

TOXIC CHEMICAL
SPECIALISTS

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**ASSESSMENT OF ATMOSPHERICALLY TRANSPORTED
ORGANOCHLORINE COMPOUNDS, CO-PLANAR POLYCHLORINATED
BIPHENYLS (PCBs), POLYCHLORINATED DIBENZO-*P*-DIOXINS (PCDDs),
AND POLYCHLORINATED DIBENZOFURANS (PCDFs)**

INTERIM SAMPLING REPORT

Prepared for

Office of the Great Lakes
Great Lakes Protection Fund
Michigan Department of Natural Resources
Lansing, Michigan

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ORGANOCHLORINE COMPOUNDS

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INTRODUCTION

Since 1974, it has been known that organochlorine substances move through the atmosphere into the Great Lakes basin. From that period through the early 1980s to the present, a series of samples from the vicinity of Isle Royale in Lake Superior have demonstrated significant deposition of organochlorine compounds in that area. Siskiwit Lake on Isle Royale, a deep, oligotrophic body of water has been historically used as a site for comparative studies with the Upper Great Lakes because of its comparable native populations of lake trout and whitefish, and its remote character (see section entitled, "Study Sites").

In essence, Siskiwit Lake was originally used as a study site because it was reasoned that if a smaller lake system with no known direct sources of persistent organic contaminants from man's activities could be located, a comparison could be made with the Great Lakes. Siskiwit Lake was the obvious choice from several perspectives:

1. Siskiwit Lake was intimately related geographically with the Great Lakes, particularly Lake Superior. Further, there was no direct interconnection between the two bodies of water enabling lake trout and whitefish access to Siskiwit Lake from Lake Superior.
2. Similar species of fish were present in both lake systems enabling direct comparisons of the same species.
3. Siskiwit Lake was remote from inhabited and industrialized areas, minimizing, if not eliminating entirely the direct industrial and cultural influences attributable to man.
4. The use of heavy equipment has never been permitted in the vicinity of Siskiwit Lake, and the use of internal combustion engines is not allowed on the lake.

The fact that every effort has been made by the National Park Service to retain the original wilderness character of the region made Siskiwit Lake nearly ideal for comparative purposes.

Data taken in 1974 - 1976 conclusively demonstrated that a variety of organochlorine substances were being transported to this remote lake setting by way of the atmosphere. A comparison of the values observed in fish from Siskiwit Lake with similar species taken from Lake Superior in the 1974 - 1976 time period is presented in Table 1.

TABLE 1
MEAN VALUES OF ORGANOCHLORINE COMPOUNDS IN WHOLE FISH
FROM LAKE SUPERIOR AS COMPARED WITH WHOLE FISH FROM
SISKIWIT LAKE, ISLE ROYALE: 1974 - 1976

Values in parenthesis indicate contaminant levels expressed as parts per million of lipid.

*Values below indicates thresholds have been regarded as
equal to zero for computation of mean values.*

Values labeled BQT were below the threshold of quantification.

Values Expressed in Parts per Million ($\mu\text{g/g}$ wet-weight)													
SITE	$\bar{x}$ length (cm)	$\bar{x}$ weight (g)	% lipid	PCB	HCB	α BHC	Heptachlor	p,p- DDE	o,p- DDT	p,p- DDD	p,p- DDT	Total DDT	Dieldrin
LAKE TROUT													
Lake Superior - all stations	52.2	1450.6	6.19	0.9 (14.54)	0.005 (0.08)	0.009 (0.15)	0.003 (0.05)	0.257 (4.15)	0.059 (0.95)	0.008 (0.13)	0.076 (1.23)	0.400 (6.46)	0.028 (0.45)
Siskiwit Lake	54.5	1617.0	3.5	1.2 (34.29)	0.005 (0.31)	0.011 (0.31)	0.008 (0.23)	2.37 (67.71)	0.030 (0.86)	0.036 (1.03)	0.455 (13.0)	2.89 (82.57)	0.011 (0.31)
WHITEFISH													
Lake Superior - all stations	54.62	497.2	5.06	0.2 (3.95)	0.003 (0.06)	0.005 (0.10)	0.002 (0.04)	0.118 (2.33)	0.024 (0.47)	0.003 (0.06)	0.039 (0.77)	0.184 (3.64)	0.017 (0.34)
Siskiwit Lake	44.44	1006.9	3.8	0.1 (2.63)	BQT	0.006 (0.16)	0.008 (0.21)	0.066 (1.74)	BQT	BQT	0.094 (2.47)	0.16 (4.21)	0.008 (0.21)

That the deposition and occurrence of those compounds in the fish of Siskiwit Lake was not a transitory phenomenon was confirmed by subsequent sampling in 1980. Further, a number of substances were added to the list of known atmospherically transported materials. A list of these substances and a comparison between the 1974-1976 and the 1980 sampling periods is provided in Table 2.

TABLE 2
COMPARISON OF RESIDUE-FORMING ORGANIC SUBSTANCES
OBSERVED IN LAKE TROUT (EVISCERATED WHOLE FISH)
FROM SISKIWIT LAKE, 1974 - 1976 AND 1980

COMPOUND	Concentration (ng/g, parts per billion)	
	1974 - 1976	1980
α BHC	11.0	3.5
α BHC	--	1.5
HCB	5.0	--
Heptachlor epoxide	8.0	5.2
Oxychlordane	--	5.3
<u>trans</u> - chlordane	--	8.8
<u>cis</u> - chlordane	--	24.4
p,p'-DDE	2370.0	318.0
p,p'-DDD	36.0	25.0
cis- nonachlor	--	25.0
Toxaphene	--	3200.0
Packed column PCBs	1.2	4.3
Capillary Column PCBs	--	0.7

The last two entries for PCBs in Table 2 reflect the enormous change in analytical technology which took place in the late 1970s and early 1980s. During this period, a new, more sensitive and discriminatory analytical technique known as high resolution capillary column gas chromatography was introduced. This methodology was able to discriminate between the overlying peaks of PCBs and toxaphene-like compounds and effectively separate these substances into their component parts. When packed column chromatograph was compared between 1974 - 1976 and 1980, there was an apparent

increase in PCB contamination of fish from 1.2 to 4.3 ppm. However, when high resolution capillary column chromatography was applied, there was an apparent decrease in PCB contamination from 12.2. to 0.7 ppm. In actual fact, neither of these datasets are directly comparable, since packed column chromatography compares poorly with capillary column data, and since toxaphene had increased dramatically in the fish of the upper Great Lakes by 1980. However, the studies do indicate the kinds of organochlorine contaminants which were being atmospherically transported, and provide inferential information about the relative magnitude of the transport problem.

In addition, using negative ionization mass spectroscopy, analyses were made of composites of Siskiwit Lake lake trout for polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). The results of these 1980 analyses are presented in Table 3.

TABLE 3
NEGATIVE IONIZATION MASS SPECTROSCOPY ANALYSES OF
EVISCERATED WHOLE LAKE TROUT FROM SISKIWIT LAKE - 1980

COMPOUND	Concentration (ng/kg, ppt) by Number of Chlordane Substitutions					
	4	5	6	7	8	Total
Chlorinated dibenzo-p-dioxins (detection limit)	ND (1.0)	ND (1.0)	ND (2.0)	TR. (2.0)	TR. (3.0)	Trace
Chlorinated dibenzofurans (detection limit)	10 (0.5)	5 (0.5)	ND (0.5)	ND (1.0)	ND (1.0)	15
Ratio of four chlorine PCDFs to Total	10:15 = 0.67					
Concentration ratio (PCDFs/PCBs) x 10 ⁶						
Packed column PCBs (15/4.3) = 3.5 x 10 ⁶						
High resolution capillary column PCBs (15/0.7) = 21.4 x 10 ⁶						

Thus, even using the relatively insensitive analytical methodology of the early 1980s, it was clear that both PCDDs and PCDFs were moving through the atmosphere to be deposited in Siskiwit Lake on Isle Royale. This fact confirms the worldwide horizon of the materials reported by other workers as "background" contamination.

1993 SAMPLING EFFORTS

In an effort to reassess contemporary additions of toxic substances to the Siskiwit Lake and Lake Superior ecosystems, a series of studies were planned. With the assistance of the Great Lakes Protection Fund and the Michigan Department of natural Resources, these studies were implemented in 1973. In July and August of 1993, field collection of specimens was undertaken. In all cases, fish and sediment core sampling was accomplished either from a canoe or from a small boat.

In order to sample the remote lake sites, sampling gear, including four hundred feet of gill net and a bronze coring device were backpacked into the site. Because repeated sets of the gill net at various locations and various depths yielded only one lake trout, the remainder of the samples were taken by hook and line at all locations. The extraordinarily low catch per unit effort with the gill net was undoubtedly a function of the mid-summer period and the warm temperatures associated with it.

Fish samples were prepared as eviscerated whole fish. Samples were sized, weighed, sorted, sex determined and wrapped for freezing in solvent-rinsed aluminum foil. At the remote sites, the fish were then sunk in the lake below the thermocline where temperature conditions of approximately 4°C prevailed. Upon returning to the mainland, the fish were placed on dry ice and frozen for shipment to the laboratory.

Sediment core samples were taken with a brass/bronze gravity corer and transported to shore for sectioning. Cores were removed from the corer using a brass extruder. Core segments were then cut with a stainless steel knife which had been previously cleaned with solvent. Core sections were then placed in solvent-rinsed glass jars with teflon lids. These jars were then placed in a cooler, and maintained under cool dark conditions.

Large volume water samples were not taken because of equipment malfunction. The alternative was to attempt to extract large volumes of water on site using liquid solvents and hand separation. Because the quality of liquid/liquid extractions done in the field could not be guaranteed, it was determined that it was better to forego water sampling than to run the risk of the introduction of error into the extremely sensitive low-level analyses for organochlorine compounds. Further, both the fish and the sediment data should be indicative of levels of these materials to be expected in the water column.

A description of the specific sample sites used for comparison with the Great Lakes is presented in the section which follows. While on nearly opposite sides of the Great Lakes system, both of these comparative sampling sites are still within the boundaries of the State of Michigan.

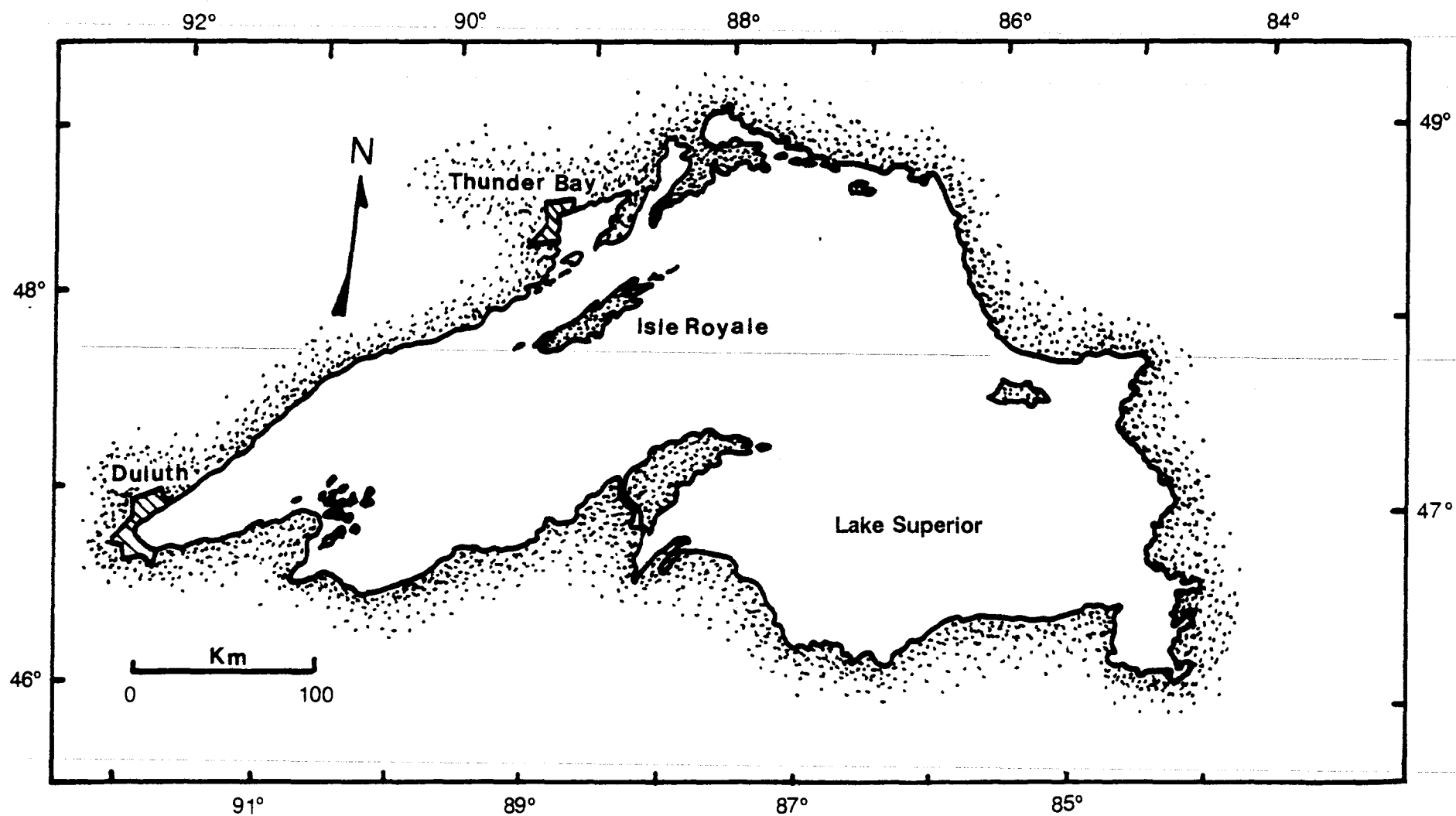


Figure 1.
Geographic Location of Isle Royale in Northern Lake Superior

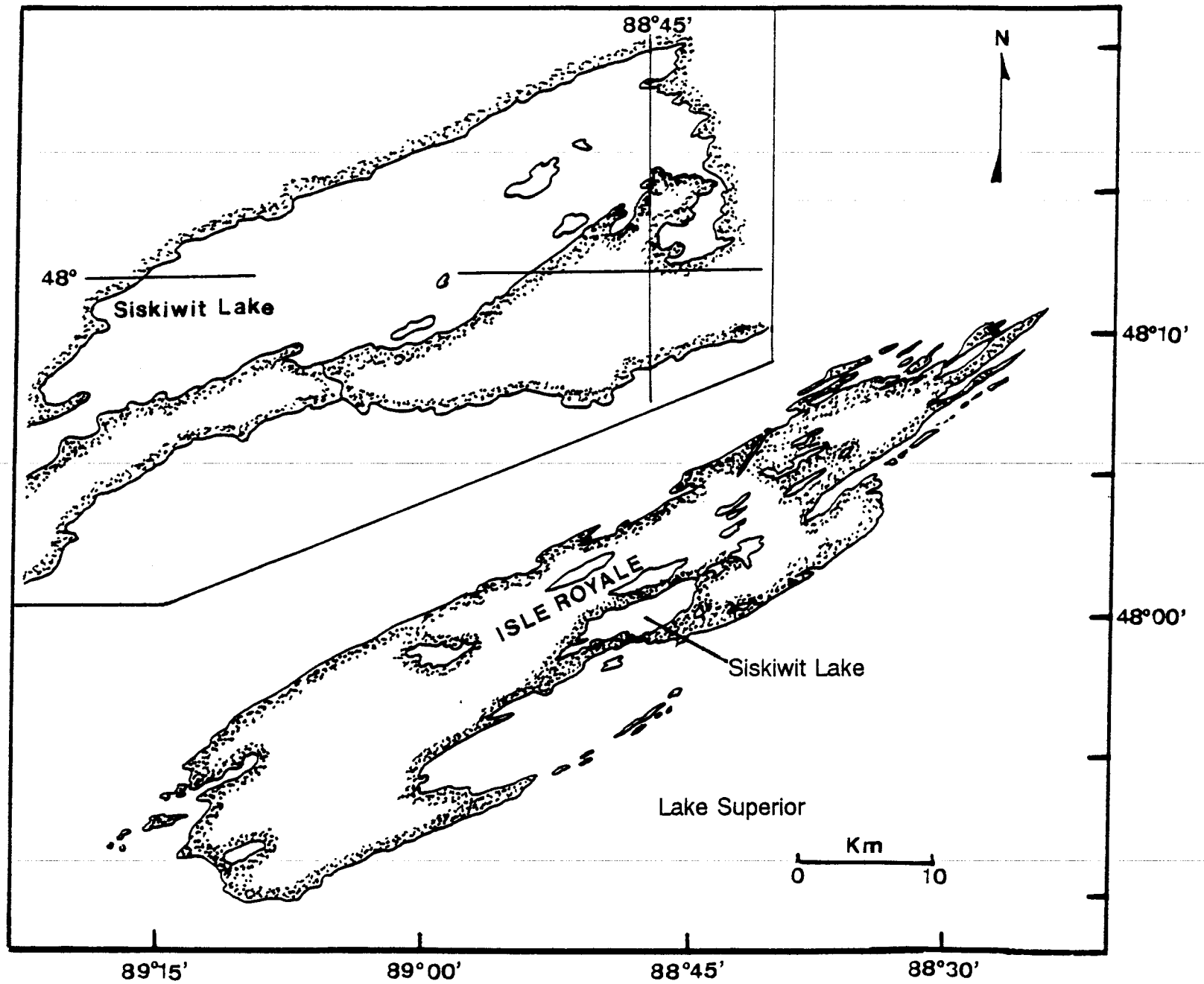


Figure 2.
Geographic Location of Siskiwit Lake on Isle Royale.

STUDY SITES

Siskiwit Lake, Isle Royale.

Isle Royale is an archipelago consisting of a central island mass, associated irregular shoreline reefs, and island outcroppings. The island is located in Lake Superior, with the closest shoreline feature being Thunder Cape, Ontario, on the northern Lake Superior shoreline, 27.36 km away. The nearest major area of population is Thunder Bay, Ontario, a distance of approximately 51.5 km (Figure 1).

Isle Royale (Figure 2) has an extreme length of nearly 70.8 km on a southwest–northeast axis. Its maximum width is 14.48 km. The entire island structure, including associated reefs, islets, and the water mass of Lake Superior extending 7.24 km from the shoreline and the immediately surrounding islands constitutes Isle Royale National Park. This park was established in April of 1940, and from that date, efforts have been made to retain its native wilderness character. In general, the island is remote from human habitation and free of the direct industrial and cultural influences attributable to man.

Siskiwit Lake is located near the southern shoreline of Isle Royale (Figure 2). It is a dimictic, oligotrophic lake lying in a depression of Precambrian Middle Keweenawan flows of the Portage Lakes volcanics, 0.6 km inland from and 17.37 m above Lake Superior. A single outlet plunges over a series of waterfalls, known as the Siskiwit Falls, to Lake Superior. The length of Siskiwit Lake is 11.10 km, the maximum breadth is 2.25 km, and the mean breadth is 1.40 km (Huber, 1975). Swackhamer *et al.* (1988) indicate that the surface area of the lake is 16.8 km², while Swain (1978) has reported the surface area to be 15.67 km², exclusive of islands. The lake's watershed is more than double the surface area, approaching 40 km² in size. The hydraulic residence time has been estimated to be 25 years (Swackhamer *et al.*, 1988). Huber (1975) gives the maximum depth of the lake as 36.58 m, however, newer bathometric information (Swackhamer *et al.*, 1988) indicates that mean depth is 21 m and maximum depth is 46 m. The present study has found 45.72 m as the maximum depth in this body of water (Figure 3).

Crystal Lake.

A second lake site for comparison with the Great Lakes was considered desirable. A number of possible locations were considered, but later rejected. These sites included El, Skegemog, Blue, North Leelanau and Thumb Lakes. The reasons for rejection were various and included influence from one of the Great Lakes or a tributary stream, biota that were not directly comparable with the Great Lakes, and the potential for human effects resulting from industrial or cultural influences due to man's activities.

Ultimately, Crystal Lake in west central Benzie County was selected as a comparative site (Figure 4). This lake is a cold, deep oligotrophic body of water which

SISKIWIT LAKE

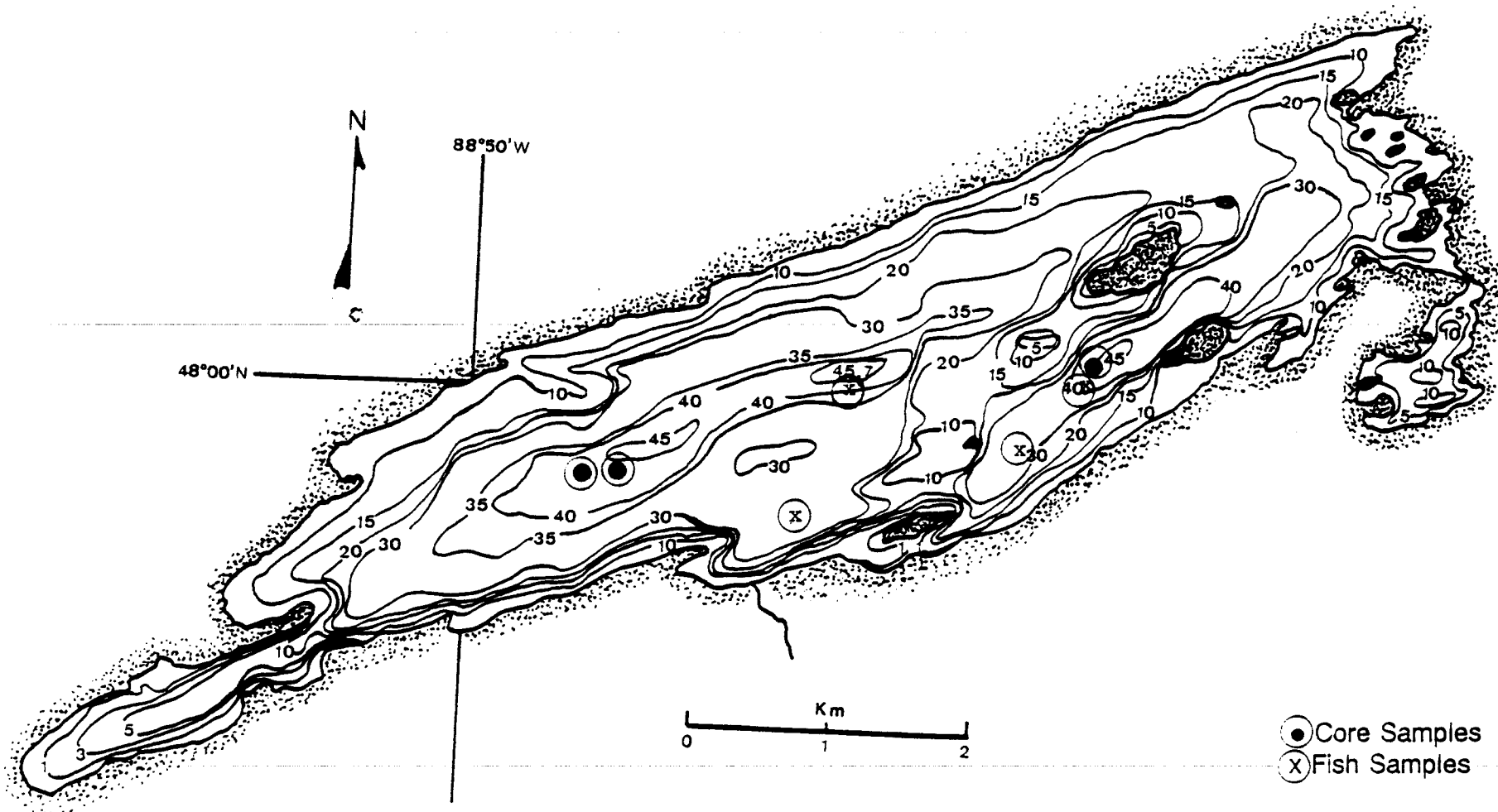


Figure 3.

The Morphometry of Siskiwit Lake, Isle Royale.

Depth contours are in meters.

Sampling sites are indicated as a "●" for Core Samples and an "⊗" for Fish Samples.

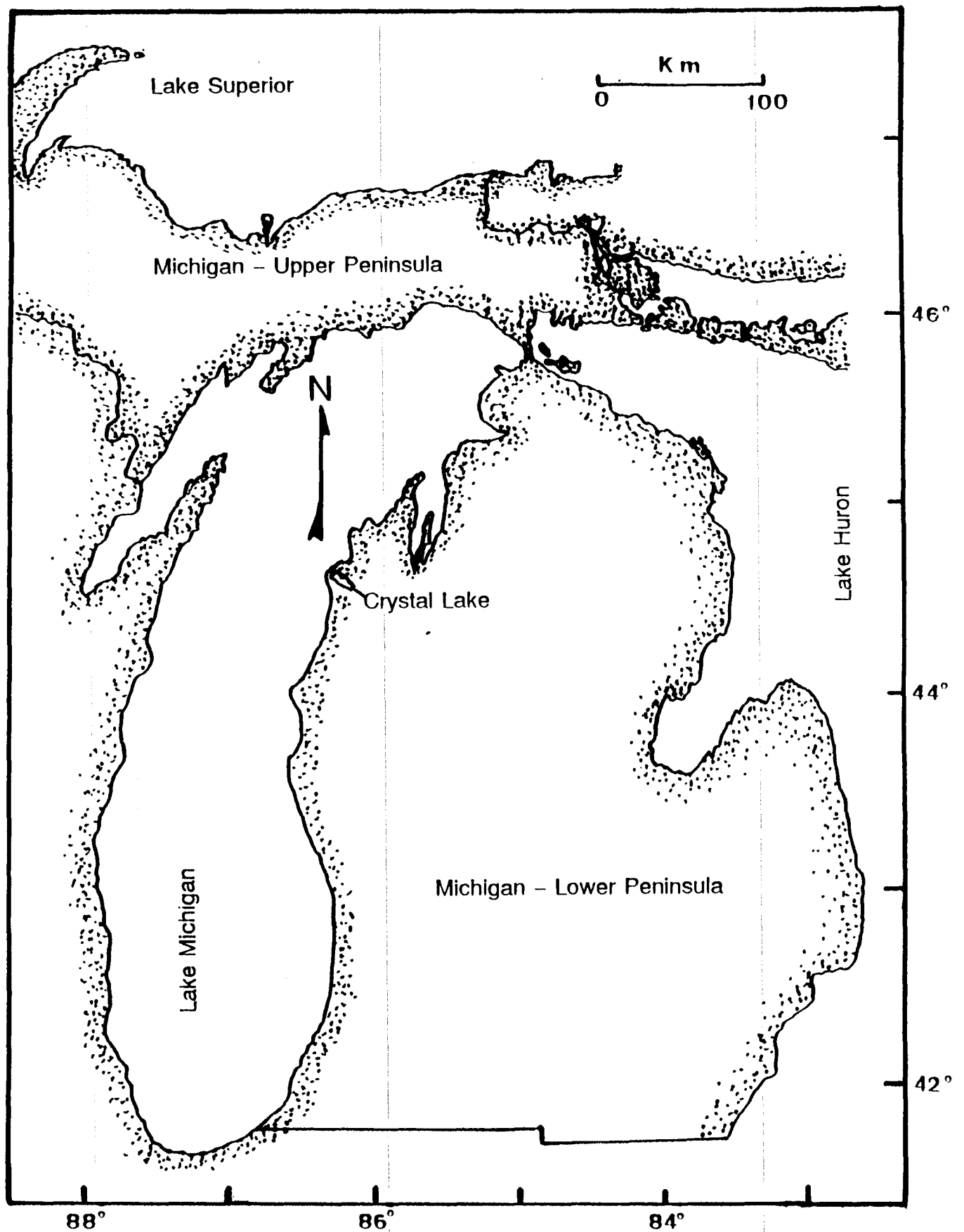


Figure 4.
Geographic Location of Crystal Lake in the Lower Peninsula of Michigan.

contains a substantial population of lake trout. Local fisherman advised that while stocking efforts had been carried out by the Michigan Department of Natural Resources, that a relatively high percentage of the lake trout population were naturally reproducing. Crystal Lake is situated slightly less than one mile from the Lake Michigan shoreline at Point Betsie. The lake drains to Lake Michigan by way of the Betsie River, although retrograde movement of fish from Lake Michigan is prevented. A small stream, Cold Creek enters the lake's east end, but this stream is thought to be relatively free of contaminants of concern because of its remote nature. In contrast with the Isle Royale site, Crystal Lake has a number of residences and vacation homes on the shoreward margins. Although industrial sites are lacking, the possibility for anthropogenic influence is greater than at the Isle Royale site.

Crystal Lake is a dimictic, oligotrophic body of water of 29.3 km² in surface area. The lake has a maximum length of 14.4 km and a maximum breadth of 4.6 km. The mean breadth is 3.4 km. The maximum depth of this lake is 53.3 m, and the average depth is 33m (Figure 5).

ARCHIVED SPECIMENS

Historic samples of fish taken during the 1980 field season at Siskiwit Lake on Isle Royale maintained in a frozen state by the United States Environmental Protection Agency's Lake Lakes Research Station at Grosse Ile, Michigan. Mr. William Richardson, present Chief of Station, and Dr. Michael Mullin, Senior Research Chemist, both of this laboratory, provided unlimited access to, and unrestricted use of these archived samples.

These historic samples will be partially thawed and a pair of representative sub-samples will be removed. The remaining sample mass will then be refrozen for long-term storage. One of the sub-samples will be extracted for analysis by the laboratory. The remaining sub-sample will be wrapped and re-frozen for transport to the USEPA Large Lakes Research Station at Grosse Ile, Michigan. Dr. Mullin will then undertake parallel extraction and analysis of selected representatives of these materials using USEPA equipment and methodologies. Ultimately, the two resulting datasets will be compared.

The 1980 archived specimens from Siskiwit Lake on Isle Royale consisted of seven composited samples. Table 4 presents the characteristics of these samples.

CRYSTAL LAKE

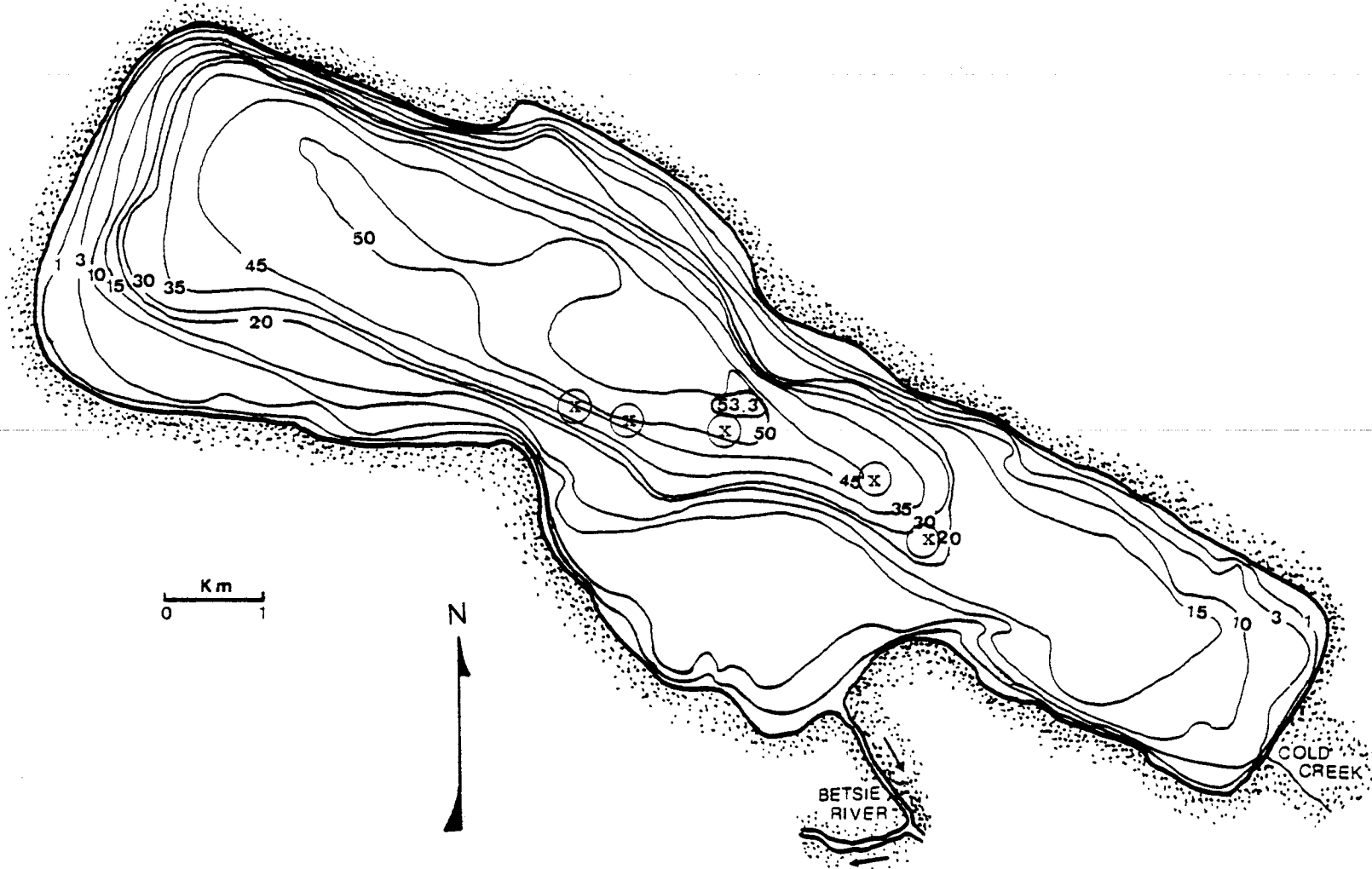


Figure 5.
The Morphometry of Crystal Lake, Benzie County, Michigan.
Depth contours are given in meters.
Fish sampling locations are indicated with an "x".

TABLE 4
CHARACTERISTICS OF 1980 ARCHIVED SPECIMENS
SISKIWIT LAKE, ISLE ROYALE

USEPA Laboratory Acquisition Number	No. of Specimens In Composite	Species	Common Name	Total Length (cm)	Total Weight (g)
CLS001 FEVONI	1	<i>Salvelinus namaycush</i>	Lake trout	71.0	4681.8
CLS002 FEVONI	4	<i>Salvelinus namaycush</i>	Lake trout		
1				56.0	1850
2				54.0	1750
3				55.0	1795
4				58.0	1741
			<i>Means (± S.D.)</i>	55.75 (± 1.71)	1784 (± 49.94)
CLS003 FEVONI	4	<i>Salvelinus namaycush</i>	Lake trout		
1				58.0	1582
2				54.0	1509
3				54.0	1755
4				54.0	1545
			<i>Means (± S.D.)</i>	55.0 (± 2.0)	1597.75 (± 108.99)
CLS004 FEVONI	5	<i>Salvelinus namaycush</i>	Lake trout		
1				53.0	1545
2				48.0	1204
3				47.0	1095
4				48.0	1036
				35.0	345
			<i>Means (± S.D.)</i>	46.2 (± 6.69)	1045 (± 438.14)
CLS007 FEVONI	4	<i>Salvelinus namaycush</i>	Lake trout		
1				52.0	1377
2				52.0	1127
3				52.0	1454
4				57.0	1691
			<i>Means (± S.D.)</i>	53.25 (± 2.5)	1412.25 (± 232.42)

TABLE 4 Cont'd.

USEPA Laboratory Acquisition Number	No. of Specimens in Composite	Species	Common Name	Total Length (cm)	Total Weight (g)
CLS006 FEVONI	5	<i>Amia calva</i>	Bowfin		
1				46.0	464
2				41.0	336
3				30.0	159
4				42.0	341
5				50.0	641
Means ($\pm$ S.D.)				41.8 ($\pm$ 7.50)	388.2 ($\pm$ 178.28)
CLS005 FEVONI	5	<i>Coregonus clupeaformis</i>	Whitefish		
1				48.0	1464
2				48.0	1355
3				48.0	1054
4				41.0	795
5				47.0	982
Means ($\pm$ S.D.)				46.4 ($\pm$ 3.05)	1130 ($\pm$ 274.81)

A number of fish specimens were collected during the 1993 field investigation prior to 30 September 1993. Table 5 presents the characteristics of these samples.

GREAT LAKES SAMPLES

Lake trout samples were taken from Lake Superior adjacent to Isle Royale in the vicinity of the entrance to Siskiwit Bay. The characteristics of these fish are summarized in Table 5.

Efforts in July and August to collect lake trout from Lake Michigan in the vicinity of Manistee, Michigan, were not successful. The catch in this area consisted solely of salmon, which were returned alive to the lake. Further efforts at collecting representative specimens from this area are planned for the October or early November period when it is expected that lake trout may be available.

TABLE 5
CHARACTERISTICS OF FISH SPECIMENS TAKEN IN THE
1993 FIELD SEASON

Collection Site	Species	Common Name	Total Length (cm)	Total Weight (g)
Siskiwit Lake	<u>Salvelinus namaycush</u>	Lake trout		
Isle Royale				1360
1			53.5	1365
2			53.5	1207
3			51.0	1360
4			56.0	
		<i>Means (± S.D.)</i>	53.5 (± 2.04)	1323 (± 77.37)
Lake Superior	<u>Salvelinus namaycush</u>	Lake trout		
1			71.0	3629
2			71.0	4763
3			70.0	4808
		<i>Means (± S.D.)</i>	70.67 (± 0.58)	4400 (± 668.08)
Crystal Lake	<u>Salvelinus namaycush</u>	Lake trout		
1			51.0	1588
2			52.0	1474
3			44.5	1456
4			37.0	408
		<i>Means (± S.D.)</i>	46.13 (± 6.93)	1231.5 (± 552.10)
Crystal Lake	<u>Salvelinus namaycush</u>	Lake trout	71.0	4082

COOPERATING ORGANIZATIONS AND INDIVIDUALS

A large number of organizations and individuals have cooperated and assisted in the development and implementation of this project. The staff at Eco Logic gratefully acknowledges the assistance provided by each.

In addition to the Office of the Great Lakes of the Michigan Department of Natural Resources (MDNR), the Fisheries Division of the Lansing office of the MDNR has been extremely helpful in the timely provision of appropriate documentation and permits for the collection of fish for scientific research (copy appended to this report). Similarly, the

cooperation and assistance of Mr. Jack Oelfke, Natural Resource Specialist of the U.S.D.I. National Park Service at Isle Royale, in securing the necessary permits for sampling at Siskiwit Lake (copy appended to this report) is sincerely appreciated.

The suggestions and assistance in making local contacts provided by Dr. Gary Glass of the United States Environmental Protection Agency's Environmental Research Laboratory – Duluth in Duluth, Minnesota, is gratefully acknowledged. In part, these suggestions and assistance led to contact with James K. Huber, Palynologist of the Archaeometry Laboratory of the University of Minnesota, Duluth, who kindly provided the use of a bronze gravity corer for use at all sampling locations at no cost to the project. This assistance saved the project hundreds of dollars of expenditure, and is deeply appreciated.

Similarly, Dr. James Ludwig of the SERE Group in Stockbridge, Michigan, is thanked for his provision of gill nets for use in sampling. This contribution also saved an expenditure of several hundreds of dollars.

Dr. Deborah Swackhamer of the School of Public Health at the University of Minnesota, Minneapolis, Minnesota, and Dr. John Robbins, of the National Oceanographic and Atmospheric Administration's Great Lakes Laboratory in Ann Arbor, Michigan, have agreed to examine core samples for organic contaminants and to provide analysis for radioactive dating of core materials. The assistance of both of these individuals in providing collection containers appropriate to each of their specialties is acknowledged with thanks.

Special thanks are owed to Dr. Michael Mullin of the United States Environmental Protection Agency's Large Lakes Research Station at Grosse Ile, Michigan. Dr. Mullin kindly provided unrestricted use of the archived specimens of fish taken in the 1980 time period from Siskiwit Lake. Further, he has agreed to provide parallel analyses of selected specimens, both of the archived materials and of the 1993 samples. The availability of this data will provide a check on the accuracy of the data generated, and in some cases, may allow for an expansion of information available to the investigators. This provision of analytical effort is being contributed at no cost to the project, and represents a contribution of the order of thousands of dollars of effort. The expected outcome of this mutual effort is one or more jointly authored scientific articles in appropriate journals.

Finally, the contribution of Mr. Thomas McManus of McManus Investigations in Hoquiam, Washington, is acknowledged with gratitude. Mr. McManus provided technical sampling assistance to the project at less than half of the rate normally charged. This contribution resulted in a proportionate savings to the project of several thousands of dollars.

ANALYTICAL PARAMETERS

Both sediment and fish samples have been transferred to the laboratory for analysis. A maximum of 36 samples will be analyzed for organochlorine pesticide concentrations and congener specific PCB analyses. The organochlorine compounds to be investigated and their associated method detection limits are summarized in Table 6.

TABLE 6
ANALYTICAL PARAMETERS FOR ORGANOCHLORINE COMPOUNDS AND
POLYCHLORINATED BIPHENYLS (PCBs) WITH THEIR
ASSOCIATED METHOD DETECTION LIMITS

<u>Organochlorine Pesticide Compounds</u>	<u>Method Detection Limit (ng/g)</u>	<u>Organochlorine Pesticide Compounds</u>	<u>Method Detection Limit (ng/g)</u>
α -BHC (HCH)	0.2	Dieldrin	0.3
β -BHC (HCH)	0.3	pp'-DDE	0.3
γ -BHC (HCH)	0.1	Endrin	0.3
δ -BHC (HCH)	0.2	β -Endosulphan	0.3
Heptachlor	0.1	pp'-DDD	0.3
Aldrin	0.2	Endrin Aldehyde	0.6
Heptachlor Epoxide	0.2	Endosulphan Sulphate	0.4
γ -Chlordane	0.8	pp'-DDT	0.5
α -Endosulphan	0.2	Methoxychlor	0.8
α -Chlordane	0.8	op'-DDT	0.5
Octachlorostyrene	0.1	Mirex	0.1
Nonachlor	0.8	Toxaphene	1.0

Polychlorinated Biphenyl Compounds

Total PCBs by congener-specific analysis
Co-Planar PCBs by congener-specific analysis.

Method Detection Limit (ng/g)

Detection limits vary by individual congener in a range between 0.1 and 0.5 ng/g.

It should be emphasized that of the 209 theoretically possible PCB congeners, only about 75 to 100 are routinely seen in environmental samples. It is expected that all of these congeners will be identified and concentrations determined. Further, the co-planar PCBs will be separated by carbon fiber column and quantified separately so that their toxicity may be assessed on the basis of toxic equivalencies (TEQs).

In addition to these substances, analysis by means of high resolution mass spectrometry will be made for polychlorinated dibenzo-*p*-dioxins (PCDDs), including the most toxic form 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), and a spectrum of polychlorinated dibenzofurans (PCDFs) on a maximum of 16 samples. The PCDDs and PCDFs to be investigated along with their associated method detection limits are summarized in Table 7.

TABLE 7

<u>Dioxins</u>	<u>Method Detection Limit (pg/g)</u>	<u>Dibenzofurans</u>	<u>Method Detection Limit (pg/g)</u>
2,3,7,8-T ₄ CDD	1.0	2,3,7,8-T ₄ CDF	1.0
Other T ₄ CDDs	1.0	Other T ₄ CDFs	1.0
1,2,3,7,8-P ₅ CDD	2.0	1,2,3,7,8-P ₅ CDF	1.0
Other P ₅ CDDs	2.0	Other P ₅ CDF	1.0
1,2,3,4,7,8-H ₆ CDD	2.0	2,3,4,6,7,8-H ₆ CDF	1.0
Other H ₆ CDDs	2.0	Other H ₆ CDFs	1.0
1,2,3,4,6,7,8-H ₇ CDD	3.0	1,2,3,4,6,7,8-H ₇ CDF	2.0
Other H ₇ CDDs	3.0	Other H ₇ CDFs	2.0
O ₈ CDD	3.0	O ₈ CDF	2.0

The resulting dataset will likely consist of a matrix of values approximately 40 (samples) by 150 (chemicals and congeners). This degree of detail should enable adequate separation of the characteristics of each of the sites from the others.