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MICHIGAN WILDLIFE CONTAMINANT TREND MONITORING

YEAR 2004 ANNUAL REPORT NESTLING BALD EAGLES

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SECTION 1.0

Executive Summary

- The bald eagle monitoring project is one component of Michigan's water quality monitoring program that was summarized by the Michigan Department of Environmental Quality (MDEQ) in the January 1997 report entitled, "A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters (Strategy)." This document serves as the sixth annual report for the bald eagle element of the Strategy. The following are the goals of the bald eagle monitoring project:

  1. Assess the current status and condition of individual waters of the state and determine whether standards are being met.

  2. Determine temporal and spatial trends in the quality of Michigan's surface waters.

- The productivity (i.e., the total number of fledged young per occupied nest) for bald eagles in the state of Michigan in 2004 was 0.94. Productivity in anadromous (1.33) breeding areas was found to be significantly greater than inland (0.95) and Great Lakes (0.84) breeding areas. Breeding area productivities did not vary significantly by subpopulations. Inland lower peninsula had the greatest subpopulation productivity (1.03), followed by Lake Superior (1.00), Lake Erie (1.00), Lake Huron (0.98), the inland upper peninsula (0.85), and Lake Michigan (0.83). No differences were found for success rate (i.e., percent of occupied nests with more than one young).

- In 2004, 69 nestling bald eagle blood plasma samples were analyzed for dichlorodiphenyl-trichloroethane (DDT) and its metabolites, hexachlorobenzene (HCB), *alpha*-hexachlorocyclohexane (HCH), *gamma*-HCH, heptachlor, heptachlor epoxide, *alpha*-chlordane, *gamma*-chlordane, dieldrin, toxaphene, and 20 polychlorinated biphenyl (PCB) congeners.

- Significant differences in total DDT and 4,4'-dichlorodiphenyldichloroethylene (4,4'-DDE) concentrations were found between inland, Great Lakes, and anadromous breeding areas ($P<0.0001$); and also between inland lower peninsula and inland upper peninsula, Lake Huron, Lake Michigan, and Lake Superior breeding areas ($P<0.0001$, $P<0.002$, respectively). Geometric mean total DDT concentrations were ranked in the following order by location from highest to lowest: Lake Huron > Lake Erie > Lake Superior > Lake Michigan > inland lower peninsula > inland upper peninsula breeding areas. Geometric mean total 4,4'-DDE concentrations were ranked in the following order by location from highest to lowest: Lake Huron > Lake Superior > Lake Erie > inland lower peninsula > Lake Michigan > inland upper peninsula breeding areas. 4,4'-DDE was quantified in 94% of the samples and was the most common DDT metabolite found in eaglet blood plasma.

- Eighteen PCB congeners were quantified and summed to determine total PCBs in nestling bald eagle blood plasma samples. Three congeners (153, 118, and 180) contributed significantly (i.e., consisting of ≥ 10% of the total PCBs) to the total PCB concentrations. At least one of the targeted PCB congeners was detected in 67 of the 69 nestlings sampled. A significant difference in total PCB concentrations was found among inland, Great Lakes, and anadromous breeding areas ($P<0.0001$), and among the inland lower peninsula, inland upper peninsula, Lake Huron, Lake Michigan, Lake Erie, and Lake Superior breeding areas

(P<0.0001). Geometric mean PCB concentrations were ranked in the following order by location from highest to lowest: Lake Erie (n=3) > Lake Huron (n=17) > Lake Michigan (n=10) > inland upper peninsula (n=7) > Lake Superior (n=3) > inland lower peninsula (n=29) breeding areas.

- Quantifiable concentrations of *alpha*-chlordane were measured in eight blood plasma samples, with four of the samples from Great Lakes breeding areas and four from anadromous breeding areas. A significant difference in *alpha*-chlordane concentrations was found between anadromous breeding areas and Great Lakes breeding areas (P<0.0014). Two of the four Great Lakes samples were Lake Michigan breeding areas, three were Lake Huron and one was from Lake Erie breeding areas. Due to small sample sizes, statistical analyses of Great Lakes breeding areas were not possible.

- HCB was quantified in only one inland lower peninsula sample. Statistical analyses could not be conducted due to the small sample size.

- Quantifiable concentrations of dieldrin were measured in 14 blood plasma samples. Four samples were from inland breeding areas and ten were from Great Lakes breeding areas. Two of the inland breeding area samples were from the lower peninsula and two were from the upper peninsula. Six of the Great Lakes samples were from Lake Michigan breeding areas, two samples were from Lake Huron, one was from Lake Erie, and one was from Lake Superior breeding areas. Of the six Lake Michigan samples, two were from anadromous breeding areas. Dieldrin concentrations for Great Lakes and anadromous breeding areas combined were greater than inland breeding areas (P<0.0331). Dieldrin concentrations for Lake Michigan were greater than Lake Superior, Lake Erie, inland upper peninsula, Lake Huron, and inland lower peninsula (P<0.0067).

- Due to analytical difficulties, the 2004 mercury data will be presented in a future report.

SECTION 2.0

INTRODUCTION

In April 1999, the MDEQ, Water Division, began monitoring environmentally persistent and toxic contaminants in bald eagles. This study is part of the wildlife contaminant monitoring project component of the MDEQ's 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 a period of approximately 15 years. This is important since one of the goals of the Strategy is to measure temporal and spatial trends in contaminant levels in Michigan's surface waters.

The bald eagle (*Haliaeetus leucocephalus*) was selected as a biosentinel species for monitoring contaminants in Michigan for the following reasons:

1. As a top-level predator, the bald eagle has a significant reliance on the aquatic food web and feeds primarily on fish and waterbirds. Specific dietary preferences of bald eagles include species of northern pike, suckers, bullheads, carp, catfish, bowfin, ducks, gulls, and deer (winter carrion and road-killed deer).

2. Past monitoring has shown that eagles accumulate organic and inorganic environmental contaminants and those contaminants may be quantified in blood, feather, and egg samples.

3. There is a viable population of bald eagles that provides sufficient sampling opportunities for a long-term monitoring program.

4. The large body size of nestling eagles allows monitoring to be conducted by blood sampling techniques and sufficient sample volumes are available to attain low quantification levels (QLs).

5. Mature bald eagles display great fidelity to their chosen nesting territory and often return to the same nest tree year after year. Although some eagles may move away from their nesting territories in the winter months, bald eagles generally reside within the state's waters throughout the year. Therefore, contaminants found in nestling bald eagles will represent the uptake of available contaminants within a particular territory.

The primary objectives of this project were to gather the sixth year of data on eaglets, evaluate temporal trends between these data and historical data available in the scientific literature, and evaluate spatial trends of contaminant concentrations among watersheds and the Great Lakes basins. Because the methods for sample collection required nest visits and handling nestling eagles, other biological measures were obtained. Therefore, the secondary objectives of the project included determining reproductive success and collecting nestling morphological data. Both spatial and temporal trends of reproductive success were also assessed in this project.

In accordance with one of the key principles of the CMI-CWF, the bald eagle monitoring protocol was planned and conducted in partnership with outside organizations. In 1999, this partnership included Lake Superior State University and Clemson University, and since 2000, this partnership included Michigan State University and Clemson University.

This document serves as the sixth annual report for the bald eagle element of the Strategy. The first (MDEQ, 2002), second (MDEQ, 2003), third (MDEQ, 2004a), fourth (MDEQ, 2004b), and fifth (MDEQ, 2008) reports contained results of the samples collected in 1999, 2000, 2001, 2002, and 2003, respectively. This report contains the analytical results for organic contaminants that were measured in nestling bald eagle blood samples, and statistical, temporal, and spatial trend analyses of the data. Also included in this report are the data for reproductive success and nestling morphological measurements. Feather analyses for mercury concentrations have not been conducted at this time due to analytical difficulties. The feather mercury data for 2004 will be presented in a separate report to the MDEQ.

SECTION 3.0

STUDY DESIGN AND METHODS

3.1 SITE SELECTION

The bald eagle monitoring project is designed to provide monitoring coverage of both the coastal Great Lakes and inland waters. Nesting eagles are found along the shorelines and on islands of each of the four Great Lakes surrounding Michigan. Further, the distribution of breeding eagles across much of Michigan provides monitoring coverage for many of the major river systems. Currently, active bald eagle breeding areas are well distributed across the upper peninsula and northern lower peninsula of Michigan.

The establishment of breeding areas in southern Michigan is relatively recent, and the number of active breeding areas continues to increase as eagles either establish new breeding areas or reoccupy historical territories. For example, the breeding areas in Arenac, Barry, Ottawa, and Wayne counties were established in 1998 or 1999. One breeding area in Monroe County was established in 1988 and the other three breeding areas were first occupied in 1998 or 1999. The first breeding areas in Allegan and Saginaw Counties were established in 1993. At the time of writing this report there were 790 breeding areas in the state of Michigan.

To facilitate the MDEQ's National Pollutant Discharge Elimination System permitting process, Michigan's watersheds, as delineated by eight-digit hydrologic unit codes (HUCs), are divided into five basin years for monitoring (Figure 1). Therefore, approximately 20% of Michigan's surface waters are assessed each year. The bald eagle sample collection schedule is consistent with the basin year delineation and complements the other monitoring activities conducted during each basin year. In addition to the basin year sampling, nests associated with the Great Lakes, the connecting channels, and 12 inland territories are sampled annually. Great Lakes and connecting channel nests are sampled annually because nesting success is highly uncertain for these sites.

The following basin year watersheds were the focus of sampling in 2004: Betsy-Two-Hearted, Tahquamenon, Waiska, Kalamazoo, Lower Grand, Manistee, Manistiques, Brevoort-Mollecoquins, St. Marys, Carp-Pine, AuGres-Rifle, Saginaw, and Clinton (Figure 2): In addition to the basin year watersheds for 2004, nests associated with the Great Lakes and connecting channels were sampled. Great Lakes-associated nests are defined as those nests within 8.0 kilometers (km) of the shorelines of the Great Lakes and along tributaries where anadromous fish are accessible.

3.2 FIELD METHODS

The methods used to collect blood and breast feather samples from nestling bald eagles are designed to avoid injury and undue stress to the birds. Sample collection and morphometric methods are adapted from Bortolotti (1984a, 1984b, 1984c), Henny and Meeker (1981), Henny *et al*. (1981), and Morizot *et al*. (1985). The methods are summarized below, but details of the procedures are published in a standard operating procedure (SOP) (Bowerman and Roe, 2002).

Blood and feather samples are collected from five- to nine-week old nestling bald eagles from May 15 through June 21, 2004. The approximate age of nestling eagles is visually estimated from two aerial survey flights that are piloted by a Michigan Department of Natural Resource (MDNR) pilot or contracted private pilot. An observer on each flight makes notes of the nest tree and location, determines an aerial latitude and longitude for the nest, and notes the reproductive status of each nest (e.g., eggs, chicks, or adult brooding behavior). From the observer's notes, field crews are directed to the nests at the appropriate time for sampling. Field staff ground truth the latitude/longitude coordinates using Global Positioning System units.

Once at the nest, a trained crewmember climbs the nest tree and secures a nestling. The nestling is placed in a restraining bag, lowered to the ground, weighed by spring scale, and prepared for sampling. Morphological measurements of the culmen, hallux claw, and bill depth are derived by using calipers. The eighth primary feather and the footpad are measured by using a ruler. Procedures developed by Bortolotti (1984b) are used to determine the age and sex of the nestlings. Sex is determined by the relationship of hallux claw length, footpad length and bill depth. Once sex is determined, the length of the eighth primary feather is used to make a sex-specific estimation of age.

Sterile techniques are used to collect blood from the brachial vein of nestling bald eagles. Syringes fitted with 22 or 25 gauge x 1" needles are used for the veinipuncture. Up to 12 cc of blood are drawn from the brachial vein and are then transferred to heparinized vacuum tubes and placed on ice in coolers for transfer out of the field. Samples of whole blood are centrifuged within 48 hours of collection and the plasma is decanted and transferred to another vacuum tube and frozen at approximately -20^{o} C for storage. Three to four feather samples also are collected from the nestling eagles. Feathers are plucked from the breast and stored in small sealed envelopes. After sampling is completed, the nestlings are banded with a Size 9 United States Fish and Wildlife Service (USFWS) rivet band. The nestling is then placed back in the restraining bag, raised, and released to the nest.

From the field, samples are transferred to prearranged collection points at various MDNR, United States Forest Service, or USFWS field stations. At the end of the sampling effort, all samples are collected and transferred to the USFWS East Lansing Field Office, entered into sample storage through a chain-of-custody tracking system, and stored frozen at approximately -20^{o} C. Upon request to the USFWS chain-of-custody officer, samples are transferred to the Clemson Institute of Environmental Toxicology (CIET) for analysis. Upon receipt at the CIET, SOPs direct that samples be logged in, checked for sample integrity and again stored frozen at approximately -20^{o} C until prepared for instrumental analysis (CIET, 1996 and 1999).

3.3 LABORATORY METHODS

All plasma samples were received at the CIET laboratory under chain-of-custody by April 12, 2005. All extractions and analyses were conducted according to procedures detailed in CIET SOPs. Plasma samples were extracted in six batches. Chicken plasma was used for laboratory control samples in all analytical batches. In addition to the eagle plasma samples, each analytical batch contained a reagent blank, a chicken plasma matrix blank, a chicken plasma matrix spike, and a chicken plasma matrix spike duplicate.

Organochlorine pesticide and PCB concentrations were quantified by capillary gas chromatography with an electron capture detector using the United States Environmental Protection Agency approved methods. All reported results were confirmed by dual column analysis. The QL for the organic compounds was 2 ng/g (parts per billion) with the exception of toxaphene which had a QL of 125 ng/g. Method validation studies were conducted on chicken plasma as a surrogate matrix to ensure that the data quality objectives of the Quality Assurance

Project Plan (CIET, 1996 and 1999) were met. Average recoveries of 70-130% for matrix spikes were required under the Quality Assurance Project Plan (CIET, 1996 and 1999). Correlation coefficients (r^2) for calibration curves consisting of five concentrations of standards were at least >0.99 for all target analytes in all batches. The average detector response for the instrumental calibration checks was within 20% of the initial calibration for each batch. The average Relative Percent Difference for the spiked analytes in the chicken plasma matrix spike and chicken plasma matrix spike duplicate were less than 30% for all batches.

3.4 STATISTICAL DESIGN

For the purposes of reporting and statistical analysis of the 2004 data, and in keeping with reporting conventions in the scientific literature, the data were broadly grouped by breeding area location. At the broadest level, Great Lakes and inland breeding areas were compared. The breeding areas located on anadromous rivers were examined separately from other Great Lakes breeding areas for organic contaminants to better assess the concentrations that may be affecting bald eagle productivity along the Great Lakes. The Great Lakes-associated nests were evaluated further by lake basin (Superior, Michigan, Huron, and Erie). Inland breeding areas were also evaluated further by peninsula (inland lower and upper peninsula). Lastly, breeding areas were also grouped by watershed (HUC).

Contaminates were analyzed independently or grouped as follows. Total DDTs were analyzed as the sum of all DDT and DDT metabolites found. 4,4'-DDE was analyzed independently because of its pervasiveness in samples and history of causing adverse ecological effects. Total PCBs were examined as the sum of the 18 PCB congeners. Heptachlor epoxide, *alpha*-Chlordane, and Dieldrin were all analyzed independently.

Statistical analyses were performed using nonparametric rank converted ANOVA tests. Nonparametric pair-wise comparisons, least significant difference, were used to determine where significant differences occurred within regions. Nonparametric statistics were employed as neither the assumptions of normality nor of linear regressions were met. All analyses were performed using SAS Institute, Inc. (1999) statistical package. A probability level = 95% (α = 0.05) was used to determine statistical significance. Differences in order (i.e., highest concentration to lowest concentration) between rank converted ANOVA and geometric mean results were observed and are the result of a combination of factors. The two factors are; the assignment of the value of 0.0001 ng/g (see Section 4.2) to all non-detects and sample size, with the former having the greatest effect on the results. These two factors have also resulted in very large standard errors for some analyses, in these cases the latter is suspected to have had the greatest effect.

SECTION 4.0

RESULTS AND DISCUSSION

4.1 REPRODUCTIVE SUCCESS

Productivity (i.e., the total number of fledged young per occupied nest) was calculated for bald eagles for all breeding areas in Michigan using the method of Postupalsky (1974). The following four comparisons were made of productivity for the 2004 breeding season (Table 1): (1) Statewide total for all nests; (2) Great Lakes and inland nests; (3) Great Lakes, anadromous, and inland nests; and (4) Lake Erie, Lake Huron, Lake Michigan, Lake Superior, and inland upper and lower peninsulas. Breeding areas were classified as inland nests if they were >8.0 km from a Great Lakes shoreline and not situated along a river open to Great Lakes fish runs (i.e., anadromous). Great Lakes breeding areas were within 8.0 km of a Great Lakes shoreline and included those situated along anadromous rivers with the exception of Analysis 3.

The productivity for bald eagles in the state of Michigan in 2004 was 0.94 young per occupied nest. The success rate (percent of nests producing at least one young) was 62.6%.

Based on the year 2004 aerial and ground surveys, there were 428 occupied nests in the state of Michigan. Different category comparisons showed only slight differences among areas of the state (Table 1). Inland breeding area productivity (0.93) was not found to be significantly different from Great Lakes breeding area productivity (0.95) ($F=0.03$, $P=0.8697$). Productivity in anadromous (1.33) breeding areas was found to be significantly greater than inland (0.95) and Great Lakes (0.86) breeding areas ($F=3.09$, $P=0.0464$). Breeding area productivities did not vary significantly by subpopulations ($F=0.81$, $P=0.5402$). Inland lower peninsula had the greatest subpopulation productivity (1.03), followed by Lake Superior (1.00), Lake Erie (1.00), Lake Huron (0.98), inland upper peninsula (0.85), and Lake Michigan (0.83). No differences were found for success rates of subpopulations ($p \leq 0.05$).

Caution must be used when using statewide productivity from only one year to determine the health of the Michigan bald eagle population. A number of factors, including weather, sample size, and which nests are occupied annually can greatly affect this determination. Individual breeding area productivities can be affected by weather, adult turnover rates, and other factors including longevity and patterns of occupancy. Furthermore, the 1.0 young per occupied nest is a recovery goal (Grier et al., 1983), derived from an early modeling effort.

4.2 ORGANIC CONTAMINANTS IN NESTLING BALD EAGLE BLOOD SAMPLES

In 2004, 69 nestling bald eagle blood samples were analyzed for organochlorine contaminants. The target list of analytes included historical organochlorine pesticides such as chlordane, dieldrin, and DDT and its metabolic products, and 20 PCB congeners. The complete list of analytes and the parameter-specific Method Detection Levels and QLs are shown in Table 2. For statistical analysis, concentrations less than the QL were reported as one-half the QL (1.00 ng/g) and non-detects were set at 0.0001 ng/g.

Of the 69 samples analyzed, 32 were from breeding areas in the 2004 basin year watersheds. Regionally, the analyzed samples were from 7 inland upper peninsula, 29 inland lower peninsula, 3 Lake Superior, 10 Lake Michigan, 17 Lake Huron, and 3 Lake Erie breeding areas. The no-observable-adverse-effect levels (NOAELs) in blood of bald eagle nestlings for DDE and

PCBs that are associated with a healthy bald eagle population (i.e., an average of one young per occupied nest) were determined using data from Bowerman et al., (2003). The NOAELs for DDE and PCBs in nestling blood are 11.4 and 36.4 ng/g, respectively.

4.21 DDT and Metabolites

Concentrations of 2,4'- and 4,4'-DDE , 2,4'- and 4,4'-DDD, and 4,4'-DDT were measured in nestling bald eagle blood samples (Table 3). The most ubiquitous metabolite, 4,4'-DDE was detected in 65 (94%) samples and on average made up 94% of the total DDT quantified. Statewide, concentrations of 4,4'-DDE ranged from <1.0-78.9 ng/g. 2,4'-DDE was quantified in 3 (4%) samples. Concentrations of 2,4'-DDE ranged from <1.0-2.7 ng/g. 2,4'- and 4,4'-DDD were quantified in 2 (3%) and 16 (23%) samples, respectively. Concentrations of 2,4'- and 4,4'-DDD ranged from non-detect-3.34 and non-detect-11.39 ng/g, respectively. 4,4'-DDT was quantified in 1 (1%) sample at a concentration of 1.0 ng/g. 2,4'-DDT was not detected in any of the 2004 bald eagle plasma samples.

Total DDT concentrations were calculated as the sum of 2,4'- and 4,4'-DDE, 2,4'- and 4,4'-DDD, and 4,4'-DDT. Of the metabolites, 4,4'-DDE contributed the most to the total DDT concentrations (Table 3). Total DDT concentrations in Great Lakes (n=23) and anadromous (n=10) breeding areas were greater than inland (n=36) breeding areas (Figure 3). Total DDT and concentrations for Great Lakes and anadromous breeding areas pooled (n=33) were greater than inland breeding areas. Total DDT concentrations in Lake Huron (n=17) and Lake Michigan (n=10) breeding areas were greater than inland upper peninsula (n=7), Lake Erie (n=3), Lake Superior (n=3), and inland lower peninsula (n=29) breeding areas (Figure 3).

Concentrations of 4,4'-DDE in Great Lakes (n=23) and anadromous (n=10) breeding areas were greater than inland (n=36) breeding areas (Figure 3). Concentrations of 4,4'-DDE for Great Lakes and anadromous breeding areas pooled (n=33) were greater than inland breeding areas. Concentrations of 4,4'-DDE in Lake Huron (n=17) and Lake Michigan (n=10) breeding areas were greater than inland upper peninsula (n=7), Lake Superior (n=3), Lake Erie (n=3), and inland lower peninsula (n=29) breeding areas.

Ten samples from anadromous breeding areas were collected in 2004 (Table 3). Of the anadromous breeding areas, a nestling at Tippy Dam in Manistee County (MN-04c) had the greatest total DDT concentration (42.19 ng/g). The remaining anadromous sites sampled were New Richmond (AN-04b in Allegan County), two at Shiawassee R SGA (SG-01f in Saginaw County), Sanford Lake (MD-02a in Midland County), Weber Pond (IA02b in Ionia County), Anderson Bayou (NE-01i in Newaygo County), two at Skully/Stoney Island (BY-01d in Bay County), and Santiago (AR-03a in Arenac County), with concentrations of 3.27, 5.50, 7.66, 10.06, 14.81, 20.64, 22.23, 38.23, and 22.8 ng/g, respectively.

Geometric mean total DDT concentrations were ranked in the following order by location from highest to lowest: Lake Huron > Lake Erie > Lake Superior > Lake Michigan > inland lower peninsula > inland upper peninsula breeding areas. Geometric mean total 4,4'-DDE concentrations were ranked in the following order by location from highest to lowest: Lake Huron > Lake Superior > Lake Erie > inland lower peninsula > Lake Michigan > inland upper peninsula breeding areas.

The greatest total DDT concentration (78.90 ng/g) in an individual breeding area was measured in a nestling from Stylus Lake W breeding area, which is located in the southeast lower peninsula in Ogemaw County (OG-07) (Table 3). The only DDT metabolite found in this eaglet was 4,4'-DDE.

No significant differences were found between Great Lakes watersheds for total DDT and 4,4'-DDE. Mean total DDT and 4,4'-DDE concentrations were ranked in the following order by Great Lakes watershed from highest to lowest: Lake Huron (n=35) > Lake Erie (n=3) > Lake Michigan (n=25) > Lake Superior (n=6) (Figure 4).

The NOAEL for 4,4'-DDE in the blood of nestling bald eagles was determined to be 11.4 ng/g based on data presented in Bowerman et al. (2003). Of the 69 nestling plasma samples analyzed in 2004, 27 (39%) exceeded the NOAEL. Of these eaglets exceeding the NOAEL, 21 (78%) were in Great Lakes breeding areas. It is therefore possible that once some of these nestlings reach breeding age, they may not be able to reproduce at a level considered to support a healthy population due to elevated concentrations of 4,4'-DDE. The finding that some nestlings have concentrations of 4,4'-DDE in their blood above the NOAEL further stresses the importance of the long-term monitoring program to track fluctuations in annual bald eagle productivity within the state of Michigan.

4.22 PCBs

Eighteen PCB congeners were quantified and summed to determine total PCBs in nestling bald eagle plasma samples (Table 4). Of these 18 congeners, only 16 were detected, with two congeners (28 and 209) detected only once. In five eaglets, only congener 153 was detected. Congener 153 was also the most ubiquitous congener and was detected in 55 (80%) samples. Statewide, concentrations of congener 153 ranged from <1.0-38.18 ng/g. Congener 153 made up 27% of the total PCBs quantified.

Statewide total PCB concentrations ranged from non-detect to 144.78 ng/g (Table 4). At least one of the targeted PCB congeners was detected in 57 (83%) of the nestlings sampled. All 12 nestlings in which no PCB congeners were detected were from inland breeding areas. PCB congeners were detected in nestlings from inland, Great Lakes, and anadromous breeding areas (Table 4).

Total PCB concentrations were calculated as the sum of all PCB congeners (Table 4). Total PCB concentrations in Great Lakes (n=23) and anadromous (n=10) breeding areas were greater than inland (n=36) breeding areas (Figure 5). Total PCB concentrations for Great Lakes and anadromous breeding areas pooled (n=33) were greater than inland breeding areas. Total PCB concentrations for Lake Erie (n=3), Lake Huron (n=17), and Lake Michigan (n=10) were greater than Lake Superior (n=3), inland upper peninsula (n=7), and inland lower peninsula breeding areas (n=29; Figure 5). The greatest total concentration of PCBs (144.8 ng/g) was found in an inland lower peninsula eaglet in Manistee County at the Manistee Airport breeding area (MN-11a; Table 4).

Ten samples from anadromous breeding areas were collected in 2004 (Table 4). Of the anadromous breeding areas, the nestling at Shiawassee R SGA (SG-01f in Saginaw County) had the greatest total PCB concentration (36.7 ng/g). The remaining anadromous sites sampled were Tippy Dam (MN-04c in Manistee County), Sanford Lake (MD-02a in Midland County), Anderson Bayou (NE-01i in Newaygo County), a second from Shiawassee R SGA (SG-01f in Saginaw County), New Richmond (AN-04b in Allegan County), Santiago (AR-03a in Arenac County), and two at Skully/Stoney Island (BY-01d in Bay County) with concentrations of 18.8, 16.8, 13.2, 12.5, 9.5, 1.0 ng/g, non-detect, and non-detect, respectively.

Geometric mean PCB concentrations were ranked in the following order by location from highest to lowest: Lake Erie (n=3) > Lake Huron (n=17) > Lake Michigan (n=10) > inland upper peninsula (n=7) > Lake Superior (n=3) > inland lower peninsula (n=29) breeding areas.

The NOAEL for total PCBs in the blood of nestling bald eagles was determined to be 36.4 ng/g based on data presented in Bowerman et al., (2003). Of the 69 nestling plasma samples analyzed in 2004, 21 (30%) of the samples exceed the NOAEL. It is therefore possible that once some of these nestlings reach breeding age, they may not be able to reproduce at a level considered to support a healthy population due to elevated concentrations of PCBs. The finding that some nestlings have concentrations of PCBs in their blood above the NOAEL further stresses the importance of the long-term monitoring program that is needed to track fluctuations in annual bald eagle productivity within the state of Michigan.

No significant differences were found between Great Lake watersheds for total PCB concentrations (p=0.1624). Geometric mean total PCB concentrations were ranked in the following order by Great Lakes watershed from highest to lowest: Lake Erie (n=3) > Lake Huron (n=35) > Lake Michigan (n=25) > Lake Superior (n=3) (Figure 5).

4.23   Other Organics

The other organic contaminants that were analyzed in the 2004 nestling samples included: HCB, *alpha*-chlordane, and dieldrin. Concentrations of *alpha*-HCH), γ-HCH, heptachlor, heptachlor epoxide, γ-chlordane, and toxaphene were not detected in any of the year 2004 samples. The analytical results for HCB, *alpha*-chlordane, and dieldrin are shown in Table 5.

alpha-chlordane was quantified in eight samples at concentrations ranging from 1.0-3.6 ng/g, with all of those samples from Great Lakes breeding areas. Four of the eight Great Lakes samples were Lake Michigan breeding areas, three were Lake Huron, and one was from a Lake Erie breeding area. Two of the Lake Michigan and one Lake Huron breeding area samples were from anadromous sites. Due to the lack of inland breeding area samples statistical analyses between inland, Great Lakes, and anadromous breeding areas and Great Lakes/anadromous pooled and inland breeding areas were not possible. A significant difference in *alpha*-chlordane concentrations was found between anadromous breeding areas and Great Lakes breeding areas (P<0.0014) (Figure 6). The greatest concentration of *alpha*-chlordane (3.6 ng/g) measured in any region was found in a nestling from the New Richmond breeding area (AN-04) in Allegan County (Table 5). *alpha*-chlordane concentrations for Lake Michigan were greater than Lake Erie, Lake Huron, inland upper peninsula, inland lower peninsula, and Lake Superior. No statistically significant results were found between Great Lakes watersheds.

HCB was quantified in only one inland lower peninsula sample (KA-04 Big Blue/Bass Lake in Kalkaska County, 1.00ng/g; Table 5). Due to the small sample sizes statistical analyses were not possible.

Dieldrin was quantified in 14 samples at concentrations ranging from 1.0-2.7 ng/g. Four samples were from inland breeding areas and ten were from Great Lakes breeding areas. Two of the inland breeding area samples were from the lower peninsula and two were from the upper peninsula. Six of the Great Lakes samples were from Lake Michigan breeding areas, two samples were from Lake Huron breeding areas, one was from Lake Erie, and one was from Lake Superior breeding areas. Of the six Lake Michigan samples, two were from anadromous breeding areas. The greatest concentration of dieldrin (2.7 ng/g) was found in a nestling from St. Helen breeding area (RO-12) in Roscommon County (Table 5). Dieldrin concentrations for Great Lakes and anadromous breeding areas combined were greater than inland breeding areas. Dieldrin concentrations for Lake Michigan were greater than Lake Superior, Lake Erie, inland upper peninsula, Lake Huron, and inland lower peninsula (Figure 7).

SECTION 5.0

FUTURE STUDIES

Several potential areas of future study were identified following the first six years of this monitoring study:

- Determine if it is possible to locate key sources of mercury contamination in bald eagles by modeling air releases.
- Conduct further investigations to determine the source of DDT and PCBs found in the various hotspots.
- Examine contaminant data to assess the partitioning of contaminants between various media and biota.
- Analyze archived eagle samples to enhance our ability to assess trends.

SECTION 6.0

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SECTION 7.0

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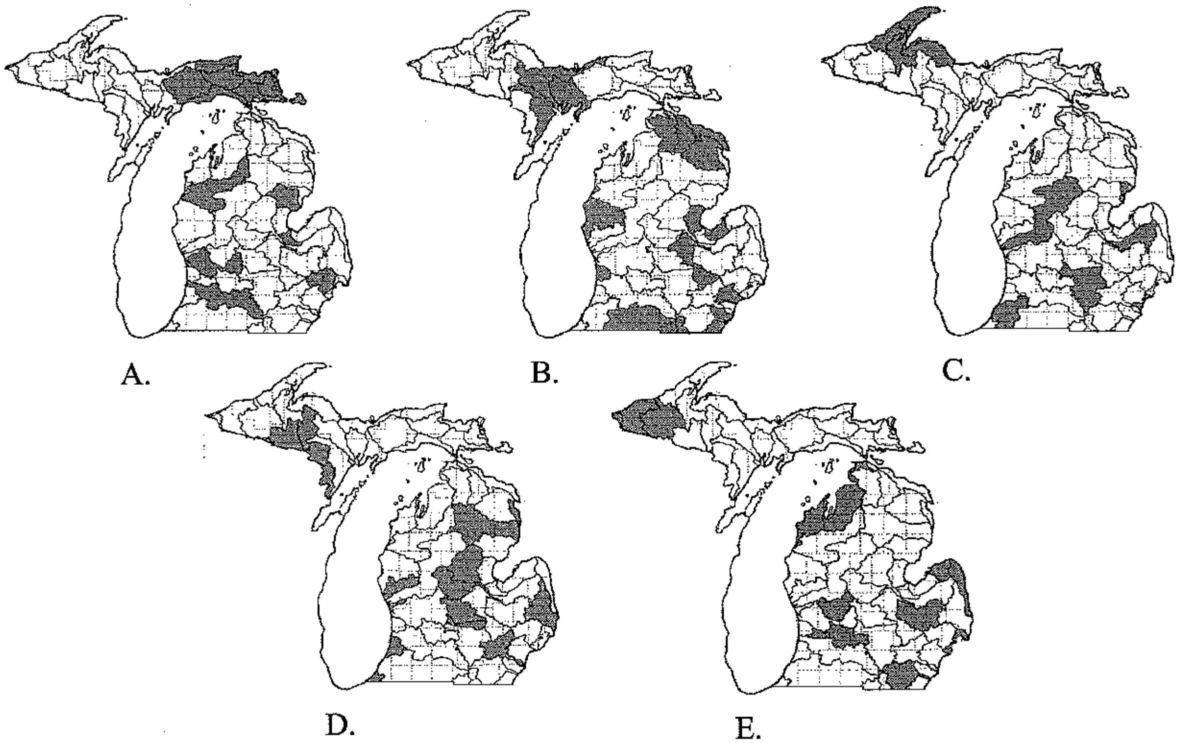
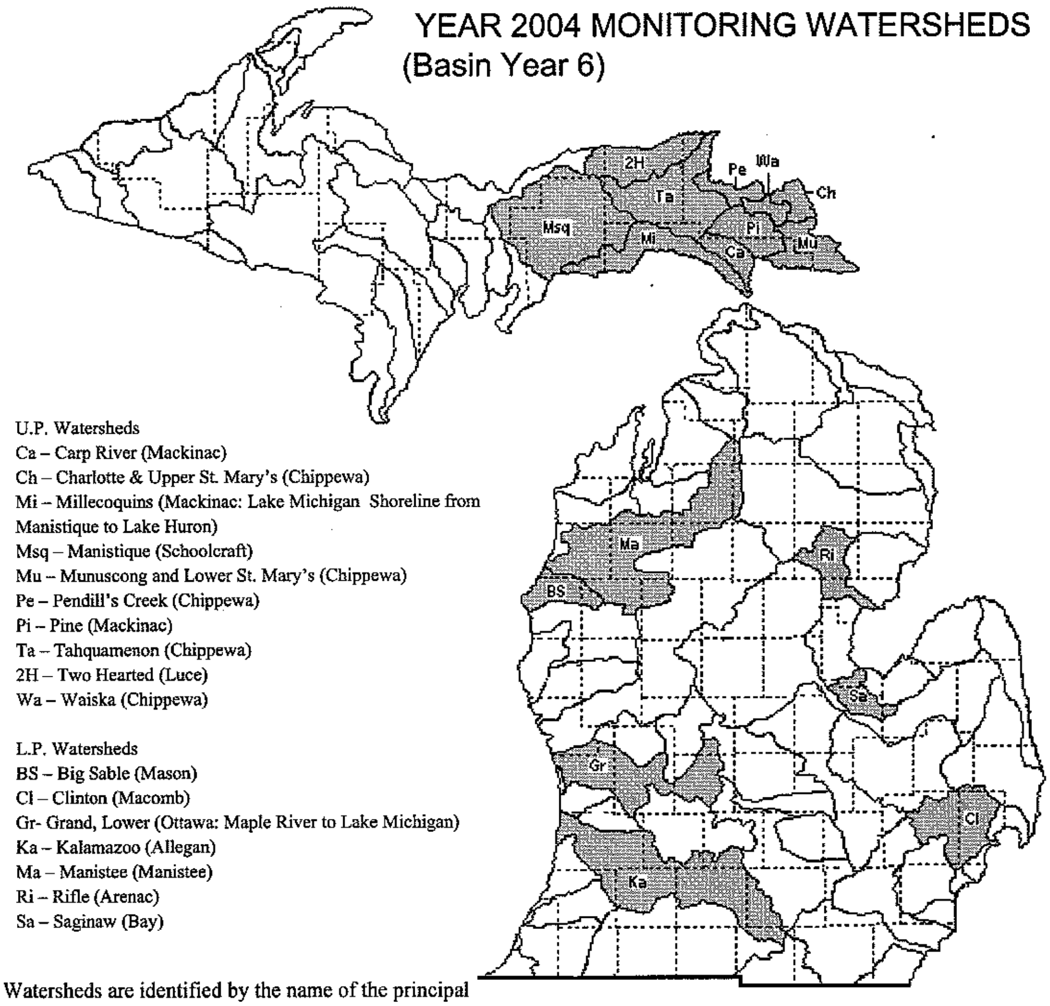


Figure 1. Michigan's basin-year watershed delineations (shaded). A.) 1999 and 2004 basin year watersheds; B.) 2000 basin year watersheds; C.) 2001 basin year watersheds; D.) 2002 basin year watersheds; and E.) 2003 basin year watersheds.

Figure 2. The 2004 basin year watersheds.



• Watersheds are identified by the name of the principal water body. The name in parentheses is the county where the most downstream segment of the principal water body is located.

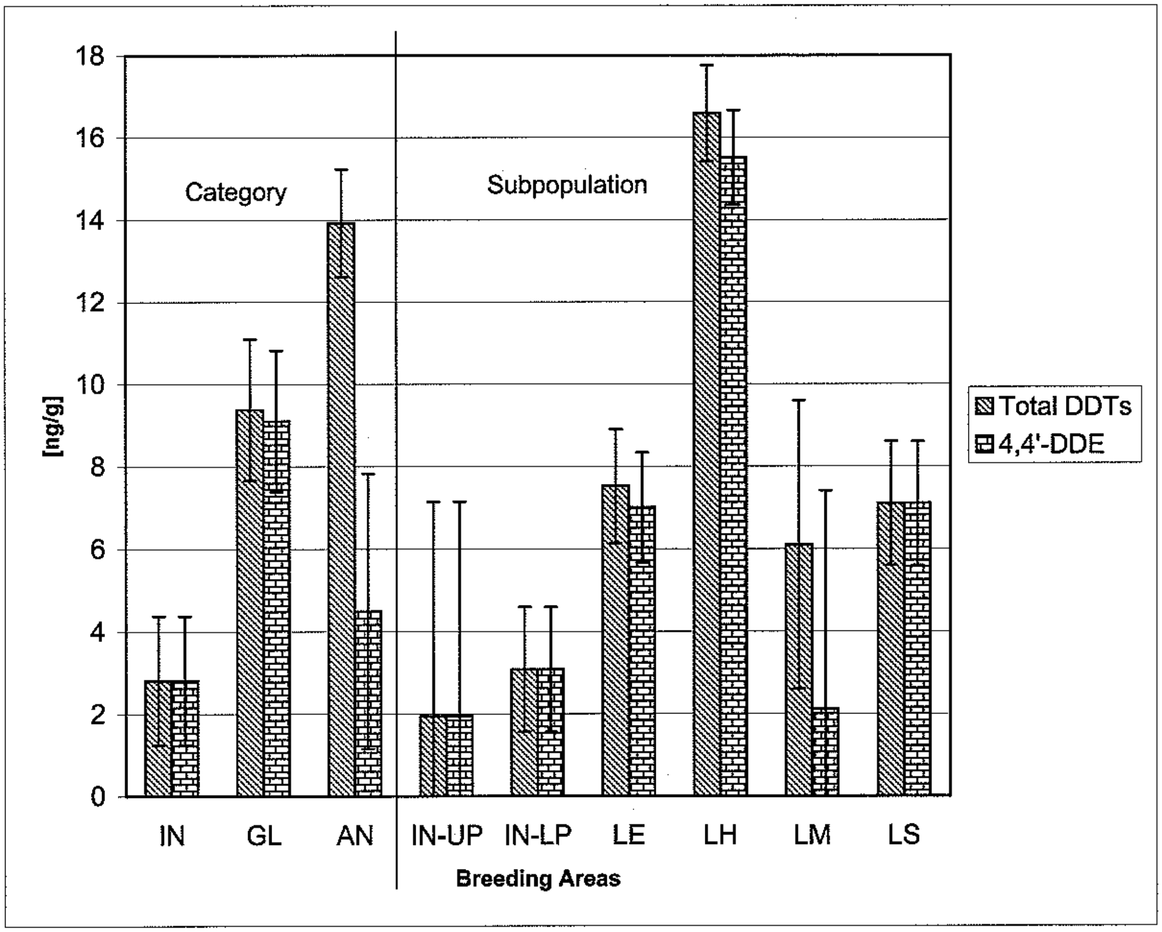


Figure 3: Geometric mean Total DDT and 4,4'-DDE concentrations (ng/g) in nestling bald eagles in 2004 by categories and subpopulations. Error bars for LM 4,4'-DDE and IN-UP Total DDTs and 4,4'-DDE have been truncated so they do not extend below the x-axis.

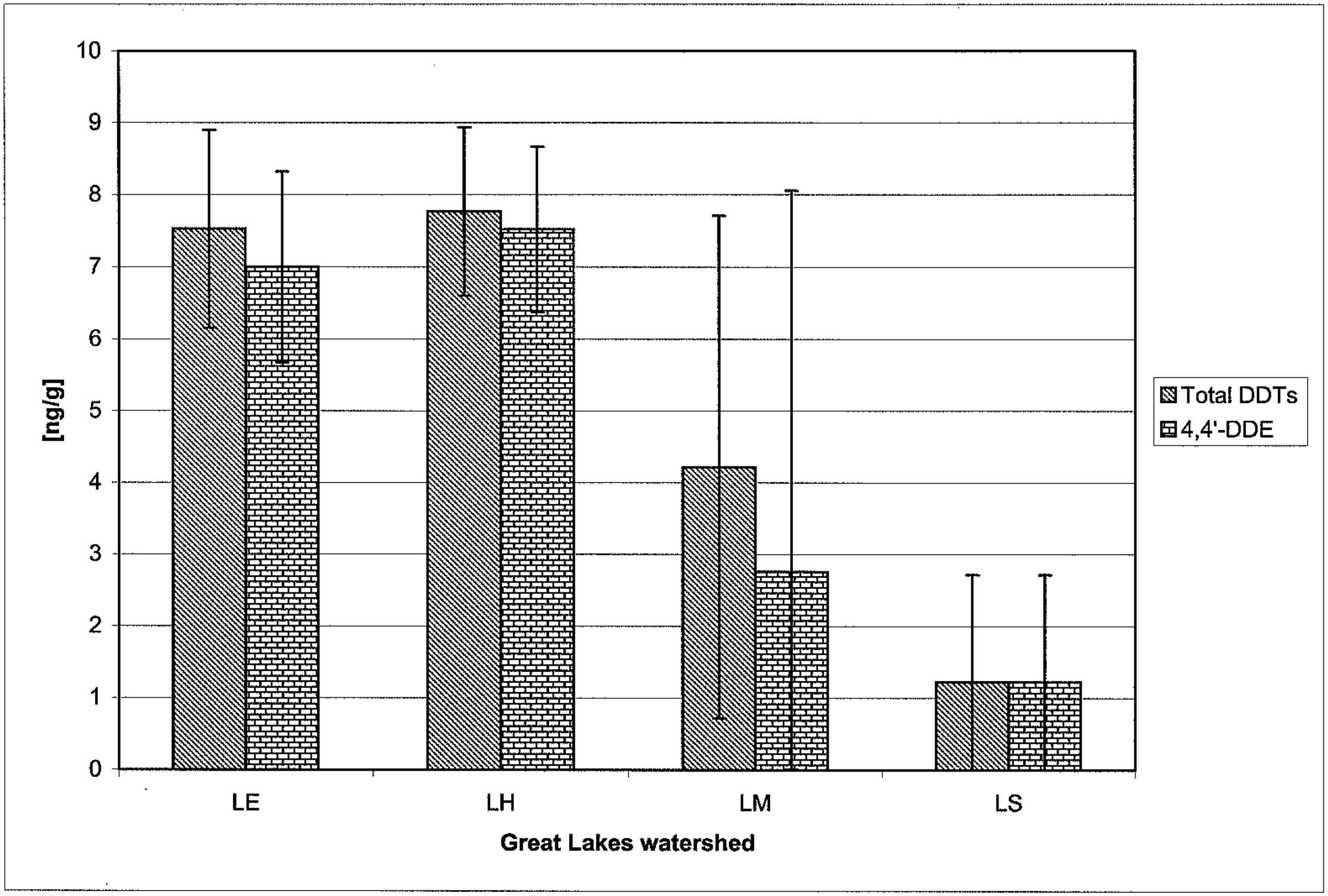


Figure 4: Geometric mean Total DDT and 4,4'-DDE concentrations (ng/g) in nestling bald eagles in 2004 by Great Lakes watersheds. Error bars for LM 4,4'-DDE and LS Total DDTs and 4,4'-DDE have been truncated so they do not extend below the x-axis.

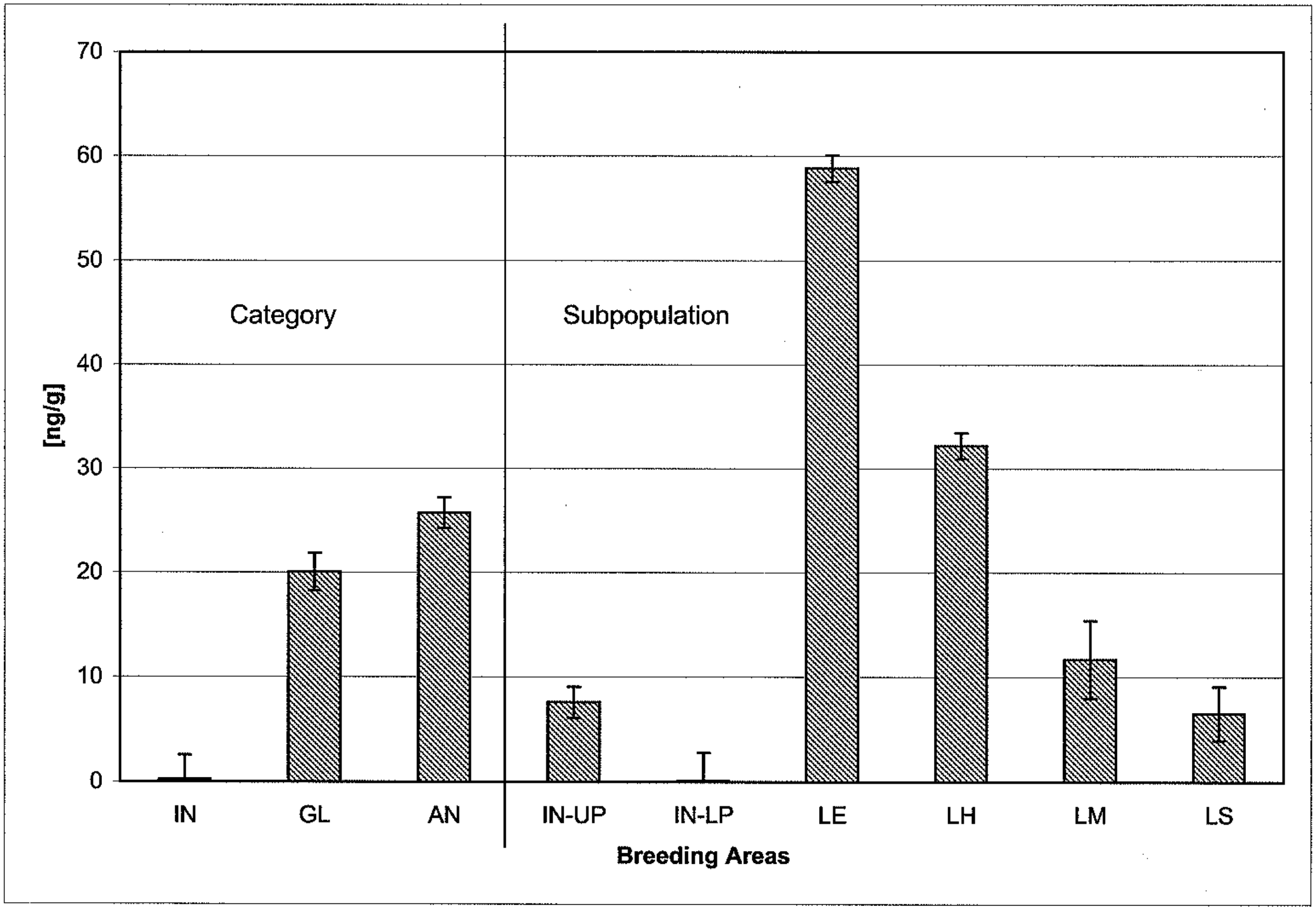


Figure 5: Geometric mean Total PCB concentrations (ng/g) in nestling bald eagles in 2004 by categories and subpopulations. Error bars for "IN" and "IN-LP" have been truncated so that they do not extend below the x-axis.

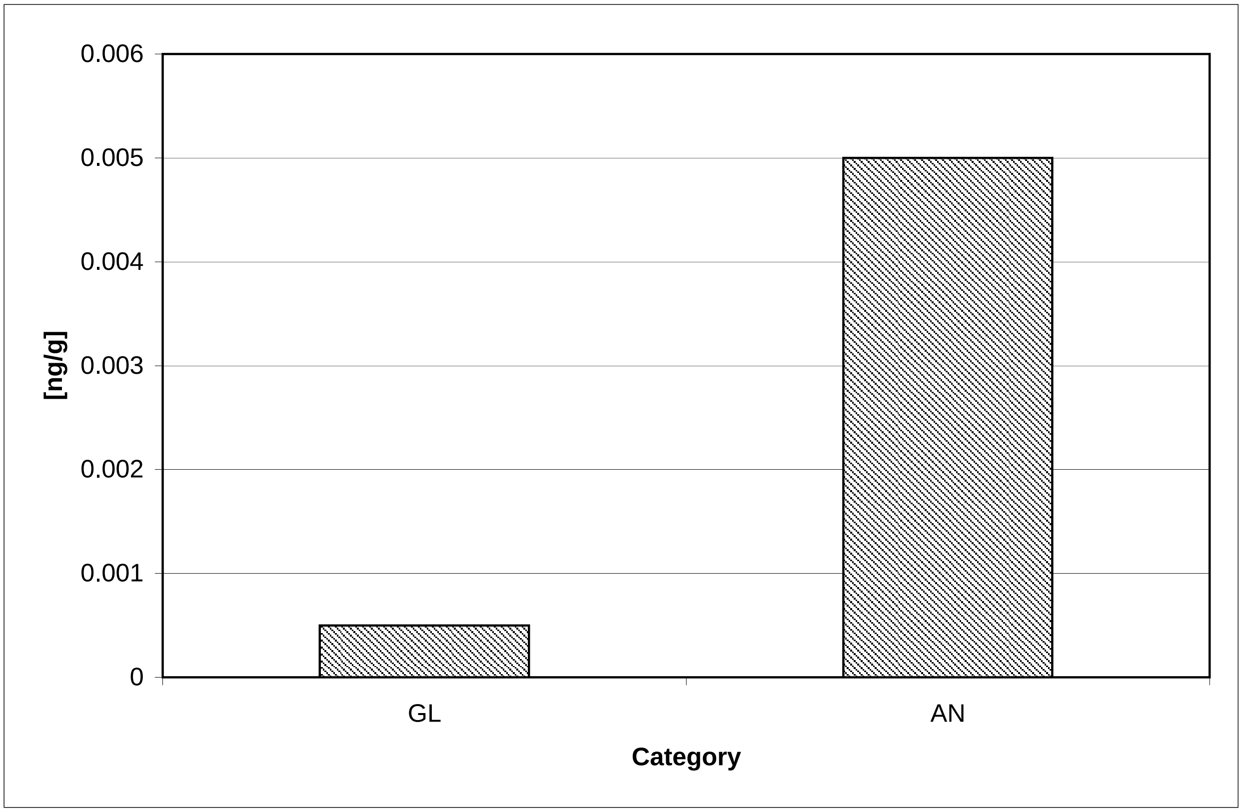


Figure 6: Geometric mean *alpha*-chlordane concentrations (ng/g) in nestling bald eagles in 2004 by Great Lakes (GL) and Anadromous (AN) breeding areas. No error bars are reported for this figure because the standard errors for GL and AN are 2.13 and 4.97, respectively.

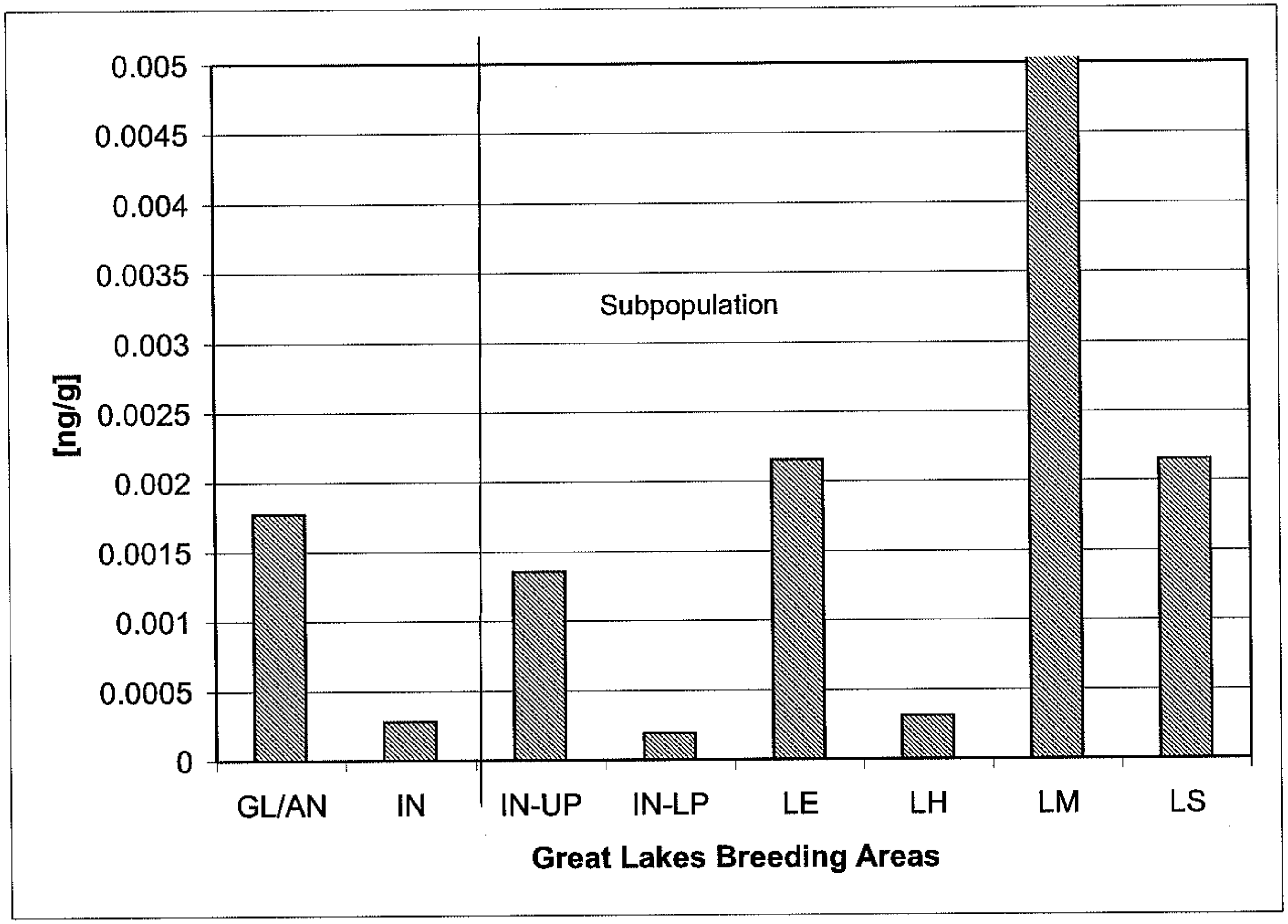


Figure 7: Geometric mean dieldrin concentrations (ng/g) in nestling bald eagles in 2004 by Great Lakes/Anadromous breeding areas and inland breeding areas. Note: The dieldrin level for Lake Michigan is 0.03 and is thus off the scale, but the scale was modified to show differences in other breeding areas. No error bars are reported for this figure because the standard errors ranged from 1.55 to 21.54.

Table 1. Productivity and success of bald eagles nesting in Michigan, 2004. Comparisons include: statewide; Great Lakes (those within 8.0 km of a Great Lake or nesting along a river open to Great Lakes fish runs) vs. inland; Great Lakes (nesting along the shoreline) vs. anadromous (those nesting along a river) vs. inland; and, subpopulations comprised of eagles nesting in the inland upper peninsula or lower peninsula, and Great Lakes sites along Lakes Superior, Michigan, Huron, and Erie.

Comparison	N=	Productivity (Young/Occupied Nest)	Success (% Nests producing young)
Statewide	428	0.94	62.6
Great Lakes	164	0.95 a	60.9 a
Inland	264	0.93 a	63.6 a
Anadromous	24	1.33 a	70.8 a
Great Lakes	140	0.84 b	59.3 a
Inland	264	0.95 b	63.6 a
Inland Lower Peninsula	143	1.03 a	68.5 a
Lake Superior	43	1.00 a	72.1 a
Lake Erie	5	1.00 a	60 a
Lake Huron	56	0.98 a	60.7 a
Inland Upper Peninsula	121	0.85 a	57.9 a
Lake Michigan	60	0.83 a	53.3 a

Same letters within a column are not significantly different from one another ($P>0.05$).

Table 2. Organochlorine contaminant analytes measured in nestling bald eagle blood samples in 2004, with parameter-specific Method Detection Levels (MDLs) and Quantification Levels (QLs).

Organochlorine Contaminant Analyte List	Method Detection Level (MDL)	Quantification Level (QL)
Hexachlorobenzene	0.54	2.01
alpha -Hexachlorocyclohexane	1.94	2.01
gamma -Hexachlorocyclohexane (Lindane)	1.84	2.01
Heptachlor	1.74	2.00
Heptachlor Epoxide	0.77	2.00
alpha -Chlordane	0.75	2.01
gamma -Chlordane	0.55	2.01
Dieldrin	0.97	2.01
Toxaphene	---	125.0
2,4'-Dichlorodiphenyldichloroethylene (2,4'-DDE)	0.86	2.01
4,4'-DDE	0.61	2.01
2,4'-Dichlorodiphenyldichloroethane (2,4'-DDD)	1.55	2.01
4,4'-DDD	1.18	2.00
2,4'-Dichlorodiphenyltrichloroethane (2,4'-DDT)	1.57	2.01
4,4'-DDT	1.95	2.01
PCB Congener 8	1.94	1.98
PCB Congener 18	1.21	1.98
PCB Congener 28	1.23	1.99
PCB Congener 44	1.52	1.98
PCB Congener 52	0.64	1.98
PCB Congener 66	0.87	2.00
PCB Congener 101	0.38	2.00
PCB Congener 105	1.44	1.98
PCB Congener 110	1.91	2.01
PCB Congener 118	0.58	1.99
PCB Congener 128	0.75	1.99
PCB Congener 138	0.65	2.00
PCB Congener 153	0.57	1.99
PCB Congener 156	1.84	2.01
PCB Congener 170	1.28	1.98
PCB Congener 180	1.62	2.00
PCB Congener 187	1.12	1.98
PCB Congener 195	1.03	2.00
PCB Congener 206	1.19	1.98
PCB Congener 209	1.03	1.99

Table 3. Concentrations of DDE, DDD, and Total DDT compounds (ng/g wet weight (ppb)) in nestling bald eagle plasma samples analyzed in 2004. Breeding areas were located in either inland lower peninsula (LP), inland upper peninsula (UP), Lake Huron (LH), Lake Michigan (LM), or Lake Superior (LS) watersheds. Territories were associated with either inland (IN), Great Lakes (GL), or anadromous (AN) water bodies.

Territory	Breeding Area Location	Territory Location	Blood Sample Number	Breeding Area Name	2,4'-DDD	2,4'-DDE	4,4'-DDD	4,4'-DDE	4,4'-DDT	DDE+DDT +DDD
AG-08e	LS	GL	BAEA-MI-2004-A-26	Au Train Ck	ND	ND	ND	3.2	ND	3.2
AG-11f	LS	GL	BAEA-MI-2004-A-40	Laughing Whitefish Pt	ND	ND	ND	9.3	ND	9.3
AG-18	UP	IN	BAEA-MI-2004-A-25	Forest Lake Basin N	ND	ND	ND	10.2	ND	10.2
AG-20a	UP	IN	BAEA-MI-2004-A-24	Hovey Lake	ND	ND	ND	6.5	ND	6.5
AL-02	LP	IN	BAEA-MI-2004-A-15	Alcona-Bamfield PD	ND	ND	ND	7.4	ND	7.4
AL-05c	LP	IN	BAEA-MI-2004-B-15	Sprinkler Lake	ND	ND	ND	1.0	ND	1.0
AN-04 b	LM	AN	BAEA-MI-2004-C-08	New Richmond	ND	ND	3.3	ND	ND	3.3
AR-03a	LH	AN	BAEA-MI-2004-A-06	Santiago	ND	ND	1.0	20.8	1.0	22.8
AR-05 a	LH	GL	BAEA-MI-2004-C-04	Pt AuGres	ND	ND	ND	12.3	ND	12.3
AR-05 a	LH	GL	BAEA-MI-2004-C-05	Pt AuGres	ND	ND	1.0	12.7	ND	13.7
BY-01 d	LH	AN	BAEA-MI-2004-C-15	Skull/Stoney Isd	ND	ND	6.9	15.3	ND	22.2
BY-01 d	LH	AN	BAEA-MI-2004-C-16	Skull/Stoney Isd	ND	ND	11.4	26.8	ND	38.2
CH-01 a	LP	IN	BAEA-MI-2004-C-10	Baker Sanctuary	ND	ND	ND	ND	ND	ND
CH-01 a	LP	IN	BAEA-MI-2004-C-11	Baker Sanctuary	ND	ND	1.0	7.2	ND	8.2
CP-02e	LH	GL	BAEA-MI-2004-A-31	Sugar Island E	ND	1.0	ND	17.5	ND	18.5
CP-10d	LH	GL	BAEA-MI-2004-A-35	Burnt Island	3.3	ND	1.0	33.4	ND	37.7
CP-20	LS	GL	BAEA-MI-2004-A-37	Tahquamenon Bay Swamp	ND	ND	ND	12.0	ND	12.0
CP-22i	LH	GL	BAEA-MI-2004-A-32	Sugar Island-Duck Bay	ND	ND	ND	9.0	ND	9.0
CP-26	LH	GL	BAEA-MI-2004-A-34	Gravel L/Isd	2.6	2.2	5.3	41.4	ND	51.4
CP-30	LH	GL	BAEA-MI-2004-A-30	Neebish Island E	ND	ND	1.0	32.6	ND	33.6
CP-32	UP	IN	BAEA-MI-2004-A-29	Chippewa Airport	ND	ND	ND	16.8	ND	16.8
CP-37	LH	GL	BAEA-MI-2004-A-36	Potagannissing Dam	ND	ND	ND	20.2	ND	20.2
CR-07a	LP	IN	BAEA-MI-2004-A-08	Bald Hill	ND	ND	ND	1.0	ND	1.0
DE-07d	LM	GL	BAEA-MI-2004-A-22	Squaw Creek	ND	ND	ND	16.6	ND	16.6
ET-06b	LM	GL	BAEA-MI-2004-B-14	Paradise Lake	ND	ND	ND	58.0	ND	58.0
HU-04 c	LH	GL	BAEA-MI-2004-C-07	Sand Pt	ND	ND	1.0	14.9	ND	15.9
IA-02 b	LM	AN	BAEA-MI-2004-C-03	Weber Pd	ND	ND	2.8	12.0	ND	14.8
IO-04b	LH	GL	BAEA-MI-2004-A-13	Allen L	ND	ND	ND	8.6	ND	8.6
IO-04b	LH	GL	BAEA-MI-2004-A-14	Allen L	ND	1.0	ND	19.4	ND	20.4
KA-04e	LP	IN	BAEA-MI-2004-A-09	Big Blue/Bass L	ND	ND	ND	1.0	ND	1.0
LA-04a	LP	IN	BAEA-MI-2004-B-04	Nebashone	ND	ND	ND	5.7	ND	5.7
LU-12	UP	IN	BAEA-MI-2004-A-39	Long Lake	ND	ND	ND	ND	ND	ND
LU-13a	UP	IN	BAEA-MI-2004-A-27	Dollarville	ND	ND	ND	9.1	ND	9.1
MC-02c	LM	GL	BAEA-MI-2004-A-41	Paquin Ck	ND	ND	1.0	ND	ND	1.0
MC-07c	UP	IN	BAEA-MI-2004-A-28	East L	ND	ND	ND	7.6	ND	7.6
MD-02a	LH	AN	BAEA-MI-2004-B-13	Sanford	ND	ND	ND	10.1	ND	10.1
MK-03a	LP	IN	BAEA-MI-2004-B-03	Seafuse Marsh	ND	ND	ND	18.4	ND	18.4
MN-04c	LM	AN	BAEA-MI-2004-B--07	Tippy Dam	ND	ND	ND	42.2	ND	42.2
MN-06e	LP	IN	BAEA-MI-2004-B-05	Wellston	ND	ND	ND	11.9	ND	11.9
MN-11a	LM	GL	BAEA-MI-2004-B-06	Little Manistee	ND	ND	ND	12.8	ND	12.8
MN-11a	LM	GL	BAEA-MI-2004-B-08	Manistee Airport	ND	ND	ND	39.1	ND	39.1
MO-02 k	LE	GL	BAEA-MI-2004-C-01	Pointe Mouille SGA	ND	ND	1.0	4.0	ND	5.0
MO-02 k	LE	GL	BAEA-MI-2004-C-02	Pointe Mouille SGA	ND	ND	ND	9.8	ND	9.8
MO-04 e	LE	GL	BAEA-MI-2004-C-06	Erie Shooting Club	ND	ND	2.1	8.8	ND	10.9
Ne-01j	LM	AN	BAEA-MI-2004-B-12	Anderson Bayou	ND	ND	ND	20.6	ND	20.6
OG-01e	LP	IN	BAEA-MI-2004-A-07	Rifle River Rec	ND	ND	ND	4.1	ND	4.1
OG-02	LP	IN	BAEA-MI-2004-A-04	Stylus Lake E	ND	ND	ND	4.0	ND	4.0
OG-02	LP	IN	BAEA-MI-2004-A-05	Stylus Lake E	ND	ND	ND	6.4	ND	6.4
OG-06a	LP	IN	BAEA-MI-2004-B-01	Sage Lake	ND	ND	ND	1.0	ND	1.0
OG-07a	LP	IN	BAEA-MI-2004-B-02	Stylus Lake W	ND	ND	ND	78.9	ND	78.9
OS-02	LP	IN	BAEA-MI-2004-A-12	Mio Pond W	ND	ND	ND	1.0	ND	1.0
OS-03e	LP	IN	BAEA-MI-2004-B-09	McKinley	ND	ND	ND	1.0	ND	1.0
OS-08c	LP	IN	BAEA-MI-2004-A-11	Mio Pond E	ND	ND	ND	2.1	ND	2.1
OT-03	LP	IN	BAEA-MI-2004-A-19	N BR Ausable	ND	ND	ND	7.9	ND	7.9

Table 3. Concentrations of DDE, DDD, and Total DDT compounds (ng/g wet weight (ppb)) in nestling bald eagle plasma samples analyzed in 2004. Breeding areas were located in either inland lower peninsula (LP), inland upper peninsula (UP), Lake Huron (LH), Lake Michigan (LM), or Lake Superior (LS) watersheds. Territories were associated with either inland (IN), Great Lakes (GL), or anadromous (AN) water bodies.

Territory	Breeding Area Location	Territory Location	Blood Sample Number	Breeding Area Name	2,4'-DDD	2,4'-DDE	4,4'-DDD	4,4'-DDE	4,4'-DDT	DDE+DDT +DDD
OT-07e	LP	IN	BAEA-MI-2004-A-21	O'Rourke L	ND	ND	ND	1.0	ND	1.0
OT-10a	LP	IN	BAEA-MI-2004-A-18	Crapo Lake	ND	ND	ND	6.3	ND	6.3
RO-04b	LP	IN	BAEA-MI-2004-A-16	Backus Lake	ND	ND	ND	29.4	ND	29.4
RO-06c	LP	IN	BAEA-MI-2004-A-03	Bear Creek Fldg	ND	ND	ND	6.3	ND	6.3
RO-07g	LP	IN	BAEA-MI-2004-B-11	North Bay	ND	ND	ND	7.1	ND	7.1
RO-08	LP	IN	BAEA-MI-2004-A-10	Wraco Lodge	ND	ND	ND	3.3	ND	3.3
RO-09g	LP	IN	BAEA-MI-2004-A-01	Marl Lake	ND	ND	ND	8.2	ND	8.2
RO-12j	LP	IN	BAEA-MI-2004-B-10	St. Hellen	ND	ND	ND	3.5	ND	3.5
RO-13b	LP	IN	BAEA-MI-2004-A-17	Prudenville	ND	ND	ND	5.3	ND	5.3
RO-14d	LP	IN	BAEA-MI-2004-A-02	Porter Ranch	ND	ND	ND	4.0	ND	4.0
SC-04	UP	IN	BAEA-MI-2004-A-38	C-2 Pool / Seney	ND	ND	ND	13.2	ND	13.2
SC-19c	LM	GL	BAEA-MI-2004-A-23	Deer Count Ck	ND	ND	ND	35.2	ND	35.2
SG-01 f	LH	AN	BAEA-MI-2004-C-13	Shiawassee R SGA	ND	ND	ND	5.5	ND	5.5
SG-01 f	LH	AN	BAEA-MI-2004-C-14	Shiawassee R SGA	ND	ND	1.0	6.7	ND	7.7
TU-03 b	LP	IN	BAEA-MI-2004-C-12	Caro	ND	ND	1.0	9.5	ND	10.5

Table 4. Concentrations of individual PCB congeners and Total PCBs (ng/g wet weight (ppb)) in nestling bald eagle plasma samples analyzed in 2004. Breeding areas were located in either inland lower peninsula (LP), inland upper peninsula (UP), Lake Huron (LH), Lake Michigan (LM), or Lake Superior (LS) watersheds. Territories were associated with either inland (IN), Great Lakes (GL), or anadromous (AN) waterbodies.

Territory	Breeding Area Location	Territory Location	Blood Sample Number	Breeding Area Name	# 028	# 044	# 052	# 066	# 101	# 105	# 110	# 118	# 128	# 138	# 153	# 156	# 170	# 180	# 187	# 195	# 206	# 209	SUM PCBs
AG-08e	LS	GL	BAEA-MI-2004-A-26	Au Train Ck	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	1.0
AG-11f	LS	GL	BAEA-MI-2004-A-40	Laughing Whitefish Pt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AG-18	UP	IN	BAEA-MI-2004-A-25	Forest Lake Basin N	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	ND	ND	ND	ND	ND	ND	ND	2.0
AG-20a	UP	IN	BAEA-MI-2004-A-24	Hovey Lake	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AL-02	LP	IN	BAEA-MI-2004-A-15	Alcona-Bamfield PD	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2.3	ND	ND	ND	ND	ND	ND	ND	3.3
AL-05c	LP	IN	BAEA-MI-2004-B-15	Sprinkler Lake	ND	ND	ND	ND	7.6	ND	3.0	11.7	2.2	15.4	19.9	ND	3.6	9.2	6.7	ND	ND	3.4	82.7
AN-04 b	LM	AN	BAEA-MI-2004-C-08	New Richmond	ND	ND	ND	ND	1.0	ND	ND	1.0	ND	3.9	3.6	ND	ND	ND	ND	ND	ND	ND	9.5
AR-03a	LH	AN	BAEA-MI-2004-A-06	Santiago	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND	1.0
AR-05 a	LH	GL	BAEA-MI-2004-C-04	Pt AuGres	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND	1.0
AR-05 a	LH	GL	BAEA-MI-2004-C-05	Pt AuGres	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BY-01 d	LH	AN	BAEA-MI-2004-C-15	Skull/Stoney Isd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BY-01 d	LH	AN	BAEA-MI-2004-C-16	Skull/Stoney Isd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CH-01 a	LP	IN	BAEA-MI-2004-C-10	Baker Sanctuary	ND	ND	ND	2.4	4.0	2.3	ND	5.9	1.0	11.2	10.1	ND	ND	5.3	3.2	ND	ND	ND	45.4
CH-01 a	LP	IN	BAEA-MI-2004-C-11	Baker Sanctuary	ND	ND	ND	1.0	3.2	ND	ND	6.0	ND	10.9	10.1	ND	ND	4.7	3.1	ND	ND	ND	39.0
CP-02e	LH	GL	BAEA-MI-2004-A-31	Sugar Island E	ND	ND	ND	ND	ND	ND	ND	1.0	ND	3.1	3.4	ND	ND	ND	ND	ND	ND	ND	7.5
CP-10d	LH	GL	BAEA-MI-2004-A-35	Burnt Island	ND	ND	ND	ND	ND	ND	ND	1.0	ND	4.8	5.9	ND	ND	4.7	2.0	ND	ND	ND	18.4
CP-20	LS	GL	BAEA-MI-2004-A-37	Tahquamenon Bay Swamp	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CP-22i	LH	GL	BAEA-MI-2004-A-32	Sugar Island-Duck Bay	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	1.0	ND	ND	ND	ND	ND	ND	ND	2.0
CP-26	LH	GL	BAEA-MI-2004-A-34	Gravel L/Isd	ND	ND	ND	ND	ND	ND	ND	1.0	ND	3.4	2.7	ND	ND	ND	ND	ND	ND	ND	7.1
CP-30	LH	GL	BAEA-MI-2004-A-30	Neebish Island E	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CP-32	UP	IN	BAEA-MI-2004-A-29	Chippewa Airport	ND	5.2	4.4	7.5	5.5	ND	3.2	5.7	ND	9.2	8.2	ND	ND	3.9	2.7	ND	ND	ND	55.3
CP-37	LH	GL	BAEA-MI-2004-A-36	Potagannissing Dam	ND	3.7	2.2	ND	4.3	ND	2.3	9.2	1.0	13.7	15.5	ND	2.1	5.8	4.5	ND	ND	ND	64.2
CR-07a	LP	IN	BAEA-MI-2004-A-08	Bald Hill	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.6	4.4	ND	ND	ND	ND	ND	ND	ND	8.0
DE-07d	LM	GL	BAEA-MI-2004-A-22	Squaw Creek	ND	ND	ND	ND	ND	ND	ND	1.0	ND	4.8	5.2	ND	ND	2.6	ND	ND	ND	ND	13.6
ET-06b	LM	GL	BAEA-MI-2004-B-14	Paradise Lake	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	1.0
HU-04 c	LH	GL	BAEA-MI-2004-C-07	Sand Pt	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.1	4.2	ND	ND	ND	ND	ND	ND	ND	6.4
IA-02 b	LM	AN	BAEA-MI-2004-C-03	Weber Pd	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	3.5	ND	ND	ND	ND	ND	ND	ND	4.5
IO-04b	LH	GL	BAEA-MI-2004-A-13	Allen L	ND	ND	ND	ND	ND	ND	ND	1.0	ND	9.4	10.7	ND	ND	4.6	1.0	ND	ND	ND	26.6
IO-04b	LH	GL	BAEA-MI-2004-A-14	Allen L	ND	ND	2.4	6.9	10.4	ND	4.7	11.8	1.0	16.8	18.2	ND	3.8	10.3	6.7	ND	ND	ND	93.1
KA-04e	LP	IN	BAEA-MI-2004-A-09	Big Blue/Bass L	ND	ND	ND	1.0	2.9	ND	ND	ND	ND	11.0	6.2	ND	3.0	8.9	4.7	ND	ND	ND	37.8
LA-04a	LP	IN	BAEA-MI-2004-B-04	Nebashone	ND	1.0	ND	2.2	2.7	ND	ND	3.1	ND	6.1	5.2	ND	ND	3.6	1.0	ND	ND	ND	25.0
LU-12	UP	IN	BAEA-MI-2004-A-39	Long Lake	ND	ND	ND	2.6	ND	ND	ND	16.9	1.0	ND	28.1	ND	4.6	14.7	6.9	ND	ND	ND	74.8
LU-13a	UP	IN	BAEA-MI-2004-A-27	Dollarville	ND	ND	ND	2.6	1.0	ND	ND	9.0	1.0	16.3	20.9	ND	3.5	11.4	5.5	ND	ND	ND	71.1
MC-02c	LM	GL	BAEA-MI-2004-A-41	Paquin Ck	ND	ND	ND	ND	1.0	ND	ND	3.5	ND	7.5	3.7	ND	ND	4.6	2.9	ND	ND	ND	23.1
MC-07c	UP	IN	BAEA-MI-2004-A-28	East L	ND	ND	ND	ND	ND	ND	ND	2.4	ND	5.3	3.0	ND	ND	2.9	1.0	ND	ND	ND	14.6
MD-02a	LH	AN	BAEA-MI-2004-B-13	Sanford	ND	ND	ND	ND	ND	ND	ND	2.7	ND	5.5	6.1	ND	ND	2.5	ND	ND	ND	ND	16.8
MK-03a	LP	IN	BAEA-MI-2004-B-03	Seafuse Marsh	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	1.0
MN-04c	LM	AN	BAEA-MI-2004-B--07	Tippy Dam	ND	ND	ND	ND	ND	ND	ND	2.1	ND	6.1	7.1	ND	ND	3.5	ND	ND	ND	ND	18.8
MN-06e	LP	IN	BAEA-MI-2004-B-05	Wellston	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MN-11a	LM	GL	BAEA-MI-2004-B-06	Little Manistee	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.6	6.9	ND	2.6	6.0	2.7	ND	ND	ND	24.7
MN-11a	LM	GL	BAEA-MI-2004-B-08	Manistee Airport	ND	ND	ND	7.1	7.2	5.9	ND	20.9	ND	29.3	38.2	ND	5.6	17.4	12.1	ND	1.0	ND	144.8
MO-02 k	LE	GL	BAEA-MI-2004-C-01	Pointe Mouille SGA	ND	ND	ND	ND	ND	ND	ND	1.0	ND	5.0	5.0	ND	ND	2.1	ND	ND	ND	ND	13.1

Table 4. Continued.

Territory	Breeding Area Location	Territory Location	Blood Sample Number	Breeding Area Name	# 028	# 044	# 052	# 066	# 101	# 105	# 110	# 118	# 128	# 138	# 153	# 156	# 170	# 180	# 187	# 195	# 206	# 209	SUM PCBs
MO-02 k	LE	GL	BAEA-MI-2004-C-02	Pointe Mouille SGA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	1.0
MO-04 e	LE	GL	BAEA-MI-2004-C-06	Erie Shooting Club	ND	ND	ND	ND	ND	ND	ND	1.0	ND	3.9	5.4	ND	ND	ND	ND	ND	ND	ND	10.3
Ne-01j	LM	AN	BAEA-MI-2004-B-12	Anderson Bayou	ND	ND	ND	ND	1.0	ND	ND	1.0	ND	5.6	5.6	ND	ND	ND	ND	ND	ND	ND	13.2
OG-01e	LP	IN	BAEA-MI-2004-A-07	Rifle River Rec	ND	1.0	ND	ND	8.2	2.4	5.0	9.0	2.2	16.2	15.6	ND	1.0	6.2	4.8	ND	ND	ND	71.4
OG-02	LP	IN	BAEA-MI-2004-A-04	Stylus Lake E	ND	2.5	ND	4.0	ND	2.6	3.2	8.4	2.2	16.6	17.4	ND	2.8	9.0	6.8	ND	1.0	ND	76.5
OG-02	LP	IN	BAEA-MI-2004-A-05	Stylus Lake E	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OG-06a	LP	IN	BAEA-MI-2004-B-01	Sage Lake	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	1.0
OG-07a	LP	IN	BAEA-MI-2004-B-02	Stylus Lake W	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	5.0	ND	ND	2.1	ND	ND	ND	ND	8.1
OS-02	LP	IN	BAEA-MI-2004-A-12	Mio Pond W	ND	ND	ND	ND	3.1	ND	ND	3.1	ND	8.3	8.0	ND	ND	2.3	1.0	ND	ND	ND	25.7
OS-03e	LP	IN	BAEA-MI-2004-B-09	McKinley	ND	ND	ND	ND	ND	ND	ND	1.0	ND	3.9	3.4	ND	ND	ND	ND	ND	ND	ND	8.3
OS-08c	LP	IN	BAEA-MI-2004-A-11	Mio Pond E	ND	ND	ND	ND	1.0	ND	ND	4.9	ND	12.3	16.1	ND	3.2	9.8	5.6	ND	ND	ND	52.9
OT-03	LP	IN	BAEA-MI-2004-A-19	N BR Ausable	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OT-07e	LP	IN	BAEA-MI-2004-A-21	O'Rourke L	ND	2.3	ND	2.6	6.4	ND	ND	3.6	ND	ND	10.5	ND	3.0	9.9	5.7	ND	ND	ND	43.9
OT-10a	LP	IN	BAEA-MI-2004-A-18	Crapo Lake	ND	ND	4.4	7.6	13.4	2.3	6.1	2.9	1.0	ND	21.7	ND	7.3	17.7	11.4	ND	ND	ND	95.7
RO-04b	LP	IN	BAEA-MI-2004-A-16	Backus Lake	ND	ND	ND	ND	ND	ND	ND	4.2	1.0	ND	6.7	ND	ND	1.0	ND	ND	ND	ND	13.0
RO-06c	LP	IN	BAEA-MI-2004-A-03	Bear Creek Fldg	ND	ND	ND	2.8	4.7	2.6	ND	7.8	ND	ND	10.5	ND	1.0	6.3	3.6	ND	ND	ND	39.4
RO-07g	LP	IN	BAEA-MI-2004-B-11	North Bay	ND	2.0	ND	4.5	7.1	ND	2.6	3.5	ND	ND	10.6	ND	ND	4.6	2.6	ND	ND	ND	37.5
RO-08	LP	IN	BAEA-MI-2004-A-10	Wraco Lodge	ND	6.5	4.9	5.9	5.3	ND	3.4	4.1	ND	ND	10.1	ND	1.0	3.2	4.1	ND	ND	ND	48.5
RO-09g	LP	IN	BAEA-MI-2004-A-01	Marl Lake	ND	ND	1.0	3.5	4.5	ND	ND	8.7	ND	ND	10.2	ND	1.0	ND	ND	ND	ND	ND	28.8
RO-12j	LP	IN	BAEA-MI-2004-B-10	St. Hellen	6.0	11.8	11.2	16.6	14.5	ND	8.9	ND	3.2	ND	19.3	ND	2.5	8.3	5.1	ND	ND	ND	107.3
RO-13b	LP	IN	BAEA-MI-2004-A-17	Prudenville	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RO-14d	LP	IN	BAEA-MI-2004-A-02	Porter Ranch	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SC-04	UP	IN	BAEA-MI-2004-A-38	C-2 Pool / Seney	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	2.0
SC-19c	LM	GL	BAEA-MI-2004-A-23	Deer Count Ck	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	2.0
SG-01 f	LH	AN	BAEA-MI-2004-C-13	Shiawassee R SGA	ND	2.1	ND	2.5	ND	ND	ND	3.6	ND	ND	4.3	ND	ND	ND	ND	ND	ND	ND	12.5
SG-01 f	LH	AN	BAEA-MI-2004-C-14	Shiawassee R SGA	ND	3.8	2.2	3.9	6.0	2.6	ND	7.6	ND	ND	9.7	ND	1.0	ND	ND	ND	ND	ND	36.7
TU-03 b	LP	IN	BAEA-MI-2004-C-12	Caro	ND	ND	6.1	9.9	13.6	6.4	ND	ND	ND	ND	25.2	ND	6.7	ND	ND	ND	ND	ND	67.9

Table 5. Concentrations of individual organochlorine compounds (ng/g wet weight (ppb)) in nestling bald eagle plasma samples analyzed in 2004. Breeding areas were located in either inland lower peninsula (LP), inland upper peninsula (UP), Lake Huron (LH), Lake Michigan (LM), or Lake Superior (LS) watersheds. Territories were associated with either inland (IN), Great Lakes (GL), or anadromous (AN) water bodies.

Territory	Breeding Area Location	Territory Location	Blood Sample Number	Breeding Area Name	a-Chlordane	Dieldrin	HCB
AG-08e	LS	GL	BAEA-MI-2004-A-26	Au Train Ck	ND	ND	ND
AG-11f	LS	GL	BAEA-MI-2004-A-40	Laughing Whitefish Pt	ND	ND	ND
AG-18	UP	IN	BAEA-MI-2004-A-25	Forest Lake Basin N	ND	ND	ND
AG-20a	UP	IN	BAEA-MI-2004-A-24	Hovey Lake	ND	ND	ND
AL-02	LP	IN	BAEA-MI-2004-A-15	Alcona-Bamfield PD	ND	ND	ND
AL-05c	LP	IN	BAEA-MI-2004-B-15	Sprinkler Lake	1.0	ND	ND
AN-04 b	LM	AN	BAEA-MI-2004-C-08	New Richmond	ND	ND	ND
AR-03a	LH	AN	BAEA-MI-2004-A-06	Santiago	ND	ND	ND
AR-05 a	LH	GL	BAEA-MI-2004-C-04	Pt AuGres	ND	ND	1.0
AR-05 a	LH	GL	BAEA-MI-2004-C-05	Pt AuGres	ND	ND	ND
BY-01 d	LH	AN	BAEA-MI-2004-C-15	Skull/Stoney Isd	ND	ND	ND
BY-01 d	LH	AN	BAEA-MI-2004-C-16	Skull/Stoney Isd	ND	ND	ND
CH-01 a	LP	IN	BAEA-MI-2004-C-10	Baker Sanctuary	ND	ND	ND
CH-01 a	LP	IN	BAEA-MI-2004-C-11	Baker Sanctuary	ND	ND	ND
CP-02e	LH	GL	BAEA-MI-2004-A-31	Sugar Island E	ND	ND	ND
CP-10d	LH	GL	BAEA-MI-2004-A-35	Burnt Island	ND	1.0	ND
CP-20	LS	GL	BAEA-MI-2004-A-37	Tahquamenon Bay Swamp	ND	ND	ND
CP-22i	LH	GL	BAEA-MI-2004-A-32	Sugar Island-Duck Bay	ND	ND	ND
CP-26	LH	GL	BAEA-MI-2004-A-34	Gravel L/Isd	ND	ND	ND
CP-30	LH	GL	BAEA-MI-2004-A-30	Neebish Island E	ND	ND	ND
CP-32	UP	IN	BAEA-MI-2004-A-29	Chippewa Airport	1.0	1.0	ND
CP-37	LH	GL	BAEA-MI-2004-A-36	Potagannissing Dam	ND	2.4	ND
CR-07a	LP	IN	BAEA-MI-2004-A-08	Bald Hill	ND	1.0	ND
DE-07d	LM	GL	BAEA-MI-2004-A-22	Squaw Creek	ND	ND	ND
ET-06b	LM	GL	BAEA-MI-2004-B-14	Paradise Lake	ND	1.0	ND
HU-04 c	LH	GL	BAEA-MI-2004-C-07	Sand Pt	ND	ND	ND
IA-02 b	LM	AN	BAEA-MI-2004-C-03	Weber Pd	ND	ND	ND
IO-04b	LH	GL	BAEA-MI-2004-A-13	Allen L	ND	ND	ND
IO-04b	LH	GL	BAEA-MI-2004-A-14	Allen L	2.1	ND	ND
KA-04e	LP	IN	BAEA-MI-2004-A-09	Big Blue/Bass L	ND	ND	ND
LA-04a	LP	IN	BAEA-MI-2004-B-04	Nebashone	ND	ND	ND
LU-12	UP	IN	BAEA-MI-2004-A-39	Long Lake	ND	2.5	ND
LU-13a	UP	IN	BAEA-MI-2004-A-27	Dollarville	ND	1.0	ND
MC-02c	LM	GL	BAEA-MI-2004-A-41	Paquin Ck	ND	ND	ND
MC-07c	UP	IN	BAEA-MI-2004-A-28	East L	ND	ND	ND
MD-02a	LH	AN	BAEA-MI-2004-B-13	Sanford	ND	ND	ND
MK-03a	LP	IN	BAEA-MI-2004-B-03	Seafuse Marsh	ND	ND	ND
MN-04c	LM	AN	BAEA-MI-2004-B--07	Tippy Dam	ND	ND	ND
MN-06e	LP	IN	BAEA-MI-2004-B-05	Wellston	ND	ND	ND
MN-11a	LM	GL	BAEA-MI-2004-B-06	Little Manistee	ND	ND	ND
MN-11a	LM	GL	BAEA-MI-2004-B-08	Manistee Airport	ND	1.0	ND
MO-02 k	LE	GL	BAEA-MI-2004-C-01	Pointe Mouille SGA	ND	ND	ND
MO-02 k	LE	GL	BAEA-MI-2004-C-02	Pointe Mouille SGA	ND	ND	ND
MO-04 e	LE	GL	BAEA-MI-2004-C-06	Erie Shooting Club	ND	ND	ND
Ne-01j	LM	AN	BAEA-MI-2004-B-12	Anderson Bayou	ND	ND	ND
OG-01e	LP	IN	BAEA-MI-2004-A-07	Rifle River Rec	1.0	1.0	ND

Table 5. Continued.

Territory	Breeding Area Location	Territory Location	Blood Sample Number	Breeding Area Name	a-Chlordane	Dieldrin	HCB
OG-02	LP	IN	BAEA-MI-2004-A-04	Stylus Lake E	1.0	1.0	ND
OG-02	LP	IN	BAEA-MI-2004-A-05	Stylus Lake E	ND	ND	ND
OG-06a	LP	IN	BAEA-MI-2004-B-01	Sage Lake	ND	ND	ND
OG-07a	LP	IN	BAEA-MI-2004-B-02	Stylus Lake W	ND	ND	ND
OS-02	LP	IN	BAEA-MI-2004-A-12	Mio Pond W	ND	ND	ND
OS-03e	LP	IN	BAEA-MI-2004-B-09	McKinley	ND	ND	ND
OS-08c	LP	IN	BAEA-MI-2004-A-11	Mio Pond E	ND	ND	ND
OT-03	LP	IN	BAEA-MI-2004-A-19	N BR Ausable	ND	ND	ND
OT-07e	LP	IN	BAEA-MI-2004-A-21	O'Rourke L	ND	1.0	ND
OT-10a	LP	IN	BAEA-MI-2004-A-18	Crapo Lake	1.0	ND	ND
RO-04b	LP	IN	BAEA-MI-2004-A-16	Backus Lake	ND	ND	ND
RO-06c	LP	IN	BAEA-MI-2004-A-03	Bear Creek Fldg	ND	ND	ND
RO-07g	LP	IN	BAEA-MI-2004-B-11	North Bay	ND	ND	ND
RO-08	LP	IN	BAEA-MI-2004-A-10	Wraco Lodge	ND	ND	ND
RO-09g	LP	IN	BAEA-MI-2004-A-01	Marl Lake	ND	ND	ND
RO-12j	LP	IN	BAEA-MI-2004-B-10	St. Hellen	3.6	2.7	ND
RO-13b	LP	IN	BAEA-MI-2004-A-17	Prudenville	ND	ND	ND
RO-14d	LP	IN	BAEA-MI-2004-A-02	Porter Ranch	ND	ND	ND
SC-04	UP	IN	BAEA-MI-2004-A-38	C-2 Pool / Seney	ND	ND	ND
SC-19c	LM	GL	BAEA-MI-2004-A-23	Deer Count Ck	ND	ND	ND
SG-01 f	LH	AN	BAEA-MI-2004-C-13	Shiawassee R SGA	ND	ND	ND
SG-01 f	LH	AN	BAEA-MI-2004-C-14	Shiawassee R SGA	ND	ND	ND
TU-03 b	LP	IN	BAEA-MI-2004-C-12	Caro	2.9	ND	ND