ASSESSMENT OF THE STATUS OF THE FISH COMMUNITY OF ONONDAGA LAKE IN 2000, ONONDAGA LAKE 2000 FISH MONITORING PROGRAM

Prepared for

ONONDAGA COUNTY DEPARTMENT OF DRAINAGE AND SANITATION
650 HIAWATHA BOULEVARD WEST
SYRACUSE, NEW YORK 13204-1194

Prepared by

ICHTHYOLOGICAL ASSOCIATES, INC.
50 Ludlowville Road,
Lansing, New York 14882
(607) 533-8801

and

ECOLOGIC, LLC.
5891 Ridge Road
Cazenovia, New York 13035
(315) 687-6397

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1.0 INTRODUCTION

1.1 Regulatory Background

The Onondaga County Department of Drainage and Sanitation (OCDDS) is conducting an Ambient Monitoring Program (AMP) on Onondaga Lake as part of an Amended Consent Judgement (ACJ) entered in January 1998 between Onondaga County, the New York State Department of Environmental Conservation (NYSDEC), and the Atlantic States Legal Foundation. This program focuses on monitoring and assessing the water quality of Onondaga Lake, its tributaries, and the Seneca River. The overall goal of the AMP is to evaluate the impacts of alterations and improvements to the County's Metropolitan Syracuse Wastewater Treatment Plant (Metro) and Combined Sewer Overflows (CSOs) on water quality. The primary focus of the AMP is to assess progress towards compliance with ambient water quality standards and assess progress towards use attainment (OCDDS 1998). Measurement of such progress will be accomplished through assessment of the physical, chemical, and biological attributes of the aquatic resources of the lake and its connecting waters.

The ACJ directs the County to "*Complement the chemical monitoring program with a biological monitoring effort to assess the densities and species composition of phytoplankton, zooplankton, macrophytes, macrobenthos, and fish*" (ACJ Appendix D, IV.4). It further directs the County to "*Evaluate the success of walleye, bass, and sunfish propagation (quantitative lakewide nest surveys, recruitment estimates, and juvenile community structure) in the lake*" (ACJ Appendix D, IV.5). These directives were the impetus for establishing the County's Onondaga Lake Fish monitoring Program. This program involves studying the fisheries resources of the lake over time as mandated improvement projects are completed at the Metro and the CSOs.

The year 2000 Onondaga Lake fish sampling program was aimed at assessing the relative abundance and species composition of the lake's fish community, evaluating propagation success of important gamefish, and establishing baseline conditions of the fish community against which the effects of improvement projects can be evaluated. The 2000 program involved extensive sampling of the larval, juvenile, and adult fish life stages and nest distribution in the lake littoral zone. This was the initial year of a sampling program scheduled to be conducted through the year 2012. This report presents the data collected during the 2000 Onondaga Lake fish sampling program and an analysis of the status of the fish community based on the data collected.

1.2 Physical Features of Onondaga Lake

Onondaga Lake is situated at the northern edge of the city of Syracuse in Onondaga County, NY. It has a surface area of 11.7 km^2 and a maximum depth of 20.5 m (Murphy 1978). The lake's drainage basin measures 600 km^2, and the lake drains from southeast to northwest, discharging into the Seneca River (Murphy 1978). The lake contains two basins (north and south) separated by a somewhat shallower saddle. The south basin is the larger and deeper of the two basins (Murphy 1978). The lake historically contained salt springs along its southern and southeastern shores, and the chloride concentration of the lake is quite high in comparison to other New York lakes (Murphy 1978). The lake has also received the considerable discharges of industrial and municipal wastes during the past century that have altered the physical, chemical, and biological characteristics of the lake.

2.0 MATERIALS AND METHODS

Sampling of the Onondaga Lake fish community was accomplished by targeting different fish life stages and habitats with collection gear suited specifically for sampling the various aspects of the community of interest. Thus, individual programs for sampling pelagic (open water) larval fish, littoral (shallow water or shoreline oriented) larval fish, littoral juvenile fish, littoral adult fish, pelagic adult fish, and littoral nesting fish were employed. The littoral habitat of the lake was divided into five strata based on a combination of substrate type and wave energy, both of which influence aquatic macrophyte abundance and, in turn, fish abundance (Figure 2-1). These five strata are:

Stratum 1. Oncolite substrate with low wave energy (NW shore of lake).

Stratum 2. Wastebeds with a mixture of $CaCO_3$ (20%), Ca silicate (10%), MgOH (8%), and other mineral substrates with silt-like texture (mid-lake, west shore).

Stratum 3. South end (with sediments reflecting influences from tributaries and wastewater/stormwater facility outfall)

Stratum 4. Oncolite substrate with high wave energy (mid-lake, east shore)

Stratum 5. Oncolite substrate with medium wave energy (NE shore of lake).

Sampling for littoral fish life stages was distributed throughout each of the five strata to try to identify any differences that might exist in the fish communities associated with these distinct habitats within the lake. The pelagic habitat of the lake was divided into two parts, the north basin and the south basin, to determine if differences existed between the fish use of these portions of the lake.

All sampling was conducted by OCDDS personnel trained in sample collection procedures. County consultants Ecologic, LLC. (EcoLogic), and Ichthyological Associates, Inc. (IA), conducted audits of OCDDS sampling methods as part of the quality assurance program for the overall fish monitoring program. Recommendations resulting from these audits were incorporated into the OCDDS sampling methods to ensure samples were collected in a consistent and valid manner.

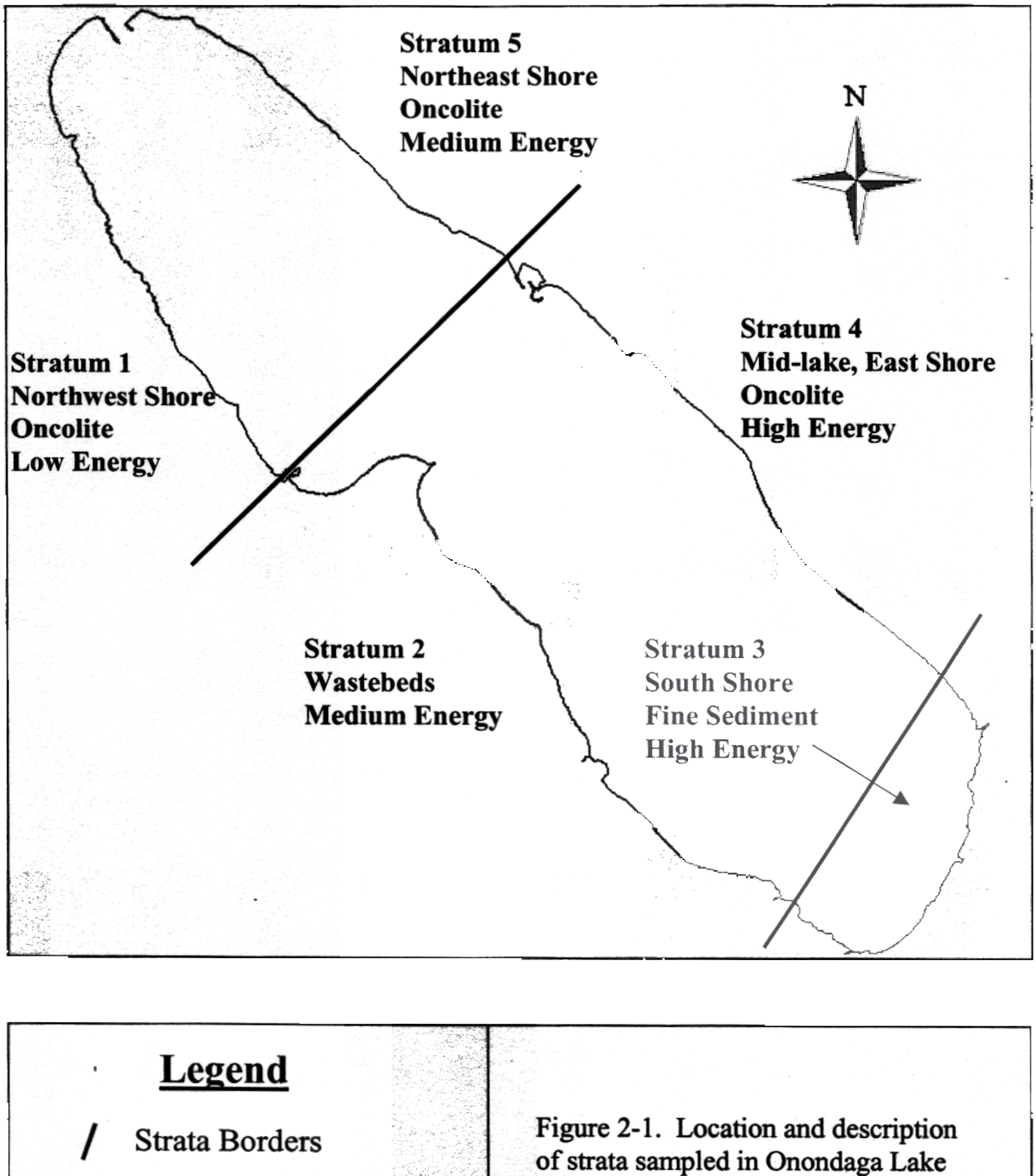


Figure 2-1. Location and description of strata sampled in Onondaga Lake during 2000.

2.1 Pelagic Larvae Sampling

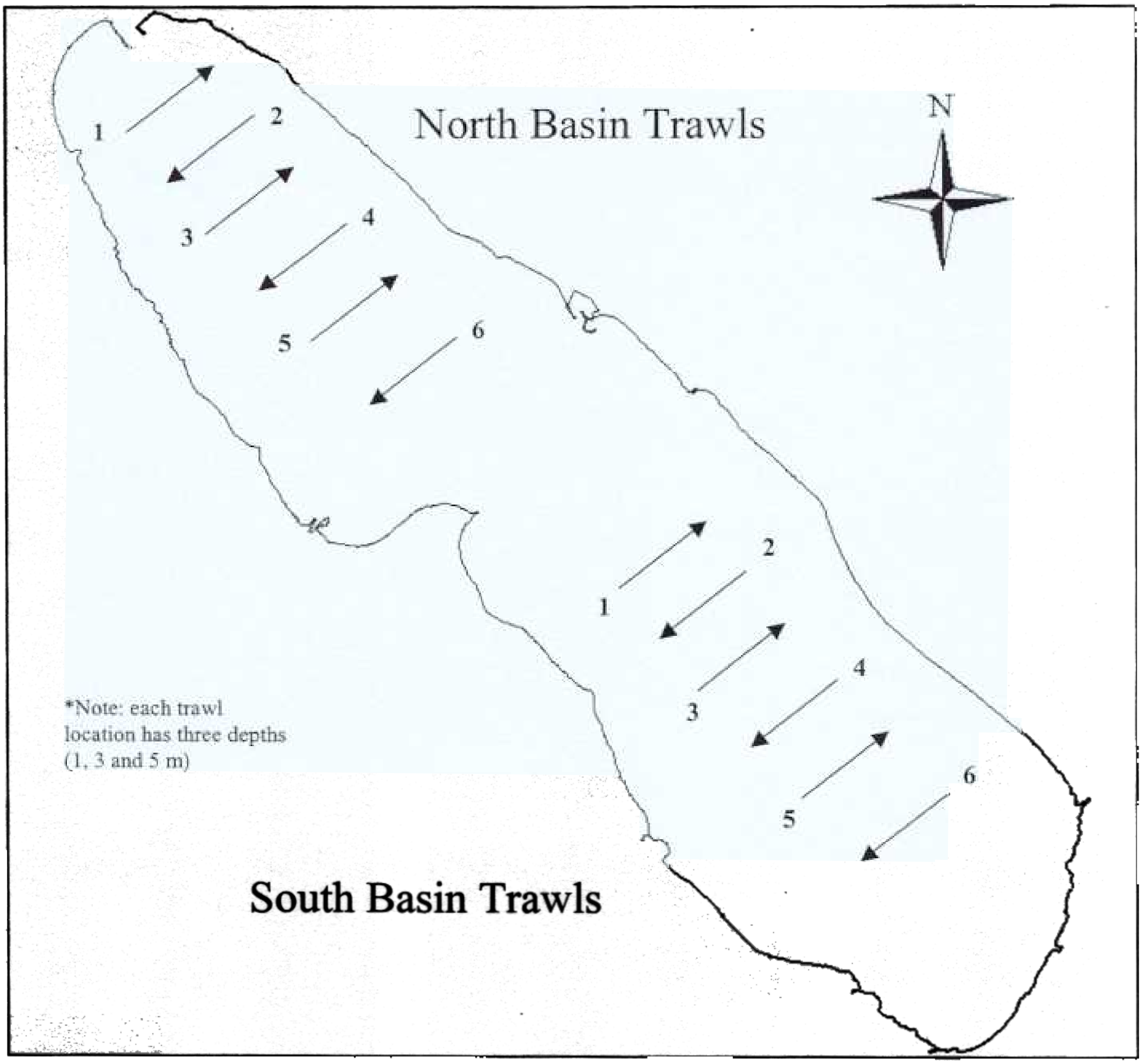
Pelagic fish larvae sampling followed the procedures outlined in the NYSDEC Percid Sampling Manual (1994). Samples were collected by trained OCDDS personnel biweekly from May through July in both the north and south basins. Larvae were sampled at night with a Miller high-speed trawl using a maximum net mesh size of 500 μm. A depressor was suspended 0.6 m (2 ft) below the trawl for stability. A calibrated flow meter was mounted in the center of the mouth opening to estimate volume of water strained. A calibrated Hydrolab multi-parameter water quality meter was used to measure a profile of water temperature, dissolved oxygen, conductivity, pH, and redox at 0.5-m intervals in each basin.

Pelagic ichthyoplankton samples were collected at depths of 1, 3, and 5 meters in open water (> 10 m) at fixed north and south basin sampling locations (Figure 2.1-1). Six replicate samples were collected from each depth for a total of 36 samples collected within Onondaga Lake during each sample period. Trawls were towed in a unilateral direction and at a constant speed for approximately four minutes. Trawls were retrieved and contents were emptied into a labeled plastic sample jar and preserved in 70% ethanol solution with rose bengal dye added to assist in sorting at the laboratory. Samples were subsequently transferred to 10% formalin at the suggestion of Darrel Snyder of the Colorado State University Larval Fish Laboratory.

Larval fish were identified to species (or the lowest possible taxon) and enumerated for each sample by OCDDS personnel trained in larval fish identification. The mean number of larvae/m^3 of each species was calculated by estimating the volume of water strained on each haul from the cross-sectional area of the trawl and water velocity determined from the flow meter in the net.

2.2 Littoral Larvae Sampling

Sampling of littoral larvae followed the same schedule as pelagic larvae. Littoral larval samples were collected by trained OCDDS personnel biweekly from May through July. A stratified random sampling design was used to decrease spatial variability. The lake was divided into five strata based on habitat type. These strata were described previously in Section 2.0



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Trawl Tow Sites

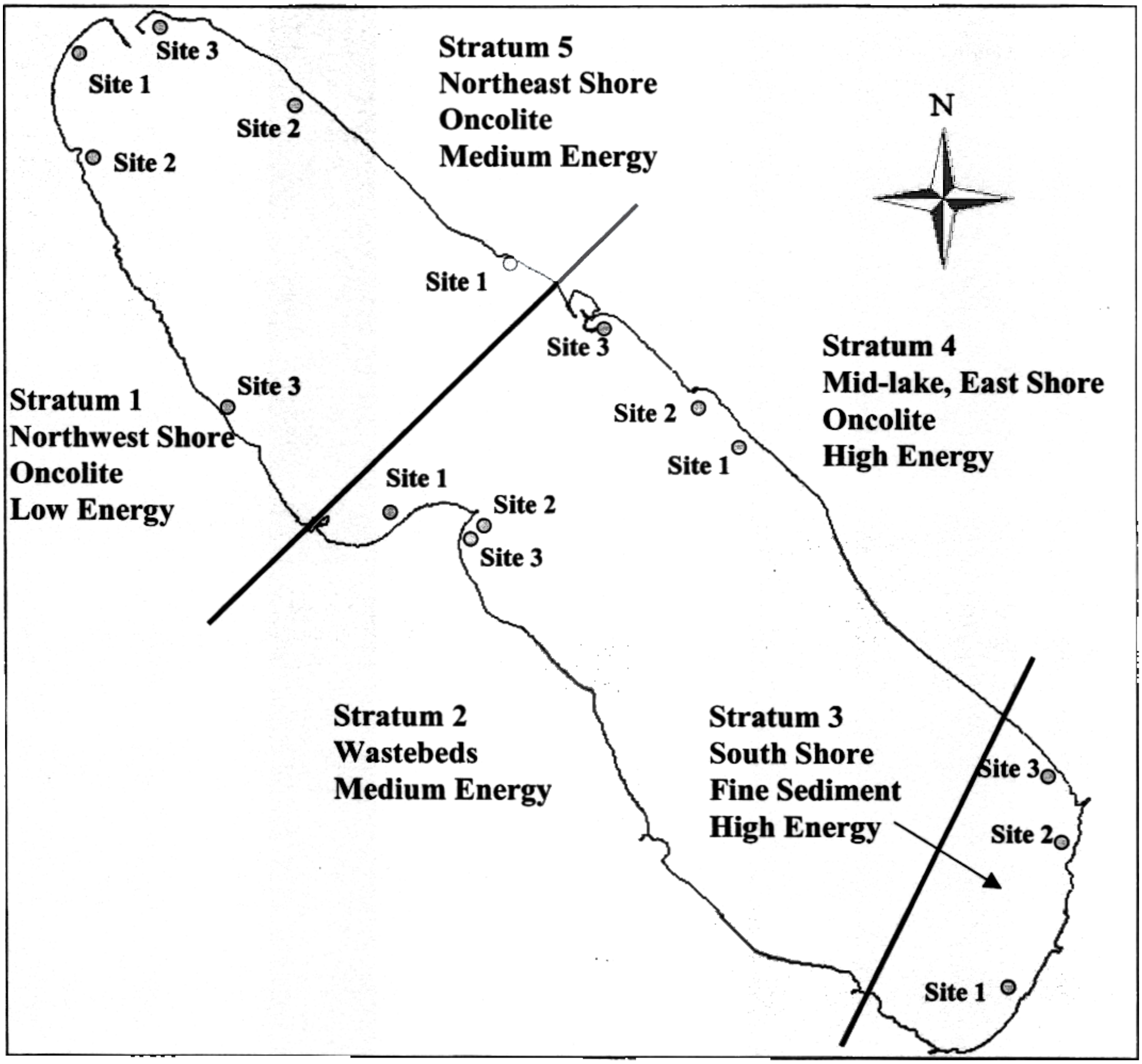
Figure 2.1-1. Pelagic larval trawl locations in Onondaga Lake during 2000.

(Figure 2.2-1). Three sites within each stratum were sampled with three replicate 10-m sweeps of a 500-µm larval fish seine dragged at a water depth of 1 m. Prior to sampling, water temperature, dissolved oxygen, conductivity, pH, and redox were measured at a depth of 1 m. After a seine sweep was completed, the seine was rinsed in a 30-gallon tub until all material was removed. The contents of the tub were then filtered through a 500-µm sieve bucket. The material from the sieve was placed in a pre-labeled sample jar and preserved in 70% ethanol with rose bengal stain added. Samples were subsequently transferred to 10% formalin at the suggestion of Darrel Snyder of the Colorado State University Larval Fish Laboratory. Larval fish from each sample were identified to species (or the lowest possible taxon) and enumerated. Some of these samples were picked, sorted, and identified by trained OCDDS personnel. The remaining samples were picked, sorted, and identified by personnel at the Colorado State University Larval Fish Laboratory in Fort Collins, CO in order to expedite sample processing. Catch per unit effort (CPUE) was calculated as number of fish per standard haul.

2.3 Juvenile Fish Sampling

Juvenile fish sampling in Onondaga Lake during 2000 was conducted by trained OCDDS personnel and followed the procedures outlined in the NYSDEC Centrarchid Sampling Manual (1989). Juvenile fish samples were collected approximately every three weeks from May to September. Seven sampling events were completed in this time frame; early May, late May, mid-June, early July, late July, mid-August, and early September. The same stratified random sampling design that was used for littoral larval seining was also used for juvenile fish seining. The lake was divided into five strata based on habitat type (see the beginning of the methods section for characteristics and location of each stratum). Three sites within each stratum were sampled with three adjacent but separate quarter-circle sweeps of a 50 ft x 4 ft, ¼-inch mesh bag seine dragged in <2 m of water, at a total of 15 sites in the lake (Figure 2.2-1).

During sampling, one brail of the seine was held on shore, the other end was extended perpendicular to shore. Holding the in-shore brail stationary, the County field team swept the lakeward brail to shore. As the outer brail approached shore, the two brails were worked together, and the seine was beached while being careful to maintain the integrity of the bag



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- Site Location
- Strata Borders

Figure 2.2-1. Littoral seine site locations in Onondaga Lake during 2000.

section of the seine. All fish were picked and placed in holding tanks immediately upon retrieval of the seine. After the three hauls were completed at a site, the fish in each holding tank were processed in the order of their collection. All fish were identified by a fisheries biologist knowledgeable in the species composition of Onondaga Lake and counted. A minimum of 10 representative individuals of each species at each site was sampled for length. Unknown species were preserved in a 10% formalin solution and identified at a later date. Smaller (less than about 30 mm) bluegill (*Lepomis macrochirus*) and pumpkinseed (*Lepomis gibbosus*) sunfish are nearly indistinguishable from each other; therefore all young-of-year sunfish were lumped into the category of "*Lepomis* spp.

2.4 Littoral Nesting Survey

Fish nests were counted along 24 transects distributed around the lake's littoral zone on June 20, 2000. Establishment of transects is described under Section 2.5.1, *Boat Electrofishing*, since these same transects were used as boat electrofishing stations. Date of the survey was determined based on the time of year (June), water temperature (between 60 and 65°F), water clarity (ability to see bottom in 2 m of water), and weather conditions (sunny and calm). Nests in each section were counted by maneuvering a small boat at constant speed, parallel to shore, in a single transect over 1 m of water. Two observers wearing polarized sunglasses stood on an elevated platform at the front of the boat reporting the number of nests observed and, if possible, the species guarding those nests. A third person recorded the observation data, while a fourth person piloted the boat.

2.5 Adult Fish Sampling

Adult fish sampling was accomplished primarily through two distinct sampling approaches: sampling the lake's littoral zone using a boat electrofisher, and sampling the lake's pelagic zone using gill nets.

2.5.1 Boat Electrofishing

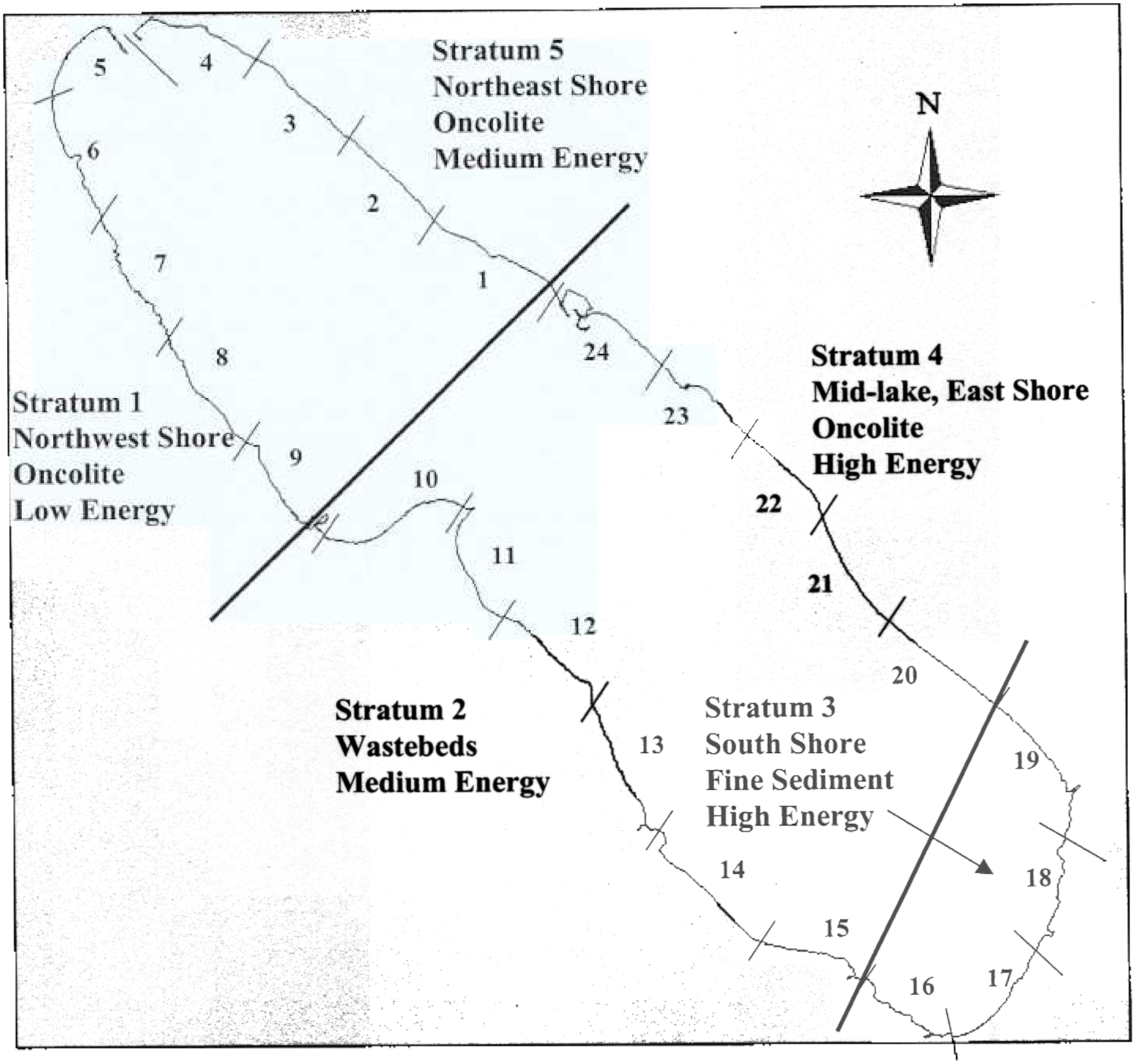
Littoral electrofishing was conducted by trained OCDDS personnel and followed the general procedures outlined in NYSDEC's *Centrarchid Sampling Manual* (NYSDEC 1989). The lake's littoral zone was divided into 24 approximately equal length segments (Figure 2.5-1), which were sampled once in the spring and twice in the fall. Sampling occurred at night (from ½ hour after sunset to ½ hour before sunrise). The first spring sampling event was used to establish the ends of a transect in each of the 24 shoreline segments. This was accomplished by dividing the shoreline into 24 even length segments and then electrofishing along a line parallel to the shoreline for 15 minutes (900 seconds) within each segment. The same length of shoreline covered in that 15 minutes was sampled in each of the subsequent sampling efforts, regardless of how long it took to cover that distance. Time electrofishing at each transect was recorded for each sampling effort to allow for computation of CPUE of electrofishing. Pulsed direct current was used for all sampling.

Transects were sampled in one of two ways. For odd-numbered transects, all fish species were targeted. For even-numbered transects, only gamefish were targeted for collection. The following species were considered gamefish for this purpose.

Largemouth bass	White crappie
Smallmouth bass	Brown bullhead
Walleye	Yellow bullhead
Yellow perch	Channel catfish
Bluegill	Northern pike
Pumpkinseed	Bowfin
Black crappie	All salmonids (trout)

Bluegill and pumpkinseed were not collected as gamefish during the spring sampling effort. The gamefish list had not been finalized at that time, and bluegill and pumpkinseed had not yet been designated as a species to be targeted at the "gamefish only" transects. These species were added to the list in summer 2000, so bluegill and pumpkinseed were collected at the "gamefish only" transects during the fall sampling efforts.

Collected fish were identified to species, measured for length (nearest mm), and, for the fall samples, measured for weight (nearest ounce). For samples in which small to moderate numbers of fish were collected, all fish were measured. For samples in which high numbers of one or



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Transcect Borders

Strata Borders

Odd No. Transects = All Fish Collected
Even No. Transects = Only Gamefish Collected

Figure 2.5-1. Boat electrofishing transect locations in Onondaga Lake during 2000.

more species were collected, subsampling was conducted in the following manner. Thirty (30) randomly selected fish of each species were measured for length and weight, and the remaining fish were identified to species and counted only. This resulted in some samples having both individual fish data and bulk fish data. All common carp (*Cyprinus carpio*) and gizzard shad (*Dorosoma cepedianum*) occurring in large schools were estimated without actually collecting the fish to minimize catch mortality and facilitate processing of the catch.

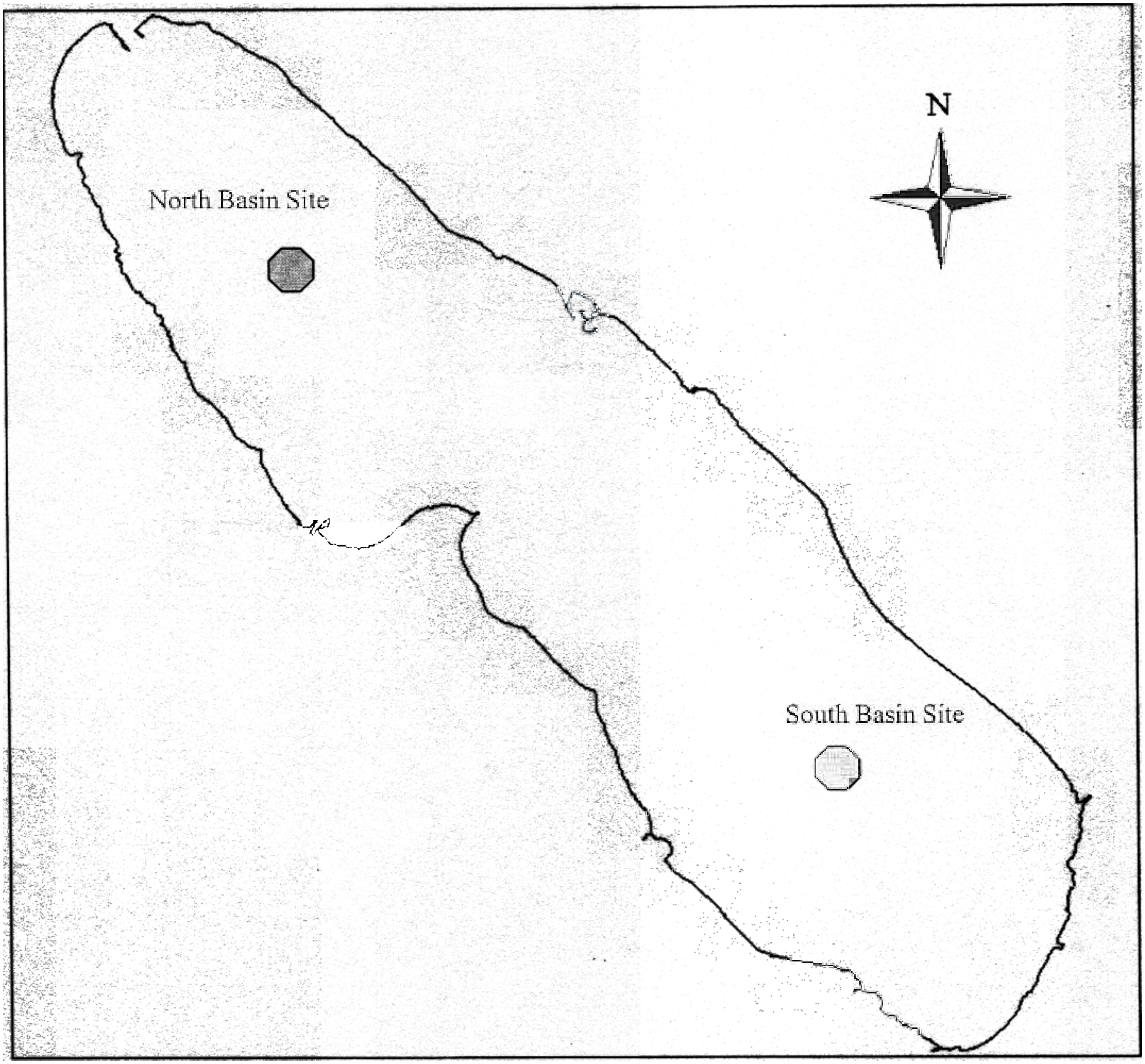
Adult gamefish in good condition were also tagged with a numbered floy tag and sampled for scales (except catfish and trout) prior to release. The floy tags were labeled with information directing anyone recovering a tagged fish to contact the OCDDS so information on the species, location/date of capture, and size of the fish can be obtained. Scale samples were collected from the first ten adult individuals of each species collected per transect, with a goal of collecting a minimum of 30 samples per species for each sampling event. Scale samples were collected from the side of the fish, below the lateral line and under the tip of the pectoral fin.

Gill Netting

Gill netting was used to sample the lake's pelagic zone. Gill netting occurred four times during the year, in May, July, September, and October and was conducted by trained OCDDS personnel. Gill netting was conducted within one week of boat electrofishing in May, September, and October. Only two gill nets were set during each sampling effort in order to minimize mortality from collection. One net was set in the north basin and one in the south basin (Figure 2.5-2). Experimental gill nets of standard NYSDEC dimensions of 1.8 m deep with 7.6 m panels of 3.8, 5.1, 6.4, 7.6, 8.9, 10.2 cm (stretch) nylon monofilament mesh were

Nets were set in the afternoon, fished overnight, and pulled in the morning. The standard unit of effort was considered one overnight set.

Gill net catch was recorded for each mesh size. Collected fish were identified to species and measured for length (nearest mm), and weight (nearest ounce). For samples in which small to moderate numbers of fish were collected, all fish were measured. For samples in which high numbers of one or more species were collected, subsampling was conducted in the following manner. Thirty (30) randomly selected fish of each species were measured for length and



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Gill Net Sites

Figure **2.5-2.** Pelagic gill net locations **in** Onondaga Lake during 2000.

weight, and the remaining fish were identified to species and counted only. This resulted in some samples having both individual fish data and bulk fish data.

2.6 Sampling Condition Measurements

Sampling conditions at each collection site were measured and recorded prior to sampling. Items recorded at every sampling location included: location, weather conditions, personnel, time, date, water clarity, habitat conditions, water temperature, dissolved oxygen conductivity, pH, and redox potential. The water-quality measurements were made at a depth of one meter at littoral sampling sites. A water-quality profile was measured at 0.5-m intervals from surface to bottom at pelagic sampling locations. Habitat variables measured varied depending on gear type being used and included substrate (seining, nest survey), cover (seining, electrofishing, nest survey), and depth (seining, electrofishing). Data were recorded in field notebooks at the time of sampling and later entered into a database by County personnel.

2.7 Data Handling and Analysis

Trained OCDDS personnel were responsible for all aspects of field data collection, including sample collection, measurement of catch and water-quality parameters, and recording of field-generated data. Data were organized, analyzed, and summarized using Microsoft Access™ database management software. Data were entered into the database by County personnel. The database was then provided to IA, one of the County's consultants, who conducted quality control procedures to ensure that the data set was complete, free of duplicate data, and logical. IA and EcoLogic (another of the County's consultants) then used the database management capabilities of Microsoft Access to sort the data into logical categories (e.g., by date, by stratum), and produce summary tables suitable for importing into Microsoft Excel™ spreadsheets for calculation of desired catch statistics.

The length-frequency distribution for largemouth bass, smallmouth bass, bluegill, pumpkinseed, and selected other species were determined by plotting the distribution of the catch of each species by 10-mm length increments, as recommended in Anderson and Neumann (1996). This analysis was performed separately for length data collected in spring (May) and fall

(September and October combined) by boat electrofishing. These statistics were not calculated for seasons in which less than 20 individuals of a species were collected

Proportional stock density (PSD) and relative stock density (RSD) also were calculated for largemouth bass, smallmouth bass, bluegill, pumpkinseed, and selected other species. In general, PSD and RSD values were based on length categories provided in Anderson and Neumann (1996). In addition, RSD values were calculated for largemouth bass of 18 inches and smallmouth bass of 12 and 18 inches. The categories used for the various species were as follows.

Species	Stock Size	Quality Size	Preferred Size
Largemouth bass	200 mm	305 mm (12 inches)	381 mm (15 inches)
Smallmouth bass	180 mm	280 mm	356 mm (14 inches)
Bluegill	80 mm	153 mm (6 inches)	203 mm (8 inches)
Pumpkinseed	80 mm	153 mm (6 inches)	203 mm (8 inches
Walleye	250 mm	380 mm	510 mm (20 inches)
Yellow perch	130 mm	200 mm	254 mm (10 inches)
Channel catfish	280 mm	410 mm	610 mm (24 inches)
Brown bullhead	150 mm.	230 mm	305 mm (12 inches)
White perch	130 mm	200 mm	254 mm (10 inches)
Gizzard shad	180 mm	280 mm	Not defined

Prior to generation of summary statistics involving the use of fish length or weight data, data from individual fish for which both length and weight data had been collected were plotted graphically to identify any individual fish for which the length-weight relationship appeared grossly abnormal. Typically, when individual fish length is plotted against individual fish weight for a population, the result is a curve that shows weight increasing exponentially with an increase in length. The points representing individual fish tend to cluster around this curve. When such plots were created for the individual species of interest, points representing a few individual fish plotted well away from the rest of the data, indicating that these data were outliers. Because these outliers did not represent the general population, they were excluded from any analyses using either length or weight in their calculations.

Relative abundance (percent composition of the catch for each species), catch per unit effort (CPUE), and species diversity were calculated for each sampling event. CPUE was calculated as larvae/m^3 for pelagic larval samples, larvae/haul for littoral larval samples, fish/seine haul for juvenile fish sampling, fish/hour for electrofishing, and fish/overnight net set for gill net sampling. Species diversity was derived using the Shannon-Weiner Index calculated using $\log_{10}$.

3.0 RESULTS

A list of the common and scientific names of all fish species collected from Onondaga Lake in 2000 is presented in Table 3-1. The results of each of the various sampling programs follow.

3.1 Pelagic Larvae Sampling

Pelagic fish larvae samples were collected during seven sampling events, with samples collected at approximately two-week intervals from May through August 2000. Samples were collected along 12 transects (six in the north basin, six in the south basin), at three depths (1, 3, and 5 m) per transect. This resulted in the collection of a total of 252 pelagic larval samples in 2000. These samples were picked, sorted, and identified by trained OCDDS personnel. The County made a formal request to NYSDEC for an extension of the deadline for reporting the results of the larval fish sampling program, so that the samples and resultant data could be appropriately analyzed (letter from the Lake Improvement Project Office to S. Eidt, NYSDEC, January 29, 2001).

3.1.1 Total Catch

It should be noted that the ease and accuracy of identification of larval fish to species varies considerably with the species, the level of larval development, and the state of preservation of the individual specimens collected. Some taxa cannot be definitively identified to species in their early larval stages and thus must be lumped into higher taxonomic categories such as genus or even family. This was the case for many specimens collected during the Onondaga Lake 2000 larval fish sampling effort. This situation complicated analysis and discussion of community measures such as species or taxonomic richness and diversity. Thus, in some instances, the following analysis of larval sampling deals with specific species and at other times addresses results on a generic or family level. Most identification in the pelagic samples was done to the family and genus levels level.

A total of 3,042 larval fish representing 10 taxa (family, genus and species combined) and at least 5 distinct species were collected from the pelagic zone of Onondaga Lake in the spring and

Table 3-1 Species code and scientific and common names of fishes collected from Onondaga Lake, New York in 2000. Fish species codes follow Kretser et al. (1980); scientific and common names follow Robins et al. (1991).

Code	Scientific Name	Common Name
	Lepisosteidae - gars	
268	*Lepisosteus osseus* (Linnaeus)	longnose gar
	Amiidae - bowfins	
271	*Amia calva* Linnaeus	bowfin
	Clupeidae - herrings	
289	*Alosa pseudoharengus* (Wilson)	alewife
294	*Dorosoma cepedianum* (Lesueur)	gizzard shad
	Salmonidae - trouts	
	Salmo trutta Linnaeus	brown trout
	Esocidae - pikes	
	Esox lucius Linnaeus	northern pike
	Cyprinidae - carps and minnows	
365	*Cyprinus carpio* Linnaeus	common carp
377	*Notemigonus crysoleucas* (Mitchill)	golden shiner
381	*Notropis atherinoides* Rafinesque	emerald shiner
400	*Pimephales notatus* (Rafinesque)	bluntnose minnnow
401	*Pimephales promelas* Rafinesque	fathead minnow
403	Rhinichthys cataractae	longnose dace
	Catostomidae - suckers	
419	*Catostomus commersoni* (Lacepede)	white sucker
423	*Hypentelium nigricans* (Lesueur)	northern hog sucker
432	*Moxostoma macrolepidotum* (Lesueur)	shorthead redhorse
	Ictaluridae - bullhead catfishes	
444	*Ameiurus nebulosus* (Lesueur)	brown bullhead
445	*Ictalurus punctatus* (Rafinesque)	channel catfish
	Cyprinodontidae - killifishes	
531	*Fundulus diaphanus* (Lesueur)	banded killifish
	Atherinidae - silversides	
	Labidesthes sicculus (Cope)	brook silverside
	Percichthyidae - temperate basses	
575	*Morone americana* (Gmelin)	white perch
576	*Morone chrysops* (Rafinesque)	white bass

Table 3-1. Continued.

Code	Scientific Name	Common Name
	Centrarchidae - sunfishes	
591	*Ambloplites rupestris* (Rafinesque)	rock bass
596	*Lepomis gibbosus* (Linnaeus)	pumpkinseed
598	*Lepomis macrochirus* Rafinesque	bluegill
600	*Micropterus dolomieu* Lacepede	smallmouth bass
601	*Micropterus salmoides* (Lacepede)	largemouth bass
603	*Pomoxis nigromaculatus* (Lesueur)	black crappie
	Percidae - perches	
613	*Etheostoma nigrum* Rafinesque	johnny darter
614	*Etheostoma olmstedi* Storer	tessellated darter
617	*Perca flavescens* (Mitchill)	yellow perch
618	*Percina caprodes* (Rafinesque)	logperch
626	*Stizostedion vitreum vitreum* (Mitchill)	walleye
	Sciaenidae - drums	
700	*Aplodinotus grunniens* Rafinesque	freshwater drum

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early summer of 2000 (Table 3.1-1). Lakewide catch per unit effort (CPUE) was 3.25 larval fish per cubic meter of water (Table 3.1-2). Differences between samples collected in the north and south basins were negligible. North basin CPUE was 3.32/m^3 (51.2% of the catch) while south basin CPUE was 3.17/ m^3 (48.8% of the catch).

Clupeids (herrings) (CPUE 2.46/m^3, 76.4% of the catch), *Lepomis* spp. (CPUE 0.37/m^3, 11.9% of the catch), and freshwater drum (0.31/m^3, 9.5% of the catch) dominated the samples. These three taxa represented 97% of the catch in each basin and the entire lake (Table 3.1-2).

3.1.2 Temporal Distribution

Sampling for larval fish was conducted approximately every two weeks from the beginning of May 2000 to the end of July 2000. No larval fish were collected in the first sampling event in early May. Temporal distribution of the pelagic larval fish community was influenced most by clupeids, *Lepomis* spp., and freshwater drum, since they were by far the most commonly captured taxa. These three taxa became abundant in the pelagic larval fish community from late June to mid-July and then showed sudden decreases in CPUE in late July (Table 3.1-3, Figure 3.1-1a and b). Yellow perch and percid (perch family) catch rates peaked earliest, in mid-May, then fell to near zero in the next sampling period (late May) and remained there through the end of sampling in late July (Figure 3.1-1c). White perch and gizzard shad became abundant in the catch from mid-June to early July then decreased through the summer.

3.1.3 Depth Distribution

Sampling of pelagic larvae was conducted at three water depths: 1 m, 3 m and 5 m.
fish were captured at the 5-m depth (Table 3.1-4 and Figure 3.1-2). The three dominant taxa, clupeids, *Lepomis* spp., and freshwater drum, influenced the overall depth relationship the most. Other species were caught in numbers too low to allow for meaningful interpretation of depth distributions. All three of the most dominant taxa were more prevalent at the 5-m depth than at 1 m or 3 m. *Lepomis* spp. showed a gradual increase in abundance from 1 m to 5 m (Figure 3.1-2). Clupeids were most abundant at 5 m and slightly less abundant at 3 m than at 1 m, but the difference was barely discernible. Freshwater drum were least abundant at 1 m and nearly equally abundant at the 3-m and 5-m depths. Although more larvae were captured at the

Table 3.1-1. Taxonomic list and number of each taxon captured during pelagic fish larvae sampling in Onondaga Lake in 2000.

Family	Genus	Species	Common Name	No.
Clupeidae (Herrings)	-	spp.	Herring	2305
	Dorosoma	*cepedianum*	Gizzard shad	15
			Total Clupeidae	**2320**
Cyprinidae (Minnows)	-	spp.	Minnow	3
			Total Cyprinidae	**3**
Percichthyidae (Temperate Basses)	*Morone*	*americana*	White perch	25
			Total Percichthyidae	**25**
Centrarchidae (Sunfishes)		spp.	Sunfish	16
	Lepomis	spp.	Sunfish	344
			Total Centrarchidae	**360**
Percidae (Perches)	-	spp.	Perch	4
	Perca	*flavescens*	Yellow perch	3
	Percina	*caprodes*	Logperch	1
			Total Percidae	**8**
Sciaenidae (Drums)	*Aplodinotus*	*grunniens*	Freshwater drum	291
			Total Sciaenidae	**291**
			Unidentified	**35**
			Total of all Taxa	**3042**

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Table 3.1-2. Catch per unit effort (No./m^3) of pelagic larval fish from the north and south basins and all of Onondaga Lake combined in 2000. Underlined CPUE indicates top three taxa in each stratum. NC= not caught.

Taxon	North Basin	South Basin	Entire Lake
Herring Family (Clupeidae)	<u>2.27</u>	<u>2.65</u>	<u>2.46</u>
Lepomis spp.	<u>0.40</u>	<u>0.34</u>	<u>0.37</u>
Freshwater drum	<u>0.56</u>	<u>0.07</u>	<u>0.31</u>
Unidentified	0.024	0.051	0.037
White perch	0.047	0.006	0.027
Sunfish Family (Centrarchidae)	0.021	0.013	0.017
Gizzard shad	NC	0.32	0.017
Perch Family (Percidae)	0.002	0.006	0.004
Yellow perch	NC	0.006	0.003
Minnows (Cyprinadae)	0.004	0.002	0.003
Logperch	0.002	NC	0.001
Total	**3.32**	**3.17**	**3.25**
Percent of Catch	**51.2%**	**48.8%**	**100%**
% Most Abundant Taxa	**68%**	**84%**	**76%**
% Top 3 Taxa	**97%**	**97%**	**97%**
Taxa Richness	**8**	**9**	**10**
Species Richness	**3**	**4**	**5**
Diversity	**0.42**	**0.28**	**0.37**

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Table 3.1-3. CPUE (No./m^3) of pelagic larvae of each taxa captured during each sampling event during 2000 in Onondaga Lake.

Taxon	Early May	Mid May	Late May	Mid June	Late June	Mid July	Late July
Herring Family (Clupeidae)				0.42	11.2	5.3	0.30
Lepomis spp.					0.69	1.6	0.26
Freshwater drum					0.66	1.4	0.037
Unidentified		0.014		0.13	0.085	0.021	
White perch				0.10	0.069	0.007	
Gizzard shad				0.047	0.062		
Sunfish Family (Centrarchidae)		0.007				0.12	
Perch Family (Percidae)		0.029					
Yellow perch		0.022					
Minnow Family (Cyprinadae)					0.008	0.007	0.007
Logperch							0.007
Total	**0**	**0.072**	**0**	**0.69**	**12.7**	**8.5**	**0.61**

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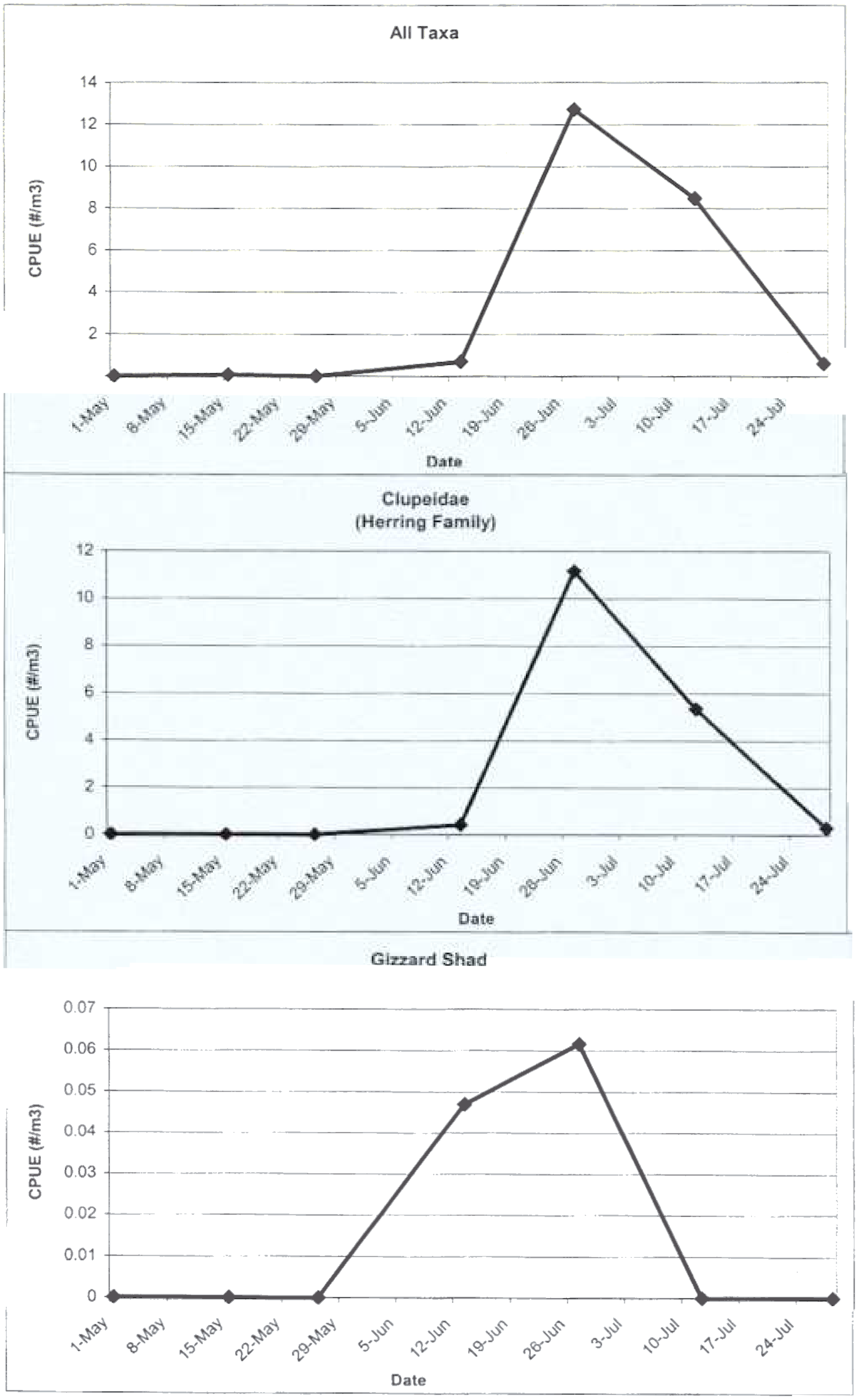

Figure 3.1-1a. **Temporal distribution of all taxa, clupeids, and gizzard shad larvae collected in Onondaga Lake in 2000.**

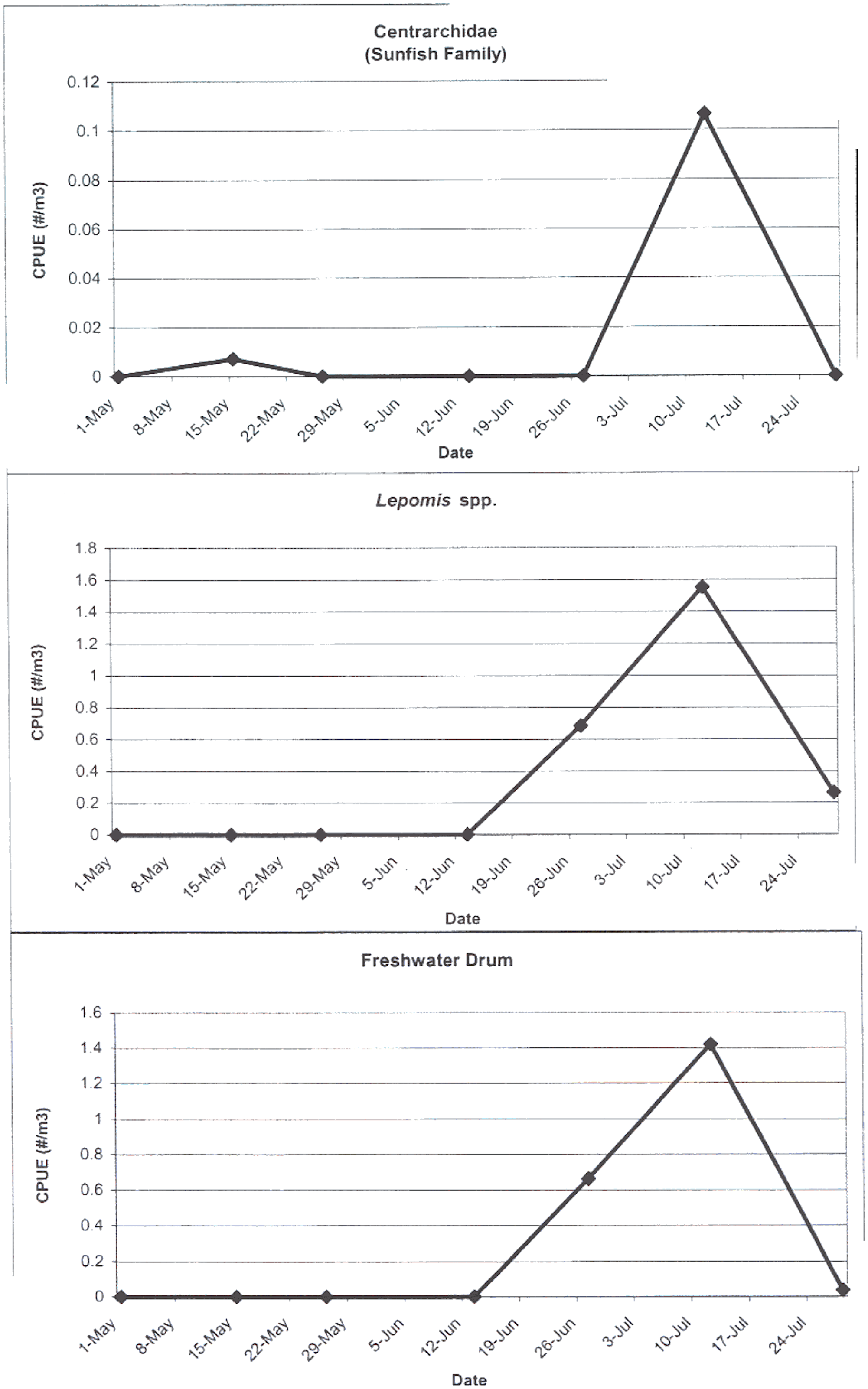

Figure 3.1-1b. **Temporal distribution of centrarchids, *Lepomis* spp., and freshwater drum larvae collected in Onondaga Lake in 2000.**

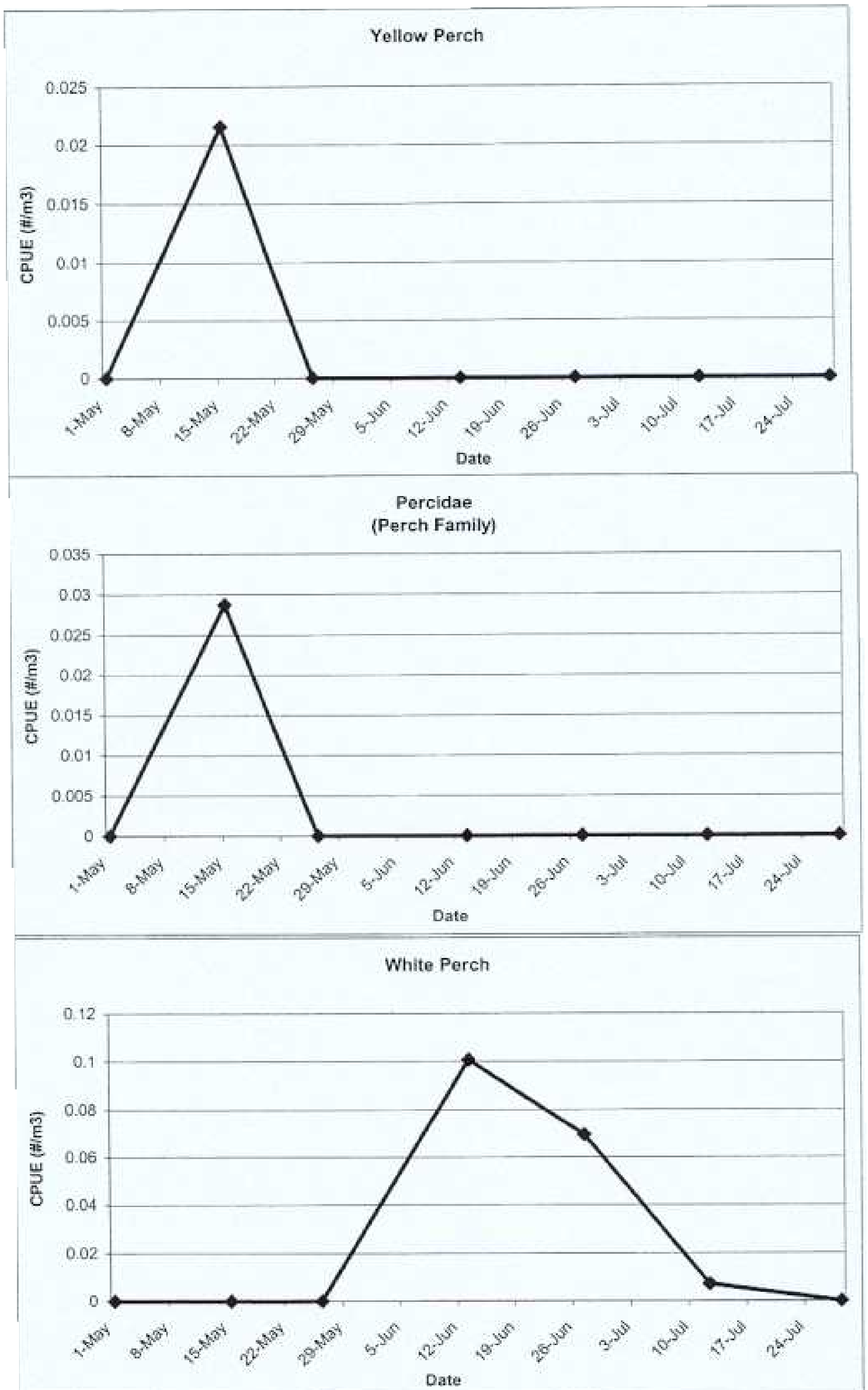

Figure 3.1-1c. Temporal distribution of yellow perch, percids and white perch larvae collected in Onondaga Lake in 2000.

Table 3.1-4. CPUE (No./m^3) of pelagic larvae at water depth intervals of 1, 3, and 5 meters in Onondaga Lake during 2000.

Taxon	**1 m**	**3 m**	**5 m**
Herring Family (Clupeidae)	2.12	1.96	3.29
Lepomis spp.	0.28	0.35	0.46
Freshwater drum	0.24	0.34	0.35
Unidentified	0.04	0.04	0.03
Gizzard shad	0.03		0.02
White perch	0.02	0.01	0.05
Sunfish Family (Centrarchidae)	0.01		0.04
Yellow perch	0.01	0.003	
Minnow Family (Cyprinadae)	0.003	0.01	
Perch Family (Percidae)	0.003		0.01
Logperch		0.003	
Total	**2.76**	**2.72**	**4.26**
Richness	**10**	**8**	**8**

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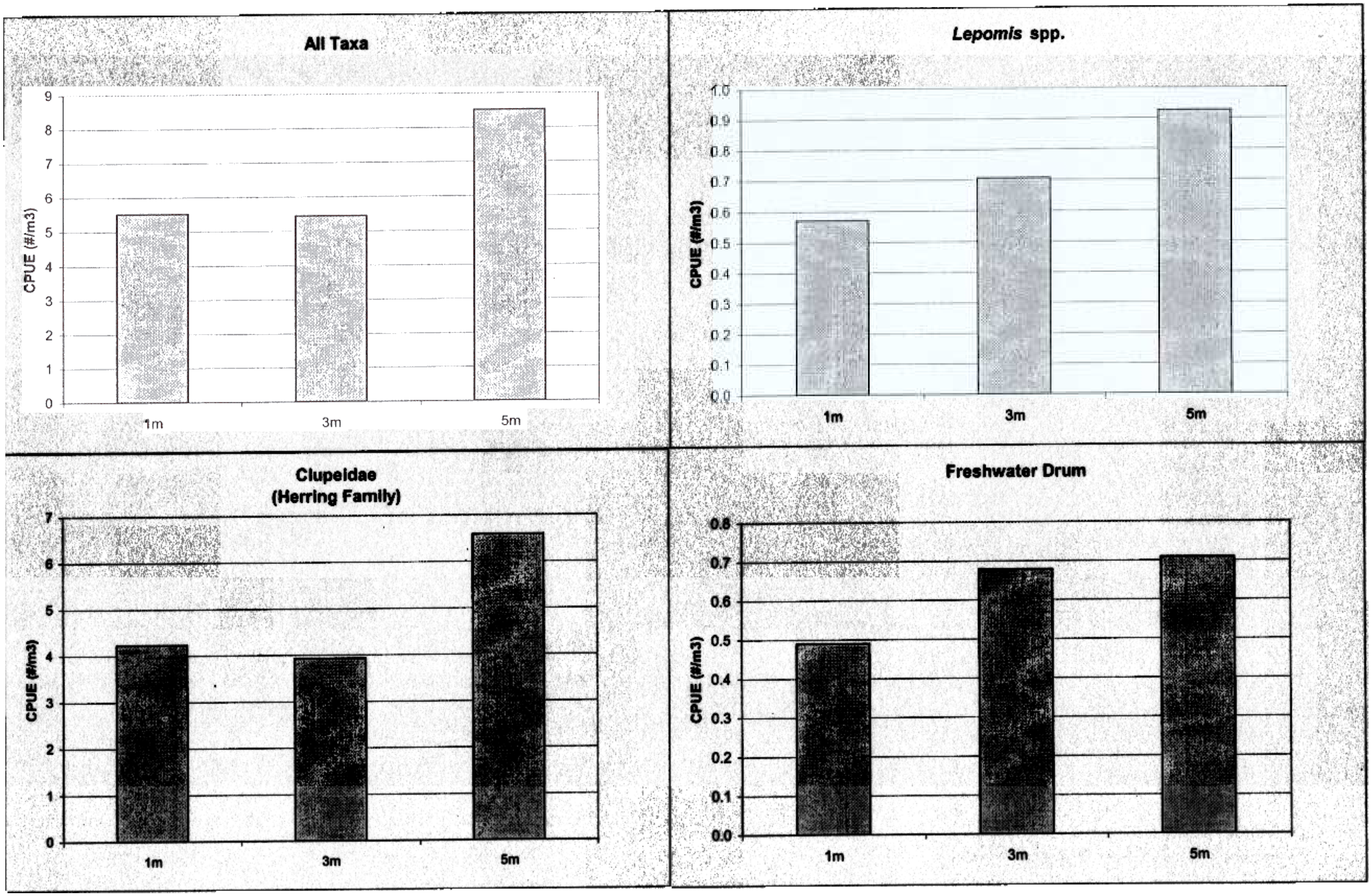

Figure 3.1-2. Pelagic larvae CPUE at water depths of 1, 3, and 5 m in Onondaga Lake in 2000.

5-m depth, taxa richness was higher at the 1-m depth (10 taxa) than at either 3 or 5 m (8 taxa each).

3.1.4 Length-Frequency Analysis

Length-frequency histograms of select pelagic species for each sample period during which they were caught are presented in Figures 3.1-3a to 3.1-3c. *Lepomis* spp. showed an initial cohort in late June, with protracted, though reduced, recruitment of larvae into late July (Figure 3.1-3a). Clupeids (herring) showed a cohort produced in mid to late June. This cohort showed steady growth through late July. There were indications of protracted reproduction of clupeids into mid-July based on the occurrence of small larvae (3-6 mm size class, Figure 3.1-3b) in the mid-July samples. Clupeids were practically non-existent in the late July sample period, probably because they were no longer effectively captured in the sampling gear due to increased body size. Freshwater drum showed protracted reproduction from late June through mid July based on the similar relative frequency of larval fish in the 4-8 mm size classes in these two sample periods. Other taxa were not captured and measured in sufficient numbers to have meaningful length-frequency analysis performed.

3.2 Littoral Larvae Sampling

Littoral fish larvae samples were collected during seven sampling events, with samples collected at approximately two-week intervals from May through August 2000. Samples were collected at 15 stations, with three stations located in each of the five strata previously described. Three replicate seine hauls were collected at each station during each sampling event. This resulted in the collection of a total of 315 littoral larval samples in 2000. Some of these samples were picked, sorted, and identified by trained OCDDS personnel. The remaining samples were picked, sorted, and identified by personnel at the Colorado State University Larval Fish Laboratory in Fort Collins, CO in order to expedite sample processing. The County made a formal request to NYSDEC for an extension of the deadline for reporting the results of the larval fish sampling program, so that the samples and resultant data could be appropriately analyzed (letter from the Lake Improvement Project Office to S. Eidt, NYSDEC, January 29, 2001).

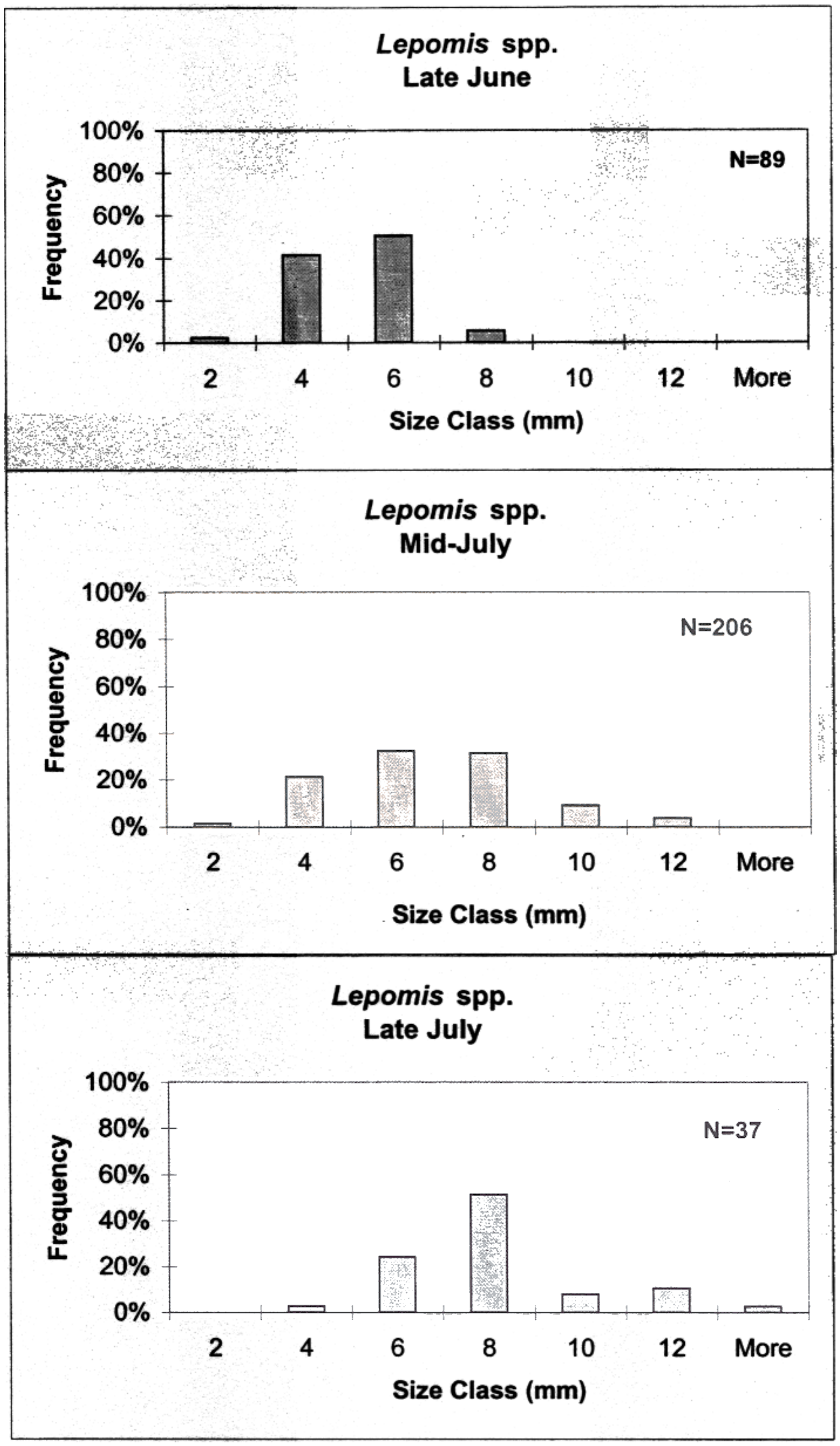

Figure 3.1-3a. Length-frequency distribution of *Lepomis* spp. collected in the pelagic zone of Onondaga Lake in 2000.

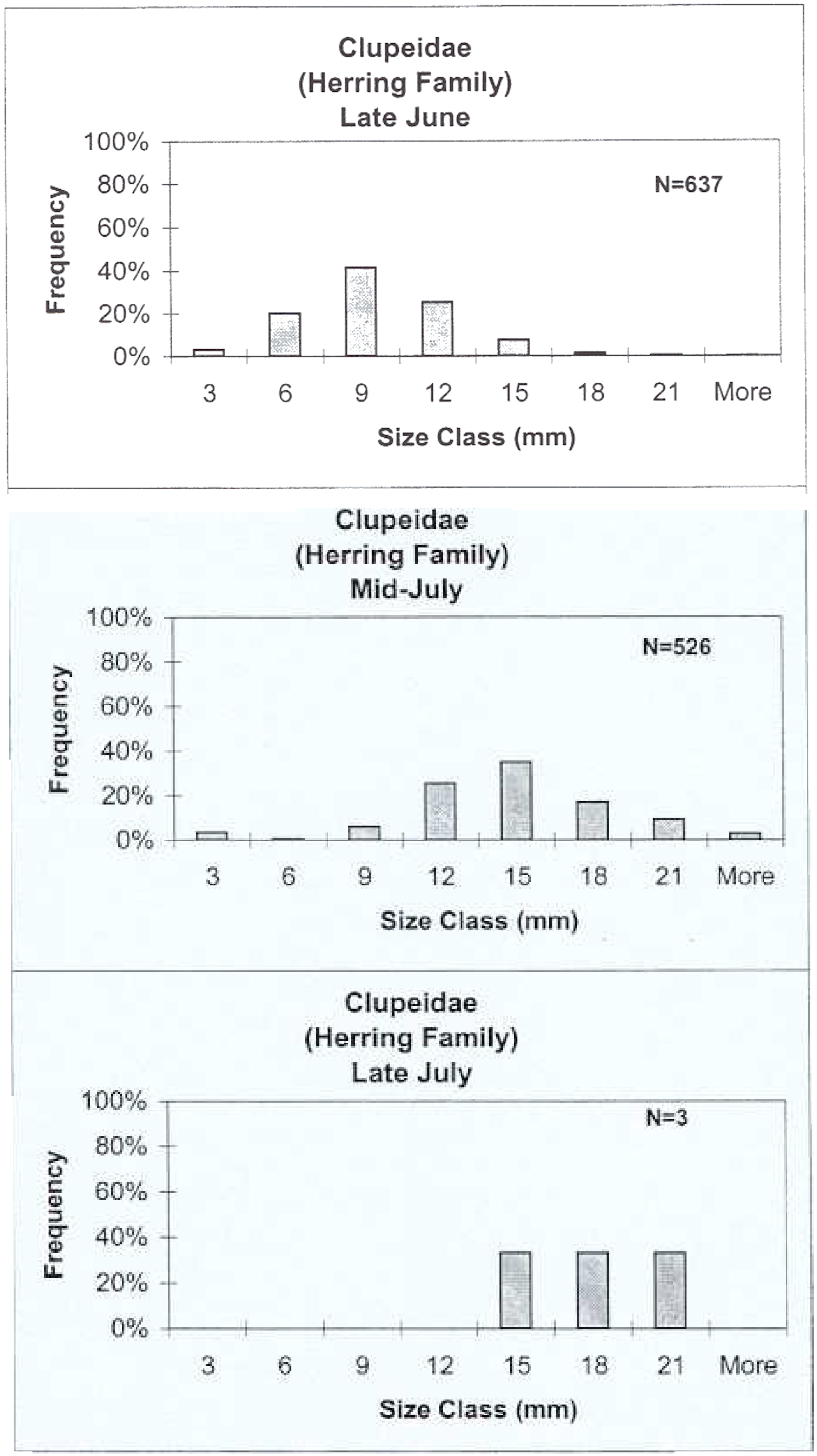

Figure 3.1-3b. Length-frequency distribution of clupeids collected in the pelagic zone of Onondaga Lake in 2000.

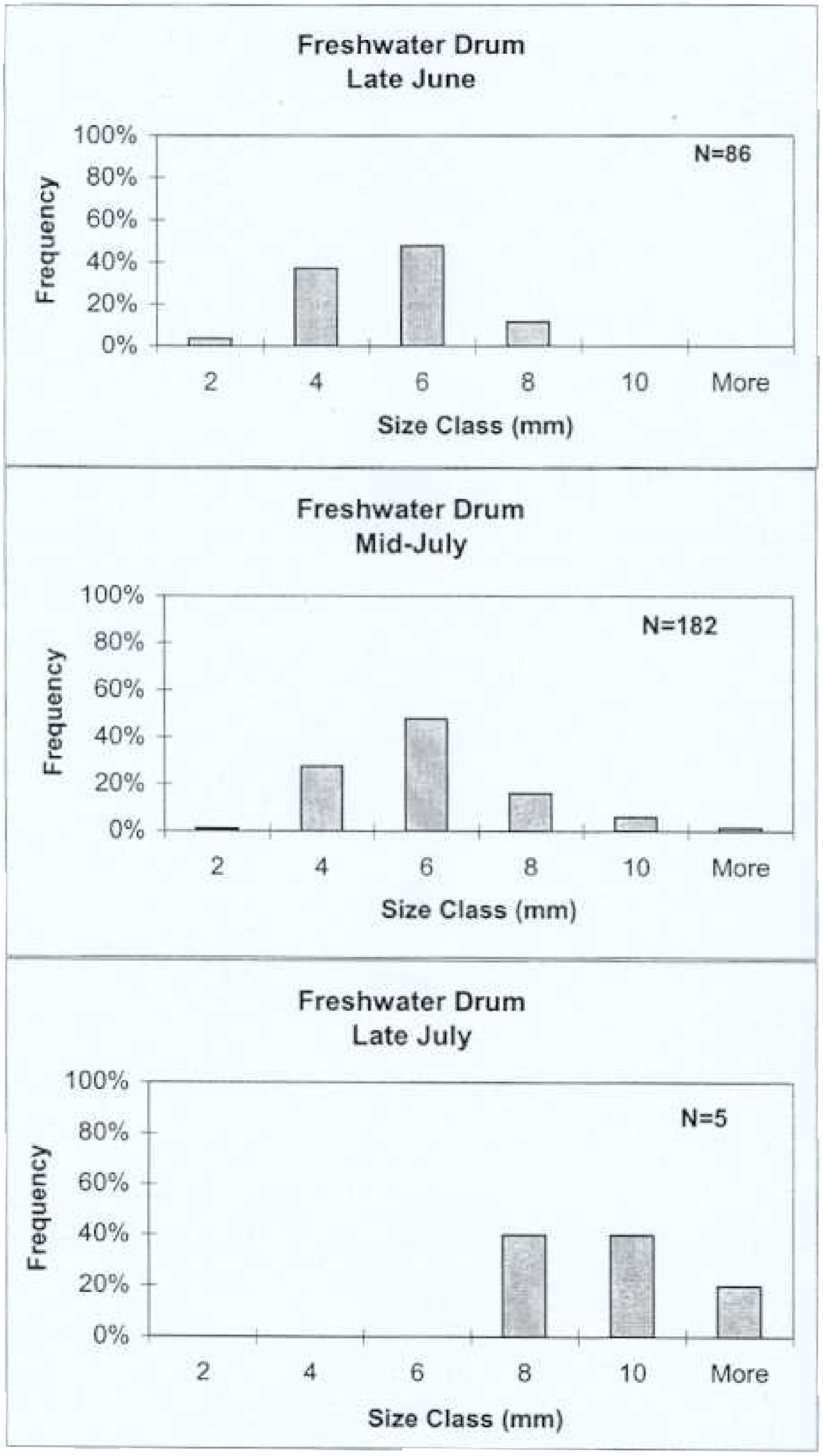

Figure 3.1-3c. Length-frequency distribution of freshwater drum collected in the pelagic zone of Onondaga Lake in 2000.

3.2.1 Total Catch

As with pelagic larvae, accuracy of identification of larval fish to species varies considerably with the species, the level of larval development, and the state of preservation of the individual specimens collected. Some taxa cannot be definitively identified to species in their early larval stages and thus must be lumped into higher taxonomic categories such as genus or even family. This was the case for some specimens collected during the Onondaga Lake 2000 littoral larval fish sampling effort. This situation complicated analysis and discussion of community measures such as species or taxonomic richness and diversity. Thus, in some instances, the following analysis of littoral larval sampling deals with specific species and at other times addresses results on a generic or family level.

A total of 13,514 larval fish representing 29 taxa (family, genus and species combined) and at least 18 distinct species was collected from the littoral zone of Onondaga Lake in the spring and early summer of 2000 (Table 3.2-1). Several taxa were unique to the littoral collections, having not been observed in the pelagic samples. Although generally similar taxa were collected in both the pelagic and littoral sampling, relative abundances of those species differed greatly (Table 3.2-2). Lakewide catch per unit effort (CPUE) of the littoral samples was 43 larval fish per seine haul and ranged from 9 (Stratum 2, wastebeds) to 110 (Stratum 1, NW shore) among the sample strata (Table 3.2-3). The CPUE for Stratum 1 was more than double that of the next closest stratum (Stratum 4, 53 larvae per haul) and more than 12 times the CPUE for Stratum 2.

Lepomis spp. (including bluegill, 43.5 % of the catch) and brook silverside (39.4%) dominated the littoral larvae catch (Table 3.2-4, Figure 3.2-1). White sucker (3.4%) was the third most commonly encountered species. Since white sucker is a stream spawner, larvae probably originated in lake tributaries and moved downstream after hatching. Common carp (2.6%), golden shiner (2.2%), yellow perch (1.5%), and freshwater drum (1.3%) were the only other species representing more than 1% of the total catch.

Table 3.2-1 Taxonomic list at number captured during littoral fish larvae sampling in Onondaga Lake in 2000.

Family	Genus	Species	Common Name	#
Clupeidae (Herrings)	-	spp.	Herring	36
	Alosa	*pseudoharengus*	Alewife	11
	Dorosoma	*cepedianum*	Gizzard shad	**114**
			Total Clupeidae	
Cyprinidae (Minnows)	-	spp.	Minnow	[illegible]
	Cyprinus	*carpio*	Carp	
	Notemigonus	*cryoleucas*	Golden shiner	
	Pimephales	spp.	Minnow	
		promelas	Fathead minnow	[illegible]
	Rhinichthys	*cataractae*	Longnose dace	
			Total Cyprinidae	
Catostomidae (Suckers)	-	spp.	Sucker	
	Catostomus	*commersoni*	White sucker	454
	Moxostoma	*macrolepidotum*	Shorthead redhorse	1
			Total Catostomidae	**469**
Cyprinodontidae (Killifishes)	*Fundulas*	*diaphanus*	Banded killifish	
			Total Cyprinodontidae	**18**
Atherinidae (Silversides)	*Labidesthes*	*sicculus*	Brook silverside	5324
			Total Atherinidae	**5324**
Percichthyidae (Temperate Basses)	-	spp.	White perch or white bass	58
	Morone	*americana*	White perch	61
		chrysops	White bass	2
			e	[illegible]
Centrarchidae (Sunfishes)		spp.	Sunfish	
	Lepomis	spp.	Sunfish	5403
		macrochirus	Bluegill	473
	Micropterus	*salmoides*	Largemouth bass	3
	Pomoxis	spp.	White and/or Black crappie	2
			Total Centrarchidae	**5979**
Percidae (Perches)	-	spp.	Perch	8
	Etheostoma	spp.	Darter	
		nigrum	Johnny darter	
		olmstedi	Tessellated darter	
	Perca	*flavescens*	Yellow perch	
	Percina	*caprodes*	Logperch	[illegible]
			Total Percidae	
Sciaenidae (Drums)	*Aplodinotus*	*grunniens*	Freshwater drum	182
			Total Sciaenidae	**182**
			Unidenitified	**342**

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Table 3.2-2. Relative percent abundance of littoral and pelagic larvae in Onondaga Lake in 2000. Note: larvae grouped into families for direct comparison. NC= not collected.

Taxon	2000 Pelagic Larvae	2000 Littoral Larvae
Herring Family (Clupeidae)	76.4%	1.2%
Sunfish Family (Centrarchidae)	11.9%	44.2%
Sciaenidae (Freshwater drum)	9.5%	1.3%
Unidentified	1.1%	2.5%
Temperate Basses (Percicthyidae)	0.8%	0.9%
Perch Family (Percidae)	0.2%	1.7%
Minnows (Cyprinadae)	0.1%	5.1%
Silversides (Atherinidae)	NC	39.5%
Suckers (Catostomidae)	NC	3.5%
Killifishes (Cyprinodontidae)	NC	0.1%

Table 3.2-3. CPUE of littoral larvae per seine haul in each sample stratum and all of Onondaga Lake in 2000. NOTE: Species taxa are denoted by italics.

Taxon	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Stratum 5	Entire Lake
Sunfish (Lepomis spp.)	60.54	0.63	2.48	16.87	5.24	17.15
Brook Silverside	30.41	2.65	9.67	25.97	15.81	16.90
Bluegill	6.87	0.05	0.02	0.56	0.02	1.50
White sucker	0.62	4.35	0.10	0.87	1.27	1.44
Carp	0.44	0.10	0.30	4.62	0.05	1.10
Unidentified	2.83	0.24	0.29	1.13	0.95	1.09
Golden shiner	3.52	0.10	0.17	0.37	0.51	0.93
Yellow perch	3.00			0.16	0.16	0.66
Freshwater drum			2.84		0.05	0.58
Gizzard shad		0.19	0.63	0.71	0.27	0.36
Sunfish Family (Centrarchidae)	0.46	0.10	0.21	0.44	0.35	0.31
White perch	0.05	0.03	0.02	0.21	0.67	0.19
Temperate Bass Family (Percithyidae)	0.29	0.10	0.02	0.11	0.41	0.18
Herring Family (Cluepeidae)	0.08	0.11	0.10	0.25	0.03	0.11
Fathead minnow			0.33	0.16	0.02	0.10
Banded killifish	0.10		0.03	0.08	0.08	0.06
Minnows (Cyprinadae)	0.03	0.05	0.08	0.10		0.05
Sucker Family (Catostomidae)		0.16		0.02	0.05	0.04
Alewife	0.10	0.06			0.02	0.03
Perch Family (Percidae)		0.06	0.02		0.05	0.03
Logperch	0.08			0.02		0.02
Largemouth bass	0.05					0.01
White bass					0.03	0.01
Crappie (Pomoxis spp.)	0.02				0.02	0.01
Darters (Ethostoma spp.)	0.03					0.01
Minnows (Pimephales spp.).			0.02			<0.01
Longnose dace				0.02		<0.01
Shorthead redhorse					0.02	<0.01
Johnny darter					0.02	<0.01
Tessellated darter		0.02				<0.01
Total	**109.51**	**8.98**	**17.30**	**52.67**	**26.06**	**42.90**

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Table 3.2-4. Relative abundance of littoral fish larvae captured in Onondaga Lake in 2000.

Taxon	Relative Abundance
Sunfish (*Lepomis* spp.)	43.5%
Brook silverside	39.4%
White sucker	3.4%
Common Carp	2.6%
Golden shiner	2.2%
Yellow perch	1.5%
Freshwater drum	1.3%
Gizzard shad	0.8%
White perch	0.5%
Fathead minnow	0.2%
Banded killifish	0.1%
Alewife	0.08%
Logperch	0.04%
Largemouth bass	0.02%
White bass	0.01%
Crappie (*Pomoxis* spp.)	0.01%
Longnose dace	0.01%
Shorthead redhorse	0.01%
Johnny darter	0.01%
Tesselated darter	0.01%
Other Taxa	4.3%

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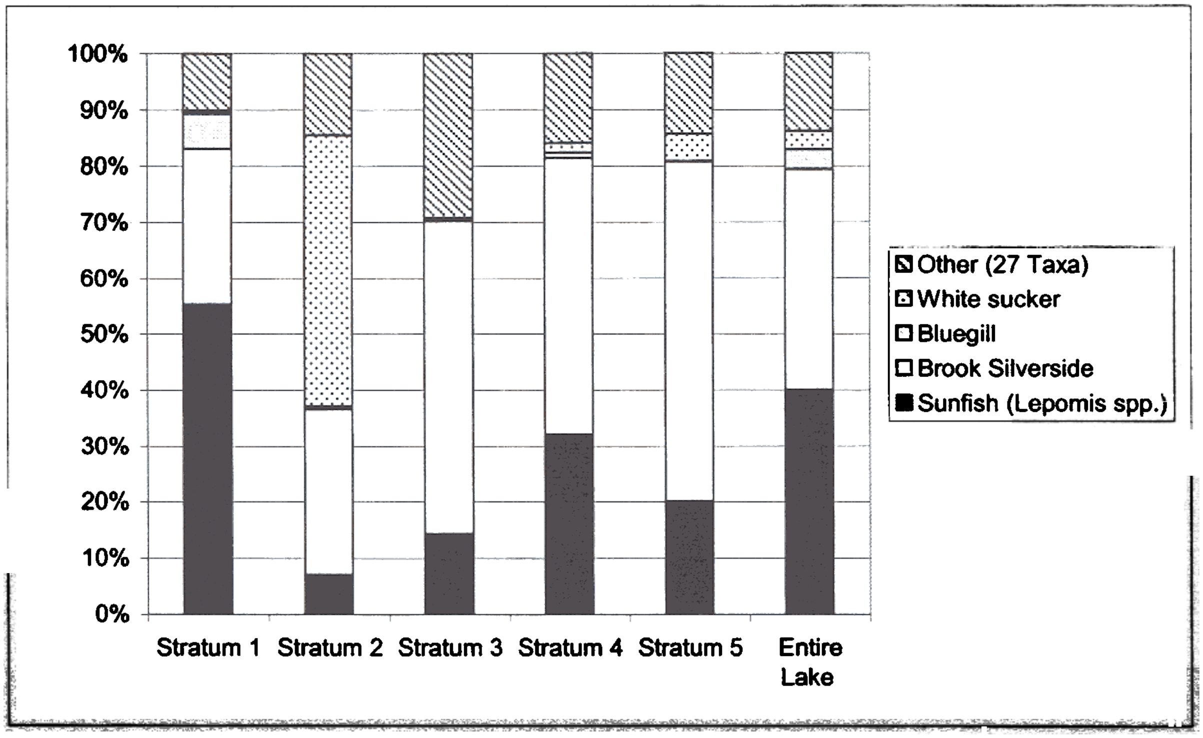

Figure 3.2-1. Relative abundance of larval fish taxa collected in the littroal zone of Onondaga Lake in 2000.

3.2.2 Spatial Distribution

Sampling of larval fish in the littoral zone was conducted in five strata, which combined encompass the entire lakes shoreline. Most larval fish were captured in Stratum 1 (NW shore, 51% of total catch) and Stratum 4 (SE shore, 25% of catch), respectively (Tables 3.2-5, Figures 3.2-2a and b). The fewest larval fish (4% and 8%) were captured in Stratum 2 (wastebeds), and Stratum 3 (south end), respectively. Stratum 5 (NE shore) had an intermediate number of larval fish captured (12%). The distribution of littoral fish larvae among the five strata could have been influenced by several factors, including differences in the quality, quantity, and variety of spawning habitat; the presence of tributaries; level of wave energy; and other physical features of the littoral zone.

Taxa richness (all taxa included) ranged from 16 in Stratum 2 to 22 in Stratum 5 (Table 3.2-5). Species richness (the number of taxa definitively identified to species) among the strata ranged from 9 in Stratum 2 to 15 in Stratum 5. Diversity was lowest for Stratum 3 (0.39) and highest for Stratum 2 (0.62) (Table 3.2-5).

Lepomis spp. (including bluegill) were most abundant in Strata 1 and 4, where 72.3 and 18.7%, respectively, of all *Lepomis* spp. larvae were collected in the littoral zone. Over 91% of the larvae definitively identified as bluegill were collected from Stratum 1. In contrast, less than 1% of all *Lepomis* spp. were collected from Stratum 2 (wastebeds).

Brook silverside was the most common or second most common species collected in all five strata, but was particularly abundant in Strata 1, 4, and 5 (Table 3.2-5). These three strata accounted for 36.0, 30.7, and 18.7%, respectively, of the brook silverside larvae collected from the littoral zone. Again, the fewest (3.1%) brook silverside were collected from Stratum 2.

Conversely, white sucker larvae were most abundant in Stratum 2, with 60.4% of littoral white sucker larvae collected from this stratum. White sucker larvae were also moderately abundant in Stratum 5 (17.6% of white sucker catch) and Stratum 4 (12.1% of catch). Not surprisingly, littoral areas where white sucker larvae were relatively abundant were typically in

Table 3.2-5.

Taxon	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Stratum 5	Entire Lake
Sunfish (*Lepomis* spp.)	**3814**	40	156	1063		5403
Brook silverside	**1916**	167	609	1636		
Bluegill	**433**	3	1	35		
				55		**454**

Freshwater drum

Sunfish Famuy (Centrarchidae)	**29**
White perch	**3**

18

58

36

32

Sucker Family (Catostomidae)

Alewife

8

6

White bass

Shorthead redhorse

Tessellated darter

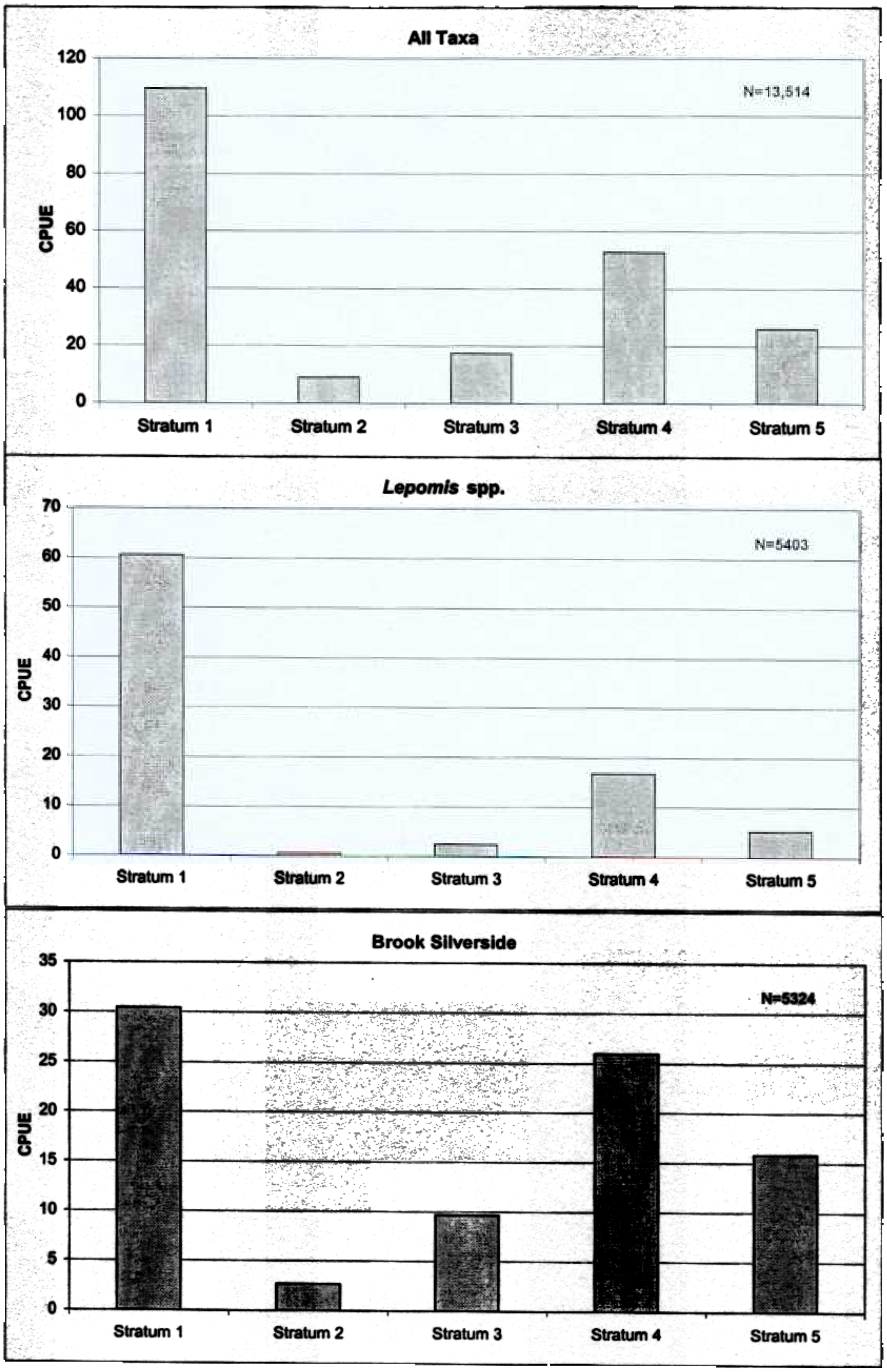

Figure 3.2-2a. Spatial distriubution of all taxa, *Lepomis* spp., and brook silverside larvae among strata in the littoral zone of Onondaga Lake in 2000.

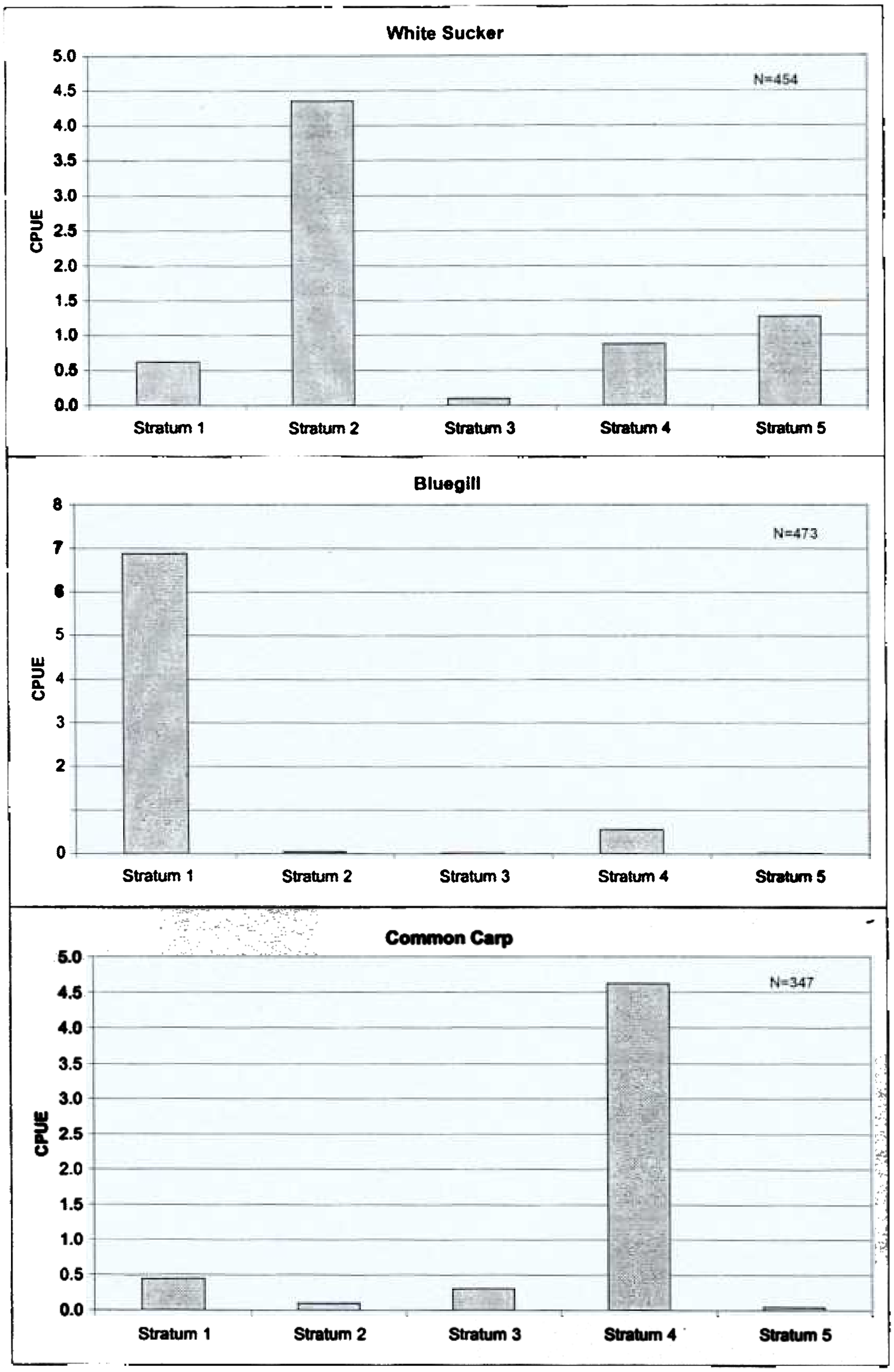

Figure 3.2-2b. Spatial distriubution of white sucker, bluegill, and common carp larvae among strata in the littoral zone of Onondaga Lake in 2000.

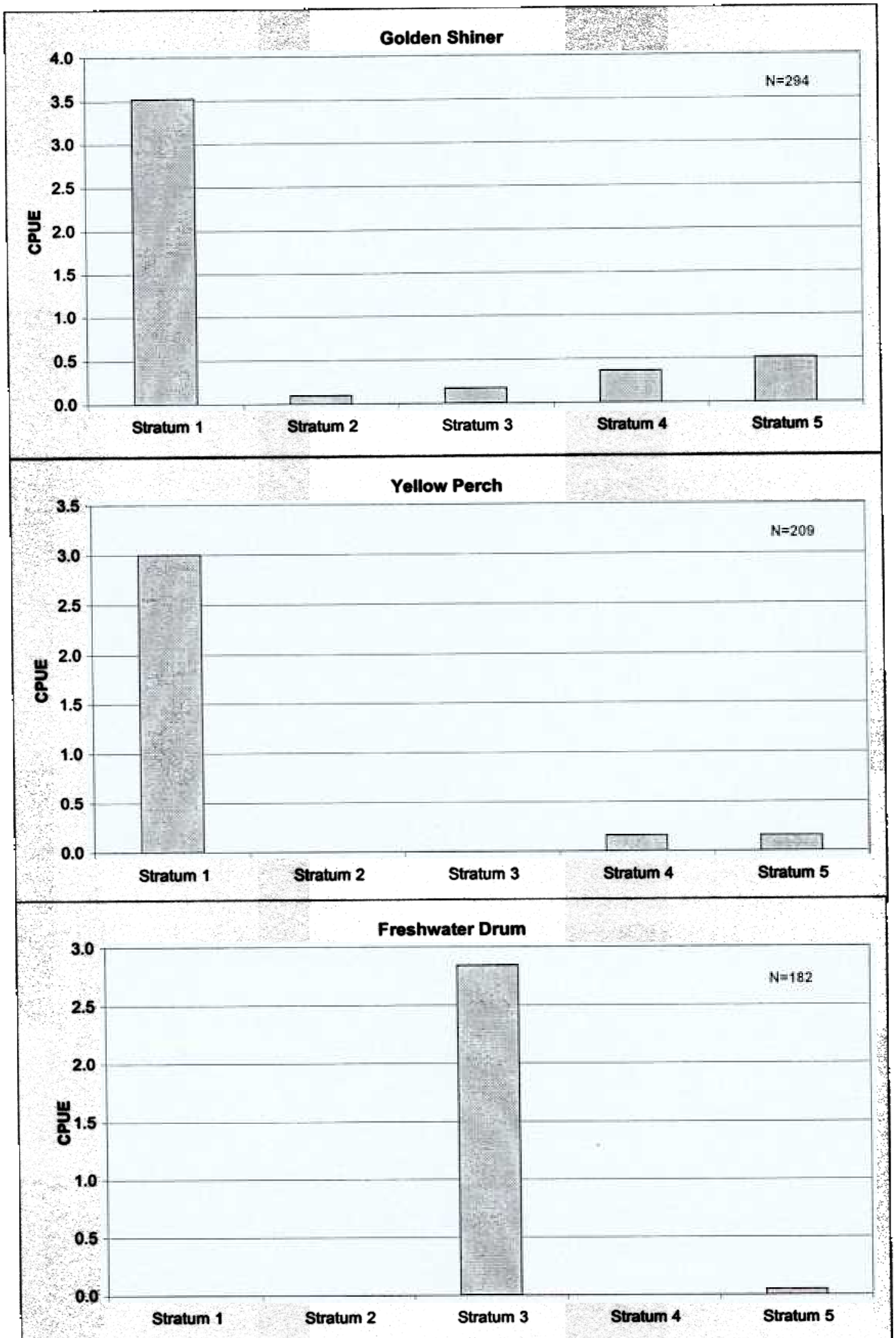

Figure 3.2-2c. Spatial distriubution of golden shiner, freshwater drum, and yellow perch larvae among strata in the littoral zone of Onondaga Lake in 2000.

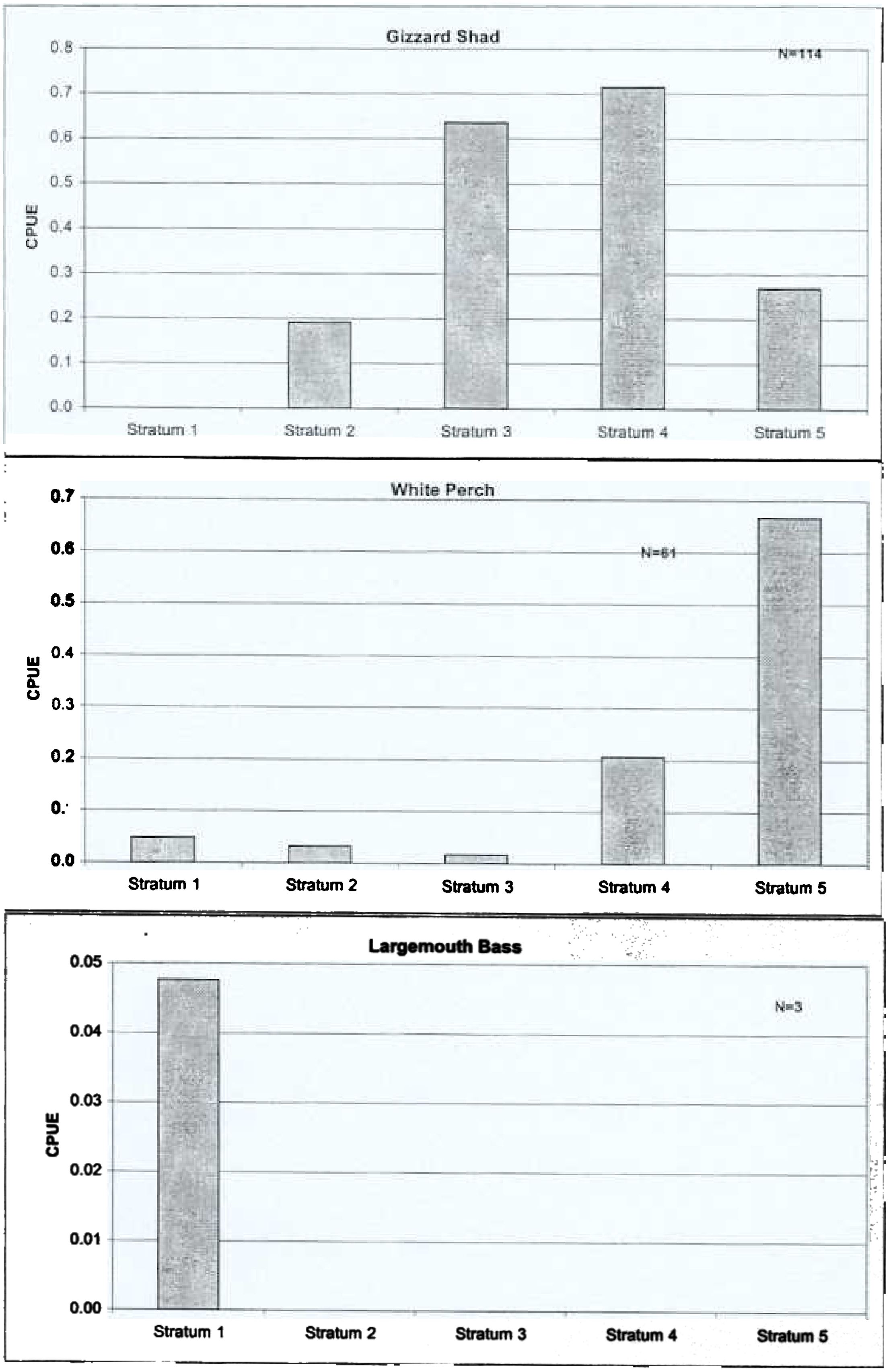

Figure 3.2-2d. Spatial distriubution of gizzard shad, white perch, and largemouth bass larvae among strata in the littoral zone of Onondaga Lake in 2000.

the vicinity of tributaries (Ninemile Creek in Stratum 2, Bloody Brook in Stratum 4, and Sawmill Creek in Stratum 5).

Common carp larvae were by far the most abundant (83.9% of common carp catch) in Stratum 4 Freshwater drum larvae were most frequently (94.8%) collected from Stratum 3 (south end). Golden shiner and yellow perch, the 6^{th} and 7^{th} most frequently collected taxa, were most frequently (75.5 and 90.4%, respectively) collected from Stratum 1 (Table 3.2-5). Spatial distribution for select taxa based on CPUE is depicted in Figure 3.2-2a through d.

3.2.3 Temporal Distribution

Sampling for larval fish was conducted every two weeks from the beginning of May 2000 to the end of July 2000. No larval fish were collected in the first sampling event in early May. Temporal distribution of the littoral larval fish community was influenced most by *Lepomis* spp. and brook silverside, since they were by far the most commonly captured taxa in the littoral zone. Both of these taxa became abundant in the larval fish community in late June and remained abundant into late July (Table 3.2-6, Figure 3.2-3a). Yellow perch and white sucker larvae catch rates peaked earliest, in mid-May, then fell to near zero in early June (Figure-3.2-3b). Yellow perch catch rates remained near zero for the remainder of the sampling. White sucker catch rates peaked again (but at a lower number) in mid-June and fell to zero in subsequent sampling events. Golden shiner and gizzard shad catch rates peaked in early June and then declined into July (Figure 3.2-3c and d). White perch and freshwater drum peaked in mid-June and were found in only small numbers in subsequent sampling events (Figure 3.2-3c). Peaks in catch rates for *Lepomis* spp., brook silverside, and common carp occurred in mid-July (Figure 3.2-3a and d). *Lepomis* spp. and brook silverside showed a decline, but were still present in substantial numbers during the last sampling event in the end of July. Common carp larval abundance in the littoral zone peaked in mid-July and then declined sharply.

Most larvae captured in the littoral zone showed a similar temporal distribution to the same taxa in the pelagic zone. The exceptions were freshwater drum and gizzard shad, which apparently reached peak abundance earlier in the littoral zone than in the pelagic zone.

Table 3.2-6 Littoral larvae fish catch for each sampling event and all events combined for Onondaga Lake in 2000. NOTE: Species taxa are denoted by italics.

Taxon	Early May	Mid-May	Early June	Mid-June	Late June	Mid-July	Late July	Total
Sunfish (Lepomis spp.)		3	4	155	837	3292	1112	5403
Brook silverside			2	16	1213	2481	1612	5324
Bluegill		1			28	106	338	473
White sucker		287	4	163				454
Common carp			1	1	12	329	4	347
Unidentified		3		16	53	183	87	342
Golden shiner				202	45	43	4	294
Yellow perch		198	5	6				209
Freshwater drum				179	3			182
Gizzard shad			66	26	22			114
Sunfish Family (Centrarchidae)					29	42	27	98
White perch				58	3			61
Temperate Bass Family (Percithyidae)		2	2	49	5			58
Herring Family (Cluepeidae)				12	23			
Fathead minnow				29	2	1		32
Banded killifish				1	2	11	4	18
Minnows (Cyprinadae)		2		8		6		16
Sucker Family (Catostomidae)		7		7				14
Alewife			2	3	6			11
Perch Family (Percidae)		5	3					
Logperch		6						6
Largemouth bass			1	2				3
White bass				2				2
Darters (Etheostoma spp.)		1	1					2
Longnose dace		1						1
Shorthead redhorse				1				1
Crappie (Pomoxis spp.)				2				2
Johnny darter		1						1
Tessellated darter				1				1
Minnows (Pimephales spp.).				1				1
Total	**0**	**518**	**91**	**940**	**2283**	**6494**	**3188**	**13514**

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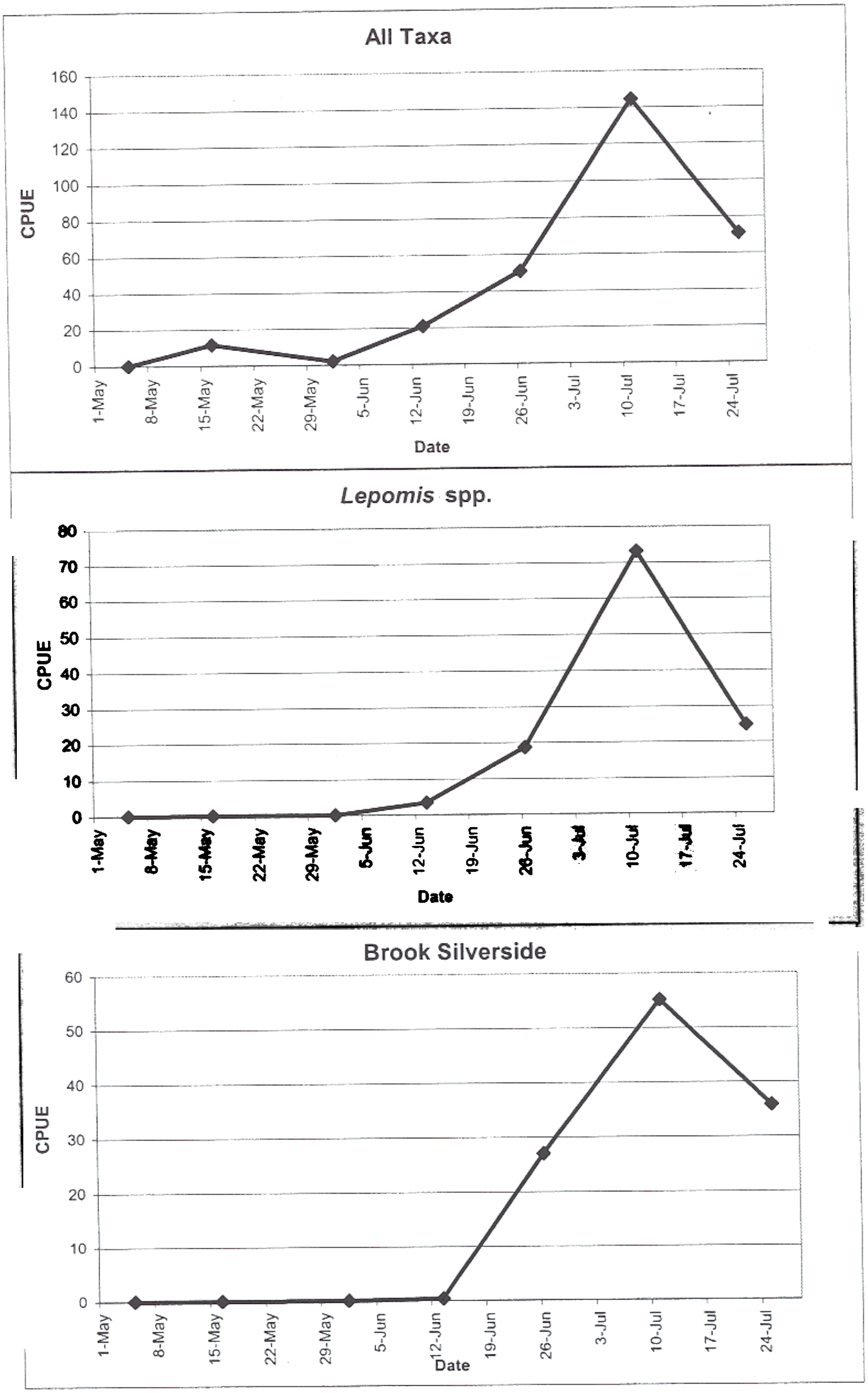

Figure 3.2-3a. Temporal distribution of all taxa, *Lepomis* spp., and brook silverside larvae collected in Onondaga Lake in 2000.

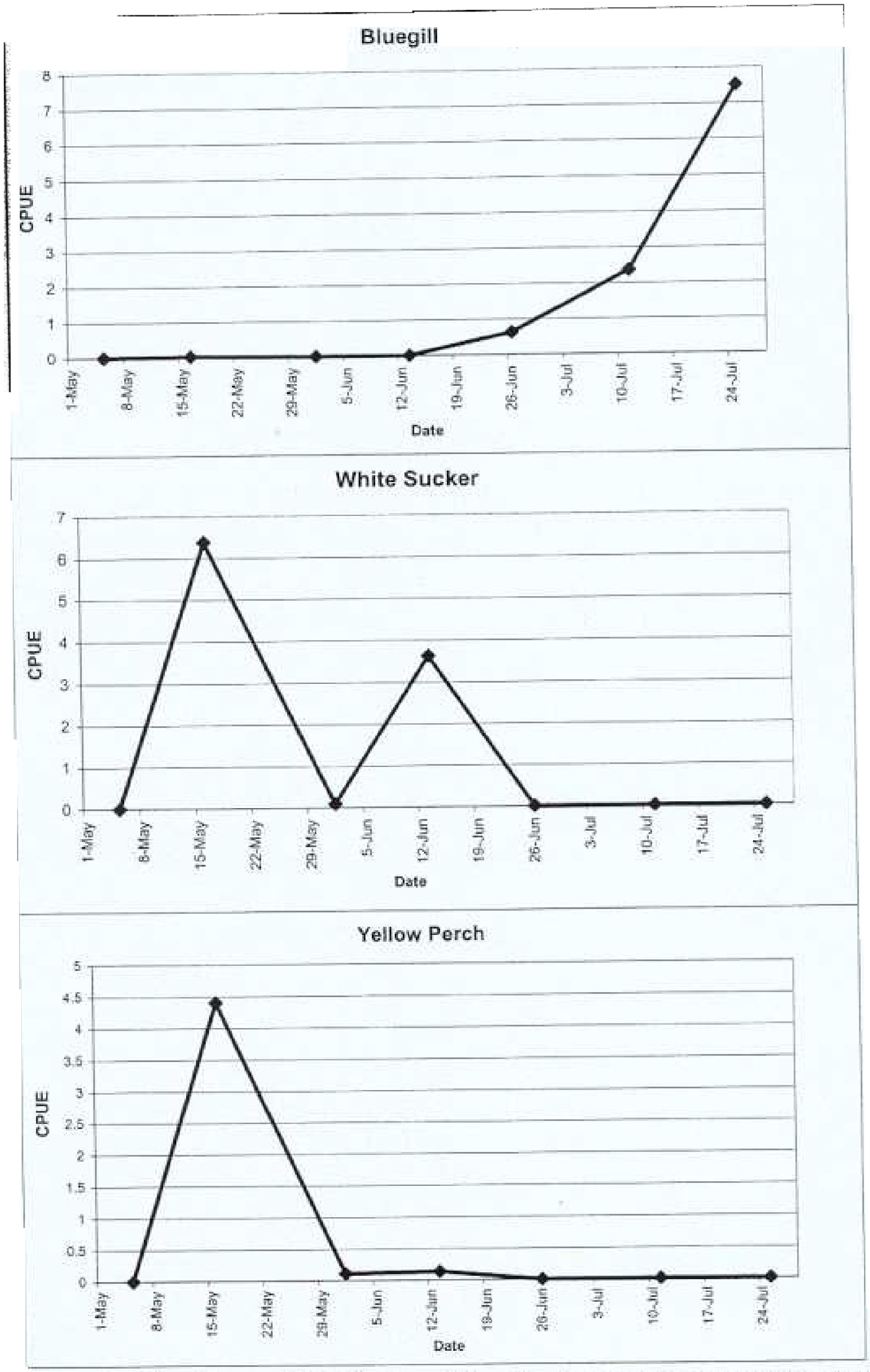

Figure 3.2-3b. Temporal distribution of bluegill, white sucker, and yellow perch larvae collected in Onondaga Lake in 2000.

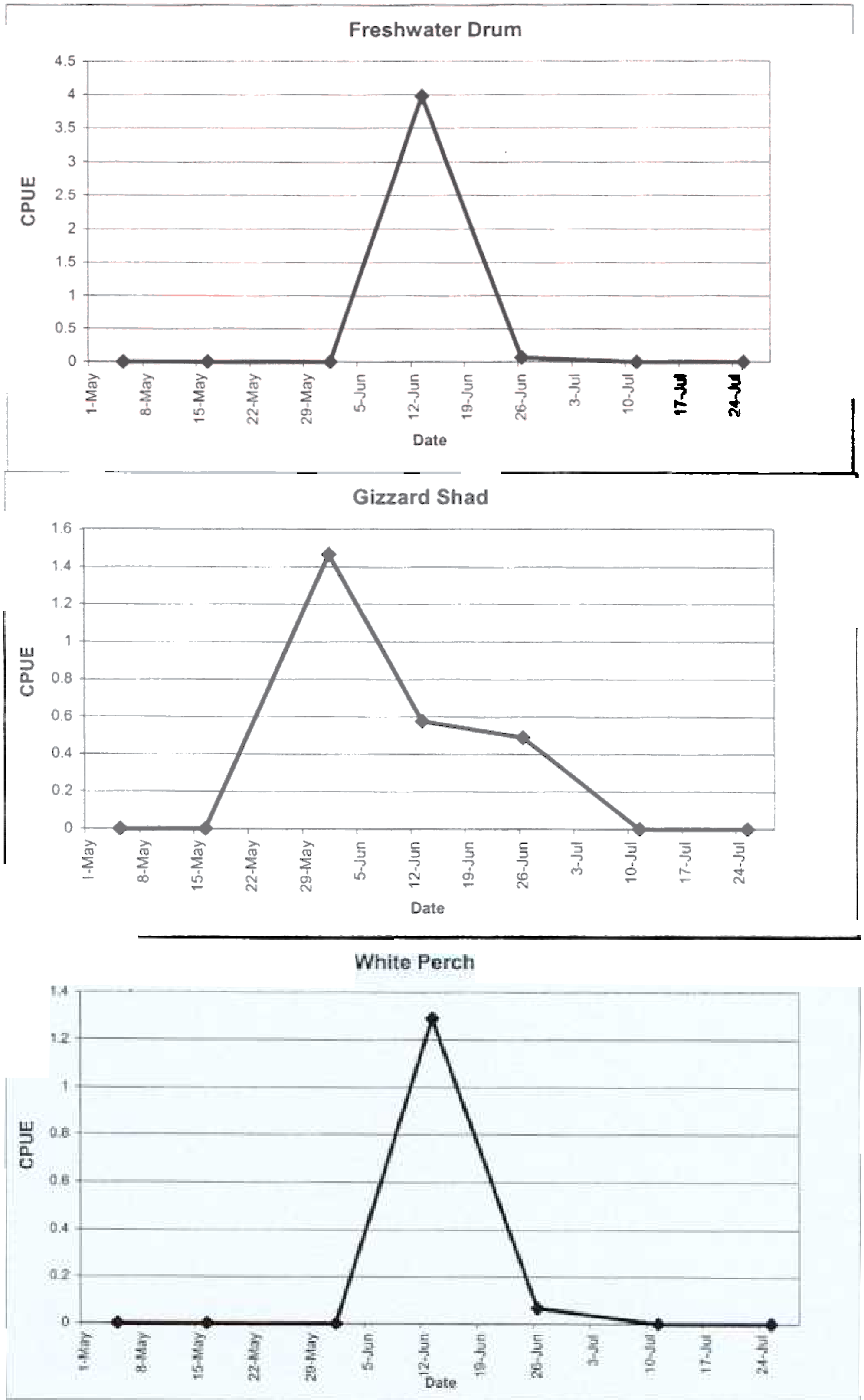

Figure 3.2-3c. Temporal distribution of freshwater drum, gizzard shad, and white perch larvae collected in Onondaga Lake in 2000.

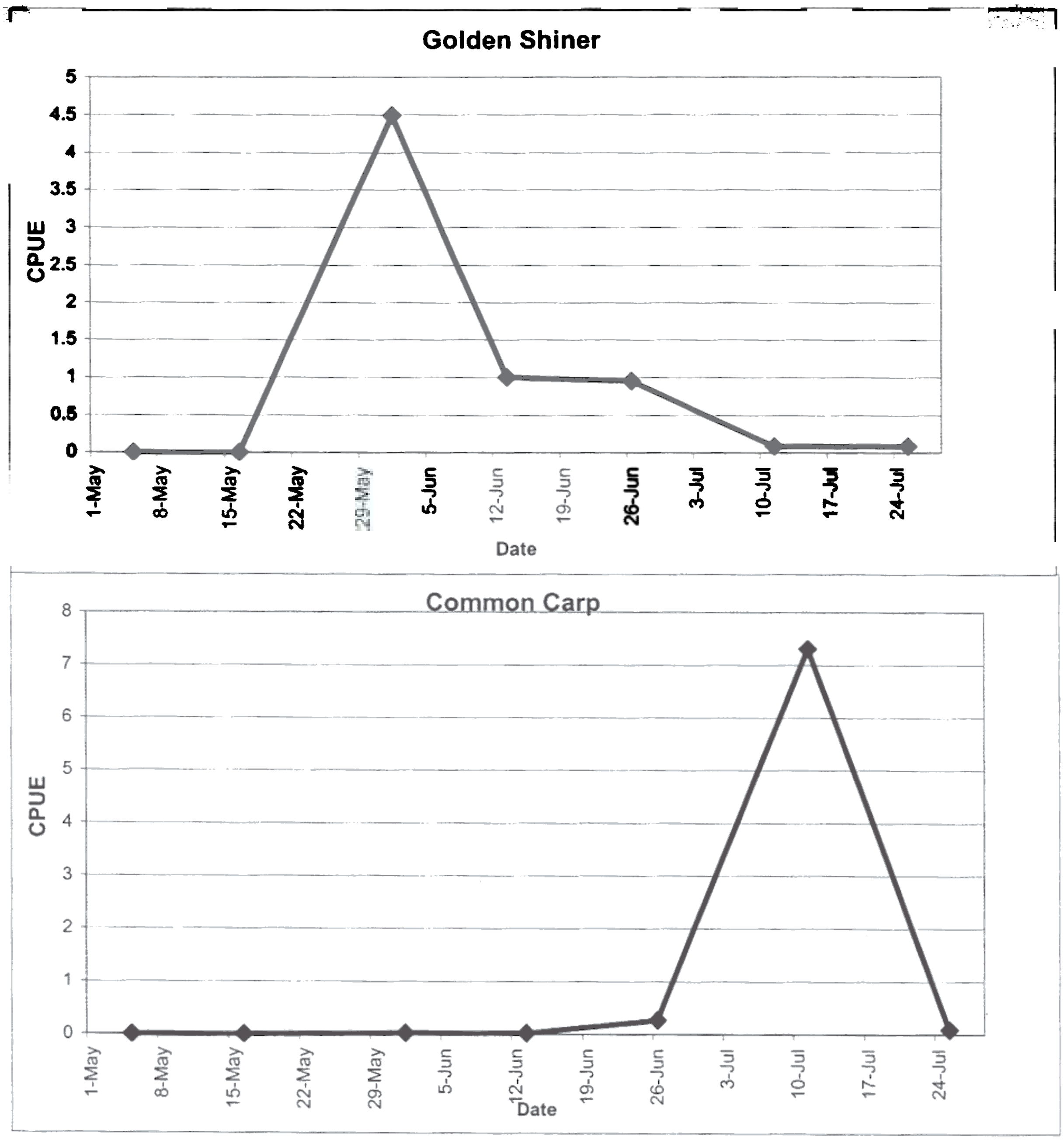

Figure 3.2-3d. Temporal distribution of golden shiner and common carp larvae collected in Onondaga Lake in 2000.

Length-Frequency Analysis

Length-frequency histograms of select species for each sample period during which they were caught are presented in Figures 3.2-4 to 3.2-6. *Lepomis* spp. showed an initial, strong cohort in mid- to late June, with protracted, though reduced, recruitment of larvae into late July (Figure 3.2-4). Brook silverside also seemed to show a prolonged reproduction period, as fish in the 5-10 mm size range were present from early June to the end of sampling in July (Figure 3.2-5). White sucker showed two peaks in larval abundance (Figure 3.2-6). This may represent two cohorts, possibly the result of different spawning runs or populations from different spawning streams. Yellow perch showed a single cohort that appeared to grow steadily throughout the sample period but drastically declined in number (Figure 3.2-6).

3.3 Juvenile Fish Sampling

Juvenile fish sampling using a seine was conducted during seven sampling events in 2000. During each sampling event, three sites were sampled in each of five strata, with three replicate seine hauls collected at each site. This yielded a total of 315 seine samples in 2000. Observation of field sampling techniques at two sites by EcoLogic was completed on September 7, 2000.

Total Catch

Although the main focus of the seining effort was to collect data on Onondaga Lake's young-of-year (YOY) fish community, many adult and non-YOY juveniles were also captured during seining. Changes to the Onondaga Lake entire fish community over time may be reflected in the total catch from seine hauls as well as other sampling strategies. Table 3.3-1 shows the catch from seine hauls for each sampling period and the total catch for the year 2000. A total of 21 species was collected in seines in 2000. Gizzard shad (51% of catch) and *Lepomis* spp. (19%) dominated the catch. Most of the individuals of these two taxa were represented by YOY fish (Table 3.3-2).

Figure 3.3-1 shows length distributions of selected species for each sampling period. Analysis of these length distributions and the time of year when fish of a particular size range

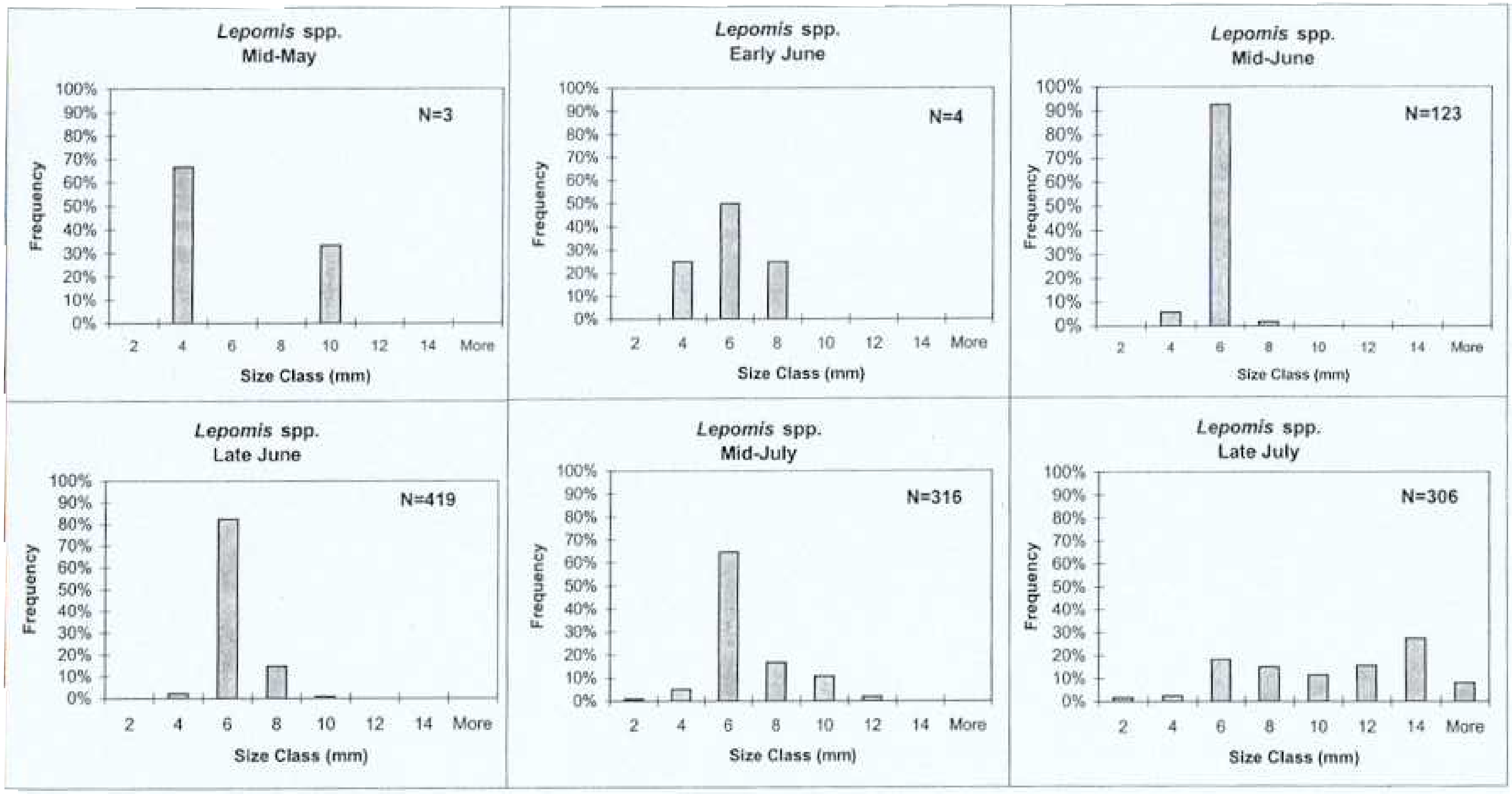

Figure 3.2-4. Length-frequency distribution of *Lepomis* spp. (probably both pumpkinseed and bluegill) collected in the littoral zone of Onondaga Lake in 2000.

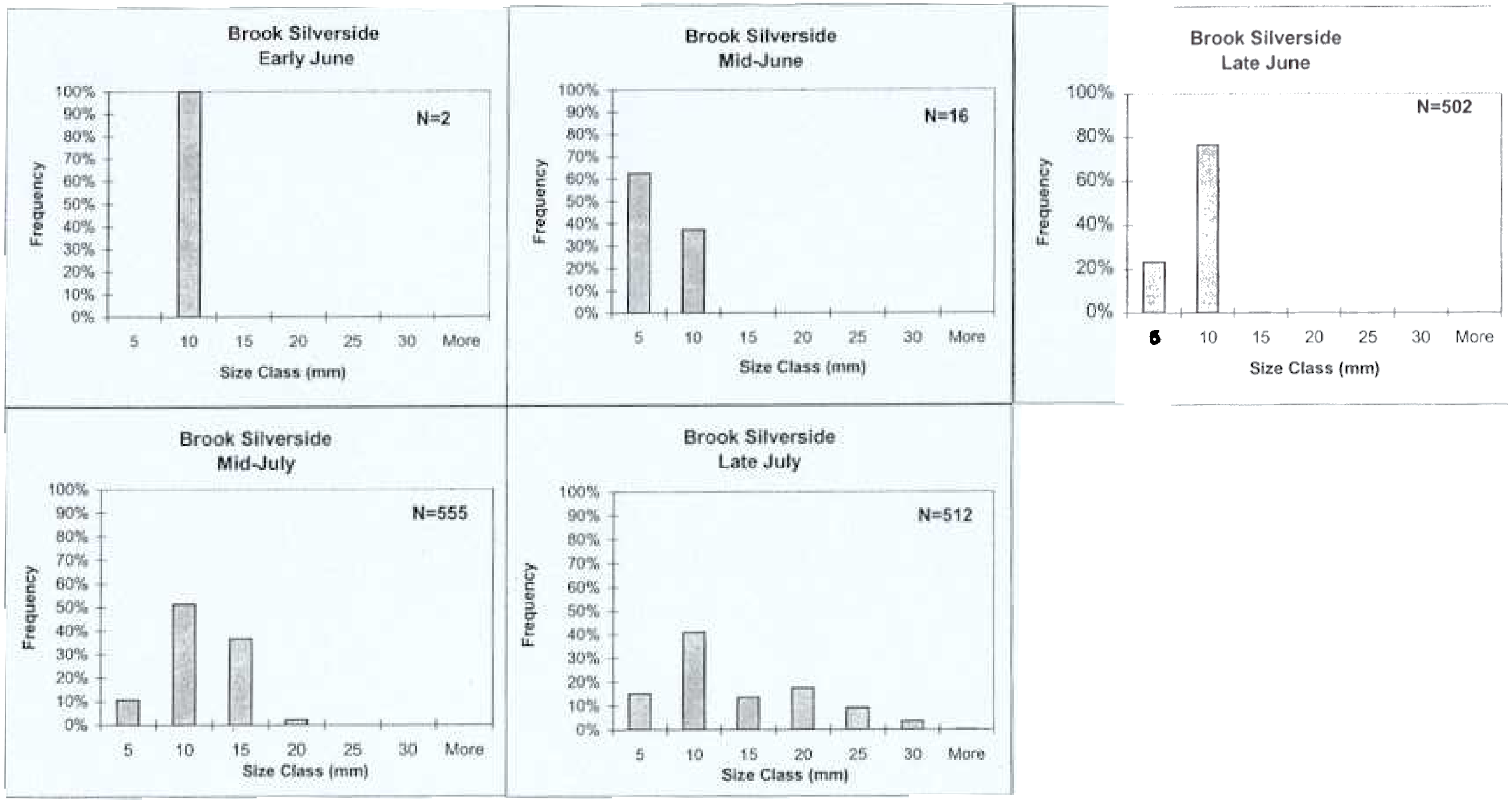

Figure 3.2-5. Length-frequency distribution of brook silverside collected in the littoral zone of Onondaga Lake in 2000.

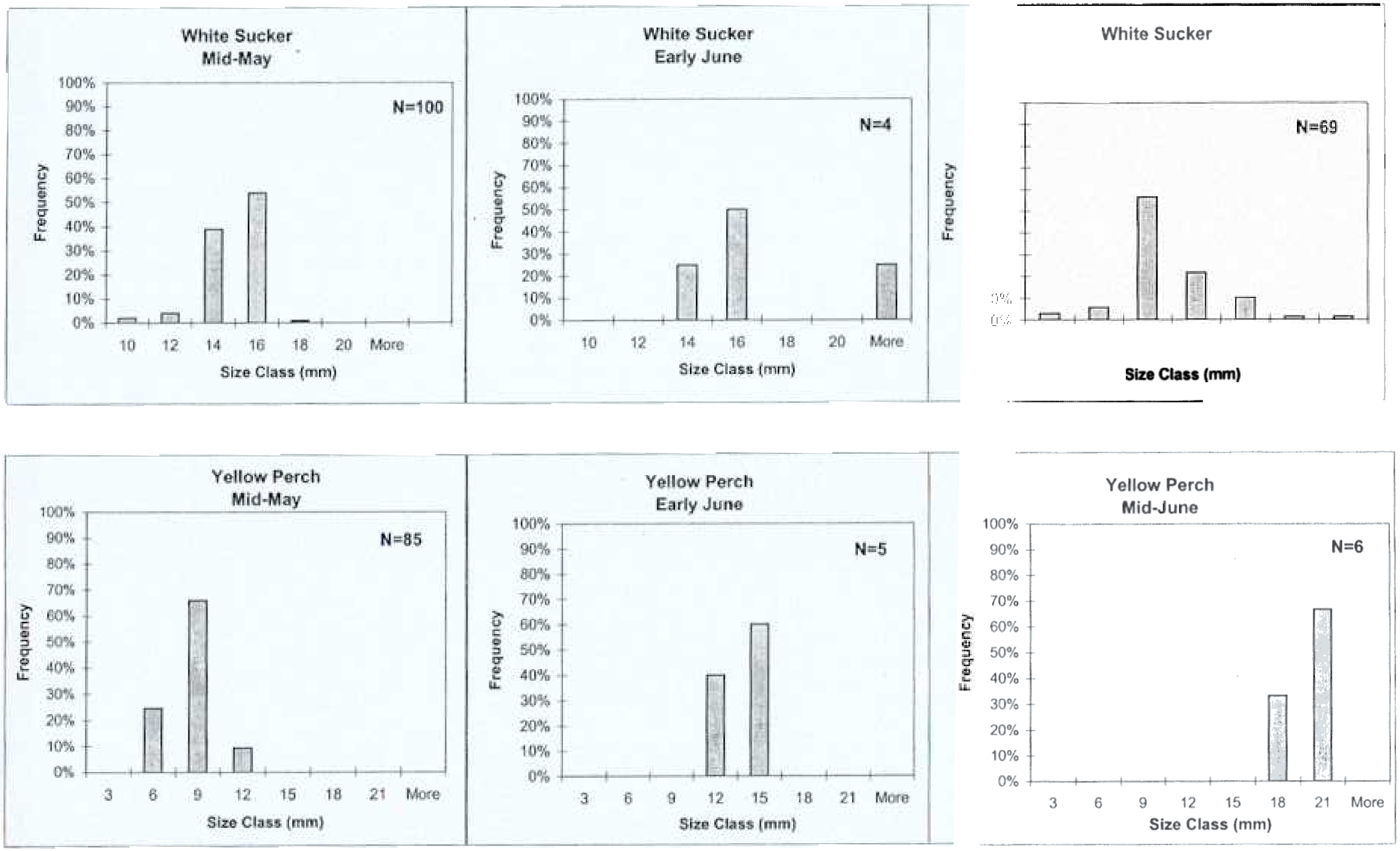

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Table 3.3- Total catch from seine hauls in during seven sampling periods in Onondaga Lake in 2000.

Species	Early May	Late May	Mid June	Early July	Late July	Mid August	Early Sept.	Total	Percent of Catch
Longnose gar					1			**1**	0.01%
Gizzard shad	1		5			3617	809	**4432**	51.09%
Common carp			34	1		1		**36**	0.41%
Golden shiner	12	2	13		4		29	**60**	0.69%
Emerald shiner	62	42	2		1	1	1	**109**	1.26%
Bluntnose minnow	29	42	1			1	2	**75**	0.86%
White sucker	3		1	1				**5**	0.06%
Northern hog sucker		1			1	1		**3**	0.03%
Banded killifish	50	126	72	31	108	29	9	**425**	4.90%
Brook silverside	38	121	35	4	108	61	1	**368**	4.24%
White perch	10	78	3	1	106	27	30	**255**	2.94%
Pumpkinseed	14	43	66	70	62	21		**276**	3.18%
Bluegill	12	114	187	93	62	23		**491**	5.66%
Lepomis spp.	20	3			5	794	791	**1613**	18.59%
Smallmouth bass	7	4	6	17	110	59	5	**208**	2.40%
Largemouth bass	1	31	52	23	61	43		**211**	2.43%
Black crappie			1					**1**	0.01%
Johnny darter	1					2		**3**	0.03%
Tessellated darter	2			1			1	**4**	0.05%
Yellow perch	15	28	1	4	13	6	2	**69**	0.80%
Logperch	1	1			13	11	4	**30**	0.35%
TOTAL TAXA	**16**	**14**	**15**	**11**	**14**	**16**	**12**	**21**	
TOTAL FISH	**278**	**636**	**479**	**246**	**655**	**4697**	**1684**	**8675**	**100%**

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Table 3.3-2. Young-of-year fish species captured in seine hauls from 2000 and 1994.
NC= not captured as YOY in that year.

Species	2000		1994 (Arrigo 1998)
	Total Catch	Percent of Catch	Percent of Catch
Gizzard shad	4426	66 %	91 %
Lepomis spp.	1590	24 %	4.0 %
Smallmouth bass	168	2.5 %	0.2 %
White perch	164	2.4 %	0.6 %
Banded killifish	119	1.8 %	NC
Largemouth bass	97	1.4 %	3.1 %
Brook silverside	76	1.1 %	0.04 %
Golden shiner	32	0.48 %	0.4 %
Logperch	17	0.25 %	NC
White sucker	4	0.06 %	0.07 %
Longnose gar	1	0.01 %	0.003 %
Common carp	1	0.01 %	0.3 %
Northern hog sucker	1	0.01 %	NC
Alewife	NC	NC	0.03 %
Brown bullhead	NC	NC	0.003 %
Rock bass	NC	NC	0.003 %
Rainbow smelt	NC	NC	0.003 %

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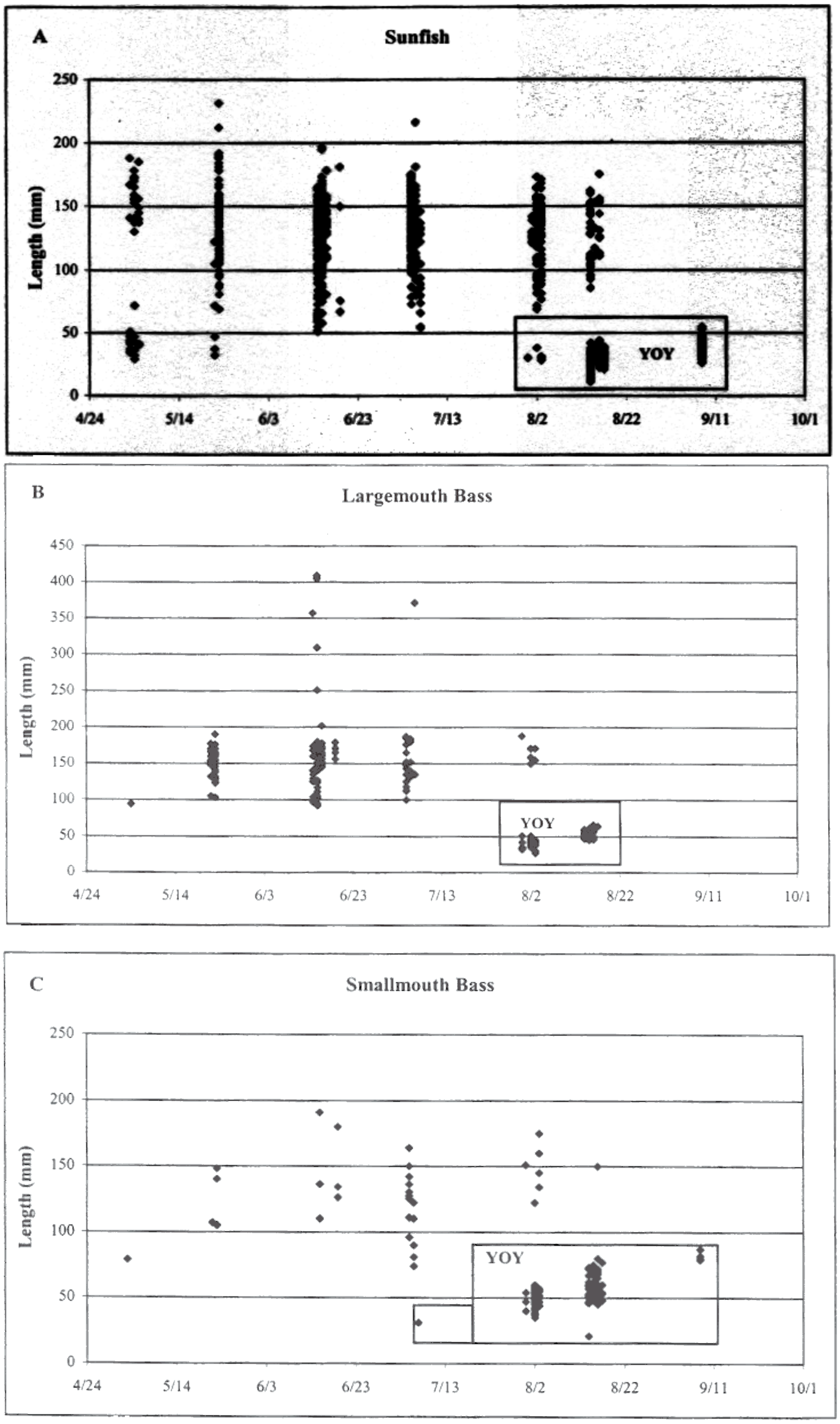


Figure 3.3- Lengths of individual fishes captured in seines from Onondaga Lake during seven sampling events in 2000. Fish considered to be young-of-year (YOY) are boxed in. Only those species with substancial numbers of individuals captured are depicted. Page 1 of 4

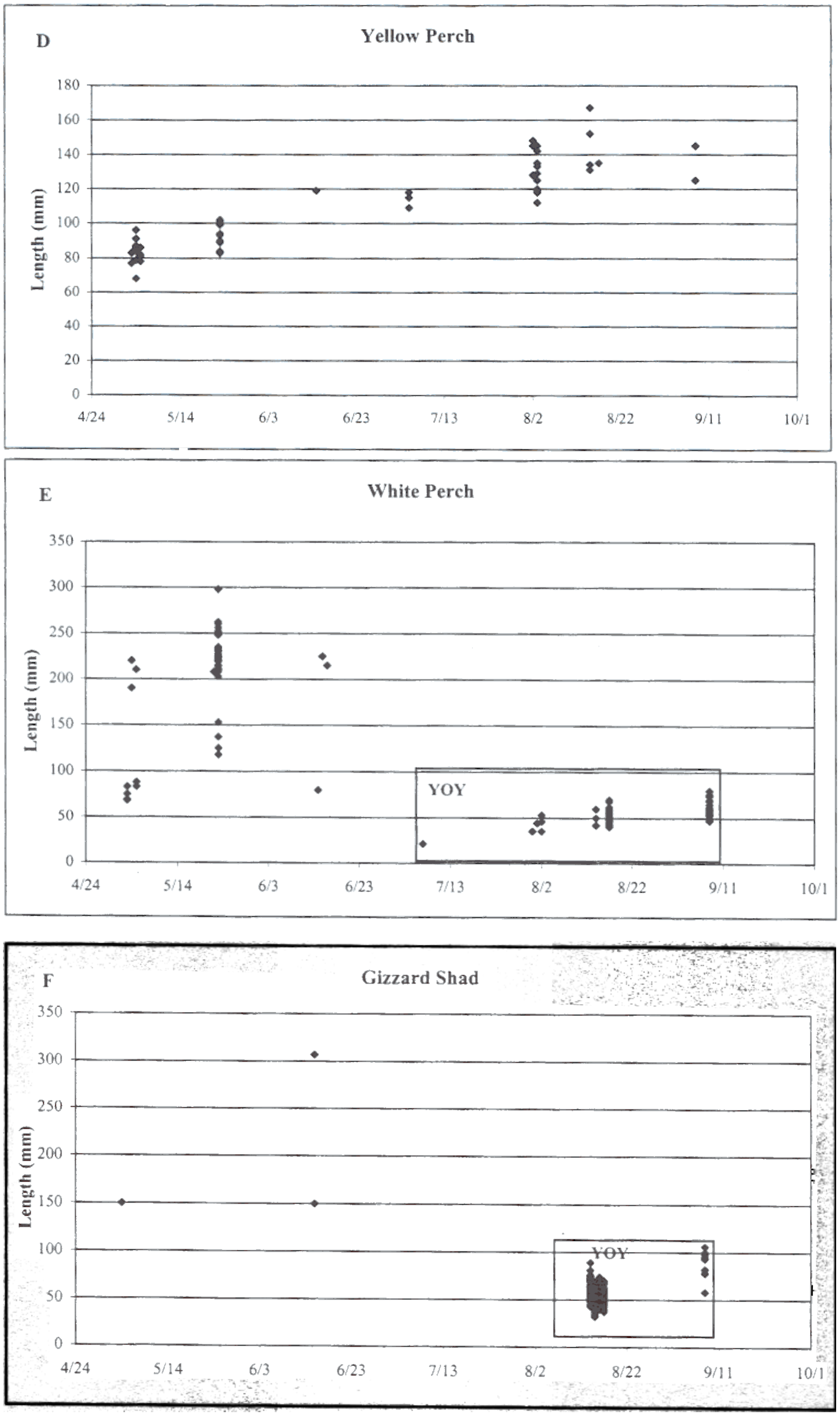
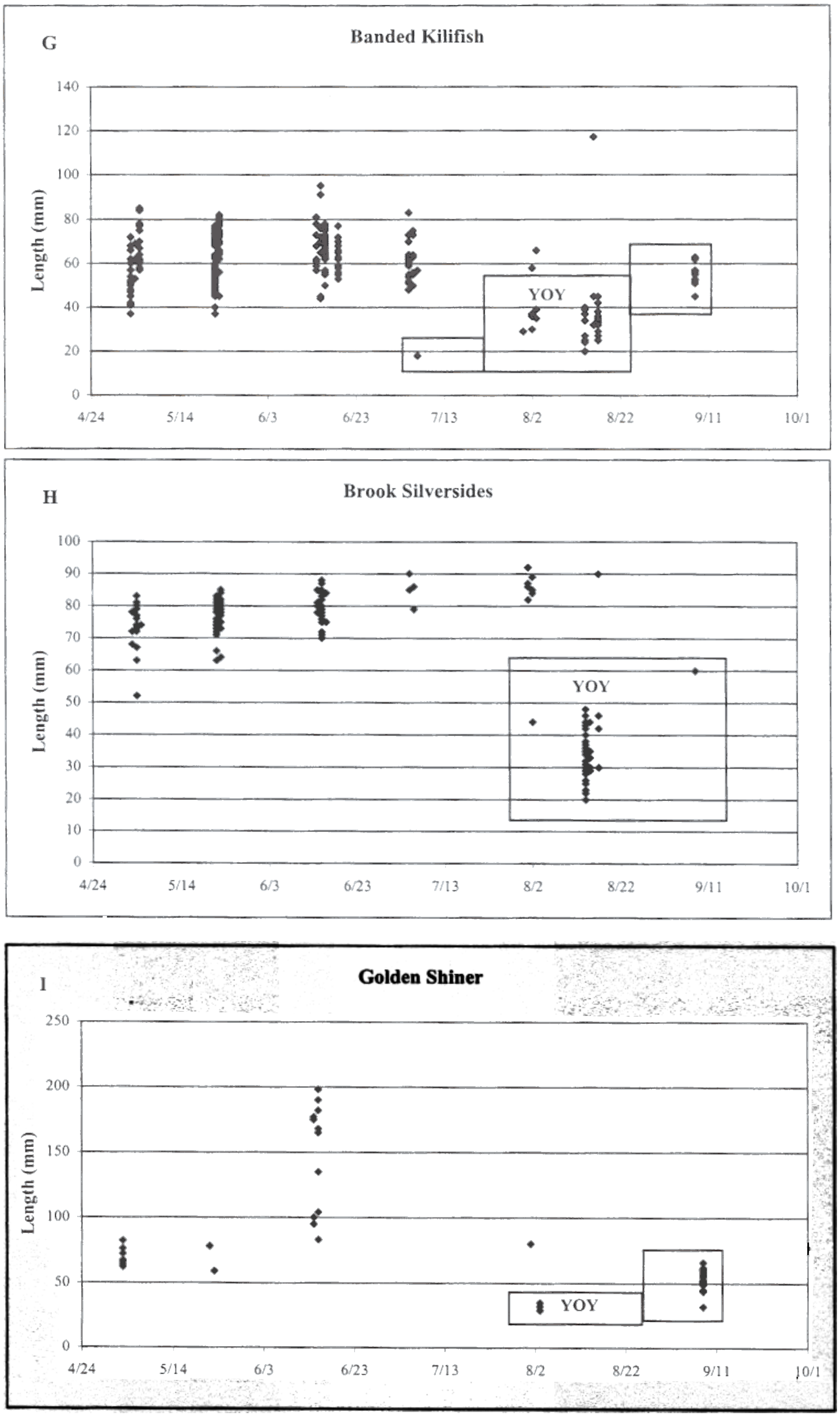


Figure 3.3-1. Continued **Page 2 of 4**



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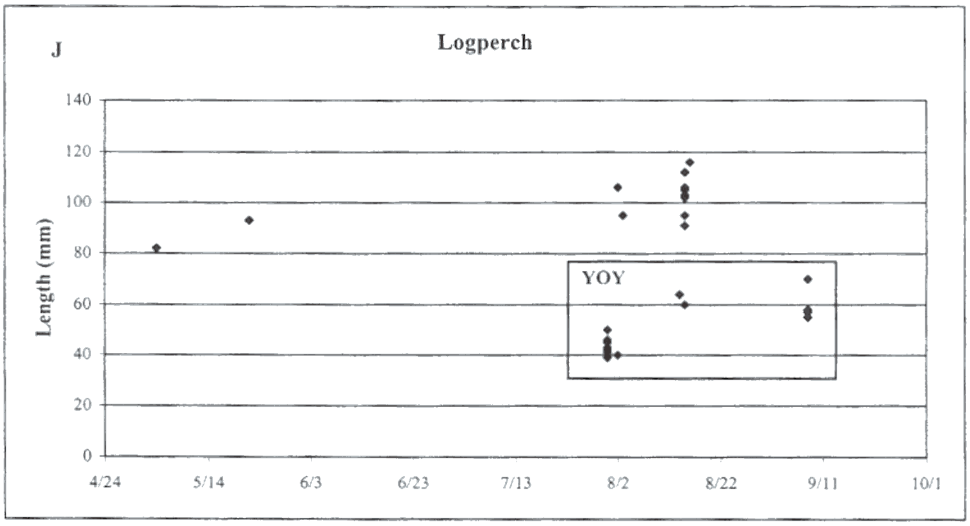

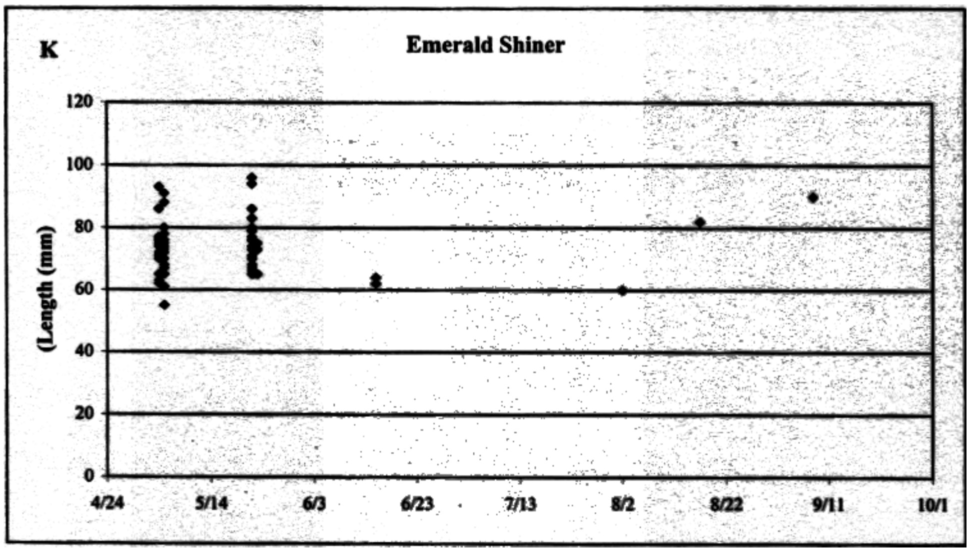

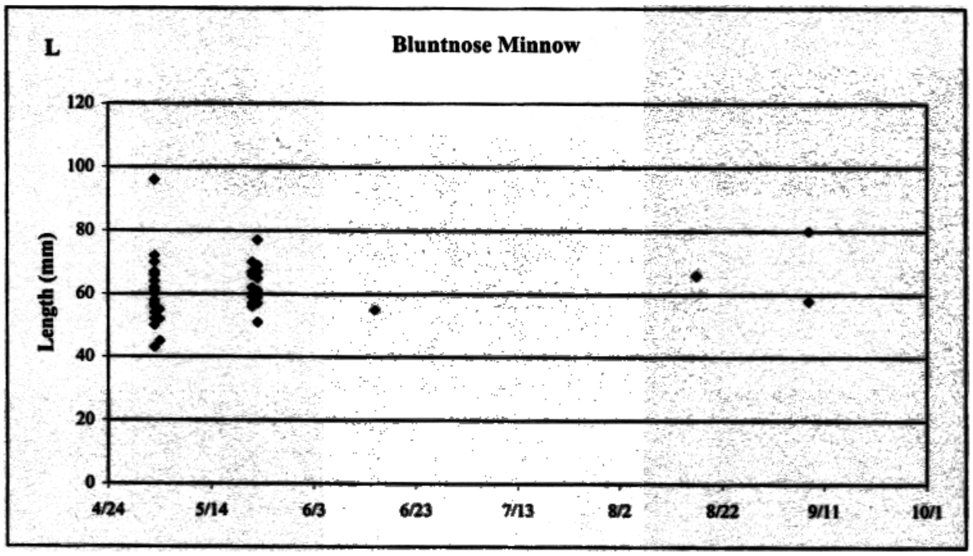

Figure 3.3- Continued

were present allowed for differentiation of YOY fish from non-YOY juvenile and adult fish The presence of non-YOY juveniles in the seine hauls gives an indication of past year-class strength. For example, brook silverside usually die before their second winter (Smith 1985), so non-YOY silversides are typically represented by only a single year-class. In Figure 3.3-1H, non-YOY brook silversides are represented by what looks to be a strong 1999 year-class, indicating that reproduction of that species was successful in 1999. Likewise non-YOY juvenile largemouth bass (probably mostly one- and two-year olds, Figure 3.3-1B) appear to be well represented, an indication of at least one or two recent strong year classes. Yellow perch (Figure 3.3-1D) seem to be represented by a single year class (likely one-year olds) whose growth through the summer can be observed through the increasing trend in their length. The presence of only non-YOY juvenile yellow perch in 2000 indicates that reproduction of this species in Onondaga Lake in 2000 was at least limited or possibly non-existent. *Lepomis* are represented by what appear to be multiple year classes through most of the summer, indicating probable successful reproduction for at least a few years prior to 2000 (Figure 3.3-1A). A group of *Lepomis* <50 mm collected in the earliest sample period (lower left side of the plot) are presumably fish produced in 1999.

Species richness varied by stratum (Figure 3.3-2). An average of about 14 species were collected in Onondaga Lake during the seven seining events in 2000 (Figure 3.3-2). Stratum 2 (wastebeds) had the lowest average richness (4), while the other strata ranged from 7 (Stratum 1, NW shore) to 10 (Stratum 4, east shore). Diversity results closely matched those of richness, with Stratum 2 being lowest (0.31) and Stratum 4 the highest (0.58) (Figure 3.3-2). The low richness and diversity in Stratum 2 suggest there is generally poor nursery and juvenile fish habitat in this area.

3.3.2 Catch of Young-of-Year

Young-of-year of 14 species were captured in Onondaga Lake seine hauls in 2000 (assuming *Lepomis spp.* represented both bluegill and pumpkinseed, Table 3.3-2). This represents 47% of the 30 adult taxa captured in the 2000 monitoring effort. This is similar to observations from 1994 when YOY of 15 species were captured, representing 40% of the adult species collected in that year (Arrigo 1998). The 47% of species represented by YOY fish in 2000 is higher than

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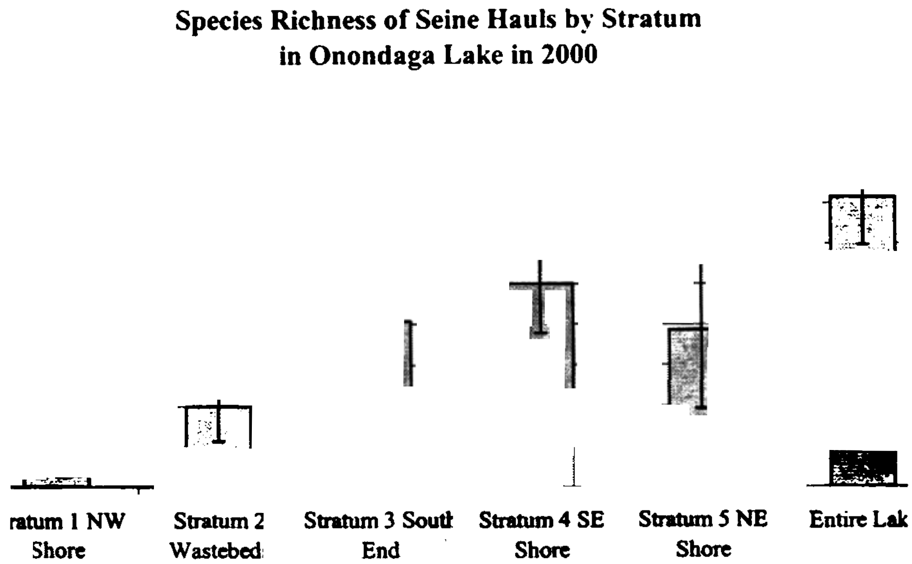

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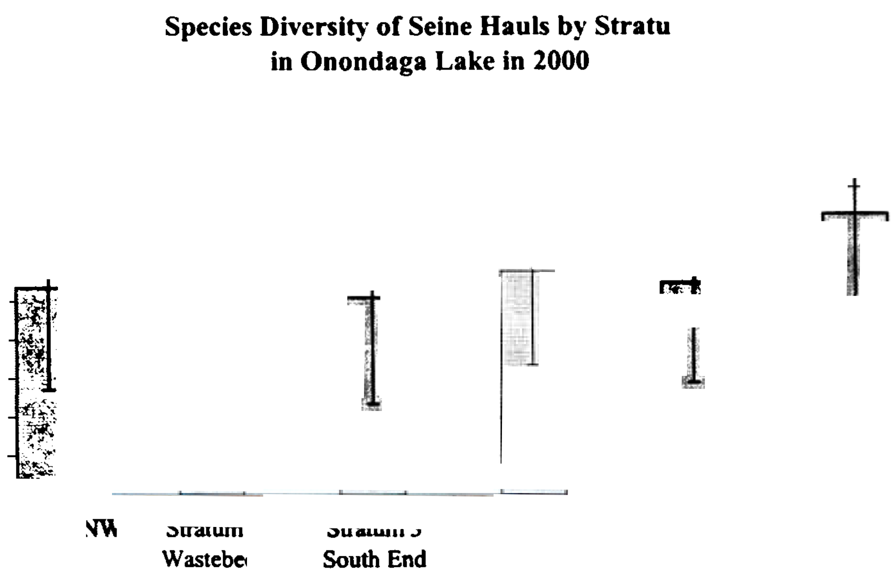


Figure 3 Mean richness and diversity within each stratum and for the entire lake for seine hauls conducted in Onondaga Lake in 2000. Bars represent one standard deviation.

observed in 1991, 1992, and 1993 when between only 15% and 35% of the adult species captured in the lake in any one year were also captured as YOY (Gandino 1996, Ringler et al. 1996, Arrigo 1998). In 2000, gizzard shad dominated the YOY catch, representing, 66% of the total YOY catch, followed by *Lepomis* spp. (24%) (Table 3.3-2, Figure 3.3-3). This is in contrast to studies in 1992 through 1994 when *Lepomis* dominated the catch in each year (81, 60, and 91% respectively) (Arrigo 1998). Future sampling efforts may help to determine whether or not the 2000 results correspond to an actual community shift or if the observed differences from studies in the early 1990s are just due to natural annual variability in YOY abundance.

Quantitative comparisons of catch per unit effort (CPUE, defined here as catch per seine haul) of YOY fish between the 2000 effort and earlier studies are not possible due to slight differences in sampling techniques. However, from a qualitative perspective, CPUE in 2000 (21 fish/haul) appeared low compared to 1993 (1,443 fish/haul) and 1994 (1,013 fish/haul) (Arrigo 1998). The two orders of magnitude lower CPUE in 2000 is closer to the CPUE for 1992 (1.3), when fish reproduction in Onondaga Lake was judged to be almost non-existent (Gandino 1996, Ringler et al. 1996, Arrigo 1998). Gandino (1996) hypothesized that the cool, wet spring and summer of 1992 was the cause of the poor reproduction in that year. Coincidently, the latter half of 2000 was also unusually cool. In fact, July 2000 was the second coldest July since 1922, and July through December 2000 was the third coldest July-December period since 1922 (National Oceanic and Atmospheric Administration data, www.nws.noaa.gov). Other factors that have been identified as limiting year-class strength include excessive wind (Kramer and Smith 1962), the presence of dense populations of planktivores that prey on larval fish (Forney 1987), the availability of forage for larval and YOY fish (VanDeValk et al 2001), and size and fecundity of the spawning stock (Kramer and Smith 1962).

Most species observed as YOY in the early 1990s still constituted the majority of the observed YOY species in 2000 (Table 3.3-2). A total of 168 smallmouth bass YOY, contributing 2.5% of the YOY catch, were captured in 2000. In the late 1980s and early 1990s smallmouth bass YOY were either absent or rare in seine catches (Mark Arrigo and Chris Gandino, unpublished data). The first substantial catch of YOY smallmouth bass was in 1994, when 61 individuals were captured, representing 0.2% of the YOY population (Arrigo 1998). The presence of substantial numbers of YOY smallmouth bass in 2000 combined with the first

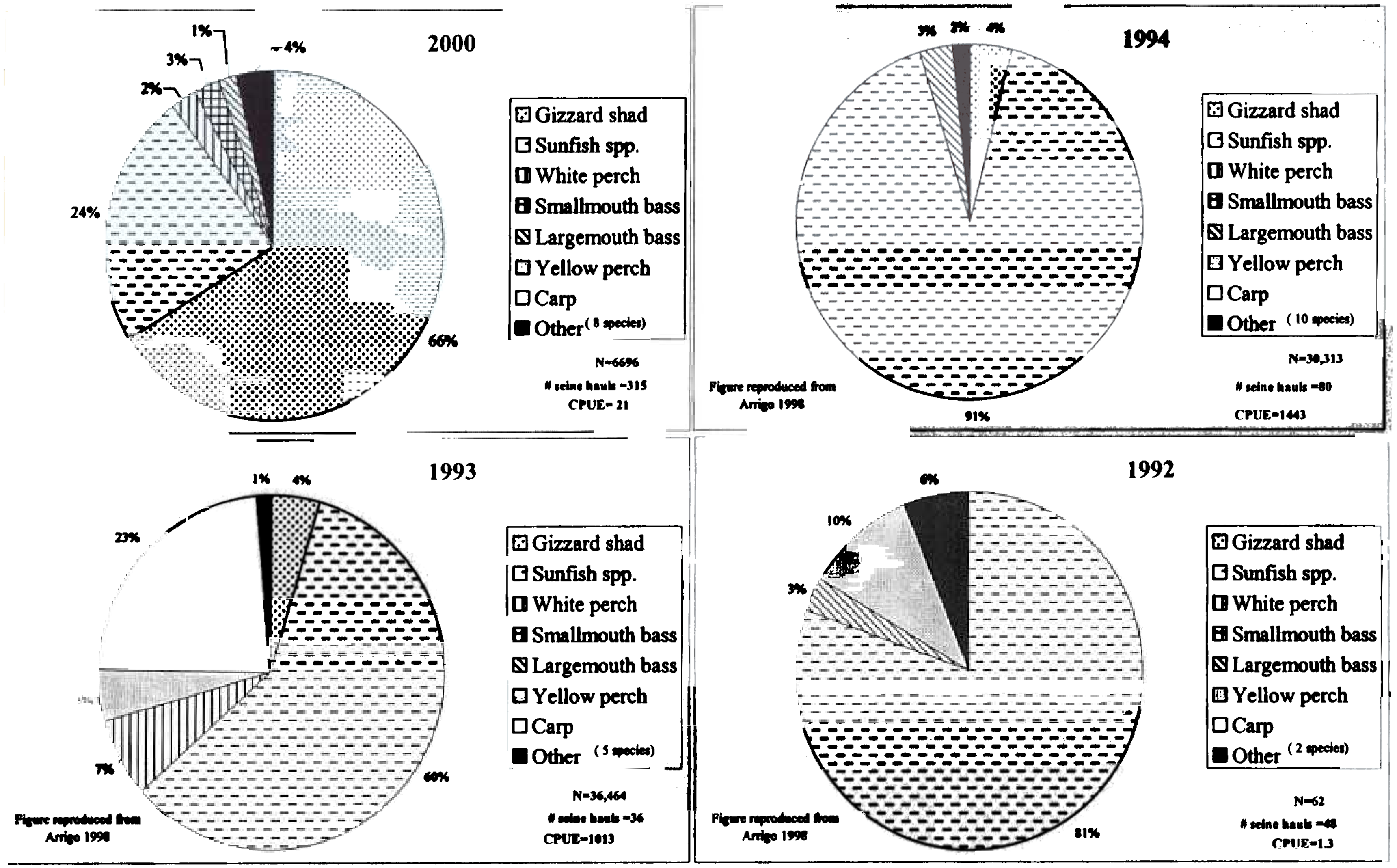


Figure 3.3-3. Community structure of the young-of-year fish community in Onondaga Lake during 2000 and 1992-1994. Sunfish (*Lepomis*) spp. are a combination of YOY bluegill and pumpkinseed. Note that seining methods differed between the 2000 effort and the 1992-1994 samples. Total catch (N) and CPUE are provided for qualitative comparisons only.

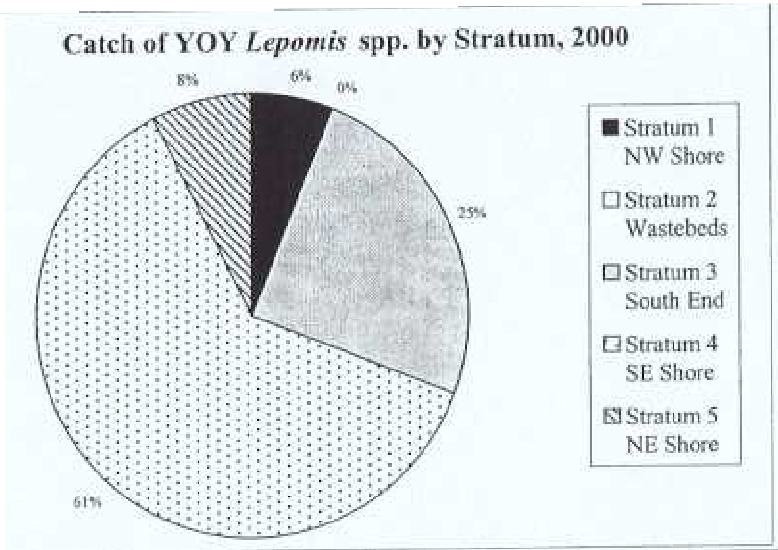
documentation of smallmouth bass nesting activity in the lake during 2000 suggest that successful reproduction of this species may be increasing. In contrast, no YOY yellow perch were collected in 2000, indicating that a year class failure possibly occurred for this species (Figure 3.3-1D). Apparent year class failures of yellow perch in Onondaga Lake have been documented in the past. Yellow perch YOY were absent in 1994, and although yellow perch YOY contributed 10% of the population in 1992, total number of individuals captured was very low (6) (Arrigo 1998). Of the four years (1992-1994 and 2000), yellow perch contributed substantially (1823 individuals captured representing 5% of the YOY catch) to the YOY community only in 1993 (Arrigo 1998).

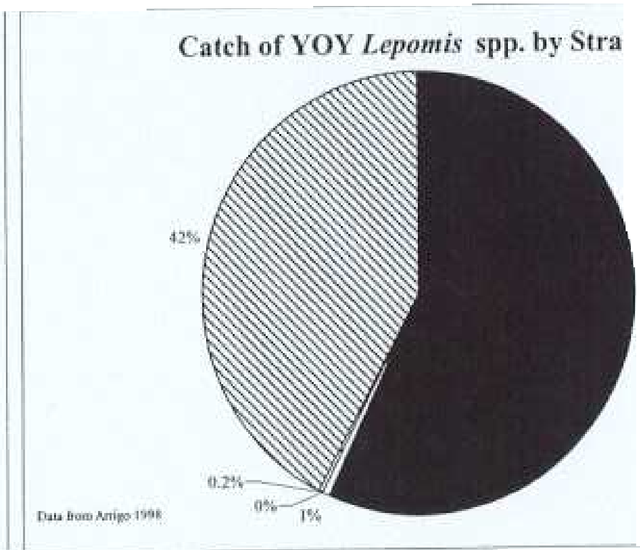
3.3.3 Spatial Distribution of Selected Young-of-Year Species

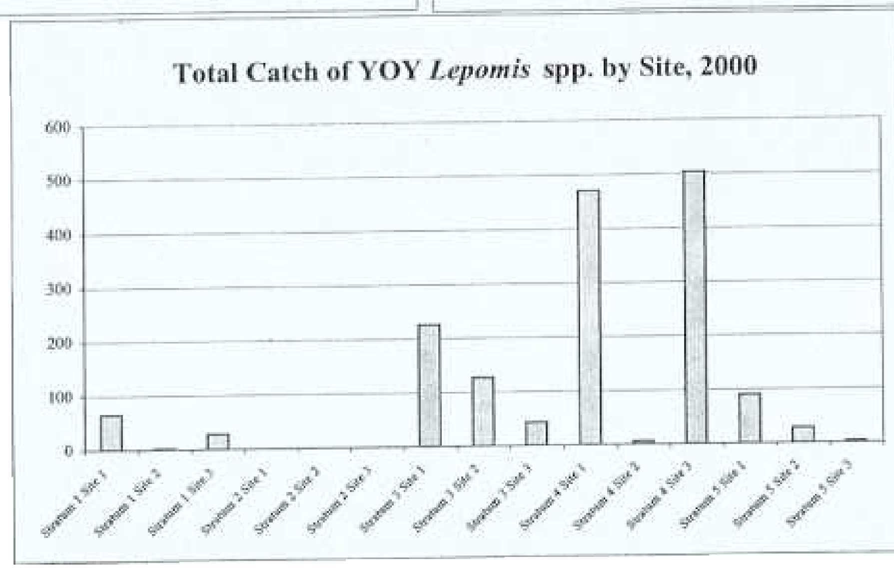
Arrigo (1998) documented the spatial distribution of *Lepomis* and largemouth bass YOY in Onondaga Lake in 1994. The sample design in 1994 was not stratified; however the eight sites used in that study fall within the borders of four of the strata used in the 2000 study (1,2,4 and 5, two sites per stratum) The results from individual sites in 1994 were grouped to correspond to the strata used in the 2000 effort for comparison purposes

3.3.3.1 Sunfish (*Lepomis* spp.)

YOY bluegill and pumpkinseed were grouped together under the designation of *Lepomis* spp. (the genus of both species) at the time of collection due to the difficulty in differentiating YOY of these two species in the field. In past studies, YOY *Lepomis* were by far the most common species collected in Onondaga Lake. Figure 3.3-4 shows the spatial distribution of *Lepomis* in 2000 compared to 1994. Overall, 86% of YOY *Lepomis* were collected in the south basin of Onondaga Lake in 2000, whereas 99% were collected in north basin sites in 1994 No YOY *Lepomis* were collected in Stratum 2 (wastebeds) in 2000, and, likewise, only 1% was collected there in 1994. Specifically, in 2000 most YOY *Lepomis* were found in Strata 4 (61%) and 3 (25%) (east shore and south end, respectively) in contrast to 1994 when most fish were found in Strata 1 (57%) and 5 (42%) (northeast and northwest shores, respectively). Site-to-site variability was high in 2000, with most sites yielding few if any YOY *Lepomis* (Figure 3.3-4). Most of the *Lepomis* in 2000 were collected at only two sites in Stratum 4 and one site in







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Stratum 3 (Figure 3.3-4). The reason for the apparent difference in spatial distribution of YOY *Lepomis* between 1994 and 2000 is unknown. The continued scarcity of YOY *Lepomis* along the wastebeds may be habitat related.

3.3.3.2 Largemouth Bass

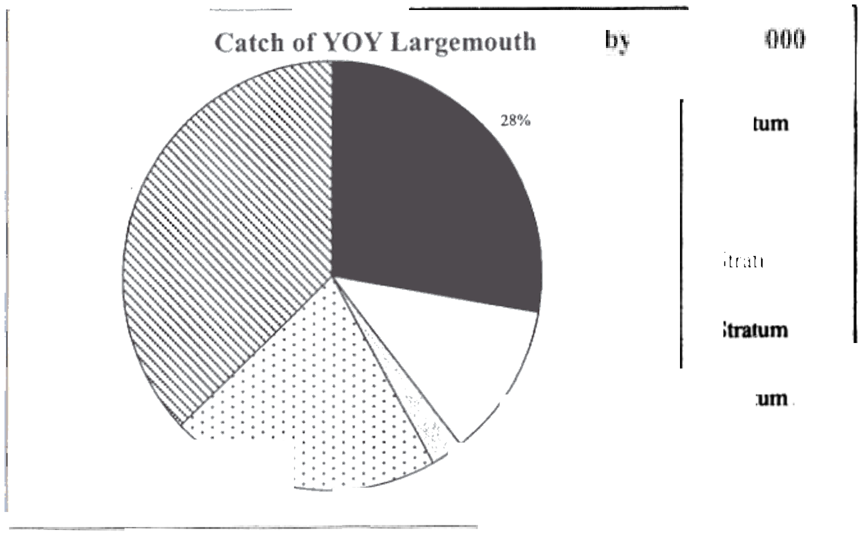
YOY largemouth bass appeared to be more evenly distributed around the lake in 2000 than in 1994 (Figure 3.3-5). Seventy-nine percent of YOY largemouth bass were collected in a single stratum (Stratum 1) in 1994, whereas the top three strata (Strata 3, 4, and 1) contributed 37%, 28% and 21% of the YOY largemouth in 2000. The majority of YOY largemouth bass (65%) were collected in the north basin in 2000. Likewise, most (90%) YOY largemouth bass in 1994 were collected in the north basin. While Stratum 1 produced the most largemouth bass in 1994, Stratum 5 produced the most in 2000. Site-to-site variability in 2000 was high, with only eight of the fifteen total sites sampled producing any YOY largemouth bass (Figure 3.3-5).

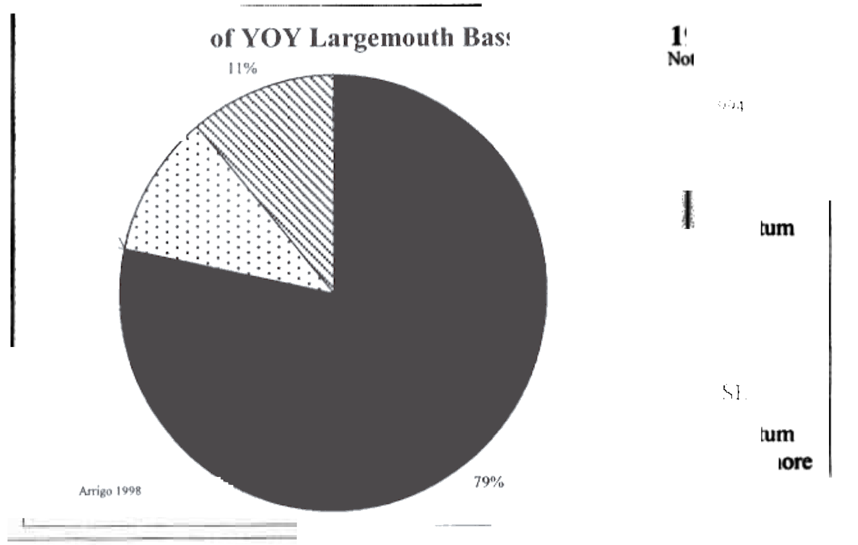
3.3.3.3 Smallmouth Bass

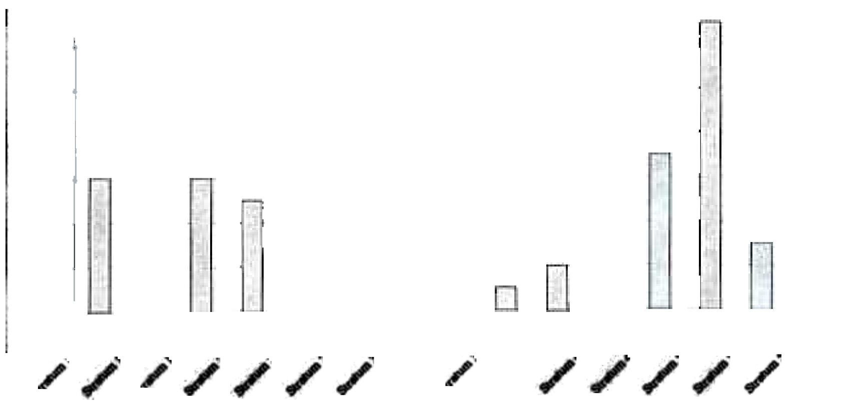
Smallmouth bass YOY were found in nearly all areas of Onondaga Lake in 2000 (Figure 3.3-6). Most smallmouth bass YOY were collected in Stratum 5 (northeast shore, 34%), Stratum 1 (northwest shore, 23%) and Stratum 4 (east shore, 23%). Lesser numbers of smallmouth bass YOY were found in Stratum 2 (wastebeds, 12%) and Stratum 3 (south end, 8%). Slightly more than half (57%) of the smallmouth bass were collected in the north basin (Strata 1 and 5 combined). Variability of catch among seine sites was high, but at least one YOY smallmouth bass was captured at all but one of the 15 seine sites (Figure 3.3-6).

3.3.3.4 Gizzard Shad

Almost all YOY gizzard shad collected in 2000 were collected from Stratum 2 (63%) and Stratum 3 (33%) (Figure 3.3-7). All of the gizzard shad collected in Stratum 2 were captured at a single site during a single sampling event (Figure 3.3-7). YOY gizzard shad were collected from only four of the 15 seine sites in 2000, even though County personnel observed large schools of YOY shad throughout the lake during the late summer. The schooling nature of gizzard shad and the tendency of these schools to continually move makes consistent sampling of young with







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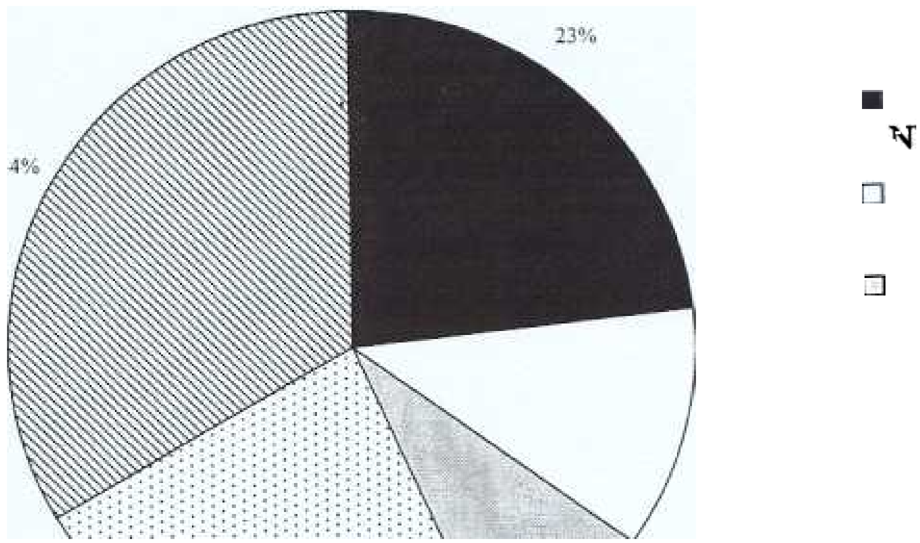
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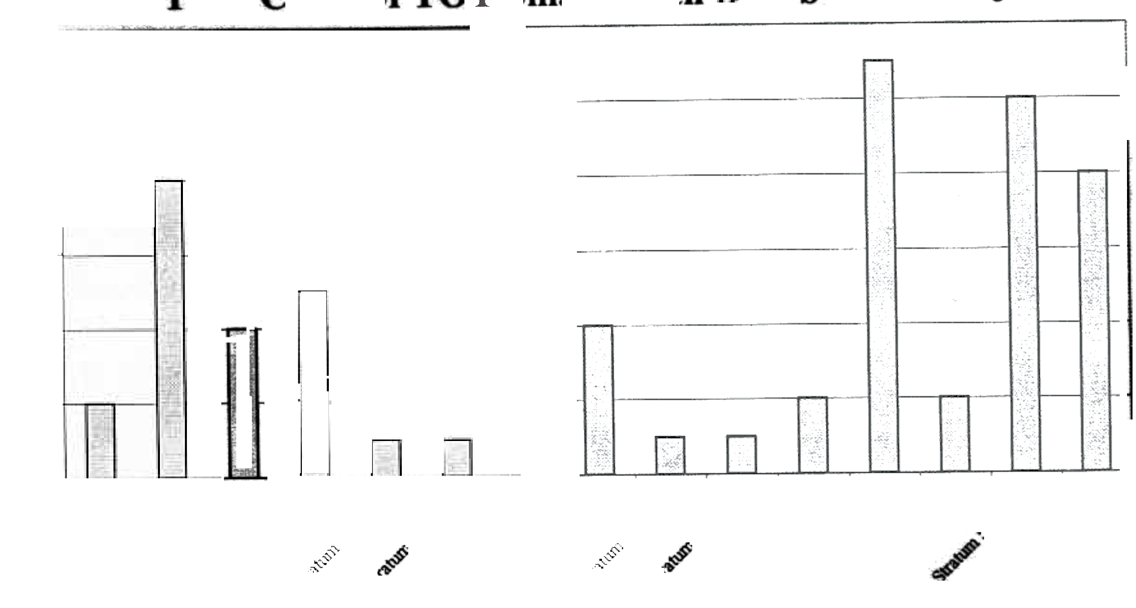
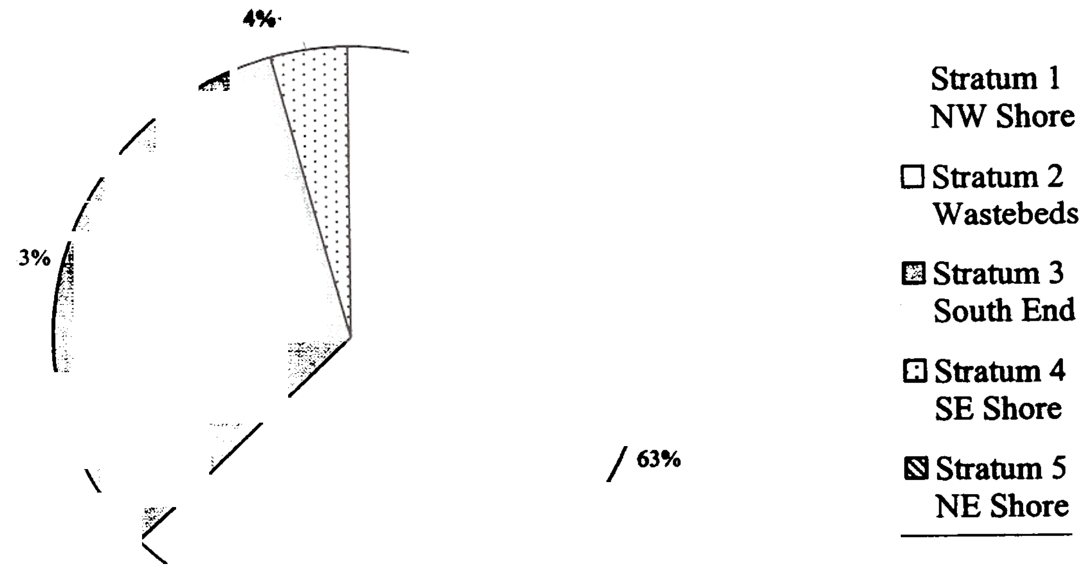


Catch of YOY Gizzard Shad by Stratum, 2000



Total Catch of YOY Gizzard Shad by Site, 2000

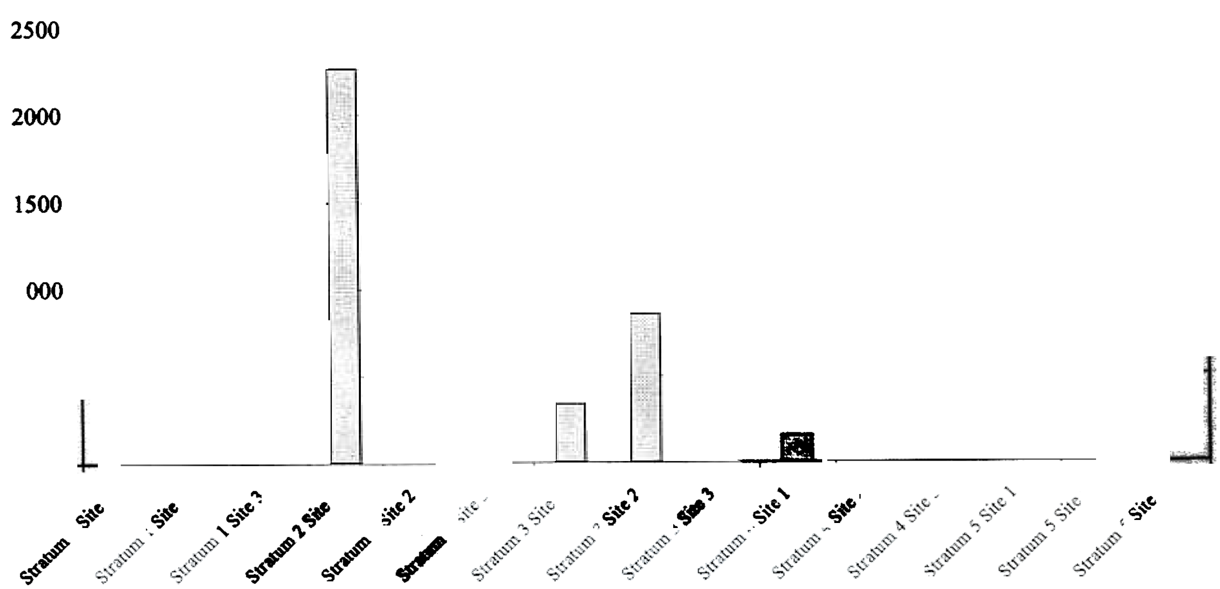


Figure 3.3-7. Relative proportion of YOY gizzard shad captured within each stratum in Onondaga Lake during 2000 (top figure), and the total catch of YOY gizzard shad at each individual site within each stratum in 2000 (lower figure).

seines difficult. If schools are encountered the catch can be very high, while at other times no fish are caught even though gizzard shad may be abundant. This is reflected in the extremely patchy distribution of YOY gizzard shad in the 2000 seine samples.

3.3.3.5 White Perch

Most YOY white perch (62%) were captured in Stratum 5 (northeast shore) in 2000 (Figure 3.3-8). Stratum 3 (18%) and Stratum 4 (18%) contributed most of the remaining white perch (south end and east shore, respectively). All of the white perch captured in Stratum 5 were collected in a single seine haul at one site during the early July sampling event. At least one YOY white perch was captured at seven of the fifteen seine sampling sites in 2000 (Figure 3.3-8).

Temporal Distribution of Select Young-of-Year Species

YOY fish must reach a certain size before they can be efficiently captured in seines. The time of the summer when peak catch rates of YOY occurs is related to both the initial time of spawning and the growth rates in any particular year. It is important to sample on multiple occasions when YOY are present to be reasonably certain that a representative sample of the YOY community has been collected, since the timing of peak catch rates changes from year to year. Seven seine sampling events were conducted in 2000. YOY were present in the last four sampling events, and most were captured in only two of these four. Adults and non-YOY juveniles dominated the early season catch (Figure 3.3-1). In past surveys (1991, 1993 and 1994), peak numbers of YOY *Lepomis* and largemouth bass in seine hauls occurred between early-July and mid-August and lasted only for a short time (Figure 3.3-9). In 2000, peak YOY largemouth bass catch rates occurred during the late-July sample period, which was very similar to 1993 but several weeks later than 1991 or 1994. Peak YOY *Lepomis* catch rates in 2000 occurred in early and mid-August, which was similar to 1994 but about a week later than was observed in 1991 and 1993 (Figure 3.3-9). YOY smallmouth bass and white perch in 2000 both peaked in seine hauls at the end of July, and gizzard shad peaked in mid-August (Figure 3.3-9). If YOY fish are the target of future monitoring efforts, periodic sampling between mid-June and

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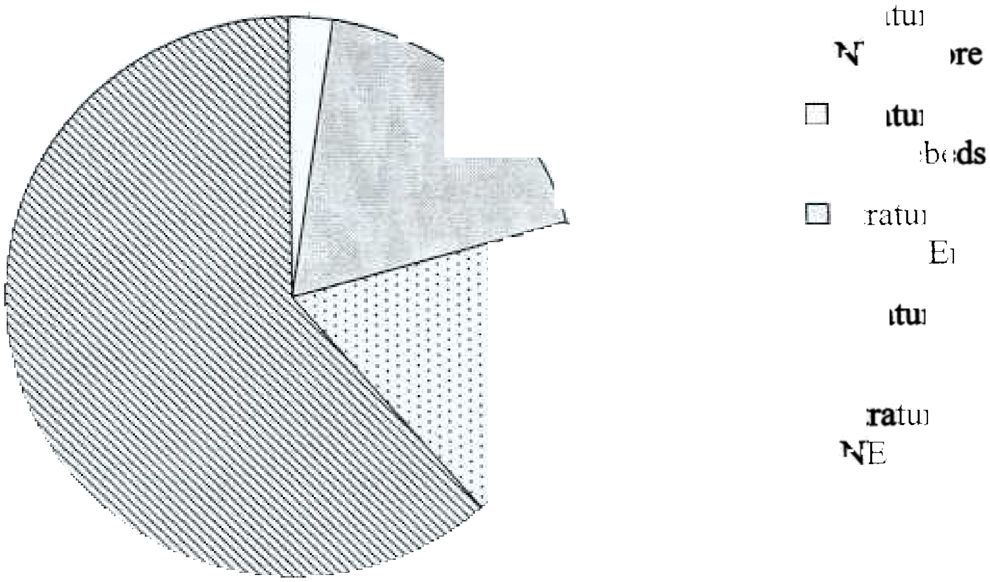

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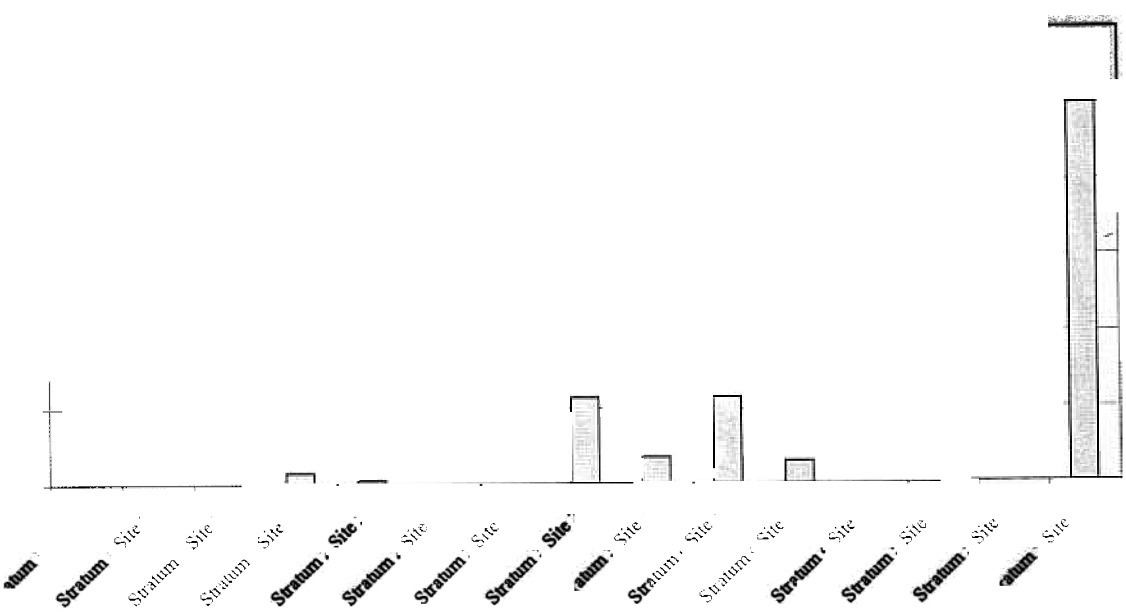

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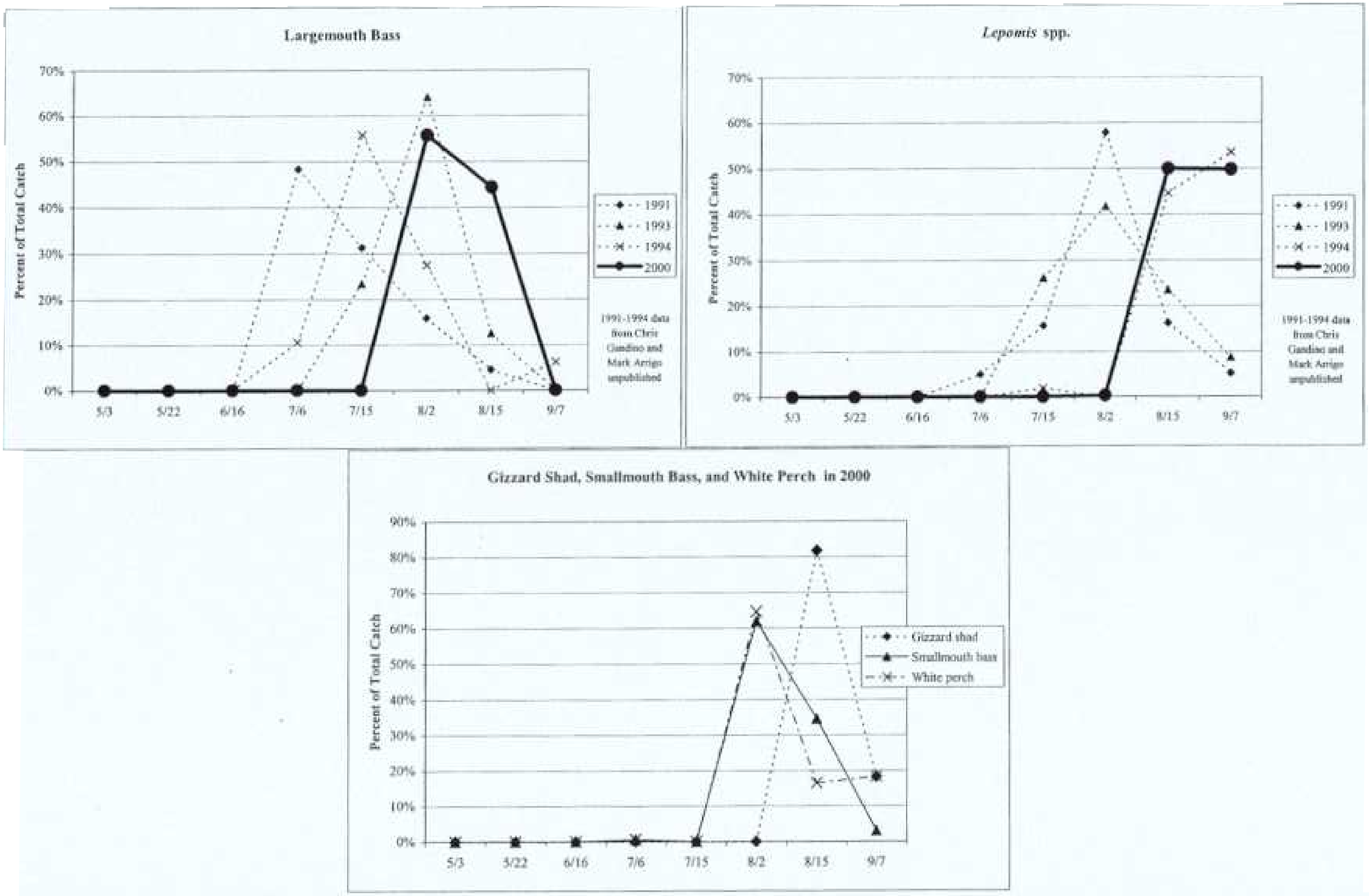

Figure 3.3-9. Temporal distribution of *Lepomis* spp. and largemouth bass YOY in Onondaga Lake during 1991, 1993, 1994, and 2000 (top figures), and for gizzard shad, smallmouth bass and white perch in 2000 (bottom figure).

mid-September would maximize the chance of identifying YOY occurrence and abundance for the species analyzed in 2000.

3.3.5 YOY Length-Frequency Distribution

Mean lengths of select YOY species in August 2000 were statistically compared to the mean lengths of those same species in August 1993 using a t-test (Figure 3.3-10). Data for smallmouth bass from 1993 and yellow perch in 2000 are not presented because no YOY of these species were captured in those years. *Lepomis*, largemouth bass, and gizzard shad YOY were significantly smaller in August 2000 than in August 1993 ($p<0.01$). There was no statistical difference in the size of white perch YOY between the two sample years. The smaller size of *Lepomis*, largemouth bass, and gizzard shad may be a function of the cool summer of 2000. explanation for why white perch in 2000 were not smaller than in 1994 is unknown.

A histogram of length-frequency distribution of selected YOY species in August 1993 and 2000 is presented in Figure 3.3-11. The differences in *Lepomis* YOY length frequency are subtle, with proportionally greater numbers of small individuals and fewer *Lepomis* greater than 40 mm present in 2000 than in 1993. Largemouth bass YOY length frequency for 2000 was considerably skewed toward smaller individuals compared to 1993. The unusually cool growing season in 2000 may have contributed to the apparent smaller size of largemouth bass in 2000 compared to 1993.

The length-frequency distribution for gizzard shad YOY in 2000 closely matches the first peak in the 1993 data (Figure 3.3-11). The 1993 data show a bi-model distribution. The first peak represents data from an early August sample, and the second peak is from data from a mid-August sample. It may be that YOY gizzard shad grew very quickly in 1993, and the two peaks represent the same size class collected at different times. It is also possible, though less likely, that the 1993 YOY gizzard shad population actually was bi-modally distributed. This typically occurs when YOY are hatched in large numbers at separate times in the spring. This can take place if poor weather interrupts spawning after an initial hatching of YOY has taken place. If spawning recommences and is successful, a bi-modal distribution can result.

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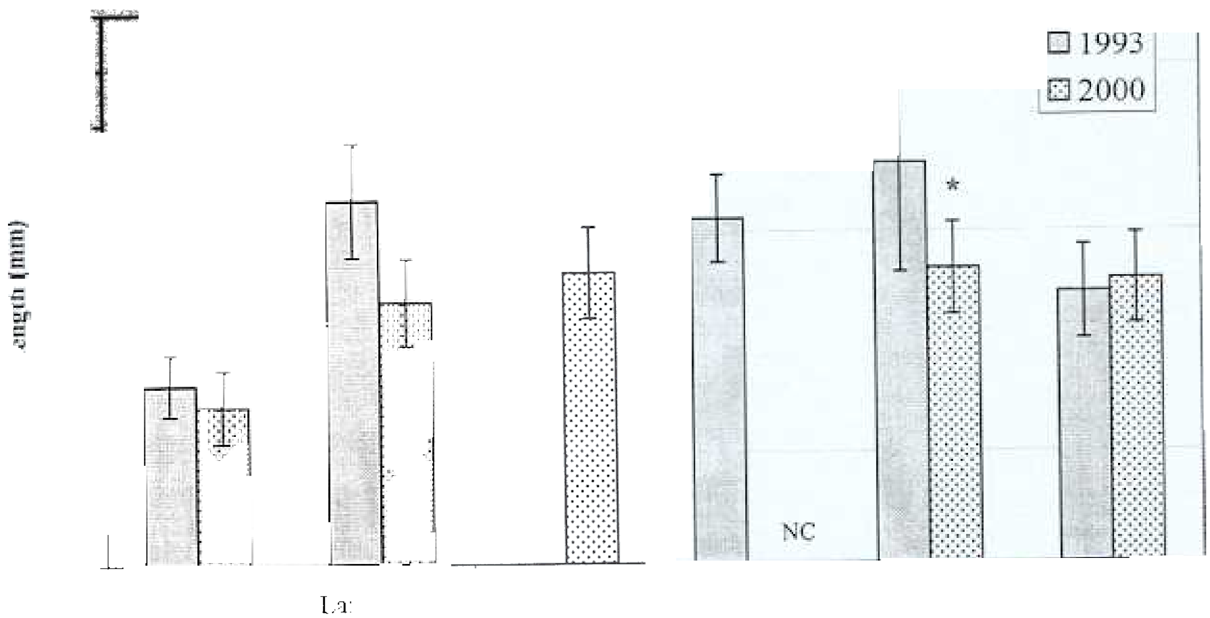

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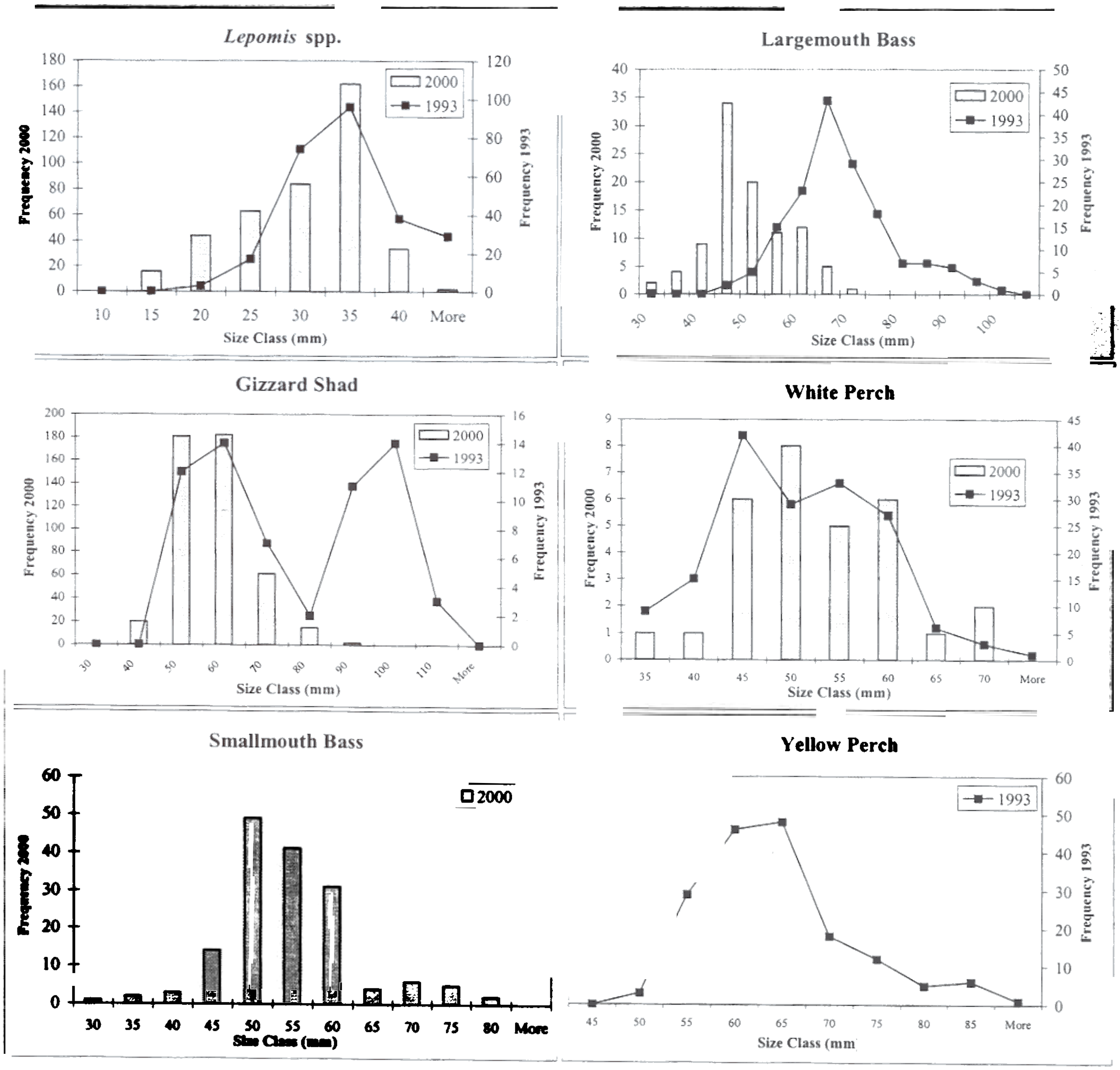

Figure 3.3-11. Length-frequency distributions of select YOY species in Onondaga Lake in 1993 and 2000. No YOY smallmouth bass were collected in 1993, and no YOY yellow perch were collected in 2000.

The length frequency distribution for YOY white perch in August 2000 closely resembled that of the August 1993 distribution. YOY smallmouth bass length frequencies from 2000 and yellow perch from 1993 set the baseline for comparison in future years, since no YOY of these species were captured in 1993 and 2000, respectively, for comparison.

3.4 Littoral Nesting Survey

Most members of the Centrarchidae (sunfish) and Ictaluridae (catfish and bullheads) families construct and guard nests in shallow water during spring and summer. Bluegill, pumpkinseed, largemouth bass, and, rarely, brown or yellow bullhead were observed on nests in Onondaga Lake in the early 1990s (Arrigo 1998). Other species such as smallmouth bass, black and white crappie, and rock bass build nests in the littoral zone of lakes but had not been previously observed doing so in Onondaga Lake.

Three nesting surveys have been conducted in Onondaga Lake prior to the 2000 Onondaga County effort. The first lakewide survey was conducted in 1991 when 1,587 nests were observed (Sagalkin 1992). In that study, neither the species guarding nests nor the spatial distribution of nests were noted. In 1993, Arrigo (1998) documented the spatial distribution of nests around the lake and in 1994 determined the species guarding those nests. The spatial distribution of nests in the 1993 and 1994 surveys was remarkably consistent (Figures 3.4-1 and 3.4-2). A total of 1,277 and 1,655 nests were observed in 1993 and 1994, respectively, with 75 to 78% located in the north basin of the lake. Bluegill (55%) and pumpkinseed (18%) were the most commonly encountered species, with largemouth bass accounting for 1.3% of the nests in 1994. The species guarding the remaining 26% of nests could not be identified.

A total of 3,588 nests was observed in Onondaga Lake in 2000 (Figures 3.4-3 and 3.4-4). This is more than double the number of nests observed in any of the previous surveys. Unidentified sunfish (54%), bluegill (26%), and pumpkinseed (11%) were the most commonly encountered species, with largemouth and smallmouth bass accounting for 1.3% and 0.3% of the nests, respectively. The species guarding the remaining 7% of nests could not be identified (Figure 3.4-5). This is the first documented observation of nesting smallmouth bass in Onondaga Lake. The occurrence of nesting smallmouth bass is coincident with an increase in the number

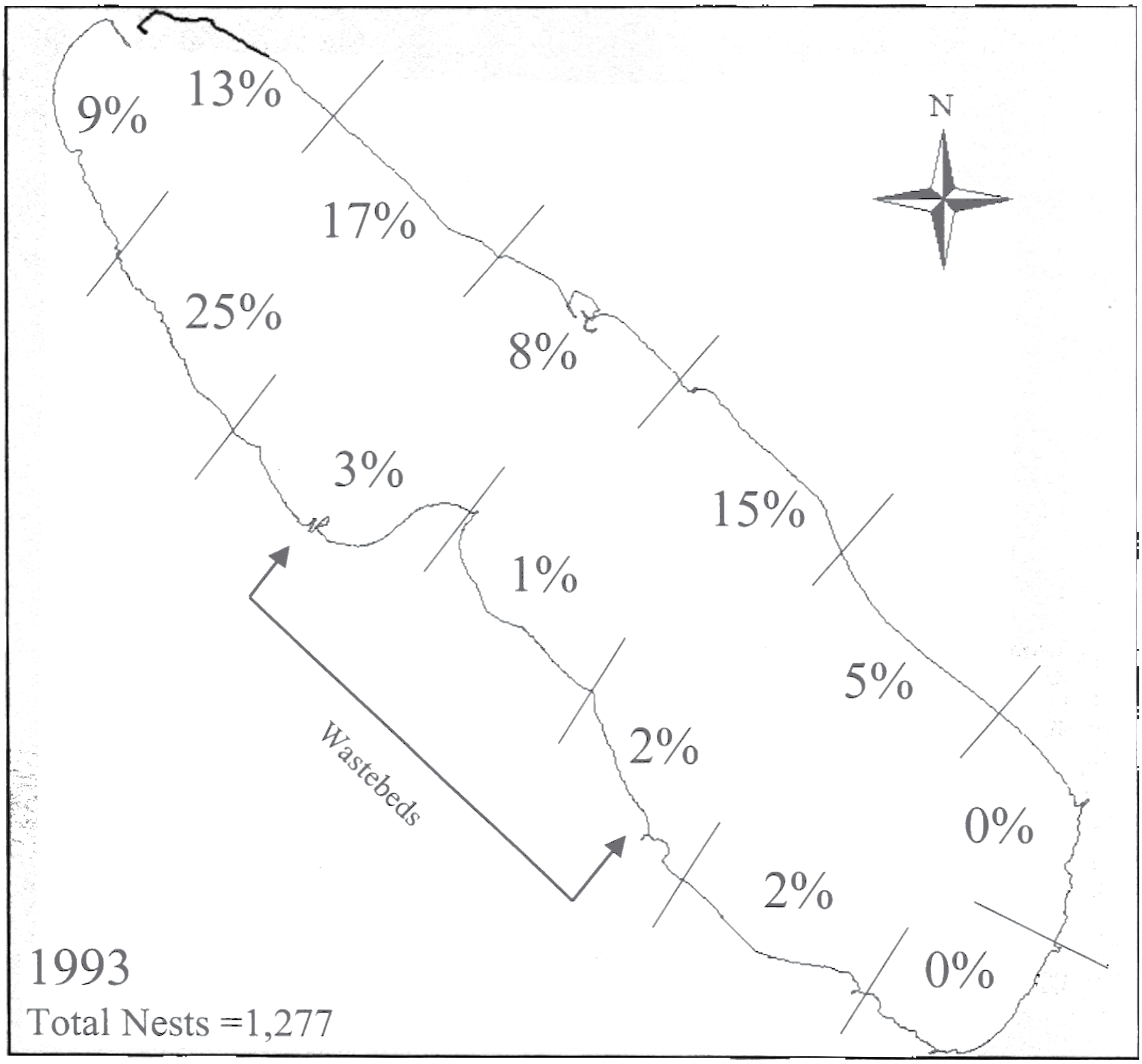

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Figure 3.4-1. Spatial distribution of fish nests in 13 sections of Onondaga Lake during June 1993.

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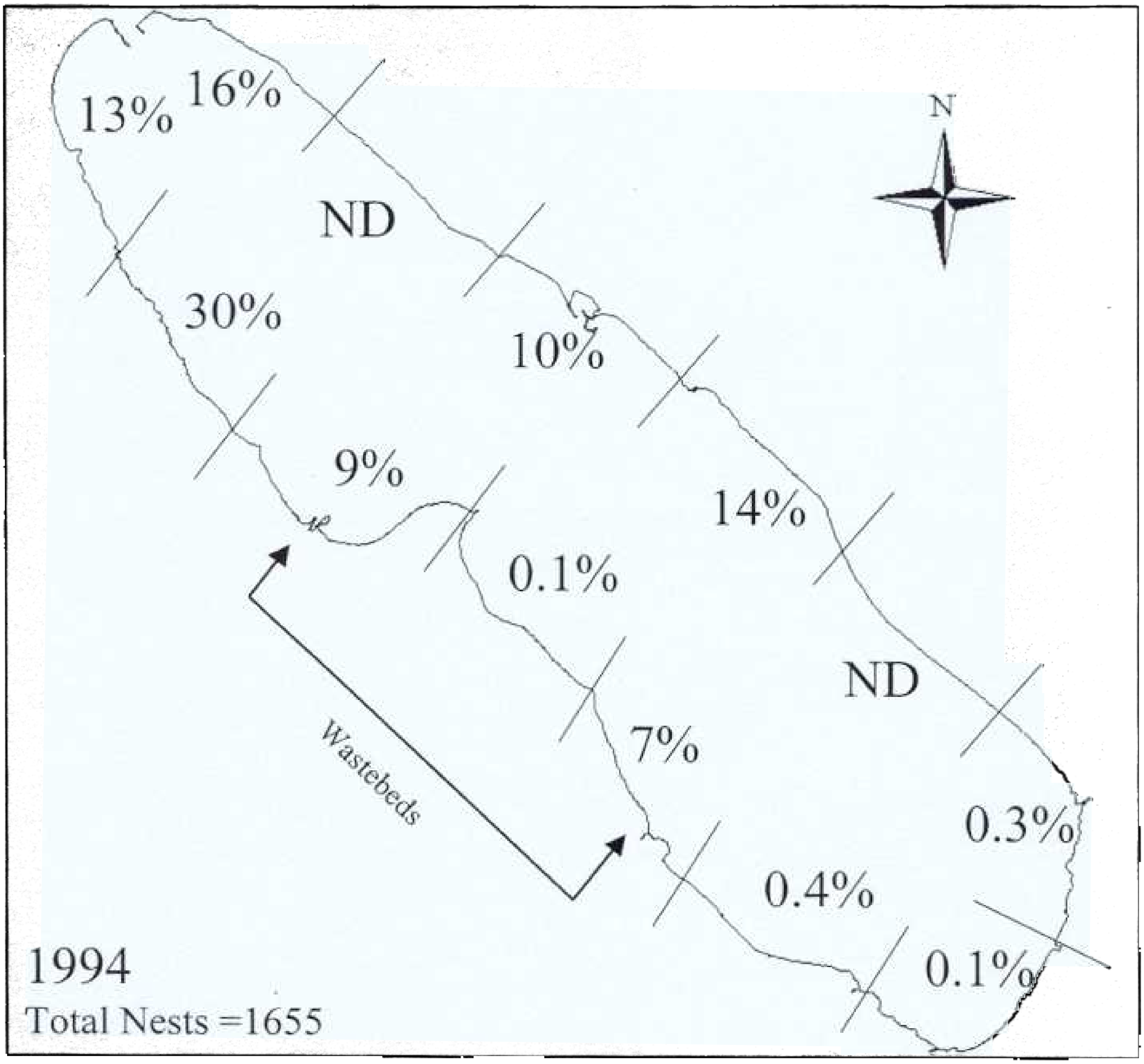

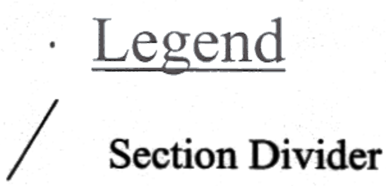

Figure 3.4-2. Spatial distribution of fish nests in 13 sections of Onondaga Lake during June 1994. ND=No Data

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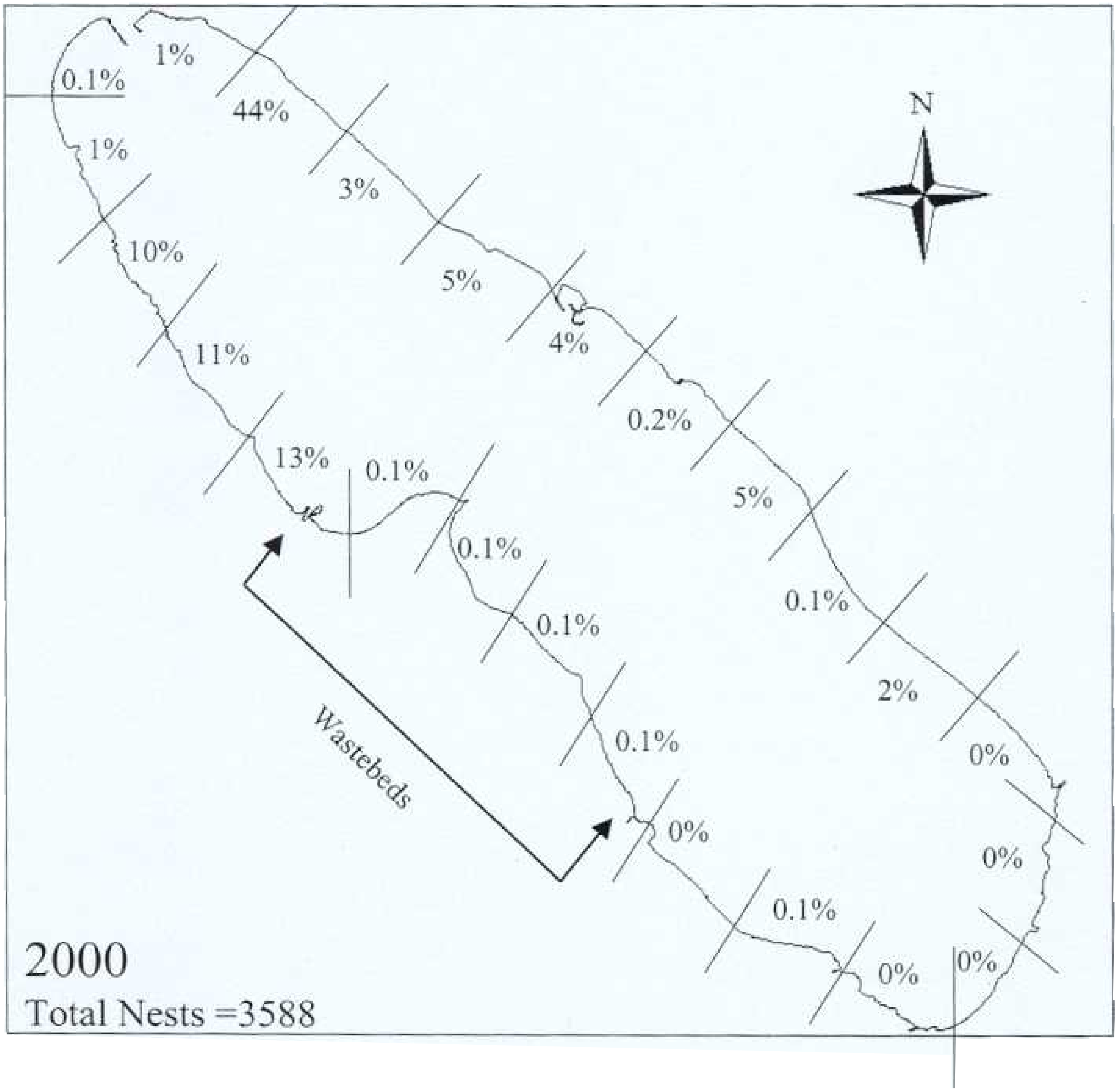

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Figure 3.4-3. Spatial distribution of fish nests in 24 sections of Onondaga Lake during June 2000.

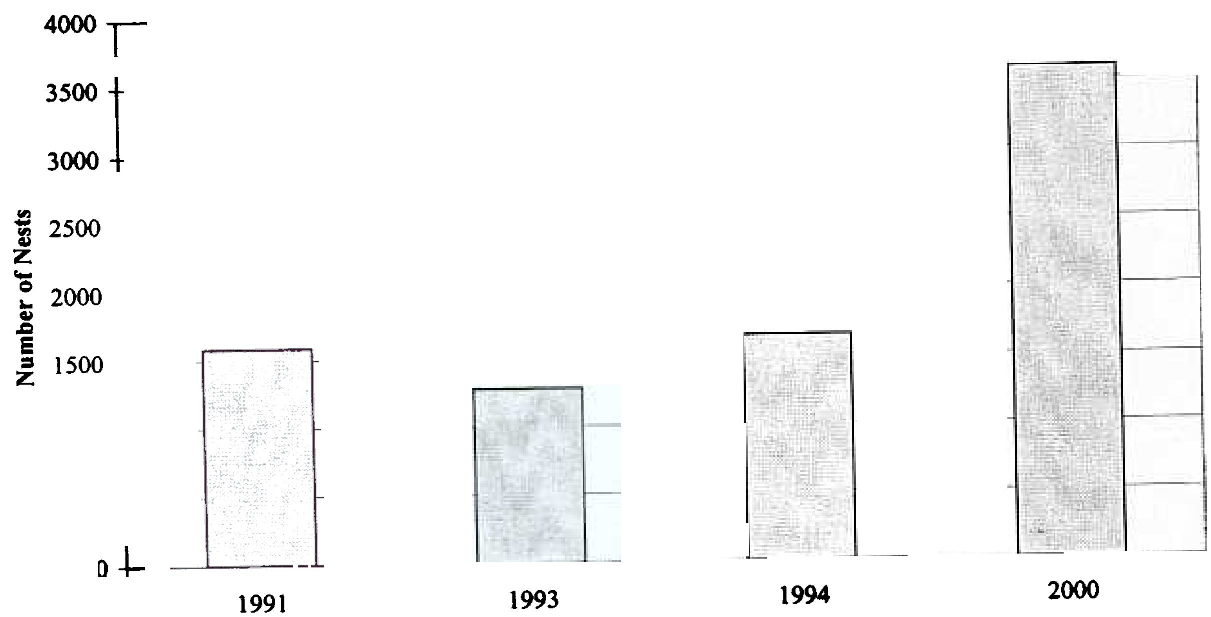

Figure 3.4-4. Total number of nests (for all species) observed in Onondaga Lake during nesting surveys in **1991, 1993, 1994 and 2000.**

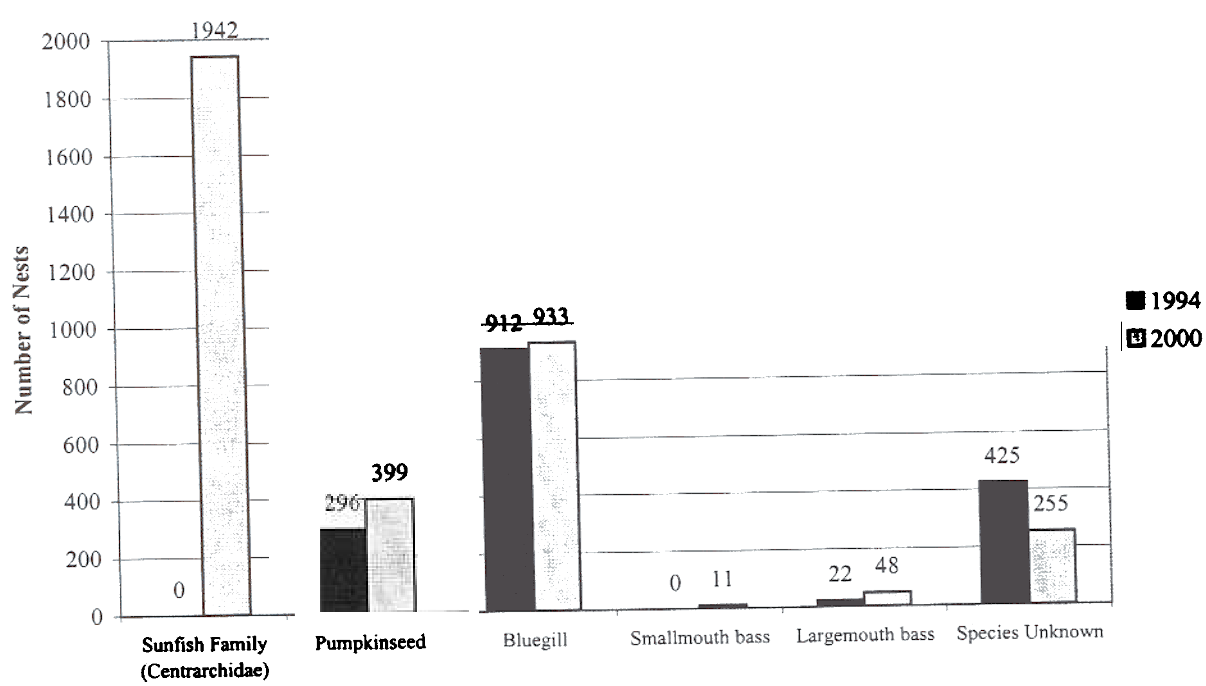

Figure 3.4-5. Number of nests observed, by species, in Onondaga Lake during nesting surveys in 1994 and 2000.

of YOY smallmouth bass in the lake in 2000 as compared to past studies (see Section 3.3 of this report). This suggests that smallmouth bass reproduction in Onondaga Lake is established and increasing in magnitude

Spatial distribution of nests in the lake during 2000 was consistent with the 1993 and 1994 efforts. Ninety-two percent of nests in 2000 were located in the north basin compared to between 75 and 78% in 1993 and 1994, respectively (Figures 3.4-1, 3.4-2 and 3.4-3) (Arrigo 1998). The wastebeds and the extreme south end of lake continue to have a scarcity of nests (Figure 3.4-3). The shale-like structure of the littoral wastebeds may not provide suitable substrate for nest building. The combination of easily disturbed fine sediments and high wave energies may limit nest building at the south end of the lake (EcoLogic 1999). Smallmouth bass also prefer to nest adjacent to cover, such as logs, stumps, or vegetation (Edwards et al. 1983). Such cover is scarce in the wastebeds area of Stratum 2 and in Stratum 3 at the south end of the lake

Nests definitively identified as those of bass appeared to be spatially segregated in the lake. Most smallmouth bass nests (73%) were located along the northeast shore (Stratum 5), while most largemouth bass nests (65%) were located on the northwest shore (Stratum 1). This may have important management implications if planned habitat modification strategies are implemented on a large scale (Madsen et al. 1996)

3.5 Adult Fish Sampling

Sampling of the adult fish community was accomplished by boat electrofishing and gill netting. Although the focus of these sampling efforts was collection of adult and larger juvenile fish, all fish captured were processed and included in the catch data.

3.5.1 Boat Electrofishing

Boat electrofishing was conducted on three occasions in 2000: May, September, and October. During each sampling event, collections were made along 24 transects distributed along the perimeter of the lake. This resulted in collection of a total of 72 boat electrofishing samples. Observation of field sampling techniques by IA was completed on two occasions in September 2000

3.5.1.1 Overall Catch for Lake

A total of 4,192 fish representing 24 species was collected during the three boat electrofishing sampling events (Table 3.5-1). Gizzard shad was the most abundant species collected, making up 54% of the catch (Figure 3.5-1). Other relatively abundant species included common carp (11% of catch), white perch (9%), bluegill (6%), and white sucker (6%). It should be noted that common carp were likely over-represented in the catch because all carp observed were counted but not netted. This could have resulted in some carp being counted more than once and assumes that all carp seen could have been successfully netted. Netting efficiency is usually not 100%, so the number of carp reported represents a liberal estimate of their numbers. Largemouth bass was the most abundant large gamefish collected, representing 2.4% of the overall catch. Sixteen of the 24 species collected each constituted less than one percent of the overall catch. Overall CPUE was 446.0 fish/hr.

3.5.1.2 Catch by Date

The greatest number of fish (1,833), the greatest number of species (22), and the highest CPUE (588.9 fish/hr) were associated with the September boat electrofishing sampling event (Table 3.5-1). The lowest number of fish (805), the lowest number of species (16), and the lowest CPUE (249.2 fish/hr) were associated with the October sampling event. Gizzard shad was by far the most abundant species in the catch in May and September (49 and 71%, respectively), and was the second most abundant (19%) in October behind common carp (29%).

There was considerable variability in catch of the more abundant species in the lake. eight species (gizzard shad, common carp, white sucker, white perch, bluegill, pumpkinseed, largemouth bass, and yellow perch) that had CPUE >15.0 fish/hr in one or more of the three sampling events showed a two-fold or more change in CPUE and relative abundance among at least two of the three sampling events (Table 3.5-1). CPUE was consistently high (>15 fish/hr for all sampling events) for gizzard shad, common carp, white sucker, and bluegill. Again,

Table 3.5 Number, catch per unit effort (CPUE, in fish/hr of electrofishing), and relative abundance (%) of fish species collected by boat electrofishing for all sampling events (all strata combined) in Onondaga Lake in 2000.

	Sampling Event											
	May			September			October			OVERALL		
Species	No.	CPUE	%[1]	No.	CPUE	%[1]	No.	CPUE	%[1]	No.	CPUE	%[1]
Longnose gar	3	1.00	0.20	1	0.37	0.06				4	0.49	0.11
Bowfin				6	1.13	0.19				6	0.37	0.08
Gizzard shad	734	244.67	49.08	1127	417.24	70.85	121	48.17	19.33	1982	241.32	54.11
Brown trout	1	0.17	0.03							1	0.06	0.01
Northern pike				1	0.19	0.03	2	0.40	0.16	3	0.18	0.04
Common carp	110	36.67	7.36	110	40.72	6.92	184	73.25	29.39	404	49.19	11.03
Golden shiner	2	0.67	0.13	2	0.74	0.13				4	0.49	0.11
White sucker	84	28.00	5.62	48	17.77	3.02	88	35.03	14.06	220	26.79	6.01
Northern hog sucker				2	0.74	0.13				2	0.24	0.05
Shorthead redhorse	5	1.67	0.33	6	2.22	0.38	11	4.38	1.76	22	2.68	0.60
Brown bullhead	8	1.33	0.27	9	1.70	0.29	14	2.80	1.12	31	1.90	0.43
Channel catfish				31	5.86	0.99	12	2.40	0.96	43	2.64	0.59
Banded killifish	1	0.33	0.07							1	0.12	0.03
White perch	277	92.33	18.52	29	10.74	1.82	36	14.33	5.75	342	41.64	9.34
Rock bass	1	0.33	0.07	5	1.85	0.31	4	1.59	0.64	10	1.22	0.27
Pumpkinseed	72	24.00	4.81	44	8.31	1.41	16	3.19	1.28	132	9.92	2.23
Bluegill	140	46.67	9.36	86	16.25	2.76	151	30.15	12.10	377	28.34	6.35
Smallmouth bass	28	4.67	0.94	19	3.59	0.61	12	2.40	0.96	59	3.62	0.81
Largemouth bass	44	7.33	1.47	91	17.19	2.92	42	8.39	3.36	177	10.86	2.43
Black crappie	1	0.17	0.03	4	0.76	0.13				5	0.31	0.07
Yellow perch	13	2.17	0.43	199	37.60	6.38	107	21.36	8.57	319	19.57	4.39
Logperch				2	0.74	0.13				2	0.24	0.05
Walleye	22	3.67	0.74	5	0.94	0.16	3	0.60	0.24	30	1.84	0.41
Freshwater drum	8	2.67	0.53	6	2.22	0.38	2	0.80	0.32	16	1.95	0.44
No. of fish	1554	498.50		1833	588.87		805	249.22		4192	445.98	
Species richness	19			22			16			24		
Species diversity[1]	0.72			0.55			0.89			0.73		

1 - Calculation based on CPUE, not number, since gamefish and non-gamefish were not sampled with equal effort.

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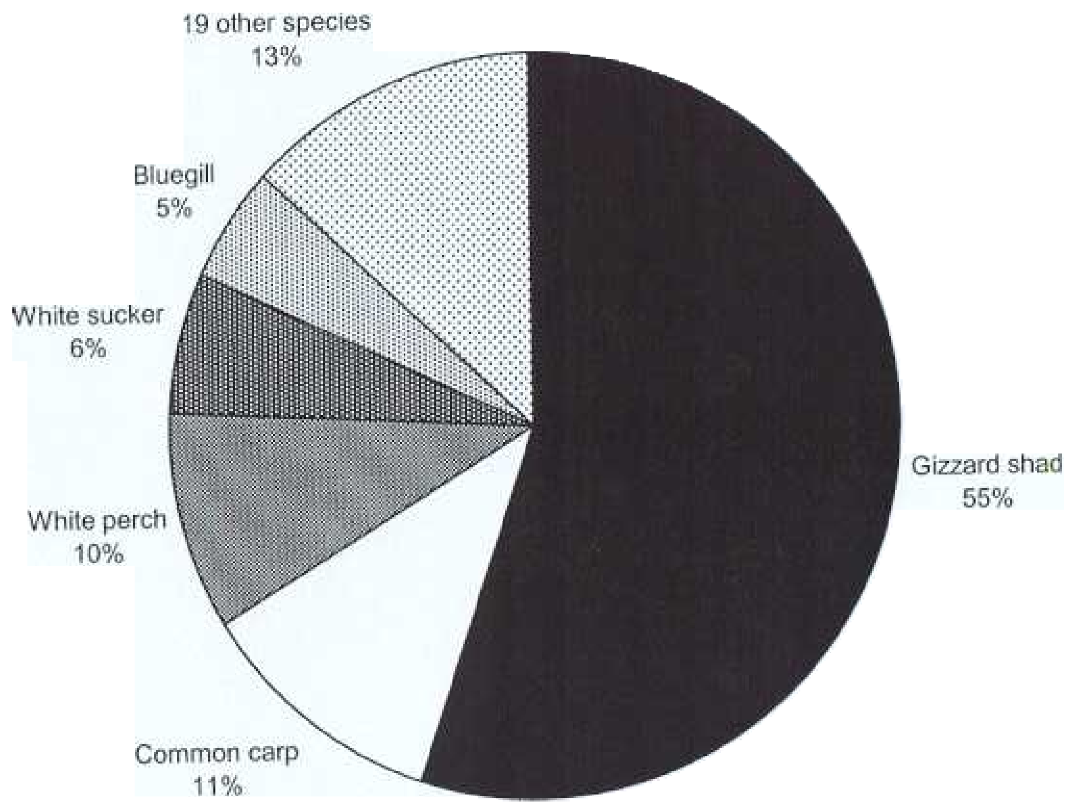

Figure 3.5-1. Species composition of boat electrofishing catch from Onondaga Lake in 2000.

common carp abundance was likely overestimated due to the method used to record numbers of this species. Largemouth bass CPUE was highest in September and lowest in May, while smallmouth bass CPUE was highest in May and lowest in October. Yellow perch had a low CPUE in May (2.17 fish/hr), but high CPUE in September and October (37.6 and 21.4 fish/hr, respectively).

Species diversity was highest in October, despite the fact that the fewest species were collected during that event (Table 3.5-1). This reflects the influence of the high numbers of gizzard shad collected during the May and September sampling events. Even though fewer species were collected in October, there was a more even distribution of catch among those species. Four of the 16 species collected in October each made up at least 10% of the catch, whereas only one species other than gizzard shad constituted more than 10% of the catch in May, and no other species represented more than about 7% of the catch in September.

3.5.1.3 Catch by Stratum

The greatest number of fish (1,626), the greatest number of species (20), and the highest CPUE (764.2 fish/hr) were associated with Stratum 1 (Table 3.5-2). Both Stratum 2 and Stratum 3 had relatively low numbers of fish (509 and 321, respectively) and CPUE (184.8 and 189.0). Strata 4 and 5 had intermediate numbers of fish (968 and 768, respectively) and relatively high CPUE (664.3 and 461.8). Gizzard shad dominated the catch from Strata 1 and 4 (77 and 73% of the catch) and was codominant with common carp (29.7 and 25.9%, respectively) in Stratum 3. White sucker, yellow perch, and common carp were the most abundant species in Stratum 2 (27.9, 19.3, and 19.2%, respectively), while white perch (33.8%) were dominant in Stratum 5. Bluegill (19.1%) and common carp (17.2%) were also relatively abundant in Stratum 5. CPUE of largemouth bass, smallmouth bass, and walleye were highest in Stratum 1, followed closely by Stratum 5. Bluegill and pumpkinseed were also most abundant in these two strata, but had their highest CPUE in Stratum 5. Common carp had a CPUE of 33 or greater in all five strata, while CPUE of gizzard shad and white sucker exceeded 17 and 12, respectively, in all strata. The extremely high CPUE of common carp in all strata may be due in part to overestimation of carp abundance due to the method used to record numbers of this

Number, catch per unit effort (CPL h/hr of electrofishing and relative abundance sh specie ollected lectrofi ing fr ach stratum in Onondaga Lake in 2000.

	Sampling Event																	
	Stratum 1			Stratum 2			Stratum 3			Stratum 4			Stratum 5			OVERALL		
Species	No.	CPUE	%[1]	No.	CPUE	%[1]	No.	CPUE	%[1]	No.	CPUE	%[1]	No.	CPUE	%[1]	No.	CPUE	%[1]
Longnose gar	1	0.51	0.07							3	2.26	0.34				4	0.49	0.11
Bowfin	6	1.77	0.23													6	0.37	0.08
Gizzard shad	1166	590.13	77.22	38	17.48	9.46	78	56.17	29.72	647	488.10	73.48	53	39.30	8.51	1982	241.32	54.11
Brown trout	1	0.29	0.04													1	0.06	0.01
Northern pike							1	0.36	0.19	1	0.30	0.05	1	0.38	0.08	3	0.18	0.04
Common carp	67	33.91	4.44	77	35.41	19.17	68	48.97	25.91	85	64.12	9.65	107	79.34	17.18	404	49.19	11.03
Golden shiner	3	1.52	0.20				1	0.72	0.38							4	0.49	0.11
White sucker	26	13.16	1.72	112	51.51	27.88	31	22.32	11.81	17	12.82	1.93	34	25.21	5.46	220	26.79	6.01
Northern hog sucker										2	1.51	0.23				2	0.24	0.05
Shorthead redhorse	2	1.01	0.13	6	2.76	1.49	4	2.88	1.52	6	4.53	0.68	4	2.97	0.64	22	2.68	0.60
Brown bullhead	4	1.18	0.15	9	2.14	1.16	7	2.54	1.34				11	4.18	0.91	31	1.90	0.43
Channel catfish	2	0.59	0.08	4	0.95	0.52	32	11.61	6.14	1	0.30	0.05	4	1.52	0.33	43	2.64	0.59
Banded killifish				1	0.46	0.25										1	0.12	0.03
White perch	38	19.23	2.52	37	17.02	9.21	9	6.48	3.43	47	35.46	5.34	211	156.46	33.88	342	41.64	9.34
Rock bass	3	1.52	0.20	2	0.92	0.50	1	0.72	0.38	1	0.75	0.11	3	2.22	0.48	10	1.22	0.27
Pumpkinseed	38	13.15	1.72	25	7.25	3.92	17	7.54	3.99	5	1.94	0.29	47	22.05	4.78	132	9.92	2.23
Bluegill	119	41.17	5.39	7	2.03	1.10	23	10.20	5.40	40	15.52	2.34	188	88.22	19.10	377	28.34	6.35
Smallmouth bass	22	6.49	0.85	17	4.05	2.19	1	0.36	0.19	5	1.50	0.23	14	5.32	1.15	59	3.62	0.81
Largemouth bass	77	22.71	2.97	11	2.62	1.42	9	3.27	1.73	30	9.02	1.36	50	19.00	4.12	177	10.86	2.43
Black crappie	3	0.88	0.12	1	0.24	0.13							1	0.38	0.08	5	0.31	0.07
Yellow perch	36	10.62	1.39	150	35.74	19.34	34	12.34	6.53	65	19.53	2.94	34	12.92	2.80	319	19.57	4.39
Logperch				2	0.92	0.50										2	0.24	0.05
Walleye	8	2.36	0.31	6	1.43	0.77	3	1.09	0.58	7	2.10	0.32	6	2.28	0.49	30	1.84	0.41
Freshwater drum	4	2.02	0.26	4	1.84	1.00	2	1.44	0.76	6	4.53	0.68				16	1.95	0.44
No. of fish	1626	764.23		509	184.76		321	189.02		968	664.29		768	461.76		4192	445.98	
Species richness	20			18			17			17			16			24		
Species diversity[1]	0.45			0.89			0.89			0.48			0.84			0.73		

1 - Calculation based on CPUE, not number, since gamefish and non-gamefish were not sampled with equal effort

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.5 C tch tistics for Selected Species

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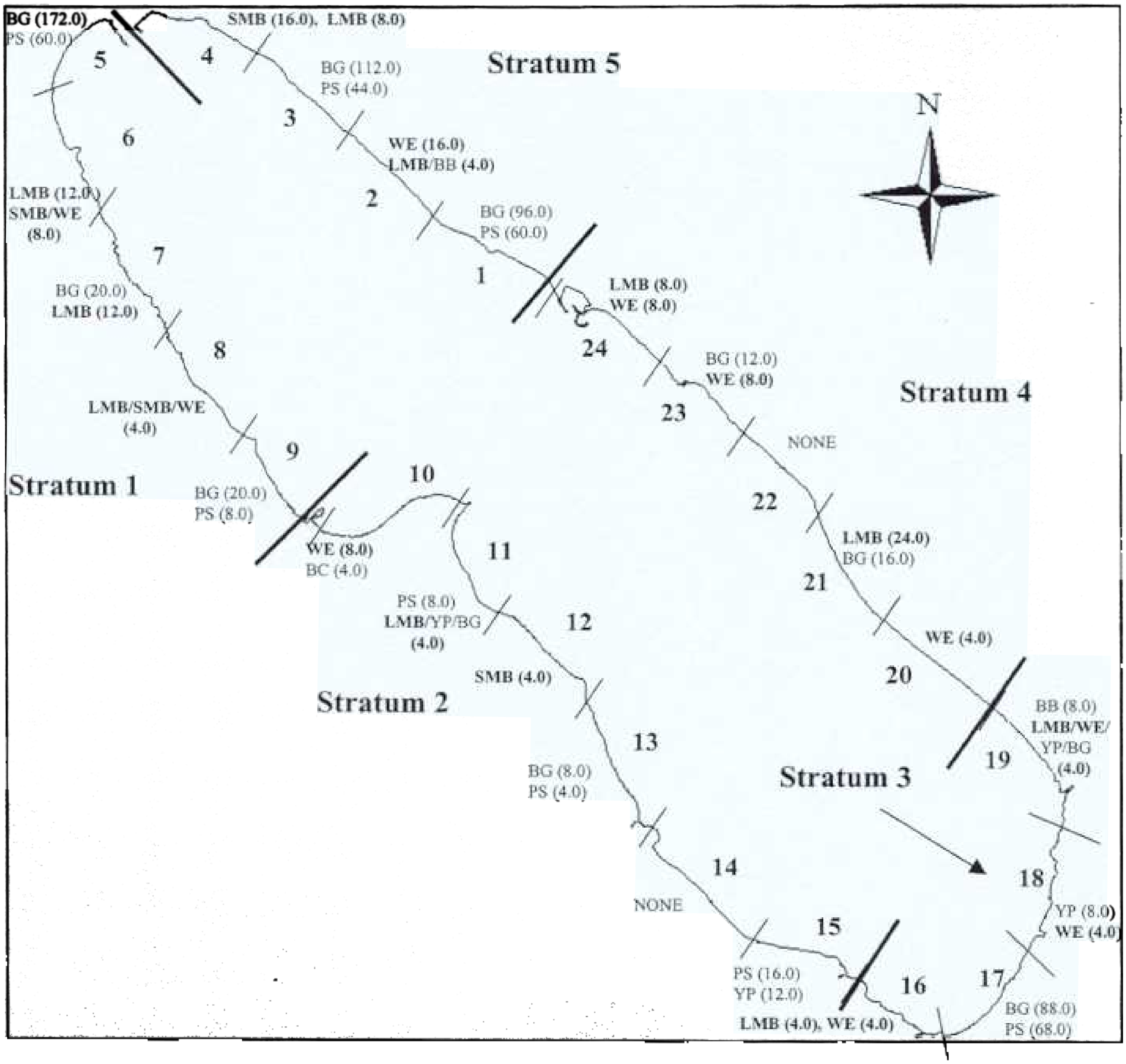

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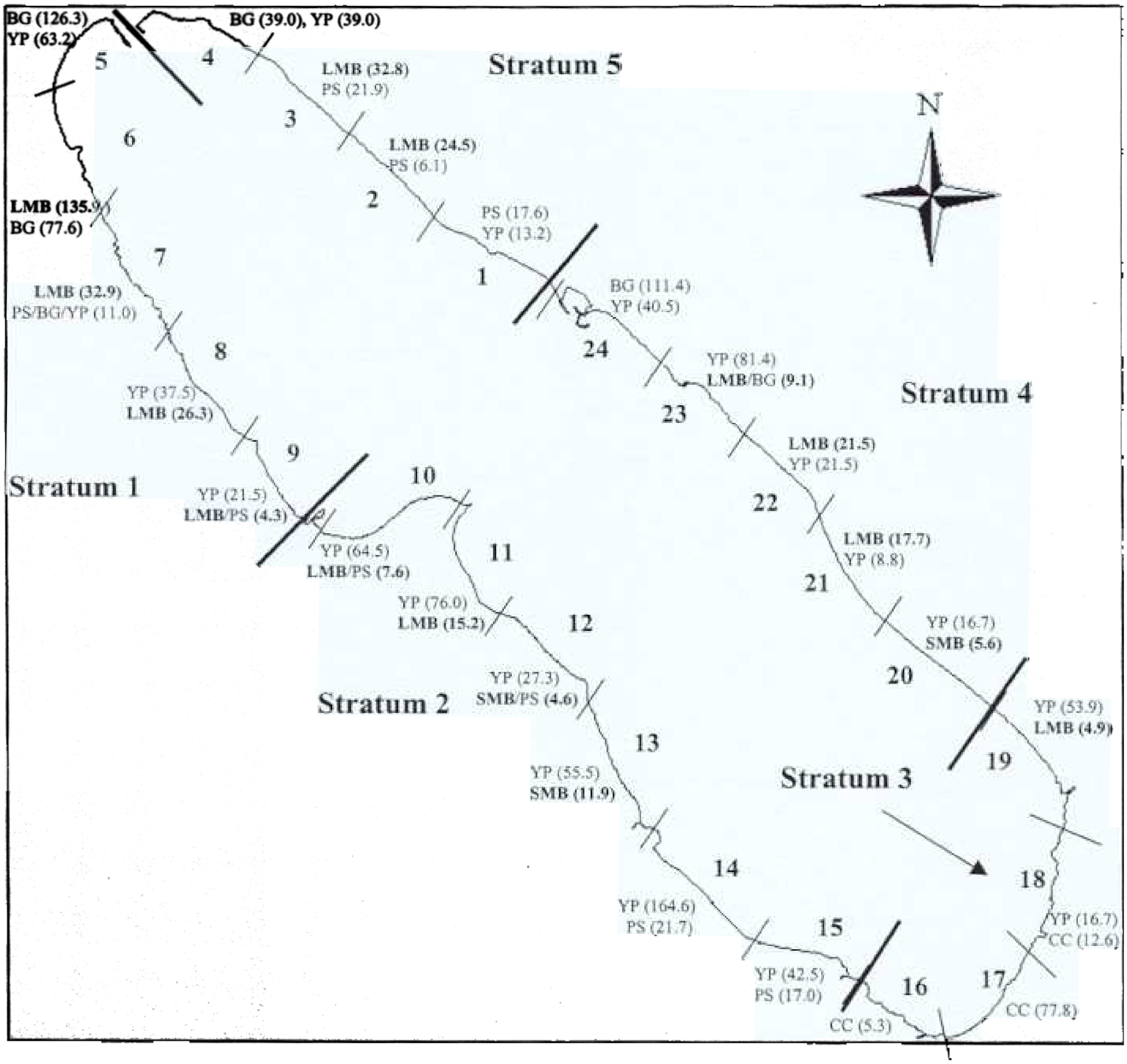
Strata Borders

Species abbreviations: BB = brown bullhead, BC = black crappie, BG = bluegill, LMB = largemouth bass, PS = pumpkinseed, SMB = smallmouth bass, WE = walleye, YP = yellow perch.

Figure 3.5-2. Catch per unit effort (fish collected/hour) of the two most abundant gamefish species collected at each boat electrofishing transect in May 2000. NOTE: *Lepomis* spp. (bluegill and pumpkinseed were not collected at the "gamefish only" (even numbered) transects during the May 2000 sampling effort.



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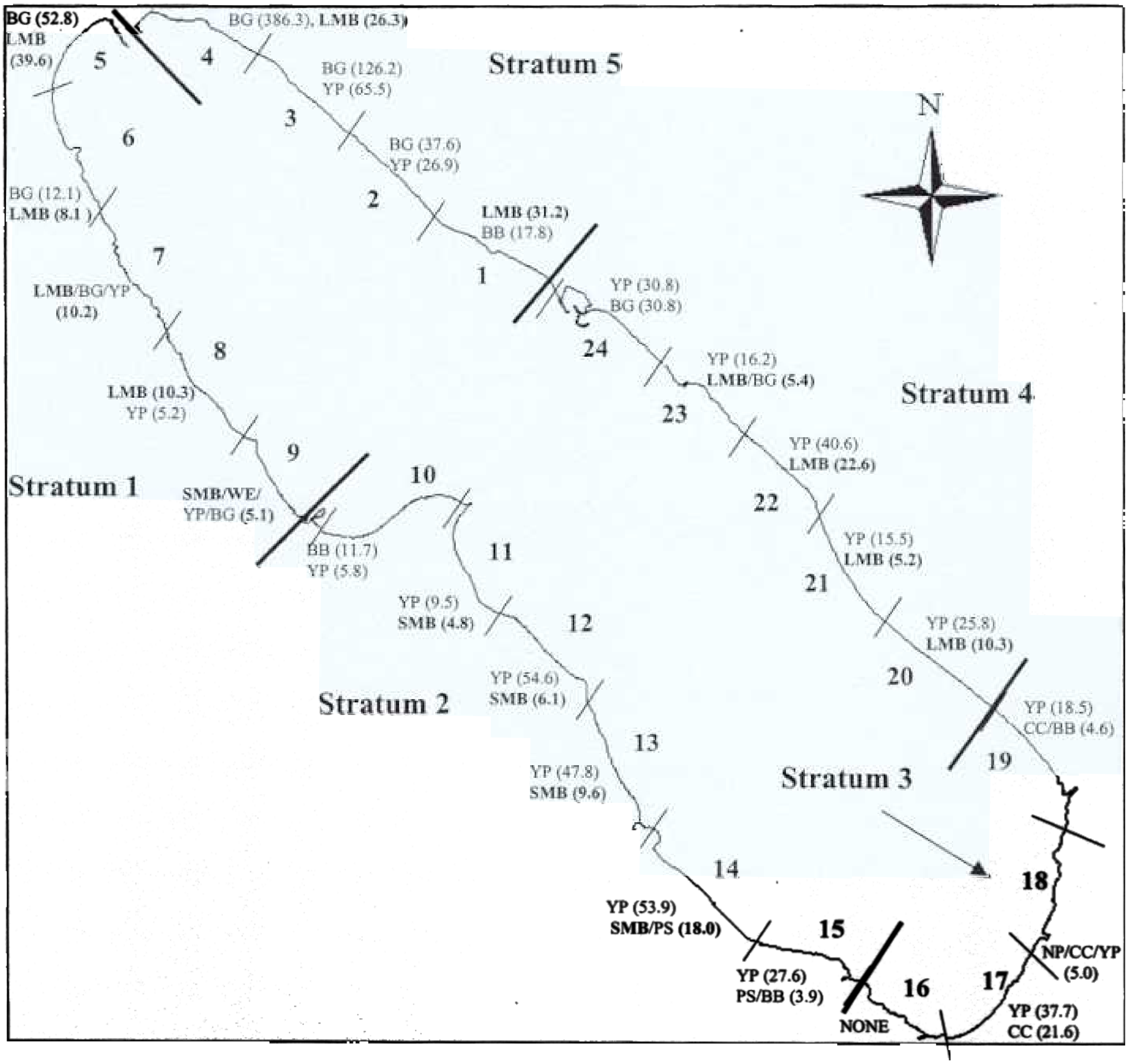
Species abbreviations: BG = bluegill, CC = channel catfish, LMB = largemouth bass, PS = pumpkinseed, SMB = smallmouth bass, YP = yellow perch.

Figure 3.5-3. Catch per unit effort (fish collected/hour) of the two most abundant gamefish species collected at each boat electrofishing transect in September 2000.



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/ Transect Borders

/ Strata Borders

Species abbreviations: BB = brown bullhead, BG = bluegill, CC = channel catfish, LMB = largemouth bass, NP = northern pike, PS = pumpkinseed, SMB = smallmouth bass, WE = walleye, YP = yellow perch.

Figure 3.5-4. Catch per unit effort (fish collected/hour) of the two most abundant gamefish species collected at each boat electrofishing transect in October 2000.

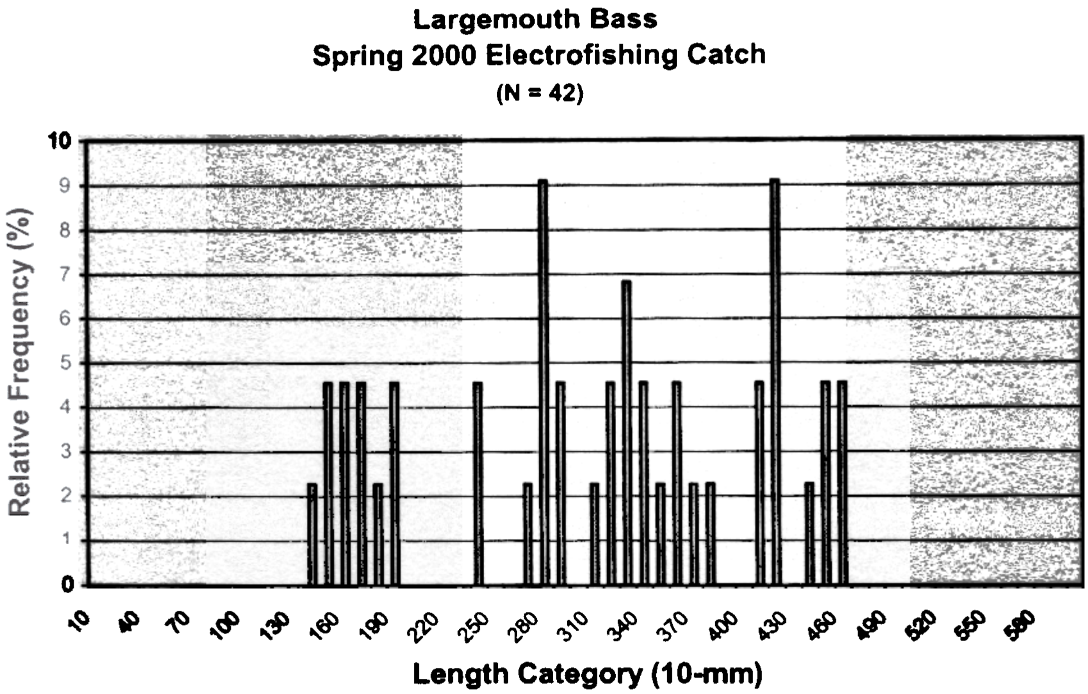
3.5.1.4.1 Largemouth Bass

The length-frequency distribution for largemouth bass was determined separately for the spring and fall electrofishing data. Largemouth bass were represented by fish from the 140-mm to 460-mm length groups in the spring and by fish from the 100-mm to 500-mm length groups in the fall (Figure 3.5-5). The wide spread in lengths of fish collected and the relatively even distribution of fish among the various length categories indicates that several year classes were present, and no one year class is dominating the population.

CPUE for various sizes of largemouth bass were calculated and are presented in the following table.

Size Class	CPUE (fish/hr)
Fall fingerling (in fall)	0.58
Spring yearling in spring (in spring)	1.67
>Fall fingerling and <10 inches (in fall)	4.56
>Spring fingerling and <10 inches (in spring)	0.33
≥10 inches and <12 inches (in spring)	1.33
≥10 inches and <12 inches (in fall)	1.07
≥12 inches (in spring)	3.83
≥12 inches (in fall)	6.41

Based on the length-frequency data for largemouth bass collected in fall, any fish <130 mm was considered a fall fingerling (Figure 3.5-5). Since no age data are available for bass collected in 2000, it was not possible to definitively identify the size group representing spring yearling largemouth bass. However, the length-frequency data for spring suggest that all bass <200 mm were spring yearlings (Figure 3.5-5). The relatively low CPUE for fall fingerlings (0.58 fish/hr) in 2000 as compared to the CPUE for spring yearlings (1.67 fish/hr) produced in 1999 suggests that the 2000 year class was not as strong as the 1999 year class. However, as stated previously, data from boat electrofishing samples tends to be biased toward larger fish. In fact, YOY (including fall fingerling) largemouth bass were well represented in the juvenile fish seine



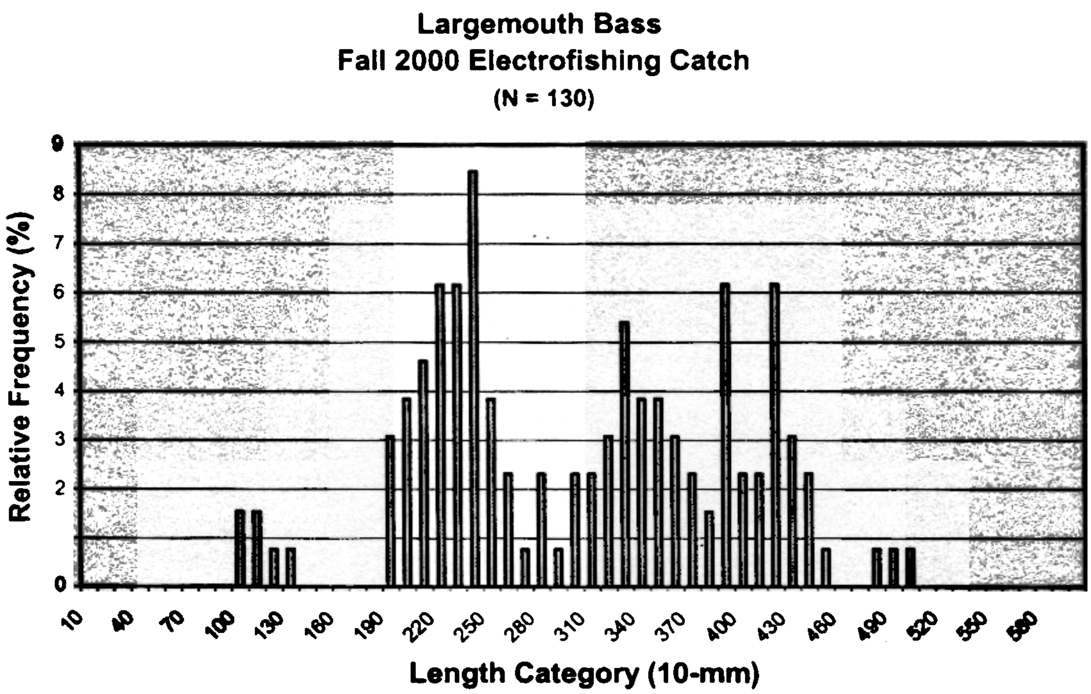


Figure 3.5-5. Length-frequency distribution for largemouth bass collected by boat electrofishing from Onondaga Lake in spring and fall 2000.

samples, suggesting that fall fingerlings were under-represented (due to lower vulnerability to collection) in the boat electrofishing catch.

NYSDEC classifies largemouth bass population densities based on CPUE of fish <10 inches and ≥10 inches (NYSDEC 1989). For largemouth bass <10 inches, CPUE <8.0 indicates a low population density, 8.0-20.0 indicates a moderate density, and >20.0 indicates high density. For largemouth bass ≥10 inches, CPUE <5.5 indicates a low population density, 5.5-13.0 indicates a moderate density, and >13.0 indicates high density. In Onondaga Lake in 2000, CPUE of largemouth bass <10 inches was 2.00 fish/hr in spring and 5.14 fish/hr in fall. These values indicate the density of largemouth bass <10 inches was low in Onondaga Lake in 2000. CPUE of largemouth bass ≥10 inches was 5.16 in spring and 7.48 in fall, indicating that the density of largemouth bass ≥10 inches was low to moderate in Onondaga Lake in 2000.

PSD and RSD for largemouth bass were calculated for both the spring and fall collections. PSD was 73 for spring and 59 for fall (Table 3.5-3). RSD_{15} values were 33 and 29, respectively, and RSD_{18} was 3 for both seasons (Table 3.5-3). These values indicate that relatively large adult bass constitute a considerable portion of the largemouth bass population. A PSD >40 with RSD_{15} >25 suggests that reproduction may be low and the population may be vulnerable to exploitation (NYSDEC 1989). A plot of largemouth bass PSD versus the combined PSD values for bluegill and pumpkinseed (*Lepomis* spp.) reveals that the populations of these species are in relative balance (Figure 3.5-6). Values lying toward the center of a tic-tac-toe plot such as that in Figure 3.5-6 indicate a desirable balance of bass and sunfish species (NYSDEC 1989). Values located toward the right margin indicate largemouth bass populations dominated by larger individuals, values toward the top margin indicate sunfish populations dominated by larger individuals, and values toward the bottom or left margins indicate populations dominated by smaller individuals, respectively (NYSDEC 1989).

3.5.1.4.2 Smallmouth Bass

The length-frequency distribution for smallmouth bass was determined separately for the spring and fall electrofishing data. The length-frequency distribution for smallmouth bass in

Table 3.5-3. PSD and RSD values for selected species of fish collected by boat electrofishing in Onondaga Lake in spring and fall 2000. Note: RSD is the relative stock density for fish greater than the number of inches indicated (e.g., 8, 10, 12, etc.).

LARGEMOUTH BASS -- Spring 2000		**LARGEMOUTH BASS -- Fall 2000**	
N = 33	PSD = **73**	N = 115	PSD = **59**
	RSD15 = **33**		RSD15 = **29**
	RSD18 = **3**		RSD18 = **3**
SMALLMOUTH BASS -- Spring 2000		**SMALLMOUTH BASS -- Fall 2000**	
N = 27	PSD = **52**	N = 28	PSD = **32**
	RSD12 = **19**		RSD12 = **25**
	RSD14 = **0**		RSD14 = **14**
	RSD18 = **0**		RSD18 = **4**
BLUEGILL -- Spring 2000		**BLUEGILL -- Fall 2000**	
N = 80	PSD = **38**	N = 181	PSD = **54**
	RSD8 = **4**		RSD8 = **1**
PUMPKINSEED -- Spring 2000		**PUMPKINSEED -- Fall 2000**	
N = 50	PSD = **36**	N = 59	PSD = **41**
	RSD8 = **0**		RSD8 = **0**
WALLEYE - Spring 2000			
N = 22	PSD = **100**		
	RSD20 = **82**		
		YELLOW PERCH -- Fall 2000	
		N = 260	PSD = **3**
			RSD10 = **1**
		CHANNEL CATFISH -- Fall 2000	
		N = 41	PSD = **100**
			RSD24 = **5**
		BROWN BULLHEAD -- Fall 2000	
		N = 21	PSD = **95**
			RSD12 = **43**
WHITE PERCH -- Spring 2000		**WHITE PERCH -- Fall 2000**	
N = 100	PSD = **87**	N = 54	PSD = **13**
	RSD10 = **11**		RSD10 = **6**
GIZZARD SHAD -- Spring 2000		**GIZZARD SHAD -- Fall 2000**	
N = 107	PSD = **93**	N = 189	PSD = **56**

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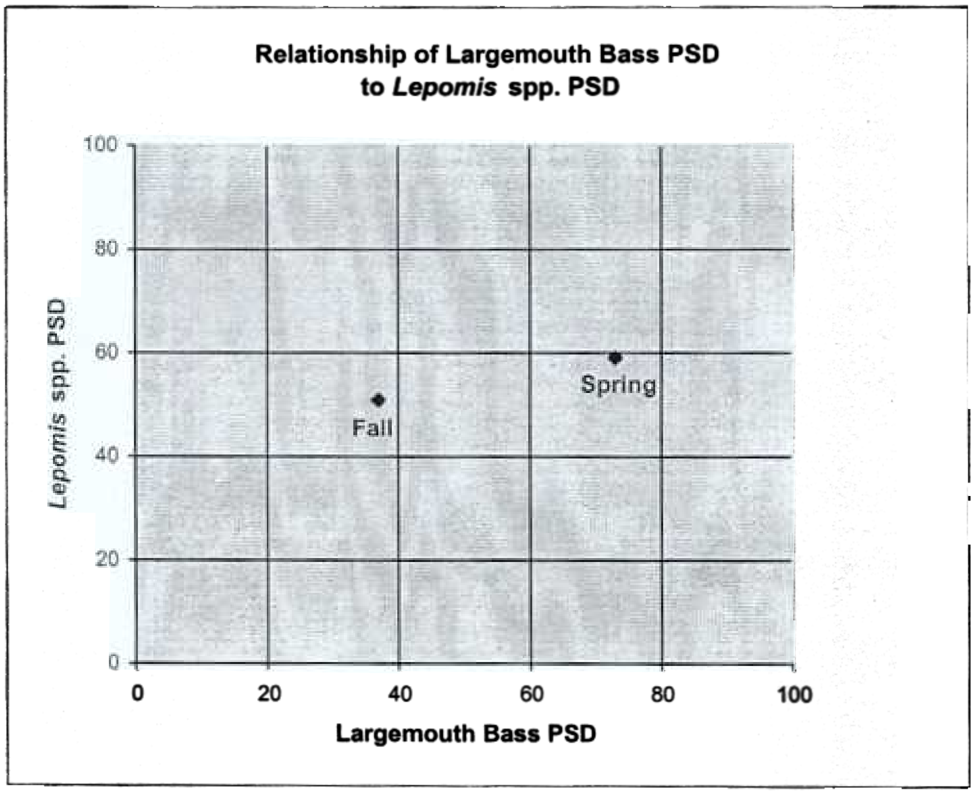


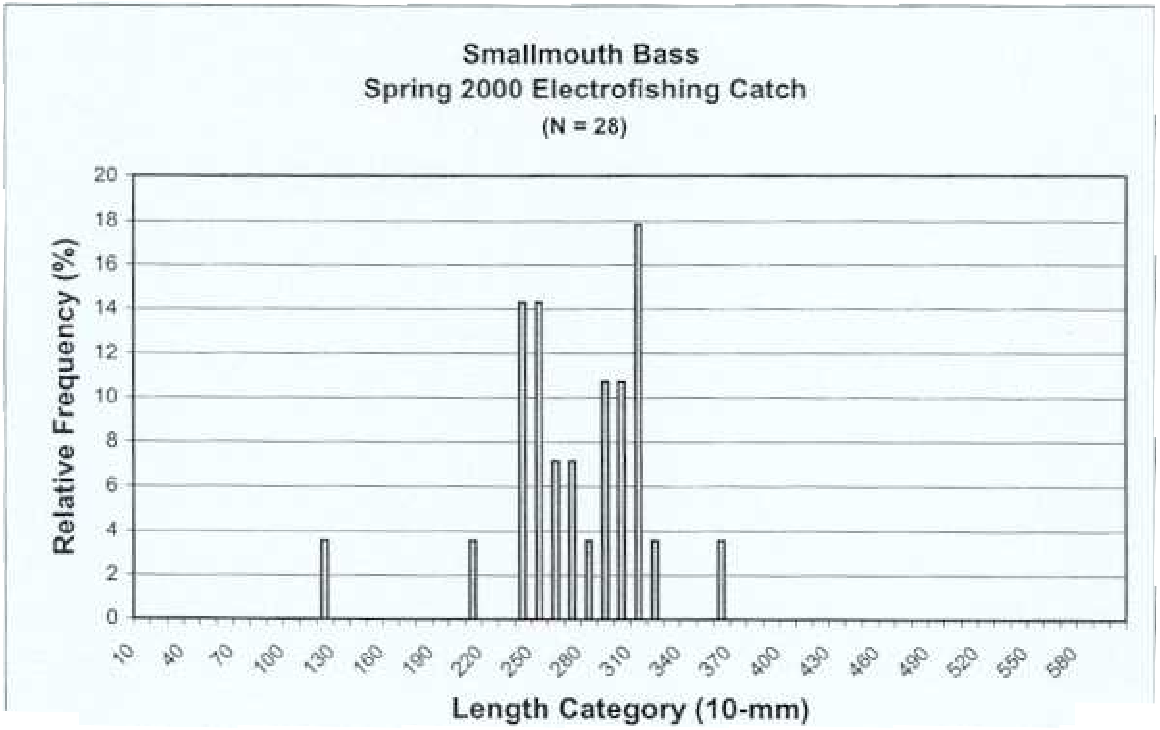
Figure 3.5-6. Relationship between the proportional stock density (PSD) of largemouth bass and sunfish (*Lepomis* spp.) in Onondaga Lake in spring and fall 2000.

spring represents fish from the 130-mm group to the 370-mm group (Figure 3.5-7). The length-frequency distribution for smallmouth bass in fall represents fish from the 130-mm group to the 470-mm group (Figure 3.5-7). The greater spread in lengths of fish collected in the fall indicates that the size distribution of the entire population may not have been accurately represented in the spring collections. Specifically, fish ≥380 mm were not collected at all in spring, and fish less than 250 mm were evidently considerably under represented in spring samples or rare or absent from the lake. Fish from approximately 180 to 330 mm appear to represent the most abundance sizes of smallmouth bass in Onondaga Lake in 2000. Fish in size groups outside this range were relatively scarce in electrofishing collections.

CPUE for various sizes of smallmouth bass were calculated and are presented in the following table

Size Class	CPUE (fish/hr)
Fall fingerling (in fall)	0.10
Spring yearling in spring (in spring)	0.17
>Fall fingerling and <10 inches (in fall)	1.75
>Spring fingerling and <10 inches (in spring)	1.67
≥10 inches and <12 inches (in spring)	2.00
≥10 inches and <12 inches (in fall)	0.49
≥12 inches (in spring)	0.83
≥12 inches (in fall)	0.68

Based on the length-frequency data for smallmouth bass collected in fall, any fish <125 mm was considered a fall fingerling (Figure 3.5-7). Since no age data are available for bass collected in 2000, it was not possible to definitively identify the size group representing spring yearling smallmouth bass. However, the length-frequency data for spring suggest that all bass <200 mm were spring yearlings (Figure 3.5-7). The low CPUE for fall fingerlings and spring yearlings in 2000 suggests that these young age classes were scarce in Onondaga Lake in 2000. However, these size groups of smallmouth bass were better represented in the juvenile fish seine collections than in the boat electrofishing samples.



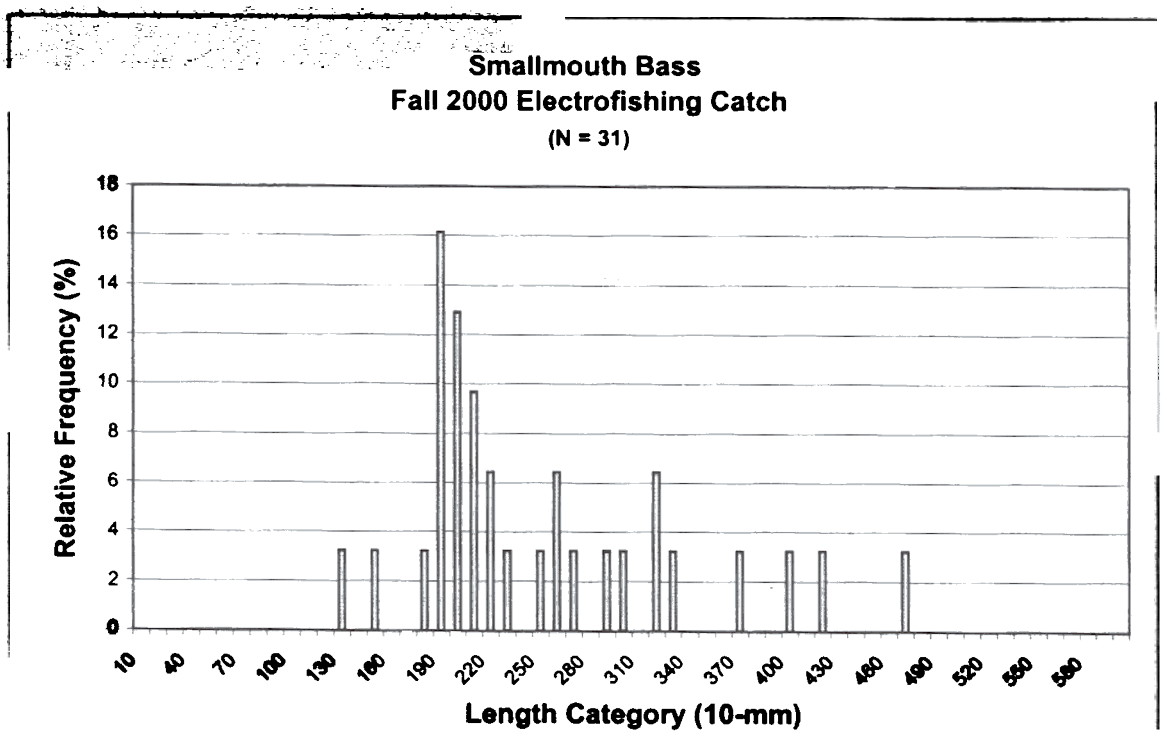


Figure 3.5-7. Length-frequency distribution for smallmouth bass collected by boat electrofishing from Onondaga Lake in spring and fall 2000.

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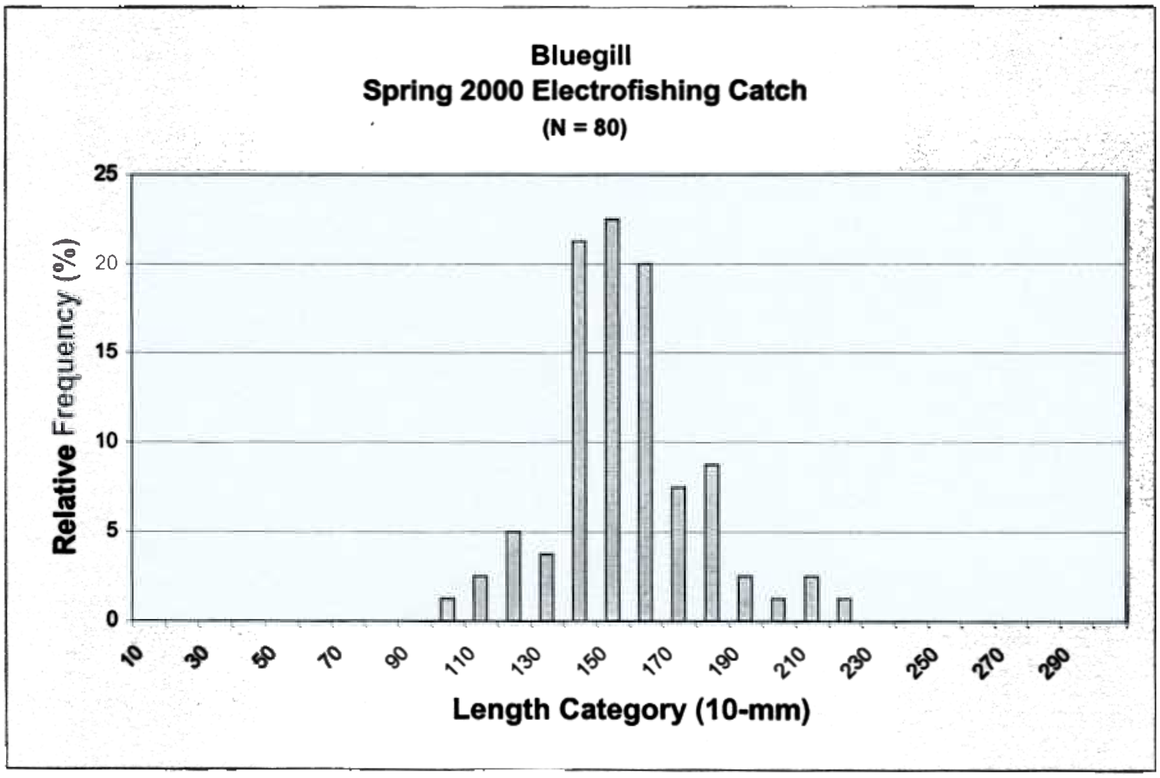


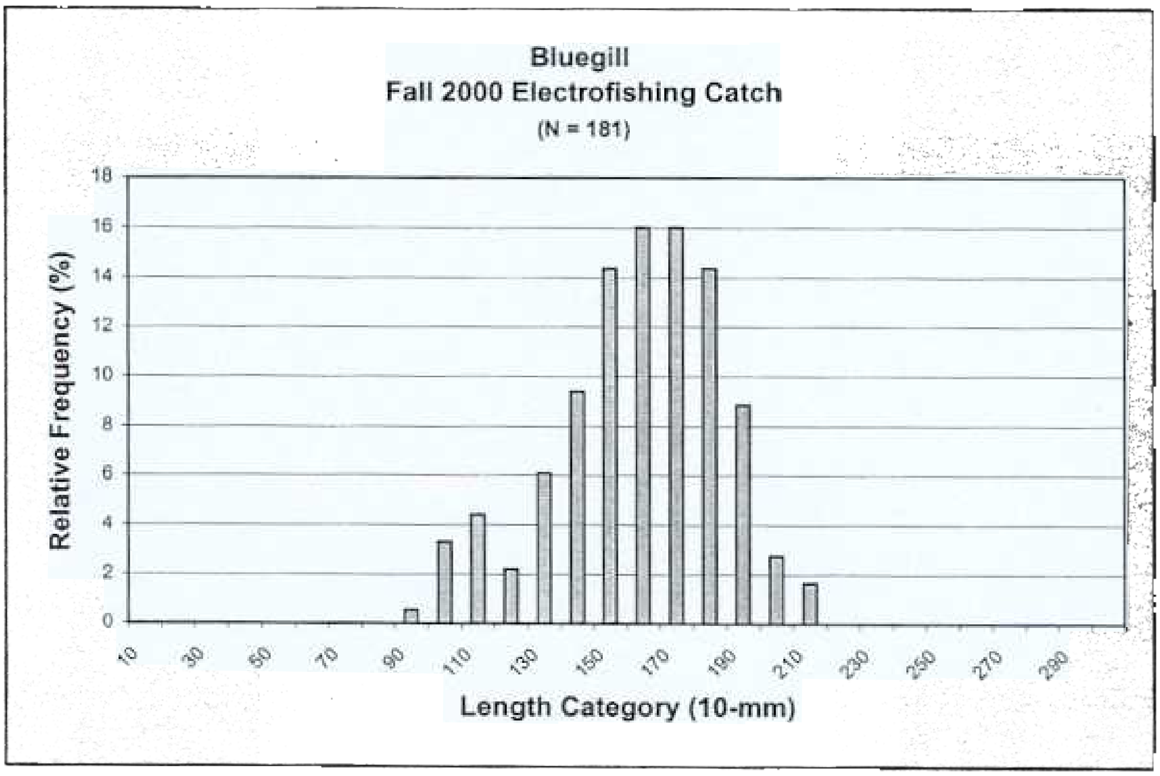


Figure 3.5-8. Length-frequency distribution for bluegill collected by boat electrofishing from Onondaga Lake in spring and fall 2000.

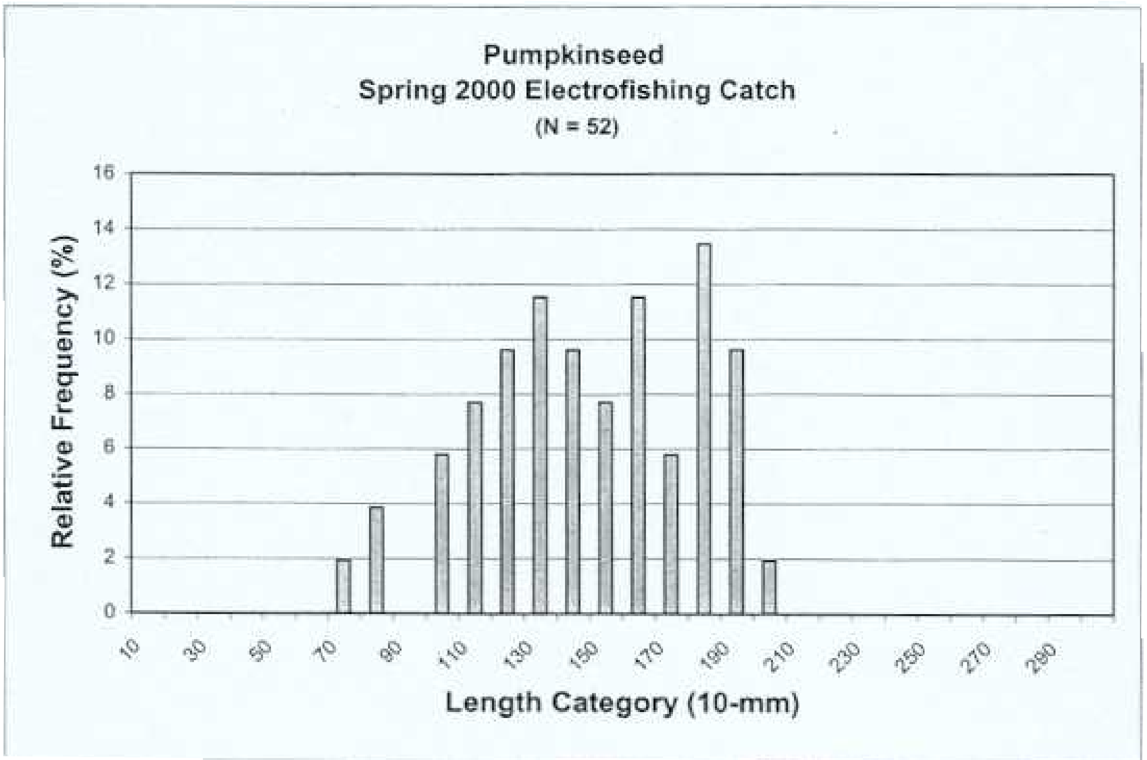
fall. The peak in distribution in the spring presumably corresponds to the peak observed in the fall distribution, with the seasonal differences in length groups of the peaks being the result of added growth from spring to fall. Fish less than 100 mm long were relatively uncommon in the electrofishing catch, but were abundant in the littoral seine collections.

PSD and RSD for bluegill were calculated for both the spring and fall collections. PSD was 38 for spring and 54 for fall (Table 3.5-3). RSD_8 values were 4 and one, respectively (Table 3.5-3). These PSD values indicate that there were moderate numbers of bluegill of quality size (i.e., >150 mm and suitable for pursuit by anglers). However, the low RSD_8 values indicate that there are relative few bluegill of preferred size (>200 mm or 8 inches). These low RSD_8 values suggest that exploitation (harvest) of bluegill is either high, the growth of bluegill after attaining quality size is inordinately slow, or the population is relatively young and the older year classes have not had time to reach preferred size.

3.5.1.4.4 Pumpkinseed

The length-frequency distribution for pumpkinseed was determined separately for the spring and fall electrofishing data. Pumpkinseed were represented by fish from the 70-mm to the 200-mm length groups, and showed similar length-frequency distributions in both spring and fall (Figure 3.5-9). The multiple-peak distribution of lengths of pumpkinseed suggests that several year classes were represented in the catch, and no one year class appears dominant. Fish less than 100 mm long are poorly represented in this data, but were abundant in the littoral seine collections.

PSD and RSD for pumpkinseed were calculated for both the spring and fall collections. PSD was 36 for spring and 41 for fall (Table 3.5-3). RSD_8 values were zero for both spring and fall (Table 3.5-3). These results are similar to those found for bluegill. The PSD values indicate that there were moderate numbers of pumpkinseed of quality size, but the zero values for RSD_8 values indicate that no pumpkinseed of preferred size (>200 mm or 8 inches) were collected. This suggests that exploitation (harvest) of pumpkinseed is either high, growth after attaining



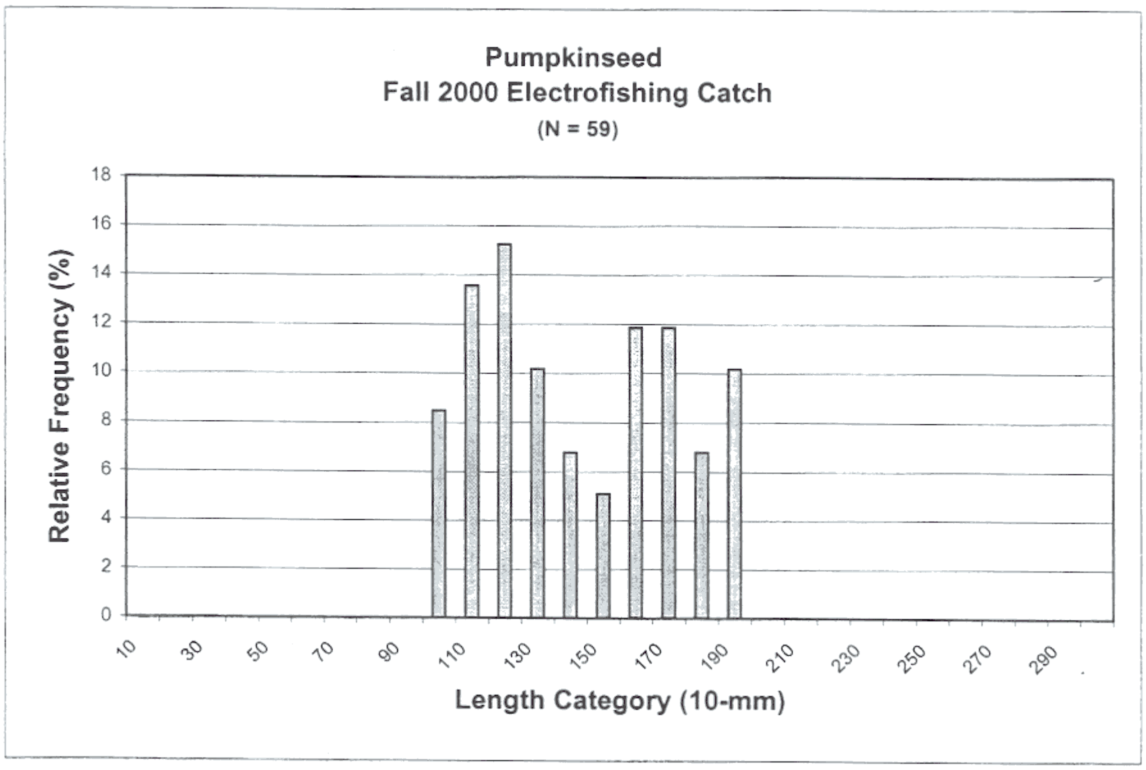


Figure 3.5-9. Length-frequency distribution for pumpkinseed **collected by boat electrofishing** from Onondaga Lake in spring and fall 2000.

quality size is inordinately slow, or the population is relatively young and the older year classes have not had time to reach preferred size.

3.5.1.4.5 Walleye

The length-frequency distribution for walleye was determined only for the spring electrofishing data, since only eight walleye were collected in the fall. Walleye were represented by fish from the 400-mm to the 670-mm length groups in the spring, and showed two peaks in length distribution (Figure 3.5-10). One peak was around the 520- to 540-mm length groups, and the other peak was at the 590- to 630-mm length groups. Few fish less than 520 mm were collected.

PSD and RSD for walleye were calculated for the spring collection only. PSD was 100, and RSD_{20} was 82 (Table 3.5-3). These values indicate that reproduction or recruitment of young into the adult population is extremely limited and exploitation (harvest) is low (NYSDEC 1989). Such a population is susceptible to over-harvest because there is a high proportion of preferred-size fish and few young fish to replace adults that are harvested.

3.5.1.4.6 Yellow Perch

length-frequency distribution for yellow perch was determined only for the fall electrofishing data, since only 13 yellow perch were collected in the spring. Yellow perch were represented by fish from the 30-mm to 310-mm length groups (Figure 3.5-11). There was a distinct peak in the length distribution at 150 mm. Given the high number of yellow perch collected in the fall and the relatively few fish of lengths greater than 180 mm, it appears that older year classes are poorly represented in the population. Few fish less than 130 mm were collected as well, but fish of that size were well represented in the littoral seining collections.

PSD and RSD for yellow perch were calculated for the fall collection only. PSD was 3, and RSD_{10} was 1 (Table 3.5-3). These values indicate that the yellow perch population is heavily dominated by fish of less than quality size (200 mm). Given that yellow perch of stock size

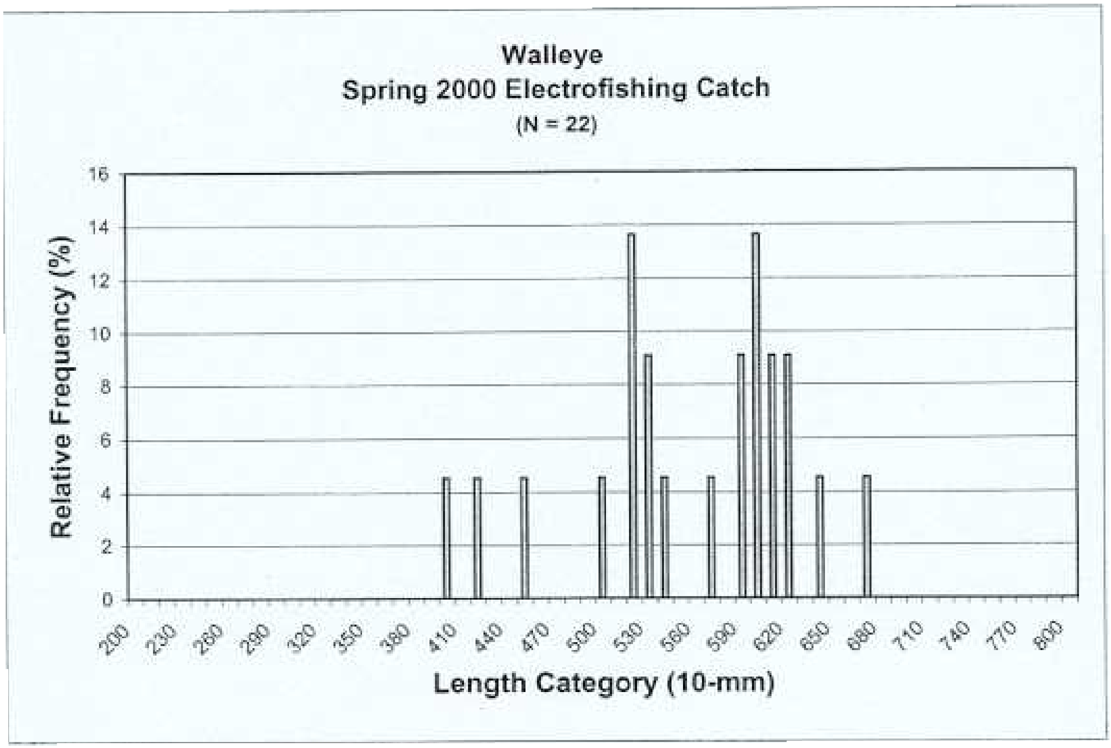


Figure 3.5-10. Length-frequency distribution for walleye collected by boat electrofishing from Onondaga Lake in spring 2000.

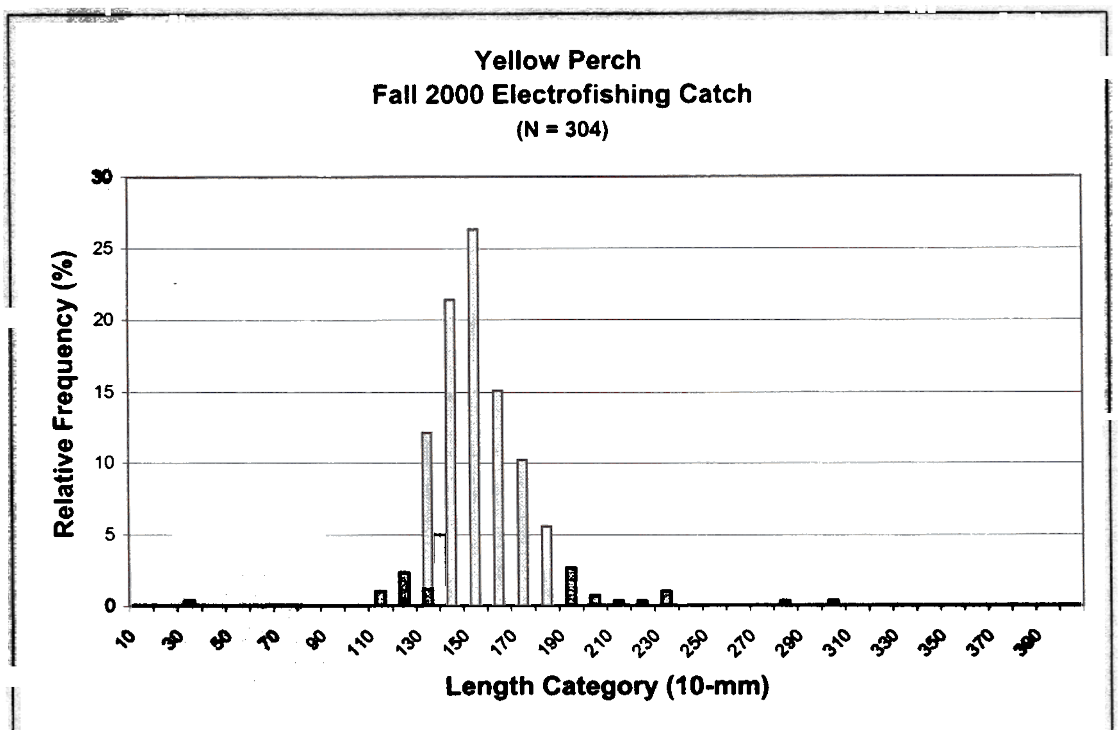


Figure 3.5-11. Length-frequency distribution for yellow perch collected by boat electrofishing from Onondaga Lake in fall 2000.

(>130 mm) were very abundant, the extremely low PSD value could be due to high reproduction of yellow perch and resultant high inter-species (with gizzard shad) and intra-species competition for forage. This would produce slow growth and delay fish from reaching quality or preferred size. The low PSD and RSD values could also be the result of poor reproductive success in the past that has resulted in very limited representation by older year classes.

3.5.1.4.7 Channel Catfish

The length-frequency distribution for channel catfish was determined only for the fall electrofishing data, since no channel catfish were collected in the spring. Channel catfish were represented by fish from the 420-mm to 670-mm length groups (Figure 3.5-12). The multiple peaks in length distribution in this range suggest that several year classes were represented in the catch. The length distribution suggests that the channel catfish population is dominated by large adult individuals, with few or any juvenile or small adult fish present. The lack of fish less than 420 mm suggests that either fish of this size were not occupying the habitats electrofished, were not susceptible to the sampling method, or were scarce or lacking in the population. No smaller channel catfish were collected in the littoral seining or the gill net collections either.

PSD and RSD for channel catfish were calculated for the fall collection only. PSD was 100, and RSD_{24} was 5 (Table 3.5-3). These values indicate that all fish collected were of quality size (410 mm) or larger. As was the case for walleye, this suggests that reproduction or recruitment of young into the adult population is extremely limited and exploitation is low (NYSDEC 1989). Such a population is susceptible to over-harvest because there is a high proportion of preferred-size fish and few young fish to replace adults that are harvested.

3.5.1.4.8 Brown Bullhead

The length-frequency distribution for brown bullhead was determined only for the fall electrofishing data, since only eight brown bullhead were collected in the spring. Brown bullhead were represented by fish from the 220-mm to 370-mm length groups (Figure 3.5-13). The multiple peaks in length distribution in this range suggest that several year classes were

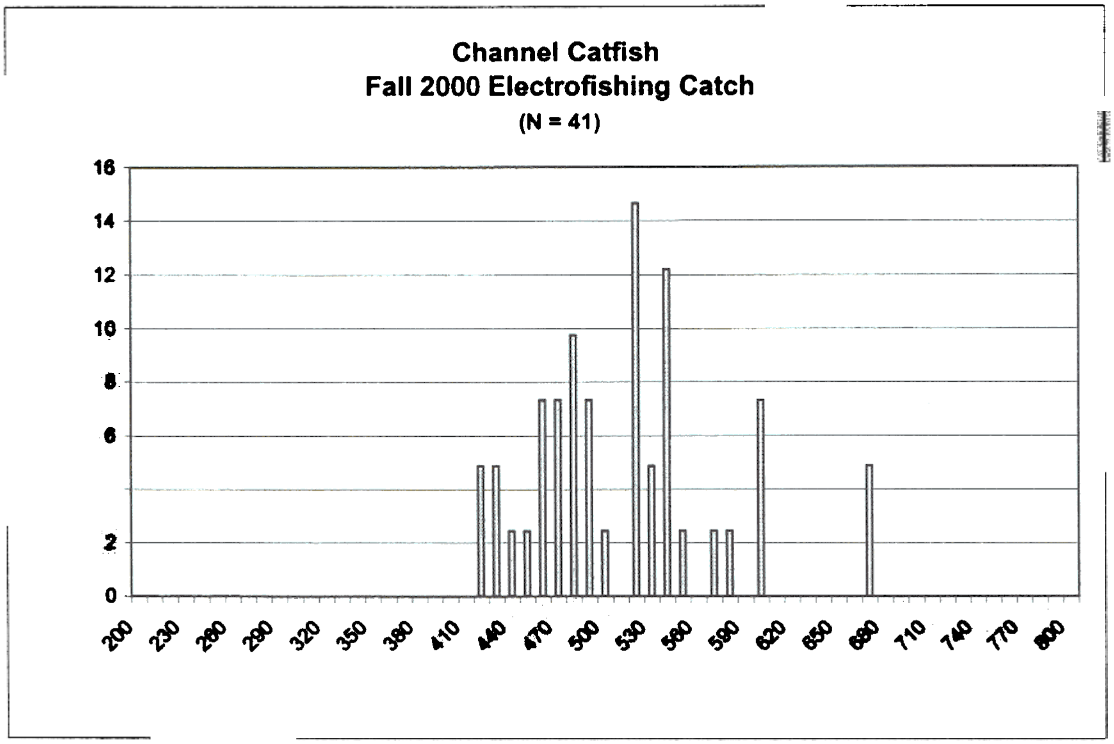


Figure 3.5-12. Length-frequency distribution for channel catfish collected by boat electrofishing from Onondaga Lake in spring 2000.

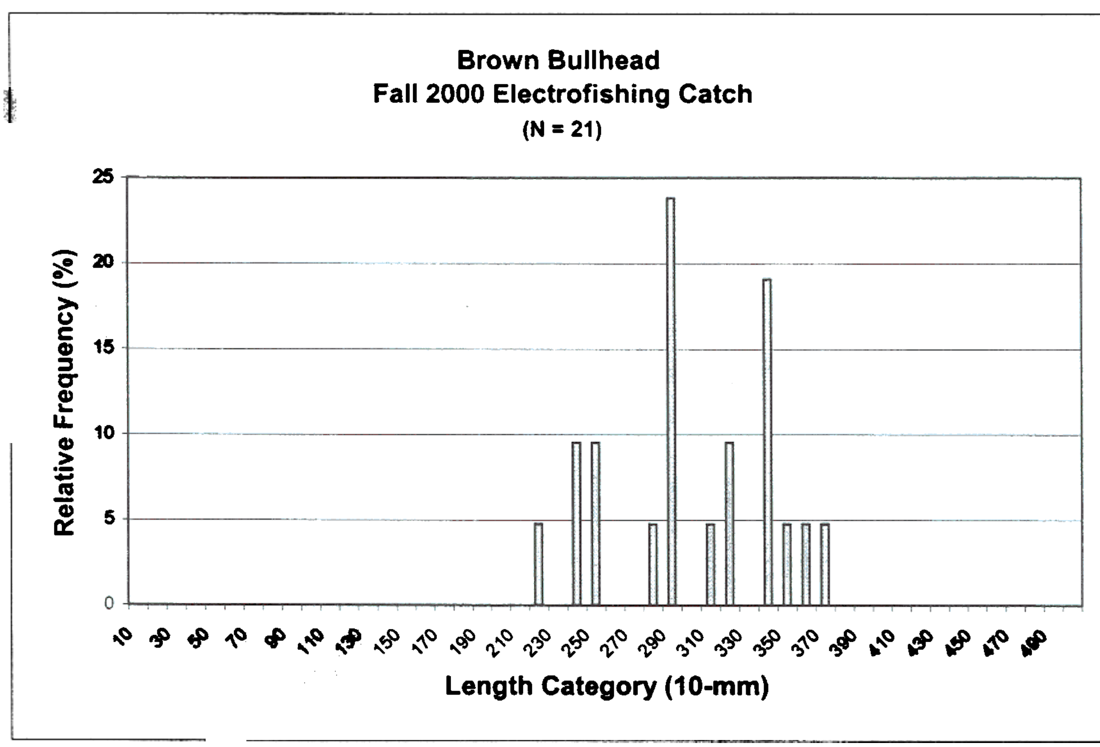


Figure 3.5-13. Length-frequency distribution for brown bullhead collected by boat electrofishing from Onondaga Lake in fall 2000.

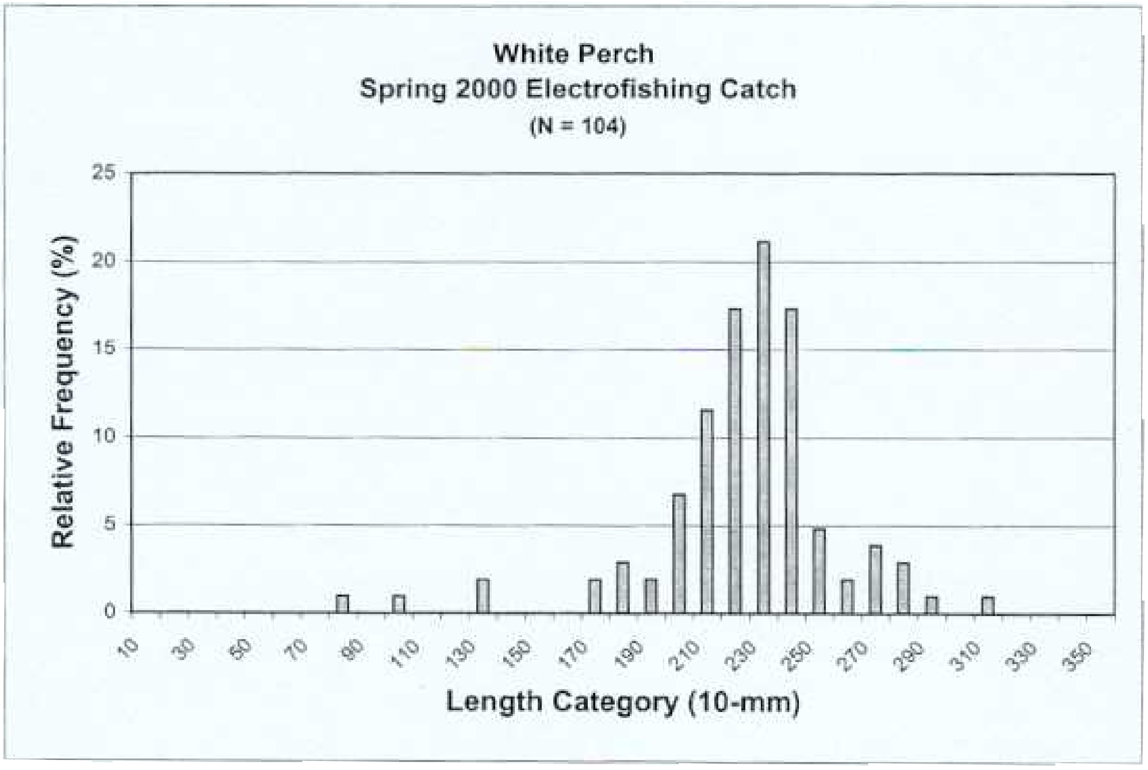
represented in the catch. The length distribution suggests that the brown bullhead population is dominated by large adult individuals, with few or any juvenile or small adult fish present. The lack of fish less than 220 mm suggests that either fish of this size were not occupying the habitats electrofished, were not susceptible to the sampling method, or were scarce or lacking in the population. No smaller brown bullhead were collected in the littoral seining or the gillnet collections either.

PSD and RSD for brown bullhead were calculated for the fall collection only. PSD was 95, and RSD_{12} was 43 (Table 3.5-3). These values indicate that nearly all fish collected were of quality size (230 mm) or larger. Again, this suggests that reproduction or recruitment of young into the adult population is extremely limited and exploitation is low (NYSDEC 1989). Such a population is susceptible to over-harvest because there is a high proportion of preferred size fish and few young fish to replace adults that are harvested.

3.5.1.4.9 White Perch

The length-frequency distribution for white perch was determined separately for the spring and fall electrofishing data. Two distinctly different length-frequency distributions were obtained for the two seasons. The length-frequency distribution for white perch in spring represents fish from the 80-mm group to the 310-mm group, with the majority of fish from 200 to 249 mm (Figure 3.5-14). The length-frequency distribution for the fall collections represents fish from the 100-mm group to the 270-mm group, with the majority of fish from 140 to 199 mm (Figure 3.5-14). Thus, fish less than 200 mm were apparently under-represented in the spring samples, and fish greater than 200 mm were apparently under-represented in the fall samples. The two major peaks in length distribution (one for each season) represent two distinct year classes that apparently dominate the white perch population of the lake.

PSD and RSD for white perch were calculated for both the spring and fall collections. Values varied considerably between the two seasons (Table 3.5-3). PSD was much higher (87 vs. 13) in spring than in fall, but RSD_{10} value was only moderately higher (11 vs. 6) in spring than in fall. The high PSD value in the spring indicates that a relatively high proportion of stock



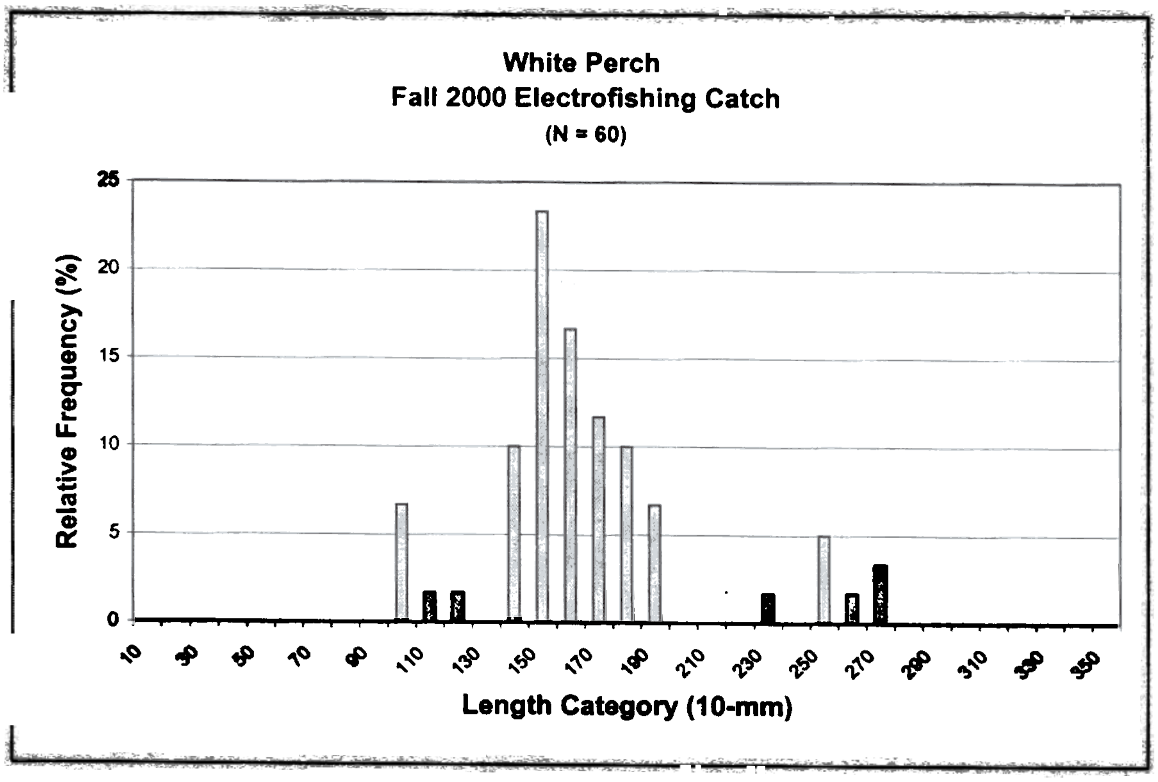


Figure 3.5-14. Length-frequency distribution for white perch collected by boat electrofishing from Onondaga Lake in spring and fall 2000.

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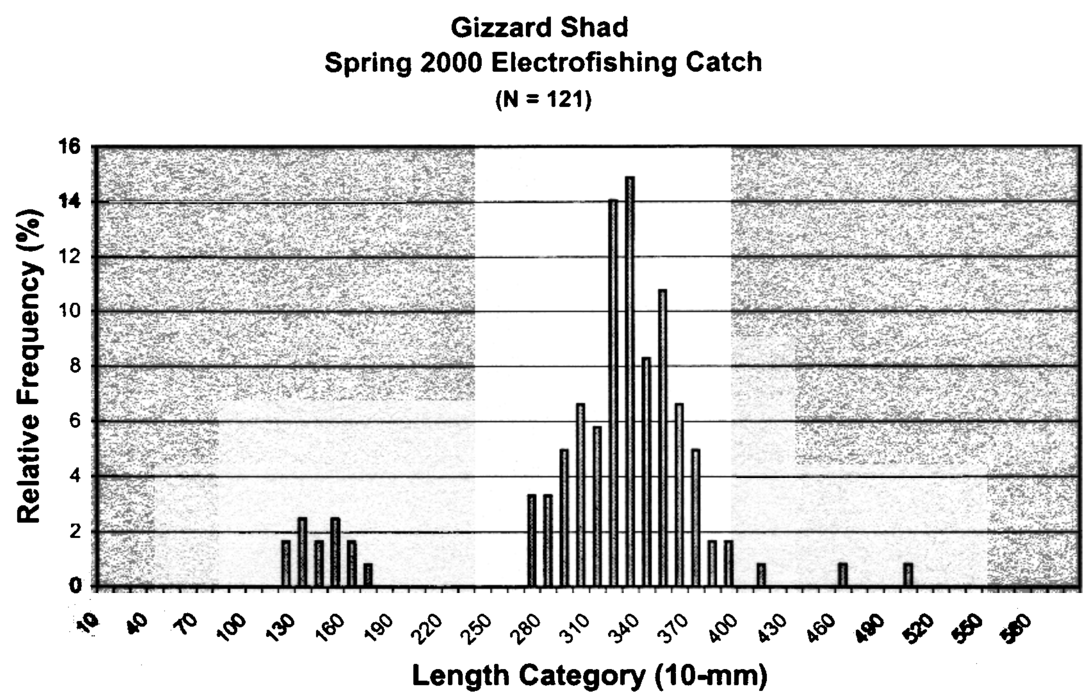

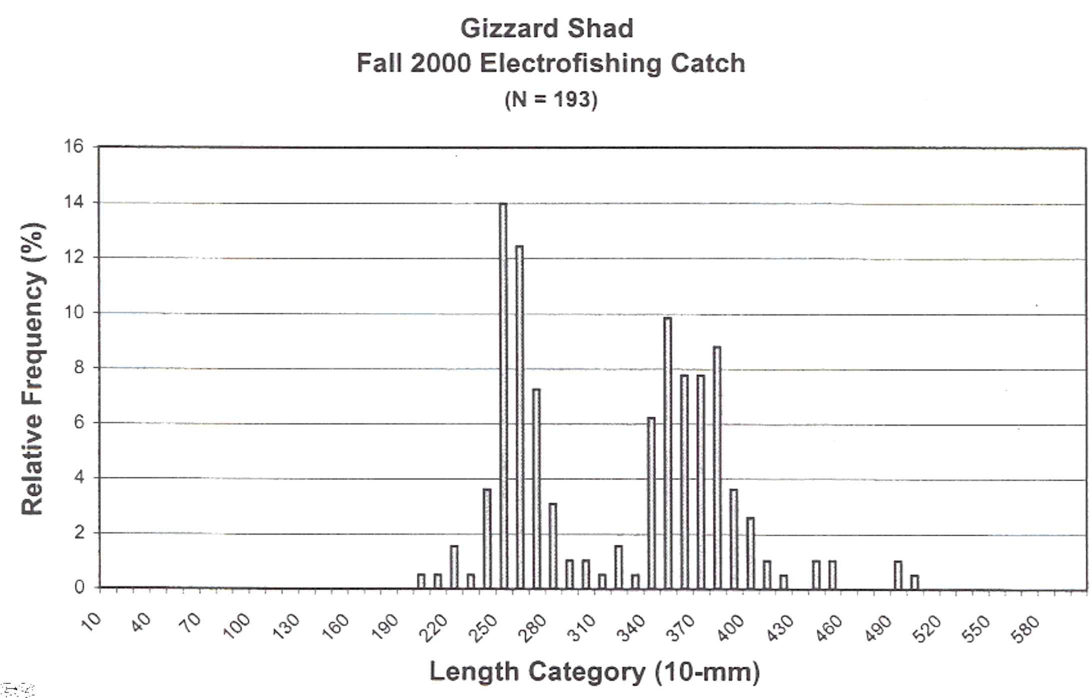

Figure 3.5-15. Length-frequency distribution for gizzard shad collected by boat electrofishing from Onondaga Lake in spring and fall 2000.

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Table 3.5-4. Number, catch per unit effort (CPUE), and relative abundance (%) of fish species collected by gill netting from each stratum in Onondaga Lake in 2000.

Species	Sampling Event														
	May			July			September			October			OVERALL		
	No.	CPUE	%	No.	CPUE	%	No.	CPUE	%	No.	CPUE	%	No.	CPUE	%
Longnose gar	1	0.50	1.28										1	0.13	0.65
Alewife	14	7.00	17.95							11	5.50	47.83	25	3.13	16.13
Gizzard shad	53	26.50	67.95	2	1	40	32	16.00	65.31	5	2.50	21.47	92	11.5	59.35
Brown trout	2	1.00	2.56										2	0.25	1.29
Shorthead redhorse							1	0.50	2.04				1	0.13	0.65
Channel catfish							4	2.00	8.16				4	0.5	2.58
White perch	8	4.00	10.26				7	3.50	14.29	4	2.00	17.39	19	2.38	12.26
Smallmouth bass				3	1.5	60	3	1.50	6.12	3	1.50	13.04	9	1.13	5.81
Walleye							2	1.00	4.08				2	0.25	1.29
No. of fish	78	39.00		5	2.50		49	24.50		23	11.50		155	19.40	
Species richness	5			2			6			4			9		
Species diversity	0.41			0.29			0.5			0.54			0.49		

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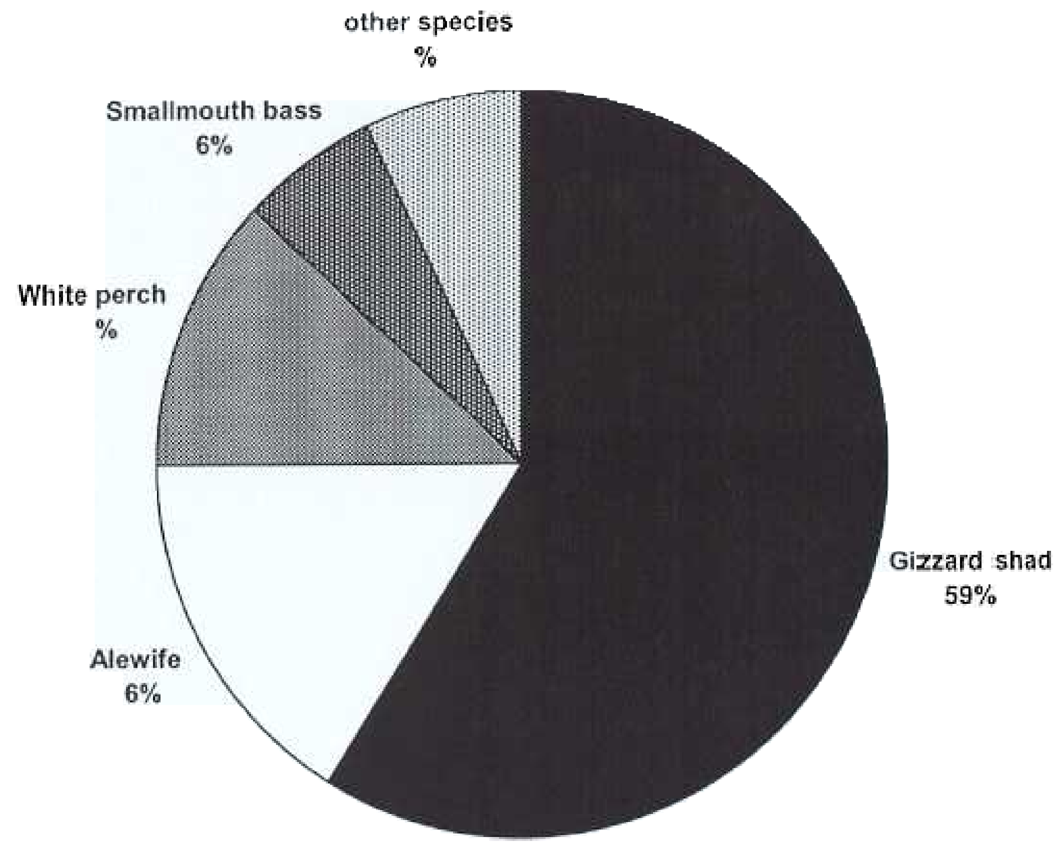

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Species diversity was highest in October, despite the fact that only four species were collected during that event (Table 3.5-4). Even though relatively few species were collected in October, there was a more even distribution of catch among those species than for the other sampling events. All four species collected in October each made up at least 13% of the catch, whereas only two species constituted more than 13% of the catch in May, July, and September.

3.5.2.3 Catch by Stratum

The greatest number of fish (91) collected by gill net was from the south basin (Table 3.5-5). Seven species were collected from each basin, but the basins had only five species (alewife, gizzard shad, white perch, smallmouth bass, and walleye) in common. Longnose gar and channel catfish were collected in the north basin, but not the south basin. Brown trout and shorthead redhorse were collected from the south basin but not the north basin. Gizzard shad was the most abundant species in the catch for both basins. Alewife was also relatively abundant (15-17% of the catch) in both basins. White perch and smallmouth bass both represented more that 10% of the catch in the north basin, but represented only 5% and 2% of the catch in the south basin.

3.6 Tagged Fish

Four hundred and forty-eight individual fish representing nine species were tagged in 2000. This number includes not only fish collected by OCDDS during the 2000 fisheries sampling program, but also some fish that were captured by anglers during fishing tournaments or recreational angling on Onondaga Lake in 2000. Largemouth bass was the most frequently tagged species, followed by smallmouth bass, channel catfish, and walleye. The distribution of tags among the various species is presented below.

Species	No. Tagged	Species	No. Tagged
Largemouth bass	257	Bowfin	10
Smallmouth bass	66	Black crappie	8
Channel catfish	45	Yellow perch	3
Walleye	32	Pumpkinseed	
Brown bullhead	15	Rock bass	
Bluegill	10		

Table 3.5-5. Number and relative abundance (%) of fish collected by gillnet from the north and south basins of Onodaga Lake in 2000.

NORTH BASIN										
	Sampling Event									
	May		July		September		October		OVERALL	
Species	No.	%	No.	%	No.	%	No.	%	No.	%
Longnose gar	1	14.29							1	1.56
Alewife	1	14.29					10	50	11	17.19
Gizzard shad	2	28.57			21	58.33	3	15	26	40.63
Channel catfish					4	11.11			4	6.25
White perch	3	42.86			7	19.44	4	20	14	21.88
Smallmouth bass			1	100	3	8.33	3	15	7	10.94
Walleye					1	2.78			1	1.56
No. of fish	7		1		36		20		64	
Species richness	4		1		5		4		7	
Species diversity	0.55		0		0.51		0.54		0.67	

SOUTH BASIN										
	Sampling Event									
	May		July		September		October		OVERALL	
Species	No.	%	No.	%	No.	%	No.	%	No.	%
Alewife	13	18.31					1	33.33	14	15.38
Gizzard shad	51	71.83	2	50	11	84.62	2	66.67	66	72.53
Brown trout	2	2.82							2	2.2
Shorthead redhorse					1	7.69			1	1.1
White perch	5	7.04							5	5.49
Smallmouth bass			2	50					2	2.2
Walleye					1	7.69			1	1.1
No. of fish	71		4		13		3		91	
Species richness	4		2		3		2		7	
Species diversity	0.36		0.30		0.23		0.28		0.41	

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4.0 DISCUSSION

The fish community of Onondaga Lake has undergone considerable change since European settlement of North America. The lake's fish fauna has been sampled sporadically since the 1800s, and several of these surveys have been conducted in the last two decades. This discussion will present an overview of the past fisheries resources of Onondaga Lake, an overview of the current status of the lake's fisheries resources based on the results of the 2000 fish sampling program, and comparison of the 2000 Onondaga Lake fisheries data to data from other New York State waters.

4.1 Historic Fisheries Resources

The current fish community of Onondaga Lake bears little resemblance to the original native population. Historically, Atlantic salmon *(Salmo salar)* migrated through the lake to spawn in the tributaries where they were harvested and shipped to the New York City market. In the late 1800s, Onondaga Lake whitefish (probably a *Coregonus* sp.) were sufficiently abundant to support a commercial fishery. The whitefish are thought to have been extirpated from the lake by 1897, presumably due to deterioration of water quality and habitat. By the turn of the century, dam construction on the Oswego River blocked the migration route of the Atlantic salmon to Onondaga Lake. Salmon, trout, bass, and yellow perch have been historically fished, both recreationally and commercially, but the commercial fishery within the lake had declined significantly by 1895 (Gandino 1996).

Several studies of the fish community in Onondaga Lake and its tributaries have been conducted over the last century. Greeley (1928) used seines, gill nets, trap nets, and set lines to capture ten species of fish in Onondaga Lake in 1927. The number of species found in the Seneca River at that same time was 39, nearly four times greater than in the lake. In 1946, fourteen species were captured over a three-day period using gill and trap nets Stone and Pasko (1946). However, over 93% of the fish captured were represented by one species, common carp. Seining of shallow areas for YOY fishes at this same time resulted in four species being captured: log perch, sunfishes *(Lepomis spp.)*, white bass *(Morone chrysops)*, and common carp.

A study in 1969 by Noble and Forney (1971) used trap and gill nets to capture 16 species within the lake. These authors found that growth of most game and panfish in Onondaga Lake compared favorably with published growth rates for fish from other waters of the Northeast (Noble and Forney 1971). In 1980-1981, NYSDEC sampled the lake's fish community as part of a mercury assessment program. Twenty-two species were collected using gill nets, trap nets, and seines. White perch was the most abundant species (63% of catch), along with alewife (14%). Seining results indicated that several year classes of most fish in the lake were missing. Chiotti (1981) concluded that, with the exception of white perch, reproduction within the lake was "sporadic

Several changes in composition of the fish community occurred between 1946 and 1980. Relative abundance of common carp dramatically decreased and relative abundance of white perch increased. The decrease in abundance of carp may reflect improvements in water quality that allowed other species to colonize the lake, thus relegating carp to a less significant role within the lake. The abundance of white perch in 1980 is probably due to natural expansion of the species throughout the region during the mid-1900s and the fact that this species is tolerant of wide range of salinity and turbidity (Smith 1985). The existence of gizzard shad in Onondaga Lake was first confirmed during the 1980 survey, and freshwater drum were first recorded from the lake in the 1950s (Tango and Ringler 1996). The increase in the number of species captured during the course of these surveys may be due to the differences in collection techniques and sampling effort. However, increases in species diversity may also have been partly due to improved water quality conditions (Tango and Ringler 1996). Murphy (1978) noted that the distribution of fish in the lake during the surveys from 1928 through 1969 was skewed toward the northwest portion of the lake. Habitat conditions along the northwest shore were less affected by industrial and municipal wastes that were discharged into the southern basin. As a result, the northwest portion of the lake supported a larger and more varied fish fauna the other portions of the lake (Murphy 1978).

Extensive fish collections were completed by Gandino (1996), Ringler et al. (1996), Arrigo (1998), and Tango (1999) during the late 1980s through mid-1990s using trap, gill, and seine nets. A total of 52 species was captured in Onondaga Lake during this period. Warmwater pelagic planktivores (white perch and gizzard shad) and littoral planktivore/insectivores (bluegill and pumpkinseed) dominated the fish community. It should be noted that although a relatively high number of species were reported from Onondaga Lake during this period, several species appeared to be sporadic and transient in their occupation of the lake. Species such as green sunfish *(Lepomis cyanellus),* burbot *(Lota lota),* troutperch *(Percopsis omiscomaycus),* and brook trout *(Salvelinus fontinalis)* were collected only once in nine surveys from 1927 though 1994 (Tango and Ringler 1996). Tributaries and the Seneca River, into which Onondaga Lake drains, apparently allow some species that have not established resident populations in the lake to use it occasionally nonetheless (Tango and Ringler 1996).

Investigations of nesting activity and young-of-year fish populations in the 1990s found these were mostly confined to the northern half of the lake (Arrigo 1998). Sparse macrophyte growth appeared to limit recruitment of juvenile fishes even in years when initial reproductive success was high (Arrigo 1998). Between 1991 and 1994, only 15 to 40% of the adult species captured in the lake in any one year were also captured as YOY (Gandino 1996, Ringler et al. 1996, Arrigo 1998).

4.2 Present Fisheries Resources

The fish sampling program in 2000 resulted in the capture of 29,578 larvae, YOY, juvenile, or adult fish composed of 33 species. The current fish community is dominated by gizzard shad, which comprised 54% of the adult fish community, 51% of the juvenile fish community, and 76% of the pelagic larval fish community. *Lepomis* spp. (sunfish) were also abundant as adults (9% of electrofishing catch), juveniles (24% of seine catch), and larvae (44% of littoral catch, 12% of pelagic catch). Common carp (11%), white perch (9%), white sucker (6%), and yellow perch (4%) were abundant only as adults or large juveniles. Large predatory fish were primarily represented by largemouth bass (177 fish, 2% of electrofishing catch) and smallmouth bass (59 fish, 1% of electrofishing catch), with lesser numbers of channel catfish (43 fish, 1%) and walleye (30 fish, <1%) also collected.

All ten of the most commonly captured adult species in 2000 (Section 3.5) were also captured as larvae (Table 4.2-1). Only brown bullhead and walleye were captured in substantial numbers as adults and not captured as larva in 2000. Overall, 13 of the 24 adult species were

Table 4.2-1 Relative percent abundance of littoral larval, YOY, and adult fish captured in Onondaga Lake in 2000. * - denotes fish from electrofishing collections only NC= not collected.

Taxon	2000 Littoral Larvae	2000 YOY	2000 Adult*
Sunfish (*Lepomis* spp.)	43.5%	24.0%	12.2%
Brook silverside	39.4%	1.1%	NC
White sucker	3.4%	0.06%	5.3%
Common Carp	2.6%	0.01%	9.6%
Golden shiner	2.2%	0.5%	0.01%
Yellow perch (6,NC,5)	1.5%	NC	7.6%
Freshwater drum	1.3%	NC	0.4%
Gizzard shad	0.8%	66.0%	47.3%
White perch	0.5%	2.4%	8.2%
Fathead minnow	0.2%	NC	NC
Banded killifish	0.1%	1.8%	0.8%
Alewife	0.08%	NC	NC
Logperch	0.04%	0.3%	0.01%
Largemouth bass	0.02%	1.4%	4.2%
White bass	0.01%	NC	NC
Crappie (*Pomoxis* spp.)	0.01%	NC	0.1%
Longnose dace	0.01%	NC	NC
Shorthead redhorse	0.01%	NC	0.5%
Johnny darter	0.01%	NC	NC
Tesselated darter	0.01%	NC	NC
Smallmouth bass	NC	2.5%	1.4%
Longnose gar	NC	0.01%	0.1%
Northern hog sucker	NC	0.01%	0.01%
Other Taxa	4.3%	NC	2.3%

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captured as larvae (assuming Lepomis spp represented both bluegill and pumpkinseed and *Pomoxis* spp. included black crappie). Three species (fathead minnow, white bass, and longnose dace) were captured as larvae but not captured as juveniles or adults. However, at least one of these species (longnose dace) likely originated from another water body as it is a stream-dwelling species. The presence of the two other species as larvae but not as juveniles or adults may indicate a small adult population in the lake or larvae being washed into the lake from connecting waterbodies.

Eleven of the 14 species captured as young-of-the-year (YOY) were also captured as larvae (assuming *Lepomis* spp. represented both bluegill and pumpkinseed, Table 4.2-1). Notably missing from the larval fish collections was smallmouth bass, which was the third most commonly encountered YOY but was not captured as larvae. Ten species captured as larvae were not captured as YOY in 2000, but eight of those species were uncommon as larvae. Only two species, yellow perch and freshwater drum, were captured in substantial numbers as larvae but not captured as YOY. The lack of YOY yellow perch captured in 2000 may be related to the strong decrease in larval yellow perch abundance seen after mid-May.

Larval fish distribution in Onondaga Lake generally appeared patchy, making identification of distinct spatial trends difficult. For example, of the 182 freshwater drum collected from the littoral zone, 179 were collected from two seine hauls in Stratum 3 in mid-June. The remaining three freshwater drum larvae from the littoral zone were collected from two seine hauls in Stratum 5 in late June. Given this patchy distribution, larvae of only two species collected in considerable numbers showed a shift in abundance between the littoral zone and the pelagic zone over time. Freshwater drum larvae were first collected in mid-June in the littoral zone, but did not show up in pelagic samples until late June. Clupeid larvae (primarily gizzard shad) first appeared and were most abundant in littoral zone samples in early June. They continued to be collected there through late June. Clupeid larvae first appeared in pelagic samples in mid-June. They became abundant there in late June and remained so through mid-July. Analysis of the size distribution of both freshwater drum and clupeid larvae collected from the littoral and pelagic zones showed that larvae that were first collected in the littoral zone were smaller than those that were subsequently collected in the pelagic zone. These observations may indicate that larvae of freshwater drum and clupeids showed a tendency to move from the littoral zone to the pelagic zone as they increased in size.

Twenty-one species were collected in seine hauls aimed at sampling the juvenile component of the fish community. Fourteen of these species were captured as YOY, representing 47% of the species captured as adults in 2000. This proportion of the community producing offspring is higher than the 15 to 40% reported for surveys in 1991 through 1994. The spatial distribution of nests in the lake in 2000 was consistent with surveys in the 1990s. In 2000, the vast majority (92%) of centrarchid nests was located in the north basin. This was true as well in 1993 (75%) and 1994 (78%) (Arrigo 1998). This suggests that the north basin, particularly Strata 1 and 5, continue to provide the highest quality and quantity of spawning and nursery habitat in the lake. One notable difference with the 2000 survey from past surveys was the documentation of notable numbers of smallmouth bass nests and YOY in 2000. This suggests that smallmouth bass reproduction in Onondaga Lake may be increasing from that of previous years.

The adult fish community is dominated by forage or panfish species. Large predatory fish make up a relatively small proportion of the overall fish community. Largemouth bass were represented by several year classes, indicating that successful reproduction has occurred for the last several years. CPUE values for largemouth bass <10 inches long indicate this size largemouth bass existed at relatively low density in 2000 (NYSDEC 1987). CPUE for largemouth bass ≥ 10 inches indicated largemouth bass of this size were somewhat more abundant, with low to moderate density in 2000 (NYSDEC 1987). PSD and RSD values for largemouth bass indicated that relatively large adult fish constituted a considerable portion of the largemouth bass population and reproduction may be somewhat limited.

Smallmouth bass was also represented by several year classes. CPUE values for smallmouth bass <10 inches and ≥ 10 inches long indicate that the population of smallmouth bass of these sizes was of moderate density in 2000 (NYSDEC 1987). PSD and RSD values for smallmouth bass also indicated that adult fish constituted a considerable portion of the smallmouth bass population and reproduction may be somewhat limited.

Walleye were relatively scarce in the fish community, as were channel catfish and brown bullhead. Collections of all three of these species were dominated by large adult fish. Conversely, bluegill, pumpkinseed, yellow perch, and white perch were relatively abundant. The bluegill population appeared to be dominated by one or two year classes, and PSD and RSD values for this species indicated that larger bluegill constituted a relatively small portion of the population. The size distribution of pumpkinseed was more evenly distributed than for bluegill, but larger pumpkinseed were also not a major portion of the population. The yellow perch population was dominated by fish 140 to 180 mm, with few large adult and no YOY fish collected. White perch size distribution varied considerably between spring and fall, with larger fish making up a large part of the collection in spring and smaller fish dominating the catch in fall. This suggests that either some size groups of this species were not effectively sampled during one or both seasons, or the size distribution of white perch changed between seasons due to emigration, immigration, or mortality.

4.3 Comparisons to Past Data and Other Lakes

Comparison of fish community data from Onondaga Lake with data from past collections and to data from other regional lakes can help to put the findings of the 2000 Onondaga Lake fish monitoring program into perspective. Comparisons of juvenile seine collections from 2000 to data collected from Onondaga Lake in the 1990s have already been discussed in the *Results* section of this report, as well as earlier in this *Discussion* section. Therefore, the remainder of this discussion will primarily focus on comparisons of data from adult or larger juvenile fish.

The 2000 larval fish sampling effort was only the second known attempt to sample the larval fish community of Onondaga Lake. The Onondaga Lake Management Conference funded the first effort in 1994. No final report was present in the archives of the Onondaga Lake Cleanup Corporation (personal communication from Ed Michalenko, Onondaga Lake Cleanup Corporation, to M. Arrigo, EcoLogic, 11-26-01), but a progress report letter from Dr. Joe Makarewicz of SUNY Brockport to the Onondaga Lake Management Conference dated October 5, 1994 that summarizes this larval fish sampling program was reviewed. The 1994 effort consisted of sampling with a Miller high-speed trawl towed weekly from April 11 through September 26, 1994. A series of five oblique tows was used along a north/south mid-lake transect along with a single tow in the littoral zone. Nets were composed of 0.5-mm mesh netting and towed at a speed of approximately 2 meters/second. A single, 10-mm long logperch was the only fish captured during the 1994 sampling effort.

The collection of only one larval fish from Onondaga Lake in 1994 raises questions regarding how representative the data collected during that effort were, since over 30,000 YOY fish were collected from the lake's littoral zone that same year (Arrigo 1998). The abundance of YOY fish in 1994 strongly suggests that many larval fish were produced in the lake as well. It is unknown why the 1994 larval sampling program did not capture more of these larvae. Because there is some question regarding how representative the 1994 larval data are, comparison of the larval fish community in 2000 to that of the 1994 survey are not made here except to note that several thousand larval fish representing at least 20 species were collected from Onondaga Lake in 2000.

In order to gain some insight into the composition of the 2000 Onondaga Lake larval fish community, larval fish catch data from nearby Oneida Lake in 2000 were obtained from Cornell University's Shackelton Point Biological Field Station (unpublished data provided by A. VanDeValk, Cornell University). Taxa from the two lakes were grouped into families for comparison purposes, since the level of taxonomic identification varied among the data sets. In Onondaga Lake, clupeids (herring) and centrarchids (sunfish) were most common in pelagic samples while centrarchids and atherinids (silversides) were most common in littoral samples. In Oneida Lake, percids (perch and walleye), sciaenids (drum), centrarchids, and clupeids were all common (Table 4.3-1). The differences in the larval fish communities of Onondaga and Oneida lakes generally reflect the differences in the adult fish communities of these lakes. Clupeids and centrarchids (*Lepomis* spp., in particular) constituted a major portion of the adult fish community in Onondaga Lake in 2000. Oneida Lake supports considerably larger populations of yellow perch, walleye, and freshwater drum than does Onondaga Lake (VanDeValk et al. 2001). Therefore, it is expected that production of larvae of these species would be greater in Oneida Lake than in Onondaga Lake.

Temporal distribution of larval fish in Onondaga Lake and Oneida Lake was similar for centrarchids and white perch (Figure 4.3-1). Freshwater drum temporal distribution in Onondaga

Table 4.3- **Relative percent abundance of littoral and pelagic larvae in Onondaga Lake in 2000 with larval fish captured in Oneida Lake tows in 2000. Note: taxa were grouped into families for direct comparison.**

Taxon	2000 Pelagic Larvae	2000 Littoral Larvae	2000 Oneida Lake
Herring Family (Clupeidae)	76.4%	1.2%	14.3%
Sunfish Family (Centrarchidae)	11.9%	44.2%	**17.6%**
Sciaenidae (Freshwater drum)	9.5%	1.3%	21.9%
Unidentified	1.1%	2.5%	NC
Temperate Basses (Percicthyidae)	0.8%	0.9%	6.0%
Perch Family (Percidae)	0.2%	1.7%	36.0%
Minnows (Cyprinadae)	0.1%	5.1%	4.2
Silversides (Atherinidae)	NC	39.5%	NC
Suckers (Catostomidae)	NC	3.5%	NC
Killifishes (Cyprinodontidae)	NC	0.1%	NC

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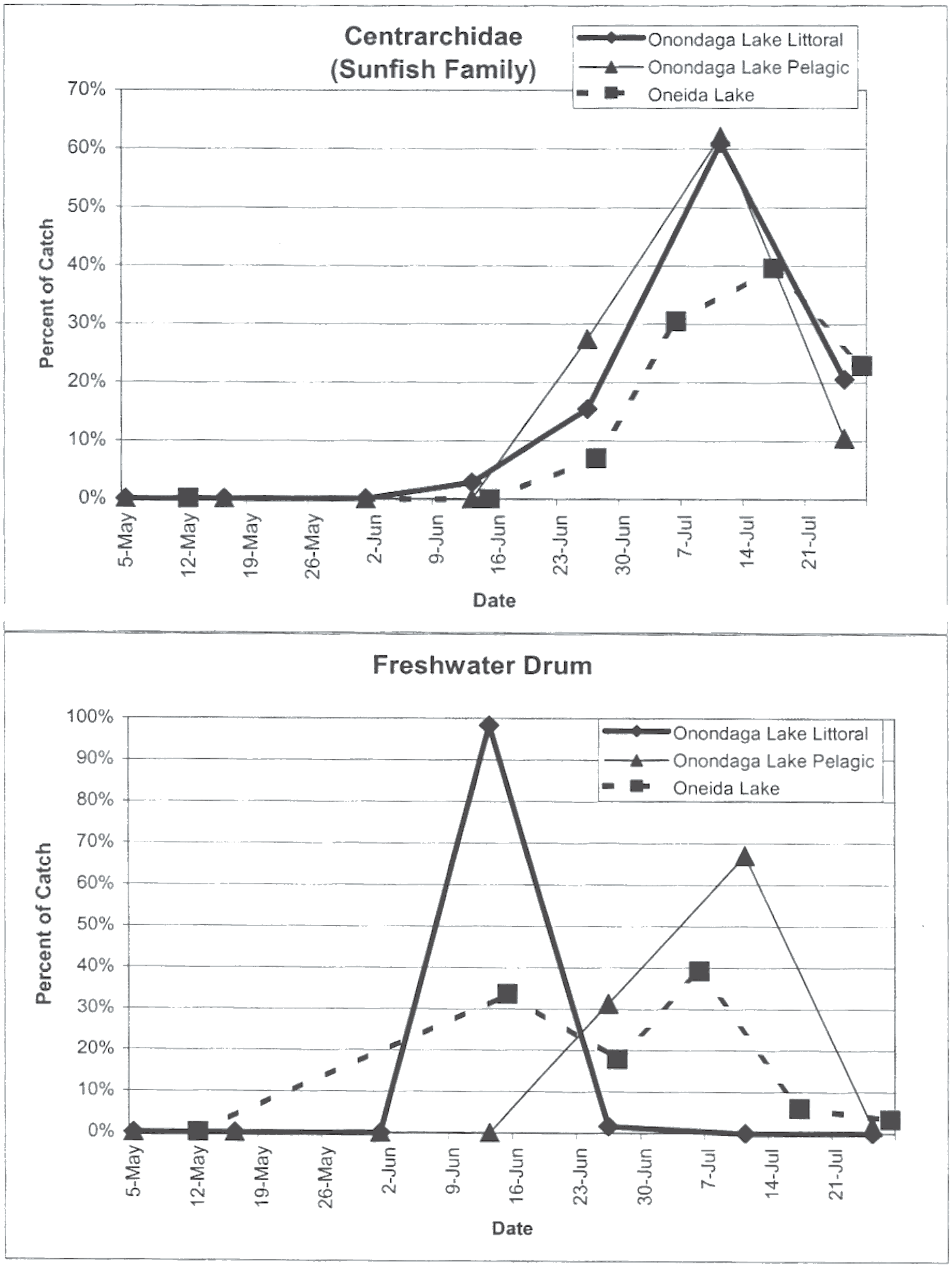

Figure 4.3-1a. Temporal distribution of centrarchid and freshwater drum larvae from Onondaga and Oneida Lakes in 2000.

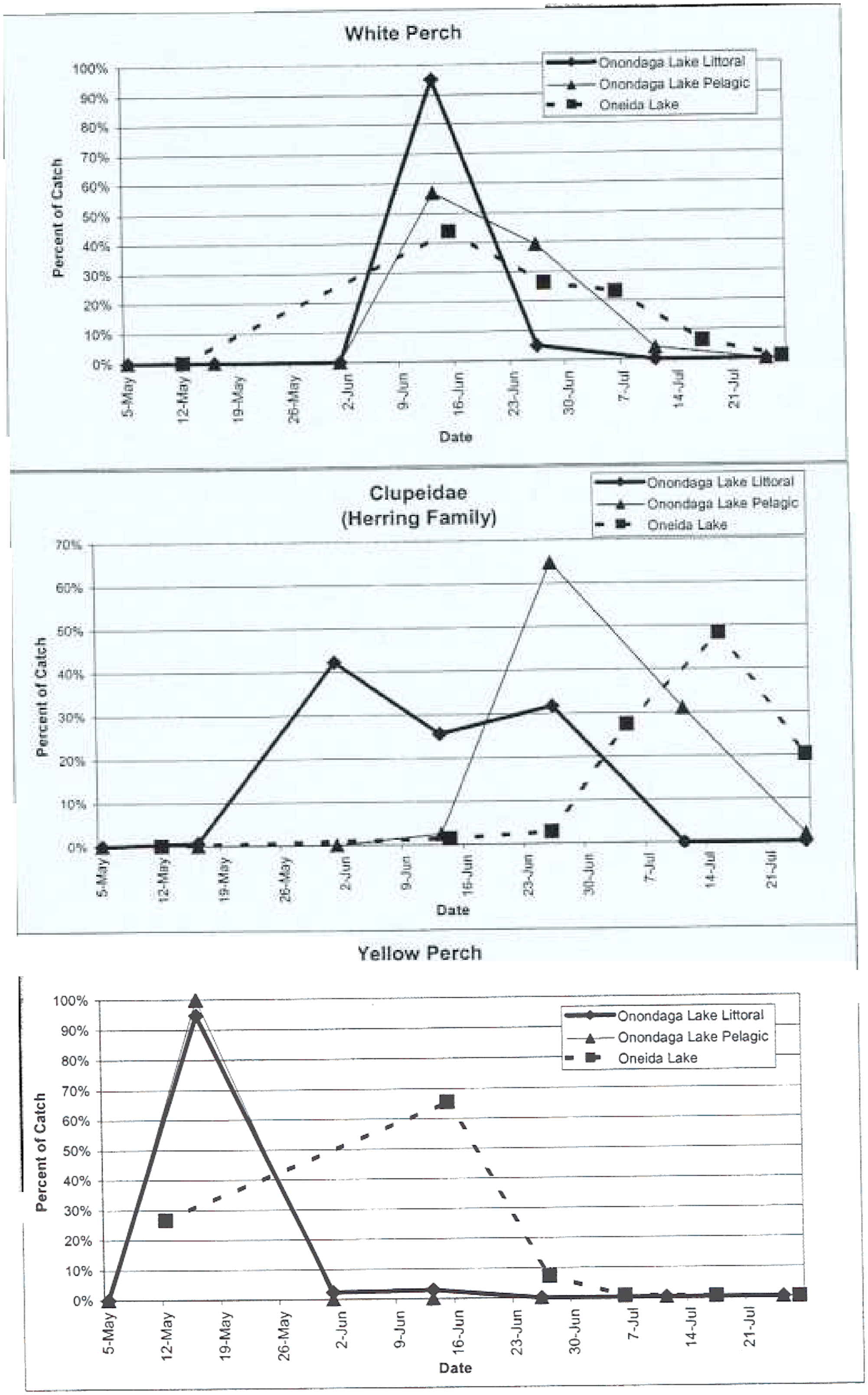

Figure 4.3-1b. Temporal distribution of white perch, clupeid, and yellow perch larvae from Onondaga and Oneida lakes in 2000.

Lake varied with sampling technique Littoral sampling caught freshwater drum larvae in mid-June, while pelagic sampling captured most drum larvae in mid-July. When the results of the two techniques are combined, the bimodal temporal distribution of freshwater drum larvae in Onondaga Lake is similar to that observed in Oneida Lake in 2000 (Figure 4.3-1a). Clupeids showed a similar segregation by sample gear in Onondaga Lake. Like freshwater drum, larval clupeids were captured in littoral samples before they were captured in pelagic samples. Data from Oneida Lake suggests that larval clupeids were present in Onondaga Lake up to a month and a half earlier than in Oneida Lake during 2000. The peak of larval yellow perch abundance in the littoral and pelagic zones of Onondaga Lake occurred simultaneously, but was about one month earlier than the peak in Oneida Lake.

Of particular interest in comparisons to other sources of data was how the 2000 Onondaga Lake fish community compared in regard to species composition and CPUE. When making comparisons among data sets, it is important to realize that differences in the data may be due to differences in how the data were collected. An effort was made to identify comparative data that were collected in a manner similar to that of the 2000 Onondaga Lake sampling program. However, the County's sampling program is unique in that multiple collections were made in one year, an effort was made to thoroughly sample the entire fish community, and multiple gear types were used. The sources of other data were studies that did not necessarily have these same objectives.

The adult fish community of Onondaga Lake was sampled by trap net in 1989 through 1991 and again in 1993 (Gandino 1996). Gill nets (similar to those used in 2000 but with fewer mesh sizes) were also used during the 1990, 1991, and 1993 surveys. A total of 42 species was collected during these four surveys (27 in 1989, 31 in 1990, 37 in 1991, and 30 in 1993). This compares with 30 species collected during the 2000 sampling program. All species collected in 2000 were collected previously in the surveys from 1989 through 1993. Species collected during 1989-1993 that were not collected as juveniles or adults in 2000 were tiger muskellunge (*Esox lucius* x *E. masquinongy*), white crappie (*Pomoxis annularis*), yellow bullhead (*Ameiurus natalis*), burbot, brook stickleback (*Culaea inconstans*), sea lamprey (*Petromyzon marinus*), American eel (*Anguilla rostrata*), redfin shiner (*Lythrurus umbratilis*), fathead minnow, rainbow trout (*Oncorhynchus mykiss*), brook trout, splake (*Salvelinus fontinalis* x *S. namaycush*), and central mudminnow (*Umbra limi*). However, with the exception of yellow bullhead and white crappie, which were collected in modest numbers in at least some years, all of these species were represented by six or fewer individuals in any one year. Given the high level of sampling effort (180-327 net nights per year), nearly all of these species were rare to extremely rare in Onondaga Lake at that time. It is likely that those few individuals that were collected were strays from tributaries or contiguous waters and did not represent a well-established population in the lake.

The adult fish community from 1989 through 1993 was dominated by pelagic planktivores (44-77% of catch, consisting primarily of white perch and gizzard shad) and littoral planktivore/insectivores (about 18-46%, consisting primarily of pumpkinseed and bluegill) (Gandino 1996). In 2000, pelagic planktivores (dominated by gizzard shad, with lesser numbers of white perch and relatively few alewife) made up 57% of the adult fish community, with littoral planktivore/insectivores (dominated by bluegill, with moderate numbers of pumpkinseed) constituting only 12% of the adult fish community. Omnivores (dominated by common carp and white sucker) constituted 16% of the adult fish community in 2000, whereas this group constituted no more than about 4% of the adult fish community in 1989 through 1993. Thus, omnivores appear to have increased in relative abundance since the surveys of the early 1990s, while littoral planktivore/insectivores have become somewhat less abundant. The relative abundance of pelagic planktivores has remained in the range observed in the early 1990s, but gizzard shad have replaced white perch as the dominant pelagic species and dominant species in the fish community as a whole.

NYSDEC has conducted periodic collections of largemouth and smallmouth bass Onondaga Lake during the last 10 years to obtain fish for tissue-contaminant analysis. Catch per unit effort of boat electrofishing for smallmouth bass ranged from a low of 6.3 fish/hour in 1996 to a high of 16.4 fish/hour in 1998 (data summary received from T. Chiotti, NYSDEC Region 7 by K. Jirka, IA, July 26, 2001). NYSDEC collections in 2000 resulted in a CPUE for smallmouth bass of 8.0 fish/hour. NYSDEC's largemouth bass CPUE ranged from 8.4 fish/hour in 1996 to 15.7 fish/hour in 1998. CPUE of smallmouth bass for the 2000 Onondaga Lake fish sampling program was only 3.6 fish/hour overall and ranged from 0.4 to 6.5 fish/hour for individual strata. CPUE of largemouth bass for the 2000 Onondaga Lake fish sampling program was 10.7 fish/hour overall and ranged from 2.6 to 22.7 fish/hour for individual strata.

The NYSDEC CPUE for smallmouth bass from Onondaga Lake was consistently higher than that of the 2000 Onondaga Lake fish sampling program. However, NYSDEC was specifically targeting smallmouth bass for collection and, presumably, targeted the best available habitat for this species. The County's sampling program required sampling specific areas for all fish or all gamefish, regardless of the suitability of the habitat for smallmouth bass. Thus, it is not surprising that the NYSDEC CPUE for smallmouth bass was greater. The CPUE of largemouth bass for the 2000 Onondaga Lake fish sampling program was similar to that obtained by NYSDEC, with the range of values obtained by the County encompassing the range of values obtained by NYSDEC. As expected, the County's CPUE was less in strata with poor habitat for adult largemouth bass (Strata 2 and 3) and similar to or higher than NYSDEC's CPUE in strata with good habitat for adult largemouth bass (particularly Strata 1 and 5).

Boat electrofishing CPUE data were obtained for various lakes in New York State for comparison to the 2000 Onondaga Lake catch data. The lakes represent those for which NYSDEC Region 7 and the Cornell University Warmwater Fisheries Unit have conducted recent (within the last 10 years) boat electrofishing surveys. A summary of these data follows. Data from boat electrofishing surveys conducted by NYSDEC during the 1990s in Otisco Lake, one of the smaller Finger Lakes located in southwest Onondaga County, were obtained from NYSDEC (data summary received from T. Chiotti, NYSDEC Region 7 by K. Jirka, IA, July 26, 2001). These surveys specifically targeted walleye and provide boat electrofishing CPUE data for this species. CPUE for walleye from Otisco Lake ranged from 6.5 fish/hour (25 fish collected) in 1992 to 56.9 fish/hour (408 fish collected) in 1997. Mean CPUE for the six surveys conducted from 1992 through 1997 was 28.4 fish/hour.

Brooking et al. (2001a) summarized 10 years of data collected from Canadarago Lake located southeast of Onondaga Lake in Otsego County. Ranges for CPUE (excluding YOY) for largemouth bass, smallmouth bass, walleye, bluegill, pumpkinseed, and yellow perch from that lake were as follows.

Species	Range of CPUE (fish/hour)
Largemouth bass	4.8-19.2
Smallmouth bass	1.1-18.8
Walleye	11.0-44.3
Bluegill	16.0-60.0
Pumpkinseed	23.0-46.0
Yellow perch	26.0-77.0

Brooking et al. (2001b) also summarized CPUE for non-YOY gamefish from five lakes around New York State These were as follows

Species	Range of CPUE (fish/hour)				
	Findley Lake	Sixtown Pond	Cayuta Lake	Eaton Brook Reservoir	Swinging Bridge Res.
Largemouth bass	13.1	10.1-22.0	22.1-34.7	33.7-52.4	2.7-11.7
Smallmouth bass	16.6	0.6	0	6.3-9.0	24.6-26.4
Walleye	7.2	11.8-27.5	2.0-22.5	2.3-4.2	1.1-8.4
Bluegill	67.0	121.0-127.0	395.0-608.0	160.0-215.0	72.0-272.0
Pumpkinseed	195.0	141.0-417.0	144.0-162.0	76.0-125.0	9.0-13.0
Yellow perch	105.0	237.0-765.0	7.0-295.0	32.0-60.0	41.0-89.0
White perch	1.0	0.0	0.0	0.0	0.0
Black crappie	76.0	2.0-6.0	3.0-19.0	4.0-6.0	4.0-9.0
Rock bass	6.0	22.0-30.0	15.0-38.0	97.0-159.0	5.0-21.0

The data from other lakes contrast markedly with that from the 2000 Onondaga Lake sampling program in several instances. With the exception of Eaton Brook Reservoir, walleye CPUE was considerably lower in Onondaga Lake than in the other lakes. CPUE for walleye from Onondaga Lake in 2000 was only 1.8 fish/hour overall (1.1-2.4 fish/hour for individual strata), whereas it was often greater than 10 fish/hour and as high as 56.9 fish/hour for the other waters. It should be noted that all of the lakes for which walleye data were obtained were receiving regular stocking of YOY walleye to support or enhance their walleye populations. Onondaga Lake receives no such stocking The lack of YOY or juvenile walleye in the 2000

Onondaga Lake catch, coupled with relatively low CPUE for adult walleye strongly suggests that reproduction of this species in Onondaga Lake is limited at best and likely has been for at least the last several years.

Smallmouth bass CPUE (3.6 fish/hour) for Onondaga Lake in 2000 was generally lower than that of the other lakes considered. The exceptions were Sixtown Pond (CPUE = 0.6), which supported good numbers of largemouth bass but relatively few smallmouth bass, and Cayuta Lake, which evidently does not contain smallmouth bass. Conversely, overall CPUE of largemouth bass (10.7) from Onondaga Lake in 2000 was similar to catch rates in Canadarago Lake (4.8-19.2), Findley Lake (13.1), Sixtown Pond (10.1-22.0), and Swinging Bridge Reservoir (2.7-11.7). Only Cayuta Lake (22.1-34.7) and Eaton Brook Reservoir (33.7-52.4) had CPUE for largemouth bass that were markedly higher than that for Onondaga Lake.

CPUE for bluegill (28.3), pumpkinseed (9.9), yellow perch (19.6), rock bass (1.2), and black crappie (0.3) from Onondaga Lake in 2000 was considerably lower than values obtained for the other lakes. Some of the difference between CPUE for these species from Onondaga Lake and the other lakes may be due to the time of year when the other lakes were sampled, since these species showed seasonal abundance peaks. However, even during periods of peak abundance, the CPUE for these species from Onondaga Lake was still generally lower than that for the other lakes.

One possible explanation for this is the limited amount of aquatic vegetation in much of the littoral zone of Onondaga Lake. Overall areal coverage of macrophytes for the lake was only 10% in 2000 (EcoLogic 2001a). Strata 2, 3, and 4 in particular were relatively sparsely vegetated, and CPUE of bluegill, pumpkinseed, rock bass, and black crappie was lowest for these three strata. Vegetated aquatic communities generally support greater densities and a greater number of aquatic macroinvertebrates than do unvegetated habitats (Schramm and Jirka 1989a). Bluegill, pumpkinseed, and likely other littoral planktivore/insectivores, feed predominantly on aquatic invertebrates associated with aquatic macrophytes when such forage is available (Schramm and Jirka 1989b, Keast 1978). The relatively limited amount of vegetated habitat in much of Onondaga Lake's littoral zone likely limits the production of insectivorous fish like sunfish, crappie, and yellow perch. The relatively poor substrate conditions for production of most aquatic macroinvertebrate taxa that exist in the areas of the wastebeds in Stratum 2 and at the south end of the lake in Stratum 3 (EcoLogic 2001b) likely further limit production of littoral insectivorous fish.

One of the most relevant measures of the fish community of Onondaga Lake can be made by comparing it to recent boat electrofishing surveys conducted on Cross Lake; a similar sized lake located about 12 miles west of Onondaga Lake that is also contiguous with the Seneca River. NYSDEC surveyed this lake in the spring of 1997 and again in the fall of 2000 (data summary received from J. Robins, NYSDEC Region 7, by K. Jirka, IA, July 30, 2001). In spring 1997, NYSDEC collected 23 species from Cross Lake, with white perch comprising 81.2% of the catch. Other species collected in moderate numbers included pumpkinseed (3.6% of catch), yellow perch (3.1%), gizzard shad (2.1%), brown bullhead (2.1%), smallmouth bass (2.0%), and common carp (2.0%). This compares with 19 species that were collected by boat electrofishing in May 2000 in Onondaga Lake. That catch was dominated by gizzard shad (49.1% of the catch), followed by white perch (18.5%) (Table 3.5-1). Bluegill (9.4%), common carp (7.4%), white sucker (5.6%), and pumpkinseed (4.8%) were also relatively abundant in the May 2000 Onondaga Lake catch. Thus, both lakes were dominated by pelagic species in the spring, but gizzard shad comprised only a small percentage of the fish community of Cross Lake. Cross Lake had a somewhat richer fauna, with two additional minnow species, trout perch, and northern pike being represented in the Cross Lake catch but not the Onondaga Lake catch. Large gamefish (bass, walleye, channel catfish, northern pike) comprised about equal parts of the fish community in Onondaga Lake (3.2%) and Cross Lake (3.3%). CPUE of sunfish (*Lepomis* spp.) was considerably higher in Onondaga Lake (70.7 fish/hour, with bluegill dominant) than in Cross Lake (25.5 fish/hour, with pumpkinseed dominant).

Comparison of CPUE values for smallmouth bass and largemouth bass for spring boat electrofishing in Cross Lake and Onondaga Lake showed considerable differences. Smallmouth bass overall CPUE was 11.0 fish/hour from Cross Lake, compared to 4.7 fish/hour from Onondaga Lake. Largemouth bass CPUE showed the opposite relationship, with the CPUE from Onondaga Lake (7.3 fish/hour) being greater than that for Cross Lake (2.8 fish/hour). When CPUE for the two bass species are combined, the value for Cross Lake (13.8 fish/hour) is slightly higher than that for Onondaga Lake (12.0). Walleye made up little of the catch in either lake, with the catch from Onondaga Lake (CPUE = 3.7 fish/hour, 0.7% of catch) being slightly higher than for Cross Lake (CPUE = 2.3 fish/hour, 0.4% of catch).

In October 2000, NYSDEC collected only 13 species from Cross Lake, but non-gamefish were sampled with only 0.5 hours of effort. Gizzard shad (43.4% of the catch) and white perch (24.3%) dominated the catch. Other species collected in moderate numbers included bluegill (14.0% of catch), yellow perch (4.7%), and brown bullhead (3.7%). This compares with 22 and 16 species that were collected by boat electrofishing in September and October 2000, respectively, in Onondaga Lake. Those catches were dominated by gizzard shad and common carp, with white sucker, bluegill, yellow perch, and white perch also relatively abundant in one or both months (Table 3.5-1). These data suggest that the fish communities of these two lakes were relatively similar in fall 2000, though white perch appear to be more abundant in Cross Lake and common carp more abundant in Onondaga Lake. Large gamefish (bass, walleye, channel catfish, northern pike) comprised slightly more of the fish community in Onondaga Lake (4.7-5.7%) than in Cross Lake (3.0%). The most abundant large gamefish in both lakes was largemouth bass. Unlike in spring, CPUE of sunfish (*Lepomis* spp.) was considerably lower in Onondaga Lake (24.6-33.3 fish/hour, with bluegill dominant) than in Cross Lake (60.0 fish/hour, bluegill only)

Comparison of CPUE values for smallmouth bass and largemouth bass for fall boat electrofishing in Cross Lake and Onondaga Lake showed smallmouth bass overall CPUE to be similar among the two lakes (3.4 fish/hour from Cross Lake, 2.4-3.7 fish/hour from Onondaga Lake). Largemouth bass CPUE in both lakes was higher than that for smallmouth bass and was considerably higher in Onondaga Lake (8.4-17.2 fish/hour) than in Cross Lake (6.0 fish/hour). Walleye made up little of the catch in either lake, with the catch from Onondaga Lake (CPUE = 0.6-0.9 fish/hour, about 0.2% of catch) being somewhat lower than for Cross Lake (CPUE = 1.7 fish/hour, 0.4% of catch). Northern pike were also relatively scarce in both lakes, with the catch from Onondaga Lake (CPUE =0.2-0.4 fish/hour, about 0.1% of catch) again being somewhat lower than for Cross Lake (CPUE = 1.7 fish/hour, 0.4% of catch).

Overall, the fish community of Onondaga Lake in 2000 has shown some considerable change from the fish community of the early 1990s. Gizzard shad replaced white perch as the dominant species; the relative abundance of littoral planktivores/insectivores (primarily *Lepomis* species) has declined somewhat, while omnivores (primarily common carp and white sucker) increased in abundance. Somewhat fewer species were also collected in 2000 than in previous surveys, but those that were missing from the 2000 catch were also extremely rare in other years.

Catch per unit effort of gamefish was generally lower in Onondaga Lake in 2000 in comparison to several other lakes in New York State. This is especially true for walleye, but most other lakes for which walleye data were available were regularly stocked with walleye to support or supplement their walleye populations. Largemouth bass was the most abundant large gamefish species collected from Onondaga Lake in 2000, with smallmouth bass also occurring in notable numbers. Largemouth bass CPUE for Onondaga Lake in 2000 generally compared favorably to CPUE from other New York waters. Smallmouth bass CPUE, however, was generally lower than that of other New York waters. Similarly, CPUE for bluegill, pumpkinseed, yellow perch, rock bass, and black crappie were generally considerably lower than values from other New York lakes. Limited areal cover of aquatic macrophytes and poor substrate for supporting aquatic macroinvertebrates in large portions of the littoral zone likely contribute to this situation.

Onondaga Lake appears to support a fish community that is quite similar to that of Cross Lake, which is in close proximity and in the same drainage system. Fish species composition differs little between these two lakes, and the fish communities of both lakes are dominated by pelagic species. The CPUE of the various gamefish species was also relatively similar for both lakes. Onondaga Lake appears to support a somewhat more abundant largemouth bass population, while smallmouth bass appear somewhat more abundant in Cross Lake. Onondaga Lake, like Cross Lake, also showed considerable variation in the CPUE and relative abundance of sunfish, yellow perch, and several other species between spring and fall sampling efforts.

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APPENDIX A

Catch by Facility Code and Date
(provided in electronic format only)