Fisheries of the Hudson River
Near Ciba-Geigy
Glens Falls, New York

Prepared For:

Ciba-Geigy Corporation
Lower Warren Street
Glens Falls, NY 12801

Prepared By:

Aquatec, Inc.
75 Green Mountain Drive
So. Burlington, VT 05403

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Aquatec Project Personnel

Investigator	Project Responsibility
Philip C. Downey, Ph.D.	Project Director, Fisheries
Neal E. Van Wyck, M.S.	Project Coordinator, Chemistry
Angela D. Shambaugh, M.A.	Quality Control Officer
Joseph K. Comeau, Ph.D.	Organic Analysis of Tissue
Joseph J. Orsini, Ph.D.	Metals Analysis of Tissue
Nicholas R. Staats, B.S.	Fisheries
H. Gregory Johnston, M.S.	Data Management
Roland R. Luxenberg, P.E.	River Topography

Executive Summary

In 1988, a study of the fish community of the Hudson River segment adjacent to the Ciba-Geigy main plant near Glens Falls, New York was undertaken. The goal of this investigation was to assess whether off-site migration of selected compounds was occurring and whether these chemicals were being accumulated in the fish population.

Two possible effects were hypothesized and examined as part of this study. The first hypothesis was that if an off-site migration of compounds was occurring in sufficient levels, a measurable adverse effect on the overall fish community in the region adjacent to the plant would be apparent. The second hypothesis was that if compounds were not at sufficient levels to produce a measurable effect in the fish community, bioaccumulation of the target compounds may still be occurring in individual fish of the community. The conceptual approach to investigate both hypotheses was to study both the population effects and bioaccumulation in individuals.

To examine the potential effects on the fish community, a synoptic fisheries survey of the Hudson River adjacent to Ciba-Geigy was conducted in September/October 1988. This survey provided data for evaluation of the species composition in this region, the age and growth of smallmouth bass, rock bass and redbreast sunfish, and the overall condition of the individual fish captured. Although 15 species of fish were identified during the survey, the community was predominantly Centrarchids (sunfishes). The relative density of smallmouth bass expressed as catch per unit effort was high, indicating an abundance of smallmouth bass in this region. Growth rates and overall condition of the sunfishes (smallmouth bass, rock bass, redbreast sunfish) were average for a riverine system the size of the Hudson River. The results of this synoptic survey indicate that the fish population near Ciba-Geigy was a thriving sunfish community with no overt signs of adverse effects attributable to off-site migrations of chemical compounds.

The investigation of specific concentrations in fish was evaluated using a Representative Important Species approach. Two species of fish, the common carp (Cyprinus carpio) and the smallmouth bass (Micropterus dolomieui), were chosen to be representative of the fish community in the Hudson River region adjacent to Ciba-Geigy. The design of this phase of the study was to collect 30 carp and 20 smallmouth bass from the downstream region (adjacent to the plant) while obtaining a representative sample (four to five individuals of each species) of common carp and smallmouth bass from the impoundment immediately upstream of the study area for control purposes.

The target chemical compounds were selected based upon the knowledge of Ciba-Geigy site history. These target compounds included organic compounds (1,2-Dichlorobenzene, 1,4-Dichlorobenzene, 3,3'-Dichlorobenzidine, Hexachlorobenzene, 4-Nitroanaline, 2-Nitroanaline, and Nitrobenzene) and inorganic parameters (cadmium, chromium, lead, mercury, nickel, strontium, and vanadium).

Two tissues, the flesh and the liver, were selected for analysis for target compounds in the common carp. The flesh was the selected tissue for smallmouth bass analyses.

The flesh of the common carp did not contain any of the target organic compounds above detection levels. Many of the inorganic compounds in carp flesh were also below detection levels. Mercury was found in the common carp flesh at both the upstream control and downstream regions but average concentrations were not significantly different between common carp captured in the two regions.

In the common carp liver analyses, target organic compounds and many of the target inorganic compounds were below detection. Mercury was detected in liver samples from fish captured in both upstream control and downstream regions but again were not significantly different between regions. Cadmium and chromium were detected in the common

carp liver samples. The concentrations of these two metals were significantly higher in the common carp captured in the downstream region adjacent to the plant than samples collected from common carp captured in the upstream control region, suggesting bioaccumulation of these two metals in common carp individuals.

Target organic compounds were not detected in the smallmouth bass flesh samples obtained from either region. Mercury was the only inorganic target compound consistently detected in smallmouth bass flesh samples obtained from both regions. Average concentrations of mercury in these samples were essentially the same in smallmouth bass captured in the upstream control and downstream regions.

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1.0 Introduction

1.1 Overview

A preliminary site investigation of Hudson River water and sediments adjacent to Ciba-Geigy's main plant near Glens Falls, New York was conducted in 1987. Water and sediment samples were collected from the Hudson River. Analysis of these sediment samples detected the presence of several metal and organic compounds. These samples were obtained from sites at which drainage and/or other indications of waste were visible. Due to the non-random sampling design, a consequence of the preliminary nature of that investigation, the extent and magnitude of any potential off-site migration of these compounds could not be precisely quantified.

Ciba-Geigy recognized that if off-site migration of these compounds was occurring, a potential pathway for these compounds to enter the Hudson River ecosystem existed. The fish community adjacent to the plant was identified as being the major biotic component of the river for concern. Aquatec was requested to investigate whether fish populations may be impacted by off-site migration, if any such migration is occurring.

Two hypotheses were examined to assess the effect of potential off-site migrations on the fish population of the Hudson River. The first hypothesis was that if an off-site migration of compounds was occurring in sufficient levels, a measurable adverse effect on the fish population in the region adjacent to the plant would be apparent. This adverse population effect may be expressed as the absence of desirable species, reduced growth, lack of reproductive success, or poorer fish condition.

The second hypothesis was that if compounds were not at sufficient levels to produce a measurable effect on the fish population, individual fish could still be accumulating these compounds resulting, presumably, in increased fish stress and a potential pathway for human

exposure. This hypothesis was to be evaluated by measuring burdens in specific tissues of individual fish and comparison to fish not exposed to off-site migration of these compounds.

The conceptual approach to investigate both hypotheses was to study both the population effects and individual effects of body burdens. To examine the population effects, a synoptic fisheries survey was undertaken in September 1988. Standard fisheries techniques for collection and analysis of data were employed in this survey. (For a detailed discussion of fisheries methods the reader is referred to Lagler 1956, Ricker 1975, APHA 1985). Species composition, age and growth of fish, age distribution of various species, and the overall condition of the fish population were analyzed as part of this survey.

A Representative Important Species (RIS) approach was selected for evaluation of body burdens in the fish population. Two species of fish, the common carp (Cyprinus carpio Linnaeus) and the smallmouth bass (Micropterus dolomieui Lacepede) were selected to be the representative species of the fish population in the Hudson River near the plant.

The common carp was selected since it represents an ideal species for general environmental assessment. Being an omnivorous species, feeding on both plant and detrital material, the carp is a good representative for both the herbivore and omnivore trophic feeding component of the target fish population. Its benthic feeding habits routinely places this fish in close contact with the river sediments.

The smallmouth bass represents a secondary consumer in the fish community feeding on other fish, bottom crustaceans, and invertebrates. It is a major component of the fish community near the plant and is probably the primary game species sought by fishermen in the area. The smallmouth bass is second on the New York State Department of Environmental Conservation's list of species for fish biomonitoring (Sloan 1986). Studies on the movements of smallmouth bass have found

that individuals typically remain in the nearly the same location from year to year, rarely migrating more than 0.5 miles (Scott and Crossman 1973). These considerations made these two species, common carp and smallmouth bass, the logical choice for analysis of body burden of target compounds.

To address the overall goal of the study, to determine whether any potential off-site migrations are affecting the fish community, two study objectives were established:

1. To evaluate the fish population near Ciba-Geigy for changes in species composition, general health, and age-and-growth, and whether these fish are adversely affected by potential off-site migrations.

2. To document body burdens of selected compounds in the representative important species of fish, specifically common carp and smallmouth bass.

On 20 July 1988, a preliminary electrofishing survey was conducted at the Ciba-Geigy plant site. This survey was conducted to evaluate the fish community composition for the purpose of identifying species of concern for the upcoming tissue analyses as well as determining fish community composition.

Electrofishing was conducted on 1 September 1988 to collect one carp and one smallmouth bass. These fish were collected primarily for the purpose of evaluating field methodology (capture, survey identification of capture location, and dissection of the fish to be used in the tissue analyses).

Evaluation of fish community composition near the plant was conducted by electrofishing and gill nets 19-23 September and 26-29 September. During this time, common carp and smallmouth bass conforming to the standards outlined in the work plan were kept and processed for tissue analysis.

Additional electrofishing collections were made 5-7 October, 31 October, 8 November, and 11-15 November. These collections were expressly for the purpose of obtaining common carp and smallmouth bass

for tissue analyses. The majority of these collections were conducted for smallmouth bass at the upstream control site. Despite the additional collection effort, the target of five smallmouth bass could not be obtained from the Hudson River at this site.

The description of the topography of the Hudson River was important for precisely locating fish collected for analysis. A bathymetry survey was made 8-9 November 1988.

1.2 Study Area

The Ciba-Geigy plant in Glens Falls, New York is located along the Hudson River. Two study regions were established in the river for the purposes of this investigation (Figure 1.1). A series of dams in the Hudson serve to define the boundaries of the regions, and also serve to separate the fish populations occurring in the river.

The region adjacent to the Ciba-Geigy plant site, a region in which any potential off-site migration of target compounds might occur, was bounded downstream by the Bakers Falls Dam (river mile 198, dam height 23 feet, data obtained from the New York Office of Dam Safety) and bounded upstream by the Finch, Pruyn and Company Dam (river mile 200, dam height 9 feet above bedrock) in Glens Falls. Logistically, the actual study area within this region was determined by boat accessibility. A breached dam, located approximately 1 mile upstream of the Baker Falls facility, prevented boat movement downstream of the breach; while an area of rapids and shallow water about 500 feet upstream of Ciba-Geigy's boundary prevented upstream sampling past this point. Fish encountered within the study area defined by boat accessibility would likely be capable of moving within the entire region.

For purposes of comparison, a second region and second population of fish was defined within the area extending from the Finch, Pruyn and Company Dam to the Feeder Dam (river mile 202, dam height 36 feet). The Finch, Pruyn and Company Dam was expected to serve as a

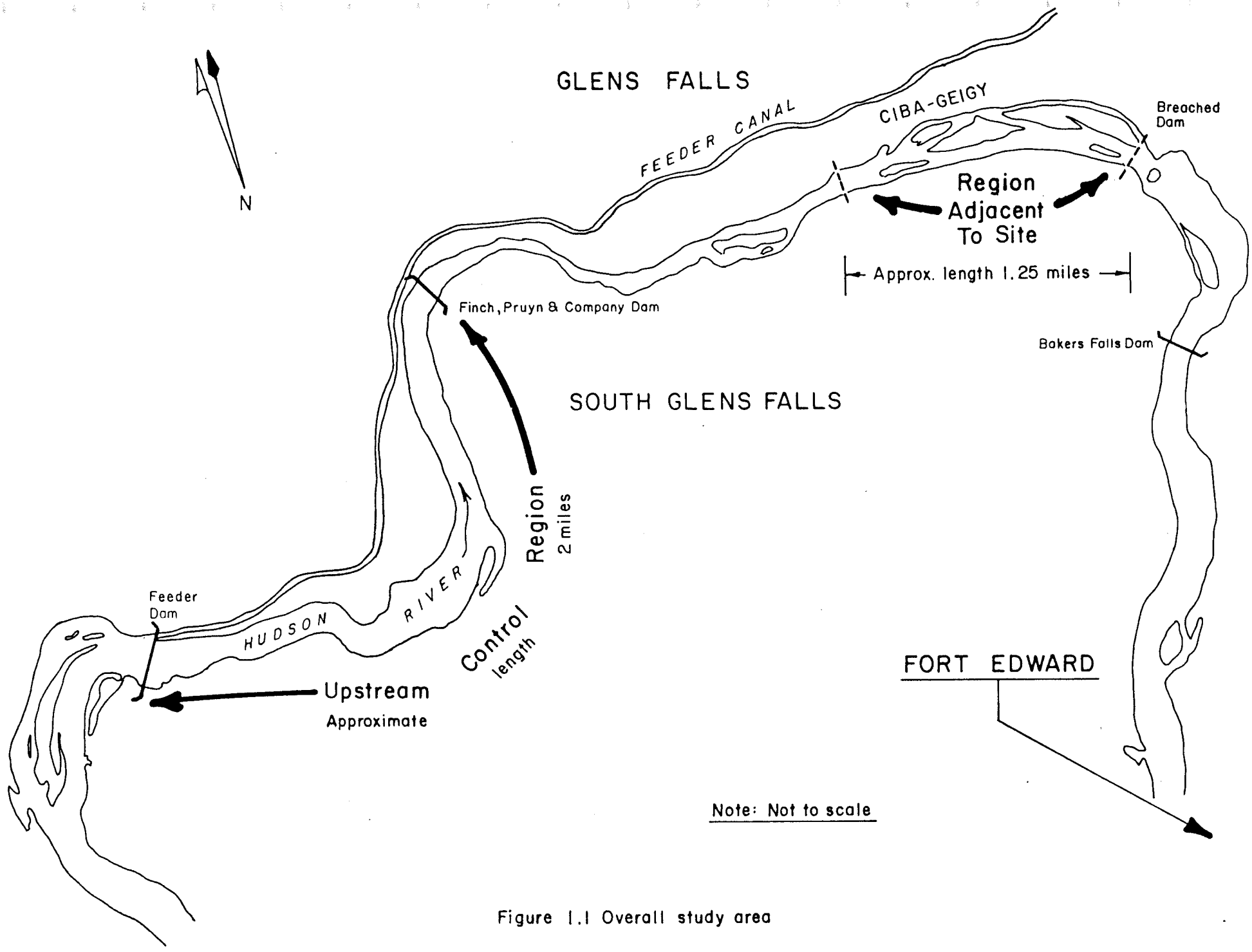

Figure 1.1 Overall study area

barrier between the fish populations of the two regions. As a result of this barrier to upstream travel, fish exposed to potential off-site migration of target compounds near Ciba-Geigy should not be found in the upstream region. These upstream fish could then serve as indicators of background conditions in the Hudson River, or control samples, with respect to the target compound body burdens.

The Hudson River adjacent to the plant is an unimpounded stretch ("run-of-the-river") and not affected by the downstream dam. The study site adjacent to the Ciba-Geigy plant included a diverse variety of habitats. There were numerous islands, large and small, in the river. Many of these were rock cribs remaining from earlier periods of timber industry on the Hudson River. A number of channels were formed by these islands, generally of shallow depth.

River depth near the Ciba-Geigy plant does fluctuate daily due to operation of dams upstream of Ciba-Geigy. During this study, we have measured fluctuations. Differences as large as two feet were noted in river height over a 10 hour period, based upon staff gauge measurements, but daily fluctuations of 6 to 10 inches were more typical.

The control region was also affected by dam operation, but actual river heights were not measured. This portion of the river was more open than the study area, with fewer islands. Rock cribs similar to those in the study area were present, but generally were submerged 3 to 4 feet below the surface. In general, the river in the control area was broader and appeared to have slower flow than the study region. Vegetation occurred in the setback areas while other locations were rocky or sand/silt substrate.

1.3 Previous Fish Studies

Through contacts with New York Department of Environmental Conservation (NYDEC), data on fishes present adjacent to the Ciba-Geigy site were obtained. These data indicate that the population contains white suckers, sunfishes, yellow bullhead, smallmouth bass, and rock

bass. The size ranges of these species suggest some of these fish were mature and probably sexually developed. In a memorandum dated 22 September 1987, NYDEC fisheries biologists described this stretch of the river as quality habitat for smallmouth bass.

The Hudson River adjacent to the site is classified to meet New York State category "D" water quality standards, the defined usage of the water body is for fishing only. Although the river from Fort Edwards to Troy is closed to fishing and fish consumption, no such ban exists upstream in the Glens Falls region of the Hudson River (Saltsman, personal communication). Fishing does occur in this area, but is limited by the accessibility for anglers.

A preliminary electrofishing study of the fishes adjacent to the site was conducted on 20 July 1988. Juveniles and adults of nine fish species were observed. From these data, the community can be categorized as a predominately bass and sunfish fishery.

2.0 Methods

2.1 River Topography

Several maps of the topography of the area and topography of the river were required to provide locational control and interpretation of the fisheries data. A map of the Ciba-Geigy site depicting ground surface elevations, produced by Rist-Frost Associates, scale 1 inch equals 60 feet, dated 30 April 1981, revision 6, was available for land topographic features. This map was prepared using stereo photogrammetric methods based on aerial photography flown on 4 March 1981 and ground control. An arbitrary grid established for horizontal and vertical control was referenced to the National Geodetic Datum of 1929 that determined a datum of mean sea level (MSL), and had a contour interval of 2 feet. The southern boundary of the map was at the water's edge of the Hudson River. For the purpose of this study, the map needed to be augmented to include bathymetry of the Hudson River adjacent to the site and to encompass the southern shoreline, numerous rock cribs, and natural islands.

Several standard land survey (theodolite, alidade, plane table) and bathymetric techniques were used to obtain a map of river bottom elevations. Labeled bench marks (iron rods) were set along the northern bank of the river and at islands in the river. The location and elevation of these bench marks were surveyed by Vermont Survey Consultants, Inc. (VSC), a New York registered surveying firm. VSC also defined shorelines and islands. Several shoreline areas were hand-drawn because these areas could not be surveyed from the control points.

Bathymetric data were collected using an acoustic sounding device (Raytheon DE719-B Fathometer), a compass, and a "Walktax" distance meter. One end of the meter line was tied to a known point onshore and the "Walktax" unit was placed on the boat. The boat then transversed the river on a known bearing while bathymetry data were recorded on a strip chart. A surveyor onshore radioed instructions to the boat operator so that a straight line could be maintained. The chart was marked at horizontal distances obtained from the "Walktax" unit.

Using this procedure a continuous trace of water depths was obtained. River water elevation was measured by standard survey level techniques before each of the 22 transects was surveyed. The fathometer strip chart and water surface data were used to plot water depths along each transect on the base map containing the outline of the river banks and islands. These data were contoured at 2 foot intervals.

Bathymetry of the Hudson River adjacent to the Ciba-Geigy site is depicted in Figure 2.1. Horizontal and vertical control points are labeled A through N, P through R, 100, 101, 103, 103A, 105, 120, and 121. Typical river water elevation in the summer was about 210 feet MSL, therefore, the dotted lines displaying elevations were usually underwater. These dotted lines are at an interval of 2 feet. Solid contoured lines, at 5 foot intervals, were traced from the map of the site prepared by Rist-Frost Associates.

2.2 Fish

2.2.1 Field Methodology

Fish studies in the control region focused on collection of common carp and smallmouth bass for tissue analysis in order to determine "background" conditions in the Hudson River near Glens Falls. A survey of the entire fish population in this region was not conducted. This region is an impounded region of the river, while the Hudson River near Ciba-Geigy is a run-of-the-river stretch.

In the region adjacent to Ciba-Geigy (downstream region) common carp and smallmouth bass were also collected for tissue analysis. A synoptic survey also was conducted on late summer fish population. The downstream region was partitioned into eight stations for logistical considerations (Figure 2.2). Since the fish in this region do move around to some degree, a discussion of fish population statistics was presented for the fish community of the region in addition to individual station data.

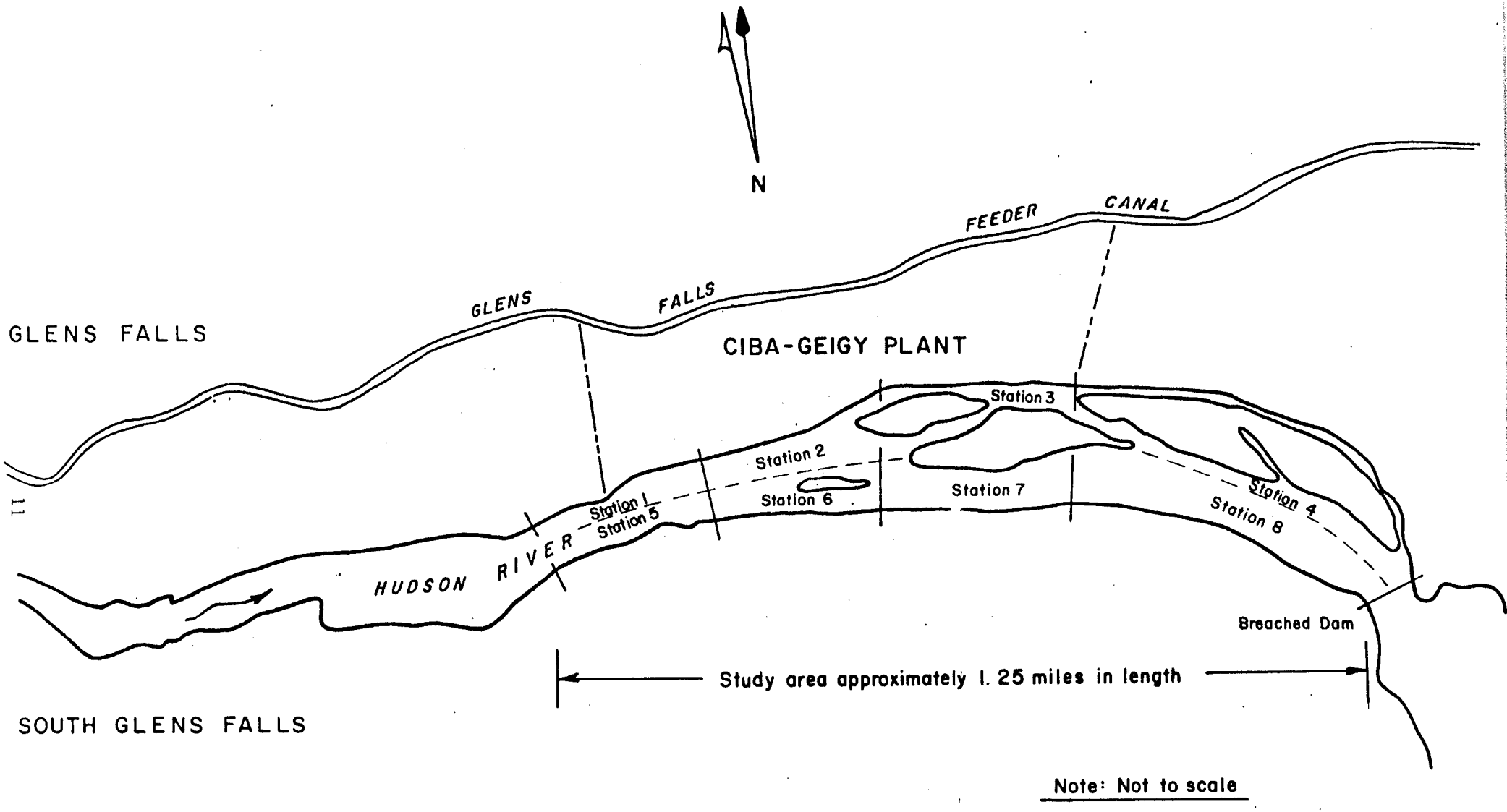

Figure 2.2 Fish species composition sampling stations

Fish collections were conducted in accordance with the New York Department of Environmental Conservation's scientific collection permit issued to conduct these studies (Permit No. SCL88-250.). Two methods of fish collection, electrofishing and gill netting, were used to sample different species and sizes of fish systematically, in an effort to obtain a more representative sample of the population. Electrofishing was conducted at night, since this is the time fish are typically in shallower waters and most vulnerable to electrofishing methods.

Electrofishing was conducted using a boat-mounted Coffelt Electronics Model VVP-15 electroshocker. The minimum electrofishing effort at each station was 20 minutes. Additional electrofishing collections were made at several stations both at night and during the day to obtain bass and carp for tissue analysis. Electrofishing sampling effort was measured with a stopwatch to the nearest minute to provide catch per unit effort (CPE) data on each station and the region as a whole. Fish were placed in a live-well, processed immediately after the station was completed and generally released alive to the river. Notable exceptions to release of fish were the common carp and smallmouth bass used for tissue analysis (see Section 2.2.3 below).

At each of the eight stations experimental gill nets were set. An experimental gill net differs from a standard gill net (see APHA 1985) in that the experiment gill net consists of a number of panels, with each panel containing a mesh opening size that differs from the remaining panels. The standard gill net consists of one longer panel of the same mesh size. The experimental gill nets used were three-inch experimental gill nets, 125 feet long with 25 foot panels of 1/2 inch, 1 inch, 1-1/2 inch, 2 inch and 3 inch box mesh and 2-1/2-inch experimental gill nets (1/2, 1, 1-1/2, 2, 2-1/2 inch box mesh panels). Two experimental gill nets were set at each station for a nominal 24-hour period. Prior to retrieval of an experimental gill net, a label buoy attached to an anchor was placed at the downstream location of the

net. These buoys were then surveyed into the existing grid system to record the precise location of the downstream end of the experimental gill net.

At both the upstream and downstream regions, additional experimental and standard gill nets were set and checked daily in an effort to obtain common carp and smallmouth bass for tissue analysis. The standard gill nets included both 3 inch and 4 inch box mesh nets, 100 to 200 feet in length. Since this effort was not successful in providing target fish, these nets were not surveyed into the grid system nor were these data used for species population analyses.

Individual fish were weighed, measured and examined for parasites and abnormalities. Fish captured in large batches, however, were not examined for parasites and abnormalities individually in order to speed their return to the river. Representative scales, obtained from below the lateral line were collected from smallmouth bass, rock bass, and redbreast sunfish. Scales were placed in labeled coin envelopes and transported to the laboratory for processing.

Two varieties of common carp were encountered in the Hudson River; scaled and mirror carp. The scaled carp is a fully scaled variety, the mirror carp contains few scales with large areas devoid of scales. Carp scales and dorsal fin spines were obtained for aging. Scales were typically obtained from below the lateral line, except on mirror carp where they were collected from wherever they occurred. Dorsal spines were obtained by excision after tissue sampling was completed. Scales and spines were placed in separately labeled coin envelopes and transported back to the laboratory.

2.2.2 Fish Population Analyses

2.2.2.1 Species Composition

Fish data collected by electrofishing and experimental gill nets were used to determine the species composition of the fish community in the sampled downstream region. Community composition was expressed as a percentage for each species of weight and number of individuals.

An estimate of relative density expressed as catch per unit effort (CPE) was also computed for total number of fish and individually for smallmouth bass from the downstream region. These CPE's were calculated by:

$$CPE = \frac{N}{E} \quad (1)$$

where;

CPE = The catch per unit effort;

N = Number of individuals;

E = Fishing effort (minutes).

2.2.2.2 Age-Growth

Scale and spine samples were received and logged in by the laboratory in accordance with Aquatec's Standard Operating Procedures (SOP). Impressions of scales from smallmouth bass, redbreast sunfish, and rock bass were made with acetate slides and a press. These scale impressions were projected with an Eberbach scale projector onto a rear-projection digitizing pad (Digipad-5, GTCO, Inc.) for analysis. Each annulus, or age ring, was measured from the center of the scale with the digitizer and the data on each annulus measurement transmitted electronically to a 1022 (Software House, Inc.) database. These data were used to examine size distribution at age for the various species and for back-calculation of length at each annulus. Each annulus was assumed to represent one year of age. Each fish analyzed was assumed to be the same age as the number of annuli present.

Comparison of the number of scale annuli with spine annuli of the same carp indicated that scale age determinations were consistently less than spine age determinations. Many scales also showed large areas of discontinuous patterns of circuli deposition, which suggested that scales may be a poor indicator of age in this species. For these reasons, only spine annuli enumerations were used in this report.

Scales from carp were mounted on glass microscope slides and examined using a compound microscope. Carp dorsal spines were cleaned by soaking in hot water for several minutes and then scraping the tissue from the spine with a scalpel. A section of the spine, about 200 microns (um) thick, was cut from the spine with a low speed bone saw (Buhler Isomet Model #11-1180). These sections were semi-permanently mounted on glass microscope slides with a thermoplastic, crystalbond (Aremco Products, Inc.), examined with a compound microscope and annuli enumerated. A photomicrograph of a sectioned carp spine is presented in Figure 2.3.

The length of fish at capture for the more important, numerically, species (common carp, smallmouth bass, rock bass and redbreast sunfish) were plotted to provide graphical representation of individual annual species growth. The scale data for the three species of sunfish (smallmouth bass, rock bass and redbreast sunfish) were used to determine back-calculated lengths.

Back-calculation is a technique used to estimate the size of a captured fish at each preceding annulus or year of age. For example, back-calculation of five annulus fish can be used to estimate the size of the fish at the 1st, 2nd, 3rd, 4th, and 5th annulus. Thus, one fish provides information not only on present conditions but also on previous years of its life. This method standardizes size at annulus from which comparisons among different aged fish can be made.

Length at each annulus was back-calculated using the Dahl-Lea equation (Ricker 1975):

$$L_i = a + \frac{S_i}{S_c} (L_c - a) \qquad (2)$$

where;

L_i = Calculated length at annulus i (mm);

a = Regression coefficient which was species specific (Carlander 1982);

A. 8 Magnification

B. 20 Magnification

Figure 2.3 Prepared cross-section of a dorsal spine obtained from a common carp captured near Ciba-Geigy, Glens Falls, New York, 1988.

Smallmouth bass a = 35
Redbreast sunfish a = 0
Rock bass a = 25

S_i = Digitized scale distance from the scale center to the ith annulus;

S_c = Digitized scale distance from the scale center to the outside border; and

L_c = Length at capture (mm).

2.2.2.3 Fish Condition

Condition factors are used to describe the "condition" or "well-being" of a fish species and are based upon the hypothesis that the heavier fish of a given length are in better condition (Bagenal and Tesch 1978). A calculated condition factor is influenced by the fish species, sex of fish and season.

Condition factors were calculated by:

$$K = (WL^{-3})10^5 \quad (3)$$

where;

K = Condition factor;

W = Fish weight (grams);

L = Fish length (mm).

Condition factors for three species of fish were calculated. These values were compared with average condition factors for the species from other bodies of water. Data gathered describing parasite burdens or abnormalities were tabulated. Parasites were numerically quantified when feasible. Infestations of black spot and white grub were described as light, medium or heavy. Abnormalities and other observations concerning general health were recorded.

2.2.3 Fish Body Burden

2.2.3.1 Processing

Smallmouth bass that were larger than 10 inches (254 mm) and all common carp obtained during field sampling were retained for tissue analysis. When one of these fish was captured, the boat was stopped and a buoy, labeled with the fish collection number, attached to an anchor was placed overboard to mark the capture location of the fish. These buoys were then surveyed into the existing grid system to record their precise capture location. Bass and common carp destined for tissue analysis were killed with a sharp blow to the head, labeled, wrapped in aluminum foil and placed in a cooler. The labeling included inserting a 100 percent rag catalog card tag containing collection number/fish number, station and date into the opercular cavity and an external label written on the aluminum foil. The fish were kept cold on ice (not frozen) until processing.

Fish captured for metals and organic analyses were wrapped in aluminum foil and stored on ice until dissected. Dissection was typically conducted within 10 hours of capture. Any cooler containing fish for dissection was sealed with chain-of-custody seals. Each fish was processed individually on a clean plate glass surface. Gloves were worn by dissecting personnel during the processing.

In the common carp, two tissues were selected for analysis; a skinless fillet of flesh and the liver. Dissection commenced on the left side for flesh for the metals analyses. Right side flesh was reserved for organics analyses. The liver of carp is actually an organ which contains cells that are hepatic (liver) in function and diffuse cells which are pancreatic in function. Histologically, this organ can also be referred to as a hepatopancreas but the term, liver, will be used throughout this report since it is a more familiar description.

For smallmouth bass, flesh was selected as the tissue to be analyzed. A skinless fillet was obtained from each fish, similar to those obtained by McMurty et al. (1989). The same conventions used for dissection of the carp were followed for the smallmouth bass.

Teflon-coated stainless steel microtome blades were used to remove skin and tissue. A minimum of 100 grams was obtained whenever possible. Livers were removed from the carp after the flesh had been removed. During the dissection, the sex of the fish was determined and dorsal spines removed from the carp.

Fish flesh and liver analytical samples were placed in certified clean I-CHEM bottles. Bottles were labeled with date, collection number, fish number and the type of tissue. All bottles were sealed with a chain-of-custody seal and placed on ice. Individual coolers used to transport the samples were also sealed with a chain-of-custody label. Bottles were transported on ice to the laboratory where they were logged in and kept frozen at -18°C. Processing data were reviewed in the field and in the laboratory before submittal for data entry.

Duplicate samples, which are defined as a second sample obtained from the target tissue (liver or flesh) during dissection of individual fish, were obtained to provide quality assurance of the field and laboratory sampling program. Ten percent of all samples were submitted in duplicate, which resulted in three flesh and three liver duplicate samples from carp and two duplicate smallmouth bass samples. These duplicate samples were obtained by taking the tissue dissected and randomly dividing it into two certified I-CHEM bottles, one labeled as the sample and one as the duplicate. All duplicates were treated as samples described above. These data provided a measure of sampling and laboratory precision.

2.2.3.2 Analytical Chemistry

Organic and inorganic constituents were determined in fish flesh and liver samples. The specific atomic and molecular compounds measured are listed with their project reporting limits in Table 2.1. These parameters were chosen since they were identified as the chemicals of concern for the site.

Table 2.1 Analytical parameters with reporting limits for fish tissue collected near Ciba-Geigy, Glens Falls, New York, 1988.

Class	Method*	Parameter	Reporting Lower Limit (mg/kg wet weight)
Inorganic	ICPAES	Cadmium	0.2
	ICPAES	Chromium	0.4
	ICPAES	Lead	2.0
	CVAAS	Mercury	0.1
	ICPAES	Nickel	0.8
	ICPAES	Strontium	0.2
	ICPAES	Vanadium	0.4
Organic	SIM	1,2-Dichlorobenzene	0.2
	SIM	1,4-Dichlorobenzene	0.2
	ITD	3,3'-Dichlorobenzidine	0.8
	SIM	Hexachlorobenzene	0.2
	ITD	2-Nitroaniline	0.4
	ITD	4-Nitroaniline	0.4
	ITD	Nitrobenzene	0.4

* ICPAES - Inductively Coupled Plasma Atomic Emission Spectrometry
CVAAS - Cold Vapor Atomic Absorption Spectrometry
SIM - Single Ion Monitor
ITD - Ion Trap Detector

Trace level determinations in biotic materials require specialized methodology dependent on the parameters chosen. Each parameter was evaluated with respect to its project reporting limit and analytical complexity. Methods were then chosen or developed to minimize potential interferences and meet these project reporting limits.

Laboratory quality assurance/quality control (QA/QC) analyses were conducted to assess the accuracy and precision of the analytical results. These analyses were in the form of matrix spike and replicate determinations on selected tissue samples. A replicate analysis is defined as a second analysis of the same sample received by the laboratory for chemistry. If volume for an individual sample was too small for replicate analysis, a second sample from the same fish was used as a replicate. If a sample is considered homogeneous then a replicate analysis is, in effect, a measure of laboratory precision. (For comparison with duplicate samples, see definition in Section 2.3.1). A matrix spike is a quality assurance sample where an aliquot of a sample is injected with known concentration(s) of the target analytical compounds. The replicate and spike sample preparations are conducted in the laboratory by the analytical chemist.

Metals

Analysis of inorganic metallic constituents in fish flesh samples was accomplished by atomic emission and atomic absorption techniques. The metals cadmium, chromium, lead, nickel, strontium and vanadium were determined by Inductively Coupled Plasma Atomic Emission Spectrometry (ICPAES) using an argon plasma and a sequential scanning monochromator detection system. Mercury was measured by Cold Vapor Atomic Absorption Spectrometry (CVAAS).

Sample preparation for ICPAES analysis consisted of an initial 16 hour cold digestion of fish tissue samples in concentrated nitric acid. The digestion of the tissue was followed by vigorous heating

and the addition of perchloric acid to oxidize the large amount of reduced carbon-containing molecules in the acid solution to carbon dioxide. Final digestates were prepared by filtration with a 0.45 micron filter and diluted to a known volume.

Fish flesh samples for mercury analysis were digested in cold nitric and sulfuric acids for 24 hours. Then, to remove potentially interfering organic materials, hydrogen peroxide and potassium permanganate were added. Final digestates were prepared by filtration and diluted to a known volume.

Instrumental determinations were made following EPA approved procedures, Methods 6010 and 7471 for ICPAES and CVAAS respectively (EPA 1986).

A pre-digestion metals spike was used for evaluation of recovery efficiency of analytical methods used. The metals (cadmium, chromium, lead, nickel, strontium, and vanadium) were spiked at 50 micrograms each, equivalent to a concentration in fish flesh of 10 mg/kg, which was added to the flesh prior to digestion (Figure 2.4). Mercury was spiked at 0.1 micrograms, which corresponds to an equivalent concentration of 0.2 mg/kg in the fish tissue. The spiking levels were at two times the project reporting limits and were chosen in anticipation of lower concentrations of target compounds in fish tissue. By spiking at levels near the project reporting limits, more information regarding the precision of the method in the reported detection range is documented.

A survey of the spike recovery values in Table 2.2 shows excellent recovery for all parameters with the exception of mercury. An inspection of the replicate analyses shows consistent agreement between replicate determinations (Table 2.3).

Additional confirmation of mercury analytical results were conducted using New York State analytical methodology (Appendix B).

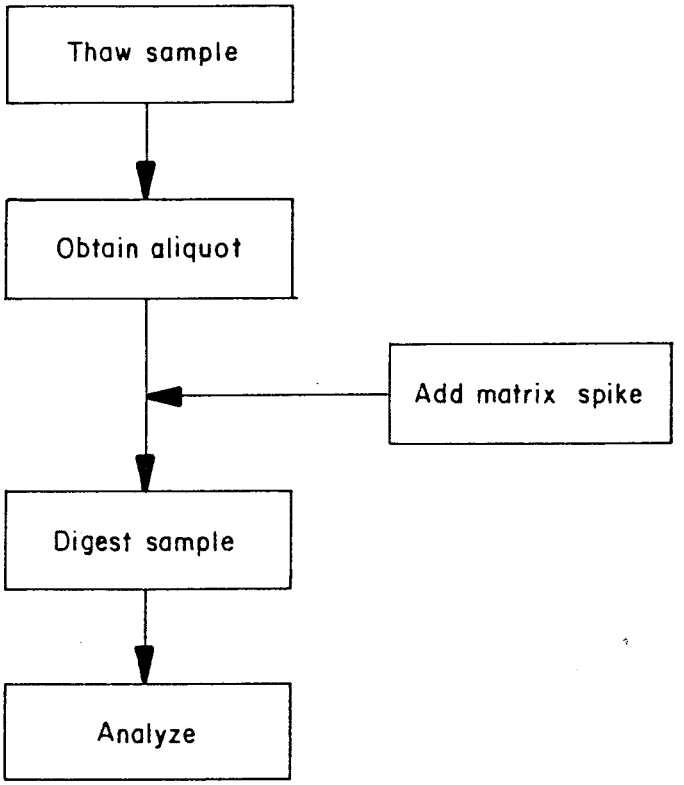

Figure 2.4 Metals tissue analysis spiking sequence.

Table 2.2 Metals matrix spike determinations for fish tissue collected near Ciba-Geigy, Glens Falls, New York, 1988. All tissues analyzed on a wet weight basis.

Lab ID	Fish Species	Tissue	Sample Type	Recovery						
				Cd	Cr	Pb	Hg	Ni	Sr	V
88678	Bass	Flesh	Matrix	97%	97%	96%	53%	99%	98%	101%
89859	Bass	Flesh	Matrix	107%	108%	102%	47%	108%	90%	104%
89987	Bass	Flesh	Matrix	92%	96%	97%	83%	95%	92%	93%
88680	Carp	Flesh	Matrix	105%	87%	84%	32%	108%	89%	109%
89865	Carp	Flesh	Matrix	104%	106%	99%	100%	103%	101%	97%
89967	Carp	Flesh	Matrix	95%	100%	94%	67%	96%	98%	99%
90498	Carp	Flesh	Matrix	104%	101%	99%	41%	102%	103%	107%
88681	Carp	Liver	Matrix	108%	98%	101%	88%	104%	96%	114%
89866	Carp	Liver	Matrix	93%	95%	92%	138%	92%	88%	93%
89968	Carp	Liver	Matrix	153%	102%	105%	89%	106%	102%	111%

Table 2.3 Metals replicate determinations for fish tissue collected near Ciba-Geigy, Glens Falls, New York, 1988. All tissues analyzed on a wet weight basis.

Lab ID	Fish Species	Tissue	Sample Type	Cd (mg/kg)	Cr (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Sr (mg/kg)	V (mg/kg)
88678	Bass	Flesh		<0.2	<0.4	<2	0.59	<0.7	<0.2	<0.4
			Replicate	<0.2	<0.4	<2	0.53	<0.7	<0.2	<0.4
89859	Bass	Flesh		<0.2	<0.4	<2	1.21	<0.8	<0.2	<0.4
			Replicate	<0.2	<0.4	<2	1.21	<0.8	<0.2	<0.4
89987	Bass	Flesh		<0.2	<0.4	<2	0.63	<0.8	<0.2	<0.4
			Replicate	<0.2	<0.4	<2	0.59	<0.8	<0.2	<0.4
88680	Carp	Flesh		<0.2	<0.4	<2	0.28	<0.7	<0.2	<0.4
			Replicate	<0.2	<0.4	<2	0.24	<0.8	<0.2	<0.4
89865	Carp	Flesh		<0.2	<0.4	<2	0.17	<0.8	0.3	<0.4
			Replicate	<0.2	<0.4	<2	0.19	<0.8	0.2	<0.4
89967	Carp	Flesh		<0.2	<0.4	<2	0.49	<0.8	<0.2	<0.4
			Replicate	<0.2	<0.4	<2	0.51	<0.8	<0.2	<0.4
90498	Carp	Flesh		<0.2	<0.4	<2	0.33	<0.8	<0.2	<0.4
			Replicate	<0.2	<0.4	<2	0.13	<0.8	<0.2	<0.4
88681	Carp	Liver		3.0	<0.4	<2	0.09	<0.8	<0.2	<0.4
			Replicate	2.2	<0.4	<2	0.07	<0.8	<0.2	<0.4
89866	Carp	Liver		2.5	<0.4	<2	<0.1	<0.8	<0.2	<0.4
			Replicate	2.4	<0.4	<2	0.08	<0.8	<0.2	<0.4
89968	Carp	Liver		12.2	0.53	<2	0.37	<0.8	<0.2	<0.4
			Replicate	15.8	0.86	<2	0.38	<0.8	<0.2	<0.4

These confirmations included the analysis of a National Bureau of Standards (NBS) reference standard (NBS RM-50) with the original U.S. Environmental Protection Agency Special Analytical Services (U.S. EPA-SAS) methodologies and duplicate analyses of the smallmouth bass flesh by the New York State methods. These analyses provided additional support and documentation of the mercury results obtained by the EPA-SAS methodology.

Organics

Organic compounds were analyzed by solvent extraction and gas chromatography/mass spectrometry (GC/MS). Because of potential interference by organic molecules in fish, the quantitative recovery and analysis of a parameter may be variable and is highly dependent upon methodologies employed. To document recovery of target compounds resulting from laboratory preparation, the following internal standards (or surrogates) were added to each individual organic analysis conducted on fish tissue:

Internal Standards

1,2-dichlorobenzene D-4
3,3'-dichlorobenzidine D-6
nitrobenzene D-5
hexachlorobenzene C(13)-6
3-nitroaniline

The first four surrogates are stable isotopes of the target analytes, while the fifth, 3-nitroaniline, is an isomer. Labeled analogs of the nitroanilines were not readily available.

Every tissue sample analyzed for organics (including replicates and duplicates) was spiked with 50 micrograms each of the surrogate compounds and their recovery was monitored for each sample. The labeled internal standards were added to the fish flesh after mincing but prior to Soxhlet extraction (Figure 2.5). The advantage of this approach is that the variability in each tissue analysis can be observed. Since the surrogate spike was at or near the reporting limit, precise statements can be made for quantitation at the reporting limit.

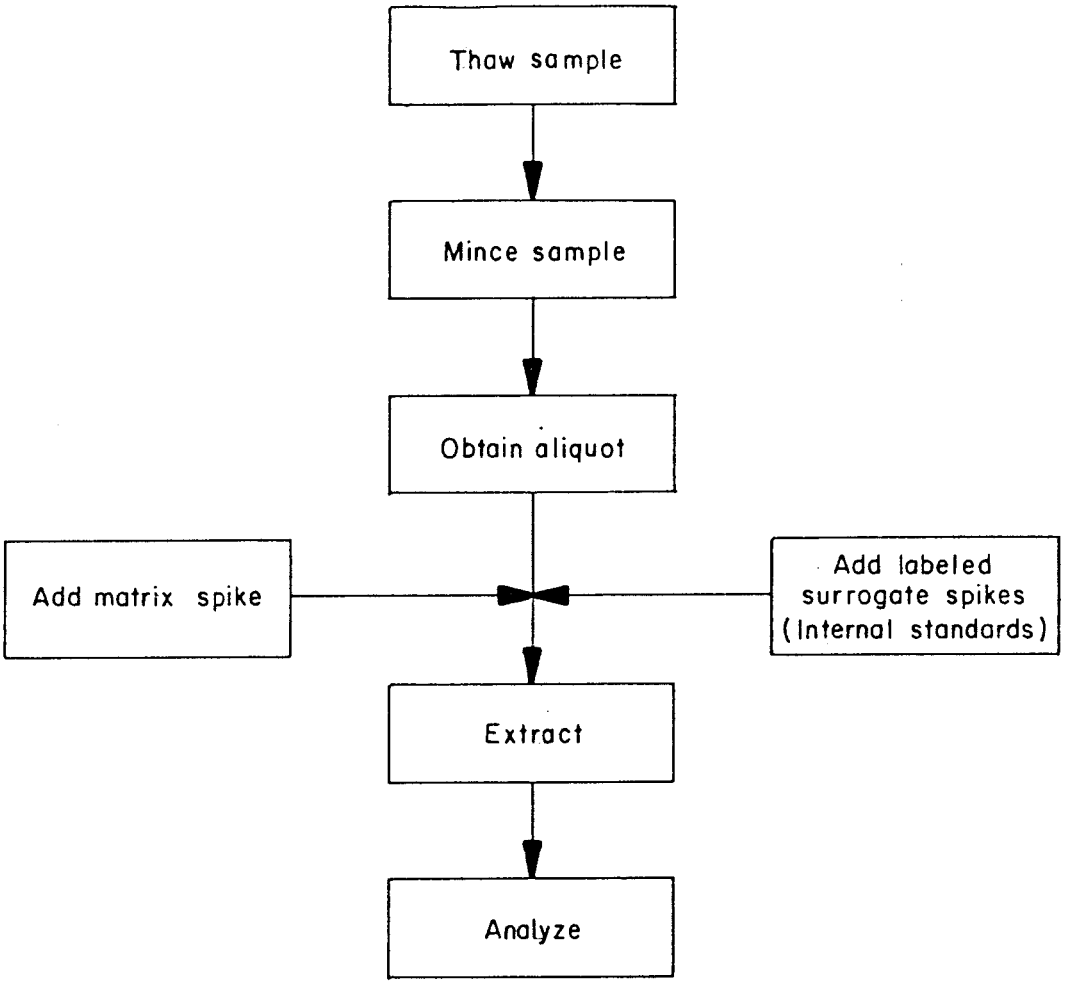

Figure 2.5 Organic tissue analysis spiking sequence.

Initially, the published Tetra-Tech semi-volatiles extraction procedure (1986) was followed and provided acceptable results. However, due to the high lipid content, particularly in the carp livers, interferences were encountered which could be diminished by a more selective extraction/clean-up procedure. The procedure takes advantage of chemical differences between the neutral and basic compounds and provides two separate cleaner extracts.

The cleaned-up extracts were then analyzed by one of two GC/MS methods. The base compounds were analyzed using an Ion Trap Detector (ITD) system. The ITD is an extremely sensitive ion cyclotron-based mass detector. The neutral compounds were analyzed by a quadrapole mass spectrometer operating in Single Ion Monitor (SIM) mode. Both detection systems were calibrated daily and the concentration of both the target analytes and the surrogates was measured in each extract.

Tables 2.4 and 2.5 contain the results of the matrix spike and replicate determinations for the organic parameters. The organic matrix spike consisted of 50 micrograms of each of the following compounds: 1,2-dichlorobenzene, 3,3'-dichlorobenzidine, hexachlorobenzene, 4-nitroaniline and nitrobenzene added to approximately 50 grams of fish tissue for an equivalent concentration of 1 mg/kg. Project reporting limits for these compounds range from one-fifth to four-fifths of the spiked concentrations. Inspection of the data shows near unit recovery for 1,2-dichlorobenzene, 3,3'-dichlorobenzidine and nitrobenzene and low but acceptable recoveries on hexachlorobenzene and 4-nitroaniline. Laboratory replication was consistent between all paired replicate comparisons.

Lipid content of fish flesh and fish liver were determined by solvent extraction and gravimetry. Nominal 50 gram aliquots of fish tissue were Soxhlet-extracted into methylene chloride and brought to a final volume. Aliquots of this extract were eluted through sodium sulfate and measured into preweighed metal dishes. Extracts were air-dried, reweighed, and percent lipids were calculated as:

Table 2.4 Organic matrix spike determinations for fish tissues collected near Ciba-Geigy, Glens Falls, New York, 1988. All tissues analyzed on a wet weight basis.

Lab ID	Species	Tissue	Sample Type	Lipids (%)	Recovery Level 1,4 DCB	3,3' DCBD	HCB	4-NA	NB
88677	Bass	Flesh	Matrix	2.0	110%	105%	46%	24%	107%
88679	Carp	Flesh	Matrix	7.2	100%	103%	36%	19%	101%
89707	Carp	Flesh	Matrix	24.3	107%	87%	57%	102%	99%
90496	Carp	Flesh	Matrix	5.1	89%	75%	67%	73%	102%
90500	Carp	Liver	Matrix	14.9	107%	106%	45%	26%	112%

DCB = dichlorobenzene
DCBD = dichlorobenzidine
HCB = hexachlorobenzene
NA = nitroaniline
NB = nitrobenzene

Table 2.5 Organic replicate determinations for fish tissues collected near Ciba-Geigy, Glens Falls, New York, 1988. Analyses are in mg/kg wet weight.

Lab ID	Species	Tissue	Sample Type	Lipids (%)	1,2 DCB	1,4 DCB	3,3' DCBD	HCB	4-NA	2-NA	NB
88677	Bass	Flesh		0.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
88679	Carp	Flesh		6.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
			Replicate	4.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
89374	Carp	Flesh		14.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
			Replicate	15.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
89708*	Carp	Flesh		24.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
89707*	Carp	Flesh	Replicate	26.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
89966	Carp	Flesh		18.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
			Replicate	14.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
90493	Carp	Flesh		1.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
			Replicate	13.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
90496	Carp	Flesh		4.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
90500	Carp	Liver		21.3	<0.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4

DCB = dichlorobenzene
DCBD = dichlorobenzidine
HCB = hexachlorobenzene
NA = nitroaniline
NB = nitrobenzene

* These samples were collected from the same fish, but placed in separate I-CHEM bottles.

$$\% \text{ Lipid} = \left(\frac{\text{Mass of Dried Extract Aliquot}}{\text{Mass of Sample}}\right)\left(\frac{\text{Volume Extract Dried}}{\text{Total Extract Volume}}\right) \times 100$$

Precision for lipid determinations was lower than that observed for other parameters. The lower replication may in fact represent variability of liver aliquots as well as laboratory precision.

2.2.3.3 Statistical Analyses

Field collection and fish identification forms were checked in the field for completeness and accuracy. They were reviewed again before submittal for data entry. Laboratory generated data were reviewed before data entry. The resulting database was reviewed by the quality control officer.

Data on analytical results of the chemical concentrations in fish tissue were examined and judged not to be of normal distribution. Many of the analytical results for target compounds were non-detectable thus suggesting that the data were less than interval scale. Since the data were not in at least an interval scale, assumptions about the values of these non-detect analyses would be required to conduct parametric tests. This assumption and the restrictive assumptions of the normal distribution indicated that parametric techniques may not be as appropriate as non-parametric methods for statistical comparison of body burdens in fish obtained from the two regions.

The Mann Whitney U test, a non-parametric technique, was used for statistical comparison of the two regions (Siegel 1956). This test was chosen since it is one of the most powerful non-parametric tests to determine whether two independent sample populations are the same. The power-efficiency of this test, which is the ability to use the test to detect significant differences when in fact there is a difference, is close to 95 percent when compared to the parametric alternative, the t-test. There are some distributions for which the U test is superior to its parametric alternative (i.e. the U test has greater power for null hypothesis rejection) (Siegel 1956).

3.0 Results

3.1 Fish Population

3.1.1 Species Composition

The analysis of the composition of fish is based upon the fish captured during electrofishing and with experimental gill nets. Fifteen species of fish representing seven families were observed near Ciba-Geigy (Table 3.1). Of the approximately 850 individuals, the sunfish (smallmouth bass, rock bass, and redbreast sunfish) predominated and collectively accounted for more than 75 percent of the total number (Table 3.2). Carp, white suckers and rock bass represented more than 80 percent of biomass collected.

The catch per unit effort (CPE) for the eight stations is presented in Table 3.3. The electrofishing CPE for smallmouth bass ranged from 5 to 72 bass per hour.

Sunfishes dominated the catch at all stations (Table 3.4). The number of fish collected at each station was relatively consistent, ranging from a low of 78 at Station 8 to 135 at Station 7.

Biomass of four stations (1, 5, 6, and 7) was predominantly carp (Table 3.5) while biomass from Stations 2, 4, and 8 consisted predominately of sunfish. Station 3, a station encompassing several slow shallow areas adjacent to Ciba-Geigy, displayed a more diverse fish community. At this station, the chain pickerel, a fish-eating species, represented nearly 20 percent of the biomass captured.

3.1.2 Age-Growth

Length of fish at capture is presented for four species, smallmouth bass, redbreast sunfish, rock bass, and carp (Figures 3.1-3.4). The length of a fish was highly correlated with age for the sunfishes.

The distribution of fish age for the sunfish species (smallmouth bass, redbreast sunfish and rock bass) indicated a multi-year class

Table 3.1 Taxonomic checklist of fish caught and released near Ciba-Geigy in Glens Falls, New York, 1988. Taxonomy from Robins (1980).

CHORDATA	
OSTEICHTHYES	
ANGUILLIFORMES	
Anguillidae	
Anguilla rostrata (Lesueur)	American eel
SALMONIFORMES	
Esocidae	
Esox niger Lesueur	chain pickerel
CYPRINIFORMES	
Cyprinidae	
Cyprinus carpio Linnaeus	common carp
Notemigonus crysoleucas (Mitchill)	golden shiner
Notropis hudsonius (Clinton)	spottail shiner
Notropis volucellus (Cope)	mimic shiner
Semotilus corporalis (Mitchill)	fallfish
Catostomidae	
Catostomus commersoni (Lacepede)	white sucker
SILURIFORMES	
Ictaluridae	
Ictalurus natalis (Lesueur)	yellow bullhead
PERCIFORMES	
Centrarchidae	
Ambloplites rupestris (Rafinesque)	rock bass
Lepomis sp.	
Lepomis auritus (Linnaeus)	redbreast sunfish
Lepomis gibbosus (Linnaeus)	pumpkinseed
Micropterus dolomieui Lacepede	smallmouth bass
Micropterus salmoides (Lacepede)	largemouth bass
Percidae	
Perca flavescens (Mitchill)	yellow perch

Table 3.2 Summary of fish caught and released near Ciba-Geigy, Glens Falls, New York, by number and weight. Control fish are not included.

Species	Number Captured	Number (%)	Total Weight (g)	Weight (%)
American eel	1	0.1	1967	0.5
Chain pickerel	8	0.9	5829	1.5
Common carp	33	3.9	266350	68.8
Fallfish	14	1.6	583	0.2
Golden shiner	4	0.5	22	0.0
Largemouth bass	7	0.8	192	0.0
Lepomis sp.	3	0.4	7	0.0
Mimic shiner	25	2.9	18	0.0
Pumpkinseed	29	3.4	1289	0.3
Redbreast sunfish	158	18.5	17172	4.4
Rock bass	294	34.4	27525	7.1
Smallmouth bass	200	23.4	21001	5.4
Spottail shiner	5	0.6	25	0.0
White sucker	30	3.5	35978	9.3
Yellow bullhead	41	4.8	8800	2.3
Yellow perch	3	0.4	292	0.1
TOTAL	855		387048	

Table 3.3 Fishing effort conducted for species composition analyses near Ciba-Geigy, Glens Falls, New York, 1988. Control fishing is not included. Catch per unit effort (CPE) is the number of fish caught per hour.

Station	Method	Number of Collections	Time (hours)	No. of Fish	CPE	No. of Small-mouth bass	CPE
Station 1	Gill nets	2	45.2	22	0.5	-	-
	Electrofishing	1	0.4	66	165.0	28	70.0
Station 2	Gill nets	3	59.9	12	0.2	-	-
	Electrofishing	1	0.6	122	203.3	35	58.3
Station 3	Gill nets	2	45.0	10	0.2	-	-
	Electrofishing	1	0.6	69	115.0	3	5.0
Station 4	Gill nets	4	81.1	9	0.1	-	-
	Electrofishing	1	0.7	96	137.1	13	18.6
Station 5	Gill nets	2	37.0	7	0.2	-	-
	Electrofishing	2	0.5	75	150.0	36	72.0
Station 6	Gill nets	2	38.6	9	0.2	-	-
	Electrofishing	1	0.4	105	262.5	25	62.5
Station 7	Gill nets	3	69.6	42	0.6	-	-
	Electrofishing	1	0.6	88	146.7	30	50.0
Station 8	Gill nets	4	79.9	8	0.1	-	-
	Electrofishing	1	0.9	70	77.8	19	21.1

Table 3.4 Summary of fish caught and released near Ciba-Geigy, Glens Falls, New York, 1988, by station.

	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8	
Species	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
American eel													1	1		
Chain pickerel					6	6	1	1					1	1		
Common carp	11	12	1	<1	3	3			10	11	2	2	6	4		
Fallfish	1	1	1	<1							10	9	2	2	1	1
Golden shiner					1	1	1	1			1	1				
Largemouth bass	4	4	1	<1	1	1	1	1								
Lepomis sp.							1	1	1	1					1	1
Mimic shiner					24	23	1	1								
Pumpkinseed					11	10	14	13			1	1			3	4
Redbreast sunfish	10	11	46	34	22	21	10	9	18	21	16	14	14	10	22	28
Rock bass	31	32	44	33	21	20	56	53	15	17	42	36	61	45	24	31
Smallmouth bass	29	30	36	27	5	5	14	13	36	42	26	22	35	26	19	24
Spottail shiner											5	4				
White sucker	5	5	1	<1	4	4	2	2	5	6	8	7	3	2	2	3
Yellow bullhead	3	3	3	2	6	6			1	1	5	4	12	9	6	8
Yellow perch	2	2	1	<1			5	5								
Total	96		134		104		106		86		116		135		78	

Table 3.5 Summary of fish caught and released near Ciba-Geigy, Glens Falls, New York, 1988, by station and weight.

	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8	
Species	wt.(g)	%	wt.(g)	%	wt.(g)	%	wt.(g)	%	wt.(g)	%	wt.(g)	%	wt.(g)	%	wt.(g)	%
American eel													1967	2		
Chain pickerel					3914	19	218	2					1697	2		
Common carp	81693	84	4178	25	6350	31			89359	86	17328	54	67441	73		
Fallfish	49	<1									377	1	84	<1	74	1
Golden shiner			10	<1	2	<1	3	<1			7	<1				
Largemouth bass	71	<1	19	<1	87	<1	15	<1								
Lepomis sp.							2	<1	3	<1					2	<1
Mimic shiner					16	<1	2	<1								
Pumpkinseed					575	3	486	4			3	<1			225	2
Redbreast sunfish	1231	1	4934	29	1676	8	1056	8	2372	2	784	2	1869	2	3251	29
Rock bass	3309	3	3340	20	1369	7	6054	46	602	1	1928	6	8861	10	2062	18
Smallmouth bass	4269	4	2403	14	469	2	2256	18	4318	4	2162	7	3364	4	1760	16
Spottail shiner											25	<1				
White sucker	5259	5	1319	8	4863	24	1711	13	7329	7	8863	28	4239	4	2395	21
Yellow bullhead	1028	1	564	3	1017	5	907	7	165	<1	640	2	2999	3	1480	13
Yellow perch	192	<1	100	1												
Total	97101		16867		20339		12710		104149		32115		92521		11249	

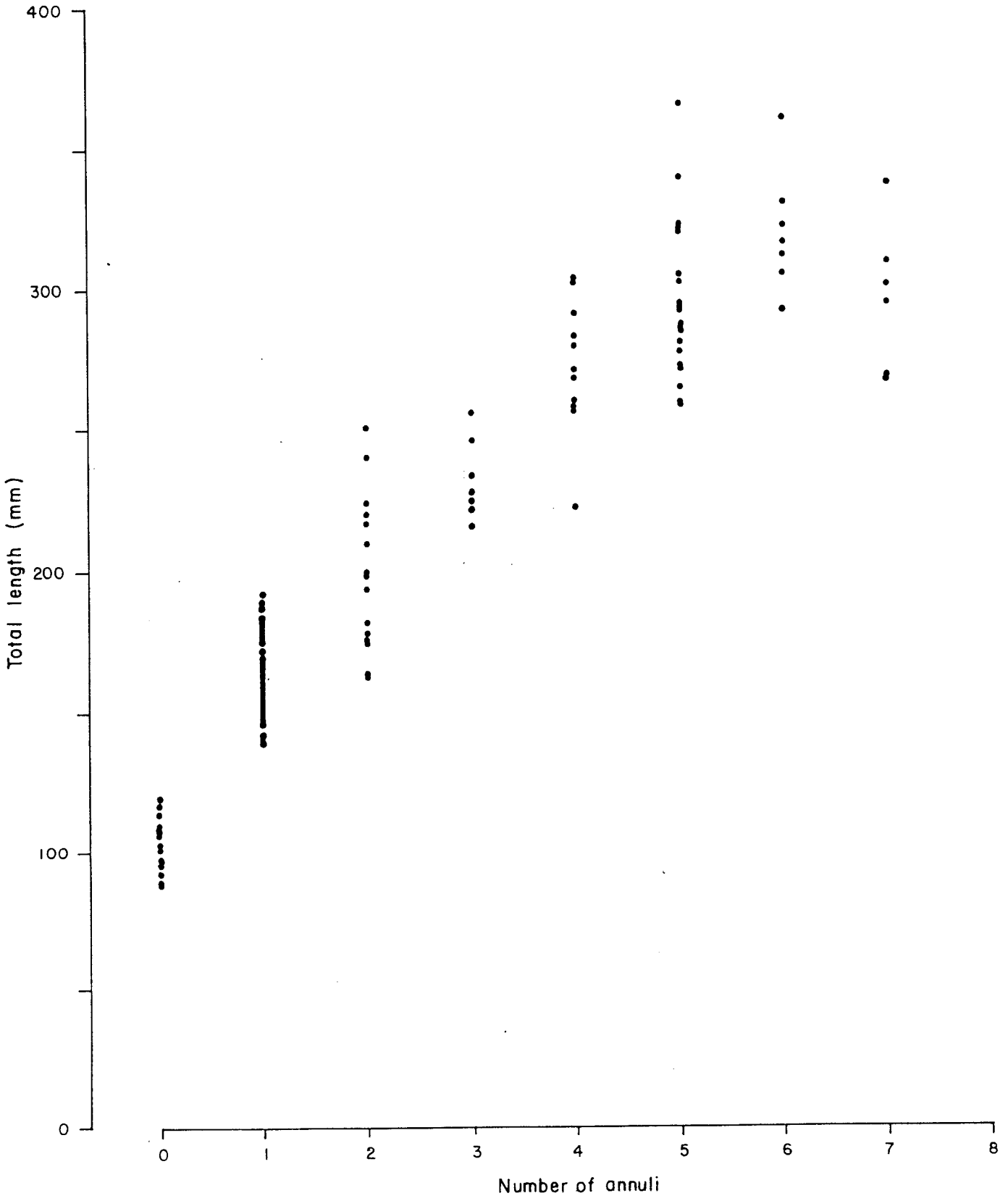

Figure 3.1 Number of annuli versus total length of smallmouth bass caught and released near Ciba-Geigy, Glens Falls, New York, 1988.

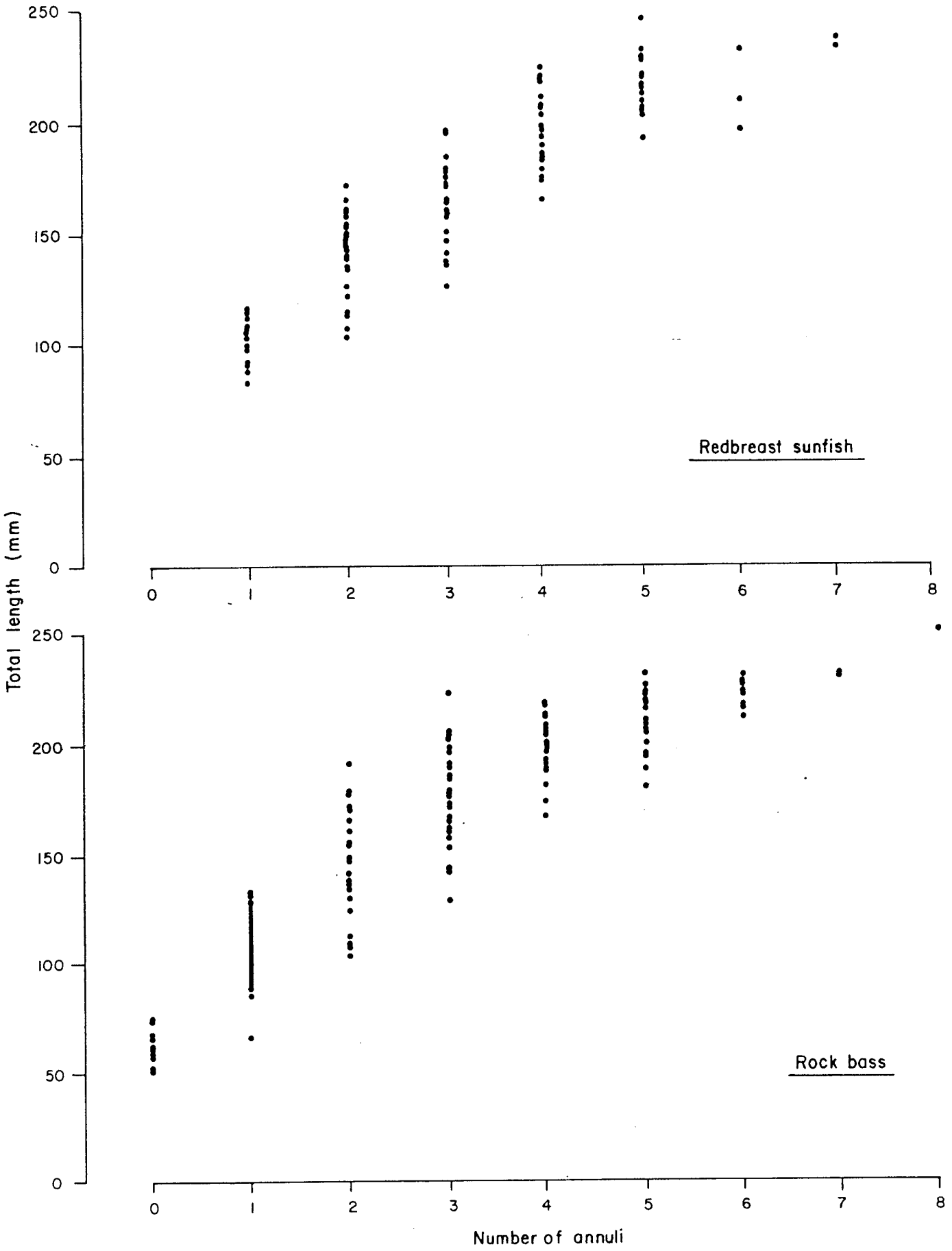

Figure 3.2 Number of annuli versus total length of redbreast sunfish and rock bass caught and released near Ciba-Geigy, Glens Falls, New York, 1988.

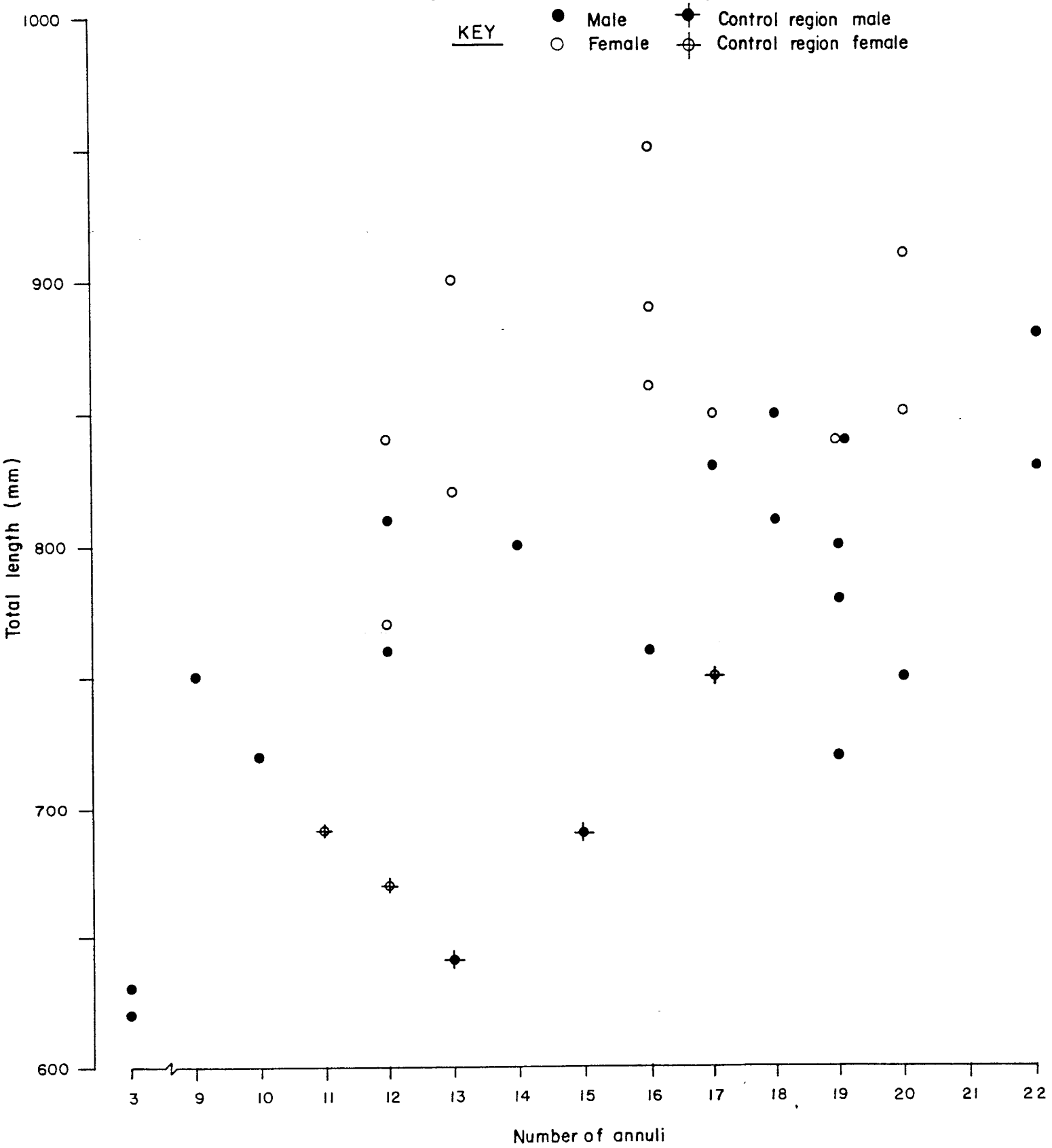

Figure 3.3 Number of annuli versus total length of common carp collected near Ciba-Geigy and the control region, Glens Falls, New York, 1988.

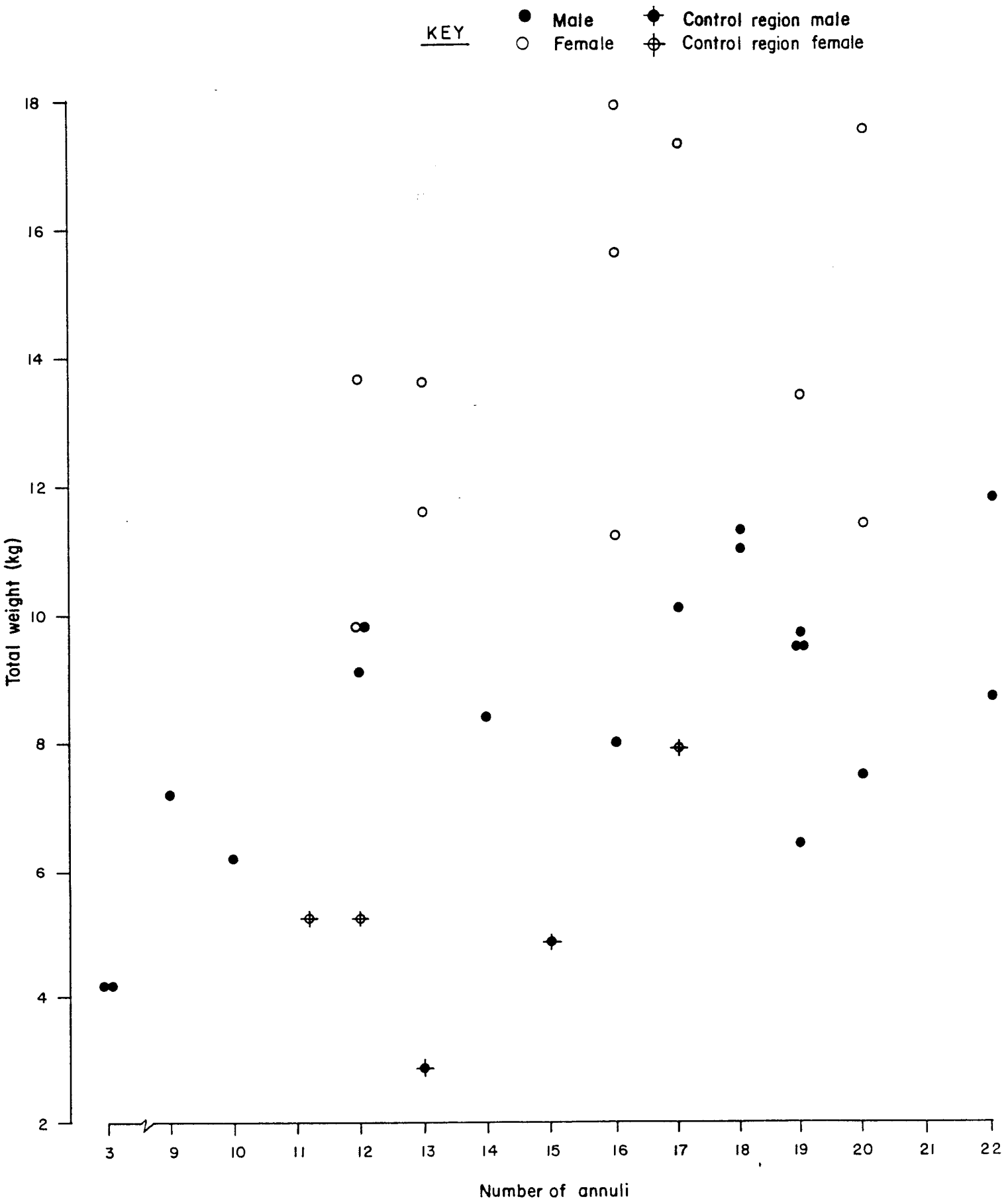

Figure 3.4 Number of annuli versus total weight of common carp collected near Ciba-Geigy and the control region, Glens Falls, New York, 1988.

population consisting of young-of-the-year fish, juveniles and adults (Figures 3.5-3.7). An 8-year old rock bass, and 7-year old smallmouth bass and redbreast sunfish were captured.

Back-calculated lengths at each annulus for the smallmouth bass, redbreast sunfish and rock bass were very consistent among the various year classes (Tables 3.6-3.8). The underlined values in Table 3.6 provide an example of the presentation of back-calculation data, underlined values are for 7^+ aged smallmouth bass captured during the 1988 study. Back-calculated ages for these smallmouth bass (7^+) are presented on a diagonal. For example, the back-calculated length at the 7^+ annulus bass was 286 mm in 1988, at 6th annulus was 271 mm in 1987 and to the first annulus was 85 mm in 1982.

The columns of these tables represent back-calculated lengths for each age group of all year classes. These lengths at age were examined for trends in annual growth over previous years. In Table 3.6, for example, the back-calculated length at age for smallmouth bass cohorts that were one year old in 1982-1988, ranges from 85-92 mm for this seven year period with no apparent increasing or decreasing trends. This suggests that annual growth in this downstream region for this species were relatively stable during the years examined.

Carp collected in the region adjacent to the plant were predominantly older fish, 3 to 22 year range (Figures 3.3 and 3.4). Two 3-year old and one 9-year old carp were the only fish captured less than 10 years of age. Age-length and age-weight relationships for carp were variable and not well correlated.

3.1.3 Fish Condition

Average condition factors for the sunfish species and carp ranged from 1.1 to nearly 2.1 (Table 3.9). The smallmouth bass average condition factor, 1.2, suggests good condition of the individual fish caught. Sample size for many of the remaining species was small, but all indications are of the generally average-above average condition of the individuals from these species. No clear trends in condition for various species were observed among the stations (Table 3.10).

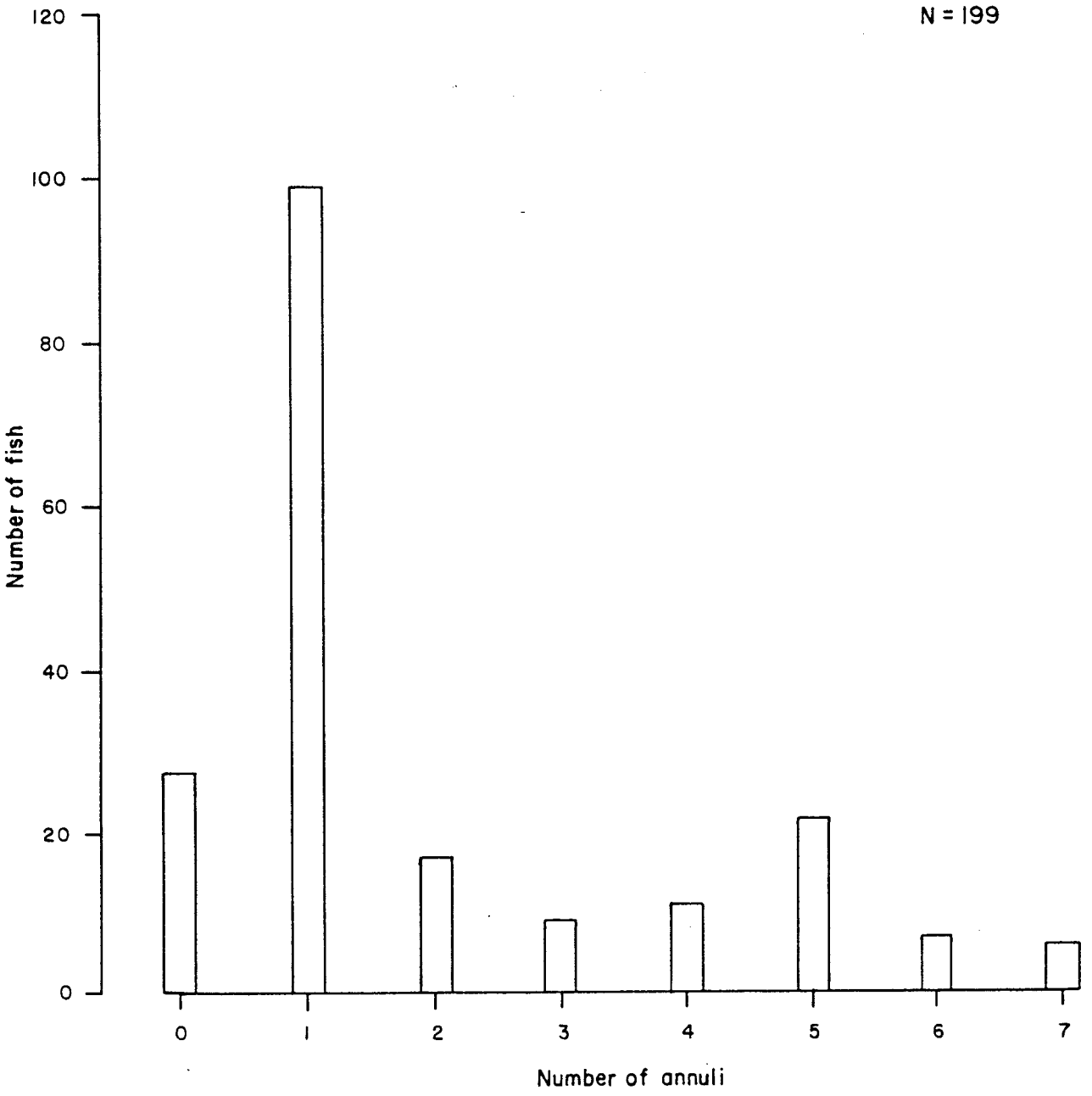

Figure 3.5 Number of annuli of smallmouth bass caught and released near Ciba-Geigy, Glens Falls, New York, 1988.

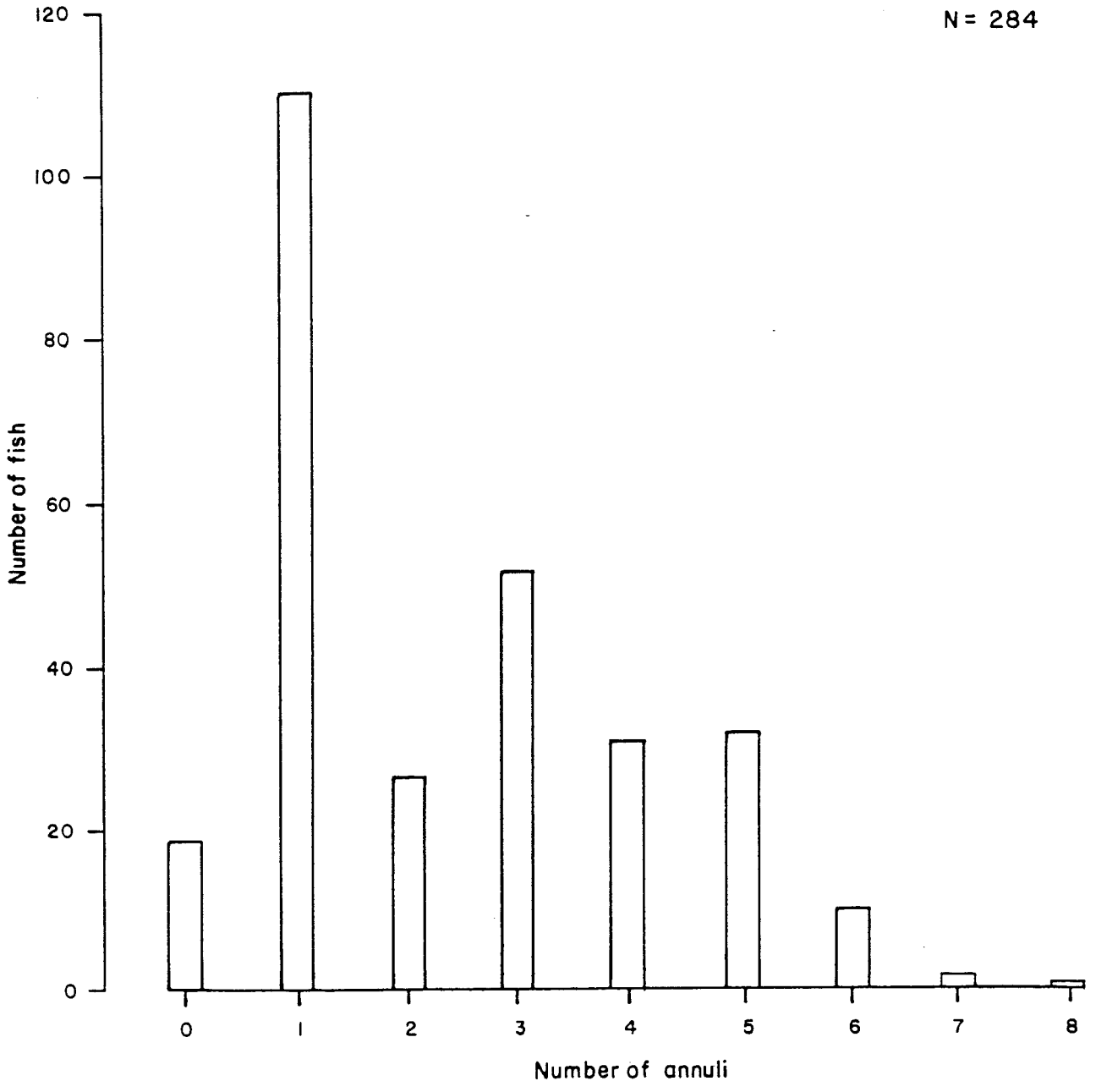

Figure 3.6 Number of annuli of rock bass caught and released near Ciba-Geigy, Glens Falls, New York, 1988.

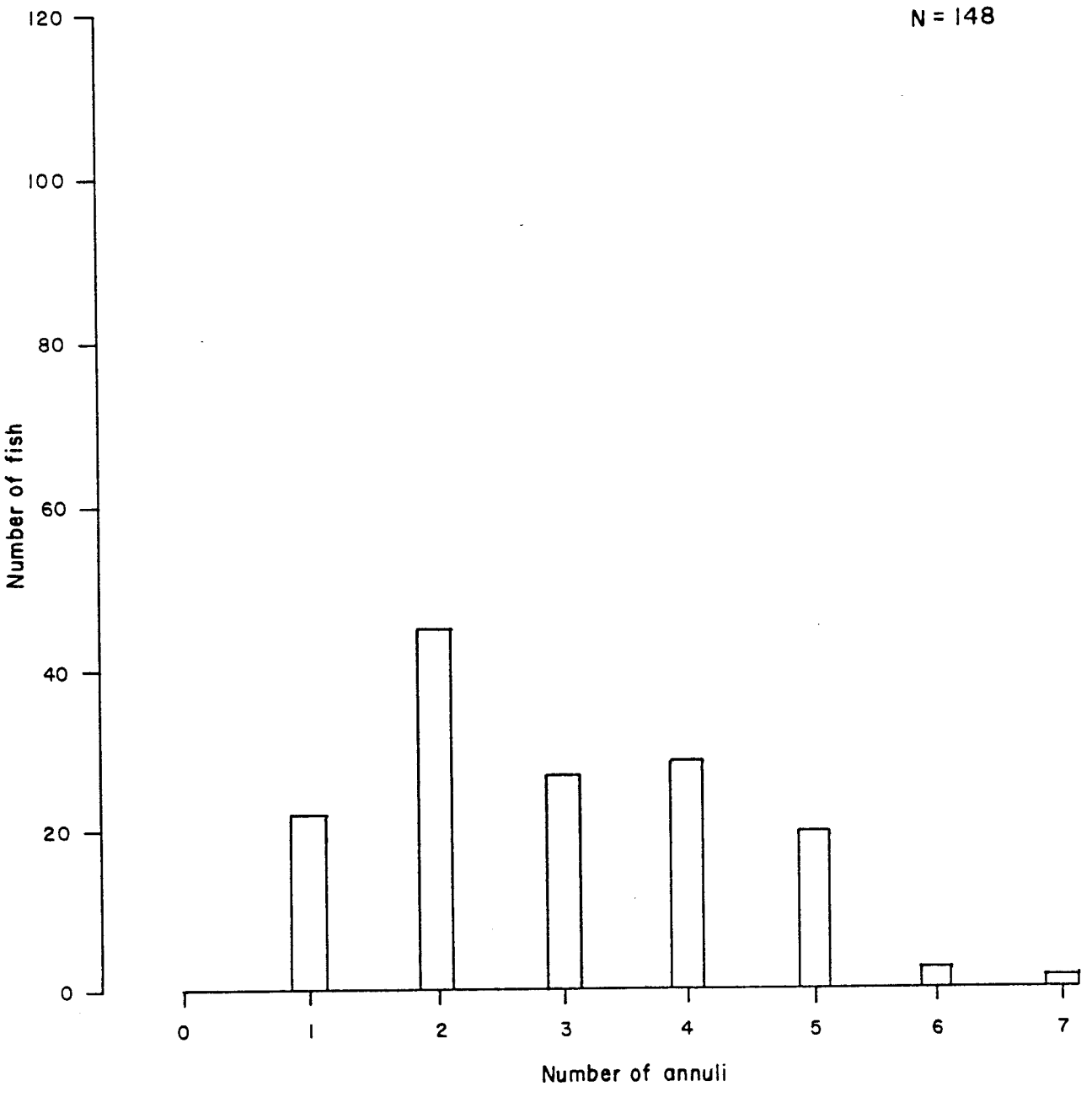

Figure 3.7 Number of annuli of redbreast sunfish caught and released near Ciba-Geigy, Glens Falls, New York, 1988.

Table 3.6 Calculated mean length at age by year for smallmouth bass caught and released near Ciba-Geigy, Glens Falls, New York, 1988. All lengths are in mm.

Year of Age	Age 1			2			3			4			5			6			7		
	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)
1982	6	85	4.8																		
1983	7	91	6.2	6	143	6.2															
1984	22	92	2.7	7	146	4.6	6	190	8.9												
1985	11	89	5.9	22	156	3.4	7	191	7.2	6	227	9.7									
1986	9	85	2.9	11	153	4.2	22	205	3.6	7	233	9.9	6	249	8.0						
1987	17	94	2.5	9	147	4.0	11	206	4.4	22	237	3.9	7	262	8.0	6	271	8.5			
1988	99	92	0.8	17	166	5.1	9	199	5.0	11	249	5.2	22	267	5.0	7	292	6.4	6	286	8.9

N = Number of fish.

X = Mean length.

SE = Standard error.

Table 3.7 Calculated mean length at age by year for redbreast sunfish caught and released near Ciba-Geigy, Glens Falls, New York, 1988. All lengths are in mm.

Year of Age	Age 1			2			3			4			5			6			7		
	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)
1982	2	35	4.2																		
1983	3	41	0.6	2	72	14.3															
1984	20	35	1.5	3	84	4.2	2	124	0.4												
1985	29	30	1.4	20	91	3.5	3	126	13.1	2	175	19.5									
1986	27	33	2.0	29	85	3.1	20	147	5.1	3	167	23.3	2	202	11.2						
1987	45	30	1.4	27	80	3.0	29	131	5.5	20	183	5.2	3	185	19.5	2	220	1.4			
1988	22	35	2.1	45	82	2.0	27	122	4.0	29	170	4.8	20	203	3.5	3	202	13.7	2	229	1.1

N = Number of fish.

X = Mean length

SE = Standard Error

Table 3.8 Calculated mean length at age by year for rock bass caught and released near Ciba-Geigy, Glens Falls, New York, 1988. All lengths are in mm.

Year of Age	Age 1			2			3			4			5			6			7			8		
	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE)	N	X	(SE
1981	1	59	0.0																					
1982	2	57	5.0	1	115	0.0																		
1983	10	60	2.9	2	109	6.6	1	157	0.0															
1984	32	58	1.2	10	101	3.9	2	160	4.6	1	203	0.0												
1985	31	54	2.1	32	102	1.9	10	142	6.4	2	193	3.8	1	222	0.0									
1986	52	54	0.8	31	101	3.4	32	149	3.4	10	175	6.2	2	207	1.1	1	232	0.0						
1987	27	54	1.3	52	97	1.7	31	141	5.0	32	176	3.3	10	197	4.2	2	216	0.0	1	237	0.0			
1988	110	57	0.5	27	99	2.8	52	143	2.0	31	179	7.1	32	196	2.6	10	209	2.9	2	223	0.7	1	244	0.0

N = Number of fish.

X = Mean length.

SE = Standard error.

Table 3.9 Condition factors (K) calculated for fish caught and released near Ciba-Geigy, Glens Falls, New York, 1988, stations 1 to 8.

Species	Total Fish Caught	Condition* Factor (K)
Common carp	26	1.9
Largemouth bass	7	1.2
Pumpkinseed	29	2.0
Redbreast sunfish	158	2.1
Rock bass	293	2.0
Smallmouth bass	196	1.2

* Condition factors between 1.0 and 2.0 reflect average condition.

Table 3.10 Condition factors (K) calculated for fish caught and released near Ciba-Geigy, Glens Falls, New York, 1988, by station.

Species	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8	
	No.	K	No.	K	No.	K	No.	K	No.	K	No.	K	No.	K	No.	K
Common carp	8	1.9	1	1.7	1	1.7			9	1.9	1	2.8	6	1.9		
Largemouth bass	4	1.1	1	1.2	1	1.5	1	1.2								
Pumpkinseed					11	2.0	14	2.0			1	1.8			3	2.4
Redbreast sunfish	10	2.0	46	2.0	22	2.1	10	2.1	18	2.3	16	1.9	14	2.1	22	2.2
Rock bass	31	2.0	44	2.0	21	2.0	56	2.1	15	2.0	42	2.0	60	2.1	24	2.0
Smallmouth bass	29	1.1	36	1.2	5	1.4	14	1.2	36	1.2	25	1.1	32	1.2	19	1.2

Based upon historical data from the Connecticut River (Aquatec 1989), and Lake Champlain (Anderson 1977), average K factors for smallmouth bass and rock bass were expected to be near 1.2-1.3 and 1.9-2.2, respectively. Although little information was available on the life history of redbreast sunfish, a reasonable average condition factor of 2.0-2.2 was assumed based on review of other similarly shaped sunfishes (pumpkinseed and bluegill). Comparison of the Hudson River data with these values from other drainages indicate average condition for the three sunfishes.

The examination of fish for parasites and external signs of disease and abnormalities revealed a relatively healthy community containing a moderately light parasite burden (Table 3.11). Fins of the fish were typically intact and in excellent condition. Incidence of fin deterioration (erosion of tissue between fin rays or reddened fins) was low (<2 percent) for species with a large sample size. Except for one fish (carp) which had a small growth on a gill, no gross abnormalities were observed. Several fish displayed hook wounds and other lesions.

Black spot was the most frequently encountered parasite during examination. Other parasites included yellow grub, identified on five species, white grub infestation of a smallmouth bass (observed in the liver and pericardium during dissection), leeches and copepods.

3.2 Body Burden

3.2.1 Data Quality

The objective of the field duplication of samples was to provide a measure of variability of the field and laboratory techniques used. High sampling variability would suggest that data interpretation may be questionable due to excessive method variability. The evaluation of duplication provides the insight into the reproducability or precision of methods employed and the validity of biological interpretation of these laboratory analyses.

Table 3.11 Parasite burden of fish caught and released near Ciba-Geigy, Glens Falls, New York, 1988.

	Abnormalities			Parasites				
Species	No. Examined	Deteriorated Fins	Remarks	No. Examined	Black Spot	Leeches	Yellow Grub	White Grub
Chain pickerel	8	1	open wound	8	2 light 1 medium		1	
Largemouth bass	6		broken jaw	6	2 light			
Pumpkinseed	10			10	5 light		1	
Redbreast sunfish	136	1	damaged caudal fin	133	33 light 1 medium	26	3	
Rock bass	198	4	hook-injured mouth	195	40 light	9	6	
Smallmouth bass	169	2	cloudy lens in eye	174	92 light 15 medium 7 heavy	3	8	1 heavy
Yellow bullhead	18		open wound chin barbel missing	15		1		
Yellow perch	1			1				

Results of duplicate analyses suggest that the laboratory analysis of target metals in fish tissue was generally of high precision (Table 3.12). Duplicate values for many of the paired comparisons were not calculated because the parameters were below detection. Of the remaining paired comparisons calculated, values never exceeded 25 percent.

Two paired comparisons of strontium analysis were not calculated due to one value being below detection and the second paired value containing detectable concentrations. The reason for this variability in strontium is unknown.

All paired duplicate analyses of tissue from bass and carp for organic compounds agreed and were all below detection limits of the analytical methods employed.

3.2.2 Carp Body Burdens

Thirty carp obtained from the region adjacent to Ciba-Geigy (Figure 3.8) and five carp from the control region were analyzed for metal and organic compounds in the flesh and liver. Male carp captured near Ciba-Geigy were about two-thirds of the total, and ranged in age from 3 to 22 years (Table 3.13). In the control region, three of the five carp captured were female. These five carp ranged in age from 11 to 17 years. Lipid concentrations in both liver and flesh samples of carp in the region adjacent to Ciba-Geigy were higher than those samples obtained from the control fish ($p < 0.05$).

Cadmium, lead, nickel and vanadium were all below detection limits in carp flesh (Table 3.14). Two flesh samples contained chromium at the detection level. Detectable strontium concentrations were observed in low frequency in flesh from both regions, but were not statistically different between regions ($p > 0.05$). Mercury was found in the flesh of carp captured from both regions. The control region had higher average flesh mercury concentrations, but these differences were not statistically significant ($p > 0.05$) (Table 3.15).

Table 3.12 Quality control/assurance results of field duplicate fish tissue submitted for analysis from Ciba-Geigy, Glens Falls, New York, 1988. All metal results are in mg/kg wet weight.

Collection Number	Fish No.	Lab ID	Fish Species	Tissue	Cadmium	Chromium	Lead	Mercury	Nickel	Strontium	Vanadium
132	02	89875	Bass	Flesh	<0.2	<0.4	<2	0.37	<0.8	<0.4	<0.4
		89877			<0.2	<0.4	<2	0.46	<0.8	<0.4	<0.4
		DIF (%)			NC	NC	NC	21.7	NC	NC	NC
131	02	89865	Carp	Flesh	<0.2	<0.4	<2	0.17	<0.8	<0.4	<0.4
		89868			<0.2	<0.4	<2	0.17	<0.8	1.1	<0.4
		DIF (%)			NC	NC	NC	0	NC	NC	NC
131	02	89866	Carp	Liver	2.5	<0.4	<2	<0.1	<0.8	<0.4	<0.4
		89869			2.6	<0.4	<2	<0.09	<0.8	<0.4	<0.4
		DIF (%)			3.9	NC	NC	NC	NC	NC	NC
148	1	90498	Carp	Flesh	<0.2	<0.4	<2	0.33	<0.8	<0.4	<0.4
		90499			<0.2	0.4	<2	0.31	<0.8	1.3	<0.4
		DIF (%)			NC	NC	NC	6.3	NC	NC	NC
148	1	90500	Carp	Liver	13.5	2.9	<2	0.22	<0.8	<0.4	<0.4
		90501			12.5	2.3	<2	0.23	<0.8	<0.4	<0.4
		DIF (%)			7.7	23.0	NC	4.4	NC	NC	NC
138	1	89987	Bass	Flesh	<0.2	<0.4	<2	0.63	<0.8	<0.4	<0.4
		89989			<0.2	<0.4	<2	0.61	<0.8	<0.4	<0.4
		DIF (%)			NC	NC	NC	3.2	NC	NC	NC
137	1	89967	Carp	Flesh	<0.2	<0.4	<2	0.49	<0.8	<0.4	<0.4
		89970			<0.2	<0.4	<2	0.51	<0.8	<0.4	<0.4
		DIF (%)			NC	NC	NC	4.0	NC	NC	NC
137	1	89968	Carp	Liver	12.2	0.5	<2	0.37	<0.8	<0.4	<0.4
		89971			14.5	0.5	<2	0.32	<0.8	<0.4	<0.4
		DIF (%)			17.2	0	NC	14.5	NC	NC	NC

NC = not calculated.

DIF = was calculated as follows: $DIF = \frac{|C_1 - C_2|}{1/2\ (C_1 + C_2)} \times 100$ where, C_1 = concentration of the metal in the original sample.
C_2 = concentration of the metal in the duplicate sample.

Table 3.13 Age distribution, sex composition and lipid concentrations for carp collected from two regions near Glens Falls, New York, 1988.

Number of Annuli	Control Region No. Male	Control Region No. Female	Region Adjacent to Ciba-Geigy No. Male	Region Adjacent to Ciba-Geigy No. Female
3			2	
9			1	
10			2	
11		1		
12		1	2	2
13	1			2
14			1	
15	1			
16			1	3
17		1	1	1
18			2	
19			4	1
20			1	2
21				
22			2	
Total Number	2	3	19	11
Regional Percentage	40	60	63	37

Average Lipid Concentrations as Percents					Range
Liver	4.5	3.8	20.4	13.6	3.1 - 33.1
Flesh	1.0	1.3	13.3	12.4	0.5 - 35.3

Table 3.14 Concentrations of selected metals in carp flesh from two regions near Glens Falls, New York, 1988. All metal results are in mg/kg wet weight.

Location	Collection Date	Collection No.	Fish No.	Sample Type	Fish Species	Fish Tissue	Fish Length (mm)	Fish Weight (g)	Fish Age	Cd	Cr	Pb	Hg	Ni	Sr	V
CONTROL	10/31/88	151	1		CARP	FLESH	750	7900	17	<0.2	<0.4	<2	0.43	<0.8	<0.2	<0.4
CONTROL	10/31/88	152	1		CARP	FLESH	670	5219	12	<0.2	<0.4	<2	0.48	<0.8	<0.2	<0.4
CONTROL	10/31/88	153	1		CARP	FLESH	690	5249	11	<0.2	<0.4	<2	0.55	<0.8	<0.2	<0.4
CONTROL	10/31/88	154	1		CARP	FLESH	690	4837	15	<0.2	<0.4	<2	0.62	<0.8	<0.2	<0.4
CONTROL	10/31/88	155	1		CARP	FLESH	640	2883	13	<0.2	<0.4	<2	0.88	<0.8	0.9	<0.4
STATION 1	09/27/88	132	5		CARP	FLESH	810	11000	18	<0.2	<0.4	<2	0.39	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	6		CARP	FLESH	860	11200	16	<0.2	<0.4	<2	<0.1	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	7		CARP	FLESH	770	9800	12	<0.2	<0.4	<2	0.44	<0.8	<0.2	<0.4
STATION 1	10/05/88	143	1		CARP	FLESH	850	11400	20	<0.2	<0.4	<2	0.14	<0.8	<0.2	<0.4
STATION 1	10/05/88	144	1		CARP	FLESH	780	9700	19	<0.2	<0.4	<2	0.46	<0.8	<0.2	<0.4
STATION 1	10/05/88	144	2		CARP	FLESH	830	10100	17	<0.2	<0.4	<2	0.23	<0.8	<0.2	<0.4
STATION 1	10/06/88	146	1		CARP	FLESH	750	7200	9	<0.2	<0.4	<2	0.27	<0.8	<0.2	<0.4
STATION 1	10/06/88	147	1		CARP	FLESH	850	11300	18	<0.2	<0.4	<2	0.15	<0.8	<0.2	<0.4
STATION 2	09/27/88	131	2		CARP	FLESH	620	4178	3	<0.2	<0.4	<2	0.17	<0.8	0.3	<0.4
STATION 2	09/27/88	131	2	DUPLIC	CARP	FLESH	620	4178	3	<0.2	<0.4	<2	0.17	<0.8	1.1	<0.4
STATION 3	09/19/88	103	1		CARP	FLESH	840	13600	12	<0.2	<0.4	<2	0.34	<0.7	0.5	<0.4
STATION 3	09/19/88	104	1		CARP	FLESH	880	11800	22	<0.2	<0.4	<2	0.46	<0.8	<0.2	<0.4
STATION 3	09/22/88	120	1		CARP	FLESH	720	6400	19	<0.2	<0.4	<2	0.54	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	1		CARP	FLESH	760	9100	12	<0.2	<0.4	<2	0.36	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	2		CARP	FLESH	750	7500	20	<0.2	<0.4	<2	0.38	<0.7	<0.2	<0.4
STATION 5	09/22/88	121	3		CARP	FLESH	840	13400	19	<0.2	<0.4	<2	0.43	<0.7	<0.2	<0.4
STATION 5	09/22/88	121	6		CARP	FLESH	720	6200	10	<0.2	<0.4	<2	0.51	<0.8	0.6	<0.4
STATION 5	09/22/88	121	7		CARP	FLESH	800	9500	19	<0.2	<0.4	<2	0.34	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	8		CARP	FLESH	--	--	10	<0.2	0.4	<2	0.19	<0.8	<0.2	<0.4
STATION 5	10/05/88	145	1		CARP	FLESH	760	8000	16	<0.2	<0.4	<2	0.50	<0.8	<0.2	<0.4
STATION 5	10/05/88	145	2		CARP	FLESH	830	8700	22	<0.2	<0.4	<2	0.40	<0.8	<0.2	<0.4
STATION 5	10/05/88	145	3		CARP	FLESH	840	9500	19	<0.2	<0.4	<2	0.34	<0.8	0.9	<0.4
STATION 5	10/06/88	148	1		CARP	FLESH	910	17500	20	<0.2	<0.4	<2	0.33	<0.8	<0.2	<0.4
STATION 5	10/06/88	148	1	DUPLIC	CARP	FLESH	910	17500	20	<0.2	0.42	<2	0.31	<0.8	1.3	<0.4
STATION 6	09/19/88	105	1		CARP	FLESH	900	13600	13	<0.2	<0.4	<2	0.42	<0.7	<0.2	<0.4
STATION 6	10/05/88	142	1		CARP	FLESH	850	17300	17	<0.2	<0.4	<2	0.50	<0.8	<0.2	<0.4
STATION 7	09/01/88	101	1		CARP	FLESH	630	4164	3	<0.2	<0.4	<2	0.28	<0.7	<0.2	<0.4
STATION 7	09/28/88	137	1		CARP	FLESH	820	11600	13	<0.2	<0.4	<2	0.49	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	1	DUPLIC	CARP	FLESH	820	11600	13	<0.2	<0.4	<2	0.51	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	2		CARP	FLESH	800	8400	14	<0.2	<0.4	<2	0.34	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	3		CARP	FLESH	950	17900	16	<0.2	<0.4	<2	0.47	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	4		CARP	FLESH	810	9800	12	<0.2	<0.4	<2	0.24	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	5		CARP	FLESH	890	15600	16	<0.2	<0.4	<2	0.41	<0.8	2.5	<0.4

Table 3.15 Mean arithmetic values calculated for mercury concentrations in common carp collected near Ciba-Geigy, Glens Falls, New York, 1988.

Location	Sample Size	Mean Concentration (mg/kg)	Two-tailed 95% Confidence Interval
Flesh			
Control Region	5	0.59	0.37 - 0.81
Stations 1-4 (north)	12	0.31	0.21 - 0.40
Stations 5-8 (south)	18	0.37	0.33 - 0.42
Stations 1-8 (both)	30	0.35	0.30 - 0.39
Liver			
Control Region	5	0.71	0 - 1.76
Stations 1-4 (north)	12	0.24	0.16 - 0.32
Stations 5-8 (south)	18	0.28	0.22 - 0.34
Stations 1-8 (both)	30	0.26	0.22 - 0.31

In the carp liver samples, concentrations of cadmium and chromium were significantly higher in the region adjacent to Ciba-Geigy ($p<0.05$) (Table 3.16). Differences in the liver concentrations of these two metals did not occur between the sexes ($p >0.05$) at either station.

Strontium and vanadium concentrations were recorded in a small proportion (<25 percent overall) of carp in both regions. These concentrations did not differ between samples collected from fish of both regions. One sample, liver from a carp collected in the downstream region, contained 3 mg/kg lead. Nickel was not detected in the liver of carp from either region.

Average mercury concentrations in liver from carp from the control region were higher but not statistically significant ($p >0.05$) than carp liver mercury concentrations collected from the downstream region adjacent to Ciba-Geigy. Organic analyses of carp flesh and liver did not detect any of the target analytes (Tables 3.17 and 3.18).

3.2.3 Smallmouth Bass Body Burden

Smallmouth bass analyzed for metals and organic compounds ranged in age from 4 to 7 years. Capture locations of these fish are presented in Figure 3.8. The male to female ratio of fish analyzed was nearly equal for both regions. Bass flesh lipid concentrations were typically less than 1 percent for both sexes and regions (Table 3.19).

No differences in any of the smallmouth bass flesh metals or organic compounds were observed ($p >0.05$). Cadmium, chromium, lead, nickel and vanadium were not detected in the smallmouth bass flesh from either region (Table 3.20). Mercury was detected in all flesh samples and average flesh concentrations in smallmouth bass were nearly equal for fish from both regions (Table 3.21). Organic analyses of bass flesh from both regions did not detect any of the target analytes (Table 3.22).

Table 3.16 Concentrations of selected metals in carp liver from two regions near Glens Falls, New York, 1988. All metal results are in mg/kg wet weight.

Location	Collection Date	Collection No.	Fish No.	Sample Type	Fish Species	Fish Tissue	Fish Length (mm)	Fish Weight (g)	Fish Age	Cd	Cr	Pb	Hg	Ni	Sr	V
CONTROL	10/31/88	151	1		CARP	LIVER	750	7900	17	2.7	<0.4	<2	0.25	<0.8	0.4	<0.4
CONTROL	10/31/88	152	1		CARP	LIVER	670	5219	12	4.5	<0.4	<2	0.25	<0.8	<0.2	<0.4
CONTROL	10/31/88	153	1		CARP	LIVER	690	5249	11	4.0	<0.4	<2	0.27	<0.8	0.3	<0.4
CONTROL	10/31/88	154	1		CARP	LIVER	690	4837	15	5.0	<0.4	<2	0.58	<0.8	<0.2	<0.4
CONTROL	10/31/88	155	1		CARP	LIVER	640	2883	13	6.9	<0.4	<2	2.2	<0.8	0.8	0.59
STATION 1	09/27/88	132	5		CARP	LIVER	810	11000	18	11.1	2.4	<2	0.35	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	6		CARP	LIVER	860	11200	16	52	2.3	<2	0.41	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	7		CARP	LIVER	770	9800	12	11.9	<0.4	<2	0.21	<0.8	0.5	<0.4
STATION 1	10/05/88	143	1		CARP	LIVER	850	11400	20	6.9	0.93	<2	0.19	<0.8	1.2	<0.4
STATION 1	10/05/88	144	1		CARP	LIVER	780	9700	19	13.6	1.86	<2	0.27	<0.8	<0.2	<0.4
STATION 1	10/05/88	144	2		CARP	LIVER	830	10100	17	5.3	0.67	<2	0.40	<0.8	0.3	<0.4
STATION 1	10/06/88	146	1		CARP	LIVER	750	7200	9	11	2.0	<2	0.15	<0.8	0.4	<0.4
STATION 1	10/06/88	147	1		CARP	LIVER	850	11300	18	5.0	1.31	<2	0.13	<0.8	0.2	<0.4
STATION 2	09/27/88	131	2		CARP	LIVER	620	4178	3	2.5	<0.4	<2	<0.1	<0.8	<0.2	<0.4
STATION 2	09/27/88	131	2	DUPLIC	CARP	LIVER	620	4178	3	2.6	<0.4	<2	<.09	<0.8	<0.2	<0.4
STATION 3	09/19/88	103	1		CARP	LIVER	840	13600	12	5.8	<0.4	<2	0.08	<0.8	<0.2	0.52
STATION 3	09/19/88	104	1		CARP	LIVER	880	11800	22	10.1	1.9	<2	<0.2	<0.7	<0.2	<0.4
STATION 3	09/22/88	120	1		CARP	LIVER	720	6400	19	21	2.9	<2	0.39	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	1		CARP	LIVER	760	9100	12	6.7	<0.4	<2	0.23	<0.7	0.6	<0.4
STATION 5	09/22/88	121	2		CARP	LIVER	750	7500	20	15.1	4.4	<2	0.40	<0.8	<0.2	0.5
STATION 5	09/22/88	121	3		CARP	LIVER	840	13400	19	8.8	0.6	3	0.22	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	6		CARP	LIVER	720	6200	10	3.7	<0.4	<2	0.18	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	7		CARP	LIVER	800	9500	19	15.0	2.0	<2	0.30	<0.8	0.2	<0.4
STATION 5	09/22/88	121	8		CARP	LIVER	--	--	10	4.3	<0.3	<2	0.25	<0.7	<0.2	<0.3
STATION 5	10/05/88	145	1		CARP	LIVER	760	8000	16	22	5.4	<2	0.45	<0.8	<0.2	0.89
STATION 5	10/05/88	145	2		CARP	LIVER	830	8700	22	4.8	<0.4	<2	0.27	<0.8	<0.2	<0.4
STATION 5	10/05/88	145	3		CARP	LIVER	840	9500	19	13.3	2.0	<2	0.30	<0.8	<0.2	<0.4
STATION 5	10/06/88	148	1		CARP	LIVER	910	17500	20	13.5	2.9	<2	0.22	<0.8	0.2	<0.4
STATION 5	10/06/88	148	1	DUPLIC	CARP	LIVER	910	17500	20	12.5	2.3	<2	0.23	<0.8	0.3	<0.4
STATION 6	09/19/88	105	1		CARP	LIVER	900	13600	13	4.4	<0.4	<2	0.12	<0.8	<0.2	<0.4
STATION 6	10/05/88	142	1		CARP	LIVER	850	17300	17	5.7	0.54	<2	0.16	<0.8	<0.2	<0.4
STATION 7	09/01/88	101	1		CARP	LIVER	630	4164	3	3.0	<0.4	<2	0.09	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	1		CARP	LIVER	820	11600	13	12.2	0.53	<2	0.37	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	1	DUPLIC	CARP	LIVER	820	11600	13	14.5	0.53	<2	0.32	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	2		CARP	LIVER	800	8400	14	23	2.8	<2	0.26	<0.8	<0.2	<0.4
STATION 7	09/28/88	137	3		CARP	LIVER	950	17900	16	9.2	2.1	<2	0.38	<0.8	5.2	<0.4
STATION 7	09/28/88	137	4		CARP	LIVER	810	9800	12	4.8	<0.4	<2	0.33	<0.8	0.2	<0.4
STATION 7	09/28/88	137	5		CARP	LIVER	890	15600	16	21	2.9	<2	0.53	<0.8	0.3	<0.4

Table 3.17 Concentrations of selected organic compounds in carp flesh from two regions near Glens Falls, New York, 1988. All organic results are in mg/kg wet weight. DCB = dichlorobenzene, DCBD = dichlorobenzidine, HCB = hexachlorobenzidine, NA = nitroaniline, NB = nitrobenzene, N/D = not determined.

Location	Collection Date	Coll. No.	Fish No.	Sample Type	Fish Species	Fish Tissue	Length (mm)	Weight (g)	Fish Age	Lipids (%)	1,2 DCB	1,4 DCB	3,3' DCBD	HCB	4-NA	2-NA	NB
CONTROL	10/31/88	151	1		CARP	FLESH	750	7900	17	0.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	152	1		CARP	FLESH	670	5219	12	1.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	153	1		CARP	FLESH	690	5249	11	1.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	154	1		CARP	FLESH	690	4837	15	2.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	155	1		CARP	FLESH	640	2883	13	0.5	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	5		CARP	FLESH	810	11000	18	13.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	6		CARP	FLESH	860	11200	16	13.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	7		CARP	FLESH	770	9800	12	6.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/05/88	143	1		CARP	FLESH	850	11400	20	27.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/05/88	144	1		CARP	FLESH	780	9700	19	14.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/05/88	144	2		CARP	FLESH	830	10100	17	26.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/06/88	146	1		CARP	FLESH	750	7200	9	2.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/06/88	147	1		CARP	FLESH	850	11300	18	1.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 2	09/27/88	131	2		CARP	FLESH	620	4178	3	15.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 2	09/27/88	131	2	DUPLIC	CARP	FLESH	620	4178	3	7.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/19/88	103	1		CARP	FLESH	840	13600	12	14.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/19/88	104	1		CARP	FLESH	880	11800	22	9.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/22/88	120	1		CARP	FLESH	720	6400	19	5.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	1		CARP	FLESH	760	9100	12	18.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	2		CARP	FLESH	750	7500	20	3.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	3		CARP	FLESH	840	13400	19	13.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	6		CARP	FLESH	720	6200	10	6.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	7		CARP	FLESH	800	9500	19	24.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	8		CARP	FLESH	--	--	10	12.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/05/88	145	1		CARP	FLESH	760	8000	16	10.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/05/88	145	2		CARP	FLESH	830	8700	22	16.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/05/88	145	3		CARP	FLESH	840	9500	19	35.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/06/88	148	1		CARP	FLESH	910	17500	20	4.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/06/88	148	1	DUPLIC	CARP	FLESH	910	17500	20	3.5	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	09/19/88	105	1		CARP	FLESH	900	13600	13	12.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	10/05/88	142	1		CARP	FLESH	850	17300	17	4.5	<1	<1	<0.8	N/D	<0.4	<0.4	<0.4
STATION 7	09/01/88	101	1		CARP	FLESH	630	4164	3	6.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	1		CARP	FLESH	820	11600	13	18.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	1	DUPLIC	CARP	FLESH	820	11600	13	11.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	2		CARP	FLESH	800	8400	14	17.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	3		CARP	FLESH	950	17900	16	13.5	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	4		CARP	FLESH	810	9800	12	15.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	5		CARP	FLESH	890	15600	16	9.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4

Table 3.18 Concentrations of selected organic compounds in carp livers from two regions near Glens Falls, New York, 1988. All organic results are in mg/kg wet weight. DCB = dichlorobenzene, DCB = dichlorobenzidine, HCB = hexachlorobenzidine, NA = nitroaniline, NB = nitrobenzene, N/D = not determined.

Location	Collection Date	Coll. No.	Fish No.	Sample Type	Fish Species	Fish Tissue	Length (mm)	Weight (g)	Fish Age	Lipids (%)	1,2 DCB	1,4 DCB	3,3' DCBD	HCB	4-NA	2-NA	NB
CONTROL	10/31/88	151	1		CARP	LIVER	750	7900	17	3.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	152	1		CARP	LIVER	670	5219	12	4.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	153	1		CARP	LIVER	690	5249	11	3.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	154	1		CARP	LIVER	690	4837	15	5.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	10/31/88	155	1		CARP	LIVER	640	2883	13	3.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	5		CARP	LIVER	810	11000	18	31.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	6		CARP	LIVER	860	11200	16	11.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	7		CARP	LIVER	770	9800	12	12.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/05/88	143	1		CARP	LIVER	850	11400	20	9.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/05/88	144	1		CARP	LIVER	780	9700	19	14.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/05/88	144	2		CARP	LIVER	830	10100	17	32.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/06/88	146	1		CARP	LIVER	750	7200	9	10.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	10/06/88	147	1		CARP	LIVER	850	11300	18	28.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 2	09/27/88	131	2		CARP	LIVER	620	4178	3	14.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 2	09/27/88	131	2	DUPLIC	CARP	LIVER	620	4178	3	12.7	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
STATION 3	09/19/88	103	1		CARP	LIVER	840	13600	12	5.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/19/88	104	1		CARP	LIVER	880	11800	22	29.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/22/88	120	1		CARP	LIVER	720	6400	19	13.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	1		CARP	LIVER	760	9100	12	24.5	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	2		CARP	LIVER	750	7500	20	17.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	3		CARP	LIVER	840	13400	19	29.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	6		CARP	LIVER	720	6200	10	14.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	7		CARP	LIVER	800	9500	19	27.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	8		CARP	LIVER	--	--	10	19.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/05/88	145	1		CARP	LIVER	760	8000	16	23.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/05/88	145	2		CARP	LIVER	830	8700	22	29.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/05/88	145	3		CARP	LIVER	840	9500	19	33.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/06/88	148	1		CARP	LIVER	910	17500	20	21.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	10/06/88	148	1	DUPLIC	CARP	LIVER	910	17500	20	4.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	09/19/88	105	1		CARP	LIVER	900	13600	13	23.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	10/05/88	142	1		CARP	LIVER	850	17300	17	23.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/01/88	101	1		CARP	LIVER	630	4164	3	7.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	1		CARP	LIVER	820	11600	13	6.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	1	DUPLIC	CARP	LIVER	820	11600	13	7.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	2		CARP	LIVER	800	8400	14	10.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	3		CARP	LIVER	950	17900	16	3.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	4		CARP	LIVER	810	9800	12	5.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	5		CARP	LIVER	890	15600	16	5.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4

Table 3.19 Age distribution, sex composition and lipid concentrations for smallmouth bass collected from two regions near Glens Falls, New York, 1988.

Number of Annuli	Control Region		Region Adjacent to Ciba-Geigy	
	Male	Female	Male	Female
4				3
5	1	1	8	5
6		1	1	2
7	1		1	1
Total Number	2	2	10	11
Region Percentage	50	50	48	52
Average Lipid Concentrations as Percent Lipid Range 0.1 - 6.0%	0.6	0.9	0.8	0.7

Table 3.20 Concentrations of selected metals in smallmouth bass flesh from two regions near Glens Falls, New York, 1988. All metal results are in mg/kg wet weight.

Location	Collection Date	Collection No.	Fish No.	Sample Type	Fish Species	Fish Tissue	Fish Length (mm)	Fish Weight (g)	Fish Age	Cd	Cr	Pb	Hg	Ni	Sr	V
CONTROL	10/31/88	149	1		BASS	FLESH	267	232	7	<0.2	<0.4	<2	0.68	<0.8	0.3	<0.4
CONTROL	11/15/88	159	1		BASS	FLESH	292	341	6	<0.2	<0.4	<2	0.64	<0.8	0.2	<0.4
CONTROL	11/17/88	167	1		BASS	FLESH	294	301	5	<0.2	<0.4	<2	0.68	<0.8	<0.2	<0.4
CONTROL	11/17/88	168	1		BASS	FLESH	365	652	5	<0.2	<0.4	<2	0.86	<0.8	<0.2	<0.4
STATION 1	09/21/88	113	1		BASS	FLESH	287	254	5	<0.2	<0.4	<2	0.54	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	1		BASS	FLESH	321	380	5	<0.2	<0.4	<2	0.37	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	2		BASS	FLESH	316	344	6	<0.2	<0.4	<2	0.37	<0.8	0.2	<0.4
STATION 1	09/27/88	132	2	DUPLIC	BASS	FLESH	316	344	6	<0.2	<0.4	<2	0.46	<0.8	0.3	<0.4
STATION 1	09/27/88	132	3		BASS	FLESH	301	282	7	<0.2	<0.4	<2	0.66	<0.8	<0.2	<0.4
STATION 1	09/27/88	132	4		BASS	FLESH	280	211	5	<0.2	<0.4	<2	0.65	<0.8	<0.2	<0.4
STATION 2	09/27/88	131	1		BASS	FLESH	286	283	5	<0.2	<0.4	<2	1.54	<0.8	<0.2	<0.4
STATION 2	09/27/88	131	52		BASS	FLESH	277	253	5	<0.2	<0.4	<2	0.49	<0.8	<0.2	<0.4
STATION 3	09/19/88	102	1		BASS	FLESH	295	290	7	<0.2	<0.4	<2	1.21	<0.7	<0.2	<0.4
STATION 3	09/28/88	128	7		BASS	FLESH	280	265	4	<0.2	<0.4	<2	1.21	<0.8	<0.2	<0.4
STATION 4	09/21/88	115	1		BASS	FLESH	302	311	4	<0.2	<0.4	<2	0.54	<0.8	<0.2	<0.4
STATION 4	09/21/88	115	2		BASS	FLESH	285	286	5	<0.2	<0.4	<2	0.73	<0.8	<0.2	<0.4
STATION 4	09/21/88	115	3		BASS	FLESH	360	553	6	<0.2	<0.4	<2	1.39	<0.8	0.6	<0.4
STATION 5	09/22/88	121	4		BASS	FLESH	339	430	5	<0.2	<0.4	<2	0.52	<0.8	<0.2	<0.4
STATION 5	09/22/88	121	5		BASS	FLESH	293	295	5	<0.2	<0.4	<2	0.37	<0.8	0.3	<0.4
STATION 6	09/28/88	138	1		BASS	FLESH	320	371	5	<0.2	<0.4	<2	0.63	<0.8	<0.2	<0.4
STATION 6	09/28/88	138	1	DUPLIC	BASS	FLESH	320	371	5	<0.2	<0.4	<2	0.61	<0.8	<0.2	<0.4
STATION 6	09/28/88	138	2		BASS	FLESH	285	263	5	<0.2	<0.4	<2	0.67	<0.8	<0.2	<0.4
STATION 7	09/01/88	100	1		BASS	FLESH	330	516	6	<0.2	<0.4	<2	0.59	<0.7	<0.2	<0.4
STATION 7	09/28/88	129	1		BASS	FLESH	302	314	5	<0.2	<0.4	<2	0.59	<0.8	0.4	<0.4
STATION 7	09/28/88	137	14		BASS	FLESH	272	228	5	<0.2	<0.4	<2	0.65	<0.8	<0.2	<0.4
STATION 8	09/21/88	114	2		BASS	FLESH	305	302	5	<0.2	<0.4	<2	0.40	<0.8	<0.2	<0.4
STATION 8	09/21/88	114	23		BASS	FLESH	271	250	4	<0.2	<0.4	<2	0.19	<0.8	<0.2	<0.4

Table 3.21 Mean arithmetic values calculated for mercury concentrations in smallmouth bass collected near Ciba-Geigy, Glens Falls, New York, 1988.

Location	Sample Size	Mean Concentration (mg/kg)	Two-tailed 95% Confidence Interval
Control Region	4	0.72	0.56 - 0.87
Stations 1-4 (north)	12	0.81	0.54 - 1.07
Stations 5-8 (south)	9	0.51	0.39 - 0.64
Stations 1-8 (both)	21	0.68	0.52 - 0.84

Table 3.22 Concentrations of selected organic compounds in smallmouth bass flesh from two regions near Glens Falls, New York, 1988. All organic results are in mg/kg wet weight. DCB = dichlorobenzene, DCBD = dichlorobenzidine, HCB = hexachlorobenzidine, NA = nitroaniline, NB = nitrobenzene.

Location	Collection Date	Coll. No.	Fish No.	Sample Type	Fish Species	Fish Tissue	Length (mm)	Weight (g)	Fish Age	Lipids (%)	1,2 DCB	1,4 DCB	3,3' DCBD	HCB	4-NA	2-NA	NB
CONTROL	10/31/88	149	1		BASS	FLESH	267	232	7	0.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	11/15/88	159	1		BASS	FLESH	292	341	6	1.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	11/17/88	167	1		BASS	FLESH	294	301	5	0.5	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
CONTROL	11/17/88	168	1		BASS	FLESH	365	652	5	0.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/21/88	113	1		BASS	FLESH	287	254	5	0.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	1		BASS	FLESH	321	380	5	0.3	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	2		BASS	FLESH	316	344	6	6.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	2	DUPLIC	BASS	FLESH	316	344	6	5.0	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	3		BASS	FLESH	301	282	7	0.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 1	09/27/88	132	4		BASS	FLESH	280	211	5	2.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 2	09/27/88	131	1		BASS	FLESH	286	283	5	1.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 2	09/27/88	131	52		BASS	FLESH	277	253	5	0.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/19/88	102	1		BASS	FLESH	295	290	7	0.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 3	09/28/88	128	7		BASS	FLESH	280	265	4	1.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 4	09/21/88	115	1		BASS	FLESH	302	311	4	0.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 4	09/21/88	115	2		BASS	FLESH	285	286	5	0.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 4	09/21/88	115	3		BASS	FLESH	360	553	6	0.2	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	4		BASS	FLESH	339	430	5	0.9	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 5	09/22/88	121	5		BASS	FLESH	293	295	5	0.4	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	09/28/88	138	1		BASS	FLESH	320	371	5	0.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	09/28/88	138	1	DUPLIC	BASS	FLESH	320	371	5	0.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 6	09/28/88	138	2		BASS	FLESH	285	263	5	0.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/01/88	100	1		BASS	FLESH	330	516	6	0.1	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	129	1		BASS	FLESH	302	314	5	0.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 7	09/28/88	137	14		BASS	FLESH	272	228	5	0.6	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 8	09/21/88	114	2		BASS	FLESH	305	302	5	0.8	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4
STATION 8	09/21/88	114	23		BASS	FLESH	271	250	4	0.7	<0.2	<0.2	<0.8	<0.2	<0.4	<0.4	<0.4

4.0 Discussion

4.1 Fish Population

The species diversity of the fish community in the region adjacent to Ciba-Geigy (downstream region) was high with fifteen species identified (Karr et al. 1986). Two species, rock bass and spottail shiner, which are considered to be intolerant to chemical degradation of the water and fish habitat were a significant component of the fish community in the downstream region. Typically, sensitive fish species are the first to disappear in degraded conditions.

Several species of sunfish (exclusive of smallmouth and largemouth bass) and one sucker species which are considered sensitive to habitat degradation and therefore good indicators of acceptable habitat were present in the fish community adjacent to the plant. Viable populations of top carnivores (such as smallmouth bass and pickerel) were a significant component of the fish community in the downstream region. The presence of these top carnivores in this region indicate a healthy trophically diverse community.

Overall, the distribution of the various fish species within this region appeared to be influenced by the habitat present. Larger smallmouth bass were typically captured in rocky areas of fast flowing water found at Stations 1, 5, 6 and 7. Station 2, an area adjacent to Ciba-Geigy, contained many smaller bass and other sunfishes. This area was relatively shallow (2-4 feet deep) and slower flowing than the main channel. The substrate observed in this area was mud with large amounts of wood slash. Station 3 was an area containing shallow (1-3 feet deep) slack-water channels. Several areas contained appreciable densities of macrophytes (Vallisneria spp. and Elodea spp. observed). Nearly all of the chain pickerel were captured at this station. During the reconnaissance survey in late July, a high density of redbreast sunfish nests (with adults on the nest) were observed in the softer mud bottom areas of this station.

The relative density of smallmouth bass, expressed as catch per unit effort (CPE) of electrofishing was high. These results were comparable to those observed by NYDEC biologists in 1987. Results of studies conducted in this region by the NYDEC in 1980 and 1987 also found that smallmouth bass was a significant species in this region (Saltsman, personal communication). Our study supports the conclusion of the NYDEC fisheries biologists that "the existing habitat supports an outstanding abundance of smallmouth bass" [in this region] (NYDEC memorandum, 22 September 1987).

The growth rates of the sunfishes and carp were about average for a riverine system the size of the Hudson River. The distribution of the different age classes of fish show a sunfish population with a high number of yearling fish indicating good spawning success and population recruitment. Young-of-the-year rock bass were captured, but no young-of-the-year redbreast sunfish were identified. This observation may be due to the inability to positively identify the young-of-the-year sunfish (Lepomis spp). Consequently, these small fish were clumped in the Lepomis spp. category. Older fish were present for these species indicating multi-year survival. Common carp captured in this region were older fish. The average age of carp captured adjacent to Ciba-Geigy was 16 years, with the oldest carp being 22 years of age, demonstrates the longevity of this species in the region.

Fish condition, measured as the condition factor, was average for the three fish species examined. The frequency of abnormalities was low, less then 1 percent, and within natural range. The incidence of parasitism was typical of a normal fish population.

Carp collected from the region adjacent to Ciba-Geigy were in good condition and were very robust. The analyses of lipid concentrations in the tissues were much higher in the fish of the downstream region than the control region carp. These data were interpreted as indicating a carp population that was in better condition near Ciba-Geigy.

The results of this study indicate that the fish population near Ciba-Geigy is a thriving sunfish community with the primary game fish being the smallmouth bass. The analysis of the late summer fish community for composition, age-growth, and fish condition did not detect degradation in the fish population that would be attributable to off-site migrations which may have occurred.

4.2 Body Burden

The analyses of common carp flesh found mercury as the only compound to be routinely above detection levels. The average flesh mercury levels from common carp collected in the downstream region adjacent to Ciba-Geigy were on the average lower than flesh samples from common carp from the control region, but these differences were not statistically significant.

The cadmium and chromium concentrations of the livers of common carp were significantly higher in fish from the region adjacent to Ciba-Geigy. The average cadmium concentration was more than double what was observed in common carp liver obtained from the upstream region. Chromium was not detected in the livers of the five control fish but was present in two-thirds of the common carp population collected in the downstream region. An increase of cadmium and chromium in the common carp liver in the region adjacent to Ciba-Geigy has occurred.

One consideration in these comparisons is the number of analyses conducted. The sample size of 30 carp near Ciba-Geigy is quite large statistically for estimation of population characteristics. The sample size of five carp from the control region is smaller, but is also statistically valid since both sample populations were randomly collected. In routine monitoring of body burdens of target compounds, NYDEC programs typically conduct five or fewer analyses from a specific drainage area (See NYDEC 1981a, 1981b, 1987).

The variability in concentrations of cadmium and chromium in control fish livers was relatively low, ranging from 2.7 to 6.9 mg/kg, which suggests that average concentrations of these metals in the control fish are relatively uniform. The analyses of the data suggest

that if sample size was increased (to 30) for the control region, only insignificant fluctuations in mean concentration of either metal (cadmium or chromium) would be expected. The increase in sample size would likely result in increased statistical probability of differences between the two regions.

The age and sex of the carp used for analyses may also be factors affecting the liver concentrations of cadmium and chromium between the two regions. In the downstream region, males were nearly two-thirds of the carp captured while about half of the carp captured at the control station were male. Differences between cadmium and chromium concentrations in males and females analyzed were not statistically significant and fish sex is not likely an important factor in these differences.

The age of the carp was biased towards older carp at the region adjacent to Ciba-Geigy and therefore presumably towards higher body burdens. However, the comparison of mean concentrations of cadmium and chromium of same age (11 to 17-year old) from the two regions had a higher statistical probability that carp from the region adjacent to Ciba-Geigy contained higher concentrations than the control region carp. All of these factors (age, sex, sample size) are important to consider but are probably not the primary causes of higher concentrations observed in the downstream region.

Metals, including cadmium and chromium, in the flesh of the carp were typically below detection limits. The binding of many of the heavy metals in fish is by specific metal-binding proteins metallothioneins (Hamilton and Mehrle 1986). In carp, the highest concentrations of metals are found in the liver, kidney, intestine, and gills under chronic exposure to cadmium (Kito et al. 1982 as cited in Hamilton and Mehrle 1986). Our results are consistent with the hypothesized mechanisms for cadmium storage in fish.

The selected organic compounds were not detected in carp or bass tissue samples. The analyses of flesh samples were conducted on skinless fillets to meet the anticipated needs of the objectives of the data usage. One concern raised was that the removal of the skin during flesh sample preparation may also reduce the amount of lipids, since these organic compounds are likely to be fat soluble and accumulated by fish in the lipid fraction of the skin. During dissection an effort was made to obtain the high lipid fractions of the flesh, such as subcutaneous and lateral line flesh.

Carp flesh lipids in the Ciba-Geigy region averaged 12 percent (range 0.5 to 35 percent) in the skinless fillets. Analyses of standard fillets (skin-on) of carp flesh in routine monitoring studies (NYDEC 1981a, 1981b, 1987) averaged 2 percent. Carp captured in the present study were typically larger than carp analyzed in the NYDEC studies. Our efforts, age differences and the robustness of Hudson River carp probably were factors in these higher percentage of lipids in skinless fillets. These comparisons indicate that the skinless fillets analyzed contain significant amounts of lipids and presumably the flesh component where the target organic compounds are likely to be accumulated. Livers were another tissue expected to contain appreciable concentrations of these organic compounds if present in significant concentrations in the fish. The entire liver was obtained from each fish and no target compounds detected.

In the smallmouth bass, the flesh was the tissue analyzed. Cadmium, chromium, lead, nickel, and vanadium were not detected in samples from either region. Mercury concentrations were encountered in all bass. The comparison of the average mercury concentrations in smallmouth bass from the two regions was nearly the same, 0.72 ± 0.05 mg/kg and 0.68 ± 0.08 mg/kg for upstream (control) region fish and downstream region fish, respectively. Average concentrations observed in smallmouth bass from the two regions were similar to those observed in smallmouth bass by the NYDEC (Appendix A).

This comparison does suggest the mean concentrations of mercury in smallmouth bass flesh between the populations of the two regions does not differ. However, several smallmouth bass collected adjacent to Ciba-Geigy displayed the highest concentrations observed in the study. In one instance, the highest recorded value of mercury in flesh was found in smallmouth bass 131-01 (1.54 mg/kg); but, another smallmouth bass, 132-01, captured about 300 feet away and also adjacent to Ciba-Geigy contained mercury concentration in flesh nearly at the lowest level observed in this study (0.37 mg/kg). Two smallmouth bass (102-01 and 128-07) captured adjacent to the downstream (easterly) property line of Ciba-Geigy both contained flesh mercury concentrations of 1.21 mg/kg. No smallmouth bass captured for analysis were within 500 feet of these fish.

A downstream bass (115-03) also contained higher (1.39 mg/kg) than average flesh mercury concentrations. However, like smallmouth bass, 131-01, smallmouth bass (fish number 115-01 and 115-02) were captured within several hundred feet (and on the same side of the river) which had flesh mercury concentrations that were roughly half of that found in bass 115-03 (0.54 and 0.73 mg/kg). The variability in flesh mercury concentrations in smallmouth bass caught such short distances apart, distances that even bass would be expected to traverse throughout the season, and the small sample size (1-2 analyses) in any one area does significantly confound the interpretation of these localized distributions.

The target organic compounds were never above detection levels in smallmouth bass tissues. Like the carp, the effect of the analysis of a skinless fillet can be debated. However, the comparison of lipid concentrations of bass analyzed in this study and in the NYDEC routine monitoring studies (NYDEC 1981a, 1981b, 1987) were close, averaging in both studies between 0.5 - 0.8% lipid. Although the fish population was diverse and stable, mercury was detected at similar levels in both

common carp and smallmouth bass adjacent to the plant and in a control region. In common carp collected adjacent to the plant, concentrations of cadmium and chromium were higher than a control population indicating bioaccumulation of these metals.

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Appendix A

Summary of NYDEC Toxic Substance Reports

Introduction

A review of New York State data evaluating the body burdens of mercury, cadmium and chromium in fish was conducted as a part of the present study. The objective of this review was to compare the data collected from the Hudson River near Glens Falls, New York, in 1988 with the published historical data available for common carp and smallmouth bass.

Approach

The New York State Department of Environmental Conservation (NYDEC) has routinely analyzed fish and wildlife in New York for body burdens of selected chemical substances (NYDEC 1978, NYDEC 1981, NYDEC 1982a, NYDEC 1982b, and NYDEC 1987). These reports, which were reviewed to provide summary data, present the average concentration of selected chemical substances and range of concentrations observed in fish and wildlife tissues. Since these reports span approximately 12 years of NYDEC investigations, there are some differences in the methodology used by the NYDEC during this period as well as differences between the NYDEC methodology and that used to evaluate the Hudson River fishes in 1988. These variations were probably as much a result of different study objectives as improvements in the approach over the 12 years of NYDEC investigation.

Data pertaining only to smallmouth bass and common carp, and the same target tissue (flesh and/or liver) as in the 1988 study were extracted from the NYDEC reports and summarized. Typically, NYDEC protocol required that standard fillet samples be obtained for analysis of flesh. This standard fillet is described as a skin-on fillet and the procedure for obtaining such fillets is described in NYDEC (1987). Several of the earlier NYDEC reports did not define the type of fillet obtained from the fish and they are presumed to be the standard fillet described in the 1987 report. In this Hudson River report, all flesh samples were analyzed as skinless fillets, similar to the analyses conducted by McMurtry et al. (1989).

The NYDEC conducted analyses predominantly on composite samples of flesh obtained from two or more fish. All fish in the Hudson River study were analyzed individually. Comparatively, the estimated average concentrations of a substance obtained through composite or individual analyses should not be significantly different if an adequate sample size was obtained. However, it is likely that the range of concentrations obtained through individual analysis would be greater than that of the composites due to the potential moderation of extreme individual concentrations (high or low) with the other samples in the composite.

Although the differences discussed above preclude statistical comparisons of the NYDEC data with that of the Hudson River study per se, inspection of the NYDEC databases can provide useful information on general trends in tissue concentrations of chemical substances.

Summary Comparisons

Mercury

Average mercury concentrations found in smallmouth bass standard fillets were between 0.2 and 1.6 ppm mercury (Figure A1, Tables A1 to A4). Generally, the concentrations were in the range of 0.2 to 1.0 ppm. Onondaga Lake fish were analyzed individually, contributing to a larger range of observed concentrations in the smallmouth bass analyzed. The data from smallmouth bass caught near Ciba-Geigy in 1988 were consistent with values from the other sites in New York.

Mercury concentrations in smallmouth bass from Cranberry Lake, located in the Adirondack Park, displayed a higher than average concentration of mercury. Since the lake and its drainage are located in an area which contains no known source of mercury contamination, the results were of interest. Armstrong and Sloan (1980) attributed these higher than average mercury concentrations to air deposition.

Few analyses were conducted by the NYDEC to determine mercury concentrations in common carp (Figure A2, Table A5). Average mercury concentrations found during the 12 year period were below detection to 0.6 ppm. Onondaga Lake fish were analyzed individually. Mercury concentrations observed in carp collected near Ciba-Geigy were among the higher values observed in the NYDEC data.

Cadmium and Chromium

Cadmium and chromium concentrations in smallmouth bass flesh were analyzed by the NYDEC during the years 1975 to 1977 (Table A6). Average cadmium concentrations were observed from below detection to 0.27 ppm; average chromium ranged from 0.03 to 0.28 ppm. Cadmium and chromium concentrations in smallmouth bass collected near Ciba-Geigy in 1988 were all below detection.

Five carp were analyzed for liver concentrations of cadmium and chromium by the NYDEC (Table A7). Flesh of carp captured near Ciba-Geigy in 1988 had concentrations of these two metals that were below detection. Liver concentrations in these fish were higher than the 0.08 and 0.32 ppm found for cadmium and chromium, respectively, in Belmont Lake, New York.

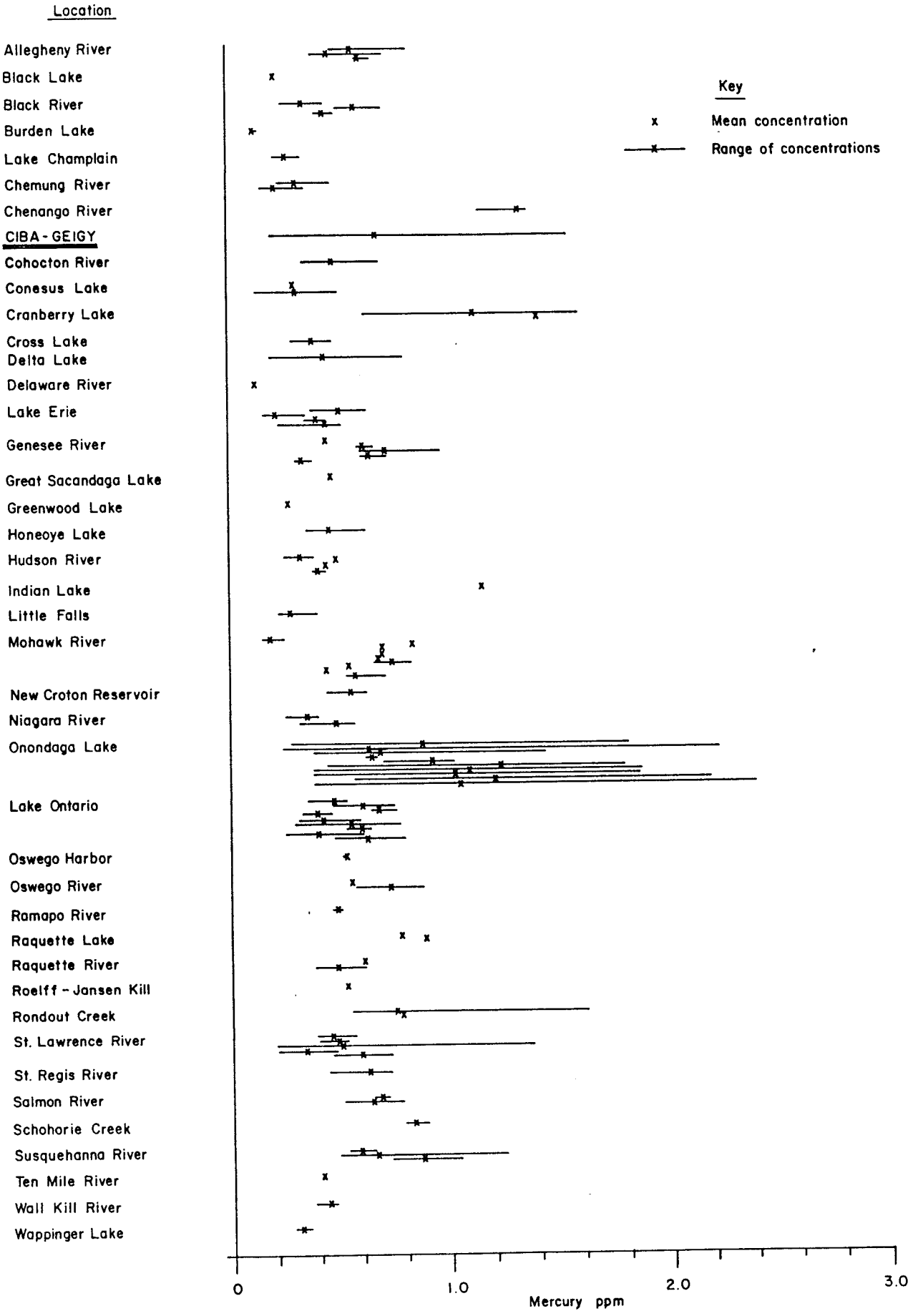

Figure A1 Comparison of mercury concentrations in flesh of smallmouth bass. Data from NYDEC Technical reports. See Appendix tables A1 to A5.

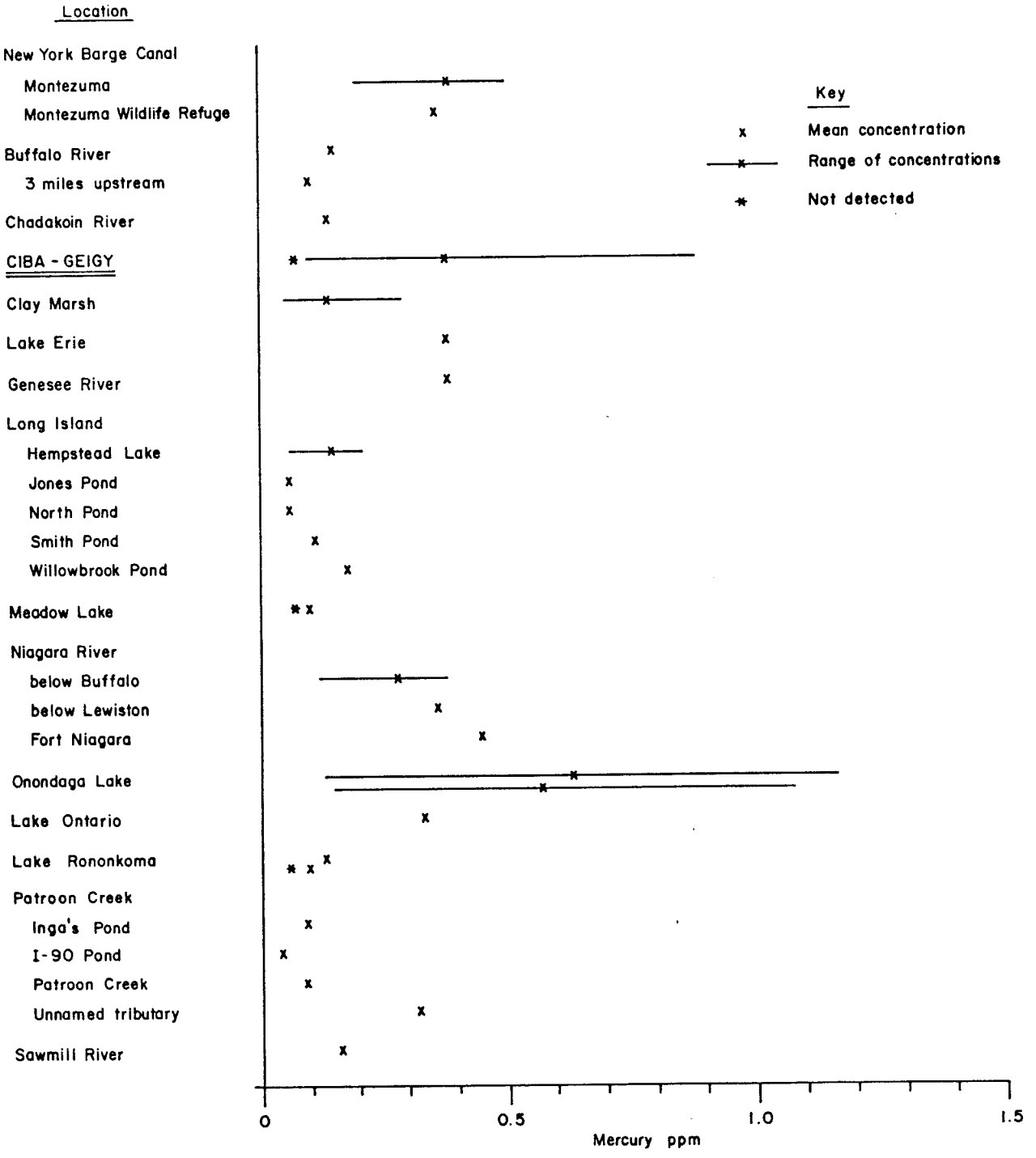

Figure A2 Comparison of mercury concentrations in flesh of common carp. Data from NYDEC Technical reports. See Appendix tables A1 to A5.

Table A1 Mercury concentrations in smallmouth bass captured in New Data was obtained from NYDEC Technical Report 78-1. Unless noted, samples are assumed to be standard (skin on) fillets by wet weight.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Black River above Greig	1977	0.89	0.74 - 1.00	7	2
Canisteo River Addison	1977	0.38	0.33 - 0.42	21	2
Lake Champlain Fort Ticonderoga	1975-76	0.40	0.30 - 0.52	14	3
Plattsburgh	1977	0.44	-	10	1
Chemung River	1975-76	0.26	0.23 - 0.30	11	2
Cohocton River Cooper Plain	1977	0.53	0.46 - 0.62	14	2
Delaware River Port Jervis	1975-76	0.76	-	2	1
Genesee River below Industry	1975-76	0.46	0.36 - 0.60	13	3
Lake George Bolton Landing	1975-76	0.49	-	5	1
Hudson River above Corinth	1975-76	0.40#	0.45 - 0.58#	11	3
Waterford	1975-76	0.40	0.31 - 0.54	10	2
Mohawk River Fonda	1977	0.60	-	10	1
Hoffmans	1977	0.71	-	10	1
Vischer Ferry	1977	0.64	-	10	1
New Croton Reservoir	1977	0.25	-	2	1
Niagara River Buffalo	1977	0.31	0.18 - 0.46	19	2
Oswegatchie River Gouveneur	1977	0.53	-	4	1
Oswego Harbor	1975-76	1.27	-	1	1

Table A1 (continued).

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Raquette River Norfolk	1975-76	0.60	0.47 - 0.76	15	3
Rondout Creek Bloomington	1977	0.64	-	10	1
St. Lawrence River Ogdensburg	1977	0.57	0.49 - 0.74	21	2
Seneca-Oswego Canal below Fulton	1975-76	1.98	-	3	1
Susquehanna River Smithboro	1975-76	0.43	0.22 - 0.64	12	2
Windsor	1977	0.48	0.36 - 0.61	12	2
Wallkill River Montgomery	1977	0.38	0.35 - 0.42	16	2
Wappingers Lake	1977	0.27	-	3	1

values as reported in the NYDEC publication

Table A2 Mercury concentrations in smallmouth bass captured in New York. Data obtained from NYDEC Technical Report 81-1. Unless noted, these samples are assumed to represent standard (skin on) fillets by wet weight.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Burden Lake	1979	0.11	0.11 - 0.12	2	*
Cranberry Lake	1979				
standard fillet		1.12	0.62 - 1.59	4	*
whole fish		0.08	-	3	1
Delta Lake	1979	0.43	0.18 - 0.80	19	*
Lake Erie					
Dunkirk	1979	0.50	0.37 - 0.63	24	2
Genesee River	1978				
lower first falls		0.44	-	5	1
Greenwood Lake	1979	0.26	-	6	1
Onondaga Lake	1977	0.87	0.27 - 1.81	20	*
	1978	0.63	0.24 - 2.22	29	29
	1979	0.68	0.38 - 1.43	52	*
Oswego River					
Hinmansville	1978	0.54	-	16	1
Raquette Lake					
North Point	1978	0.77	-	12	1
Raquette River					
Unionville	1978	0.60	-	7	1
Rondout Creek					
below Eddyville					
Dam	1979	0.75	0.54 - 1.61	5	2
St. Lawrence River					
Alexandria Bay	1979	0.45	0.38 - 0.56	20	2
Massena	1979	0.47	0.39 - 0.52	14	2
St. Regis River					
Helena	1978	0.61	0.43 - 0.72	24	2

* Not reported

Table A3 Mercury contamination in smallmouth bass captured in New York. Data from NYDEC Technical Report 82-1. Unless noted, these samples are assumed to represent standard (skin on) fillets by wet weight.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Allegheny River					
above Oleon	1979	0.57	0.47 - 0.82	10	3
below Oleon	1979	0.47	0.39 - 0.72	15	3
Black River					
Brownville	1979	0.34	0.25 - 0.44	30	2
Black Lake					
Morristown	1979	0.21	0.21 - 0.21	14	2
Lake Champlain					
Ticonderoga	1979	0.26	0.21 - 0.33	9	2
Chemung River					
Chemung	1979	0.31	0.23 - 0.47	23	2
Chemung	1980	0.21	0.15 - 0.35	27	3
Hudson River					
North Creek	1979	0.32	0.24 - 0.38	24	2
Luzerne	1979	0.48	-	13	1
	1980	0.44	-	5	1
Glens Falls	1980	0.40	0.38 - 0.44	15	2
Mohawk River					
Little Falls	1979	0.17	0.14 - 0.24	23	2
Fonda	1980	0.84	-	14	1
Hoffmans	1980	0.70	-	12	1
Vischer Ferry	1980	0.70	-	15	1
Onondaga Lake	1979	0.64	0.62 - 0.67	19	2
Lake Ontario					
Pultneyville	1979	0.47	0.35 - 0.53	25	2
Oswego Harbor	1979	0.60	0.46 - 0.75	26	2
Salmon River					
(Lake Ontario)	1979	0.67	0.64 - 0.71	24	2
Susquehanna River					
Smithboro	1979	0.58	0.52 - 0.64	29	2

Table A4 Mercury concentrations in smallmouth bass collected in New York. Data from NYDEC Technical Report 82-2. Unless noted, these samples represent standard (skin on) fillets by wet weight.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Allegheny River					
below Allegheny	1982	0.60	0.58 - 0.66	7	2
Black River					
Brownville to					
Dexter	1982	0.58	0.50 - 0.72	19	3
above Greig	1982	0.44	0.40 - 0.48	2	2
Chenango River					
Chenango Forks	1982	1.33	1.14 - 1.36	16	2
Cohocton River					
Coopers Plains	1982	0.48	0.34 - 0.69	5	2
Conesus Lake					
McPherson Pt.	1983	0.30	-	3	1
Old Orchard Pt.	1983	0.31	0.12 - 0.50	7	3
Cranberry Lake	1981	1.40	-	3	2
Cross Lake	1981	0.39	0.28 - 0.48	9	2
Delaware River					
Knights Eddy	1982	0.12	-	1	*
Lake Erie	1980	0.21	0.15 - 0.35	19	*
Dunkirk	1981	0.39	0.34 - 0.44	24	2
Lackawanna	1981	0.44	0.23 - 0.52	19	2
Genesee River					
Belvidere	1982	0.61	0.58 - 0.66	3	2
Canadea	1982	0.72	0.60 - 0 97	3	2
Fillmore	1982	0.63	0.60 - 0.72	4	2
lower falls	1982	0.33	0.30 - 0.38	7	2
Great Sacandaga Lake					
Cranberry Creek	1982	0.46	-	15	1
Honeoye Lake					
Richmond	1983	0.45	0.35 - 0.62	15	3
Hudson River					
Luzerne	1980	0.28	-	6	1
Indian Lake					
Fort Drum	1982	1.15	-	1	*

Table A4 (continued).

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Little Falls	1980	0.27	0.22 - 040	11	3
Mohawk River					
Fonda	1980	0.68	-	16	1
	1983	0.74	0.66 - 0.83	20	3
Hoffmans	1980	0.54	-	18	1
Vischer Ferry	1980	0.44	-	15	1
	1983	0.57	0.53 - 0.71	20	4
New Croton Reservoir	1981	0.54	0.44 - 0.62	18	3
Niagara River					
below Buffalo	1981	0.34	0.24 - 0.40	21	2
Fort Niagara	1981	0.48	0.31 - 0.57	12	2
Onondaga Lake	1980	0.92	0.70 - 1.02	22	2
	1981	1.23	0.45 - 1.78	50	*
	1983	1.08	0.38 - 1.86	50	*
	1984	1.03	0.38 - 1.85	50	*
	1985	1.20	0.56 - 2.18	46	46
	1986	1.05	0.38 - 2.39	50	50
Lake Ontario					
Chaumont Bay	1983(spr)	0.39	0.32 - 0.46	2	*
	1983(sum)	0.42	0.30 - 0.58	13	*
Galloo Island	1983	0.54	0.28 - 0.77	23	*
Pultneyville	1981	0.58	0.52 - 0.64	30	2
	1983	0.40	0.24 - 0.60	43	*
Stony Island	1982	0.62	0.47 - 0.80	15	*
Oswego River below Hinmansville	1981	0.72	0.57 - 0.88	4	2
Oswego Harbor	1981	0.51	0.50 - 0.53	24	2
Ramapo River Sloatsburg	1983	0.48	0.45 - 0.50	21	2
Raquette Lake North Point	1982	0.89	-	5	1
Raquette River Unionville	1982	0.48	0.38 - 0.61	28	4
Roelff-Jansen Kill below papermill	1981	0.52	-	1	1

Table A4 (continued).

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Rondout Creek above Eddyville dam	1982	0.77	0.76 - 0.78	7	2
St. Lawrence River	1983	0.49	0.19 - 1.37	62	*
Alexandria Bay	1981	0.32	0.20 - 0.47	5	3
Massena	1981	0.58	0.45 - 0.71	19	2
St. Regis River Helena	1981	0.44	0.38 - 0.50	12	2
Salmon River Port Ontario/ Pulaski	1981	0.64	0.51 - 0.78	18	2
Schoharie Creek Esperance	1981	0.83	0.79 - 0.89	7	2
Susquehanna River					
Smithboro	1982	0.65	0.47 - 1.24	19	5
Windsor	1982	0.85	0.71 - 1.03	17	2
Ten Mile River Webatuck	1983	0.40	-	1	*
Wallkill River Montgomery	1982	0.44	0.38 - 0.46	10	2
Wappingers Lake	1981	0.30	0.27 - 0.34	13	2

* Not reported.

Table A5 Mercury concentrations in carp collected in New York. Data is from NYDEC Technical Reports 81-1, 82-1, 82-2, and 87-4. Unless noted, these samples are assumed to represent standard (skin on) fillets by wet weight.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
NY Barge Canal					
Montezuma	1978	0.38	0.20 - 0.50	20	2
Montezuma Wildlife Refuge	1981	0.36	-	13	1
Belmont Lake	1981	0.06	-	5	1
Buffalo River	1980	0.15	0.14 - 0.16	13	2
3 miles upstream	1983	0.10	0.10 - 0.12	10	2
Buffalo					
South Park Lake	1977	0.03	-	20	1
Tifft Farm Pond	1977	0.02	-	6	1#
Buffalo River					
Buffalo	1977	0.12	-	10	1
Chadakoin River					
below Jamestown	1979	0.14	-	1	*
Clay Marsh	*	0.14	0.05 - 0.29	*	2
Delaware Park Lake	1977	0.02	-	20	1
Erie Canal					
Clyde River	1975-76	0.28	0.17 - 0.46	8	2
Lake Erie					
Lackawanna	1981	0.38	-	19	1
Genesee River					
W. Henrietta	1982	0.38	-	3	1
Long Island					
Hempstead Lake	1985	0.15	0.06 - 0.21	5	5
Jones Pond	1984	0.06	0.06 - 0.07	3	3
North Pond	1980	0.06	-	15	1
Smith Pond	1984	0.11	0.10 - 0.11	2	2
Willowbrook Pond	1984	0.18	-	1	1
Meadow Lake - NYC					
Fairgrounds	1982	<0.10	<0.10 - <0.10	3	2

Table A5 (continued).

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Niagara River					
below Buffalo	1981	0.28	0.12 - 0.38	24	2
below Lewiston	1981	0.36	-	12	1
Fort Niagara	1981	0.44	-	6	1
Onondaga Lake	1985	0.63	0.13 - 1.16	14	14
	1986	0.57	0.15 - 1.07	20	20
Lake Ontario					
Irondequoit Bay	1981	0.33	-	14	1
Lake Ronkonkoma	1978	0.13	-	2	1
	1981	<0.10	-	4	1
Patroon Creek					
Inga's Pond	1981	0.09	-	1	*
I-90 pond	1981	0.04	-	1	*
Patroons Creek	1981	0.09	-	1	*
unnamed tributary	1981	0.32	-	1	*
Rochester					
Monroe Community College Pond	1977	0.02	-	20	1
Rondout Creek					
Bloomington	1975-76	0.42	-	3	1
Sawmill River					
Farragut Ave.	1982	0.16	-	3	1
Seneca - Oswego Canal below Fulton	1975-76	0.50	-	5	1
Susquehanna River					
Smithboro	1975-76	0.46	0.40 - 0.51	11	2

Carp, goldfish analyzed. Head and viscera removed from goldfish.
* Not reported.

Table A6 Cadmium (Cd) and chromium (Cr) concentrations in smallmouth bass captured in New York. Data obtained from NYDEC Technical Reports 78-1 and 81-1. Unless noted, samples are assumed to be standard (skin on) fillets by wet weight.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Black River above Greig	1977	0.04 Cd	0.03 - 0.04	7	2
		0.09 Cr	0.09 - 0.09	7	2
Canisteo River Addison	1977	<0.01 Cd	<0.01 - <0.01	21	2
		0.03 Cr	0.02 - 0.04	21	2
Lake Champlain Fort Ticonderoga	1975-76	<0.05 Cd	<0.05 - <0.05	10	2
Plattsburg	1977	0.03 Cd	-	10	1
		0.15 Cr	-	10	1
Chemung River	1975-76	<0.25 Cd	-	5	1
Cohocton River Cooper Plain	1977	<0.01 Cd	<0.01 - <0.01	14	2
		0.03 Cr	0.01 - 0.04	14	2
Delaware River Port Jervis	1975-76	0.27 Cd	-	2	1
Genesee River below Industry	1975-76	0.08 Cd	-	4	1
Hudson River Waterford	1975-76	<0.05 Cd	<0.05 - <0.05	10	2
Mohawk River Fonda	1977	0.09 Cd	-	10	1
		0.28 Cr	-	10	1
Hoffmans	1977	0.09 Cd	-	10	1
		0.14 Cr	-	10	1
Vischer Ferry	1977	0.09 Cd	-	10	1
		0.20 Cr	-	10	1
New Croton Reservoir	1977	<0.01 Cd	-	2	1
		0.24 Cr	-	2	1
Niagara River Buffalo	1977	<0.01 Cd	<0.01 - <0.01	19	2
		0.09 Cr	0.02 - 0.16	19	2

Table A6 (continued).

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Oswegatchie River Gouveneur	1977	0.05 Cd	-	4	1
		0.10 Cr	-	4	1
Raquette River Norfolk	1975-76	<0.05 Cd	-	5	1
Rondout Creek Bloomington	1977	0.04 Cd	-	10	1
		0.07 Cr	-	10	1
Oswego Harbor	1975-76	<0.01 Cd	-	1	1
		0.24 Cr	-	1	1
St. Lawrence River Ogdensburg	1977	0.05 Cd	0.05 - 0.05	21	2
		0.09 Cr	0.08 - 0.10	21	2
Susquehanna River Windsor	1977	<0.01 Cd	<0.01 - <0.01	12	2
		0.08 Cr	0.08 - 0.08	12	2
Wallkill River Montgomery	1977	0.14 Cd	0.14 - 0.14	16	2
		0.04 Cr	0.03 - 0.05	16	2
Wappingers Lake	1977	<0.01 Cd	-	3	1
		0.08 Cr	-	3	1

* Not reported.

Table A7 Cadmium and chromium concentrations in carp captured in New York. Data obtained from NYDEC Technical Report 82-2. Samples were analyzed from carp livers.

Location	Date	Average (ppm)	Range (ppm)	No. of Fish	No. of Analyses
Belmont Lake	1981	0.08 Cd	-	5	1
		0.32 Cr	-	5	1

Appendix B

Comparisons of Mercury Extraction Methodologies

Introduction

Mercury was the one compound routinely found in fish flesh during the initial analytical analyses conducted for the Hudson River study. Since these concentrations were routinely above detection levels, additional studies were conducted to evaluate the implied precision and accuracy of the EPA-SAS chemical analytical methods used. A second objective of this investigation of the analytical methods was to compare analytical results from the EPA-SAS methods to those obtained using the New York State analytical methods for determining mercury in fish tissue.

Summary

In the original analytical approach, a laboratory quality control program which included the use of 10 percent laboratory spikes and 10 percent matrix spikes was employed. This QC program differed from the New York State analytical program which uses a National Bureau of Standards (NBS) mercury reference standard (NBS RM-50) in albacore tuna.

As an initial step in these method evaluations, the NBS mercury standard in tuna was obtained and analyzed using the EPA-SAS methods. Four replicate analyses of this NBS RM-50 tuna standard, which is reported to contain an average of 0.95 mg/kg mercury, yielded an average recovery with EPA-SAS methodology of 55 percent (47%, 51%, 60%, 60%). These recoveries were not as high as what is typically reported in published literature for other methods, and additional studies were indicated.

The New York State methods were obtained from the NYDEC (through Ralph Karcher, chemist) and used for analysis of fish flesh and the NBS RM-50 standard (Table B1). The recovery on the NBS standard was high (97.8%). The two fish tissues analyzed were consistent with the original EPA-SAS method results, differing by less than 20 percent of the original values.

A decision was made to reanalyze all the smallmouth bass flesh samples utilizing the New York State methods with a quality control program which included three laboratory replicates, four matrix spikes (flesh samples were spiked at 0.8 mg/kg), and four NBS RM-50 tuna standards. The precision of the replicate analyses by New York State methodology ranged from 7.7 to 24 percent (Table B2), averaging less than 15 percent. The recovery of the mercury matrix spikes ranged from 90 to 137 percent (Table B3). The NBS RM-50 standard recovery ranged from 68 to 96 percent, averaging 80 percent (Table B4).

The results of the reanalysis of the smallmouth bass flesh samples were compared with the original results obtained by EPA-SAS methods (Table B5). The absolute difference between the paired analyses was typically (46%) less than 0.12 mg/kg. The overall difference between the paired analyses, calculated by subtraction of the New York State value from the EPA-SAS value, was -0.08 mg/kg. Differences in the analytical results between the two methods were not statistically significant ($p > 0.05$).

The investigations into the methodology used to analyze the mercury concentrations in fish flesh are similar in terms of implied precision and accuracy. These comparisons indicate that even if New York State methods are used in the original analytical determinations, the resulting data and ecological interpretation would not have been different.

Table B1 Initial comparison of mercury concentrations in fish flesh collected near Ciba-Geigy, Glens Falls, New York, 1988, analyzed by EPA-SAS and New York State Department of Environmental Conservation methodologies.

Collection-Fish Number	Species	Aquatec Laboratory No. Original	Aquatec Laboratory No. Reanalysis	EPA-SAS Analysis (mg/kg)	New York State Analysis (mg/kg)	Paired Difference (mg/kg)
115-02	smallmouth bass	89435	95680	0.73	0.60	+0.13
115-01	common carp	91543	95681	0.88	0.91	-0.03
NBS RM-50	albacore tuna	-	-	-	0.97*	-

* Reported value 0.95 mg/kg for NBS RM-50 standard.

Table B2 Mercury replicate determinations for smallmouth bass flesh collected near Ciba-Geigy, Glens Falls, New York, 1988, utilizing New York State Department of Environmental Conservation methodologies.

Collection-Fish Number	Aquatec Laboratory No. Original	Aquatec Laboratory No. Reanalysis	Replicate Values (mg/kg) Original	Replicate Values (mg/kg) Reanalysis	Percent Difference
102-01	89373	95896	0.83	1.06	24%
131-52	89871	95909	0.54	0.49	9.3%
168-01	92253	95922	0.94	1.02	7.7%

Table B3 Mercury matrix spike recoveries from smallmouth bass tissue collected near Ciba-Geigy, Glens Falls, New York, 1988, utilizing New York State Department of Environmental Conservation methodologies.

Collection-Fish Number	Aquatec Laboratory Number		Recovery of Hg
	Original	Reanalysis	
100-01	88678	95895	112%
115-02	89435	95901	90%
131-01	89863	95908	137%
149-01	91504	95919	99%

Table B4 Recoveries obtained from NBS RM-50 albacore tuna standards analyzed utilizing New York State Department of Environmental Conservation methodologies. Reported mercury concentration in the standard is 0.95 mg/kg methyl mercury.

Aquatec Laboratory Number	Mercury (mg/kg)	Recovery
95894	0.81	85%
95903	0.91	96%
95914	0.68	71%
95923	0.64	68%

Table B5 Comparison of mercury concentrations in smallmouth bass flesh collected near Ciba-Geigy, Glens Falls, New York, 1988, analyzed by the EPA-SAS method and New York State Department of Environmental Conservation methodologies.

Collection-Fish Number	Aquatec Laboratory Number		EPA-SAS Analysis (mg/kg)	New York State Analysis (mg/kg)	Paired Difference (mg/kg)
	Original	Reanalysis			
100-01	88678	95895	0.59	0.86	-0.27
102-01	89373	95896	1.21	0.83	+0.38
113-01	89427	95897	0.54	0.44	+0.10
114-02	89429	95898	0.40	0.51	-0.11
114-23	89431	95899	0.19	0.27	-0.08
115-01	89433	95900	0.54	0.52	+0.02
115-02	89435	95901	0.73	0.63	+0.10
115-03	89437	95902	1.39	1.02	+0.37
121-04	89700	95904	0.52	0.34	+0.18
121-05	89703	95905	0.37	0.42	-0.05
128-07	89859	95906	1.21	1.1	+0.11
129-01	89861	95907	0.59	0.72	-0.13
131-01	89863	95908	1.54	1.31	+0.23
131-52	89871	95909	0.49	0.54	-0.05
132-01	89873	95910	0.37	0.57	-0.20
132-02	89875	95911	0.37	0.56	-0.19
132-02D	89877	95912	0.46	0.53	-0.07
132-03	89879	95913	0.66	0.69	-0.03
132-04	89881	95915	0.65	0.50	+0.15
138-01	89987	95916	0.41	0.71	-0.30
138-01D	89989	95917	0.44	0.65	-0.21
138-02	89991	95918	0.67	0.59	+0.08
149-01	91504	95919	0.68	0.77	-0.09
159-01	92077	95920	0.64	0.86	-0.22
167-01	92251	95921	0.68	0.76	-0.08
168-01	92253	95922	0.86	0.94	-0.08

Figure 2. Bathymetry of the Hudson River near Glen-Sanitary, Glens Falls, New York, 1988.

Figure 3.8 Capture locations of redacted smallmouth bass and carp near Cobo-Geigy, Glens Falls, New York, 1988.