# PCB, Organochlorine Pesticide and Mercury Changes <br> in Lake Trout (Salvelinus namaycush) <br> from Five Finger Lakes, New York State 

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#### Abstract

Polychlorinated biphenyls (PCBs), organochlorine pesticides and mercury have been measured episodically in lake trout of know age taken from four Finger Lakes (Canadice, Canandaigua, Keuka, Seneca) over an approximate 25 year period and from Cayuga Lake for nearly 40 years. Concentrations of PCBs, total p,p'-DDT, p,p'-DDE, total chlordane, transnonachlor and mercury increase with age of the lake trout until about age 7 to 8 , after which the rate of accumulation with age slows. For all five lakes, concentrations of PCBs, DDT and metabolites, chlordane compounds and hexachlorobenzene have declined over the period of measurement by 70 percent or more. The patterns of declines are not consistent among lakes and chemical compounds. Keuka Lake has shown increases of several chemical residues in the last few years. Mirex, a compound not used in the Finger Lakes basin, had residues that were initially absent, then low concentrations near the detection limit of $2 \mathrm{ng} / \mathrm{g}$ were frequently found in the mid 1990's, but again became non-detectable after 2000.

Mercury concentrations in fish aged 3 through 6 are generally less than $500 \mathrm{ng} / \mathrm{g}$, and older fish contain mercury frequently in excess of $500 \mathrm{ng} / \mathrm{g}$. Within Seneca Lake, mercury concentrations have remained relatively stable over the period of measurement. Since 1970, mercury in Cayuga Lake lake trout has declined an average of 42 percent, but the decline occurred between 1970 and 1988 and concentrations have been stable since 1988. Mercury in Canadice, Canandaigua and Keuka Lakes was stable from 1988 through the mid 1990s, but since then specific age group mercury concentrations have increased at least 40 percent in each lake, and up to 128 percent in age 5 lake trout from Canandaigua Lake. However, in Canandaigua Lake, mercury subsequently declined in 2009. The specific causal factors for the mercury increases are unknown.

The historical record for chemical residues in lake trout from other Finger Lakes is also presented. Notably, DDT levels in Hemlock Lake fish appear to have declined by at least 95 percent in the 38 year record, and residues of all organic compounds have declined in lake trout from Owasco, Otsego and Skaneateles Lakes.


## Table of Contents

Page
Abstract ..... ii
List of Tables ..... iv
List of Figures ..... vii
Introduction ..... 1
The lakes ..... 1
Chemical compounds of primary concern ..... 1
Health advisories ..... 3
Methods ..... 5
Results ..... 7
Lipids ..... 7
PCBs ..... 7
DDT and metabolites ..... 9
Chlordane and trans-nonachlor ..... 10
Mercury ..... 12
Mirex ..... 12
Dieldrin ..... 13
Hexachlorobenzene (HCB) ..... 13
Lipid, PCB, organochlorine pesticide and mercury data for fish over 8 years old ..... 13
Discussion ..... 14
Comparisons with historical data ..... 14
Sample portions ..... 14
Analytical methods ..... 15
Temporal changes ..... 16
Hemlock Lake ..... 18
Other Finger Lakes ..... 18
Remedial efforts ..... 18
A possible role of zebra mussels? ..... 20
Conclusions ..... 23
PCB and organochlorine pesticides ..... 23
Mercury ..... 24
Health advisories ..... 24
Acknowledgments ..... 26
References Cited ..... 27

## List of Tables

TablePage
1 Recommended maximum concentrations of certain chemical ..... 1 ..... 38 residues in fish for the protection of human health.
2 Recommended maximum concentrations of certain chemical residues in fish for the protection of fish-consuming wildlife.
3 Health advisories for human consumers of fish for fish taken
 from the Finger Lakes, New York
4 Changes in the incidence of some organochlorine residues in

$$
\text { lake trout taken from five Finger Lakes between } 1983 \text { and } 2008 .
$$ lake trout taken from five Finger Lakes between 1983 and 2008. lake trout.

Total p,p'-DDT concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets)
Incidence of some organochlorine pesticide analytes determined in recent collections of Finger Lakes lake trout.
Lipid concentrations (percent wet weight in standard fillets) in aged lake trout taken from five Finger Lakes, New York.
Kruskal-Wallis comparisons (or Mann-Whitney test comparisons) of total PCB concentrations by age for lake trout taken from five Finger Lakes, New York.
Temporal comparisons of total PCB concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York. for aged lake trout taken from five Finger Lakes, New York.
Kruskal-Wallis comparisons (or Mann-Whitney test comparisons) of p,p'-DDE concentrations by age for lake trout taken from five Finger Lakes, New York.
Temporal comparisons of $\mathrm{p}, \mathrm{p}$ '-DDE concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

14 Detection (percent of samples by year) of chlordane analytes in lake trout taken from the Finger Lakes, New York.
Distribution of chlordane analytes in Finger Lakes lake trout.

Total chlordane concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) in aged lake trout taken from five Finger Lakes, New York.

Temporal comparisons of trans-nonachlor concentrations (ng/g wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

Kruskal-Wallis comparisons (or Mann-Whitney test comparisons) of trans-nonachlor concentrations by age for lake trout taken from five Finger Lakes, New York.

Kruskal-Wallis comparisons (or Mann-Whitney test comparisons) of mercury concentrations by age for lake trout taken from five Finger Lakes, New York.

Temporal comparisons of mercury concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York. 1970.

Total p,p'-DDT and p,p'-DDE concentrations in Cayuga Lake lake trout taken in 1968 through 1970.

Chemical residue concentrations in lake trout from four other Finger Lakes in New York.

## List of Figures

Figure ..... Page
1 The Finger Lakes of New York. ..... 1042
Temporal changes in polychlorinated biphenyl concentrations on ..... 105wet weight and lipid bases in aged lake trout from Canadice Lake.Temporal changes in polychlorinated biphenyl concentrations on106wet weight and lipid bases in aged lake trout from CanandaiguaLake.
4

Temporal changes in polychlorinated biphenyl concentrations onTemporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordaneconcentrations in aged lake trout taken from Keuka Lake.
11 Temporal changes in total p,p'-DDT and total chlordane
Temporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordane
concentrations in aged lake trout taken from Seneca Lake. wet weight and lipid bases in aged lake trout from Cayuga Lake.
Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Keuka Lake.
Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Seneca Lake.
Temporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordane concentrations in aged lake trout taken from Canadice Lake.
Temporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordane concentrations in aged lake trout taken from Canandaigua Lake.
Temporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordane concentrations in aged lake trout taken from Cayuga Lake.
Temporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordane concentrations in aged lake trout taken from Keuka Lake.
Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Canadice Lake.
13 Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Canandaigua Lake.
Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Cayuga Lake.

Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Keuka Lake.

Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Seneca Lake.

$$
\begin{aligned}
& \text { Temporal changes in trans-nonachlor concentrations on wet } \\
& \text { weight } \\
& \text { and lipid bases in lake trout taken from Canadice Lake. }
\end{aligned}
$$

Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in lake trout taken from Canandaigua Lake.

Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in lake trout taken from Cayuga Lake.

Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in lake trout taken from Keuka Lake.

Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in lake trout taken from Seneca Lake.

Temporal changes in mercury concentrations in aged lake trout from Canadice, Canandaigua, Keuka and Seneca Lakes, New York.

$$
\begin{aligned}
& \text { Temporal changes with age in mercury concentrations } \\
& (\mathrm{ng} / \mathrm{g} \text { wet weight) in aged lake trout from Cayuga Lake, New } \\
& \text { York. }
\end{aligned}
$$

Historical comparison of polychlorinated biphenyl concentrations in aged lake trout taken from Cayuga Lake, New York.

Historical comparison of $\mathrm{p}, \mathrm{p}$ '-DDE and total $\mathrm{p}, \mathrm{p}$ '-DDT
concentrations in aged lake trout taken from Cayuga Lake, New York.

Locations of four other Finger Lakes with chemical residue data

## INTRODUCTION

Persistent organochlorine pesticides were developed and marketed in the 1940's through early 1970's for applications to control a broad spectrum of insects, mites, spiders and other pests of crops, dwellings, nursery stock, livestock, and humans. At the time of their development, little was known of these chemicals' ability to accumulate in fish and wildlife, or their ability to produce a variety of toxic and/or chronic effects in biota, most notably reproductive impairment.

Based on scattered reports and studies, Rachel Carson (1964) first awakened the general public to the potential dangers of persistent pesticides in her famous book "Silent Spring". Her synthesis and vision led the way to a vast and continuing examination of these and other chemical compounds, including polychlorinated biphenyls (PCBs). Based on the accumulated body of study findings, stringent government regulations have been imposed to control or eliminate most applications of persistent organochlorine compounds.

This paper recounts the historical chemical contamination of lake trout (Salvelinus namaycush) for the Finger Lakes of New York. It examines long term temporal changes and age related accumulation of chemical residues in lake trout taken from five Finger Lakes (i.e., Canadice, Canandaigua, Cayuga, Keuka, and Seneca Lakes). The chemicals addressed include polychlorinated biphenyls (PCBs), DDT and metabolites, chlordane compounds, mirex and photomirex, hexachlorobenzene (HCB), dieldrin, and mercury. In addition, the relationship of chemical residues to efforts to control these compounds is explored.

## The lakes

The Finger Lakes are a series of long narrow steep-sided deep north-south oriented lakes located in central and western New York state (Figure 1). The lakes were created by repeated glacial sculpting of the earth and deposition of glacial moraines on the ends of each lake. The lakes have limited drainage basins with dominant inputs of water from the south; lake waters exit from the north. Most tributaries on the east and west shores contain small flows or are intermittent. The dominant land use is for agriculture (primarily cash crops and vegetables), including viticulture which supports a locally important wine industry. Population centers are primarily at the terminal ends of each lake (Bloomfield, 1978).

## Chemical compounds of primary concern

Organochlorine pesticides were introduced in the 1940s and 1950s, and have been of dominant interest due to the propensity of several compounds, most notably DDT and its metabolites, to readily accumulate and persist in tissues of fish and wildlife. Burdick et al. (1964) documented reproductive impairment, including total reproductive failure, of lake trout in New York waters where DDT had been used for mosquito control within the watershed. Numerous investigators demonstrated reproductive impairment in birds, especially birds of prey, due to the elevated concentrations of DDT and metabolites in bird eggs (Ratcliffe, 1967; Hickey
and Anderson, 1968; Heath et al., 1969; and more recently, Wiemeyer et al., 1984; Blus, 1996). As a consequence, New York first banned DDT use in watersheds containing lake trout in 1965, then expanded the DDT ban statewide in 1971. A total ban on DDT production and use in the United States followed in 1972.

In 1971, New York banned the use of a number of other pesticides including endrin, toxaphene, and mercury compounds used as pesticides (NYS Executive Chamber, 1970a and 1970b). Certain other pesticides were restricted to certain designated uses and concentration limits, including chlordane, dieldrin, aldrin and heptachlor. The latter four compounds were banned for all uses in New York in 1985 (NYSDEC, 1985, 1987). These four compounds have had little use within the Finger Lakes drainage basin.

Polychlorinated biphenyls (PCBs) are another class of chemical compounds introduced in the late 1940's for uses in electrical equipment, hydraulic systems, flame retardants, immersion oils, paints, carbonless copy paper, and in a host of other applications. While some PCBs are highly accumulative, they did not readily display the acute toxic properties of DDT and other organochlorine pesticides, and thus were thought to be relatively benign. Beginning in the 1970's, PCBs have been linked to reproductive impairment in mink (Mustela vison) (Jensen, 1972; Ringer et al., 1972; Aulerich et al., 1973; Platnow and Karstad, 1973; Aulerich and Ringer, 1977; Jensen et al., 1977; Bleavins et al., 1980; Hornshaw et al., 1983; Ringer, 1983; Sleight, 1983; Aulerich et al., 1986; Wren, 1991; Heaton et al., 1995), and more recently were thought to be contributors to reproductive and other effects in birds (Wiemeyer et al., 1984; Bowerman et al., 1995; Hoffman et al., 1996) and fish (Walker and Peterson, 1991; Mac et al., 1993; Zabel et al., 1995; Walker et al., 1996). PCBs have been linked to a variety of sensitive neurological impacts in human children (Jacobson and Jacobson, 1997; Grandjean et al., 2001; reviews by Ribas-Fitó et al., 2001 and Schantz et al., 2003), including possible depression of IQ (Jacobson and Jacobson, 1996; Lai, T.-J., et al., 2002; Gray et al., 2005). In addition, PCBs are a probable human carcinogen (USEPA 1997). The federal Resource Conservation and Recovery Act of 1978 banned production of PCBs and called for scheduled phase out of all uses of PCBs.

Lastly, mercury is a metal with universal distribution and use. Environmental exposures occurred through use of mercury in the chloralkali process for production of chlorine, production of acetaldehyde, for gold mining, use in pesticides, paints, dental amalgams, fluorescent lighting, explosives, and a host of other products. Mercury in air emissions are a by-product of combustion of coal (such as in power plants), metals smelting and solid waste incineration. Some uses of mercury are no longer permitted (e.g., use in pesticides), and better materials have replaced other mercury applications. Recent state regulations will cause the phase out of other uses of mercury (ECL § 27-2101 and implementing regulations), control select sources (e.g., dental amalgams; 6 NYCRR 374-4), and control mercury in air emissions from incinerators ( 6 NYCRR 219). Most recently, New York promulgated new regulations to reduce air emissions of mercury from its coal-fired power plants (NYSDEC, 2006; 6 NYCRR 246). However, major inputs of mercury to the environment via coal combustion and smelting in other regions of the continent continue to occur. In New York, modeling shows 80 to 90 percent of the environmental exposure to mercury comes from sources outside of the state (Walchek and

Kallos, 2005; Miller et al., 2005). For humans, the primary causes for concern are the well documented neurological impacts of mercury (e.g., mad hatters disease and Minamata disease) (Tokuomi, 1960; Tsubaki and Irukayama, 1977; Harada, 1986 and 2006); where there are severe exposures the neurological impacts are accompanied by developmental impacts in children as well (e.g., congenital Minamata disease) (Grandjean et al., 1997; Saito, 2004). While these severe impacts are well documented, acute mercury exposures seldom occur in the United States. However, evidence of more subtle mercury impacts on the nervous system has been determined more recently. Transplacental exposure to methylmercury has led to significant impairments of the fetus and children, including IQ deficits (NRC, 2000; Trasande et al., 2005). Methylmercury $(\mathrm{MeHg})$ is the principal form of mercury in freshwater fish, composing 90 percent or more of the total mercury load (Bloom, 1992; NRC, 2000). MeHg in fish is positively linked with deposition of atmospheric mercury (Hammerschmidt and Fitzgerald, 2006). The primary route of human exposure to methylmercury, generally over 95 percent, has been through ingestion of mercury contaminated fish (NRC, 2000).

Relationships of size or age with chemical residue concentration have frequently been documented. Distinct age-contaminant associations have been reported by Bache et al. (1972) and Wszolek et al. (1979) for PCBs in lake trout, Bache et al. (1971), Scott and Armstrong (1972) and Sloan et al. (1987b) for mercury, and Youngs et al. (1972) and Wszolek et al. (1979) for DDT and its metabolites. Similar size-contaminant associations have been reported for mercury (Bache et al., 1971; Sloan et al, 1987b) which are normally a consequence of increasing duration of exposure (age). However, associations between age and contaminant burdens do not always occur, such as with PCB in striped bass (Morone saxatilus) in the Hudson River (Sloan et al., 1995) and Long Island Sound (Skinner et al., 2009).

## Health advisories

Various regulatory agencies have provided tolerances, action levels or recommendations for limits on concentrations of PCBs, organochlorine pesticides and mercury in fish for public health protection (Table 1). Several of these guidelines are under active scrutiny because some of the recommended concentrations are believed to pose a continuing human health threat to some populations. Among the chemicals under review are PCBs and mercury. Similarly, some agencies have provided recommendations (Table 2) identifying chemical residue concentrations in biota above which increased risks are posed to sensitive wildlife consumers of those organisms. The values provided for protection of human consumers of fish, and for protection of wildlife, may be used to provide one type of assessment for chemical residues in Finger Lakes lake trout, but are not expounded on hereafter.

Due to the presence of excessive concentrations of some chemical contaminants, the New York State Department of Health issues health advisories which, if followed, would restrict ingestion of fish containing excessive levels of chemical residues, thereby providing protection of human consumers of fish. Most of the major waters of New York are included in the health advisories. The chemical compounds that have caused the issuance of health advisories in freshwaters and New York Harbor (NYSDOH, 2009) include:

## Compounds

Polychlorinated biphenyls
Mercury
Chlordane
Dioxins
Mirex
DDT and metabolites 2
Cadmium
Dieldrin

11
No. of waters listed

## 43

88 (90)*
13
18
5

1

* Updated for 2010 based on a news release by the New York State Department of Health (NYSDOH, 2010).

Regional advisories for fish in waters of the Adirondack and Catskill Mountains have been issued due to elevated mercury levels, and advisories for marine waters are also available.

The health advisories apply to the waters listed and to their tributaries up to the first barrier impassable to fish. The health advisories for each Finger Lake are found in Table 3.

## METHODS

Lake trout were selected for sampling because they are a long lived fatty piscivore, and as a consequence, they have a greater tendency to accumulate elevated levels of certain chemical residues. Lake trout were collected via gill netting from five Finger Lakes: Canadice Lake, Canandaigua Lake, Cayuga Lake, Keuka Lake and Seneca Lake (Figure 1). Each lake was selected due to past elevations of certain chemical residues in lake trout, notably PCB and/or DDT (Burdick et al., 1964; Bache et al., 1972; Youngs et al., 1972; Spagnoli and Skinner, 1977; Wszolek et al., 1979). Beginning in 1983, more intensive monitoring was begun with collections being made roughly triennially thereafter. Each lake trout specimen was aged so that the status of and changes in chemical residue concentrations could be more accurately assessed. Ages of lake trout were determined by fisheries biologists by scale aging or by the presence of fin clips denoting year of stocking. Lake trout ranged in age from 2 years to 16 years but data analyses were limited to age groups with the largest sample sizes, generally ages 3 through 8.

Lake trout were also collected episodically from other Finger Lakes. While the data are included in this report, they were not used for assessing age or temporal relationships among chemical residues.

Chemical residue concentrations were determined by the New York State Department of Environmental Conservation's (Department) Analytical Services Unit at the Hale Creek Field Station, Gloversville, NY. Most chemical analyses were conducted on individual fish. Standard fillets, minus scales, were ground three times, homogenized, and freeze dried. Lipids were extracted and measured gravimetrically. For PCB and organochlorine pesticide extraction from lipids, a Soxhlet apparatus with hexane or a 1:1 hexane:acetone mixture followed by Florisil column clean-up with petroleum ether was used. The first elution ( 2 percent from 1983 through 1996, 6 percent after 1996) of the extract was made using an ethyl ether/petroleum ether solution ( $\mathrm{v} / \mathrm{v}$ ), concentrated by Rotovap, and diluted to a known volume with isooctane. The second elution ( 35 percent from 1983 through 1996, 20 percent thereafter) was similarly made with ethyl ether/petroleum ether $(\mathrm{v} / \mathrm{v})$. The 35 percent elution was then saponified prior to GC injection. The 20 percent elution was transferred to isooctane for GC analysis. Aliquots of each sample were taken for analyte determination via GC/ECD using capillary columns (see Appendix 1 for analytical method descriptions). Current detection limits for PCBs are $10 \mathrm{ng} / \mathrm{g}$ for Aroclor 1242 and $30 \mathrm{ng} / \mathrm{g}$ for a combination of Aroclors 1254 and 1260. Detection limits for p,p'-DDT analytes are $2 \mathrm{ng} / \mathrm{g}$, as well as for mirex and hexachlorobenzene (HCB). All other organochlorine pesticides were determined using, most commonly, a detection limit of $5.0 \mathrm{ng} / \mathrm{g}$.

In the period 1983 to 1998, mercury analyses were conducted by the cold vapor technique (Hatch and Ott, 1968) involving acid digestion followed by analytical determination on a MAS-50A mercury analyzer. From 1998 to the present, acid digestion was followed by analytical determinations made by cold vapor atomic absorption spectrometry (based on Lobring and Potter, 1991; known as USEPA Method 245.6) which achieves greater sensitivity and accuracy. The current detection limit for total mercury is $6.0 \mathrm{ng} / \mathrm{g}$

All concentrations were reported on a wet weight basis. However, PCBs and organochlorine pesticides are lipophilic. Therefore, if significant changes in lipid concentrations occur they may mask or cause spurious changes in apparent trends in these compounds if assessed on only a wet weight basis. To aid trend determinations for lipophilic compounds, wet weight concentrations have been converted to lipid based concentrations for comparisons and the findings compared in figures.

In statistical computations, one-half the value of the detection limit has been used for non-detects where mean values were determined. If all values were non-detect, then the detection limit is reported.

Age-contaminant relationships were assessed within each lake and year sampled. Temporal trends in chemical residue concentrations were analyzed based on selected ages of fish and temporal trend data are graphically presented. Due to the frequent small sample sizes and occasional values greater than three times the mean concentration that could bias parametric tests, the non-parametric Kruskal-Wallis rank test (Conover, 1980) was used to test relationships of contaminant levels within a given year by age, and of temporal trends by age. In the few instances where data were available for only two ages within a year, or only two years for a given analyte and/or age, the Mann-Whitney test (Conover, 1980) was employed. In tables containing these comparisons, underlined ages indicate the groups that are statistically the same.

Certain terminology is used in this paper. The term $\mathrm{p}, \mathrm{p}^{\prime}$-DDT analytes means $\mathrm{p}, \mathrm{p}{ }^{\prime}$-DDT, $\mathrm{p}, \mathrm{p}^{\prime}-\mathrm{DDE}$ and $\mathrm{p}, \mathrm{p}^{\prime}-\mathrm{DDD}$. Total $\mathrm{p}, \mathrm{p}^{\prime}-\mathrm{DDT}$ is the sum of concentrations for the $\mathrm{p}, \mathrm{p}^{\prime}-\mathrm{DDT}$ analytes. The term o,p'-DDT analytes includes o,p'-DDT, o,p'-DDE and o,p'-DDD. Total chlordane is the sum of concentrations of cis-chlordane, trans-chlordane, oxychlordane and trans-nonachlor. Cis-nonachlor was not analyzed until 2005.


#### Abstract

RESULTS The primary chemical compounds that are the basis for concern in this study are polychlorinated biphenyls (PCBs), p,p'-DDT and its metabolites (particularly p,p'-DDE), chlordane, and mercury. The remaining analytes were either not detected (photomirex), or often detected with a low frequency (hexachlorobenzene, cis-chlordane, trans-chlordane and oxychlordane) (Table 4). For collections in 2002 and thereafter, the organochlorine pesticide analyte list was expanded; however, the added analytes (aldrin, heptachlor and its epoxide, the o,p'-DDT group, cis-nonachlor, and the lindane (hexachlorocyclohexane) group of compounds) were seldom detected, or if detected they generally approximate their respective detection limits (Table 5). Each of the primary analytes of concern is addressed individually below.


Special notes on detection of mirex, dieldrin and hexachlorobenzene (HCB) in Finger Lakes lake trout are also included.

## Lipids

PCB and organochlorine pesticides are lipophilic, therefore, significant changes in lipid content may have an impact on concentrations of these chemical residues. In general, lipid concentrations in lake trout increase with increasing age although they tend to reach a plateau at age 7 or 8 and thereafter (Tables 6 and 24). Further, lipid levels are relatively stable within ages between sampling years although exceptions do occur. The exceptions are summarized below.

In 1984, lipids in Canadice Lake fish were 1.5 to 2.5 times values in subsequent years. Canandaigua Lake lake trout had the greatest lipid concentrations in 2002 and 2009 in fish 4 through 7 years old. Cayuga Lake showed significant lipid changes in each year measured with a decline between 1985 and 1988 followed by an increase in 1991, another decline in 1995 and higher lipid levels in 2007. Lipids in lake trout of ages 6 through 8 from Keuka Lake declined between the period 1985-1988 and 1997 and thereafter. Lipids were in greatest concentration in 1983 in Seneca Lake lake trout 4 and 5 years old.

## PCBs

Within each year, PCB concentrations generally increased with increasing age (Table 7). Between years and within age groups, PCB concentrations generally declined through time (Table 8) although there are exceptions addressed hereafter. The significance and magnitude of declines varied with age, i.e., declines had increasing degrees of magnitude with increasing fish age. As PCBs declined over time, the differences in PCB concentrations with increasing age (Figures 2 through 6) became progressively smaller or, in some cases such as Keuka Lake in 1991 (Table 8), lost any difference due to the proximity of PCB concentrations to the detection limit.

In the initial sampling event, PCB rankings over all ages by lake from greatest to lowest
concentration were Canadice $>$ Canandaigua $>$ Seneca $>$ Cayuga $=$ Keuka. The relative ranking changed in recent years to Canadice $>$ Canandaigua $=$ Cayuga $>$ Keuka $=$ Seneca.

In Canadice Lake during the mid 1980's, older lake trout commonly contained greater than $10,000 \mathrm{ng} / \mathrm{g}$ PCB; indeed, more than $20,000 \mathrm{ng} / \mathrm{g}$ in some fish. This distinguished the lake as having the greatest PCB levels of any of the Finger Lakes studied, and having PCB levels one to two orders of magnitude greater than Keuka and Seneca Lakes which had the lowest PCB values. Following control of the PCB source in the Canadice Lake drainage basin, the PCB concentrations have declined by approximately 80 percent. Between 1984 and 2008, the average PCB in age 8 fish declined from approximately $14700 \mathrm{ng} / \mathrm{g}$ to about $2400 \mathrm{ng} / \mathrm{g}$. Similarly, the youngest fish tested (age 3) have declined from $1657 \mathrm{ng} / \mathrm{g}$ to $264 \mathrm{ng} / \mathrm{g}$ PCB in 2003 (Table 8; Figure 2). Despite these declines, PCBs in 2008 were nearly doubled those in 2003.

Canandaigua Lake lake trout displayed a unique temporal PCB pattern characterized by declines between 1983 and 1994 of 85 to 90 percent, followed by approximate doubling of PCB levels through 2006, then declining to approximate the lowest levels know for the lake. Age 3 fish declined from $499 \mathrm{ng} / \mathrm{g}$ to $59 \mathrm{ng} / \mathrm{g}$, increased to $98 \mathrm{ng} / \mathrm{g}$, then declined to $69 \mathrm{ng} / \mathrm{g}$. Similarly, PCBs in age 6 fish declined from $1032 \mathrm{ng} / \mathrm{g}$ to $93 \mathrm{ng} / \mathrm{g}$, increased to $243 \mathrm{ng} / \mathrm{g}$, then declined to $102 \mathrm{ng} / \mathrm{g}$. Older fish (ages 7 and 8 ) declined from over $2000 \mathrm{ng} / \mathrm{g}$ to about $300 \mathrm{ng} / \mathrm{g}$ in the 26 year time period. Overall, there has been an 86 to 94 percent (mean 89 percent) decline in PCB levels from 1983 to 2009 (Table 8; Figure 3).

Cayuga Lake had substantially lower PCB concentrations in the mid 1980s, and has shown a significant decline in PCB concentrations, averaging about 80 percent (Table 8; Figure 4). However, over time the Cayuga Lake trend was inconsistent and showed an initial decline follow by an increase, then another decline all between 1985 and 1995. For age 4 and 5 fish, initial declines were 60 to 65 percent between 1985 and 1988, followed by an approximate doubling of concentrations by 1991, and a decline of 60 to 75 percent by 1995. The 2008 samples approximate 1995 concentrations. These changes were correlated ( $\mathrm{p}<0.05$ ) with changes in lipid content of the fish. When wet weight concentrations were converted to lipid concentrations of PCB, a general downward temporal trend became more evident (Figure 4). Samples of 6 and 7 year old fish were not collected in 1988 and 1991; thus, the pattern cannot be reinforced with these age groups. Overall, between 1985 and 1995, age 4 fish declined from 337 $\mathrm{ng} / \mathrm{g}$ to $81 \mathrm{ng} / \mathrm{g}$ PCB ( $76 \%$ ) while age 7 fish declined from $1323 \mathrm{ng} / \mathrm{g}$ to $207 \mathrm{ng} / \mathrm{g}$ PCB ( $84 \%$ ).

In the mid 1980s, Keuka Lake lake trout had the lowest PCB concentrations of the five lakes, but the lake has displayed differing PCB relationships with fish age, and differing trends over time. Within years, PCB concentrations with age did not differ as greatly as in other lakes due to lower PCB concentrations and PCBs nearly disappeared in 1991 when many of the younger fish had non-detectable PCB concentrations (Table 8). Indeed, of the 288 PCB measurements made from 1983 through 2000, $98 \%$ were less than $500 \mathrm{ng} / \mathrm{g}$ and 85 percent were less than $200 \mathrm{ng} / \mathrm{g}$. PCB concentrations in all ages of lake trout declined between 1983-85 and 1991 with declines in most ages exceeding $90 \%$. Initial concentrations were about $325 \mathrm{ng} / \mathrm{g}$ in age 3 fish, ranging up to $780 \mathrm{ng} / \mathrm{g}$ in age 8 fish. In 1991, 90 percent of 49 fish 4 through 6 years
old had non-detectable PCB concentrations (less than $20 \mathrm{ng} / \mathrm{g}$ ) while age 8 fish averaged 134 ng/g PCB. From 1991 to 2000, PCB levels increased three or more times, with age 5 fish having $86 \mathrm{ng} / \mathrm{g}$ PCB and age 8 fish averaging $197 \mathrm{ng} / \mathrm{g}$ PCB. Thereafter, to 2007, PCBs have remained relatively stable. The 2007 concentrations were $61 \mathrm{ng} / \mathrm{g}$ in age 4 fish and ranged to $335 \mathrm{ng} / \mathrm{g}$ in age 8 fish (Table 8; Figure 5). Over time, lake trout of ages 7 and 8 have not shown a statistically significant change in PCB concentrations due to the high variability of analytical results in some years; however, some decline is evident. The overall decline in PCB concentrations between the earliest sampling event and 2007 averaged $72 \%$ (range from $53 \%$ to $85 \%)$.

Seneca Lake PCB concentrations declined from $641 \mathrm{ng} / \mathrm{g}$ to $62 \mathrm{ng} / \mathrm{g}$ in age 4 fish, and from 630 to $132 \mathrm{ng} / \mathrm{g}$ ( $79 \%$ ) in age 7 fish (Table 8; Figure 6). Overall, from 1983 to 2008, PCB concentrations have declined at least $89 \%$ in age 4 and 5 fish.

## DDT and metabolites

In all years the p,p'-DDT analytes were measured; in 2002 through 2009 the o,p'-DDT analytes were also analyzed. $\mathrm{p}, \mathrm{p}$ '-DDE is the dominant analyte measured, typically representing 60 to 90 percent of total DDT concentrations (Table 9). Consequently, p,p'-DDE is the principal basis for age and temporal comparisons. The o,p'-DDT analytes normally comprise an insignificant proportion of the total DDT concentrations as evidenced in the latest data (Table 5). Total p,p'-DDT residue concentrations are given in Table 10, and are shown in Figures 7 through 11. However, further discussions will focus principally on $\mathrm{p}, \mathrm{p}$ '-DDE.

As with PCBs, p,p'-DDE concentrations generally increase with increasing age of the fish (Table 11). An overall declining temporal trend is evident within each age group (Table 12; Figures 12 through 16) for all five lakes studied. However, the patterns of p,p'-DDE changes differ among lakes. A continuous decline in p,p'-DDE concentrations is evident in Seneca Lake ( $90 \%$ in fish ages 4 and 5), Canadice Lake (average 80\%) and Keuka Lake (average 85\%).

Relative ranking of the five Finger Lakes for $\mathrm{p}, \mathrm{p}^{\prime}-\mathrm{DDE}$ and total DDT concentrations in early years differs from PCB and is as follows: Keuka $>$ Canandaigua $>$ Seneca $>$ Cayuga $>$ Canadice. In later years the relative rankings have changed somewhat, viz.: Keuka > Canandaigua $>$ Cayuga $=$ Seneca $=$ Canadice .

Seneca and Canadice Lakes, along with Cayuga Lake (Table 12), contained the lowest p,p'-DDE concentrations at the initiation of this study. For younger fish (ages 3 to 5), DDE in Seneca Lake declined from 250 to $300 \mathrm{ng} / \mathrm{g}$ to less than $50 \mathrm{ng} / \mathrm{g}$ (Figure 16), whereas Canadice Lake fish declined from 50 to $100 \mathrm{ng} / \mathrm{g}$ to 10 to $25 \mathrm{ng} / \mathrm{g}$ (Figure 12). In age 8 fish, both lakes began with over $500 \mathrm{ng} / \mathrm{g}$ DDE, but the decline in Canadice Lake was more rapid than in Seneca Lake although the most recent average concentrations are $86 \mathrm{ng} / \mathrm{g}$ and $92 \mathrm{ng} / \mathrm{g}$, respectively. Overall, the p,p'-DDE declines for Canadice Lake average $80 \%$ (range 67 to $92 \%$ ) while Seneca Lake experienced a decline of $84 \%$. In all three lakes, the age-p,p'DEE relationship nearly
disappeared when expressed on a lipid basis.
Keuka Lake lake trout contained the greatest p,p'-DDE and total DDT concentrations (Tables 12 and 9, respectively) with a maximum concentration of $29,400 \mathrm{ng} / \mathrm{g}$ DDE reported in an 8 -year old fish taken in 1988. In the mid 1980's, by age group, p,p'-DDE values were at least an order of magnitude greater than in corresponding age groups for the remaining four lakes. With an approximate order of magnitude decline in p,p'-DDE values (Figure 15), the 2007 p,p'DDE concentrations approximate values observed in the other Finger Lakes 20 to 25 years ago. Illustrative of the p,p'-DDE declines are the age 4 fish, which declined from $2320 \mathrm{ng} / \mathrm{g}$ to 341 $\mathrm{ng} / \mathrm{g}$, and age 6 fish that declined from $9530 \mathrm{ng} / \mathrm{g}$ to $807 \mathrm{ng} / \mathrm{g}$ in 2007. The p,p'-DDE concentrations in age 7 and 8 fish were around $1000 \mathrm{ng} / \mathrm{g}$ in 2003 and 2007. A p,p'-DDE decline of $86 \%$ occurred for age 4 and 5 lake trout between 1983 and 2007 .

In Cayuga Lake, p,p'-DDE concentrations, like PCBs, showed an initial decline of 28 to 43 percent, followed by a near doubling of levels, then another decline of 50 to 61 percent (Table 12). In age 4 fish, $\mathrm{p}, \mathrm{p}^{\prime}$-DDE concentrations progressed from 124 to 70 to 110 to 55 to $37 \mathrm{ng} / \mathrm{g}$, while in age 5 fish the levels went from 180 to 129 to 207 to 80 to $41 \mathrm{ng} / \mathrm{g}$. When compared with PCB, the temporal pattern is identical, and although the size of the initial decline is smaller, the following increase and decline in concentrations are of the same magnitude. Unlike PCB, lipid content was not as decisive a factor in changes in p,p'-DDE levels (Figure 14). Overall, there has been a average 66 percent decline in $\mathrm{p}, \mathrm{p}^{\prime}$-DDE concentrations.

In contrast to the other four lakes, Canandaigua Lake experienced initial declines in p,p'-DDE concentrations across all ages between 1983 and 1994, averaging 81\%. Then a reversal of the decline showed increases ranging up to 61 percent for age 8 fish and 185 percent for age 7 fish; the average increase between 1994 and 2002 was 112 percent which approximates a doubling of 1994 p,p'-DDE levels. In 2009, p,p'-DDE declined to the lowest levels recorded for the lake (Table 12). An illustrative example is the age 6 fish which had $862 \mathrm{ng} / \mathrm{g}$ in 1983, then declined to $92 \mathrm{ng} / \mathrm{g}$ in 1994, followed by an increase to $242 \mathrm{ng} / \mathrm{g}$ in 2002 and a decline to 71 $\mathrm{ng} / \mathrm{g}$ in 2009. The temporal pattern was identical to that of PCB. Overall, from 1983 to 2009, there has been a average 87 percent decline (range 80 to $92 \%$ ) in $\mathrm{p}, \mathrm{p}$ '-DDE levels on a wet weight basis.

## Chlordane and trans-nonachlor

Total chlordane concentrations (Table 15; Figures 7 through 11) are comprised principally of trans-nonachlor and to a lesser extent cis-chlordane (Table 13). Oxychlordane and trans-chlordane concentrations were near the detection limit in the mid 1980's but after the early years of measurement they were seldom found in detectable quantities. Detection limits were generally $5 \mathrm{ng} / \mathrm{g}$ for each chlordane analyte except oxychlordane which had detection limits of 5 or $10 \mathrm{ng} / \mathrm{g}$ (Table 14). For the 2002 through 2008 collections, cis-nonachlor was also determined but was not detected or seldom detected (Table 5). The concentrations of cisnonachlor were not included in summary tables so that total chlordane data comparability is
preserved.
While total chlordane values are reported in Table 15, the use of one-half the detection limit for statistical computations involving non-detectable analytes frequently obscures trends. Therefore, trans-nonachlor, a primary chlordane degradation product (Table 13), was used for trend analysis (Table 16). Due to the differing trends in trans-nonachlor concentrations, the relative ranking of the lakes has changed over time. In the mid 1980s the rankings were approximately Keuka $>$ Cayuga $=$ Seneca $>$ Canadice $>$ Canandaigua, whereas in 2006-2009 period the ranking best approximates Cayuga $>$ Keuka $=$ Seneca $=$ Canandaigua $>$ Canadice. In fish from Keuka and Canandaigua Lakes, trans-nonachlor did not decline as rapidly as in fish from the remaining lakes.

As with PCB, DDT and DDE, a positive age-trans-nonachlor relationship exists (Table 17). However, the relationship disappears as the analyte concentrations approach detection limits.

Canadice Lake had the second greatest concentrations of trans-nonachlor in older lake trout (ages 7 and 8) during the mid-1980s with mean levels up to $146 \mathrm{ng} / \mathrm{g}$. From 1984 to 2003, trans-nonachlor declined to non-detection (less than $5 \mathrm{ng} / \mathrm{g}$ ) in all but the oldest fish; age 8 fish had an average $10 \mathrm{ng} / \mathrm{g}$. Declines exceeded 90 percent (Table 16; Figure 17).

Similarly, Keuka and Seneca Lakes have shown dramatic declines in trans-nonachlor. In 1985 , older Keuka Lake fish contained the greatest (up to $200 \mathrm{ng} / \mathrm{g}$ ) trans-nonachlor concentrations of the five lakes but declines of 80 to 90 percent have reduced the levels to 30 $\mathrm{ng} / \mathrm{g}$ or less by 2007 (Table 16; Figure 20). Indeed, trans-nonachlor is seldom detected in younger fish. Seneca Lake has shown declines of 40 to 50 percent in the 23-year period with levels in older fish (age 8) declining from $83 \mathrm{ng} / \mathrm{g}$ to $13 \mathrm{ng} / \mathrm{g}$ ( $84 \%$ ), and in young fish (age 4) declining from 17 to $4.9 \mathrm{ng} / \mathrm{g}$ ( $71 \%$ ) (Table 16; Figure 21).

Cayuga Lake fish displayed the more complex cycling of trans-nonachlor with high values occurring in 1985 and 1991 alternating with low values in 1988, 1995 and 2007. The pattern mimics PCB and p,p'-DDE in the lake. Overall, a concentration decline has occurred from 1985 to 1995 of about 60 percent and by 77 percent between 1985 and 2007, but the alternating high and low concentrations confound the observation (Table 16; Figure 19).

Trends in levels of trans-nonachlor in Canandaigua Lake lake trout mimic those found for PCB and p,p'-DDE (Table 16). Concentrations in 1985 ranged from averages of $25 \mathrm{ng} / \mathrm{g}$ and $36 \mathrm{ng} / \mathrm{g}$ in age 5 and 6 fish, respectively. Declining concentrations ( 60 to 70 percent) occurred from 1985 through 1994 followed by increasing concentrations through 2002 to levels approximating those present in 1985 (Figure 18). In 2006, trans-nonachlor levels returned to levels observed in 1994 and continued to decline through 2009. In age 5 and 6 fish, the most recent trans-nonachlor concentrations were $5.8 \mathrm{ng} / \mathrm{g}$ and $6.0 \mathrm{ng} / \mathrm{g}$ representing declines of 77 and 83 percent, respectively.

## Mercury

Mercury has been measured with a lower frequency than PCBs and the organochlorine pesticides. As with the other analytes noted above, there are generally increasing mercury concentrations with increasing age of lake trout (Table 18), although for older fish (greater than age 7) there is a tendency for loss of significance in mercury concentrations with increasing age as the variability in mercury concentrations increases or in some areas as the uncertainty of the aging increases. Mercury concentrations were generally less than $500 \mathrm{ng} / \mathrm{g}$ in all but the oldest fish. From 1983 to the present there were no consistent temporal changes in mercury concentrations in the five lakes, although there was year to year variability in mercury levels within age groups (Table 19, Figures 22 and 23). In Seneca Lake, mercury concentrations were stable over time. Young fish in Canadice Lake had stable mercury levels but in older fish mercury values initially declined between 1990 and 1998 but then increased in recent years to levels experienced in 1990. Lake trout in Canandaigua and Keuka Lakes showed increases in mercury concentrations at all ages through 2007 but in 2009 mercury in Canandaigua Lake declined to levels near those found in 1988 through 1994. In Cayuga Lake, mercury levels also tended to be greatest in recent years but the comparison is limited to two age classes. The changes in mercury concentrations cannot be explained by the change in analytical methodology.

The general ranking of lakes by mercury concentration for years 1988 through 1994 was Cayuga $>$ Seneca $>$ Canandaigua $=$ Keuka $=$ Canadice. In the most recent collections, the ranking changed to Seneca $=$ Cayuga $>$ Keuka $=$ Canandaigua $>$ Canadice.

## Mirex

Mirex was used for fire ant control in southeastern United States and used experimentally as a flame retardant in cork or on children's clothing. It is not known to have been used within the Finger Lakes drainage basin although mirex was produced in Niagara Falls and used at several locations within the Lake Ontario drainage basin. Mirex would not be anticipated to be detected in Finger Lakes fish in the absence of long range aerial transport. Mirex is readily found in fish taken from Lake Ontario, a distance of 42 to 70 kilometers ( 26 to 44 miles) north of the five Finger Lakes addressed here. Except in 1984 for Canadice Lake fish, mirex was not measured in the 1983 to 1985 lake trout collections. Since then, mirex has been found sporadically in lake trout from each of the five Finger Lakes studied although it is generally absent since 2000 (Table 20). Mirex has been documented in some fish from other Great Lakes, particularly for Lakes Erie and Huron (Sergeant et al., 1993). As described for fish from the upper Great Lakes, mirex concentrations in Finger Lakes fish are generally at concentrations that are one percent or less of the concentrations found in fish taken from Lake Ontario. The presence of mirex in Finger Lakes fish further documents the probable aerial transport of this compound from Lake Ontario to regional waters.

## Dieldrin

Dieldrin was often at concentrations near or below analytical detection limits (5 to 10 $\mathrm{ng} / \mathrm{g}$ ), especially for younger lake trout in all five lakes (Table 21). For younger fish (ages 3 through 6), changes in the frequency of non-detection of dieldrin may be as good an indicator of trends in concentration over time as any other method of evaluation. Canandaigua, Cayuga and Keuka Lakes experienced increasing non-detection of dieldrin. In Seneca Lake non-detection was at a low and stable rate through 1991. Canadice Lake experienced variable rates of detection. Where significantly higher levels of dieldrin were detected they generally occurred in fish aged 7 and 8 years old (e.g., Canadice, Canandaigua and Keuka Lakes) (Table 22).

## Hexachlorobenzene (HCB)

HCB concentrations (Table 23) were generally within a factor of two of the detection limit ( $2 \mathrm{ng} / \mathrm{g}$ ) in nearly all samples from all five lakes, and less than the detection limit in most samples since 2000. However, the 1984 Canadice Lake lake trout showed more elevated levels of HCB with up to an average of $44 \mathrm{ng} / \mathrm{g}$ in age 8 fish. Few HCB detections occurred thereafter. The HCB declines in Canadice Lake ranged from 80 to 98 percent.

## Lipid, PCB, organochlorine pesticide and mercury data for fish over 8 years old

The discussions and data tables presented previously considered PCB, organochlorine pesticide and mercury data for lake trout of ages 3 through 8 only, although examination of agecontaminant relationships included fish over 8 years old where sample numbers were sufficient for the analysis (minimum of 3 samples per age). Sample numbers for older fish are often very limited; thus the lack of inclusion in discussions elsewhere. The contaminant data for the older fish are summarized in Table 24.

Based on age-contaminant relationships in Tables 7, 11, 17 and 18, there appears to be substantial overlap of chemical residue concentration distributions by age among older fish. Older lake trout of ages 9 through 12 frequently have chemical residue concentrations similar to their age 7 or 8 year old counterparts.

## DISCUSSION

## Comparisons with historical data

Armstrong and Sloan (1980) first described apparent trends in chemical residue concentrations in fish on a statewide or regional basis within New York. This has been followed by reports for specific waters, e.g., for PCBs in the Hudson River (Sloan et al., 1995 and 2005), 2,3,7,8-tetrachlorodibenzo-p-dioxin in young fish below Love Canal (Skinner, 1993), PCBs, DDT and dioxins in New York Harbor (Skinner, 2001; McReynolds et al., 2004a, 2004b), PCBs, mirex and dioxins in Lake Ontario (DeVault et al., 1996; Scheider et al., 1998; Makarewicz et al., 2003; Hickey et al., 2006; O'Keefe et al., 2006), and PCBs in Long Island Sound (Skinner et al., 2009). Among the Finger Lakes, Cayuga Lake has the longest history of chemical residue measurements in aged lake trout. The ability to make temporal comparisons of historical information with the data generated for this study could yield further insights into changes in residue levels. However, the data must be used with caution due to differences in the portions of fish analyzed and differences in analytical methods and instrumentation.

## Sample portions

Chemical residue concentrations in Cayuga Lake lake trout reported for the period 1968 through 1970 were determined in whole fish (Bache et al., 1971; Bache et al., 1972; Youngs et al., 1972), in contrast to whole fish minus head, viscera and fins used for the 1978 determinations (Wszolek et al., 1979) or the standard fillets (skin on, scales off) in this study. Wszolek et al. (1979) stated that after removal of head, viscera and fins, "the remaining edible portion" was taken for analysis; therefore, it is uncertain whether the vertebrae, ribs and scales were included in the preparation of the samples. Fish analyzed as whole minus head and viscera most closely approximate standard fillets.

The portions taken for chemical analysis may affect the analytical outcome based on the mechanism for binding the chemical residue to the flesh. For PCB and organochlorine pesticides, including DDT compounds, the compounds are bound to lipids and since lipid concentrations vary in different portions of the fish, the resulting chemical residue concentrations will tend to vary with the lipid content of the portion analyzed. Fatty organs (such as the liver) and fatty deposits within the body cavity will enhance the concentrations of these compounds reported for whole fish. Sloan et al. (1987a) reported concentrations of PCBs and organochlorine pesticides in fillets, carcass and the reconstructed whole lake trout from Lake Ontario taken in 1980, 1981 and 1985. In 1980 and 1981, whole fish concentrations could be approximated by multiplying fillet concentrations by 1.2 , whereas in 1985 a factor of 1.4 would be more appropriate. Further, the impact of depositional location of lipids was demonstrated by Skea et al. (1979) and Voiland et al. (1991) for brown trout (Salmo trutta) where PCB, DDE and mirex residue concentrations were reduced by 43 to 52 percent by trimming the skin and fatty deposits from the fillet, and by Zabik and Zabik (1995) where similar trimming reduced 2,3,7,8TCDD residue levels by about 62 percent in lake trout. Based on this information, any
comparisons of the PCB and DDT compounds residue data for the period 1968 through 1970 to later studies cannot be made without adjustment of the earlier data. Therefore, for potential trend comparisons, the Bache et al. (1972) and Youngs et al. (1972) data have been reduced by 30 percent to estimate standard fillet residue concentrations. The original data are also presented (Table 25 for PCBs and Table 26 for total p,p'-DDT and p,p'-DDE).

The differing portion of fish used in the analysis of mercury are of less concern. Mercury is bound to protein of fish and other organisms (Gutenmann and Lisk, 1991). Therefore, the distribution of mercury within the body is expected to be relatively uniform. Gutenmann and Lisk (1991) showed what appeared to be higher levels of mercury in brown trout fillets following skinning "but the increases were not significant ( $\mathrm{p}<0.05$ ) using Duncan's multiple range test". Based on the apparent comparability of the data, mercury concentrations (Table 25) can be compared, without adjustment, among the differing sample preparation methods.

## Analytical methods

Analytical methods for PCB and DDT compounds have improved dramatically in the period circa 1970 to the present time. Gas chromatography was in its infancy at the time of the original measurements of these compounds. The original analytical methods employed by Bache et al. (1972) and Youngs et al. (1972) are not well described but instrumentation was indicated as being "electron affinity gas chromatography" (interpreted to be GC with electron capture detectors - GC/ECD - which current instruments employ) but the columns prior to the detector were different. The original studies used a U-shaped borosilicate glass tube 7 mm inside diameter (i.d.), 6 ft . long with packing a mix (equal weights) of $10 \% \mathrm{DC}-200$ on 100-200 mesh Gas Chrome Q and $15 \%$ QF-1 on Gas Chrome Q and operated at $200^{\circ} \mathrm{C}$. The short column, large column bore and the packing mix are now known to be insufficient to cause full separation of all analytes that may be present. Therefore, interference by other chemical residues may have occurred and reported concentrations may be biased high. Wszolek et al. (1979) did not report full analytical methods, but they used GC/ECD with a somewhat improved column, i.e., a glass column 4 mm inside diameter, 2 m long and packed with $3 \%$ OV-17 on 100/120 mesh Gas Chrome Q and operated at $185^{\circ} \mathrm{C}$. Resolution may be better due to the smaller column inside diameter and better packing materials. Further, Wszolek et al. (1979) confirmed the presence and approximate concentrations of PCBs and the DDT compounds by use of GC/mass spectrometry. Therefore, due to confirmation by GC/MS, their reported concentrations are considered reliable and without a need for adjustment. In the current study, GC/ECD continues to be employed but with a capillary column 0.25 mm i.d. and 60 m long. Temperature was ramped from $200^{\circ} \mathrm{C}$ to $350^{\circ} \mathrm{C}$ over a period of 45 minutes (Method OC1.105; the full methods are described in Appendix 1). The long, small diameter column and higher analytical temperatures provide excellent separation of most analytes for subsequent quantification.

Bache et al. (1971) analyzed whole lake trout for mercury using the cold vapor technique of Hatch and Ott (1968). This analytical method is the general basis for future methods of
mercury analyses including the analytical method in this study. The instrumentation used by Bache et al. (1971) was less sensitive to low mercury concentrations than current analytical instruments, but the differences in equipment are inconsequential since mercury residues in most fish were considerably greater than the detection limits of all instruments employed. Therefore, the mercury data generated by the differing analytical methods for all studies with lake trout from Cayuga Lake are believed to be directly comparable without significant reservation.

## Temporal changes

Since the mid 1980s, concentrations of PCBs, DDT compounds, chlordane analytes and other organic compounds have declined by 70 percent or more in lake trout from each of five Finger Lakes, i.e., Canadice, Canandaigua, Cayuga, Keuka and Seneca Lakes. The patterns of decline vary among the lakes and the analytes. Despite the declines, concentrations of PCBs in Canadice Lake and total DDT residues in Keuka Lake lake trout remain above concentrations considered acceptable for human consumption (NYSDOH 2009). In contrast to organic chemicals, mercury concentrations in lake trout from Cayuga and Seneca Lakes have remained relatively stable during the study period, but in Canadice, Canandaigua and Keuka Lakes and increase in mercury concentration of about 40 percent has occurred since the 1990s.

For temporal comparisons of aged lake trout from Cayuga Lake, as noted previously, the data of Bache et al. (1972) for PCBs, and Youngs et al. (1972) for p,p'-DDE have been reduced by 30 percent while the data of Wszolek et al. (1979) and the current studies are unchanged. These comparisons show significant declines in both PCB and p,p'-DDE have occurred between the period 1970 and 1995 for PCBs (Figure 24) and between 1968 and 1995 for p,p'-DDE (Figure 25). The data suggest the average declines are approximately 96 percent each (equivalent to nearly two orders of magnitude) for PCB and p,p'-DDE in lake trout of ages 4, 6, 7 and 8 . The decline is also reflected in total p,p'-DDT concentrations.

Burdick et al. (1964) provided limited data for DDT and DDE in a small sample in unaged reproductive female lake trout (lengths and weights were not reported) taken from Seneca Lake in the years 1960 through 1962. The analyses of DDT were conducted by a colorimetric method (the Schecter-Haller method after Schecter et al. (1945)) for which estimated concentrations may be less reliable than more recent analytical methods. In addition, the sample portion analyzed was a one-half inch section taken anterior to the anal opening, a sample portion that is not comparable to methods in this study. The mean and standard deviation concentrations for each year for DDT and DDE in fillets ( $\mathrm{n}=3$ in each year) were:

|  | Concentration $(\mu \mathrm{g} / \mathrm{g}$ wet weight $)$ |  |
| :--- | ---: | ---: |
| Year |  | $\mathrm{DDT}^{*}$ |
| 1960 |  |  |
| 1961 | $8.83 \pm 4.57$ | $19.97 \pm 6.36$ |
| 1962 | $5.07 \pm 2.67$ | $14.63 \pm 4.92$ |
|  |  | $6.67 \pm 5.51$ |

*DDT and DDD (a DDT metabolite) had similar color absorbency, therefore, DDT levels may reflect DDD concentrations as well. This possible interference would produce a probable overestimate of DDT concentrations.

Despite the lack of comparability with current methods, the reported concentrations suggest concentrations of DDT compounds were significantly higher during the period of active DDT usage within the drainage basin, and the concentrations may have been declining in the period examined, although sample size was small.

Bache et al. (1971) was the first to report a positive age-mercury relationship in lake trout (Figure 23) and that general relationship continues to be observed for essentially all mercury data where ages of fish have been determined. Comparison of mercury data for Cayuga Lake lake trout aged $4,6,7$ and 8 years (the only ages with three or more samples in each age group in each study) suggests an apparent decline in mercury concentrations averaging 42 percent (ranging from 29 to 49 percent) between 1970 and 1995 and 47 percent for the period 1970 to 2007 for age 4 fish (Tables 19 and 25). The apparent declines occurred between 1970 and 1988.

Mercury concentrations have increased in recent collections of lake trout from three of the five lakes studied (i.e., Canadice, Canandaigua and Keuka Lakes). The causes of the increases are not known but several factors must be considered. Electric utilities remain the major source ( 72 percent) of total air emissions of mercury ( $89,444 \mathrm{lbs}$ in 2008) in the United States (USEPA 2009). Total mercury emissions in the United States have declined nearly 19 percent from about 152,900 lbs in 2001 to about 124,500 lbs in 2008 (mercury emissions reporting from electric utilities was not required until 1998) (USEPA 2009). Modeling of mercury air transport suggests some of the lowest total mercury deposition rates occur over Cayuga and Seneca Lakes ( 5 to $8 \mu \mathrm{~g} / \mathrm{m}^{3} / \mathrm{yr}$ ) while total mercury deposition rates over the remaining three Finger Lakes are about three times higher (Miller et al. 2005).

New York has few significant sources of air emissions of mercury. There are coal-fired power plants near or within (AES Greenidge Power Plant on Seneca Lake and AES Milliken Station on Cayuga Lake) the Finger Lakes basin, some present for over 50 years. One of the more recent new sources of mercury is the AES Somerset coal-fired power plant that became operational on the shores of western Lake Ontario in 1984 and is located 65 to 90 miles northwest of the three lakes. Annual mercury emissions of up to 67 lbs per year have been reported, but whether this is a significant source to the Finger Lakes is uncertain.

## Hemlock Lake

Hemlock Lake is the only undeveloped Finger Lake, and is a water source for the City of Rochester, located on the western extent of the Finger Lakes (Figure 26). As a consequence, the lake might be considered a "reference lake". However, the lake does not appear to be a true reference lake in that levels of DDT and metabolites were elevated from 1969 through at least 1984 (Table 27), likely due to its use within the drainage basin prior to the statewide ban on DDT use in 1970. The current primary source of other organic chemicals, and likely much of the mercury, is via aerial transport and deposition.

Chemical residues in aged lake trout were determined in fish collected in 2002 and 2007 (Table 27). PCBs, DDT and metabolites, chlordane compounds, and mercury were present, but with the exception of DDT compounds, the concentrations were comparable with the lowest levels observed in other Finger Lakes for the time period examined. Total DDT and particularly DDE concentrations were greater than most of the other Finger Lakes - similar to the elevated DDT concentrations in Keuka Lake - which may reflect the long recovery time following DDT use. No significant changes in concentrations have occurred between 2002 and 2008. However, over the 38 year year record, DDT concentrations appear to have declined by at least 95 percent. As with the other lakes, chemical residue concentrations increased with age of fish.

## Other Finger Lakes

Lake trout have been collected in Owasco, Otsego and Skaneateles Lakes (Table 27). The fish were not aged, therefore, temporal comparisons of residue data in aged fish was not possible. However, it is evident that declines in PCBs, DDT, chlordane and HCB have occurred and are frequently 70 percent or more.

## Remedial efforts

In 1975, lake trout from Canadice Lake contained no detectable PCBs (Spagnoli and Skinner 1977). By 1984, PCB levels in lake trout had increased dramatically; some larger lake trout contained in excess of $20,000 \mathrm{ng} / \mathrm{g}$ PCB. That year, in the Canadice Lake drainage basin, on tributary 5a (noted incorrectly as tributary 13C on the Department website), located on the southeastern portion of the drainage basin, a small transformer and capacitor metals reclamation site was discovered. A private landowner salvaging metals from electrical components drained PCBs and other liquids contained within transformers and capacitors onto the ground near an intermittent tributary of the lake. The devices were then disassembled to reclaim metals for sale as scrap metal. In 1985, the Department caused cessation of the unregulated activities, removal of metals and other wastes, and began removal of contaminated soils; final clean-up was completed in February 1987 (William Abraham, personal communication, October 27, 1994; NYSDEC 2010). Declines in PCB concentrations in lake trout from Canadice Lake (Table 8) may be related to elimination of this active PCB source. Other sources of PCBs to the lake are
not known. Residuals of PCBs within the lake appear to still contribute to elevated and unacceptable PCB levels within lake trout.

Active use of DDT within the Keuka Lake drainage was evident in the elevated DDT concentrations in lake trout in 1970 (Table 28) and levels of total DDT in excess of $5000 \mathrm{ng} / \mathrm{g}$ were present until at least 1991 (Table 10). Because levels of DDT were remaining higher than expected following the statewide ban on all DDT use in 1970, another source of DDT was suspected. In 1982, it was learned that dicofol may have been used in vineyards as a miticide. Dicofol is produced from DDT and could then contain up to $15 \%$ DDT as a contaminant of the pesticide product. Fluke et al., (1982) suggested dicofol usage was limited to about 900 acres of vineyards in New York and Pennsylvania combined, which suggests dicofol use on vineyards in the Finger Lakes was much smaller. The US Environmental Protection Agency suspended use of dicofol in 1986 but reinstated its use in 1998 with the provision that DDT could not exceed 0.1 percent of technical grade dicofol. Currently, dicofol is not registered for use in New York (Tim Sinnott, NYSDEC, personal communication). Some active use of DDT may have occurred as late as the early 1990s based on an anonymous phone call to the Department in which the caller stated he had applied about 400 lb of DDT in the Keuka Lake area (Gail Mortimer, Region 8 Pesticide Inspector, personal communication March 15, 2010). However, sufficient information was lacking which prevented conduct of an investigation and a determination of the veracity of the call. Residues of DDT in lake trout declined through the 1990s, suggesting an application did not occur. In 1996 through 1999, trackdown of the potential sources of elevated DDT levels in Keuka Lake was conducted in tributaries of the lake (Preddice et al. 1997; Spodaryk et al. 1998 and 2000). In PISCES samplers, elevated DDT levels were found at the mouth of Brandy Brook near Keuka Park but not at other tributaries of the lake having flowing water. An examination of the affected drainage on foot failed to disclose a source of the DDT. Based on the foregoing, the declines in total DDT concentrations in Keuka Lake lake trout appear to be related to the ban on DDT usage and, possibly, the cessation of dicofol use on vineyards.

Burdick et al. (1964) reported agricultural use of DDT within the drainage basin of Seneca Lake. However, the amount of DDT used could not be quantified. Armstrong and Sloan (1980) reported DDT levels in Seneca Lake initially declined between 1970 and 1976 then appeared to increase in 1978. This observation triggered, in 1981, a special investigation of tributaries of Seneca Lake to identify potential sources of DDT to the lake. Six tributaries in the southeastern portion of the lake basin contained detectable levels of DDT residues in sediments. Searches of the basins failed to identify specific DDT sources. In 1982, a new landowner reported to the Department the discovery of a DDT cache on a tributary in Hector, NY. Upon investigation, about 555 lbs of DDT packaged in rusting 5 lb steel cans - some cans had ruptured and were losing DDT - were found in a pile covered with vines and vegetation on the banks of the tributary. The Department required the landowner to conduct rapid removal of the DDT and removal of contaminated soils and debris in the area of the pile. All wastes were handled by trained personnel and sent to a regulated hazardous waste treatment facility (NYSDEC 1982). Declines in DDT concentrations in lake trout from Seneca Lake may, in part, be related to removal of the active DDT source as well as the statewide ban on DDT use instituted in 1970.

## A possible role of zebra mussels?

The study of the impacts of zebra mussels (Dreissenia polymorpha) has been limited primarily to very large lakes (e.g., the Great Lakes), or to large rivers (e.g., Niagara, St. Lawrence and Hudson Rivers). However, studies on several Finger Lakes have been conducted.

Zebra mussels are an introduced species within the Finger Lakes drainage basin. Introductions were first confirmed in 1991 in Seneca Lake, 1994 in Canandaigua and Keuka Lakes, but no confirmed infestation was known in Canadice Lake through 1998 (Pearsall and Richardson, 2001) although zebra mussels were reported by personnel with the City of Rochester as present in 2008 (Webster Pearsall, personal communication). Zebra mussels were introduced to Cayuga Lake in the early 1990s but the precise year is not known. Burlakova et al. (2006) note that zebra mussels may be present for several years before their populations reach densities large enough to be detected. Pearsall (personal communication) has indicated that zebra mussel populations expanded rapidly in Canandaigua Lake to a maximum in 2000 followed by a population crash in 2001, then population rebuilding through 2006. In Keuka Lake a similar zebra mussel population crash may have occurred in 2004 but it is unconfirmed. In other Finger Lakes having zebra mussels, none of the lakes are known to have experienced this population cycle (Pearsall, personal communication).

Zebra mussels are capable of restructuring the vertical aquatic food web into a benthic dominated food web thereby causing energy resources to be driven towards the benthic community. Canandaigua Lake is known to have experienced a 63 to 89 percent increase in water clarity, a reduced lake trout population, changes in the zooplankton community, and, based on anecdotal evidence, an increase in the crayfish population. In Keuka Lake, changes in the structure of zooplankton communities and the alewife populations that depend on them for food have been suggested since the alewife and smelt populations were experiencing record low numbers. However, a direct causal link could not be established since data on zooplankton populations prior to introduction of zebra mussels were lacking. These effects are consistent with observations in other waters, i.e., increased water clarity, reduced algal volume and reduced suspended particle size (Idrisi et al., 2001; Makarewicz et al., 1999; Zhu et al., 2006; Howell et al., 1996), nutrient shifts to the benthic community (Johengen et al., 1995; Makarewicz et al., 2000), changes in benthic community structure including greater mass comprised primarily of added mass of zebra mussels (Ward and Ricciardi 2007; Haynes et al., 2005; Dermott and Kerec, 1997; Howell et al., 1996), and changes in submerged macrophyte communities (Zhu et al. 2006). These examples are suggestive that an oligotrophication process is on-going since the introduction of zebra mussels to these two lakes (Pearsall and Richardson, 2001). This process has been described as "benthification" (Zhu et al., 2006).

The impact of the presence of zebra mussels on contaminant dynamics is inconclusive. Metals concentrations in zebra mussels were not related to concentrations of metals in sediments (Rutzke et al., 2000; Lowe and Day, 2002), but transfer of metals by zebra mussels from the
water column to sediment has been shown (Klerks et al., 1997). Metals in zebra mussels were related to known point sources of pollution in the St. Lawrence River (Kwan et al., 2003) but in the Niagara River a relationship to point sources was not shown although significant variations between sampling sites were found (Richman and Somers 2005). With regard to organic chemicals, zebra mussels enhanced the transfer of chlorinated dioxins and furans and dioxin-like PCBs from water to sediment (Marvin et al., 2002). In the Niagara River, concentrations of $\alpha$ BHC and two trichlorobenzenes in zebra mussels from the American side of the river were greater than on the Canadian side, and similarly, in quagga mussels ( $D$. bugensis) PCBs, octachlorostyrene, pentachlorobenzene and hexachlorobenzene were at greater concentrations on the American side of the river and may be reflective of sources at US chemical industries (Richman and Somers 2005, 2010).

Only one study was found that addressed chemical transfers to fish. The presence of zebra mussels did not alter mercury transfer to predatory fish, i.e., smallmouth bass (SouthwardHogan et al., 2007). Therefore, the impact of zebra mussels on chemical relationships in fish has not been addressed sufficiently.

Lesser scaup (Aythya affinis) and greater scaup (A. marila) feed on aquatic invertebrates, including zebra mussels. At least three studies (Custer and Custer 2000; Fox et al., 2005; Petrie et al., 2007) have examined chemical residues in these waterfowl species. Of 18 trace elements, only selenium concentrations were shown to be elevated and are of toxicological concern. The remaining elements were at background or below no-effect levels suggesting no impact due to the consumption of zebra mussels. Of organic chemicals, PCBs and p,p'-DDE were present but at levels well below effects concentrations, although PCBs did exceed the US Food and Drug Administration's action level of $3.0 \mu \mathrm{~g} / \mathrm{g}$ in lipid of poultry. Other organochlorine pesticides were generally not detectable. Again, a change in chemical residue concentrations due to the presence of zebra mussels appears unlikely.

The previous discussion suggests chemical residue uptake may be mediated though interaction with trophic structure. The growth of the zebra mussel population in Canandaigua Lake is coincident with the increases in chemical residue levels (PCBs, DDT compounds, transnonachlor and mercury) in lake trout. Similarly, in Keuka Lake the changes in residues of PCBs may be coincident with zebra mussel population status but the potential linkage is even more tenuous. However, the concurrent changes in an array of chemical residues in lake trout suggest that some unifying environmental factor may be at work. The only known common factor is the introduction of zebra mussels.

Several hypothetical scenarios may be possible which suggest zebra mussels may have some influence on chemical residue levels in lake trout. The hypotheses have not been tested so their validity is unknown. The three hypotheses are advanced for future consideration:

- the change in trophic structure may trigger release of nutrients and chemical residues from the sediments which are then accumulated by biota, including lake trout;
- because of the changes in trophic structure toward stronger benthic communities, there is less biomass in the water column to accumulate the available chemical residues present within the ecosystem, therefore, greater residue concentrations in biota may be anticipated; and
- with regard to mercury, the accumulation of zebra mussel waste products at the sediment-water interface may change water chemistry near the sediment-water interface to favor growth of anaerobic bacteria which would promote conversion of dissolved inorganic mercury to methylmercury, the form of mercury accumulated by fish.
However, the findings of Southward-Hogan et al. (2007) suggest this hypothesis may be tenuous, at best.

In addition to these hypotheses, there may be an interplay between biomass, available habitat for zebra mussels (including water chemistry parameters such as available calcium), and lake volume that may affect the ability of a specific water to experience measurable changes in chemical residues within biota.

## CONCLUSIONS

A number of general conclusions are apparent, including:

- there is a positive age-chemical residue relationship for all residues where detectable concentrations are available for all ages. However, the relationship breaks down as residues approach or fall below the detection limit. The positive age-chemical residue relationship is consistent with observations for other fisheries.
- overall, there have been declines in organic chemical residues in all the five lakes studied, i.e., Canadice, Canandaigua, Cayuga, Keuka and Seneca Lakes. However, residues of some compounds and mercury appear to have increased in lake trout Canadice, Canandaigua and Keuka Lakes in recent years.

The patterns of change in chemical residues have not been consistent between lakes. Overall, there is a sharp decline into the 1980s or 1990s followed by relative stability or a rise in concentration. The patterns are addressed separately below.

## PCBs and organochlorine pesticides

The following summarizes chemical residue observations on a wet weight basis. Because PCBs and organochlorine pesticides preferentially accumulate in lipids, Figures 2 through 6 and 12 through 21 present the information on a lipid basis, thereby reducing the impact of variable lipid concentrations. Observations for $\mathrm{p}, \mathrm{p}$ '-DDE are generally applicable for total $\mathrm{p}, \mathrm{p}$ '-DDT residues and, similarly, changes in trans-nonachlor are applicable to total chlordane, due to these two compounds comprising the majority of the residues of their respective analyte totals.

- Canadice Lake lake trout contained the highest PCB concentrations of all five lakes in 1984 with levels of 10 to 20 ppm in fish 7 or 8 years old. By 2003, PCB levels had declined by at least 65 percent in younger fish and by about 90 percent in the 7 and 8 year old fish. In 2008, PCB levels increased by about double. Similarly, Canadice Lake fish (along with Keuka Lake lake trout) had the greatest trans-nonachlor concentrations in 1984 but the levels have declined by 90 percent or more; trans-nonachlor is now non-detectable (less than $5 \mathrm{ng} / \mathrm{g}$ ) in most lake trout. p,p'-DDE concentrations have declined across all ages by 67 to 92 percent (average 80 percent).
- From 1983 through 1994, Canandaigua Lake lake trout experienced declining concentrations of PCBs, p,p'-DDE, and trans-nonachlor, with declines of 89,80 and 66 percent, respectively. Between 1994 and 2006, concentrations of the organic compounds increased by doubling in concentration, or more in some cases. In 2009, residues of these organic compounds again declined. Over the entire period (1983 through 2009), residue concentrations of PCBs, p,p'DDE and trans-nonachlor declined an average of 89,87 and 80 percent, respectively.
- Between 1985 and 2007, Cayuga Lake lake trout have shown declines in PCB and p,p'-DDE of about 80 percent and 66 percent, respectively. Data generated by other studies for the 1968 to 1970 period are not comparable to values from 1985 and thereafter. Adjustments of the historic data in an attempt to achieve data comparability suggest declines in PCB and p,p'-DDE concentrations from 1968-70 through 2007 have exceeded 95 percent. Concentrations of transnonachlor declined by about 70 percent between 1985 and 1995. In the period from 1985 to 1995, concentrations of detectable organic compounds have shown a "yo-yo effect" (alternating declines and increases) which appears to be related to significant changes in lipid content for these lipophilic compounds. Lipid normalized data dampened or eliminated the "yo-yo effect" and demonstrated declining chemical residue concentrations throughout the time period sampled in this study.
- Keuka Lake PCB concentrations were the lowest of any of the five Finger Lakes examined. PCB concentrations in younger fish (ages 4 through 6) showed declines from 1983 through 1991, then increased through 2000, declined in 2003, and increased in 2007. DDT compounds in this lake were the greatest of the Finger Lakes and declined dramatically from 1983 through 2007. trans-Nonachlor concentrations have declined to near non-detectable levels. Overall, concentrations of PCBs, p,p'-DDE and trans-nonachlor have declined by approximately 72,85 and 86 percent, respectively.
- In Seneca Lake, PCB, p,p'-DDE and trans-nonachlor concentrations declined approximately 87, 85 and 81 percent, respectively, across ages. In general, PCB concentrations are now below $200 \mathrm{ng} / \mathrm{g}$, DDE is less than $100 \mathrm{ng} / \mathrm{g}$, and trans-nonachlor is less than $20 \mathrm{ng} / \mathrm{g}$.


## Mercury

Concentrations of mercury in lake trout show differing patterns in each lake. Relative stability across all years and ages of lake trout was found in Seneca Lake. In Canadice and Keuka Lakes there was evidence of declines in mercury from the 1980s through the mid 1990s but then an increase in mercury concentrations has occurred in recent years. In Canandaigua Lake, mercury levels were stable from 1983 through 1994, but doubled in concentration through 2006 and declined in 2009. In Cayuga Lake, mercury concentrations were stable between 1988 and 2007. However, using historic data in literature, it is suggested that mercury levels may have declined between 1970 and 1988 by approximately 40 percent but remained stable thereafter.

## Health advisories

Residues of PCBs in lake trout from Canadice and Canandaigua Lakes and DDT in Keuka Lake fish were the source of health advisory recommendations to restrict human consumption of fish. The temporal declines in contaminant levels have caused relaxation of the health advisories, including abandonment of restrictive health advice for Canandaigua Lake lake trout. However, the increased levels of PCBs in Canadice Lake lake trout in 2008 have caused return of more
restrictive health advice, i.e, eat no lake trout greater than 23 inches, eat no more than one meal per month of smaller lake trout, and women of childbearing age and children under 15 years of age should not eat any fish from Canadice Lake (NYSDOH 2010). Additional reduction of DDT residues in Keuka Lake fish are required before the New York State Department of Health will cause further relaxation of health advice.

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Table 1: $\quad$ Recommended maximum concentrations of certain chemical residues in fish for the protection of human health.

| Chemicals | Agency or agreement concentration ( $\mathrm{ng} / \mathrm{g})^{1}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | USFDA | USEPA | GLWQO | Other |
| Polychlorinated biphenyls | 2000 | $50^{2}$ |  | $20^{3}$ |
| DDT + metabolotes |  | 5000 | 1000 |  |
| Chlordane |  | 300 |  |  |
| Dieldrin |  | 300 | 300 |  |
| Mirex |  | 100 |  |  |
| Hexachlorobenzene |  |  |  |  |
| Heptachlor + heptachlor epoxide |  |  |  |  |
| Lindane |  |  | 300 |  |
| Mercury | $1000^{4}$ | $300^{5}$ |  | $50^{6}$ |

[^1]Table 2: $\quad$ Recommended maximum concentrations of certain chemical residues in fish for the protection of fish-consuming wildlife.

|  | Concentration (ng/g wet weight) <br> Chemicals |  |
| :--- | :---: | :---: |
|  | Newell et al., 1987 | $\underline{\text { GLWQO}^{2}}$ |
| Polychlorinated biphenyls | 110 | 100 |
| DDT + metabolites | 200 | 1000 |
| Dieldrin | 120 | 300 |
| Chlordane | 500 | $\mathrm{nd}^{3}$ |
| Mirex | 330 |  |
| Hexachlorobenzene (HCB) |  | 500 |
| Mercury |  |  |

${ }^{1}$ Non-carcinogenic risk basis.
${ }^{2}$ Great Lakes water quality objective (IJC, 1988).
${ }^{3}$ No detectable concentration.

Table 3: Health advisories for human consumers of fish for fish taken from the Finger Lakes, New York.

| Lake | Fish species | Current health advice | Chemicals of concern | Date of first issuance | Changes over time? | Notes |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Canadice | Lake trout over 23 inches <br> Smaller lake trout, brown trout | Eat none. <br> Eat no more than one meal per month; women of childbearing age and children under 15 years of age should not eat any fish from this lake | PCBs | 11/15/1984 | Yes | Original advice: lake trout over 21" eat none; brown trout over 21" eat none added 5/27/1986; changed to lake trout and brown trout eat no more than one meal per month on 6/18/1999; changed to lake trout over 25 inches and brown trout eat no more than one meal per month on $4 / 14 / 2005$; changed to current advice on $5 / 28 / 2010$ |
| Canandaigua | All species | All people, eat no more than one meal per week (the statewide advisory) | None | 5/31/1983 | Yes | Original advice: lake trout over 30" eat none due to PCBs; changed to lake trout over 24 " on 5/24/1985; changed to current advisory on 7/6/2004 |
| Cayuga | All species | All people, eat no more than one meal per week (the statewide advisory) | None | 5/20/1971 | No |  |


| Keuka | Lake trout over 25 inches | Eat no more than one meal per month; women of childbearing age and children under 15 years of age should not eat any fish from this lake | DDT | 5/31/1983 | No |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Seneca | All species | All people, eat no more than one meal per week (the statewide advisory) | None | 5/20/1971 | No |  |
| Onondaga | Walleye | All people, eat none | Mercury | 5/15/1970 | Yes | Original restrictions on 5/15/1970: No fishing and eat no fish; fishing permitted 5/15/1986 but health advice continued to be eat none; advice for walleye separated from all other species on 6/18/1999; other chemicals of concern for carp and channel catfish added 7/10/2001 |
|  | Carp Channel catfish | Eat no more than one meal per month; women of childbearing age and children under 15 years of age should not eat any fish from this lake | Mercury, Dioxins, PCB | 7/10/2001 |  |  |
|  | All other species | Eat no more than one meal per month; women of childbearing age and children under 15 years of age should not eat any fish from this lake | Mercury | 6/18/1999 |  |  |
| All other <br> Finger Lakes <br> -Conesus <br> -Hemlock <br> -Honeoye <br> -Otisco <br> -Owasco <br> -Skaneateles | All species | All people, eat no more than one meal per week (the statewide advisory) | None | 5/20/1971 | No |  |

Table 4: $\quad$ Changes in the incidence of some organochlorine residues in lake trout taken from five Finger Lakes between 1983 and 2008.

| Lake <br> Canadice | Parameter <br> Year <br> n | \% incidence $>$ detection limit/maximum concentration ( $\mathrm{ng} / \mathrm{g}$ wet weight)/detection limit ( $\mathrm{ng} / \mathrm{g}$ ) |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{array}{r} 1984 \\ 21 \end{array}$ | $\begin{array}{r} 1987 \\ 44 \end{array}$ | $\begin{array}{r} 1990 \\ 45 \end{array}$ | $\begin{array}{r} 1993 \\ 33 \end{array}$ | $\begin{array}{r} 1998 \\ 17 \end{array}$ | $\begin{array}{r} 2003 \\ 76 \end{array}$ | $\begin{array}{r} 2008 \\ 46 \end{array}$ |  |  |
|  | HCB | $\begin{array}{r} 100 \\ 58 \\ 1 \end{array}$ | $\begin{array}{r} 9.1 \\ 11 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <2 \\ 2 \end{array}$ | 42 7 2 | 47 3 2 | $\begin{array}{r} 0.0 \\ <2 \\ 2 \end{array}$ | $\begin{array}{r} 0.0 \\ <2 \\ 2 \end{array}$ |  |  |
|  | Photomirex | na - - | $\begin{array}{r} 0.0 \\ <10 \\ 10 \end{array}$ | $\begin{gathered} 0.0 \\ <5 \\ 5 \end{gathered}$ | $\begin{array}{r} 0.0 \\ <2 \\ 2 \end{array}$ | $\begin{gathered} 0.0 \\ <5 \\ 5 \end{gathered}$ | $\begin{gathered} 0.0 \\ <5 \\ 5 \end{gathered}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ |  |  |
|  | cis-Chlordane | $\begin{array}{r} 100 \\ 84 \\ 2 \end{array}$ | $\begin{aligned} & 32 \\ & 39 \\ & 10 \end{aligned}$ | $\begin{array}{r} 20 \\ 42 \\ 5 \end{array}$ | 6.0 6 5 | $\begin{array}{r} 59 \\ 10 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 6.5 \\ 8 \\ 5 \end{array}$ |  |  |
|  | trans-Chlordane | $\begin{array}{r} 95 \\ 33 \\ 2 \end{array}$ | $\begin{aligned} & 6.8 \\ & 25 \\ & 10 \end{aligned}$ | $\begin{array}{r} 11 \\ 21 \\ 5 \end{array}$ | 4.1 8 5 | $\begin{array}{r} 53 \\ 11 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ |  |  |
|  | Oxychlordane | $\begin{array}{r} 100 \\ 25 \\ 2 \end{array}$ | $\begin{array}{r} 0.0 \\ <10 \\ 10 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <10 \\ 10 \end{array}$ | $\begin{array}{r} 0.0 \\ <10 \\ 10 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ |  |  |
| Canandaigua | $\begin{aligned} & \text { Year } \\ & \mathrm{n} \end{aligned}$ | $\begin{array}{r} 1983 \\ 43 \end{array}$ | $\begin{array}{r} 1985 \\ 19 \end{array}$ | $\begin{array}{r} 1988 \\ 35 \end{array}$ | $\begin{array}{r} 1991 \\ 70 \end{array}$ | $\begin{array}{r} 1994 \\ 60 \end{array}$ | $\begin{array}{r} 1998 \\ 39 \end{array}$ | $\begin{array}{r} 2002 \\ 41 \end{array}$ | $\begin{array}{r} 2006 \\ 42 \end{array}$ | $\begin{array}{r} 2009 \\ 39 \end{array}$ |
|  | HCB | $\begin{array}{r} 100 \\ 10 \\ 1 \end{array}$ | na - - | 0.0 $<2$ 2 | $\begin{array}{r} 73 \\ 31 \\ 2 \end{array}$ | $\begin{array}{r} 0.0 \\ <2 \\ 2 \end{array}$ | 18 4 2 | $\begin{array}{r} 2.4 \\ 2 \\ 2 \end{array}$ | 81 7 2 | 38 5 2 |
|  | Photomirex | na | na - - | 0.0 $<5$ 5 | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | 0.0 $<5$ 5 |
|  | cis-Chlordane | na | $\begin{array}{r} 100 \\ 83 \\ 2 \end{array}$ | 91 59 5 | 71 50 5 | 25 7 5 | 28 12 5 | $\begin{array}{r} 0.0 \\ <5 \\ 5 \end{array}$ | 21 10 5 | 15 9 5 |


|  | trans-Chlordane | na | 95 | 8.6 | 30 | 0.0 | 2.6 | 0.0 | 0.0 | 0.0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | - | 16 | 10 | 213 | <5 | 5 | <5 | <5 | <5 |
|  |  | - | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | Oxychlordane | na | 100 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 |
|  |  | - | 24 | $<10$ | $<10$ | $<10$ | $<10$ | <10 | 6 | <5 |
|  |  | - | 2 | 10 | 10 | 10 | 10 | 10 | 5 | 5 |
| Cayuga | Year | 1985 | 1988 | 1991 | 1995 | 2007 |  |  |  |  |
|  | n | 31 | 40 | 40 | 53 | 22 |  |  |  |  |
|  | HCB | $100^{3}$ | 15 | 30 | 13 | 4.5 |  |  |  |  |
|  |  | 7 | 7 | 4 | 2 | 3 |  |  |  |  |
|  |  | 1 | 2 | 2 | 2 | 2 |  |  |  |  |
|  | Photomirex | na | 0.0 | 0.0 | 0.0 | 0.0 |  |  |  |  |
|  |  | - | <5 | <5 | <5 | <5 |  |  |  |  |
|  |  | - | 5 | 5 | 5 | 5 |  |  |  |  |
|  | cis-Chlordane | 100 | 53 | 83 | 45 | 0.0 |  |  |  |  |
|  |  | 32 | 15 | 24 | 11 | <5 |  |  |  |  |
|  |  | 5 | 5 | 5 | 5 | 5 |  |  |  |  |
|  | trans-Chlordane | 97 | 7.5 | 30 | 1.9 | 0.0 |  |  |  |  |
|  |  | 13 | 17 | 14 | 5 | $<5$ |  |  |  |  |
|  |  | 5 | 5 | 5 | 5 | 5 |  |  |  |  |
|  | Oxychlordane | 100 | 10 | 2.5 | 0.0 | 0.0 |  |  |  |  |
|  |  | 32 | 17 | 5 | $<10$ | <5 |  |  |  |  |
|  |  | 5 | 10 | 5 | 10 | 5 |  |  |  |  |
| Keuka | Year | 1983 | 1985 | 1988 | 1991 | 1994 | 1997 | 2000 | 2003 | 2007 |
|  | n | 9 | 27 | 58 | 50 | 42 | 53 | 49 | 50 | 57 |
|  | HCB | 100 | 100 | 5.2 | 0.0 | 29 | 26 | 35 | 4.0 | 40 |
|  |  | 7 | 9 | 3 | <2 | 6 | 6 | 7 | 2.4 | 10 |
|  |  | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
|  | Photomirex | na | na | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  |  | - |  | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
|  |  | - | - | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | cis-Chlordane | na | 100 | 47 | 0.0 | 64 | 36 | 35 | 22 | 23 |
|  |  | - | 59 | 102 | $<10$ | 29 | 22 | 26 | 14 | 8 |
|  |  | - | 2 | 5 | 10 | 5 | 5 | 5 | 5 | 5 |


|  | trans-Chlordane | na | 81 | 0.0 | 0.0 | 19 | 1.9 | 2.0 | 0.0 | 0.0 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  |  | - | 86 | $<5$ | $<10$ | 12 | 6 | 8 | $<5$ | $<5$ |
| Seneca | - | 2 | 5 | 10 | 5 | 5 | 5 | 5 | 5 |  |
|  | Oxychlordane | na | 93 | 19 | 0.0 | 0.0 | 0.0 | 14 | 0.0 | 1.8 |
|  |  | - | 37 | 51 | $<20$ | $<10$ | $<10$ | 10 | $<5$ | 5 |
|  | Year | - | 5 | 10 | 20 | 10 | 10 | 5 | 5 | 5 |
|  | n |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | HCB | 1983 | 1985 | 1988 | 1991 | 2002 | 2005 | 2008 |  |  |

[^2]Table 5: Incidence of some organochlorine analytes determined in recent collections of Finger Lakes lake trout.

| Parameter | \% incidence > detection limit/maximum concentration ( $\mathrm{ng} / \mathrm{g}$ wet weight) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Lake | Canadice | Canandaigua | Cayuga | Keuka | Seneca |
| Year | 2008 | 2009 | 2007 | 2007 | 2008 |
| n | 46 | 39 | 22 | 57 | 76 |
| Aldrin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | $<5$ | <5 | $<5$ | <5 | <5 |
| Heptachlor | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | <5 | <5 | <5 | <5 | <5 |
| Heptachlor epoxide | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | <5 | <5 | <5 | <5 | <5 |
| cis-Nonachlor | 19 | 13 | 0.0 | 19 | 3.9 |
|  | 8.2 | 7.8 | <5 | 18 | 8 |
| o,p'-DDT | 0.0 | 0.0 | 44 | 18 | 0.0 |
|  | <5 | <5 | 25 | 12 | <5 |
| o,p'-DDE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | <5 | <5 | <5 | <5 | <5 |
| o,p'-DDD | $\mathrm{nm}{ }^{1}$ | nm | nm | 0.0 | nm |
|  |  |  |  | <5 |  |
| $\alpha$-BHC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | <5 | <5 | <5 | <5 | <5 |
| $\beta$-BHC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | <5 | <5 | <5 | <5 | <5 |
| $\gamma$-BHC | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | <5 | <5 | <5 | <5 | <5 |

${ }_{1}^{1} \mathrm{~nm}=$ not measured.

Table 6: Lipid concentrations (percent wet weight in standard fillets) in aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $4.70 \pm 1.45$ | 5 | $4.59 \pm 1.30$ | -- | -- | 1 | 15.74 | 3 | $16.48 \pm 2.45$ | 3 | $19.88 \pm 4.39$ |
|  | 1987 | 5 | $2.07 \pm 0.91$ | 15 | $3.66 \pm 1.54$ | 10 | $4.93 \pm 0.87$ | 4 | $6.77 \pm 1.54$ | 4 | $9.76 \pm 2.41$ | 3 | $9.87 \pm 0.93$ |
|  | 1990 | 3 | $1.48 \pm 0.47$ | 7 | $3.37 \pm 1.51$ | 11 | $4.63 \pm 1.41$ | 14 | $5.86 \pm 2.18$ | 7 | $9.87 \pm 2.41$ | 1 | 7.29 |
|  | 1993 | 16 | $2.42 \pm 0.95$ | 13 | $3.64 \pm 1.14$ | 4 | $4.75 \pm 1.23$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} 4.70 \\ (4.00 ; 5.40) \end{gathered}$ | 3 | $6.06 \pm 3.04$ | 1 | 5.75 | 8 | $13.29 \pm 3.57$ | 2 | $\begin{gathered} 13.04 \\ (11.84 ; 14.24) \\ \hline \end{gathered}$ |
|  | 2003 | 6 | $2.89 \pm 1.26$ | 6 | $5.04 \pm 0.86$ | 8 | $5.39 \pm 1.36$ | 36 | $7.75 \pm 1.92$ | 8 | $9.36 \pm 1.40$ | 7 | $10.90 \pm 1.70$ |
|  | 2008 | -- | -- | 2 | $\begin{gathered} 4.44 \\ (3.37 ; 5.51) \\ \hline \end{gathered}$ | 16 | $4.59 \pm 1.00$ | 12 | $7.75 \pm 3.23$ | 4 | $9.14 \pm 3.82$ | 8 | $10.78 \pm 2.81$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canandaigua | 1983 | 3 | $1.30 \pm 0.29$ | 10 | $2.00 \pm 0.83$ | 10 | $2.52 \pm 0.88$ | 3 | $2.66 \pm 0.81$ | 9 | $9.12 \pm 1.39$ | 4 | $8.98 \pm 1.79$ |
|  | 1985 | -- | -- | -- | -- | 12 | $3.09 \pm 0.90$ | 6 | $3.46 \pm 1.99$ | -- | -- | -- | -- |
|  | 1988 | 3 | $1.44 \pm 0.48$ | 3 | $2.36 \pm 1.05$ | 14 | $2.39 \pm 1.08$ | 6 | $2.31 \pm 0.64$ | 1 | 5.38 | 4 | $6.29 \pm 1.09$ |
|  | 1991 | 3 | $1.71 \pm 0.36$ | 24 | $1.65 \pm 0.86$ | 25 | $1.76 \pm 0.84$ | 3 | $2.49 \pm 0.48$ | 3 | $2.86 \pm 0.58$ | 5 | $6.26 \pm 3.86$ |
|  | 1994 | 6 | $1.66 \pm 0.68$ | 29 | $1.63 \pm 0.66$ | 21 | $2.22 \pm 0.67$ | 4 | $3.51 \pm 3.02$ | -- | -- | -- | -- |
|  | 1998 | 5 | $0.91 \pm 0.29$ | 5 | $1.36 \pm 0.46$ | 14 | $1.55 \pm 1.25$ | 4 | $3.09 \pm 1.86$ | 4 | $7.58 \pm 3.83$ | 1 | 9.30 |
|  | 2002 | -- | -- | 6 | $4.65 \pm 1.43$ | 15 | $4.58 \pm 2.12$ | 12 | $6.09 \pm 2.97$ | 5 | $8.02 \pm 2.29$ | 1 | 9.01 |
|  | 2006 | -- | -- | 6 | $3.76 \pm 1.78$ | 12 | $3.53 \pm 0.87$ | 8 | $4.20 \pm 1.77$ | 7 | $4.67 \pm 2.01$ | 5 | $6.25 \pm 2.37$ |
|  | 2009 | 2 | $\begin{gathered} \hline 3.26 \\ (3.16 ; 3.36) \\ \hline \end{gathered}$ | 1 | 2.28 | 16 | $5.07 \pm 1.92$ | 6 | $5.99 \pm 1.56$ | 8 | $8.33 \pm 3.04$ | 3 | $13.35 \pm 5.69$ |

Table 6 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Cayuga | 1985 | -- | -- | 10 | $4.88 \pm 1.41$ | 12 | $7.47 \pm 3.54$ | 3 | $9.24 \pm 1.31$ | 5 | $13.95 \pm 3.89$ | -- | -- |
|  | 1988 | -- | -- | 20 | $1.95 \pm 0.80$ | 20 | $3.64 \pm 1.43$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $3.82 \pm 0.95$ | 20 | $5.97 \pm 2.19$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $2.24 \pm 1.15$ | 20 | $3.77 \pm 1.84$ | 6 | $6.59 \pm 1.84$ | 6 | $5.28 \pm 2.55$ | 5 | $7.72 \pm 3.72$ |
|  | 2007 | -- | -- | 14 | $4.64 \pm 1.82$ | 8 | $5.07 \pm 1.39$ | -- | -- | -- | -- | -- | -- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Keuka | 1983 | -- | -- | 2 | $\begin{gathered} \hline 5.57 \\ (3.15 ; 3.42) \end{gathered}$ | 6 | $5.77 \pm 1.75$ | 1 | 10.90 | -- | -- | -- | -- |
|  | 1985 | -- | -- | 9 | $4.27 \pm 2.00$ | 11 | $5.57 \pm 2.56$ | 4 | $8.49 \pm 1.80$ | 3 | $8.60 \pm 3.31$ | -- | -- |
|  | 1988 | -- | -- | 20 | $2.31 \pm 1.19$ | 18 | $4.94 \pm 2.04$ | 11 | $7.16 \pm 2.78$ | 6 | $8.45 \pm 1.49$ | 3 | $11.88 \pm 2.36$ |
|  | 1991 | -- | -- | 20 | $4.97 \pm 1.30$ | 17 | $6.02 \pm 2.17$ | 8 | $8.31 \pm 2.02$ | 1 | 13.30 | 4 | $10.43 \pm 6.43$ |
|  | 1994 | -- | -- | 19 | $4.13 \pm 1.33$ | 23 | $5.75 \pm 2.15$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $4.27 \pm 2.31$ | 15 | $4.21 \pm 1.15$ | 18 | $4.07 \pm 1.32$ | 12 | $5.57 \pm 1.99$ | 4 | $8.59 \pm 2.17$ |
|  | 2000 | -- | -- | 1 | 3.79 | 14 | $5.38 \pm 1.50$ | 13 | $4.68 \pm 1.53$ | 12 | $5.44 \pm 1.68$ | 6 | $4.98 \pm 2.41$ |
|  | 2003 | -- | -- | 8 | $2.83 \pm 0.90$ | 23 | $4.13 \pm 1.30$ | 10 | $4.87 \pm 2.05$ | 8 | $4.37 \pm 2.15$ | -- | -- |
|  | 2007 | -- | -- | 12 | $5.00 \pm 1.77$ | 21 | $5.22 \pm 1.74$ | 11 | $4.44 \pm 2.74$ | 4 | $5.03 \pm 2.12$ | 5 | $3.33 \pm 1.28$ |

Table 6 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Seneca | 1983 | -- | -- | 10 | $4.53 \pm 1.95$ | 9 | $5.81 \pm 3.00$ | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $1.99 \pm 0.84$ | 7 | $3.81 \pm 1.87$ | 5 | $11.02 \pm 0.94$ | -- | -- | 2 | $\begin{gathered} 10.70 \\ (10.40 ; 11.10) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $2.29 \pm 1.36$ | 15 | $3.82 \pm 1.94$ | -- | -- | 1 | 10.27 | 4 | $7.90 \pm 1.39$ |
|  | 1991 | -- | -- | 17 | $1.85 \pm 0.71$ | 20 | $3.80 \pm 1.73$ | 1 | 6.63 | 3 | $6.56 \pm 1.58$ | 3 | $4.34 \pm 3.54$ |
|  | 2002 | -- | -- | 11 | $2.24 \pm 0.96$ | 8 | $2.89 \pm 0.75$ | -- | -- | 5 | $8.81 \pm 0.96$ | 3 | $7.96 \pm 2.49$ |
|  | 2005 | 3 | $2.07 \pm 0.25$ | 23 | $3.66 \pm 1.22$ | 13 | $3.52 \pm 0.99$ | 4 | $4.32 \pm 1.28$ | 7 | $7.66 \pm 3.27$ | 10 | $6.79 \pm 2.88$ |
|  | 2008 | 1 | 4.80 | 32 | $3.45 \pm 1.16$ | 11 | $3.91 \pm 1.18$ | 13 | $6.56 \pm 3.46$ | 4 | $8.14 \pm 2.51$ | 9 | $7.00 \pm 2.32$ |

Table 7: Kruskal-Wallis comparisons (or Mann-Whitney test comparisons ${ }^{1}$ ) of total PCB concentrations by age for lake trout taken from five Finger Lakes, New York.

| Lake | $\begin{aligned} & \text { Year } \\ & 1984 \end{aligned}$ | Age in rank order (low to high) |  |  |  |  |  | Quantile |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Canadice |  |  | 43 | 78 | 78 |  |  | 99 |
|  | $1987$ |  | $3 \quad 45$ | 6 |  |  |  | 99 |
|  | 1990 |  | 34 | 56 | 7 |  |  | 99 |
|  | 1993 | 345 |  |  |  |  |  | 99 |
|  | 1998 | 57 |  |  |  |  |  | <95 |
|  | 2003 |  | $3 \quad 54$ | $\underline{6}$ | 79 |  |  | 99 |
|  | 2008 |  | 56 | 78 |  |  |  | 99 |
| Canandaigua | 1983 | $3 \quad 456$ |  |  | 87 |  |  | 99 |
|  | 1985 |  |  |  |  |  |  | <95 |
|  | 1988 | $\begin{array}{llll}4 & 3 & 6\end{array}$ |  |  | 8 |  |  | 95 |
|  | 1991 |  | 34 | 65 | 78 |  | 9 | 99 |
|  | 1994 | 34 |  | 56 |  |  |  | 95 |
|  | 1998 |  | 34 | 56 | 7 |  |  | 99 |
|  | 2002 |  | 45 | 67 |  |  |  | 99 |
|  | 2006 | $4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9$ |  |  |  |  |  | 99 |
|  | 2009 | 5678 |  |  |  |  |  | 99 |

Table 7 continued.


Table 7 continued.


[^3]Table 8: $\quad$ Temporal comparisons ${ }^{1}$ of total PCB concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $1657 \pm 864 \mathrm{~A}$ | 5 | $982 \pm 160 \mathrm{~A}$ | -- | -- | 1 | 6790 | 3 | $11061 \pm 3173 \mathrm{~A}$ | 3 | $14697 \pm 3269 \mathrm{~A}$ |
|  | 1987 | 5 | $599 \pm 198 \mathrm{~B}$ | 15 | $941 \pm 358 \mathrm{~A}$ | 10 | $1120 \pm 364 \mathrm{~A}$ | 4 | $1440 \pm 144 \mathrm{~A}$ | 4 | $3925 \pm 2323 \mathrm{BC}$ | 3 | $8278 \pm 3915 \mathrm{~A}$ |
|  | 1990 | 3 | $332 \pm 34 \mathrm{C}$ | 7 | $569 \pm 227 \mathrm{~B}$ | 11 | $732 \pm 316 \mathrm{~B}$ | 14 | $876 \pm 461 \mathrm{~B}$ | 7 | $4580 \pm 3996 \mathrm{AB}$ | 1 | 3050 |
|  | 1993 | 16 | $332 \pm 62 \mathrm{C}$ | 13 | $407 \pm 123 \mathrm{C}$ | 4 | $631 \pm 123 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} \hline 481 \\ (433 ; 529) \end{gathered}$ | 3 | $669 \pm 263 \mathrm{BC}$ | 1 | 369 | 8 | $1111 \pm 332 \mathrm{D}$ | 2 | $\begin{gathered} 1444 \\ (1219 ; 1669) \end{gathered}$ |
|  | 2003 | 6 | $264 \pm 48 \mathrm{D}$ | 6 | $326 \pm 106 \mathrm{C}$ | 8 | $301 \pm 88 \mathrm{D}$ | 36 | $488 \pm 170 \mathrm{C}$ | 8 | $978 \pm 317 \mathrm{D}$ | 7 | $1717 \pm 518 \mathrm{C}$ |
|  | 2008 | -- | -- | 2 | $\begin{gathered} 778 \\ (530 ; 1026) \\ \hline \end{gathered}$ | 16 | $519 \pm 92 \mathrm{C}$ | 12 | $911 \pm 619 \mathrm{~B}$ | 4 | $2014 \pm 1002 \mathrm{C}$ | 8 | $2383 \pm 344 \mathrm{~B}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canan- <br> daigua | 1983 | 3 | $499 \pm 196 \mathrm{~A}$ | 10 | $704 \pm 207 \mathrm{~A}$ | 10 | $876 \pm 354 \mathrm{~A}$ | 3 | $1032 \pm 644 \mathrm{~A}$ | 9 | $2496 \pm 1105 \mathrm{~A}$ | 4 | $2275 \pm 471 \mathrm{~A}$ |
|  | 1985 | -- | -- | -- | -- | 12 | $412 \pm 432 \mathrm{~B}$ | 6 | $487 \pm 369 \mathrm{AB}$ | -- | -- | -- | -- |
|  | 1988 | 3 | $258 \pm 278$ AB | 3 | $112 \pm 55 \mathrm{C}$ | 14 | $297 \pm 247 \mathrm{BC}$ | 6 | $234 \pm 94 \mathrm{BC}$ | 1 | 808 | 4 | $892 \pm 374 \mathrm{~B}$ |
|  | 1991 | 3 | $116 \pm 72 \mathrm{~B}$ | 24 | $182 \pm 90 \mathrm{~B}$ | 25 | $241 \pm 164 \mathrm{BC}$ | 3 | $200 \pm 45 \mathrm{BC}$ | 3 | $277 \pm 84 \mathrm{CD}$ | 5 | $758 \pm 551 \mathrm{C}$ |
|  | 1994 | 6 | $59 \pm 23 \mathrm{C}$ | 29 | $70 \pm 40 \mathrm{D}$ | 21 | $93 \pm 63 \mathrm{E}$ | 4 | $93 \pm 18 \mathrm{D}$ | -- | -- | -- | -- |
|  | 1998 | 5 | $98 \pm 55 \mathrm{BC}$ | 5 | $142 \pm 114 \mathrm{C}$ | 14 | $192 \pm 80 \mathrm{CD}$ | 4 | $243 \pm 36 \mathrm{BC}$ | 4 | $678 \pm 262 \mathrm{~B}$ | 1 | 600 |
|  | 2002 | -- | -- | 6 | $103 \pm 32 \mathrm{C}$ | 15 | $154 \pm 74 \mathrm{D}$ | 12 | $225 \pm 110 \mathrm{BC}$ | 5 | $403 \pm 238 \mathrm{C}$ | 1 | 406 |
|  | 2006 | -- | -- | 6 | $124 \pm 56 \mathrm{C}$ | 12 | $164 \pm 68 \mathrm{D}$ | 8 | $195 \pm 73 \mathrm{C}$ | 7 | $194 \pm 55 \mathrm{E}$ | 5 | $448 \pm 114 \mathrm{C}$ |
|  | 2009 | 2 | $\begin{gathered} 69.3 \\ (68.2 ; 70.4) \\ \hline \end{gathered}$ | 1 | 40.9 | 16 | $95.8 \pm 23.0 \mathrm{E}$ | 6 | $102 \pm 19.9 \mathrm{D}$ | 8 | $199 \pm 86.0 \mathrm{DE}$ | 3 | $287 \pm 106 \mathrm{D}$ |

Table 8 continued.


Table 8 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Seneca | 1983 | -- | -- | 10 | $641 \pm 364 \mathrm{~A}$ | 9 | $591 \pm 213 \mathrm{~A}$ | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $220 \pm 96 \mathrm{~B}$ | 7 | $362 \pm 220 \mathrm{BC}$ | 5 | $730 \pm 210 \mathrm{~A}$ | -- | -- | 2 | $\begin{gathered} 945 \\ (859 ; 1030) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $274 \pm 130 \mathrm{~B}$ | 15 | $559 \pm 419 \mathrm{AB}$ | -- | -- | 1 | 1086 | 4 | $710 \pm 514 \mathrm{~A}$ |
|  | 1991 | -- | -- | 17 | $265 \pm 120 \mathrm{~B}$ | 20 | $305 \pm 76 \mathrm{C}$ | 1 | 337 | 3 | $630 \pm 163 \mathrm{~A}$ | 3 | $663 \pm 43 \mathrm{~A}$ |
|  | 2002 | -- | -- | 11 | $84 \pm 24 \mathrm{C}$ | 8 | $125 \pm 35 \mathrm{D}$ | -- | -- | 5 | $374 \pm 135 \mathrm{~B}$ | 3 | $380 \pm 72 \mathrm{~A}$ |
|  | 2005 | 3 | $28 \pm 13$ | 23 | $70 \pm 32 \mathrm{D}$ | 13 | $70 \pm 23 \mathrm{E}$ | 4 | $85 \pm 26 \mathrm{~B}$ | 7 | $207 \pm 117 \mathrm{C}$ | 10 | $228 \pm 93 \mathrm{~B}$ |
|  | 2008 | 1 | 66 | 32 | $62 \pm 24 \mathrm{E}$ | 11 | $64 \pm 23 \mathrm{E}$ | 13 | $85 \pm 27 \mathrm{~B}$ | 4 | $132 \pm 47 \mathrm{C}$ | 9 | $154 \pm 67 \mathrm{~B}$ |

[^4]Table 9: Concentration distributions of p,p'- DDT analytes in Finger Lakes lake trout.

| Lake | Year | Ages | $\underline{\mathrm{n}}$ | Percent of total $p, p^{\prime}$-DDT concentration |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | p,p'-DDT | p,p'-DDE | p,p'-DDD |
| Canadice | 1984 | 3, 4 | 13 | 17.4 | 66.1 | 16.5 |
|  | 1987 | 3, 4 | 20 | 11.4 | 75.7 | 12.9 |
|  | 1990 | 3, 4 | 10 | 26.6 | 52.8 | 20.3 |
|  | 1993 | 3, 4 | 29 | 18.7 | 59.3 | 22.3 |
|  | 1998 | 4, 5, 7 | 13 | 13.9 | 71.8 | 14.2 |
|  | 2003 | 3, 4 | 12 | 5.5* | 86.0 | 8.9 |
|  |  | 5, 6, 7 | 52 | 3.2* | 85.1 | 10.5 |
|  | 2008 | 5, 6, 7 | 32 | 18.6 | 70.6 | 10.8 |
| Canandaigua | 1983 | 3-6 | 26 | 18.3 | 74.3 | 7.4 |
|  | 1985 | 5,6 | 18 | 12.1 | 80.1 | 7.9 |
|  | 1988 | 3-6 | 26 | 7.3 | 87.0 | 5.5 |
|  | 1991 | 3-6 | 55 | 11.3 | 78.4 | 10.7 |
|  | 1994 | 3-6 | 60 | 10.4 | 82.4 | 7.6 |
|  | 1998 | 3-6 | 28 | 7.1 | 87.2 | 5.8 |
|  | 2002 | 4-6 | 33 | 3.3 | 89.2 | 7.2 |
|  | 2006 | 4-6 | 26 | 4.0 | 88.9 | 7.1 |
|  | 2009 | 4-6 | 23 | 13.2 | 78.5 | 8.2 |
| Cayuga | 1985 | 4,5 | 22 | 10.6 | 79.7 | 9.1 |
|  | 1988 | 4, 5 | 40 | 11.2 | 78.0 | 11.2 |
|  | 1991 | 4, 5 | 40 | 8.7 | 80.4 | 11.1 |
|  | 1995 | 4,5 | 30 | 8.0 | 85.4 | 7.4 |
|  | 2007 | 4, 5 | 22 | 3.3 | 86.3 | 10.3 |
| Keuka | 1983 | 4-6 | 9 | 17.1 | 75.0 | 7.8 |
|  | 1985 | 4-6 | 24 | 19.5 | 72.3 | 8.2 |
|  | 1988 | 4-6 | 49 | 11.8 | 81.6 | 6.8 |
|  | 1991 | 4-6 | 45 | 8.6 | 83.4 | 8.1 |
|  | 1994 | 4, 5 | 42 | 9.1 | 83.4 | 7.6 |
|  | 1997 | 4-6 | 37 | 8.4 | 85.8 | 5.6 |
|  | 2000 | 4-6 | 28 | 6.9 | 87.6 | 5.6 |
|  | 2003 | 4-6 | 41 | 4.3 | 89.0 | 6.1 |
|  | 2007 | 4-6 | 44 | 1.8 | 92.3 | 5.8 |
| Seneca | 1983 | 4, 5 | 19 | 18.8 | 71.0 | 10.3 |
|  | 1985 | 4,5 | 20 | 13.3 | 74.1 | 12.0 |
|  | 1988 | 4, 5 | 34 | 10.7 | 81.0 | 8.1 |
|  | 1991 | 4, 5 | 37 | 14.8 | 74.1 | 11.5 |
|  | 2002 | 4, 5 | 19 | 1.4 | 92.4 | 7.1 |
|  | 2005 | 4,5 | 36 | 9.8 | 81.4 | 8.8 |
|  | 2008 | 4, 5 | 43 | 13.8 | 78.9 | 7.4 |

[^5]Table 10: Total p,p'-DDT concentrations ${ }^{1}(\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $143 \pm 58$ | 5 | $99 \pm 24$ | -- | -- | 1 | 577 | 3 | $653 \pm 25$ | 3 | $808 \pm 139$ |
|  | 1987 | 5 | $40 \pm 12$ | 15 | $54 \pm 18$ | 10 | $63 \pm 19$ | 4 | $81 \pm 20$ | 4 | $206 \pm 124$ | 3 | $334 \pm 101$ |
|  | 1990 | 3 | $27 \pm 9.2$ | 7 | $41 \pm 22$ | 11 | $53 \pm 24$ | 14 | $75 \pm 45$ | 7 | $227 \pm 168$ | 1 | 139 |
|  | 1993 | 16 | $23 \pm 8.8$ | 13 | $37 \pm 13$ | 4 | $51 \pm 12$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} 46 \\ (36 ; 55) \end{gathered}$ | 3 | $48 \pm 30$ | 1 | 40 | 8 | $126 \pm 36$ | 2 | $\begin{gathered} 146 \\ (126 ; 165) \end{gathered}$ |
|  | 2003 | 6 | $16 \pm 4.0$ | 6 | $23 \pm 5.7$ | 8 | $20 \pm 6.2$ | 36 | $32 \pm 9.8$ | 8 | $61 \pm 18$ | 7 | $119 \pm 33$ |
|  | 2008 | -- | -- | 2 | $\begin{gathered} 30 \\ (21 ; 40) \\ \hline \end{gathered}$ | 16 | $24 \pm 4.1$ | 12 | $41 \pm 27$ | 4 | $93 \pm 47$ | 8 | $117 \pm 25$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canan- <br> daigua | 1983 | 3 | $317 \pm 179$ | 10 | $591 \pm 218$ | 10 | $596 \pm 273$ | 3 | $1042 \pm 946$ | 9 | $1701 \pm 793$ | 4 | $1693 \pm 646$ |
|  | 1985 | -- | -- | -- | -- | 12 | $260 \pm 145$ | 6 | $328 \pm 172$ | -- | -- | -- | -- |
|  | 1988 | 3 | $336 \pm 361$ | 3 | $196 \pm 42$ | 14 | $511 \pm 585$ | 6 | $301 \pm 78$ | 1 | 827 | $\begin{gathered} 4 \\ (3)^{2} \end{gathered}$ | $\begin{gathered} 1161 \pm 871 \\ (729 \pm 148)^{2} \end{gathered}$ |
|  | 1991 | 3 | $99 \pm 28$ | 24 | $119 \pm 50$ | 25 | $138 \pm 81$ | 3 | $171 \pm 15$ | 3 | $195 \pm 31$ | 5 | $370 \pm 164$ |
|  | 1994 | 6 | $83 \pm 37$ | 29 | $90 \pm 45$ | 21 | $115 \pm 53$ | 4 | $112 \pm 17$ | -- | -- | -- | -- |
|  | 1998 | 5 | $55 \pm 21$ | 5 | $128 \pm 103$ | 14 | $156 \pm 70$ | 4 | $216 \pm 21$ | 4 | $598 \pm 166$ | 1 | 507 |
|  | 2002 | -- | -- | 6 | $142 \pm 43$ | 15 | $192 \pm 88$ | 12 | $272 \pm 125$ | 5 | $480 \pm 293$ | 1 | 482 |
|  | 2006 | -- | -- | 6 | $103 \pm 53$ | 12 | $145 \pm 57$ | 8 | $160 \pm 84$ | 7 | $180 \pm 63$ | 5 | $412 \pm 120$ |
|  | 2009 | 2 | $\begin{gathered} 47.0 \\ (45.3 ; 48.7) \\ \hline \end{gathered}$ | 1 | 43.3 | 16 | $86.6 \pm 22.1$ | 6 | $91.7 \pm 17.9$ | 8 | $184 \pm 82.2$ | 3 | $253 \pm 74.4$ |

Table 10 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Cayuga | 1985 | -- | -- | 10 | $153 \pm 48$ | 12 | $229 \pm 132$ | 3 | $413 \pm 319$ | 5 | $463 \pm 259$ | -- | -- |
|  | 1988 | -- | -- | 20 | $86 \pm 24$ | 20 | $173 \pm 54$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $137 \pm 32$ | 20 | $257 \pm 108$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $64 \pm 35$ | 20 | $94 \pm 61$ | 6 | $174 \pm 60$ | 6 | $165 \pm 40$ | 5 | $203 \pm 45$ |
|  | 2007 | -- | -- | 14 | $43 \pm 15$ | 8 | $47 \pm 9.1$ | -- | -- | -- | -- | -- | -- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Keuka | 1983 | -- | -- | 2 | $\begin{gathered} 2841 \\ (1611 ; 4071) \end{gathered}$ | 6 | $3882 \pm 2117$ | 1 | 14170 | -- | -- | -- | -- |
|  | 1985 | -- | -- | 9 | $1312 \pm 398$ | 11 | $1797 \pm 919$ | 4 | $5690 \pm 1907$ | 3 | $4750 \pm 894$ | -- | -- |
|  | 1988 | -- | -- | 20 | $728 \pm 277$ | 18 | $1797 \pm 732$ | 11 | $2698 \pm 1116$ | 6 | $6980 \pm 5027$ | 3 | $20787 \pm 16425$ |
|  | 1991 | -- | -- | 20 | $884 \pm 428$ | 17 | $1289 \pm 949$ | 8 | $2426 \pm 1845$ | 1 | 3509 | 4 | $6856 \pm 3325$ |
|  | 1994 | -- | -- | 19 | $526 \pm 212$ | 23 | $674 \pm 456$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $330 \pm 192$ | 15 | $406 \pm 196$ | 18 | $\begin{gathered} 722 \pm 966 \\ (497 \pm 154 ; \\ \mathrm{n}=17) \end{gathered}$ | 12 | $\begin{gathered} 875 \pm 802 \\ (662 \pm 331 ; \\ \mathrm{n}=11) \end{gathered}$ | 4 | $1057 \pm 543$ |
|  | 2000 | -- | -- | 1 | 508 | 14 | $522 \pm 176$ | 13 | $663 \pm 268$ | 12 | $832 \pm 333$ | 6 | $934 \pm 328$ |
|  | 2003 | -- | -- | 8 | $233 \pm 84$ | 23 | $329 \pm 185$ | 10 | $612 \pm 305$ | 8 | $1119 \pm 304$ | -- | -- |
|  | 2007 | -- | -- | 12 | $375 \pm 84$ | 21 | $387 \pm 98$ | 11 | $860 \pm 639$ | 4 | $943 \pm 191$ | 5 | $1546 \pm 378$ |

Table 10 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Seneca | 1983 | -- | -- | 10 | $387 \pm 191$ | 9 | $374 \pm 151$ | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $107 \pm 78$ | 7 | $214 \pm 142$ | 5 | $271 \pm 159$ | -- | -- | 2 | $\begin{gathered} 706 \\ (653 ; 759) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $218 \pm 124$ | 15 | $422 \pm 290$ | -- | -- | 1 | 926 | 4 | $907 \pm 290$ |
|  | 1991 | -- | -- | 17 | $96 \pm 26$ | 20 | $177 \pm 47$ | 1 | 200 | 3 | $360 \pm 70$ | 3 | $303 \pm 76$ |
|  | 2002 | -- | -- | 11 | $59 \pm 16$ | 8 | $90 \pm 35$ | -- | -- | 5 | $357 \pm 136$ | 3 | $373 \pm 87$ |
|  | 2005 | 3 | $12 \pm 3.9$ | 23 | $24 \pm 16$ | 13 | $28 \pm 13$ | 4 | $30 \pm 14$ | 7 | $93 \pm 66$ | 10 | $118 \pm 50$ |
|  | 2008 | 1 | 43 | 32 | $30 \pm 11$ | 11 | $35 \pm 9.0$ | 13 | $50 \pm 20$ | 4 | $91 \pm 31$ | 9 | $112 \pm 49$ |

${ }^{1}$ Sum of p,p'-DDT, p,p'-DDE and p,p'-DDD. One-half the detection limit was used when values were less than the detection limit ( $\mathrm{DL}=2.0 \mathrm{ng} / \mathrm{g}$ ).
${ }^{2}$ Excludes an outlier concentration.

Table 11: Kruskal-Wallis comparisons (or Mann-Whitney test comparisons ${ }^{1}$ ) of $\mathrm{p}, \mathrm{p}^{\prime}$-DDE concentrations by age for lake trout taken from five Finger Lakes, New York.


Table 11 continued.

| Lake | $\begin{aligned} & \underline{\text { Year }} \\ & 1968^{2} \end{aligned}$ | $\underline{\text { Age in rank order (low to high) }}$ |  |  |  |  |  | Quantile$99$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Cayuga |  | 12 | 3 | 45 | 6 | 7 | 8 |  |
|  | $1969^{2}$ | 12 | $\underline{3}$ | 45 | $\underline{6}$ | 7 | $\underline{8}$ | 99 |
|  | $1970^{2}$ | 12 | 3 | 47 | 6 | 8 | 12 | 99 |
|  | $1978{ }^{3}$ | $6 \quad 7$ | 8 | $9 \quad 10$ |  |  |  | 95 |
|  | 1985 | $4 \quad 5$ | 6 |  |  |  |  | <95 |
|  | 1988 | $4 \underline{5}$ |  |  |  |  |  | 99 |
|  | 1991 | $4 \quad 5$ |  |  |  |  |  | 99 |
|  | 1995 | 45 | 7 | 69 | 8 |  |  | 99 |
|  | 2007 | 45 |  |  |  |  |  | $<95$ |
| Keuka | 1983 | Insufficient data |  |  |  |  |  |  |
|  | 1985 | 45 | 7 | 6 |  |  |  | 99 |
|  | 1988 | $\underline{4}$ | $\underline{6}$ | 78 |  |  |  | 99 |
|  | 1991 | 45 | 6 |  |  |  |  | 99 |
|  | 1994 | 45 |  |  |  |  |  | <95 |
|  | 1997 | $4 \quad 5$ | 6 | 78 |  |  |  | 99 |
|  | 2000 | 56 | 7 | 8 |  |  |  | 95 |
|  | 2003 | 45 | $\underline{6}$ | 7 |  |  |  | 99 |
|  | 2007 | 45 | 6 | 78 |  |  |  | 99 |

Table 11 continued.

${ }^{1}$ The Mann-Whitney test was conducted when only two ages could be compared. A quantile of $<95$ indicates no significant age difference in $\mathrm{p}, \mathrm{p}^{\prime}$-DDE concentration.
${ }^{2}$ Calculated from: Bache et al., 1972.
${ }^{3}$ Calculated from: Wszolek et al., 1978.

Table 12: Temporal comparisons ${ }^{1}$ of $\mathrm{p}, \mathrm{p}^{\prime}$-DDE concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $97 \pm 43 \mathrm{~A}$ | 5 | $63 \pm 12 \mathrm{~A}$ | -- | -- | 1 | 391 | 3 | $436 \pm 36 \mathrm{~A}$ | 3 | $564 \pm 132 \mathrm{~A}$ |
|  | 1987 | 5 | $30 \pm 11 \mathrm{~B}$ | 15 | $41 \pm 14 \mathrm{~B}$ | 10 | $49 \pm 14 \mathrm{~A}$ | 4 | $64 \pm 13 \mathrm{~A}$ | 4 | $148 \pm 85$ B | 3 | $234 \pm 74 \mathrm{~A}$ |
|  | 1990 | 3 | $13 \pm 1.2 \mathrm{C}$ | 7 | $23 \pm 8.5 \mathrm{C}$ | 11 | $28 \pm 5.8 \mathrm{~B}$ | 14 | $37 \pm 20 \mathrm{~B}$ | 7 | $132 \pm 79 \mathrm{~B}$ | 1 | 105 |
|  | 1993 | 16 | $16 \pm 4.9 \mathrm{C}$ | 13 | $22 \pm 7.7 \mathrm{C}$ | 4 | $31 \pm 8.2 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} 33 \\ (27,39) \end{gathered}$ | 3 | $33 \pm 21 \mathrm{~B}$ | 1 | 31 | 8 | $92 \pm 25 \mathrm{BC}$ | 2 | $\begin{gathered} 107 \\ (91,123) \end{gathered}$ |
|  | 2003 | 6 | $13 \pm 3.8 \mathrm{D}$ | 6 | $20 \pm 4.8 \mathrm{C}$ | 8 | $17 \pm 5.4 \mathrm{C}$ | 36 | $27 \pm 8.7 \mathrm{C}$ | 8 | $53 \pm 16 \mathrm{CD}$ | 7 | $103 \pm 31 \mathrm{C}$ |
|  | 2008 | -- | -- | 2 | $\begin{gathered} 21 \\ (15,27) \\ \hline \end{gathered}$ | 16 | $16 \pm 2.5 \mathrm{C}$ | 12 | $29 \pm 19 \mathrm{C}$ | 4 | $68 \pm 33 \mathrm{D}$ | 8 | $86 \pm 21 \mathrm{C}$ |

Table 12 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | $5+$ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canandaigua | 1983 | 3 | $231 \pm 128 \mathrm{~A}$ | 10 | $434 \pm 189 \mathrm{~A}$ | 10 | $436 \pm 233 \mathrm{~A}$ | 3 | $862 \pm 874 \mathrm{~A}$ | 9 | $1316 \pm 639 \mathrm{~A}$ | 4 | $1098 \pm 390 \mathrm{~A}$ |
|  | 1985 | -- | -- | -- | -- | 12 | $212 \pm 119 \mathrm{~B}$ | 6 | $254 \pm 139 \mathrm{~B}$ | -- | -- | -- | -- |
|  | 1988 | 3 | $300 \pm 347 \mathrm{~A}$ | 3 | $165 \pm 41 \mathrm{AB}$ | 14 | $455 \pm 536 \mathrm{~A}$ | 6 | $249 \pm 76 \mathrm{AB}$ | 1 | 728 | 4 | $1012 \pm 794 \mathrm{~A}$ |
|  | 1991 | 3 | $81 \pm 16 \mathrm{~B}$ | 24 | $94 \pm 41 \mathrm{C}$ | 25 | $107 \pm 68 \mathrm{D}$ | 3 | $132 \pm 15 \mathrm{CD}$ | 3 | $148 \pm 19 \mathrm{C}$ | 5 | $260 \pm 119 \mathrm{BC}$ |
|  | 1994 | 6 | $67 \pm 29 \mathrm{BC}$ | 29 | $75 \pm 39 \mathrm{C}$ | 21 | $94 \pm 49 \mathrm{D}$ | 4 | $92 \pm 12 \mathrm{DE}$ | -- | -- | -- | -- |
|  | 1998 | 5 | $49 \pm 19 \mathrm{C}$ | 5 | $116 \pm 93 \mathrm{C}$ | 14 | $135 \pm 59 \mathrm{C}$ | 4 | $180 \pm 23 \mathrm{BC}$ | 4 | $517 \pm 157 \mathrm{~B}$ | 1 | 428 |
|  | 2002 | -- | -- | 6 | $130 \pm 39 \mathrm{BC}$ | 15 | $170 \pm 78 \mathrm{~B}$ | 12 | $242 \pm 112 \mathrm{~B}$ | 5 | $423 \pm 260 \mathrm{~B}$ | 1 | 419 |
|  | 2006 | -- | -- | 6 | $89 \pm 45 \mathrm{C}$ | 12 | $129 \pm 50 \mathrm{C}$ | 8 | $144 \pm 74 \mathrm{CD}$ | 7 | $159 \pm 60 \mathrm{C}$ | 5 | $367 \pm 112 \mathrm{~B}$ |
|  | 2009 | 2 | $\begin{gathered} 38.0 \\ (37.8 ; 38.1) \\ \hline \end{gathered}$ | 1 | 35.8 | 16 | $68.0 \pm 17.7 \mathrm{E}$ | 6 | $71.3 \pm 13.6 \mathrm{E}$ | 8 | $150 \pm 68.9 \mathrm{C}$ | 3 | $210 \pm 68.0 \mathrm{C}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cayuga | 1985 | -- | -- | 10 | $124 \pm 42 \mathrm{~A}$ | 12 | $180 \pm 113 \mathrm{~B}$ | 3 | $352 \pm 289 \mathrm{~A}$ | 5 | $\begin{gathered} 353 \pm 216 \mathrm{~A} \\ (419 \pm 181 \mathrm{~A})^{2} \end{gathered}$ | -- | -- |
|  | 1988 | -- | -- | 20 | $70 \pm 19 \mathrm{~B}$ | 20 | $129 \pm 37 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $110 \pm 27 \mathrm{~A}$ | 20 | $207 \pm 87 \mathrm{~A}$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $55 \pm 29 \mathrm{C}$ | 20 | $80 \pm 50 \mathrm{C}$ | 6 | $149 \pm 52 \mathrm{~B}$ | 6 | $141 \pm 37 \mathrm{~B}$ | 5 | $171 \pm 38$ |
|  | 2007 | -- | -- | 14 | $37 \pm 13 \mathrm{D}$ | 8 | $41 \pm 7.6 \mathrm{D}$ | -- | -- | -- | -- | -- | -- |

Table 12 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Keuka | 1983 | -- | -- | 2 | $\begin{gathered} 2320 \\ (1160 ; 3480) \end{gathered}$ | 6 | $2878 \pm 1406 \mathrm{~A}$ | 1 | 9530 | -- | -- | -- | -- |
|  | 1985 | -- | -- | 9 | $952 \pm 247 \mathrm{~A}$ | 11 | $1277 \pm 661 \mathrm{BC}$ | 4 | $4258 \pm 1470 \mathrm{~A}$ | 3 | $\begin{gathered} 3397 \pm 623 \\ \text { A } \end{gathered}$ | -- | -- |
|  | 1988 | -- | -- | 20 | $594 \pm 259 \mathrm{C}$ | 18 | $1490 \pm 654 \mathrm{AB}$ | 11 | $2148 \pm 905 \mathrm{AB}$ | 6 | $\begin{aligned} & \hline 5658 \pm \\ & 4730 \mathrm{~A} \end{aligned}$ | 3 | $\begin{aligned} & 17407 \pm \\ & 13935 \mathrm{~A} \end{aligned}$ |
|  | 1991 | -- | -- | 20 | $754 \pm 367$ B | 17 | $1045 \pm 792 \mathrm{C}$ | 8 | $2025 \pm 1610 \mathrm{~B}$ | 1 | 2820 | 4 | $\begin{aligned} & 5533 \pm \\ & 2688 \mathrm{~A} \end{aligned}$ |
|  | 1994 | -- | -- | 19 | $448 \pm 171 \mathrm{D}$ | 23 | $552 \pm 378 \mathrm{D}$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $282 \pm 169 \mathrm{EF}$ | 15 | $344 \pm 167 \mathrm{E}$ | 18 | $\begin{gathered} 627 \pm 901 \mathrm{D} \\ (417 \pm 129 \mathrm{D} \\ \mathrm{n}=17)^{2} \end{gathered}$ | 12 | $\begin{gathered} 712 \pm 658 \mathrm{D} \\ (538 \pm 278 ; \\ \mathrm{n}=11)^{2} \end{gathered}$ | 4 | $894 \pm 448 \mathrm{C}$ |
|  | 2000 | -- | -- | 1 | 429 | 14 | $460 \pm 158 \mathrm{D}$ | 13 | $578 \pm 257 \mathrm{CD}$ | 12 | $698 \pm 291 \mathrm{CD}$ | 6 | $830 \pm 308 \mathrm{C}$ |
|  | 2003 | -- | -- | 8 | $212 \pm 81 \mathrm{~F}$ | 23 | $291 \pm 170 \mathrm{E}$ | 10 | $543 \pm 277 \mathrm{CD}$ | 8 | $1004 \pm 271 \mathrm{~B}$ | -- | -- |
|  | 2007 | -- | -- | 12 | $341 \pm 81 \mathrm{E}$ | 21 | $350 \pm 90 \mathrm{E}$ | 11 | $807 \pm 636 \mathrm{C}$ | 4 | $822 \pm 190 \mathrm{BC}$ | 5 | $2546 \pm 2265 B$ |

Table 12 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Seneca | 1983 | -- | -- | 10 | $263 \pm 129 \mathrm{~A}$ | 9 | $278 \pm 123 \mathrm{~A}$ | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $78 \pm 63 \mathrm{BC}$ | 7 | $163 \pm 117 \mathrm{~B}$ | 5 | $208 \pm 124 \mathrm{~A}$ | -- | -- | 2 | $\begin{gathered} 548 \\ (511 ; 585) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $178 \pm 104 \mathrm{~A}$ | 15 | $338 \pm 227 \mathrm{~A}$ | -- | -- | 1 | 752 | 4 | $801 \pm 264 \mathrm{~A}$ |
|  | 1991 | -- | -- | 17 | $70 \pm 18 \mathrm{~B}$ | 20 | $133 \pm 37 \mathrm{~B}$ | 1 | 142 | 3 | $278 \pm 63 \mathrm{~A}$ | 3 | $235 \pm 66 \mathrm{~A}$ |
|  | 2002 | -- | -- | 11 | $56 \pm 15 \mathrm{C}$ | 8 | $80 \pm 34 \mathrm{C}$ | -- | -- | 5 | $317 \pm 110 \mathrm{~A}$ | 3 | $341 \pm 79 \mathrm{~A}$ |
|  | 2005 | 3 | $9.6 \pm 3.9$ | 23 | $20 \pm 13 \mathrm{E}$ | 13 | $23 \pm 11 \mathrm{D}$ | 4 | $24 \pm 11 \mathrm{C}$ | 7 | $76 \pm 55 \mathrm{~B}$ | 10 | $99 \pm 45 \mathrm{~B}$ |
|  | 2008 | 1 | 35 | 32 | $24 \pm 9.1 \mathrm{D}$ | 11 | $27 \pm 7.1 \mathrm{D}$ | 13 | $39 \pm 16 \mathrm{~B}$ | 4 | $72 \pm 26 \mathrm{~B}$ | 9 | $92 \pm 45 \mathrm{~B}$ |

[^6]Table 13: Distribution of chlordane analytes in Finger Lakes lake trout.

| Lake | Year | Ages | $\underline{\mathrm{n}}$ | Percent of total chlordane ${ }^{1}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | cis-Chlordane | trans-Chlordane | trans-Nonachlor | Oxychlordane |
| Canadice | 1984 | 4-6 | 29 | 20.1 | 18.1* | 43.6 | 18.1* |
|  | 1987 | 4, $6^{2}$ | 6 | 26.2 | 18.7 | 43.1 | 17.1 |
|  | 1990 | 4-6 | 32 | 19.2 | 16.5 | 48.6 | 15.7* |
|  | 1993 | 4, $5^{2}$ | 17 | 14.0 | 15.5 | 46.2 | 24.3* |
|  | 1998 | 4-6 | 6 | 14.5 | 18.3 | 42.3 | 24.9* |
|  | 2003 | 4-6 | 50 | 25.0* | 25.0* | 25.0* | 25.0* |
|  | 2008 | 4-6 | 30 | 24.0* | 24.0* | 28.1 | 24.0* |
| Canandaigua | 1983 | 4-6 | 26 | na ${ }^{3}$ | na | na | na |
|  | 1985 | 5, $6^{2}$ | 18 | 30.7 | 11.9 | 41.2 | 16.3 |
|  | 1988 | 4-6 | 23 | 24.1 | 8.0* | 52.0 | 15.9* |
|  | 1991 | 4-6 | 52 | 21.7 | 13.6 | 47.3 | 17.5* |
|  | 1994 | 4-6 | 54 | 16.7 | 12.9* | 44.6 | 25.8* |
|  | 1998 | 4-6 | 23 | 15.8 | 11.8* | 48.7 | 23.7* |
|  | 2002 | 4-6 | 33 | 6.3* | 6.3* | 81.2 | 6.3* |
|  | 2006 | 4-6 | 26 | 18.9 | 14.9* | 51.4 | 14.9* |
|  | 2009 | 4-6 | 23 | 19.0* | 19.0* | 42.9 | 19.0* |
| Cayuga | 1985 | 4, 5 | 22 | 22.4 | 8.2 | 46.4 | 23.0 |
|  | 1988 | 4, 5 | 40 | 18.2 | 11.1 | 49.1 | 21.6 |
|  | 1991 | 4, 5 | 40 | 16.7 | 8.4 | 69.0 | 5.9 |
|  | $1995$ | 4, 5 | 30 | 14.1 | 11.2* | 52.3 | 22.4* |
|  | 2007 | 4, 5 | 22 | 18.4* | 18.4* | 44.8 | 18.4* |
|  | 1985 | 4-6 | 25 | 22.5 | 8.2 | 48.2 | 21.2 |
|  | 1995 | 4-6 | 36 | 14.3 | 9.8* | 56.4 | 19.5* |

Table 13 continued.

| Lake | Year | Ages | n | Percent of total chlordane |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | cis-Chlordane | trans-Chlordane | trans-Nonachlor | Oxychlordane |
| Keuka | 1983 | 4-6 | 9 | na | na | na | na |
|  | 1985 | 4-6 | 24 | 18.8 | 26.3 | 42.7 | 12.2 |
|  | 1988 | 4-6 | 49 | 17.0 | 7.5* | 56.7 | 18.8 |
|  | 1991 | 4-6 | 45 | 14.1* | 14.1* | 43.7 | 28.1* |
|  | 1994 | 4, $5^{2}$ | 42 | 24.0 | 6.6 | 53.1 | 16.3* |
|  | 1997 | 4-6 | 37 | 17.4 | 11.9* | 47.0 | 23.7* |
|  | 2000 | 4-6 | 28 | 18.6 | 12.7* | 62.0 | 6.8 |
|  | 2003 | 4-6 | 41 | 22.9 | 18.7* | 39.7 | 18.7* |
|  | 2007 | 4-6 | 44 | 19.0 | 17.2* | 46.6 | 17.2* |
| Seneca | 1983 | 4, 5 | 19 | na | na | na | na |
|  | 1985 | 4, 5 | 20 | 26.6 | 9.8 | 52.1 | 11.4 |
|  | 1988 | 4,5 | 34 | 22.9 | 8.9 | 47.3 | 20.9 |
|  | 1991 | 4, 5 | 37 | 23.6 | 8.7 | 54.8 | 12.9* |
|  | 2002 | 4, 5 | 19 | 12.5* | 12.5* | 62.5 | 12.5* |
|  | 2005 | 4, 5 | 36 | 22.1* | 22.1* | 33.8 | 22.1* |
|  | 2008 | 4, 5 | 43 | 20.1* | 20.1* | 39.7 | 20.1* |

[^7]Table 14: Detection (percent of samples by year) of chlordane analytes in lake trout taken from the Finger Lakes, New York.

| Lake | Analyte | Year/n/Age/\% of n detectable/Detection limit |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Canadice | Year | 1984 | 1987 | 1990 | 1993 | 1998 | 2003 | 2003 | 2008 |  |
|  | n | 13 | 20 | 10 | 29 | 5 | 71 | 11 | 30 |  |
|  | Ages | 3, 4 | 3, 4 | 3, 4 | 3, 4 | 4, 5 | 3-7 | 8-10 | 4-6 |  |
|  | cis-chlordane | 100 | 0.0 | 10 | 6.9 | 20 | 0.0 | 0.0 | 0.0 |  |
|  |  | 1 | 10 | 5 | 5 | 5 | 5 | 5 | 5 |  |
|  | trans-chlordane | 100 | 0.0 | 0.0 | 10 | 40 | 0.0 | 0.0 | 0.0 |  |
|  |  | 1 | 10 | 5 | 5 | 5 | 5 | 5 | 5 |  |
|  | trans-nonachlor | 100 | 45 | 40 | 72 | 100 | 0.0 | 63.6 | 6.7 |  |
|  |  | 1 | 10 | 5 | 5 | 5 | 5 | 5 | 5 |  |
|  | Oxychlordane | 100 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |  |
|  |  | 1 | 10 | 5 | 10 | 10 | 5 | 5 | 5 |  |
| Canandaigua | Year | 1983 | 1985 | 1988 | 1991 | 1994 | 1998 | 2002 | 2006 | 2009 |
|  | n | 26 | 18 | 26 | 55 | 60 | 28 | 33 | 26 | 23 |
|  | Ages | 3-6 | 5,6 | 3-6 | 3-6 | 3-6 | 3-6 | 4-6 | 4-6 | 4-6 |
|  | cis-chlordane | na | 100 | 89 | 64 | 29 | 21 | 0.0 | 15 | 0.0 |
|  |  |  | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | trans-chlordane | na | 94 | 0.0 | 22 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  |  |  | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | trans-nonachlor | na | 100 | 81 | 98 | 88 | 75 | 94 | 77 | 87 |
|  |  |  | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | Oxychlordane | na | 100 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  |  |  | 2 | 10 | 10 | 10 | 10 | 5 | 5 | 5 |
| Cayuga Year |  | 1985 | 1988 | 1991 | 1995 | 2007 |  |  |  |  |
|  | n | 22 | 40 | 40 | 30 | 22 |  |  |  |  |
|  | Ages | 4, 5 | 4, 5 | 4, 5 | 4, 5 | 4, 5 |  |  |  |  |
|  | cis-chlordane | 100 | 47 | 80 | 13 | 0.0 |  |  |  |  |
|  |  | 2 | 5 | 5 | 5 | 5 |  |  |  |  |
|  | trans-chlordane | 96 | 7.5 | 30 | 0.0 | 0.0 |  |  |  |  |
|  |  | 2 | 5 | 5 | 5 | 5 |  |  |  |  |
|  | trans-nonachlor | 100 | 90 | 100 | 93 | 82 |  |  |  |  |
|  |  | 2 | 5 | 5 | 5 | 5 |  |  |  |  |
|  | Oxychlordane | 100 | 10 | 2.5 | 0.0 | 0.0 |  |  |  |  |
|  |  | 2 | 10 | 5 | 10 | 5 |  |  |  |  |

Table 14 continued.

| Lake | Analyte | $\underline{\text { Year/n/Age/\% of } \mathrm{n} \text { detectable/Detection limit }}$ |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Keuka | Year | 1983 | 1985 | 1988 | 1991 | 1994 | 1997 | 2000 | 2003 | 2007 |
|  | n | 9 | 24 | 49 | 45 | 42 | 37 | 28 | 41 | 44 |
|  | Ages | 4-6 | 4-6 | 4-6 | 4-6 | 4, 5 | 4-6 | 4-6 | 4-6 | 4-6 |
|  | cis-chlordane | na | 100 | 37 | 0.0 | 64 | 24 | 21 | 15 | 9.1 |
|  |  |  | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | trans-chlordane | na | 83 | 0.0 | 0.0 | 19 | 0.0 | 0.0 | 0.0 | 0.0 |
|  |  |  | 5 | 5 | 10 | 5 | 5 | 5 | 5 | 5 |
|  | trans-nonachlor | na | 100 | 82 | 60 | 100 | 87 | 93 | 39 | 73 |
|  |  |  | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  | Oxychlordane | na | 92 | 22 | 0.0 | 0.0 | 0.0 | 11 | 0.0 | 0.0 |
|  |  |  | 5 | 10 | 20 | 10 | 10 | 5 | 5 | 5 |
| Seneca | Year | 1983 | 1985 | 1988 | 1992 | 2002 | 2005 | 2008 |  |  |
|  | n | 19 | 20 | 34 | 37 | 19 | 36 | 43 |  |  |
|  | Ages | 4, 5 | 4, 5 | 4, 5 | 4, 5 | 4, 5 | 4, 5 | 4, 5 |  |  |
|  | cis-chlordane | na | 100 | 82 | 97 | 0.0 | 0.0 | 0.0 |  |  |
|  |  |  | 2 | 5 | 5 | 5 | 5 | 5 |  |  |
|  | trans-chlordane | na | 65 | 53 | 27 | 0.0 | 0.0 | 0.0 |  |  |
|  |  |  | 2 | 5 | 5 | 5 | 5 | 5 |  |  |
|  | trans-nonachlor | na | 100 | 97 | 100 | 95 | 33 | 60 |  |  |
|  |  |  | 2 | 5 | 5 | 5 | 5 | 5 |  |  |
|  | Oxychlordane | na | 75 | 38 | 0.0 | 0.0 | 0.0 | 0.0 |  |  |
|  |  |  | 2 | 10 | 10 | 10 | 5 | 5 |  |  |

Table 15: Total chlordane ${ }^{1}$ concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) in aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $43 \pm 15$ | 5 | $30 \pm 8.2$ | -- | -- | 1 | 168 | 3 | $179 \pm 36$ | 3 | $249 \pm 68$ |
|  | 1987 | 5 | $21 \pm 2.7$ | 15 | $25 \pm 7.5$ | 10 | $28 \pm 6.0$ | 4 | $34 \pm 3.6$ | 4 | $60 \pm 28$ | 3 | $108 \pm 22$ |
|  | 1990 | 3 | $10 \pm 0.0$ | 7 | $14 \pm 4.4$ | 11 | $14 \pm 2.7$ | 14 | $18 \pm 9.2$ | 7 | $65 \pm 48$ | 1 | 37 |
|  | 1993 | 16 | $15 \pm 2.5$ | 13 | $20 \pm 5.5$ | 4 | $22 \pm 5.9$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} 20 \\ (18 ; 22) \\ \hline \end{gathered}$ | 3 | $21 \pm 9.0$ | 1 | 18 | 8 | $40 \pm 11$ | 2 | $\begin{gathered} 41 \\ (36 ; 46) \\ \hline \end{gathered}$ |
|  | 2003 | 6 | $10 \pm 0.0$ | 6 | $10 \pm 0.0$ | 8 | $10 \pm 0.0$ | 36 | $10 \pm 0.0$ | 8 | $10 \pm 0.0$ | 7 | $18 \pm 6.1$ |
|  | 2008 | -- | -- | 2 | $10 \pm 0.0$ | 16 | $10 \pm 0.0$ | 12 | $11 \pm 2.7$ | 4 | $16 \pm 6.4$ | 8 | $17 \pm 3.6$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canandaigua | 1983 | 3 | na ${ }^{2}$ | 10 | na | 10 | na | 3 | na | 9 | na | 4 | na |
|  | 1985 | -- | -- | -- | -- | 12 | $64 \pm 26$ | 6 | $81 \pm 31$ | -- | -- | -- | -- |
|  | 1988 | 3 | $22 \pm 12$ | 3 | $18 \pm 4.6$ | 14 | $35 \pm 30$ | 6 | $28 \pm 5.2$ | 1 | 68 | 4 | $70 \pm 34$ |
|  | 1991 | 3 | $20 \pm 4.6$ | 24 | $26 \pm 12$ | 25 | $30 \pm 12$ | 3 | $35 \pm 2.0$ | 3 | $40 \pm 7.5$ | 5 | $92 \pm 49$ |
|  | 1994 | 6 | $17 \pm 4.6$ | 29 | $18 \pm 3.9$ | 21 | $21 \pm 5.0$ | 4 | $22 \pm 3.6$ | -- | -- | -- | -- |
|  | 1998 | 5 | $13 \pm 1.1$ | 5 | $17 \pm 6.0$ | 14 | $21 \pm 6.7$ | 4 | $27 \pm 2.7$ | 4 | $57 \pm 9.9$ | 1 | 54 |
|  | 2002 | -- | -- | 6 | $26 \pm 11$ | 15 | $28 \pm 12$ | 12 | $41 \pm 18$ | 5 | $54 \pm 21$ | 1 | 68 |
|  | 2006 | -- | -- | 6 | $15 \pm 6.6$ | 12 | $17 \pm 5.1$ | 8 | $18 \pm 8.6$ | 7 | $19 \pm 3.5$ | 5 | $39 \pm 9.6$ |
|  | 2009 | 2 | $<20$ | 1 | $<20$ | 16 | $13.3 \pm 1.5$ | 6 | $13.5 \pm 2.0$ | 8 | $20.9 \pm 8.2$ | 3 | $23.1 \pm 9.1$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cayuga | 1985 | -- | -- | 10 | $51 \pm 22$ | 12 | $74 \pm 37$ | 3 | $96 \pm 58$ | 5 | $159 \pm 98$ | -- | -- |
|  | 1988 | -- | -- | 20 | $22 \pm 5.3$ | 20 | $33 \pm 13$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $34 \pm 11$ | 20 | $53 \pm 22$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $19 \pm 5.9$ | 20 | $24 \pm 11$ | 6 | $38 \pm 10$ | 6 | $36 \pm 5.8$ | 5 | $43 \pm 7.6$ |
|  | 2007 | -- | -- | 14 | $13 \pm 2.8$ | 8 | $14 \pm 1.1$ | -- | -- | -- | -- | -- | -- |

Table 15 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Keuka | 1983 | -- | -- | 2 | na | 6 | na | 1 | na | -- | -- | -- | -- |
|  | 1985 | -- | -- | 9 | $69 \pm 24$ | 11 | $92 \pm 51$ | 4 | $153 \pm 74$ | 3 | $216 \pm 70$ | -- | -- |
|  | 1988 | -- | -- | 20 | $18 \pm 4.2$ | 18 | $36 \pm 21$ | 11 | $61 \pm 21$ | 6 | $127 \pm 68$ | 3 | $285 \pm 211$ |
|  | 1991 | -- | -- | 20 | $28 \pm 9.4$ | 17 | $35 \pm 20$ | 8 | $55 \pm 34$ | 1 | 90 | 4 | $75 \pm 72$ |
|  | 1994 | -- | -- | 19 | $27 \pm 14$ | 23 | $37 \pm 23$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $22 \pm 6.4$ | 15 | $18 \pm 6.1$ | 18 | $24 \pm 18$ | 12 | $32 \pm 19$ | 4 | $32 \pm 15$ |
|  | 2000 | -- | -- | 1 | 26 | 14 | $16 \pm 4.4$ | 13 | $27 \pm 15$ | 12 | $33 \pm 21$ | 6 | $26 \pm 9.8$ |
|  | 2003 | -- | -- | 8 | $10 \pm 0.0$ | 23 | $13 \pm 3.9$ | 10 | $17 \pm 7.4$ | 8 | $32 \pm 15$ | -- | -- |
|  | 2007 | -- | -- | 12 | $12 \pm 2.0$ | 21 | $13 \pm 2.4$ | 11 | $20 \pm 5.3$ | 4 | $24 \pm 2.8$ | 5 | $42 \pm 19$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Seneca | 1983 | -- | -- | 10 | na | 9 | na | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $32 \pm 24$ | 7 | $62 \pm 37$ | 5 | $68 \pm 31$ | -- | -- | 2 | $\begin{gathered} \hline 145 \\ (135 ; 154) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $42 \pm 21$ | 15 | $90 \pm 76$ | -- | -- | 1 | 135 | 4 | $130 \pm 56$ |
|  | 1991 | -- | -- | 17 | $34 \pm 12$ | 20 | $43 \pm 9.6$ | 1 | 51 | 3 | $71 \pm 13$ | 3 | $58 \pm 9.2$ |
|  | 2002 | -- | -- | 11 | $17 \pm 4.7$ | 8 | $23 \pm 3.5$ | -- | -- | 5 | $46 \pm 14$ | 3 | $46 \pm 6.4$ |
|  | 2005 | 3 | $10 \pm 0.0$ | 23 | $12 \pm 2.4$ | 13 | $11 \pm 1.8$ | 4 | $13 \pm 3.0$ | 7 | $23 \pm 14$ | 10 | $25 \pm 8.6$ |
|  | 2008 | 1 | 14 | 32 | $12 \pm 2.3$ | 11 | $13 \pm 2.3$ | 13 | $14 \pm 3.0$ | 4 | $19 \pm 5.6$ | 9 | $21 \pm 7.1$ |

${ }^{1}$ Sum of cis-chlordane, trans-chlordane, trans-nonachlor and oxychlordane. One-half the detection limit was used whenever a value was less than the detection limit (generally $5.0 \mathrm{ng} / \mathrm{g}$ for each analyte although greater detection limits were sometimes used). A mean concentration of $10 \mathrm{ng} / \mathrm{g}$ reported above indicates all analytes in each sample were less than detection.
${ }^{2} \mathrm{na}=$ Nor analyzed for chlordane and metabolites.

Table 16: Temporal comparisons ${ }^{1}$ of trans-nonachlor concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | ${ }^{6+}$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $24 \pm 9.8 \mathrm{~A}$ | 5 | $16 \pm 4.1 \mathrm{~A}$ | -- | -- | 1 | 100 | 3 | $111 \pm 7.6 \mathrm{~A}$ | 3 | $146 \pm 39 \mathrm{~A}$ |
|  | 1987 | 5 | $4.2 \pm 3.8 \mathrm{~B}$ | 15 | $9.5 \pm 6.4 \mathrm{~B}$ | 10 | $13 \pm 5.5 \mathrm{~A}$ | 4 | $19 \pm 3.6 \mathrm{~A}$ | 4 | $46 \pm 24 \mathrm{~B}$ | 3 | $65 \pm 11 \mathrm{~A}$ |
|  | 1990 | 3 | <5D | 7 | $5.9 \pm 3.5 \mathrm{~B}$ | 11 | $6.5 \pm 2.7 \mathrm{~B}$ | 14 | $9.6 \pm 6.9 \mathrm{~A}$ | 7 | $42 \pm 27 \mathrm{~B}$ | 1 | 30 |
|  | 1993 | 16 | $4.4 \pm 2.3 \mathrm{C}$ | 13 | $8.7 \pm 3.7 \mathrm{~B}$ | 4 | $12 \pm 5.0 \mathrm{~A}$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} 9.0 \\ (8 ; 10) \end{gathered}$ | 3 | $8.3 \pm 4.9 \mathrm{AB}$ | 1 | 8.0 | 8 | $23 \pm 6.4 \mathrm{C}$ | 2 | $\begin{gathered} 23 \\ (19 ; 26) \\ \hline \end{gathered}$ |
|  | 2003 | 6 | <5D | 6 | <5C | 8 | <5C | 36 | <5B | 8 | $<5 \mathrm{E}$ | 7 | $10 \pm 6.1 \mathrm{~B}$ |
|  | 2008 | -- | -- | 2 | $<5$ | 16 | $<5 \mathrm{C}$ | 12 | $3.6 \pm 2.7 \mathrm{~B}$ | 4 | $8.3 \pm 5.2 \mathrm{D}$ | 8 | $9.9 \pm 3.6 \mathrm{~B}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Canandaigua | 1983 | 3 | na ${ }^{2}$ | 10 | na | 10 | na | 3 | na | 9 | na | 4 | Na |
|  | 1985 | -- | -- | -- | -- | 12 | $25 \pm 12 \mathrm{~A}$ | 6 | $36 \pm 16 \mathrm{~A}$ | -- | -- | -- | -- |
|  | 1988 | 3 | $9.8 \pm 9.8 \mathrm{~A}$ | 3 | $4.0 \pm 2.6 \mathrm{C}$ | 14 | $20 \pm 26 \mathrm{CD}$ | 6 | $14 \pm 3.9 \mathrm{CD}$ | 1 | 44 | 4 | $41 \pm 26 \mathrm{~A}$ |
|  | 1991 | 3 | $8.7 \pm 2.1 \mathrm{~A}$ | 24 | $12 \pm 6.0 \mathrm{~B}$ | 25 | $14 \pm 7.1 \mathrm{BC}$ | 3 | $20 \pm 2.1 \mathrm{AB}$ | 3 | $23 \pm 4.7 \mathrm{~A}$ | 5 | $45 \pm 20 \mathrm{~A}$ |
|  | 1994 | 6 | $6.7 \pm 3.6 \mathrm{~A}$ | 29 | $7.4 \pm 3.4 \mathrm{C}$ | 21 | $10 \pm 3.9 \mathrm{DE}$ | 4 | $10 \pm 2.2 \mathrm{DE}$ | -- | -- | -- | -- |
|  | 1998 | 5 | $3.0 \pm 1.1 \mathrm{~A}$ | 5 | $7.4 \pm 6.0 \mathrm{C}$ | 14 | $10 \pm 5.5 \mathrm{E}$ | 4 | $15 \pm 0.81 \mathrm{BC}$ | 4 | $38 \pm 9.4 \mathrm{~A}$ | 1 | 37 |
|  | 2002 | -- | -- | 6 | $19 \pm 11 \mathrm{~A}$ | 15 | $21 \pm 12 \mathrm{AB}$ | 12 | $34 \pm 18 \mathrm{~A}$ | 5 | $47 \pm 21 \mathrm{~A}$ | 1 | 61 |
|  | 2006 | -- | -- | 6 | $7.0 \pm 4.8 \mathrm{C}$ | 12 | $8.9 \pm 4.3 \mathrm{E}$ | 8 | $9.5 \pm 6.6 \mathrm{E}$ | 7 | $12 \pm 3.5 \mathrm{~B}$ | 5 | $28 \pm 7.5 \mathrm{~A}$ |
|  | 2009 | 2 | <5 | 1 | <5 | 16 | $5.8 \pm 1.5 \mathrm{~F}$ | 6 | $6.0 \pm 1.5 \mathrm{E}$ | 8 | $12.3 \pm 6.0 \mathrm{~B}$ | 3 | $18.1 \pm 6.5 \mathrm{~A}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cayuga | 1985 | -- | -- | 10 | $23 \pm 9.9 \mathrm{~A}$ | 12 | $35 \pm 19 \mathrm{~A}$ | 3 | $55 \pm 37 \mathrm{~A}$ | 5 | $87 \pm 50 \mathrm{~A}$ | -- | -- |
|  | 1988 | -- | -- | 20 | $11 \pm 4.7 \mathrm{~B}$ | 20 | $16 \pm 9.5 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $23 \pm 7.7 \mathrm{~A}$ | 20 | $37 \pm 15 \mathrm{~A}$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $9.0 \pm 5.3 \mathrm{~B}$ | 20 | $14 \pm 8.8 \mathrm{~B}$ | 6 | $25 \pm 7.8 \mathrm{~A}$ | 6 | $23 \pm 4.4 \mathrm{~B}$ | 5 | $28 \pm 5.9$ |
|  | 2007 | -- | -- | 14 | $5.8 \pm 2.8 \mathrm{C}$ | 8 | $6.7 \pm 1.1 \mathrm{C}$ | -- | -- | -- | -- | -- | -- |

Table 16 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | $n$ | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Keuka | 1985 | -- | -- | 9 | $29 \pm 8.6 \mathrm{~A}$ | 11 | $37 \pm 22 \mathrm{~A}$ | 4 | $73 \pm 33 \mathrm{~A}$ | 3 | $105 \pm 26 \mathrm{~A}$ | -- | -- |
|  | 1988 | -- | -- | 20 | $5.4 \pm 2.4 \mathrm{C}$ | 18 | $18 \pm 14 \mathrm{~B}$ | 11 | $45 \pm 14 \mathrm{~A}$ | 6 | $89 \pm 59 \mathrm{~A}$ | 3 | $200 \pm 151 \mathrm{~A}$ |
|  | 1991 | -- | -- | 20 | $8.2 \pm 9.4 \mathrm{C}$ | 17 | $15 \pm 20 \mathrm{C}$ | 8 | $35 \pm 34 \mathrm{~B}$ | 1 | 70 | 4 | $55 \pm 72 \mathrm{~A}$ |
|  | 1994 | -- | -- | 19 | $13 \pm 9.2 \mathrm{~B}$ | 23 | $19 \pm 16 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $6.1 \pm 3.2 \mathrm{C}$ | 15 | $7.2 \pm 4.6 \mathrm{DE}$ | 18 | $13 \pm 15 \mathrm{C}$ | 12 | $17 \pm 13 \mathrm{C}$ | 4 | $18 \pm 10 \mathrm{~A}$ |
|  | 2000 | -- | -- | 1 | 14 | 14 | $8.6 \pm 3.9 \mathrm{CD}$ | 13 | $16 \pm 9.4 \mathrm{~B}$ | 12 | $20 \pm 11 \mathrm{C}$ | 6 | $16 \pm 8.2 \mathrm{~A}$ |
|  | 2003 | -- | -- | 8 | $<5 \mathrm{D}$ | 23 | $4.4 \pm 3.6 \mathrm{~F}$ | 10 | $9.5 \pm 6.2 \mathrm{C}$ | 8 | $20 \pm 12 \mathrm{~B}$ | -- | -- |
|  | 2007 | -- | -- | 12 | $4.3 \pm 2.0 \mathrm{CD}$ | 21 | $5.6 \pm 2.4 \mathrm{EF}$ | 11 | $12 \pm 5.1 \mathrm{BC}$ | 4 | $15 \pm 2.6 \mathrm{~B}$ | 5 | $31 \pm 1.6 \mathrm{~A}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Seneca | 1983 | -- | -- | 10 | na | 9 | na | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $17 \pm 12 \mathrm{BC}$ | 7 | $33 \pm 17 \mathrm{~A}$ | 5 | $36 \pm 19 \mathrm{~A}$ | -- | -- | 2 | $\begin{gathered} 83 \\ (77 ; 88) \\ \hline \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $22 \pm 11 \mathrm{~A}$ | 15 | $40 \pm 38 \mathrm{~A}$ | -- | -- | 1 | 66 | 4 | $71 \pm 18 \mathrm{~A}$ |
|  | 1991 | -- | -- | 17 | $17 \pm 6.9 \mathrm{AB}$ | 20 | $25 \pm 7.1 \mathrm{~A}$ | 1 | 30 | 3 | $47 \pm 11 \mathrm{~A}$ | 3 | $37 \pm 7.6 \mathrm{~A}$ |
|  | 2002 | -- | -- | 11 | $10 \pm 4.7 \mathrm{C}$ | 8 | $16 \pm 3.5 \mathrm{~B}$ | -- | -- | 5 | $39 \pm 14 \mathrm{~A}$ | 3 | $39 \pm 6.4 \mathrm{~A}$ |
|  | 2005 | 3 | $<5$ | 23 | $4.0 \pm 2.4 \mathrm{D}$ | 13 | $3.6 \pm 1.8 \mathrm{C}$ | 4 | $5.0 \pm 3.0 \mathrm{~B}$ | 7 | $12 \pm 9.3 \mathrm{~B}$ | 10 | $15 \pm 6.1 \mathrm{~B}$ |
|  | 2008 | 1 | 6.6 | 32 | $4.9 \pm 2.3 \mathrm{D}$ | 11 | $5.0 \pm 2.3 \mathrm{C}$ | 13 | $6.3 \pm 3.0 \mathrm{~B}$ | 4 | $11 \pm 4.2 \mathrm{~B}$ | 9 | $13 \pm 5.7 \mathrm{~B}$ |

${ }^{1}$ Same lettering between years within a lake's age group indicate data sets that are statistically the same (significance level of $\mathrm{p}<0.05$ ).
${ }^{2} \mathrm{na}=$ Not ananlyzed.

Table 17: Kruskal-Wallis comparisons (or Mann-Whitney test comparisons ${ }^{1}$ ) of trans-nonachlor concentrations by age for lake trout taken from five Finger Lakes, New York.

| Lake | $\begin{aligned} & \frac{\text { Year }}{1984} \end{aligned}$ | Age in rank order (low to high) |  |  |  | Quantile |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Canadice |  | $4 \quad 3 \quad 7 \quad 8$ |  |  |  | 99 |
|  | 1987 | $3 \quad 456$ | 7 |  |  | 99 |
|  | 1990 | $3 \quad 4 \quad 56$ | 7 |  |  | 99 |
|  | 1993 | 345 |  |  |  | 99 |
|  | 1998 | 57 |  |  |  | 99 |
|  | 2003 | 3 4 56 | 7 | $\underline{8}$ |  | 99 |
|  | 2008 | $5 \quad 6 \quad 789$ | 9 |  |  | 99 |
| Canandaigua | 1985 | 56 |  |  |  |  | <95 |
|  | 1988 | 4365 | 8 |  |  | 95 |
|  | 1991 | $3 \quad 4 \quad 5$ | 7 | 10 | 9 | 99 |
|  | 1994 | $3 \quad 4 \quad 5 \quad 6$ |  |  |  | 95 |
|  | 1998 | $\begin{array}{llll}3 & 4 & 5\end{array}$ | 7 |  |  | 99 |
|  | 2002 | 5 467 |  |  |  | 95 |
|  | 2006 | $4 \quad 6 \quad 5 \quad 7 \quad 9 \quad 8$ |  |  |  | 99 |
|  | 2009 |  |  |  |  | 99 |

Table 17 continued.

${ }^{1}$ The Mann-Whitney test was conducted when only two ages could be compared. A quantile of $<95$ indicates no significant age difference in trans-nonachlor concentration.

Table 18: Kruskal-Wallis comparisons (or Mann-Whitney test comparisons ${ }^{1}$ ) of mercury concentrations by age for lake trout taken from five Finger Lakes, New York.


Table 18 continued.

| Lake | Year | Age in rank order (low to high) |  |  |  |  |  | Quantile$99$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Keuka | 1988 |  | 4 5 | 6 | 7 | 8 |  |  |
|  | 1991 |  | 65 | 8 |  |  |  | $<95$ |
|  | 1994 |  | 45 |  |  |  |  | $<95$ |
|  | 1997 |  | 45 | 6 | 7 | 8 |  | 99 |
|  | 2000 |  | 57 | 6 | 8 |  |  | 99 |
|  | 2003 |  | 54 | 6 | 7 |  |  | 99 |
|  | 2007 |  | 45 | 7 | 6 | 8 |  | 99 |
| Seneca | 1988 |  | $5 \quad 4$ | 8 | 9 |  |  | 99 |
|  | 1991 |  | 57 | 8 |  |  |  | $<95$ |
|  | 2002 |  | 45 | 8 | 7 |  |  | 99 |
|  | 2005 |  | 345 | 56 | 6 | 7 | 89 | 99 |
|  | 2008 |  | $5 \quad 4$ | 6 | 8 | 9 | 7 | 99 |

[^8]Table 19: Temporal comparisons ${ }^{1}$ of mercury concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) for aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $n \mathrm{n}^{2}$ | 5 | na | -- | -- | 1 | na | 3 | na | 3 | na |
|  | 1987 | 5 | na | 15 | na | 10 | na | 4 | na | 4 | na | 3 | na |
|  | 1990 | 3 | $174 \pm 35 \mathrm{~A}$ | 7 | $120 \pm 36 \mathrm{~A}$ | 11 | $143 \pm 43 \mathrm{~A}$ | 14 | $172 \pm 69 \mathrm{~B}$ | 7 | $455 \pm 216 \mathrm{~A}$ | 1 | 442 |
|  | 1993 | 16 | $79 \pm 57 \mathrm{~B}$ | 13 | $104 \pm 56 \mathrm{~A}$ | 4 | $198 \pm 88 \mathrm{~A}$ | -- | -- | - | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $\begin{gathered} 125 \\ (110 ; 139) \end{gathered}$ | 3 | $110 \pm 16 \mathrm{~B}$ | 1 | 142 | 8 | $218 \pm 38 \mathrm{C}$ | 2 | $\begin{gathered} 279 \\ (227 ; 330) \end{gathered}$ |
|  | 2003 | 6 | $102 \pm 26 \mathrm{~B}$ | 6 | $111 \pm 8.8 \mathrm{~A}$ | 8 | $95.6 \pm 17 \mathrm{~B}$ | 36 | $155 \pm 42 \mathrm{~B}$ | 8 | $288 \pm 72 \mathrm{~B}$ | 7 | $391 \pm 74 \mathrm{~B}$ |
|  | 2008 | -- | -- | 2 | $\begin{gathered} 162 \\ (148,175) \\ \hline \end{gathered}$ | 16 | $151 \pm 25 \mathrm{~A}$ | 12 | $228 \pm 69 \mathrm{~A}$ | 4 | $504 \pm 183 \mathrm{~A}$ | 8 | $506 \pm 30 \mathrm{~A}$ |

Table 19 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canandaigua | 1983 | 3 | na | 10 | na | 10 | na | 3 | na | 9 | na | 4 | na |
|  | 1985 | -- | -- | -- | -- | 12 | na | 6 | na | 1 | na | -- | -- |
|  | 1988 | 3 | $102 \pm 51 \mathrm{~A}$ | 3 | $113 \pm 22 \mathrm{~B}$ | 14 | $153 \pm 60 \mathrm{BC}$ | 6 | $185 \pm 83 \mathrm{C}$ | 1 | 349 | 4 | $432 \pm 124 \mathrm{~B}$ |
|  | 1991 | 3 | na | 24 | na | 6 | $161 \pm 32 \mathrm{BC}$ | 3 | $174 \pm 46 \mathrm{C}$ | 3 | $183 \pm 42 \mathrm{C}$ | 5 | $283 \pm 97 \mathrm{C}$ |
|  | 1994 | 6 | $110 \pm 23 \mathrm{~A}$ | 29 | $126 \pm 38 \mathrm{~B}$ | 21 | $150 \pm 40 \mathrm{C}$ | 4 | $164 \pm 51 \mathrm{C}$ | -- | -- | -- | -- |
|  | 1998 | 5 | $181 \pm 72 \mathrm{~A}$ | 5 | $238 \pm 60 \mathrm{~A}$ | 14 | $299 \pm 67 \mathrm{~A}$ | 4 | $306 \pm 60 \mathrm{~B}$ | 4 | $342 \pm 58 \mathrm{~B}$ | 1 | 419 |
|  | 2002 | -- | -- | 6 | $246 \pm 29 \mathrm{~A}$ | 15 | $299 \pm 54 \mathrm{~A}$ | 12 | $392 \pm 67 \mathrm{~A}$ | 5 | $481 \pm 69 \mathrm{~A}$ | 1 | 533 |
|  | 2006 | -- | -- | 6 | $208 \pm 27 \mathrm{~A}$ | 12 | $343 \pm 71 \mathrm{~A}$ | 8 | $\begin{gathered} \hline 337 \pm \\ 117 \mathrm{AB} \\ \hline \end{gathered}$ | 7 | $471 \pm 43 \mathrm{~A}$ | 5 | $648 \pm 106 \mathrm{~A}$ |
|  | 2009 | 2 | $\begin{gathered} 150 \\ (139 ; 161) \\ \hline \end{gathered}$ | 1 | 222 | 16 | $179 \pm 40 \mathrm{~B}$ | 6 | $219 \pm 20 \mathrm{C}$ | 8 | $326 \pm 79 \mathrm{~B}$ | 3 | $373 \pm 17 \mathrm{C}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cayuga | 1985 | -- | -- | 10 | na | 12 | na | 3 | na | 5 | na | -- | -- |
|  | 1988 | -- | -- | 20 | $194 \pm 92 \mathrm{~B}$ | 20 | $243 \pm 54 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | -- | -- | 14 | $305 \pm 73 \mathrm{~A}$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $219 \pm 28 \mathrm{~A}$ | 20 | $253 \pm 44 \mathrm{~B}$ | 6 | $291 \pm 26$ | 6 | $309 \pm 87$ | 5 | $283 \pm 31$ |
|  | 2007 | -- | -- | 14 | $228 \pm 63 \mathrm{~A}$ | 8 | $269 \pm 27 \mathrm{AB}$ | -- | -- | -- | -- | -- | -- |

Table 19 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Keuka | 1988 | -- | -- | 20 | $101 \pm 28 \mathrm{C}$ | 18 | $160 \pm 59 \mathrm{~B}$ | 11 | $248 \pm 81 \mathrm{AB}$ | 6 | $365 \pm 60 \mathrm{~A}$ | 3 | $496 \pm 17 \mathrm{~A}$ |
|  | 1991 | -- | -- | 1 | 93 | 4 | $233 \pm 103 \mathrm{~A}$ | 8 | $170 \pm 89 \mathrm{C}$ | 1 | 249 | 4 | $249 \pm 132 \mathrm{~B}$ |
|  | 1994 | -- | -- | 19 | $125 \pm 80 \mathrm{C}$ | 23 | $150 \pm 82 \mathrm{~B}$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $99 \pm 30 \mathrm{BC}$ | 15 | $157 \pm 56 \mathrm{~B}$ | 18 | $184 \pm 56 \mathrm{C}$ | 12 | $216 \pm 92 \mathrm{~B}$ | 4 | $244 \pm 67 \mathrm{~B}$ |
|  | 2000 | -- | -- | 1 | 152 | 14 | $149 \pm 69 \mathrm{~B}$ | 13 | $278 \pm 150 \mathrm{~B}$ | 12 | $239 \pm 62 \mathrm{~B}$ | 6 | $290 \pm 83 \mathrm{~B}$ |
|  | 2003 | -- | -- | 8 | $140 \pm 45 \mathrm{~B}$ | 23 | $138 \pm 47 \mathrm{~B}$ | 10 | $203 \pm 88 \mathrm{BC}$ | 8 | $337 \pm 127 \mathrm{~A}$ | -- | -- |
|  | 2007 | -- | -- | 12 | $193 \pm 53 \mathrm{~A}$ | 21 | $229 \pm 65 \mathrm{~A}$ | 11 | $322 \pm 92 \mathrm{~A}$ | 4 | $292 \pm 66 \mathrm{~A}$ | 5 | $402 \pm 43 \mathrm{~A}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Seneca | 1983 | -- | -- | 10 | na | 9 | na | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | na | 7 | na | 5 | na | -- | -- | 2 | na |
|  | 1988 | -- | -- | 19 | $264 \pm 94 \mathrm{~A}$ | 15 | $264 \pm 103 \mathrm{~A}$ | -- | -- | 1 | 376 | 4 | $467 \pm 59 \mathrm{~A}$ |
|  | 1991 | -- | -- | -- | -- | 7 | $280 \pm 39 \mathrm{~A}$ | 1 | 242 | 3 | $392 \pm 176 \mathrm{~A}$ | 3 | $441 \pm 151 \mathrm{~A}$ |
|  | 2002 | -- | -- | 11 | $286 \pm 105 \mathrm{~A}$ | 8 | $376 \pm 81 \mathrm{~A}$ | -- | -- | 5 | $507 \pm 76 \mathrm{~A}$ | 3 | $486 \pm 105 \mathrm{~A}$ |
|  | 2005 | 3 | $256 \pm 220$ | 23 | $285 \pm 118 \mathrm{~A}$ | 13 | $295 \pm 82 \mathrm{~A}$ | 4 | $349 \pm 126 \mathrm{~A}$ | 7 | $506 \pm 125 \mathrm{~A}$ | 10 | $508 \pm 137 \mathrm{~A}$ |
|  | 2008 | 1 | 231 | 32 | $279 \pm 119 \mathrm{~A}$ | 11 | $261 \pm 78 \mathrm{~A}$ | 13 | $329 \pm 75 \mathrm{~A}$ | 4 | $457 \pm 103 \mathrm{~A}$ | 9 | $424 \pm 83 \mathrm{~A}$ |

[^9]Table 20: Changes over time in the frequency of detection of mirex in lake trout taken from five Finger Lakes, New York.

| Lake | Year / N / \% incidence |  |  |  |  |  |  |  |  | Minimum distance to L. Ontario $\underline{\mathrm{km}}$ (mi) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Canadice | 1984 | 1987 | 1990 | 1993 | 1998 | 2003 | 2008 |  |  | 61 (38) |
|  | 21 | 44 | 45 | 33 | 17 | 76 | 46 |  |  |  |
|  | 4.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |  |  |  |
| Canandaigua | 1983 | 1985 | 1988 | 1991 | 1994 | 1998 | 2002 | 2006 | 2009 | 45 (28) |
|  | 43 | 19 | 35 | 70 | 60 | 39 | 41 | 42 | 39 |  |
|  | $n{ }^{2}$ | na | 5.7 | 32.9 | 0.0 | 15.4 | 0.0 | 0.0 | 0.0 |  |
| Cayuga | 1985 | 1988 | 1991 | 1995 | 2007 |  |  |  |  | 42 (26) |
|  | 31 | 40 | 40 | 53 | 22 |  |  |  |  |  |
|  | na | 0.0 | 0.0 | 3.8 | 0.0 |  |  |  |  |  |
| Keuka | 1983 | 1985 | 1988 | 1991 | 1994 | 1997 | 2000 | 2003 | 2007 | 70 (44) |
|  | 9 | 27 | 58 | 50 | 42 | 53 | 49 | 50 | 57 |  |
|  | na | na | 0.0 | 0.0 | 0.0 | 1.9 | 12.2 | 0.0 | 0.0 |  |
| Seneca | 1983 | 1985 | 1988 | 1991 | 2002 | 2005 | 2008 |  |  | 45 (28) |
|  | 19 | 27 | 49 | 46 | 29 | 64 | 76 |  |  |  |
|  | na | na | 2.0 | 50.0 | 0.0 | 0.0 | 1.3 |  |  |  |

${ }^{1}$ Detection limits in nearly all cases were $2.0 \mathrm{ng} / \mathrm{g}$. The exceptions were $1.0 \mathrm{ng} / \mathrm{g}$ in 1984 and $5.0 \mathrm{ng} / \mathrm{g}$ in 1987, both in Canadice Lake. Percentages based on all samples analyzed.
${ }^{2}$ na $=$ Not analyzed.

Table 21: Changes over time in the frequency of non-detection of dieldrin in lake trout (ages 3 through 6 years old) taken from five Finger Lakes, New York.

| Lake | $\underline{\text { Year / N / \% less than detection limit/detection limit }}$ |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Canadice | 1984 | 1987 | 1990 | 1993 | 1998 | 2003 | 2008 |  |  |
|  | 14 | 34 | 35 | 33 | 6 | 56 | 46 |  |  |
|  | 0.0 | 44 | 11 | 83 | 0.0 | na ${ }^{1}$ | na |  |  |
|  | 5 | 5 | 5 | 5 | 5 |  |  |  |  |
| Canandaigua | 1983 | 1985 | 1988 | 1991 | 1994 | 1998 | 2002 | 2006 | 2009 |
|  | 26 | 18 | 26 | 55 | 60 | 28 | 33 | 42 | 39 |
|  | 0.0 | 0.0 | 3.8 | 36 | 60 | 61 | na | na | na |
|  | 20 | 2 | 5 | 5 | 5 | 5 |  |  |  |
| Cayuga | 1985 | 1988 | 1991 | 1995 | 2007 |  |  |  |  |
|  | 25 | 40 | 40 | 36 | 22 |  |  |  |  |
|  | 56 | 15 | 0.0 | 81 | na |  |  |  |  |
|  | 10 | 5 | 5 | 5 |  |  |  |  |  |
| Keuka | 1983 | 1985 | 1988 | 1991 | 1994 | 1997 | 2000 | 2003 | 2007 |
|  | 9 | 24 | 49 | 45 | 42 | 37 | 28 | 41 | 57 |
|  | 0.0 | 54 | 6.1 | 100 | 4.7 | 94 | 96 | na | na |
|  | 10 | 10 | 5 | 20 | 5 | 5 | 5 |  |  |
| Seneca | 1983 | 1985 | 1988 | 1991 | 2002 | 2005 | 2008 |  |  |
|  | 19 | 25 | 34 | 38 | 19 | 43 | 76 |  |  |
|  | 0.0 | 12 | 5.9 | 7.9 | na | na | na |  |  |
|  | 10 | 5 | 5 | 5 |  |  |  |  |  |

[^10]Table 22: Dieldrin concentrations ${ }^{1}(\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) in aged lake trout taken from five Finger Lakes, New York.


Table 22 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Cayuga | 1985 | -- | -- | 10 | $4.6 \pm 0.70$ | 12 | $5.3 \pm 2.2$ | 3 | $5.0 \pm 0.0$ | 5 | $5.2 \pm 0.45$ | -- | -- |
|  | 1988 | -- | -- | 20 | $5.9 \pm 3.1$ | 20 | $9.1 \pm 3.4$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $13 \pm 6.4$ | 20 | $13 \pm 6.0$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | $<5$ | 20 | $3.3 \pm 2.1$ | 6 | $5.3 \pm 2.8$ | 6 | $4.8 \pm 2.5$ | 5 | $8.2 \pm 3.1$ |
|  | 2007 | -- | -- | 14 | na | 8 | na | -- | -- | -- | -- | -- | -- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Keuka | 1983 | -- | -- | 2 | $\begin{gathered} 23 \\ (13 ; 33) \end{gathered}$ | 6 | $28 \pm 12$ | 1 | 63 | -- | -- | -- | -- |
|  | 1985 | -- | -- | 9 | $5.8 \pm 1.6$ | 11 | $5.2 \pm 1.9$ | 4 | $7.5 \pm 3.7$ | 3 | $8.0 \pm 2.6$ | -- | -- |
|  | 1988 | -- | -- | 20 | $6.1 \pm 2.0$ | 18 | $16 \pm 5.7$ | 11 | $30 \pm 10$ | 6 | $39 \pm 11$ | 3 | $48 \pm 30$ |
|  | 1991 | -- | -- | 20 | $<20$ | 17 | $<20$ | 8 | $<20$ | 1 | $<20$ | 4 | $<20$ |
|  | 1994 | -- | -- | 19 | $6.9 \pm 2.3$ | 23 | $9.3 \pm 4.1$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $<5$ | 15 | $2.7 \pm 0.65$ | 18 | $2.6 \pm 0.59$ | 12 | $4.0 \pm 2.3$ | 4 | $5.0 \pm 2.9$ |
|  | 2000 | -- | -- | 1 | $<5$ | 14 | $2.8 \pm 0.94$ | 13 | $<5$ | 12 | $2.7 \pm 0.72$ | 6 | $<5$ |
|  | 2003 | -- | -- | 8 | na | 23 | na | 10 | na | 8 | na | -- | -- |
|  | 2007 | -- | -- | 12 | na | 21 | na | 11 | na | 4 | na | 5 | na |

Table 22 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Seneca | 1983 | -- | -- | 10 | $18 \pm 8.7$ | 9 | $17 \pm 9.6$ | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $7.5 \pm 3.9$ | 7 | $10 \pm 5.3$ | 5 | $29 \pm 4.2$ | -- | -- | 2 | $\begin{gathered} 35 \\ (31 ; 39) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $9.9 \pm 4.9$ | 15 | $22 \pm 11$ | -- | -- | 1 | $<5$ | 4 | $18 \pm 18$ |
|  | 1991 | -- | -- | 17 | $9.1 \pm 4.6$ | 20 | $11 \pm 4.7$ | 1 | 15 | 3 | $13 \pm 6.1$ | 3 | $12 \pm 8.9$ |
|  | 2002 | -- | -- | 11 | na | 8 | na | -- | -- | 5 | na | 3 | na |
|  | 2005 | 3 | na | 23 | na | 13 | na | 4 | na | 7 | na | 10 | na |
|  | 2008 | 1 | na | 32 | na | 11 | na | 13 | na | 4 | na | 9 | na |

[^11]Table 23: Hexachlorobenzene (HCB) concentrations ( $\mathrm{ng} / \mathrm{g}$ wet weight in standard fillets) in aged lake trout taken from five Finger Lakes, New York.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | $6+$ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canadice | 1984 | 8 | $\begin{aligned} 13 & \pm 17 \\ (6.6 & \pm 3.1 ; \\ \mathrm{n} & =7) \end{aligned}$ | 5 | $5.1 \pm 1.6$ | -- | -- | 1 | 28 | 3 | $40 \pm 5.8$ | 3 | $44 \pm 12$ |
|  | 1987 | 5 | $<5^{1}$ | 15 | $<5$ | 10 | $<5$ | 4 | $<5$ | 4 | $3.6 \pm 2.3$ | 3 | $6.2 \pm 4.4$ |
|  | 1990 | 3 | $<2^{1}$ | 7 | $<2$ | 11 | $<2$ | 14 | $<2$ | 7 | $<2$ | 1 | $<2$ |
|  | 1993 | 16 | $1.6 \pm 1.1$ | 13 | $2.1 \pm 1.7$ | 4 | $1.5 \pm 0.58$ | -- | -- | -- | -- | -- | -- |
|  | 1998 | -- | -- | 2 | $<2$ | 3 | $<2$ | 1 | $<2$ | 8 | $2.0 \pm 0.76$ | 2 | $\begin{gathered} 2.5 \\ (2 ; 3) \end{gathered}$ |
|  | 2003 | 6 | $<2$ | 6 | $<2$ | 8 | $<2$ | 36 | $<2$ | 8 | $<2$ | 7 | $<2$ |
|  | 2008 | -- | -- | 2 | $<2$ | 16 | $<2$ | 12 | $<2$ | 4 | <2 | 8 | $<2$ |

Table 23 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Canandaigua | 1983 | 3 | $1.3 \pm 0.58$ | 10 | $1.9 \pm 0.57$ | 10 | $2.1 \pm 0.78$ | 3 | $2.3 \pm 0.58$ | 9 | $7.0 \pm 1.5$ | 4 | $7.0 \pm 1.6$ |
|  | 1985 | -- | -- | -- | -- | 12 | $n \mathrm{na}^{2}$ | 6 | na | -- | -- | -- | -- |
|  | 1988 | 3 | $<2$ | 3 | $<2$ | 14 | $<2$ | 6 | $<2$ | 1 | $<2$ | 4 | $<2$ |
|  | 1991 | 3 | $2.3 \pm 1.5$ | 24 | $2.3 \pm 2.1$ | 25 | $3.1 \pm 2.0$ | 3 | $3.0 \pm 0.0$ | 3 | $4.0 \pm 1.0$ | 5 | $15 \pm 11$ |
|  | 1994 | 6 | <2 | 29 | $<2$ | 21 | $<2$ | 4 | $<2$ | -- | -- | -- | -- |
|  | 1998 | 5 | $<2$ | 5 | $<2$ | 14 | $1.1 \pm 0.27$ | 4 | $1.3 \pm 0.50$ | 4 | $3.0 \pm 0.82$ | 1 | 3.0 |
|  | 2002 | -- | -- | 6 | $<2$ | 15 | $<2$ | 12 | $<2$ | 5 | $1.2 \pm 0.45$ | 1 | $<2$ |
|  | 2006 | -- | -- | 6 | $3.0 \pm 1.4$ | 12 | $2.8 \pm 1.7$ | 8 | $2.8 \pm 1.0$ | 7 | $3.8 \pm 1.6$ | 5 | $4.5 \pm 1.8$ |
|  | 2009 | 2 | <2 | 1 | $<2$ | 16 | $<2$ | 6 | $1.1 \pm 0.34$ | 8 | $1.5 \pm 0.55$ | 3 | $2.0 \pm 1.4$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cayuga | 1985 | -- | -- | 9 | $2.6 \pm 0.73$ | 9 | $4.0 \pm 2.1$ | 3 | $6.0 \pm 1.0$ | 5 | $7.6 \pm 3.6$ | -- | -- |
|  | 1988 | -- | -- | 20 | $1.4 \pm 0.88$ | 20 | $1.6 \pm 1.6$ | -- | -- | -- | -- | -- | -- |
|  | 1991 | -- | -- | 20 | $1.2 \pm 0.37$ | 20 | $1.8 \pm 1.0$ | -- | -- | -- | -- | -- | -- |
|  | 1995 | -- | -- | 10 | <2 | 20 | $1.1 \pm 0.31$ | 6 | $1.2 \pm 0.41$ | 6 | $<2$ | 5 | $1.2 \pm 0.44$ |
|  | 2007 | -- | -- | 14 | $1.1 \pm 0.44$ | 8 | $<2$ | -- | -- | -- | -- | -- | -- |

Table 23 continued.

| Lake | Year | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Keuka | 1983 | -- | -- | 2 | $\begin{gathered} 2.5 \\ (2 ; 3) \end{gathered}$ | 6 | $2.5 \pm 2.0$ | 1 | 7.0 | -- | -- | -- | -- |
|  | 1985 | -- | -- | 9 | $2.7 \pm 1.4$ | 11 | $3.5 \pm 1.6$ | 4 | $5.5 \pm 3.4$ | 3 | $5.3 \pm 1.2$ | -- | -- |
|  | 1988 | -- | -- | 20 | $1.3 \pm 0.64$ | 18 | $<2$ | 11 | $<2$ | 6 | $<2$ | 3 | <2 |
|  | 1991 | -- | -- | 20 | $<2$ | 17 | <2 | 8 | <2 | 1 | <2 | 4 | <2 |
|  | 1994 | -- | -- | 19 | $1.3 \pm 0.75$ | 23 | $1.8 \pm 1.4$ | -- | -- | -- | -- | -- | -- |
|  | 1997 | -- | -- | 4 | $<2$ | 15 | $1.1 \pm 0.26$ | 18 | $1.2 \pm 0.38$ | 12 | $1.9 \pm 1.2$ | 4 | $2.0 \pm 0.82$ |
|  | 2000 | -- | -- | 1 | <2 | 14 | $1.6 \pm 0.51$ | 13 | $1.4 \pm 0.51$ | 12 | $2.3 \pm 1.6$ | 6 | $1.8 \pm 0.75$ |
|  | 2003 | -- | -- | 8 | $<2$ | 23 | $<2$ | 10 | $<2$ | 8 | $1.18 \pm 0.51$ | -- | -- |
|  | 2007 | -- | -- | 12 | $1.5 \pm 1.8$ | 21 | $2.3 \pm 2.2$ | 11 | $1.3 \pm 1.3$ | 4 | $1.2 \pm 1.4$ | 5 | $1.4 \pm 0.94$ |

Table 23 continued.

| Lake |  | Age (years) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 3+ |  | 4+ |  | 5+ |  | 6+ |  | 7+ |  | 8+ |  |
|  |  | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD | n | Mean $\pm$ SD |
| Seneca | 1983 | -- | -- | 10 | $2.7 \pm 0.95$ | 9 | $2.9 \pm 1.3$ | -- | -- | -- | -- | -- | -- |
|  | 1985 | -- | -- | 13 | $1.3 \pm 0.48$ | 7 | $2.0 \pm 0.82$ | 5 | $5.4 \pm 1.5$ | -- | -- | 2 | $\begin{gathered} 6.5 \\ (6 ; 7) \end{gathered}$ |
|  | 1988 | -- | -- | 19 | $1.6 \pm 1.0$ | 15 | $4.2 \pm 3.2$ | -- | -- | 1 | 6.0 | 4 | $3.5 \pm 3.0$ |
|  | 1991 | -- | -- | 17 | $2.3 \pm 1.1$ | 20 | $3.5 \pm 3.0$ | 1 | 10 | 3 | $5.7 \pm 4.5$ | 3 | $3.7 \pm 4.6$ |
|  | 2002 | -- | -- | 11 | <2 | 8 | <2 | -- | -- | 5 | $1.5 \pm 0.69$ | 3 | $<2$ |
|  | 2005 | 3 | <2 | 23 | <2 | 13 | $<2$ | 4 | <2 | 7 | $1.3 \pm 0.70$ | 10 | <2 |
|  | 2008 | 1 | $<2$ | 32 | $<2$ | 11 | $<2$ | 13 | $<2$ | 4 | $<2$ | 9 | $<2$ |

${ }^{1}$ Values preceeded by a less than sign $(<)$ are detection limits. All samples in the group contained non-detectable HCB.
${ }^{2} \mathrm{na}=$ Not analyzed for chlordane and metabolites.

Table 24: Chemical residue concentrations in other aged lake trout taken from five Finger Lakes, New York during 1983 through 2008.

| Age | Year ${ }^{2}$ | n | Length (mm) | Lipids (\%) | Concentration (Mean $\pm$ SD; ng/g wet weight in standard fillets) ${ }^{1}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p,p'-DDE | $\sum$ DDT $^{3}$ | Dieldrin | $\Sigma$ Chlordane $^{4}$ | HCB | Hg |
| Canadice Lake |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 1987 | 1 | 306 | 0.88 | 278 | 10 | 20 | <5 | $<40$ | $<5$ | $n a^{5}$ |
| 9 | 1984 | 1 | 728 | 22.26 | 20540 | 687 | 1007 | 55 | 258 | 50 | na |
|  | 1987 | 2 | $\begin{gathered} 692 \\ (680 ; 703) \end{gathered}$ | $\begin{gathered} 9.06 \\ (8.17 ; 9.95) \end{gathered}$ | $\begin{gathered} 4075 \\ (2855 ; 5295) \end{gathered}$ | $\begin{gathered} 179 \\ (104 ; 253) \end{gathered}$ | $\begin{gathered} 249 \\ (142 ; 355) \end{gathered}$ | $\begin{gathered} 13 \\ (13 ; 13) \end{gathered}$ | $\begin{gathered} 78 \\ (59 ; 97) \end{gathered}$ | $\begin{gathered} 3.8 \\ (<5,5) \end{gathered}$ | na |
|  | 1990 | 1 | 733 | 12.51 | 3070 | 134 | 315 | 38 | 87 | $<2$ | 675 |
|  | 1998 | 1 | 690 | 8.50 | 2527 | 138 | 177 | 8 | 40 | <2 | 698 |
|  | 2003 | 3 | $684 \pm 31$ | $8.97 \pm 1.01$ | $1377 \pm 550$ | $85 \pm 38$ | $101 \pm 50$ | na | $14 \pm 6.9$ | <2 | $453 \pm 131$ |
|  | 2008 | 3 | $682 \pm 20$ | $12.52 \pm 3.04$ | $3637 \pm 533$ | $149 \pm 18$ | $197 \pm 29$ | na | $24 \pm 9$ | $<2$ | $574 \pm 145$ |
| 10 | 1990 | 1 | 712 | 10.51 | 12310 | 283 | 469 | 32 | 132 | <2 | 575 |
|  | 2003 | 1 | 768 | 8.19 | 2301 | 130 | 145 | na | 22 | $<2$ | 437 |
|  | 2008 | 1 | 663 | 9.61 | 2375 | 93 | 123 | na | 17 | $<2$ | 585 |

Table 24 continued.

| Age | Year ${ }^{2}$ | n | Length (mm) | Lipids (\%) | Concentration (Mean $\pm$ SD; ng/g wet weight in standard fillets) ${ }^{1}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p,p'-DDE | $\sum$ DDT $^{\underline{3}}$ | Dieldrin | $\Sigma$ Chlordane $^{4}$ | HCB | Hg |
| Canandaigua Lake |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 1998 | 1 | 274 | 0.51 | 51 | 31 | 34 | $<5$ | 13 | $<2$ | 123 |
|  | 2009 | 1 | 308 | 5.71 | 92 | 45 | 64 | na | $<20$ | 2.0 | 113 |
| 9 | 1983 | 2 | $\begin{gathered} 673 \\ (655 ; 690) \end{gathered}$ | $\begin{gathered} 7.88 \\ (7.69 ; 8.06) \end{gathered}$ | $\begin{gathered} 2625 \\ (2495 ; 2755) \end{gathered}$ | $\begin{gathered} 1058 \\ (995 ; 1120) \end{gathered}$ | $\begin{gathered} 1497 \\ (1467 ; 1527) \end{gathered}$ | $\begin{gathered} 31 \\ (14 ; 47) \end{gathered}$ | na | $\begin{gathered} 7.0 \\ (6 ; 8) \end{gathered}$ | na |
|  | 1988 | 1 | 602 | 4.06 | 620 | 719 | 784 | 12 | 52 | $<2$ | 372 |
|  | 1991 | 3 | $677 \pm 26$ | $5.14 \pm 1.61$ | $1692 \pm 851$ | $848 \pm 424$ | $1041 \pm 492$ | $22 \pm 5.0$ | $176 \pm 84$ | $7.3 \pm 1.2$ | $447 \pm 69$ |
|  | 2002 | 1 | 600 | 9.58 | 311 | 412 | 450 | na | 72 | $<2$ | 414 |
|  | 2006 | 4 | $668 \pm 66$ | $6.96 \pm 2.41$ | $506 \pm 206$ | $371 \pm 126$ | $415 \pm 137$ | na | $39 \pm 13$ | $3.7 \pm 2.0$ | $627 \pm 122$ |
|  | 2009 | 2 | $\begin{gathered} 624 \\ (614 ; 634) \end{gathered}$ | $\begin{gathered} 12.05 \\ (11.38 ; 12.72) \end{gathered}$ | $\begin{gathered} 315 \\ (284 ; 345) \end{gathered}$ | $\begin{gathered} 237 \\ (202 ; 271) \end{gathered}$ | $\begin{gathered} 291 \\ (254 ; 328) \end{gathered}$ | na | $\begin{gathered} 32.8 \\ (29.6 ; 35.9) \end{gathered}$ | $\begin{gathered} 4.5 \\ (4.0 ; 5.0) \end{gathered}$ | $\begin{gathered} 299 \\ (245 ; 352) \end{gathered}$ |
| 10 | 1985 | 1 | 657 | 11.23 | 1630 | 1300 | 1724 | 8.0 | 234 | na | na |
|  | 1988 | 1 | 662 | 6.45 | 1770 | 1600 | 1889 | 31 | 154 | <2 | 640 |
|  | 1991 | 3 | $604 \pm 33$ | $4.91 \pm 1.87$ | $824 \pm 235$ | $373 \pm 119$ | $482 \pm 130$ | $22 \pm 7.0$ | $86 \pm 9.3$ | $8.3 \pm 3.1$ | $328 \pm 122$ |
| 11 | 1988 | 1 | 745 | 8.96 | 1470 | 1990 | 2302 | na | 148 | $<2$ | 670 |
|  | 1991 | 1 | 680 | 1.85 | 3958 | 2917 | 3035 | $<5$ | 125 | 2.0 | 603 |
| 12 | 1983 | 2 | $\begin{gathered} 727 \\ (715 ; 738) \end{gathered}$ | $\begin{gathered} 9.53 \\ (8.86 ; 10.2) \end{gathered}$ | $\begin{gathered} 3185 \\ (3025 ; 3345) \end{gathered}$ | $\begin{gathered} 1375 \\ (1010 ; 1740) \end{gathered}$ | $\begin{gathered} 2002 \\ (1488 ; 2516) \end{gathered}$ | $\begin{gathered} 20 \\ (<20 ; 29) \end{gathered}$ | na | $\begin{gathered} 8.0 \\ (8 ; 8) \end{gathered}$ | na |
|  | 1988 | 1 | 722 | 6.24 | 4430 | 5810 | 6439 | 41 | 300 | $<2$ | 901 |

Table 24 continued.

| Age | Year ${ }^{2}$ | n | Length (mm) | Lipids (\%) | Concentration (Mean $\pm$ SD; ng/g wet weight in standard fillets) ${ }^{1}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p,p'-DDE | $\sum \mathrm{DDT}^{3}$ | Dieldrin | $\sum$ Chlordane ${ }^{4}$ | HCB | Hg |
| Cayuga Lake |  |  |  |  |  |  |  |  |  |  |  |
| 9 | 1985 | 1 | 712 | 8.78 | 1410 | 131 | 303 | $<10$ | 204 | 8.0 | na |
|  | 1995 | 5 | $662 \pm 40$ | $5.97 \pm 2.65$ | $219 \pm 55$ | $174 \pm 80$ | $205 \pm 86$ | $5.2 \pm 2.1$ | $44 \pm 11$ | $1.2 \pm 0.44$ | $365 \pm 60$ |
| 10 | 1995 | 1 | 692 | 6.43 | 306 | 179 | 218 | 7.0 | 49 | 2.0 | 416 |
| Keuka Lake |  |  |  |  |  |  |  |  |  |  |  |
| 9 | 2003 | 1 | 540 | 7.13 | 175 | 1600 | 1793 | na | 47 | 2.1 | 299 |
|  | 2007 | 2 | $\begin{gathered} 602 \\ (552 ; 652) \\ \hline \end{gathered}$ | $\begin{gathered} \hline 5.56 \\ (5.52 ; 5.60) \\ \hline \end{gathered}$ | $\begin{gathered} 211 \\ (158 ; 263) \\ \hline \end{gathered}$ | $\begin{gathered} \hline 1235 \\ (829 ; 1640) \\ \hline \end{gathered}$ | $\begin{gathered} 1379 \\ (976 ; 1784) \\ \hline \end{gathered}$ | na | $\begin{gathered} 34 \\ (31 ; 36) \\ \hline \end{gathered}$ | $\begin{gathered} \hline 2.3 \\ (2.1 ; 2.4) \\ \hline \end{gathered}$ | $\begin{gathered} 365 \\ (330 ; 400) \\ \hline \end{gathered}$ |
| 10 | 2000 | 2 | $\begin{gathered} 630 \\ (620 ; 640) \end{gathered}$ | $\begin{gathered} 6.71 \\ (5.72 ; 7.70) \end{gathered}$ | $\begin{gathered} 321 \\ (180 ; 462) \end{gathered}$ | $\begin{gathered} 3158 \\ (771 ; 5545) \end{gathered}$ | $\begin{gathered} 3425 \\ (970 ; 5880) \end{gathered}$ | $<5$ | $\begin{gathered} 64 \\ (37 ; 91) \end{gathered}$ | $\begin{gathered} 2.5 \\ (2 ; 3) \end{gathered}$ | $\begin{gathered} 330 \\ (226 ; 433) \end{gathered}$ |
| 11 | 2000 | 1 | 695 | 2.07 | 460 | 4621 | 4953 | $<5$ | 43 | <2 | 534 |
|  | 2007 | 1 | 720 | 3.58 | 430 | 2117 | 2222 | na | 34 | $<2$ | 770 |
| $n \mathrm{nr}^{6}$ | 2007 | 1 | 530 | 2.27 | 177 | 1220 | 1291 | na | 20 | $<2$ | 401 |

Table 24 continued.

| Age | Year ${ }^{2}$ | n | Length (mm) | Lipids (\%) | Concentration (Mean $\pm$ SD; ng/g wet weight in standard fillets) ${ }^{1}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p, ${ }^{\prime}$ '-DDE | $\sum$ DDT $^{3}$ | Dieldrin | $\Sigma$ Chlordane $^{4}$ | HCB | Hg |
| Seneca Lake |  |  |  |  |  |  |  |  |  |  |  |
| 9 | 1988 | 4 | $689 \pm 25$ | $9.17 \pm 2.28$ | $862 \pm 329$ | $1040 \pm 272$ | $1160 \pm 312$ | $35 \pm 10$ | $138 \pm 30$ | $<2$ | $477 \pm 19$ |
|  | 2002 | 1 | 695 | 12.22 | 373 | 300 | 325 | na | 71 | 3 | 421 |
|  | 2005 | 3 | $612 \pm 21$ | $6.02 \pm 0.89$ | $219 \pm 90$ | $94 \pm 47$ | $112 \pm 51$ | na | $25 \pm 9.7$ | <2 | $510 \pm 85$ |
|  | 2008 | 6 | $671 \pm 48$ | $9.22 \pm 2.62$ | $168 \pm 67$ | $104 \pm 45$ | $129 \pm 55$ | na | $23 \pm 8.0$ | $<2$ | $438 \pm 72$ |
| 10 | 1988 | 2 | $\begin{gathered} 730 \\ (730 ; 730) \end{gathered}$ | $\begin{gathered} 6.77 \\ (6.03 ; 7.51) \end{gathered}$ | $\begin{gathered} 383 \\ (315 ; 440) \end{gathered}$ | $\begin{gathered} 562 \\ (103 ; 1020) \end{gathered}$ | $\begin{gathered} 678 \\ (225 ; 1130) \end{gathered}$ | $<5$ | $\begin{gathered} 149 \\ (117 ; 180) \end{gathered}$ | $\begin{gathered} 3.5 \\ (<2 ; 6) \end{gathered}$ | $\begin{gathered} 489 \\ (461 ; 516) \end{gathered}$ |
|  | 2005 | 1 | 632 | 9.66 | 784 | 353 | 401 | na | 75 | $<2$ | 784 |
| 11 | 1988 | 1 | 700 | 9.57 | 466 | 760 | 847 | 29 | 117 | <2 | 411 |
|  | 1991 | 2 | $\begin{gathered} 693 \\ (690 ; 695) \end{gathered}$ | $\begin{gathered} 2.02 \\ (1.16 ; 2.88) \end{gathered}$ | $\begin{gathered} 878 \\ (554 ; 1202) \end{gathered}$ | $\begin{gathered} 361 \\ (258 ; 464) \end{gathered}$ | $\begin{gathered} 440 \\ (301 ; 579) \end{gathered}$ | $\begin{gathered} 7.3 \\ (<5 ; 12) \end{gathered}$ | $\begin{gathered} 70 \\ (50 ; 89) \end{gathered}$ | $\begin{gathered} 3.0 \\ (<2 ; 5) \end{gathered}$ | $\begin{gathered} 724 \\ (663 ; 784) \end{gathered}$ |
|  | 2002 | 1 | 670 | 7.01 | 611 | 628 | 669 | na | 62 | 2 | 700 |
| 13 | 1988 | 1 | 700 | 11.94 | 936 | 1260 | 1381 | 60 | 157 | <2 | 428 |
| 16 | 1988 | 2 | $\begin{gathered} 810 \\ (800 ; 820) \end{gathered}$ | $\begin{gathered} 12.86 \\ (11.75 ; 13.97) \end{gathered}$ | $\begin{gathered} 2052 \\ (683 ; 3420) \end{gathered}$ | $\begin{gathered} 2610 \\ (2210 ; 3010) \end{gathered}$ | $\begin{gathered} 3012 \\ (2451 ; 3573) \end{gathered}$ | $\begin{gathered} 35 \\ (5 ; 64) \end{gathered}$ | $\begin{gathered} 327 \\ (283 ; 370) \end{gathered}$ | $\begin{gathered} 4.0 \\ (4 ; 4) \end{gathered}$ | $\begin{gathered} 483 \\ (456 ; 510) \end{gathered}$ |

[^12]generally $10 \mathrm{ng} / \mathrm{g}$ in 1984 and 1987, but thereafter, it was $5 \mathrm{ng} / \mathrm{g}$ for cis-chlordane, trans-chlordane and trans-nonachlor, except for oxychlordane was $10 \mathrm{ng} / \mathrm{g}$ from 1990 through 1995 and again was reduced to $5.0 \mathrm{ng} / \mathrm{g}$ thereafter.
${ }_{6}^{5} \mathrm{na}=$ not analyzed.
${ }^{6} \mathrm{nr}=$ not reported.

Table 25: $\quad$ PCB and mercury concentrations in Cayuga Lake lake trout in 1970.

| Age | $\mathbf{n}$ | PCB $^{\mathbf{1}}$ |  | Mercury $^{\mathbf{2}}$ <br> as reported) $^{2}$ <br>  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | As reported | $\mathbf{7 0}^{\mathbf{3}}$ |  |
| 2 | 3 | $1933 \pm 603$ | $630 \pm 426$ | $1353 \pm 422$ |
| 3 | 3 | $1933 \pm 643$ | $1353 \pm 450$ | $273 \pm 32$ |
| 4 | 3 | $4233 \pm 808$ | $2963 \pm 566$ | $370 \pm 85$ |
| 5 | 1 | 5200 | 3640 | $430 \pm 17$ |
| 6 | 3 | $7233 \pm 3365$ | $5063 \pm 2356$ | 430 |
| 7 | 3 | $6667 \pm 3405$ | $4667 \pm 2384$ | $503 \pm 45$ |
| 8 | 3 | $11800 \pm 6646$ | $8260 \pm 4652$ | $433 \pm 31$ |
| 9 | 1 | 30400 | 21280 | $553 \pm 72$ |
| 10 | - | - | - | 530 |
| 11 | 1 | 12400 | 8680 | - |
| 12 | 3 | $15667 \pm 9603$ | $10967 \pm 6722$ | 580 |

${ }^{1}$ Source: Bache et al. (1972). Whole fish analyses.
${ }^{2}$ Source: Bache et al. (1971). Whole fish analyses.
${ }^{3} 70 \%$ values may approximate standard filet concentrations. Applicable to lipophilic substances (e.g., PCB) only.

Table 26: Total p,p'-DDT ${ }^{1}$ and p,p'-DDE concentrations in Cayuga Lake lake trout taken in 1968 through 1970.

| Age | 1968 |  |  | 1969 |  |  | 1970 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | n | As reported | 70 \% ${ }^{2}$ | n | As reported | 70 \% | n | As reported | 70 \% |
| Total p, ${ }^{\prime}$ - DD $^{1}{ }^{1}$ |  |  |  |  |  |  |  |  |  |
| 1 | 4 | $1050 \pm 451$ | $735 \pm 316$ | 6 | $417 \pm 117$ | $292 \pm 82$ | 3 | $400 \pm 0.0$ | $280 \pm 0.0$ |
| 2 | 4 | $2025 \pm 1159$ | $1418 \pm 811$ | 10 | $1290 \pm 288$ | $903 \pm 202$ | 3 | $867 \pm 208$ | $607 \pm 146$ |
| 3 | 4 | $2150 \pm 252$ | $1505 \pm 176$ | 10 | $1870 \pm 283$ | $1309 \pm 198$ | 3 | $1400 \pm 557$ | $980 \pm 390$ |
| 4 | 4 | $2750 \pm 480$ | $1925 \pm 336$ | 10 | $3020 \pm 603$ | $2114 \pm 422$ | 3 | $2767 \pm 808$ | $1937 \pm 566$ |
| 5 | 4 | $5525 \pm 1239$ | $3868 \pm 867$ | 10 | $3380 \pm 452$ | $2366 \pm 316$ | 1 | 3200 | 2240 |
| 6 | 3 | $6167 \pm 503$ | $4317 \pm 352$ | 10 | $4550 \pm 857$ | $3185 \pm 600$ | 3 | $5900 \pm 1513$ | $4130 \pm 1059$ |
| 7 | 4 | $7875 \pm 1239$ | $5513 \pm 867$ | 10 | $6500 \pm 508$ | $4550 \pm 356$ | 3 | $4233 \pm 1155$ | $2963 \pm 1059$ |
| 8 | 4 | $20750 \pm 9248$ | $14525 \pm 6474$ | 10 | $8440 \pm 1359$ | $5908 \pm 951$ | 3 | $11867 \pm 8316$ | $8307 \pm 5821$ |
| 9 | - | - | - | 2 | $6950( \pm 495)$ | $4865( \pm 347)$ | 1 | 9900 | 6930 |
| 10 | - | - | - | 2 | $11600( \pm 424)$ | $8120( \pm 297)$ | - | - | - |
| 11 | - | - | - | - | - | - | 1 | 28700 | 20090 |
| 12 | - | - | - | - | - | - | 3 | $13867 \pm 5925$ | $9707 \pm 4148$ |

${ }^{1}$ Sum of p,p'-DDT, p,p'-DDE and p,p'-DDD.

Table 26 continued.

| Age | 1968 |  |  | 1969 |  |  | 1970 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | n | As reported | 70 \% ${ }^{2}$ | n | As reported | 70 \% | n | As reported | 70 \% |
| p, $\mathbf{p}^{\prime}$-DDE ${ }^{1}$ |  |  |  |  |  |  |  |  |  |
| 1 | 4 | $650 \pm 252$ | $455 \pm 176$ | 6 | $183 \pm 41$ | $128 \pm 29$ | 3 | $200 \pm 0.0$ | $140 \pm 0.0$ |
| 2 | 4 | $1125 \pm 737$ | $788 \pm 516$ | 10 | $530 \pm 157$ | $371 \pm 110$ | 3 | $433 \pm 58$ | $303 \pm 41$ |
| 3 | 4 | $1025 \pm 96$ | $718 \pm 67$ | 10 | $840 \pm 135$ | $588 \pm 95$ | 3 | $867 \pm 351$ | $607 \pm 246$ |
| 4 | 4 | $1675 \pm 340$ | $1173 \pm 238$ | 10 | $1750 \pm 327$ | $1225 \pm 229$ | 3 | $1733 \pm 306$ | $1213 \pm 214$ |
| 5 | 4 | $3125 \pm 699$ | $2188 \pm 489$ | 10 | $2020 \pm 346$ | $1414 \pm 242$ | 1 | 2300 | 1610 |
| 6 | 3 | $3433 \pm 351$ | $2403 \pm 246$ | 10 | $2690 \pm 605$ | $1883 \pm 424$ | 3 | $3733 \pm 723$ | $2613 \pm 506$ |
| 7 | 4 | $4350 \pm 695$ | $3045 \pm 487$ | 10 | $3800 \pm 271$ | $2660 \pm 190$ | 3 | $3333 \pm 862$ | $2333 \pm 603$ |
| 8 | 4 | $12025 \pm 5792$ | $8418 \pm 4054$ | 10 | $5030 \pm 842$ | $3521 \pm 589$ | 3 | $9133 \pm 6700$ | $6393 \pm 4690$ |
| 9 | - | - | - | 2 | 4250 ( $\pm 353)$ | 2975 ( $\pm 247$ ) | 1 | 7200 | 5040 |
| 10 | - | - | - | 2 | $7000( \pm 0.0)$ | $4900( \pm 0.0)$ | - | - | - |
| 11 | - | - | - | - | - | - | 1 | 21800 | 15260 |
| 12 | - | - | - | - | - | - | 3 | $7867 \pm 3365$ | $5507 \pm 2356$ |

[^13]Table 27: Chemical residue concentrations in lake trout from four other Finger Lakes in New York.

| Year | Age | n | Length (mm) | Lipids (\%) | Concentration (ng/g wet weight in standard fillets) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p,p'-DDE | $\sum \mathrm{p}, \mathrm{p}$ '-DDT | Dieldrin | EChlordane | HCB | Hg |
| Hemlock Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1969 | nd ${ }^{1}$ | 3 | $735 \pm 55$ | nr | na | $8240 \pm 6420$ | $14300 \pm 6010$ | na | na | na | na |
| 1970 | nd | 11 | $729 \pm 56$ | nr | na | $4637 \pm 4485$ | $7822 \pm 6416$ | na | na | na | $\begin{gathered} 506 \pm 130 \\ (8)^{4} \\ \hline \end{gathered}$ |
| 1975 | nd | 10 | $623 \pm 140$ | $13.34 \pm 4.44$ | $<500$ | $\mathrm{nr}^{2}$ | $1834 \pm 1375{ }^{3}$ | na | na | na | $348 \pm 93$ |
| 1984 | nd | 14 | $644 \pm 69$ | $17.78 \pm 2.89$ | $492 \pm 149$ | $441 \pm 169$ | $729 \pm 250$ | $24 \pm 4.6$ | $103 \pm 26$ | $3.1 \pm 1.4$ | na |
| 2002 | 4 | 5 | $445 \pm 49$ | $6.03 \pm 2.58$ | $40.2 \pm 26.2$ | $94.7 \pm 44.3$ | $99.6 \pm 42.6$ | na | $11.0 \pm 2.2$ | $<2$ | $189 \pm 57.1$ |
|  | 5 | 23 | $499 \pm 42$ | $6.00 \pm 1.52$ | $50.7 \pm 24.1$ | $103 \pm 31.4$ | $133 \pm 39.1$ | na | $11.5 \pm 4.8$ | $<2$ | $203 \pm 38.6$ |
|  | 6 | 5 | $576 \pm 40$ | $10.57 \pm 2.20$ | $109 \pm 30.0$ | $206 \pm 73.7$ | $253 \pm 83.7$ | na | $14.4 \pm 9.8$ | $<2$ | $364 \pm 179$ |
|  | 7 | 2 | $\begin{gathered} 578 \\ (545 ; 611)^{5} \end{gathered}$ | $\begin{gathered} 7.91 \\ (5.67 ; 10.15) \end{gathered}$ | $\begin{gathered} 78 \\ (44 ; 112) \end{gathered}$ | $\begin{gathered} 154 \\ (95.2 ; 212) \end{gathered}$ | $\begin{gathered} 194 \\ (128 ; 259) \end{gathered}$ | na | $\begin{gathered} 10 \\ (<20 ;<20) \end{gathered}$ | $<2$ | $\begin{gathered} 275 \\ (268 ; 281) \end{gathered}$ |
|  | 8 | 1 | 751 | 3.99 | 329 | 651 | 758 | na | 47.7 | $<2$ | 1030 |
|  | 9 | 2 | $\begin{gathered} 828 \\ (805 ; 851) \end{gathered}$ | $\begin{gathered} 9.24 \\ (8.98 ; 9.50) \end{gathered}$ | $\begin{gathered} 478 \\ (265 ; 690) \end{gathered}$ | $\begin{gathered} 746 \\ (561 ; 930) \end{gathered}$ | $\begin{gathered} 906 \\ (680 ; 1132) \end{gathered}$ | na | $\begin{gathered} 65.9 \\ (47.5 ; 84.2) \\ \hline \end{gathered}$ | $<2$ | $\begin{gathered} 608 \\ (558 ; 658) \end{gathered}$ |
| 2007 | 3 | 1 | 400 | 2.60 | 25 | 37 | 44 | na | 10 | $<2$ | 203 |
|  | 4 | 16 | $431 \pm 30$ | $5.34 \pm 1.91$ | $54 \pm 22$ | $72 \pm 33$ | $84.5 \pm 37.6$ | na | $10 \pm 1.1$ | $2.9 \pm 2.3$ | $214 \pm 92$ |
|  | 5 | 6 | $499 \pm 55$ | $8.96 \pm 2.92$ | $87 \pm 28$ | $103 \pm 33$ | $123 \pm 39.3$ | na | $12 \pm 2.1$ | $2.0 \pm 2.5$ | $250 \pm 113$ |
|  | 6 | 4 | $552 \pm 40$ | $7.44 \pm 1.34$ | $70 \pm 35$ | $112 \pm 48$ | $129 \pm 55.2$ | na | $11 \pm 2.5$ | $2.8 \pm 3.7$ | $293 \pm 76$ |
|  | 7 | 9 | $663 \pm 29$ | $8.91 \pm 2.78$ | $173 \pm 104$ | $238 \pm 114$ | $291 \pm 143$ | na | $22 \pm 9.3$ | $<2$ | $496 \pm 167$ |
|  | 8 | 1 | 710 | 11.98 | 256 | 525 | 630 | na | 35 | $<2$ | 505 |
|  | 10 | 1 | 781 | 7.44 | 280 | 299 | 347 | na | 25 | 4.5 | 421 |
|  | 11 | 1 | 765 | 6.81 | 212 | 241 | 301 | na | 20 | <2 | 475 |

Table 27 continued.

| Year | Age | n | Length <br> (mm) | Lipids <br> (\%) | Concentration (ng/g wet weight in standard fillets) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum$ PCBs | p,p'-DDE | Ep,p'-DDT | Dieldrin | $\Sigma$ Chlordane | HCB | Hg |
| Owasco Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1970 | nd | 2 | $\begin{gathered} \hline 663 \\ (615 ; \\ 711) \end{gathered}$ | $n \mathrm{r}$ | na | $\begin{gathered} 690 \\ (610 ; 770) \end{gathered}$ | $\begin{gathered} 7355 \\ (1310 ; \\ 13400) \end{gathered}$ | na | na | na | $\begin{gathered} 535 \\ (510 ; 560) \end{gathered}$ |
| 1977 | nd | 20/2 | $470 \pm 104$ | $\begin{aligned} & 11.49 \\ & (6.65 ; \\ & 16.32) \end{aligned}$ | $\begin{gathered} 575 \\ (280 ; 870) \end{gathered}$ | $n \mathrm{r}$ | $\begin{gathered} 1675 \\ (950 ; 2400) \end{gathered}$ | $\begin{aligned} & 130 \\ & (40 ; \\ & 200) \end{aligned}$ | na | na | $\begin{gathered} 280 \\ (240 ; 320) \end{gathered}$ |
| 1979 | nd | 28/3 | $573 \pm 134$ | $\begin{aligned} & 12.43 \\ & (6.65 ; \\ & 16.89) \end{aligned}$ | $\begin{gathered} 1002 \\ (430 ; 1460) \end{gathered}$ | $n \mathrm{r}$ | $\begin{gathered} 1068 \\ (410 ; 1670) \end{gathered}$ | $\begin{gathered} 25 \\ (10 ; 40) \end{gathered}$ | $\begin{gathered} 89 \\ (40 ; 130) \end{gathered}$ | na | $\begin{gathered} 502 \\ (380 ; 620) \end{gathered}$ |
| 1982 | nd | 7/2 | $645 \pm 53$ | $\begin{gathered} 13.44 \\ (12.39 ; \\ 14.22) \\ \hline \end{gathered}$ | $\begin{gathered} 2070 \\ (1620 ; \\ 2410) \\ \hline \end{gathered}$ | nr | $\begin{gathered} 2020 \\ (1270 ; \\ 2580) \\ \hline \end{gathered}$ | $\begin{gathered} \hline 72 \\ (22 ; \\ 102) \\ \hline \end{gathered}$ | $\begin{gathered} 240 \\ (130 ; 320) \end{gathered}$ | $<10$ | $\begin{gathered} 695 \\ (640 ; 750) \end{gathered}$ |
| 2009 | nd | 10 | $545 \pm 20$ | $9.05 \pm 1.79$ | $80.4 \pm 15.2$ | $38.6 \pm 7.37$ | $51.3 \pm 10.1$ | na | $13.2 \pm 1.93$ | $\begin{gathered} 1.51 \pm \\ 0.67 \\ \hline \end{gathered}$ | $\begin{gathered} 312 \pm \\ 79.6 \\ \hline \end{gathered}$ |
| Otsego Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1969 | nd | 3 | $471 \pm 126$ | nr | na | nr | $1523 \pm 1898$ | na | na | na | na |
| 1970 | nd | 1 | 597 | nr | na | 410 | 740 | na | na | na | 360 |
| 1978 | nd | 12/2 | $444 \pm 68$ | $\begin{gathered} 3.18 \\ (1.96 ; 6.85) \\ \hline \end{gathered}$ | $\begin{gathered} 503 \\ (330 ; 1020) \\ \hline \end{gathered}$ | nr | $\begin{gathered} 70 \\ (50 ; 130) \\ \hline \end{gathered}$ | $<10$ | na | na | $\begin{gathered} 270 \\ (240 ; 360) \\ \hline \end{gathered}$ |
| 2001 | nd | 9 | $586 \pm 40$ | $6.84 \pm 2.34$ | $135 \pm 42$ | $25.2 \pm 8.64$ | $38.8 \pm 13.5$ | na | $17.2 \pm 5.39$ | $<2$ | $\begin{gathered} \hline 195 \pm \\ 26.3 \\ \hline \end{gathered}$ |
| 2006 | nd | 10 | $583 \pm 65$ | $7.87 \pm 2.28$ | $117 \pm 42$ | $30.3 \pm 14.7$ | $45.5 \pm 22.0$ | na | $15.6 \pm 6.37$ | $\begin{gathered} 1.11 \pm \\ 0.34 \\ \hline \end{gathered}$ | $\begin{gathered} 202 \pm \\ 71.0 \\ \hline \end{gathered}$ |

Table 27 continued.

| Year | Age | n | Length (mm) | Lipids (\%) | Concentration (ng/g wet weight in standard fillets) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p,p'-DDE | Ep, p'-DDT | Dieldrin | EChlordane | HCB | Hg |
| Skaneateles Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1970 | nd | 1 | 734 | nr | na | na | na | na | na | na | 2000 |
| 1977 | nd | 20/2 | $359 \pm 55$ | $\begin{gathered} 2.62 \\ (1.70 ; 3.54) \end{gathered}$ | $\begin{gathered} \hline 420 \\ (260 ; 560) \end{gathered}$ | nr | $\begin{gathered} 625 \\ (550 ; 700) \end{gathered}$ | $\begin{gathered} 30 \\ (20 ; 40) \end{gathered}$ | na | na | $\begin{gathered} 310 \\ (200 ; 420) \end{gathered}$ |
| 1980 | nd | 30/2 | $434 \pm 29$ | $\begin{gathered} 3.82 \\ (3.66 ; 4.06) \\ \hline \end{gathered}$ | $\begin{gathered} 412 \\ (340 ; 460) \\ \hline \end{gathered}$ | nr | $\begin{gathered} 562 \\ (460 ; 630) \\ \hline \end{gathered}$ | $<10$ | $\begin{gathered} 52 \\ (40 ; 60) \\ \hline \end{gathered}$ | na | $\begin{gathered} 704 \\ (590 ; 780) \end{gathered}$ |
| 1983 | nd | 24/4 | $424 \pm 26$ | $\begin{gathered} 2.43 \\ (1.34 ; 3.35) \end{gathered}$ | $\begin{gathered} 610 \\ (290 ; 1100) \\ \hline \end{gathered}$ | $\begin{gathered} 580 \\ (229 ; 1278) \end{gathered}$ | $\begin{gathered} 640 \\ (270 ; 1380) \end{gathered}$ | $\begin{gathered} 10 \\ (<10 ; 10) \end{gathered}$ | $\begin{gathered} 110 \\ (60 ; 170) \\ \hline \end{gathered}$ | <10 | $\begin{gathered} 580 \\ (450 ; 740) \end{gathered}$ |
| 2008 | nd | 10 | $467 \pm 28$ | $1.60 \pm 1.08$ | $100 \pm 68$ | $39.3 \pm 21.9$ | $44.6 \pm 26.5$ | na | $10.8 \pm 1.68$ | $<2$ | $168 \pm 71.4$ |

${ }^{1} \mathrm{nd}=$ Not determined.
${ }^{2} \mathrm{nr}=$ Not reported.
${ }^{3}$ Total of all p,p'-DDT and o,p'-DDT analytes. All DDT analytes were converted to dichlorobenzophenone prior to quantitation.
${ }^{4}$ Parenthetic value is number of samples analyzed where different from $n$.
${ }^{5}$ Minimum and maximum lengths or concentrations are in parenthesis when $n=2$ individual samples or samples include composites of several fish.

Table 28: Chemical residue concentrations in lake trout from five Finger Lakes, New York, prior to 1983.

| Year | Age | $\mathrm{n}^{1}$ | Length (mm) | Lipids (\%) | Concentration (ng/g wet weight in standard fillets) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum$ PCBs | p,p'-DDE | Ep,p'-DDT | Dieldrin | EChlordane | HCB | Hg |
| Canadice Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1969 | $\mathrm{nd}^{2}$ | 3 | $618 \pm 145$ | $\mathrm{nr}{ }^{3}$ | na ${ }^{4}$ | $1470 \pm 1069$ | $4150 \pm 3038$ | na | na | na | na |
| 1970 | nd | 7 | $492 \pm 127$ | nr | na | $185 \pm 246$ (6) ${ }^{5}$ | $318 \pm 318^{6}$ | na | na | na | $304 \pm 158$ |
| 1975 | nd | 7 | $556 \pm 65$ | $9.87 \pm 3.85$ | $<100$ | nr | $210 \pm 248^{5}$ | na | na | na | $363 \pm 139$ |
| 1980 | nd | 18/5 | $594 \pm 86$ | $\begin{gathered} 15.72 \\ (10.06 ; \\ 20.06)^{7} \end{gathered}$ | $\begin{gathered} 5080 \\ (1370 ; 9180)^{7} \end{gathered}$ | $n \mathrm{r}$ | $\begin{gathered} 332 \\ (80 ; 890)^{7} \end{gathered}$ | $\begin{gathered} 25 \\ (<10 ; \\ 120)^{7} \\ \hline \end{gathered}$ | $\begin{gathered} 58 \\ (30 ; 90)^{7} \end{gathered}$ | na | $\begin{gathered} 310 \\ (180 ; \\ 460)^{7} \\ \hline \end{gathered}$ |
| Canandaigua Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1967 | nd | 1 | 566 | nr | na | 1200 | 2340 | na | na | na | na |
| 1970 | nd | 3 | $302 \pm 27$ | nr | na | $495 \pm 670$ | $885 \pm 1300$ | na | na | na | na |
|  | nd | 4 | $530 \pm 64$ | nr | na | $3160 \pm 1480$ | $5490 \pm 3310$ | na | na | na | na |
| 1975 | nd | 6/1 | $224 \pm 47$ | 3.05 | 1450 | nr | 730 | na | na | na | na |
|  | nd | 7 | $465 \pm 81$ | $7.79 \pm 2.61$ | $3504 \pm 1374$ | nr | $1799 \pm 601$ | na | na | na | na |
|  | nd | 4 | $758 \pm 60$ | $\begin{gathered} 10.82 \pm 3.07 \\ (3)^{5} \\ \hline \end{gathered}$ | $29030 \pm 14769$ | nr | $4000 \pm 1109$ | na | na | na | na |
| 1976 | nd | 15 | $741 \pm 59$ | $10.93 \pm 3.47$ | $9560 \pm 6200$ | nr | $4480 \pm 4140$ | na | na | na | na |
|  | nd | 1 | 317 | 3.18 | 2510 | nr | 1150 | na | na | na | na |
| 1978 | nd | 8/2 | $775 \pm 74$ | $\begin{gathered} \hline 10.25 \\ (7.61 ; \\ 11.84)^{7} \\ \hline \end{gathered}$ | $\begin{gathered} 3670 \\ (2510 ; 4360)^{7} \end{gathered}$ | $n \mathrm{r}$ | 9928 $(4140 ;$ $13400)^{7}$ | $\begin{gathered} 115 \\ (90 ; \\ 130)^{7} \\ \hline \end{gathered}$ | $<10$ | na | $\begin{gathered} \hline 808 \\ (720 ; \\ 860)^{7} \\ \hline \end{gathered}$ |
| 1979 | nd | 20/2 | $474 \pm 98$ | $\begin{gathered} 5.67 \\ (3.16 ; 8.18)^{7} \end{gathered}$ | $\begin{gathered} 1125 \\ (530 ; 1520)^{7} \end{gathered}$ | nr | $\begin{gathered} 1635 \\ (1120 ; \\ 2150)^{7} \\ \hline \end{gathered}$ | $\begin{gathered} 40 \\ (30 ; 50)^{7} \end{gathered}$ | $<10$ | na | $\begin{gathered} 400 \\ (280 ; \\ 520)^{7} \\ \hline \end{gathered}$ |
| 1980 | nd | 25/5 | $574 \pm 67$ | $\begin{gathered} 10.56 \\ (5.66 ; \\ 12.79)^{7} \end{gathered}$ | $\begin{gathered} 1733 \\ (1200 ; 2910)^{7} \end{gathered}$ | nr | $\begin{gathered} 1832 \\ (790 ; 3220)^{7} \end{gathered}$ | $\begin{gathered} 12 \\ (<10 ; \\ 20)^{7} \end{gathered}$ | $\begin{gathered} 118 \\ (50 ; 240)^{7} \end{gathered}$ | na | $\begin{gathered} \hline 412 \\ (280 ; \\ 540)^{7} \\ \hline \end{gathered}$ |

Table 28 continued.

| Year | Age | n | Length (mm) | Lipids (\%) | Concentration (ng/g wet weight in standard fillets) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum$ PCBs | p,p'-DDE | Ep,p'-DDT | T Dieldrin | $\sum$ Chlordane | e HCB | Hg |
| Cayuga Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1970 | nd | 5 | $653 \pm 41$ | na | na | $1684 \pm 1061$ | 1 $3900 \pm 2182$ | 2 na | na | na | $394 \pm 35$ |
| 1975 | nd | 7 | $658 \pm 67$ | $11.65 \pm 2.16$ | $6157 \pm 2821$ | nr | $1727 \pm 891$ | na | na | na | Na |
| 1976 | $\mathrm{dnr}^{8}$ | 5 | $674 \pm 23$ | $12.39 \pm 2.52$ | $8552 \pm 2359$ | nr | $2390 \pm 620$ | - na | na | na | Na |
| 1979 | nd | 15/1 | $313 \pm 32$ | 1.71 | 270 | nr | 70 | 60 | 100 | na | 300 |
|  | nd | 30 | $617 \pm 114$ | $11.18 \pm 3.15$ | $1498 \pm 1137$ | nr | $795 \pm 829$ | $38 \pm 17$ | $120 \pm 67$ | na | $469 \pm 97$ |
| 1980 | nd | 19/3 | $485 \pm 93$ | $\begin{gathered} 9.96 \\ (7.99 \\ 11.86) \\ \hline \end{gathered}$ | $\begin{gathered} 429 \\ (230 ; 600)^{7} \end{gathered}$ | nr | $\begin{gathered} 238 \\ (140 ; 430)^{7} \end{gathered}$ | $\begin{gathered} 13 \\ (10 ; 20)^{7} \end{gathered}$ | $\begin{gathered} 61 \\ (40 ; 90)^{7} \end{gathered}$ | na | $\begin{gathered} 333 \\ (260 ; \\ 480)^{7} \\ \hline \end{gathered}$ |
| Keuka Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1970 | nd | 2 | $\begin{gathered} 509 \\ (495 ; \\ 523)^{7} \\ \hline \end{gathered}$ | na | na | $\begin{gathered} 8505 \\ (570 ; \\ 16440)^{7} \\ \hline \end{gathered}$ | $\begin{array}{r} 12860 \\ (2780 \\ 22940)^{7} \\ \hline \end{array}$ | na | na | na | $\begin{gathered} 250 \\ (200 ; \\ 300)^{7} \\ \hline \end{gathered}$ |
| 1975 | nd | 6/1 | $194 \pm 5.5$ | 5.58 | ND ${ }^{9}$ | nr | 1570 | na | na | na | Na |
|  | nd | 6/1 | $399 \pm 17$ | 8.03 | ND ${ }^{9}$ | nr | 7410 | na | na | na | Na |
|  | nd | 5 | $608 \pm 40$ | $12.43 \pm 1.26$ | $372 \pm 787^{10}$ | nr | $2500 \pm 408$ | na | na | na | Na |
| 1979 | nd | 19/2 | $489 \pm 149$ | $\begin{gathered} 9.02 \\ (3.56 ; \\ 13.93)^{7} \end{gathered}$ | $\begin{gathered} 568 \\ (200 ; \\ 1000)^{7} \\ \hline \end{gathered}$ | nr | $\begin{gathered} 6241 \\ (2730 ; 9400)^{7} \end{gathered}$ | $\begin{gathered} 67 \\ (30 ; \\ 100)^{7} \\ \hline \end{gathered}$ | $<20$ | na | $\begin{gathered} 325 \\ (220 ; \\ 420)^{7} \\ \hline \end{gathered}$ |
| 1980 | nd | 31/8 | $582 \pm 109$ | $\begin{gathered} 11.24 \\ (4.99 ; \\ 15.14)^{7} \\ \hline \end{gathered}$ | $\begin{gathered} 441 \\ (80 ; 680)^{7} \end{gathered}$ | nr | $\begin{gathered} 6196 \\ (2040 ; 8770)^{7} \end{gathered}$ | $\begin{gathered} 39 \\ (10 ; 80)^{7} \end{gathered}$ | $\begin{gathered} 84 \\ (30 ; 100)^{7} \end{gathered}$ | na | $\begin{gathered} 368 \\ (230 ; \\ 450)^{7} \\ \hline \end{gathered}$ |
| $\begin{gathered} 12 / \\ 1983 \end{gathered}$ | 4 | 10 | $441 \pm 54$ | $4.82 \pm 2.21$ | $233 \pm 88$ | $2148 \pm 1045$ | $2620 \pm 1257$ | $20 \pm 13$ | na | $\begin{gathered} 1.9 \pm \\ 0.74 \\ \hline \end{gathered}$ | Na |
|  | 5 | 10 | $472 \pm 15$ | $6.15 \pm 2.31$ | $409 \pm 210$ | $3745 \pm 2086$ | $4705 \pm 2608$ | $19 \pm 9.0$ | na | $\begin{gathered} 3.3 \pm \\ 0.82 \end{gathered}$ | Na |
|  | 6 | 10 | $616 \pm 42$ | $7.62 \pm 3.21$ | $478 \pm 186$ | $5488 \pm 3856$ | $7774 \pm 5409$ | $18 \pm 7.4$ | na | $4.9 \pm 1.7$ | Na |
|  | 7 | 2 | $\begin{gathered} 650 \\ (630 ; \\ 670)^{7} \end{gathered}$ | $\begin{gathered} 10.37 \\ (9.83 \\ 10.90)^{7} \end{gathered}$ | $\begin{gathered} 697 \\ (599 ; 794)^{7} \end{gathered}$ | $\begin{gathered} 6855 \\ (5280 ; \\ 8430)^{7} \end{gathered}$ | 9776 $(7151 ;$ $12400)^{7}$ | $\begin{gathered} 36 \\ (31 ; 40)^{7} \end{gathered}$ | na | $\begin{gathered} 6.5 \\ (5 ; 8)^{7} \end{gathered}$ | Na |

Table 28 continued.

| Year | Ag | N | Length (mm) | Lipids (\%) | Concentration (ng/g wet weight in standard fillets) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | $\sum \mathrm{PCBs}$ | p,p'-DDE | Ep,p'-DDT | Dieldrin | EChlordane | HCB | Hg |
| Seneca Lake |  |  |  |  |  |  |  |  |  |  |  |
| 1970 | nd | 4 | $667 \pm 181$ | nr | na | $6125 \pm 4955$ | $10565 \pm 8585$ | na | na | na | Na |
| 1975 | nd | 10 | $\begin{gathered} 665 \pm 68 \\ (8)^{5} \\ \hline \end{gathered}$ | $\begin{gathered} 12.27 \pm \\ 3.88 \end{gathered}$ | $\begin{gathered} 6432 \pm \\ 4094 \\ \hline \end{gathered}$ | nr | $2164 \pm 1006$ | na | na | na | Na |
| 1976 | nd | 15 | $617 \pm 104$ | $7.62 \pm 2.62$ | $\begin{gathered} \hline 2785 \pm \\ 1900 \\ \hline \end{gathered}$ | nr | $668 \pm 213$ | na | na | na | Na |
| 1978 | nd | 17/2 | $604 \pm 88$ | $\begin{gathered} 10.33 \\ (9.86 \\ 10.78)^{7} \end{gathered}$ | $\begin{gathered} 2044 \\ (1410 \\ 2960)^{7} \end{gathered}$ | nr | $\begin{gathered} 2746 \\ (1470 ; 4570)^{7} \end{gathered}$ | $\begin{gathered} 116 \\ (100 ; \\ 140)^{7} \\ \hline \end{gathered}$ | na | na | $\begin{gathered} 582 \\ (500 ; \\ 700)^{7} \\ \hline \end{gathered}$ |
| 1980 | nd | 55/8 | $609 \pm 111$ | 10.55 (4.47; $13.48)^{7}$ | 658 (150; 2120) ${ }^{7}$ | $n \mathrm{r}$ | $\begin{gathered} 1100 \\ (270 ; 2070)^{7} \end{gathered}$ | $\begin{gathered} 43 \\ (10 ; 80)^{7} \end{gathered}$ | $\begin{gathered} 103 \\ (30 ; 180)^{7} \end{gathered}$ | na | $\begin{gathered} 425 \\ (100 ; \\ 660)^{7} \end{gathered}$ |

${ }^{1}$ Where n is a single number, all samples were analyzed individually. Where n is in the form $\mathrm{x} / \mathrm{y}, \mathrm{x}$ is the number of fish which were composited in y number of samples. Where $\mathrm{x} / \mathrm{y}$ is used, all concentrations are weighted averages.
${ }^{2}$ nd = Not determined.
${ }^{3} \mathrm{nr}=$ Not reported.
${ }^{4} \mathrm{na}=$ Not analyzed.
${ }^{5}$ Parenthetic value is number of samples analyzed where different from n .
${ }^{6}$ In Canadice Lake, 1970 and 1975 total DDT is sum of all six DDT analytes. Five of six samples had concentrations less than detection limit in 1970 and five of seven samples were less than detection limit in 1975.
${ }^{7}$ Minimum and maximum lengths or concentrations are in parenthesis.
${ }^{8} \mathrm{dnr}=$ ages were determined but not reported here due to low sample numbers.
${ }^{9} \mathrm{ND}=$ Not detected.
${ }^{10}$ Four of five samples were characterized as having trace quantities of PCBs; the detection limit was not reported. The remaining sample had $1770 \mathrm{ng} / \mathrm{g}$ PCB.

Figure 1: $\quad$ The five study Finger Lakes of New York.


Figure 2: Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Canadice Lake.



Figure 3: Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Canandaigua Lake.



Figure 4: Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Cayuga Lake.



Figure 5: Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Keuka Lake.



Figure 6: Temporal changes in polychlorinated biphenyl concentrations on wet weight and lipid bases in aged lake trout from Seneca Lake.



Figure 7: Temporal changes in total p,p'-DDT and total chlordane concentrations in aged lake trout from Canadice Lake.



Figure 8: Temporal changes in total $\mathrm{p}, \mathrm{p}$ '-DDT and total chlordane concentrations in aged lake trout from Canandaigua Lake.



Figure 9: Temporal changes in total p,p'-DDT and total chlordane concentrations in aged lake trout from Cayuga Lake.



Figure 10: Temporal changes in total p,p'-DDT and total chlordane concentrations in aged lake trout from Keuka Lake.



Figure 11: Temporal changes in total p,p'-DDT and total chlordane concentrations in aged lake trout from Seneca Lake.



Figure 12: Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Canadice Lake.



Figure 13: Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Canandaigua Lake.



Figure 14: Temporal changes in p,p'-DDE concentrations on wet weight and lipid bases in aged lake trout from Cayuga Lake.



Figure 15: Temporal changes in p,p'-DDE concentrations on wet weight and lipid bases in aged lake trout from Keuka Lake.



Figure 16: Temporal changes in $\mathrm{p}, \mathrm{p}$ '-DDE concentrations on wet weight and lipid bases in aged lake trout from Seneca Lake.



Figure 17: Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in aged lake trout from Canadice Lake.



Figure 18: Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in aged lake trout from Canandaigua Lake.



Figure 19: Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in aged lake trout from Cayuga Lake.



Figure 20: Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in aged lake trout from Keuka Lake.



Figure 21: Temporal changes in trans-nonachlor concentrations on wet weight and lipid bases in aged lake trout from Seneca Lake.



Figure 22: Temporal changes in mercury concentrations in aged lake trout from Canadice, Canandaigua, Keuka and Seneca Lakes.


Figure 23: Temporal changes in mercury concentrations in aged lake trout from Cayuga Lake ${ }^{1}$.

(All age classes included below)

${ }^{1} 1970$ data from Bache et al., 1971; whole fish analyses.

Figure 24: Historical comparison of polychlorinated biphenyl concentrations in aged lake trout from Cayuga Lake, New York.

(Expanded view of Ages 4 through 8 below)


Figure 25: Historical comparison of $\mathrm{p}, \mathrm{p}$ '-DDE and total $\mathrm{p}, \mathrm{p}$ '-DDT concentrations in aged lake trout from Cayuga Lake, New York.



Figure 26: Locations of four other Finger Lakes with chemical residue data for lake trout.


## APPENDIX 1

# DETERMINATION OF ORGANOCHLORINE RESIDUES NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION <br> Hale Creek Field Station <br> Toxic Substances Monitoring Laboratory 

Reference: See FDA Pesticide Analytical Manual Vol. I, Sec. 211, 253 2nd Edition

Summary: Samples are analyzed for PCBs and selected organochlorine pesticides by capillary GC-ECD. At least ten percent of the samples are qualitatively confirmed by capillary GC-MS. Prior to analysis, each sample is freeze-dried and soxhlet-extracted with hexane/acetone (1:1), followed by a florisil cleanup step. All samples are analyzed for three PCB Aroclors (Aroclors 1242 and sum of Aroclors 1254/1260) and 19 organochlorine pesticides and metabolites (4,4'-DDE; 4,4'-DDD; 4,4'-DDT; 2,4'-DDE; 2,4'-DDT; heptachlor; heptachlor epoxide; trans-chlordane; cis-chlordane; transnonachlor; cis-nonachlor; oxychlordane; aldrin; photomirex; mirex; HCB; alpha-HCH; beta- HCH ; and gamma- HCH ).

## 1. Extraction:

a. Using an analytical balance, weigh a 250 mL flat bottom boiling flask (24/40) containing 2-3 Teflon boiling chips (hexane/acetone-extracted).
b. Pour ca $200 \mathrm{~mL} 50 / 50$ hexane/acetone into boiling flask and place on hot plate (turned off and cold).
c. Place pre-extracted glass wool in soxhlet, covering the bottom and siphon tube inlet. Quantitatively transfer, using hexane, freeze-dried sample into soxhlet. Be sure level of sample is below top of siphon tube (the sample may be compressed with a wad of glass wool). Add glass stoppers to soxhlet to hold down the glass wool. Connect soxhlet to condenser and boiling flask.
d. Turn on hot plate and extract at least 7 hrs . Check after 30 min to ensure vigorous boiling and vapor condensation. After 7 hr , turn off the soxhlets and let cool (ca 30-60 minutes).
e. Remove boiling flask and soxhlet from hot plate. Drain, through siphon tube, remaining hexane/acetone into boiling flask and remove soxhlet.
f. Evaporate hexane/acetone, just to dryness, using the rotary evaporator (rotovap, $\mathrm{T}=40 \mathrm{C}$ ). Place flask in desiccator overnight.
2. Cleanup:
a. Weigh boiling flask and calculate weight of hexane/acetone-extractable material (lipid).
b. Determine an appropriate dilution (with hexane) from which $1-8 \mathrm{~mL}$ will yield ca 0.1 g of sample lipid (e.g.: If total weight of extracted lipid is 0.5115 g : Add 10.0 mL hexane, stopper and dissolve lipid; transfer 2.0 mL , which contains 0.1023 g of sample, onto column.)
c. Place a 22 mm ID glass chromatography column with a 300 mL reservoir in a clamp. Place small wad of hexane/acetone-extracted glass wool in bottom of column.
d. Fill column with $10 \mathrm{~g}(\sim 40 \mathrm{~mL})$ of activated Florisil (heated at 675 C for 6 hrs., stored overnight at 130C). Tap column to eliminate channeling in the Florisil.
e. Pour 5 g of anhydrous $\mathrm{Na}_{2} \mathrm{SO}_{4}$ (heated at 600 C for 6 hrs ., stored at room temperature) into column.
f. Add ca 80 ml petroleum ether (pet ether) to the packed column. Drain the pet ether into a waste beaker until pet ether level is at the $\mathrm{Na}_{2} \mathrm{SO}_{4}$ layer. Turn off stopcock and discard eluate.
g. Place a labeled glass 250 mL Erlenmeyer flask (24/40), containing 2-3 Teflon boiling chips, underneath the column.
h. Quantitatively transfer subsample (as determined in 2b above).
i. Allow sample to drain through column into flask at $4-5 \mathrm{~mL}$ per minute. Elute until solution is just at the $\mathrm{Na}_{2} \mathrm{SO}_{4}$ layer. Close the stopcock.
j. Pour 200 mL of $6 \%$ ethyl ether/pet ether ( $\mathrm{v} / \mathrm{v}$ ) solution onto column. Remove flask and rinse the neck of the flask with pet ether.
k. Add $\sim 10$ drops of keeper solution ( 1 mL paraffin oil in 100 mL acetone) to flask. Evaporate just to dryness on rotovap.

1. Dilute with isooctane (containing OCN as an internal standard) to an appropriate concentration and stopper. Shake briefly to dissolve sample. The sample is now ready for analysis by gas chromatography.
2. Analysis:
a. Prepare analytical standard solutions from either primary standards or certified standard solutions available from many suppliers. Stock solutions in isooctane may be stored refrigerated up to one year. Working refrigerated standards may be used up to six months. New working standards should agree to within $10 \%$ of previous standards (as determined by gas chromatography). All samples are analyzed for three PCB Aroclors (Aroclors 1242 and sum of Aroclors 1254/1260) and 19 organochlorine pesticides and metabolites (4,4'-DDE; 4,4'-DDD; 4,4'DDT; 2,4'-DDE; 2,4'-DDT; heptachlor; heptachlor epoxide; transchlordane; cis-chlordane; trans-nonachlor; cis-nonachlor; oxychlordane; aldrin; photomirex; mirex; HCB; alpha-HCH; beta- HCH ; and gammaHCH).
b. Gas Chromatography
3. Use Hewlett Packard 5890 GC/ECD or equivalent. At the start of a run, five standards are analyzed and a calibration table is calculated. A standard is then run at least once every ten samples and the calibration table recalculated, if necessary. The range of the calibration table is extended $20 \%$ above the high level standard and $20 \%$ below the low level standard. The correlation coefficient $\left(r^{2}\right)$ is expected to be $\geq 0.95$. If $r^{2}<0.95$, the sample will be rerun or calculated from the standard which most closely matches it in peak area. At least ten percent of samples should be quantitatively confirmed by GC/MS (Hewlett Packard 6890/5973 GC/MS or equivalent).
4. Use hydrogen as carrier gas. Use DB-1 capillary column 60 mX 0.25 mm ID X 0.25 um Film for GC/ECD and GC/MS.

## 4. Quality Control Samples:

a. With every 5 environmental samples, a quality control sample is analyzed. The quality control samples are either a reagent blank, a reference material, a matrix spike, or a duplicate sample. The type of quality control sample that is run is alternated among the 4 types.
b. The acceptable limits for the reference materials, spikes and duplicates are based on recommended control limits in Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, $3^{\text {rd }}$ edition
(USEPA Office of Water, November 2000). Control limits for spike accuracy are percent recovery $=50-150$ percent. Control limits for SRM or CRM accuracy are percent recovery $=70-130$ percent. The control limit for precision is relative standard deviation $($ RSD $) \leq 50$ percent. The acceptable criteria for reagent blanks are that no peak will interfere with the quantitation at a level greater than the detection limit.
c. If a quality control sample falls outside the acceptable limits, the sample is examined and possibly reanalyzed. If the reanalyzed sample still falls outside the acceptable limits, all analyses are stopped until the problem is rectified. Data from the quality control group are then considered suspect and the samples should be reanalyzed. If the samples cannot be reanalyzed, the data from that quality control group is flagged.


[^0]:    ${ }^{1}$ New York State Department of Environmental Conservation Division of Fish, Wildlife and Marine Resources
    625 Broadway
    Albany, New York 12233-4756
    ${ }^{2}$ Formerly (now retired):
    New York State Department of Environmental Conservation
    Division of Solid and Hazardous Materials
    625 Broadway
    Albany, New York 12233
    ${ }^{3}$ New York State Department of Environmental Conservation
    Hale Creek Field Station
    182 Steele Avenue Extension
    Gloversville, New York 12078
    ${ }^{4}$ Formerly (now retired):
    New York State Department of Environmental Conservation
    Division of Air
    Sterling Laboratory Facility
    Rensselaer, New York 12144
    ${ }^{5}$ Now retired.

[^1]:    ${ }^{1}$ USFDA = US Food and Drug Administration tolerance or action levels.
    USEPA = US Environmental Protection Agency action levels (except for mercury) enforced by USFDA. GLWQO = Great Lakes water quality objectives in the Great Lakes Water Quality Agreement of 1978 as amended in 1987.
    ${ }^{2}$ The USEPA (2002) Preliminary Remediation Goal for protection of human health due to consumption of fish from the Hudson River.
    ${ }^{3}$ The Anderson et al. (1993) recommendation for the maximum concentration of PCBs in fish that permits unrestricted consumption of fish.
    ${ }^{4}$ As methylmercury.
    ${ }^{5}$ The USEPA (2001) recommendation for the maximum acceptable methylmercury concentrations in fish for the derivation of the methylmercury water quality criterion.
    ${ }^{6}$ The Anderson and McCann (2007) recommendation for the maximum concentration of mercury in fish that permits unrestricted consumption of fish.

[^2]:    ${ }^{1}$ In this table, n is the total number of samples analyzed for each lake and year.
    ${ }^{2} \mathrm{na}=$ Not analyzed. The following dash marks $(-)$ indicate no data available.
    ${ }^{3} \mathrm{n}=27$ samples analyzed.

[^3]:    ${ }^{1}$ The Mann-Whitney test was conducted when only two ages could be compared. A quantile of $<95$ indicates no significant age difference in total PCB concentration.
    ${ }_{2}^{2}$ Calculated from: Bache et al., 1972.
    ${ }^{3}$ Calculated from: Wszolek et al., 1978.

[^4]:    ${ }^{1}$ Same lettering between years within a lake's age group indicate data sets that are statistically the same (significance level of $\mathrm{p}<0.05$ ).
    ${ }^{2}$ All samples less than detection limit. One-half the detection limit is given.
    ${ }^{3}$ Excludes an outlier concentration.

[^5]:    * p,p'-DDT was not detected; the detection limit was $2 \mathrm{ng} / \mathrm{g}$. Percentages are based on use of one-half the detection limit.

[^6]:    ${ }^{1}$ Same lettering between years within a lake's age group indicate data sets that are statistically the same (significance level of $\mathrm{p}<0.05$ ).
    ${ }^{2}$ Excludes an outlier concentration.

[^7]:    ${ }^{1}$ Computations assume one-half the detection limit where values are less than the detection limits. Computations are for selected ages to provide comparability over time.
    ${ }^{2}$ For Canadice Lake, no age 5 fish in 1987 and no age 6 fish in 1993 were available. For Canandaigua Lake, no age 4 fish were available in 1985.
    For Keuka Lake, no age 6 fish were available in 1994.
    ${ }^{3}$ Chlordane compounds were not analyzed.

    * Not detected in any sample.

[^8]:    ${ }^{1}$ The Mann-Whitney test was conducted when only two ages could be compared. A quantile of $<95$ indicates no significant age difference in mercury concentration.
    ${ }^{2}$ Calculated from: Bache et al., 1971.

[^9]:    Same lettering between years within a lake's age group indicate data sets that are statistically the same (significance level of $\mathfrak{p}<0.05$ ).
    ${ }^{2} \mathrm{na}=$ Not analyzed.

[^10]:    ${ }^{1}$ na $=$ Dieldrin was not analyzed.

[^11]:    ${ }_{2}^{1}$ Where values were less than the detection limit, one-half the detection limit was used for computations.
    ${ }_{3}^{2}$ All values were less than the detection limit given.
    ${ }^{3} \mathrm{na}=$ Not analyzed.

[^12]:    ${ }^{1}$ Mean $\pm$ standard deviation concentrations are given. Where a less than ( $<$ ) sign is given, the value following is the detection limit, or for total chlordane the sum of the detection limits for the age 2 fish. One half the detection limit is used for computations except for PCBs where a zero is assigned concentrations less than detection limits. Where only two samples were taken for a given age and year, the mean concentration is followed by the two concentrations determined.
    ${ }^{2}$ Collections were made in September of 1984 and in June in each successive year sampled.
    ${ }^{3} \sum$ DDT is the sum of concentrations for $\mathrm{p}, \mathrm{p}^{\prime}$-DDT, p,p'-DDE, and p,p'-DDD. The detection limits for each compound were $5 \mathrm{ng} / \mathrm{g}$ in $1984 \mathrm{and} 2 \mathrm{ng} / \mathrm{g}$ in each year thereafter.
    ${ }^{4} \sum$ Chlordane is the sum of concentrations for cis-chlordane, trans-chlordane, trans-nonachlor and oxychlordane. The detection limit for each analyte was

[^13]:    ${ }^{1}$ Source of original data: Youngs et al. (1972). Total p,p'-DDT is the sum of p,p'-DDT, p,p'-DDE and p,p'-DDD.
    ${ }^{2} 70 \%$ values approximate concentrations in a standard filet.

