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2010 ONONDAGA LAKE LITTORAL MACROINVERTEBRATE MONITORING

Significant Findings and Data Summaries

PREPARED FOR:

ONONDAGA COUNTY
DEPARTMENT OF WATER ENVIRONMENT PROTECTION

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1.0 INTRODUCTION

Macroinvertebrate sampling is among the requirements of the Amended Consent Judgment signed in January 1998. Onondaga County is required to assess the macroinvertebrate communities of selected Onondaga Lake tributaries (Appendix D, III. 5 ".... *Sample the stream's macroinvertebrate communities and calculate the New York State Department of Environmental Conservation (NYSDEC) rapid Field Biotic Index throughout the tributaries' length....")* and the Lake (Appendix D, IV. 4 "*Complement the chemical monitoring program with a biological monitoring effort to assess the densities and species composition of phytoplankton, zooplankton, macrophytes, macrobenthos, and fish*"). Sampling in the tributaries is conducted every two years, and sampling in the lake's littoral zone is conducted every five years. Both sampling programs began in 2000. The objectives of monitoring this element of the aquatic ecosystem are to:

- Characterize the existence and severity of use impairment, and
- Evaluate the effectiveness of control actions [improvements to wastewater collection and treatment, both at Metro and the combined sewer overflows (CSOs)].

The design of the current program was finalized following a 1999 investigation to determine sampling locations and the number of replicates.

2.0 ENVIRONMENTAL AND REGULATORY BACKGROUND

Macroinvertebrates are an important component of the aquatic food web. Freshwater macroinvertebrate taxa include aquatic insects (Insecta), worms (Oligochaeta), snails (Gastropoda), clams (Bivalvia), leeches (Hirudinea), and crustaceans (Crustacea). These organisms provide the link in the food web between microscopic organisms and fish, and facilitate the transfer of energy and materials between the terrestrial and aquatic ecosystems.

There are important differences among groups of macroinvertebrates that influence the structure and function of a particular community. Difference in tolerance to environmental conditions is the basis for using these organisms as biological indicators of environmental quality. The biological community integrates the effects of different pollutant stressors and thus provides a holistic measure of their aggregate effect. Benthic macroinvertebrates are good indicators of localized conditions; their limited migration patterns and largely sessile existence make them well suited to assess site-specific impacts of point and nonpoint source discharges. Many state agencies, including NYSDEC, examine the structure and abundance of the macroinvertebrate community as an indication of long-term water quality and habitat conditions.

One important difference between groups of macroinvertebrates is their tolerance to organic (oxygen-demanding) wastes. Macroinvertebrates can be grouped into three broad categories: intolerant, moderately tolerant, and tolerant to this class of pollutant. The intolerant group includes species of mayflies, stoneflies, caddisflies, riffle beetles, and hellgrammites; the tolerant group includes worms, some midges, leeches, and some snails. The moderately tolerant group includes most snails, sowbugs, scuds, blackflies, craneflies, fingernail clams, dragonflies, and some midges (Welch 1980).

3.0. DESCRIPTION OF LAKE SAMPLING SITES

Five sampling sites within the lake's littoral zone were sampled during the 2010 monitoring effort. These sites were selected to reflect major sediment characteristics and proximity to point source discharges (Figure 1). The site locations were the same as those used in 2000 and 2005. Six replicate samples were taken at each of three depths (approximately 0.5 m, 1.0 m, and 1.5 m) at each site for a total of 18 samples per site.

3.1 Lake Site 1 – Maple Bay

Maple Bay is located in the northwest corner of the lake (43° 06' 25.62" N, 76° 14' 34.8" W). This area is characterized by generally soft, silty sediment and extensive macrophyte growth. The area is largely protected from predominant north/northwest winds and is typically the calmest area of the lake.

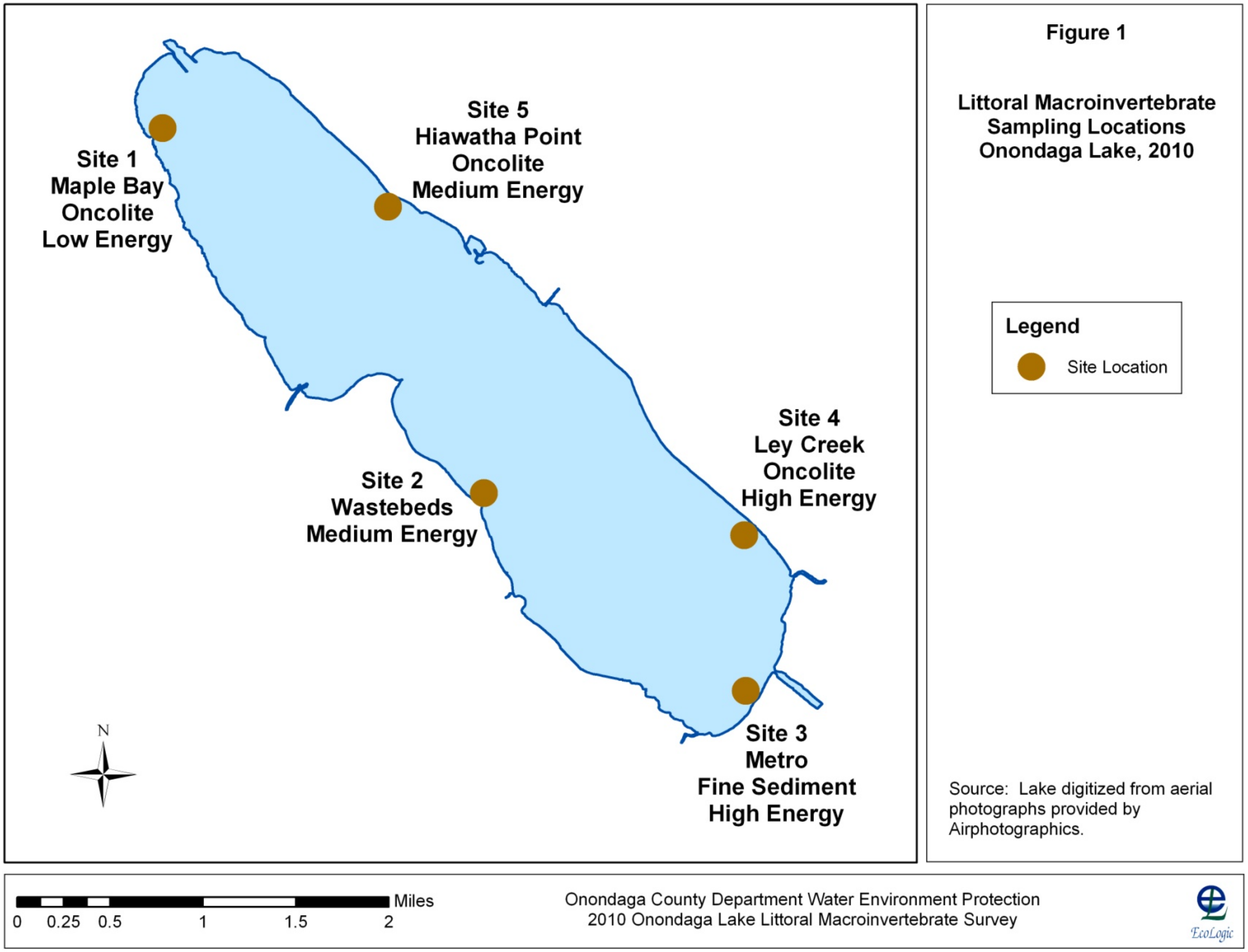

Figure 1

Littoral Macroinvertebrate Sampling Locations Onondaga Lake, 2010

Source: Lake digitized from aerial photographs provided by Airphotographics.

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2010 Onondaga Lake Littoral Macroinvertebrate Survey

3.2 Lake Site 2 – Wastebeds

This site is located along the wastebeds on the southwestern shore near Interstate 690 (45° 05’ 5.04” N, 76° 12’ 49.32” W). Littoral sediments are characterized by a calcium carbonate ($CaCO_3$) crust in near-shore areas and clay, sand, and silt in slightly deeper water. Some of the clays are bright blue, and it is not known if these are natural clays or of industrial origin. Periphyton is commonly found growing on the bottom crust layer.

3.3 Lake Site 3 – Metro

This site is located just west of the Metro Outfall 001 surface discharge at the southern end of the lake (45° 03’ 56.64” N, 76° 11’ 0” W). This section of the lake receives high wave energy because of the large fetch from the predominant north/northwest winds. Historically, high sediment loads from the Tully mud boils in the Onondaga Creek subwatershed were deposited in this area. Remedial efforts in the mid-1990’s resulted in a decrease in sediment loading to Onondaga Creek and, therefore, to the lake (USGS 1999). This area of the lake is shallow and the bottom substrate is composed mostly of fine sand and silt sediments.

3.4 Lake Site 4 – Ley Creek

This site is north of Ley Creek along the southeastern shoreline of Onondaga Lake (43° 04’ 40.14” N, 76° 10’ 53.82” W). The substrate consists of a combination of ovoid calcium carbonate concretions called oncolites, dreissenid (zebra and quagga) mussel shells, and sand mixed with old shell fragments.

3.5 Lake Site 5 – Hiawatha Point

This site is located on the east shore along Onondaga Lake Park at Hiawatha Point (43° 06’ 14.94” N, 76° 13’ 13.56” W). This area receives a moderate amount of wave energy (EcoLogic, 1999). Sediments are predominantly oncolites, dreissenid mussel shells, and sand.

4.0 METHODS

4.1 Protocols

The protocols for data collection, analysis, and interpretation used for this study are consistent with the 2009 New York State Department of Environmental Conservation Division of Water's *Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State* (NYSDEC 2009).

4.2 Sample Collection

Macroinvertebrate sampling was conducted at the five locations in Onondaga Lake on June 21, 2010. The field crew was composed of OCDWEP technicians and engineers. An environmental scientist from EcoLogic LLC was present during the first day of sampling for QA/QC purposes.

A total of 18 replicates per site were collected. Two boats were used; one to collect the samples and the second to sieve the samples. The same two technicians collected the samples to minimize potential bias. A calibrated rope was attached to the petite Ponar dredge to determine the depth of sample collection. The dredge was set, lowered into the water, and allowed to free-fall for approximately the last 0.5 m to the bottom. The impact with the bottom activated the closing mechanism. The dredge was then slowly brought to the surface and the sample was placed into a labeled stainless steel pail. The samples were retaken if the dredge was only partially filled with sediment. Possible causes of less than a full sample include non-vertical deployment, premature triggering of the closing mechanism, or an object stuck in the jaws of the grab sampler. If the sampling team observed material draining from the dredge, the sample was retaken. To the extent possible, comparable substrate was collected. The pails containing the samples were transferred to the wash boat for in-field processing.

The contents of each discrete sample replicate were placed into a U.S. Standard No. 30 mesh (0.590 mm opening) Nalgene™ sieve inside a washtub overhanging the side of the boat. The sample was gently washed with lake water provided via a small impeller pump, a bucket, or a wash bottle to remove small particles (clays and silts). The contents remaining in the sieve were transferred to labeled wide-mouth glass sample jars of various sizes depending on the amount of material. A 10% solution of formalin was added before storing the sample.

The field teams used a calibrated YSI instrument to measure and record water temperature (°C), conductivity (μS), dissolved oxygen (mg/L), and pH.

4.3 Laboratory Sorting

Prior to sorting, all samples that had initially been fixed with formalin were rinsed through a U.S. Standard No. 60 sieve with water, transferred back to their original sample bottle, and preserved with 75% ethyl alcohol containing Rose Bengal stain. Samples were washed through a U.S. Standard No. 40 sieve with tap water to remove any remaining fine sediments and excess Rose Bengal stain. The remaining material was transferred to a metal pan with a small amount of water and distributed evenly. A Plexiglas divider was placed in the tray to divide the tray into quarters. A single quarter was selected randomly and sorted under magnification. The first 100 organisms were removed from the debris as they were encountered; this was considered sort #1. If 100 organisms were not present in a single quarter, another quarter was selected and sorted. This procedure continued until either 100 organisms were removed or the entire sample had been sorted. The sorted organisms were sorted into major groups, placed in labeled vials containing 75% ethyl alcohol, and counted. Then the number of dreissenid mussels from sort #1 was determined and a number of non-dreissenid organisms equal to the number of dreissenid mussels from sort #1 was removed; this was considered sort #2. These organisms were sorted into major groups, placed in labeled vials containing 75% ethyl alcohol separate from sort #1. This sorting technique resulted in two samples of 100 organisms each; one with dreissenid mussels and one without. This approach was used to provide a means of evaluating the macroinvertebrate community without including dreissenid mussels, if the data suggested that the abundance of dreissenid mussels was inordinately influencing the analysis.

After sort #1 and #2 were completed, the remaining dreissenid mussels in the unfinished quarter were counted, but not removed. The number of quarters sampled and the total number of dreissenid mussels sorted and counted were recorded to calculate dreissenid mussel density in the sample.

4.4 Identification

All organisms were sent to Aquatic Resources Center (ARC) of Nashville, Tennessee, for identification. All organisms were identified to the lowest possible taxonomic level. Generally, chironomids and oligochaetes needed to be cleared, slide-mounted, and viewed through a compound microscope for proper identification. Most other organisms could be identified using a dissecting stereomicroscope. The number of individuals of each species from each sample were recorded on laboratory data sheets and entered into an Excel spreadsheet. All individuals not permanently mounted on slides were returned to their original major group vial. Vials were labeled with the identifications and numbers of individuals for each taxon. Identified organisms were returned to Onondaga County for an archived reference collection.

NYSDEC protocols require that a 100-organism subsample be used for benthic invertebrate sampling. To ensure that 100 organisms are removed from each sample, it is often necessary to sort slightly more than 100 organisms due to possible fragments or unidentifiable pieces of organisms, particularly oligochaetes. When samples with >100 individuals were encountered, subsampling for identification purposes was done based on the following criteria.

All individuals in each major taxonomic group (e.g., Oligochaeta, Chironomidae, Amphipoda, Ephemeroptera, and Trichoptera) were identified. For those groups with ≤25 individuals, actual numeric enumerations were recorded for each taxon identified. If there were >25 individuals in a group, a percentage of that group was used which would make the final total number of organisms equal 100.

Example 1. If there were 15 amphipods, 10 isopods, 8 plecopterans and 96 oligochaetes listed on the laboratory bench sheet, then enumerations for all taxa in each of the first three groups were used (=33), and the number of individuals for each oligochaete taxon was multiplied by the ratio 67/96 (or 0.698), thus making the final total number 100 (Table 1).

Example 2. If there were 15 amphipods, 10 isopods, 8 plecopterans, 50 oligochaetes and 30 chironomids listed on the sort sheet, then enumerations for all taxa in each of the first three groups were used (=33), and percentages based on their relative abundances representing the oligochaetes and chironomids were identified [in this case, 50 (oligochaetes) ÷ 80 (oligochaetes + chironomids) x 67 (number to be identified to make 100 total) = 42 oligochaetes to be identified and 25 chironomids (30 ÷ 80 x 67)]. The ratio applied to each oligochaete taxon enumeration would then be the number to be identified (42) over the total number in the sample (50) (Table 2). For chironomid larvae enumerations it would be 25/30.

Table 1. Count and calculations (example 1).

Taxon	Count	Multiplier ratio (if appropriate)	Adjusted count
Crangonyx	8		8
Gammarus	7		7
Caecidotea	10		10
Agnetina	8		8
Enchytraeidae	10	0.698	7
Limnodrilus	75	0.698	52
Tubifex	11	0.698	8
Total number of individuals reported			**100**

Table 2. Count and calculations (example 2).

Taxon	Count	Multiplier ratio (if appropriate)	Adjusted count
Crangonyx	8		8
Gammarus	7		7
Caecidotea	10		10
Agnetina	8		8
Enchytraeidae	10	42/50 = 0.84	8
Limnodrilus	25	0.84	21
Tubifex	15	0.84	13
Chironomus	20	25/30 = 0.83	17
Nanocladius	10	0.83	8
Total number of individuals reported			**100**

The following method was used to calculate the number of organisms to be identified from the sort #2 subsamples. This method follows those described above.

Example 3. The total number of organisms is calculated by summing the number of organisms from the sort #1 subsample (minus the number of dreissenid mussels) plus the number of organisms from sort #2. All individuals in a major group (e.g., Oligochaeta, Chironomidae, and Amphipoda) were identified if that group contained ≤25 individuals. If there are >25 individuals in a group, a percentage of that group was used which would make the final total number of organisms equal 100. For the sample in Table 3, all the individuals of Chironomidae were identified and percentages based on their relative abundances representing the oligochaetes and amphipods were identified [in this case, 36 oligochaetes (7 from Sort 1 and 29 from Sort 2) and 47 amphipods (24 from sort #1 and 23 from sort #2)].

Table 3. Count and calculations (example 3).

Taxon	Sort 1	Sort 2	Sort 1+2	Identified 1+2
Chironomidae	4	13	17	17
Oligochaeta	7	38	45	36
Amphipoda	24	36	60	47
Total number of individuals			**122**	**100**

Sample replicates that did not produce the requisite 100 organisms after the entire sample was sorted were treated in the following manner. If the total number of organisms within a sample was 90 or more, data from the sample were used to calculate the various metrics as described in Section 5.0 below. Replicates with less than 90 organisms were excluded from the data set used to calculate metrics since the number of organisms in these samples fell well short of what the NYSDEC protocols require and inordinately low numbers of organisms in relatively few samples could skew the overall results. Data from all samples, regardless of total numbers of organisms found were included in calculation of dreissenid mussel densities.

5.0 ANALYSIS

Biological monitoring programs using benthic macroinvertebrates to assess water quality often rely on several different indices of community composition to evaluate the ecological status of the sampled community (Novak and Bode 1992). The Onondaga County macroinvertebrate monitoring program uses NYSDEC Biological Assessment Profiles (BAP) as the primary measure of the macroinvertebrate community for the littoral community. Criteria developed for samples collected in soft sediments in rivers and lakes using a petite Ponar grab were used for this analysis.

5.1 Biological Assessment Profile (BAP)

Sites were compared using NYSDEC Biological Assessment Profiles (BAP). An overall assessment of water quality for each site is calculated by averaging results of five individual metrics obtained through a scaled ranking of the metric values. The metric values are converted to a common scale of water quality ranging from 0-10, with 0 being the most severely impacted and 10 completely non-impacted. After all metric values for a site were converted to a common scale, they were averaged to obtain a score denoting an overall assessment of water quality (the BAP).

The score results in a designation of one of four categories: *non-impacted*, *slightly impacted*, *moderately impacted*, or *severely impacted*. Lake assessments were calculated for petite Ponar samples by using a combined index incorporating species richness, diversity, Hilsenhoff Biotic Index (HBI), dominance-3, and percent model affinity (PMA). The reader is directed to the 2009 NYSDEC *Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State* (NYSDEC 2009) for more detailed information.

5.2 HBI Score

The Hilsenhoff Biotic Index (HBI) is a reliable and widely used measure of water-quality status based on macroinvertebrate community composition (Novak and Bode 1992). HBI is based on the tolerance of individual taxa to low dissolved oxygen concentration, a condition often associated with elevated loading of organic (oxygen-demanding) waste. Taxa are assigned tolerance values ranging from zero to ten, where zero and ten represent the extremes for intolerance and tolerance respectively (Hilsenhoff 1987). HBI not only includes the numbers of species and the distribution of individuals among species, but weighs abundance of each species according to its known ability to tolerate adverse water quality conditions, particularly organic inputs. High HBI values are typically associated with adverse impacts of organic pollution. Low HBI values indicate that the macroinvertebrate community is not affected by organic pollution. Because this relationship is the opposite of the NYSDEC BAP assessments (high values indicate no impact), the HBI values reported herein have been scaled to the NYSDEC BAP score. This essentially inverts the HBI scale so that high values indicate less impact.

Because this index directly tests for the impacts of organic enrichment, it is tracked independently and as part of the BAP.

5.3 Percent Oligochaetes

The change in percent contribution of oligochaetes was also used as an index of change in the macroinvertebrate community over time. Oligochaetes can often thrive in areas where other invertebrates may not because of factors such as competition, soft substrate, organic enrichment, or low oxygen conditions. As oligochaetes are often found in high relative abundance in areas impaired by organic enrichment, their percent contribution to the community can be a good measure of this stressor. More importantly, the change in the percent contribution of oligochaetes over time, as well as the species composition, can be an effective measure of the change in organic enrichment at the study sites.

6.0 RESULTS

As noted previously, samples were sorted in such a way that they could be analyzed by including or excluding dreissenid mussels in the 100-organism subsamples. Analysis of samples both including and excluding dreissenid mussels was performed in 2005. This analysis found that the two primary metrics of interest, the NYSDEC BAP and HBI scores, were not significantly affected by inclusion of dreissenid mussels in the analysis. Given this result and the reduced densities of dreissenid mussels in 2010 (see Section 6.2.5) compared to 2005, the 2010 analysis used the data that included dreissenid mussels in the sorts.

6.1 2010 Results

The macroinvertebrate community of the littoral zone of Onondaga Lake in 2010 was characterized as *slightly* to *severely impacted* based on NYSDEC criteria, with mean BAP scores ranging from 2.3 to 6.2 (on a scale of 0 to 10) (Table 4). Three of the five sites (2, 4, and 5) were categorized as *slightly impacted* (Table 4, Figure 2A). The site at the NW corner of the lake (Maple Bay) was *moderately impacted*, and site in the south end of the lake (Metro) was *severely impacted* based upon NYSDEC BAP calculations. BAP scores did not reflect a spatial gradient, but the least impacted sites were found along the eastern shore. The HBI scores reflected the same level of impact as the NYSDEC BAP scores for all five stations (Figure 2B). The three sites categorized as *slightly impacted* had more balanced macroinvertebrate communities than the other two stations, with the dominant taxonomic group representing less than 40% of the overall community (Figure 2C). Stations 1, 2, and 4 had a relatively low percentage (30% or less) of the community represented by oligochaetes (Figure 2D). Site 3 had 90% of its community represented by oligochaetes, contributing considerably to the *severely impacted* assessment of this site.

Table 4. Mean index value and corresponding NYSDEC water quality value from petite Ponar samples (with dreissenid mussels included in the sample) for sites in Onondaga Lake in 2010.

Index	**Site 1 Maple Bay**		**Site 2 Wastebeds**		**Site 3 Metro**		**Site 4 Ley Creek**		**Site 5 Hiawatha Point**	
	Index Mean	*NYSDEC WQ Scale Mean*	*Index Mean*	*NYSDEC WQ Scale Mean*	*Index Mean*	*NYSDEC WQ Scale Mean*	*Index Mean*	*NYSDEC WQ Scale Mean*	*Index Mean*	*NYSDEC WQ Scale Mean*
Richness	13.6	4.41	11.7	3.48	9.94	2.44	12.6	3.91	14.9	5.22
Diversity	2.45	4.56	2.65	5.78	2.26	3.81	2.86	6.65	3.02	7.29
Dominance-3	0.722	5.40	0.702	5.77	0.805	4.08	0.641	6.82	0.608	7.37
PMA	45.0	3.04	59.1	5.82	28.4	0.433	59.6	5.92	57.4	5.49
HBI	8.12	4.71	7.27	6.82	9.70	0.744	7.52	6.20	7.80	5.51
NYSDEC Mean Water Quality Value	**4.4**		**5.5**		**2.3**		**5.9**		**6.2**	
Level of Impact	**Moderate**		**Slight**		**Severe**		**Slight**		**Slight**	

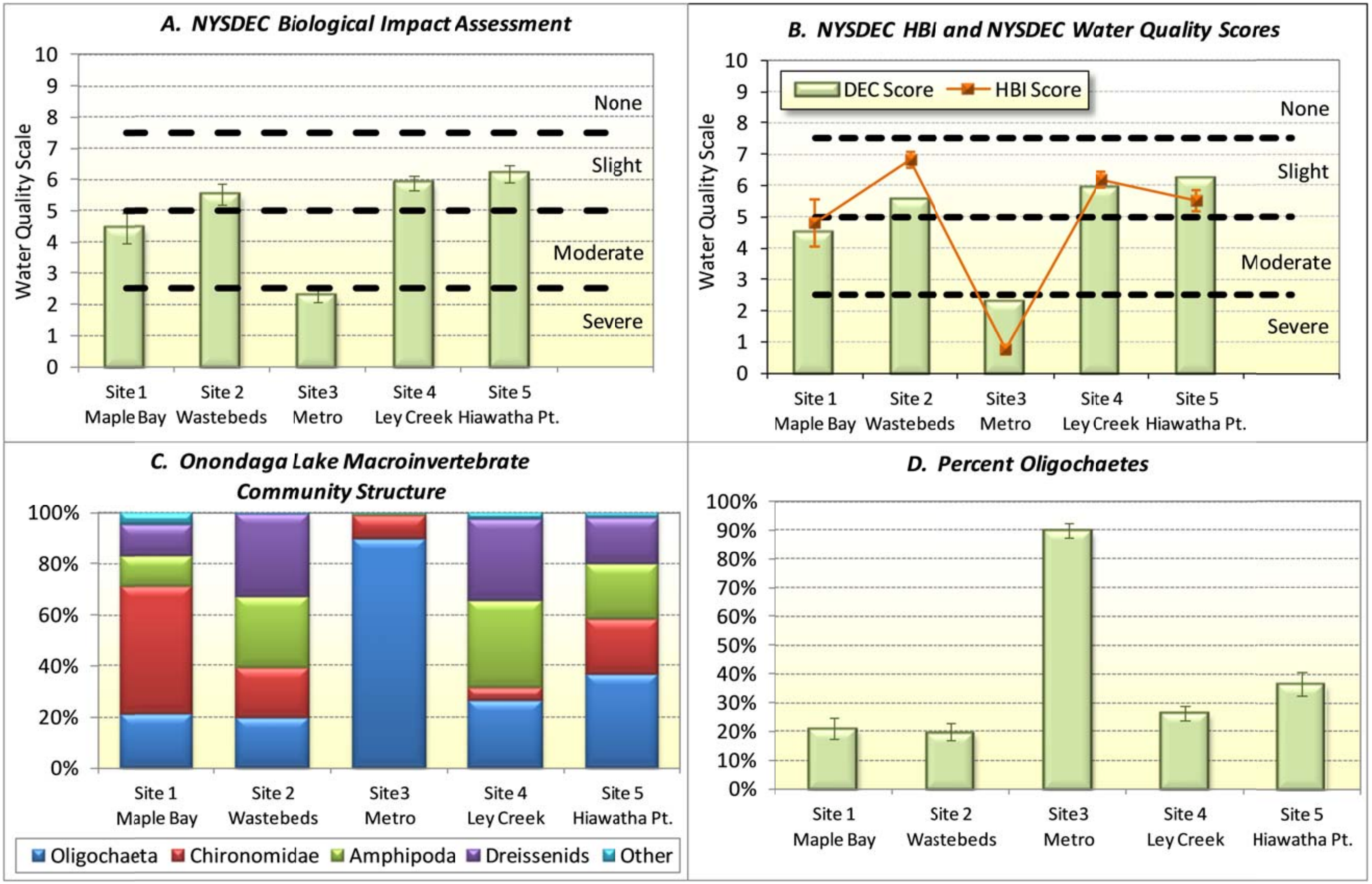

Figure 2. Macroinvertebrate community measures for the five sites sampled on Onondaga Lake in 2010. Error bars represent standard error. Dreissenid mussels include both quagga (*Dreissena bugensis*) and zebra (*D. polymorpha*) mussels.

6.2 Comparison of the 2010 Macroinvertebrate Communities to 2005 and 2000

6.2.1 NYSDEC Biological Assessment Profiles

The 2010 NYSDEC BAP for sites in Onondaga Lake showed varying degrees of change from the 2005 assessment, with the impact characterizations changing from *moderately impacted* to *slightly impacted* for two (sites 2 and 4) of the five sites (Figure 3A). In addition, the score for site 5 changed from being on the border between *moderately* and *slightly impacted* in 2005 to being well within the *slightly impacted* category in 2010. The BAP score for site 3 (Metro) improved considerably from previous scores and fell just below the demarcation between *severely impacted* and *moderately impacted*. All sites have shown improvement in BAP score since 2000.

6.2.2 Hilsenhoff Biotic Index NYSDEC Scores

Trends in HBI scores since 2000 have shown varying levels of improvement at sites 2 through 5 and no consistent trend at Site 1 (Figure 3B). Scores at sites 4 and 5 improved from *moderately impacted* in 2005 to *slightly impacted* in 2010. The HBI scores for Site 3 (Metro) have improved consistently since 2000, but these improvements have been small and have not resulted in improvement in the overall assessment of this site. Site 1 (Maple Bay) had an HBI score in the *slightly impacted* range in 2000, but the score declined into the *moderately impacted* range in 2005 and, though improving some, remained there in 2010. The HBI scores for all sites in 2010 improved from those in 2005, suggesting that organic enrichment at these locations has declined and oxygen levels in the shallow-water sediments have improved. These improvements were most evident at Site 2 (Wastebeds) and Site 4 (Ley Creek).

6.2.3 Community Structure

All sites have shown a considerable shift in community composition since 2000, with the exception of Site 3 (Metro) (Figure 3C). The greatest change at Site 1 (Maple Bay) has been a

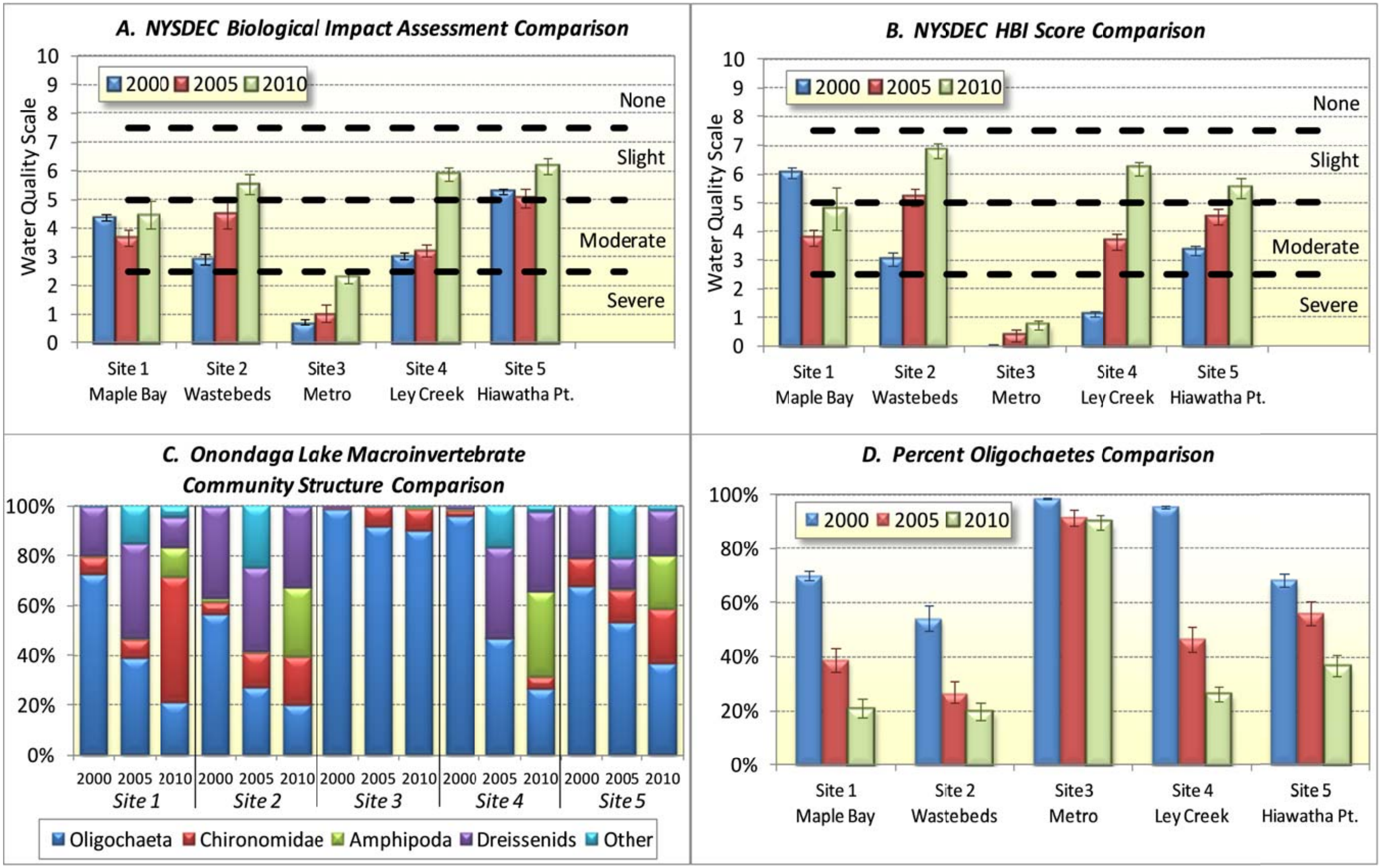

Figure 3. Macroinvertebrate community measures for the five sites sampled on Onondaga Lake in 2000, 2005, and 2010. Error bars represent standard error. Dreissenid mussels include both quagga (*Dreissena bugensis*) and zebra (*D. polymorpha*) mussels.

large increase in the relative abundance of Chironomidae, which comprised the largest component of the community in 2010. Prior to 2010, oligochaetes were the dominant taxon at Site 1. Site 2 has seen a notable increase in the relative abundance of amphipods since 2000, which were the second most abundant taxon in 2010 at this location. Dreissenid mussels replaced oligochaetes as the dominant taxon at Site 2 in 2005 and remained so in 2010. Oligochaetes have consistently dominated the community at Site 3 (Metro), comprising at least 90% of the community in 2000, 2005, and 2010. Site 4 (Ley Creek) has shown a shift from a community comprised nearly entirely of oligochaetes in 2000 to one in which oligochaetes, dreissenid mussels, and amphipods are co-dominant. Site 5 (Hiawatha Point) also has shown considerable change, with amphipods becoming moderately abundant in 2005 and remaining so in 2010 and oligochaetes declining about 15% between each sampling event.

Amphipods comprised less than 2% of the community at any site in 2000 and 2005, but were relatively abundant (>10% of the community) at sites 1, 2, 4, and 5 in 2010. The increase in relative abundance of amphipods since 2005 could be related to the substantial increase in macrophyte coverage in the lake since that time.

6.2.4 Percent Oligochaetes

The percent of oligochaetes in samples has declined consistently from 2000 to 2010 at sites 1, 2, 4, and 5, with the most dramatic improvement at Site 4 (Ley Creek) (Figure 3D). The magnitude of declines in percent of oligochaetes at these sites since 2000 ranged from 31% at Site 5 to 69% at Site 4. The percent of oligochaetes at Site 3 declined from 99% in 2000 to 95% in 2005, but declined only another 1% in 2010. The declines in oligochaete relative abundance reflect the increasing diversification of the macroinvertebrate communities throughout much of the lake (excluding the south end). This is likely a result of improvements to overall water quality (e.g., reduced nitrogen levels), improving dissolved oxygen conditions in littoral sediments, and increases in macrophyte abundance and coverage.

6.2.5 Dreissenid Mussel Density

Dreissenid mussel density declined from 2005 to 2010 at all five sampling sites (Figure 4). The greatest decline occurred at Site 1 (Maple Bay), where density dropped by over 4,000 mussels/m^2. The fewest dreissenids were found at Site 3 (Metro), where no mussels were collected in 2010. Mussel densities were the lowest recorded at sites 1, 2, and 3 since sampling began in 2000. Densities at sites 4 and 5 were lower than in 2005, but not lower than in 2000. The decline in dreissenid mussel density at all sites from 2005 to 2010 suggests a real decline in the abundance of dreissenids lake-wide. However, dreissenids readily colonize aquatic macrophytes, so part of the decline seen in benthic petite Ponar samples may be due to a shift in habitat use by dreissenids to increasingly abundant macrophyte substrate.

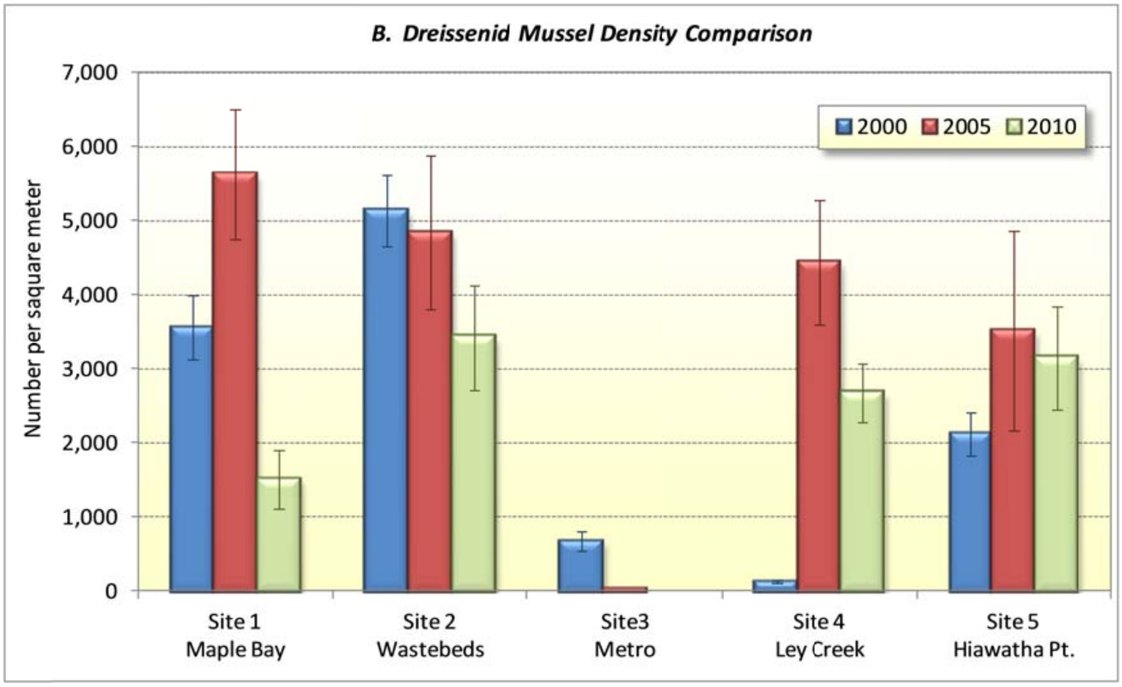

Figure 4. Densities of dreissenid mussels at the five sites sampled on Onondaga Lake in 2000, 2005, and 2010. Error bars represent standard error. Dreissenid mussels include both quagga (*Dreissena bugensis*) and zebra (*D. polymorpha*) mussels.

6.2.6 Incidence of Chironomid Deformities

Chironomidae (non-biting midges) is a family of flies with aquatic larvae that are widespread and tolerant of a wide range of environmental perturbation. The incidence and frequency of deformities (a departure in the morphology of a structure from normal appearance in size, shape, or structure as a result of exposure to a toxic pollutant) in mouth parts and antennae of some taxa of Chironomidae have been used as a means of biomonitoring sediment toxicity (e.g., elevated levels of metals) and organic loading in freshwaters (Lenat 1993; Hudson and Ciborowski 1996; Diggins and Stewart 1998; Bisthoven and Gerhardt 2005). Chironomidae in samples taken as part of the 2010 Onondaga Lake littoral macroinvertebrate monitoring program were examined for incidences of deformities as a secondary means of assessing water and sediment quality at the sampling locations.

Populations of sensitive taxa (*Chironomus* and *Procladius*) at "clean" reference sites have been found to contain around 3% deformities. For a doubling of deformity incidence over 3% background levels to be considered significant, a sample size of 125 from each site would be required (Hudson and Ciborowski 1996). The maximum number of Chironomidae found in any of the 2010 lake samples with deformed Chironomidae was 98 (Site 1, Maple Bay), and the majority of samples with deformed Chironomidae had fewer than 50 total Chironomidae. Thus, sample size was too small to make definitive conclusions regarding the level of environmental impact based on the incidence of Chironomidae deformities; however, the preliminary findings of this analysis are present here.

The mean percent of chironomids with deformities was low at all sites in Onondaga Lake, ranging from 0.0% at Site 4 (Ley Creek) to 4.1% at Site 5 (Hiawatha Point) (Table 5). There was no spatial gradient to incidence of deformities in the lake, though the two stations with the highest incidence were located in the lake's northern basin. Lenat (1993) used just 15-25 specimens of *Chironomus* per site to compare sites in North Carolina streams and found clean water sites averaged about 5% deformities, moderately impaired sites averaged 24%, and severely impaired sites averaged 44%. Only six of the 90 (7%) samples collected from the lake in 2010 had overall deformity levels greater than 10%, and all of these had low numbers of individuals. Larger samples had deformity levels near background levels (3-5%). Based on this, the range of chironomid deformities found in Onondaga Lake is indicative of non-impacted conditions with regard to sediment toxicity. Again, it should be understood that the results of the chironomid deformities analysis presented here are based on small sample sizes that are statistically insufficient to allow for making definitive assessments of water quality or sediment toxicity at the sites sampled. These data are presented herein as a preliminary analysis only.

Table 5. Incidence of deformities in Chironomidae at Onondaga Lake littoral macroinvertebrate sampling sites in 2010.

Sampling Location	Mean % Deformities
Site 1, Maple Bay	3.5
Site 2, Wastebeds	1.2
Site 3, Metro	2.8
Site 4, Ley Creek	0.0
Site 5, Hiawatha Point	4.1

7.0 CONCLUSIONS

The macroinvertebrate community of the littoral zone has shown considerable improvement since 2000. This improvement is most pronounced at those stations (Site 3 – Metro, and Site 4 – Ley Creek) that were in the poorest condition in 2000. Although the community at Site 3 was still categorized as *severely impacted* in 2010, it has improved steadily since 2000 and is approaching a *moderately impacted* condition. Three (Sites 2, 4, and 5) of the five sites are now categorized as *slightly impacted*. Changes in macroinvertebrate community composition are evident throughout much of the lake in the form of higher species richness and diversity, which have resulted in improved scores for BAP, HBI, and PMA metrics. These changes are likely a response to improvements in water quality, decreased organic loading, improved dissolved oxygen conditions in littoral sediments, and increases in macrophyte abundance and coverage.

Despite the noted improvements, the littoral macroinvertebrate community of Onondaga Lake still exhibits signs of stress, especially at the south end. This is the area of the lake that was the most impaired and will take the longest time to recover from decades of impacts from municipal and industrial influences. Full recovery at the south end of the lake may take many years, and the diversity and richness of the macroinvertebrate community at this location may never equal that seen in other areas of the lake due to the poorer habitat quality of the predominantly fine sediments at the south end of the lake.

The improving trends in littoral macroinvertebrate community metrics since 2000 should continue as the lake responds to improvements in wastewater collection and treatment, both at Metro and the combined sewer overflows, and other remediation efforts occurring within the lake and surrounding watershed. The ongoing expansion and diversification of the aquatic macrophyte community throughout the lake littoral zone will also contribute to changes and likely improvements to the littoral macroinvertebrate community.

8.0 RECOMMENDATIONS

1) The County should examine the five littoral sampling sites with respect to the planned remedial dredging program prior to completing the next survey. Some adjustment in location to comparable areas of sediment texture and tributary influence may be needed.

2) Dreissenid mussels are a potentially significant forcing variable for the macroinvertebrate community. Obtaining density estimates is important to determine if any future changes to the macroinvertebrate community are related to changes in dreissenid mussel densities. Processing of samples to allow for calculation of metrics with and without dreissenid mussels should continue.

9.0 LITERATURE CITED

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APPENDIX A

ONONDAGA LAKE LITTORAL MACROINVERTEBRATE TAXA LIST (2000-2010)

Taxonomic List of Littoral Macroinvertebrates Collected from Onondaga Lake, 2000-2010.

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2005	2010
Annelida	Clitellata	Haplotaxida	Enchytraeidae		Enchytraeidae		x	x
					Lumbricillus	x		
			Naididae		*Chaetogaster diaphanus*	x		
					Dero digitata	x	x	x
					Nais			x
					Nais barbata	x		
					Nais bretscheri	x	x	
					Nais communis/variabilis	x		
					Nais elinguis	x		
					Nais pardalis	x	x	
					Nais simplex	x		
					Nais variabilis	x	x	x
					Ophidonais serpentina	x		
					Paranais frici	x		
					Specaria josinae		x	
					Stylaria lacustris	x	x	x
					Vejdovskyella intermedia	x	x	
			Tubificidae		*Aulodrilus pigueti*	x	x	x
					Ilyodrilus templetoni	x	x	x
					Limnodrilus cervix	x	x	x
					Limnodrilus hoffmeisteri	x	x	x
					Limnodrilus profundicola	x		
					Limnodrilus udekemianus		x	x
					Potamothix bavaricus		x	x
					Potamothrix bavaricus	x		
					Potamothrix bedoti	x		x
					Potamothrix moldaviensis	x	x	x
					Tubifex tubifex	x	x	x
					Tubificid immature: bifid	x		
					Tubificid immature: bifid chaetae	x		
					Tubificid immature: hair + pectinate	x		
					Tubificidae (newly hatched)	x		
					Tubificinae: bifid chaetae		x	x
					Tubificinae: hair + pectinate chaetae		x	x

Taxonomic List of Littoral Macroinvertebrates Collected from Onondaga Lake, 2000-2010.

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2005	2010
Annelida (cont.)	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphoniinae	*Placobdella papillifera*			x
Arthropoda	Arachnida	Acariformes	Hydrachnidae		*Hydrachnida*	x		
			Limnesiidae		*Limnesia*	x		
			Unionicolidae		*Koenikea*	x		
					Neumania	x		
					Unionicola	x		
	Crustacea	Amphipoda	Gammaridae		*Gammaridae*	x		
					Gammarus	x	x	x
					Gammarus fasciatus	x	x	x
					Gammarus pseudolimnaeus	x		
					Amphipoda	x		
		Isopoda	Asellidae		*Caecidotea*	x	x	x
					Caecidotea racovitzai		x	x
	Insecta	Diptera	Chironomidae	Chironominae	*Chironomidae pupae*	x		
					Chironomini			x
					Chironomus	x	x	x
					Chironomus sp.	x		
					Cladopelma	x	x	x
					Cladotanytarsus	x	x	
					Cladotanytarsus sp.	x		x
					Cryptochironomus		x	
					Cryptochironomus sp.	x		x
					Cryptotendipes	x	x	
					Demicryptochironmus		x	
					Dicrotendipes		x	x
					Dicrotendipes modestus	x	x	x
					Dicrotendipes neomodestus	x		x
					Dicrotendipes nervosus	x		
					Dicrotendipes sp.	x		
					Endochironomus	x	x	
					Endochironomus sp.	x		x
					Glyptotendipes	x	x	
					Parachironomus		x	
					Parachironomus cf. monochromus	x		

Taxonomic List of Littoral Macroinvertebrates Collected from Onondaga Lake, 2000-2010.

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2005	2010
Arthropoda (cont.)	Insecta (cont.)	Diptera (cont.)	Chironomidae (cont.)	Chironominae (cont.)	*Parachironomus monochromus*			x
					Parachironomus sp.	x		
					Paratanytarsus sp.	x	x	x
					Paratendipes			x
					Phaenopsectra		x	
					Polypedilum	x	x	x
					Polypedilum halterale			x
					Polypedilum halterale gp.		x	
					Polypedilum scalaenum			x
					Pseudochironomus sp.	x		x
					Tanytarsus	x	x	
					Tanytarsus sp.	x		x
					Tribelos			x
					Unknown Chironomini	x		
				Orthocladiinae	*Corynoneura*	x		
					Cricotopus		x	
					Cricotopus (Isocladius)	x		x
					Cricotopus (Isocladius) cf. intersectus	x		
					Cricotopus (Isocladius) sylvestris grp.	x		
					Cricotopus bicinctus		x	x
					Cricotopus reversus grp.			x
					Cricotopus sp.	x		
					Cricotopus sylvestris gp.		x	x
					Cricotopus trifascia	x		
					Cricotopus vierriensis			x
					Cricotopus/Orthocladius	x		
					Psectrocladius		x	x
					Psectrocladius psilopterus gp.		x	
					Psectrocladius sp.	x		
					Psectrocladius vernalis		x	
					Thienemanniella			x
					Thienemanniella lobapodema			x
				Tanypodinae	*Ablabesmyia*			x

Taxonomic List of Littoral Macroinvertebrates Collected from Onondaga Lake, 2000-2010.

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2005	2010
Arthropoda (cont.)	Insecta (cont.)	Diptera (cont.)	Chironomidae (cont.)	Tanypodinae (cont.)	*Ablabesmyia mallochi*	x		x
					Procladius		x	
					Procladius (H)			x
					Procladius (Holotanypus)	x		
					Procladius (Psilotanypus) bellus			x
					Tanypus			x
					Nanocladius		x	x
					Nanocladius alternantherae		x	x
					Nanocladius cf. rectinervis	x		
					Nanocladius crassicornis/rectinervis		x	
					Nanocladius distinctus/minimus		x	
					Orthocladiinae		x	
			Psychodidae		*Pericoma*	x		
		Ephemeroptera	Baetidae		*Baetidae*	x		
		Lepidoptera	Pyralidae		*Acentria*	x	x	x
		Trichoptera	Hydroptilidae		*Hydroptila*			x
					Hydroptilidae	x		
	Malacostraca	Amphipoda	Hyalellidae		*Hyalella azteca*			x
	Ostracoda	Podocopida			*Podocopida*	x		
Cnidaria	Hydrozoa	Anthoathecatae	Hydridae		*Hydra*	x		
Mollusca	Bivalvia	Veneroida	Dreissenidae		*Dreissena bugensis*			x
					Dreissena polymorpha	x	x	x
			Pisidiidae		*Pisidium*		x	
	Gastropoda	Basommatophora	Physidae		*Physa*	x		
					Physa/Physella		x	
			Planorbidae		*Gyraulus*		x	
					Planorbidae		x	
		Heterostropha	Valvatidae		*Valvata*		x	
					Valvata piscinalis		x	
					Valvatidae		x	
		Neotaenioglossa	Hydrobiidae		*Amnicola (Lyogyrus)*		x	
Nemata					*Nematoda*	x	x	x
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae		*Girardia*			x