MEMO

To: David Gould and Kim Michaelis
DPW Environmental Management
11 Lincoln Street
Plymouth, MA 02360

Date: August 27, 2008

RE: Pond Monitoring Program: Results for August 2008

Monitoring was conducted on Great Herring Pond (August 9th) and Great South Pond (August 23rd) according to the program schedule for August. Monitoring efforts consisted of the following: water column measurements of hydrographic parameters (temperature, specific conductance, pH, and dissolved oxygen) measured with a multiprobe at intervals of one meter over the deepest portion of each pond basin, measurement of Secchi transparency, plankton sampling, and a macrophyte survey consisting of an inspection of the littoral zone and characterization of the aquatic plant community of each pond.

Additionally, the first task completed at Great South Pond was to record and map water depths along multiple transects across the pond in order to identify the deepest contour of the basin. This was necessary because no bathymetric map exists for this pond while maps of most other ponds are available on the MassWildlife website. Initial soundings show the center of the main basin is uniformly deep (45 feet or greater) with a maximum depth contour of 50 feet located southeast of the center of the basin. A preliminary bathymetric map based on these soundings is in preparation. Results of these monitoring tasks are given in the sections below.

<u>Water Column Measurements (see Table 1 on page 2 and Figures 1 and 2 on page 7)</u>

Measurement of hydrographic parameters at intervals from the surface to the bottom give a "profile" of each parameter through the water column. Both Great Herring Pond and Great South Pond are deep and, therefore, become thermally stratified in summer. The warm, less dense surficial layer of the water column ("epilimnion") extends to a depth of 8 meters in these ponds (Figure 1). Below the epilimnion, a temperature gradient ("thermocline") exists extending to cooler, denser water with depth. Only a small central portion of Great Herring Pond is deeper than 9 meters (30 feet) and this limited area of the basin extends just three meters more to a maximum depth of 12 meters (39 feet). For this reason, the thermocline in Great Herring Pond spans a range of only 7°C with temperature at the bottom a relatively warm 18.6°C. In contrast, much of Great South Pond is deeper than 9 meters and it has a maximum depth of 15.3 meters (50 feet), so the thermocline spans a range of 14°C with a bottom temperature of 10.4°C.

Despite its depth, stratification structure in Great South Pond consists of a thermocline extending to the bottom and lacks a clearly defined hypolimnion (a stratum having nearly uniform temperature). This is likely due to the great clarity of the water (Secchi transparency of 30 feet; discussed below) and the concomitant deep penetration of solar radiation into the water column.

Dissolved oxygen concentrations in the epilimnion of Great Herring Pond were at or near saturation to a depth of around six meters, but then were undersaturated at seven and eight meters and, in the region of the thermocline below a depth of nine meters, were extremely hypoxic. These measurements reflect intense decomposition of sedimenting plankton and indicate that Great Herring Pond supports significant productivity by plankton during the summer stratification period.

TABLE 1 - WATER COLUMN PROFILES OF PLYMOUTH PONDS RECORDED IN AUGUST 2008

Great Herring Pond on August 9, 2008
(Secchi Transparency = 10 feet / 3 meters)

Depth meters	Temp degC	SpCond uS/cm	DO %Sat	DO mg/l	pH units
0.3	25.44	80.0	100.9	8.27	7.34
1	25.42	80.0	101.3	8.30	7.32
2	25.33	80.1	102.2	8.39	7.18
3	25.20	80.1	97.7	8.04	7.26
4	25.14	80.0	99.2	8.18	7.26
5	25.13	80.0	96.1	7.92	7.25
6	25.13	80.0	95.7	7.89	7.38
7	24.98	80.1	76.7	6.34	7.23
8	24.59	80.7	30.9	2.57	7.25
9	23.69	84.5	1.7	0.14	7.23
10	22.08	95.8	1.4	0.12	7.03
11	19.19	118.7	1.0	0.09	6.69
12	18.57	121.3	1.0	0.09	6.76
Inlet	23.41	86.1	98.9	8.41	7.95

Great South Pond on August 23, 2008
(Secchi Transparency = 30 feet / 9.1 meters)

Depth meters	Temp degC	SpCond uS/cm	DO %Sat	DO mg/l	pH units
0.3	24.40	39.5	104.0	8.69	6.09
1	24.20	39.3	103.8	8.71	6.14
2	23.93	39.2	103.9	8.76	6.14
3	23.91	39.0	104.0	8.77	6.22
4	23.89	39.3	104.0	8.77	6.23
5	23.87	39.3	103.8	8.76	6.25
6	23.77	39.5	103.2	8.72	6.24
7	23.70	39.1	103.4	8.75	6.26
8	23.66	39.4	103.4	8.76	6.26
9	22.48	40.3	120.7	10.45	8.22
10	18.40	46.4	148.3	13.93	8.94
11	15.82	41.7	129.7	12.85	8.49
12	13.53	40.3	44.8	4.67	7.23
13	11.73	47.7	4.7	0.51	6.12
14	11.13	58.4	2.2	0.24	5.73
15.3	10.35	72.2	1.6	0.18	5.88

The epilimnion of Great South Pond was slightly supersaturated throughout its volume and oxygen concentrations spike to even higher levels in the upper portion of the thermocline at depths of 9 to 11 meters where saturation values reach 120.7% to 148.3%. Associated with this spike in dissolved oxygen were very high pH values (8.22 to 8.94). These measurements are analogous to those recorded in Long Pond on July 6th and indicate an aggregation of photosynthetically active phytoplankton in this stratum. Most likely, phytoplankton sedimenting down from the epilimnion became aggregated in this stratum due to a slowing of their sinking rate as they encountered the density gradient associated with thermal stratification. Below this stratum, dissolved oxygen concentrations decline rapidly with depth. The bottom two meters of the water column are hypoxic due to decomposition of sedimenting phytoplankton.

Also noteworthy in the Great South Pond measurements, are the very low conductivity values. Epilimnetic values of conductivity are about 39 uS/cm in Great South Pond; much lower than Great Herring Pond and the four ponds monitored in July. These low values attest to extremely low concentrations of dissolved ions that are characteristic of pristine kettle ponds situated in glacial deposits of stratified drift.

Measurement of Secchi transparency also demonstrates the pristine character of Great South Pond with an exceptional reading of 30 feet. Water of this clarity is characteristic of systems having very low productivity ("oligotrophic") and indicates that Great South Pond supports very low densities of phytoplankton. Great Herring Pond had moderate transparency of 10 feet.

Plankton Sampling (see Table 2 on page 5)

Plankton in each pond were sampling using a net with 35 micron mesh openings manipulated vertically through the water column. Samples were preserved in the field using Lugol's Solution and analyzed using a compound microscope to identify phytoplankton taxa and determine their relative abundance.

Both ponds exhibited diverse phytoplankton communities. The phytoplankton community of Great Herring Pond was dominated by the diatom *Tabellaria* with significant representation by the chlorophyte *Pandorina* and by the chrysophyte *Dinobryon*. The phytoplankton community of Great South Pond was dominated by the cyanophyte *Anabaena* and by the chlorophyte *Gloeocystis*. The ascendancy of *Anabaena* in Great South Pond likely indicates that instead of phosphorus being the nutrient limiting phytoplankton growth, which is typical of most temperate lakes and ponds, the limiting nutrient in this system is nitrogen. *Anabaena* and certain other cyanophytes are capable of utilizing atmospheric nitrogen ("nitrogen fixation") and have a competitive advantage over other organisms in a system low in nitrogen. If phytoplankton productivity is limited by a short supply of nitrogen relative to other nutrients, *Anabaena* often supplants other forms due to its ability to augment the limited supply in the water with atmospheric nitrogen. This may be only a seasonal pattern with nitrogen inputs at other times of the year causing the system to revert to limitation by phosphorus. All of the organisms observed in these ponds are common and typical of freshwater plankton communities.

Macrophyte Survey (see Table 3 on page 6)

Growth of aquatic macrophytes in the littoral zones of both ponds is generally sparse. Submerged vegetation is mostly limited to low-growing species such as Pipewort (*Eriocaulon*), Golden-pert (*Gratiola*), Waterwort (*Elatine*), and Spike-rush (*Eleocharis*) growing between embedded substrates. The littoral zones of both pond are characterized by extensive areas of sand, gravel, and cobble lacking macrophyte growth.

The inlet channel at the north end of Great Herring Pond supported the greatest density of growth observed anywhere in this system and consisted of Tapegrass (*Vallisneria*), Sparganium (Bur-reed), and Pondweed (*Potamogeton*). Localized beds of Slender Arrowhead *(Sagittaria teres*) and Naiad (*Najas*) were observed in deeper water. Patches of emergent Water-willow (*Decodon*) occur in scattered locations along the eastern shoreline and in the southwest cove. No alien plant species were observed in Great Herring Pond.

In contrast to the relatively sterile condition of most of Great South Pond discussed above, a dense community of macrophytes exists in the small cove in the extreme southwest corner of the pond. This cove contains more submerged plant biomass than the total for all other areas of the pond combined. Unfortunately, as with the case of Billington Sea, it must again be reported that the alien Fanwort (*Cabomba caroliniana*) was observed here. Other macrophyte species are present in this cove including Water-starwort (*Callitriche*), Bladderwort (*Utricularia*), Water-milfoil (*Myriophyllum*), Waterweed (*Elodea*), Naiad (*Najas*), Pondweed (*Potamogeton*), and Slender Arrowhead *(Sagittaria teres*), but Fanwort is dominant. The concentration of macrophytes in this small cove is striking and is likely due to a combination of factors including its uniformly shallow depth (8 feet or less) and its enclosed setting which has likely intensified the rate of accumulation of fine organic sediments in which these plants have taken root. It remains to be seen if Fanwort expands its distribution in Great South Pond, but the spread of this invasive plant is likely being restricted by the sterile, sandy substrates that comprise most of the littoral zone outside this cove.

Two other species are notable in the main basin of Great South Pond: Slender Arrowhead *(Sagittaria teres*) which forms extensive beds in deeper water and emergent White-bracted Boneset (*Eupatorium leucolepis*) which were conspicuously in flower along many shoreline areas.

In addition to the macrophytes observed in Great South Pond, suspended masses of green filamentous algae were frequently evident in shallow water. These subsurface “clouds” of biomass in the water column and the algae composing them are known as metaphyton. In Great South Pond, these masses were composed entirely of the green alga *Mougeotia*, a common metaphytic organism.

TABLE 2 - RESULTS OF PHYTOPLANKTON SAMPLING OF PLYMOUTH PONDS IN AUGUST 2008

(Estimates of percent composition indicated as follows: **A**bundant = 60-100%, **V**ery Common = 30-60%, **C**ommon = 5-30%, **O**ccasional = 1-5%, **R**are < 1%)

	Sampling Location	
	Great Herring Pond (net to 8 m)	**Great South Pond** (net to 10 m)
Phytoplankton Taxa		
Bacillariophyceae (diatoms)		
Asterionella		R
Attheya	R	
Cyclotella	R	R
Fragilaria		R
Melosira	O	R
Rhizosolenia		R
Synedra	R	
Tabellaria	**V**	R
Chlorophyta (green algae)		
Botryococcus	R	R
Coelastrum	R	R
Crucigenia		**C**
Gloeocystis	R	**V**
Kirchneriella		R
Mougeotia	R	
Oocystis	R	R
Pandorina	**C**	
Pediastrum	R	R
Quadrigula		R
Sorastrum	R	
Sphaerocystis		R
Staurastrum	R	R
Xanthidium	R	
Chrysophyta (yellow-green algae, excluding diatoms)		
Dinobryon	**C**	
Mallomonas	R	R
Rhizochrysis	R	
Synura	R	
Cyanophyta (blue-green algae)		
Anabaena	R	**V**
Aphanocapsa	R	
Aphanizomenon		R
Chroococcus	R	
Dactylococcopsis		**C**
Microcystis	O	R
Pyrrhophyta (dinoflagellates)		
Ceratium		R
Peridinium	R	

TABLE 3 - MACROPHYTES OF PLYMOUTH PONDS OBSERVED IN AUGUST 2008*

SPECIES NAME	COMMON NAME	Great Herring Pond	Great South Pond
Submerged Plants			
Cabomba caroliniana	Fanwort (alien)		▲
Callitriche sp.	Water-starwort		x
Elatine minima	Waterwort	x	x
Eleocharis sp.	Spike-rush	x	x
Elodea nuttallii	Waterweed		x
Eriocaulon sp.	Pipewort		▲
Gratiola aurea	Golden-pert	x	x
Myriophyllum humile	Water-milfoil		x
Najas flexilis	Naiad	x	x
Potamogeton sp.	Pondweed	x	
Sagittaria teres	Arrowhead	▲	▲
Sparganium sp.	Bur-reed	x	
Utricularia sp.	Bladderwort		x
Vallisneria americana	Tapegrass	x	
Emergent Plants			
Decodon verticillatus	Water-willow	x	
Eupatorium leucolepis	White-bracted Boneset		▲
Gratiola aurea	Golden-pert	x	x
Iris versicolor	Blue Flag		x
Lobelia dortmanna	Water Lobelia	x	

*** dominant species indicated with a triangle ▲**

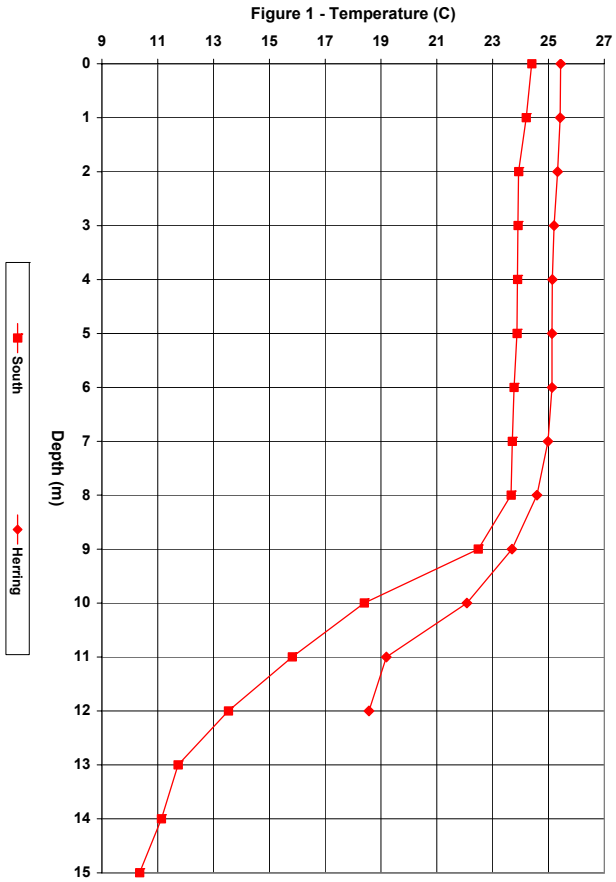
Figure 1 - Temperature (C)
9
11
13
15
17
19
21
23
25
27
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
South
Herring

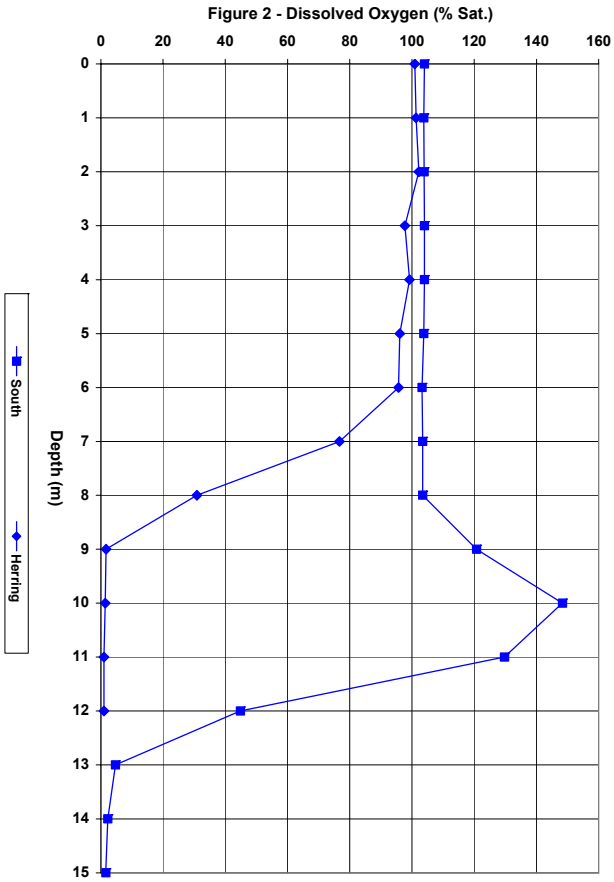
Figure 2 - Dissolved Oxygen (% Sat.)
0
20
40
60
80
100
120
140
160
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
South
Herring