Princeton University Water Watch
Water Monitoring Quality Report:
Academic Year 2004-2005

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&
the Water Monitoring Research Team

This brief report summarizes the observations of the Princeton University Water Watch Water Monitoring program for the academic year 2004-2005. We include here only a summary of our findings to date and a discussion of what these findings suggest about the extent and sources of pollution at the lake. We are currently formulating recommendations for mitigation of the identified pollution sources, however we would like to inform and support such recommendations with further data before we present them and have not included these recommendations here.

Monitoring Objectives:

Our objective in studying the water quality of lake Carnegie is to acquire the data necessary to identify the current ecological health of the lake and to evaluate the nature and extent of existing pollution sources. We hope to use this data not only to identify the primary pollution sources, but also to help us make recommendations for improving the quality of the lake an advocating from an informed position for that improvement. We also hope this data will help inform our parent organization the New Jersey Public Interest Research Group in their evaluation of state environmental concerns and their advocacy of mitigating measures. By engaging university students, local high school students, and community members in the active process of water quality monitoring we also hope to foster a sense of community responsibility for our shared environmental resources and hence promote better environmental stewardship, community activism, and general awareness.

Materials and Methods

Benthic macroinvertebrate sampling was carried out throughout the fall, when the organisms are most abundent and easily collected (Mitchell, and Stapp, 2000). Macroinvertebrates were collected using ten Hester-Dendy artificial substrate samplers (Wildlife Co.) distributed at five locations throughout the lake on both shores and at both ends. Only five samplers were in the lake at any one time. These were collected after two weeks and replaced with clean samplers while the collections were sorted and analyzed.

In all, over 500 organisms were collected, sorted, and identified. Benthic macroinvertebrates are a diverse class of organism with a broad range of tolerances to different levels of different pollution sources. Researchers have developed several metrics to relate the relative distribution of species to the nature and severity of pollution. The metrics we used come from the EPA's Rapid BioAssessment Protocol II, a family level analysis widely used in studying water pollution biology across the country. These metrics include Hilsonoff Family Taxa Value, Family Biotic Index, Taxa Richness, EPT richness, and EPT/chromididae ratio. Scores that indicate cause for concern are noted under "Research Findings".

Chemical sampling was carried out approximately biweekly. Eleven parameters were sampled, dissolved oxygen, fecal coliform bacteria, biochemical oxygen demand, water temperature, air temperature, pH, dissolved nitrates, dissolved free phosphates, chloride concentration, turbidity and total solids. Due to some variability in the availability of all the testing equipment not every parameter was sampled at each event. Most of the data from fall 2004 includes all of the tests except total solids due to the difficulty of obtaining an analytical balance and the limited information included in this parameter.

Research Findings

Observation of Concern	Implications
Fecal coliform bacteria counts are consistently **above 200 colony producing units/100mL**. This exceeds the national health standards for swimmable water ways.	Swimming in water with high FC counts can result in ear-infections and gastro-intestinal diseases.
Nitrate levels from the past 2 years consistently **average over 3ppm**. This is 20 times the concentration observed in healthy lakes!	Nutrient pollution is one of the leading causes for loss of bio-diversity and algal blooms.
Nitrate levels **over 10ppm** have been recorded in the lake	Concentrations of 10 ppm are toxic and can cause significant cardiovascular health problems if ingested.
Dissolved oxygen levels average only **9ppm**. Percent saturation frequently **55-80%**.	Dissolved oxygen is critical for almost all forms of aquatic life. Those not directly dependent on it such as water fowl are none-the-less affected through their food supply. Low dissolved oxygen may indicate high concentrations of aerobic bacteria and/or a lack of healthy submergent plant vegetation.
Biochemical Oxygen Demand averages around **2.3ppm** for a five day incubation. Healthy lakes frequently have scores of 0-1ppm.	High BOD levels are another indicator of aerobic bacteria. While some bacteria are necessary for natural nutrient cycling, high levels can increase the chance of infection from water contact and disrupt ecological balances.
Taxa Richness: 12 Direct measure of biodiversity. Healthy water ways often have scores of 20 or higher.	This taxa richness score indicates impaired biodiversity. It is not as poor as many eutrophied ponds and lakes in New Jersey. With time and more pollution control the ecological community could recover.
Hilsonoff Organic pollution index: 5.81	This HPI indicates substantial organic pollution likely. Organic pollution greatly elevates the nutrient levels and increases the susceptibility of the lake to algal blooms and cultural eutrophication.
No evident EPT referring to three important orders of pollution sensitive macroinvertebrates abundant in healthy aquatic systems, Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies).	Evening allowing for some loss of EPT organisms in recovering the Hester-Dendy samplers, the very high numbers of chromididae collected would likely leave this ratio to the well to the significant organic pollution range.

Pollution Sources of the Lake

Storm-runoff

Harry's brook drains some of Pinceton's storm sewers directly into Lake Carnegie. This carries oil from cars, feces from pets, and other discarded waste into the Lake. This is a potential source of the high fecal colliform bacteria levels in the lake that make it unsafe for swimming. It is also a source of excess organic carbon. These effects are currently under thorough evaluation by the a research group in the department of Environmental Engineering led by Bernice Rosenwig. Water Watch is collaborating with this research group to help inform our own studies and with the intent of assisting in further data collection.

Nutrient Pollution

Run-off also washes fertilizer off of lawns which finds its way into the Lake by draining over the land, over hard-surfaces, and through storm drains. This fertilizer is nutrient rich in nitrates and phosphates. While these nutrients are needed for growth, aquatic ecosystems need to maintain a careful balance that is disrupted by this external nutrient loading. The lack of free nutrients limits growth until organisms die, at which point the nutrients are released and reincorporated into new organisms. Excess nutrients allow for unbridled growth in which the faster growing species such as algae quickly take over. This process is called cultural eutrophication. Such algal 'blooms' in lakes are particularly dangerous as algal mats block sunlight to the lower levels of the lake and reduce atmospheric mixing of the water. In consequence dissolved oxygen plummets as submergent vegetation dies. The remaining aquatic life follows shortly thereafter.

Ecological Imbalance

Such ecological imbalance can occur from more than just nutrient pollution. A combination of factors has led the Canada geese to stop migrating and produced a similar over-abundance of a single population in the area. The geese produce large amounts of nitrogen rich waste (a pound per bird per day of fecal matter). This contributes significantly to the nutrient pollution. The high levels of nitrates we consistently detected last year is a telling sign the population of geese is more than the lake can handle. This may also be a source of fecal coliform.

Lack/Loss of Riparian Barriers

Natural lakes however have a common defense mechanism that helps protect against such storm-runoff, nutrient pollution and other threats such as erosion. This is in the riparian barriers, swaths of vegetation that line the shore. This vegetation binds the bank and prevents erosion that carries sediment and nutrient bound soil particles into the lake. The vegetation reduces bulk flow overland of runoff and filters nutrients out of the soil before they reach the lake. Riparian barriers also provide a more natural energy input source in the form of dead plant matter and provide shade for species that prefer to escape direct sunlight and stay in cool shallow water. Removal of these barriers to provide a clear park view of the lake greatly reduces the lakes ability to cope with the stresses of the heavy land use around it.

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Fall 2004 Lake Carnegie Benthic Macroinvetebrate Sampling Data

Taxa	Common Name	**Hilsenhoff FTV**	4 samplers November	3 samplers December	Total	Nov. Density (no./m^2)	Dec. Density (no./m^2)	Tot. Density (no./m^2)	**Family Biotic Index**	Food	Indicate
						Hester-Dendy sampler area:	0.061850104				
Class Insecta	Insects										
Order Diptera	true flies										
Family Ceratopognidae	no-see-ums	**6**	40	20	60	162	108	139	0.71	Detritus	
Family Chironominae	blood midges	**8**	12	3	15	49	16	35	0.24	Detritus	
Family Chironomidae	midges	**6**	174	42	216	703	226	499	2.56	Detritus	
Family Simuliidae	blackfly	**6**	1	0	1	4	0	2	0.01		
Order Odonata	Dragonflies & damselflies										
Family Gomphidae	club-tail dragonfly	**1**	1	0	1	4	0	2	0.00	Predator	
Class Hirundinea	leeches										
Order Helobdella	leeches	**6**	3	0	3	12	0	7	0.04		
Class Crustacea	Crustaceans										
Order Isopoda	pillbugs & sowbugs										
Family Asellidae	Aquatic sowbug	**8**	37	19	56	150	102	129	0.88	Detritus	
Order Amphipoda	shrimp										
Family Gammaridae	scud	**4**	73	52	125	295	280	289	0.99	Detritus	few fish
Class Gastropoda	snails										
Family Ancylidae	Limpet	**7**	5	4	9	20	22	21	0.12		
Family Planorbidae	round snails	**6**	5	5	10	20	27	23	0.12		
Family Physidae	left whirl	**7**	3	7	10	12	38	23	0.14		
Family Lymnaeidae	right whirl	**6**	0	1	1	0	5	2	0.01		
		Totals:	354	153	**507**	1431	825	1171	**5.81**		

Total Taxa: **12**

Hilsenhoff Index degree of Organic Pollution: **substantial organic pollution likely**