Strategic Monitoring of Mercury in New York State Fish

Final Report 08-11
April 2008

New York State
Energy Research and
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Strategic Monitoring of Mercury in New York State Fish

Final Report

Prepared for the

New York State Energy Research and Development Authority

Albany, NY
www.nyserda.org

Mark Watson
Program Manager

Prepared by:

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Howard Simonin
Jeff Loukmas
Larry Skinner

Division of Fish, Wildlife and Marine Resources

and

Karen Roy

Adirondack Long Term Monitoring Program
Division of Air Resources

NYSERDA
Report 08-11

NYSERDA 7612

April 2008

NOTICE

ABSTRACT

The prevalence of high mercury levels in fish is an important environmental and human health concern. Previous monitoring of fish mercury concentrations in New York identified the Catskill and Adirondack Parks as the principal problem areas in the State. However, fish from only about 4% of New York's 4,000 lakes, ponds, and reservoirs had been analyzed thus substantial monitoring gaps remained. Atmospheric deposition is now recognized as the primary source of mercury to most of the State, and recent legislation has led to national and regional decreases in mercury emissions. In order to further our understanding of spatial and temporal patterns of mercury concentrations in fish, we examined 131 lakes from throughout New York State over a four-year period beginning in 2003. Our study focused on largemouth and smallmouth bass, walleye and yellow perch, piscivorous fish shown to accumulate high mercury concentrations, and species important to local fisheries. The data showed that fish from most Adirondack and Catskill Forest Preserve lakes have higher mercury concentrations than fish from other regions of the State. Standard size (229 mm, 9 in.) yellow perch from Adirondack and Catskill lakes had a median mercury concentration of 382 ng/g, and perch from lakes outside of these parks had a median concentration of 162 ng/g. Water chemistry parameters and watershed wetland area measurements were taken to assess potential relationships with mercury contamination in fish. Variability in fish mercury concentrations between nearby individual lakes may be significant due to differences in water chemistry, lake productivity, presence or absence of a dam on the outlet, and the abundance of wetlands in the watershed. Fish length, lake pH, specific conductivity, and lake water mercury concentration were significantly correlated with mercury in fish. Simple models were developed and refined to predict mercury concentrations in our four target fish species. Data from 12 Adirondack lakes were used to evaluate mercury trends in fish over time, and indicated an average decline of 16% in yellow perch mercury concentration over the past 15 years. Data collected for the project have been used by the New York State Department of Health to issue new fish consumption advisories on numerous lakes. Project data were also the impetus behind new region-wide advice for the Adirondack and Catskill Parks.

KEY WORDS

Mercury, Fish, Consumption Advisories, Trends, Water Chemistry, Bioaccumulation, Adirondack Mountains, Catskill Mountains

ACKNOWLEDGMENTS

We thank the New York State Energy Research and Development Authority for substantial funding for this project. We also thank Erik Latremore, Dustin Edwards, Chris Swamp, Neal Liddle, and Tom Pope, who contributed long hours to the project. The New York State Department of Environmental Conservation (NYSDEC) regional fisheries staffs assisted with some fish collections, and personnel from the Adirondack Lakes Survey Corporation (ALSC) conducted Adirondack field collections and analyzed all water samples. ALSC staff included Susan Capone, Phil Snyder, Sara Burke, Theresa Cleary, Paul Casson, Christopher Buerkett, Jeff Brown, Pam Hyde, Monica Schmidt , Dale Bath, James Pinheiro, Ryan Coulter, Tony Laflamme, and Chris Swamp. Anthony Gudlewski and others at the NYSDEC Hale Creek Field Station assisted in the processing of fish samples.

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EXECUTIVE SUMMARY

Mercury has been recognized as an environmental pollutant for many years. It is a potent neurotoxin and has been shown to affect humans, fish, and wildlife. Mercury is a naturally-occurring element and is also a commercially important chemical. It has been used in thermostats, thermometers, barometers, gas regulators, medical devices, batteries, paint, pesticides, fluorescent lights, dental fillings and various other consumer products. Since mercury is a liquid metal at room temperature, it is uniquely useful in many industrial applications. Consequently, mercury has been widely used. It has been found throughout the environment and in watersheds distant from point sources.

After the discovery of high mercury concentrations in fish during the late 1960s, legislation was passed to address mercury in the aquatic environment. The Clean Water Act of 1970 required reductions of mercury from industrial effluents, which consequently led to lower mercury concentrations in many rivers and lakes. The New York State Department of Environmental Conservation (NYSDEC) began monitoring mercury concentrations in fish in the late 1960s and documented declines in mercury levels subsequent to implementing these water pollution controls. Monitoring of contaminants in fish has continued since that time, including a Statewide Toxic Substances Monitoring Program that ran from 1976 until 1993. More recently, the monitoring of fish for mercury analysis occurs primarily for research purposes or is related to specific projects. Continued monitoring is necessary to document changes over time and evaluate lakes and ponds that have never been tested.

Although the removal of mercury from most effluents and industrial discharges has helped to reduce mercury concentrations in fish and wildlife, mercury continues to enter ecosystems from atmospheric deposition. Mercury, in gaseous form or bound to particles, is released when coal and municipal waste are burned and when medical waste is incinerated. This mercury is then added to the global atmospheric pool of mercury and is deposited both near to the sources and on distant watersheds. With the passage of the Clean Air Act Amendments in 1990 came provisions to reduce the emissions of toxic air contaminants such as mercury. Mercury emissions have now been reduced from most municipal waste combustors, medical waste incinerators, and a number of other sources. Mercury as a component of many consumer products has also been greatly reduced. The primary large remaining source of mercury to the environment is from coal combustion at large power generating stations. Many of these sources are located upwind of New York, in states to the west and south.

In 2003, the NYSDEC began a four-year project to strategically monitor selected fish from lakes, ponds, and reservoirs across New York State. This project was supported in large part by funding from the New York State Energy Research and Development Authority (NYSERDA). Fish species targeted were those previously found to accumulate high concentrations of mercury, and included walleye, largemouth bass, smallmouth bass and yellow perch. An objective of the study was to gather new data from waters that had not yet been surveyed. Other objectives included the testing of a model to predict mercury levels in fish based on lake characteristics and water chemistry, and evaluation of changes in mercury in a group of lakes where older data were available. Data gathered by the project were provided to the New York State Department of Health (NYSDOH) to evaluate the need for fish consumption advisories. Water chemistry data collected during the project were used to evaluate relationships with fish mercury concentrations.

A total of 2,605 individual fish samples from 131 lakes were analyzed for total mercury as part of this project. Mercury was detected in all fish samples analyzed. As found in other studies, the larger, predatory fish had the highest mercury concentrations. The highest mercury concentrations were greater than 3,000 ng/g (3 ppm) in three of the four target fish species. Walleye, northern pike, and chain pickerel were most often the fish with the highest levels although there was considerable variability among lakes. Smallmouth bass mercury concentrations were on average similar to or slightly higher than the mercury concentrations in largemouth bass of the same size. Yellow perch had the lowest mercury concentrations of the species tested in our study. Other monitoring efforts that tested other fish species in New York State have documented lower mercury concentrations in shorter-lived fish that feed lower on the food chain; these include sunfish, bullheads, and most trout species.

Of the study samples, 62% (1,630 fish) had total mercury concentrations that exceeded the United States Environmental Protection Agency (USEPA) water quality criterion for methyl mercury in fish (300 ng/g) for the protection of human health. The United States Food and Drug Administration (FDA) marketplace standard for mercury in commercial fish is 1,000 ng/g methyl mercury. The NYSDOH considers the FDA mercury standard and other factors when deriving fish consumption advisories. Ten percent of the fish in this study (263) exceeded the FDA marketplace standard. Based on the data from this study, NYSDOH issued new specific advisories for 50 lakes throughout New York State. Within the Adirondack and Catskill Park regions 62% (42 out of 68) of the lakes we surveyed were issued specific fish consumption advisories, whereas only 19% (12 out of 63) of the lakes surveyed outside of the parks were issued fish consumption advisories. In response to the higher mercury levels in certain fish species from the Adirondack and Catskill Park regions (in comparison to similar fish from other regions in the State), the NYSDOH issued a new regional advisory for the Adirondack and Catskill Parks. The new advisory recommends that children under the age of 15 and women of childbearing age should not eat chain pickerel, northern pike, smallmouth and largemouth bass, walleye, and yellow perch longer than 10 inches (254 mm) from any waters in the Adirondack and Catskill Mountain regions.

In order to be able to compare the mercury concentrations in fish from various lakes, we determined the average size for each species from all waters combined and used the data from each lake to calculate the predicted mercury concentration in that lake for that size fish. This allowed us to evaluate the importance of water chemistry variables and lake physical variables to the fish mercury levels. Across New York State the most important variable associated with high mercury levels in fish appeared to be acidity of the water. In 80% of the low pH lakes (pH less than 6.5) our data predicted that 9-inch (229 mm) yellow perch would have mercury concentrations above 300 ng/g, while only 20% of the higher pH lakes (pH from 7.5 to 8.5) would be expected to have yellow perch above this level. Lakes and ponds that had low pH, low acid neutralizing capacity (ANC), low calcium, and low conductivity had fish with higher concentrations of mercury. In general, these water chemistry variables characterize most waters in the Adirondack and Catskill Park regions. Other variables that were important on a statewide basis included conductivity, other cations, total mercury in the water, total dissolved aluminum, and the presence of a dam on the outlet. Chlorophyll-a was an important variable related to mercury in the two bass species but not in yellow perch or walleye. The area of contiguous wetlands bordering the lake was also important in some cases and appeared to be more important for walleye and yellow perch than the other species.

New York State lakes are highly variable in terms of size, other physical characteristics, water chemistry, and biology. As a result, we observed considerable variability in the mercury concentrations in water and fish from across the State. Neighboring lakes often differed considerably in mercury levels. It appears that multiple factors are important in the methylation of mercury and in the accumulation up the food chain to large piscivorous fish. Another objective of our project was to develop predictive models that could help resource managers identify lakes and fish that may be high in mercury. The results of this work showed that length of the fish and acidity of the water were the two variables that appeared important in most cases. For yellow perch the third variable of importance in predicting mercury concentrations was the area of contiguous wetlands bordering the lake. These mathematical models are presented in the report.

In order to evaluate trends in mercury concentrations, we surveyed fish from a number of waters that had been sampled previously. In the Adirondack Park, we collected yellow perch from 12 lakes that had been sampled in the late 1980s or early 1990s. There was considerable variability among the lakes, but overall there was a 16% average decline in the mercury concentration of a standard size (229 mm, 9 in.) yellow perch. Although this is a relatively small change, it is encouraging, because mercury emissions have been reduced, and acidic deposition has declined. Both of these events would hopefully result in lower mercury concentrations in fish. We also analyzed several fish species from seven other lakes that had been monitored during previous surveys. While four lakes exhibited declines in fish mercury concentrations, two lakes showed significant increases in mercury and may warrant further investigation.

Our extensive monitoring project of lakes across New York State documents the wide extent of mercury in the environment. Future monitoring and research projects will need to further evaluate the effects of reductions in mercury emissions and continuing reductions in acidic deposition. We hope that mercury concentrations in fish will continue to decline, but this will require continued reductions in mercury emissions. As our study demonstrated, the many variables affecting mercury bioaccumulation result in considerable lake-to-lake variability. There also remain many lakes and ponds that have never been monitored for mercury in biota. Since some of these waters are heavily used by the public, more waters should be surveyed. Baseline measurements of contaminants in the environment are important in our understanding and conservation of healthy natural resources.

INTRODUCTION

Mercury is a naturally occurring toxic metal that has become an important environmental and human health concern. Mercury sequestered in the earth's crust is released into the atmosphere through both natural (e.g., volcanoes, forest fires) and anthropogenic processes (e.g., coal burning, gold mining, chlor-alkali plants and waste incineration, USEPA 2001). Atmospheric deposition is the principle form of transport of mercury to much of the northeastern United States (USEPA 1997). When mercury is mobilized in terrestrial and aquatic systems, it can be converted by bacteria into methyl mercury, a highly toxic and biologically available form. In aquatic environments, methyl mercury bioaccumulates in organisms and biomagnifies up the food chain and may concentrate to high levels in large predatory fish. Mercury concentrations are highest in large piscivorous fish and lowest in short-lived omnivorous fish. Typically about 90% - 100% of the mercury in top trophic level fish is in the methylated form (Bloom 1992, NAS 2000, Loukmas et al. 2006).

Mercury cycling in the environment has been an active field of research for many years. Still there are questions regarding why certain lakes and fish have higher mercury concentrations than others. Factors which have been shown to influence mercury methylation in lakes include the presence of abundant wetlands (Drysdale et al. 2005), dissolved organic carbon (DOC) of the water (Driscoll et al. 1995), the acidity of the water (Wiener et al. 1990, Simonin et al. 1994, Driscoll et al. 1994), whether or not the water is an impoundment (Schetagne and Verdon 1999b), and the productivity of the water (Chen and Folt 2005). In numerous lakes, mercury levels are high enough to threaten aquatic ecosystem health and pose potential health risks to humans who eat fish from these waters (Kamman et al. 2005, Evers 2005). Consumption of fish is the main route of exposure to humans and piscivorous wildlife.

The New York State Department of Environmental Conservation (NYSDEC) has been monitoring fish for mercury concentrations for over 30 years. Prior to this study, the New York State Department of Health (NYSDOH) determined that fish from 36 lakes and reservoirs in New York State had mercury concentrations high enough to warrant specific consumption advice (NYSDOH 2003). Mercury was the most prevalent fish contaminant of concern in the State. However, this was based on a relatively small number of sampled lakes, ponds and reservoirs (166). The vast majority of New York State lakes and ponds (over 4,000) had never been surveyed for mercury concentrations in fish. Thus, while mercury was clearly a significant fish contaminant concern, the overall statewide magnitude and extent of the problem were largely unknown.

Evidence of recent declines in mercury deposition (Lorey and Driscoll 1999, Kamman and Engstrom 2002) and acid precipitation (Driscoll et al. 2003, Burns et al. 2006) in conjunction with new federal and state emission control legislation is expected to lead to a subsequent decrease in fish mercury levels. In order to increase the number of analyzed waters in the State, to monitor for potential decreases in mercury concentrations in fish from previously sampled lakes, and to gain a better understanding of mercury in the aquatic environment, a four-year monitoring program was developed. The project objectives were the following:

1. Monitor mercury concentrations in fish from New York State lakes that have not yet been surveyed for mercury.
2. Monitor mercury levels in fish from specific lakes where historic data are available to document possible trends by comparing current levels with those observed 10-15 years ago.
3. Provide data to the NYSDOH to determine the need for additions to or changes in fish consumption advisories.
4. Evaluate and refine a simple model for predicting mercury concentrations in fish based on water chemistry and the size and species of fish.
5. Summarize the statewide NYSDEC database of mercury concentrations in fish with an aim to better understand mercury bioaccumulation and biomagnification in lakes and to characterize the mercury problem in New York State.

PATTERNS OF MERCURY CONCENTRATIONS IN FISH

Methods

<u>Lake and species selection</u>

We selected 131 lakes for assessment from three sections of the State: 40 lakes (31%) from the southeast (NYSDEC regions 1, 2, 3 and 4), 75 lakes (57%) from the northeast (regions 5 and 6), and 16 lakes (12%) from the west (regions 7, 8 and 9, Figure 1). The number of waters studied from each section of the State was based on the number of available waters in that section. According to the NYS Gazetteer of Lakes (Greeson and Williams 1970), there are 4,155 lakes, ponds, and reservoirs in New York State that are greater than 6.4 acres (0.01 square miles). Of these waters 33.5% are in the southeast section, 52.6% in the northeast, and 13.9% in the western section of the State. Of the lakes and ponds we studied 65 were in the Adirondack Park region, three were within the Catskill Park, and 63 waters were outside of these park regions. The selection of waters in each section was based on several criteria: availability for public fishing; the presence of one and preferably two or more of the following species: yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieu)*, largemouth bass (*Micropterus salmoides*), and walleye (*Sander vitreus*); the availability of suitable historic fish mercury data so changes in mercury concentrations over time can be evaluated, and waters were chosen to represent a variety of different size classes. Our project design was to conduct an extensive and quantitative monitoring study of as many lakes as possible within the funding and personnel limitations of the project.

We targeted a maximum of 30 fish (10 each of yellow perch, black bass [smallmouth and largemouth bass], and walleye) for collection from each water. This number was selected to provide a reasonable representation of the legal sized edible fish population within each lake. Because species assemblages and abundance can vary from lake to lake, and because walleye are not as ubiquitous as yellow perch and black bass, we assumed a 100% occurrence rate for either yellow perch or black bass, a 50% occurrence rate for the other species, and a 25% occurrence rate for walleye among our sample sites. Therefore, we planned to collect an average of 17.5 fish per lake, or a total of 2,293 fish for the study.

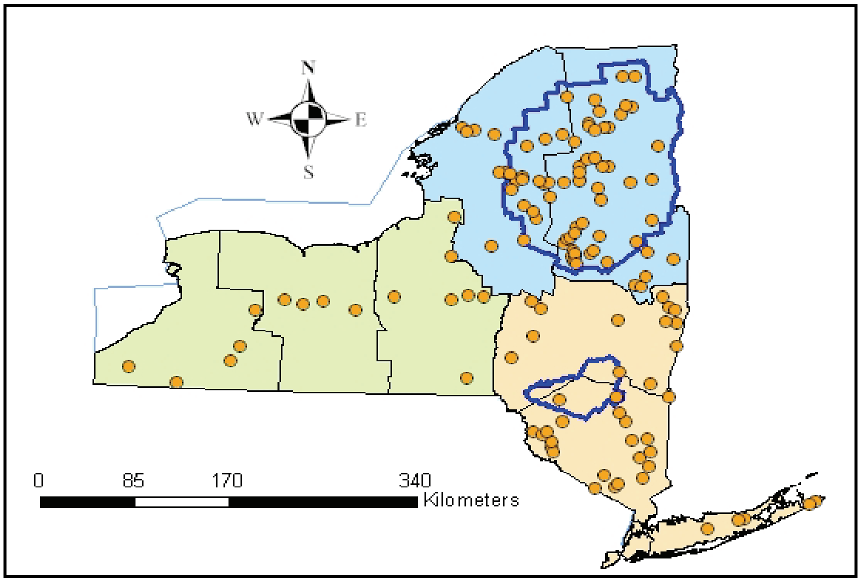

Figure 1. Map of New York State showing 131 study lake locations, the three selected regions of the State, and the Adirondack and Catskill Parks blue lines

Experienced fisheries biologists and technicians with the ALSC (northeast section) and NYSDEC (southeast and west sections) conducted the fish sampling. Lakes were sampled for fish and for water chemistry once during the study. Some lakes were sampled over more than one year to increase sample size. All chemistry data were collected in July of each year that the fish sampling occurred in that lake. Fish were sampled by a variety of means including electrofishing, gill netting, trap netting, and angling. Legal edible sizes of fish were targeted. Fish were handled according to standard NYSDEC fish collection and handling procedures (Appendix A). This required recording the date of collection, assigning unique identification numbers, the location including GIS coordinates, species, length in millimeters, weight in grams, and method of collection on standard specimen collection forms. In addition, fish scales were collected for aging. Chain of Custody forms were maintained and samples kept cool and then frozen immediately after handling, on the same or following day of collection.

Tissue preparation and mercury analysis

Each fish sample was processed according to standard NYSDEC methods (Appendix A). This included partially thawing the fish sample, removing scales, and then removing a skin-on and rib bone-in fillet that extended from the gill cover to the caudal fin (i.e., standard fillet). The fillet was then homogenized in a food processor, and aliquots were placed in cleaned, labeled glass jars and refrozen. Frozen samples that were prepared for shipment to contract laboratories were placed in styrofoam shipping containers, which were packed with styrofoam nuggets. Sample analysis request information was included, and the containers were then sealed and shipped to CEBAM Analytical, Inc. by overnight delivery. Upon receipt, all samples were checked for condition and logged into a sample tracking system.

Total mercury was analyzed in the fish samples using EPA method 1631 (USEPA 2002). Research has shown that 90-100% of the mercury in top-predator fish is in the methylated form (Bloom 1992, NAS 2000, Loukmas et al. 2006). Analytical quality control for mercury consisted of certified reference materials, matrix spikes and matrix spike duplicates, sample duplicates, and method blanks. The rates of the quality control samples were one duplicate for every 16 samples, one matrix spike for every 19 samples, one method blank for every 22 samples, and one reference material for every 41 samples. All mercury data are presented as wet weight concentrations.

Data reporting and statistical analyses

Summary descriptive statistics, calculated within a Microsoft Excel© database, for fish samples tested for mercury were reported in tabular format and typically include sample sizes, lengths, weights, and mercury concentration means, standard deviations (where appropriate), and ranges. Statistix® 8 software (Analytical Software 2003) was used to perform statistical tests. The Shapiro-Wilk test was used to assess fish length and mercury levels for normality. Nonparametric tests were used when data were not normally distributed. Linear regressions were also performed using mercury concentrations and fish length as the dependent and independent variables, respectively, with subsequent regression-based predictions made for average-sized fish of target species in order to make intra-specific comparisons among study lakes and regions.

Results

Sample collections

We collected 2,605 fish from 131 lakes for analysis. The number of fish collected from each lake ranged from five from Lake Taghkanic in the lower Hudson River valley to 41 from Fort Pond on Long Island (Appendix B). The mean collection rate (19.9 ± 8 fish/lake) was higher than our expected target (17.5 fish/lake). Some surplus fish collected during 2000 – 2002 were used as samples for this study. Eleven fish from one lake were collected in 2000; 237 fish from 12 lakes were collected during 2001; 62 fish from five lakes were collected in 2002. Of the waters sampled specifically for this study, 641 fish from 40 lakes were collected in 2003, 843 fish from 51 lakes were collected in 2004, and 811 fish from 38 lakes were collected in 2005 (Appendix B). Several lakes were sampled during more than one year to increase the sample size. Nine species of fish were part of the total collection. Yellow perch were the most commonly collected target species (1,101 were collected from 113 waters), followed by smallmouth bass (573 from 73 waters), largemouth bass (539 from 75 waters), and walleye (260 from 37 waters). Chain pickerel (*Esox niger*, 75 from 21 waters), northern pike (*Esox lucius*, 42 from 12 waters), muskellunge (*Esox masquinongy*, three from two waters), tiger muskellunge (*Esox lucius* x *Esox masquinongy*, two from one water), and white perch (*Morone americana*, 10 from one water) were the species not initially considered as targets but were collected and used as substitutes when the availability of target species was limited within study waters.

Mercury

Total mercury was detected in all 2,605 fish tissue samples (Appendix B). Table 1 shows summary results on a wet weight basis for the four target species in the study. The mean mercury concentration for all fish was 490 ± 404 ng/g and levels ranged from 12 ng/g in a yellow perch from Lake Ronkonkoma on Long Island to 4,305 ng/g in a chain pickerel from Sunday Lake in the western Adirondacks. Northern pike had the highest mean mercury concentrations among the six most commonly collected species (747 ± 465 ng/g), while yellow perch had the lowest levels (346 ± 334 ng/g).

Table 1. Mercury concentrations (ng/g wet weight) measured during 2003-05 in the four target fish species collected from New York State lakes

Species	n	Mercury Concentrations (ng/g)	
		RANGE	MEAN
Walleye	260	110 to 3,600	660
Smallmouth Bass	573	40 to 3,320	625
Largemouth Bass	539	20 to 2,130	499
Yellow Perch	1,101	12 to 3,240	346

Fish mercury concentrations differed substantially from one lake to another, and this added to the overall variability in the data. When all of the walleye mercury concentration data were plotted against fish length, the linear relationship was significant, but poor (R^2 = 0.07, Figure 2a). However, plotting these same parameters from four individual lakes (Figure 2b) as examples shows that there is a stronger linear relationship (R^2 ranged from 0.76 to 0.87) on an individual lake basis. Similar patterns were observed for other lakes and fish species in our study.

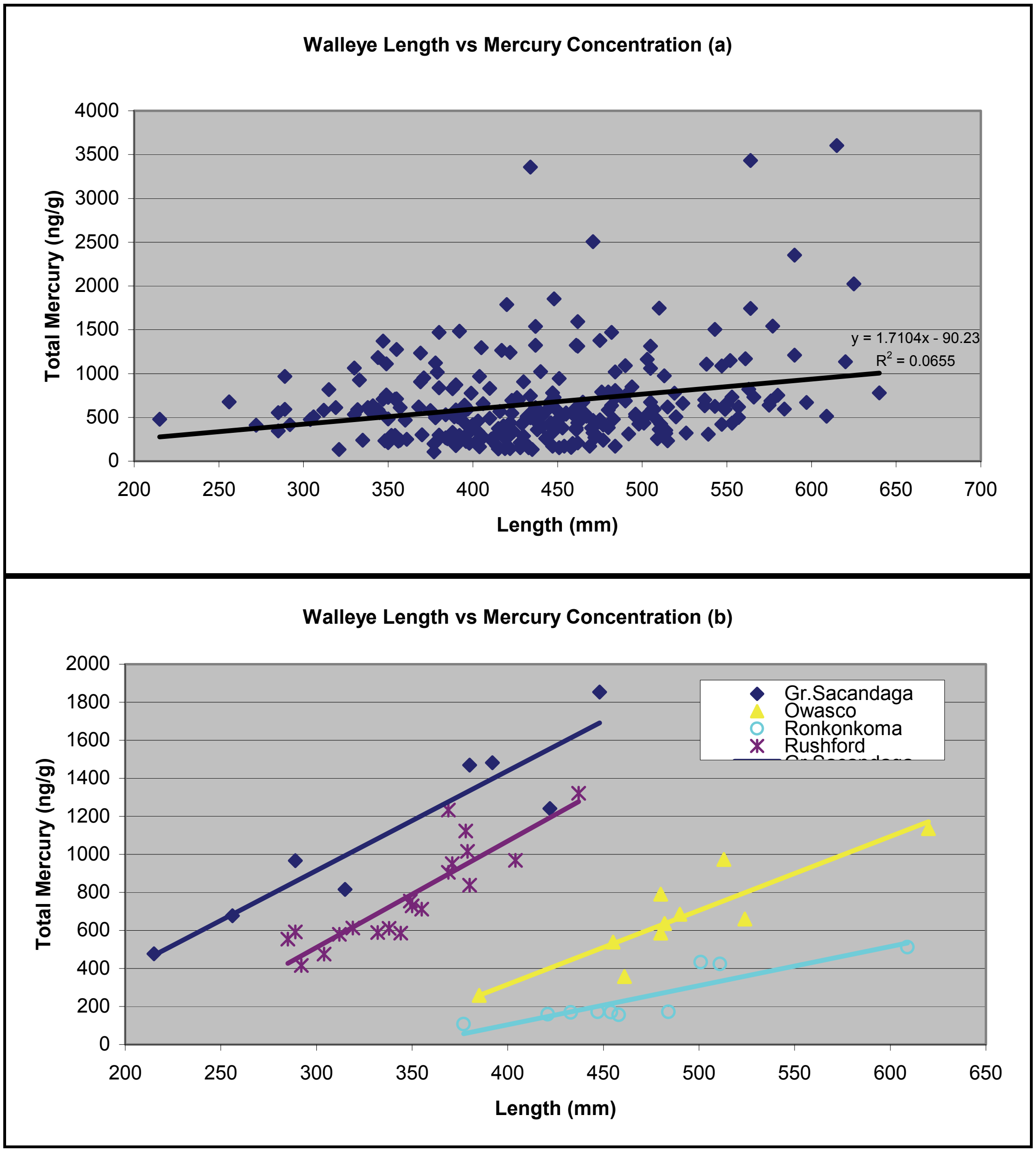

Figure 2. Relationship between walleye length (mm) and mercury concentration (ng/g wet weight)— (a) all walleye data from this project; (b) individual lake data for four New York State lakes.

Because mean fish size differed among waters (Appendix B), there was a need to standardize fish lengths in order to make mercury concentration comparisons between waters. Regression-based predicted values for average-sized fish (based on the mean length of each species for all waters combined) were determined for the four target species in waters where at least three individuals were collected. For a more complete statewide assessment, we included regression-derived predicted fish mercury data for some analyses from an additional 19 waters where data were collected since 2001 (i.e., data from 17 New York City reservoirs [Loukmas and Skinner 2005, Loukmas et al. 2006] and two routinely sampled lakes from 2002). Standard sizes used for each species were: 229 mm (9 in.) for yellow perch, 356 mm (14 in.) for both largemouth and smallmouth bass, and 457 mm (18 in.) for walleye. The regression-derived predicted mercury concentrations in standard-size fish for the 131 lakes in this study are included in Appendix D.

Standardized mercury values were calculated for 356 mm (14 in.) smallmouth bass from 76 waters (Figure 3). The mean predicted mercury concentration for all lakes was 646 ± 318 ng/g with a range of 98 ng/g from Honeoye Lake in western NY to 1,463 ng/g from Schoharie Reservoir, in the Catskill region.

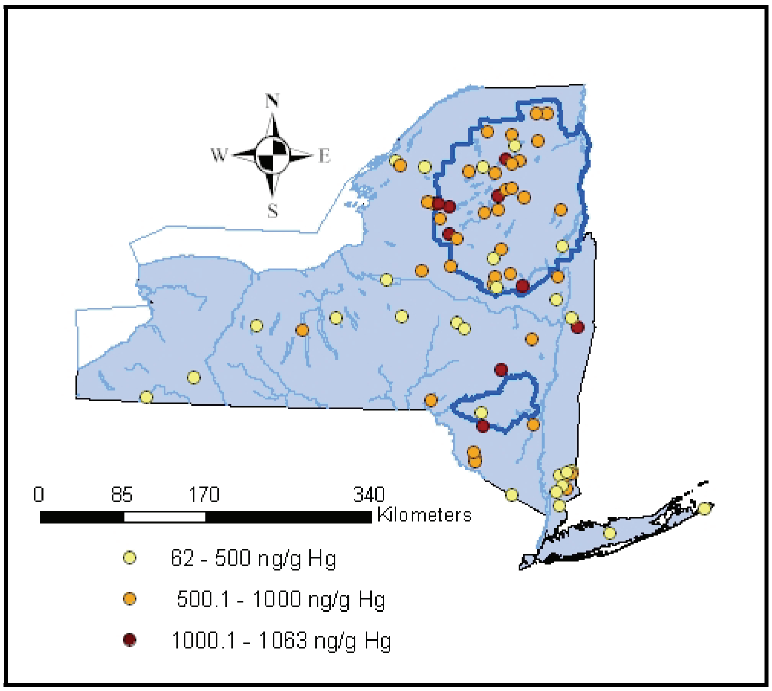

Figure 3. Map showing locations of lakes where smallmouth bass were collected and the predicted concentration of mercury in a 356 mm (14 in.) fish

Most lakes with predicted smallmouth bass mercury levels > 500 ng/g were located in the Adirondack and Catskill Park regions. One exception was Dunham Reservoir, located near the eastern border of the State, where the predicted value was 1,138 ng/g.

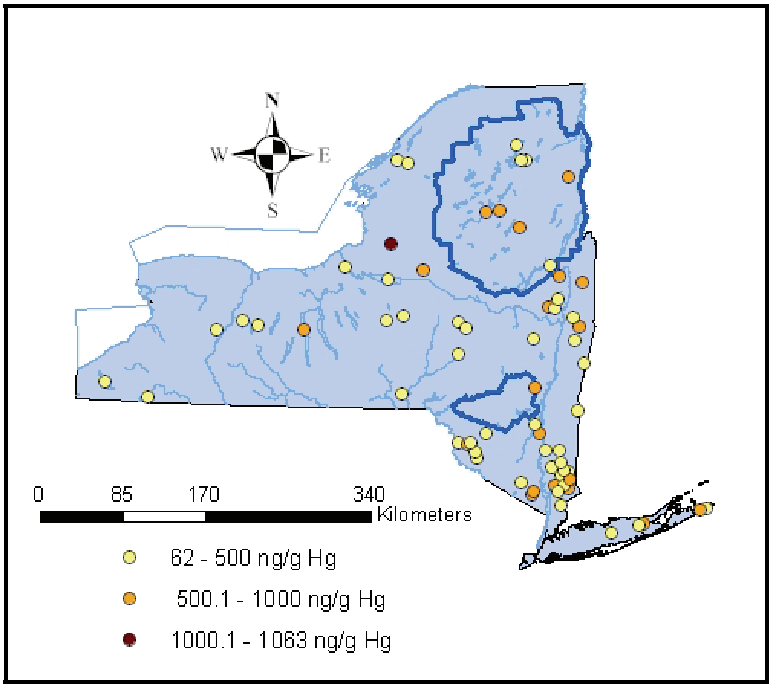

Figure 4. Map showing locations of lakes where largemouth bass were collected and the predicted concentration of mercury in a 356 mm (14 in.) fish

Standardized mercury concentrations were calculated for 356 mm (14 in.) largemouth bass from 72 waters (Figure 4). The mean predicted mercury concentration for all lakes was 450 ± 196 ng/g with a range of 62 ng/g from Middle Branch Reservoir in southeastern NY to 1,063 ng/g from Salmon River Reservoir in north-central NY. In contrast to smallmouth bass, no clear spatial pattern of elevated mercury levels was evident in or around the Adirondack and Catskill parks. Largemouth bass mercury levels were more moderate overall than smallmouth bass, with fewer locations predicted to have standard-size bass > 1,000 ng/g.

In order to more closely compare the species, predicted mercury concentrations were compared on 31 lakes where we collected both smallmouth and largemouth bass. For these lakes, the mean mercury concentration in smallmouth bass (472 ± 232 ng/g) was slightly higher than what was determined for largemouth bass (420 ± 180 ng/g). Smallmouth bass had higher predicted mercury concentrations in 18 (56%) of the waters (Figure 5). Shapiro-Wilk tests determined that data for both species were normally distributed ($p = 0.215$ for largemouth bass, $p = 0.194$ for smallmouth bass), so a one-way ANOVA and a

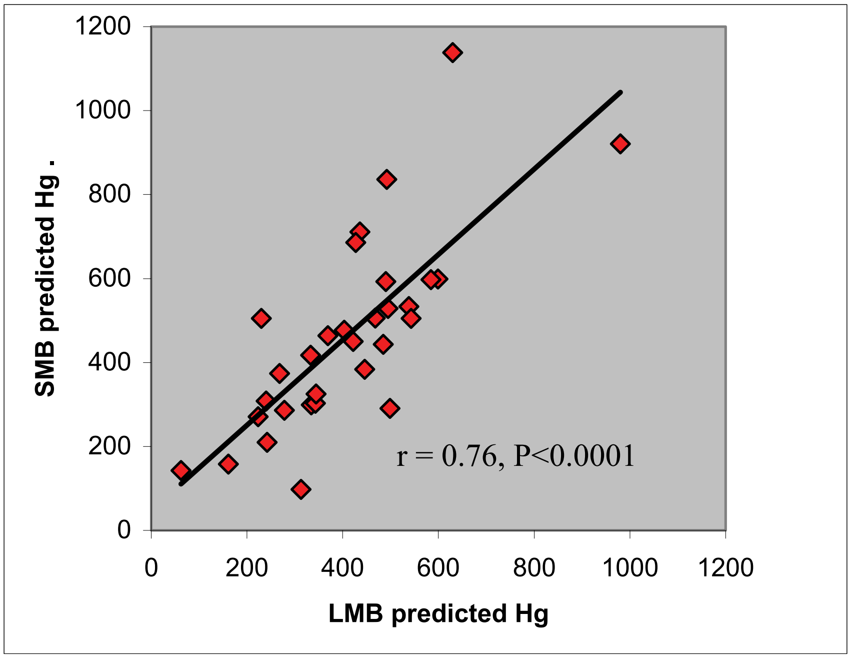

Figure 5. Relationship between predicted mercury concentrations (ng/g) in 356 mm (14 in.) smallmouth bass and largemouth bass in lakes where both species were collected (n = 31)

Pearson correlation were conducted to test for relationships between the species. Despite the difference in means, correlation analysis determined that predicted mercury concentrations for both species were positively related (r = 0.76, p = <0.0001, Figure 5) and the ANOVA did not detect a difference in mean mercury levels between the species (p = 0.167).

Standardized mercury concentrations were determined for 229 mm (9 in.) yellow perch from 116 waters (Figure 6). The mean predicted mercury concentration for all lakes was 326 ± 271 ng/g with a range of 43 ng/g from Greenwood Lake on the NY-NJ border to 1,655 ng/g from Meacham Lake in the northern Adirondacks. There were only three lakes where standardized mercury levels were above 1,000 ng/g and these were all located in the western Adirondack Park along with most of the lakes with moderately elevated mercury concentrations (500 – 1,000 ng/g). Nine of the 10 lakes with the highest predicted mercury concentrations were located in the Adirondack Park.

Standardized mercury concentrations were determined for 457 mm (18 in.) walleye from 33 waters (Figure 7). The mean predicted mercury concentration for all lakes was 838 ± 580 ng/g with a range of 222 ng/g from Lake Ronkonkoma on Long Island to 2,595 ng/g from Dunham Reservoir near the eastern border of NY. There were nine lakes where standardized mercury concentrations were above 1,000 ng/g. Eight of these were located in the eastern half of the State, widely distributed among the Adirondack, Catskill, southeastern, and east-central regions.

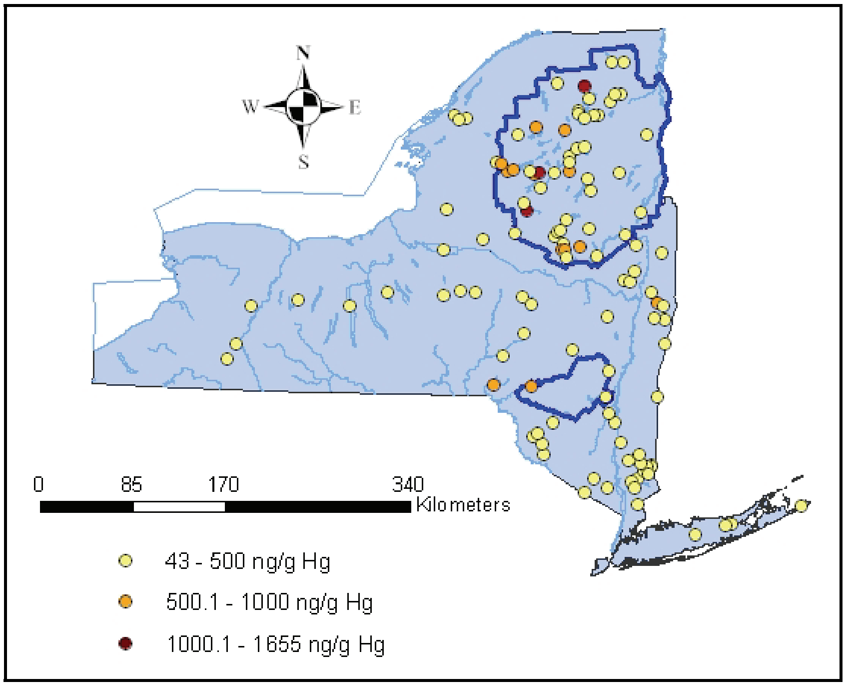

Figure 6. Map showing locations of lakes where yellow perch were collected and the predicted concentration of mercury in a 229 mm (9 in.) fish

Because of the apparent geographic pattern of higher mercury concentrations for yellow perch and smallmouth bass within the Adirondack and Catskill Park regions, nonparametric Wilcoxon Rank Sum tests were used to test for intraspecific differences between lakes within and outside the parks for all four target species. Standard mercury concentrations for yellow perch ($p<0.001$), smallmouth bass ($p<0.001$), and walleye ($p = 0.053$) were determined to be higher in and around the parks versus outside the parks. Largemouth bass standard mercury concentrations were not significantly different between the regional categories in this analysis ($p = 0.110$).

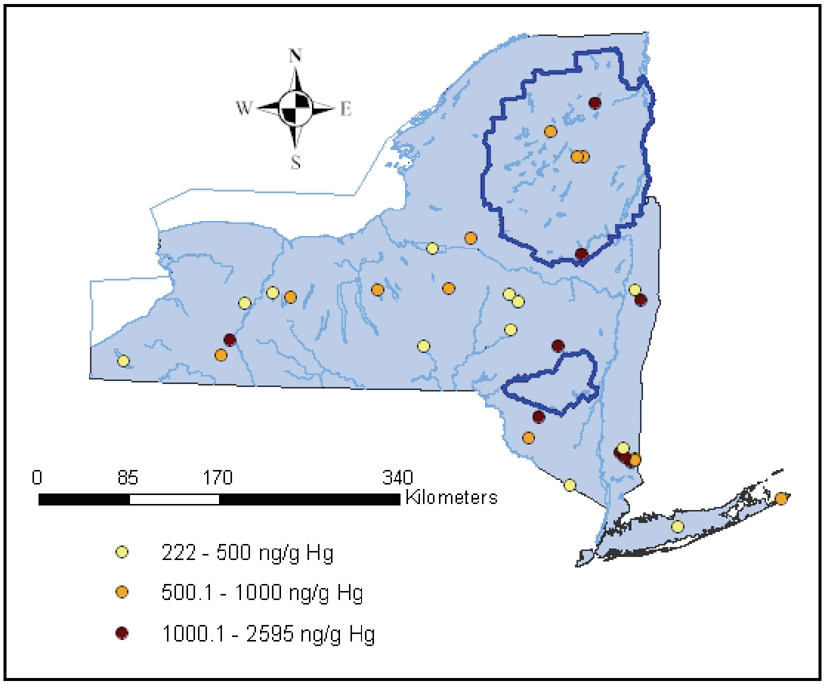

Figure 7. Map showing locations of lakes where walleye were collected and the predicted concentration of mercury in a 457 mm (18 in.) fish

Analytical quality control

USEPA (2000) recommended guidelines were used for determining quality assurance and quality control for all sample analyses. For mercury, most quality control results were within the general guidelines (Table 2). The only deviation from the guidelines occurred where mercury was detected at slightly above the detection limit of 0.5 ng/g in one method blank sample (0.6 ng/g); however, it was not elevated enough to cause a concern about instrument contamination.

Table 2. Summary of quality control results for analysis of mercury in fish from the statewide study lakes, 2000 - 2005

QC sample type	Units	n	Mean ± SD	Range
Method blanks	ng/g	120	< 0.5	<0.5 - 0.6[1]
Calibration standards	% recovery	136	99.1 ± 4.8	84.4 - 112.1
Check standards	% recovery	136	99.4 ± 5.0	78.6 – 116.2
Reference materials	% recovery	63	96.2 ± 3.2	88.6 - 102.3
Sample duplicates	RPD[2]	159	3.7 ± 3.1	<0.1 – 17.4

[1] *The method detection limit (MDL) is 0.5 ng/g*
[2] *RPD = relative percent difference*

Discussion

Data collected as part of this study represents a significant addition to the existing NYSDEC mercury database. Mercury was found in all the fish samples that were analyzed, with the highest concentrations generally in lakes in the Adirondack or Catskill Park regions. Our study focused on fish species known to accumulate higher levels of mercury, due primarily to the facts that these species are piscivorous, and they may live longer than other fish. Other fish species such as trout, sunfish, and bullhead have been reported to have lower concentrations of mercury (Simonin and Meyer 1998, USEPA 2004), including within the Adirondack Park.

Fish length was an important variable related to mercury concentration, and using a standard length method was a very useful way to compare lakes. However, it is important to note that the predicted mercury values indicated on the maps (Figures 3, 4, 6 and 7) are for average-sized fish and therefore larger fish with considerably higher mercury concentrations may be present at these locations. Similarly, smaller fish from these lakes would be expected to have lower mercury levels.

Several other factors contribute to the variability in mercury concentrations among individual fish in a lake. Growth rate and age of the fish are related to length and weight, but are not as easily measured. In a productive lake where fish grow quickly, they may have lower mercury concentrations at a given size than in a lake with slower growth. Individual fish feeding on benthic organisms would be expected to have lower mercury levels than individuals feeding on minnows. Longer food chains have also been associated with higher mercury concentrations in the top predators. Since our study focused on older, piscivorous fish, we did not expect to see much change in mercury concentration through the sampling season.

We observed considerable variability in standard size fish mercury concentrations among lakes, with neighboring lakes sometimes having very different concentrations of mercury in fish of the same size. There are clearly lake specific characteristics that are important in controlling the bioavailability of mercury. The role of lake water chemistry and physical characteristics in terms of mercury bioavailability are presented in Section 3 of this report. Averaging mercury concentrations over a large region would over-simplify these lake-to-lake differences, and focusing on individual lake data appears to be a better approach.

The mercury data collected in our study clearly show that mercury is widespread and of serious concern in certain areas. In particular the Adirondack and Catskill Park regions have a large number of lakes with high mercury concentrations in fish. This is based on hundreds of individual fish samples, multiple species, and a systematic sampling of lakes across the State. No previous New York State studies have monitored so many waters in a consistent and relevant manner. Other studies have identified the Adirondack Mountain region as an area where fish mercury levels are high (Evers 2005), and our data indicate that the Catskill Mountain region is another area of concern. Likewise, Loukmas and Skinner (2005) found that New York City reservoirs in the Croton River system (south-eastern Hudson River valley) that receive water from the Catskill Mountain region, constitute another area of concern. As a result of data from our project the NYSDOH has issued specific fish consumption advisories for 42 of the 68 lakes surveyed (62%) from the Adirondack and Catskill Park regions. Of the lakes outside of the parks, NYSDOH issued advisories for 11 lakes of the 63 surveyed (17%). See Section 6 for additional discussion of fish consumption advice.

WATER CHEMISTRY AND LANDSCAPE PARAMETERS

Methods

Lake chemical and physical data thought to influence mercury methylation were measured as part of this project. Surface water samples were collected by hand grab at the deepest part of the study lakes during July of 2003, 2004, and 2005. Water temperature and dissolved oxygen were measured at one meter depth intervals, and Secchi depth and other physical characteristics of the lakes were measured on-site. Water samples were placed on ice and transported to the analytical lab for analysis of lab pH, air-equilibrated (AE) pH, sulfate, nitrate, ammonium, calcium, chloride, magnesium, potassium, sodium, silica, fluoride, total dissolved aluminum, dissolved organic carbon (DOC), acid-neutralizing capacity (ANC), color, specific conductance, total and organic monomeric aluminum. Inorganic monomeric aluminum values were derived by calculation. The Adirondack Lakes Survey Corporation laboratory in Ray Brook, NY analyzed these water samples using standard procedures, which included QA/QC checks and interlaboratory comparisons. The use of a single water sample to characterize lake water chemistry has limitations, but this approach has proved successful in numerous other synoptic studies (Grieb et al. 1990; Driscoll et al. 1994; Simonin et al. 1994).

In addition, separate water samples were collected by field staff for analysis of total and methyl mercury on the same day that surface chemistry was collected. These collections were made using "clean-hands" procedures to minimize possible sample contamination (see Appendix A for details). Samples were kept on ice and shipped to Frontier Geosciences, Inc. (Seattle, WA) within 24 hours for analysis. Chlorophyll-a was measured from a separate integrated water sample collected from a column of water from the surface to two times the Secchi depth. These samples were filtered in the field on 25 mm glass-microfiber filters (GF/C). The volume of water filtered was determined by the Secchi depth. Filters were wrapped in aluminum foil, placed in a plastic bag, frozen, and later sent to Upstate Freshwater Institute (Syracuse, NY) for analysis.

We obtained wetland map coverages (1:24,000) from two sources: the National Wetlands Inventory (NWI, FWS 2004) and the Adirondack Park Agency (APA, 2001 and 2002). NWI coverages were accessed through DEC's Master Habitat Databank and APA wetlands layers were obtained from CD-ROM. APA wetland coverages were available for about 75% of the Adirondack Park; NWI coverages were available for about 50% of the State. Therefore, wetland layers were not available for lakes in some parts of the State. For study lakes where NWI and/or APA wetland coverages were available, we measured aerial extent of wetlands that were considered contiguous (i.e., directly adjacent to the waterbody or within 1 km and connected via an inlet stream). For lakes where APA wetland coverages were available, we also measured individual lake watershed wetland area (lake watersheds were designated in APA, but not in NWI coverages). We used ESRI's ArcGIS 9 ArcMap for spatial analysis of wetlands. Wetlands were measured by individually selecting wetlands in the designated category (contiguous and/or watershed) and calculating total area of wetlands within each designation. Where data were available, we standardized wetland measurements by calculating percent of contiguous wetland area relative to lake area ([lake area + contiguous wetland area]/lake area x 100 - 100) and the percentage of lake watershed area consisting as wetlands (area of watershed wetlands/watershed area x 100).

The impoundment status of most water bodies was also recorded from field observations and evaluated since this is known to impact mercury availability and methylation (Schetagne and Verdon 1999b). This variable was recorded in the data as presence or absence of an outlet dam.

We used Statistix®8 (Analytical Software, 2003) for much of the statistical analysis of our data and for non-parametric analyses of groups of data. In order to evaluate the full lake dataset in terms of mercury concentrations in fish, we used the SAS System for Windows Version 7 (1998). Because mercury concentration in fish is related to fish length, we determined a standard size fish for each species and calculated the mercury concentration for that size for each lake. This method was discussed in Section 2. We then used the calculated fish mercury concentrations to compare various lakes.

Many water chemistry variables were auto-correlated and varied in response to differences in acidity, productivity, or watershed characteristics. Using SAS (SAS Institute 1998) we conducted a VARCLUS procedure to determine which variables were clustered. This procedure assumed that variables are linearly related and resulted in an oblique principal component cluster analysis. Log transformations were made for many water chemistry parameters to make the relationships linear, and these data were included in statistical analyses. We also used SAS (SAS Institute 1998) to conduct multivariate analyses and Pearson correlation coefficient determinations.

Results

Water chemistry data for each of the 131 study lakes are presented in Appendix C. A total of 65 lakes sampled occurred within the Adirondack Park, three within the Catskill Park and 63 outside of these parks within NYS. The physical parameters, watershed wetland measurements, and other variables are presented in Appendix D. New York State has a wide variety of lake types ranging from sand-bottom ponds, to organic tea-colored bog waters, to rocky reservoirs, to deep glacial lakes. As a result, the water chemistry of the study lakes ranged widely. The minimum, maximum, mean and median values for the water chemistry, physical and wetland variables are shown in Table 3 along with predicted mercury levels in standard-sized fish. Study lakes ranged in pH from 4.97 to 8.49, calcium from one to 68 mg/L, SO_4 from 2.1 to 41.6 mg/L, DOC from 0.4 to 12.3 mg/L, and chlorophyll-a from 0.4 to 46.2 µg/L.

The median values (less influenced by extremes than mean values) of numerous water chemistry parameters are presented in Table 4 for the three regions of New York State shown in Figure 1. In general, lakes in the southeast region are lower in elevation, smaller, and more productive than lakes in the other two regions. For many variables, lakes in the southeast region fell in between the other two regions. Lakes in the western region included several Finger Lakes and Oneida Lake, and were on average larger than lakes in the other two regions. They also were the highest in ANC, pH, calcium, and conductivity. Lakes in the northeast region, which includes the Adirondack Park, had the lowest ANC, pH, calcium, and conductivity and had the highest aluminum, mercury, DOC and color. The only variable in Table 4 that was not significantly different among the three regions was the predicted Hg in 356 mm (14 in.) largemouth bass (Kruskal-Wallis test, $p < 0.05$). With the other three species of fish (smallmouth bass, walleye and yellow perch), the northeast region had significantly higher mercury concentrations than either the southeast or western regions, but these other regions were not significantly different from each other.

In order to further evaluate and possibly better separate the lake chemical and physical data, we compared the data for lakes within the Adirondack or Catskill Parks vs. NYS lakes outside of the parks (Table 5). In this comparison all of the variables listed were significantly different ($p < 0.05$) between the two groups except lake area and the area of contiguous wetlands. Comparing the water chemistry between the two groupings in Table 5, we found significantly lower ANC, pH, calcium and specific conductivity in the Adirondack/Catskill Park lakes. These lakes also were significantly less productive (lower chlorophyll- a) and more colored (higher DOC and color) than lakes from other parts of the State.

Table 3. Summary statistics of water chemistry and landscape parameters and predicted standard-size fish mercury concentrations from New York State study lakes

Parameter	**N**	**Median**	**Mean**	**SD**	**Minimum**	**Maximum**
Aluminum, inorganic monomeric (μg/L)	131	5	9.13	13.4	0	72
Aluminum, organic monomeric (μg/L)	131	29	32.04	10.42	20	76
Aluminum, total monomeric (μg/L)	131	34	40.77	18.13	24	140
Aluminum, total dissolved (μg/L)	131	15	44.05	63.77	5	377
ANC (μeq/L)	131	206.35	559.44	713.61	-8.50	2632.3
Calcium (mg/L)	131	5.05	12.69	15.25	0.92	68.29
Chlorophyll-a (μg/L)	131	3.59	5.79	6.43	0.40	46.16
Chloride (mg/L)	131	8.83	15.24	22.36	0.19	151.55
Dissolved Organic Carbon (mg/L)	131	3.86	4.30	1.88	0.39	12.3
Fluoride (mg/L)	131	0.05	0.05	0.02	0.02	0.14
Potassium (mg/L)	131	0.40	0.71	0.63	0.06	2.95
Magnesium (mg/L)	131	1.24	2.58	3.29	0.19	17.76
NO_3 (mg/L)	131	0.04	0.30	0.50	0.02	3.65
Sodium (mg/L)	131	5.29	8.92	11.81	0.30	67.42
NH_4 (mg/L)	131	0.014	0.028	0.32	0.01	0.22
SO_4 (mg/L)	131	4.79	7.10	6.02	2.06	41.59
SiO_2 (mg/L)	131	2.17	2.64	2.00	0.04	9.26
Lab pH	131	7.36	7.30	0.94	5.00	9.16
Air Eq. pH	131	7.51	7.40	0.84	4.97	8.49
Color (PtCo)	131	25	31.6	38.8	3	360
Secchi (m)	131	3.5	3.68	1.88	0.7	11
Specific conductance (μS/cm)	131	67.33	124.59	127.77	12.97	652
Total mercury (ng/L)	131	0.98	1.24	0.99	0.25	7.71
Methyl mercury (ng/L)	130	0.04	0.12	0.35	0.03	3.60
Elevation (m)	131	399	355.66	166.43	1	652
Shoreline length (km)	129	7.6	17.04	28.91	1.13	210.80
Lake area (ha)	131	93.51	819.35	2739.7	5.30	20676
Contiguous wetlands area (ha)	84	35.46	138.93	275.82	0	1785.3
% Contiguous wetlands relative to lake area	84	27.86	87.98	214.27	0	1389
Watershed area (ha)	69	1111	16967	47869	48.55	337300
Watershed wetland area (ha)	38	45.16	328.88	681.59	0	2836.2
% Watershed wetlands	38	6.69	6.88	5.48	0	25.69
Predicted Hg in 14" Largemouth Bass (ng/g)	60	439	463.65	188.26	125	1063
Predicted Hg in 14" Smallmouth Bass (ng/g)	64	598	662.28	301.60	98	1366
Predicted Hg in 18" Walleye (ng/g)	26	531.00	772.15	591.59	222	2595
Predicted Hg in 9" Yellow Perch (ng/g)	103	250.00	329.17	276.46	43	1655

Table 4. Median values for selected water chemistry and physical parameters and associated mercury concentrations (ng/g wet weight) in standard-size fish for each of the three regions of New York State (LMB = Largemouth Bass, SMB = Smallmouth Bass, WEYE = Walleye, YP = Yellow Perch; 14" = 356 mm, 18" = 457 mm, 9" = 229 mm)

	Southeast	**Northeast**	**Western**
DEC regions	1, 2, 3, 4	5, 6	7, 8, 9
Number of lakes	40	75	16
ANC (µeq / L)	353.42[a]	98.73[b]	1344.49[c]
DOC (mg / L)	3.62[a]	4.23[a]	2.76[b]
Ca (mg / L)	8.87[a]	3.17[b]	30.81[c]
Al Tot Dis (µg / L)	10[a]	32[b]	8[a]
Air Eq. pH	7.79[a]	7.3[b]	8.33[c]
Color (PtCo)	22.5[a]	30[a]	10[b]
Sp. Cond (µS / cm)	138.05[a]	37.4[b]	208.3[a]
Total Hg (ng / L)	0.815[a]	1.36[b]	0.61[c]
Methyl Hg (ng / L)	0.035[a]	0.062[a]	0.025[b]
Chlorophyll (mg / L)	6.77[a]	2.89[b]	2.6[b]
Elevation (m)	266[a]	468[b]	379.5[a]
Lake area (ha)	50.5 [a]	122.62 [b]	530.29 [c]
Contiguous Wetlands (ha)	7.56 [a]	39.69 [b]	228.03 [b]
Predicted Hg in 14" LMB (n)	431.5 [a] (32)	504.5 [a] (16)	390 [a] (12)
Predicted Hg in 14" SMB (n)	452 [a] (14)	811 [b] (42)	385 [a] (8)
Predicted Hg in 18" WEYE (n)	468 [a] (11)	924.5 [b] (6)	506 [a] (9)
Predicted Hg in 9" YP (n)	176.5 [a] (32)	319 [b] (59)	135 [a] (12)

[abc] *Numbers followed by different superscript letters on each line are significantly different using the Wilcoxon Rank Sum test ($p < 0.05$).*

In addition, the Adirondack and Catskill Park lakes had higher concentrations of total dissolved aluminum, total mercury and methyl mercury. Figure 8 shows geographically the lakes with lower pH and ANC and higher DOC and methyl mercury. Comparing the median predicted mercury concentrations in standard-size fish from the Adirondack/Catskill Park grouping with the predicted concentrations from the northeast region (Table 4), we found higher predicted concentrations for the Adirondack/Catskill Park grouping in three of the four fish species.

We used the SAS (SAS Institute 1998) VARCLUS procedure to determine which variables were clustered. Using the entire statewide dataset resulted in four clusters, which explained 65% of the variability in the chemical/physical data: Cluster 1 – SO_4, Cl, ANC, Ca, Mg, Na, K, LabpH, AEpH, Specific Conductance, and Elevation; Cluster 2 – DOC, Color, Secchi Depth, SiO_2, NH_4, Total Hg, and Methyl Hg; Cluster 3 - Total Dis. Al, Tot. Monomeric Al, Organic Monomeric Al, Inorganic Monomeric

Al, F, and NO_3; Cluster 4 – Chlorophyll a, Shoreline, and Lake Area. These clusters could be roughly labeled, respectively, Acidity, Transparency, Aluminum, and Physical Variables. We then also conducted a VARCLUS procedure on the subset of Adirondack and Catskill Park lakes (n = 68 lakes). In this case the variables again clustered in similar groups with the Acidity Cluster including pH, ANC, and base cations; the Transparency Cluster including water color, DOC, chlorophyll a, and mercury; the Aluminum Cluster including Total Dissolved and Monomeric Al, NO_3, and F; and the Physical Variables

Table 5. Median values for selected water chemistry and physical parameters and associated mercury concentrations (ng/g wet weight) in standard-size fish for lakes within the Adirondack and Catskill Parks compared with lakes outside of these parks (LMB = Largemouth Bass, SMB = Smallmouth Bass, WEYE = Walleye, YP = Yellow Perch; 14" = 356 mm, 18" = 457 mm, 9" = 229 mm)

	Adirondack and Catskill Parks	**NYS Lakes Not in Parks**
Number of Lakes	68	63
ANC (µeq / L)	87.53 *	926.40
DOC (mg / L)	4.18 *	3.55
Ca (mg / L)	2.82 *	20.21
Al Tot Dis (µg / L)	36.5 *	8.0
Air Eq. pH	7.09 *	8.17
Color (PtCo)	27.5 *	20.0
Sp. Cond (µS / cm)	30.7 *	189.34
Total Hg (ng / L)	1.42 *	0.71
Methyl Hg (ng / L)	0.068 *	0.032
Chlorophyll (mg / L)	2.65 *	5.55
Elevation (m)	475 *	248
Lake Area (ha)	106.35	93.51
Contiguous Wetlands (ha)	26.4	39.0
Predicted Hg in 14" LMB (n)	511 * (9)	422 (51)
Predicted Hg in 14" SMB (n)	854 * (37)	450 (27)
Predicted Hg in 18" WEYE (n)	852 * (5)	470 (21)
Predicted Hg in 9" YP (n)	382 * (52)	162 (51)

** Indicates significant difference in median values between the two regions, using the Wilcoxon Rank Sum Test ($p < 0.05$)*

Cluster including shoreline, lake area, and elevation. Log transformations of various chemical variables did not result in different cluster groups. Adding the contiguous wetlands and watershed wetlands data to the analysis reduced the number of lakes with complete data but did not result in other distinct clusters. The area of contiguous wetlands and area of watershed wetlands appeared associated with the Physical Variables Cluster; and the percent contiguous wetland relative to lake area variable and the percent watershed wetlands were associated with the Transparency Cluster.

Using the entire database and log transformations of numerous water chemistry variables to calculate Pearson correlation coefficients, we found that the variables that characterize lake acidity were the variables best correlated with predicted mercury concentrations in standard size fish (Table 6). Measurements of lab pH, air equilibrated pH and the log transformations of ANC and the various base cations were all highly correlated with the mercury concentrations in all four species of fish. Figure 9

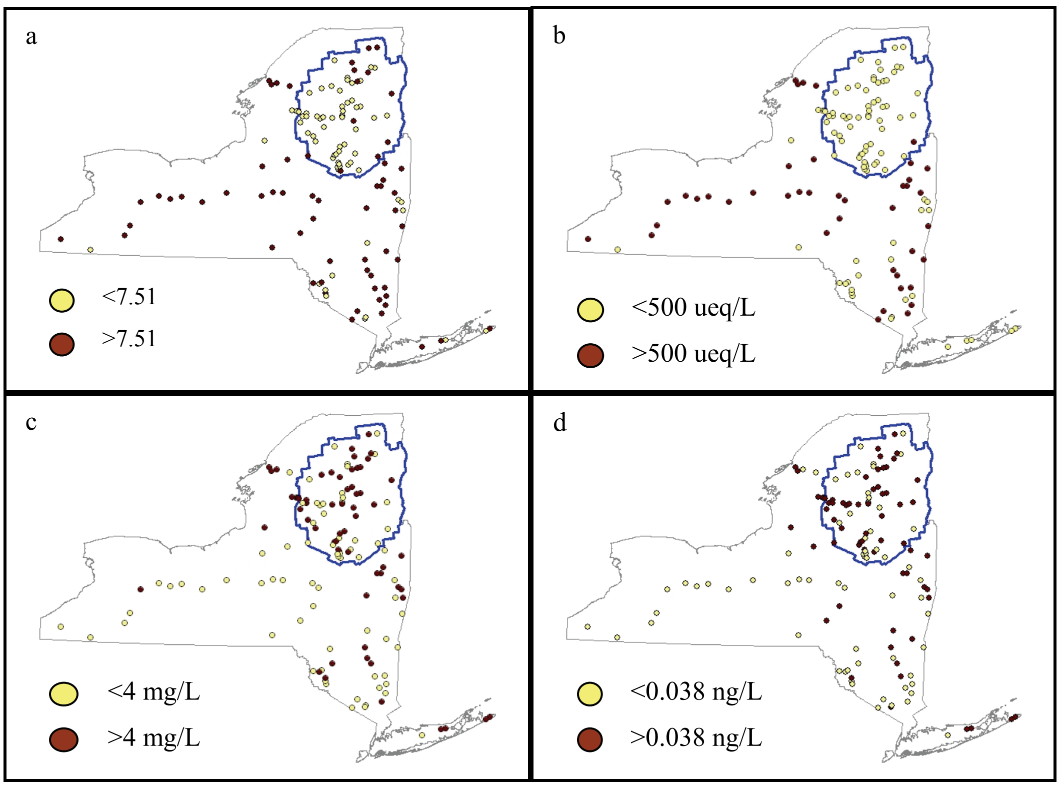

Figure 8. Maps of New York State showing locations of the 131 waters sampled during the study with selected water chemistry variables above and below a given midpoint. Parameters shown include air equilibrated pH (a), ANC (b), DOC (c) and methyl mercury (d)

shows the percentage of lakes in three pH ranges where we found nine-inch (229 mm) yellow perch with a predicted mercury concentration above the 300 ng/g EPA guideline. In most cases, using the log transformation of the water chemistry variable produced a higher correlation coefficient than using the measured concentration. Walleye data were somewhat different from the other three fish species, with water color, log methyl mercury, and area of contiguous wetlands being the variables best correlated with the mercury concentrations. Water color and area of contiguous wetlands were not important variables in the other three fish species. Both log total mercury and log methyl mercury in the water were moderately important in all four fish species. Chlorophyll a was significantly correlated with mercury concentrations in the two bass species but not in yellow perch or walleye. Predictive models are discussed in more detail in Section 5 of this report.

Table 6. Correlation coefficients (r) for selected water chemistry and watershed parameters best correlated with predicted mercury concentrations in standard-size fish using the Statewide NYS database (ns = not significant; $p > 0.05$)

	Predicted Hg in 14" LMB	**Predicted Hg in 14" SMB**	**Predicted Hg in 18" WEYE**	**Predicted Hg in 9" YP**
Variable	**n = 60**	**n = 64**	**n = 26**	**n = 103**
AE pH	-0.57	-0.67	-0.48	-0.59
Lab pH	-0.58	-0.66	-0 46	-0.56
Log ANC	-0.52	-0.67	-0.46	-0.55
Log Mg	-0.48	-0.68	-0.52	-0.54
Log K	-0.52	-0.57	-0.54	-0.44
Log Ca	-0.49	-0.64	-0.48	-0.54
Log Sp Cond	-0.51	-0.65	-0.49	-0.55
Log Total Hg	0.55	0.51	0.51	0.45
Log Methyl Hg	0.45	0.49	0.68	0.26
Log Tot Dis Al	0.57	0.54	0.40	0.59
Color	ns	0.32	0.61	ns
Elevation	ns	0.43	ns	0.46
Area ContigWet	ns	ns	0.59	0.33
Chlorophyll-a	-0.34	-0.34	ns	ns

Since the lakes within the Adirondack and Catskill Parks had several significant differences in water chemistry and physical characteristics when compared to other lakes in the State (Table 5), we analyzed these lakes as a group. The Adirondack and Catskill Park lakes include most of the acidic, low alkalinity lakes in our study and also the lakes with higher mercury in the water and higher mercury concentrations in fish. Pearson correlation coefficients between the predicted fish mercury concentrations and the water chemistry/watershed variables are presented in Table 7. The number of study lakes with largemouth bass and walleye in the Adirondack and Catskill Parks is limited, and this low number restricts our ability to present significant correlation coefficients. The only variable significantly correlated with predicted mercury concentrations in 14" largemouth bass was lab pH. Variables correlated with mercury in 18" walleye included nitrate and the area of contiguous wetlands. Lab pH and log of magnesium also were significantly correlated with mercury in walleye, but in the opposite direction of expected results. Small sample size may be a factor.

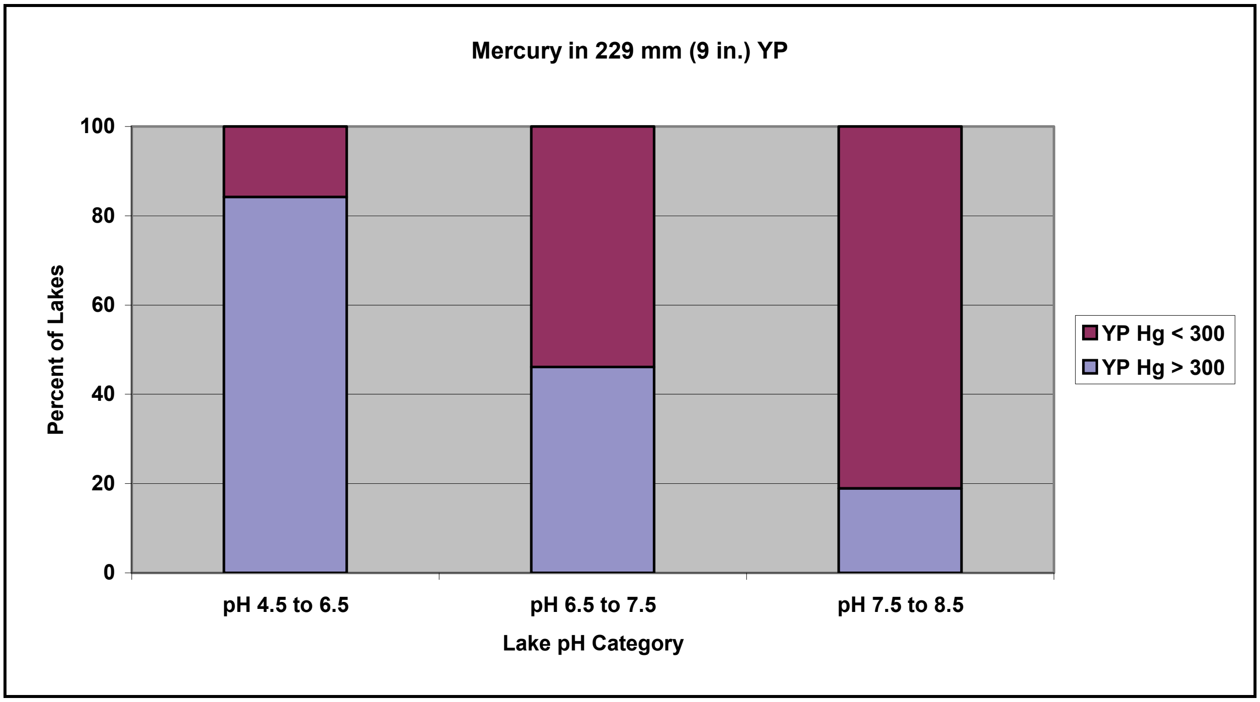

Figure 9. Percentage of study lakes in three pH categories where predicted mercury concentrations in 229 mm (9 in.) yellow perch are above or below the 300 ng/g EPA methylmercury criterion

Aluminum concentrations (both total dissolved and total monomeric) were the variables most highly correlated with predicted mercury levels in both smallmouth bass and yellow perch in the Adirondack/Catskill Parks region (Table 7). Nitrate was also highly correlated with the predicted mercury in 14-inch smallmouth bass, 18-inch walleye (small sample size), and to some extent nine-inch yellow perch. Other variables correlated with predicted mercury concentrations were the variables associated with lake acidity (pH, ANC, cations, specific conductance). Water color and DOC were not significantly correlated with mercury in fish within the Adirondack/Catskill Park regions, and the log of total mercury in the water was only correlated with predicted mercury in yellow perch.

The presence of a dam on the outlet was an important variable related to mercury in fish in the Adirondack/Catskill Park regions. We found that the predicted mercury concentration in a standard size yellow perch from a lake with an outlet dam was 628 ng/g ($n = 20$ lakes), compared to a mean of 414 ng/g in lakes without a dam ($n = 19$ lakes). This difference was statistically significant ($p < 0.05$), as was the difference in mercury between standard size smallmouth bass from lakes with an outlet dam, with a mean mercury concentration of 959 ng/g (n = 15 lakes) compared to 715 ng/g mercury in those from lakes without a dam (n = 15 lakes). Comparing the water chemistry of lakes in the Adirondack/ Catskill Park regions with an outlet dam (n = 26 lakes) and without a dam (n = 26 lakes), we found no significant difference in pH, ANC, DOC or total mercury between the two groups ($p < 0.05$).

Table 7. Correlation coefficients for selected water chemistry and watershed parameters best correlated with predicted mercury concentrations in standard-size fish using data from lakes in the Adirondack/Catskill Parks (ns = not significant; $p > 0.05$)

	Predicted Hg in 14" LMB	**Predicted Hg in 14" SMB**	**Predicted Hg in 18" WEYE**	**Predicted Hg in 9" YP**
Variable	**n = 10**	**n = 36**	**n = 5**	**n = 52**
AE pH	ns	-0.47	ns	-0.43
Lab pH	-0.67	-0.46	0.88	-0.42
Log ANC	ns	-0.45	ns	-0.37
Log Mg	ns	-0.41	0.89	-0.33
NO_3	ns	0.58	0.92	0.32
Log Ca	ns	-0.44	ns	-0.37
Log Sp Cond	ns	-0.40	ns	-0.32
Log Total Hg	ns	ns	ns	0.35
Color or DOC	ns	ns	ns	ns
Total Dis Al	ns	0.61	ns	0.53
Total Mono Al	ns	0.53	ns	0.57
Area ContigWet	ns	ns	0.97	0.40
Chlorophyll-a	ns	-0.36	ns	ns

Using the statewide database, we compared eight groupings of lakes sorted by pH (less than or greater than 7.2), the presence or absence of a dam on the outlet, and chlorophyll-a concentration (Table 8). This comparison showed that the lakes with the highest mercury in standard-sized yellow perch were more acidic (pH<7.2), had a dam on the outlet, and were of low productivity (chlorophyll-a < 5 µg/L) (statistically significant at $p<0.05$, Least Significant Difference method).

Table 8. Mean predicted mercury concentrations (ng/g wet weight) for 229 mm (9 in.) yellow perch based on three lake variables: acidity (pH), presence or absence of an outlet dam, and chlorophyll-a concentration, using the statewide NYS database

pH	Dam on the Outlet	Chlorophyll-*a* (µg/L)	Number of lakes	Mean Hg Conc. (ng/g) in 229 mm (9 in.) YP (Standard Error)
< 7.2	yes	< 5	10	746 (131) a*
		> 5	3	450 (146) a,b
	no	< 5	10	451 (63) b
		> 5	3	434 (99) a,b
> 7.2	yes	< 5	15	254 (33) b
		> 5	12	372 (127) b
	no	< 5	8	216 (49) b
		> 5	5	219 (72) b

** means followed by different letters are significantly different using the Least Significant Difference method (p < 0.05).*

We also evaluated whether the presence or absence of an anoxic zone in the deep water was related to fish mercury concentrations. We arbitrarily defined anoxia in the lake hypolimnion as 4m depth or more with less than 2 mg/L dissolved oxygen in the July lake profile. Anoxia in the hypolimnion was observed in 34 of our study lakes (approximately one third of the 99 stratified lakes). The remaining 65 lakes were categorized with 'good oxygen' in the hypolimnion. The lakes with anoxia also had significantly higher chlorophyll-a concentrations than the lakes with good oxygen in the hypolimnion (average of 8.65 ug/L chlorophyll-a compared with 3.68 ug/L in the lakes with good oxygen, $p = 0.0002$). When we compared the predicted mercury concentrations in 229 mm yellow perch and 457 mm walleye from the lakes with good oxygen compared to lakes with anoxia, we observed no significant differences in the two groups of lakes. When we made the same comparison with 356 mm largemouth bass or 356 mm smallmouth bass we found that the lakes with good oxygen in the hypolimnion had higher mercury concentrations than the lakes with anoxia ($p = 0.004$ and 0.038 respectively).

Discussion

Water chemistry and watershed characteristics in New York State lakes varied widely. Our study lakes ranged from deep Finger Lakes to shallow Adirondack ponds and from large reservoirs to productive lakes surrounded with cottages. Consequently, we consider that this set of water chemistry data is a good representation of lakes in the State and will be valuable for use by other programs and projects interested in these lake parameters. This large synoptic survey of fish mercury concentrations with uniformly collected water chemistry and lake physical characteristics is unique for New York State. A required limitation in this dataset, however, was that all of our lakes were known to have yellow perch and/or bass. We did not survey brook trout ponds or waters known to only have salmonid populations, so these lakes are under-represented in our study lakes. We also surveyed public waters that are popular for fishermen or campers, so small, private waters also are under-represented in this survey.

We found significant differences in the water chemistry and physical parameters between lakes in the Adirondack and Catskill Park regions of the State and lakes in the rest of the State (Table 5). This is not surprising, although it has not often been reported as systematically as in this study. Waters in the park regions are generally higher elevation with thinner, more poorly buffered soils. The Adirondack and Catskill regions also are more forested and receive more precipitation (and atmospheric deposition) than other regions of the State. As a result of these physical characteristics, the water chemistry of most lakes is also poorly buffered, low productivity soft water with low calcium and ANC.

Tables 4 and 5 show some of the differences we observed in median water chemistry values for various regions of the state. Certain parameters showed greater variability between regions; in particular pH, ANC, and calcium, which were 10 times higher in lakes outside of the Adirondack and Catskill Parks compared to lakes within these parks. The large differences in the acidity variables between these two regions may explain in part why these variables were better correlated with the mercury concentrations in standard size fish. Other parameters that were significantly different between these two regions were only different by a factor of about two. These parameters included chlorophyll-a, total mercury, methyl mercury, and lake elevation (Table 5).

We expected to see a strong correlation between mercury concentrations in fish and the acidity of the water, observed in previous studies (Cope et al. 1990; Grieb et al. 1990; Simonin et al. 1994). Greenfield et al. (2001) also reported that pH was the strongest predictor of yellow perch mercury levels in a group of 43 lakes in Wisconsin, USA. We found that acidity related variables were all strongly correlated with mercury concentrations in each of the four species of fish (Table 6). In a cluster analysis of the data, these acidity variables were grouped together, but pH was overall the variable with the highest correlation coefficient. When just the Adirondack/ Catskill Park lakes were evaluated, these relationships were not as strong, most likely due to the fact that these waters as a group are more acidic than other lakes in the State (Table 5). Mercury concentrations in yellow perch and smallmouth bass in the Adirondack/ Catskill regions were still correlated with pH, ANC, and cation concentrations, but aluminum and nitrate were also important. In Nova Scotia's wetland dominated acidic lakes pH was strongly correlated with mercury in yellow perch (Drysdale et al. 2005), but in Maryland's circum-neutral reservoirs, mercury concentrations in largemouth bass were not correlated with acidity (Sveinsdottir and Mason 2005).

Taking a closer look at data from neighboring Adirondack waters with differing concentrations of mercury in the fish revealed a potential role of watershed and within lake processes. In the northeast corner of the Adirondack Park, Chazy and Upper Chateaugay Lakes are both large, moderately developed lakes, yet yellow perch from Upper Chateaugay have predicted mercury concentrations twice as high as those from Chazy Lake. Similarly, in the southwest corner of the Adirondack Park, predicted mercury in yellow perch from North Lake are many times higher than predicted mercury in nearby Woodhull Lake. Both Woodhull and Chazy Lakes (the lower mercury waters) have lower total mercury and methyl mercury in the water, and lower DOC and color than their neighboring lakes. Acidity, ANC and total monomeric aluminum are similar between Chazy and Upper Chateaugay, but North is more acidic, with lower ANC and higher total monomeric aluminum than neighboring Woodhull. Fish consumption advisories were issued by the NYSDOH for smallmouth bass from Upper Chateaugay and yellow perch from North Lake, but not for Chazy or Woodhull Lakes. These comparisons point out the fact that neighboring lakes may be quite different, and that watershed and lake processing of mercury are likely important variables in determining mercury concentrations in biota.

Chlorophyll-a concentrations were used as our primary measure of lake productivity, and these were highest in the southeast region of the State (Table 4). Pickhardt et al. (2002) and Chen and Folt (2005) reported that high plankton densities result in lower mercury concentrations in fish because the mercury is diluted among more organisms. Although the correlation coefficients were not as high as for the acidity variables, we found that chlorophyll-a was significantly negatively correlated with the mercury concentrations in smallmouth and largemouth bass on a statewide basis ($r = -0.34$, $p < 0.05$), but not with yellow perch or walleye. Looking only at the Adirondack/ Catskill Park data chlorophyll-a was again negatively correlated with mercury in 356 mm (14 in.) smallmouth bass. In addition there were 19 lakes with chlorophyll-a concentrations greater than 10 μg/L, and mercury concentrations in standard yellow perch from these lakes were all relatively low (mean = 228 ng/g, max. = 495 ng/g). Lakes in our study that had yellow perch with greater than 500 ng/g mercury also had chlorophyll-a concentrations less than 10 μg/L. These observations further support the dilution theory of Pickhardt et al. (2002) and Chen and Folt (2005).

DOC concentrations did not appear to be as important as expected in determining mercury levels in yellow perch or bass. Driscoll et al. (1994) reported that DOC is important in mercury transport in the watershed, but also can bind with methyl mercury and reduce its bioavailability. We found that statewide DOC concentrations were correlated with total mercury ($r = 0.69$, $p < 0.0001$) and methyl mercury concentrations in the water ($r = 0.60$, $p < 0.0001$), similar to what Driscoll et al. (1995) reported. However, they also found that as DOC increased in their group of Adirondack lakes, the mercury concentrations in yellow perch aged three to five years also increased. In Nova Scotia's wetland-dominated acidic lakes, Drysdale et al. (2005) found that total organic carbon concentrations were positively correlated with mercury in yellow perch, and in Quebec, high fish mercury concentrations were usually associated with lakes with high organic content (Schetagne and Verdon 1999a). In our study, only walleye mercury concentrations from the statewide dataset were significantly correlated with DOC concentration ($r = 0.41$, $p = 0.04$).

Many studies show that wetlands are important mercury-methylating environments, and when connected to lakes and streams, they can contribute to the overall methyl mercury load in the water and biota of those systems (St. Louis et al. 1994, Driscoll et al. 1995, Hurley et al. 1995, Paller et al. 2004). The area of contiguous wetlands was an important variable in our dataset and was the second variable in two-variable models predicting mercury concentrations in yellow perch and walleye on a statewide basis and in yellow perch and largemouth bass in the Adirondack/Catskill Park regions.

As an individual variable, total dissolved aluminum in Adirondack/Catskill Park lakes was the most highly correlated with mercury in smallmouth bass, and total monomeric aluminum the most highly correlated with yellow perch. This agrees with the findings of Driscoll et al. (1994) who found total dissolved aluminum the only variable significantly correlated with mercury in yellow perch aged three+ to five+ years. Driscoll et al. (1995) discusses this further and concludes that both aluminum and DOC are important determinants of methyl mercury bioavailability. Aluminum, which is highest in acidic waters, competes with mercury for binding sites with DOC, resulting in greater mercury bioavailability in lakes with a high ratio of total dissolved aluminum to DOC.

Reservoirs have been known for some time to often have fish with higher mercury concentrations (Abernathy and Cumbie 1977). We recorded this variable in our dataset as the presence or absence of an outlet dam. Since the data were recorded as a 'yes' or 'no', this variable was not included in statistical analyses or modeling. We also did not include a measure of the age of the dam, but in most cases this would have been 20 years or more. North, Meacham and Tupper Lake for example have all been impounded for well over 50 years. Reservoirs are more common than may be expected in New York State and were constructed for hydroelectric, water supply, and flood control purposes. It is the flooding of forest land and the fluctuation of water levels that play a role in promoting more mercury methylation in these waters. In Rushford Lake, a western NY reservoir with high mercury levels in walleyes, the large (40 feet or more) annual water level fluctuations may contribute to the high mercury concentrations in the fish. Sorensen et al. (2005) report that annual water level fluctuations were strongly correlated with mercury levels in young-of-the-year yellow perch. Schetagne and Verdon (1999b) report that in Quebec, the mercury concentrations in several fish species reached their highest levels in new impoundments after 5 to 13 years and then declined. In our study we still observed higher mercury levels in fish from impounded waters, even though the reservoirs were older than those in Quebec.

Anoxia in the hypolimnion did not appear correlated with high mercury concentrations in the fish, possibly because of the conflicting influence of bloom dilution in these lakes. It was expected that under anoxic conditions there would be an increased amount of methyl mercury in the water (Watras et al. 2005) and consequently, we would see higher mercury concentrations in the fish. However, the only relationship we observed was in the opposite direction, with higher mercury levels in bass from lakes with good oxygen than in lakes with anoxia. Although we did not measure mercury concentrations in the hypolimnion, the lakes with anoxia had higher chlorophyll-a concentrations, and any additional methyl mercury produced in the anoxic hypolimnion may have been taken up by the abundant plankton. It is possible that the influence of bloom dilution more than counteracts the increased methyl mercury production in these lakes.

Lakes are different from one another in many physical, chemical and biological aspects. It appears that there is no one variable that determines the bioavailability of mercury to fish in all situations. However, several variables were found to be important in predicting whether mercury concentrations may be high. Acidity of the water appears to be a key variable, and should be considered important in most cases. Naturally acidic wetlands are good environments for the methylation of mercury, and higher DOC levels in these systems allow for better transport of methyl mercury to the lake itself. Acidic deposition has resulted in acidified surface waters in the Adirondack, Catskill, and other sensitive areas. Sulfur-reducing bacteria responsible for mercury methylation are stimulated by increases in biologically available sulfur deposited on a watershed (Jeremiason et al. 2006). Other parameters that co-vary with acidity (pH) include ANC, calcium, magnesium, sodium, potassium, aluminum, and conductivity. The relationship between acidic deposition, reductions in lake sulfate concentrations, and potential decreases in mercury bioavailability will be discussed further in the next section of this report. Biological variables that may impact the mercury concentration in fish include the productivity of the lake and the length of food chains. If phytoplankton at the base of the food chain are abundant, as in a productive lake, the methylmercury is diluted and fish do not accumulate high levels. Because biomagnification occurs within each trophic level, the more levels in the food chain, the higher the mercury concentrations.

TRENDS IN FISH MERCURY CONCENTRATIONS

Methods

Historical data and background

During the early 1990s two studies looked at mercury concentrations in yellow perch from the Adirondack region of New York (Simonin et al. 1994; Driscoll et al. 1994). These studies focused on yellow perch because of the following reasons: this species is widely distributed; it has been studied in other regions; and it has been found to accumulate relatively high levels of mercury. Both studies found that mercury varied with size and age of the fish and that there was considerable variability in mercury concentrations among fish and among lakes in the Adirondacks. Lakes that were more acidic had higher mercury levels in the fish. Driscoll et al. (1994) also reported a relationship between lake water DOC and the bioavailability of methyl mercury.

Over the past 10-20 years a number of changes have occurred in terms of reducing mercury in air emissions, recycling mercury, and reducing mercury in products and mercury control technologies. These changes were implemented with a goal of reducing mercury concentrations in the environment. The Clean Air Act Amendments of 1990 required reductions in mercury emissions from municipal waste combustors, medical waste incinerators and several other sources. In addition, these same regulations required reductions in acidic deposition, and over the past 20 years, sulfate deposition in particular has been reduced (Lynch et al. 2000). Recent trends in sulfate concentrations of wet deposition at Huntington Forest in the Adirondack Park show it declining at a rate of 0.84 μeq/L-yr during 1978 to 2004 (Driscoll et al. 2007a). Since acidity and sulfate both influence mercury methylation and accumulation by fish, our expectation is that mercury concentrations in fish should be declining. Natural resource managers, scientists, and policy makers are interested in whether this is in fact occurring.

Lake selection and data collection

We collected fish for trend analysis from 19 lakes across New York State. Yellow perch were collected from 12 Adirondack lakes that had previously been sampled in earlier studies (Simonin et al. 1994; Driscoll et al. 1994). Collection methods were similar to the earlier studies, and fish were processed as described in the previous section of this report. Fish tissue preparation and analytical procedures in the earlier studies were comparable to the current study and are discussed in Simonin et al. (1994). Where possible, we collected 20 yellow perch for the trend analyses and attempted to replicate the same size range of fish as in the earlier studies. Netting efforts from several lakes did not result in enough fish to evaluate trends, so these lakes were dropped from the trend analysis. Several lakes were also found to be private with no public access, so these lakes were dropped. Lakes that were not included were Crane Pond, Harris Lake, Middle Stoner Lake, Moshier Lake, Spy Lake and Vandenberg Pond.

NYSDEC maintains and updates a large database of fish mercury concentrations dating back to 1970, and we selected seven waters in other parts of the State where adequate data existed to compare with data from this strategic monitoring effort. The species that we used to measure trends from this group of waters were yellow perch (two lakes), walleye (three lakes), largemouth bass (two lakes) and smallmouth bass (three lakes).

Results

Adirondack yellow perch trends

An average of 15 yellow perch (range = 7 to 20 fish) were collected from each of the 12 Adirondack lakes in the trend analysis (fish from Rondaxe Lake were collected and analyzed by NYSDEC in 2000). Data were analyzed using analysis of covariance for each lake to determine if there was a significant difference in the relationship between length and mercury concentration between the two years. Fish that were outside of the length range of the other year were generally excluded from the comparison. Half of the lakes showed no significant difference in comparing the two years of data (Table 9). In four of the 12 lakes, there was a significant decline in mercury concentrations in the recent fish samples. In two lakes, there was a significant increase in mercury concentrations.

When we calculated the mercury concentrations in standard-sized yellow perch (229 mm, 9 in.) from each lake during each of the survey years, we found an overall decrease in mercury concentration in nine out of 12 lakes (Table 9), with an average decrease of 81 ng/g. This amounts to an overall 16% decline in mercury concentration in standard size yellow perch. The lake with the lowest mercury concentration in standard size yellow perch was Lake Adirondack, which was also the lake with the lowest mercury concentrations in the study by Simonin et al. (1994). The lakes with higher mercury levels also were the lakes with high levels in earlier studies, although there was some variability. Figure 10 shows the change in mercury concentration in standard size yellow perch in each lake. The four lakes that had the highest mercury concentrations in the earlier studies all showed lower mercury concentrations in the recent survey. Big Moose Lake and Ferris Lake had the largest declines in mercury concentrations in standard sized yellow perch; and these lakes were also the two lakes with the highest mercury levels in the earlier studies.

Table 9. Mercury concentrations (ng/g wet weight) (with 95% confidence limits) predicted in standard-size (229 mm, 9 in.) yellow perch from Adirondack lakes sampled during 1987 or 1992 compared with 2003 – 2005 data. All 1987 data are from Simonin et al. (1994) and 1992 data are from Blette et al. (1995). (Significant Difference is based on Analysis of Covariance; ns = not significant; $p > 0.05$)

LAKE	**Year**	**n**	**Older Hg Conc in Std Size YP**	**2003 -05 n**	**New Hg in Std Size YP**	**Change in Hg (ng/g)**	**Significant Difference**
Adirondack L	1987	30	82 (65-104)	20	158 (140-180)	76	increase
Big Moose L	1992	25	1,022 (761-1,371)	10	671 (544-828)	-351	decrease
Chase L	1987	26	330* (251-434)	16	364* (296-447)	34	ns
Fall L	1987	17	488 (376-633)	20	407 (329-505)	-81	ns
Ferris L	1987	33	841 (496-1,425)	20	580 (490-686)	-261	decrease
Francis L	1992	30	682 (583-799)	10	592 (519-675)	-90	ns
Kings Flow	1987	28	339* (282-407)	20	204* (179-232)	-135	decrease
Limekiln L	1992	31	307** (226-416)	10	284** (236-342)	-23	ns
Rondaxe L	1992	30	412 (356-478)	10	530*** (434-646)	118	increase
Round P	1987	28	409 (359-466)	20	392 (359-428)	-17	ns
Sunday L	1992	30	817** (706-945)	18	687** (573-825)	-130	ns
West Caroga L	1987	24	410 (339-496)	7	313 (211-465)	-97	decrease

** Std-Size YP = 200 mm*
*** Std-Size YP = 180 mm*
**** Fish collected in 2000*

Water chemistry data collected in 1987 or 1992 from the Adirondack study lakes had higher sulfate levels and lower pH in all lakes and lower ANC levels in 10 of the 12 lakes when compared to recent samples. Overall there was a 26.7% average decrease in sulfate concentration in the 12 lakes. The amount of change in water chemistry parameters did not in all cases coincide with equal changes in mercury in yellow perch, although overall the changes were consistent with expectations.

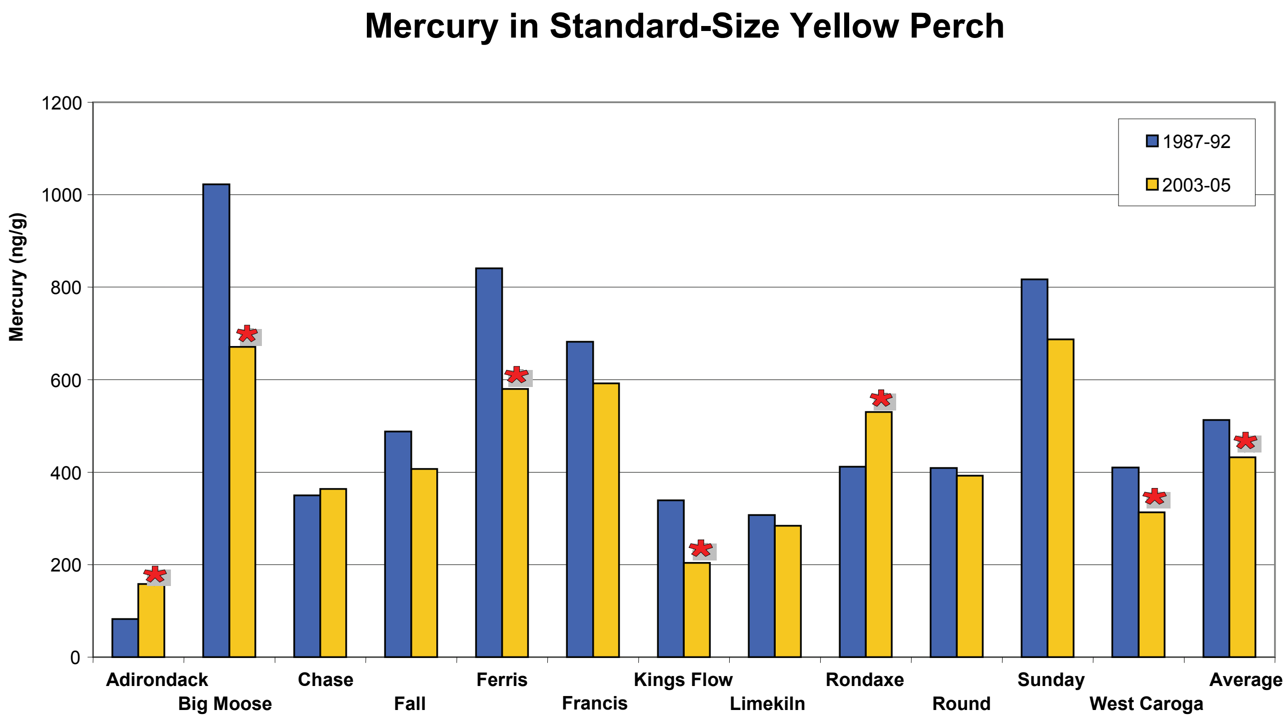

Figure 10. Change in mercury concentrations (ng/g wet weight) in standard-size yellow perch in 12 Adirondack lakes from 1987 or 1992 compared to 2003-05 (* indicates a significant difference, $p < 0.05$).

Trends in fish mercury levels in other NY lakes

Seven other lakes in this strategic monitoring project had been surveyed previously, and fish mercury data were available for comparison with the recent data. The number of fish sampled in the older monitoring efforts was in many cases limited, and required us to combine several years of data in order to get an adequate number of samples of a particular fish species (Table 10). Largemouth bass trend analysis was possible in Silver Lake and Wappinger Lake, and in both cases showed a significant decrease in mercury concentrations using length as a covariate. Smallmouth bass comparisons were possible in three lakes: Cranberry, Delta, and Honeoye. Two of these lakes had significantly lower mercury concentrations today than in the older samples, but Delta Lake had no statistically significant difference in the two groups of data. In yellow perch Delta Lake showed a small but significant increase in mercury concentrations, while Oneida Lake yellow perch showed no significant change. Walleye trend analysis was possible in

Table 10. Mercury concentrations (ng/g wet weight) (with 95% confidence limits) predicted in standard-size yellow perch (229 mm, 9 in.), smallmouth or largemouth bass (356 mm, 14 in.) and walleye (457 mm, 18 in.) from New York State lakes sampled from 1977 to 1994 compared with 2003 – 2005 data — Historic data are from NYSDEC mercury database. (significant difference is based on Analysis of Covariance; ns = not significant; p > 0.05)

LAKE	Species	Year	n	Hg in Std Size Fish	03-05 n	New Hg in Std Size Fish	Change in Hg (ng/g)	Significant Difference
Cranberry L	SMB	1993	11	1,456 (1,271-1,668)	13	842 (689-1,030)	-614	decrease
Delta L	SMB	1988, 1994	5	477 (388-587)	5	523 (472-578)	46	ns
Delta L	WEYE	1988, 1994	13	475* (369-611)	4	815* (556-1,194)	340	increase
Delta L	YP	1988, 1994	8	222 (184-268)	10	276 (218-350)	54	increase
Great Sacandaga L	WEYE	1978, 1982	4	1,236 (959-1,593)	8	1,897 (1,475-2,439)	661	increase
Honeoye L	SMB	1983, 1984	3	438* (370-519)	5	299* (243-367)	-139	decrease
Oneida L	WEYE	1979, 1981	5	403* (334-486)	10	391* (312-489)	-12	ns
Oneida L	YP	1979, 1981	5	190 (99-365)	10	144 (74-278)	-46	ns
Silver L	LMB	1983, 1990	4	415 (346-497)	10	330 (293-373)	-85	decrease
Wappinger L	LMB	1977, 1981	5	352** (302-410)	7	155** (86-280)	-197	decrease

** Std Size = 400 mm*
*** Std Size = 300 mm*

Delta and Oneida Lakes and Great Sacandaga Reservoir. Both Delta Lake and Great Sacandaga Reservoir walleye had higher mercury concentrations in the recent survey than in the older data, while Oneida Lake walleye were not significantly different from the older data.

Water chemistry data were not available for the older fish sample dates, so comparisons of fish mercury levels with water chemistry changes were not possible. Water chemistry data for the recent monitoring efforts are reported in Appendix C.

Discussion

In comparing the 1987-92 fish mercury data with the 2003-05 data, we observed statistically significant decreases or no change in mercury in fish from most of our study lakes. We also observed considerable variability in individual lake response. Both of these observations are consistent with other studies (Hrabik and Watras 2002; Hutcheson et al. 2006). We also acknowledge that in some lakes, the number of fish sampled may have been too small to be able to detect a difference between the two sample periods. In Massachusetts, Hutcheson et al. (2006) reported that mercury concentrations in yellow perch from eight lakes decreased an average of 15.4% from 1999 to 2004. Although this was a shorter time period, it compares favorably with our observed average of 16% decrease in mercury concentrations over the past 15-20 years for Adirondack yellow perch. Hutcheson et al. (2006) observed larger decreases in mercury in fish (26% to 62% decline) from northeastern Massachusetts waters downwind from an area where mercury emissions from local point sources were substantially reduced. We did not have specific waters or regions where we expected large changes in fish mercury levels due to specific sources of mercury emissions in our study.

In an earlier study evaluating trends in contaminants, Armstrong and Sloan (1980) reported that mercury concentrations in walleye from Great Sacandaga Lake had increased from 1970 to 1978, and that mercury in largemouth bass from Wappinger Lake had decreased from 1971 to 1977. In our trend analyses for these two waters, we found that these same trends have continued. We observed a 53% increase in mercury levels in Great Sacandaga Lake walleyes (457 mm, 18 in.) when we compared the combined 1978/1982 data with the 2005 data. In Wappinger Lake, we found a 63% decline in mercury concentration in 300 mm largemouth bass. Our more recent data are after more than 20 years time, and we cannot say when the changes in mercury occurred. However, it is a concern that the walleye mercury concentrations in Great Sacandaga Lake have continued to increase. Armstrong and Sloan (1980) attributed increases in mercury concentrations in Adirondack waters to increasing acidity due to acidic deposition. However, many Adirondack waters are now decreasing in acidity due to reductions in acidic deposition, and leading us to expect reductions in fish mercury concentrations. We do not have long-term water chemistry data for Great Sacandaga Reservoir, but the data from our study indicate that it is neutral in its acidity status (pH = 7.5).

As discussed above, mercury emissions have been reduced substantially in recent years as a result of the Clean Air Act Amendments of 1990. Engstrom and Swain (1997) reported that for Minnesota lakes, mercury deposition peaked in the 1960s and 1970s. They also report that global emissions have not been reduced and that decreased input to their study lakes was most likely due to regional reductions in emissions. Monitoring of mercury deposition in the Adirondack region and the northeast in general has been limited, and a recent study was not able to detect a significant reduction in mercury deposition in northeastern North America over the 1996-2002 time- period (VanArsdale et al. 2005). The first year of complete data from the only New York site (Huntington Forest, Hamilton County) was 2000. It is not clear whether or not earlier reductions (prior to 1996) occurred in mercury deposition, although it is possible. Removing mercury from batteries, paint, fungicides, and other products has reduced mercury in the environment, and chlor-alkali plants have been replaced by other industrial processes that do not use mercury. However, mercury is a global pollutant, and mercury emissions in other countries continue to be substantial.

The variability in the amount of change in fish mercury concentrations among our lakes is certainly in part due to the variability in lake physical and chemical characteristics. Appendices C and D report the summer water chemistry data and wetland information, and it is clear that there is wide variability among lakes in most of the parameters. In terms of lake chemistry changes over time, Driscoll et al. (2003) showed an approximately 30% decrease in sulfate concentrations in Adirondack lakes over the 1982 to 2000 time period. When we compared the recent sulfate data in our Adirondack yellow perch lakes with water chemistry data collected 12 to 17 years prior, we observed an average decrease of 28% in sulfate concentrations. This reduction in sulfate would likely lead to less methylmercury available for uptake by the foodchain. In a recent study where sulfate was added to a wetland, the result was increased methylmercury production (Jeremiason et al. 2006). This relationship with sulfate is due in large part to the need for sulfate reducing bacteria in the conversion of mercury into biologically available methylmercury. Comparing the two sampling periods in our study, we also found that pH increased in all 12 lakes. As discussed in the water chemistry section of this report we observed a strong relationship between lower fish mercury concentrations and higher pH levels.

In summary, the downward trends we observed in mercury concentrations in fish are small but encouraging. Our study demonstrates that mercury is widespread, and the more lakes that we survey, the more we will find mercury levels of concern in the large predatory fish. The connections between mercury emission reductions changes in mercury deposition and reductions in fish mercury concentrations are not clearly evident from our data. Larger reductions in emissions and better monitoring of deposition may be necessary to document the relationship between emissions and future mercury levels in fish.

PREDICTIVE MODEL TESTING AND REFINEMENT

Methods

In an earlier study by Simonin et al. (1994), a simple model was developed to predict mercury levels in yellow perch in the Adirondacks:

$$Hg\ (\mu g/g)\ \text{in yellow perch} = 1.754 - 0.315\ (\text{AE pH}) + 0.004\ (\text{length in mm})$$

This model was tested as part of this current project, both on a statewide basis and for the Adirondack/ Catskill Park regions. In addition, similar lake chemistry - fish length models were developed for yellow perch, smallmouth bass, largemouth bass and walleye using data from the current project.

Two methods were used to evaluate the relationship between fish mercury concentrations and lake variables. In the first method, the Standard Size Method, a single mercury concentration for each species was calculated for each lake based on standardized lengths. Standard lengths were calculated using the overall average lengths for each fish species in the full dataset. We then plotted for each individual lake the species-specific regression lines of mercury concentration against length. From each regression line we determined the predicted mercury concentration at the standard length for each fish species in the lakes where at least three individuals were collected. We used this predicted mercury concentration even in the few cases where the regression relationship was not significant, because this standardized value was the best estimate of fish mercury concentration comparable across multiple lakes. In this method, for each species each lake was represented by one line of data which included all the water chemistry and watershed variables

In the second method, the All Data Method, all of the individual fish mercury concentrations along with the fish length and weight data were used. In this method as many as 20 individual fish of one species were included using the same individual lake water chemistry and watershed variables. This method was somewhat biased toward lakes with a greater number of fish samples. In both methods the various water chemistry (Appendix C) and physical/watershed variables (Appendix D) were evaluated to determine the relationship to fish mercury concentration. We used SAS (SAS Institute 1998) to conduct multivariate analyses, stepwise regressions and Pearson correlation coefficient determinations of the data.

Results

Using the model developed by Simonin et al. (1994) we calculated a predicted mercury concentration for each lake where yellow perch were collected. We used a 229 mm (9 in.) standard length for each lake (n = 103) and the air equilibrated pH data to calculate a predicted concentration. When these predicted model values were then compared with 229 mm (9 in.) standard yellow perch concentration calculated from the recent data, we found that the simple model correctly predicted in 83% of the study lakes whether mercury concentrations were greater than 500 ng/g in these standard size fish. However, in 26% of the cases the predicted mercury concentration was over 200 ng/g different (+ or -) from the actual concentration for a 229 mm (9 in.) yellow perch.

When we applied the yellow perch model to the Adirondack/ Catskill Parks subset (n = 52 lakes) of data, we observed similar results of good agreement. The predicted mercury concentration in 229 mm (9 in.) perch was correctly predicted as above or below the 500 ng/g threshold in 73% of the lakes. If we used 1,000 ng/g (the FDA marketplace standard) as the threshold 94% of the lakes were correctly predicted as above or below this level.

Again using the "Standard Size Method" and the statewide dataset, the best two-variable model for predicting mercury concentration (ng/g) in 356 mm (14 in.) smallmouth bass included log of specific conductance and lake area. For 356 mm (14 in.) largemouth bass, the best model included air equilibrated pH and chlorophyll-a concentration. The best two-variable model for both 229 mm (9 in.) yellow perch and 457 mm (18 in.) walleye included air equilibrated pH and the area of contiguous wetlands. The model equations are as follows:

Hg (ng/g) in 356 mm (14 in.) smallmouth bass = 1581 – 513(log sp. conductance) + 0.03 (lake area)

($R^2 = 0.59$, n = 34 lakes)

(std. error for log sp. conductance = 75.3, for lake area = 0.011; and slopes were sig., $p<0.008$)

Hg (ng/g) in 356 mm (14 in.) largemouth bass = 2350 – 227 (AEpH) – 11.9 (chlorophyll-a)

($R^2 = 0.53$, n = 37 lakes)

(std. error for AEpH = 45.07, for chlorophyll-a = 3.69; and slopes were sig., $p < 0.003$)

Hg (ng/g) in 229 mm (9 in.) yellow perch = 2153 – 251 (AE pH) + 0.47 (area of contiguous wetlands)
(R^2 = 0.60, n = 61 lakes)
(std. error for AEpH = 29.88, for area of contig. wetlands = 0.09; and slopes were sig., $p < 0.0001$)

Hg (ng/g) in 457 mm (18 in.) walleye = 4792 - 548 (AE pH) + 0.66 (area of contiguous wetlands)
(R^2 = 0.72, n = 15 lakes)
(std. error for AEpH = 133.5, for area of contig. wetlands = 0.17; and slopes were sig., $p < 0.002$)

Using the stepwise regression procedure in SAS, the best two-variable model for predicting mercury in 229 mm (9 in.) yellow perch in the Adirondack and Catskill Park regions included total monomeric aluminum and the area of contiguous wetlands (n = 31, R^2 = 0.58). The best two-variable model for predicting mercury in 356 mm (14 in.) smallmouth bass included nitrate and silica (n = 20, R^2 = 0.41). Although only six study lakes had largemouth bass and wetlands data, a two-variable model included lab pH and ammonium (n = 6, R^2 = 0.91). Lower numbers of lakes with walleye and wetland data limited our ability to create a multivariate model for this species.

Similar results were observed using all of the individual fish data (All Data Method) in the statistical analyses. In this case fish length (mm) was one of the top two variables related to mercury concentration in three of the four species (r = 0.38 to 0.68). In walleye log of the methyl mercury concentration in the water was the single variable best correlated with fish mercury concentration (r = 0.48).

Using the "All Data Method" to determine the best two variable predictive models for each of the four fish species, we used the SAS REG Stepwise procedure to determine the following equations:

Hg (µg/g) in smallmouth bass = 0.192 – 0.462(log sp. conductance) + 0.004 (length)
(R^2 = 0.52, n = 544 samples, 73 lakes)
(std. error for log sp. conductance = 0.030, for length = 0.0002; and slopes were sig., $p < 0.0001$)

Hg (µg/g) in largemouth bass = - 0.049 – 0.322 (log sp. conductance) + 0.003 (length)
(R^2 = 0.63, n = 373 samples, 75 lakes)
(std. error for log sp. conductance = 0.025, for length = 0.0002; and slopes were sig., $p < 0.0001$)

Hg (μg/g) in yellow perch = 1.156 – 0.227 (AE pH) + 0.004 (length)

(R^2 = 0.46, n = 1074 samples, 113 lakes)

(std. error for AEpH = 0.009, for length = 0.0002; and slopes were sig., $p < 0.0001$)

Hg (μg/g) in walleye = 1.946 + 1.139 (log methyl Hg) + 0.0004 (weight)

(R^2 = 0.41, n = 215 samples, 37 lakes)

(std. error for log methyl Hg = 0.104, for weight = 0.00006; and slopes were sig., $p < 0.0001$)

If the yellow perch model above is expanded, the third variable is 'area (ha) of contiguous wetlands' and R^2 increases to 0.61. This is a significant increase in ability to explain the variability in the data. Adding a third variable to the other predictive models resulted in much smaller changes in R^2. The three-variable equation for yellow perch is:

Hg (μg/g) in yellow perch = 1.466 – 0.263(AEpH) + 0.0005(area of contiguous wetlands) + 0.003(length)

(R^2 = 0.61, n = 672 samples, 70 lakes)

(std. error for AEpH = 0.010, for area of contiguous wetlands = 0.00003, for length = 0.0002; and slopes were significant, $p< 0.0001$)

Using the "All Data Method" for just the Adirondack/Catskill data, we found that length was again the first variable identified in the stepwise regression procedure with log of the total dissolved aluminum the second variable of importance. The resulting equation in this case is:

Hg (μg/g) in yellow perch = -1.280 + 0.340 (log total dissolved Al) + 0.005 (length)

(R^2 = 0.43, n = 372 samples, 36 lakes)

(std. error for log total dissolved Al = 0.033, for length = 0.0004; and slopes were sig., $p<0.0001$)

Discussion

The predictive models obtained in this study are in agreement with the relationships observed in Chapter 3 and were in most cases expected. For example, using the "Standard Size Method,"one of the acidity variables was the first variable identified in the models developed for each species. This has been observed by other researchers (Cope et al. 1990; Grieb et al. 1990; Driscoll et al. 1994) and was expected to be important. In several models, AEpH was the first variable identified as important in the model, however specific conductance was most important in several cases. Specific conductance is associated with acidity, and is low when calcium, magnesium, potassium and other cations are low; it is therefore not unexpected that this variable is associated with mercury in fish. The area of contiguous wetlands was similarly expected to be important, because methyl mercury is produced in wetlands. It was not expected that wetlands would be more important for yellow perch and walleye than for other fish species. The importance of nitrate and silica in the Adirondack/Catskill smallmouth bass model is interesting and needs further investigation.

The reason why mercury or methyl mercury concentrations in the water were not better associated with mercury in the fish may have been partly due to the complex nature of mercury methylation and movement through aquatic ecosystems (Loukmas et al. 2006; Driscoll et al. 2007b). An additional source of variability in our mercury-water data is due to our use of one surface water sample to characterize each lake. Mercury and methyl mercury in a lake may be concentrated in certain areas and not evenly distributed throughout the water. Both biotic and abiotic factors are important in determining the availability of mercury to bioaccumulate up the food chain. These detailed studies were beyond the scope of our project.

Predictive models can be important tools in the wise use of our natural resources. They can be used effectively to predict whether or not certain untested lakes or ponds may have fish with high mercury concentrations. Since acidity of the water is strongly correlated with mercury concentrations in fish, a relatively easy measurement of lake pH, along with knowledge of fish species present, amount of wetlands bordering the lake and knowledge of the presence or absence of an outlet dam, would be very useful in predicting mercury concentrations in the fish. Natural resource managers and fishermen can use this information to identify lakes and ponds where fish mercury levels may be high. On a statewide basis, the best two-variable predictive models from our study for three of the four fish species (yellow perch, smallmouth bass and largemouth bass) included an acidity variable and length of the fish. Air-equilibrated pH, ANC, and specific conductivity are generally auto-correlated and can be considered acidity variables (see Section 3). The length of the fish is a surrogate for age, or length of time for mercury uptake; therefore, higher mercury concentrations would be expected with older/larger fish. Our best two-variable model for walleye included log methyl mercury and weight, which are related to acidity and length, respectively.

The model developed for yellow perch by Simonin et al. (1994) on data from 12 Adirondack lakes was very similar to the model developed using statewide yellow perch data from the current project (n = 113 lakes). Using only the Adirondack/ Catskill Park regions, yellow perch data resulted in a predictive model that included total monomeric aluminum and area of contiguous wetlands variables not measured by the Simonin et al. (1994) study. Water chemistry measurements of monomeric aluminum and methyl mercury are expensive, and not commonly done, but in general, lake acidity still is a viable inexpensive alternative.

Acidic deposition has resulted in acidified surface waters in the Adirondacks, Catskills, and other sensitive areas. Sulfur-reducing bacteria responsible for mercury methylation are stimulated by increases in biologically available sulfur deposited on a watershed (Jeremiason et al. 2006). Because of the close relationship between lake acidity variables and fish mercury concentrations, it is hoped that as sulfur deposition decreases (Driscoll et al. 2003), the mercury concentrations in fish also decrease.

Our study did not measure or evaluate mercury deposition as a possible variable between lake sites. Differences in mercury deposition occur across New York State and are predicted by computer models (Miller et al. 2005). Although mercury deposition has been directly tied to mercury concentrations in fish (Hammerschmidt and Fitzgerald 2006), water chemistry variables and wetlands also play an important role. In our study, lakes we were not aware of any local sources of mercury emissions that would impact our findings.

Lakes differ from one another in physical, chemical, and biological aspects. It appears that there is no one variable that determines the bioavailability of mercury to fish in all situations. However, several variables were found in this and other studies to be important in predicting whether mercury concentrations may be high. Acidity of the water appears to be a key variable and should be considered important in most cases. Naturally acidic wetlands are good environments for the methylation of mercury, and higher DOC levels in these systems allow for better transport of methyl mercury to the lake itself. Other parameters that co-vary with acidity (pH) include ANC, calcium, magnesium, sodium, potassium, aluminum, and conductivity. Multiple factors that contribute to the higher mercury levels in the Adirondack/Catskill Park regions include acidic lakes in part due to acidic deposition, low productivity oligotrophic lakes, and abundant wetlands (in the Adirondacks) with higher DOC levels.

FISH CONSUMPTION ADVICE

Methods

Criteria to protect the health of human consumers of mercury-contaminated fish have been developed by the EPA and the United States Food and Drug Administration (FDA). These criteria provide the comparative values necessary for evaluation of potential human health effects. The FDA criterion is 1000 ng/g (1 ppm), which was determined to be the federal action level for commercially sold fish (i.e., FDA can legally enforce this criterion by restricting sale of contaminated fish, if warranted). In selecting this criterion, FDA considered a variety of issues including risks to consumers, economics, and adequate food supply. In contrast, EPA recommends issuing consumption advice when fish mercury concentrations meet or exceed 300 ng/g (USEPA 2001). The EPA criterion was established as a risk-based consumption guideline based on human health endpoints.

In New York State, NYSDOH issues advisories on eating sportfish (fish caught by anglers, not for commercial sale). NYSDOH considers FDA marketplace standards, potential health risks, and many other factors when setting fish advisories. The balance between the benefits and risks of eating fish with methyl mercury may be different for at-risk populations (women of childbearing age, infants and young children) versus the general population. NYSDOH takes these differences into account during the fish advisory setting process.

The following are some important features of the NYSDOH advisories and advisory-setting process:

1. NYSDOH issues a general advisory to eat no more than one meal per week of fish from all New York State fresh waters because some chemicals are commonly found in New York State fish (e.g., mercury and PCBs), fish from all waters have not been tested, and fish may contain unidentified contaminants (e.g., polybrominated diphenyl ethers).

2. When reviewing fish contaminant data to determine fish advisories for a specific water body or region, the NYSDOH considers the following:

- fish contaminant levels, including fish sampling characteristics (e.g., number and type of samples, species, age, length, percent lipid, sample location, etc.) and patterns of contamination
- health risks

- populations at greater potential risk
- the FDA marketplace standard
- health benefits
- risk communication issues

3. NYSDOH recommends that infants, children under the age of 15, and women of childbearing age EAT NO fish at all from waters with specific advisories. Thus NYSDOH provides protective advice to a high-risk population where data suggest contamination but without needing data for all species.

Project staff annually provided available fish mercury data to NYSDOH for review, and fish consumption advice based on project data was issued in 2004, 2005, and 2006.

Results

The FDA marketplace standard of 1,000 ng/g (1 ppm) for mercury levels in fish was exceeded in 263 of the study samples (10% of all analyzed samples) and included six species from 66 lakes. Smallmouth bass most frequently exceeded this level (n = 91), followed by yellow perch (n=52), largemouth bass (n=50), walleye (n = 44), chain pickerel (n = 15), and northern pike (n = 11). The species with the highest proportion of species-specific samples above this criterion was northern pike (26%), followed by chain pickerel (20%), walleye (17%), smallmouth bass (16%), largemouth bass (9%), and yellow perch (5%). The lakes with the highest number of samples that exceeded this tolerance level were Meacham Lake (n = 16), Tupper Lake (n = 13), and North Lake (n = 11). Meacham Lake and North Lake were the only lakes where all analyzed samples exceeded 1,000 ng/g. Based on the study data, NYSDOH issued advisories for high mercury levels in six fish species from 54 study lakes (plus two lakes connected to study lakes, Figure 11, Appendix E). The majority of these lakes (41) were located in the Adirondack region. Along with previously issued advisories, there are now 84 lakes and three rivers with mercury-related fish consumption advice (NYSDOH 2007).

No specific fish consumption advisories were issued for 77 waters in this study. Appendix F lists waters and fish species where at least five fish were tested and none of them exceeded 1,000 ng/g mercury; no NYSDOH specific fish advisories apply. We provide Appendix F to identify waters where data

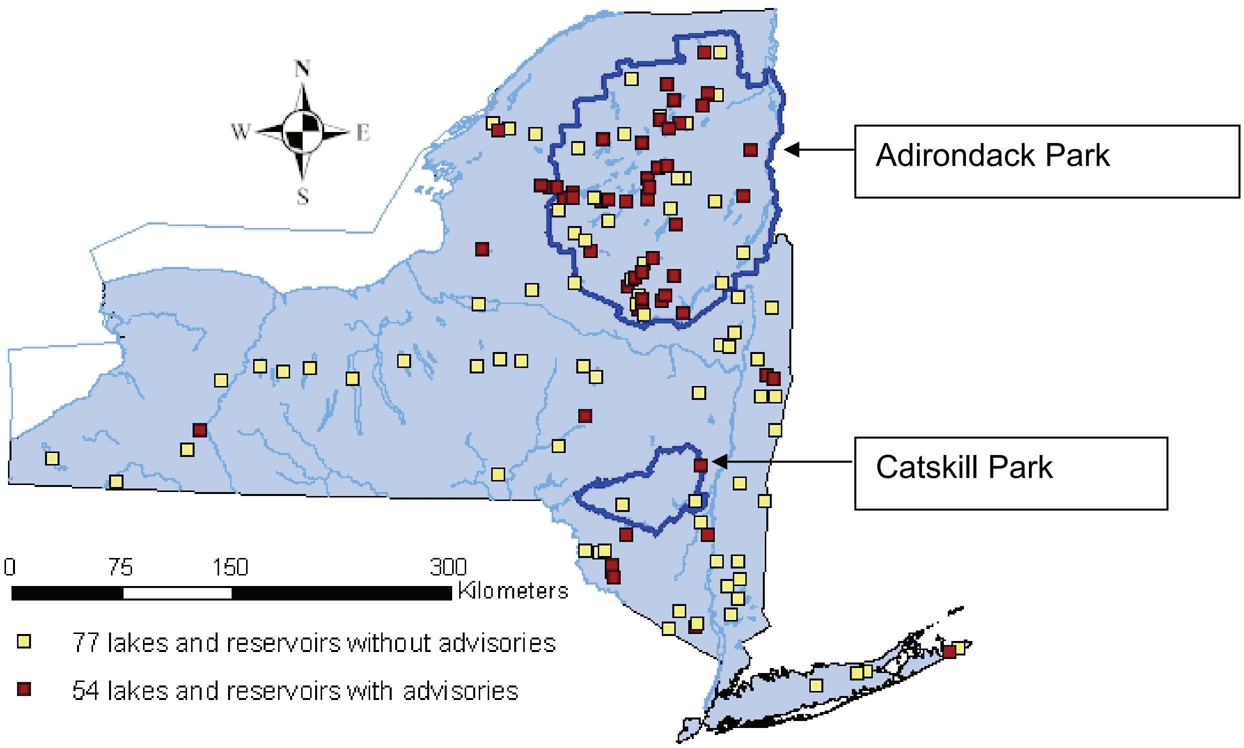

Figure 11. Map of New York State showing locations of study lakes and resulting fish consumption advisories (from NYSDOH 2007)

indicate that fish have lower mercury levels than waters with specific fish advisories. However, we did not analyze fish for other contaminants as part of this study. For all fresh waters in New York State, the NYSDOH statewide advisory to eat no more than one meal per week remains in effect for fish from these unlisted waters; and regional advisories apply to all waters in the Adirondack and Catskill regions.

The EPA criterion of 300 ng/g was met or exceeded in 1,630 samples (62% of all analyzed samples) and included eight species from 128 lakes. Yellow perch (the most-sampled species) had the highest number of samples exceeding this level (n = 483), followed by smallmouth bass (n = 458), largemouth bass (n = 377), walleye (n = 210), chain pickerel (n = 59), northern pike (n = 34), white perch (n = 8), and muskellunge (n = 1). Of the six most common species, the highest proportion of species-specific samples above this criterion were northern pike and walleye (81%), followed by smallmouth bass (80%), chain pickerel (79%), largemouth bass (70%), and yellow perch (44%). There were 20 lakes where all analyzed samples were above 300 ng/g; 16 of those were located in the Adirondacks (Appendix B).

Because of the high prevalence of elevated mercury concentrations documented in large, predatory fish from the Adirondack (from this study and previous NYSDEC monitoring) and Catskill Mountain regions (Loukmas and Skinner 2005, Loukmas et al. 2006, see Section 2), NYSDOH issued regional consumption advice for these areas in 2005 (NYSDOH 2005). Specifically, the advice was for children under the age of 15 and women of childbearing age to eat no chain pickerel, northern pike, smallmouth and largemouth bass, walleye, and yellow perch longer than 254 mm (10 in.). The general statewide advice of eat no more than one meal per week remains in effect for other fish caught in the Adirondack and Catskill Park regions.

Discussion

This project did not seek to evaluate the rationale or basis for fish consumption advice. Our objective was to add to the volume of data available to make informed decisions regarding use and management of New York State fish populations, and also to provide data for fish advisory assessment. While the NYSDEC provides fish contaminant data and consults with the NYSDOH regarding data interpretation, the NYSDOH takes the lead in deriving fish advisories in New York State. The NYSDEC also assists the NYSDOH in publicizing the list of waters and fish species where fish consumption advisories have been issued. Our hope is that a better understanding of mercury concentrations in the environment (through this and similar studies) will lead to policy decisions resulting in lower mercury concentrations in fish and wildlife and fewer numbers of human fish consumption advisories.

CONCLUSIONS

One of the major outcomes of this research/monitoring project was the creation of a more adequate baseline of mercury data from a relatively large number of lakes and ponds in NYS that had never been surveyed. The expansion of this baseline, which included a large variety of lake types distributed across all of NYS focusing on four key fish species, allowed for the development of preliminary models to predict mercury concentrations in selected species by lake characteristics. Furthermore, these data, shared with the NYSDOH, provided a more informed database for determining the need for fish consumption advisories for human health. The magnitude of the mercury problem is indicated by the large number of lakes that contained fish with high mercury levels. Clearly there is a need to try to reduce mercury levels in the environment and in particular in fish commonly consumed by the general sportfishing public. Educational outreach should also be expanded to inform anglers of the advisories and encourage them to follow and stay informed regarding new additions or changes in fish consumption advisories.

The following conclusions are drawn from this project to provide a better understanding of mercury in the environment:

- As other studies have shown, the larger predatory fish had higher mercury concentrations than the smaller fish.
- Fish from acidic lakes had the highest mercury concentrations.
- Important variables correlated with high mercury concentrations differed among fish species, but most often included pH, conductivity, ANC or base cation concentrations. Other variables of importance for a lake included mercury concentration of the water, the presence of an outlet dam, and the amount of contiguous wetlands.
- Mercury in certain game fish species is widespread in New York State and was found in all fish samples.
- Higher mercury concentrations were found in fish from the Adirondack and Catskill Park regions than in fish from other regions of the State.
- The mercury concentration to fish length relationship varied among lakes, with a stronger relationship observed in the more acidic lakes.

- Limited data on mercury trends in fish over time indicated an average decline of 16% in yellow perch mercury concentration over the past 15 years from 12 Adirondack lakes. However, there was considerable lake to lake variability.
- Mercury is the most prevalent fish contaminant of concern in New York State, and anglers should regularly check the latest consumption advisories published yearly by the NYSDOH.

REFERENCES

Abernathy, A. R. and P. M. Cumbie. 1977. Mercury accumulation by largemouth bass (*Micropterus salmoides*) in recently impounded reservoirs. Bulletin of Environmental Contamination and Toxicology 17: 595-602.

Analytical Software. 2003. Statistix® 8. Tallahassee, FL. USA.

APA. 2001. Shared Adirondack Park Geographic Information CD-ROM. Ver. 1. Adirondack Park Agency, Raybrook, NY.

APA. 2002. The St. Lawrence Part 2 Geographic Information CD-ROM. Adirondack Park Agency, Raybrook, NY.

Armstrong, R. W. and R. J. Sloan. 1980. Trends in levels of several known chemical contaminants in fish from New York State waters. New York State Department of Environmental Conservation Technical Report 80-2, Albany, NY.

Blette, V. L., R. K. Munson, S. A. Gherini, C. T. Driscoll, and C. L. Schofield. 1995. Mercury in Adirondack fish and surface waters. Research Report prepared for Empire State Electric Energy Research Corporation, NY.

Bloom, N. S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Canadian Journal of Fisheries and Aquatic Sciences 49: 1010-1017.

Burns, D. A., M. R. McHale, C. T. Driscoll, and K. M. Roy. 2006. Response of surface water chemistry to reduced levels of acid precipitation: comparison of trends in two regions of New York, USA. Hydrological Processes 20: 1611-1627.

Chen, C. Y. and C. L. Folt. 2005. High plankton densities reduce mercury biomagnification. Environmental Science and Technology 39: 115-121.

Cope, W. G., J. G. Wiener and R. G. Rada. 1990. Mercury accumulations in yellow perch in Wisconsin seepage lakes: relation to lake characteristics. Environmental Toxicology and Chemistry 9: 931-940.

Driscoll, C. T., V. Blette, C. Yan, C. L. Schofield, R. Munson and J. Holsapple. 1995. The role of dissolved organic carbon in the chemistry and bioavailability of mercury in remote Adirondack lakes. Water, Air, and Soil Pollution 80: 499-508.

Driscoll, C. T., K. M. Driscoll, K. M. Roy and J. Dukett. 2007a. Changes in the chemistry of lakes in the Adirondack region of New York following declines in acidic deposition. Applied Geochemistry 22:1181-1188.

Driscoll, C. T., K. M. Driscoll, K. M. Roy and M. J. Mitchell. 2003. Chemical response of lakes in the Adirondack region of New York to declines in acidic deposition. Environmental Science and Technology 37:2036-2042.

Driscoll, C. T., Y.-J. Han, C. Y. Chen, D. C. Evers, K. F. Lambert, T. M. Holsen, N. C. Kamman, and R. K. Munson. 2007b. Mercury contamination in forest and freshwater ecosystems in the Northeastern United States. BioScience 57:17-28.

Driscoll, C. T., C. Yan, C. L. Schofield, R. Munson, and J. Holsapple. 1994. The mercury cycle and fish in the Adirondack lakes. Environmental Science and Technology 28:136A-143A.

Drysdale, C., N. M. Burgess, A. D'Entremont, J. Carter and G. Brun. 2005. Mercury in brook trout, white perch and yellow perch in Kejimkujik National Park. in N. J. O'Driscoll, A. N. Rencz, and D. R. S. Lean, eds. Mercury Cycling in a Wetland-Dominated Ecosystem: A Multidisciplinary Study. SETAC Press, Pensacola, FL.

Engstrom, D. R. and E. B. Swain. 1997. Recent declines in atmospheric mercury deposition in the Upper Midwest. Environmental Science and Technology 31:960-967.

Evers, D. C. 2005. Mercury connections: The extent and effects of mercury pollution in northeastern North America. BioDiversity Research Institute. Gorham, Maine. 28 pp.

FWS. 2004. National Wetlands Inventory Data. U. S. Department of Interior, Fish and Wildlife Service, Washington D.C.

Greenfield, B. K., T. R. Hrabik, C. J. Harvey, and S. R. Carpenter. 2001. Predicting mercury levels in yellow perch: use of water chemistry, trophic ecology, and spatial traits. Canadian Journal of Fisheries and Aquatic Sciences 58: 1419-1429.

Greeson, P. E. and G. E. Williams. 1970. Characteristics of New York Lakes, Part 1A - Gazetteer of Lakes, Ponds, and Reservoirs by Counties. U. S. Geological Survey and N. Y. S. Department of Environmental Conservation. 121pp.

Grieb, T. M., C. T. Driscoll, S. P. Gloss, C. L. Schofield, G. L. Bowie, and D. B. Porcella. 1990. Factors affecting mercury accumulation in fish in the upper Michigan peninsula. Environmental Toxicology and Chemistry 9: 919-930.

Hammerschmidt, C. D. and W. F. Fitzgerald. 2006. Methylmercury in freshwater fish linked to atmospheric mercury deposition. Environmental Science and Technology 40: 7764-7770.

Hrabik, T. R. and C. J. Watras. 2002. Recent declines in mercury concentration in a freshwater fishery: isolating the effects of de-acidification and decreased atmospheric mercury deposition in Little Rock Lake. The Science of the Total Environment 297: 229-237.

Hurley J. P., J. M. Benoit, C. L. Babiarz, M. M. Shafer, A. W. Andren, J. R. Sullivan, R. Hammond, and D. A. Webb. 1995. Influences of watershed characteristics on mercury levels in Wisconsin rivers. Environmental Science and Technology 29:1867–1875.

Hutcheson, M. S., J. Rose, C. M. Smith, C. R. West, O. Pamcorbo, J. Sullivan, and B. Eddy. 2006. Massachusetts Fish Tissue Mercury Studies: Long-term Monitoring Results, 1999 - 2004. Massachusetts Department of Environmental Protection Report. 28 pp.

Kamman, N. and D. Engstrom. 2002. Historical and present fluxes of mercury to Vermont and New Hampshire lakes inferred from 210Pb dated sediment cores. Atmospheric Environment 36:1599-1609.

Kamman, N. C., N. M. Burgess, C. T. Driscoll, H. A. Simonin, W. Goodale, J. Linehan, R. Estabrook, M. Hutcheson, A. Major, A. Scheuhammer, and D. A. Scruton. 2005. Mercury in freshwater fish of Northeast North America – a geographic perspective based on fish tissue monitoring databases. Ecotoxicology 14: 163-180.

Jeremiason, J. D., D. R. Engstrom, E. B. Swain, E. A. Nater, B. M. Johnson, J.E. Almendinger, B. A. Monson, and R. K. Kolka. 2006. Sulfate addition increases methylmercury production in an experimental wetland. Environmental Science and Technology 40:3800-3806.

Lorey, P., and C. T. Driscoll. 1999. Historical trends in mercury deposition in Adirondack lakes. Environmental Science and Technology. 33:718-722.

Loukmas, J. J., and L. C. Skinner. 2005. Mercury and organic chemicals in fish from the New York City Reservoir system. Division of Fish, Wildlife, and Marine Resources, Bureau of Habitat Technical Report. New York State Department of Environmental Conservation. 144 pp.

Loukmas, J. J., S. O. Quinn, and J. A. Bloomfield. 2006. Total and methyl mercury in the Neversink Reservoir watershed. Division of Fish, Wildlife, and Marine Resources. Technical Report. New York State Department of Environmental Conservation. 58 pp.

Lynch, J. A., V. C. Bowersox and J. W. Grimm. 2000. Changes in sulfate deposition in eastern USA following implementation of Phase I of Title IV of the Clean Air Act Amendments of 1990. Atmospheric Environment 34:1665-1680.

Miller E. K., A. Vanarsdale, G. J. Keeler, A. Chalmers, L. Poissant, N. C. Kamman, and R. Brulotte. 2005. Estimation and mapping of wet and dry mercury deposition across northeastern North America. Ecotoxicology 14:53-70.

NAS (National Academy of Science). 2000. Toxicological Effects of Methylmercury. National Academy Press, Washington, DC.

NYSDOH. 2003. Chemicals in sportfish and game: health advisories 2003-2004. New York State Department of Health, Troy, NY. 22 pp.

NYSDOH. 2005. Chemicals in sportfish and game: health advisories 2005-2006. New York State Department of Health, Troy, NY. 25 pp.

NYSDOH. 2007. Chemicals in sportfish and game: health advisories 2007-2008. New York State Department of Health, Troy, NY. 27 pp.

Paller, M. H., C. H. Jagoe, H. Bennett, H. A. Brant and, J. A. Bowers. 2004. Influence of methylmercury from tributary streams on mercury levels in Savannah River Asiatic clams. Science of the Total Environment 325: 209-219.

Pickhardt, P. C., C. L. Folt, C. Y. Chen, B. Klaue, and J. D. Blum. 2002. Algal blooms reduce the uptake of toxic methylmercury in freshwater food webs. Proceedings of the National Academy of Sciences 99:4419-4423.

SAS, System for Windows Version 7. 1998. The SAS Institute, Cary, NC. USA.

Schetagne, R. and R. Verdon. 1999a. Mercury in fish of natural lakes of Northern Quebec. in M. Lucotte, R. Schetagne, N. Therien, C. Langlois and A. Tremblay, eds. Mercury in the Biogeochemical Cycle. Springer-Verlag, NY.

Schetagne, R. and R. Verdon. 1999b. Post-impoundment evolution of fish mercury levels at the La Grande Complex, Quebec, Canada (from 1978 to 1996). in M. Lucotte, R. Schetagne, N. Therien, C. Langlois, and A. Tremblay, eds. Mercury in the Biogeochemical Cycle. Springer-Verlag, NY.

Simonin, H. A., S. P. Gloss, C. T. Driscoll, C. L. Schofield, W. A. Kretser, R. W. Karcher, and J. Symula. 1994. Mercury in yellow perch from Adirondack drainage lakes (New York, U.S.). in C. J. Watras and J. W. Huckabee, eds. Mercury Pollution, Integration and Synthesis. Lewis Publishers, Boca Raton, FL.

Simonin, H. A. and M. W. Meyer. 1998. Mercury and other air toxics in the Adirondack region of New York. Environmental Science and Policy 1, 199-209.

Sorensen, J. A., L. W. Kallemeyn, and M. Sudor. 2005. Relationship between mercury accumulation in young-of-the-year yellow perch and water-level fluctuations. Environmental Science and Technology 39: 9237-9243.

St. Louis V.L., J. V. M. Rudd, C. A. Kelly, K. G. Beaty, N. S. Bloom, and R. J. Flett. 1994. Importance of wetlands as sources of methylmercury to boreal forest ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 51:1065–1076.

Sveinsdottir, Y. S. and R. P. Mason. 2005. Factors controlling mercury and methylmercury concentrations in largemouth bass (*Micropterus salmoides*) and other fish from Maryland reservoirs. Archives of Environmental Contamination and Toxicology 49: 528-545.

USEPA. 1997. Mercury Study Report to Congress. EPA-452-R-97-004. Office of Air Quality Planning and Standards and Office of Research and Development, Washington, D.C.

USEPA. 2000. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 1: Fish sampling and analysis, third edition. EPA 823-B-00-007. Office of Water, Washington, D.C.

USEPA. 2001. Water quality criterion for the protection of human health: methylmercury. EPA-823-R-01-001. Office of Science and Technology and Office of Water, Washington, D.C.

USEPA. 2002. Method 1631, Revision E, "Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry." Office of Water, U.S. Environmental Protection Agency (EPA-821-R-02-019).

USEPA. 2004. "Origin of 1 Meal /Week Noncommercial Fish Consumption Rate in National Advisory for Mercury." National Fish and Wildlife Contamination Program, Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

VanArsdale, A., J. Weiss, G. Keeler, E. Miller, G. Boulet, R. Brulotte, and L. Poissant. 2005. Patterns of mercury deposition and concentration in Northeastern North America (1996-2002). Ecotoxicology 14:37-52.

Watras, C. J., K. A. Morrison, A. Kent, N. Price, O. Regnell, C. Eckley, H. Hintelmann, and T. Hubacher. 2005. Sources of methylmercury to a wetland-dominated lake in northern Wisconsin. Environmental Science and Technology 39:4747-4758.

Wiener, J. G., R. E. Martini, T. B. Sheffy, and G. E. Glass. 1990. Factors influencing mercury concentrations in walleyes in northern Wisconsin lakes. Transactions of the American Fisheries Society 119:862-870.

APPENDIX A— Standard procedures for NYSDEC fish handling and processing forms, water sample collection, and clean hands/dirty hands protocol

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

GENERAL FISH COLLECTION PROCEDURES

A. Following data are to be taken on each fish collected:

1. Date collected

2. Species identification (please be explicit enough to enable assigning genus and species)

3. Total length (nearest mm or smallest sub-unit on measuring instrument) and weight (nearest g or smallest sub-unit of weight on weighing instrument)- take all measures as soon as possible with calibrated, protected instruments (e.g. from wind and upsets) and prior to freezing.

4. Method of collection (gill net, hook and line, etc.)

5. Sample location (waterway and nearest prominent identifiable landmark)

6. Sex - fish may be cut enough to allow sexing, but do not eviscerate.

7. Tag number (each specimen to be individually tagged, immediately upon collection, with jaw tag). Must be a unique number, NYSDEC can supply bags and tags, if necessary. For composites of small fish, double bag with tag inside bag. If compositing small fish, try to group similar species together.

Record length and weight as soon as possible after collection and before freezing. Other data are recorded in the field upon collection. An age determination of each fish is optional, but if done, it is recorded in the appropriate "Age" column.

The original of all collection record and continuity of evidence forms shall accompany delivery of fish to the lab. A copy shall be directed to Larry skinner or Ron Sloan. All necessary forms will be supplied by the Bureau of Habitat. Please submit photocopies of topographic maps or good quality navigation charts indicating sampling locations. These records are of immense help to us (and hopefully you) in providing documented location records that are not dependent on memory and/or the same collection crew. In addition, they may be helpful for contaminant source trackdown and control efforts of the Department.

B. Each fish to be wrapped in a plastic bag—the Bureau of Habitat will supply the bags.
C. Groups of fish, by species, to be placed in one large plastic bag per sampling location—the Bureau of Habitat will supply the larger bags.
D. Do not eviscerate.
E. All fish must be kept at a temperature below 45ºF immediately following data processing as soon as possible and must freeze at 0º F + 10º F. Due to occasional freezer failures, daily freezer temperature logs are required.
F. Prior to any delivery of fish, coordinate delivery with, and send copies of the collection records, continuity of evidence forms, and freezer temperature logs, to:

Larry Skinner
Bureau of Habitat
625 Broadway, Albany, New-York 12233-4756

Samples will then be directed to: The analytical facility and personnel noted on specific project descriptions.

NEW YORK STATE **DEPARTMENT OF ENVIRONMENTAL CONSERVATION**

I,___________________, of _______________________________________ have collected the following
(Print Name) (Print Address)
on _______________, 20____ from _________________________ in the vicinity of ________________________
Town of _____________________, ________________ County.
Item(s):____
____
____

said sample(s) were in my possession and handled according to standard procedures provided to me prior to collection. The sample(s) were placed in the custody of a representative of the New York State Department of Environmental Conservation on ______________________, 20____.

____________________________________ __________________
Signature Date

I, ___________________________, have received the above mentioned same(s) on the date specified and have assigned identification number(s) _______________________________ to the sample(s). I have recorded pertinent data for the sample(s) on the attached collection records. The sample(s) remained in my custody until subsequently transferred, prepared or shipped at times and data as attested to below.

____________________________________ __________________
Signature Date

SECOND RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
THIRD RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
FOURTH RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
RECEIVED IN LABORATORY BY (Print Name)		TIME & DATE
SIGNATURE	UNIT	
LOGGED IN BY (Print Name)	TIME & DATE	ACCESSION NUMBERS
SIGNATURE	UNIT	

Notice of Warranty

By signature to the chain of custody (reverse) , the signator warrants that the information provided is truthful and accurate to the best of his/her* ability. The signator affirms that he/she is willing to testify to those 'facts provided and the circumstances surrounding same. Nothing in this warranty or chain of custody negates responsibility nor liability of the signators for the truthfulness and accuracy of the statements provided.

Handling Instructions

On day of collection, collector(s) name(s), address(es), date, geographic location of capture (attach a copy of topographic map or navigation chart), species, number kept of each species, and description of capture vicinity (proper noun, if possible) along with name of Town and County must be indicated on reverse.

Retain organisms in manila tagged plastic bags to avoid mixing capture locations. Note appropriate information on each bag tag.

Keep samples as cool as possible. Put on ice if fish cannot be frozen within 12 hours. If fish are held more than 24 hours without freezing, they will not be retained or analyzed.

Initial recipient (either DEC or designated agent) of samples from collector(s) is responsible for obtaining and recording information on the collection record forms that will accompany the Chain of Custody form. This person will seal the container using packing tape and will write his signature, time, and date across the tape onto the container with indelible marker. Any time a seal is broken, for whatever purpose, the incident must be recorded on the Chain of Custody (reason, time, and date) in the "Purpose of Transfer" block. Container then is resealed using new tape and rewriting signature, with time and date.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF FISH, WILDLIFE AND MARINE RESOURCES

FROM REGION ________ FOR ______________________________ TOXIC SUBSTANCE MONITORING PROGRAM
BY COLLECTOR(S) ______________________________ USING ______________ COLLECTION METHOD.
SPECIMENS PRESERVED BY ______________________ METHOD.

FILL IN APPROPRIATE BLANKS AS COMPLETELY AS POSSIBLE.

FOR LAB USE ONLY - LAB ENTRY NO.	COLLECTION OR TAG NO.	SPECIES	DATE TAKEN	LOCATION	AGE	SEX &/OR REPROD. CONDIT.	LENGTH ( )	WEIGHT ( )	REMARKS

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BUREAU OF HABITAT

FISH PREPARATION PROCEDURES FOR CONTAMINANT ANALYSIS

Background

New York State Department of Environmental Conservation (DEC) conducts studies requiring chemical analysis on fish tissues. Routine monitoring and surveillance studies develop data on contaminants in fish for several reasons:

1. To identify sources of environmental contamination

2. To identify the geographic extent of environmental contamination

3. To identify temporal trends of contaminants in fish and wildlife

4. To provide information regarding human consumption advisories

Chemical analyses of edible-fish flesh have been determined to be the most appropriate analyses for satisfying all of these objectives. The following methodology has been developed in order to standardize the tissues under analysis and to adequately represent the contaminant levels of fish flesh. The methodology is slightly modified from the U.S. Food and Drug Administration procedures. The portion of edible flesh analyzed will be referred to as the standard fillet unless otherwise noted. For some species, the procedure is modified as indicated below.

Procedures for Standard Filleting:

1. Remove scales from fish. Do not remove the skin.

2. Make a cut along the ventral midline of the fish from the vent to the base of the jaw.

3. Make diagonal cut from base of cranium following just behind gill to the ventral side just behind pectoral fin.

4. Remove the flesh and ribcage from one-half of the fish by cutting from the cranium along the spine and dorsal rays to the caudal fin. The ribs should remain on the fillet.

5. Score the skin and homogenize the entire fillet.

Modifications to Standard Fillet

Four modifications of the standard fillet procedure are designed to account for variations in fish size or known preferred preparation-methods of the fish for human consumption.

1. Some fish are too small to fillet by the above procedure. Fish less than approximately six inches long and rainbow smelt are prepared by cutting the head off from behind the pectoral fin and eviscerating the fish. Ensure that the belly flap is retained on the carcass to be analyzed. When this modification is used, it should be noted when reporting analytical results.

2. Some species are generally eaten by skinning the fish. The skin from these species is also relatively difficult to homogenize in the sample. Hence, for the following list of species, the fish is first skinned prior to filleting:

Brown bullhead	White catfish
Yellow bullhead	Channel catfish
Atlantic sturgeon	Lake sturgeon
Black bullhead	

3. American eel are analyzed by removing the head, skin, and viscera; filleting is not attempted.

4. Forage fish and young-of-year fish are analyzed whole. This category is considered to be less than 150mm (6 inches).

Standard Operating Procedure
For
Mercury Water Chemistry and Chlorophyll-a Sampling

1. Locate the deepest portion of the lake from the bathymetric map. Anchor the boat securely. Record the pond # date, time, surface conditions, percent cloud cover on a REC 9 form.
   - Water clarity via Secchi disc;
     1. Lower the disc into the water on the shady side of the boat and note the depth at which the disc disappears.
     2. Raise the disc and note the depth at which it reappears.
     3. Calculate the mean of the two depths and record in tenths of inches, record on Rec 9.
   - Visual water color;
     1. Raise the disc approximately half way to surface and note the visual color (ex. Green, brown etc.) enter code on Rec 9 form.
2. Perform temperature and Dissolved Oxygen profile.
   - YSI meter operation; Calibrate meter entering elevation in M.
     1. Starting with a surface reading lower probe at 1 m intervals, record temperature (°F) and dissolved oxygen level (mg/l) to the tenth. Continue until bottom is reached. Record on Rec 9.
3. Collect water for Chlorophyll-a sample.
   - The Chlorophyll-a sample will be taken with the vinyl tubing. Sampling should be completed upwind of the motor avoiding all substrate disturbances.
     1. Determine the depth of the chlorophyll sample; twice the secchi reading, or one meter above the bottom if depth is not sufficient.
     2. Lower the chlorophyll sampling hose and the attached rope over the side of the boat being careful not to twist the rope around the hose. Weight can be added just above the hose end via a rock bag to prevent any current drift from displacing the hose and affecting the sample. Any variance from sampling procedure should be recorded on the Rec 16 Comment form.
     3. Crimp the open end of the tube as close to the water surface as possible. Retrieve the weighted lower portion of the hose by pulling up on the rope, plug end with thumb, keep the crimped end above the weighted end of the tube at all times. Place the weighted end of the hose into the top of the carboy making sure the valve is closed at the bottom of the carboy. Release the crimp and discharge the sample into the carboy by gradually lifting the open end of the hose as the water fills the carboy. Cap the carboy and store until returning to shore.
4. Take the two mercury water samples using the clean hands/ dirty hands protocol attached to this SOP.
5. Collect sample for ALSC analysis.
   - The sample will be hand dipped at the surface. Sampling should be completed upwind of the motor avoiding all substrate disturbances.
     1. Complete the label on the liter bottle for the ALSC lab with permanent marker. Fill out COC.
     2. With gloves on, rinse the liter bottle 3 times with lake water and fill, capping underwater to exclude any air from the bottle.
6. Place all water samples on ice immediately and return to shore.
7. Complete the Chlorophyll-a sampling.
   - Procedure for Chlorophyll-a filtering
   1. Back at the vehicle, filter specific amount of the water from the carboy.
      - For lakes with secchi disk reading < 2 meters - filter 25ml

- For lakes with secchi disk reading = 2-5 meters - filter 50ml
- For lakes with secchi disk reading > 5 meters - filter 100ml

2. Assemble the hand vacuum pump and filter assembly.
   - Attach the hose to the glass flask to form the bottom of the filter assembly.
   - Place the rubber stopper and glass filter stand on the top of the glass flask.
   - Place the filter on top of the filter stand using a pair of forceps, place the checker-board pattern side of the filter facing up.
   - Apply six drops of magnesium carbonate to the filter.
   - Place the filter funnel on top of the filter and use the metal clamp to hold the filter funnel and filter stand together creating a good seal .
3. Before pouring the sample water from the carboy into the filter assembly, release any vacuum pressure in the assembly by squeezing the lower forward trigger on the vacuum hand pump. This must be done every time before the filter funnel is filled to ensure the proper amount of sample is measured and filtered.
4. After the appropriate amount of sample is filtered, prepare a piece of aluminum foil for wrapping the filter. Fold the filter into quarters using the forceps, while trying not to touch the filter. Place the filter in the aluminum foil and wrap before placing it in a properly labeled whirl-pak.
5. The whirl-pak label should include the date, pond number, and pond name, volume of water filtered, and depth of sample. Place the packaged filter on ice in a cooler immediately. Place in freezer upon returning to office.

All chain of custodies should be filled out correctly, and included with sample shipments. Copies should be made of any COC shipped out of the office, to be filed.

- Deliver the liter sample to the ALSC lab with COC.
- FedEx or UPS the Hg samples and COC to Frontier lab to ensure delivery within 24 hours. Place COC in ziplock bag in cooler.
- Place whirl-pak bag with Chlorophyll sample in freezer in the ALSC lab for delivery to Syracuse. Retain COC for Upstate Freshwater Institute.

Clean Hands / Dirty Hands Protocol
Hg Sampling

1. Bring one cooler for each water to be sampled, always carry one extra set. Each cooler contains; a bag of gloves, two numbered Teflon bottles, a shipping label and a COC.
2. Each person removes a pair of gloves from the zip-lock bag and puts them on with care not to touch the outside of the glove.
3. The person who will take the samples is designated as “clean hands”; do not touch anything after gloves have been put on, not even the sides of the boat.
4. The person who is designated as “dirty hands” will prepare the bottles for removal and use.
5. “Dirty hands” will grab one of the two Teflon bottles from the cooler and only open the outside zip-lock bag. Do not touch the inner bag.
6. “Clean hands” will open the second (inner) zip-lock bag (without touching the outside zip- lock bag) and remove the sampling bottle.
7. Rinse bottle once with lake water and take sample from the upwind side of the boat. Cap bottle underwater to avoid allowing air bubbles in the sample.
8. “Clean hands” will return the full sample bottle into the inner zip-lock bag, seal, and tuck neatly into the outer zip-lock bag. (Avoid touching outside zip-lock bag)
9. “Dirty hands” will then seal the outer zip lock bag and place sample on ice to be chilled. Record sample time on Frontier COC forms.
10. Repeat steps 4 - 8 for the second Teflon sampling bottle.
11. Place bottles in clean, ice filled, ALSC cooler in order to cool samples as much as possible before shipment. To ship, place samples in cooler provided by Frontier with as many ice packs as you can fit and ship overnight to Frontier.
12. Use the plastic zip lock bag (that the sampling gloves were in), put one copy of the Frontier COC in it, and ship it with the samples in the cooler. (This prevents the COC from getting wet during shipment). Keep a copy of the COC for file.

APPENDIX B —Summary table of fish Hg concentrations in 131 New York lakes

Site	Lake #	Region	County	Species	N	Length (mm)[1]	Weight (g)[1]	Total Mercury (ng/g) [1,2]
Ballston Lake	071090	5	Saratoga	Largemouth bass	10	338 ± 59 264 - 417	610 ± 320 293 - 1152	459 ± 297 261 - 1002
				Yellow perch	10	237 ± 18 220 - 275	164 ± 38 124 - 241	205 ± 90 99 - 430
Big Moose Lake	040752	6	Herkimer	Yellow perch	10	180 ± 57 143 - 338	85 ± 128 31 - 448	519 ± 452 253 - 1784
Black River Pond	07806	4	Rensselaer	Yellow perch	10	176 ± 26 145 - 231	59 ± 31 30 - 135	353 ± 104 230 - 554
Blue Mountain Lake	060307	5	Hamilton	Largemouth bass	5	332 ± 124 194 - 475	705 ± 711 85 - 1490	652 ± 584 128 - 1503
				Smallmouth bass	11	301 ± 94 191 - 450	425 ± 408 69 - 1175	547 ± 381 163 - 1160
Breakneck Pond	13150d	3	Rockland	Largemouth bass	10	356 ± 88 259 - 489	708 ± 501 241 - 1442	778 ± 338 352 - 1322
				Yellow perch	2	293 ± 32 270 - 315	311 ± 65 265 - 357	608 ± 54 570 - 646
Butterfield Lake	040054	6	Jefferson	Largemouth bass	10	311 ± 48 235 - 382	483 ± 273 155 - 1104	292 ± 139 161 - 546
				Smallmouth bass	3	350 ± 62 285 - 408	528 ± 235 292 - 762	451 ± 167 330 - 641
				Walleye	1	563	1880	821
				Yellow perch	10	233 ± 16 212 - 258	172 ± 43 126 - 243	128 ± 34 82 - 183

Canada Lake	070717	5	Fulton	Chain pickerel	1	610	1500	1184
				Smallmouth bass	11	371 ± 46 294 - 435	778 ± 256 400 - 1093	1012 ± 566 505 - 2504
Canadarago Lake	16392	4	Otsego	Largemouth bass	9	351 ± 53 304 - 474	751 ± 453 420 - 1870	317 ± 209 20 - 708
				Smallmouth bass	10	358 ± 44 311 - 431	697 ± 275 410 - 1210	302 ± 84 212 - 445
				Walleye	10	448 ± 34 396 - 498	801 ± 230 510 - 1210	447 ± 151 226 - 749
				Yellow perch	10	264 ± 29 215 - 294	270 ± 82 150 - 360	169 ± 62 105 - 321
Canandaigua Lake	010286	8	Ontario	Largemouth bass	11	434 ± 37 384 - 504	1311 ± 486 676 - 2214	840 ± 197 621 - 1218
				Smallmouth bass	7	399 ± 63 286 - 474	1060 ± 465 288 - 1722	668 ± 272 209 - 913
				Yellow perch	10	224 ± 10 211 - 241	137 ± 29 100 - 189	117 ± 27 60 - 151
Canopus Lake	130168a	3	Putnam	Largemouth bass	10	385 ± 71 303 - 540	923 ± 663 350 - 2500	569 ± 236 304 - 1049
				Yellow perch	10	228 ± 34 190 - 272	157 ± 68 80 - 240	192 ± 99 53 - 344
Carter Pond	050075	5	Washington	Largemouth bass	3	331 ± 30 310 - 365	602 ± 147 474 - 762	484 ± 86 404 - 575
				Yellow perch	6	226 ± 23 207 - 268	169 ± 65 121 - 298	304 ± 104 181 - 432
Chase Lake	050164	5	Fulton	Yellow perch	16	237 ± 39 160 - 314	174 ± 94 47 - 410	824 ± 514 224 - 2195

Chautauqua Lake	12122	9	Chautauqua	Largemouth bass	10	330 ± 15 308 - 358	573 ± 104 421 - 723	126 ± 103 77 - 415
				Walleye	10	424 ± 53 321 - 514	na	226 ± 60 132 - 318
				Yellow perch	10	182 ± 8 173 - 194	na	54 ± 14 34 - 79
Chazy Lake	020020	5	Clinton	Largemouth bass	1	425	1331	528
				Smallmouth bass	11	310 ± 37 260 - 398	404 ± 203 196 - 911	511 ± 122 362 - 752
				Yellow perch	13	266 ± 22 239 - 313	222 ± 60 132 - 340	341 ± 105 231 - 543
Chodikee Lake	130437	3	Ulster	Largemouth bass	10	389 ± 59 316 - 485	950 ± 506 420 - 1900	729 ± 383 323 - 1368
				Yellow perch	7	241 ± 18 222 - 267	160 ± 33 120 - 200	168 ± 32 136 - 220
Conesus Lake	110067	8	Livingston	Largemouth bass	10	390 ± 35 350 - 454	956 ± 291 692 - 1642	337 ± 132 215 - 610
				Walleye	10	536 ± 43 428 - 584	1853 ± 436 860 - 2340	597 ± 143 212 - 733
Cranberry Lake	040309	6	St. Lawrence	Smallmouth bass	13	329 ± 40 210 - 388	535 ± 158 117 - 832	783 ± 254 457 - 1389
				Yellow perch	6	212 ± 11 195 - 228	109 ± 22 77 - 138	485 ± 129 312 - 641

Crane Pond	050421	5	Essex	Largemouth bass	2	276 ± 34 252 - 300	323 ± 103 250 - 396	331 ± 130 239 - 422
				Smallmouth bass	8	331 ± 91 232 - 489	583 ± 538 166 - 1700	791 ± 372 413 - 1397
				Yellow perch	2	277 ± 21 262 - 292	229 ± 72 178 - 280	736 ± 225 576 - 895
Cuba Lake	12115	9	Allegany	Largemouth bass	1	345	758	274
				Smallmouth bass	10	352 ± 33 309 - 429	644 ± 184 440 - 1094	374 ± 127 216 - 578
				Walleye	10	399 ± 35 356 - 476	643 ± 188 477 - 1075	363 ± 164 230 - 789
				Yellow perch	10	275 ± 26 233 - 319	274 ± 75 153 - 386	208 ± 64 136 - 334
Delta Lake	071059	6	Oneida	Largemouth bass	4	352 ± 15 337 - 370	676 ± 130 542 - 815	531 ± 172 362 - 763
				Smallmouth bass	5	388 ± 65 325 - 481	850 ± 437 464 - 1564	616 ± 175 425 - 874
				Walleye	4	357 ± 36 330 - 410	393 ± 115 286 - 556	677 ± 125 535 - 832
				Yellow perch	10	230 ± 22 197 - 261	162 ± 51 98 - 258	298 ± 125 141 - 595

DeRuyter Reservoir	160056	7	Onondaga	Chain pickerel	1	461	589	388
				Largemouth bass	4	292 ± 42 236 - 327	409 ± 147 234 - 533	188 ± 83 112 - 298
				Smallmouth bass	2	341 ± 17 329 - 353	602 ± 104 528 - 675	282 ± 91 218 - 346
				Yellow perch	5	216 ± 35 155 - 239	153 ± 67 38 - 208	173 ± 50 118 - 232
Dunham Reservoir	07425	4	Rensselaer	Largemouth bass	4	373 ± 38 331 - 422	767 ± 240 580 - 1108	682 ± 146 513 - 838
				Smallmouth bass	5	339 ± 20 315 - 369	528 ± 108 395 - 693	1197 ± 187 964 - 1434
				Walleye	3	468 ± 85 405 - 564	1015 ± 707 525 - 1825	2696 ± 1213 1297 - 3433
				Yellow perch	10	268 ± 10 248 - 283	238 ± 23 205 - 285	669 ± 43 580 - 729
Dyken Pond	070445	4	Rensselaer	Largemouth bass	3	431 ± 16 415 - 446	1260 ± 262 1040 - 1550	995 ± 82 906 - 1068
				Walleye	2	353 ± 1 352 - 354	365 ± 21 350 - 380	295 ± 1 294 - 295
				Yellow perch	10	210 ± 33 173 - 267	105 ± 50 50 - 205	347 ± 151 177 - 580
East Sidney Reservoir	160262	4	Delaware	Largemouth bass	1	354	709	782
				Smallmouth bass	1	246	205	335
				Yellow perch	9	212 ± 24 182 - 248	126 ± 37 82 - 182	214 ± 78 122 - 321

Eaton Brook Reservoir	16163	7	Madison	Largemouth bass	10	305 ± 19 273 - 327	412 ± 68 304 - 495	367 ± 75 244 - 484
				Smallmouth bass	5	317 ± 33 260 - 345	474 ± 127 264 - 608	338 ± 103 181 - 447
				Walleye	9	388 ± 46 335 - 441	546 ± 169 368 - 775	395 ± 201 211 - 747
				Yellow perch	10	281 ± 22 246 - 310	318 ± 75 196 - 438	180 ± 73 96 - 300
Effley Falls Reservoir	040426	6	Lewis	Chain pickerel	4	407 ± 46 359 - 447	467 ± 117 319 - 600	863 ± 231 524 - 1013
				Smallmouth bass	10	342 ± 44 292 - 410	523 ± 194 325 - 825	1119 ± 579 616 - 2512
				Yellow perch	1	257	227	805
Elmers Falls Reservoir	040425	6	Lewis	Smallmouth bass	10	249 ± 69 170 - 362	243 ± 223 64 - 688	495 ± 309 260 - 1172
				Yellow perch	10	186 ± 19 163 - 210	91 ± 26 58 - 128	257 ± 46 197 - 341
Fall Lake	050243	5	Hamilton	Yellow perch	20	222 ± 15 185 - 245	157 ± 32 83 - 202	397 ± 158 140 - 697
Ferris Lake	070777	5	Hamilton	Yellow perch	20	294 ± 50 224 - 374	328 ± 207 108 - 711	1181 ± 679 535 - 3244
Forge Pond	14555	1	Suffolk	Largemouth bass	10	340 ± 50 273 - 422	581 ± 232 284 - 915	508 ± 283 182 - 858
				Yellow perch	4	221 ± 65 142 - 301	193 ± 143 96 - 405	96 ± 32 60 - 132

Fort Pond	140755	1	Suffolk	Largemouth bass	10	342 ± 54 265 - 440	764 ± 416 268 - 1530	315 ± 128 203 - 643
				Smallmouth bass	10	352 ± 47 301 - 426	576 ± 241 341 - 988	297 ± 84 189 - 422
				Walleye	10	474 ± 43 434 - 576	1015 ± 361 750 - 1942	539 ± 65 460 - 689
				Yellow perch	11	187 ± 41 140 - 252	82 ± 50 31 - 157	140 ± 55 71 - 220
Francis Lake	040451	6	Lewis	Chain pickerel	6	518 ± 33 480 - 560	777 ± 146 609 - 974	1234 ± 331 828 - 1666
				Yellow perch	10	212 ± 33 123 - 234	114 ± 18 94 - 143	579 ± 96 459 - 771
Franklin Falls Flow	020076	5	Franklin	Walleye	10	397 ± 94 330 - 615	610 ± 608 250 - 2200	1513 ± 877 707 - 3604
				Yellow perch	10	223 ± 10 209 - 244	123 ± 20 100 - 163	455 ± 80 372 - 592
Fresh Pond	140753	1	Suffolk	Largemouth bass	10	371 ± 35 302 - 422	762 ± 242 395 - 1245	966 ± 241 392 - 1188
Glass Lake	070394	4	Rensselaer	Chain pickerel	5	393 ± 50 337 - 443	365 ± 144 224 - 560	381 ± 68 286 - 471
				Largemouth bass	10	286 ± 29 242 - 313	340 ± 88 224 - 431	346 ± 81 228 - 483
				Yellow perch	10	254 ± 29 195 - 308	209 ± 69 92 - 355	333 ± 118 145 - 516

Good Luck Lake	050265	5	Hamilton	Chain pickerel	2	347 282 - 412	255 115 - 395	391 317 - 465
				Yellow perch	10	235 ± 20 198 - 271	170 ± 42 98 - 234	497 ± 173 210 - 816
Goodyear Lake	16360	4	Otsego	Largemouth bass	10	404 ± 42 356 - 466	1074 ± 388 680 - 1660	512 ± 181 338 - 931
				Walleye	8	525 ± 67 411 - 597	1320 ± 510 590 - 2090	660 ± 269 253 - 1169
				Yellow perch	10	259 ± 18 236 - 292	205 ± 51 140 - 320	237 ± 56 163 - 330
Great Sacandaga Lake	050127	5	Saratoga	Smallmouth bass	10	252 ± 92 140 - 449	290 ± 357 36 - 1201	710 ± 361 251 - 1609
				Walleye	8	340 ± 83 215 - 448	349 ± 222 74 - 670	1123 ± 468 477 - 1854
				Yellow perch	12	262 ± 46 190 - 374	249 ± 148 82 - 673	603 ± 213 253 - 1066
Greenwood Lake	131026	3	Orange	Smallmouth bass	10	341 ± 44 283 - 409	533 ± 226 310 - 930	150 ± 88 53 - 332
				Walleye	10	492 ± 34 445 - 539	1215 ± 268 780 - 1570	331 ± 159 154 - 663
				Yellow perch	10	234 ± 23 206 - 270	161 ± 42 110 - 220	43 ± 11 33 - 69
Gull Lake	040717	6	Herkimer	Smallmouth bass	7	173 ± 36 137 - 246	69 ± 49 35 - 174	324 ± 172 181 - 659

Harris Lake	050680	5	Essex	Smallmouth bass	10	296 ± 46 240 - 374	415 ± 216 206 - 838	538 ± 148 303 - 787
				Walleye	10	391 ± 38 340 - 484	549 ± 195 349 - 1067	599 ± 118 468 - 809
High Falls Pond	040418	6	Lewis	Chain pickerel	2	354 ± 38 327 - 381	265 ± 92 200 - 330	330 ± 161 216 - 444
				Smallmouth bass	11	312 ± 74 195 - 434	460 ± 328 99 - 1030	599 ± 486 208 - 1719
				Yellow perch	2	164 ± 11 156 - 172	50 ± 16 39 - 61	295 ± 48 261 - 329
Hinckley Reservoir	070799	6	Herkimer	Smallmouth bass	10	298 ± 46 235 - 385	401 ± 177 177 - 749	633 ± 216 416 - 1075
				Yellow perch	10	203 ± 14 183 - 220	114 ± 29 76 - 153	406 ± 138 247 - 650
Hoel Pond	020161	5	Franklin	Yellow perch	10	270 ± 19 248 - 297	252 ± 64 173 - 363	465 ± 177 291 - 858
Honeoye Lake	11057	8	Ontario	Largemouth bass	10	335 ± 64 274 - 484	618 ± 452 308 - 1775	273 ± 196 115 - 687
				Smallmouth bass	5	427 ± 29 399 - 473	1159 ± 300 859 - 1612	401 ± 133 293 - 626
				Walleye	10	452 ± 48 392 - 547	902 ± 308 524 - 1580	507 ± 225 261 - 944
				Yellow perch	10	225 ± 75 145 - 331	211 ± 191 34 - 501	82 ± 38 13 - 149

Kings Flow	050588a	5	Hamilton	Largemouth bass	10	395 ± 67 286 - 501	962 ± 547 314 - 2200	661 ± 287 175 - 1088
				Yellow perch	20	172 ± 21 145 - 225	56 ± 27 32 - 136	183 ± 33 133 - 241
Lake Adirondack	050587a	5	Hamilton	Yellow perch	20	231 ± 24 195 - 285	157 ± 51 96 - 285	164 ± 43 105 - 228
Lake Eaton	060248	5	Hamilton	Smallmouth bass	5	316 ± 70 243 - 410	455 ± 288 195 - 820	821 ± 412 336 - 1296
				Yellow perch	17	251 ± 45 189 - 321	198 ± 111 66 - 378	613 ± 357 94 - 1094
Lake Flower	020086	5	Franklin	Largemouth bass	8	288 ± 42 219 - 351	365 ± 165 151 - 694	295 ± 163 141 - 552
				Walleye	1	377	454	197
				Yellow perch	10	254 ± 16 227 - 281	205 ± 50 123 - 283	268 ± 85 138 - 398
Lake George	020367	5	Warren	Largemouth bass	2	402 ± 3 400 - 404	1051 ± 115 969 - 1132	554 ± 22 539 - 570
				Smallmouth bass	10	336 ± 33 281 - 395	494 ± 132 256 - 723	426 ± 187 153 - 728
				Yellow perch	11	234 ± 60 161 - 300	174 ± 126 35 - 330	279 ± 234 44 - 660

Lake Huntington	09216	3	Sullivan	Largemouth bass	6	284 ± 11 268 - 298	305 ± 34 264 - 351	125 ± 19 105 - 155
				Smallmouth bass	2	234 225 - 243	165 149 - 180	85 43 - 126
Lake Luzerne	050318	5	Warren	Largemouth bass	11	294 ± 63 183 - 407	359 ± 216 75 - 866	344 ± 94 211 - 506
				Northern pike	4	447 ± 71 368 - 540	534 ± 273 282 - 916	439 ± 39 400 - 492
				Yellow perch	11	251 ± 17 228 - 280	185 ± 42 141 - 263	297 ± 91 209 - 538
Lake Mahopac	130053	3	Putnam	Largemouth bass	10	401 ± 50 322 - 456	1052 ± 340 500 - 1500	529 ± 219 185 - 709
				Smallmouth bass	10	365 ± 40 318 - 454	649 ± 246 440 - 1250	367 ± 226 212 - 982
				Yellow perch	2	287 ± 1 286 - 287	335 ± 7 330 - 340	185 ± 37 158 - 211
Lake Moraine	160152	7	Madison	Chain pickerel	6	462 ± 47 414 - 537	652 ± 166 512 - 928	228 ± 80 153 - 344
				Largemouth bass	1	325	596	292
				Yellow perch	10	246 ± 33 204 - 308	201 ± 75 122 - 350	130 ± 85 59 - 293
Lake Ozonia	030165	6	St. Lawrence	Smallmouth bass	10	345 ± 52 290 - 470	634 ± 409 330 - 1711	762 ± 211 530 - 1250
				Yellow perch	10	270 ± 13 247 - 290	247 ± 37 200 - 320	391 ± 76 269 - 530

Lake Ronkonkoma	140304	1	Suffolk	Largemouth bass	4	348 ± 4 345 - 350	613 ± 66 566 - 659	161 ± 114 71 - 324
				Smallmouth bass	4	369 ± 84 266 - 440	747 ± 491 234 - 1200	177 ± 142 60 - 353
				Walleye	10	470 ± 63 377 - 609	1086 ± 490 462 - 2248	247 ± 147 108 - 511
				Yellow perch	10	161 ± 5 154 - 169	45 ± 5 39 - 56	34 ± 15 12 - 52
Lake Superior	90104	3	Sullivan	Largemouth bass	10	380 ± 66 308 - 485	908 ± 553 440 - 1850	698 ± 216 431 - 1062
				Yellow perch	10	248 ± 34 188 - 298	201 ± 87 70 - 350	291 ± 82 190 - 443
Lake Taghkanic	130869	4	Columbia	Chain pickerel	1	361	307	302
				Largemouth bass	2	389 ± 8 383 - 394	933 ± 54 894 - 971	521 ± 80 465 - 578
				Yellow perch	2	274 ± 1 273 - 274	276 ± 8 270 - 282	347 ± 35 322 - 371
Lake Welch	130150c	3	Rockland	Largemouth bass	10	367 ± 48 312 - 467	733 ± 421 340 - 1730	639 ± 169 420 - 977
				Yellow perch	6	207 ± 39 155 - 260	113 ± 46 70 - 190	107 ± 39 69 - 168
Limekiln Lake	040826	5	Herkimer	Yellow perch	10	184 ± 22 164 - 230	65 ± 36 35 - 150	297 ± 70 175 - 388

Lincoln Pond	020315	5	Essex	Largemouth bass	9	359 ± 64 246 - 434	676 ± 334 192 - 1225	727 ± 376 263 - 1224
				Northern pike	10	556 ± 73 480 - 700	1064 ± 593 566 - 2500	640 ± 296 208 - 1263
				Tiger Muskellunge	2	444 ± 132 350 - 537	509 ± 358 256 - 762	246 ± 49 211 - 281
				Yellow perch	10	247 ± 36 193 - 302	181 ± 87 76 - 308	358 ± 116 176 - 531
Loch Sheldrake	0951	3	Sullivan	Largemouth bass	10	367 ± 42 304 - 429	876 ± 346 460 - 1420	504 ± 230 252 - 895
				Walleye	6	494 ± 69 437 - 625	1277 ± 626 870 - 2510	1482 ± 461 675 - 2025
				Yellow perch	8	239 ± 25 203 - 266	180 ± 55 100 - 240	216 ± 85 120 - 369
Long Lake	060241	5	Hamilton	Northern pike	5	667 ± 31 629 - 710	1410 ± 313 875 - 1658	1026 ± 294 665 - 1408
				Smallmouth bass	10	405 ± 26 366 - 453	876 ± 179 635 - 1148	840 ± 167 571 - 1032
				Yellow perch	10	307 ± 33 264 - 358	310 ± 101 197 - 470	671 ± 209 448 - 1092

Lower Saranac Lake	020104	5	Franklin	Largemouth bass	10	339 ± 51 247 - 434	586 ± 284 249 - 1271	451 ± 130 237 - 673
				Northern pike	1	522	1072	678
				Smallmouth bass	10	332 ± 66 228 - 430	517 ± 261 171 - 1020	731 ± 360 217 - 1315
				Walleye	1	388	582	828
				Yellow perch	15	227 ± 28 185 - 270	144 ± 48 73 - 241	275 ± 119 131 - 492
Massawepie Lake	030369	6	St. Lawrence	Smallmouth bass	13	351 ± 39 292 - 415	555 ± 190 309 - 846	372 ± 122 202 - 644
Meacham Lake	030179A	5	Franklin	Northern pike	2	769 703 - 835	3220 2320 - 4120	1740 1739 - 1741
				Smallmouth bass	4	435 ± 40 383 - 476	1198 ± 270 900 - 1450	2092 ± 911 1241 - 3315
				Yellow perch	10	267 ± 24 231 - 302	249 ± 59 142 - 330	1864 ± 290 1544 - 2606
Middle Stoner Lake	070721	5	Fulton	Chain pickerel	2	482 ± 5 478 – 485	637 ± 37 611 – 663	483 ± 122 397-569
				Smallmouth Bass	10	365 ± 47 305 – 450	637 ± 191 359 – 945	1084 ± 742 459-2998
Mohansic Lake	130049	3	Westchester	Largemouth bass	10	409 ± 59 318 - 487	1026 ± 488 400 - 1780	706 ± 204 404 - 1002
				Yellow perch	10	262 ± 23 219 - 291	233 ± 58 140 - 320	177 ± 109 39 - 427

Mongaup Falls Reservoir	090096a	3	Sullivan	Largemouth bass	5	386 ± 70 327 - 503	1068 ± 852 500 - 2560	597 ± 378 264 - 1231
				Smallmouth bass	7	343 ± 25 311 - 372	523 ± 116 380 - 700	691 ± 101 534 - 845
				Walleye	2	518 ± 173 395 - 640	1920 ± 1952 540 - 3300	609 ± 243 437 - 780
Mongaup Pond	90328	3	Sullivan	Smallmouth bass	10	326 ± 35 287 - 406	399 ± 135 250 - 730	398 ± 123 268 - 598
Moreau Lake	050101	5	Saratoga	Chain pickerel	2	352 ± 112 272 - 431	287 ± 260 103 - 471	273 ± 118 189 - 357
				Largemouth bass	10	266 ± 21 245 - 301	246 ± 54 196 - 339	276 ± 90 194 - 464
				Smallmouth bass	5	380 ± 101 279 - 495	865 ± 687 269 - 1775	579 ± 327 222 - 891
				Yellow perch	16	278 ± 36 214 - 345	315 ± 135 118 - 633	326 ± 110 130 - 580
Moshier Reservoir	040478	6	Herkimer	Smallmouth bass	10	349 ± 53 294 - 478	606 ± 417 277 - 1695	1231 ± 462 286 - 2123
Mud Pond	050226	5	Hamilton	Chain pickerel	9	416 ± 55 330 - 505	354 ± 110 180 - 569	404 ± 61 317 - 487
				Yellow perch	10	226 ± 14 209 - 251	134 ± 25 100 - 176	152 ± 74 101 - 345
Muller Pond	050394	5	Essex	Northern pike	1	472	772	154
				Yellow perch	10	252 ± 60 163 - 342	219 ± 157 48 - 524	343 ± 268 92 - 853

Nathaniel Cole Pond	165467	7	Broome	Largemouth bass	5	290 ± 54 251 - 377	382 ± 289 198 - 873	260 ± 104 148 - 411
				Smallmouth bass	3	275 ± 11 263 - 284	294 ± 39 254 - 331	353 ± 128 278 - 501
Nine Corner Lake	070719	5	Fulton	Yellow perch	10	180 ± 14 165 - 205	57 ± 17 39 - 91	441 ± 126 246 - 612
North Lake	041007	6	Herkimer	Yellow perch	11	286 ± 16 266 - 315	285 ± 47 222 - 375	1407 ± 257 1048 - 1836
North-South Lake	130921	4	Greene	Largemouth bass	10	387 ± 63 284 - 472	878 ± 441 298 - 1521	900 ± 463 330 - 1482
				Yellow perch	10	199 ± 16 185 - 240	90 ± 19 74 - 140	340 ± 100 213 - 515
Oneida Lake	010026	7	Oswego	Largemouth bass	10	372 ± 40 292 - 416	824 ± 257 374 - 1133	540 ± 197 326 - 877
				Smallmouth bass	10	403 ± 29 351 - 434	943 ± 193 626 - 1134	428 ± 146 241 - 743
				Walleye	10	437 ± 64 272 - 510	895 ± 108 738 - 1045	417 ± 122 284 - 725
				Yellow perch	10	272 ± 17 239 - 293	308 ± 90 168 - 480	215 ± 64 113 - 305
Onteora Lake	130845	3	Ulster	Yellow perch	10	235 ± 12 214 - 258	155 ± 28 120 - 220	235 ± 60 147 - 313

Osgood Pond	030202	5	Franklin	Largemouth bass	10	344 ± 86 239 - 483	694 ± 532 160 - 1822	443 ± 317 100 - 932
				Northen pike	5	594 ± 65 518 - 690	1298 ± 391 818 - 1777	340 ± 132 168 - 502
				Smallmouth bass	10	423 ± 48 306 - 468	1105 ± 301 428 - 1414	969 ± 462 253 - 1710
				Yellow perch	10	233 ± 48 182 - 310	152 ± 105 53 - 370	334 ± 197 146 - 691
Otsego Lake	16404	4	Otsego	Largemouth bass	10	402 ± 34 353 - 465	998 ± 260 607 - 1410	446 ± 101 290 - 589
				Smallmouth bass	8	374 ± 36 300 - 422	826 ± 268 310 - 1210	388 ± 135 141 - 562
				Walleye	10	431 ± 21 414 - 477	850 ± 180 700 - 1210	221 ± 107 134 - 413
				Yellow perch	11	222 ± 22 200 - 276	147 ± 46 112 - 270	137 ± 64 68 - 310
Owasco Lake	01212	7	Cayuga	Smallmouth bass	10	370 ± 52 305 - 451	848 ± 352 442 - 1532	409 ± 163 196 - 666
				Walleye	10	489 ± 60 385 - 620	1333 ± 471 612 - 2426	662 ± 262 258 - 1136
				Yellow perch	10	249 ± 14 216 - 261	194 ± 33 120 - 238	165 ± 57 83 - 289

Payne Lake	040068	6	Jefferson	Largemouth bass	6	258 ± 46 195 - 296	236 ± 113 83 - 355	80 ± 27 30 - 105
				Muskellunge	2	494 470 - 517	654 534 - 774	55 49 - 62
				Northern pike	2	615 601 - 630	1341 1331 - 1350	106 105 - 106
				Yellow perch	10	213 ± 26 189 - 271	125 ± 50 81 - 242	65 ± 35 29 - 137
Pine Lake	070724	5	Fulton	Largemouth bass	2	417 ± 18 404 - 430	1228 ± 298 1017 - 1438	1216 ± 255 1036 - 1396
				Yellow perch	10	211 ± 19 184 - 245	108 ± 33 69 - 168	533 ± 246 290 - 1191
Polliwog Pond	020120	5	Franklin	Smallmouth bass	9	274 ± 85 195 - 412	361 ± 382 82 - 1058	560 ± 544 96 - 1612
				Yellow perch	10	209 ± 17 188 - 250	84 ± 30 62 - 165	364 ± 161 138 - 605
Quaker Lake	125359	9	Cattaraugus	Largemouth bass	10	309 ± 22 280 - 340	421 ± 95 306 - 560	350 - 70 276 - 507
				Smallmouth bass	10	332 ± 37 290 - 394	506 ± 186 275 - 813	350 ± 77 254 - 474
Queechy Lake	070057	4	Columbia	Chain pickerel	1	337	220	191
				Largemouth bass	10	302 ± 14 281 - 326	390 ± 70 315 - 496	363 ± 65 257 - 462
				Yellow perch	10	272 ± 34 240 - 353	246 ± 57 187 - 358	264 ± 190 115 - 650

Raquette Lake	060293	5	Hamilton	Largemouth bass	10	347 ± 73 252 - 495	700 ± 557 193 - 2100	914 ± 546 293 - 2130
				Smallmouth bass	8	291 ± 37 245 - 349	336 ± 140 171 - 579	544 ± 282 251 - 982
				Yellow perch	12	248 ± 23 199 - 275	185 ± 78 84 - 380	421 ± 69 324 - 561
Red Lake	040012	6	Jefferson	Largemouth bass	2	329 ± 81 272 - 386	632 ± 441 320 - 943	733 ± 352 484 - 982
				Smallmouth bass	8	332 ± 70 247 - 445	529 ± 335 210 - 1252	685 ± 251 426 - 1077
				Walleye	2	450 ± 46 417 - 482	874 ± 297 664 - 1084	1367 ± 146 1264 - 1470
				Yellow perch	10	239 ± 43 121 - 270	230 ± 63 94 - 326	298 ± 65 208 - 413
Rich Lake	050682	5	Essex	Smallmouth bass	2	408 ± 46 375 - 440	988 ± 301 775 - 1200	716 ± 270 526 - 907
				Walleye	10	404 ± 48 345 - 505	546 ± 226 284 - 1055	687 ± 197 482 - 1059
Rio Reservoir	0979a	3	Sullivan	Largemouth bass	2	302 278 - 326	381 314 - 447	589 308 - 871
				Smallmouth bass	10	328 ± 70 235 - 431	537 ± 336 165 - 1089	641 ± 348 251 - 1118
				Yellow perch	7	196 ± 30 162 - 228	81 ± 34 42 - 123	161 ± 107 52 - 347

Rock Pond	050645	5	Hamilton	Largemouth bass	10	364 ± 104 217 - 490	911 ± 707 150 - 2000	899 ± 396 407 - 1541
				Muskellunge	1	640	650	645
				Yellow perch	9	178 ± 20 160 - 206	64 ± 25 41 - 111	331 ± 123 185 - 544
Round Lake	071089	5	Saratoga	Largemouth bass	5	383 ± 52 322 - 460	960 ± 455 512 - 1688	494 ± 192 308 - 811
				Northern pike	1	607	1615	291
				Yellow perch	5	250 ± 42 182 - 294	203 ± 85 76 - 306	196 ± 92 84 - 316
Round Pond	050687	5	Hamilton	Smallmouth bass	10	344 ± 66 257 - 429	545 ± 284 221 - 950	570 ± 160 313 - 775
				Yellow perch	20	242 ± 30 147 - 282	178 ± 40 89 - 251	470 ± 104 318 - 666
Rudd Pond	151134	3	Dutchess	Largemouth bass	6	351 ± 75 261 - 465	842 ± 532 276 - 1756	273 ± 239 128 - 735
				Yellow perch	10	249 ± 24 220 - 290	215 ± 104 120 - 438	159 ± 50 89 - 269
Rushford Lake	110146	9	Allegany	Walleye	20	348 ± 40 285 - 437	442 ± 100 283 - 652	778 ± 256 416 - 1322
				Yellow perch	8	227 ± 21 206 - 257	149 ± 52 85 - 227	213 ± 34 168 - 260
Russian Lake	040774	5	Hamilton	Yellow perch	10	188 ± 58 151 - 304	101 ± 114 31 - 329	741 ± 518 303 - 1944

Sacandaga Lake	050314	5	Hamilton	Chain pickerel	1	448	576	720
				Smallmouth bass	10	350 ± 32 292 - 395	582 ± 186 313 - 889	951 ± 193 618 - 1287
				Walleye	4	381 ± 16 357 - 391	578 ± 67 482 - 631	563 ± 43 525 - 614
Salmon River Reservoir	08019a	7	Oswego	Largemouth bass	10	348 ± 36 305 - 390	589 ± 163 397 - 793	1007 ± 257 648 - 1442
				Smallmouth bass	1	358	652	1065
				Yellow perch	10	220 ± 29 185 - 273	129 ± 54 64 - 234	342 ± 124 190 - 604
Sand Lake	050225	5	Hamilton	Chain pickerel	8	443 ± 53 385 - 535	445 ± 163 239 - 735	1254 ± 419 752 - 1919
				Yellow perch	7	172 ± 28 151 - 230	57 ± 35 32 - 126	438 ± 107 291 - 581
Saratoga Lake	050027	5	Saratoga	Chain pickerel	6	400 ± 68 325 - 525	504 ± 263 280 - 1020	330 ± 230 122 - 729
				Largemouth bass	9	287 ± 32 248 - 349	391 ± 120 280 - 675	272 ± 73 183 - 400
				Smallmouth bass	7	341 ± 16 323 - 362	625 ± 135 500 - 811	403 ± 130 233 - 586
				Walleye	1	590	1950	1210
				Yellow perch	10	239 ± 23 203 - 269	232 ± 61 125 - 310	160 ± 32 114 - 204

Seneca Lake	010369	8	Seneca	Smallmouth bass	6	291 ± 52 226 - 365	456 ± 265 158 - 890	421 ± 151 222 - 668
				Yellow perch	10	262 ± 28 225 - 322	294 ± 111 201 - 574	295 ± 177 129 - 678
Silver Lake	11115	9	Wyoming	Largemouth bass	10	362 ± 23 320 - 394	554 ± 97 346 - 674	348 ± 64 222 - 414
				Walleye	10	430 ± 24 398 - 465	794 ± 166 607 - 1094	391 ± 72 275 - 528
				Yellow perch	10	263 ± 10 252 - 280	250 ± 24 205 - 278	91 ± 23 56 - 123
Snake Pond	040579	6	Herkimer	Yellow perch	7	203 ± 18 183 - 235	89 ± 28 65 - 143	354 ± 119 195 - 526
Soft Maple Dam Pond	040431	6	Lewis	Smallmouth bass	9	292 ± 88 186 - 415	376 ± 286 76 - 833	907 ± 684 299 - 2108
				Yellow perch	6	204 ± 32 161 - 255	102 ± 46 45 - 179	708 ± 135 512 - 900
South Pond	060245	5	Hamilton	Yellow perch	10	267 ± 69 202 - 350	262 ± 201 83 - 552	815 ± 643 256 - 1668
Spy Lake	050232	5	Hamilton	Smallmouth bass	10	434 ± 58 344 - 502	1253 ± 482 570 - 2100	1011 ± 510 396 - 1808
				Yellow perch	1	154	35	123

Star Lake	040281	6	St. Lawrence	Largemouth bass	2	231 171 - 291	170 55 - 285	161 114 - 209
				Smallmouth bass	5	235 ± 17 219 - 260	162 ± 35 125 - 202	283 ± 47 235 - 344
				Yellow perch	9	247 ± 32 185 - 290	190 ± 67 90 - 312	212 ± 92 112 - 385
Stony Lake	040617	6	Lewis	Chain pickerel	5	419 ± 37 382 - 465	414 ± 106 316 - 534	558 ± 115 445 - 738
				Smallmouth bass	10	365 ± 53 266 - 435	685 ± 232 302 - 984	770 ± 280 336 - 1221
				Yellow perch	2	167 ± 40 139 - 195	56 ± 35 31 - 81	245 ± 89 182 - 308
Sturgeon Pool	130453a	3	Ulster	Largemouth bass	10	359 ± 70 294 - 523	720 ± 489 360 - 1900	479 ± 289 249 - 1013
				Smallmouth bass	10	322 ± 31 294 - 388	437 ± 146 300 - 750	348 ± 150 230 - 726
				Walleye	1	480	1100	384
				White perch	10	238 ± 8 225 - 250	177 ± 25 140 - 220	429 ± 120 238 - 594
				Yellow perch	8	232 ± 12 215 - 248	129 ± 31 100 - 180	172 ± 55 87 - 253
Sunday Lake	040473	6	Herkimer	Chain pickerel	2	456 ± 62 412 - 499	616 ± 260 432 - 799	2835 ± 2079 1365 - 4305
				Yellow perch	18	169 ± 17 143 - 196	58 ± 19 35 - 105	678 ± 191 330 - 1021

Swan Pond	14570	1	Suffolk	Chain pickerel	1	350	260	120
				Largemouth bass	4	295 ± 48 225 - 335	357 ± 154 171 - 526	294 ± 122 123 - 407
				Yellow perch	10	264 ± 19 225 - 290	249 ± 49 145 - 319	94 ± 35 55 - 164
Swinging Bridge Reservoir	09108a	3	Sullivan	Largemouth bass	9	381 ± 74 297 - 508	924 ± 604 400 - 2140	527 ± 324 253 - 1017
				Smallmouth bass	9	346 ± 39 294 - 405	507 ± 151 310 - 740	647 ± 187 409 - 969
				Walleye	10	459 ± 43 423 - 543	861 ± 282 600 - 1470	878 ± 348 520 - 1504
				Yellow perch	9	263 ± 38 215 - 319	217 ± 115 100 - 450	216 ± 66 150 - 377
Sylvan Lake	130352	3	Dutchess	Largemouth bass	10	398 ± 57 310 - 466	942 ± 408 440 - 1480	436 ± 164 206 - 683
Sylvia Lake	040088	6	St. Lawrence	Smallmouth bass	10	291 ± 126 171 - 542	549 ± 835 59 - 2200	135 ± 134 40 - 451
Taylor Pond	020227	5	Clinton	Yellow perch	15	264 ± 33 209 - 325	227 ± 84 96 - 396	371 ± 169 214 - 770
Thompsons Lake	70274	4	Albany	Largemouth bass	7	277 ± 50 244 - 388	299 ± 217 194 - 788	376 ± 81 291 - 540
				Smallmouth bass	3	342 ± 82 288 - 437	590 ± 479 288 - 1142	494 ± 221 341 - 747
				Yellow perch	10	252 ± 39 167 - 292	202 ± 81 53 - 294	308 ± 156 99 - 540

Tomhannock Reservoir	71095	4	Rensselaer	Largemouth bass	10	391 ± 39 343 - 470	1009 ± 403 620 - 1880	333 ± 104 173 - 516
				Smallmouth bass	10	393 ± 32 352 - 444	869 ± 243 580 - 1340	294 ± 112 169 - 478
				Walleye	10	498 ± 48 411 - 557	1100 ± 323 570 - 1580	465 ± 143 242 - 731
				Yellow perch	10	205 ± 35 164 - 262	109 ± 57 50 - 220	101 ± 25 71 - 154
Tupper Lake	060109	5	Franklin	Smallmouth bass	7	378 ± 43 323 - 446	701 ± 172 404 - 930	1151 ± 473 758 - 2102
				Walleye	10	523 ± 41 461 - 590	1433 ± 284 1050 - 1780	1240 ± 483 672 - 2354
				Yellow perch	10	227 ± 18 201 - 252	142 ± 45 80 - 220	667 ± 258 407 - 1290
Union Falls Flow	020074	5	Franklin	Largemouth bass	1	387	903	808
				Northern pike	4	732 ± 65 670 - 815	2545 ± 623 1700 - 3200	1348 ± 364 820 - 1653
				Smallmouth bass	6	339 ± 60 255 - 424	519 ± 229 227 - 833	947 ± 200 666 - 1268
				Walleye	3	337 ± 73 285 - 420	405 ± 300 203 - 750	880 ± 791 346 - 1789
				Yellow perch	11	228 ± 17 198 - 251	134 ± 28 83 - 171	336 ± 82 157 - 454

Upper Chateaugay Lake	030006b	5	Clinton	Largemouth bass	2	324 ± 2 322 - 325	465 ± 66 418 - 511	518 ± 41 489 - 547
				Northern pike	3	596 ± 79 506 - 656	1305 ± 606 621 - 1776	761 ± 172 569 - 899
				Smallmouth bass	11	374 ± 65 269 - 459	798 ± 389 238 - 1395	1045 ± 562 393 - 2073
				Yellow perch	11	231 ± 40 179 - 287	158 ± 95 45 - 312	478 ± 280 56 - 1062
Walton Lake	13257	3	Orange	Largemouth bass	9	398 ± 38 346 - 463	937 ± 295 550 - 1370	436 ± 137 238 - 613
				Smallmouth bass	1	340	550	144
				Yellow perch	10	220 ± 44 145 - 276	144 ± 62 80 - 250	51 ± 37 13 - 112
Wappinger Lake	130365	3	Dutchess	Largemouth bass	7	344 ± 31 300 - 389	571 ± 148 380 - 800	364 ± 230 173 - 800
				Yellow perch	10	250 ± 13 228 - 267	171 ± 27 140 - 220	176 ± 56 90 - 266
Weller Pond	020209	5	Franklin	Northern pike	4	565 ± 40 506 - 595	1125 ± 193 896 - 1329	971 ± 406 616 - 1423
				Smallmouth bass	5	236 ± 65 160 - 321	210 ± 177 52 - 492	266 ± 157 71 - 439
				Yellow perch	11	251 ± 40 200 - 325	202 ± 102 91 - 406	329 ± 174 167 - 793

West Caroga Lake	070698	5	Fulton	Smallmouth bass	10	387 ± 54 295 - 465	997 ± 413 371 - 1796	581 ± 244 253 - 990
				Walleye	1	577	2400	1541
				Yellow perch	7	200 ± 34 146 - 231	91 ± 46 19 - 136	234 ± 103 88 - 328
White Lake	09117	3	Sullivan	Chain pickerel	4	397 ± 20 368 - 411	407 ± 60 335 - 463	158 ± 28 127 - 195
				Largemouth bass	3	327 ± 20 306 - 346	524 ± 102 422 - 625	255 ± 63 199 - 324
				Yellow perch	10	257 ± 36 167 - 313	232 ± 89 54 - 417	88 ± 51 30 - 220
White Pond	130079	3	Putnam	Largemouth bass	10	409 ± 39 353 - 452	1093 ± 383 576 - 1511	462 ± 96 336 - 683
				Walleye	3	470 ± 35 433 - 503	998 ± 250 812 - 1282	385 ± 202 154 - 529
				Yellow perch	8	229 ± 32 181 - 288	na	145 ± 44 76 - 209
Willis Lake	050215	5	Hamilton	Chain pickerel	6	430 ± 19 410 - 460	423 ± 62 367 - 524	499 ± 95 447 - 692
				Largemouth bass	2	345 ± 64 300 - 390	790 ± 570 387 - 1193	437 ± 162 322 - 551
				Smallmouth bass	3	452 ± 18 432 - 468	1196 1147 - 1276	1368 ± 127 1268 - 1510
				Yellow perch	9	230 ± 52 167 - 312	144 ± 87 48 - 290	379 ± 209 125 - 779

Woodhull Lake	040982	6	Herkimer	Smallmouth bass	5	239 ± 54 202 - 335	220 ± 191 116 - 560	324 ± 113 264 - 524
				Yellow perch	12	210 ± 12 190 - 235	108 ± 19 78 - 138	202 ± 37 142 - 259
Woods Lake	050156	5	Hamilton	Smallmouth bass	12	334 ± 75 207 - 440	537 ± 345 103 - 1125	748 ± 374 256 - 1275
				Yellow perch	3	221 ± 7 213 - 225	104 ± 11 93 - 114	375 ± 194 241 - 597

[1] *Values given are the mean ± standard deviation. Minimum and maximum values are reported on the second line.*

[2] *1,000 ng/g = 1ppm*

APPENDIX C— Table of lake water chemistry data

Lake Name	Ballston Lake	Big Moose Lake	Black River Pond	Blue Mountain Lake	Breakneck Pond	Butterfield Lake	Canada Lake	Canadarago Lake	Canandaigua Lake	Canopus Lake	Carter Pond	Chase Lake
Pond #	071090	040752	070806	060307	130150D	040054	070717	160392	010286	130168A	050075	050164
Date	7/6/05	7/22/03	7/17/03	7/19/05	7/29/03	7/27/04	7/28/03	7/2/03	7/26/05	7/12/04	7/6/05	7/29/04
SO_4 (mg/L)	10.95	4.20	4.96	4.14	5.56	7.35	4.19	11.09	23.97	7.81	4.10	3.49
NO_3 (mg/L)	0.17	0.85	0.05	0.20	0.05	0.03	0.44	1.00	0.78	0.02	0.03	0.03
Cl (mg/L)	44.80	0.33	9.86	18.63	1.27	15.77	7.05	24.75	32.72	40.15	15.59	0.27
F (mg/L)	0.07	0.07	0.08	0.06	0.10	0.06	0.04	0.06	0.08	0.07	0.05	0.05
ANC (µeq/L)	1458.40	13.21	25.84	121.46	0.82	926.40	56.52	2632.25	2168.48	294.87	1790.72	17.81
DOC (mg/L)	6.54	3.70	5.70	2.84	2.15	4.75	2.95	3.12	2.61	3.28	5.84	4.45
SiO_2 (mg/L)	4.65	3.61	4.25	2.50	0.89	0.98	2.47	0.50	3.04	0.44	8.07	1.86
Ca (mg/L)	29.94	1.43	2.26	4.00	1.18	22.01	2.29	52.04	49.19	8.71	35.73	1.22
Mg (mg/L)	7.42	0.24	0.39	0.56	0.40	3.32	0.54	4.02	11.27	2.23	6.23	0.29
Na (mg/L)	21.43	0.60	6.64	11.58	1.43	9.73	4.86	12.35	14.98	24.70	9.48	0.66
K (mg/L)	1.59	0.28	0.25	0.37	0.22	1.06	0.18	1.36	1.89	0.80	1.05	0.10
NH_4 (mg/L)	0.08	0.01	0.01	0.01	0.03	0.01	0.03	0.03	0.01	0.01	0.01	0.01
Al Tot Dis (µg/L)	5	161	180	18	50	5	50	8	14	5	5	84
Al Total Monomeric (µg/L)	29	66	66	30	34	31	33	56	46	29	28	54
Al Organic Monomeric (µg/L)	29	44	55	25	35	26	30	40	24	26	29	33
Al Inorganic Monomeric (µg/L)	0	22	11	5	0	5	3	16	22	3	0	21
Lab pH	7.61	5.66	5.93	7.16	5.55	8.17	6.76	8.50	8.65	7.41	7.41	5.71
Air Eq. pH	8.27	5.75	6.29	7.32	5.64	8.27	7.02	8.35	8.46	7.73	8.36	5.82
Color (PtCo)	40	25	60	5	25	20	15	15	5	25	60	35
Sp Cond (µS/cm)	299.00	18.31	55.24	90.30	22.70	163.86	46.80	350.46	353.43	191.69	235.00	15.19
Secchi Depth (m)	2.2	5.8	2.2	7.5	2.9	3.8	4.0	4.0	5.5	4.1	1.5	3.0
Total Hg (ng/L)	1.68	1.36	3.65	0.63	2.04	0.36	1.87	0.86	0.35	0.55	1.76	1.46
Methyl Hg (ng/L)	0.13	0.08	0.23	0.03	0.14	0.05	0.04	0.03	0.03	0.03	0.87	0.11
Chlorophyll (µg/L)	6.10	0.8	2.1	1.00	2.6	6.17	1.6	3.5	1.30	3.47	11.50	3.14

Lake Name	Chatauqua Lake	Chazy Lake	Chodikee Lake	Conesus Lake	Cranberry Lake	Crane Pond	Cuba Lake	Delta Lake	DeRuyter Res.	Dunham Res.	Dyken Pond	East Sidney Res.	Eaton Brook Res.
Pond #	120122	020020	130437	110067	040309	050421	120115	701059	160056	070425	070445	160262	160163
Date	7/16/03	7/5/05	7/7/04	7/21/04	7/30/03	7/26/04	7/16/03	7/1/04	7/21/05	7/17/03	7/14/04	7/7/05	7/2/03
SO_4 (mg/L)	11.11	3.49	7.53	19.11	4.36	4.68	8.40	6.97	8.22	4.70	3.87	6.54	7.19
NO_3 (mg/L)	0.03	0.02	0.02	0.04	0.56	0.03	0.45	1.39	0.03	0.03	0.03	0.71	0.42
Cl (mg/L)	20.68	9.33	27.11	44.47	0.47	0.36	7.44	9.00	9.66	21.31	1.50	11.88	6.25
F (mg/L)	0.05	0.04	0.04	0.06	0.08	0.05	0.04	0.04	0.04	0.08	0.07	0.04	0.04
ANC (µeq/L)	1042.35	353.89	1653.84	2172.97	54.63	128.42	785.43	1138.53	1410.94	129.79	50.93	526.67	1278.04
DOC (mg/L)	2.89	3.25	6.10	3.85	4.11	3.25	2.84	2.53	2.42	5.19	5.01	2.00	2.17
SiO_2 (mg/L)	0.93	2.15	1.04	0.87	4.95	2.09	1.20	3.16	1.05	1.27	1.55	1.53	2.31
Ca (mg/L)	20.21	6.58	35.77	40.32	2.05	3.38	14.95	30.95	32.45	4.51	2.18	10.96	23.48
Mg (mg/L)	4.22	1.68	2.85	11.34	0.46	0.67	2.73	2.55	3.70	0.87	0.45	2.23	3.33
Na (mg/L)	10.76	5.29	30.07	25.69	0.84	0.64	5.03	6.01	5.88	12.50	1.27	6.64	3.83
K (mg/L)	1.02	0.40	0.35	2.36	0.36	0.24	1.18	0.85	0.77	0.39	0.32	1.37	0.57
NH_4 (mg/L)	0.01	0.01	0.02	0.04	0.04	0.01	0.02	0.04	0.01	0.01	0.08	0.03	0.06
Al Tot Dis (µg/L)	5	23	5	5	52	5	15	44	8	34	9	16	6
Al Total Monomeric (µg/L)	34	29	70	55	34	28	35	39	37	28	31	36	40
Al Organic Monomeric (µg/L)	27	26	26	27	38	29	28	25	28	28	33	20	41
Al Inorganic Monomeric (µg/L)	7	3	44	28	0	0	7	14	9	0	0	16	0
Lab pH	8.03	7.64	8.35	8.81	6.64	7.18	8.08	8.08	8.44	7.27	6.61	8.61	8.08
Air Eq. pH	8.24	7.78	8.26	8.41	6.91	7.40	8.19	8.29	8.34	7.40	6.73	7.95	8.03
Color (PtCo)	15	10	40	20	3	20	10	20	10	40	35	15	10
Sp Cond (µS/cm)	197.80	78.10	262.64	392.00	23.30	27.93	126.82	162.36	183.30	103.95	23.46	111.00	163.55
Secchi Depth (m)	3.1	4.5	1.5	2.5	4.5	5.5	4.8	4.1	6.5	3.3	2.8	1.5	10.2
Total Hg (ng/L)	0.59	0.76	1.13	0.33	2.67	1.05	0.88	0.69	0.25	1.73	1.50	1.31	0.63
Methyl Hg (ng/L)	0.03	0.03	0.04	0.03	0.04	0.05	0.03	0.06	0.03	0.18	0.09	0.04	0.03
Chlorophyll (µg/L)	5.8	1.80	7.42	7.32	2.6	1.89	7.5	2.89	2.60	8.3	12.57	7.10	<0.4

Lake Name	Effley Falls Res.	Elmers Falls Res.	Fall Lake	Ferris Lake	Forge Pond	Fort Pond	Francis Lake	Franklin Falls Flow	Fresh Pond	Glass Lake	Good Luck Lake	Goodyear Lake	Great Sacandaga Lake	Green-wood Lake
Pond #	040426	040425	050243	070777	140555	140755	040451	020076	140753	070394	050265	160360	050127	131026
Date	7/9/03	7/20/04	7/21/04	7/29/03	7/9/03	7/28/04	7/14/04	7/15/03	7/13/05	7/11/05	7/29/03	7/2/03	7/20/05	7/10/03
SO_4 (mg/L)	4.05	3.67	2.27	3.60	6.76	9.93	3.86	5.60	4.42	5.74	3.54	9.91	4.01	9.17
NO_3 (mg/L)	1.03	0.92	0.04	0.06	0.72	0.02	0.03	0.58	0.03	0.03	0.02	1.03	0.64	0.03
Cl (mg/L)	0.30	0.30	0.31	0.25	13.56	63.42	0.26	10.91	18.37	12.80	0.91	16.56	5.39	43.13
F (mg/L)	0.07	0.07	0.06	0.03	0.03	0.05	0.10	0.04	0.02	0.08	0.04	0.06	0.04	0.06
ANC (µeq/L)	36.54	37.76	211.63	13.39	247.75	282.59	14.41	317.32	20.40	316.54	21.24	1927.13	182.80	549.13
DOC (mg/L)	4.21	4.05	10.60	3.64	12.31	6.03	3.99	5.64	5.82	2.91	6.65	3.02	3.21	2.71
SiO_2 (mg/L)	4.79	4.45	7.34	0.97	9.26	0.62	1.50	6.40	0.46	0.72	2.86	2.15	4.57	0.32
Ca (mg/L)	1.90	1.81	3.50	1.19	4.90	6.04	1.35	6.72	1.04	8.33	1.33	39.55	4.04	12.27
Mg (mg/L)	0.36	0.37	1.17	0.32	1.73	3.85	0.28	1.63	1.50	1.49	0.39	2.93	0.98	3.40
Na (mg/L)	0.68	0.70	1.14	0.48	8.99	30.90	0.59	6.58	9.78	11.88	0.99	8.46	3.34	23.74
K (mg/L)	0.37	0.34	0.35	0.10	1.38	2.16	0.29	0.50	0.61	0.70	0.16	1.14	0.29	0.92
NH_4 (mg/L)	0.01	0.02	0.03	0.03	0.22	0.01	0.04	0.08	0.01	0.01	0.02	0.05	0.02	0.01
Al Tot Dis (µg/L)	124	102	98	110	105	11	71	26	59	5	212	15	24	5
Al Total Monomeric (µg/L)	41	41	46	43	50	33	39	33	34	24	90	48	30	36
Al Organic Monomeric (µg/L)	38	36	39	38	51	25	43	27	37	21	71	41	30	28
Al Inorganic Monomeric (µg/L)	3	5	7	5	0	8	0	6	0	3	19	7	0	8
Lab pH	6.30	6.36	6.57	5.85	6.68	7.52	5.81	7.46	6.05	7.58	5.71	8.30	7.46	7.93
Air Eq. pH	6.63	6.50	7.31	6.07	7.51	7.64	5.93	7.71	6.11	7.69	5.94	8.17	7.50	7.93
Color (PtCo)	35	40	160	20	360	25	35	50	70	10	70	20	20	20
Sp Cond (µS/cm)	20.38	19.00	31.90	14.90	96.24	275.38	15.74	83.36	80.29	119.40	19.20	269.28	49.90	220.50
Secchi Depth (m)	3.8	3.9	1.0	4.0	0.7	1.7	3.1	2.5	1.5	5.0	2.0	3.9	4.0	3.3
Total Hg (ng/L)	1.43	1.56	5.77	1.64	7.71	0.83	1.29	1.60	2.26	0.45	3.06	1.03	0.77	0.76
Methyl Hg (ng/L)	0.09	0.10	1.54	0.07	3.60	0.06	0.07	0.21	0.25	0.04	0.19	0.05	0.03	0.03
Chlorophyll (µg/L)	1.2	1.59	17.09	1.3	2.4	13.00	3.59	3.6	5.60	4.00	12.9	3.0	1.70	7.0

Lake Name	Gull Lake	Harris Lake	High Falls Pond	Hinckley Res.	Hoel Pond	Honeoye Lake	Kings Flow	Lake Adirondack	Lake Eaton	Lake Flower	Lake George	Lake Huntington	Lake Luzerne	Lake Mahopac
Pond #	040717	050680	040418	070799	020161	110057	050588A	050587A	060248	020086	020367	090216	050318	130053
Date	7/19/04	7/22/04	7/20/04	7/13/05	7/21/03	7/23/03	7/26/04	7/26/04	7/17/03	7/8/04	7/21/05	7/28/03	7/13/05	7/15/04
SO_4 (mg/L)	3.48	4.30	3.71	3.87	4.24	12.41	3.47	2.93	4.79	4.82	7.46	7.00	5.07	9.02
NO_3 (mg/L)	0.03	0.08	0.91	0.33	0.08	0.02	0.03	0.03	0.30	0.02	0.03	0.02	0.10	0.04
Cl (mg/L)	0.30	4.45	0.37	2.94	0.37	21.33	0.31	13.98	8.31	8.37	14.57	29.26	9.32	83.21
F (mg/L)	0.05	0.06	0.08	0.05	0.02	0.06	0.06	0.03	0.09	0.03	0.05	0.05	0.12	0.03
ANC (µeq/L)	33.76	170.24	55.20	253.18	55.23	1095.16	151.77	465.02	91.56	98.73	552.81	390.30	323.75	849.76
DOC (mg/L)	5.55	5.08	4.43	3.99	3.43	3.58	5.88	5.72	3.33	5.26	1.94	3.88	3.53	3.55
SiO_2 (mg/L)	1.71	4.30	4.71	5.11	1.96	2.27	2.22	1.03	3.34	4.01	1.96	0.18	6.08	0.32
Ca (mg/L)	1.53	4.50	2.09	5.52	2.30	20.70	3.59	15.16	3.15	5.05	13.28	9.03	6.67	24.33
Mg (mg/L)	0.38	0.83	0.43	0.80	0.35	6.72	0.73	1.42	0.59	1.23	2.31	1.74	1.60	5.40
Na (mg/L)	0.70	3.32	0.76	2.08	0.68	11.23	0.75	6.94	5.28	5.46	8.78	18.54	5.24	44.99
K (mg/L)	0.32	0.24	0.38	0.28	0.24	1.09	0.06	0.29	0.40	0.33	0.46	1.73	0.47	2.63
NH_4 (mg/L)	0.07	0.04	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.03
Al Tot Dis (µg/L)	85	13	89	73	11	7	55	5	11	20	5	15	10	8
Al Total Monomeric (µg/L)	47	29	39	34	26	41	30	32	28	30	33	31	30	34
Al Organic Monomeric (µg/L)	40	28	36	29	27	28	31	29	29	27	23	26	25	30
Al Inorganic Monomeric (µg/L)	7	1	3	5	0	13	0	3	0	3	10	5	5	4
Lab pH	6.32	7.20	6.53	7.57	6.86	8.16	7.04	8.06	7.13	7.14	7.92	7.57	7.36	8.02
Air Eq. pH	6.33	7.48	6.65	7.62	6.97	8.31	7.45	8.04	7.18	7.38	7.98	7.86	7.66	8.03
Color (PtCo)	50	35	40	30	10	15	50	25	10	35	5	10	30	10
Sp Cond (µS/cm)	16.80	49.00	21.50	47.52	21.38	218.79	28.13	113.09	55.34	64.97	120.10	163.50	79.40	382.14
Secchi Depth (m)	2.5	3.5	3.0	3.7	7.3	4.2	2.0	3.0	5.8	2.0	9.0	5.3	3.5	4.7
Total Hg (ng/L)	1.83	1.36	1.97	1.34	0.72	0.92	1.78	0.42	0.68	0.98	0.31	0.90	0.93	0.37
Methyl Hg (ng/L)	0.10	0.06	0.08	0.06	0.03	0.03	0.11	0.03	0.03	0.05	0.03	0.03	0.08	0.03
Chlorophyll (µg/L)	4.14	3.30	1.31	4.90	2.2	1.4	4.17	2.63	3.1	5.19	0.60	22.5	8.60	6.69

Lake Name	Lake Moraine	Lake Ozonia	Lake Ron-konkoma	Lake Superior	Lake Taghkanic	Lake Welch	Limekiln Lake	Lincoln Pond	Loch Sheldrake	Long Lake	Lower Saranac Lake	Massawepie Lake
Pond #	160152	030165	140304	090104	130869	130150C	040826	020315	090051	060241	020104	030369
Date	7/22/04	7/8/04	7/28/04	7/8/04	7/12/05	7/13/04	7/6/04	7/11/05	7/30/03	7/7/05	7/6/05	7/15/04
SO_4 (mg/L)	7.59	4.11	12.62	5.41	5.83	6.20	3.88	4.00	6.55	3.88	4.54	4.32
NO_3 (mg/L)	0.03	0.02	0.02	0.02	0.04	0.04	0.90	0.03	0.02	0.26	0.04	0.03
Cl (mg/L)	9.91	1.14	35.00	9.39	16.47	8.56	0.53	33.94	24.28	4.64	11.97	3.92
F (mg/L)	0.04	0.05	0.02	0.04	0.04	0.07	0.05	0.03	0.04	0.07	0.03	0.06
ANC (µeq/L)	1937.05	175.96	399.19	135.39	521.64	130.38	30.70	252.89	173.92	86.18	199.15	200.51
DOC (mg/L)	2.69	3.47	3.86	5.17	3.08	3.87	2.80	4.37	6.10	4.87	5.33	4.14
SiO_2 (mg/L)	0.41	1.47	1.31	0.23	1.14	2.55	3.13	3.94	0.81	5.25	5.12	6.87
Ca (mg/L)	33.49	4.03	9.39	3.91	13.35	3.81	1.79	6.73	6.68	2.57	4.44	4.13
Mg (mg/L)	5.79	0.98	2.85	1.07	1.63	1.08	0.34	1.50	1.24	0.52	1.13	1.19
Na (mg/L)	7.42	1.17	22.80	6.37	8.58	6.05	0.72	18.77	13.67	2.70	5.24	2.95
K (mg/L)	1.18	0.29	2.11	1.28	0.54	0.41	0.25	0.29	0.83	0.34	0.37	0.40
NH_4 (mg/L)	0.04	0.01	0.01	0.01	0.01	0.13	0.02	0.01	0.01	0.02	0.01	0.05
Al Tot Dis (µg/L)	5	15	5	5	5	6	65	10	12	32	15	6
Al Total Monomeric (µg/L)	37	27	31	28	36	27	33	26	32	34	26	28
Al Organic Monomeric (µg/L)	27	25	26	25	29	27	30	20	35	33	26	31
Al Inorganic Monomeric (µg/L)	10	2	5	3	7	0	3	6	0	1	0	0
Lab pH	8.86	7.30	7.52	7.14	8.20	7.06	6.35	7.44	7.28	6.80	7.17	7.21
Air Eq. pH	8.47	7.30	7.85	7.39	7.94	7.36	6.61	7.60	7.31	7.02	7.53	7.49
Color (PtCo)	10	15	25	35	15	30	10	25	30	25	30	30
Sp Cond (µS/cm)	233.00	34.40	197.96	64.88	439.00	60.98	18.91	148.70	126.70	37.40	64.50	47.02
Secchi Depth (m)	3.0	5.0	1.3	2.6	3.2	2.5	7.0	2.5	3.5	3.5	3.5	3.3
Total Hg (ng/L)	0.28	0.67	0.36	0.79	0.37	0.57	0.70	1.47	1.28	1.56	1.40	0.84
Methyl Hg (ng/L)	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.19	0.04	0.05	0.08	0.03
Chlorophyll (µg/L)	7.26	2.66	25.82	24.08	5.50	9.29	1.24	9.10	5.4	1.60	2.40	4.56

Lake Name	Meacham Lake	Middle Stoner Lake	Mohansic Lake	Mongaup Falls Res.	Mongaup Pond	Moreau Lake	Moshier Res.	Mud Pond	Muller Pond	Nathianel Cole Pond	Nine Corner Lake	North Lake	North-South Lake
Pond #	030179A	070721	130049	090096A	090328	050101	040478	050226	050394	165467	070719	041007	130921
Date	7/23/03	7/7/04	7/12/04	7/13/04	7/8/04	7/13/05	7/14/04	7/22/03	7/26/04	7/7/05	7/24/03	7/1/03	7/6/04
SO_4 (mg/L)	4.56	4.35	8.98	6.80	4.25	6.84	3.69	3.22	3.13	6.04	4.52	3.84	3.36
NO_3 (mg/L)	0.08	0.14	0.02	0.40	0.02	0.03	1.01	0.03	0.03	0.04	0.61	0.55	0.03
Cl (mg/L)	3.05	11.32	92.84	22.66	0.42	8.99	0.24	0.23	2.28	7.20	0.32	0.22	0.53
F (mg/L)	0.05	0.04	0.04	0.04	0.03	0.04	0.06	0.03	0.03	0.04	0.04	0.05	0.03
ANC (µeq/L)	206.35	80.17	1308.92	192.70	171.83	635.22	28.17	30.87	113.68	312.53	-8.50	8.93	95.92
DOC (mg/L)	6.64	2.93	5.59	3.53	2.60	2.71	4.23	10.06	6.91	2.94	0.39	4.41	3.31
SiO_2 (mg/L)	6.08	3.19	2.34	0.78	0.96	0.80	4.27	3.09	4.13	0.21	1.09	3.54	1.06
Ca (mg/L)	4.00	2.93	36.77	6.75	4.50	14.55	1.74	1.57	3.04	6.04	0.98	1.19	2.94
Mg (mg/L)	1.33	0.66	8.47	1.31	0.60	2.10	0.35	0.55	0.60	1.54	0.22	0.27	0.48
Na (mg/L)	2.35	7.22	52.41	13.35	0.30	5.49	0.64	0.64	1.92	5.19	0.44	0.55	0.58
K (mg/L)	0.41	0.23	1.93	0.96	0.29	0.43	0.34	0.12	0.12	0.68	0.16	0.20	0.12
NH_4 (mg/L)	0.01	0.01	0.02	0.11	0.01	0.01	0.10	0.01	0.01	0.01	0.04	0.01	0.01
Al Tot Dis (µg/L)	41	28	5	6	8	28	119	210	29	9	145	260	19
Al Total Monomeric (µg/L)	35	28	43	27	30	40	47	91	33	26	59	140	25
Al Organic Monomeric (µg/L)	32	27	32	30	26	27	51	73	28	20	28	75	25
Al Inorganic Monomeric (µg/L)	3	1	11	0	4	13	0	18	5	6	31	65	0
Lab pH	7.44	6.82	8.10	7.29	7.42	8.27	6.05	5.92	6.84	7.54	5.00	5.38	6.97
Air Eq. pH	7.56	6.98	8.36	7.54	7.56	8.02	6.33	6.23	7.32	7.71	4.97	5.37	7.11
Color (PtCo)	60	15	25	20	20	5	35	100	70	10	5	35	25
Sp Cond (µS/cm)	45.64	62.07	460.60	116.33	31.56	110.19	18.12	17.23	29.99	73.80	17.92	16.90	22.77
Secchi Depth (m)	2.3	6.0	4.1	4.8	2.4	6.5	4.0	1.2	1.5	3.5	11.0	4.0	2.9
Total Hg (ng/L)	2.43	1.07	0.55	0.80	0.69	0.71	1.67	2.85	1.82	0.85	1.49	2.17	1.67
Methyl Hg (ng/L)	0.13	0.03	0.03	0.04		0.07	0.08	0.32	0.15	0.04	0.03	0.09	0.06
Chlorophyll (µg/L)	7.2	1.66	13.01	3.36	12.46	2.00	0.95	8.6	6.54	2.30	1.4	1.1	5.34

Lake Name	Oneida Lake	Onteora Lake	Osgood Pond	Otsego Lake	Owasco Lake	Payne Lake	Pine Lake	Polliwog Pond	Quaker Lake	Queechy Lake	Raquette Lake	Red Lake	Rich Lake
Pond #	010026	130845	030202	160404	010212	040068	070724	020120	125359	070057	060293	040010	050682
Date	7/5/05	7/7/04	7/12/05	7/2/03	7/15/04	7/16/03	7/14/05	7/21/03	7/20/04	7/11/05	7/19/05	7/27/04	7/17/03
SO_4 (mg/L)	41.59	3.79	4.61	11.51	14.67	5.93	3.94	4.50	7.22	7.90	4.13	7.76	4.47
NO_3 (mg/L)	0.76	0.02	0.03	2.17	3.65	0.03	0.04	0.03	0.49	0.03	0.35	0.03	0.15
Cl (mg/L)	22.77	1.00	4.39	16.15	21.34	2.31	0.29	0.34	2.01	23.43	5.39	18.13	3.54
F (mg/L)	0.06	0.04	0.04	0.05	0.05	0.13	0.03	0.03	0.04	0.02	0.06	0.08	0.07
ANC (µeq/L)	1966.17	271.25	281.87	2075.70	2062.44	1081.76	21.22	15.00	229.94	2231.32	80.28	1084.19	141.43
DOC (mg/L)	3.56	7.37	6.46	2.46	2.50	6.05	2.14	3.31	1.83	2.46	4.84	5.66	5.24
SiO_2 (mg/L)	2.21	3.53	2.16	0.14	1.59	2.10	2.52	0.1	4.10	1.87	4.93	1.58	4.40
Ca (mg/L)	55.67	4.90	5.53	42.92	40.14	15.54	1.21	1.56	5.03	35.29	2.52	24.45	3.96
Mg (mg/L)	9.68	1.37	1.83	3.33	8.67	4.62	0.28	0.25	1.50	13.15	0.56	4.50	0.70
Na (mg/L)	14.14	1.34	2.52	8.06	12.56	2.25	0.58	0.54	1.94	14.68	2.91	10.84	2.35
K (mg/L)	1.26	0.51	0.46	1.42	1.50	0.91	0.17	0.24	0.66	0.51	0.35	1.44	0.24
NH_4 (mg/L)	0.04	0.03	0.01	0.02	0.05	0.01	0.01	0.01	0.05	0.01	0.01	0.02	0.01
Al Tot Dis (µg/L)	43	6	35	9	377	6	30	16	8	11	38	5	40
Al Total Monomeric (µg/L)	56	29	29	44	102	63	27	28	30	53	29	28	31
Al Organic Monomeric (µg/L)	34	26	24	39	30	30	27	28	25	23	30	24	33
Al Inorganic Monomeric (µg/L)	22	3	5	5	72	33	0	0	5	30	0	4	0
Lab pH	8.26	8.27	7.39	8.46	8.58	9.16	6.32	6.12	7.42	8.54	6.84	8.27	7.15
Air Eq. pH	8.42	7.60	7.64	8.17	8.40	8.35	6.28	6.12	7.38	8.49	7.06	8.34	7.39
Color (PtCo)	15	60	50	10	10	35	5	10	15	10	25	30	35
Sp Cond (µS/cm)	354.00	41.85	57.20	284.13	313.83	126.72	15.05	17.13	52.70	301.00	38.50	186.10	40.39
Secchi Depth (m)	4.5	0.8	2.0	2.1	2.8	1.0	3.5	3.5	8.1	4.1	5.0	3.5	3.5
Total Hg (ng/L)	0.86	0.99	1.92	0.52	0.69	0.78	0.63	0.76	0.58	0.64	1.09	0.59	1.54
Methyl Hg (ng/L)	0.03	0.20	0.07	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.09
Chlorophyll (µg/L)	2.20	46.16	5.00	2.6	14.57	34.2	2.50	3.2	0.56	1.80	1.30	4.94	1.9

Lake Name	Rio Res.	Rock Pond	Round Lake	Round Pond	Rudd Pond	Rushford Lake	Russian Lake	Sacandaga Lake	Salmon River Res.	Sand Lake	Saratoga Lake	Seneca Lake	Silver Lake	Snake Pond
Pond #	090079A	050645	071089	050687	151134	110146	040774	050314	080019A	050225	050027	010369	110115	040579
Date	7/29/03	7/7/03	7/6/05	7/12/04	7/15/04	7/26/05	7/21/04	7/20/05	7/1/03	7/22/03	7/18/05	7/20/05	7/21/04	7/14/03
SO_4 (mg/L)	6.99	4.06	12.94	3.78	5.72	12.08	3.92	3.69	3.35	3.49	10.51	38.31	17.46	4.34
NO_3 (mg/L)	0.07	0.03	0.03	0.02	0.03	1.26	0.79	0.04	0.32	0.03	0.04	1.40	0.13	0.17
Cl (mg/L)	20.03	0.50	51.03	0.20	12.84	12.23	0.19	7.88	0.46	0.19	44.24	151.55	27.83	0.26
F (mg/L)	0.04	0.09	0.07	0.04	0.02	0.05	0.05	0.03	0.03	0.03	0.05	0.10	0.06	0.10
ANC (µeq/L)	157.14	62.97	1821.15	128.30	1884.98	1214.69	5.74	182.05	279.09	8.22	1746.44	1697.53	1975.03	4.89
DOC (mg/L)	3.29	8.01	5.67	8.10	3.55	2.38	3.18	4.43	4.44	4.70	4.05	2.35	4.39	2.77
SiO_2 (mg/L)	0.33	0.52	5.72	3.00	7.47	3.02	2.83	1.42	1.36	0.90	3.47	0.33	0.30	4.37
Ca (mg/L)	5.69	2.23	41.72	3.53	31.48	29.16	1.08	4.43	5.38	1.05	38.40	48.70	37.57	1.10
Mg (mg/L)	1.15	0.54	8.02	0.60	12.43	4.30	0.19	1.01	1.40	0.27	7.79	10.68	9.06	0.23
Na (mg/L)	11.16	0.87	35.53	0.98	8.37	7.88	0.40	4.19	0.60	0.48	23.83	67.42	15.14	0.55
K (mg/L)	0.72	0.30	1.74	0.19	0.36	1.44	0.37	0.27	0.20	0.11	1.15	2.40	2.95	0.26
NH_4 (mg/L)	0.02	0.01	0.01	0.02	0.05	0.01	0.04	0.01	0.04	0.01	0.02	0.02	0.05	0.01
Al Tot Dis (µg/L)	12	149	6	33	13	23	227	9	34	152	6	7	5	185
Al Total Monomeric (µg/L)	32	59	37	31	46	41	107	30	37	77	55	58	68	74
Al Organic Monomeric (µg/L)	32	64	23	30	26	24	39	26	32	50	30	29	28	36
Al Inorganic Monomeric (µg/L)	0	0	14	1	20	17	68	4	5	27	25	29	40	38
Lab pH	7.72	6.39	8.20	6.97	8.73	8.32	5.23	7.43	7.40	5.48	8.63	8.71	8.78	5.43
Air Eq. pH	7.31	6.80	8.43	7.32	8.36	8.27	5.18	7.47	7.51	5.49	8.42	8.45	8.40	5.50
Color (PtCo)	20	70	40	70	25	10	15	20	45	35	20	5	15	15
Sp Cond (µS/cm)	107.30	22.08	387.00	26.85	238.59	186.42	16.30	55.10	41.00	14.06	332.00	652.00	327.00	16.17
Secchi Depth (m)	3.0	2.1	1.5	1.8	1.5	4.0	5.0	3.5	3.1	2.6	3.0	3.0	3.3	5.0
Total Hg (ng/L)	1.34	2.54	1.48	1.94	0.47	0.41	1.52	0.71	1.96	1.68	0.38	0.35	0.65	1.71
Methyl Hg (ng/L)	0.03	0.35	0.19	0.14	0.03	0.03	0.08	0.03	0.10	0.14	0.03	0.03	0.03	0.04
Chlorophyll (µg/L)	10.2	5.9	10.30	8.60	16.56	2.20	0.80	2.60	2.7	11.1	4.00	2.50	8.39	1.0

Lake Name	Soft Maple Dam Pond	South Pond	Spy Lake	Star Lake	Stony Lake	Sturgeon Pool	Sunday Lake	Swann Pond	Swinging Bridge Res.	Sylvan Lake	Sylvia Lake	Taylor Pond	Thompsons Lake
Pond #	040431	060245	050232	040281	040617	130453A	040473	140570	090108A	130352	040088	020227	070274
Date	7/9/03	7/7/03	7/28/04	7/31/03	7/25/05	7/7/04	7/14/04	7/9/03	7/29/03	7/15/04	7/16/03	7/15/03	7/6/04
SO_4 (mg/L)	4.02	4.88	3.60	3.78	2.60	21.63	2.98	8.67	6.79	21.65	28.38	5.03	6.66
NO_3 (mg/L)	1.01	0.66	0.03	0.02	0.06	1.27	0.19	0.03	0.06	0.03	0.63	0.03	0.03
Cl (mg/L)	0.27	5.41	14.11	8.94	0.34	52.48	0.24	7.96	23.25	32.80	13.17	0.71	38.64
F (mg/L)	0.06	0.07	0.04	0.06	0.06	0.08	0.14	0.03	0.04	0.04	0.04	0.04	0.03
ANC (µeq/L)	28.90	24.84	54.59	184.45	93.84	2260.94	46.03	288.33	205.63	2165.99	1263.75	179.38	2066.59
DOC (mg/L)	4.33	3.66	3.03	2.63	5.11	7.16	8.33	8.60	4.10	3.48	2.70	3.59	4.38
SiO_2 (mg/L)	4.39	5.57	3.13	0.36	0.64	3.25	5.21	2.47	0.73	1.03	5.32	2.15	1.37
Ca (mg/L)	1.69	1.80	2.49	4.34	2.70	68.29	1.67	5.36	6.72	44.51	26.26	3.95	41.13
Mg (mg/L)	0.34	0.40	0.71	0.89	0.36	10.85	0.38	2.13	1.35	17.76	6.42	0.92	3.49
Na (mg/L)	0.72	3.35	8.80	5.50	0.50	31.63	1.04	5.92	13.36	19.75	8.25	1.13	17.77
K (mg/L)	0.36	0.27	0.22	0.63	0.20	2.28	0.34	2.37	0.88	1.07	0.59	0.38	1.38
NH_4 (mg/L)	0.01	0.02	0.01	0.01	0.01	0.20	0.06	0.02	0.02	0.03	0.01	0.01	0.01
Al Tot Dis (µg/L)	136	131	5	13	8	20	251	14	11	13	5	5	12
Al Total Monomeric (µg/L)	46	53	27	32	28	64	79	31	32	47	51	28	50
Al Organic Monomeric (µg/L)	41	54	25	32	24	27	76	31	35	29	28	26	25
Al Inorganic Monomeric (µg/L)	5	0	2	0	4	37	3	0	0	18	23	2	25
Lab pH	6.09	6.08	6.73	7.36	6.95	8.65	6.21	6.92	7.25	8.90	8.37	7.38	8.45
Air Eq. pH	6.41	6.24	7.01	7.44	7.18	8.44	6.47	7.59	7.37	8.44	8.32	7.51	8.43
Color (PtCo)	35	20	20	10	30	40	160	140	20	10	10	15	15
Sp Cond (µS/cm)	19.40	35.84	67.33	62.20	20.59	432.18	18.41	83.30	124.20	360.36	236.61	37.52	310.86
Secchi Depth (m)	3.2	4.5	4.5	5.5	2.5	3.9	1.2	0.8	2.5	7.6	7.0	5.2	5.2
Total Hg (ng/L)	1.60	1.36	0.88	0.60	0.98	0.65	3.81	0.71	1.39	0.30	0.57	0.64	0.53
Methyl Hg (ng/L)	0.10	0.04	0.03	0.03	0.11	0.03	0.80	0.29	0.08	0.03	0.03	0.03	0.03
Chlorophyll (µg/L)	1.3	2.5	3.84	2.2	5.10	2.62	3.32	15.4	12.2	6.85	1.5	2.1	10.93

Lake Name	Tomhan-nock Res.	Tupper Lake	Union Falls Flow	Upper Chateaugay Lake	Walton Lake	Wappinger Lake	Weller Pond	West Caroga Lake	White Lake	White Pond	Willis Lake	Woodhull Lake	Woods Lake
Pond #	071095	060109	020074	030006B	130257	130365	020209	070698	090117	130079	050215	040982	050156
Date	7/14/04	6/30/03	7/12/05	7/5/05	7/29/03	7/12/05	7/2/03	7/7/04	7/28/03	7/12/04	7/8/03	7/10/03	7/26/05
SO_4 (mg/L)	8.38	2.06	4.37	4.16	12.44	15.80	5.26	4.49	6.23	8.76	4.27	3.88	3.34
NO_3 (mg/L)	0.55	0.28	0.56	0.06	0.02	1.41	0.02	0.12	0.02	0.03	0.03	0.72	0.03
Cl (mg/L)	19.77	3.24	8.83	4.19	116.72	48.23	0.45	14.14	19.03	37.14	0.52	0.28	0.27
F (mg/L)	0.05	0.03	0.04	0.06	0.05	0.05	0.03	0.03	0.04	0.03	0.03	0.06	0.03
ANC (µeq/L)	594.62	33.21	240.47	428.52	719.87	2258.07	88.88	222.42	216.20	403.41	52.28	20.81	16.37
DOC (mg/L)	2.69	4.85	8.49	6.00	3.69	3.47	6.40	3.84	3.91	2.78	3.76	2.30	1.93
SiO_2 (mg/L)	0.58	4.51	6.54	5.40	0.91	5.76	3.61	3.56	0.19	0.49	1.25	2.71	2.17
Ca (mg/L)	15.65	2.70	5.42	7.16	16.74	50.37	3.17	5.47	6.63	13.14	2.11	1.44	0.92
Mg (mg/L)	2.90	0.57	1.37	1.94	3.72	10.48	0.55	1.11	1.01	2.12	0.41	0.27	0.22
Na (mg/L)	10.28	1.80	4.74	3.18	63.09	36.33	1.02	8.80	5.62	18.26	0.89	0.56	0.56
K (mg/L)	1.30	0.31	0.38	0.55	1.38	1.44	0.21	0.39	0.76	0.89	0.08	0.23	0.12
NH_4 (mg/L)	0.10	0.07	0.02	0.03	0.03	0.03	0.02	0.01	0.04	0.02	0.02	0.01	0.01
Al Tot Dis (µg/L)	5	41	54	122	11	5	38	25	9	5	14	48	11
Al Total Monomeric (µg/L)	35	34	32	28	35	49	34	31	30	30	39	32	24
Al Organic Monomeric (µg/L)	28	36	27	28	34	30	33	27	27	25	44	27	23
Al Inorganic Monomeric (µg/L)	7	0	5	0	1	19	1	4	3	5	0	5	1
Lab pH	8.87	6.92	7.22	7.48	7.98	8.14	6.92	7.34	7.24	7.61	6.65	6.00	6.09
Air Eq. pH	7.94	7.13	7.51	7.81	8.06	8.43	7.05	7.52	7.52	7.89	6.75	6.21	6.19
Color (PtCo)	15	30	70	35	15	30	40	25	15	15	25	10	5
Sp Cond (µS/cm)	149.39	31.40	66.70	70.50	470.00	125.30	27.52	84.55	105.60	189.34	20.29	16.37	12.97
Secchi Depth (m)	3.4	3.0	1.3	2.5	2.9	1.5	3.5	5.5	2.9	3.2	2.5	8.0	6.0
Total Hg (ng/L)	0.27	1.63	3.08	1.94	0.95	1.07	1.73	0.85	1.08	0.55	1.04	1.18	0.33
Methyl Hg (ng/L)	0.03	0.05	0.26	0.10	0.03	0.12	0.08	0.03	0.03	0.03	0.09	0.03	0.03
Chlorophyll (µg/L)	10.20	7.00	5.10	1.80	4.6	4.90	5.7	3.37	2.7	5.00	3.6	1.5	0.90

APPENDIX D— Lake physical and wetlands information and predicted Hg concentrations in fish

Lake Name	Ballston Lake	Big Moose Lake	Black River Pond	Blue Mountain Lake	Breakneck Pond	Butterfield Lake	Canada Lake	Canadarago Lake	Canandaigua Lake	Canopus Lake	Carter Pond	Chase Lake
Pond #	071090	040752	070806	060307	130150D	040054	070717	160392	010286	130168A	050075	050164
Elevation (m)	77	556	425	545	331	85	472	389	210	279	134	442
Watershed Area (ha)		9481	1655	1871.01	146.7				47700	325.8		567.2
Shoreline (km)	11.43	24.14	2	13.52	3.4	16.26	25.3	14.48	57.78	6.7	1.35	2.85
Outlet Dam		N	Y	N	N					Y		Y
Predicted Hg in 14" SMB (ng/g)				750		464	873	299	493			
Predicted Hg in 14" LMB (ng/g)	537				778	369		334	468	484	547	
Predicted Hg in 18" WEYE (ng/g)								470				
Predicted Hg in 9" YP (ng/g)	175	904	488			122		126	122	193	314	728
Lake Area (ha)	107.54	489.54	14.10	503.20	26.20	393.34	217.70	773.11	4260.92	43.78	7.97	27.25
Contiguous Wetlands (ha)	96.43	149.97		33.97		265.59	331.80	264.20	353.49	4.36	110.68	23.36
% Contig. Wetland Relative to Lake Area	89.67	30.64		6.75		67.52	152.41	34.17	8.30	9.95	1388.97	85.74
Watershed Wetland Area (ha)		549.01		21.91								36.28
% Watershed Wetland Area		16.30		1.17								6.40

Lake Name	**Chatauqua Lake**	**Chazy Lake**	**Chodikee Lake**	**Conesus Lake**	**Cranberry Lake**	**Crane Pond**	**Cuba Lake**	**Delta Lake**	**Deruyter Res.**	**Dunham Res.**	**Dyken Pond**	**East Sidney Res.**	**Eaton Brook Res.**
Pond #	120122	020020	130437	110067	040309	050421	120115	701059	160056	070425	070445	160262	160163
Elevation (m)	399	470	88	249	453	329	471	167	390	401	494	367	436
Watershed Area (ha)	46750			23100	25207.6	2068				3019.6	390.4		
Shoreline (km)	68.32	15.45	2.09	29.72	89.32	5.8	9.98	30.8	9.33	4.8	7.6	23.82	9.01
Outlet Dam	Y			Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Predicted Hg in 14" SMB (ng/g)		588			870	890	378	533		1138			450
Predicted Hg in 14" LMB (ng/g)	125		529	232				538	296	630			422
Predicted Hg in 18" WEYE (ng/g)	253			372			596	997		2595			675
Predicted Hg in 9" YP (ng/g)		237	164		568		162	297	185	689	187	266	136
Lake Area (ha)	5326.92	730.40	24.24	1296.95	2800.33	78.37	183.90	1004.90	240.56	37.80	71.30	76.75	114.71
Contiguous Wetlands (ha)	340.79		77.51	310.74	274.16	5.50			1.55			10.13	35.68
% Contig. Wetland Relative to Lake Area	6.40		319.77	23.96	9.79	7.02			0.64			13.20	31.11
Watershed Wetland Area (ha)					2836.17	7.12							
% Watershed Wetland Area					11.25	0.34							

Lake Name	Effley Falls Res.	Elmers Falls Res.	Fall Lake	Ferris Lake	Forge Pond	Fort Pond	Francis Lake	Franklin Falls Flow	Fresh Pond	Glass Lake	Good Luck Lake	Goodyear Lake	Great Sacandaga Lake	Green-wood Lake
Pond #	040426	040425	050243	070777	140555	140755	040451	020076	140753	070394	050265	160360	050127	131026
Elevation (m)	354	338	512	525	6	1	440	446	1	252	506	351	235	192
Watershed Area (ha)	63521		4241	578.1			445.2	76491						
Shoreline (km)	9.5	2.57	1.4	4.9	6.28	5.15	5.4	11.6	1.77	4.51	1.93	15.61	167.2	16.74
Outlet Dam	Y	Y	N	N	Y	N	N	Y	N	Y	N	Y	Y	
Predicted Hg in 14" SMB (ng/g)	1278	947				303							1055	174
Predicted Hg in 14" LMB (ng/g)					579	343			875	396		404		
Predicted Hg in 18" WEYE (ng/g)						524		2023				468	1739	350
Predicted Hg in 9" YP (ng/g)		290	436	426	100	205	599	476		261	463	197	461	43
Lake Area (ha)	121.50	13.00	9.90	48.40	44.54	72.49	54.60	184.20	12.60	49.20	34.20	165.74	10297.11	776.80
Contiguous Wetlands (ha)			119.53		28.89	0.45			19.89			68.89	1472.83	
% Contig. Wetland Relative to Lake Area			1207.34		64.86	0.63			157.87			41.57	14.30	
Watershed Wetland Area (ha)			307.39											
% Watershed Wetland Area			7.25											

Lake Name	Gull Lake	Harris Lake	High Falls Pond	Hinckley Res.	Hoel Pond	Honeoye Lake	Kings Flow	Lake Adirondack	Lake Eaton	Lake Flower	Lake George	Lake Huntington	Lake Luzerne	Lake Mahopac
Pond #	040717	050680	040418	070799	020161	110057	050588A	050587A	060248	020086	020367	090216	050318	130053
Elevation (m)	539	473	279	373	493	245	521	506	525	466	97	368	190	200
Watershed Area (ha)	75.1	9133.3			651.6	9500	5275	378.3	1100	48626			490.812	
Shoreline (km)	2.7	8.5	15.69	39.99	9.8	17.45	6.5	9.8	7.72	6.5	210.8	2.57	4.35	6.12
Outlet Dam	Y	N	Y	Y	N	N	Y	Y		Y				
Predicted Hg in 14" SMB (ng/g)	1182	711	840	895		98			1031		500			325
Predicted Hg in 14" LMB (ng/g)						313	511			498		212	403	344
Predicted Hg in 18" WEYE (ng/g)		742				506								
Predicted Hg in 9" YP (ng/g)				465	130	80	232	164	453	165	261		233	
Lake Area (ha)	14.80	121.78	75.00	1126.70	181.70	726.44	82.97	80.47	230.74	67	11396	33.70	40.44	234.53
Contiguous Wetlands (ha)	24.88	35.23				336.97	102.42	18.65	17.82				21.98	13.92
% Contig. Wetland Relative to Lake Area	168.10	28.93				46.39	123.45	23.18	7.72				54.37	5.94
Watershed Wetland Area (ha)	8.28	61.27					184.62	16.51	38.61				25.61	
% Watershed Wetland Area	11.03	0.67					3.50	4.36	3.51				5.22	

Lake Name	Lake Moraine	Lake Ozonia	Lake Ron-konkoma	Lake Superior	Lake Taghkanic	Lake Welch	Limekiln Lake	Lincoln Pond	Loch Sheldrake	Long Lake	Lower Saranac Lake	Massawepie Lake
Pond #	160152	030165	140304	090104	130869	130150C	040826	020315	090051	060241	020104	030369
Elevation (m)	369	421	17	385	199	308	576	314	445	496	467	461
Watershed Area (ha)		761.54					1110.7			13149		1364.8
Shoreline (km)	9.17	11.6	3.54	5.95	5.79	6.12	10	18.91	2.09	55.52	27.36	11.2
Outlet Dam	Y	N	N				N				N	N
Predicted Hg in 14" SMB (ng/g)		786	158							579	836	385
Predicted Hg in 14" LMB (ng/g)			161	623		607		712	450		492	
Predicted Hg in 18" WEYE (ng/g)			222						1331			
Predicted Hg in 9" YP (ng/g)	97	250	60	260		120	344	309	201	270	279	
Lake Area (ha)	96.20	157.60	93.51	72.50	64.80	85.50	188.49	260.30	25.87	1626.9	933.20	151.23
Contiguous Wetlands (ha)	21.21		0				21.99		0	151.64		15.45
% Contig. Wetland Relative to Lake Area	22.05		0				11.67		0	9.32		10.22
Watershed Wetland Area (ha)		32.31					35.99			699.29		27.80
% Watershed Wetland Area		4.24					3.24			5.32		2.04

Lake Name	Meacham Lake	Middle Stoner Lake	Mohansic Lake	Mongaup Falls Res.	Mongaup Pond	Moreau Lake	Moshier Res.	Mud Pond	Muller Pond	Nathianel Cole Pond	Nine Corner Lake	North Lake	North-South Lake
Pond #	030179A	070721	130049	090096A	090328	050101	040478	050226	050394	165467	070719	041007	130921
Elevation (m)	473	503	137	285	652	104	500	544	446	390	570	555	649
Watershed Area (ha)	10192.1	987.9	440				47141	79.6	246.3		204.6	8126	443.4
Shoreline (km)	11.27	2.9	4.1	9.33	4.18	5.79	10.1	1.13	3.38		5.7	17.6	4.5
Outlet Dam	Y	N	N	Y			Y			Y	Y	Y	Y
Predicted Hg in 14" SMB (ng/g)	741	958		711	487	505	1275						
Predicted Hg in 14" LMB (ng/g)			543	436		543				358			682
Predicted Hg in 18" WEYE (ng/g)													
Predicted Hg in 9" YP (ng/g)	1655		77			273		161	271		786	1640	473
Lake Area (ha)	960.52	33.40	42.20	46.60	39.57	45.32	122.62	5.30	17.42	20.19	45.29	179.01	36.39
Contiguous Wetlands (ha)	1785.34		37.29		2.03	1.10	114.83	25.78	26.05	13.02	1.62	91.19	0.75
% Contig. Wetland Relative to Lake Area	185.87		88.36		5.14	2.43	93.65	486.34	149.55	64.47	3.58	50.94	2.05
Watershed Wetland Area (ha)								20.45	41.91			543.66	
% Watershed Wetland Area								25.69	17.02			6.69	

Lake Name	Oneida Lake	Onteora Lake	Osgood Pond	Otsego Lake	Owasco Lake	Payne Lake	Pine Lake	Polliwog Pond	Quaker Lake	Queechy Lake	Raquette Lake	Red Lake	Rich Lake
Pond #	010026	130845	030202	160404	010212	040068	070724	020120	125359	070057	060293	040010	050682
Elevation (m)	112	129	503	363	217	105	479	486	409	311	537	93	477
Watershed Area (ha)	337300		792.38		53900			331.8			14839.7		2452
Shoreline (km)	88.03	2.09	10.3	32.19	39.75	4.5	4.81	7.6		4.83	52.79	9.3	8.37
Outlet Dam	N		N					N	Y		N		Y
Predicted Hg in 14" SMB (ng/g)	291		443	417	386			1054	384		921	762	
Predicted Hg in 14" LMB (ng/g)	499		485	333		125			446	406	980		
Predicted Hg in 18" WEYE (ng/g)	426			278	538								852
Predicted Hg in 9" YP (ng/g)	159	230	319	145	134	250	558	375		190	384	297	
Lake Area (ha)	20676	7.80	207.52	1661.25	2735.57	59.97	69.85	84.20	109.40	51.80	2167.71	145.41	153.75
Contiguous Wetlands (ha)		4.19	26.41	182.78	299.33	192.09	23.49				611.61	82.68	42.29
% Contig. Wetland Relative to Lake Area		53.72	12.73	11.00	10.94	320.30	33.63				28.21	56.86	27.51
Watershed Wetland Area (ha)			52.08								1711.54		159.77
% Watershed Wetland Area			6.57								11.53		6.51

Lake Name	Rio Res.	Rock Pond	Round Lake	Round Pond	Rudd Pond	Rushford Lake	Russian Lake	Sacandaga Lake	Salmon River Res.	Sand Lake	Saratoga Lake	Seneca Lake	Silver Lake	Snake Pond
Pond #	090079A	050645	071089	050687	151134	110146	040774	050314	080019A	050225	050027	010369	110115	040579
Elevation (m)	248	539	47	498	240	439	565	526	286	541	62	136	412	588
Watershed Area (ha)		48.55		1497			203.1	3626.65		696.29		183100		188.1
Shoreline (km)	14.97	1.93	4.35	6.4	2.9	8.53	2.1	21.24	49.25	4.02	37.06	121.3	11.9	1.2
Outlet Dam	Y	N	N	Y		Y	Y		Y		Y	N		N
Predicted Hg in 14" SMB (ng/g)	778			597				969			477	599		
Predicted Hg in 14" LMB (ng/g)		870	405		285				1063		403		337	
Predicted Hg in 18" WEYE (ng/g)						1390							432	
Predicted Hg in 9" YP (ng/g)	270	590	154	470	140	214	1100		380	300	152	125	115	492
Lake Area (ha)	170.90	20.4	140.61	88.60	25.77	230.50	15.27	648.24	1068.98	47.43	1577.14	17558.92	334.14	6.39
Contiguous Wetlands (ha)		0.27	208.09	79.77	1.85		5.16	112.38	156.72	39.49	561.58	634.63	147.95	0
% Contig. Wetland Relative to Lake Area		1.31	147.99	90.04	7.17		33.81	17.34	14.66	83.27	35.61	3.61	44.28	0
Watershed Wetland Area (ha)		0.27		100.64			8.28	288.69		103.15				0
% Watershed Wetland Area		0.55		6.72			4.07	7.96		14.81				0

Lake Name	Soft Maple Dam Pond	South Pond	Spy Lake	Star Lake	Stony Lake	Sturgeon Pool	Sunday Lake	Swann Pond	Swinging Bridge Res.	Sylvan Lake	Sylvia Lake	Taylor Pond	Thompsons Lake
Pond #	040431	060245	050232	040281	040617	130453A	040473	140570	090108A	130352	040088	020227	070274
Elevation (m)	392	538	505	441	407	40	503	11	326	98	199	424	387
Watershed Area (ha)	61772	5445	1075	269	102.2		995.8			236.3			
Shoreline (km)	6.1	10.7	7.4	7.4	3.2	9.17	1.3	2.41	27.7	2.8	6.67	13.36	3.54
Outlet Dam	Y	N	N		N	Y	Y	Y	Y	Y			
Predicted Hg in 14" SMB (ng/g)	1366		384		724	506			686		201		529
Predicted Hg in 14" LMB (ng/g)						468		289	427	329			495
Predicted Hg in 18" WEYE (ng/g)									861				
Predicted Hg in 9" YP (ng/g)	794	472		186		175	860	70	178			240	495
Lake Area (ha)	36.10	175.28	150.19	91.21	28.00	85.50	7.97	23.25	347.10	45.56	127.1	346.50	51.80
Contiguous Wetlands (ha)		54.41	39.69	0	3.00		47.42	19.77		0	38.96		
% Contig. Wetland Relative to Lake Area		31.04	26.42	0	10.72		595.19	85.01		0	30.65		
Watershed Wetland Area (ha)		146.62	106.22	0	9.42		48.40						
% Watershed Wetland Area		4.58	9.88	0	9.22		4.86						

Lake Name	Tomhan-nock Res.	Tupper Lake	Union Falls Flow	Upper Chateaugay Lake	Walton Lake	Wappinger Lake	Weller Pond	West Caroga Lake	White Lake	White Pond	Willis Lake	Woodhull Lake	Woods Lake
Pond #	071095	060109	020074	030006B	130257	130365	020209	070698	090117	130079	050215	040982	050156
Elevation (m)	119	471	429	399	215	26	468	443	403	253	397	572	418
Watershed Area (ha)		20608		15852.4	268.9		373.9	1413.4		237.9	139.4	1841.16	177.57
Shoreline (km)	28.16	67.59	23.66	27.5	4	5.31	6.9	4.9	6.76	3.5	2.6	25.27	3.38
Outlet Dam	Y	Y	Y	N	N	Y	N	N		Y	N	Y	Y
Predicted Hg in 14" SMB (ng/g)	210	926	994	904			520	458				560	854
Predicted Hg in 14" LMB (ng/g)	242				339	437			343	440			
Predicted Hg in 18" WEYE (ng/g)	382	743								311			
Predicted Hg in 9" YP (ng/g)	110	690	340	471	60	138	250	304	60	150	380	210	
Lake Area (ha)	696.70	1939.2	658.10	1028.56	47.80	40.81	72.80	129.10	108.80	56.95	13.35	437.10	28.51
Contiguous Wetlands (ha)		322.88		425.46		7.56				6.72	9.68		0
% Contig. Wetland Relative to Lake Area		16.65		41.36		18.53				11.80	72.54		0
Watershed Wetland Area (ha)		2521.27		1598.42							12.74	135.29	0.43
% Watershed Wetland Area		12.23		10.08							9.14	7.35	0.24

APPENDIX E
Study lakes with new fish consumption advice from NYSDOH

NYSDOH fish consumption advisories for specific waters based on mercury data for fish sampled for this project (NYSDOH 2007). (NYSDOH also recommends that women of childbearing age, infants and children under 15 years of age EAT NO fish of any species from these waters, and that they EAT NO northern pike, pickerel, walleye, largemouth and smallmouth bass and larger yellow perch (>10") from **any** Adirondack and Catskill Mountain region waters. In addition, the NYSDOH general advisory recommends that everyone eat no more than one meal per week of fish from any of the state's fresh waters and some waters at the mouth of the Hudson River)

Lake	Species	Recommendations
Big Moose Lake (Herkimer County)	Yellow perch > 9 inches	Eat no more than one meal per month
Blue Mountain Lake (Hamilton County)	Largemouth bass > 15 inches and smallmouth bass > 15 inches	Eat no more than one meal per month
Breakneck Pond (Rockland County)	Largemouth bass > 15 inches	Eat no more than one meal per month
Canada Lake (Fulton County)	Smallmouth bass > 15 inches and chain pickerel (all sizes)	Eat no more than one meal per month
Chase Lake (Fulton County)	Yellow perch > 9 inches	Eat no more than one meal per month
Chodikee Lake (Ulster County)	Largemouth bass > 15 inches	Eat no more than one meal per month
Cranberry Lake (St. Lawrence County)	Smallmouth bass	Eat no more than one meal per month
Crane Pond (Essex County)	Smallmouth bass > 15 inches	Eat no more than one meal per month
Dunham Reservoir (Rensselaer County)	Smallmouth bass	Eat no more than one meal per month
	Walleye	Eat none
Dyken Pond (Rensselaer County)	Largemouth bass	Eat no more than one meal per month
Effley Falls Reservoir (Lewis County)	Chain pickerel and smallmouth bass	Eat no more than one meal per month
Elmer Falls Reservoir (Lewis County)	Smallmouth bass	Eat no more than one meal per month
Ferris Lake (Hamilton County)	Yellow perch > 12 inches	Eat none
	Smaller yellow perch	Eat no more than one meal per month

Francis Lake (Lewis County)	Chain pickerel and yellow perch > 9 inches	Eat no more than one meal per month
Franklin Falls Flow (also known as Franklin Falls Pond; Franklin and Essex Counties)	Walleye	Eat none
Fresh Pond (in Hither Hills State Park, Suffolk County)	Largemouth bass > 15 inches	Eat no more than one meal per month
Goodyear Lake (Otsego County)	Walleye > 22 inches	Eat no more than one meal per month
Great Sacandaga Lake (Fulton and Saratoga Counties)	Smallmouth bass and walleye	Eat no more than one meal per month
High Falls Pond (Lewis County)	Smallmouth bass > 15 inches	Eat no more than one meal per month
Kings Flow (Hamilton County)	Largemouth bass > 15 inches	Eat no more than one meal per month
Lake Eaton (Hamilton County)	Smallmouth bass (also yellow perch >10", based on previous data not from this study)	Eat no more than one meal per month
Lincoln Pond (Essex County)	Largemouth bass > 15 inches.	Eat no more than one meal per month
Loch Sheldrake (Sullivan County)	Walleye	Eat no more than one meal per month
Long Lake (Hamilton County)	Northern pike	Eat no more than one meal per month
Lower Saranac Lake (Franklin County)	Smallmouth bass > 15 inches	Eat no more than one meal per month
Meacham Lake (Franklin County)	Smallmouth bass (also yellow perch>12", based on previous data not from this study)	Eat none
Middle Stoner Lake (Also known as East Stoner Lake; Fulton County)	Northern pike (also smaller yellow perch, based on previous data not from this study)	Eat no more than one meal per month
	Smallmouth bass > 15 inches	Eat no more than one meal per month
Moshier Reservoir (Herkimer County)	Smallmouth bass (also yellow perch, based on previous data not from this study)	Eat no more than one meal per month

North Lake (Town of Ohio, Herkimer County)	Yellow perch	Eat no more than one meal per month
North-South Lake (Greene County)	Largemouth bass > 15 inches	Eat no more than one meal per month
Osgood Pond (Franklin County)	Smallmouth bass	Eat no more than one meal per month
Pine Lake (Fulton County)	Largemouth bass	Eat no more than one meal per month
Polliwog Pond (Franklin County)	Smallmouth bass	Eat no more than one meal per month
Raquette Lake (Hamilton County)	Largemouth bass	Eat no more than one meal per month
Red Lake (Jefferson County)	Walleye	Eat no more than one meal per month
Rio Reservoir (Orange and Sullivan Counties)	Smallmouth bass > 15 inches	Eat no more than one meal per month
Rock Pond and Lake Durant (Town of Indian Lake, Hamilton County)	Largemouth bass > 15 inches	Eat no more than one meal per month
Round Pond (Hamilton County)	Yellow perch > 12 inches	Eat no more than one meal per month
Rushford Lake (Allegany County)	Walleye	Eat no more than one meal per month
Russian Lake (Hamilton County)	Yellow perch > 9 inches	Eat no more than one meal per month
Sacandaga Lake (Hamilton County)	Smallmouth bass	Eat no more than one meal per month
Sand Lake (Town of Arietta, Hamilton County)	Chain pickerel	Eat no more than one meal per month
Salmon River Reservoir (Oswego County)	Largemouth bass and smallmouth bass	Eat no more than one meal per month
Soft Maple Dam Pond and Soft Maple Reservoir (Lewis County)	Smallmouth bass (also rock bass, based on previous data not from this study)	Eat no more than one meal per month
South Pond (Town of Long Lake, Hamilton)	Yellow perch larger than 10 inches	Eat no more than one meal per month

Spy Lake (Hamilton County)	Smallmouth bass > 15 inches	Eat no more than one meal per month
Sunday Lake (Herkimer County)	Chain pickerel	Eat none
Swinging Bridge Reservoir (Sullivan County)	(also yellow perch>12”, based on previous data not from this study.)	Eat no more than one meal per month
Tupper Lake (Franklin and St. Lawrence Counties)	Walleye	Eat no more than one meal per month
Union Falls Flow (Clinton and Franklin Counties)	Smallmouth bass (also walleye, based on previous data not from this study.)	Eat no more than one meal per month
	Northern pike and smallmouth bass	Eat no more than one meal per month
Upper Chateaugay Lake (Clinton County)	Smallmouth bass > 15 inches	Eat no more than one meal per month
Weller Pond (Franklin County)	Northern pike	Eat no more than one meal per month
Willis Lake (Hamilton County)	Smallmouth bass	Eat no more than one meal per month
Woods Lake (Hamilton County)	Smallmouth bass > 15 inches.	Eat no more than one meal per month

APPENDIX F—Study lakes where no fish consumption advice was warranted

Lakes and fish monitored as part of this project where the NYSDOH has not issued specific fish consumption advisories due to mercury. Fish species listed are those where five or more fish were analyzed for mercury and none of these had mercury levels ≥1,000 ng/g [ppb]. (In all freshwaters of New York State the NYSDOH advises people to eat no more than one meal of fish per week to minimize potential adverse health impacts.)

Lake	County	Species
Ballston Lake	Saratoga	Yellow perch
Black River Pond	Rensselaer	Yellow perch
Butterfield Lake	Jefferson	Largemouth bass, Yellow perch
Canadarago Lake	Otsego	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Canandaigua Lake	Ontario	Smallmouth bass, Yellow perch
Canopus Lake	Putnam	Yellow perch
Carter Pond	Washington	Yellow perch
Chautauqua Lake	Chautauqua	Largemouth bass, Walleye, Yellow perch
Chazy Lake	Clinton	Smallmouth bass, Yellow perch
Conesus Lake	Livingston	Largemouth bass, Walleye
Cuba Lake	Allegany	Smallmouth bass, Walleye, Yellow perch
Delta Lake	Oneida	Smallmouth bass, Yellow perch
DeRuyter Reservoir	Onondaga	Yellow perch
East Sidney Reservoir	Delaware	Yellow perch
Eaton Brook Reservoir	Madison	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Fall Lake	Hamilton	Yellow perch
Forge Pond	Suffolk	Largemouth bass
Fort Pond	Suffolk	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Glass Lake	Rensselaer	Chain pickerel, Largemouth bass, Yellow perch
Good Luck Lake	Hamilton	Yellow perch
Greenwood Lake	Orange	Smallmouth bass, Walleye, Yellow perch
Harris Lake	Essex	Smallmouth bass, Walleye
Hinckley Reservoir	Herkimer	Yellow perch
Hoel Pond	Franklin	Yellow perch
Honeoye Lake	Ontario	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Lake Adirondack	Hamilton	Yellow perch
Lake Flower	Franklin	Largemouth bass, Yellow perch
Lake George	Warren	Smallmouth bass, Yellow perch

Lake Huntington	Sullivan	Largemouth bass
Lake Luzerne	Warren	Largemouth bass, Yellow perch
Lake Mahopac	Putnam	Largemouth bass, Smallmouth bass
Lake Ozonia	St. Lawrence	Yellow perch
Lake Ronkonkoma	Suffolk	Walleye, Yellow perch
Lake Superior	Sullivan	Yellow perch
Lake Welch	Rockland	Largemouth bass, Yellow perch
Limekiln Lake	Herkimer	Yellow perch
Massawepie Lake	St. Lawrence	Smallmouth bass
Mohansic Lake	Westchester	Yellow perch
Mongaup Falls Reservoir	Sullivan	Smallmouth bass
Mongaup Pond	Sullivan	Smallmouth bass
Moreau Lake	Saratoga	Largemouth bass, Smallmouth bass, Yellow perch
Mud Pond	Hamilton	Chain pickerel, Yellow perch
Muller Pond	Essex	Yellow perch
Nathaniel Cole Pond	Broome	Largemouth bass
Oneida Lake	Oswego	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Onteora Lake	Ulster	Yellow perch
Otsego Lake	Otsego	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Owasco Lake	Cayuga	Smallmouth bass, Yellow perch
Payne Lake	Jefferson	Largemouth bass, Yellow perch
Quaker Lake	Cattaraugus	Largemouth bass, Smallmouth bass
Queechy Lake	Columbia	Largemouth bass, Yellow perch
Round Lake	Saratoga	Largemouth bass, Yellow perch
Rudd Pond	Dutchess	Largemouth bass, Yellow perch
Saratoga Lake	Saratoga	Chain pickerel, Largemouth bass, Smallmouth bass, Yellow perch
Seneca Lake	Seneca	Smallmouth bass, Yellow perch
Silver Lake	Wyoming	Largemouth bass, Walleye, Yellow perch
Snake Pond	Herkimer	Yellow perch
Star Lake	St. Lawrence	Smallmouth bass, Yellow perch
Stony Lake	Lewis	Chain pickerel
Sturgeon Pool	Ulster	Smallmouth bass, White perch, Yellow perch
Swann Pond	Suffolk	Yellow perch
Sylvan Lake	Dutchess	Largemouth bass
Sylvia Lake	St. Lawrence	Smallmouth bass
Taylor Pond	Clinton	Yellow perch

Thompsons Lake	Albany	Largemouth bass, Yellow perch
Tomhannock Reservoir	Rensselaer	Largemouth bass, Smallmouth bass, Walleye, Yellow perch
Walton Lake	Orange	Largemouth bass, Yellow perch
Wappinger Lake	Dutchess	Largemouth bass, Yellow perch
West Caroga Lake	Fulton	Smallmouth bass, Yellow perch
White Lake	Sullivan	Yellow perch
White Pond	Putnam	Largemouth bass, Yellow perch
Woodhull Lake	Herkimer	Smallmouth bass, Yellow perch

For information on other
NYSERDA reports, contact:

New York State Energy Research
and Development Authority
17 Columbia Circle
Albany, New York 12203-6399

toll free: 1 (866) NYSERDA
local: (518) 862-1090
fax: (518) 862-1091

info@nyserda.org
www.nyserda.org

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Final Report 08-11

State of New York

David A Paterson, Governor

New York State Energy Research and Development Authority

Vincent A. DeIorio, Esq., Chairman