 2014 portray water quality during August-September that was in the eutrophic region.

Table 4.3 Relationships among Trophic Index, chlorophyll *a*, phosphorus, Secchi depth and Trophic Class.

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 2014, Washing Pond exhibits water quality similar to other Island ponds studied by the Nantucket Land Council. The pond has high productivity characterized as eutrophic and based upon the numerical analysis of 3 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 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.

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.

Sutherland, J. W. and E. MacKinnon. 2014. Head of Hummock Pond. 2013 Water Quality Program. A Summary of Physical, Chemical and Biological Monitoring. Prepared for The Nantucket Land Council. 92 pp. + Appendices.

Sutherland, J.W. 2013. Hummock Pond. The 2012 Water Quality Program. A Summary of Physical, Chemical and Biological Monitoring. Prepared for The Nantucket Land Council. 64 pp. + Appendices.