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CONCENTRATIONS OF ENVIRONMENTAL CONTAMINANTS IN HERRING GULL EGGS FROM GREAT LAKES COLONIES IN MICHIGAN, 2002-2006

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EXECUTIVE SUMMARY

The following are some of the important findings of this report:

- The five-year medians for total PCBs, TEQ, *beta*-HCH, OCS, and p,p'-DDT varied significantly among the ten Michigan colonies. The following are noteworthy findings:
    - The Detroit Edison colony (Lake Erie) had the highest concentration of total PCBs, TEQ, and OCS.
    - The Little Charity Island colony (Saginaw Bay) had the highest p,p'-DDT concentration and the second highest concentration of total PCBs and OCS.
    - The Five Mile Island colony (St. Marys River) had the lowest concentration of total PCBs and p,p'-DDT.
    - The West Twin Pipe colony (St. Marys River) which is downriver of the Five Mile Island colony had higher levels of many contaminants.
    - The Bellow Island colony (Grand Traverse Bay) had the second highest concentration of p,p'-DDT.
    - The Tahquamenon Island colony (Whitefish Bay) had the highest concentration of *beta*-HCH.

- The concentration of total PCBs in two of the ten Michigan colonies (Detroit Edison and Little Charity Island) exceeded the no observed effect level established for herring gull eggs.

- The five-year medians for total PCBs, TEQ, *beta*-HCH, OCS, heptachlor epoxide, chlordane, mirex, and mercury varied significantly among lakes. The following are noteworthy findings:
    - Lake Erie had the highest concentration of total PCBs, TEQ, OCS, and *alph*a-chlordane.
    - Lake Superior had the highest concentration of *beta*-HCH, heptachlor epoxide, and oxychlordane.
    - Lake Huron had the highest concentration of mirex.
    - Lakes Michigan, Huron, Superior, and the St. Marys River had similar concentrations of mercury.

- There were significant differences in the 5-year median concentrations of numerous chemicals monitored in the Great Lakes by Michigan and Canada. The following are noteworthy differences per Great Lake:
    - p,p'-DDE concentrations were higher in the Michigan colonies in Lakes Erie, Huron, and Superior.
    - Total PCBs were higher in the Michigan colony in Lake Erie.
    - OCS concentrations were higher in the Michigan colonies in Lakes Erie and Michigan.
    - Heptachlor epoxide and *cis*-nonachlor concentrations were higher in Michigan colonies in Lake Huron.
    - Mercury levels were lower in the Michigan colonies monitored in Lakes Erie and Superior.

- No temporal trends were assessed for the Michigan colonies since only five years of data were available. All of the Canadian colonies showed decreases in total PCBs and p,p'-DDE concentrations from 1998-2002 to 2002-2006. Trends for the other contaminants varied depending on the colony.
- The use of pooled egg samples was determined to be a valid technique for assessment of contaminant levels in the ten Michigan colonies.

INTRODUCTION

The ability to determine spatial and temporal differences in bioaccumulative compounds of concern (BCCs) is important for understanding risks to human and wildlife populations in affected areas. Most BCCs are biomagnified in the aquatic system through ingestion of prey and increase in concentrations at higher trophic levels. Biosentinel wildlife species are typically tertiary predators that integrate these compounds in their tissues. These tissues can be analyzed to determine concentrations of BCCs and to assess spatial and temporal trends.

The longest continuous wildlife monitoring program of water-borne environmental pollutants in the Great Lakes is the Canadian Wildlife Service's (CWS) Great Lakes Herring Gull Monitoring Program which began in 1974 (Hebert et al., 1999). Herring gull (*Larus argentatus)* eggs are collected annually in 15 colonies across the Great Lakes and are analyzed for organochlorine (OC) pesticides, polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), polychlorinated dibenzodioxins (PCDDs), and metals. Eggs are archived for use in monitoring new and emerging chemicals such as dioxin-like compounds, brominated fire-retardants, and perfluorinated compounds.

Herring gull eggs can be easily collected from known sites annually to determine trends in adult exposure. Herring gulls are an intermediary fish-eating predator that nests along the Great Lakes coast of Michigan each year. Herring gulls breed every year and are less sensitive to the effects of BCCs than eagles; therefore, availability of eggs each year is virtually guaranteed. The population in the Great Lakes basin is robust enough to withstand annual collections of eggs from colonies without any effect on the gull population. Herring gulls display a great fidelity to their breeding colonies and are year-round residents of the Great Lakes. Only those nesting along Lake Superior are known to migrate among lakes during the winter.

In April of 1999, the Michigan Department of Environmental Quality (MDEQ), Water Bureau, began monitoring environmentally persistent and toxic contaminants in bald eagles. This study is part of the wildlife contaminant monitoring component of the MDEQ's monitoring strategy (MDEQ, 1997). The November 1998 passage of the Clean Michigan Initiative-Clean Water Fund (CMI-CWF) bond proposal resulted in a substantial increase in annual funding for statewide surface water quality monitoring beginning in 2000. The CMI-CWF offers reliable funding for the monitoring of surface water quality over an extended period of time. This is important since one of the goals of the monitoring strategy is to measure temporal and spatial trends in contaminant levels in Michigan's surface waters.

The CMI funds were used to continue the bald eagle (*Haliaeetus lecucocephalus*) contaminant monitoring project. In 2001, a second biosentinel species, herring gulls, was added to better monitor BCCs along the coastal regions of Michigan's Great Lakes. The herring gull monitoring study was designed in consultation with the CWS program managers to ensure that it would complement and not duplicate the ongoing CWS program. In addition, all gull egg analytical work is completed either by the CWS or an approved contract laboratory.

There were several objectives for this study. The first objective was to determine the spatial trends of BCCs within herring gull eggs collected from ten colonies in Michigan. The second objective was to compare the concentrations of contaminants in the Michigan and CWS colonies. The third objective was to assess temporal trends using the Canadian data. The fourth objective was to compare the variance in concentrations of BCCs among eggs collected from a single colony to the variance among years in a single colony to determine the validity of using pooled samples to represent colony exposure each year.

METHODS

GULL COLONY SELECTION

In 2001, ten colonies across the Michigan waters of the Great Lakes were selected to complement the current 15 colonies used for the CWS program (Figure 1). Three colonies were selected on Lake Superior (LS), two on the St. Marys River (SMR), two on Lake Michigan (LM), two on Lake Huron (LH), and one on Lake Erie (LE). The Lake Superior colonies were located on Net Island (NI) near Isle Royale, Huron Islands National Wildlife Refuge (HI), and Tahquamenon Island (T). The St. Marys River colonies were originally the Sault Locks and West Twin Pipe Island (WTP) so that both the upper and lower river segments could be studied. However, since the colony at the locks was not active in 2002, a new colony was found downstream at Five Mile Island (FMI). The Lake Michigan colonies were located at Green Island (GRI) near the Straits of Mackinac, and Bellow Island (BI), in the West Bay of Grand Traverse Bay. These locations complemented the CWS colony within the Beaver Island chain. The Lake Huron colonies were located at Scarecrow Island National Wildlife Refuge (SCI) and on Little Charity Island (LCI) in Saginaw Bay. These locations complemented the CWS colony at the head of Saginaw Bay at the Confined Disposal Facility. The Lake Erie colony was located near the Raisin River on the Detroit Edison (DE) property. Table 1 provides the lake, colony name, and abbreviations for the CMI and CWS colonies.

There are 15 primary colonies and eight alternate colonies used in the CWS program making the total number of colonies in the CWS dataset equal to 23. A total of 33 colonies were used for statistical analysis and reporting.

GULL EGG COLLECTIONS

We collected 13 eggs from each colony using protocols identical to the ones used by the CWS (Hebert et al., 1999). Briefly, one egg was collected from complete three egg clutches at random nests across a colony. Eggs were measured, floated in a container to ensure they were freshly laid, and then placed into a container filled with a foam insert to ensure they were protected during handling and shipping.

Eggs were processed using the CWS protocol (Hebert et al., 1999). Briefly, each egg was measured, weighed, volume was determined using the water displacement method, scored equatorially, contents were poured into a chemically clean jar, the jar was sealed, and then placed in a freezer. Eggs were transferred to the Great Lakes Institute for Environmental Research (GLIER) at the University of Windsor, Ontario, Canada, for analyses.

CHEMICAL ANALYSIS

EXTRACTION AND CLEAN-UP (PCBS, NON-ORTHO PCBS (NO-PCBS), OC-PESTICIDES AND PCDD/PCDFS)

Analytical methods for congener specific PCB and organochlorine-pesticide analysis were performed by gas-chromatography-mass selective detector (GC-MSD) as described fully in GLIER SOP-02-004 which is accredited under the Canadian Association for Environmental Analytical Laboratories (ISO17025). Additional literature on sample extraction and clean-up for PCBs, NO-PCBs and OC-pesticides are provided in Lazar et al (1992) and GC-MSD instrument conditions for PCBs in O'Rourke et al (2004). Co-planar PCBs and PCDD/PCDFs were analyzed by gas chromatography – high resolution, time-of-flight, mass selective detection (GC-HR (TOF) MSD) using the method described below. For each batch of 6 samples extracted, a method blank (sodium sulphate) and reference tissue (Canadian Wildlife Service Double Crested Cormorant Egg Homogenate for PCBs/OC-pesticides) were extracted and analyzed. For

PCDD/PCDFs, an additional in-house reference tissue consisting of a Chicken Egg Homogenate spiked with priority PCDD/PCDFs was extracted with every batch of 6 samples.

Twenty grams of egg homogenates were dried with 60-80 g of anhydrous sodium sulphate using a glass mortar and pestle. The dried homogenate powder was wet packed into a 60 x 2.5 i.d.-cm glass chromatography column containing 15 g sodium sulphate over a glass wool plug at the outlet and 100mL of dichloromethane (DCM):hexane (1:1 v/v). Each column was then spiked with a series of internal recovery standards. For PCB/OCs, the column was spiked with 100 ng each of ^{13}C-PCB 52 and 153 (Cambridge Isotopes, MA). For NO-PCBs, the column was spiked with 20 ng each of ^{13}C-PCB 77, 126 and 169 (Wellington Scientific). For PCDD/PCDFs, the column was spiked with 4 - 20 ng each congener of ^{13}C-labelled PCDDs (2,3,7,8-TCDD, 1,2,3,7,8-PCDD, 1,2,3,6,7,8-HCDD, 1,2,3,4,6,7,8-HpCDD, and OCDD) and ^{13}C-labelled PCDFs (2,3,7,8-TCDF, 1,2,3,7,8-PCDF, 1,2,3,4,7,8-HCDF, and 1,2,3,4,6,7,8-HpCDF) obtained from Wellington Laboratories (8290SFS Solution). After 1 h, the column was eluted into a 500 mL round bottom flask followed by additional elution with 250 mL DCM:Hexane (1:1 v/v). The extracts were reduced to approximately 5 mL by rotary evaporator and then made up to 10 mL in a volumetric flask. One mL was removed for neutral lipid determination (Drouillard et al., 2004) by gravimetric technique and the remaining 9 mL were concentrated to 2 mL by rotary evaporator.

Gel permeation chromatography (GPC) was performed to remove lipids and co-extracted high molecular weight biogenic molecules. The GPC columns consisted of 50 cm x 2.2 cm glass chromatography columns with a 2 cm glass wool plug wet packed with 50 g of S-X3 BioBeeds (BioRad) in 50% DCM/Hexane (v/v). Each column was fitted with a 250 mL pressure equalizing separatory funnel. Due to the large sample size and high lipid content of egg homogenates, each sample extract was split into 3 equal aliquots and each aliquot run simultaneously on three separate GPC-columns. Each aliquot was loaded onto a GPC column and eluted with 300 mL DCM/hexane (50% v/v). The first 120 mL of eluant containing high MW biogenic materials was discarded and the remaining 180 mL collected. The collected fraction from the three aliquots were combined and concentrated to 2 mL by rotary evaporator.

Florisil chromatography was performed using 25 cm x 1 i.d.-cm glass columns fixed with 250 mL reservoirs. The column was plugged with 2 cm glass wool and wet packed with 6 g fully activated (activated by heating at 120^{o}C over night) florisil in hexane with a 2 cm sodium sulphate cap. The sample was added to the florisil column and the column eluted in four fractions. The first fraction, containing PCBs and some OC-pesticides (e.g. DDT's), was collected by elution with 50 mL hexanes. The second fraction containing the remaining OC-pesticides and NO-PCBs (Lazar et al., 1992) was collected by elution with 50 mL of DCM/Hexane (15/85% v/v). The third fraction containing dieldrin and heptachlor epoxide was eluted with 50 mL of DCM/Hexane (60/40% v/v). The final fraction, containing PCDDs and PCDFs was collected by elution with 100 mL toluene. Fractions 1-3 were concentrated to 5 mL by rotary evaporator and stored in GC-vials at 4^{o}C until instrument analysis. Following analysis for PCBs and OC-pesticides (described below), fraction 2 was re-capped and submitted for analysis of NO-PCBs by GC-HR (TOF) MSD. Fraction 4 was concentrated to 2 mL and subjected to additional clean-up by acidic/basic silica-gel and carbon column.

Acidic/Basic Silica-gel and Carbon Column Clean Up (PCDD/PCDFs)

Fraction 4 was concentrated to 1 mL and added to an acid/basic silica gel column consisting of 25 cm x 1 –i.d. cm chromatography column wet packed with: 1 cm sodium sulphate; 1 g basic silica gel (100-200 µm mesh silica prepared the previous night by adding 35 g 1N KOH to 100 g activated silica gel and shaking until free flowing), 1 cm sodium sulphate layer; 2 g acid silica (prepared by addition of 27.2 mL concentrated H_2SO_4 to 100 g activated silica-gel and shaking overnight) and a 1 cm sodium sulphate cap.

The extracts were eluted from the acid/basic silica gel column with 50 mL DCM and concentrated to 1 mL under reduced pressure.

The carbon column consisted of a 0.6 cm x 10 cm glass column with 7/25 ground joints at both ends. A 2 cm bed of 5% activated carbon (AX-21, Anderson Development Company)/silica gel (100-200 µM mesh, Supelco) was packed in the center of the column between 2 x 1 cm glass wool beds. Prior to adding the sample, the column was activated by rinsing with 5 mL toluene, 10 mL of DCM, followed by 5 mL hexane. The concentrated sample was then added to the top of the column and allowed to drip into the activated carbon bedding. The carbon column was eluted with 5 mL hexane followed by 5 mL DCM and the eluant discarded. The column was then inverted and eluted with 25 mL toluene. The toluene was concentrated to approximately 1 mL by rotary evaporated and further concentrated to 200 µL under a nitrogen gas stream.

GAS CHROMATOGRAPHY ANALYSIS (GC-LOW RESOLUTION MSD) FOR PCBS/OC-PESTICIDES

Analysis was conducted using a Hewlett-Packard 5890 gas chromatograph (GC) with a low resolution 5973 mass selective detector (MSD), and 7673 auto-sampler. The GC was equipped with a DB-5 column (60 m X 0.25 mm i.d. X 0.10 µm film thickness) and used helium as a carrier gas (1 mL/min). The injection volume was 2 µL splitless at an injection port temperature of 250^{o}C. Separate GC-methods were run for PCBs and OC-pesticides in selective ion monitoring mode, necessitating injection of each sample two times in sequence. Both methods used the same temperature program. The temperature program was as follows: 90^{o}C for 3 min followed by a 7^{o}C/min temperature ramp until 150^{o}C, followed by another increase of 3^{o}C/min until a final temperature of 280^{o}C where it was held for 5.1 min. For PCBs, the following ion windows were used: 10-27 min (ions 256, 290), 27-33 min (ions 290, 326, 360, 337), 33-39.5 min (ions 326, 360, 360, 372), 39.5 – 43.5 min (ions 360, 394, 428), 43.5 -60 min (ions 394, 428, 464, 494). For the OC-pesticide method the ion windows were: 15-20 min (ions 250, 284), 20-27 min (ions 284, 219, 308), 27-31.5 min (ions 308, 353, 387), 31.5-34 min (ions 409), 34-36 min (ions 409, 380), 36-38 min (ions 409-235), and 38-60 min (ions 235-272).

Instrument analysis was performed in the sequence of sample batch extractions. The analysis order of sample injections onto the GC-MSD was as follows: External PCB Standard (Accustandard C-QME-01 containing: PCB IUPAC # 18, 17, 28/31, 33, 52, 49, 44, 74, 70/76, 95, 101, 99, 87, 110, 118, 105, 82, 151, 149, 153/132, 138, 158, 128, 156, 187/182, 183, 177, 171, 180, 191, 170/190, 201, 195, 194, 205, 208, 206, 209); OC-Pesticide Standard #2 (Accustandard custom standard containing: 1,2,4,5-TCB; 1,2,3,4-TCB; QCB, HCB, *alpha*-HCH, *beta*-HCH, *gamma*-HCH, *delta*-HCH, OCS, oxychlordane, *alpha*-chlordane, *gamma*-chlordane, *trans*-nonachlor, *cis*-nonachlor, p,p'-DDE, p,p'-DDD, p,p'-DDT, and mirex); OC-Pesticide Standard #3 (Accustandard custom standard containing: dieldrin and heptachlor epoxide); Recovery Standard (^{13}C-PCB-52 and 153); Sample Blank, Samples 1-6 and Sample Reference Tissue. The blank, samples and reference tissues were injected in duplicate, the first injection corresponding to the PCB method and the second injection using the OC-pesticide method.

GAS CHROMATOGRAPHY ANALYSIS (GC-HR (TOF) MSD) FOR NO-PCBS, PCDDS AND PCDFS

Analysis for NO-PCBs, PCDDs, and PCDFs was conducted using a Waters GCT-premier instrument that consisted of an Agilent 6890 GC, 7673B auto-sampler with a DB-5 column (30 m x 0.25 mm. i.d. x 0.10 µm film thickness; helium as a carrier gas (1 mL/min)) coupled with a Waters Premier orthogonal acceleration time-of-flight (oa-TOF) mass spectrometer. The injector temperature was maintained at 275^{o}C in splitless mode. The oven program was: 90^{o}C held for 1 min, ramped at 30^{o}C/min to 200^{o}C held for 2 min and ramped at 3^{o}C/min to 280^{o}C and held for 10 min. The oa-TOF was run in EI-mode following daily tuning and mass resolution calibration using Metri (68.9952, 121.0014, 189.9966, 265.9965, and 284.9949) calibration solution. The 284.9949 ion was used as the lock mass during sample runs.

Fraction 2 from the florisil clean-up was analyzed for NO-PCBs, while fraction 4 from florisil/acid-basic silica-gel/carbon column clean-up was examined for PCDD/PCDFs. For each batch of samples extracted, the sample injection sequences were set in the following manner: 5 external standard calibration curve for NO-PCBs (Wellington Laboratories certified PCB 77, 126, 169 standard series) or for PCDD/PCDF (Wellington Laboratories EPA-8290HRCC1-5); Dioxin Performance Standard Solution (dioxin analysis only; Wellington Laboratories 8290RSS); sample Blank, sample reference homogenate and 6 egg homogenate samples. An additional 5 calibration external standard curves for NO-PCBs or PCDD/PCDF were run at the conclusion of each sample batch injection series to check for instrument response.

Post processing of HR-MSD output was performed using QuanLynx software. The three dominant ions (e.g. for 2,3,7,8 -TCDD ions: 319.87, 321.893, 323.891) were extracted from the total ion chromatogram over a window of ± 10 s from the expected analyte retention time. For PCDD/PCDF samples, peak areas were adjusted based on the dioxin performance standard response spiked into the GC-vial just prior to capping. Raw areas (NO-PCBs) or performance compound adjusted areas (PCDD/PCDFs) were then quantified using the analyte response relative to the external standard calibration curve.

Statistical Analysis

Statistical analyses were performed using the SAS 9.2 statistical package (SAS Institute Inc. 2007). The fit of the data to first normal then lognormal distribution was assessed using the Kolmogorov-Smirnof test. Due to the nonparametric nature of the distributions, medians and interquartile ranges are reported as the measures of central tendency and dispersion, respectively. Differences for all BCC concentrations in the five year dataset (2002-2006) were analyzed among colonies and among Great Lakes using rank converted analysis of variance and general linear models. A conservative post-hoc pairwise comparison was used because there were multiple comparisons (Tukeys, experiment-wise *alpha* = 0.05). In cases where rank conversion was not sufficient to homogenize variance, the Satterthwaite statistic was used and effective degrees of freedom were rounded to the nearest integer.

Results

The results for the following BCCs are reported here: Total PCBs, TEQs, DDE, DDD, DDT, HCB, OCS, heptachlor epoxide, *beta*-HCH, *alpha*-chlordane, dieldrin, mirex, mercury, *trans*-nonachlor, *cis*-nonachlor, and oxychlordane. TEQs were only available for the CMI colonies so no comparisons were made to the CWS colonies in the tables and figures. Three analytes, *alpha*-HCH, *gamma*-HCH, and *gamma*-chlordane are not included in these analyses since >50% of all samples analyzed were below detection limits (70%, 77%, and 73%, respectively). Table 2 lists the 19 BCCs and their abbreviations used in this report. The following appendices provide the data used for the various analyses:

- Appendix A provides the five-year median BCC concentrations in herring gull eggs for the Great Lakes and the Detroit, Niagara, and St. Lawrence Rivers for 33 breeding colonies in Michigan and Canada from 2002 to 2006.

- Appendix B provides the five-year median BCC concentrations in herring gull eggs for 23 breeding colonies in Canada from 2002 to 2006.

- Appendix C provides the five-year median BCC concentrations in herring gull eggs for ten breeding colonies in Michigan from 2002 to 2006.

- Appendix D provides the median BCC concentrations in herring gull eggs by year for each of the Great Lakes for 23 breeding colonies in Canada from 2002 to 2006.

- Appendix E provides the median BCC concentrations by year for each of the Great Lakes for ten breeding colonies in Michigan from 2002 to 2006.

SINGLE VERSUS POOLED EGGS ANALYSIS

Variability among years was always greater than variability among individual eggs. In all 23 cases, the Root MSE for the general linear model was greater for the variation among years compared to the variation in the general linear model which included the individual egg data. The predictive relationship for a trend in BCCs was the same using either model.

CMI DATA

AMONG COLONIES – FIVE YEAR MEDIANS

The five year median concentration of each BCC was calculated for each colony. Medians of total PCBs, *beta*-HCH, OCS, and p,p'-DDT varied significantly among colonies. The following is a summary of the results for each of these contaminants:

- Median total PCBs ranged from 2772.5 to 10782.7 ppb for the ten colonies sampled. Total PCBs were significantly different among colonies ($F = 3.82$, $df = 9$, $p = 0.0023$) with Detroit Edison being significantly higher in total PCBs than Huron Island, West Twin Pipe, and Five Mile Island. Little Charity Island was significantly higher than Five Mile Island (Table 3, Figure 2).

- Median TEQ concentrations ranged from 129 to 702 ppt for the ten colonies sampled. TEQ concentrations were significantly different among colonies ($df=9$, $p<0.001$) with Detroit Edison being significantly higher than all other colonies except Bellow and Little Charity islands. The latter two colonies had TEQ concentrations significantly higher than Tahquamenon Island (Table 4, Figure 3).

- Median *beta*-HCH concentrations ranged from 0.2 to 1.4 ppb for the ten colonies sampled. The concentrations of *beta*-HCH were significantly different among colonies ($F = 3.46$, $df = 9$, $p = 0.0044$) with Tahquamenon being significantly higher in *beta*-HCH concentration than Detroit Edison and Scarecrow Island (Table 5, Figure 4).

- Median concentrations of OCS ranged from 1.4 to 11.2 ppb for the ten colonies sampled. Concentrations of OCS were significantly different among colonies ($F = 3.00$, $df = 9$, $p =0.0103$) with Detroit Edison being significantly higher in OCS concentration than Five Mile Island and Huron Island (Table 6, Figure 5).

- Median concentrations of p,p'-DDT ranged from 3.9 to 30.5 ppb for the ten colonies sampled. Concentrations of p,p'-DDT were significantly different among colonies ($F = 2.76$, $df = 9$, $p =0.0164$) with Little Charity Island being significantly higher in p,p'-DDT concentration than Five Mile Island (Table 7, Figure 6).

Colonies were ranked from one to ten for most contaminated to least contaminated for each contaminant that was found to differ significantly. Detroit Edison was ranked first (most contaminated) for total PCBs, TEQ, and OCS, and second for p,p'-DDT. Little Charity Island was ranked first for p,p'-DDT, second for both total PCBs and OCS, and third for TEQ. For the two colonies in the St. Marys River, Five-Mile Island ranked tenth, tenth, and ninth for total PCBs, p,p'-DDT, and OCS, respectively, whereas, West Twin Pipe ranked seventh, fifth, and sixth, respectively (Table 8). The comparison of the rankings of these two colonies suggests that the more southern colony, West Twin Pipe, may be more contaminated than the more northern colony.

AMONG LAKES – FIVE YEAR MEDIANS

The five year median of each BCC was calculated for each lake. Medians of total PCBs, *beta*-HCH, OCS, heptachlor epoxide, chlordane, mirex, and mercury varied significantly among lakes. The following is a summary of the results for each of these contaminants:

- Total PCBs were significantly different among lakes ($F = 8.33$, $df = 4$, $p < 0.001$) with Lake Erie being significantly higher in total PCB concentration than Lake Michigan, Lake Superior, and St. Marys River. Lake Huron was significantly higher than St. Marys River (Table 9, Figure 7).

- TEQ concentrations were significantly different among lakes ($df=4$, $p<0.001$) with Lake Erie being significantly higher than all four other waterbodies (Table 10, Figure 8).

- The concentrations of *beta*-HCH were significantly different among lakes ($F = 4.19$, $df = 4$, $p = 0.0067$) with Lake Superior being significantly higher in *beta*-HCH concentration than Lake Huron and Lake Erie (Table 11, Figure 9).

- Concentrations of OCS were significantly different among lakes ($F = 6.03$, $df = 4$, $p = 0.0008$) with Lake Erie being significantly higher in concentrations of OCS than Lake Michigan, Lake Superior, and St. Marys River (Table 12, Figure 10).

- Concentrations of heptachlor epoxide were significantly different among lakes ($F = 3.48$, $df = 4$, $p =0.0164$) with Lake Superior being significantly higher in concentrations of heptachlor epoxide than Lake Erie (Table 13, Figure 11).

- Concentrations of oxychlordane were significantly different among lakes ($F = 3.02$, $df = 4$, $p = 0.0296$) with Lake Superior being significantly higher in oxychlordane concentrations than Lake Erie (Table 14, Figure 12). Concentrations of *alpha*-chlordane were significantly different among lakes ($F = 3.36$, $df = 4$, $p = 0.0193$) with Lake Erie being significantly higher in *alpha*-chlordane concentrations than Lake Huron (Table 15, Figure 13).

- Concentrations of mirex were significantly different among lakes ($F = 3.47$, $df = 4$, $p = 0.0167$) with Lake Huron and Lake Michigan being significantly higher in mirex concentration than Lake Erie (Table 16, Figure 14).

- Concentrations of mercury were significantly different among lakes ($F = 3.24$, $df = 4$, $p = 0.0256$) with Lake Michigan, Lake Superior, and Lake Huron being significantly higher in mercury concentration than Lake Erie (Table 17, Figure 15).

For each of the compounds that were found to differ significantly among lakes, lakes were ranked from one to five for most contaminated to least contaminated (Table 18). Lake Erie was ranked first for three of the eight BCCs, specifically total PCBs, OCS, and *alpha*-chlordane. Lake Superior was ranked first for three of the eight BCCs, *beta*-HCH, heptachlor epoxide, and oxychlordane. Lake Michigan was ranked second for five of the eight BCCs, including *beta*-HCH, heptachlor epoxide, oxychlordane, *alpha*-chlordane, and mirex. Interestingly, the concentration of mercury in colonies from Lake Huron, Lake Michigan, Lake Superior, and St. Marys River was the same.

COMBINED CMI AND CWS DATASETS

AMONG COLONIES – FIVE YEAR MEDIANS

The five year median concentration was calculated for each colony using both datasets and these median concentrations were compared. When comparing all 33 colonies from the CMI and CWS data sets, medians of total PCBs, OCS, heptachlor epoxide, mirex, and mercury varied significantly among colonies. The following is a summary of the results for each of these contaminants:

- Median total PCB concentrations for the combined datasets ranged from 1605.6 to 14068.5 ppb. Total PCBs were significantly different among colonies ($F = 8.31$, $df = 28$, $p < 0.0001$) (Table 19, Figure 16). Middle Sister Island was significantly higher in total PCB concentrations than Green Island, Tahquamenon, Huron Island, West Twin Pipe, Granite Island, Port Colborne Light House, Unnamed Island, Five Mile Island, Agawa Rocks, Double Island, Heisdort Rocks, and Chantry Island. Fighting Island was significantly higher in total PCB concentrations than Tahquamenon, Huron Island, West Twin Pipe, Granite Island, Port Colborne Light House, Unnamed Island, Five Mile Island, Agawa Rocks, Double Island, Heisdort Rocks, and Chantry Island. Channel-Shelter Island and Detroit Edison were significantly higher in total PCB concentrations than Huron Island, West Twin Pipe, Granite Island, Port Colborne Light House, Unnamed Island, Five Mile Island, Agawa Rocks, Double Island, Heisdort Rocks, and Chantry Island. Middle Island was significantly higher in total PCB concentrations than West Twin Pipe, Granite Island, Port Colborne Light House, Unnamed Island, Five Mile Island, Agawa Rocks, Double Island, Heisdort Rocks, and Chantry Island. Little Charity Island had significantly higher total PCB concentrations than Double Island, Heisdort Rocks, and Chantry Island. Hamilton Harbour, West Sister Island, and Gull Island were significantly higher in total PCB concentrations than Heisdort Rocks, and Chantry Island.

- Median concentrations of OCS for the combined dataset ranged from 0.75 to 19.45 ppb. Concentrations of OCS were significantly different among colonies ($F= 3.17$, $df= 28$, $p < 0.0001$) (Table 20, Figure 17). Middle Sister Island, Channel-Shelter Island, and Detroit Edison were significantly higher in OCS concentrations than Port Colborne Light House.

- Median concentrations of heptachlor epoxide ranged from 0.05 to 48.68 ppb for the combined dataset. Concentrations of heptachlor epoxide were significantly different among colonies ($F = 6.63$, $df = 28$, $p < 0.0001$) (Table 21, Figure 18). Tahquamenon was significantly higher in heptachlor epoxide concentrations than Hamilton Harbour, Unnamed Island, Port Colborne Light House, and Strachan Island. Bellow Island, Net Island, and Huron Island were significantly higher in heptachlor epoxide concentrations than Port Colborne Light House and Strachan Island. Gull Island, Green Island, West Twin Pipe, Agawa Rocks, and Middle Sister Island were significantly higher in heptachlor epoxide concentrations than Strachan Island.

- Median concentrations of mirex ranged from 11.19 to 897.5 ppb for the combined dataset. Concentrations of mirex were significantly different among colonies ($F = 6.75$, $df = 28$, $p < 0.0001$) (Table 22, Figure 19). West Sister Island was significantly higher in mirex concentration than Granite Island, Agawa Rocks, Big Sister Island, Channel-Shelter Island, Port Colborne Light House, Five Mile Island, Huron Island, Fighting Island, Middle Island, Detroit Edison, and Middle Sister Island. Leslie Street Split was significantly higher in mirex concentration than Agawa Rocks, Big Sister Island, Channel-Shelter Island, Port Colborne Light House, Five Mile Island, Huron Island, Fighting Island, Middle Island, Detroit Edison, and Middle Sister Island. Tommy Thompson Park was significantly higher in mirex concentration than Channel-Shelter Island, Port Colborne Light House, Five Mile Island, Huron Island, Fighting Island, Middle Island, Detroit Edison, and Middle Sister Island. Strachan Island was significantly higher in mirex concentration than Port Colborne Light House, Five Mile Island, Huron Island, Fighting Island, Middle Island, Detroit Edison, and Middle Sister Island. Heisdort Rocks was significantly higher in mirex concentrations than Huron Island, Fighting Island, Middle Island, Detroit Edison, and Middle Sister Island. Snake Island was significantly higher in mirex concentrations than Fighting Island, Middle Island, Detroit Edison, and Middle Sister Island.

- Median concentrations of mercury ranged from 0.09 to 1.00 ppm for the combined dataset. Concentrations of mercury were significantly different among colonies ($F = 10.00$, $df = 28$, $p < 0.0001$) (Table 23, Figure 20). Middle Sister Island was significantly higher in mercury concentrations than Chantry Island, Tahquamenon, Bellow Island, Green Island, Scarecrow Island, Net Island, West Twin Pipe, Little Charity Island, Huron Island, Five Mile Island, and Detroit Edison. Heisdort Rocks, Strachan Island, Snake Island, and Agawa Rocks had significantly higher mercury concentrations than Tahquamenon, Bellow Island, Green Island, Scarecrow Island, Net Island, West Twin Pipe, Little Charity Island, Huron Island, Five Mile Island, and Detroit Edison. West Sister Island and Channel-Shelter Island were significantly higher in mercury concentrations than Bellow Island, Green Island, Scarecrow Island, Net Island, West Twin Pipe, Little Charity Island, Huron Island, Five Mile Island, and Detroit Edison. Granite Island, Fighting Island, Tommy Thompson Park, Middle Island, and Gull Island were significantly higher in mercury concentration than West Twin Pipe, Little Charity Island, Huron Island, Five Mile Island, and Detroit Edison. Double Island was significantly higher in mercury concentration than Five Mile Island, and Detroit Edison.

Colonies were ranked from one to 29 for most contaminated to least contaminated for each of the contaminants that were found to differ significantly among colonies (Table 24). Middle Sister Island was ranked first for three of the five BCCs found to have significant differences among colonies, specifically total PCBs, OCS, and mercury.

AMONG LAKES – FIVE YEAR MEDIANS

The 2002-2006 five year median concentration of each BCC was calculated for each lake. When comparing four of the Great Lakes and four rivers using both datasets, medians of 11 of the 15 BCCs varied significantly among lakes. The following is a summary of the findings for each of these BCCs:

- Concentrations of total PCBs were significantly different among lakes ($F= 6.50$, $df= 8$, $p <0.0001$) with the Detroit river being significantly higher than all others, Lake Erie being significantly higher than Lakes Michigan, Huron, Superior, St. Marys River and the Niagara River. Lake Ontario and the St. Lawrence River were significantly higher in total PCB concentrations than

Lake Superior, the St. Marys River, and the Niagara River. Lake Michigan was significantly higher than St. Marys River and the Niagara River (Table 25, Figure 21).

- Concentrations of OCS were significantly different among lakes (F= 2.99, df= 8, p = 0.0043) with the Detroit River being greater than all other lakes. Lake Erie concentrations of OCS were greater than Lake Superior, Niagara River, St. Marys River, and Lake Michigan. Lake Huron OCS concentrations were greater than St. Marys River and Niagara River (Table 26, Figure 22).

- Concentrations of heptachlor epoxide were significantly different among lakes (F= 16.56, df= 8, p <0.0001) with Lake Superior, Lake Michigan, and St. Marys River significantly greater than Lakes Huron, Erie, Ontario, the Detroit River, Niagara River, and St. Lawrence River. Lakes Erie and Huron were significantly higher in concentration of heptachlor epoxide than the Niagara River and the St. Lawrence River. The Detroit River was significantly higher than the St. Lawrence River (Table 27, Figure 23).

- Concentrations of oxychlordane were significantly different among lakes (F= 6.13, df= 8, p <0.0001) with Lake Michigan and Lake Superior having significantly greater concentrations of oxychlordane than all other lakes. St. Marys River had significantly higher concentrations than St. Lawrence River and Niagara River. Lake Huron was significantly higher than the Niagara River (Table 28, Figure 24).

- Concentrations of *trans*-nonachlor were significantly different among lakes (F= 5.78, df= 8, p < 0.0001) with Lake Michigan having significantly greater concentrations of *trans*-nonachlor than Lakes Huron, Erie, and Ontario, the Detroit River, St. Lawrence River and the Niagara River. Lake Superior was significantly higher than Lake Ontario, the Detroit River, St. Lawrence River and the Niagara River. St. Marys River had significantly higher concentrations of *trans*-nonachlor than the St. Lawrence River and the Niagara River. Lake Huron was significantly higher in concentration than the Niagara River (Table 29, Figure 25).

- Concentrations of p,p'-DDE were significantly different among lakes (F= 3.93, df= 8, p = 0.0004) with Lake Michigan having significantly greater concentrations of p,p'-DDE than St. Marys River, Lake Huron, Detroit River, Lake Erie and the Niagara River. St. Lawrence River, Lake Superior, Lake Ontario, St. Marys River, and Lake Huron were significantly higher than Niagara River (Table 30, Figure 26).

- Concentrations of dieldrin were significantly different among lakes (F= 4.58, df= 8, p < 0.0001) with Lake Michigan having significantly greater concentrations of dieldrin than Detroit River, Lake Ontario, Niagara River, and the St. Lawrence River. Lake Superior, Lake Erie and St. Marys River were significantly greater in concentration than the Niagara River and the St. Lawrence River. Lake Huron was significantly greater than the St. Lawrence River (Table 31, Figure 27).

- Concentrations of p,p'-DDD were significantly different among lakes (F= .69, df= 8, p = 0.0007) with Detroit River being significantly greater in concentration than Niagara River, Lake Superior, and St. Lawrence River. Lake Erie was significantly higher than Lake Superior and the St. Lawrence River. Lake Michigan, St. Marys River, Lake Huron, Lake Ontario, and the Niagara River were significantly higher than the St. Lawrence River (Table 32, Figure 28).

- Concentrations of *cis*-nonachlor were significantly different among lakes (F= 9.38, df= 8, p <0.0001) with Lake Michigan having significantly higher concentrations than Lake Huron, Lake Erie, Lake Ontario, Detroit River, Niagara River, and St. Lawrence River. Lake Superior and St.

Marys River had significantly higher concentrations of *cis*-nonachlor than Lake Erie, Lake Ontario, Detroit River, Niagara River, and St. Lawrence River. Lake Huron had significantly higher concentrations of than the Detroit River, Niagara River, and St. Lawrence River. Lake Erie was significantly higher than St. Lawrence River (Table 33, Figure 29).

- Concentrations of p,p'-DDT were significantly different among lakes (F= 2.52, df= 8, p = 0.0143) with Lake Michigan and the Detroit River being significantly higher in concentrations of p,p'-DDT than the Niagara River and the St. Lawrence River. Lake Huron was significantly higher than the St. Lawrence River (Table 34, Figure 30).

- Concentrations of mirex were significantly different among lakes (F= 17.33, df= 8, p <0.0001) with Lake Ontario and St. Lawrence River having significantly higher concentrations of mirex than Niagara River, Lake Huron, Lake Michigan, Lake Superior, St. Marys River, Lake Erie, and Detroit River. Niagara River was significantly higher than Lake Michigan, Lake Superior, St. Marys River, Lake Erie, and the Detroit River. Lake Huron was significantly higher than Lake Erie and the Detroit River. Lake Michigan, Lake Superior, and St. Marys River were significantly higher than the Detroit River (Table 35, Figure 31).

For each of the BCCs that were found to differ significantly among lakes, lakes were ranked from one to nine for most contaminated to least contaminated (Table 36). Of the BCCs with significant differences among lakes for their five year median concentrations, Lake Michigan was ranked first for seven of the 11 BCCs. Detroit River was ranked first for three of the 11 BCCs. Lake Superior was ranked second for six of the 11 BCCs and Lake Erie ranked second for three of the 11 BCCs.

DISCUSSION

COMPARISON TO TOXIC REFERENCE VALUES (TRVS)

The TRV of 5.0 ppm for total PCBs is the NOEC for embryonic deformities and egg lethality in herring gulls (Weseloh et al., 1991). For the CMI dataset, two colonies had five year median concentrations above the TRV for herring gulls, Detroit Edison (10.8 ppm) and Little Charity Island (5.9 ppm). For the CWS dataset, eight colonies had five year median concentrations above the 5.0 ppm TRV; Channel-Shelter Island (10.6 ppm), Fighting Island (11.5 ppm), Gull Island (5.2 ppm), Hamilton Harbour (6.0 ppm), Middle Island (10.3 ppm), Middle Sister Island (14.1 ppm), Strachan Island (5.2 ppm), and West Sister Island (5.4 ppm). In the combined dataset, five year median concentrations for the Detroit River, Lake Erie, and St. Lawrence River colonies were above the TRV with concentrations of 10.8, 8.3, and 5.2 ppm, respectively.

While there is currently no TRV for p,p'-DDE in herring gulls, a TRV of 10 ppm for double crested cormorants (*Phalacrocorax auritus)* has been established for no reproductive effects (Fox and Bowerman, 2005) and a TRV of 3.5 ppm is used as a NOAEC for eggshell thinning in bald eagles (*Haliaeetus leucocephalus*) (Wiemeyer et al., 1984). Only the 2002 CWS data for Lake Michigan exceeded the 3.5 ppm TRV for p,p'-DDE.

SINGLE VERSUS POOLED COMPARISON

We confirmed that the use of pooled egg samples is a valid technique for the ten Michigan colonies. This was originally tested in the CWS program when costs became prohibitive to continue analyzing 150 individual eggs per year compared to analyzing 15 pooled samples per year (Turle and Collins, 1992).

Since 1986, the CWS program has used pooled samples to assess spatial and temporal relationships among the 15 CWS colonies. The MDEQ program has utilized eight pooled colony samples and two colonies where ten individual eggs were analyzed each year to ensure that the same assumptions made in the CWS program were valid for Michigan's program. Since there were no significant differences among trends in the Michigan colonies when using either pooled samples with the mean concentration used for the year of single egg analysis, versus the same analysis using all 14 pooled plus single egg analyses, the CWS results were confirmed in the MDEQ program. It would therefore be appropriate to use pooled egg analysis for all colonies every year for the Michigan program.

CMI Data versus CWS Data

For five year median concentrations, datasets were compared for each BCC to look for significant differences among lakes (Table 35). The concentrations of p,p'-DDE and p,p'-DDD were significantly different between datasets for three of the four lakes shown to have significant differences. Mercury was significantly different between datasets for Lake Erie and Lake Superior.

Total PCBs versus TEQs

There were no statistical relationships between total PCBs and TEQs for the DEQ dataset. This is not surprising considering that, while PCBs contribute the greatest percentage of TEQs for most Great Lakes samples, there are areas in Michigan where significant portions of TEQs can be attributable to dioxins, furans, and other chlorinated hydrocarbons. This contributes to the assertion that each colony must be evaluated separately to best understand the actual toxicity of the compounds that contribute to TEQs.

Spatial Assessment

The more polluted sites in Michigan are well known and were reflected in the data for total PCBs. These sites included two Superfund sites, Saginaw Bay (LCI) and the Raisin River (DE). The TEQ concentrations at BI in Grand Traverse Bay, WTP in the lower St. Marys River, HI in a remote area of Marquette County, and NI on Isle Royale were surprising. None of these sites are near major industrial sources of PCBs, dioxins, or furans, nor are sediment concentrations from these regions known to be high in these compounds. Huron Island (HI) concentrations are interesting and confirm the same pattern observed in bald eagle plasma for this general area. Since the 1980s, nestling plasma of bald eagles in this region of Marquette County has been found to have much higher total PCB concentrations, with the source of the PCBs being unknown (Bowerman et al., 2003).

When comparing concentrations of chemicals among lakes using the combined CMI and CWS datasets, Lake Michigan had the highest concentrations for seven of the 12 chemicals which showed significant differences among lakes. The Detroit River had the highest concentrations of three of the 12 chemicals and the St. Lawrence River had the highest concentrations of two of the 12 chemicals. When comparing significant differences between colonies using the combined datasets, only five chemicals showed significant differences among colonies, and of those five, Middle Sister Island had the highest concentrations for three of the five chemicals.

Mercury concentrations by lakes are within the range of concentrations in the CWS dataset (Koster et al., 1996). Concentrations of mercury did not differ significantly among colonies for the CMI dataset but did differ significantly in the combined dataset analysis. Mercury concentrations differed significantly among Great Lakes for the CMI dataset but did not differ significantly in the combined datasets. When comparing the five year median concentrations of the two datasets among lakes, mercury was significantly different in Lake Erie and Lake Superior. This may be a reflection of atmospheric deposition patterns and not indicative of point source pollution.

Temporal Trends

The 2002 to 2006 CWS dataset was compared to the 1998 to 2002 dataset published by Weseloh et al. (2006). All 14 of the colonies sampled during both five year periods showed decreased concentrations of total PCBs and p,p'-DDE. The concentration of dieldrin decreased for all CWS colonies except Middle Island where dieldrin concentrations were relatively unchanged over time with concentrations of 43.8 and 43.5 ppb for the two sampling periods. Hexachlorobenzene concentrations decreased over time for all colonies except Middle Island (10.8 to 12.0 ppb), Gull Island (12.2 to 12.2 ppb), and Agawa Rocks (11.0 to 11.3 ppb). Heptachlor epoxide concentrations decreased for all colonies except Middle Island where the 1998 to 2002 median concentration was 19.4 ppb and the 2002 to 2006 median concentration was 21.6 ppb. Mirex concentrations increased or stayed the same for Port Colborn (20.0 to 21.1 ppb), Middle Island (10.0 to 14.0 ppb), Fighting Island (10.0 to 14.1 ppb), Gull Island (30.0 to 29.9 ppb), and Agawa Rocks (20.0 to 19.4 ppb). Temporal trends in mercury were not assessed in this report because mercury data were not included in the Weseloh et al. (2006) paper.

FUTURE DIRECTION

A refinement for herring gull egg collection protocol would be the potential integration of both embryo toxicokinetic models for PCBs (Drouillard et al., 2003) and egg volume loss models to correct for non-fresh egg collections. Due to logistical problems and problems caused by global climate change, the loss of data for a single year can occur. Having a series of correction factors for egg concentrations that are defendable and allow for the conversion of concentrations to fresh egg volumes allows for non-fresh eggs to potentially be used. As budgets for monitoring programs shrink or become less dependable, and personnel reach retirement age, these types of correction factors may be more important, especially when new collectors are added to the program. Correction factors will also be useful in dealing with changes associated with global climate change. Unpredictable or catastrophic weather events could delay egg collection, change the timing of egg-laying, and affect sediment transfer of contaminants. Changing weather may also affect the feeding of adult herring gulls, changing the composition and abundance of prey species.

Further analysis of the herring gull data needs to occur to assess the relationship between the concentrations of organochlorine substances and trophic level. It is important to understand how changes in diet may influence spatial and temporal patterns of concentrations of BCCs within herring gull eggs (Hebert et al., 1999, Hebert et al., 2006). Spatial trends reflecting great changes in trophic status have been observed in environmental pollutants monitored in gull eggs (Pekarik and Weseloh, 1998) and a number of these changes were observed after dreissenid mussel (*Dreissena polymorpha, D. bugensis*) invasions occurred.

The analysis of raw data from both the CWS and CMI programs from 2002-2006 gives an even clearer understanding of how the CMI data ranks for Great Lakes colonies. There were significant differences in seven BCC concentrations between the two datasets including five year median concentrations of total PCBs, OCS, p,p'-DDE, p,p'-DDD, heptachlor epoxide, *cis*-nonachlor, and mercury. The ten CMI colonies fill in geographical holes in the CWS dataset, allowing for a more extensive and complete analysis of the contaminants in the Great Lakes ecosystem.

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TABLES

Table 1: Herring gull colony abbreviations sorted by lake with map reference numbers.

Lake (Abbreviation)	Colony Name	Abbreviation	Data Set	Map Reference*
Lake Superior (LS)	Granite Island	GI	CWS	1
	Agawa Rocks	AR	CWS	4
	Marathon	MAR	CWS	
	Chene Island	CHNI	CWS	
	Net Island	NI	CMI	2
	Huron Island	HI	CMI	3
	Tahquamenon	T	CMI	5
St. Marys River (SMR)	Pumpkin Point	PMPT	CWS	
	Five Mile Island	FMI	CMI	6
	West Twin Pipe	WTP	CMI	7
Lake Huron (LH)	Chantry Island	CHI	CWS	14
	Double Island	DI	CWS	12
	Channel-Shelter Island	CSI	CWS	16
	Heisdort Rocks	HDR	CWS	
	Scarecrow Island	SCI	CMI	13
	Little Charity Island	LCI	CMI	15
Lake Michigan (LM)	Gull Island	GILM	CWS	9
	Big Sister Island	BSIGB	CWS	8
	Green Island	GRI	CMI	11
	Bellow Island	BI	CMI	10
Detroit River (DR)	Fighting Island	FI	CWS	
	Turkey Island	TKYI	CWS	
Lake Erie (LE)	Middle Island	MI	CWS	19
	Port Colborne Light House	PCLH	CWS	20
	Middle Sister Island	MSI	CWS	
	West Sister Island	WSI	CWS	
	Detroit Edison	DE	CMI	18
Niagara River (NR)	Unnamed Island	UNINR	CWS	21
Lake Ontario (LO)	Leslie Street Split	LSS	CWS	23
	Snake Island	SNI	CWS	24
	Hamilton Harbour	HH	CWS	22
	Tommy Thompson Park	TTP	CWS	
St. Lawrence River (SLR)	Strachan Island	SI	CWS	25

*See Figure 1

Table 2: Bioaccumulative compounds of concern (BCCs) assessed in herring gull eggs

BCC	Abbreviation
Polychlorinated biphenyls	**PCB**
Hexachlorobenzene	**HCB**
alpha-Hexachlorocyclohexane	**a-HCH**
beta-Hexachlorocyclohexane	**b-HCH**
gamma-Hexachlorocyclohexane	**g-HCH**
Octachlorostyrene	**OCS**
Heptachlor epoxide	**HEP**
Oxychlordane	**o-CHL**
gamma-Chlordane	**g-CHL**
alpha-Chlordane	**a-CHL**
trans-Nonachlor	**t-NON**
p,p'-DDE	**DDE**
Dieldrin	**DIEL**
p,p'-DDD	**DDD**
cis-Nonachlor	**c-NON**
p,p'-DDT	**DDT**
Mirex	**MIR**
Mercury	**Hg**
Toxicity Equivalent	**TEQ**

CMI DATASET

AMONG COLONIES – FIVE YEAR MEDIANS

Table 3: Significant differences among colonies for total PCB concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)			
DE	10782.70	A		
LCI	5952.40	A	B	
SCI	4088.60	A	B	C
BI	3144.00	A	B	C
NI	3586.45	A	B	C
GRI	3038.40	A	B	C
T	3321.60	A	B	C
HI	3032.20		B	C
WTP	3093.80		B	C
FMI	2772.45			C

Table 4: Significant differences among colonies for TEQ concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)			
DE	701.9	A		
BI	565	A	B	
LCI	433	A	B	
WTP	233		B	C
FMI	221.1		B	C
NI	199.9		B	C
HI	180.9		B	C
SCI	178.3		B	C
GRI	172.9		B	C
T	129.2			C

Table 5: Significant differences among colonies for b-HCH concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)		
T	1.40	A	
NI	0.95	A	B
GRI	1.10	A	B
WTP	1.30	A	B
HI	0.65	A	B
LCI	0.60	A	B
BI	0.70	A	B
FMI	0.50	A	B
DE	0.20		B
SCI	0.40		B

Table 6: Significant differences among colonies for OCS concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)		
DE	11.20	A	
LCI	6.81	A	B
SCI	3.40	A	B
GRI	2.69	A	B
T	2.14	A	B
NI	2.44	A	B
BI	1.66	A	B
WTP	2.31	A	B
FMI	1.38		B
HI	1.44		B

Table 7: Significant differences among colonies for p,p'-DDT concentration (colonies with the same letter are not significantly different).

Colony	**Median (ppb)**		
LCI	30.48	A	
DE	25.07	A	B
BI	27.75	A	B
GRI	18.95	A	B
WTP	18.63	A	B
NI	15.73	A	B
T	9.54	A	B
SCI	12.72	A	B
HI	10.35	A	B
FMI	3.91		B

Table 8: CMI dataset colony rankings, colonies are ranked from most contaminated to least contaminated (1-10). Only BCCs with significant differences are shown.

		PCB		TEQ		b-HCH		OCS		p,p'-DDT	
Colony	Lake	Rank	ppb	Rank	ppt	Rank	ppb	Rank	ppb	Rank	ppb
NI	LS	4	3586.5	6	199.9	4	1.0	5	2.4	6	15.7
HI	LS	9	3032.2	7	180.9	5	0.7	10	1.4	8	10.4
T	LS	5	3321.6	10	129.2	1	1.4	7	2.1	9	9.5
FMI	SMR	10	2772.5	5	221.1	8	0.5	9	1.4	10	3.9
WTP	SMR	7	3093.8	4	233	2	1.3	6	2.3	5	18.6
SCI	LH	3	4088.6	8	178.3	9	0.4	3	3.4	7	12.7
LCI	LH	2	5952.4	3	433	7	0.6	2	6.8	1	30.5
GRI	LM	8	3038.4	9	172.9	3	1.1	4	2.7	4	19.0
BI	LM	6	3144.0	2	565	6	0.7	6	1.7	2	27.8
DE	DR	1	10782.7	1	701.9	10	0.2	1	11.2	3	25.1

CMI DATASET

AMONG LAKES – FIVE YEAR MEDIANS

Table 9: Significant differences among lakes for total PCB concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)			
Lake Erie	10782.70	A		
Lake Huron	4570.35	A	B	
Lake Michigan	3091.20		B	C
Lake Superior	3332.95		B	C
St. Marys River	3093.80			C

Table 10: Significant differences among lakes for TEQ concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Erie	701.9	A	
Lake Michigan	233.8		B
Lake Huron	226.7		B
St. Marys River	221.1		B
Lake Superior	165.0		B

Table 11: Significant differences among lakes for b-HCH concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Superior	1.10	A	
Lake Michigan	0.90	A	B
St. Marys River	0.50	A	B
Lake Huron	0.50		B
Lake Erie	0.20		B

Table 12: Significant differences among lakes for OCS concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Erie	11.20	A	
Lake Huron	3.58	A	B
Lake Michigan	2.51		B
Lake Superior	2.20		B
St. Marys River	1.87		B

Table 13: Significant differences among lakes for heptachlor epoxide concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Superior	39.03	A	
Lake Michigan	42.51	A	B
Lake Huron	25.26	A	B
St. Marys River	20.02	A	B
Lake Erie	23.48		B

Table 14: Significant differences among lakes for oxychlordane concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Superior	56.92	A	
Lake Michigan	64.43	A	B
Lake Huron	43.55	A	B
St. Marys River	30.23	A	B
Lake Erie	28.82		B

Table 15: Significant differences among lakes for *alpha*-chlordane concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Erie	2.02	A	
Lake Michigan	1.92	A	B
Lake Superior	0.78	A	B
St. Marys River	0.52	A	B
Lake Huron	0.54		B

Table 16: Significant differences among lakes for mirex concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Huron	46.40	A	
Lake Michigan	31.89	A	
Lake Superior	33.99	A	B
St. Marys River	25.76	A	B
Lake Erie	11.19		B

Table 17: Significant differences among lakes for mercury concentration (lakes with the same letter are not significantly different).

Lake	**Median (ppm)**		
Lake Michigan	0.22	A	
Lake Superior	0.21	A	
Lake Huron	0.23	A	
St. Marys River	0.18	A	B
Lake Erie	0.09		B

Table 18: CMI dataset lake rankings, with lakes ranked from most contaminated to least contaminated (1-5). Only BCCs with significant differences are reported.

	PCB		TEQ		b-HCH		OCS		HEP		o-CHL		a-CHL		mirex		Hg	
Lake	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppm**
Lake Erie	1	10782.7	1	701.9	5	0.2	1	11.2	4	23.5	5	28.8	1	2.0	5	11.2	5	0.1
Lake Huron	2	4570.4	3	226.7	4	0.5	2	3.6	3	25.3	3	43.6	5	0.5	1	46.4	3	0.2
Lake Michigan	5	3091.2	2	233.8	2	0.9	3	2.5	1	42.5	1	64.4	2	1.9	3	31.9	1	0.2
Lake Superior	3	3333.0	5	165.0	1	1.1	4	2.2	2	39.0	2	56.9	3	0.8	2	34.0	2	0.2
St. Marys River	4	3093.8	4	221.1	3	0.5	5	1.9	5	20.0	4	30.2	4	0.5	4	25.8	4	0.2

Combined CMI and CWS Datasets

Among Colonies – Five Year Medians

Table 19: Significant differences among colonies for total PCB concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)							
MSI	14068.50	A						
FI	11464.67	A	B					
CSI	10606.30	A	B	C				
DE	10782.70	A	B	C				
MI	10285.89	A	B	C	D			
LCI	5952.40	A	B	C	D	E		
HH	6038.08	A	B	C	D	E	F	
WSI	5356.00	A	B	C	D	E	F	
GILM	5231.90	A	B	C	D	E	F	
SI	3093.80	A	B	C	D	E	F	G
LSS	4356.00	A	B	C	D	E	F	G
TTP	4806.10	A	B	C	D	E	F	G
BSIGB	4818.80	A	B	C	D	E	F	G
SNI	3965.60	A	B	C	D	E	F	G
SCI	4088.60	A	B	C	D	E	F	G
BI	3144.00	A	B	C	D	E	F	G
NI	3586.45	A	B	C	D	E	F	G
GRI	3038.40		B	C	D	E	F	G
T	3321.60			C	D	E	F	G
HI	3032.20				D	E	F	G
WTP	3093.80					E	F	G
GI	3224.00					E	F	G
PCLH	2733.60					E	F	G
UNINR	2890.70					E	F	G
FMI	2772.45					E	F	G
AR	2877.00					E	F	G
DI	1908.00						F	G
HDR	2060.20							G
CHI	1605.55							G

Table 20: Significant differences among colonies for OCS concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)		
MSI	19.45	A	
CSI	12.25	A	
DE	11.20	A	
FI	7.73	A	B
WSI	5.40	A	B
LCI	6.81	A	B
MI	6.65	A	B
SNI	3.40	A	B
TTP	3.70	A	B
SCI	3.40	A	B
HDR	2.60	A	B
GRI	2.69	A	B
T	2.14	A	B
SI	2.90	A	B
HH	2.60	A	B
NI	2.44	A	B
BI	1.66	A	B
WTP	2.31	A	B
GI	1.63	A	B
LSS	2.00	A	B
DI	1.38	A	B
UNINR	1.85	A	B
CHI	1.14	A	B
AR	1.31	A	B
FMI	1.38	A	B
GILM	0.83	A	B
HI	1.44	A	B
BSIGB	0.75	A	B
PCLH	0.85		B

Table 21: Significant differences among colonies for heptachlor epoxide concentration (colonies with the same letter are not significantly different).

Colony	Median (ppb)				
T	48.68	A			
BI	45.21	A	B		
NI	36.69	A	B		
HI	35.01	A	B		
GILM	42.94	A	B	C	
GRI	26.91	A	B	C	
WTP	43.59	A	B	C	
AR	32.25	A	B	C	
MSI	31.75	A	B	C	
SCI	25.73	A	B	C	D
BSIGB	29.49	A	B	C	D
GI	21.05	A	B	C	D
LCI	24.79	A	B	C	D
HDR	21.40	A	B	C	D
FMI	18.61	A	B	C	D
DE	23.48	A	B	C	D
MI	21.60	A	B	C	D
WSI	16.90	A	B	C	D
DI	15.19	A	B	C	D
TTP	13.80	A	B	C	D
CSI	14.95	A	B	C	D
SNI	11.80	A	B	C	D
CHI	10.65	A	B	C	D
LSS	11.00	A	B	C	D
FI	12.33	A	B	C	D
HH	9.05		B	C	D
UNINR	8.11		B	C	D
PCLH	7.52			C	D
SI	0.05				D

Table 22: Significant differences among colonies for mirex concentration (colonies with the same letter are not significantly different).

Colony	**Median (ppb)**							
WSI	897.50	A						
LSS	343.00	A	B					
TTP	318.80	A	B	C				
SI	206.75	A	B	C	D			
HH	198.85	A	B	C	D	E		
SNI	197.56	A	B	C	D	E	F	
HDR	55.10	A	B	C	D	E	F	G
SCI	56.31	A	B	C	D	E	F	G
UNINR	62.60	A	B	C	D	E	F	G
NI	61.04	A	B	C	D	E	F	G
LCI	37.56	A	B	C	D	E	F	G
BI	29.23	A	B	C	D	E	F	G
CHI	31.54	A	B	C	D	E	F	G
GRI	34.55	A	B	C	D	E	F	G
WTP	27.05	A	B	C	D	E	F	G
DI	26.35	A	B	C	D	E	F	G
T	31.43	A	B	C	D	E	F	G
GILM	29.85	A	B	C	D	E	F	G
GI	21.95		B	C	D	E	F	G
AR	19.43			C	D	E	F	G
BSIGB	21.50			C	D	E	F	G
CSI	20.60				D	E	F	G
PCLH	21.13					E	F	G
FMI	17.47					E	F	G
HI	19.22						F	G
FI	14.05							G
MI	13.97							G
DE	11.19							G
MSI	16.05							G

Table 23: Significant differences among colonies for mercury concentration (colonies with the same letter are not significantly different).

Colony	Median (ppm)	Significance						
MSI	1.00	A						
HDR	0.78	A	B					
SI	0.75	A	B					
SNI	0.97	A	B					
AR	0.70	A	B					
WSI	0.70	A	B	C				
CSI	0.66	A	B	C				
GI	0.64	A	B	C	D			
FI	0.70	A	B	C	D			
TTP	0.59	A	B	C	D			
MI	0.64	A	B	C	D			
GILM	0.60	A	B	C	D			
DI	0.57	A	B	C	D	E		
HH	0.48	A	B	C	D	E	F	
BSIGB	0.43	A	B	C	D	E	F	G
UNINR	0.51	A	B	C	D	E	F	G
PCLH	0.46	A	B	C	D	E	F	G
LSS	0.48	A	B	C	D	E	F	G
CHI	0.37		B	C	D	E	F	G
T	0.29			C	D	E	F	G
BI	0.21				D	E	F	G
GRI	0.22				D	E	F	G
SCI	0.24				D	E	F	G
NI	0.20				D	E	F	G
WTP	0.19					E	F	G
LCI	0.17					E	F	G
HI	0.17					E	F	G
FMI	0.17						F	G
DE	0.09							G

Table 24: Combined dataset colony rankings, colonies are ranked from most contaminated to least contaminated (1-29). Only BCCs with significant differences are shown.

		PCB		OCS		HEP		mirex		Hg	
Colony	**Lake**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**	**Rank**	**ppb**
GI	LS	17	3224.0	20	1.6	15	21.1	19	22.0	9	0.6
AR		24	2877.0	24	1.3	7	32.3	23	19.4	5	0.7
NI		15	3586.5	14	2.4	5	36.7	8	61.0	25	0.2
HI		22	3032.2	23	1.4	6	35.0	24	19.2	27	0.2
T		16	3321.6	16	2.1	1	48.7	14	31.4	20	0.3
FMI	SMR	26	2772.5	22	1.4	16	18.6	25	17.5	28	0.2
WTP		19	3093.8	15	2.3	3	43.6	17	27.1	26	0.2
CHI	LH	29	1605.6	25	1.1	24	10.7	13	31.5	19	0.4
DI		27	1908.0	21	1.4	18	15.2	18	26.4	13	0.6
CSI		3	10606.3	2	12.3	19	15.0	22	20.6	7	0.7
HDR		28	2060.2	12	2.6	14	21.4	10	55.1	3	0.8
SCI		13	4088.6	10	3.4	11	25.7	9	56.3	23	0.2
LCI		7	5952.4	5	6.8	12	24.8	11	37.6	24	0.2
GILM	LM	9	5231.9	27	0.8	4	42.9	15	29.9	12	0.6
BSIGB		10	4818.8	28	0.8	9	29.5	20	21.5	18	0.4
GRI		21	3038.4	10	2.7	10	26.9	12	34.6	22	0.2
BI		18	3144.0	19	1.7	2	45.2	16	29.2	21	0.2
FI	DR	2	11464.7	4	7.7	21	12.3	27	14.1	8	0.7
MI	LE	5	10285.9	6	6.7	13	21.6	28	14.0	11	0.6
PCLH		25	2733.6	26	0.9	27	7.5	21	21.1	16	0.5
MSI		1	14068.5	1	19.5	8	31.8	26	16.1	1	1.0
WSI		8	5356.0	7	5.4	17	16.9	1	897.5	6	0.7
DE		4	10782.7	3	11.2	12	23.5	29	11.2	29	0.1
UNINR	LO	23	2890.7	18	1.9	26	8.1	7	62.6	15	0.5
LSS		12	4356.0	17	2.0	23	11.0	2	343.0	17	0.5
SNI		14	3965.6	9	3.4	22	11.8	6	197.6	2	1.0
HH		6	6038.1	13	2.6	25	9.1	5	198.9	14	0.5
TTP		11	4806.1	8	3.7	20	13.8	3	318.8	10	0.6
SI	SLR	20	3093.8	11	2.9	28	0.05	4	206.8	4	0.8

Combined CMI and CWS Datasets
Among Lakes – Five Year Medians

Table 25: Significant differences among lakes for total PCB concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)			
Detroit River	10814.90	A		
Lake Erie	8297.30	A	B	
Lake Ontario	4506.40	A	B	C
St. Lawrence River	5170.78	A	B	C
Lake Michigan	4414.20		B	C
Lake Huron	3405.55		B	C
Lake Superior	3207.35			C
St. Marys River	3093.80			C
Niagara River	2890.70			C

Table 26: Significant differences among lakes for OCS concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Detroit River	7.85	A	
Lake Erie	5.68	A	B
Lake Huron	3.40	A	B
Lake Ontario	3.00	A	B
St. Lawrence River	2.90	A	B
Lake Superior	1.79		B
Lake Michigan	1.52		B
Niagara River	1.85		B
St. Marys River	1.87		B

Table 27: Significant differences among lakes for heptachlor epoxide concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)				
Lake Michigan	37.35	A			
Lake Superior	33.82	A			
St. Marys River	20.02	A	B		
Lake Huron	16.70	A	B	C	
Lake Erie	17.50		B	C	
Lake Ontario	10.58		B	C	D
Detroit River	12.66			C	D
Niagara River	8.11			C	D
St. Lawrence River	0.05				D

Table 28: Significant differences among lakes for oxychlordane concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Michigan	67.63	A	
Lake Superior	53.28	A	
St. Marys River	30.23	A	B
Lake Huron	32.00	A	B
Lake Ontario	29.25	A	B
Lake Erie	26.91	A	B
Detroit River	25.00		B
St. Lawrence River	19.15		B
Niagara River	15.90		B

Table 29: Significant differences among lakes for *trans*-nonachlor concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)			
Lake Michigan	18.87		A	
Lake Superior	17.12	B	A	
St. Marys River	10.88	B	A	C
Lake Huron	11.30	B	A	C
Lake Erie	9.06	B	A	C
Lake Ontario	9.10	B	A	C
Detroit River	9.00	B		C
St. Lawrence River	5.15			C
Niagara River	6.60			C

Table 30: Significant differences among lakes for p,p'-DDE concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Michigan	2111.39	A	
Lake Superior	1189.61	A	B
St. Lawrence River	1084.4	A	B
Lake Ontario	1086.82	A	B
St. Marys River	984.53	A	B
Lake Huron	1122.80	A	B
Lake Erie	887.89		B
Detroit River	798.10		B
Niagara River	565.45		B

Table 31: Significant differences among lakes for dieldrin concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)			
Lake Michigan	40.96	A		
Lake Superior	34.84	A	B	
Lake Erie	36.60	A	B	C
St. Marys River	24.62	A	B	C
Lake Huron	26.75	A	B	C
Lake Ontario	22.66	A	B	C
Detroit River	25.74	A	B	C
Niagara River	16.85		B	C
St. Lawrence River	10.94			C

Table 32: Significant differences among lakes for p,p'-DDD concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Detroit River	5.00	A	
Lake Erie	4.88	A	
Lake Michigan	3.78	A	
St. Marys River	3.27	A	B
Lake Huron	3.40	A	B
Lake Ontario	2.59	A	B
Niagara River	2.48	A	B
Lake Superior	1.37	A	B
St. Lawrence River	0.75		B

Table 33: Significant differences among lakes for *cis*-nonachlor concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)			
Lake Michigan	31.85	A		
Lake Superior	28.77	A	B	
St. Marys River	25.73	A	B	
Lake Huron	18.70	A	B	C
Lake Erie	14.48	A	B	C
Lake Ontario	13.90		B	C
Niagara River	9.40			C
Detroit River	10.66			C
St. Lawrence River	7.53			C

Table 34: Significant differences among lakes for p,p'-DDT concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)		
Lake Michigan	18.48	A	
Lake Huron	12.00	A	B
Lake Erie	15.34	A	B
Detroit River	14.00	A	B
St. Marys River	13.79	A	B
Lake Superior	10.60	A	B
Lake Ontario	10.20	A	B
St. Lawrence River	4.85	A	B
Niagara River	3.50		B

Table 35: Significant differences among lakes for mirex concentration (lakes with the same letter are not significantly different).

Lake	Median (ppb)			
St. Lawrence River	206.75	A		
Lake Ontario	256.94	A		
Niagara River	62.60	A	B	
Lake Huron	30.08		B	C
Lake Michigan	29.11		B	C
Lake Superior	23.36		B	C
St. Marys River	25.76		B	C
Lake Erie	14.94			C
Detroit River	13.11			C

Table 36: Combined dataset lakes rankings, only BCCs with significant differences are shown, lakes are ranked from most contaminated to least contaminated (1-9)

	PCB		OCS		HEP		o-CHL		t-NON		p,p'-DDE		p,p'-DDD		p,p'-DDT	
BCC	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**
Detroit River	1	10814.9	1	7.9	6	12.7	7	25.0	7	9.0	8	798.1	1	5.0	3	14.0
Lake Erie	2	8297.3	2	5.7	4	17.5	6	26.9	5	9.1	7	887.9	2	4.9	2	15.3
Lake Huron	6	3405.6	3	3.4	5	16.7	3	32.0	3	11.3	3	1122.8	4	3.4	5	12.0
Lake Michigan	5	4414.2	9	1.5	1	37.4	1	67.6	1	18.9	1	2111.4	3	3.8	1	18.5
Lake Ontario	4	4506.4	4	3.0	7	10.6	5	29.3	6	9.1	4	1086.8	6	2.6	7	10.2
Lake Superior	7	3207.4	8	1.8	2	33.8	2	53.3	2	17.1	2	1189.6	8	1.4	6	10.6
Niagara River	9	2890.7	6	1.9	8	8.1	9	15.9	9	6.6	9	565.5	7	2.5	9	3.5
St. Lawrence River	3	5170.8	5	2.9	9	0.1	8	19.2	9	5.2	5	1084.4	9	0.8	8	4.9
St. Marys River	8	3093.8	7	1.9	3	20.0	4	30.2	4	10.9	6	984.5	5	3.3	4	13.8

Table 36 (cont.): Combined dataset lakes rankings, only BCCs with significant differences are shown, lakes are ranked from most contaminated to least contaminated (1-9)

	c-NON		dieldrin		mirex	
BCC	**rank**	**ppb**	**rank**	**ppb**	**rank**	**ppb**
Detroit River	7	10.7	5	25.7	9	13.1
Lake Erie	5	14.5	2	36.6	8	14.9
Lake Huron	4	18.7	4	26.8	4	30.1
Lake Michigan	1	31.9	1	41.0	5	29.1
Lake Ontario	6	13.9	7	22.7	1	256.9
Lake Superior	2	28.8	3	34.8	7	23.4
Niagara River	8	9.4	8	16.9	3	62.6
St. Lawrence River	9	7.5	9	10.9	2	206.8
St. Marys River	3	25.7	6	24.6	6	25.8

COMPARING CMI AND CWS DATASETS

Table 37: Significant differences in five year median BCC concentrations between CMI and CWS datasets by lake. Only chemicals and lakes with significant differences are reported.

Lake	Chemical	CMI Medians (ppb)	CWS Medians (ppb)	p-value	df
Lake Erie	PCB	10782.70	7937.20	0.015	15
	OCS	11.20	5.00	0.0082	14
	p,p'-DDE	662.94	1119.72	0.0445	16
	p,p'-DDD	7.86	3.00	0.0029	16
	mercury	90.00	600.00	0.0262	15
Lake Huron	heptachlor epoxide	25.26	13.90	0.0048	22
	p,p'-DDE	1537.06	737.60	0.0061	21
	cis-nonachlor	25.64	14.35	0.0236	22
Lake Michigan	OCS	2.51	0.75	0.0443	18
	p,p'-DDD	5.96	2.84	0.0069	18
Lake Superior	p,p'-DDE	1498.80	1062.32	0.0165	18
	p,p'-DDD	3.67	0.50	0.0146	18
	mercury	210.00	500.00	0.0012	18

FIGURES

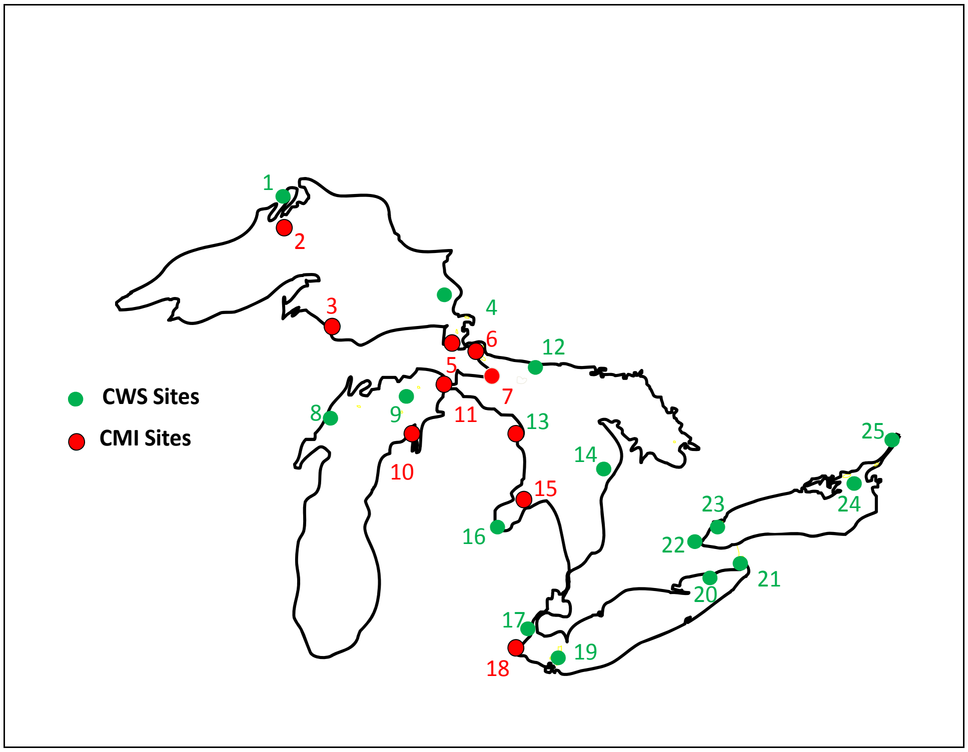

Figure 1: Location of herring gull annual monitoring colonies for CMI and CWS

CMI Dataset

Among Colonies – Five Year Medians

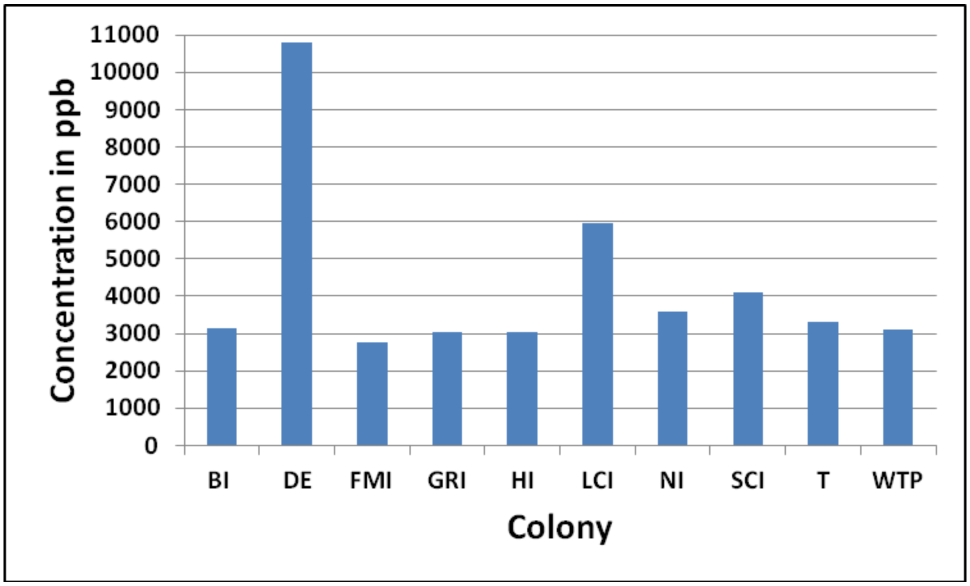

Figure 2: Five year median concentrations of total PCBs in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

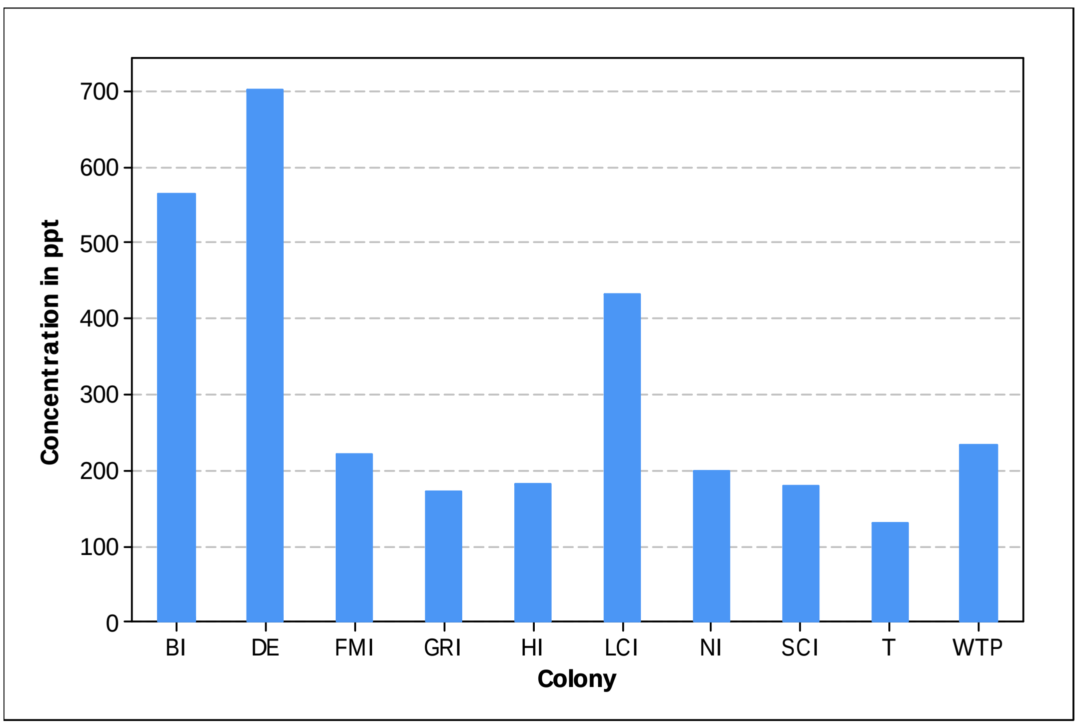

Figure 3: Five year median concentrations of TEQ in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

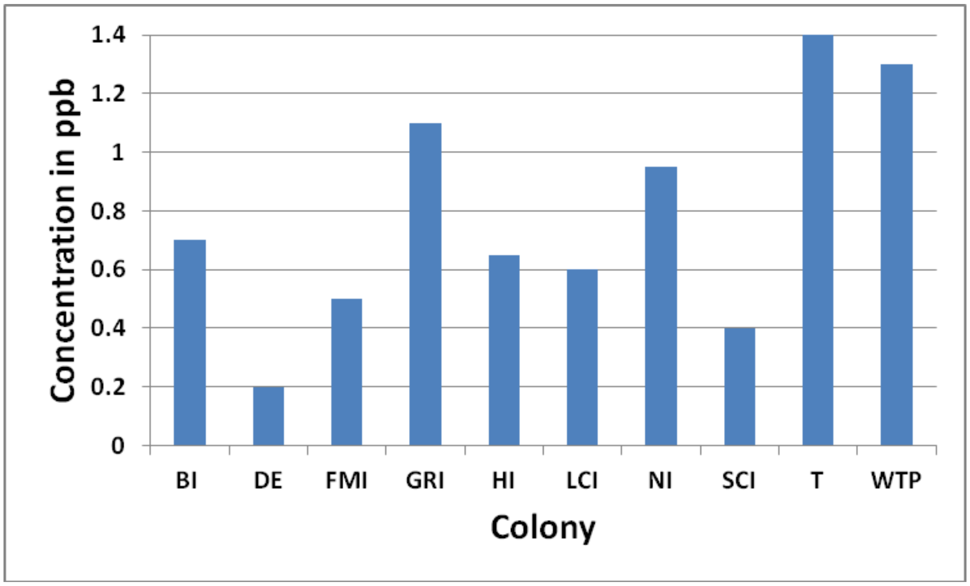

Figure 4: Five year median concentrations of *beta*-HCH in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

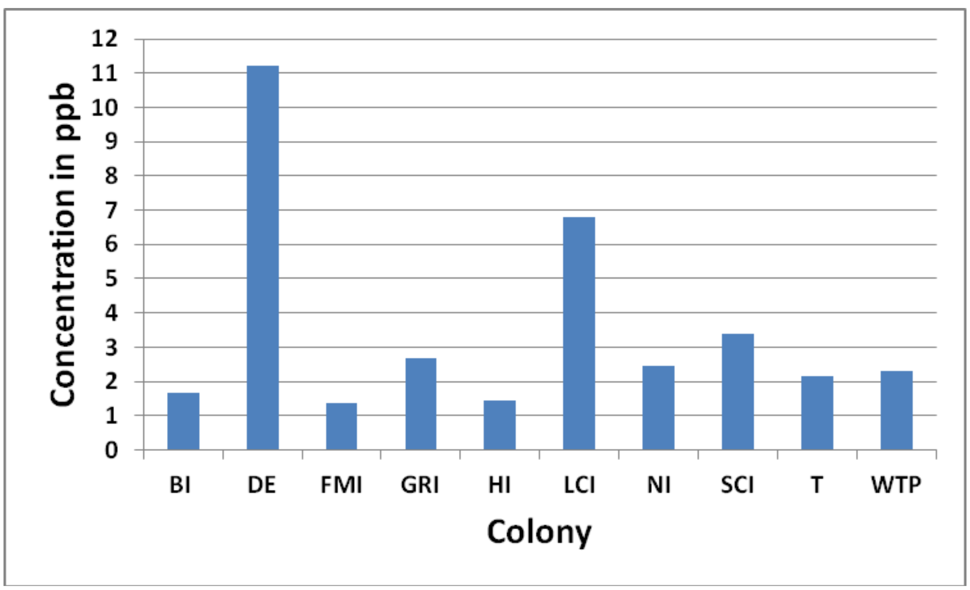

Figure 5: Five year median concentrations of OCS in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

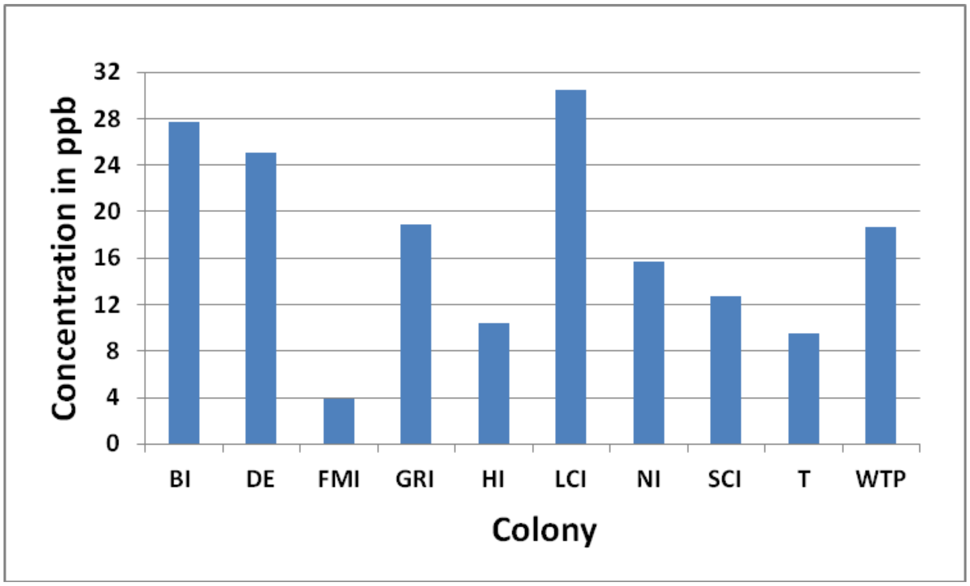

Figure 6: Five year median concentrations of p,p'-DDT in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

CMI DATASET

AMONG LAKES – FIVE YEAR MEDIANS

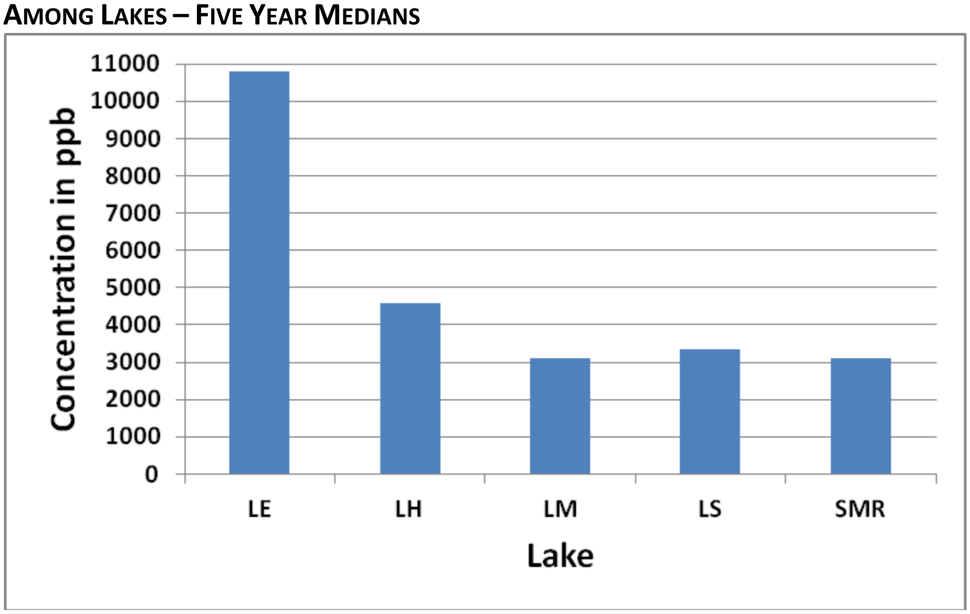

Figure 7: Five year median concentrations of total PCBs in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

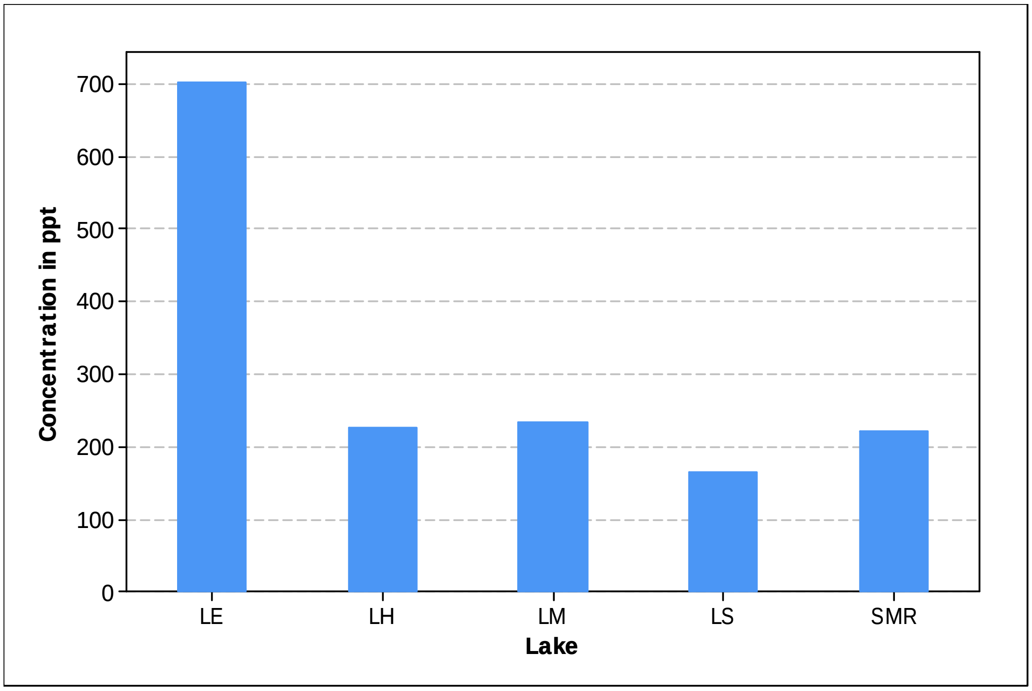

Figure 8: Median concentrations of TEQ in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

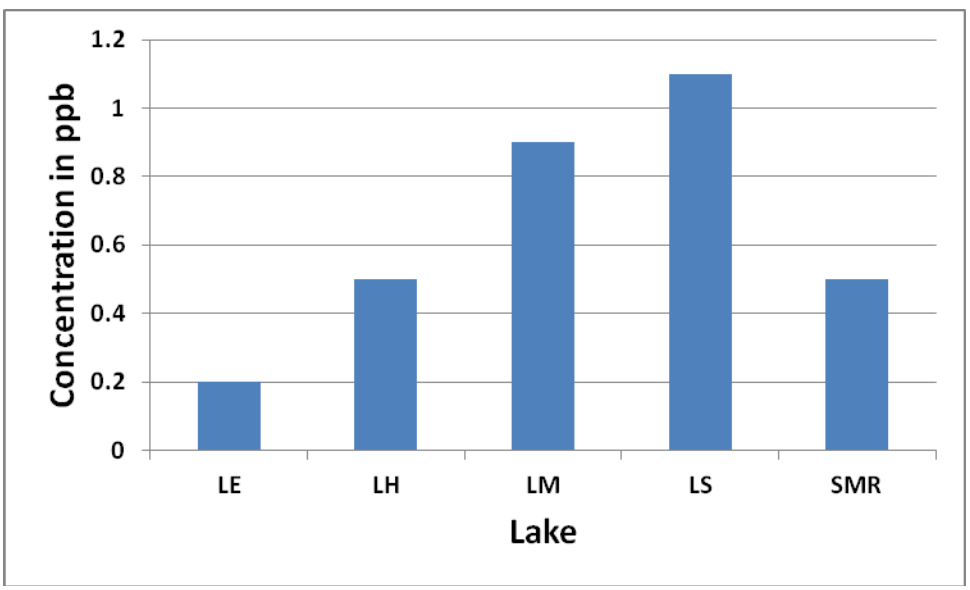

Figure 9: Median concentrations of *beta*-HCH in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

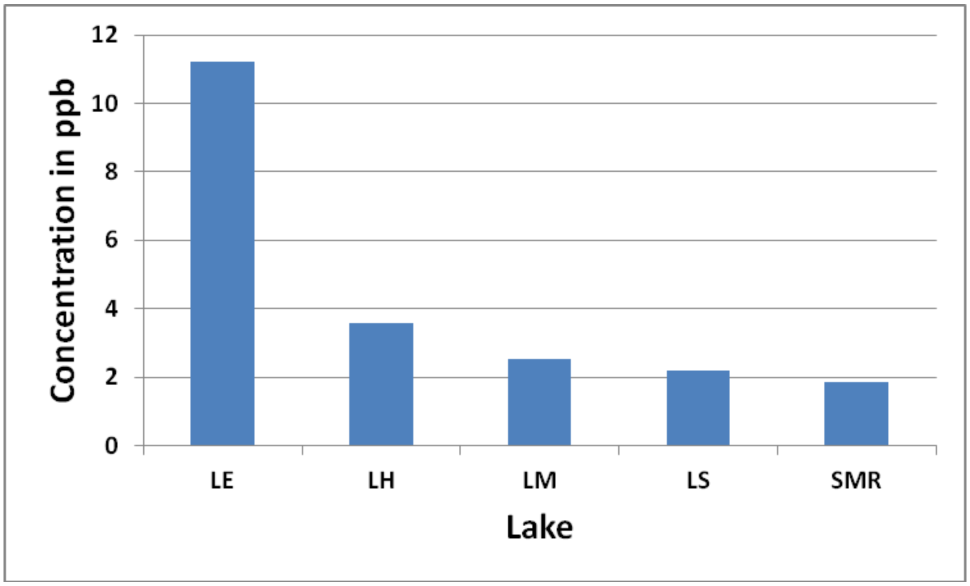

Figure 10: Five year median concentrations of OCS in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

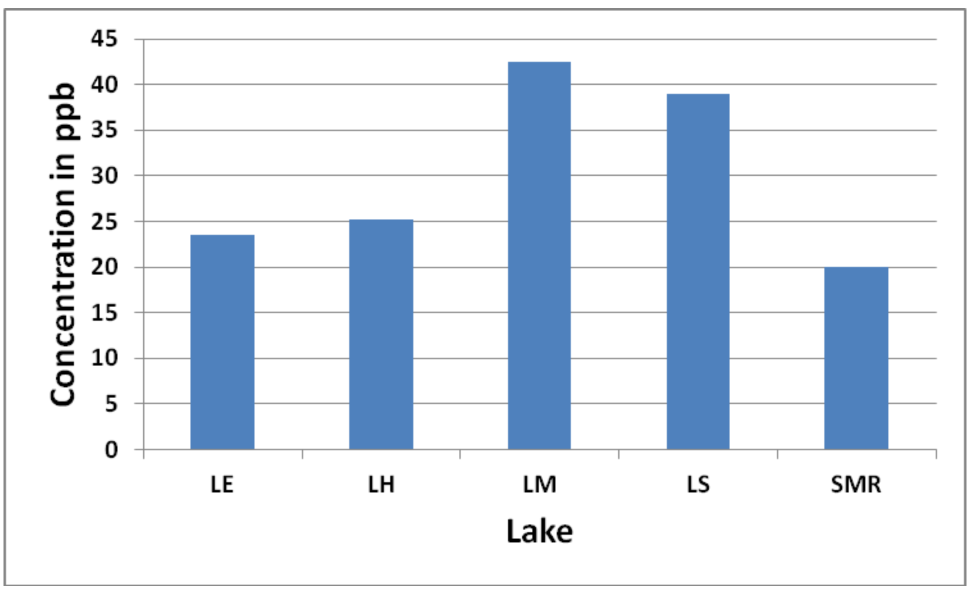

Figure 11: Five year median concentrations of heptachlor epoxide in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

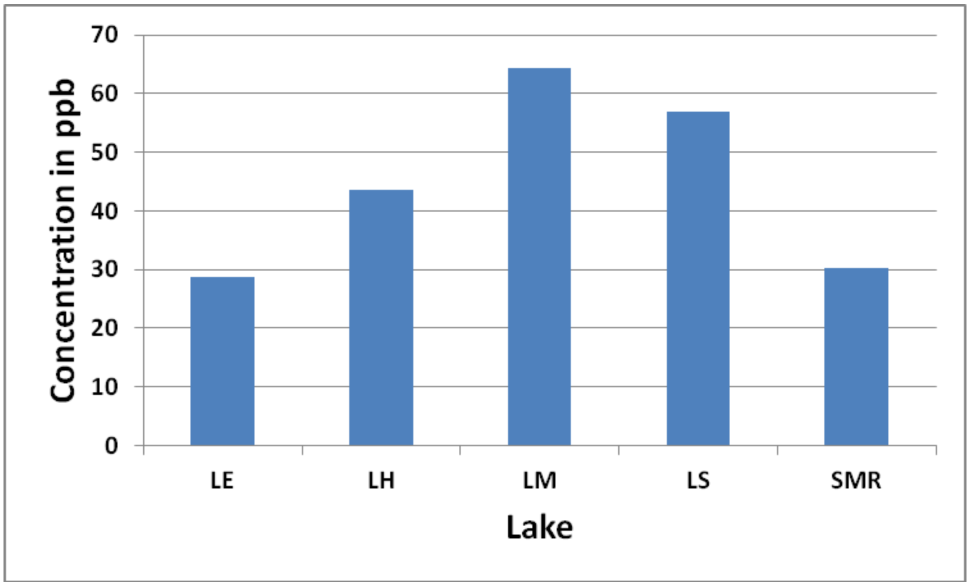

Figure 12: Five year median concentrations of oxychlordane in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

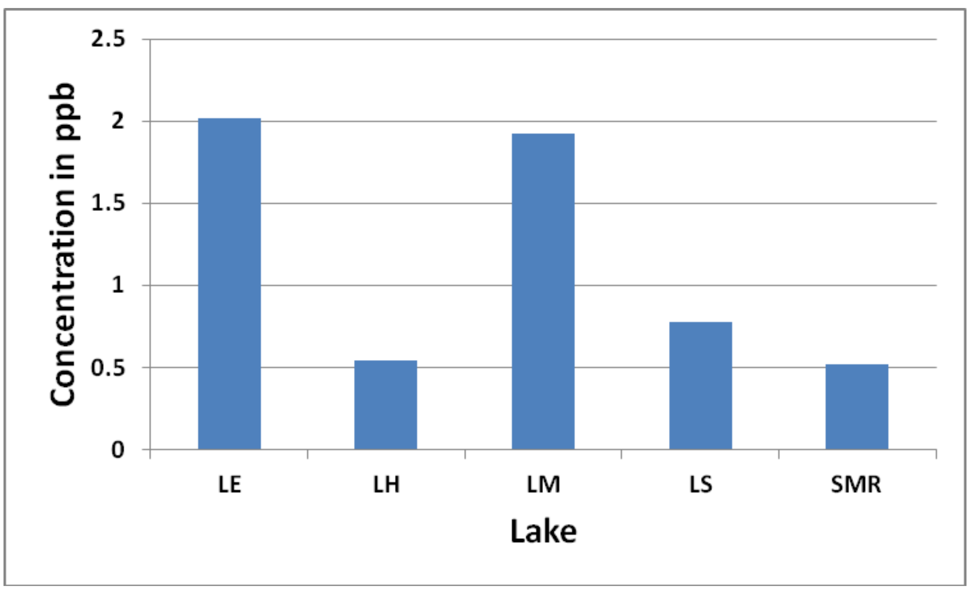

Figure 13: Five year median concentrations of *alpha*-chlordane in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

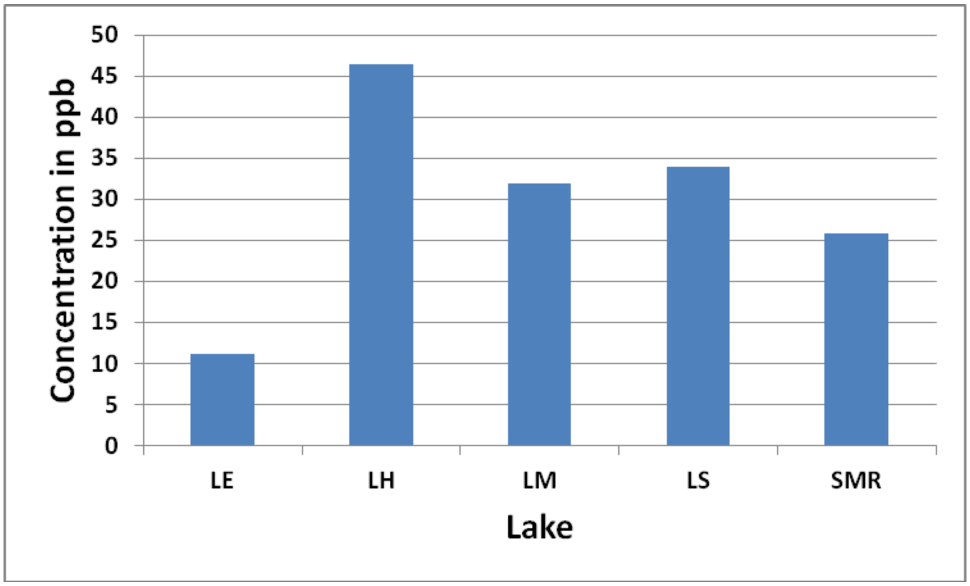

Figure 14: Five year median concentrations of mirex in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

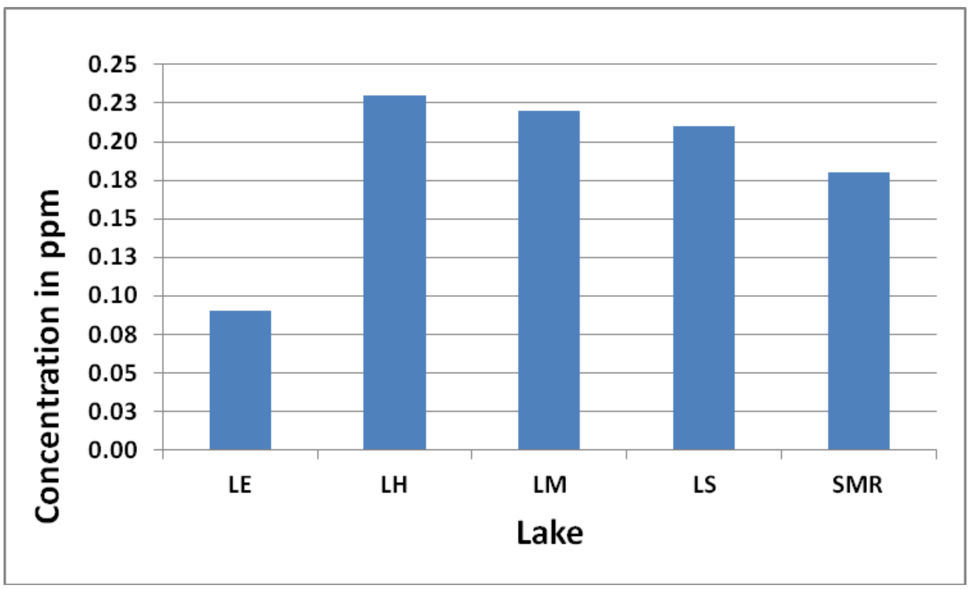

Figure 15: Five year median concentrations of mercury in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006.

Combined CMI and CWS Datasets

Among Colonies – Five Year Medians

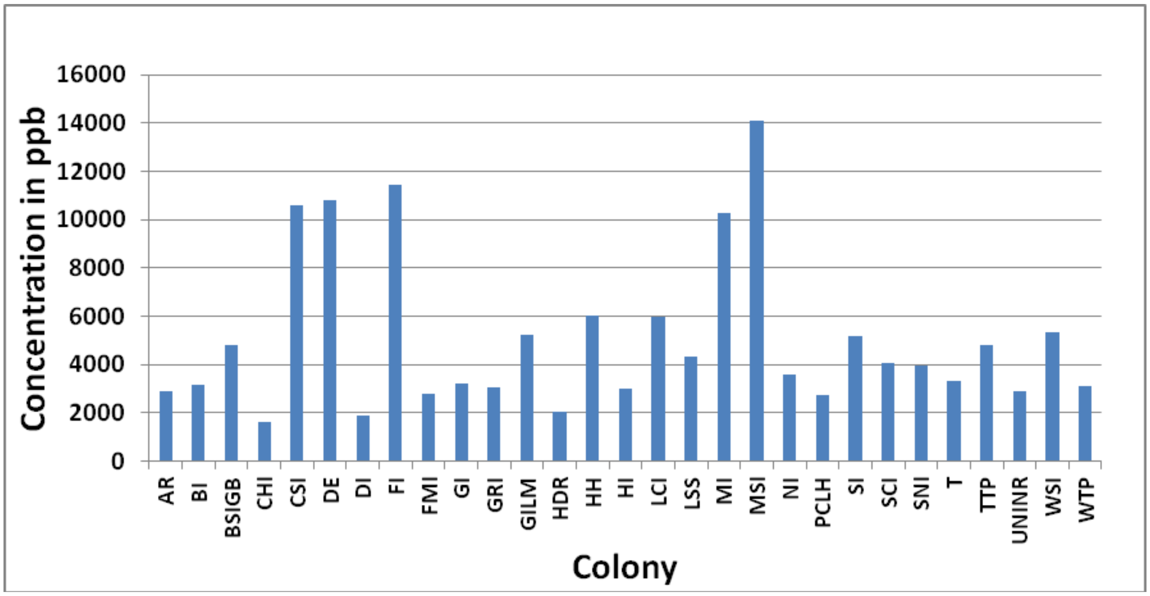

Figure 16: Median concentrations of total PCBs in herring gull (*Larus argentatus*) eggs collected from 29 breeding colonies in Michigan and Canada, 2002-2006.

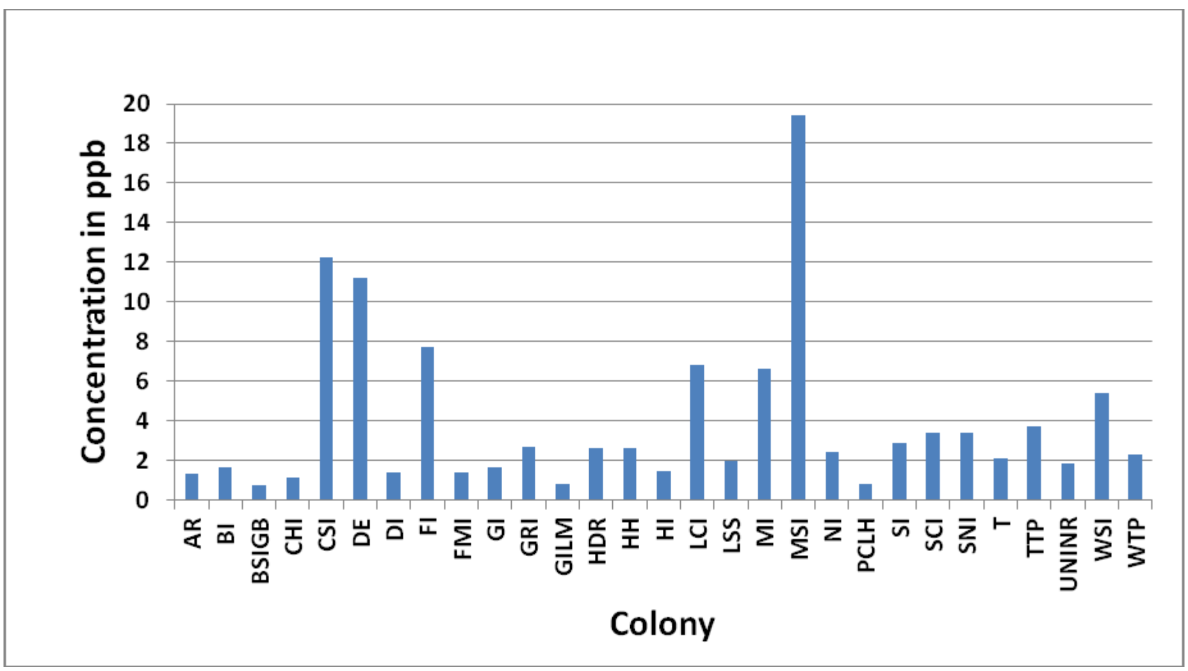

Figure 17: Five year median concentrations of OCS in herring gull (*Larus argentatus*) eggs collected from 29 breeding colonies in Michigan and Canada, 2002-2006.

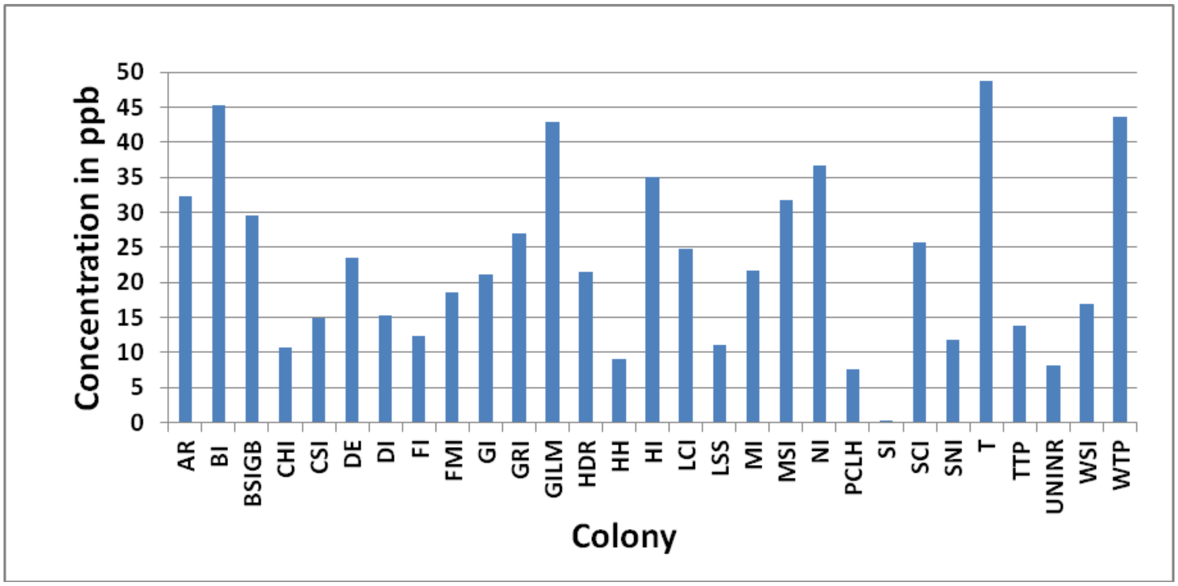

Figure 18: Five year median concentrations of heptachlor epoxide in herring gull (*Larus argentatus*) eggs collected from 29 breeding colonies in Michigan and Canada, 2002-2006.

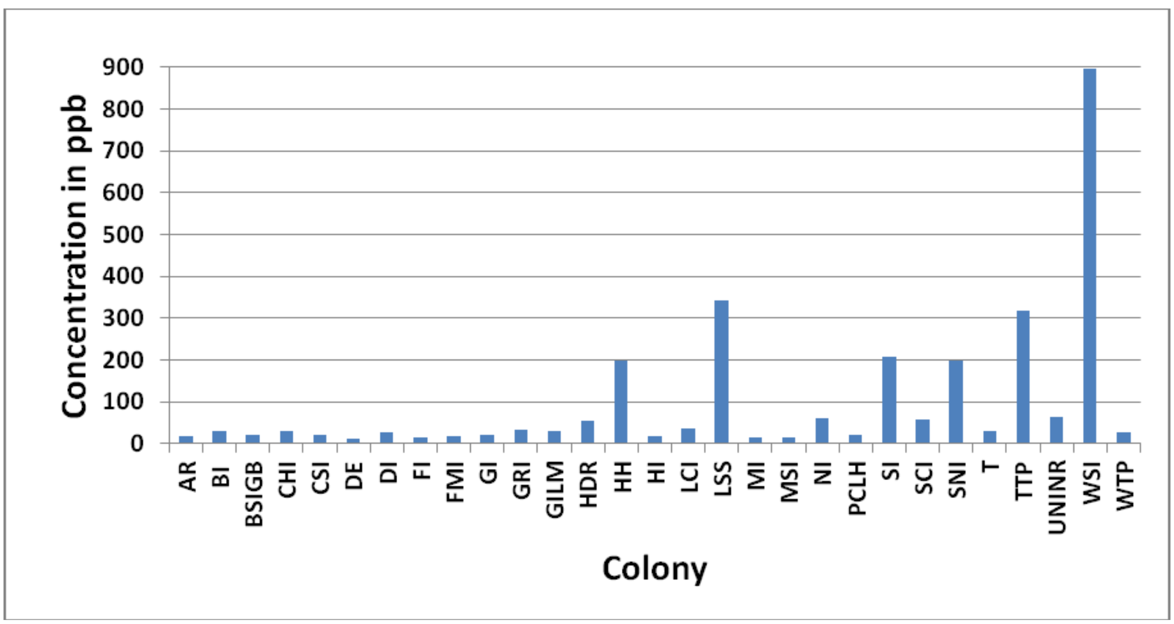

Figure 19: Five year median concentrations of mirex in herring gull (*Larus argentatus*) eggs collected from 29 breeding colonies in Michigan and Canada, 2002-2006.

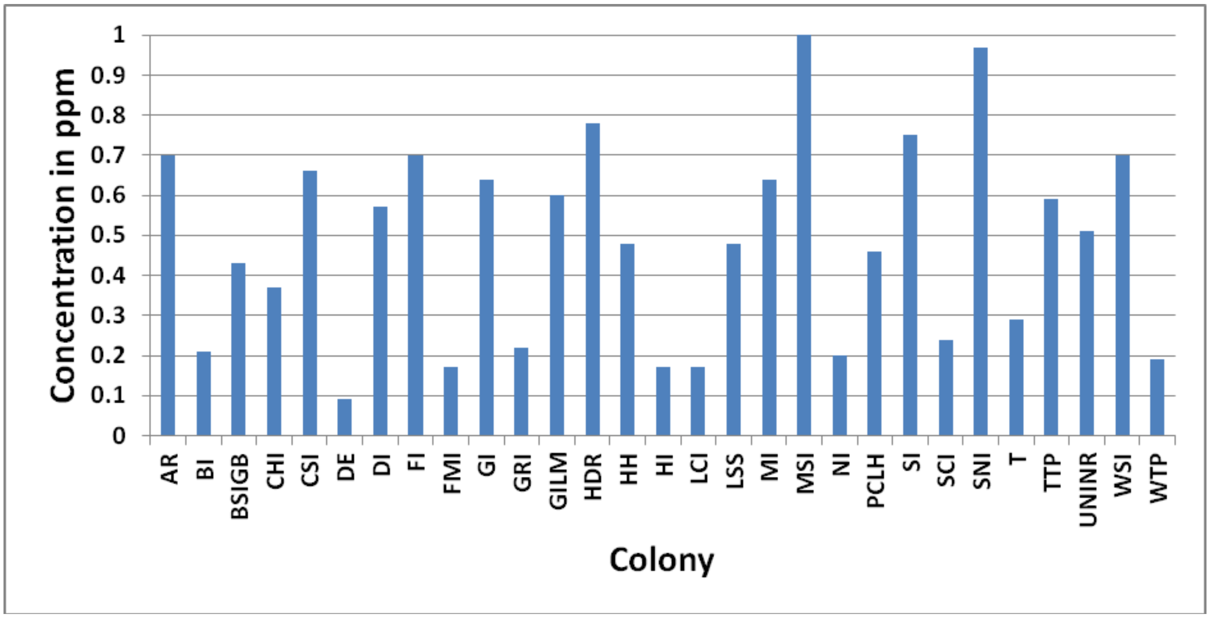

Figure 20: Five year median concentrations of mercury in herring gull (*Larus argentatus*) eggs collected from 29 breeding colonies in Michigan and Canada, 2002-2006.

Combined CMI and CWS Datasets

Among Lakes – Five Year Median

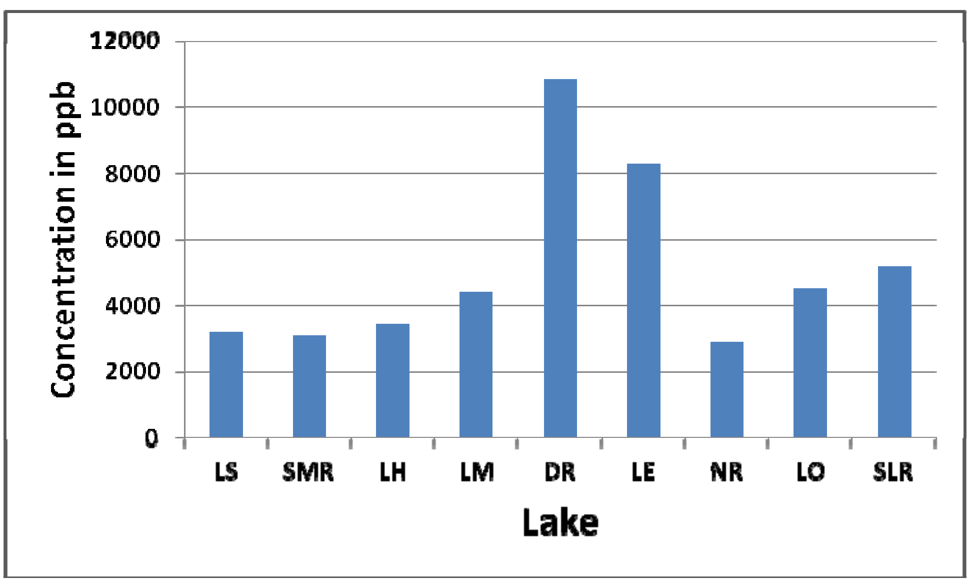

Figure 21: Five year median concentrations of total PCBs in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

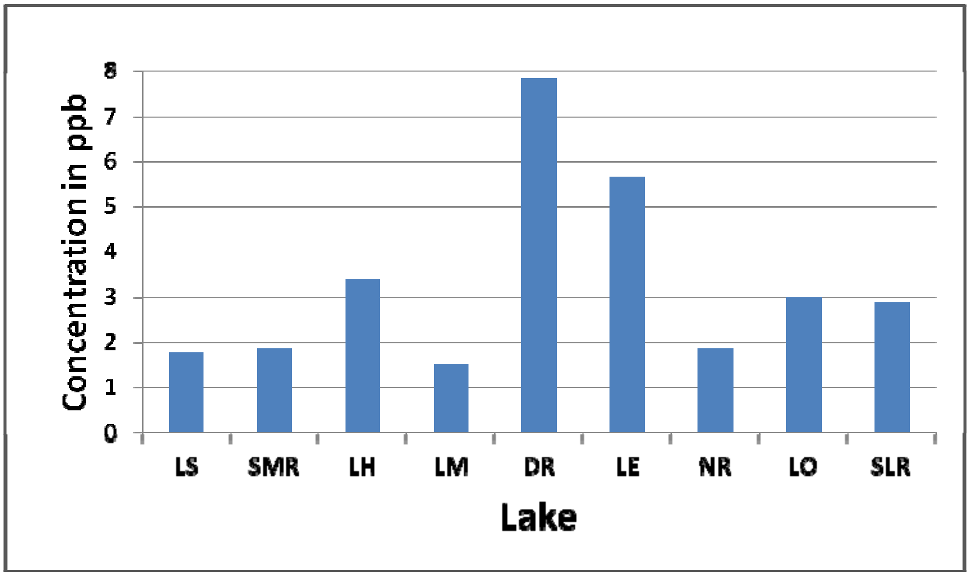

Figure 22: Five year median concentrations of OCS in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

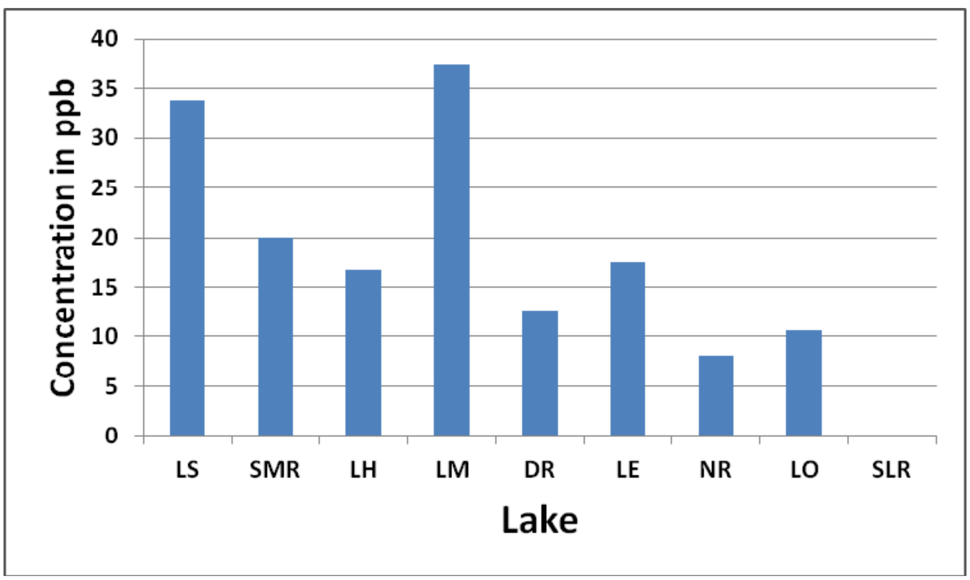

Figure 23: Five year median concentrations of heptachlor epoxide in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

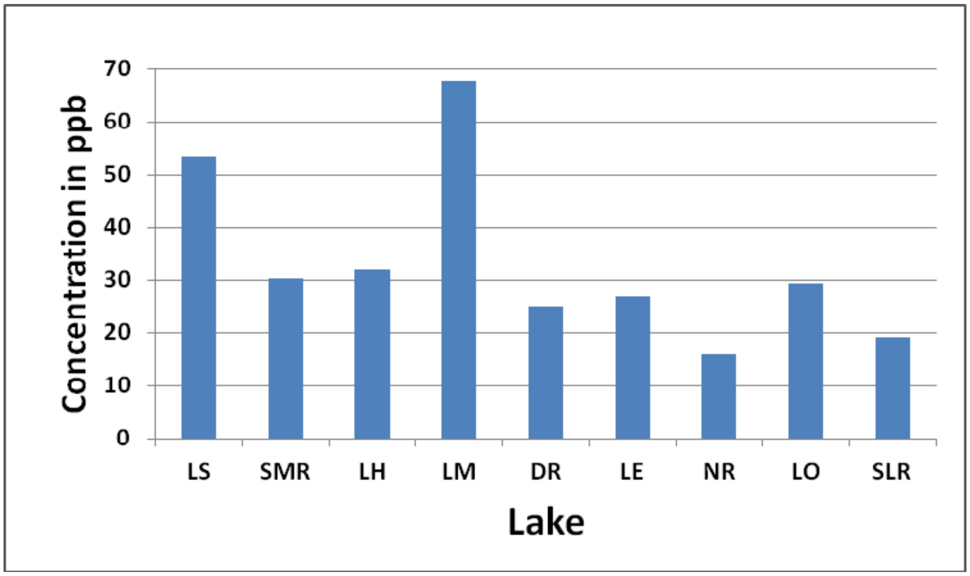

Figure 24: Five year median concentrations of oxychlordane in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

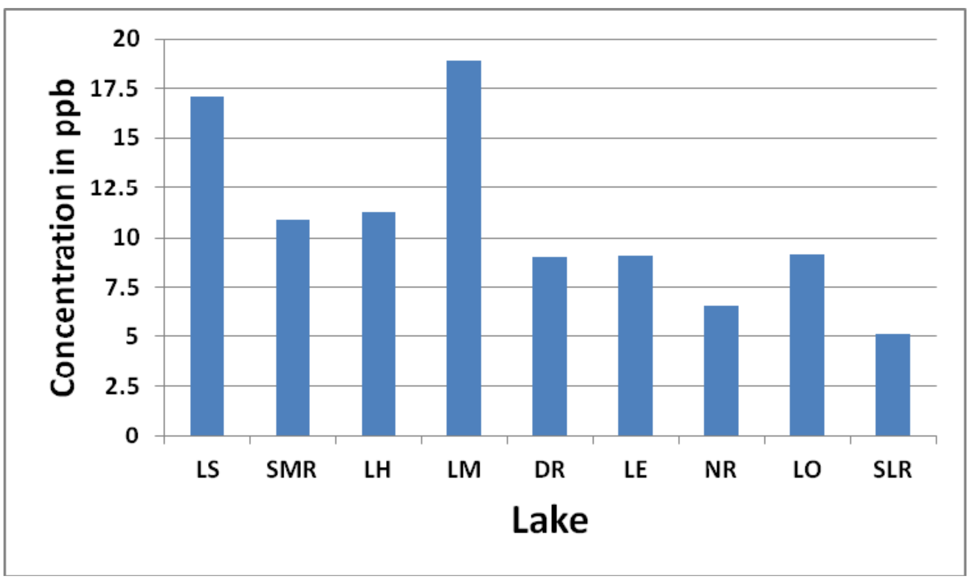

Figure 25: Five year median concentrations of *trans*-nonachlor in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

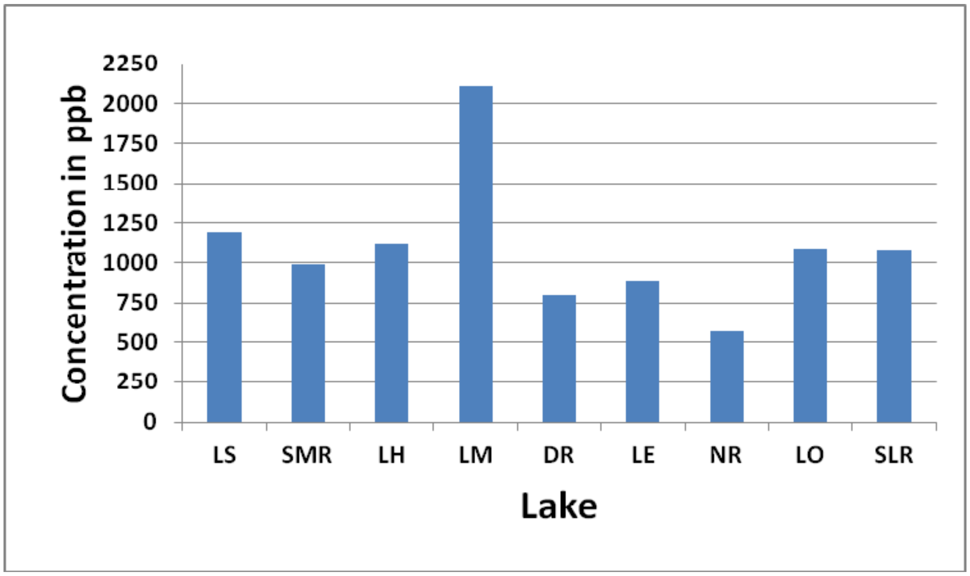

Figure 26: Five year median concentrations of p,p'-DDE in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

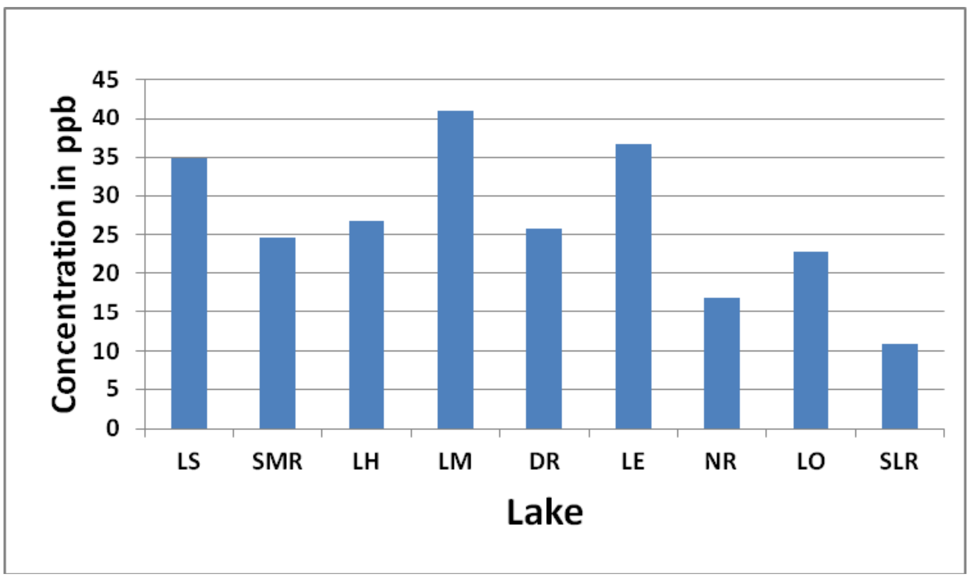

Figure 27: Five year median concentrations of dieldrin in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

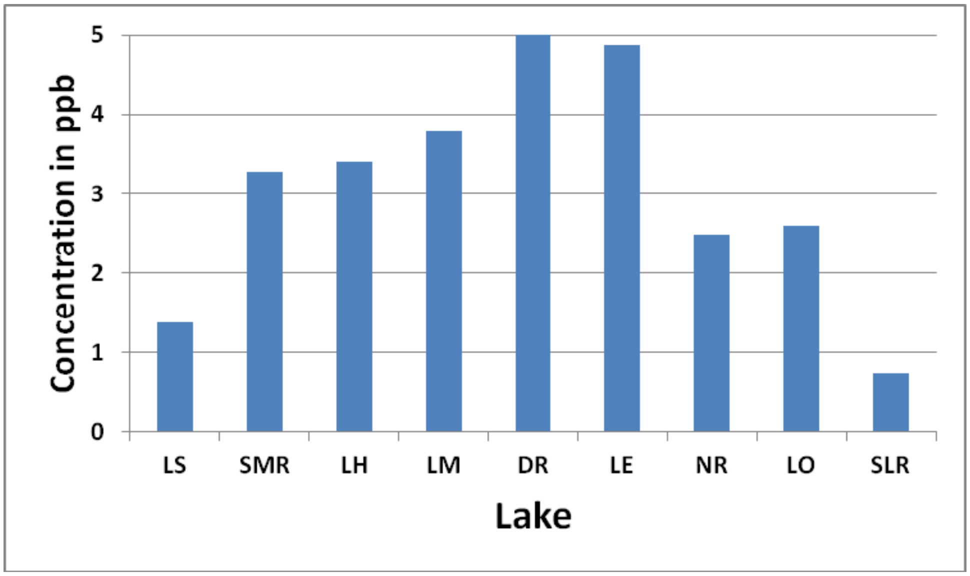

Figure 28: Five year median concentrations of p,p'-DDD in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

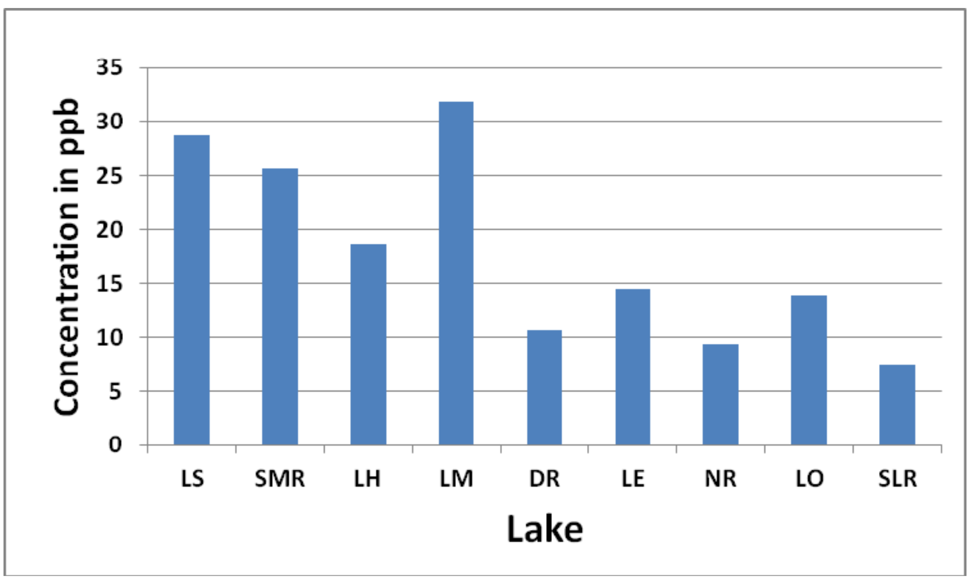

Figure 29: Five year median concentrations of *cis*-nonachlor in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

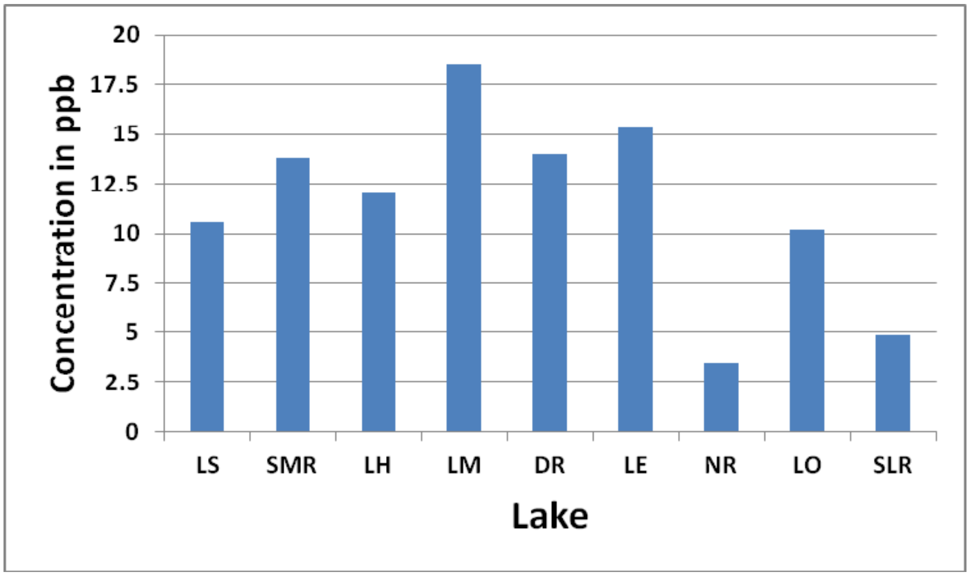

Figure 30: Five year median concentrations of p,p'-DDT in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

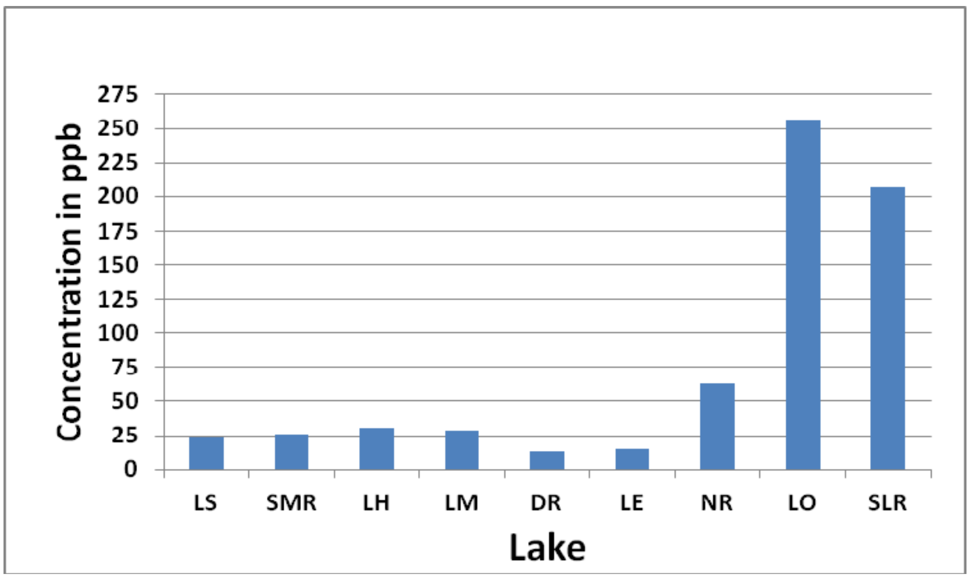

Figure 31: Five year median concentrations of mirex in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006.

Appendix A: Five year median concentration by Great Lake or river of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006 (measured in ppb).

	Lake Superior		**St. Marys River**		**Lake Huron**		**Lake Michigan**		**Detroit River**	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	3207.4	1372.8	3093.8	1163.8	3405.6	6320.0	4414.2	3151.5	10814.9	1419.0
HCB	10.9	6.5	9.3	4.9	9.8	7.4	10.3	10.6	9.6	2.6
***alpha*-HCH**	0.1	0.3	0.1	0.0	0.1	0.5	0.1	0.5	0.5	1.5
***beta*-HCH**	0.9	1.4	0.5	0.8	0.5	0.8	0.5	1.1	0.5	2.1
***gamma*-HCH**	0.2	1.1	0.2	1.0	0.1	0.2	0.2	0.4	0.1	0.0
OCS	1.8	1.7	1.9	1.6	3.4	5.6	1.5	2.2	7.9	2.4
Heptachlor epoxide	33.8	21.8	20.0	25.2	16.7	12.8	37.4	30.8	12.7	3.2
Oxychlordane	53.3	59.5	30.2	56.2	32.0	27.4	67.6	69.0	25.0	19.2
***trans*-Chlordane**	0.1	0.5	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0
***cis*-Chlordane**	0.8	1.3	0.5	0.4	1.0	1.2	2.0	2.7	2.1	1.9
***trans*-Nonachlor**	17.1	13.7	10.9	4.3	11.3	9.3	18.9	16.7	9.0	3.1
p,p'-DDE	1189.6	598.8	984.5	688.4	1122.8	1075.1	2111.4	1278.6	798.1	602.5
Dieldrin	34.8	32.6	24.6	23.7	26.8	27.4	41.0	60.3	25.7	0.7
p,p'-DDD	1.4	4.0	3.3	3.6	3.4	6.4	3.8	3.1	5.0	4.9
***cis*-Nonachlor**	28.8	17.5	25.7	21.8	18.7	14.9	31.9	21.6	10.7	3.7
p,p'-DDT	10.6	10.1	13.8	14.7	12.0	24.9	18.5	28.2	14.0	19.7
Mirex	23.4	34.4	25.8	12.3	30.1	34.0	29.1	30.0	13.1	4.2
Mercury[a]	0.4	0.3	0.4	0.3	0.5	0.4	0.4	0.3	0.7	0.0

[a] measured in ppm

Appendix A: (cont.) Five year median concentration by Great Lake or river of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 33 breeding colonies in Michigan and Canada, 2002-2006 (measured in ppb).

	Lake Erie		Niagara River		Lake Ontario		St. Lawrence River	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	8297.3	8133.6	2890.7	1021.8	4506.4	1755.0	5170.8	3481.9
HCB	9.1	10.2	9.4	5.7	9.8	7.6	4.9	4.9
***alpha*-HCH**	0.1	0.7	0.1	1.0	0.1	1.2	0.1	0.0
***beta*-HCH**	0.2	1.5	0.3	6.3	0.3	2.2	1.0	1.4
***gamma*-HCH**	0.1	0.2	0.1	0.0	0.1	0.0	0.1	0.0
OCS	5.7	10.3	1.9	0.8	3.0	2.7	2.9	1.8
Heptachlor epoxide	17.5	16.0	8.1	3.4	10.6	6.1	0.1	6.4
Oxychlordane	26.9	24.1	15.9	6.4	29.3	23.7	19.2	17.9
***trans*-Chlordane**	0.1	0.3	0.1	0.0	0.1	0.5	0.3	0.5
***cis*-Chlordane**	2.0	2.5	1.7	0.3	1.6	1.9	0.5	1.2
***trans*-Nonachlor**	9.1	12.1	6.6	1.9	9.1	5.4	5.2	12.4
p,p'-DDE	887.9	818.5	565.5	285.9	1086.8	616.6	1084.4	1355.8
Dieldrin	36.6	53.2	16.9	13.1	22.7	15.0	10.9	14.5
p,p'-DDD	4.9	6.4	2.5	1.4	2.6	1.4	0.8	1.5
***cis*-Nonachlor**	14.5	17.3	9.4	4.0	13.9	9.8	7.5	7.7
p,p'-DDT	15.3	41.2	3.5	11.0	10.2	18.3	4.9	10.5
Mirex	14.9	15.0	62.6	50.7	256.9	201.4	206.8	149.3
Mercury[a]	0.6	0.4	0.5	0.2	0.6	0.4	0.8	0.3

[a] **measured in ppm**

Appendix B: Five year median concentrations by colony of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 23 breeding colonies in Canada, 2002-2006 (measured in ppb).

		AR		**BSIGB**		**CHI**		**CSI**		**DI**		**FI**	
	Units	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	ppb	2877.0	1843.9	4818.8	3270.3	1605.6	367.8	10606.3	3590.7	1908.0	1151.6	11464.7	2926.3
HCB	ppb	11.3	5.9	8.0	3.0	5.9	5.0	11.4	6.8	8.2	6.0	9.5	4.8
***alpha*-HCH**	ppb	0.3	1.2	0.3	0.5	0.3	1.6	0.1	0.0	0.3	0.5	1.0	2.4
***beta*-HCH**	ppb	0.1	1.8	0.3	0.5	0.3	1.1	0.3	1.1	0.3	1.3	1.3	1.9
***gamma*-HCH**	ppb	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.5
OCS	ppb	1.3	1.4	0.8	1.8	1.1	2.1	12.3	6.9	1.4	2.5	7.7	3.6
Heptachlor epoxide	ppb	32.3	23.1	29.5	20.2	10.7	6.2	15.0	2.8	15.2	15.7	12.3	6.8
Oxychlordane	ppb	60.3	29.6	71.1	65.6	19.8	28.7	29.9	35.7	33.8	28.7	21.4	25.4
***trans*-Chlordane**	ppb	0.3	0.5	0.3	0.5	0.1	0.0	0.1	0.5	0.1	0.5	0.1	0.2
***cis*-Chlordane**	ppb	1.4	1.9	1.2	1.7	0.5	1.2	1.9	1.7	0.9	1.2	2.1	2.3
***trans*-Nonachlor**	ppb	13.7	15.0	13.4	7.6	5.8	6.9	11.4	3.8	8.0	9.6	8.3	4.6
p,p'-DDE	ppb	1062.3	596.6	2111.4	2109.7	434.7	271.5	1753.4	1026.5	714.9	541.2	785.0	600.2
Dieldrin	ppb	37.0	38.8	35.0	31.2	13.1	18.2	25.8	19.4	21.1	27.1	25.5	11.3
p,p'-DDD	ppb	1.1	0.8	2.5	1.7	0.5	0.7	6.9	5.9	0.8	1.4	4.1	4.6
***cis*-Nonachlor**	ppb	23.5	18.3	26.3	17.2	9.7	10.1	13.9	7.2	16.7	14.9	10.3	5.9
p,p'-DDT	ppb	12.4	11.9	21.0	75.7	40.5	65.9	16.5	116.7	7.3	9.6	13.9	16.6
Mirex	ppb	19.4	12.7	21.5	29.6	31.5	40.3	20.6	10.8	26.4	8.3	14.1	17.8
Mercury[a]	ppm	0.7	0.1	0.4	0.1	0.4	0.2	0.7	0.1	0.6	0.1	0.7	0.2

[a]measured in ppb

Appendix B (cont.): Five year median concentrations by colony of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 23 breeding colonies in Canada, 2002-2006 (measured in ppb).

	GI		GILM		HDR		HH		LSS	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
PCB	3224.0	1261.1	5231.9	5341.7	2060.2	0.0	6038.1	2645.3	4356.0	0.0
HCB	10.0	3.0	12.2	14.6	11.6	0.0	9.3	4.9	8.0	0.0
***alpha*-HCH**	0.1	0.5	0.1	0.5	0.5	0.0	0.3	1.2	0.1	0.0
***beta*-HCH**	0.3	1.1	0.3	2.1	0.5	0.0	0.3	2.4	0.1	0.0
***gamma*-HCH**	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
OCS	1.6	1.9	0.8	1.2	2.6	0.0	2.6	1.6	2.0	0.0
Heptachlor epoxide	21.1	18.7	42.9	36.3	21.4	0.0	9.1	2.7	11.0	0.0
Oxychlordane	38.8	74.5	90.2	104.2	27.4	0.0	21.8	12.9	33.0	0.0
***trans*-Chlordane**	0.3	0.5	0.1	0.5	0.5	0.0	0.1	0.5	0.1	0.0
***cis*-Chlordane**	0.5	1.3	2.8	1.9	1.9	0.0	1.6	1.8	1.0	0.0
***trans*-Nonachlor**	10.4	9.9	22.1	14.6	19.4	0.0	8.5	1.4	7.0	0.0
p,p'-DDE	960.6	763.2	2274.2	1725.1	707.0	0.0	1021.4	283.1	1682.0	0.0
Dieldrin	32.8	19.3	46.0	59.5	43.4	0.0	19.8	13.3	47.0	0.0
p,p'-DDD	0.5	0.0	3.1	2.8	1.4	0.0	3.0	0.6	2.0	0.0
***cis*-Nonachlor**	19.6	13.9	34.6	32.6	26.3	0.0	13.9	5.8	9.0	0.0
p,p'-DDT	8.0	6.2	17.7	13.7	11.2	0.0	8.8	4.9	4.0	0.0
Mirex	22.0	19.5	29.9	29.3	55.1	0.0	198.9	138.4	343.0	0.0
Mercury[a]	0.6	0.2	0.6	0.1	0.8	0.0	0.5	0.2	0.5	0.0

[a]measured in ppm

Appendix B (cont.): Five year median concentrations by colony of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 23 breeding colonies in Canada, 2002-2006 (measured in ppb).

	MI		MSI		PCLH		SI		SNI	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	10285.9	7164.3	14068.5	7541.0	2733.6	428.3	5170.8	3481.9	3965.6	648.7
HCB	12.0	14.1	21.6	19.1	4.4	3.4	4.9	4.9	8.9	14.4
***alpha*-HCH**	0.3	0.5	0.1	0.0	0.5	1.7	0.1	0.0	0.1	1.3
***beta*-HCH**	0.1	1.6	0.1	0.0	0.8	4.6	1.0	1.4	0.3	2.2
***gamma*-HCH**	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
OCS	6.7	7.6	19.5	16.9	0.9	0.8	2.9	1.8	3.4	4.9
Heptachlor epoxide	21.6	17.7	31.8	27.5	7.5	6.5	0.1	6.4	11.8	15.2
Oxychlordane	37.9	23.1	43.4	36.7	13.4	11.1	19.2	17.9	30.0	23.2
***trans*-Chlordane**	0.1	0.5	0.1	0.0	0.1	0.5	0.3	0.5	0.1	0.0
***cis*-Chlordane**	2.4	2.5	4.3	4.6	0.7	0.6	0.5	1.2	0.5	1.5
***trans*-Nonachlor**	12.9	10.3	15.7	15.3	3.5	3.6	5.2	12.4	8.8	8.6
p,p'-DDE	825.0	444.1	1390.5	500.9	334.3	103.5	1084.4	1355.8	1175.2	888.2
Dieldrin	43.5	40.1	67.6	61.1	12.6	13.9	10.9	14.5	20.5	33.2
p,p'-DDD	5.1	4.1	12.1	18.1	1.3	1.1	0.8	1.5	1.6	5.4
***cis*-Nonachlor**	21.7	20.7	29.4	30.7	6.7	5.6	7.5	7.7	14.4	13.8
p,p'-DDT	38.2	92.2	125.0	244.0	5.1	7.8	4.9	10.5	17.5	27.1
Mirex	14.0	19.5	16.1	10.1	21.1	18.8	206.8	149.3	197.6	239.4
Mercury[a]	0.6	0.1	1.0	0.0	0.5	0.3	0.8	0.3	1.0	0.6

[a] measured in ppm

Appendix B (cont.): Five year median concentrations by colony of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 23 breeding colonies in Canada, 2002-2006 (measured in ppb).

	TTP		UNINR		WSI	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	4806.1	1078.1	2890.7	1021.8	5356.0	0.0
HCB	13.5	9.1	9.4	5.7	12.4	0.0
***alpha*-HCH**	0.5	0.5	0.1	1.0	1.6	0.0
***beta*-HCH**	0.5	1.7	0.3	6.3	2.2	0.0
***gamma*-HCH**	0.1	0.0	0.1	0.0	0.1	0.0
OCS	3.7	2.4	1.9	0.8	5.4	0.0
Heptachlor epoxide	13.8	3.9	8.1	3.4	16.9	0.0
Oxychlordane	36.7	40.8	15.9	6.4	32.7	0.0
***trans*-Chlordane**	0.1	0.5	0.1	0.0	0.5	0.0
***cis*-Chlordane**	1.8	0.6	1.7	0.3	3.7	0.0
***trans*-Nonachlor**	11.0	4.8	6.6	1.9	21.6	0.0
p,p'-DDE	1117.7	611.5	565.5	285.9	1605.0	0.0
Dieldrin	23.6	6.6	16.9	13.1	36.2	0.0
p,p'-DDD	2.6	0.9	2.5	1.4	5.4	0.0
***cis*-Nonachlor**	15.0	7.9	9.4	4.0	21.7	0.0
p,p'-DDT	20.5	27.4	3.5	11.0	15.9	0.0
Mirex	318.8	247.5	62.6	50.7	897.5	0.0
Mercury[a]	0.6	0.3	0.5	0.2	0.7	0.0

[a] measured in ppm

Appendix C: Five year median concentrations by colony of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006 (measured in ppb).

		BI		DE		FMI		GRI		HI		LCI	
	Units	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	ppb	3144.0	2468.2	10782.7	1586.0	2772.5	1264.5	3038.4	2185.3	3032.2	1182.2	5952.4	7012.1
HCB	ppb	15.2	9.3	15.5	6.1	7.7	3.7	15.7	15.0	9.1	3.0	14.4	4.4
***alpha*-HCH**	ppb	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1
***beta*-HCH**	ppb	0.7	0.4	0.2	0.5	0.5	0.3	1.1	0.8	0.7	0.3	0.6	0.3
***gamma*-HCH**	ppb	0.4	0.3	0.2	0.6	0.9	1.2	0.2	0.0	0.7	1.0	0.2	0.7
OCS	ppb	1.7	2.7	11.2	4.4	1.4	1.6	2.7	0.4	1.4	1.6	6.8	10.4
Heptachlor epoxide	ppb	45.2	35.7	23.5	2.8	18.6	8.2	26.9	32.4	35.0	3.3	24.8	14.0
Oxychlordane	ppb	67.1	18.0	28.8	9.1	26.6	10.7	33.9	38.3	65.3	49.7	29.4	20.8
***trans*-Chlordane**	ppb	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
***cis*-Chlordane**	ppb	2.3	5.0	2.0	1.5	0.4	0.4	1.9	0.7	0.4	0.4	0.6	1.3
***trans*-Nonachlor**	ppb	23.2	20.2	13.9	5.4	10.3	3.7	20.9	15.2	14.3	5.2	15.4	9.9
p,p'-DDE	ppb	2184.0	813.9	1119.7	138.6	883.3	405.3	1657.8	890.5	1519.1	1074.3	1260.6	1121.4
Dieldrin	ppb	124.4	98.5	65.5	25.6	23.1	16.8	31.0	31.5	28.2	11.2	41.8	45.5
p,p'-DDD	ppb	5.3	3.6	7.9	2.9	2.6	3.4	6.6	6.1	2.5	0.8	5.5	10.8
***cis*-Nonachlor**	ppb	42.4	17.0	17.2	4.3	20.9	10.5	37.2	45.0	29.6	1.7	21.0	16.2
p,p'-DDT	ppb	27.8	10.7	25.1	20.9	3.9	3.5	19.0	32.0	10.4	6.1	30.5	9.7
Mirex	ppb	29.2	23.3	11.2	3.1	17.5	8.6	34.6	38.8	19.2	7.2	37.6	29.5
Mercury [a]	ppm	0.2	0.1	0.1	0.0	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1
TEQ	ppb	738.9	277.1	686.3	37.5	221.4	38.2	228.5	79.0	397.1	403.8	738.8	958.0

[a] measured in ppm

Appendix C (cont.): Five year median concentrations by colony of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002-2006 (measured in ppb).

	NI		SCI		TI		WTP	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
PCB	3586.5	1059.5	4088.6	893.2	3321.6	940.4	3093.8	1150.2
HCB	12.7	6.7	11.1	8.5	16.9	8.1	11.0	4.3
***alpha*-HCH**	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0
***beta*-HCH**	1.0	1.4	0.4	0.1	1.4	0.4	1.3	0.8
***gamma*-HCH**	1.0	4.6	0.2	0.0	0.9	1.3	0.2	0.0
OCS	2.4	2.2	3.4	1.5	2.1	6.7	2.3	1.2
Heptachlor epoxide	36.7	38.9	25.7	11.6	48.7	150.0	43.6	24.8
Oxychlordane	79.8	64.6	47.4	32.4	55.6	120.6	80.7	57.5
***trans*-Chlordane**	0.1	0.0	0.1	0.0	0.1	0.8	0.1	0.0
***cis*-Chlordane**	0.7	0.6	0.5	0.5	3.7	53.7	0.6	3.5
***trans*-Nonachlor**	21.3	13.6	16.0	11.7	30.4	193.0	10.9	15.6
p,p'-DDE	1881.5	1168.5	1537.3	29.5	1481.7	468.2	1470.5	700.7
Dieldrin	49.0	37.9	26.8	14.5	44.3	68.9	24.6	33.4
p,p'-DDD	4.9	2.5	4.8	3.2	3.6	6.7	3.6	3.1
***cis*-Nonachlor**	37.6	32.4	29.8	19.5	39.4	55.1	37.8	20.2
p,p'-DDT	15.7	13.8	12.7	10.1	9.5	19.6	18.6	11.3
Mirex	61.0	25.7	56.3	37.5	31.4	26.2	27.1	18.2
Mercury [a]	0.2	0.1	0.2	0.1	0.3	0.2	0.2	0.1
TEQ	217.5	350.8	182.7	60.2	185.0	65.4	412.3	321.1

[a] **measured in ppm**

Appendix D: Median concentrations by lake of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 23 breeding colonies in Canada, 2002 – 2006 (measured in ppb).

Dataset	**CWS**											
Year	**2002**				**2003**				**2004**			
Lake	**LE**	**LH**	**LM**	**LS**	**LE**	**LH**	**LM**	**LS**	**LE**	**LH**	**LM**	**LS**
PCB	6924.5	1908.0	8764.5	3050.5	8836.3	2723.4	5434.2	2716.9	7909.3	2873.9	7448.9	3719.0
HCB	10.0	7.0	9.0	9.5	11.2	12.3	16.3	12.5	5.6	9.2	11.1	12.3
***alpha*-HCH**	0.1	0.1	0.1	0.1	0.8	0.5	0.5	0.9	5.4	2.5	4.5	4.5
***beta*-HCH**	0.1	0.1	0.1	0.1	1.6	1.2	1.3	1.5	5.7	3.5	4.3	4.7
***gamma*-HCH**	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
OCS	5.2	1.0	0.8	1.5	7.6	3.3	1.1	2.4	3.4	1.8	1.8	1.4
Heptachlor epoxide	17.0	16.0	35.5	24.0	16.7	19.1	42.7	29.3	13.3	13.4	36.9	38.5
Oxychlordane	24.0	32.0	94.5	50.0	23.1	27.1	66.8	45.5	57.4	68.9	171.9	158.7
***trans*-Chlordane**	0.1	0.1	0.1	0.1	0.5	0.5	0.5	1.4	0.1	0.1	0.3	0.5
***cis*-Chlordane**	2.0	0.5	1.3	0.5	2.1	1.9	3.8	1.5	1.5	0.5	2.2	2.3
***trans*-Nonachlor**	8.0	9.0	14.0	10.0	11.3	14.6	25.2	16.3	7.5	6.9	22.4	21.5
p,p'-DDE	926.5	953.0	4240.0	1182.5	628.9	933.5	2304.8	906.8	525.1	612.4	2118.2	1247.6
Dieldrin	36.6	16.0	41.0	33.5	36.6	37.6	83.0	46.0	21.5	14.1	40.0	41.4
p,p'-DDD	3.5	0.5	3.0	0.5	4.3	1.7	3.2	0.9	3.0	0.5	4.1	0.8
***cis*-Nonachlor**	15.0	12.0	29.0	19.0	19.0	22.5	40.3	24.1	10.0	11.5	31.8	30.7
p,p'-DDT	2.5	4.0	15.0	6.5	17.8	15.6	16.6	10.0	31.9	10.6	57.6	14.7
Mirex	18.0	29.0	42.0	20.5	44.5	56.2	40.7	114.6	17.8	22.8	33.6	30.7
Mercury[a]	0.6	0.6	0.5	0.7	0.8	0.8	0.9	0.8	0.5	0.5	0.5	0.7

[a] measured in ppm

Appendix D (cont.): Median concentrations by lake of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 23 breeding colonies in Canada, 2002 – 2006 (measured in ppb).

Dataset	**CWS**								
Year	**2005**					**2006**			
Lake	**LE**	**LH**	**LM**	**LS**		**LE**	**LH**	**LM**	**LS**
PCB	5343.75	1628.30	3692.95	4656.80		7937.20	1695.10	3106.15	2464.15
HCB	2.80	2.30	2.85	3.40		21.80	15.70	18.20	23.05
***alpha*-HCH**	0.28	0.50	0.28	0.50		0.05	0.05	0.05	0.05
***beta*-HCH**	0.05	0.50	0.50	0.50		0.05	0.05	0.05	0.05
***gamma*-HCH**	1.10	0.50	1.20	1.50		0.05	0.05	0.05	0.05
OCS	1.20	0.50	0.50	1.30		16.80	5.40	3.65	4.90
Heptachlor epoxide	3.00	3.80	7.20	4.80		35.80	25.00	44.75	244.60
Oxychlordane	4.90	8.80	15.90	7.80		46.10	47.20	115.55	85.83
***trans*-Chlordane**	0.50	0.50	0.50	0.50		0.05	0.05	0.05	0.05
***cis*-Chlordane**	0.50	0.50	1.15	0.50		4.50	1.90	3.85	2.68
***trans*-Nonachlor**	2.30	2.30	4.85	3.40		18.30	16.20	21.45	25.13
p,p'-DDE	147.30	198.00	603.05	376.30		1107.00	817.50	2927.35	1506.78
Dieldrin	5.45	4.60	9.55	6.50		72.80	56.30	84.60	76.90
p,p'-DDD	1.00	0.50	0.50	0.50		11.40	7.80	3.50	5.28
***cis*-Nonachlor**	3.25	4.20	6.95	4.90		40.20	30.40	45.55	44.93
p,p'-DDT	0.50	2.90	2.40	2.10		247.00	455.00	248.20	329.78
Mirex	4.95	9.00	5.30	64.00		16.30	31.00	22.50	20.88
Mercury[a]	0.40	0.56	0.50	0.60		0.68	0.57	0.54	0.68

[a] measured in ppm

Appendix E: Median concentrations by lake of bioaccumulative compounds of concern in herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002 – 2006 (measured in ppb).

Dataset	**CMI**											
Year	**2002**				**2003**				**2004**			
Lake	**LE**	**LH**	**LM**	**LS**	**LE**	**LH**	**LM**	**LS**	**LE**	**LH**	**LM**	**LS**
PCB	10914.20	4123.75	6069.90	3623.30	10782.70	6084.20	2392.05	3207.35	9328.20	4088.60	4056.90	3221.90
HCB	16.34	14.64	16.86	13.27	15.49	17.97	21.33	15.55	10.02	11.09	13.99	15.02
***alpha*-HCH**	0.10	0.17	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.08
***beta*-HCH**	0.10	0.50	0.90	0.70	0.20	0.45	0.90	1.15	0.90	0.20	0.95	2.10
***gamma*-HCH**	0.20	0.57	0.30	0.20	0.75	0.20	0.20	0.36	1.33	0.40	1.92	4.57
OCS	8.74	2.41	2.18	4.82	13.18	5.29	2.04	2.50	11.20	3.40	4.01	2.48
Heptachlor epoxide	24.49	26.10	48.09	41.38	20.92	37.45	55.54	42.77	23.74	25.73	51.23	63.12
Oxychlordane	36.02	51.08	106.63	108.10	28.82	60.89	65.00	55.93	24.83	47.39	70.78	81.29
***trans*-Chlordane**	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
***cis*-Chlordane**	4.25	0.90	1.43	0.43	1.89	0.69	7.61	3.38	2.02	0.10	1.77	0.83
***trans*-Nonachlor**	15.99	16.38	25.80	23.26	13.86	20.79	48.46	31.07	10.64	8.78	21.94	24.79
p,p'-DDE	1231.87	1337.67	2844.33	2056.31	1119.72	1398.72	1792.49	1277.36	1093.32	1751.31	1714.25	1664.00
Dieldrin	80.49	30.09	43.89	45.42	54.90	38.57	164.45	93.80	65.51	20.82	75.44	64.70
p,p'-DDD	16.41	4.61	8.50	4.46	9.44	11.44	9.05	5.12	7.86	6.87	6.31	4.16
***cis*-Nonachlor**	17.17	27.31	49.25	42.87	19.29	31.34	56.75	41.21	14.96	21.35	35.25	49.13
p,p'-DDT	48.94	21.24	34.32	7.28	25.07	18.79	36.31	26.07	17.56	5.53	23.35	17.13
Mirex	11.19	33.27	71.88	52.22	10.45	90.60	44.45	38.71	10.03	31.58	26.14	41.63
Mercury[a]	0.09	0.18	0.19	0.21	0.14	0.25	0.26	0.29	0.10	0.09	0.24	0.17
TEQ	680.1	581.7	530.90	209.8	686.3	182.4	186.1	175.3	248.5	221.9	453.6	494.5

[a] **measured in ppm**

Appendix E (cont.): Median concentrations by lake of bioaccumulative compounds of concern in fresh herring gull (*Larus argentatus*) eggs collected from 10 breeding colonies in Michigan, 2002 – 2006 (measured in ppb).

Dataset	**CMI**							
Year	**2005**				**2006**			
Lake	**LE**	**LH**	**LM**	**LS**	**LE**	**LH**	**LM**	**LS**
PCB	8098.30	2548.20	2766.05	2509.55	19947.90	8076.40	3656.85	4029.30
HCB	6.38	9.81	8.42	7.82	16.14	11.53	18.24	14.85
***alpha*-HCH**	0.10	0.10	0.33	0.10	0.10	0.10	0.10	0.10
***beta*-HCH**	0.20	0.50	0.50	1.10	0.70	0.75	1.35	1.40
***gamma*-HCH**	0.20	0.20	0.33	1.53	0.20	0.20	0.20	0.20
OCS	5.87	2.11	1.32	1.02	17.98	8.82	4.35	1.44
Heptachlor epoxide	11.63	24.56	17.76	26.35	23.48	20.86	51.82	43.82
Oxychlordane	14.55	39.70	26.48	41.95	33.91	25.54	48.51	48.88
***trans*-Chlordane**	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
***cis*-Chlordane**	1.39	0.46	0.64	0.43	3.35	1.05	5.31	1.61
***trans*-Nonachlor**	5.72	15.96	10.47	9.26	22.68	15.51	47.33	17.98
p,p'-DDE	838.88	1122.80	1142.06	1283.48	2857.80	1912.92	1920.90	1888.41
Dieldrin	20.34	26.75	15.79	27.33	84.46	39.57	79.64	29.00
p,p'-DDD	5.18	4.79	2.91	1.93	6.59	1.75	5.96	1.00
***cis*-Nonachlor**	8.16	29.79	20.42	15.32	34.15	25.64	67.59	28.73
p,p'-DDT	9.81	17.22	12.47	8.46	38.40	23.36	23.62	8.52
Mirex	13.58	56.31	28.07	33.99	32.19	62.16	44.81	19.59
Mercury[a]	0.08	0.23	0.16	0.15	0.19	0.40	0.33	0.73
TEQ	717.6	182.7	352.8	179.8	1095.5	410	761.7	196.3

[a] **measured in ppm**