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Dioxins and Furans in Fish Below Love Canal, New York

Concentration Reduction Following Remediation

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Dioxins and furans in fish below Love Canal, New York: Concentration reduction following remediation.

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ABSTRACT

The Cayuga Creek drainage basin has served as the receiving waters for leachates originating from the inactive hazardous waste site known as Love Canal. Among the numerous chemical compounds originating from the site, the most toxic is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8,-TCDD). To examine the efficacy of remedial work associated with Love Canal, monitoring of young fish for dioxins and dibenzofurans was conducted. Of the chemicals examined, the sole compound diagnostic for Love Canal was 2,3,7,8-TCDD. Declines in 2,3,7,8-TCDD concentrations averaged 70 percent between 1982 and 1987, and further declines ranging between 46 and 86 percent occurred between 1987 and 1992 dependent on location in the basin. The reductions were consistent with completion of encapsulation of the Love Canal site, and later cleaning of storm water drainage systems and removal of the most highly contaminated sediments from tributaries of Cayuga Creek. Total reduction of 2,3,7,8-TCDD concentrations were 84 percent or more.

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INTRODUCTION

Love Canal is an inactive hazardous waste site located in Niagara Falls, New York. The site achieved national notoriety in 1978, and thereafter, due to perceived human health impacts to residents located adjacent to the site. The human health impacts are believed to be caused by the disposal of chemical wastes by the former Hooker Chemical Corporation (the company is now owned by Occidental Chemical Corp.). The estimated 21,800 tons of chemical wastes disposed in Love Canal include, among others, chlorinated solvents, oils, chlorobenzenes, hexachlorocyclohexanes, polychlorinated biphenyls (PCB), and trichlorophenol (NYSDOH, 1981). Dioxins are contaminants of trichlorophenol (Firestone, 1972; Rappe et al., 1978a) and dibenzofurans are contaminants of PCB (Bowes et al., 1975a and 1975b) and chlorophenols (Rappe et al., 1978).

Water and leachate from Love Canal entered the Cayuga Creek drainage basin via storm drain discharges to Black Creek. The chemicals were subsequently distributed successively to downstream waters and sediments in Bergholtz Creek, Cayuga Creek, the Little River and the Niagara River. In preliminary work, crayfish from Bergholtz Creek immediately downstream of Black Creek showed 3700 pg/g of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) (NYSDOH, 1981). Subsequent analysis of fish demonstrated 2,3,7,8-TCDD concentrations as great as 113 pg/g (Kuzia, 1985; O'Keefe et al., 1983). Dibenzofurans were not analyzed. In whole carp from the Little River, Stalling (1982) reported 644 pg/g total dioxins of which 417 pg/g was contributed by the 2,3,7,8-TCDD congener. Further, the carp contained 1019 pg/g total dibenzofurans which were principally comprised of 1,2,3,4,7,8-hexachloro-, 1,2,3,4,6,7,8-heptachloro, and octachloro - dibenzofurans.

Extensive remedial work has been conducted in the environs surrounding Love Canal. The site has been encapsulated, all known drainage terminated, a leachate collection and treatment system installed, and homes most likely to be impacted were destroyed. Remediation also included cleaning the storm water drainage system and removing soils and sediments from the Cayuga Creek basin (Black and Bergholtz Creek) where 2,3,7,8-TCDD concentrations exceeded 1.0 part per billion. To evaluate the effectiveness of these latter actions, a monitoring program was instituted which incorporated fish as one component. This latter study and its findings are reported here.

METHODS

Sample Collection

Young-of-the-year fish were collected by the NYS Department of Environmental Conservation's Region 9 fisheries biologists. Collections were made at seven locations in the Cayuga Creek drainage basin in October of the years 1987, 1990 and 1992. The 1987 collections were made prior to dredging of Black and Bergholtz Creeks. The 1990 and 1992 collections were successively one year and three years post-dredging. Fish were collected at the following six stations in all three sampling years (see Figure 1 and 2):

Station No.	Location
1	Little River upstream of the mouth of Cayuga Creek opposite the southern tip of Cayuga Island
2	Little River downstream of the mouth of Cayuga Creek
3	Cayuga Creek at the Lindberg Avenue Bridge
4	Cayuga Creek at the Cayuga Drive bridge
5	Bergholtz Creek approximately 100 meters west of Williams Road
6	Cayuga Creek at the Porter Road bridge

In 1987, the seventh station, Cayuga Creek upstream of Lockport Road (a control location), did not contain fish. For 1990, the station was moved to the Niagara River upstream of Little River as a control. In 1992, the station was returned to Cayuga Creek upstream of Lockport Road where brook stickleback (*Culea inconstans*) were collected.

Due to differing habitat and fish-habitat preferences, the fish species available differed between stations in any given year. Fish population structure fluctuates from year to year thus differing collections of fish species were expected between years. Further, the dredging activity modified the available habitat at several stations which resulted in further alteration of fish species and population composition. In 1992, young-of-the-year fish were not available in sufficient numbers for chemical analysis at four locations. Therefore, older aged fish (normally aged 1+) were collected to fill sampling gaps. Older aged fish may introduce greater data variability due to a potentially longer duration of chemical exposure and to the greater mobility of the fish.

Fish were collected by use of electrofishing gear or seines as appropriate for the site conditions.

All fish collected were measured for total length to the nearest millimeter. Fish were placed into composite samples by species at each location. A composite weight of approximately 50 grams was desired for analysis but not always obtained. A unique identification number was assigned to each composite sample. All pertinent data were recorded on "Fish/Wildlife Collection Record" forms and "Chain of Custody" forms (Appendix I) were completed for each transfer of the samples. Following recording of data, the samples were placed on hexane - rinsed aluminum foil, wrapped, labelled and placed on ice. All samples were frozen at the end of the day. Samples were later transferred in a frozen state to the Hale Creek Field Station, Gloversville, NY. At the station, samples were unwrapped, ground whole, homogenized, repackaged in solvent-rinsed glass jars and frozen. The processed samples were shipped by express overnight delivery to a contract laboratory (Triangle Laboratories, Inc., Research Triangle Park, North Carolina) for chemical analysis.

Chemical Analysis

Chemical analysis for tetrachloro-through octachloro-congeners of dioxins and dibenzofurans were conducted by methods described in "National Dioxin Study Analytical Procedures and Quality Assurance Plan for the Analysis of 2,3,7,8-TCDD" (EPA/600/3-85/09) but with one modification. The modification substituted chlorhydric acid in sample digestion to prevent decomposition of certain dioxin and furan congeners. This modified method has become known as EPA Method 8290 (U.S.E.P.A., 1989). All results were reported in units of pg/g (equivalent to parts per trillion) on a wet weight basis for each individual congener or congener group.

Data analysis

The data produced may have one of several qualifiers and thus are treated differently. Where a concentration is qualified as an "EMPC" (estimated maximum possible concentration) value, it was assigned a value of zero since identification of the congener did not comply with criteria for positive identification. All non-detectable concentrations were assigned a value of zero for calculation purposes. Where all values for a congener and species are at less than detectable quantities, the largest detection limit is reported accompanied by a less than (<) sign. In some instances the calculation of means where some sample results are less than detection would result in a mean concentration that was less than stated detection limits. It was judged that these values were reasonable approximations of likely true concentrations for the population being evaluated and do not add substantially to overall concentrations of dioxins and dibenzofurans or to their toxic equivalents.

In some instances, particularly the 1992 data set, blank contamination was noted. Blank contamination occurred most frequently for octachlorodibenzodioxin, although in one case a heptachlorodibenzodioxin was significantly affected. For samples associated with contaminated blanks, the sample datum for the congener affected was modified. Where sample data were less than or equal to two times the corresponding blank sample results, the data were discarded by assigning a value of zero. Since the blank contamination was generally at low concentrations where analytical variability could be as much as 100%, the conservative approach above was taken. Where sample data was greater than two times the corresponding sample blank value, the blank value was subtracted from the corresponding sample concentration prior to calculation of statistics. In this latter instance, sample data was normally substantially greater than the blank contamination value. The aforementioned data treatments had a negligible impact on calculation of toxic equivalents and statistical treatment of sample comparisons.

Since data sets for specific locations, species or years were often small, standard parametric tests to evaluate statistical changes were not appropriate. A non-parametric test, the Kruskal-Wallis test, was used as a measure of statistical differences within the data.

RESULTS

Fish collections

A total of nine species of fish were collected and analyzed. The predominant species was bluntnose minnow (*Pimephales notatus*) taken from seven of eight stations. Rock bass (*Ambloplites rupestris*) was the second most frequently caught fish species (four stations) largely from the Niagara River - Little River areas. Due to their general absence from Cayuga Creek, rock bass are excluded from statistical comparisons between locations and years. The alewife (*Alosa pseudoharengus*) was represented as only one sample in 1987. The alewife is excluded for statistical comparisons since they are believed to be migrants from Lake Erie.

Changes in fish population structure over time were anticipated. These changes reflect differences in reproductive success as affected by weather and habitat modifications. Cooler, wetter weather than normal occurred in the area during summer 1992. This may have contributed to smaller than anticipated numbers of young-of-the-year fish during the collection period. To compensate for the lack of young-of-the-year fish at certain locations, older aged fish were taken. Where older fish were analyzed, the information is footnoted in the tables.

The most significant habitat modification was the 1989 dredging of Bergholtz Creek to remove sediments containing excessive concentrations of dioxins (Division of Hazardous Waste Remediation, 1991). As a consequence, the fish population changed from one dominated by golden shiners (Notimegonus crysoleucus) to more diverse populations with bluntnose minnow and common shiner (Notropis cornutus) as the most common species.

Dioxins

Mean concentrations of dioxin congeners containing the 2,3, 7,8-chloro congener in the young-of-the-year fish by location, fish species and year of collection are noted in Table 1. Corresponding mean total dioxin concentrations by congener group for these fish are provided in Table 2.

On a species basis, the rock bass, a predatory fish, generally contains the greatest concentrations of the lower chlorinated dioxin congener groups. The 2,3,7,8-TCDD levels are generally at least two times concentrations found in minnow species. With the exception of a white sucker (Catostomus commersoni) sample from the Little River downstream of Cayuga Creek, there is relative consistency of reported concentrations of each dioxin congener group amongst minnow species within location and year.

In a comparison of the sum of 2,3,7,8-chloro congener dioxins (Table 1) with total dioxins (Table 2), at least 80% of the total dioxins found were composed of the 2,3,7,8-chloro congener groups in 81% of the 43 comparisons (Table 3). The remaining eight comparisons contained the 2,3,7,8-chloro congener groups in amounts ranging from 54 to 73 percent of the total dioxin found. The distribution of these latter eight observations is random. Therefore, distribution patterns observed for the 2,3,7,8-chloro congener groups are equally applicable to total dioxins.

In 1987, prior to sediment dredging, the greatest concentrations of 2,3,7,8-TCDD were found in Bergholtz Creek (36.4 ppt) with progressively lower concentrations downstream towards the mouth of Cayuga Creek (Table 4). Subsequent to removal of highly contaminated sediments from Bergholtz Creek in 1989, 2,3,7,8-TCDD concentrations in Bergholtz Creek fish declined to levels statistically the same as those for control areas of Cayuga Creek (Table 4). When age 1+ fish are excluded, significant ($p < 0.05$) declines in 2,3,7,8-TCDD concentrations have occurred at and downstream of Love Canal. These declines occurred between 1982 and 1987, and between 1987 and the two succeeding collection periods (Table 5).

There are no spatial or temporal differences in the distribution of pentachlorodioxins and hexachlorodioxins. In most cases, these two groups of compounds are at concentrations near or below their respective detection limits.

The heptachlorodioxin levels reported were almost solely composed of the 1,2,3,4,6,7,8-heptachloro-congener. Heptachlorodioxin concentrations were highly variable from year to year at locations in the Little River and downstream Cayuga Creek. No temporal trend was discernable. On a spatial basis heptachlorodibenzofurans in the Little River and the most downstream Cayuga Creek station (Lindberg Avenue bridge) were at concentrations significantly ($p < 0.05$) greater than in upstream and control locations during collection years 1987 and 1992. There were no significant differences in heptachlorodioxin levels spatially during 1990 (Table 6).

Octachlorodioxin (OCDD) was observed in fish at concentrations that were comparable to or greater than 2,3,7,8-TCDD. The greatest concentration was 175 pg/g (Table 1). Spatial differences in OCDD levels occurred in 1987 only. OCDD concentrations increased progressively ($p<0.05$) downstream in Cayuga Creek (Table 7). OCDD levels in the Little River were highly variable in all three years sampled. The OCDD levels significantly ($p<0.05$) declined in the downstream Cayuga Creek locations from 41.3 pg/g in 1987 to non-detectable levels in 1992 (Table 8).

Dibenzofurans

Table 9 provides a summary of mean concentrations of 2,3,7,8-chloro congener containing dibenzofurans in young-of-the-year fish by location, fish species and year of collection. The corresponding total dibenzofurans by congener group are presented in Table 10.

The 2,3,7,8-tetrachloro congener containing groups make up a substantially smaller part of total furans than in corresponding comparison of dioxins (Table 3). The 2,3,7,8-tetra chloro congener groups were the primary constitutents of total dibenzofurans in only 4.7 percent of the comparisons. Approximately 46.5% of the comparisons contained less than 40% of the 2,3,7,8-congener groups.

Contrary to dioxins, no single fish species appears to preferentially accumulate dibenzofurans. Year to year variation in concentration of the various congeners are small and non-significant. Consequently the data for Cypriniform fishes for the years 1987, 1990 and 1992 were combined to examine spatial differences in distribution of the congener groups containing the 2,3,7,8-tetrachloro congener (Table 11). Fish from the Little River and Niagara River tend to have greater concentrations of

dibenzofurans than fish in the Cayuga Creek drainage basin. This tendency is statistically significant ($p < 0.05$) for hexachlorodibenzofurans and octachlorodibenzofurans. For heptachlorodibenzofurans, a greater variation in concentration was encountered. In addition, reported concentrations of each congener group tended to increase with increasing degree of chlorination, particularly for samples collected in the Little River and Niagara River. It is apparent that the primary sources of dibenzofurans are locations other than the Love Canal.

2,3,7,8-TCDD Toxicity Equivalents

Due to the large differences in the toxicity of congeners of dioxins and dibenzofurans, the concentrations of the 2,3,7,8-tetrachloro - containing congener groups were converted to 2,3, 7,8-TCDD toxicity equivalents (Table 12) using the international toxicity equivalency factors in U.S.E.P.A. (1989b). The toxicity equivalents range from 0.89 for a control location in 1992 to 37.6 for Bergholtz Creek in 1987 prior to removal of dioxin contaminated sediments.

The dominant compound contributing to the calculated toxicity equivalents is 2,3,7,8-TCDD. At the two downstream locations in Cayuga Creek and in the 1987 collections from Bergholtz Creek, 2,3,7,8-TCDD generally provided 90 percent or more of the toxicity equivalents. In upstream Cayuga Creek, Little River and in 1990 and 1992 collections from Bergholtz Creek, 2,3,7,8 - TCDD contributed about 50 to 80 percent of the toxicity equivalents. In the Niagara River upstream of Cayuga Creek, 2,3,7,8-TCDD was a minor constituent contributing about 20% of the toxicity equivalents. In the latter case, 2,3,4,7,8 - pentachlorodibenzofuran was a principal contributor that provided 40 to 50 percent of the calculated toxicity equivalents.

In 1990, the influence of dioxins from the Cayuga Creek basin on fish from the Little River is evident when a comparison of data for the Niagara River and Little River is made. Toxicity equivalents in the Little River doubled those observed in the Niagara River. Further, the relative concentration of 2,3,7,8-TCDD increased by at least four-fold in the Little River compared to the Niagara River.

DISCUSSION

Based on the foregoing information, it is apparent that 2, 3,7,8-TCDD is the only dioxin or dibenzofuran congener that can be conclusively associated with the inactive hazardous waste site at Love Canal, Niagara Falls, New York. Therefore, this discussion will focus primarily on 2,3,7,8-TCDD.

2,3,7,8-TCDD

In a review of remedial activities conducted in association with Love Canal, the Division of Hazardous Waste Remediation (1991) noted that encapsulation of the Love Canal site was completed during 1979 and 1980. These activities included installation of a leachate collection and treatment system. Sanitary and storm sewers, including those discharging to Black and Bergholtz Creeks, were cleaned in 1986 and 1987. These sewers contained as much as 600 ng/g 2,3,7,8-TCDD in the sediments. Black and Bergholtz Creeks were dredged from the point of interception of storm water drainage from the Love Canal area downstream to the junction with Cayuga Creek during 1989. The linear distance dredged was approximately 3000 meters (NYSDEC, 1990). Sediment concentrations of 2,3,7,8-TCDD in Bergholtz Creek, and it's tributary Black Creek, averaged 380 pg/g with areas in excess of 1 ppt. The main stem of Cayuga Creek downstream of Bergholtz Creek contained 2,3,7,8-TCDD concentrations averaging 300 pg/g. Excluding elevated dioxin concentrations at the mouths of storm sewer outfalls, Cayuga Creek contained an average 213 pg/g 2,3,7,8-TCDD in sediments (calculated from Slack, 1986).

In a comparison of 2,3,7,8-TCDD concentrations in Cypriniform fish (Table 13), substantial declines in 2,3,7,8 - TCDD levels have occurred during two periods, i.e. 1982 to 1987 and 1987 to 1992. The declines evident in Bergholtz Creek fish and fish from downstream portions of Cayuga Creek correspond with remedial activities associated with Love Canal. During the initial period, Bergholtz Creek experienced 2,3,7,8-TCDD declines of approximately 68 percent. An additional 86 percent decline occurred between 1987 and subsequent years. Corresponding declines in Cayuga Creek were approximately 72 and 46 percent, respectively. Overall, 2,3,7,8-TCDD in young-of-the-year fish from Bergholtz Creek has declined about 96 percent in the ten year time frame between 1982 and 1992. Declines in Cayuga Creek were 84 percent (Table 14).

When all the dioxin and dibenzofuran data is converted to 2, 3,7,8-TCDD equivalents (Table 15), the declines noted for 2,3,7, 8-TCDD are essentially unchanged. This is due to the general predominance of 2,3,7,8-TCDD in the computation of 2,3,7,8-TCDD toxicity equivalents (Tables 3 and 12).

The New York State Department of Health (NYSDOH) uses a criterion of 10 pg/g 2,3,7,8-TCDD or its equivalents as a guideline for protection of human consumers of fish. While young-of-the-year fish are not normally consumed by humans, it is evident that 2,3,7,8-TCDD values in fish from the downstream portion of Cayuga Creek approximate the NYSDOH criterion. Older age fish of edible species that reside in the lower reaches of Cayuga Creek could be expected to contain greater levels of 2,3,

7,8-TCDD due to their greater duration of exposure. Based on this likelihood, and the existence of elevated dioxin concentrations in sediments prior to and during 1986, the posting of Black and Bergholtz Creeks against public and angler access was warranted (Division of Hazardous Waste Remediation, 1991). Further, the NYSDOH health advisory against eating fish from Cayuga Creek, (Horn and Skinner, 1985; NYSDOH, 1992) is appropriate until data on edible fish of edible/legal sizes is obtained that would demonstrate a different conclusion. A study to examine dioxins in older aged fish for human health purposes is recommended as a follow-up effort.

Newell et al (1987) developed criteria for chemical contaminants in fish for the protection of fish-eating wildlife. The criterion for 2,3,7,8-TCDD is 2.3 pg/g. Young-of-the-year fish are commonly foraged upon by species such as mink, herring gulls, herons, cormorants, and other fish. Based on the criterion of Newell et al (1987), young-of-the-year fish from the lower portions of Cayuga Creek and from Bergholtz Creek continue to represent a threat to the health of piscivorous wildlife. However, the threat in 1992 is substantially reduced when compared to 2,3,7,8-TCDD values observed in earlier years.

The fact that in 1992 fish from the lower reaches of Cayuga Creek continued to contain elevated dioxin concentrations and that older aged fish are likely to contain greater concentrations of dioxins suggests that further remedial work may be necessary. However, the last remedial activity directly impacting the stream occurred in 1989 and declines in dioxins are documented between 1990 and 1992 (Tables 13, 14 and 15). It is suggestive that reductions in dioxins in fish may continue and that dioxin levels may reach acceptable levels from a human health perspective at some time in the future. Verification of this supposition should be conducted in the future, perhaps 1995. At this time, it would appear to be inappropriate to conduct additional remedial work with Cayuga Creek sediments in the absence of data which would negate the hypothesis that further declines in dioxins are likely.

Dibenzofurans

No criteria exist for acceptable levels of dibenzofurans in fish for the protection of fish - consuming wildlife. The substantial concentrations of dibenzofurans observed in fish from the Niagara River and Little River in this study (Tables 9 and 10) and by Suns et al (1985) (i.e. up to 3179 pg/g total furans) are suggestive that further evaluation of dibenzofuran toxicity to wildlife and development of criteria protective of wildlife are necessary. Since Suns et al (1985) did not find a correlation between dibenzofurans and PCB (dibenzofurans are contaminants of PCB as well as other compounds) in fish from the Niagara River, it can not be assumed that criteria for PCB will

subsume dibenzofurans. The use of an alternative (2,3,7,8-TCDD toxicity equivalents,) does provide a measure for evaluating dibenzofuran toxicity to wildlife. Newell et al. (1987) recommended a criterion of 2.3 pg/g of TCDD in fish as an acceptable level for piscivorous wildlife. If this concentration is accepted as toxicity equivalents, then fish from the Niagara River and Little River contain excessive concentrations of dibenzofurans for fish consuming wildlife. Further efforts toward source identification and control appear warranted.

Other impacts

The criteria of Newell et al (1987) for protection of wildlife is based on acute toxicity, carcinogenesis and/or chronic impacts potentially caused by fish consumption. However, dioxins present hazards to wildlife that are not fish consumers. Christian (1983) observed significantly reduced density and life expectancy of voles in close proximity to Love Canal when compared to a control group one mile away. The same voles developed fatty degeneration of the livers, severely reduced glycogen (a major energy source in all animals) levels in livers, reduced weights of several vital organs when compared to controls, and proportionately more female voles dying prematurely than male voles. Dioxin concentrations in the voles were not measured, however, qualitative analysis found a wide array of halogenated hydrocarbons, including large quantities of hexachlorocyclohexanes (Lindane group of compounds). These latter compounds were disposed in Love Canal in the largest quantity and were found in soil, water, leachate and air in the vicinity of Love Canal (NYSDOH, 1981). Dioxin was also reported in soil, sediment, water and leachates thus may also exert an impact on the voles.

With regard to fisheries, the dioxin source at Love Canal is believed to be one of the major contributors to observed dioxin concentrations in Lake Ontario fish. In 1981 to 1983 collections of young-of-the-year spottail shiners, Suns et al (1985) demonstrated that the Cayuga Creek drainage was the major source of 2,3,7,8-TCDD in the Niagara River basin. The primary source of 2,3,7,8-TCDD to Lake Ontario is via the Niagara River. A number of investigators (O'Keefe et al., 1983; Smith et al., 1984; Stalling et al., 1983; DeVault et al., 1989; and Zacharewski et al., 1989) have demonstrated the presence of 2,3,7,8-TCDD in an array of fish species, with greatest concentrations present in lake trout and four other salmonid species. In Lake Ontario lake trout, Symula et al (1990) and Simonin (1990) documented blue sac disease incidence in hatching eggs which resulted in nearly 50 percent mortality of lake trout sac fry. This is consistent with observed reproductive

impairment in Lake Ontario (Marsden et al. 1988). Blue sac disease has also been reported in lake trout from the upper Great Lakes (Mac et al, 1985) as have reproductive impairment (Jude et al., 1981; Nestor and Poe, 1984). Walker and Peterson (1990) believe chlorinated dioxins, furans and biphenyls are significant contributors to the incidence of blue sac disease. Other causes that have been associated with the disease include the bacterium Cytophaga psychrophila (Warren, 1981, Symula et al., 1990), ammonia from metabolic wastes and improper egg incubation temperatures (Wolf, 1957). However, 2,3,7,8-TCDD has been definitely linked with production of blue sac disease in early life stages of lake trout in laboratory experimentation (Walker and Peterson, 1990; Walker et al., 1991; Spitzbergen et al., 1991). The lowest concentration of 2,3,7,8-TCDD in eggs that produced blue sac disease was approximately 40 pg/g. In the absence of a known relationship between 2,3,7,8-TCDD concentrations in adult lake trout and lake trout eggs produced by the same fish, one could assume a 1:1 ratio. In this case, lake trout eggs examined by Symula (1991) and Simonin (1990) could contain 2,3,7,8-TCDD concentrations in excess of 40 pg/g, and potentially in excess of 100 pg/g for some samples from fish with highly elevated dioxin levels. Since Symula et al (1991) and Simonin (1990) did not examine 2,3,7,8-TCDD in lake trout eggs in their studies conducted from 1979 through 1984, and since Cytophaga psychrophila was detected in only the 1984 samples from Lake Ontario used by Symula et al. (1991) and lastly because adult lake trout from Lake Ontario have the greatest 2,3,7,8-TCDD concentrations of any of the Great Lakes (DeVault et al., 1989; Zacharewski et al., 1989) the role of 2,3,7,8-TCDD in production of blue sac disease in progeny from Lake Ontario lake trout cannot be ruled out. Indeed, it appears that 2,3,7,8-TCDD may be a significant contributor to reproductive impairment in lake trout from Lake Ontario.

For 2,3,7,8-TCDD toxicity, lake trout are the most sensitive fish examined to date (Walker et al., 1991). However, similar reproductive impacts at higher 2,3,7,8-TCDD concentrations in fish eggs have been observed in laboratory experimentation with rainbow trout (Helder, 1981) and northern pike (Helder, 1980). The role 2,3,7,8-TCDD may play in reproduction of other fish species and other fish species from Lake Ontario is currently unknown.

Two characteristics of blue sac disease, i.e. subcutaneous edema of the yolk sac and subcutaneous hemorrhage, are also characteristics of chick edema disease in herring gulls from Lake Ontario (Gilbertson, 1982) and chickens exposed to dioxin via food contamination (Firestone, 1973; Flick et al., 1972). Although the herring gulls were exposed to other chemical contaminants at elevated levels, notably PCB and DDE, none of the

other compounds have produced the symptomology observed in chick edema disease. Indeed, there was no correlation between concentrations of PCB, DDE or other compounds examined and disease incidence. Only 2,3,7,8-TCDD appears to present a significant correlation with chick edema disease incidence. Since herring gulls are opportunistic feeders that will consume large quantities of fish when available, including young fish, a ready route of exposure to chemical contaminants is provided in the Lake Ontario and Niagara River ecosystems.

If indeed 2,3,7,8-TCDD is a significant or major cause of reproductive failure in lake trout stocked in Lake Ontario, then its presence has been a major impediment to re-establishment of lake trout populations. These efforts to re-establish lake trout have been conducted by the New York State Department of Environmental Conservation (Eckert, 1984) and Ontario Ministry of Natural Resources since 1973 and are on-going. The few signs of returning reproductive success (Marsden et al., 1988) are encouraging.

Lastly, Hickey et al. (1990) reported that brown bullhead from the Little River-Cayuga Creek vicinity showed a significantly reduced incidence of parasites (25 percent compared to 98 percent in control fish) and significantly increased incidence of chronic inflammation of gills, kidney and liver. The latter changes were not parasite associated but are consistent with exposure to environmental contaminants. The specific causative agents were not identified. Hickey (personal communication) indicated that brown bullhead growth appears to be retarded and the population age structure is altered when compared to control fish from an uncontaminated source. A report on the latest findings is in preparation.

CONCLUSIONS

The important findings of this study are:

1. Of the dioxins and dibenzofurans examined, 2,3,7,8-TCDD concentrations in fish from the Cayuga Creek basin are the only diagnostic measure of success of remedial activities associated with Love Canal. No other dioxin congener or dibenzofuran were reliable indicators of remedial efficacy.

2. 2,3,7,8-TCDD concentrations in young-of-the-year fish have declined in two stages. The first stage decline (between 1982 and 1987) of approximately 70 percent is associated with securing the Love Canal landfill site and to cleaning of stormwater drainage systems containing 2,3,7,8-TCDD. The second decline (between 1987 and 1992) of an additional 46

to 86 percent is dependent on location and is due to removal of highly contaminated sediments from Black and Bergholtz Creeks. The total reduction in 2,3,7,8-TCDD concentrations in young-of-the-year fish between 1982 and 1992 ranges from 84 to 96 percent.

3. Despite the reduction in 2,3,7,8-TCDD concentrations, young fish continue to possess dioxin levels in excess of criteria recommended for the protection of piscivorous wildlife, i.e. in excess of 2.3 pg/g. At downstream locations, some fish samples exceed the New York State Department of Health recommendation of 10 pg/g 2,3,7,8-TCDD for human consumption of fish. However, the concentrations observed in 1992 are dramatically improved when compared to values in excess of 50 pg/g observed in 1982. These latter values occurred in some species from downstream locations, most notably Bergholtz Creek immediately downstream of Love Canal and Cayuga Creek at Lindberg Avenue.

4. Declines in heptachloro and octachloro-dioxin congeners and in hexa -, hepta -, and octachloro congeners of dibenzofurans are documented.

5. The principal sources of dibenzofurans in fish from the Cayuga Creek drainage basin appears to be from upstream sources in the Niagara River. A specific source locality was not determined or sought.

6. 2,3,7,8-TCDD is the principal component of 2,3,7,8-TCDD toxicity equivalents calculated for fish from Cayuga Creek and its tributary, Bergholtz Creek. In contrast, 2,3,4,7,8-pentachlorodibenzofuran is the major component of 2,3,7,8-TCDD toxicity equivalents in fish from the Niagara River. As a consequence, the increased proportion of 2,3,4,7,8-PCDF in Little River fish is primarily due to sources from the Niagara River and dioxin concentrations in the Little River are reduced due to dilution with waters from the Niagara River.

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Table 1: Mean concentrations of dioxins containing the 2,3,7,8-chloro congener group in young-of-the-year fish from the Cayuga Creek drainage basin, Niagara Falls, New York.

Location	Species	Year	No. of Samples	No. of Fish	Length (mm) Mean	Length (mm) Min-Max	Dioxin congener group (pg/g wet weight)[a] 2,3,7,8	5Cl	6Cl	7Cl	8Cl	Sum
Little River upstream of Cayuga Creek	Alewife	1987	1	56	NA[b]	NA	1.2	<0.1	0.9	2.5	10.0	14.6
	Bluntnose minnow	1990	2	85	49	32-69	7.5	0.4	2.1	8.7	51.5	70.2
		1992	1	90	36	26-45	1.9	1.7	6.4	8.8	49.5	68.3
	Rock bass	1987	3	180	NA	NA	20.1	1.7	12.3	19.1	37.4	90.6
		1990	1	27	43	36-57	16.2	1.3	4.7	7.6	15.2	45.0
		1992	3	94	43	26-54	5.3	1.1	2.7	9.5	167.8	186.4
	Spottail shiner	1987	1	31	NA	NA	2.1	<0.3	<0.3	3.3	6.7	12.1
	White sucker	1987	1	25	NA	NA	10.2	<1.5[d]	13.8	47.9	106.2	178.1
Little River downstream of Cayuga Creek	Bluntnose minnow	1987	1	151	NA	NA	6.9	<0.3	3.1	14.2	47.0	71.2
		1990	1	89	41	26-57	6.7	<0.9[d]	0.4	<6.1[d]	21.4	28.5
		1992	1	100	37	26-50	7.8	1.6	4.7	22.2	175.5	211.8
	Golden shiner	1987	1	72	NA	NA	5.9	<0.8[d]	<1.4[d]	2.0	5.0	12.9
		1990	1	36	51	42-71	4.7	0.9	<0.8	<1.5[d]	5.1	10.7
		1992	1	44	49	41-57	7.9	1.0	2.1	4.2	e	15.2
	Rock bass	1987	2	67	NA	NA	17.2	1.5	3.9	3.1	7.5	33.2
		1990	1	24	46	36-61	11.2	1.5	1.5	<2.9[d]	8.1	22.3
		1992	1	18	43	31-53	15.2	1.8	2.9	2.4	e	22.3

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Table 1: (continued)

Location	Species	Year	No. of Samples	No. of Fish	Length (mm) Mean	Length (mm) Min-Max	Dioxin congener group (pg/g wet weight)[a] 2,3,7,8	5Cl	6Cl	7Cl	8Cl	Sum
Cayuga Creek at Lindberg Avenue bridge	Bluntnose minnow	1987	3	300	NA	NA	26.7	0.5	1.3	11.2	56.8	96.5
		1990	2	152	40	25-62	12.9	<1.3	<2.1	1.5	16.1	30.5
		1992	1	166	32	21-42	10.6	0.6	5.6	4.3	e	21.1
			2[f]	76	52	41-60	28.1	0.5	3.0	3.4	e	35.0
	Golden shiner	1990	1	22	47	30-64	16.7	<1.8	<2.4	<3.8	8.0	24.7
Cayuga Creek at Cayuga Drive bridge	Bluntnose minnow	1987	3	237	NA	NA	17.0	0.2	1.4	3.4	25.8	47.8
		1990	3	153	47	32-61	13.3	0.3	1.3	6.6	17.2	38.7
		1992	1[g]	90	37	21-50	10.5	<0.2	0.6	2.0	e	13.1
			2[f]	64	57	43-65	12.3	0.4	1.0	2.3	e	16.0
	Rock bass	1992	1[f]	9	65	61-71	22.2	0.8	0.8	e	e	23.8
Cayuga Creek below Porter Road	Bluntnose minnow	1990	1	9	54	34-66	2.8	<0.9[d]	1.1	<1.7[d]	7.1	11.0
		1992	1[f]	23	61	56-68	1.9	<0.4[d]	0.3	2.7	e	4.9
	Common shiner	1987	3	113	NA	NA	1.9	<0.8	<0.8	<0.7	3.3	5.2
		1990	1	68	44	29-65	4.1	0.7	0.9	1.3	11.4	18.4
		1992	1	124	35	22-46	0.5	0.3	0.1	1.6	e	2.5
	Creek chub	1990	1	32	49	38-68	1.9	1.0	0.9	1.6	12.0	17.4
		1992	1	10	41	32-51	1.2	<0.6[d]	0.6	5.3	50.0	57.1
	White sucker	1990	1	5	68	62-75	0.8	0.4	0.3	1.3	12.7	15.5

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Table 1: (continued)

Location	Species	Year	No. of Samples	No. of Fish	Lenght (mm) Mean	Lenght (mm) Min-Max	Dioxin congener group (pg/g wet weight)[a] 2,3,7,8	5Cl	6Cl	7Cl	8Cl	Sum
Cayuga Creek above Lockport Road[i]	Brook stickleback	1992	1	65	42	30-54	0.6	<0.4[d]	0.4	1.3	e	2.3
Bergholtz Creek 100 meters west of Williams Road	Bluntnose minnow	1990	1	33	50	32-66	8.4	0.6	0.6	4.0	21.7	35.3
		1992	1[g]	19	61	32-84	5.0	0.7	0.8	e	e	6.5
	Common shiner	1990	2	82	57	45-70	3.7	0.5	0.5	0.7	5.0	10.4
		1992	2[h]	24	84	70-97	9.7	1.6	2.5	2.9	e	16.7
	Golden shiner	1987	3	107	NA	NA	36.4	0.4	<1.7	0.5	5.0	42.3
Niagara River upstream of Little River[j]	Bluntnose minnow	1990	1	57	49	31-68	1.1	0.5	0.3	1.7	11.4	15.0
	Rock bass	1990	1	21	51	35-64	1.5	1.2	0.4	<0.4	2.0	5.1

a Analyzed as whole fish composites. Values less than detection and EMPC values (see footnote d) are given a value of zero in computation of means and sum of dioxins.

b NA = Not available; Only composite weight (g) is available.

c Less than (<) values represent detection limits unless a "d" footnote appears. The largest detection limit is reported where more than one sample is below detection.

d Estimated maximum possible concentration (EMPC) value. This is a tentative identification which did not meet all requirements for positive identification.

e Blank contamination invalidates reported concentration.

f Age 1+ fish.

g Mixture of fish with ages 0+ and 1+.

h Mixture of fish with ages 1+ and 2+.

i No fish were present during the 1987 sampling effort. This station was not sampled in 1990.

j This station was not sampled in 1987 and 1992.

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Table 2: Mean concentrations of all dioxin congeners in young-of-the-year fish from the Cayuga Creek drainage basin, Niagara Falls, New York.

Location	Species	Year	No. of Samples	No. of Fish	Length (mm)		Dioxin congener group (pg/g wet weight) [a]					
					Mean	Min-Max	4Cl	5Cl	6Cl	7Cl	8Cl	Total
Little River upstream of Cayuga Creek	Alewife	1987	1	56	NA[b]	NA	1.2	<0.1[c]	1.0	4.1	10.0	16.3
	Bluntnose minnow	1990	2	85	49	32-69	9.7	0.7	5.6	19.6	51.5	87.1
		1992	1	90	36	26-45	8.4	4.8	15.2	17.6	49.5	95.5
	Rock bass	1987	3	180	NA	NA	20.2	1.7	17.8	25.8	37.4	102.9
		1990	1	27	43	36-57	16.7	1.3	4.8	11.0	15.2	49.0
		1992	3	94	43	26-54	8.3	1.9	7.5	22.0	167.8	207.5
	Spottail shiner	1987	1	31	NA	NA	2.1	<0.3	<3.7[d]	4.8	6.7	13.6
	White sucker	1987	1	25	NA	NA	10.2	<6.1[d]	30.9	67.9	106.2	215.2
Little River downstream of Cayuga Creek	Bluntnose minnow	1987	1	151	NA	NA	6.9	1.0	9.6	24.2	47.0	88.7
		1990	1	89	41	25-57	6.7	<8.2[d]	1.6	4.4	21.4	34.1
		1992	1	100	37	26-50	11.5	3.3	18.9	52.1	175.5	261.3
	Golden shiner	1987	1	72	NA	NA	5.9	<0.8[d]	<3.4[d]	2.0	5.0	12.9
		1990	1	36	51	42-71	5.9	0.9	<2.3[d]	<1.5[d]	5.1	11.9
		1992	1	44	49	42-57	10.5	1.3	4.8	7.6	k	24.2
	Rock bass	1987	2	67	NA	NA	17.3	1.5	4.2	3.1	7.5	33.6
		1990	1	24	46	36-61	12.2	1.5	1.5	<4.3[d]	8.1	23.3
		1992	1	18	43	31-53	16.5	2.0	4.5	3.5	k	26.5
Cayuga Creek at Lindberg Avenue bridge	Bluntnose minnow	1987	3	300	NA	NA	28.4	1.9	6.6	18.7	56.8	112.4
		1990	2	152	40	25-62	12.9	f	0.8	5.0	16.1	34.8
		1992	1	166	32	21-42	11.8	4.2	15.3	7.3	k	38.6
			2[e]	76	52	41-60	28.9	1.4	7.3	5.7	k	43.3
	Golden shiner	1990	1	22	47	30-64	16.7	<1.7[d]	<1.2[d]	<3.8	8.0	24.7

Table 2: (continued)

Location	Species	Year	No. of Samples	No. of Fish	Length (mm) Mean	Length (mm) Min-Max	Dioxin congener group (pg/g wet weight) [a] 4Cl	5Cl	6Cl	7Cl	8Cl	Total
Cayuga Creek at Cayuga Drive bridge	Bluntnose minnow	1987	3	237	NA	NA	17.3	0.5	3.0	5.2	25.8	51.8
		1990	3	153	47	32-61	14.4	0.3	2.2	11.3	17.2	45.4
		1992	1 [g]	90	37	21-50	11.4	<22.5[d]	1.4	3.5	k	16.3
			2 [e]	64	57	43-65	12.7	0.6	2.0	4.2	k	19.5
				9	65	61-71						
	Rock bass	1992	1 [e]				22.3	0.9	1.0	k	k	24.2
Cayuga Creek below Porter Road	Bluntnose minnow	1990	1	9	54	34-66	4.0	0.1	1.7	1.0	8.1	14.9
		1992	1 [e]	23	61	56-68	2.0	<3.0[d]	1.3	4.6	k	7.9
	Common shiner	1987	3	113	NA	NA	1.9	<0.8	<0.4	<0.7	3.3	5.2
		1990	1	68	44	29-65	4.4	0.9	1.2	1.3	11.4	19.2
		1992	1	124	35	22-46	0.5	0.3	0.3	2.9	k	4.0
	Creek chub	1990	1	32	49	38-68	1.9	1.0	1.2	2.7	12.0	18.8
		1992	1	10	41	32-51	1.2	<1.1 [d]	1.2	9.2	50.0	61.6
	White sucker	1990	1	5	68	62-75	0.8	0.4	0.3	2.3	12.7	16.5
Cayuga Creek above Lockport Road [h]	Brook stickleback	1992	1	65	42	30-54	0.6	<0.8 [d]	0.5	2.3	k	3.4
Bergholtz Creek 100 meters west of Williams Road	Bluntnose minnow	1990	1	33	50	32-66	8.4	0.6	1.1	6.3	21.7	38.1
		1992	1 [g]	19	61	32-84	5.5	0.7	1.1	k	k	7.3
	Common shiner	1990	2	82	57	45-70	4.4	0.6	0.7	0.7	5.0	11.4
		1992	2 [i]	24	84	70-97	11.3	1.6	3.0	3.9	k	19.8
	Golden shiner	1987	3	107	NA	NA	36.4	0.4	<1.7	0.5	5.0	42.3
Niagara River upstream of Little River [j]	Bluntnose minnow	1990	1	57	49	31-68	3.9	0.8	2.1	3.3	11.4	21.5
	Rock bass	1990	1	21	51	35-64	2.0	1.2	0.4	<0.4	2.0	5.6

[a] Analyzed as whole fish composites. Values less than detection and EMPC values (see footnote "d") are given a value of zero in computation of means and sums of dioxins.
[b] NA = Not available. Only composite weight (g) is available.
[c] Less than (<) values represent detection limits unless a "d" footnote appears. Where more than one sample was less than the detection limit, the largest detection limit is reported.
[d] Estimated maximum possible concentration. This is a tentative identification which did not meet all requirements for positive identification.
[e] Age 1^+ fish.

Table 2: (continued)

[f] Estimated maximum possible concentrations of 6.7 pg/g and 92.9 pg/g were reported. See footnote d for further notations.
[g] Mixture of ages 0^+ and 1^+ fish.
[h] No fish were present in Cayuga Creek above Lockport Road during the 1987 sampling effort. This station was not sampled in 1990.
[i] Mixture of ages 1^+ and 2^+ fish.
[j] This station was not sampled in 1987 and 1992.
[k] Blank contamination invalidates reported concentration.

LCS4.TBL/LC8.H

Table 3: The distribution of relative percentage contributions of the 2,3,7,8 - tetrachloro - congener to total dioxins and total dibenzofurans concentrations in young-of-the-year fish from the Cayuga Creek basin, Niagara Falls, New York.

	2,3,7,8-tetrachloro congener contribution (percentage range)[a]			
Compounds	± 80	60-79.9	40-59.9	20-39.9
Total Dioxins	81.4	16.3	2.3	0
Total Dibenzofurans	4.7	48.8	37.2	9.3

a n= 43 comparisons

LS291.tbl/rd30

Table 4: Comparison of mean 2,3,7,8-TCDD concentrations in young-of-the-year Cypriniform fish for all locations by year of collection, Cayuga Creek basin, Niagara Falls, New York.

Location	N	2,3,7,8-TCDD (pg/g[a]) Mean	95% Confidence Interval	Group Comparisons[b]
1987				
Cayuga Cr. below Porter Rd.[f]	3	1.9	- 2.4 - 6.2	]
Little River	4	6.3	0.92-11.7	]]
Cayuga Creek at Cayuga Dr.	3	17.0	14.0 -19.8	]]
Cayuga Creek at Lindberg Ave.	3	26.7	24.8 -28.6	]]
Bergholtz Cr.	3	36.4	26.8 -46.0	]
1990				
Niagara River - upstream[f]	1	1.1	-[c]	]
Cayuga Cr. below Porter Rd.[f]	4	2.4	0.21- 4.6	]]
Bergholtz Cr.	3	5.2	-1.9 -12.5	]]
Little River	4	6.6	4.5 - 8.7	]]
Cayuga Cr. at Cayuga Dr.	3	13.3	10.7 -15.9	]
Cayuga Cr. at Lindberg Ave.	2	21.2[d]	16.7 -25.7[d]	
1992				
Cayuga Cr. below Porter Rd.[f]	3	1.2[e]	-0.50 - 3.0	]
Bergholtz Creek	1	5.0[e]	-[c]	]]
Little River	3	5.9	-2.6 -14.4	]]
Cayuga Cr. at Cayuga Dr.	3	11.7[e]	6.6 -16.7	]
Cayuga Cr. at Lindberg Ave.	3	22.2[e]	-3.6 -48.1	

a Concentrations in pg/g wet weight whole fish basis.
b Based on Kruskal-Wallis test paired comparisons where $p < 0.05$.
c Insufficient data for calculation
d Minimum and maximum concentrations given. A third sample had an estimated maximum possible concentration of 27 pg/g but was excluded for this comparison.
e Includes age 1+ fish.
f Control location.

LS292.tbl/rd30

Table 5: Comparison of 2,3,7,8-TCDD concentrations in young-of-the-year Cypriniform fish over time for the Cayuga Creek drainage basin downstream of Love Canal, Niagara Falls, New York.

		2,3,7,8 - TCDD (pg/g)[a]		
Year	N	Mean	95% Confidence Interval	Group Comparisons[b]
		Cayuga Creek below Porter Road (control)		
1992	3	1.2[d]	-0.51 - 3.0	]
1987	3	1.9	-0.92 - 11.7	]
1990	4	2.4	0.21 - 4.6	]
1982[c]	1	10.7	- [f]	]
		Cayuga Creek drainage at and downstream of Love Canal[e]		
1992	3	8.7	0.73 - 16.7	]
1990	9	10.9	4.7 - 17.0	]
1987	9	26.7	20.0 - 33.4	]
1982[c]	3	96.7	- 5.2 - 198	]

a All concentrations are in pg/g wet weight whole fish basis.
b Group comparisons using the Kruskal-Wallis test pair comparisons where $p < 0.05$.
c Data from Kuzia (1985).
d Age 1+ fish are included for the control location only.
e This comparison includes data from Bergholtz Creek and Cayuga Creek at Cayuga Drive and Lindberg Avenue bridges.
f The 95% confidence limit can not be calculated.

LS293.tbl/rd30

Table 6: Comparison of mean concentrations of 2,3,7,8-tetrachloro-containing heptachlorodibenzodioxins in young-of-the-year Cypriniform fish by year in the Little River and the Cayuga Creek basin, Niagara Falls, New York

Location	N	Heptachlorodibenzodioxins (pg/g)[a] Mean	95% Confidence Interval	Group Comparisons[b]
		1987		
Cayuga Cr. at Porter Road[e]	3	ND[c]	–[d]	
Bergholtz Creek	3	0.50	-1.63 - 2.63	
Cayuga Cr. at Cayuga Drive	3	3.39	-4.28 - 11.1	
Cayuga Cr. at Lindberg Avenue	3	11.2	3.47 - 19.0	
Little River	4	16.8	-17.27 - 50.9	
		1990		
Cayuga Cr. at Lindberg Avenue	1	1.00	-3.29 - 5.30	
Cayuga Cr. at Porter Road[e]	3	1.05	0.07 - 2.18	
Bergholtz Creek	3	1.82	-2.88 - 6.52	
Little River	3	4.35	-9.49 - 18.2	
Cayuga Cr. at Cayuga Drive	3	6.63	4.34 - 8.92	
		1992		
Bergholtz Creek	1	ND[c]	–[d]	
Cayuga Cr. at Cayuga Drive	3	2.19	1.47 - 2.91	
Cayuga Cr. at Porter Road[e]	3	3.20	-1.52 - 7.92	
Cayuga Cr. at Lindberg Avenue	3	3.72	1.75 - 5.69	
Little River	3	11.8	-11.5 - 35.1	

a Fish analyzed on a wet weight whole fish basis.
b Group comparisons using the Kruskal-Wallis test pair comparisons where $p < 0.05$.
c ND = below the detection limit.
d The 95% confidence interval can not be calculated.
e Control location.

LS2.TBL/CB25

Table 7: Comparison of mean octachlorodibenzodioxin concentrations in young-of-the-year Cypriniform fish from Cayuga Creek and Bergholtz Creek during 1987; Niagara Falls, New York.

Location	N	Octachlorodibenzodioxin (pg/g)[a] Mean	95% Confidence Interval	Group Comparison[b]
Cayuga Cr. at Porter Road	3	4.82	3.95 - 5.69	]
Bergholtz Creek	3	4.98	-6.20 - 16.2	]
Cayuga Cr. at Cayuga Drive	3	25.8	9.54 - 42.2	]
Cayuga Cr. at Lindberg Avenue	3	56.8	-4.98 - 119	]

a Fish analyzed on a wet weight whole body basis.

b Group comparisons using the Kruskal-Wallis test pair comparisons where $p < 0.05$.

LS3.TBL/CB25

Table 8: Comparison of mean concentrations of octachlorodibenzodioxin in young-of-the-year Cypriniform fish in the Cayuga Creek basin over time; Niagara Fall, New York

Year	N	Octachlorodibenzodioxin (pg/g)[a] Mean	95% Confidence Interval	Group Comparisons[b]
		Upstream locations[c]		
1987	6	4.90	1.89 - 7.90	]
1990	7	11.0	5.80 - 16.3	]
1992	4	12.5[f]	-27.3 - 52.3	]
		Downstream Locations[d]		
1992	6	ND[e]	-[e]	]
1990	6	17.4	3.41 - 31.5	]]
1987	6	41.3	16.6 - 66.1	]

a Fish analyzed on a wet weight whole body basis.
b Group comparisons using the Krushal-Wallis test pair comparisons where $p < 0.05$.
c Bergholtz Creek and Cayuga Creek at Porter Road.
d Cayuga Creek at Lindberg Avenue and Cayuga Drive.
e ND = below detection limits. The 95% confidence interval can not be calculated.
f Three of four values were below the detection limit. The remaining value was 50 pg/g.

LS4.TBL/CB25

Table 9: Mean concentrations of dibenzofurans containing the 2,3,7,8-chloro congener group in young-of-the-year fish from the Cayuga Creek drainage basin, Niagara Falls, New York.

Location	Species	Year	No. of Samples	Dibenzofuran congener group (pg/g wet weight)[a]					
				2,3,7,8	5Cl	6Cl	7Cl	8Cl	Sum
Little River upstream of Cayuga Creek	Alewife	1987	1	1.7	1.9	1.7	1.0	<0.2[b]	6.3
	Bluntnose minnow	1990	2	2.6	5.0	7.8	8.1	19.5	43.0
		1992	1	3.9	6.3	14.1	22.0	38.3	84.6
	Rock bass	1987	3	9.3	16.5	13.8	3.6	2.7	45.9
		1990	1	5.8	9.6	7.6	2.0	2.7	27.7
		1992	3	7.1	12.6	15.9	7.3	10.2	53.1
	Spottail shiner	1987	1	2.4	1.6	10.5	<0.3	<0.4	14.5
	White sucker	1987	1	<3.5[c]	11.8	25.1	8.2	14.1	59.2
Little River downstream of Cayuga Creek	Bluntnose minnow	1987	1	8.3	<2.9	14.6	26.6	39.4	88.9
		1990	1	4.2	3.6	5.5	10.1	26.1	49.5
		1992	1	3.8	4.7	10.9	12.5	19.5	51.4
	Golden shiner	1987	1	9.3	2.9	2.0	1.2	1.7	17.1
		1990	1	3.7	2.7	1.5	<0.8	4.1	12.0
		1992	1	4.4	4.9	5.0	3.3	6.4	24.0
	Rock bass	1987	2	9.2	10.0	8.8	3.3	1.8	33.1
		1990	1	6.5	7.5	5.2	2.7	3.8	25.7
		1992	1	6.1	11.9	11.2	4.5	4.9	38.6

LS5.TBL/CB25

Table 9: (continued)

Location	Species	Year	No. of Samples	Dibenzofuran congener group (pg/g wet weight)[a] 2,3,7,8	5Cl	6Cl	7Cl	8Cl	Sum
Cayuga Creek at Lindberg Avenue bridge	Bluntnose minnow	1987	3	8.3	2.6	2.8	3.2	5.2	22.1
		1990	2	2.3	1.9	0.7	<2.2	<5.4	4.9
		1992	1	2.4	2.1	2.3	1.0	1.4	9.2
			2[d]	3.2	2.4	2.1	0.9	1.6	10.2
	Golden shiner	1990	1	3.5	<1.0	<2.0	<2.3	<6.6	3.5
Cayuga Creek at Cayuga Drive bridge	Bluntnose minnow	1987	3	12.6	3.2	3.4	1.5	<0.8	20.7
		1990	3	3.1	2.6	1.5	2.4	5.1	14.7
		1992	1[c]	<2.5[c]	0.6	1.0	<0.7	1.5	3.1
			2[d]	2.6	1.4	0.8	0.7	1.5	7.0
	Rock bass	1992	1[d]	1.7	1.8	0.6	0.2	0.4	4.7
Cayuga Creek at Porter Road	Bluntnose minnow	1990	1	4.9	3.8	1.5	0.6	1.0	11.8
		1992	1[d]	1.7	0.7	1.0	0.5	1.0	4.9
	Common shiner	1987	3	5.0	1.1	0.8	<0.6	<1.0	6.9
		1990	1	4.3	2.0	0.6	0.3	0.8	8.0
		1992	1	<1.2[c]	0.6	0.2	0.2	<0.3	1.0
	Creek chub	1990	1	3.2	1.4	0.3	0.4	1.1	6.4
		1992	1	1.6	<0.3	0.9	<0.6	<1.0	2.5
	White sucker	1990	1	1.3	0.7	0.4	0.4	1.2	4.0

LS5.TBL/CB25

Table 9: (continued)

Location	Species	Year	No. of Samples	Dibenzofuran congener group (pg/g wet weight)[a] 2,3,7,8	5Cl	6Cl	7Cl	8Cl	Sum
Cayuga Creek above Lockport Road[g]	Brook stickleback	1992	1	<1.3[c]	0.5	0.3	0.6	1.1	2.5
Bergholtz Creek 100 meters west of Williams Road	Bluntnose minnow	1990	1	4.8	2.3	0.2	<0.3	<1.5[c]	7.3
		1992	1[e]	7.1	3.1	1.7	0.4	0.5	12.8
	Common shiner	1990	2	3.5	2.1	0.9	0.3	0.2	7.0
		1992	2[f]	9.9	9.2	4.5	0.6	0.4	24.6
	Golden shiner	1987	3	6.5	<1.1	3.0	<1.4	<2.7	9.5
Niagara River upstream of Little River[h]	Bluntnose minnow	1990	1	4.1	4.9	8.2	16.4	36.1	69.7
	Rock bass	1990	1	5.1	10.3	6.7	20.5	23.6	66.2

a Analyzed as whole fish composites. Values less than detection and EMPC values (see footnote c) are given a value of zero in computation of means and sum of dibenzofurans.
b Less than (<) values represent detection limits unless a "c" footnote appears. The largest detection limit is reported where more than one sample is below detection.
c Estimated maximum possible concentration (EMPC) value. This is a tentative identification which did not meet all requirements for positive identification.
d Age 1+ fish.
e Mixture of fish of ages 0+ and 1+.
f Mixture of fish of ages 1+ and 2+.
g No fish were present during the 1987 sampling effort. This station was not sampled in 1992.
h This station was not sampled in 1987 and 1992.

LS5.TBL/CB25

Table 10: Mean concentrations of all dibenzofuran congeners in young-of-the-year fish from the Cayuga Creek drainage basin, Niagara Falls, New York.

Location	Species	Year	No of Samples	Dibenzofuran congener group (pg/g wet weight) [a]					
				4C1	5C1	6C1	7C1	8C1	Total
Little River upstream of Cayuga Creek	Alewife	1987	1	2.0	2.6	2.0	1.1	< 0.2[b]	7.7
	Bluntnose minnow	1990	2	9.5	9.4	12.0	10.9	19.5	61.3
		1992	1	14.1	25.3	21.6	26.6	38.3	125.9
	Rock bass	1987	3	12.8	34.2	20.1	5.8	2.7	75.6
		1990	1	7.7	11.2	11.2	2.5	2.7	35.3
		1992	3	14.6	29.4	19.6	8.7	10.2	82.5
	Spottail shiner	1987	1	4.1	3.3	5.9	1.7	<0.4	15.0
	White sucker	1987	1	5.5	43.1	36.2	16.0	14.1	114.9
Little River downstream of Cayuga Creek	Bluntnose minnow	1987	1	23.0	15.4	21.9	30.7	39.4	130.4
		1990	1	6.1	10.8	9.7	14.3	26.1	67.0
		1992	1	9.7	15.1	15.7	15.0	19.5	75.0
	Golden shiner	1987	1	10.9	3.7	2.8	2.3	1.7	21.4
		1990	1	5.6	4.7	1.8	<3.7[c]	4.1	16.2
		1992	1	9.9	10.9	4.7	4.7	6.4	36.6
	Rock bass	1987	2	11.7	17.0	12.2	5.1	1.8	47.8
		1990	1	9.1	13.6	6.8	4.2	3.8	37.5
		1992	1	8.9	19.2	12.8	5.4	4.9	51.2
Cayuga Creek at Lindberg Avenue bridge	Bluntnose minnow	1987	3	16.5	11.0	8.0	6.1	5.2	46.8
		1990	2	4.6	4.9	0.8	<1.7	<5.4	10.3
		1992	1	5.6	8.2	4.2	1.0	1.4	20.4
			2[c]	6.1	5.7	3.3	1.0	1.6	17.7
	Golden shiner	1990	1	4.7	1.3	<6.6[e]	<1.7	<6.6	6.0

Table 10: (continued)

Location	Species	Year	No of Samples	Dibenzofuran congener group (pg/g wet weight) [a]					
				4C1	5C1	6C1	7C1	8C1	Total
Cayuga Creek at Cayuga Drive bridge	Bluntnose minnow	1987	3	14.0	18.8	8.5	10.6	<0.8	51.9
		1990	3	8.6	5.8	3.9	4.2	5.1	27.6
		1992	1[d]	2.2	6.0	1.5	<5.9[h]	1.5	11.2
			2[c]	4.6	3.6	1.4	0.9	1.5	12.0
	Rock bass	1992	1[c]	2.6	2.8	0.8	0.2	0.4	6.8
Cayuga Creek below Porter Road	Bluntnose minnow	1990	1	11.4	8.0	2.3	1.4	1.0	24.1
		1992	1[c]	3.9	3.9	1.1	0.6	1.0	10.5
	Common shiner	1987	3	7.0	3.7	0.9	1.2	<1.0	12.8
		1990	1	6.5	4.2	1.1	0.4	0.8	13.0
		1992	1	0.3	1.4	0.2	0.4	<0.3	2.3
	Creek chub	1990	1	4.5	2.9	0.6	0.5	1.1	1.6
		1992	1	3.6	0.7	0.9	<0.8[h]	<1.0	5.2
	White sucker	1990	1	2.1	1.5	0.6	0.9	1.2	6.3
Cayuga Creek above Lockport Road[e]	Brook stickleback	1992	1	0.2	1.3	0.5	0.7	1.1	3.8
Bergholtz Creek 100 meters west of Williams Road	Bluntnose minnow	1990	1	12.2	6.7	0.9	<2.4[e]	<1.5[e]	19.8
		1992	1[d]	13.2	5.9	2.0	0.3	0.5	21.9
	Common shiner	1990	2	6.6	4.7	1.3	0.7	0.2	13.5
		1992	2[f]	18.9	21.3	5.3	0.8	0.4	46.7
	Golden shiner	1987	3	13.3	10.3	5.6	3.2	<2.7	32.4
Niagara River upstream of Little River [g]	Bluntnose minnow	1990	1	13.2	14.0	15.6	22.3	36.1	101.2
	Rock bass	1990	1	8.2	16.4	9.6	25.4	23.6	83.2

Table 10: (continued)

[a] Analyzed as whole fish composites. Values less than detection and EMPC values (see footnote h) are given a value of zero in computation of means and the sum of dibenzofurans.

[b] Less than (<) values represent detection limits. Where more than one sample was less than the detection limit, the largest detection limit is reported.

[c] Age 1+ fish.

[d] Mixture of ages 0^+ and 1^+ fish.

[e] No fish were present in Cayuga Creek above Lockport Road during the sampling effort in 1987. This station was not sampled in 1990.

[f] Mixture of ages 1^+ and 2^+ fish.

[g] This station was not sampled in 1987 and 1992.

[h] Estimated maximum possible concentration (EMPC) value. This is a tentative identification which did not meet all requirements for positive identification.

LCS2.TBL/LC8.H

Table 11: Comparison of concentrations of dibenzofurans containing the 2,3,7,8-tetrachloro congener group in young-of-the-year Cypriniform fish by location, Cayuga Creek drainage basin, Niagara Falls, New York.

Location	N	Concentration (pg/g wet weight) [a] Mean	95% confidence interval	Group comparison[b]
2,3,7,8-tetrachlorodibenzofuran				
Little R. upstream	5	2.3	- 0.58 - 5.2	
Cayuga Cr. at Porter Rd.	10	3.2	1.8 - 4.7	
Niagara R. upstream	1	4.1	- [c]	
Cayuga Cr. at Cayuga Dr.	9	4.2	1.6 - 6.8	
Cayuga Cr. at Lindberg Ave.	9	4.6	2.2 - 7.0	
Bergholtz Cr.	7	5.5	3.9 - 7.0	
Little R. downstream	6	5.6	2.9 - 8.3	
2,3,4,7,8-pentachlorodibenzofuran [d]				
Cayuga Cr. at Porter Rd.	10	1.0	0.34 - 1.8	
Bergholtz Cr.	7	1.2	0.14 - 2.2	
Cayuga Cr. at Lindberg Av.	9	1.9	1.1 - 2.6	
Cayuga Cr. at Cayuga Dr.	9	1.9	1.1 - 2.7	
Little R. downstream	6	2.3	0.98 - 3.6	
Niagara R. upstream	1	4.1	- [c]	
Little R. upstream	5	4.7	0.94 - 8.5	

Table 11 (continued)

Location	N	Concentration (pg/g wet weight) [a] Mean	95% confidence interval	Group comparison [b]
	Hexachlorodibenzofurans [e]			
Cayuga Cr. at Porter Rd.	10	0.72	0.19 - 1.3	
Bergholtz Cr.	7	1.8	-0.41 - 4.0	
Cayuga Cr. at Cayuga Dr.	9	1.9	0.52 - 3	
Cayuga Cr. at Lindberg Ave.	9	1.8	0.84 - 2.8	
Little R. downstream	6	6.6	1.1 - 12.1	
Niagara R. upstream	1	8.2	- [c]	
Little R. upstream	5	11.8	1.5 - 22.1	
	1,2,3,4,6,7,8-heptachlorodibenzofuran [f]			
Bergholtz Cr.	7	0.14	-0.05 - 0.33	
Cayuga Cr. at Porter Rd.	10	0.23	0.07 - 0.39	
Cayuga Cr. at Lindberg Av.	9	1.4	0.27 - 2.5	
Cayuga Cr. at Cayuga Dr.	9	1.5	0.68 - 2.2	
Little R. downstream	6	9.0	-1.6 - 19.5	
Little R. upstream	5	9.3	-0.67 - 19.2	
Niagara R. upstream	1	16.4	- [c]	

Location	N	Concentration (pg/g wet weight) [a] Mean	95% confidence interval	Group comparison [b]
	Octachlorodibenzofuran			
Bergholtz Cr.	7	0.11	-0.07 - 0.29	
Cayuga Cr. at Porter Rd.	10	0.50	0.11 - 0.89	
Cayuga Cr. at Cayuga Dr.	9	2.2	-0.67 - 5.1	
Cayuga Cr. at Lindberg Av.	9	2.3	0.44 - 4.1	
Little R. downstream	6	16.2	0.62 - 31.8	
Little R. upstream	5	18.3	1.1 - 35.4	
Niagara R.	1	36.1	- [c]	

[a] Whole fish composites. Combined data for 1987, 1990 and 1992 since year to year variations were statistically insignificant.
[b] Group comparisons calculated using the Kruskal-Wallis test pair comparisons where $p < 0.05$.
[c] Insufficient data to calculate the 95% confidence interval.
[d] The 2,3,4,7,8-pentachlorodibenzofuran is the predominant congener making up in excess of 95% of the 2,3,7,8-congener containing pentachlorofurans.
[e] The only detected 2,3,7,8-congener containing hexachlorodibenzofurans detected were the 1,2,3,4,7,8-hexachloro and 1,2,3,6,7,8-hexachloro-congeners.
[f] The 1,2,3,4,6,7,8-heptachlorodibenzofuran is the only 2,3,7,8-congener containing heptafuran detected.

Table 12: 2,3,7,8-TCDD toxicity equivalents and percent contribution to 2,3,7,8-TCDD toxicity equivalents by 2,3,7,8-TCCD and 2,3,4,7,8-PCDF in young-of-the-year fish from the Cayuga Creek drainage basin, Niagara Falls, New York.

Location	Species	Year	2,3,7,8-TCDD toxicity equivalents	% contributed by: 2,3,7,8-TCDD	% contributed by: 2,3,4,7,8-PCDF
Little R. upstream of Cayuga Cr.	Alewife	1987	2.6	46	36
	Bluntnose minnow	1990	11.1	68	17
		1992	8.0	24	29
	Rock bass	1987	30.7	65	20
		1990	22.3	73	15
		1992	13.5	38	36
	Spottail shiner	1987	3.6	58	23
	White sucker	1987	19.8	52	25
Little R. downstream of Cayuga Cr.	Bluntnose minnow	1987	10.0	69	15
		1990	9.1	73	13
		1992	12.8	61	13
	Golden shiner	1987	8.5	70	17
		1990	6.6	71	14
		1992	11.4	70	15
	Rock bass	1987	24.0	72	15
		1990	15.8	71	15
		1992	22.9	66	18
Cayuga Cr. at Lindberg Ave. bridge	Bluntnose minnow	1987	29.6	90	4.2
		1990	14.1	47	44
		1992[c]	24.4	90	4.2
	Golden shiner	1990	17.1	98	ND[g]
Cayuga Cr. at Cayuga Drive bridge	Bluntnose minnow	1987	20.3	84	6.9
		1990	15.2	87	6.8
		1992[c]	10.7	98	ND
		1992[b]	13.6	91	4.2
	Rock bass	1992[b]	23.6	94	1.7

Table 12. (continued)

Location	Species	Year	2,3,7,8-TCDD toxicity equivalents	% contributed by: 2,3,7,8-TCDD	2,3,4,7,8-PCDF
Cayuga Cr. below Porter Road	Bluntnose minnow	1990	5.2	54	31
		1992[b]	2.6	73	14
	Common shiner	1987	3.0	63	18
		1990	5.8	71	12
		1992	0.92	56	20
	Creek chub	1990	3.3	57	14
		1992	1.6	74	ND
	White sucker	1990	1.6	54	17
Bergholtz Cr. 100 meters west of Williams Rd.	Bluntnose minnow	1990	10.2	82	9.3
		1992[c]	7.5	67	16
	Common shiner	1990	5.4	68	18
		1992[e]	16.5	59	26
	Golden shiner	1987	37.6	97	ND
Cayuga Cr. above Lockport Rd.[d]	Brook stickleback	1992	0.89	64	26
Niagara R. upstream of Little R.[f]	Bluntnose minnow	1990	4.9	22	42
	Rock bass	1990	7.7	19	53

[a] Based on toxicity equivalency factors published in U.S.E.P.A., 1989.
[b] Age 1+ fish
[c] Mixture of fish of ages 0+ and 1+.
[d] No fish were present during the 1987 sampling effort. This station was not sampled in 1990.
[e] Mixture of fish of ages 1+ and 2+.
[f] This station was not sampled in 1987 and 1992.
[g] ND = Not detected.

Table 13: Comparison of 2,3,7,8-TCDD concentrations in Cypriniform fish from the Cayuga Creek drainage basin by year, Niagara Falls, NY.

Location	2,3,7,8-TCDD concentration (pg/g) in year			
	1982[a]	1987	1990	1992
Little River	7.3	6.3	6.6	4.9
Cayuga Creek				
- Lindberg Ave.	127	26.7	14.8	10.6[b]
- Cayuga Drive	50	17.0	13.3	11.4[b]
- below Porter Rd.	10.7	1.9	2.4	1.2[b]
- above Lockport Rd.	2.0	c	d	0.6[e]
Bergholtz Creek	113	36.4	6.1	5.0[b]
Niagara River	d	d	1.3	d

[a] Source: Kuzia, 1985.
[b] Includes some age 1+ fish
[c] No fish were present.
[d] No collections were attempted.
[e] Brook stickleback, a non-Cypriniform fish species, was the only species collected.

lcsTbl.13
fb4.h

Table 14: Percentage change in 2,3,7,8-TCDD concentrations with time in Cypriniform fish from the Cayuga Creek drainage basin, Niagara Falls, NY.

Location	% change in 2,3,7,8-TCDD concentration between		
	1982-1987	1987-1992	1982-1992
Little River	- 14	- 22	- 33
Cayuga Creek			
- Lindberg Ave.	- 79	- 60	- 92
- Cayuga Drive	- 66	- 33	- 77
- below Porter Rd.	- 82	- 37	- 83
- above Lockport Rd.	a	a	- 70
Bergholtz Creek	- 68	- 86	- 96

a No collections were made in 1987

lcsTbl.14
fb4.h

Table 15: Comparison of 2,3,7,8-TCDD toxicity equivalents in Cypriniform fishes from the Cayuga Creek drainage basin by year; Niagara Falls, New York.

Location	2,3,7,8-TCDD toxicity equivalents in year			
	1982[a]	1987	1990	1992
Little River	12.5	10.5	9.5	10.1
Cayuga Creek				
-Lindberg Ave.	140	29.6	15.7	12.8[b]
-Cayuga Drive	55.6	20.3	15.2	10.7[b]
-below Porter Rd.	17.0	3.0	4.0	1.7[b]
-above Lockport Rd.	3.1	c	d	0.89[e]
Bergholtz Creek	151	37.6	7.8	7.5[b]
Niagara River	d	d	6.3	d

[a] Estimated toxicity equivalents as derived from 2,3,7,8,TCDD concentration reported by Kuzia (1985) divided by the average percent 2,3,7,8-TCDD in toxicity equivalents for Cypriniform fishes at each location during the current study.
[b] Includes some age 1+ fish.
[c] No fish were present.
[d] No collections were attempted.
[e] Brook stickleback, a non-Cypriniform fish species, was the only species collected.

lcsTbl.15
fb4.h

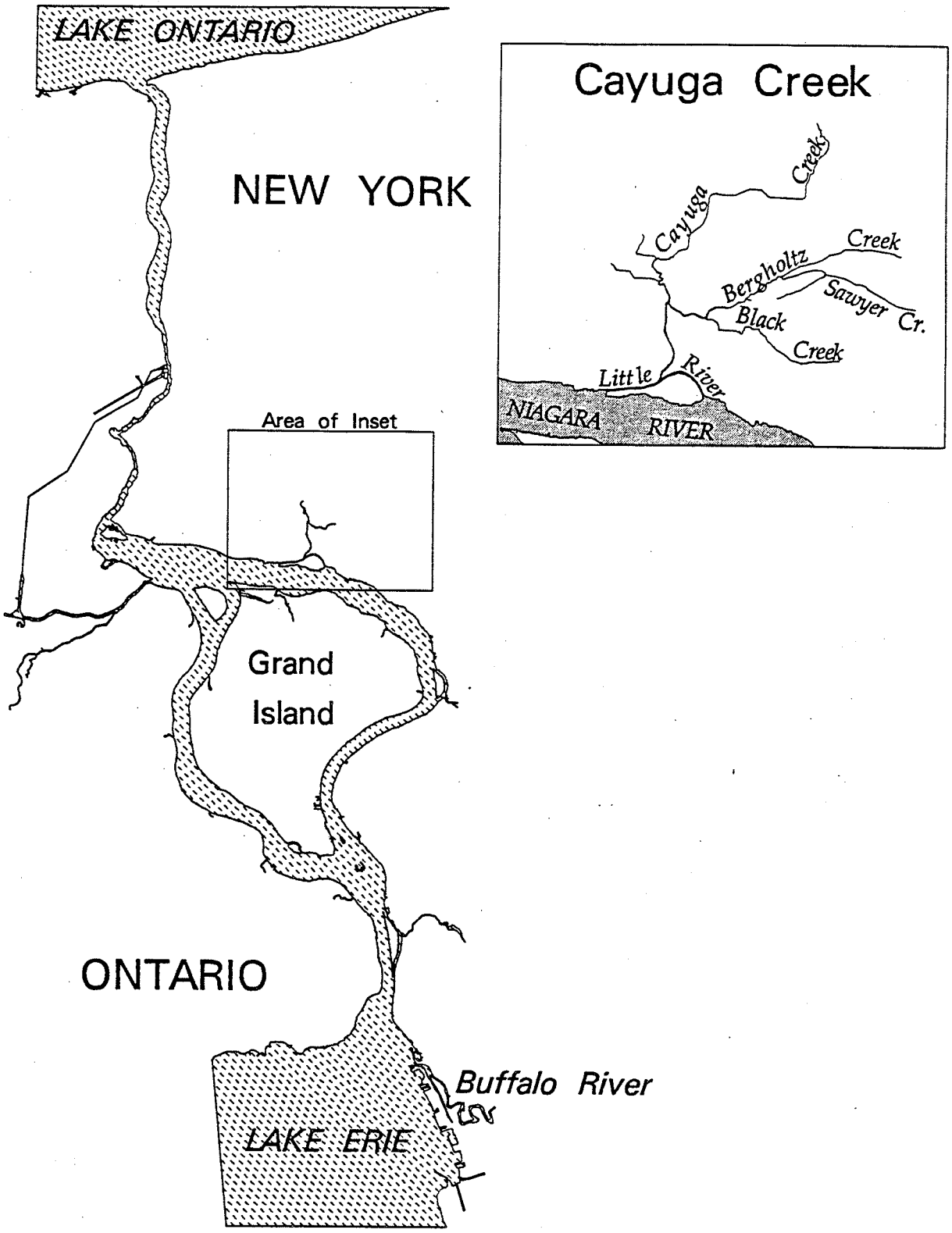

Figure 1: General and specific area of study for assessing dioxins and furans in young-of-the-year fish from the Cayuga Creek drainage basin.

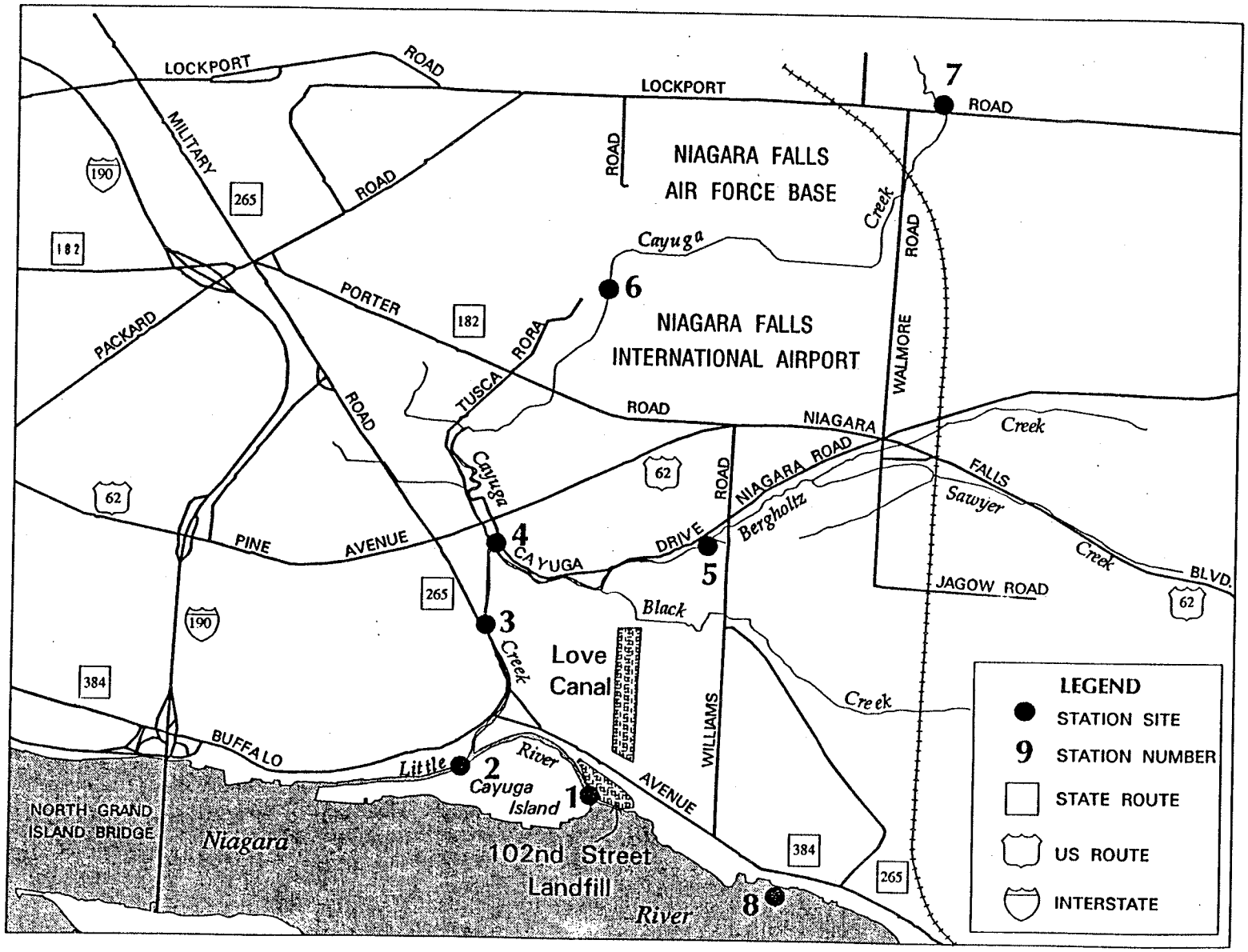

Figure 2: Sampling sites for assessing dioxins and furans in young-of-the-year fish from the Cayuga Creek drainage basin.

Appendix I

82-14-64 (7/85)

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

CHAIN OF CUSTODY

I, _____ (Print Name), of _____ (Print Address) have collected the on _____, 198__ from _____ in the vicinity of _____ Town of _____, _____ County.

Items: _____

_____

_____

_____

said sample(s) were in my possession and handled according to standard procedures provided to me prior to collection. The sample(s) were placed in the custody of a representative of the New York State Department of Environmental Conservation on _____, 198__.

_____ Signature _____ Date

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

_____ Signature _____ Date

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

SEE REVERSE SIDE

NOTICE OF WARRANTY

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

Handling Instructions

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

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

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

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

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF FISH AND WILDLIFE

FROM REGION_____ FOR _____ TOXIC SUBSTANCE MONITORING PROGRAM

BY COLLECTOR(S) _____ USING _____ COLLECTION METHOD.

SPECIMENS PRESERVED BY _____ METHOD.

FILL IN APPROPRIATE BLANKS AS COMPLETELY AS POSSIBLE.

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