# FISH SPECIES PRESENT IN SUDBURY LAKES

## Results of the 1989 and 1990 Urban Lakes Survey

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**ABSTRACT**

In the summer of 1989 and 1990, Environmental Youth Corps students were employed by Ontario's Ministry of Natural Resources to conduct chemical and biological surveys of twenty-three lakes in the Sudbury region. The results of the surveys indicated that several lakes are acidified and contaminated with metals from local smelters. However, many lakes did have suitable water quality to support abundant and diverse fish communities. A total of thirty different fish species were captured. Yellow perch, white suckers and brown bullheads were the most common fish species. Ten of the study lakes contained at least one sportfish species, including walleye, northern pike, largemouth bass, lake trout, smallmouth bass and splake.

Our results to date, indicate that many Sudbury lakes presently support diverse and abundant fish population, but several lakes are under increasing pressure from shoreline development and other forms of environmental stress. Rehabilitation, protection of fish habitat, reducing sulfur emissions, and liming of some watershed areas, are options to consider for improving fish populations. The need for increased public access or additional hatchery stocking of fish should also be considered to improve recreational opportunities.

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## INTRODUCTION

The city of Sudbury contains 34 named lakes and approximately 20 unnamed small lakes and ponds. The combined surface area of the city's lakes and ponds is about 3000 ha or approximately 10% of the surface area of the city (J. Gunn pers. comm.). This large number of water bodies within an urban area is considered an important natural asset (Lautenbach, 1990), but to date there has been very little information on the biota inhabiting these waters. Sport fish are known to occur in some lakes, but a standardized survey of the complete fish community in these urban lakes has not occurred in the past. Lack of information on species occurrence in Sudbury's lakes limits managers' ability to protect fish and their habitats from detrimental forms of shoreline development or inputs of industrial effluents.

During the summers of 1989 and 1990 twenty-three lakes in the Sudbury region were surveyed by students employed through the Environmental Youth Corps Program of Ontario's Ministry of Natural Resources (MNR). All but two of these lakes are within the city limits of Sudbury. In addition to the biological survey, a chemical survey of the lakes was conducted during January and February 1990.

This report presents findings from the 1989-90 surveys. Additional surveys are proposed for the near future, therefore this report is considered in interim report that will be updated as more lakes are studied.

### Study Lakes

The study lakes ranged in size from 3 ha Still Lake, to 1331 ha Long Lake. A map showing the study lakes is provided as Fig. 1 and some physical characteristics of these lakes are included in Table 1.

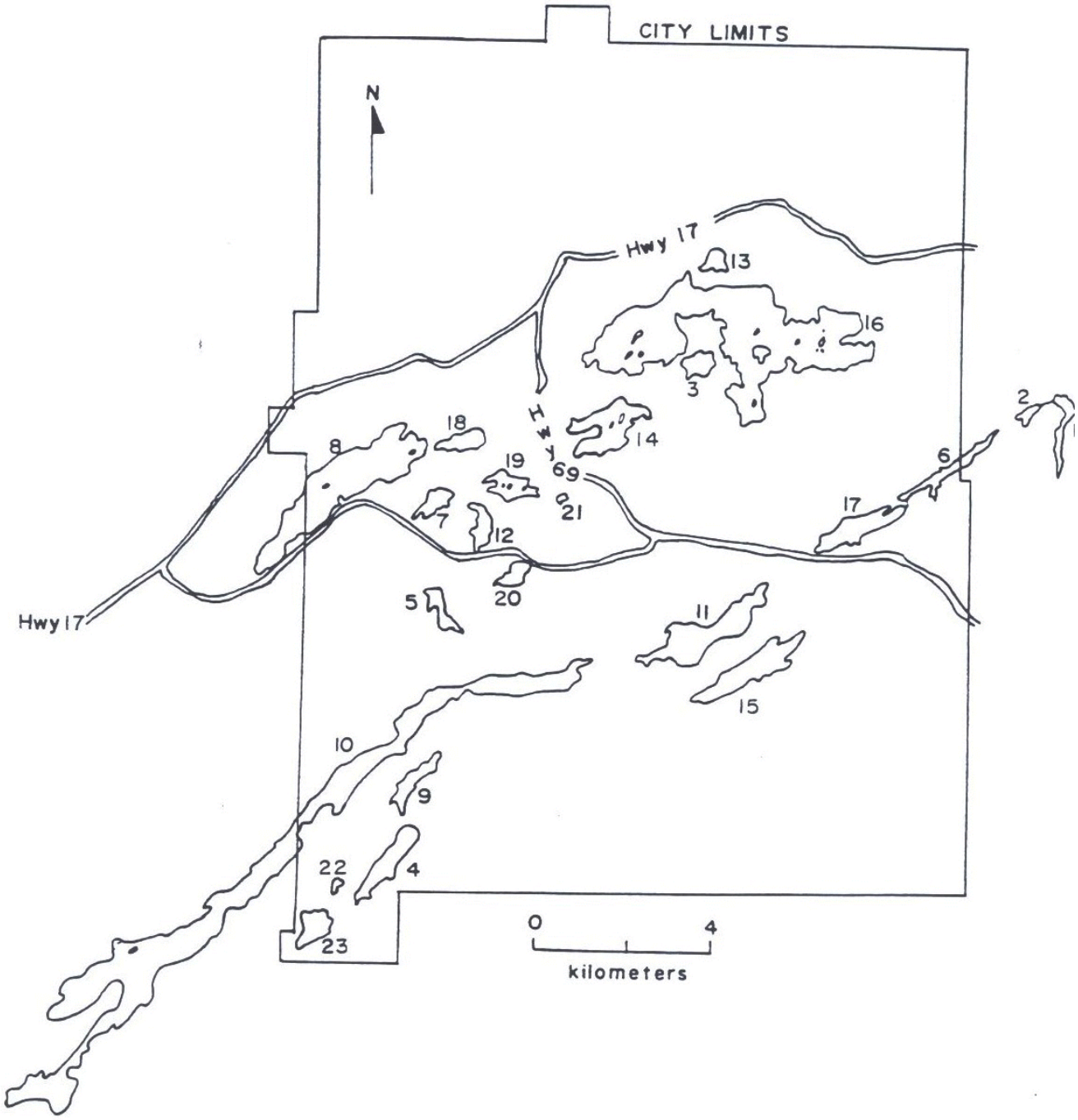


**Fig. 1: Location of 1989 and 1990 study lakes in the Sudbury region. The names and physical description of numbered lakes are provided in Table 1.**

Table 1: Physical description of the 1989 and 1990 study lakes in the Sudbury region.

| | LAKE | AREA (ha) | PERIMETER (km) | MEAN DEPTH (m) | MAXIMUM DEPTH (m) | VOLUME (x104m3) | NO. OF HOUSES | ACCESS POINTS* | % CROWN LAND |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Alice ** | 27.0 | 4.6 | 5.1 | 14.0 | 139 | 0 | 0 | 0 |
| 2 | Baby ** | 11.9 | 3.0 | 9.6 | 22.5 | 114 | 0 | 0 | 100 |
| 3 | Bethel | 30.5 | 2.2 | 2.7 | 5.0 | 81 | 26 | 1 | 0 |
| 4 | Clearwater | 75.6 | 4.4 | 8.4 | 21.5 | 642 | 43 | 2 | 3 |
| 5 | Crooked | 26.2 | 3.4 | 3.8 | 8.0 | 102 | 43 | 0 | 0 |
| 6 | Daisy | 36.1 | 5.5 | 5.2 | 14.0 | 188 | 0 | 0 | 80 |
| 7 | hannah | 27.2 | 2.2 | 4.0 | 8.5 | 105 | 9 | 0 | 5 |
| 8 | Kelley | 339.3 | 16.8 | 5.9 | 17.0 | 1987 | 0 | 1 | 0 |
| 9 | Lohi | 40.8 | 4.2 | 6.2 | 19.5 | 250 | 29 | 0 | 3 |
| 10 | Long | 1331.1 | 43.5 | 10.4 | 36.5 | 8095 | 445 | 2 | 8 |
| 11 | McFarlane | 140.6 | 9.0 | 7.3 | 20.0 | 1020 | 93 | 1 | 15 |
| 12 | Middle | 28.0 | 3.3 | 6.2 | 15.0 | 170 | 8 | 0 | 35 |
| 13 | Minnow | 20.6 | 1.9 | 1.1 | 3.1 | 25 | 36 | 1 | 0 |
| 14 | Nepahwin | 124.6 | 9.9 | 8.3 | 22.0 | 1040 | 218 | 1 | 0 |
| 15 | Raft | 105.5 | 2.1 | 8.9 | 13.0 | 896 | 13 | 0 | 40 |
| 16 | Ramsey | 795.2 | 28.0 | 8.4 | 20.5 | 6683 | 405 | 4 | 1 |
| 17 | Richard | 79.4 | 5.5 | 3.9 | 9.5 | 298 | 43 | 2 | 10 |
| 18 | Robinson | 32.5 | 2.7 | 1.5 | 2.0 | 50 | 5 | 1 | 0 |
| 19 | St.Charles | 40.8 | 4.2 | 2.5 | 6.0 | 102 | 53 | 0 | 0 |
| 20 | Silver | 23.1 | 2.7 | 4.8 | 10.0 | 111 | 29 | 1 | 20 |
| 21 | Still | 3.1 | 0.7 | - | 3.0 | - | 14 | 0 | 0 |
| 22 | Swan | 6.1 | 1.5 | - | 8.0 | - | 0 | 0 | 100 |
| 23 | Tilton | 50.9 | 2.0 | 6.5 | 12.0 | 342 | 33 | 0 | 40 |

* Access points are sites where people can unload a boat from a road vehicle and go fishing or enjoy other water based recreation. In not all cases are the access points public property.

** Not within city limts.

The lakes are primarily located in three clusters. The first cluster is the chain of lakes along the fault line from Daisy Lake (#6) down to Long Lake (#10) (Fig. 1). Baby (#2) and Alice (#1) were presumably part of this chain historically, but have been separated by the construction of the railway line on the east end of Daisy Lake. The second cluster is the group of lakes draining into Kelly Lake (#8), and includes Hannah (#7), Middle (#12), St. Charles (#19), Robinson (#18) and Nepahwin (#14) Lakes. The third cluster is Ramsey Lake (#15) in the center of the city, with Minnow (#13) and Bethel Lake (#3) draining into it.

All of the study lakes, with the exception of Alice, Baby, Daisy and Kelley Lakes, have houses or summer cottages on their shorelines (Table 1). In general, access to Sudbury lakes is limited to a few pubic boat ramps. One exception is Ramsey Lake, where public access is readily available. Some lakes are entirely enclosed by private property but there are still several Sudbury lakes with considerable amounts of crown land along their shores (Table 1).

## METHODS

Water Quality:

A water quality assessment was carried out on the lakes during January and February 1990. Depth profiles of water temperature, dissolved oxygen and conductivity were measured (at 1 m intervals) through a hole in the ice, with a YSI Model 51-B dissolved oxygen-temperature meter and a YSI Model 33 conductivity meter.

Water samples were collected using a 5 m long, 2.5 m diameter weighed tygon tube. Prior to collecting a water sample, the sampling tube, mixing container, and sample jars were rinsed thoroughly with lake water. Where lakes had less than 5 m of water, the sample was taken after the tube was lowered to within 0.5 m from the bottom. Samples were sent to the Ministry of the Environment (OMOE) lab in Rexdale for analysis of pH, conductivity, alkalinity (TIA), metals and major ions (OMOE, 1981).

During the summer of 1990, a Secchi disk reading was taken as a measure of the clarity of the lake water. A second dissolved oxygen-temperature profile was also conducted at the same time.

Mapping:

Outline, contour and shoreline cruise maps were prepared for each lake. The contour maps for the lakes were produced from transects with a Furuno FG-200 echo sounder. The shoreline cruise was completed by visual mapping of areas of potential fish habitat, disturbed areas (eg. erosion) and other pertinent physical features.

A pantograph and a Placom digital planimeter were used to determine surface area. Shoreline perimeter was measured with a map measurer. Volume and mean depth were calculated by methods described in Dodge et Al. (1985).

Netting Assessment:

Most of the lakes were surveyed with a minimum of three days netting effort using two 4 foot (‘) trapnets, two plexiglass traps and ten pairs of wire mesh minnow traps set each night (Table 2). For Kelley, Long, McFarlane, Ramsey and Richard Lakes, a six day survey was conducted and included the above gear as well as 6 foot (‘) trapnets (Table 2). A gillnet was also used on Long Lake for one night to sample fish in the deep basins. Alice and Baby Lakes were surveyed for two days with one gillnet, two plexiglass traps and ten pairs of minnow traps (Table 2). Nepahwin, Still and Swan Lakes were surveyed for one day. Two plexiglass traps and five sets of minnow traps were used on Still Lake while Swan Lake had the standard effort of two 4' trapnets, two plexiglass traps and ten pairs of minnow traps. Nepahwin Lake had three gillnets, one 4' trapnet, four plexiglass traps and eight minnow traps (Table 2). Bethel was surveyed for three days with two 6' trapnets, two plexiglass traps and ten pairs of minnow traps. Daisy was surveyed for three days with two 4' trapnets, one gillnet, two plexiglass traps and 10 pairs of minnow traps (Table 2).

Nets and traps were set overnight, checked the following day and then moved to a new location on the lake. A subsample (100-200) of each species of fish caught were weighed and measured, and scale samples collected when time permitted. The remaining fish were counted and grouped weighed. Almost all fish were live released at the site of capture.

Table 2: The effort (days) per gear type of the 1989 and 1990 study lakes in the Sudbury region.

| LAKE | 6' TRAPNET | 4' TRAPNET | GILLNET | PLEXI * | MINNOW TRAPS ** |
|---|---|---|---|---|---|
| Alice | - | - | 3.4 | 3.6 | 17.8 |
| Baby | - | - | 3.3 | 3.9 | 17.9 |
| Bethel | 5.6 | - | - | 5.6 | 25.4 |
| Clearwater | - | 5.9 | - | 5.8 | 28.8 |
| Crooked | - | 5.8 | - | 6.0 | 28.8 |
| Daisy | - | 4.0 | 3.7 | 4.0 | 19.0 |
| hannah | - | 46.6 | - | 8.0 | - |
| Kelley | 11.1 | 11.2 | - | 11.9 | 55.0 |
| Lohi | - | 5.7 | - | 2.9 | 28.0 |
| Long | 11.2 | 11.0 | 0.7 | 11.6 | 50.7 |
| McFarlane | 11.6 | 11.8 | - | 12.1 | 61.2 |
| Middle | - | 48.2 | - | 8.0 | - |
| Minnow | - | 3.5 | - | 3.6 | 34.9 |
| Nepahwin | - | 0.7 | 1.7 | 2.1 | 4.3 |
| Raft | - | 5.7 | - | 6.0 | 27.5 |
| Ramsey | 11.5 | 11.5 | - | 7.1 | 47.4 |
| Richard | 11.3 | 11.7 | - | 11.8 | 59.2 |
| Robinson | 2.0 | 4.0 | - | 4.0 | 38.0 |
| St.Charles | - | 5.6 | - | 5.6 | 28.8 |
| Silver | - | 5.7 | - | 5.7 | 28.1 |
| Still | - | - | - | 2.0 | 4.8 |
| Swan | - | 1.8 | - | 1.9 | 8.9 |
| Tilton | - | 5.7 | - | 5.8 | 28.9 |

* Plexiglass minnow traps as described by Casselman and Harvey (1973)

** Standard wire mesh minnow trap

## RESULTS

The water quality sampling indicated that acid deposition is a serious problem for Sudbury area lakes. Seven of the survey lakes had pH < 6.0 (Table 3), the pH level below which biological damage to sensitive aquatic organisms is expected to occur (Matuszek et al., 1990; Keller et al., 1990, Schindler, 1988). Six of these lakes, Clearwater, Crooked, Daisy, Lohi, Silver and Swan Lakes, were so acidic (pH < 5.0) that no fish were expected to occur in them (Table 4). Our 1989 and 1990 netting assessments of central mudminnow (Umbra limi), a relatively acid tolerant species, were observed. The other acid lakes were completely fishless.

Almost all lake waters in the city exceeded MOE's water quality criteria for metals, particularly the metals from smelter emissions (MOE criteria: Cu < 5 ug/l, Ni < 25 ug/l). Copper ranged from 8 ug/l to 410 ug/l, while nickel ranged from 62 ug/l to1100 ug/l (Table 3). Depleted oxygen conditions (<5 ppm) in bottom waters was generally a less serious problem (Appendix I). Three lakes, including Kelley, McFarlane and Nepahwin showed substantial drops in oxygen in the hypolimnion (lower portion of lake).

Apart from the acid lakes, most of the remaining lakes contained a relatively rich assortment of fish (Table 4). A total of thirty different species of fish were captured. Yellow perch (Perca flavescens) was the most common species, occurring in 17 of the 18 fish-containing lakes. Other common species included: brown bullhead (Ictalurus nebulosus) (14 lakes), pumpkinseed (Lepomis gibbosus) (12 lakes) and white sucker (Catastomus commersoni) (10 lakes) (Table 4). Ten lakes contained at least one of the "sportfish" species. These included: largemouth bass (Micropterus salmoides), lake trout (Salvelinus namaycush), northern pike (Esox lucius), smallmouth bass (Micropterus dolomieui), splake (lake trout/brook trout hybrid) and walleye (Stizostedion vitreum).

Table 3 Water chemistry of the 1989 and 1990 study lakes in the Sudbury region.

| LAKE | pH | TIA ALK (mg/l) | COND. (umhos/cm) | Ca (mg/l) | Mg (mg/l) | Na (mg/l) | K (mg/l) | SiO3 (mg/l) | Cl (mg/l) | SO4 (mg/l) | Cu (ug/l) | Ni (ug/l) | Zn (ug/l) | Fe (ug/l) | Mn (ug/l) | Al (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alice | 7.3 | 18.8 | 280 | - | - | - | - | - | - | 98.4 | 15 | 1100 | 7 | 37 | 140 | 28 |
| Baby | 6.7 | 3.6 | 71 | - | - | - | - | - | - | 21.1 | 21 | 240 | 18 | 45 | 38 | 17 |
| Bethel | 7.4 | 59.0 | 472 | 21.2 | 8.6 | 56.4 | 2.4 | 1.1 | 96.2 | 13.0 | 18 | 62 | 5 | 250 | 380 | 29 |
| Clearwater | 4.7 | -0.8 | 84 | 6.5 | 1.4 | 3.2 | 0.6 | 0.7 | 10.0 | 17.6 | 47 | 180 | 25 | 46 | 290 | 140 |
| Crooked | 4.4 | -1.5 | 98 | 6.7 | 2.1 | 2.2 | 0.9 | 2.5 | 4.0 | 28.3 | 120 | 460 | 41 | 120 | 220 | 370 |
| Daisy | 4.7 | -1.0 | 60 | 4.0 | 1.4 | 1.4 | 0.6 | 1.6 | 0.9 | 21.1 | 87 | 370 | 22 | 25 | 200 | 330 |
| hannah | 7.1 | 13.9 | 388 | 15.7 | 5.3 | 47.0 | 2.1 | 0.5 | 82.5 | 27.6 | 20 | 200 | 6 | 20 | 8 | 10 |
| Kelley | 7.4 | 50.2 | 1780 | 222.0 | 21.9 | 127.0 | 19.6 | 3.4 | - | 732.1 | 39 | 400 | 14 | 82 | 130 | 86 |
| Lohi | 4.6 | -0.8 | 92 | 6.8 | 1.8 | 3.6 | 0.8 | 0.3 | 9.9 | 20.6 | 90 | 250 | 36 | 39 | 260 | 170 |
| Long | 7.3 | 17.0 | 168 | 11.1 | 3.4 | 13.6 | 1.1 | 1.4 | 24.8 | 20.6 | 15 | 88 | 9 | 45 | 17 | 23 |
| McFarlane | 7.5 | 35.6 | 327 | 18.2 | 5.4 | 35.0 | 1.6 | 0.5 | 59.9 | 22.0 | 8 | 72 | 3 | 20 | 6 | 10 |
| Middle | 6.8 | 7.2 | 261 | 11.1 | 3.8 | 28.6 | 1.6 | 0.9 | 53.1 | 27.6 | 21 | 250 | 15 | 20 | 16 | 10 |
| Minnow | 7.5 | 71.8 | 969 | 37.6 | 8.9 | 139.0 | 2.7 | 1.4 | 232.0 | 46.7 | 10 | 120 | 19 | 92 | 340 | 31 |
| Nepahwin | 7.5 | 32.2 | 531 | 21.4 | 6.8 | 70.1 | 2.7 | 0.9 | 115.0 | 30.2 | 17 | 86 | 10 | 25 | 5 | 25 |
| Raft | 6.8 | 4.2 | 52 | 4.8 | 1.5 | 1.2 | 0.6 | 0.3 | 0.7 | 15.3 | 11 | 95 | 8 | 20 | 5 | 10 |
| Ramsey | 7.5 | 26.8 | 321 | 17.5 | 5.4 | 36.1 | 1.7 | 0.4 | 60.4 | 26.4 | 28 | 110 | 6 | 22 | 5 | 26 |
| Richard | 7.1 | 18.2 | 181 | 11.9 | 3.6 | 17.9 | 1.1 | 0.5 | 31.2 | 19.2 | 14 | 120 | 5 | 20 | 26 | 28 |
| Robinson | 7.1 | 45.6 | 772 | 24.9 | 8.0 | 83.9 | 2.5 | 2.7 | 147.0 | 36.2 | 35 | 210 | 19 | 250 | 230 | 78 |
| St.Charles | 7.0 | 11.3 | 249 | 13.2 | 5.2 | 21.0 | 1.9 | 1.6 | 37.4 | 34.4 | 27 | 220 | 18 | 66 | 98 | 20 |
| Silver | 4.2 | -2.7 | 384 | 9.9 | 3.7 | 47.5 | 1.5 | 2.7 | 81.4 | 41.4 | 410 | 770 | 94 | 55 | 190 | 1100 |
| Still | 7.1 | 36.8 | 833 | 28.0 | 9.0 | 117.0 | 2.7 | 2.0 | 212.0 | 37.1 | 20 | 220 | 39 | 220 | 310 | 80 |
| Swan | 4.8 | -0.8 | 70 | 6.1 | 1.0 | 2.0 | 0.4 | 0.1 | 6.9 | 14.9 | 23 | 140 | 16 | 100 | 120 | 80 |
| Tilton | 5.8 | 0.8 | 60 | 5.2 | 1.4 | 1.8 | 0.5 | 1.0 | 3.8 | 16.2 | 16 | 110 | 14 | 45 | 82 | 72 |

All analysis by Ontario Ministry of the Environment using methods described in MOE 1981.
All metals are expressed as total values.

Table 4: Species diversity and total number of fish caught in the 1989-1990 urban lake survey.

| | LAKE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SPECIES | Alice | Baby | Bethel | Clearwater | Crooked | Daisy | Hannah | Kelley |
| brown bullhead | 1 | 6 | 22 | 0 | 0 | 0 | 0 | 611 |
| black crappie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| blacknose shiner | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| bluntnose minnow | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| brook stickleback | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 13 |
| cisco | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| creek chub | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 |
| central mudminnow | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| common shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| emerald shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 |
| finescale dace | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| fathead minnow | 18 | 1 | 613 | 0 | 0 | 0 | 0 | 188 |
| golden shiner | 3 | 3 | 3165 | 0 | 0 | 0 | 1 | 92 |
| Iowa darter | 5 | 0 | 0 | 0 | 0 | 0 | 36 | 2 |
| johnny darter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| largemouth bass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| lake trout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| mimic shiner | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| northern pike | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| north. redbelly dace | 23 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| pearl dace | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| pumpkinseed | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 463 |
| rock bass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| rainbow smelt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| smallmouth bass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| splake/lake trout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| spottail shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| walleye | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| white sucker | 79 | 0 | 0 | 0 | 0 | 0 | 0 | 1360 |
| yellow perch | 15 | 41 | 119 | 0 | 0 | 0 | 966 | 15 |
| Total # of species | 12 | 9 | 5 | 0 | 0 | 1 | 4 | 13 |

Table 4, continued

| SPECIES | LAKE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lohi | Long | McFarlane | Middle | Minnow | Nepahwin | Raft | Ramsey |
| brown bullhead | 0 | 282 | 140 | 0 | 350 | 1 | 24 | 8 |
| black crappie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| blacknose shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| bluntnose minnow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| brook stickleback | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| cisco | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| creek chub | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| central mudminnow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| common shiner | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| emerald shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| finescale dace | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| fathead minnow | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| golden shiner | 0 | 2 | 9 | 6 | 41 | 0 | 0 | 362 |
| Iowa darter | 0 | 3 | 1 | 5 | 7 | 0 | 39 | 0 |
| johnny darter | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| largemouth bass | 0 | 13 | 131 | 0 | 0 | 0 | 0 | 0 |
| lake trout | 0 | 8 | 0 | 0 | 0 | 17 | 0 | 0 |
| mimic shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| northern pike | 0 | 1 | 3 | 0 | 2 | 0 | 0 | 6 |
| north. redbelly dace | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| pearl dace | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 |
| pumpkinseed | 0 | 116 | 170 | 0 | 125 | 8 | 196 | 7 |
| rock bass | 0 | 0 | 0 | 0 | 68 | 6 | 0 | 10 |
| rainbow smelt | 0 | 0 | 0 | 0 | 0 | 138 | 0 | 0 |
| smallmouth bass | 0 | 79 | 60 | 0 | 0 | 1 | 0 | 1 |
| splake/lake trout | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| spottail shiner | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| walleye | 0 | 22 | 7 | 0 | 0 | 0 | 0 | 369 |
| white sucker | 0 | 108 | 33 | 0 | 30 | 8 | 21 | 15 |
| yellow perch | 0 | 400 | 82 | 2052 | 718 | 1 | 372 | 3025 |
| Total # of species | 0 | 15 | 11 | 5 | 9 | 9 | 6 | 10 |

Table 4, continued

| SPECIES | Richard | Robinson | St. Charles | LAKE Silver | Still | Swan | Tilton |
|---|---|---|---|---|---|---|---|
| brown bullhead | 199 | 2328 | 27 | 0 | 0 | 0 | 1 |
| black crappie | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| blacknose shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| bluntnose minnow | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| brook stickleback | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| cisco | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| creek chub | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| central mudminnow | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| common shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| emerald shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| finescale dace | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| fathead minnow | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| golden shiner | 0 | 0 | 0 | 0 | 100 | 0 | 0 |
| Iowa darter | 0 | 1 | 39 | 0 | 0 | 0 | 0 |
| johnny darter | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| largemouth bass | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| lake trout | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| mimic shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| northern pike | 23 | 23 | 0 | 0 | 0 | 0 | 0 |
| north. redbelly dace | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| pearl dace | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| pumpkinseed | 532 | 2 | 0 | 0 | 600 | 0 | 0 |
| rock bass | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| rainbow smelt | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| smallmouth bass | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| splake/lake trout | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| spottail shiner | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| walleye | 30 | 1 | 0 | 0 | 0 | 0 | 0 |
| white sucker | 1 | 270 | 0 | 0 | 0 | 0 | 0 |
| yellow perch | 787 | 218 | 3919 | 0 | 58 | 0 | 528 |
| Total # of species | 8 | 8 | 3 | 0 | 3 | 0 | 3 |

Northern pike, the most common sportfish occurred in nine lakes (Table 4, Fig. 2). Walleye were present in Ramsey, Richard, McFarlane and Long Lakes (Fig. 2). One walleye was also captured in Robinson Lake and two were captured in Kelley Lake. These fish presumably moved down from Ramsey Lake. Largemouth bass, far more common than previously thought, were captured in Richard, McFarlane and Long Lakes (Fig. 2). A largemouth bass was also caught by one of the authors (J. Gunn) in Grant Lake (small lake between McFarlane and Long Lake), but no formal survey of this lake was performed. Lake trout were present in Long and Nepahwin Lakes while splake were captured in Nepahwin Lake. Long Lake containing five out of six sportfish species found in the Sudbury region (Fig. 2), also had the richest overall fish diversity, with fifteen fish species present (Table 4).

Six foot trapnets were very successful at live capturing fish especially brown bullheads, and white suckers for which catch per unit effort (CUE) reached > 100 fish/night in some lakes (Table 5). The CUE for walleye ranged from 0.1 to 17.5 fish/night in trapnets. Ramsey Lake had the highest CUE values, for both 6' trapnets (17.5) and 4' trapnets (14.56) (Table 5 and 6). Largemouth bass were most numerous in McFarlane Lake with CUE's of 3.6 and 3.9 in the 6' trapnets and plexiglass traps (Table 5 and 7). Northern pike were most numerous in Robinson Lake with CUE's of 4.0 and 3.8 for the 6' and 4' trapnets respectively (Table 5 and 6). Minnow Lake, surprisingly for such a small and heavily disturbed lake, also contained a few pike. Long Lake had the highest catch of smallmouth bass with 5.2 fish/day in the 6' trapnets and 1.2 fish/day in the 4' trapnets.

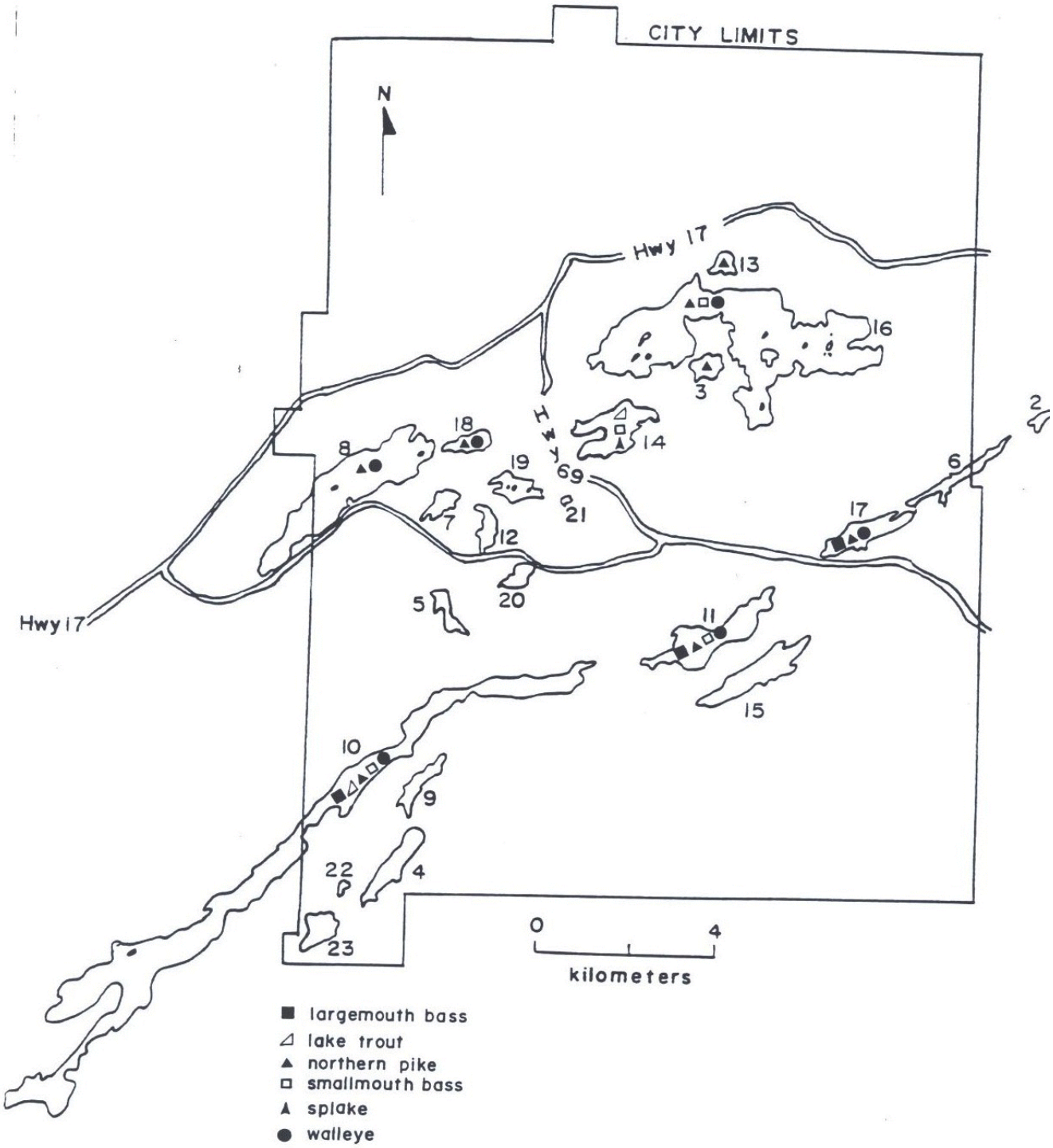


**Fig. 2: Sudbury lakes supporting sportfish species.**

Table 5: Catch per unit (#/day) of fish caught in six-foot trapnets in the 1989-90 urban lakes survey. A total of 6 net sets per lake were used unless otherwise indicated.

| SPECIES | LAKE | | | | | | |
|---|---|---|---|---|---|---|---|
| | Bethel | Kelley * | Long * | McFarlane * | Ramsey * | Richard * | Robinson |
| brown bullhead | 3.9 | 28.6 | 22.3 | 9.0 | 0.5 | 140.0 | 138.5 |
| black crappie | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| golden shiner | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 |
| largemouth bass | 0.0 | 0.0 | 0.4 | 3.9 | 0.0 | 0.4 | 0.0 |
| northern pike | 0.0 | 0.0 | 0.0 | 0.3 | 0.5 | 1.7 | 4.0 |
| pumpkinseed | 0.0 | 0.2 | 0.8 | 2.9 | 0.3 | 12.7 | 0.0 |
| rock bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| smallmouth bass | 0.0 | 0.0 | 5.2 | 3.2 | 0.1 | 0.0 | 0.0 |
| walleye | 0.0 | 0.2 | 1.9 | 0.6 | 17.5 | 1.7 | 0.0 |
| white sucker | 0.0 | 59.9 | 7.2 | 1.0 | 0.1 | 0.0 | 45.0 |
| yellow perch | 0.0 | 0.5 | 1.7 | 2.4 | 0.1 | 0.9 | 1.0 |

* 12 net sets were used

Note: The netting effort was relatively light, and the sampling date varied between studied lakes. Therefore one should be cautious in using such CUE values to compare relative abundance between lakes.

Table 6: Catch per unit effort (#/day) of fish caught in four-foot trapnets in the 1989-90 urban lake survey. A total net sets per lake were used unless otherwise indicated.

| SPECIES | Hannah | Kelley * | Long * | McFarlane * | Middle | Minnow | Nepahwin ** | Raft | Ramsey * | Rchard * | Robinson | St. Charles | Tilton |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | LAKE | | | | | | |
| brown bullhead | 0.0 | 26.4 | 1.2 | 3.1 | 0.0 | 100.6 | 1.5 | 4.2 | 0.2 | 3.2 | 512.5 | 4.8 | 2.0 |
| creek chub | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| common shiner | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| emerald shiner | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| fathead minnow | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| golden shiner | 0.0 | 5.0 | 0.1 | 0.0 | 0.0 | 9.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| lake trout/splake | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| largemouth bass | 0.0 | 0.0 | 0.1 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| northern pike | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.3 | 3.8 | 0.0 | 0.0 |
| pearl dace | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| pumpkinseed | 0.0 | 0.1 | 1.5 | 3.9 | 0.0 | 35.6 | 5.8 | 19.8 | 0.3 | 7.5 | 0.5 | 0.0 | 0.0 |
| rainbow smelt | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| rock bass | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 19.3 | 4.4 | 0.0 | 0.7 | 0.0 | 0.5 | 0.0 | 0.0 |
| smallmouth bass | 0.0 | 0.0 | 1.2 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| walleye | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.6 | 0.9 | 0.3 | 0.0 | 0.0 |
| white sucker | 0.0 | 51.3 | 2.5 | 1.0 | 0.0 | 8.6 | 11.6 | 3.7 | 0.0 | 0.1 | 45.0 | 0.0 | 0.0 |
| yellow perch | 20.4 | 0.9 | 4.9 | 2.4 | 40.7 | 198.0 | 0.0 | 7.6 | 65.7 | 3.6 | 30.0 | 129.1 | 10.5 |

* 12 net sets were used
** 1 net set was used

Note: The netting effort was relatively light, and the sampling date varied between studied lakes. Therefore one should be cautious in using such CUE values to compare relative abundance between lakes.

Table 7 Catch per unit effort (#/day) of fish caught in plexiglass traps (WD) in the 1989-90 urban lake survey. A total of 6 trap sets per lake were used unless otherwise indicated. (continued on next page)

| SPECIES | LAKE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Alice ** | Baby ** | Bethel | Daisy | Hannah | Kelley * | Long * | McFarlane * | Middle | Minnow |
| brown bullhead | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 |
| blacknose shiner | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| bluntnose minnow | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| stickleback | 0.6 | 0.5 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| creek chub | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| central mudminnow | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| common shiner | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| emerald shiner | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| finescale dace | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| fathead minnow | 4.9 | 0.0 | 5.4 | 0.0 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 1.9 |
| golden shiner | 0.8 | 0.5 | 312.4 | 0.0 | 0.0 | 0.3 | 0.1 | 0.0 | 0.3 | 1.9 |
| Iowa darter | 0.3 | 0.0 | 0.0 | 0.0 | 4.5 | 0.0 | 0.3 | 0.1 | 0.6 | 1.9 |
| johnny darter | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| largemouth bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 | 0.0 | 0.0 |
| north. redbelly dace | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| pear dace | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| pumpkinseed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.5 | 0.7 | 0.3 | 0.0 | 0.3 |
| rock bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| smallmouth bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.0 | 0.0 | 0.0 |
| white sucker | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| yellow perch | 0.6 | 0.0 | 18.0 | 0.0 | 2.1 | 0.0 | 10.0 | 0.1 | 11.0 | 2.5 |

* 12 net sets were used
** 4 net sets were used
*** 2 net sets were used

Note: The netting effort was relatively light, and the sampling date varied between studied lakes. Therefore one should be cautious in using such CUE values to compare relative abundance between lakes.

Table 7 Catch per unit effort (#/day) of fish caught in plexiglass traps (WD) in the 1989-90 urban lake survey. A total of 6 trap sets per lake were used unless otherwise indicated. (continued on next page)

| SPECIES | LAKE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Alice ** | Baby ** | Bethel | Daisy | Hannah | Kelley * | Long * | McFarlane * | Middle | Minnow |
| brown bullhead | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 |
| blacknose shiner | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| bluntnose minnow | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| stickleback | 0.6 | 0.5 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| creek chub | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| central mudminnow | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| common shiner | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| emerald shiner | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| finescale dace | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| fathead minnow | 4.9 | 0.0 | 5.4 | 0.0 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 1.9 |
| golden shiner | 0.8 | 0.5 | 312.4 | 0.0 | 0.0 | 0.3 | 0.1 | 0.0 | 0.3 | 1.9 |
| lowa darter | 0.3 | 0.0 | 0.0 | 0.0 | 4.5 | 0.0 | 0.3 | 0.1 | 0.6 | 1.9 |
| johnny darter | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| largemouth bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 | 0.0 | 0.0 |
| north. redbelly dace | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| pear dace | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| pumpkinseed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.5 | 0.7 | 0.3 | 0.0 | 0.3 |
| rock bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| smallmouth bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.0 | 0.0 | 0.0 |
| white sucker | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| yellow perch | 0.6 | 0.0 | 18.0 | 0.0 | 2.1 | 0.0 | 10.0 | 0.1 | 11.0 | 2.5 |

* 12 net sets were used
** 4 net sets were used
*** 2 net sets were used

Note: The netting effort was relatively light, and the sampling date varied between studied lakes. Therefore one should be cautious in using such CUE values to compare relative abundance between lakes.

Plexiglass traps and minnow traps were very efficient at catching minnows, shiners and other small fish. Golden shiners (Notemigonus crysoleucas) were especially abundant in Bethel with 312.4 fish/day in the plexiglass and minnow traps, while pumpkinseed were numerous in Still Lake (Table 7 and 8). A very high population of small yellow perch were captured in plexiglass traps in Still Lake (Table 7).

Table 8: Catch per unit effort (#/day) of fish caught in wire mesh minnow traps in the 1989-90 urban lake survey. A total of 30 trap sets per lake were used unless otherwise indicated.

| SPECIES | LAKE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alice ** | Baby ** | Bethel | Kelley * | Long * | McFarlane * | Minnow | Nepahwin **** | Raft | Ramsey * | Richard * | Robinson | St. Charles | Still *** | Tilton |
| brown bullhead | 0.1 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| brook stickleback | 0.2 | 0.1 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| creek chub | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| central mudminnow | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| common shiner | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| emerald shiner | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| fathead minnow | 0.3 | 0.1 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| finescale dace | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| golden shiner | 0.0 | 0.1 | 56.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.4 | 0.0 | 0.0 | 20.6 | 20.6 | 0.0 |
| Iowa darter | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| largemouth bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| mimic shiner | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| northern pike | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| north. redbelly dace | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| pearl dace | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| pumpkinseed | 0.0 | 0.1 | 0.0 | 1.1 | 1.6 | 1.4 | 0.0 | 0.9 | 2.8 | 0.0 | 4.2 | 0.0 | 42.6 | 42.6 | 0.0 |
| rock bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| smallmouth bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| white sucker | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| yellow perch | 0.5 | 0.1 | 0.8 | 0.0 | 4.2 | 0.4 | 0.6 | 0.0 | 6.2 | 31.4 | 10.8 | 2.4 | 10.8 | 10.8 | 1.6 |

* 60 net sets were used
** 20 net sets were used
*** 5 net sets were used
**** 8 net sets were used

Note: The netting effort was relatively light, and the sampling date varied between studied lakes. Therefore one should be cautious in using such CUE values to compare relative abundance between lakes.

## DISCUSSION

The lakes of the Sudbury area are highly variable - physically, chemically and biologically. Lakes vary from small to large, heavily developed to near wilderness in appearance, from heavily polluted to relatively free of contaminants, and from fishless to those containing complex fish communities.

With the proximity of metal smelters, the overwhelming influence of air pollutants on lake water quality and aquatic life cannot be denied. Watershed soils (Negusanti and McIlveen, 1990), lake sediments (Semkin and Kramer, 1976) and lake water (Keller and Pitblado, 1986, Table 3) all contain elevated levels of smelter metals such as Cu, Ni and Zn, and the damaging effects of high inputs of acid precipitation on local lakes has long been recognized (Gorham and Gordon, 1960). For example, Clearwater Lake was limed as early as 1957 in an unsuccessful attempt to neutralize the high acid conditions and restore suitable water quality for fish (MNR, 1957). However, with recent reduction in emissions, and increasing evidence of water quality improvements (Dillon et al., 1986, Huthinson and Havas, 1986, Keller and Pitblado, 1986), and biological communities showing signs of recovery (Gunn and Keller, 1990, Keller et al., 1990), the future of Sudbury lakes appears far rosier than in the past.

Our results for the 1989 and 1990 surveys show that fishless, highly acidic and metal contaminated lakes (e.g. Clearwater, Lohi, Daisy, Crooked, Silver and Swan) still exist, and therefore reinforces the need for further emission reductions for the area smelters. However, the surprising results of finding fish in lakes such as Hannah Lake and Middle Lake, are encouraging signs that natural recolonization and recovery can occur.

Middle, Hannah, Clearwater and Lohi Lakes were part of the Sudbury Environmental Study (S.E.S.), an intensive chemical and biological study conducted by Ontario Ministry of the Environment and Ontario Ministry of Natural Resources during the period 1973-1979 (OMOE, 1982). When the S.E.S. study began all four lakes were acidic (ph < 4.6), heavily contaminated with smelter metals and devoid of fish. Clearwater Lake was selected as an untreated control lake to examine changes over time, while the remaining lakes were used to test the effectiveness of remedial procedures: liming (Lohi, Middle, Hannah) and fertilization (Middle, Hannah). The direct treatment of lake water with neutralization agents ($CaCO_3$, $Ca(OH)_2$) or fertilizers (to increase production and natural alkalinity generation) proved unsuccessful (OMOE, 1982). Lohi Lake reacidified within four years of treatment (OMOE, 1982). Middle and Hannah Lakes did maintain a high pH (pH > 6.5) until the end of the study, however, metals remained at toxic levels.

In 1976, MNR stocked the experimental SES lakes with various fish species to test survival of fish in these "treated" lakes. Lohi Lake (pH 6.2, Cu 40 ug/l, Ni 160 ug/l, Zn 32 ug/l), was stocked with 1200 yearling brook trouts (Savelinus fontinalis), 1400 Iowa darters (Etheostoma exile) and 170 brook sticklebacks (Culaea inconstans) (Powell, 1977). No fish appeared to survive until the end of the first summer and Powell (1977) concluded that copper toxicity was likely the primary cause of mortality. Similarly, in Middle Lake 2500 "young-of-the year" smallmouth bass, 500 Iowa darters and 200 brook sticklebacks were stocked in 1976. Despite considerable effort (eight plexiglass traps for 193 hrs, twelve 4' trapnets for 290 hrs, and two gillnets for 51 hrs) to capture fish the next year (1977) no fish were observed (Powell, unpublished data). Yan et al. (1979) confirmed the persistent toxicity problem by holding rainbow trout (Salmo gairdneri) in submerged cages in Middle and Lohi Lakes. They died in less than four days (Yan et al., 1979).

The situation is now quite different in the S.E.S. lakes. Clearwater Lake and Lohi Lake remain acidic and fishless, however, water quality, at least in Clearwater Lake (little current data on Lohi Lake), is slowly improving under reduced smelter emissions (Dillon et al., 1986). In Hannah and Middle Lakes the changes are dramatic, with pH remaining high (pH 6.8 - 7.1), metal levels reduced by more than 50% since 1976 and several fish species present in each lake (Middle: Iowa darter, golden shiner, johnny darter, northern redbelly dace, and yellow perch; Hannah: creek chub, golden shiner, Iowa darter and yellow perch). These changes may be due to smelter emission reductions and persistent effects of S.E.S. liming and fertilizing experiments, but land liming in the watershed of these lakes in 1983 by the Regional Municipality of Sudbury (VETAC, 1985) may also be involved. Watershed liming has proven to be an effective method of treating acid lakes in other areas (Boutacoff, 1990) and offers considerable promise in dealing with the acid and metal runoff problem in areas like Sudbury. For this reason, the Regional Municipality of Sudbury (VETAC, 1990) is proposing to use watershed liming as a means to improve water quality in five Sudbury lakes (Daisy, Silver, Crooked, Middle, Hannah) during the next five years.

Beyond the status of individual lakes, the surveys illustrated how lakes in the Sudbury Area are linked into systems that can affect species distribution. For example, largemouth bass, a species previously not know to occur in these lakes, appears to be moving along the length of the Long Lake chain, with population now in Richard, McFarlane, Grant and Long Lakes. Similarly, the small number of walleye in Robinson (n=1) and Kelley (n=2) are likely stocked (or native) walleye that have moved down from Ramsey Lake, by way of Lily Creek. Movement between lakes is also likely responsible for rapid “recovery” in certain lakes. For example, yellow perch in Middle and Hannah Lakes are most likely from St. Charles Lake, while Baby Lake has been colonized recently by

several species that presumably moved in from nearby Alice Lake.

The connected nature of Sudbury's lakes, emphasizes the need to manage lakes on a watershed basis and to protect aquatic systems from undesired introductions of plants and animals. For example, we found one black crappie (Pomoxis nigromaculatus) in Ramsey Lake, a species that has shown negative effects on walleye populations in other areas (Schiavone, 1985). This introduction may have come from Georgian Bay as an intentional (pet fish from cottage) or unintentional (e.g. bait fish bucket) introduction. Similarly, rainbow smelt (Osmerus mordax) are now in Nepahwin Lake, again presumably as recent introduction by humans (perhaps by washing out fertilized eggs from smelt collection bucket or nets). Smelt can reach large numbers in small inland lakes, and have been reported to detrimentally affect some native species (Evans and Loftus, 1987). One only needs to consider the zebra mussel problem in the Great Lakes, or the eurasian milfoil growths in McFarlane Lake to realize the potential problems posed by introduction or exotic species.

Many of the lakes in Sudbury are under heavy pressure from residential development along the shorelines. Such developments in the past have often lead to destruction of fish habitat through loss of wetlands (for feeding and nursery areas), sedimentation and erosion (loss of spawning sites) and excessive runoff of nutrients (eutrophication). In the face of proposed additional development of shorelines of Sudbury lakes, the current species list will provide managers with information to encourage protection of these lakes. However, with the potential of widespread environmental improvements in the future, through abatement of industrial emissions, managers, land owners and developers, can also now consider working towards rehabilitation, instead of simply maintenance of status quo for Sudbury lakes.

## CONCLUSIONS AND RECOMMENDATIONS

Sudbury presently contains a rich diversity of lakes and aquatic life that offers great potential for recreational activities for citizens and visitors to the area. Many of the lakes are presently in a degraded environmental state and require rehabilitation. All lakes need special attention to prevent any further damage from occurring. Sudbury District's Fisheries Management Plan (MNR, 1990) outlines actions to achieve these goals. They include:

- conduct surveys on the remaining eleven lakes to complete this study
- continue to enforce habitat protection laws
- continue to provide public education regarding biology and habitat needs of fish and wildlife in city lakes
- rehabilitate damaged systems (ie: watershed liming, reducing sulfur emissions, nutrient inputs, etc.)

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Appendix I: Dissolved oxygen (mg/l) profile for the study lakes during the summer of 1990.

| LAKE | SAMPLING DATE | MAXIMUM DEPTH (m) | SAMPLING DEPTH (m) 0.0 | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 | 12.0 | 16.0 | 20.0 | 24.0 | 28.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alice | 90/06/01 | 14.0 | 10.8 | 10.8 | 10.6 | 11.0 | 10.2 | | | | | | | |
| Baby | 90/05/30 | 22.5 | 10.6 | 10.6 | 10.6 | 10.6 | 11.2 | 11.0 | 10.8 | 9.1 | 7.4 | | | |
| Bethel | 89/07/07 | 5.0 | 8.1 | 7.8 | 7.6 | | | | | | | | | |
| Clearwater | 90/07/11 | 21.5 | 8.6 | 8.6 | 8.6 | 8.6 | 8.5 | 8.7 | 11.5 | 7.2 | | | | |
| Crooked | 90/07/23 | 8.0 | 9.4 | 9.2 | 8.8 | 6.6 | 0.9 | | | | | | | |
| Daisy | 90/05/23 | 14.0 | 11.0 | 10.9 | 10.1 | 10.1 | 9.5 | 10.5 | 10.4 | | | | | |
| Hannah | 90/03/16 | 8.5 | 13.3 | 11.4 | 10.6 | 10.6 | | | | | | | | |
| Kelley | 90/08/28 | 17.0 | 8.2 | 8.3 | 8.3 | 7.6 | 6.2 | 4.6 | 0.8 | 0.1 | | | | |
| Lohi | 90/07/11 | 19.5 | 8.0 | 8.2 | 8.2 | 8.0 | 8.2 | | | | | | | |
| Long | 90/09/26 | 36.5 | 9.5 | 8.8 | 8.9 | 8.9 | 8.8 | 8.8 | 8.6 | 6.0 | 6.6 | 7.1 | 6.6 | 6.2 |
| McFarlane | 90/09/15 | 20.0 | 8.4 | 8.5 | 8.5 | 8.5 | 8.5 | 2.7 | 2.7 | 2.3 | 2.2 | | | |
| Middle | 90/03/20 | 15.0 | 12.9 | 11.2 | 10.7 | 10.7 | 6.4 | | | | | | | |
| Minnow | 90/05/15 | 3.1 | 11.6 | 11.4 | | | | | | | | | | |
| Nepahwin | 90/10/12 | 22.0 | 10.3 | 10.2 | 10.0 | 10.0 | 10.0 | 9.9 | 9.8 | 2.0 | 1.2 | | | |
| Raft | 90/08/16 | 13.0 | 8.4 | 8.0 | 7.9 | 8.2 | 7.7 | 5.6 | 1.4 | | | | | |
| Ramsey | 90/03/20 | 20.5 | 13.0 | 13.0 | 12.4 | 11.4 | 10.7 | 10.2 | 10.4 | 10.6 | 7.4 | | | |
| Richard | 90/08/13 | 9.5 | 7.6 | 7.4 | 7.4 | 7.5 | 7.4 | | | | | | | |
| Robinson | 90/05/10 | 2.0 | 9.6 | 9.5 | | | | | | | | | | |
| St. Charles | 90/07/03 | 6.0 | 9.2 | 9.3 | 9.2 | 5.6 | | | | | | | | |
| Silver | 90/06/20 | 10.0 | 8.3 | 8.3 | 8.2 | 8.2 | 8.1 | 7.5 | | | | | | |
| Still | 90/08/21 | 3.0 | 8.6 | 7.2 | | | | | | | | | | |
| Swan | 90/07/18 | 8.0 | 8.6 | 8.6 | 8.6 | 7.9 | 3.2 | | | | | | | |
| Tilton | 90/08/07 | 12.0 | 9.0 | 8.9 | 8.9 | 8.8 | 8.2 | 5.3 | 1.7 | | | | | |

Appendix II: Stocking history of the 1989 and 1990 urban study lakes.

| YEAR | NO. STOCKED | SPECIES | AGE |
|---|---|---|---|
| Clearwater Lake | | | |
| 1951 | 10000 | brook trout | ? |
| 1952 | 3000 | small mouth bass | ? |
| 1956 | ? | n. redbelly dace | ? |
| 1957 | ? | smallmouth bass | ? |
| 1959 | 5000 | brook trout | ? |
| Lohi Lake | | | |
| 1951 | 2500 | brook trout | ? |
| 1953 | 6000 | brook trout | ? |
| 1976 | 1200 | brook trout | yearling |
| 1976 | 1375 | Iowa darter | ? |
| 1976 | 171 | brook stickleback | ? |
| 1977 | 1196 | brook trout | ? |
| Long Lake | | | |
| 1951 | 3000 | lake trout | ? |
| 1951 | 4000 | smallmouth bass | ? |
| 1953 | 3000 | smallmouth bass | ? |
| 1958 | 2000 | smallmouth bass | ? |
| 1958 | 2000 | smallmouth bass | fingerling |
| 1959 | 2500 | smallmouth bass | ? |
| 1959 | 175000 | walleye | ? |
| 1959 | 2000 | speckled trout | fingerling |
| 1960 | 4500 | smallmouth bass | ? |
| 1960 | 175000 | walleye | ? |
| 1976 | 5000 | smallmouth bass | ? |
| 1977 | 16292 | lake trout | ? |
| 1977 | 21875 | smallmouth bass | ? |
| 1978 | 6962 | lake trout | ? |
| 1984 | 9000 | lake trout | ? |
| 1985 | 9000 | lake trout | 17 months |
| 1986 | 5000 | lake trout | ? |
| 1987 | 5000 | lake trout | 15 months |
| 1988 | 600 | walleye | 3 months |
| 1989 | 5000 | lake trout | 17 months |
| McFarlane Lake | | | |
| 1951 | 4000 | smallmouth bass | ? |
| 1953 | 3000 | smallmouth bass | ? |
| 1953 | 150000 | walleye | ? |
| 1956 | 6000 | smallmouth bass | ? |
| 1956 | 325000 | walleye | ? |
| 1959 | 175000 | walleye | ? |
| 1960 | 6000 | smallmouth bass | ? |
| 1961 | 6000 | smallmouth bass | ? |
| 1974 | 1000 | muskellunge | ? |
| 1987 | 50000 | walleye | ? |

Appendix II, continued

| YEAR | NO. STOCKED | SPECIES | AGE |
|---|---|---|---|
| Middle Lake | | | |
| 1974 | ? | central mudminnow | ? |
| 1974 | ? | lake trout | ? |
| 1974 | ? | johnny darter | ? |
| 1976 | 2541 | smallmouth bass | ? |
| 1976 | 174 | brook stickleback | ? |
| 1976 | 5165 | Iowa darter | ? |
| Nepahwin Lake | | | |
| 1976 | 391 | smallmouth bass | ? |
| 1983 | 4118 | splake | ? |
| 1984 | 5000 | splake | ? |
| 1985 | 3600 | splake | ? |
| 1986 | 5000 | splake | 17 months |
| 1987 | 3000 | splake | 16 months |
| 1988 | 4000 | splake | 18 months |
| 1989 | 3000 | lake trout | 17 months |
| Raft Lake | | | |
| 1954 | 2000 | smallmouth bass | ? |
| Ramsey Lake | | | |
| 1952 | 5000 | lake trout | ? |
| 1976 | 1000 | walleye | ? |
| 1977 | 19875 | bass | ? |
| 1977 | 10000 | walleye | fingerling |
| 1978 | 5000 | bass | ? |
| 1978 | 10000 | walleye | fingerling |
| 1979 | ? | rainbow trout | ? |
| 1982 | ? | walleye | ? |
| 1983 | ? | walleye | ? |
| 1987 | 400 | walleye | 3 months |
| 1987 | 50000 | walleye | 1 month |
| 1988 | 2000 | walleye | 3 months |
| 1989 | 60 | walleye | 1 year |
| Richard Lake | | | |
| 1952 | 2000 | smallmouth bass | ? |
| 1953 | 200000 | walleye | ? |
| 1956 | 6000 | smallmouth bass | ? |
| 1974 | 4000 | smallmouth bass | ? |
| 1974 | 5000 | muskellunge | ? |
| 1976 | 4000 | smallmouth bass | ? |
| 1987 | 200000 | walleye | 1 month |
| 1987 | 800 | walleye | 3 months |

Appendix II, continued

| YEAR | NO. STOCKED | SPECIES | AGE |
|---|---|---|---|
| Siver Lake | | | |
| 1952 | 2500 | smallmouth bass | ? |
| | | | |
| Tilton Lake | | | |
| 1951 | 10000 | brook trout | ? |
| 1952 | 3000 | smallmouth bass | ? |
| 1953 | 3000 | smallmouth bass | ? |
| 1954 | 3000 | smallmouth bass | ? |
| 1957 | 1000 | smallmouth bass | ? |