Co-operative Freshwater Ecology Unit – 2004 Program

Nordic Fish Survey (2003 + 2004)

A survey of fish communities present in 25 Sudbury lakes was performed using the international standard Nordic Method. The Nordic multi-mesh gillnet method for fish biodiversity studies was developed for Scandinavian lakes which are similar to Canadian Shield lakes. Each net contains 12 different mesh sizes. This international standard uses a random depth-stratified design to provide accurate whole-lake estimates of species richness, relative abundance and biomass. Surveys require 2-8 days to complete depending on the size of the lake. Lakes included in this survey and their surface areas are as follows:

Ashigami (434.7 ha)
Bear (691.9 ha)
Caswell (39.8 ha)
Clearwater (76 ha)
Daisy (36.6 ha)
Fairbank (705.1ha)
Fraleck (166.3 ha)
Hannah (27.7 ha)
Joe (216.2 ha)
Kukagami (1864.8 ha)
Little Panache (102.9 ha)
Lohi (41.6 ha)
Long (861.3 ha)
Matagamasi (1317.1ha)
Massey/St. Jean (78.5 ha)
McFarlane (166.1 ha)
Middle (28.1 ha)
Nelson (308.8 ha)
Nepahwin (127 ha)
Ramsey (792.2 ha)
Sans Chamber (15 ha)
Silver (21.8 ha)
St. Charles (41.3 ha)
Vermillion (1126.6 ha)
Whitson (473.4 ha)

SES Intensive Monitoring Lakes

The intensive monitoring lakes are sampled once (and in some cases, twice) a month usually at the deepest location during the ice free season. The monitoring of some of these lakes goes back to the early 1970'sgenerating some of the longest acid rain monitoring records in the world. It is for this group of city lakes that we possess the longest running, most detailed, and largest collection of data. The intensive monitoring for these lakes includes water chemistry, zooplankton, phytoplankton, some benthic invertebrates, oxygen, temperature, and Secchi depth (a measure of water clarity). Lakes included in this monitoring group follow.

Clearwater (76 ha)
Daisy (36.6 ha)
Hannah (27.7 ha)
Joe (216.2 ha)
Lohi (41.6 ha)
Middle (28.1 ha)
Nelson (308.8 ha)
Swan (6 ha)
Sans Chamber (15 ha)

SES Extensive Monitoring Lakes

The extensive monitoring lakes are sampled for water quality once a year (usually at a mid-lake location) to monitor recovery from acidification and metal contamination due to Sudbury smelter emissions. This monitoring dates back to the early 1980's for some lakes. There are a total of 45 lakes included in this monitoring program, of which the following 11 are within the Greater City of Sudbury.

Clearwater (76 ha)
Crooked (26.3 ha)
Fraleck (166.3 ha)
Matagamasi (1317.1 ha)
Sans Chamber (15 ha)
Silver (21.8 ha)
Silvester (56.1 ha)
Tilton (51.7 ha)
Wanapitei (13256.8 ha)
Whitson (473.4 ha)
Wolf (87.5 ha)

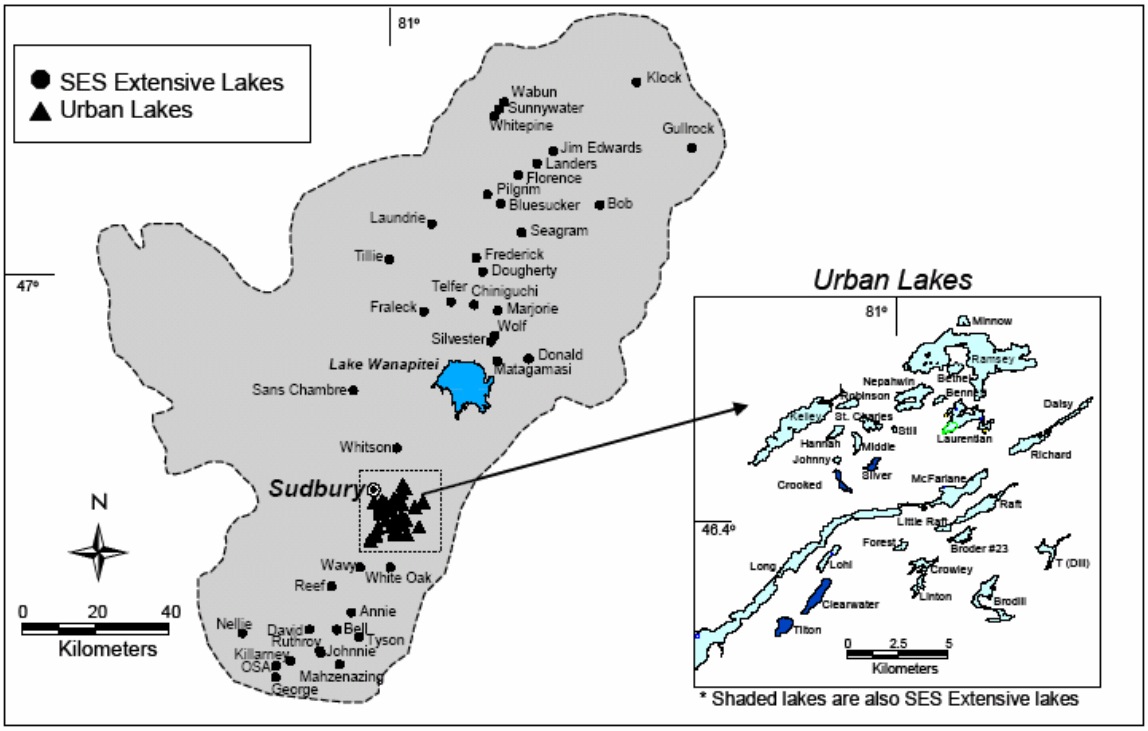


Fig. 1. The zone of lakes affected by Sudbury smelters (Neary et al., 1990)

Urban Lake Water Recovery (1990-2003)

This before and after study focused on 'Urban' lakes within the old boundary of the City of Sudbury, and compared water quality results from monitoring performed in 1990, with more recent results from 2003. The lakes included in this monitoring follow.

Bethel (31.2 ha)
Bennet (13.6 ha)
Broder #23 (36.9 ha)
Brodill (112.1 ha)
Clearwater (76 ha)
Lohi (41.6 ha)
Long (11.6 ha)
McFarlane (166.1 ha)
Middle (28.1 ha)
Minnow (20.9 ha)

Crooked (26.3 ha
Crowley (43.5 ha)
Daisy (36.6 ha)
Forest (15.8 ha)
Hannah (27.7 ha)
Johnny (8.1 ha)
Kelly (340.8 ha)
Laurentian (157 ha)
Linton (27.7 ha)
Little Raft (19.7 ha)
Raft (109.6 ha)
Ramsey (792.2 ha)
Richard (83.6 ha)
Robinson (33.6 ha)
Silver (21.8 ha)
St. Charles (41.3 ha)
Still (3.1 ha)
T (Dill) (44.4 ha)
Tilton (51.7 ha)

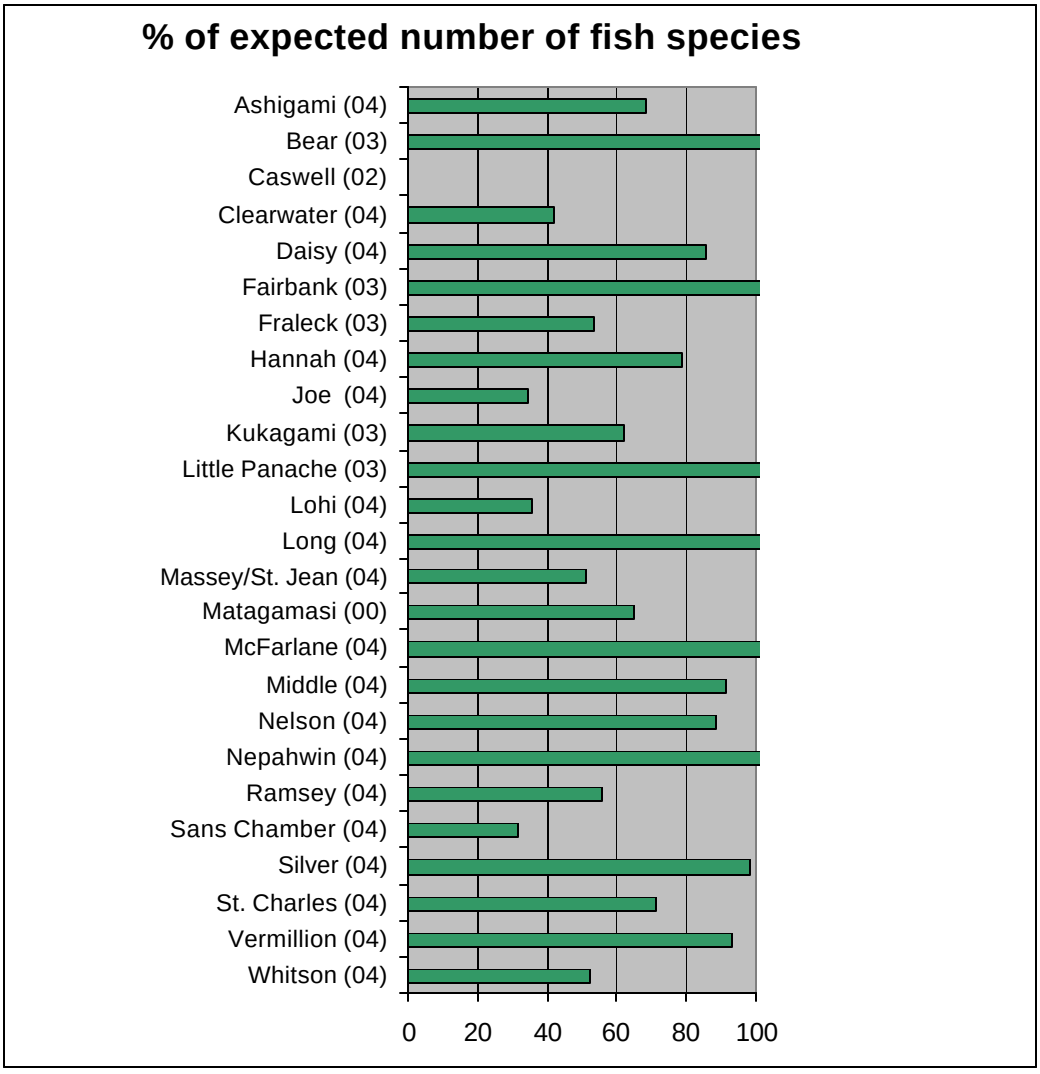


Fig. 2. A comparison of the number of species of fish in a lake with the number expected for a lake that size. The number of expected species is calculated with the following equation : Expected # of species = $0.99 + 4.59 \text{Log}_{10}\text{Area}$ (E. Snucins and J. Gunn).

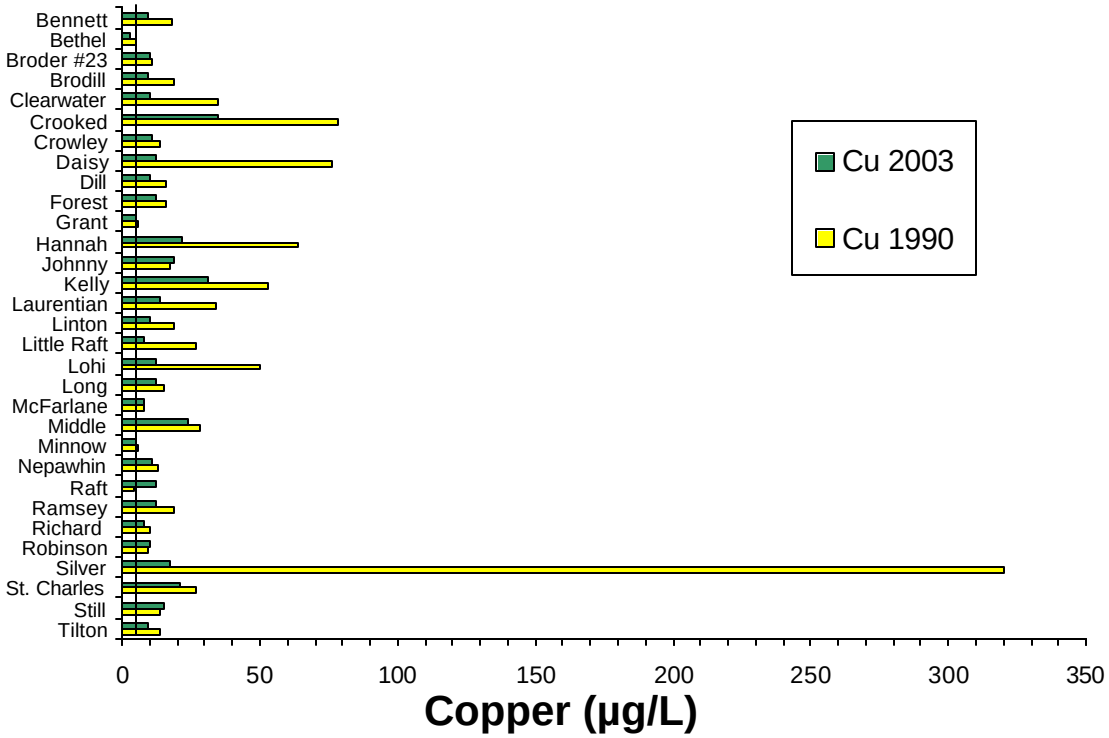


Fig.3. The change in lake water concentration of total copper in City of Greater Sudbury lakes. Lakes sampled in 1990 and again in 2000. Note: the Ontario Water Quality objective for Cu is 5 µg/L.

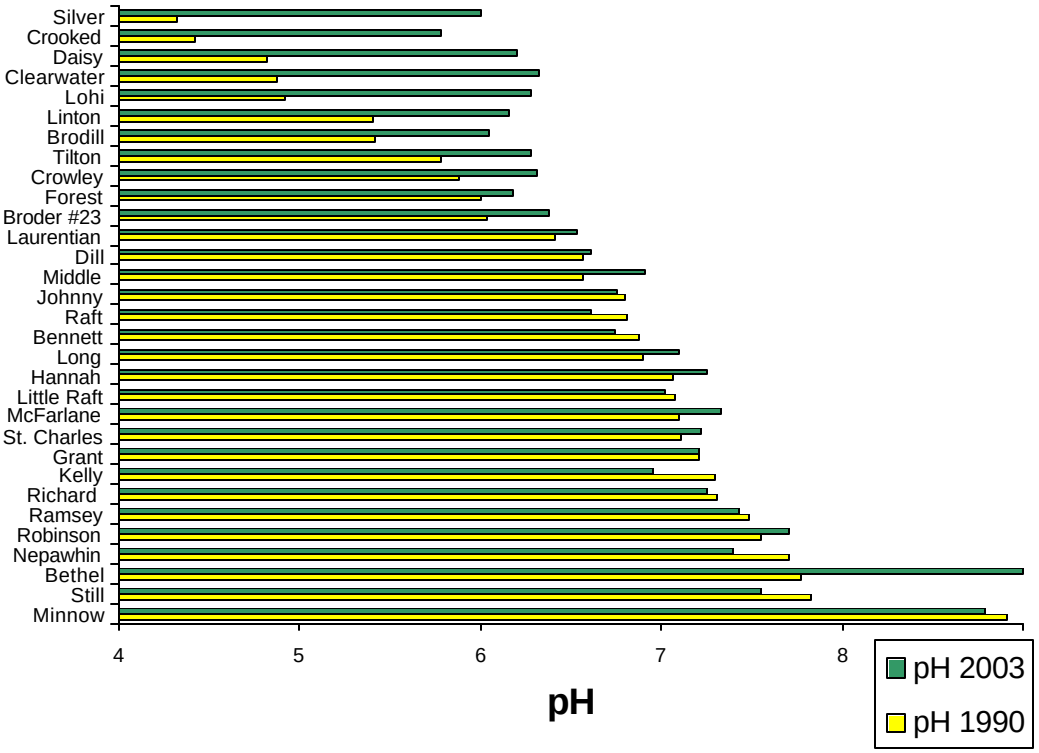


Fig. 4. Changes in pH (a measure of acidity) in a select lists of lakes in the Greater City of Sudbury between 1990 and 2003. Most aquatic organisms (fish and invertebrates) are protected if pH remains above 6.0.

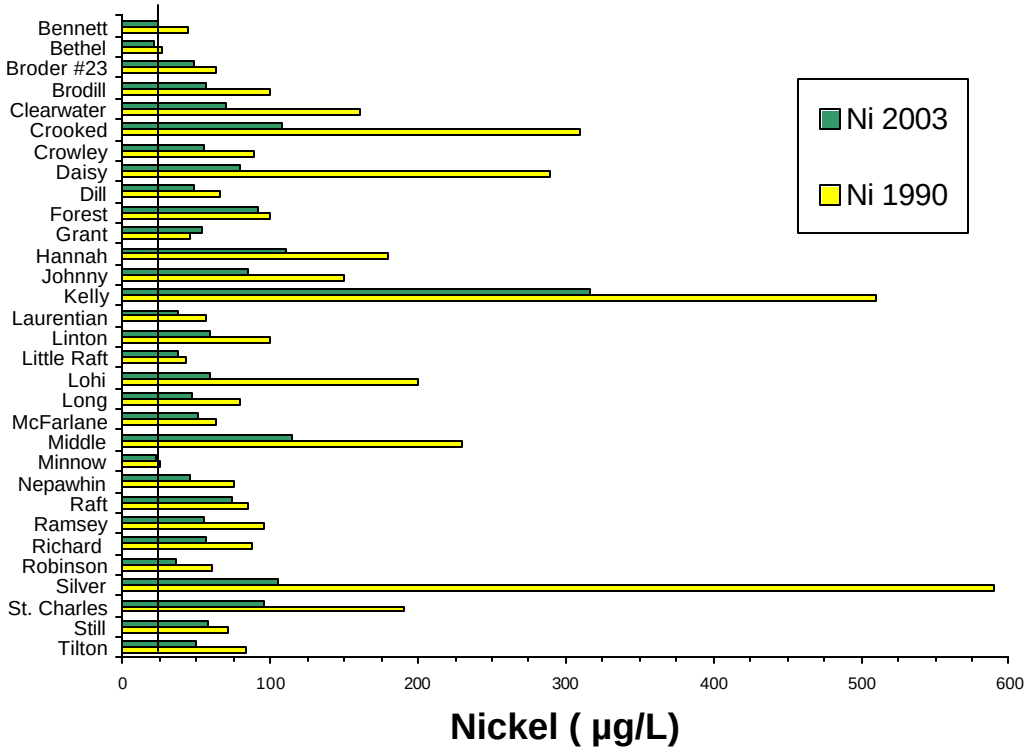
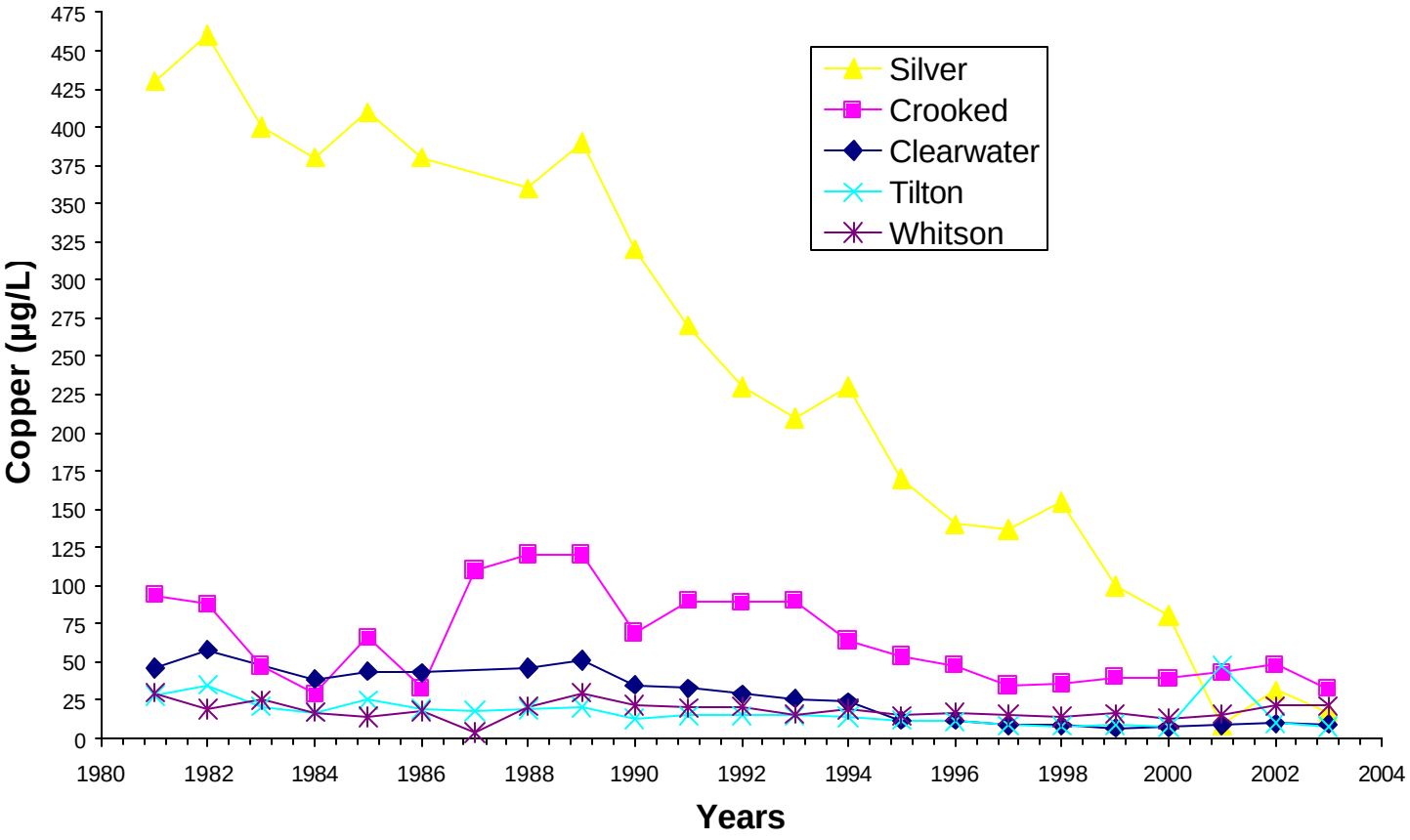
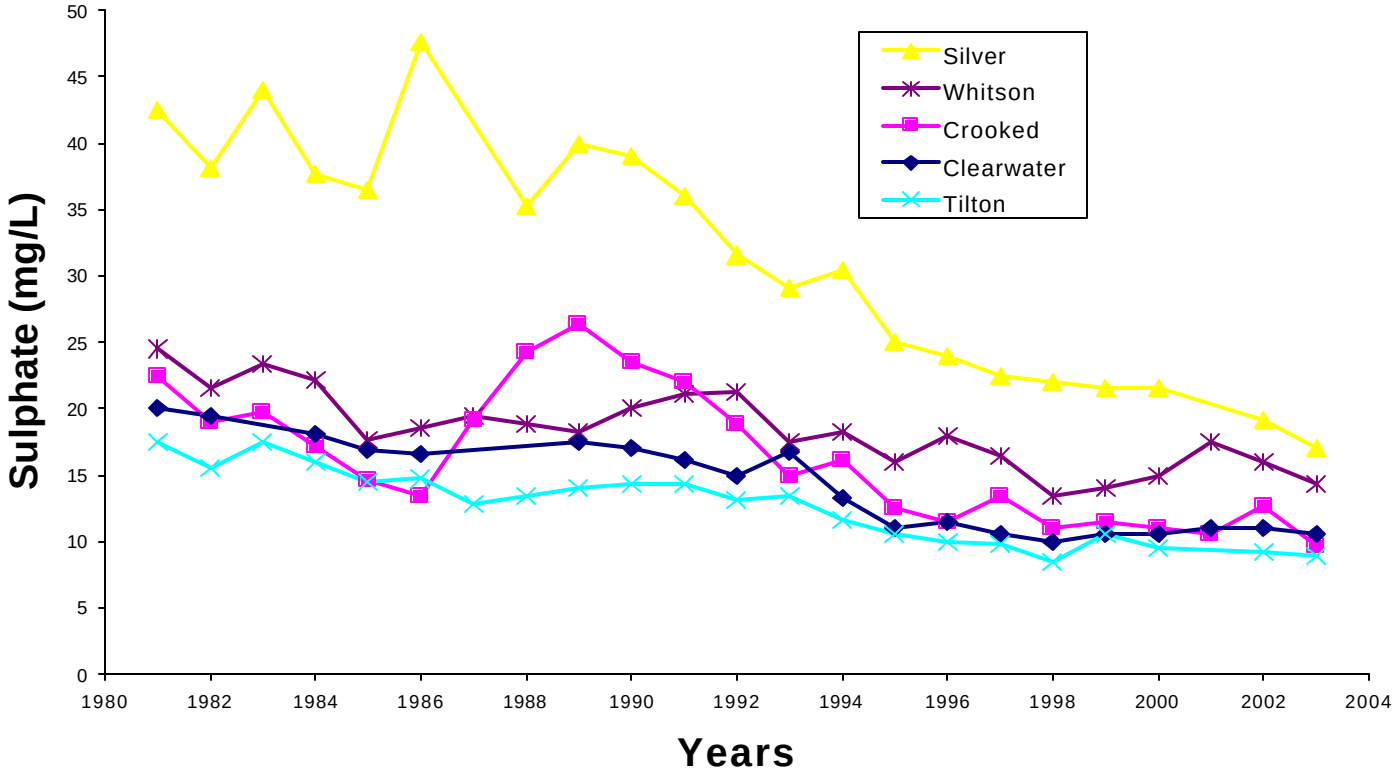
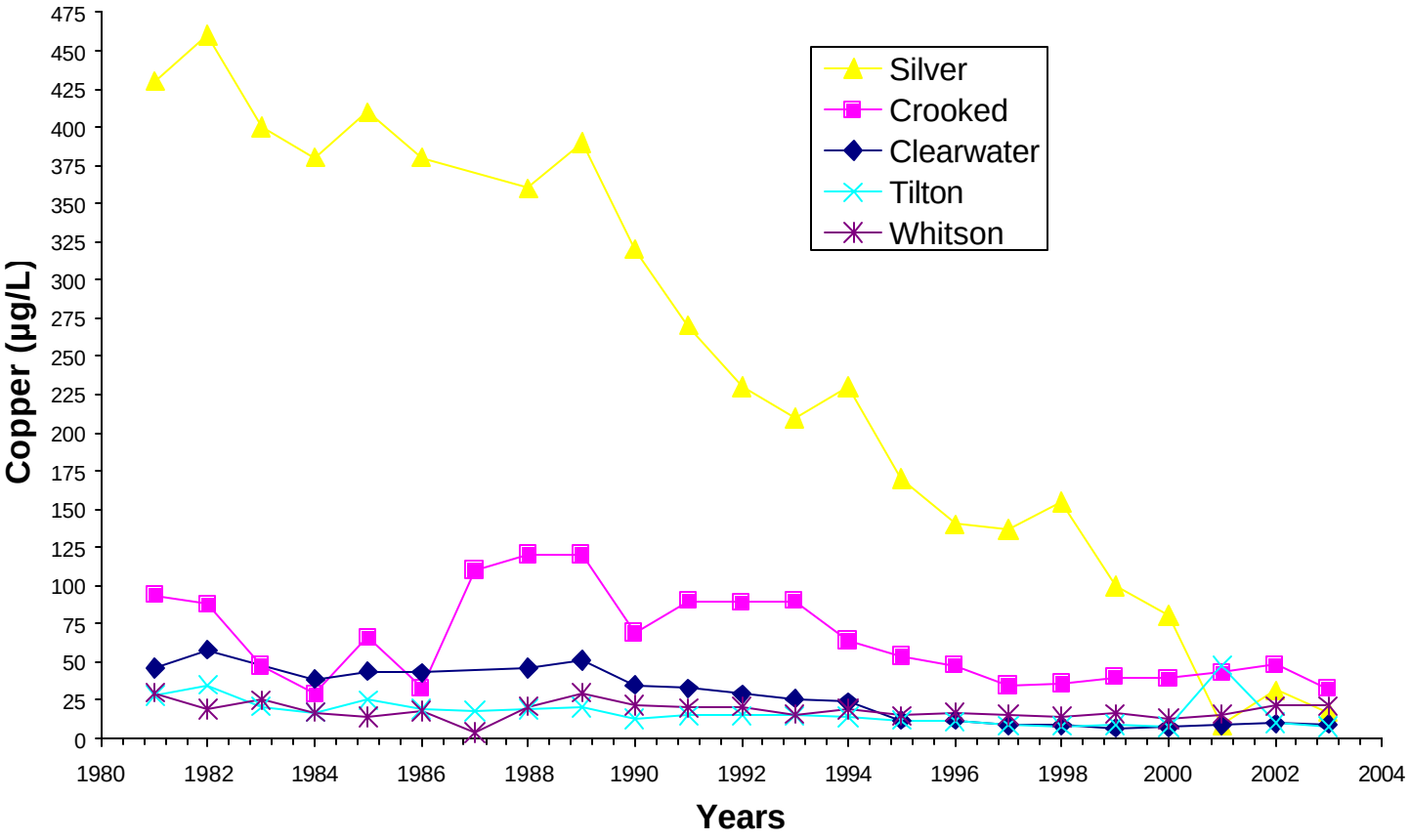


Fig. 5. The change in lake water concentration of total nickel in City of Greater Sudbury lakes. Lakes sampled in 1990 and again in 2000. Note: the Ontario Water Quality objective for Cu is 25 µg/L.


Copper (µg/L)
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Years
Silver
Crooked
Clearwater
Tilton
Whitson


Sulphate (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Years
Silver
Whitson
Crooked
Clearwater
Tilton


Copper (µg/L)
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
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25
0
1980
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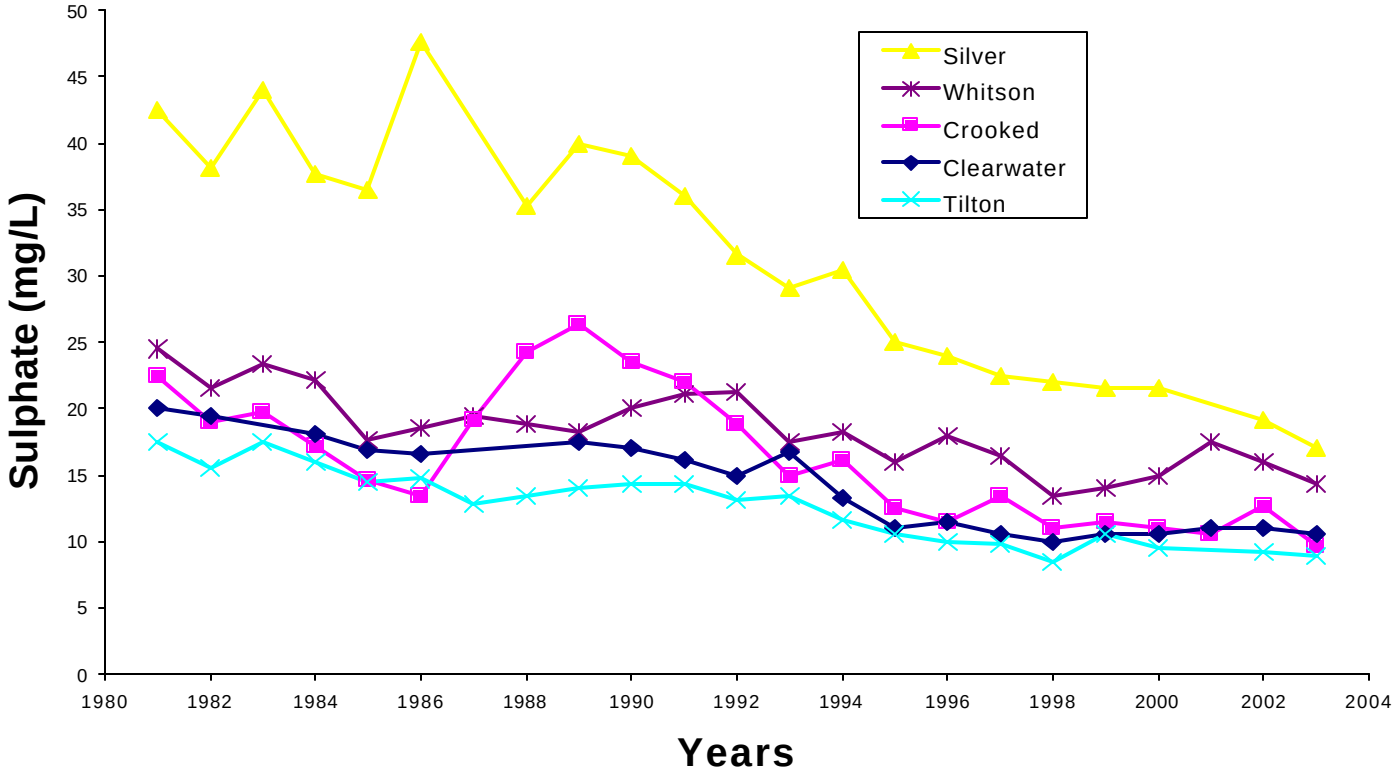
Years
Silver
Crooked
Clearwater
Tilton
Whitson


Sulphate (mg/L)
50
45
40
35
30
25
20
15
10
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0
1980
1982
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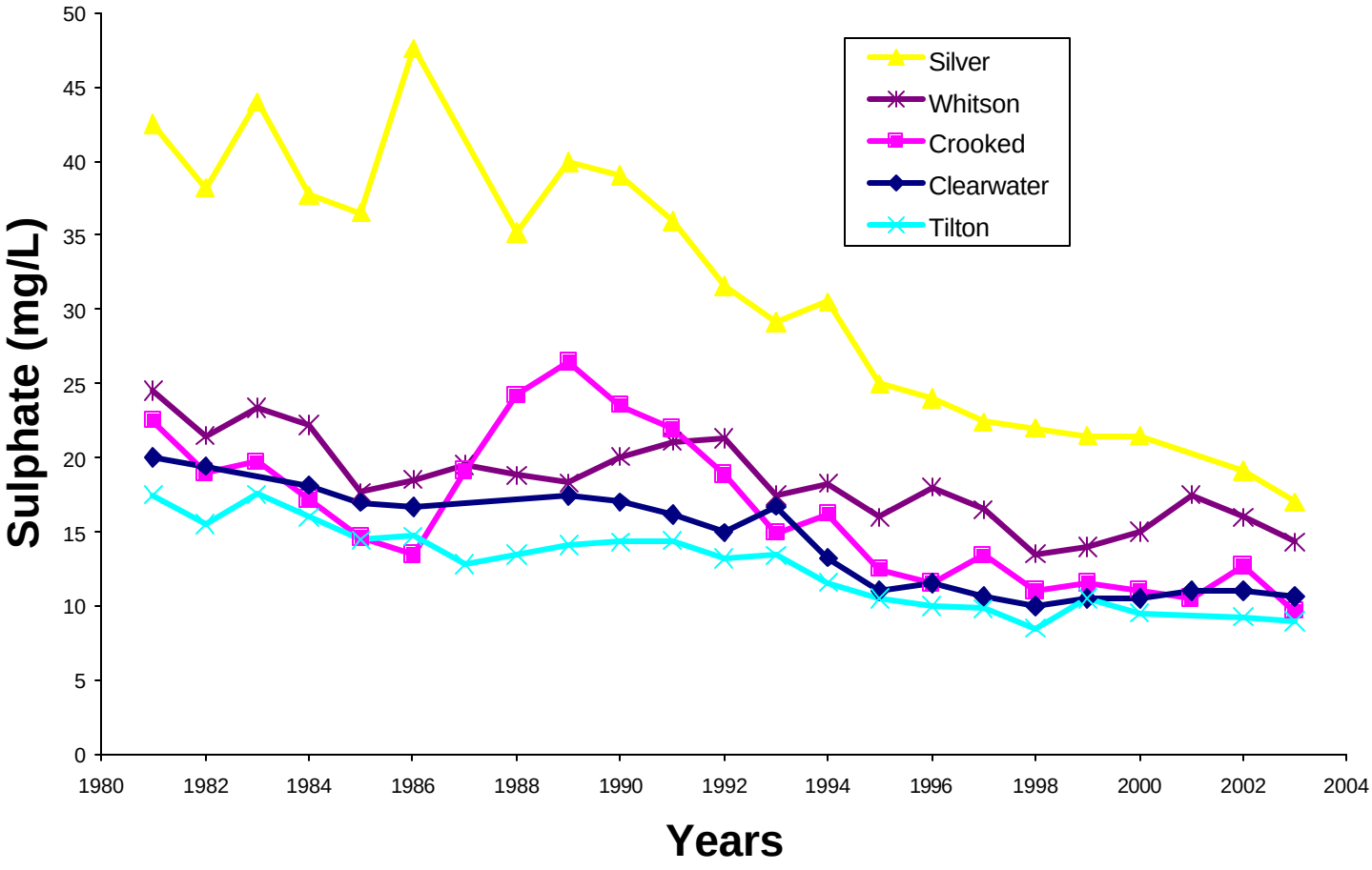
1994
1996
1998
2000
2002
2004
Years
Silver
Whitson
Crooked
Clearwater
Tilton


Sulphate (mg/L)
50
45
40
35
30
25
20
15
10
5
0
1980
1982
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1992
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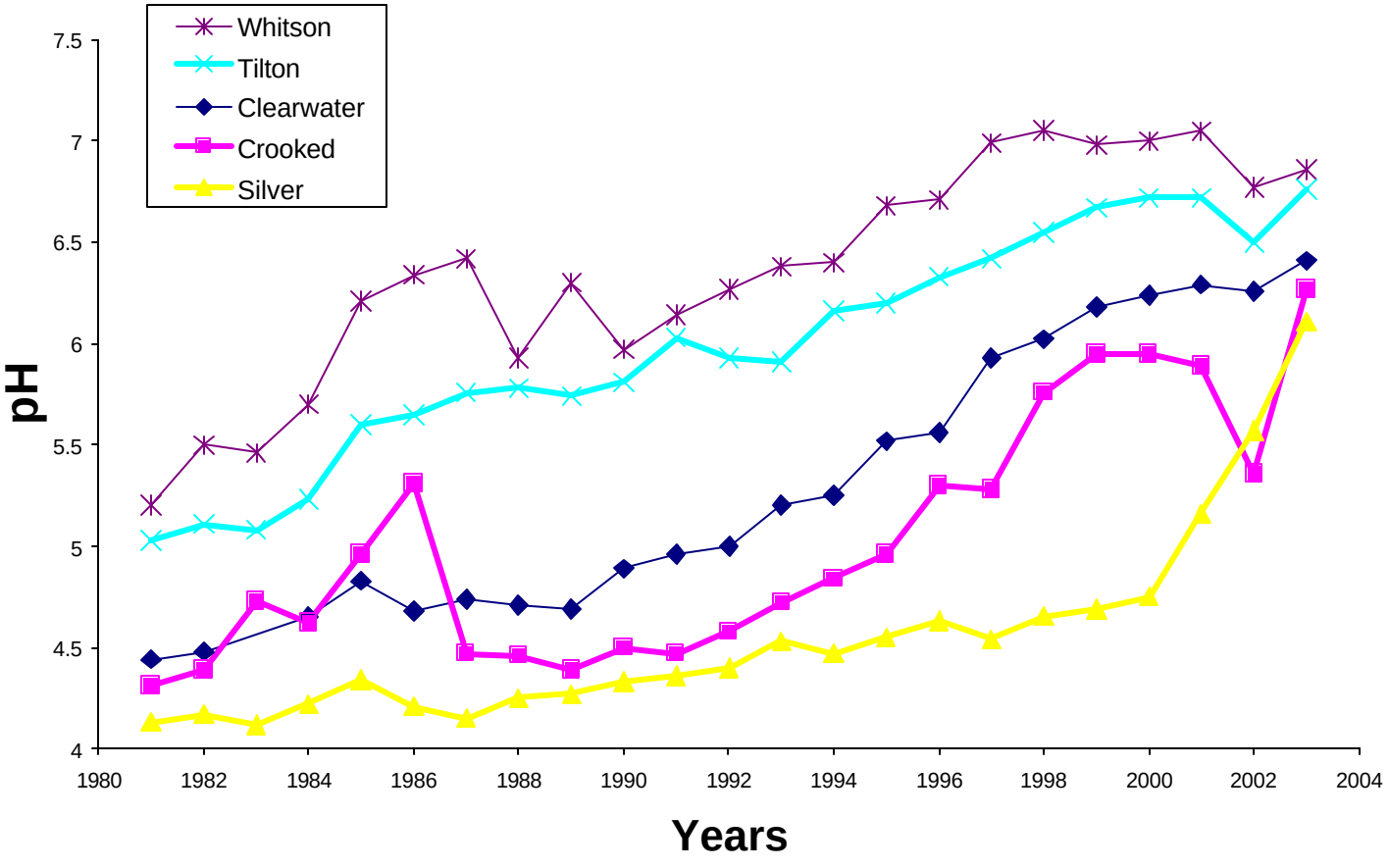
2002
2004
Years
Silver
Whitson
Crooked
Clearwater
Tilton


Whitson
Tilton
Clearwater
Crooked
Silver
pH
7.5
7
6.5
6
5.5
5
4.5
4
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Years

Fish Species Found in 25 Greater City of Sudbury Lakes.

Lakes surveyed with the Int. Nordic Multimesh Netting Standard Method during 2000-2004

Fish species	Ashigami	Bear	Caswell	Clearwater	Daisy	Fairbank	Fraleck	Hannah	Joe	Kukagami	Little Panache	Lohi	Long	Matagamasi
Blacknose dace		X												
Bluegill		X												
Bluntnose minnow		X				X					X			
Brown bullhead	X	X			X			X		X	X		X	X
Burbot		X								X				
Cisco (lake herring)		X				X					X		X	
Common shiner	X	X											X	
Creek chub									X				X	
Fathead minnow				X								X		
Golden shiner					X								X	X
Iowa darter						X		X					X	
Lake chub									X					
Lake trout		X				X	X			X				X
Lake whitefish		X				X				X				
Largemouth bass													X	
Logperch	X	X				X							X	
Mottled sculpin		X												
Ninespine stickleback						X								
Northern pike		X			X	X		X			X		X	X
Pearl dace										X				
Pumkinseed		X		X	X	X	X	X			X	X	X	
Rainbow smelt		X									X			
Rock bass	X	X				X				X	X			X
Slimy sculpin		X									X			
Smallmouth bass	X	X		X		X	X	X	X	X	X		X	X
Spoonhead sculpin						X								
Spottail shiner	X					X							X	X
Trout-perch		X												
Walleye	X	X			X	X	X			X	X		X	X
White sucker	X	X			X	X	X		X	X	X		X	X
Yellow perch	X	X		X	X	X	X	X		X	X	X	X	X
Number of Species	9	21	0	4	7	16	6	6	4	10	12	3	15	10

****Data for Bear, Clearwater, Fairbank, Fralek, Kukagami, and Little Panache is from 2003

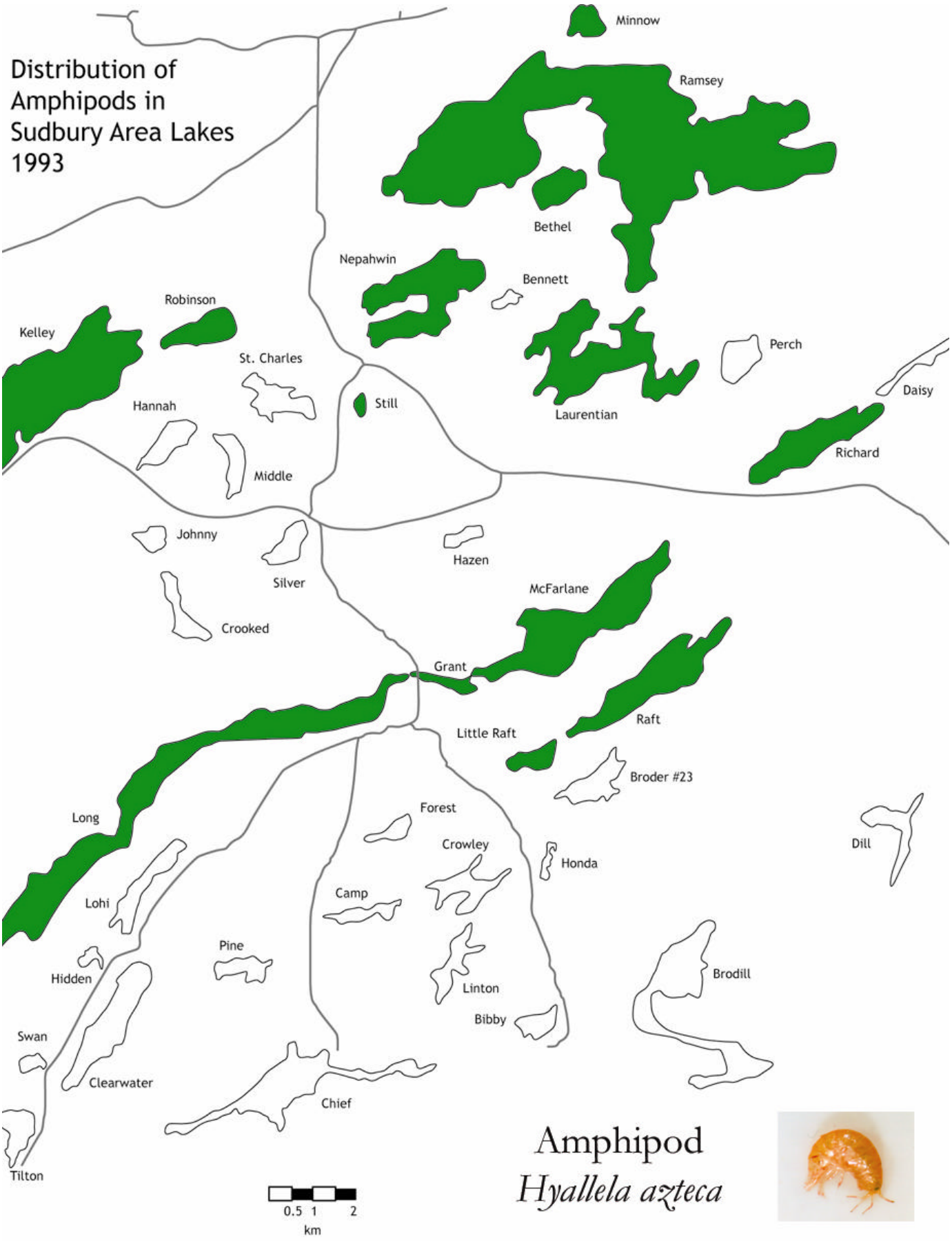
****Data for Caswell is from 2002 and data for Matagamasi is from 2000

****Additional data from 1989/90 for Long Lake was used because of a less than complete survey in 2004

****All other lake data is from 2004

Fish species	Massey	McFarlane	Middle	Nelson	Nepahwin	Ramsey	Sans Chamber	Silver	St.Charles	Vermillion	Whitson
Blacknose dace											
Blacknose shiner					X					X	
Bluegill									X		
Bluntnose minnow											
Brown bullhead	X	X	X	X	X	X	X	X	X	X	X
Burbot				X							
Cisco (lake herring)		X								X	
Common shiner		X		X						X	
Creek chub				X				X			
Emerald shiner		X									
Fathead minnow								X			
Finescale dace								X			
Golden shiner					X						
Iowa darter			X	X							
Lake chub				X							
Lake trout				X							
Lake whitefish											
Largemouth bass		X									
Logperch		X								X	
Mottled sculpin											
Ninespine stickleback											
Northern pike	X	X	X		X	X		X	X	X	X
Northern redbelly dace								X			
Pearl dace								X			
Pumkinseed		X	X		X	X			X	X	X
Rainbow smelt					X						
Rock bass					X	X				X	
Slimy sculpin											
Smallmouth bass		X	X	X	X	X	X			X	X
Splake					X						
Spottail shiner		X								X	
Trout-perch										X	
Walleye	X	X	X			X			X	X	X
White sucker	X	X		X	X	X				X	X
Yellow perch	X	X	X	X	X	X			X	X	X
Number of Species	5	13	7	10	11	8	2	7	6	14	7

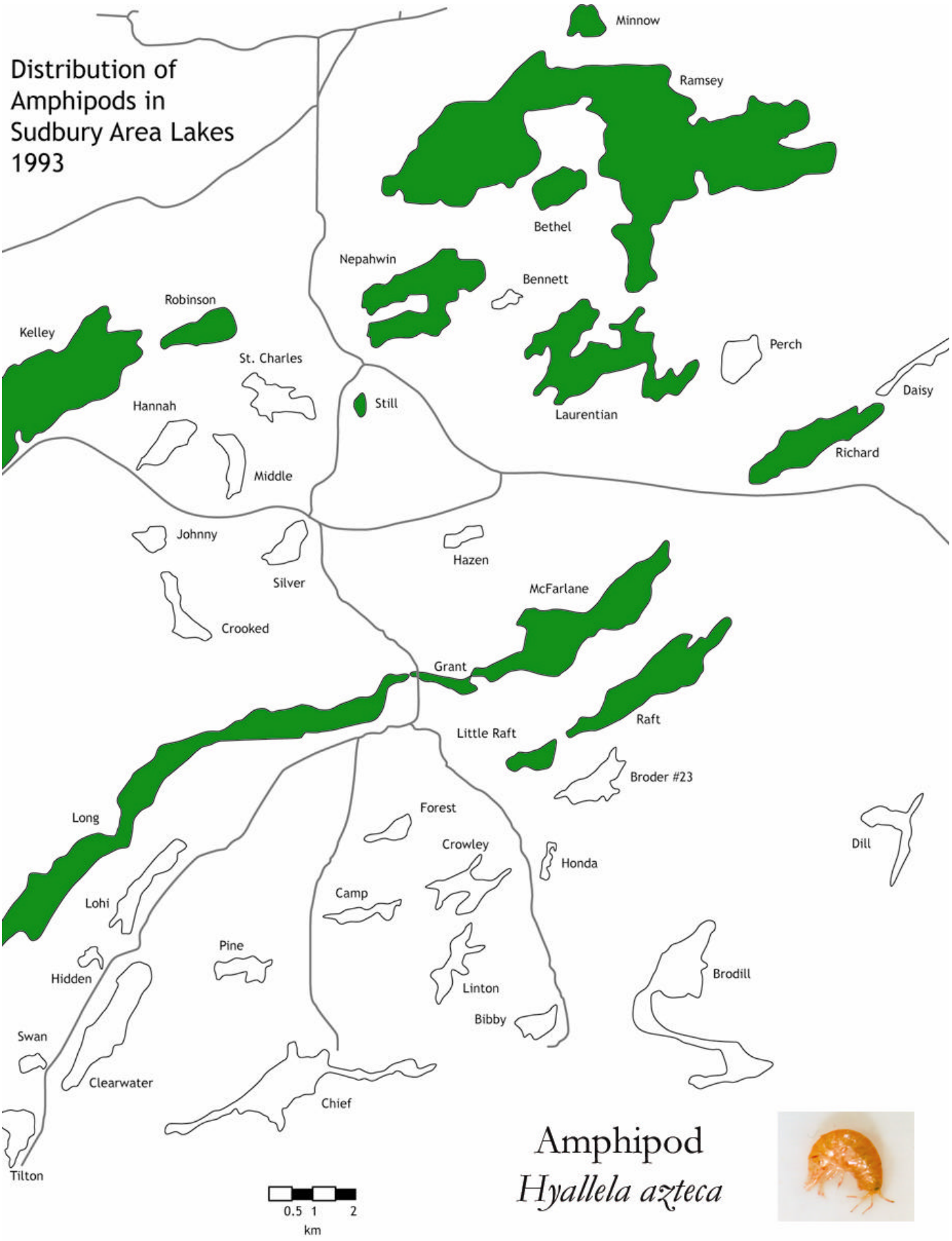
Distribution of Amphipods in Sudbury Area Lakes 1993



Amphipod

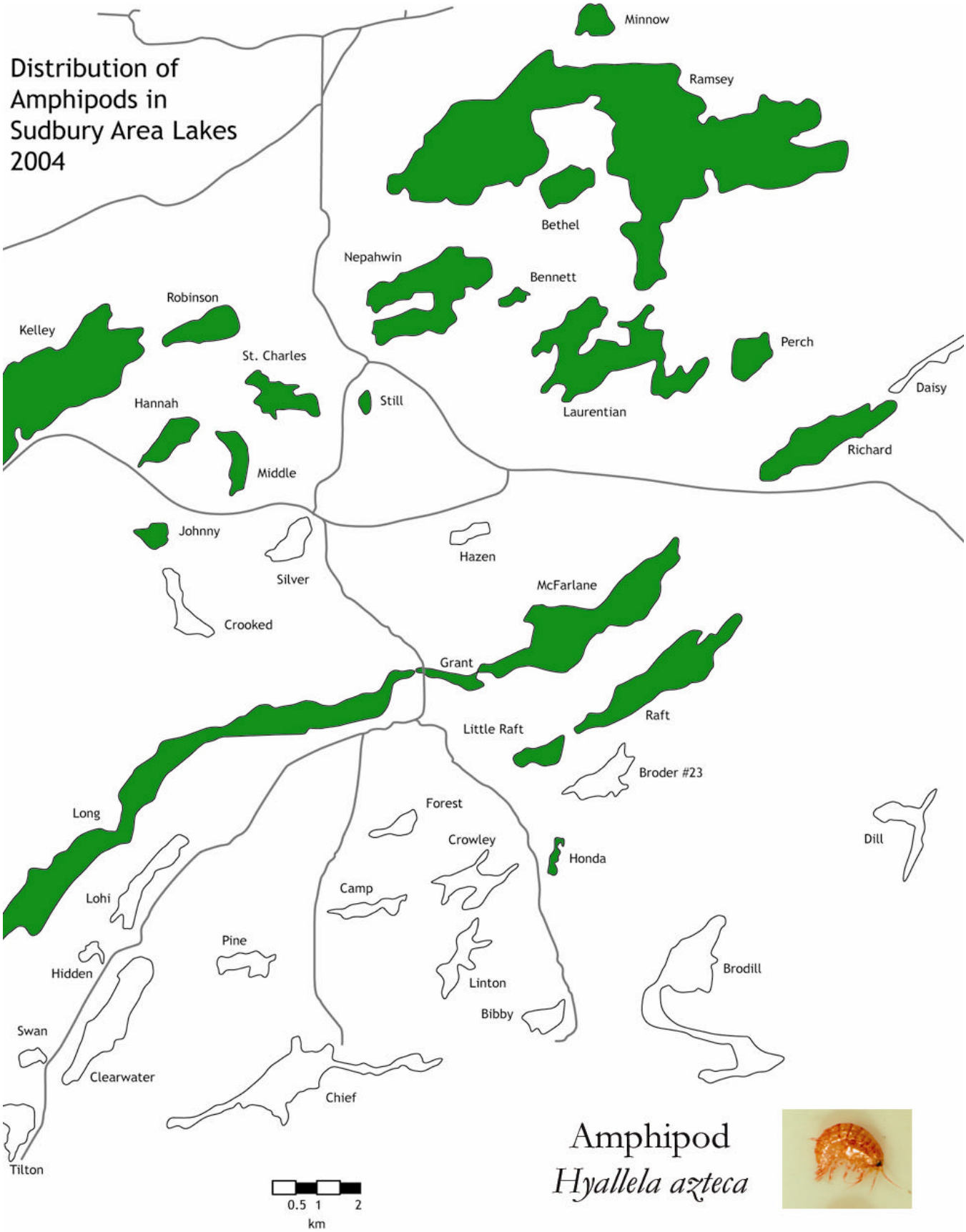
Hyallela azteca

Distribution of Amphipods in Sudbury Area Lakes 1993



Amphipod

Hyallela azteca


Distribution of Amphipods in Sudbury Area Lakes 2004
Minnow
Ramsey
Bethel
Nepahwin
Bennett
Robinson
Kelley
St. Charles
Perch
Daisy
Hannah
Still
Laurentian
Richard
Middle
Johnny
Hazen
Silver
McFarlane
Crooked
Grant
Raft
Little Raft
Broder #23
Long
Forest
Crowley
Honda
Dill
Lohi
Camp
Pine
Brodill
Hidden
Linton
Bibby
Swan
Clearwater
Chief
Tilton
0.5 1 2
km
Amphipod
Hyallela azteca

Appendix 1- Water Chemistry

Water chemistry data for 31 lakes in the core area of the City of Greater Sudbury in 1990 and 2003. Non-volume-weighted, tygon tube composite samples through the epilimnion and metalimnion were taken during midsummer at a single deep basin in each lake. Analyses were conducted by the Ontario Ministry of the Environment.

Appendix 2 – Sediment Chemistry

Results of analyses of sediment samples from 11 Sudbury area lakes sampled in the mid-1990's (W. Keller, Ontario Ministry of the Environment). Samples represent the top 2 cm of sediment collected with an Ekman dredge. Three replicate samples were taken in a single deep basin in each lake. Analyses were conducted by the Ontario Ministry of the Environment.

Appendix 3 – Fish Species

Fish species present in 17 recently surveyed (2000-2003) lakes within the City of Greater Sudbury. Sampling conducted using the Nordic multimesh gillnets.

Appendix 4 – Walleye Harvest Statistics

Sudbury area late winter creel survey summary statistics for 4 walleye lakes. Creel survey conducted from March 1 to April 15, 2003.

Appendix 5 – Zooplankton Species

Crustacean zooplankton species collected in 32 lakes in the City of Greater Sudbury in 1990 and 2003. Samples were single vertical net hauls with an 80 u mesh, 30 cm-mouth-diameter, nonmetered net. Single samples were taken during midsummer at a single deep basin in each lake.

Appendix 1 - Water Chemistry

	Bennett		Bethel		Broder #23		Brodill		Clearwater		Crooked		Crowley		Daisy		Dill	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
pH	6.88	6.74	7.77	9.00	6.04	6.38	5.42	6.05	4.88	6.33	4.43	5.78	5.88	6.31	4.82	6.20	6.57	6.61
Conductivity (µS/cm)	32.6	27.2	401.5	255.0	42.3	29.2	38.9	27.2	80.5	61.0	84.0	54.2	35.2	27.6	55.0	35.4	47.6	37.4
Alkalinity (mg/L)	6.39	6.06	48.40	50.42	2.72	2.45	0.14	0.94	-0.85	1.19	-2.40	1.33	1.69	2.10	-0.88	2.02	3.74	4.46
Ca (mg/L)	3.39	2.44	17.90	13.50	3.24	2.34	2.88	1.94	6.10	4.30	5.20	2.50	3.30	3.28		2.58	3.52	2.84
Mg (mg/L)	1.10	0.85	7.32	5.45	1.16	0.84	1.05	0.75	1.36	1.09	1.60	1.05	0.98	0.76		1.23	1.64	1.29
Na (mg/L)	1.08	0.96	50.90	27.20	0.96	0.94	1.02	0.93	3.14	4.00	1.96	1.94	1.02	0.95		1.09	1.45	1.70
K (mg/L)	0.640	0.395	2.320	1.840	0.600	0.445	0.560	0.420	0.640	0.575	0.770	0.685	0.540	0.435		0.420	0.710	0.545
Cl (mg/L)	<0.8	0.67	92.30	39.23	<0.60	0.36	<0.40	0.43	9.10	8.00	3.30	2.48	<0.60	0.35	<0.70	0.73	1.70	2.59
SO_4 (mg/L)	11.52	3.71	9.28	7.32	11.09	8.10	12.20	8.17	16.74	10.70	23.35	9.55	11.94	7.85	19.08	10.43	10.22	6.54
SiO_3 (mg/L)	<0.22	1.10	1.12	0.68	0.98	0.96	1.70	1.26	0.76	1.10	2.26	0.98	1.34	0.92		1.40	<0.10	0.60
Al (µg/L)	<30	14	<40	30	<30	23	<100	47	130	16	230	87	<50	26	360	30	<60	48
As (µg/L)		<2.0		<0.5		<=0.5		<=0.5		<=0.5		<0.5		<=0.5		<=0.5		<=0.5
Ba (µg/L)		11.3		26.8		15.6		15.8		17.6		17.8		14.5		16.0		11.4
Be (µg/L)		<=0.03		<=0.03		<=0.03		0.03		<=0.03		0.03		<=0.03		<=0.03		<=0.03
Cd (µg/L)		<=1.0		<=1.0		<=1.0		<=1.0		<=0.6		<=0.8		<=0.6		<=0.6		<=0.6
Cr (µg/L)		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.7		<=1.0
Co (µg/L)		<=1.5		<=1.5		<=1.5		<=1.5		<=1.5		2.4		<=1.5		<=1.5		<=1.5
Cu (µg/L)	18	9	5	3	11	10	19	9	35	10	78	35	14	11	76	12	16	10
Fe (µg/L)	370	319	120	99	170	36	<80	60	<60	15	350	781	110	49	<80	36	370	331
Mn (µg/L)	9	15	270	127	48	28	89	44	250	26	160	58	71	32	150	24	17	32
Mo (µg/L)		<=1.6		<=1.6		<=1.6		<=1.6		<=0.8		<=1.5		<=0.8		<=1.9		<=0.8
Ni (µg/L)	44	24	26	21	63	49	100	56	160	70	310	108	89	55	290	80	66	49
Pb (µg/L)	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<8	<=11	<=5	<=11	<=5	<=11	<=5	<=11
Se (µg/L)		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5
Sr (µg/L)		12.0		45.9		13.8		14.7		21.7		14.2		13.4		12.9		16.0
Ti (µg/L)		1.54		1.53		1.64		1.44		<=0.30		0.70		1.39		1.06		1.67
V (µg/L)		<=1.5		<=1.5		<=1.5		<=1.5		<=0.9		<=1.0		<=0.9		<=2.0		<=0.9
Zn (µg/L)	6	3	<1	1	7	5	12	14	23	11	29	11	9	6	17	6	7	5
P (µg/L)	21	32	156	56	<2	6	<6	6	<=2	5	<7	19	<7	9	2	9	17	19
NH_3+NH_4 (µg/L)	54	168	234	468	122	60	30	36	26		86	52	36	36	<=2		34	76
NO_2 (µg/L)	<=1		6		9		7		<3		<2		<2		<=1		9	
NO_3+NO_2 (µg/L)	<=5	8	<=5	50	<5	20	65	36	<5		<=5	14	<10	6	<10		<5	8
TKN (µg/L)	540	459	1620	3320	340		200	200	140	233	230	354	250	218			430	388
DOC (mg/L)	5.0	8.0	7.3	7.7	2.8	3.0	2.2	3.2	0.5	2.9	<0.2	5.3	2.9	3.3		2.0	5.9	6.4

Appendix 1 - Water Chemistry

	Forest		Grant		Hannah		Johnny		Kelley		Laurentian		Linton		Little Raft	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
pH	6.01	6.18	7.21	7.21	7.06	7.25	6.80	6.76	7.30	6.95	6.41	6.53	5.41	6.16	7.08	7.02
Conductivity (µS/cm)	41.0	36.4	310.0	355.0	359.0	190.0	310.0	297.0	1720.0	1690.0	33.5	129.0	40.2	24.0	51.0	39.4
Alkalinity (mg/L)	0.95	1.48	34.71	39.18	12.10	16.93	6.25	13.22	64.77	41.49	3.43	3.23	0.56	1.10	8.17	6.31
Ca (mg/L)	3.94	2.94	17.70	15.70	13.40	10.60	13.10	9.22	204.00	274.00	2.28	3.44	3.20	2.08	4.39	3.30
Mg (mg/L)	1.02	1.00	5.24	4.82	4.56	3.57	4.14	2.96	22.00	43.50	1.08	1.35	0.94	0.71	1.48	1.13
Na (mg/L)	1.22	1.52	35.10	49.90	44.60	62.80	38.10	42.70	122.00	112.00	1.26	17.20	1.02	0.98	1.34	1.55
K (mg/L)	0.580	0.515	1.570	2.540	1.980	1.660	1.160	0.940	18.400	20.100	0.720	0.710	0.520	0.375	0.730	0.535
Cl (mg/L)	1.50	1.79	58.50	79.77	76.30	91.90	30.70	78.86	114.00	107.00	<0.90	33.01	<0.50	0.30	<0.50	1.45
SO_4 (mg/L)	12.13	14.55	17.87	13.65	28.98	16.60	26.18	12.30	621.31		6.60	5.25	12.97	8.11	9.44	7.78
SiO_3 (mg/L)	0.68	1.06	0.74	0.60	0.38	0.26	0.46	1.26	3.22	1.98	0.42	0.34	0.88	0.66	2.02	0.86
Al (µg/L)	<30	27	<=10	7	200	13	<=10	31	150	32	<90	38	<80	34	10	9
As (µg/L)		<=0.5		<1.0		<1.0		<1.0		<1.0		<=0.5		<=0.5		<1.0
Ba (µg/L)		22.0		29.0		21.9		29.3		37.9		11.0		14.4		14.6
Be (µg/L)		<=0.03		<=0.03		<=0.03		<=0.03		0.04		<=0.03		<=0.03		<=0.03
Cd (µg/L)		<=0.6		<=0.6		<=0.6		<=1.0		<=0.6		<=0.6		<=0.6		<=1.0
Cr (µg/L)		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0
Co (µg/L)		<=1.5		1.9		<=1.5		<=1.5		14.0		<=1.5		<=1.5		<=1.5
Cu (µg/L)	16	12	6	5	64	22	17	19	53	31	34	14	19	10	27	8
Fe (µg/L)	<70	50	<=20	161	290	114	270	656	950	249	650	585	<90	50	350	82
Mn (µg/L)	77	39	720	1020	38	70	28	168	190	102	19	30	61	25	24	27
Mo (µg/L)		<=0.8		<=0.8		<=1.2		<=1.6		<=0.8		<=0.8		<=0.8		<=1.6
Ni (µg/L)	100	91	46	53	180	111	150	85	510	317	56	37	100	59	43	38
Pb (µg/L)	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11
Se (µg/L)		<=0.5		<=0.5		<=0.5		<=0.5		<1.0		<=0.5		<=0.5		<=0.5
Sr (µg/L)		17.2		53.5		57.3		50.1		425.0		17.7		12.6		18.1
Ti (µg/L)		1.23		1.12		<=0.30		2.17		<=0.30		2.19		1.66		1.56
V (µg/L)		<=0.9		<=0.9		<=1.5		<=1.5		<=0.9		<=0.9		1.0		<=1.5
Zn (µg/L)	11	10	<1	5	11	3	6	3	15	14	7	2	11	7	6	2
P (µg/L)	<=2	6	<=20	36	21	8	<9	14	88	39	39	33	<6	8	35	15
NH_3+NH_4 (µg/L)	18	24	<6	122	20	66	42	262		742	70	116	48	34	36	86
NO_2 (µg/L)	<=1		<=1		6		<=1		139		12		<3		5	
NO_3+NO_2 (µg/L)	<20	6	<=5	22	<=5	<6	<5	12	1490	126	<10	30	<15	8	<=5	8
TKN (µg/L)	<150	211	325	400	430	418	780	503	5200	5420	740	533	260	207	575	331
DOC (mg/L)	3.2	3.1	4.1	4.8	3.8	3.6	5.1	5.3	4.5	4.3	6.9	6.1	2.9	3.0	2.5	3.5

Appendix 1 - Water Chemistry

	Forest		Grant		Hannah		Johnny		Kelley		Laurentian		Linton		Little Raft	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
pH	6.01	6.18	7.21	7.21	7.06	7.25	6.80	6.76	7.30	6.95	6.41	6.53	5.41	6.16	7.08	7.02
Conductivity (µS/cm)	41.0	36.4	310.0	355.0	359.0	190.0	310.0	297.0	1720.0	1690.0	33.5	129.0	40.2	24.0	51.0	39.4
Alkalinity (mg/L)	0.95	1.48	34.71	39.18	12.10	16.93	6.25	13.22	64.77	41.49	3.43	3.23	0.56	1.10	8.17	6.31
Ca (mg/L)	3.94	2.94	17.70	15.70	13.40	10.60	13.10	9.22	204.00	274.00	2.28	3.44	3.20	2.08	4.39	3.30
Mg (mg/L)	1.02	1.00	5.24	4.82	4.56	3.57	4.14	2.96	22.00	43.50	1.08	1.35	0.94	0.71	1.48	1.13
Na (mg/L)	1.22	1.52	35.10	49.90	44.60	62.80	38.10	42.70	122.00	112.00	1.26	17.20	1.02	0.98	1.34	1.55
K (mg/L)	0.580	0.515	1.570	2.540	1.980	1.660	1.160	0.940	18.400	20.100	0.720	0.710	0.520	0.375	0.730	0.535
Cl (mg/L)	1.50	1.79	58.50	79.77	76.30	91.90	30.70	78.86	114.00	107.00	<0.90	33.01	<0.50	0.30	<0.50	1.45
SO_4 (mg/L)	12.13	14.55	17.87	13.65	28.98	16.60	26.18	12.30	621.31		6.60	5.25	12.97	8.11	9.44	7.78
SiO_3 (mg/L)	0.68	1.06	0.74	0.60	0.38	0.26	0.46	1.26	3.22	1.98	0.42	0.34	0.88	0.66	2.02	0.86
Al (µg/L)	<30	27	<=10	7	200	13	<=10	31	150	32	<90	38	<80	34	10	9
As (µg/L)		<=0.5		<1.0		<1.0		<1.0		<1.0		<=0.5		<=0.5		<1.0
Ba (µg/L)		22.0		29.0		21.9		29.3		37.9		11.0		14.4		14.6
Be (µg/L)		<=0.03		<=0.03		<=0.03		<=0.03		0.04		<=0.03		<=0.03		<=0.03
Cd (µg/L)		<=0.6		<=0.6		<=0.6		<=1.0		<=0.6		<=0.6		<=0.6		<=1.0
Cr (µg/L)		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0
Co (µg/L)		<=1.5		1.9		<=1.5		<=1.5		14.0		<=1.5		<=1.5		<=1.5
Cu (µg/L)	16	12	6	5	64	22	17	19	53	31	34	14	19	10	27	8
Fe (µg/L)	<70	50	<=20	161	290	114	270	656	950	249	650	585	<90	50	350	82
Mn (µg/L)	77	39	720	1020	38	70	28	168	190	102	19	30	61	25	24	27
Mo (µg/L)		<=0.8		<=0.8		<=1.2		<=1.6		<=0.8		<=0.8		<=0.8		<=1.6
Ni (µg/L)	100	91	46	53	180	111	150	85	510	317	56	37	100	59	43	38
Pb (µg/L)	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11
Se (µg/L)		<=0.5		<=0.5		<=0.5		<=0.5		<1.0		<=0.5		<=0.5		<=0.5
Sr (µg/L)		17.2		53.5		57.3		50.1		425.0		17.7		12.6		18.1
Ti (µg/L)		1.23		1.12		<=0.30		2.17		<=0.30		2.19		1.66		1.56
V (µg/L)		<=0.9		<=0.9		<=1.5		<=1.5		<=0.9		<=0.9		1.0		<=1.5
Zn (µg/L)	11	10	<1	5	11	3	6	3	15	14	7	2	11	7	6	2
P (µg/L)	<=2	6	<=20	36	21	8	<9	14	88	39	39	33	<6	8	35	15
NH_3+NH_4 (µg/L)	18	24	<6	122	20	66	42	262		742	70	116	48	34	36	86
NO_2 (µg/L)	<=1		<=1		6		<=1		139		12		<3		5	
NO_3+NO_2 (µg/L)	<20	6	<=5	22	<=5	<6	<5	12	1490	126	<10	30	<15	8	<=5	8
TKN (µg/L)	<150	211	325	400	430	418	780	503	5200	5420	740	533	260	207	575	331
DOC (mg/L)	3.2	3.1	4.1	4.8	3.8	3.6	5.1	5.3	4.5	4.3	6.9	6.1	2.9	3.0	2.5	3.5

Appendix 1 - Water Chemistry

	Lohi		Long		McFarlane		Middle		Minnow		Nepahwin		Raft		Ramsey	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
pH	4.92	6.28	6.90	7.10	7.10	7.33	6.57	6.91	8.91	8.79	7.71	7.40	6.81	6.61	7.48	7.43
Conductivity (µS/cm)	90.8	71.6	161.0	184.0	314.0	380.0	258.0	286.0	2000.0	575.0	500.0	418.0	50.4	37.8	300.0	357.0
Alkalinity (mg/L)	-0.69	2.57	13.79	16.83	31.68	33.72	5.78	11.71	40.74	45.22	30.91	37.93	3.75	3.72	23.74	30.26
Ca (mg/L)	6.18	4.34	10.20	8.46	16.40	15.70	10.30	11.00	24.80	19.40	20.50	19.10	4.08	3.18	15.40	15.20
Mg (mg/L)	1.75	1.31	3.10	2.79	5.08	4.75	3.53	3.21	6.02	4.65	6.57	6.23	1.46	1.11	4.82	4.33
Na (mg/L)	3.89	5.71	14.20	22.40	33.50	52.50	29.70	40.30	82.50	79.50	70.70	82.30	1.05	1.17	31.80	47.80
K (mg/L)	0.850	0.720	1.120	1.430	1.610	1.810	1.510	0.730	1.930	1.280	2.540	2.910	0.640	0.505	1.610	1.470
Cl (mg/L)	10.30	10.78	24.80	36.44	58.10	86.35	50.30	66.29	134.00	153.23	115.00	134.00	<0.90	0.69	56.30	80.13
SO_4 (mg/L)	19.57	10.39	18.13	13.46	20.66	16.04	25.37	17.53	36.00	17.80	30.26	23.20	14.89	10.37	24.75	18.21
SiO_3 (mg/L)	0.56	1.12	1.28	1.02	1.00	0.58	1.20	0.80	0.60	0.64	<0.20	<=0.02	<0.18	0.30	1.52	0.32
Al (µg/L)	130	22	<20	14	<50	8	<30	13	<40	25	<20	10	<=10	10	<20	4
As (µg/L)		<=0.5		<=0.5		<=0.5		<=0.5		<1.0		<=0.5		<=0.5		<1.0
Ba (µg/L)		14.5		16.6		19.6		22.6		25.0		19.3		14.0		15.7
Be (µg/L)		<=0.03		<=0.03		<=0.03		<=0.03		<=0.03		<=0.02		<=0.03		<=0.03
Cd (µg/L)		<=0.6		<=0.6		<=0.6		<=0.6		<=1.0		<=1.3		<=1.0		<=1.0
Cr (µg/L)		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0
Co (µg/L)		<=1.5		<=1.5		<=1.5		<=1.5		<=1.5		<=1.5		<=1.5		<=1.5
Cu (µg/L)	50	12	15	12	8	8	28	24	6	5	13	11	4	12	19	12
Fe (µg/L)	130	106	30	27	<40	22	<80	26	180	155	<80	19	<=20	24	<=20	11
Mn (µg/L)	230	41	16	9	170	59	110	20	110	29	9	36	14	31	5	12
Mo (µg/L)		<=0.8		<=0.8		<=0.8		<=0.8		<=1.6		<=1.5		<=1.6		<=0.8
Ni (µg/L)	200	59	80	47	63	51	230	114	25	22	76	45	85	74	95	55
Pb (µg/L)	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11	<=5	<=11
Se (µg/L)		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5
Sr (µg/L)		21.4		32.6		50.7		50.4		74.4		67.4		16.1		49.1
Ti (µg/L)		<=0.30		1.23		1.41		<=0.30		1.44		<=0.30		1.81		<=0.30
V (µg/L)		<=0.9		<=0.9		<=0.9		<=0.9		<=1.5		<=1.0		<=1.5		<=0.9
Zn (µg/L)	29	10	7	7	2	9	16	11	3	1	4	4	9	7	3	2
P (µg/L)	<=2	9	<5	8	10	18	<6	7	24	33	<=2	18	<=2	9	<6	9
NH_3+NH_4 (µg/L)	44		<14		<8		20		28	124	36	74	10	34	20	
NO_2 (µg/L)	<1		<2		<2		<1		<2		<3		<1		<4	
NO_3+NO_2 (µg/L)	45		90		40		<20		<=5	14	<=5	12	<5	10	50	
TKN (µg/L)	<=170	300	160	242	180	383	270	312	470	408	340	352	<=200	257	260	300
DOC (mg/L)	1.1	3.4	3.4	4.1	3.8	4.6	3.3	3.6	4.6	4.5	3.5	4.0	2.3	2.5	2.8	3.5

Appendix 1 - Water Chemistry

	Richard		Robinson		Silver		St. Charles		Still		Tilton	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
pH	7.31	7.25	7.55	7.70	4.32	6.00	7.11	7.22	7.83	7.55	5.78	6.28
Conductivity (µS/cm)	187.0	195.0	362.0	389.0	377.0	355.0	210.0	243.0	600.0	605.0	57.0	58.8
Alkalinity (mg/L)	17.61	21.85	29.85	34.36	-2.90	0.87	7.66	14.70	31.83	38.43	0.84	2.63
Ca (mg/L)		8.46	17.40	15.80	9.00	7.34	10.60	9.24	20.50	18.00	4.83	3.50
Mg (mg/L)		2.81	5.66	5.22	3.22	2.74	3.94	3.38	6.11	5.84	1.22	0.97
Na (mg/L)		24.50	42.10	78.80	42.60	54.60	19.50	29.10	92.20	28.00	1.77	2.01
K (mg/L)		0.890	1.970	1.840	1.290	1.750	1.800	1.550	2.060	2.180	0.520	0.460
Cl (mg/L)	31.90	9.70	70.40	88.77	75.10	93.50	34.60	50.08	143.00	158.72	3.60	3.77
SO_4 (mg/L)	15.73	2.50	25.43	17.74	38.07	17.20	29.15	18.13	22.65	15.42	14.06	9.00
SiO_3 (mg/L)		0.24	1.22	0.04	2.18	0.12	0.86	0.32	1.44	0.56	0.74	0.74
Al (µg/L)	<20	6	<30	46	860	14	<60	16	<50	181	<40	17
As (µg/L)		<=0.5		<2.0		<=0.5		<=0.5		<1.5		<=0.5
Ba (µg/L)		17.2		18.6		22.4		19.2		40.7		14.6
Be (µg/L)		<=0.03		<=0.03		<=0.02		<=0.03		<=0.03		<=0.02
Cd (µg/L)		<=0.6		<=1.0		<=1.3		<=1.0		<=1.0		<=0.8
Cr (µg/L)		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0		<=1.0
Co (µg/L)		<=1.5		<=1.5		4.9		<=1.5		<=1.5		<=1.5
Cu (µg/L)	10	8	9	10	320	17	27	21	14	15	14	9
Fe (µg/L)	<=20	53	320	227	<80	90	120	76	130	424	190	75
Mn (µg/L)	42	168	38	39	160	88	50	18	64	100	90	45
Mo (µg/L)		<=0.8		<=1.6		<=1.5		<=1.6		<=1.6		<=1.5
Ni (µg/L)	88	57	60	36	590	105	190	95	72	58	83	50
Pb (µg/L)	<=5	<=11	<=5	<=11	<20	<=11	<=5	<=11	<=5	<=11	<=5	<=11
Se (µg/L)		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5		<=0.5
Sr (µg/L)		31.5		55.6		40.6		42.1		75.0		20.3
Ti (µg/L)		0.96		1.74		0.40		1.48		6.33		<=0.30
V (µg/L)		<=0.9		<=1.5		<=1.0		<=1.5		<=1.5		<=1.0
Zn (µg/L)	<=0.5	3	7	1	79	18	15	6	4	8	11	12
P (µg/L)	2	12	24	35	<3	7	11	8	19	45	<8	7
NH_3+NH_4 (µg/L)	<=2		34	144	30	44	12	44	64	222	22	32
NO_2 (µg/L)	<=1		<3		<3		5		<2		<4	
NO_3+NO_2 (µg/L)	<5		<=5	22	205	<6	25	10	<10	36	<=5	<=2
TKN (µg/L)		250	440	459	130	238	450	296	680	790	220	203
DOC (mg/L)		2.8	4.1	4.7	<0.3	3.4	4.8	4.8	10.8	10.2	2.5	2.6

Appendix 2 - Sediment Chemistry

	CLEARWATER			DAISY			FAIRBANK			GENEVA		
	A	B	C	A	B	C	A	B	C	A	B	C
pH	4.10	4.00	4.00	4.30	4.50	4.50	5.00	4.90	5.30	3.80	3.90	3.80
Loss on ign. (mg/g dry)	198.00	200.00	208.00	134.00	147.00	126.00	107.00	108.00	99.00	211.00	214.00	208.00
Carbon, Total Organic (mg/g dry)	96.00	97.00	100.00	60.00	67.00	61.00	41.00	45.00	41.00	110.00	110.00	110.00
Aluminum (µg/g dry)	18000.00	18000.00	18000.00	25000.00	25000.00	24000.00	13000.00	13000.00	15000.00	12000.00	12000.00	12000.00
Barium (µg/g dry)	78.00	75.00	80.00	110.00	85.00	85.00	740.00	560.00	590.00	61.00	63.00	63.00
Beryllium (µg/g dry)	<0.71	<0.84	<0.68	<0.81	<0.61	<0.7	<0.62	<0.66	<0.69	<0.8	<0.82	<0.8
Cadmium (µg/g dry)	7.70	7.20	4.70	1.70	1.10	1.10	5.80	5.80	5.20	3.00	2.70	2.90
Chromium (µg/g dry)	53.00	51.00	52.00	69.00	66.00	64.00	33.00	35.00	40.00	30.00	30.00	29.00
Cobalt (µg/g dry)	80.00	88.00	61.00	45.00	45.00	43.00	23.00	22.00	22.00	18.00	21.00	19.00
Copper (µg/g dry)	1900.00	1800.00	1600.00	670.00	730.00	760.00	280.00	260.00	250.00	79.00	89.00	79.00
Iron (µg/g dry)	21000.00	26000.00	23000.00	29000.00	31000.00	39000.00	46000.01	69000.02	45000.01	24000.00	26000.00	25000.00
Lead (µg/g dry)	150.00	150.00	150.00	57.00	64.00	73.00	150.00	140.00	150.00	99.00	110.00	110.00
Manganese (µg/g dry)	130.00	140.00	150.00	230.00	180.00	190.00	69000.00	38000.00	34000.00	440.00	460.00	450.00
Molybdenum (µg/g dry)	<2.5	<2.4	<2.2	<=0.5	<0.85	<0.74	34.00	25.00	20.00	<1.1	<1.4	<0.85
Nickel (µg/g dry)	2100.00	2300.00	1700.00	1200.00	1300.00	1100.00	350.00	320.00	310.00	95.00	110.00	96.00
Strontium (µg/g dry)	20.00	20.00	21.00	27.00	23.00	23.00	43.00	36.00	39.00	25.00	24.00	23.00
Titanium (µg/g dry)	440.00	450.00	430.00	670.00	640.00	610.00	390.00	390.00	510.00	660.00	610.00	600.00
Vanadium (µg/g dry)	39.00	40.00	40.00	45.00	46.00	44.00	41.00	46.00	49.00	41.00	41.00	42.00
Zinc (µg/g dry)	330.00	350.00	200.00	120.00	85.00	89.00	270.00	260.00	260.00	140.00	150.00	160.00

Appendix 2 - Sediment Chemistry

	JOHNNIE			LONG			MCFARLANE			NEPAHWIN		
	A	B	C	A	B	C	A	B	C	A	B	C
pH	4.10	4.20	4.20	4.80	4.70	4.70	4.70	4.50	4.50	4.70	4.40	4.60
Loss on ign. (mg/g dry)	280.00	261.00	283.00	89.20	84.10	85.30	102.00	107.00	110.00	115.00	114.00	103.00
Carbon, Total Organic (mg/g dry)	140.00	130.00	140.00	46.00	42.00	41.00	49.00	51.00	52.00	58.00	55.00	57.00
Aluminum (µg/g dry)	29000.00	28000.00	27000.00	20000.00	19000.00	19000.00	16000.00	17000.00	17000.00	22000.00	22000.00	22000.00
Barium (µg/g dry)	52.00	62.00	63.00	120.00	120.00	110.00	37.00	26.00	33.00	20.00	22.00	19.00
Beryllium (µg/g dry)	<1.8	<1.6	<1.7	<1.1	<1.1	<1.1	<0.66	<0.7	<0.68	<0.88	<0.87	<0.88
Cadmium (µg/g dry)	5.10	4.20	5.00	4.60	4.80	4.40	6.40	7.10	6.90	9.80	10.00	10.00
Chromium (µg/g dry)	47.00	45.00	45.00	57.00	55.00	55.00	50.00	58.00	51.00	72.00	72.00	74.00
Cobalt (µg/g dry)	41.00	27.00	27.00	90.00	90.00	88.00	110.00	130.00	120.00	200.00	200.00	210.00
Copper (µg/g dry)	140.00	100.00	180.00	1300.00	1300.00	1200.00	1200.00	1200.00	1200.00	3200.00	2900.00	3200.00
Iron (µg/g dry)	42000.01	41000.00	28000.00	31000.00	30000.00	30000.00	32000.00	34000.00	33000.00	47000.01	44000.01	46000.01
Lead (µg/g dry)	130.00	97.00	150.00	110.00	110.00	110.00	110.00	120.00	110.00	270.00	260.00	280.00
Manganese (µg/g dry)	560.00	680.00	320.00	510.00	470.00	460.00	910.00	1100.00	970.00	1700.00	1700.00	1700.00
Molybdenum (µg/g dry)	<2	<1.3	<1.8	<=0.5	<=0.5	<=0.5	<0.74	<=0.5	<=0.5	2.60	2.80	2.90
Nickel (µg/g dry)	210.00	130.00	210.00	1400.00	1400.00	1400.00	2200.00	2400.00	2200.00	4400.00	4200.00	4600.00
Strontium (µg/g dry)	25.00	25.00	24.00	32.00	30.00	30.00	30.00	32.00	31.00	34.00	35.00	33.00
Titanium (µg/g dry)	530.00	430.00	480.00	720.00	750.00	780.00	720.00	750.00	740.00	760.00	770.00	730.00
Vanadium (µg/g dry)	62.00	59.00	56.00	45.00	43.00	44.00	40.00	41.00	41.00	53.00	53.00	53.00
Zinc (µg/g dry)	320.00	220.00	300.00	290.00	290.00	290.00	420.00	460.00	450.00	650.00	670.00	680.00

Appendix 2 - Sediment Chemistry

	RAMSEY			TYSON			WHITSON		
	A	B	C	A	B	C	A	B	C
pH	4.40	4.40	4.50	4.40	4.40	4.10	4.70	4.70	4.80
Loss on ign. (mg/g dry)	82.00	86.10	88.30	195.00	207.00	196.00	210.00	133.00	140.00
Carbon, Total Organic (mg/g dry)	48.00	48.00	45.00	95.00	95.00	90.00	97.00	60.00	63.00
Aluminum (µg/g dry)	19000.00	20000.00	21000.00	23000.00	23000.00	24000.00	17000.00	15000.00	15000.00
Barium (µg/g dry)	69.00	51.00	140.00	150.00	110.00	140.00	84.00	66.00	66.00
Beryllium (µg/g dry)	<0.75	<0.79	<0.81	<1.4	<1.4	<1.5	<0.63	<0.52	<0.52
Cadmium (µg/g dry)	7.30	8.50	6.40	4.10	3.70	4.00	2.80	2.20	2.30
Chromium (µg/g dry)	62.00	70.00	76.00	45.00	44.00	47.00	49.00	46.00	44.00
Cobalt (µg/g dry)	160.00	190.00	160.00	33.00	45.00	33.00	48.00	53.00	57.00
Copper (µg/g dry)	2900.00	3200.00	2700.00	200.00	180.00	220.00	1100.00	760.00	780.00
Iron (µg/g dry)	43000.01	47000.01	44000.01	64000.01	73000.02	59000.01	52000.01	43000.01	46000.01
Lead (µg/g dry)	240.00	270.00	220.00	150.00	140.00	150.00	160.00	120.00	130.00
Manganese (µg/g dry)	430.00	420.00	420.00	1600.00	2200.00	840.00	250.00	410.00	500.00
Molybdenum (µg/g dry)	<1.5	<1.2	<1	<1.5	<2	<1.6	<0.93	<0.75	<0.72
Nickel (µg/g dry)	4100.00	4900.00	3900.00	280.00	270.00	300.00	1400.00	1100.00	1100.00
Strontium (µg/g dry)	32.00	33.00	38.00	29.00	29.00	29.00	32.00	26.00	26.00
Titanium (µg/g dry)	710.00	750.00	840.00	560.00	540.00	590.00	440.00	530.00	500.00
Vanadium (µg/g dry)	52.00	54.00	57.00	65.00	65.00	64.00	47.00	42.00	42.00
Zinc (µg/g dry)	400.00	460.00	360.00	230.00	200.00	230.00	130.00	110.00	110.00

Appendix 3 - Fish Species

	Ashigami	Bear	Caswell	Clearwater	Fairbank	Fraleck	Hannah	Kukagami	Lac St. Jean (Massey)	Little Panache	Long	Matagamasi	McFarlane	Nelson	Ramsey	Vermilion	Whitson
Surface Area (ha)	482	683	35	77	703	174	378	1900	77	131	861	1393	141	316	874	1079	437
Survey Year	2003	2003	2002	2003	2003	2003	2003	2003	2003	2003	2003	2000	2003	2000	2003	2003	2003
Number of Species	8	21	0	4	16	6	4	10	5	12	12	10	12	8	8	13	6
Blacknose dace - *Rhinichthys atratulus*		x															
Bluegill - *Lepomis macrochirus*		x															
Bluntnose minnow - *Pimephales notatus*		x			x					x							
Brown bullhead - *Ameiurus nebulosus*	x	x					x	x	x	x	x	x	x		x	x	x
Burbot - *Lota lota*		x						x						x			
Cisco (lake herring) - *Coregonus artedi*		x			x					x	x		x			x	
Common shiner - *Luxilus comutus*	x	x									x		x	x		x	
Fathead minnow - *Pimephales promelas*				x													
Golden shiner - *Notemigonus crysoleucas*												x		x			
Iowa darter - *Etheostoma exile*					x		x										
Lake chub - *Couesius plumbeus*														x			
Lake trout - *Salvelinus namaycush*		x			x	x		x			x	x		x			
Lake whitefish - *Coregonus clupeaformis*		x			x			x									
Largemouth bass - *Micropterus salmoides*													x				
Logperch - *Percina caprodes*	x	x			x						x		x			x	
Mottled sculpin - *Cottus bairdi*		x															
Ninespine stickleback - *Pungitius pungitius*					x												
Northern pike - *Esox lucius*		x			x				x	x	x	x	x		x	x	x
Pearl dace - *Margariscus margarita*								x									
Pumpkinseed - *Lepomis gibbosus*		x		x	x	x				x	x		x		x	x	x
Rainbow smelt - *Osmerus mordax*		x								x							
Rock bass - *Ambloplites rupestris*	x	x			x			x		x		x			x	x	
Slimy sculpin - *Cottus cognatus*		x								x							
Smallmouth bass - *Micropterus dolomieu*	x	x		x	x	x		x		x	x	x	x	x	x	x	
Spoonhead sculpin - *Cottus ricei*					x												
Spottail shiner - *Notropis hudsonius*					x						x	x	x			x	
Trout-perch - *Percopsis omiscomaycus*		x														x	
Walleye (yellow pickerel) - *Sander vitreus*	x	x			x	x	x	x	x	x	x	x	x		x	x	x
White sucker - *Catostomus commersoni*	x	x			x	x		x	x	x	x	x	x	x	x	x	x
Yellow perch - *Perca flavescens*	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x

Appendix 4 - Walleye Harvest Statistics

Lake	Fishing Effort	Walleye Angler Success Rate	Number Harvested	Average Size of Walleye	Walleye Yield
McFarlane	784 angler-hours (5.6 hours$\cdot$ha^{-1})	None caught	0 walleye		
Ramsey	9016 angler-hours (10.3 hours$\cdot$ha^{-1})	0.403 walleye$\cdot$hour^{-1} (1 fish for 2 hours)	1738 walleye	283mm 181g	314kg (0.36kg$\cdot$ha^{-1})
Vermilion	3491 angler-hours (3.2 hours$\cdot$ha^{-1})	0.089 walleye$\cdot$hour^{-1} (1 fish for 11 hours)	59 walleye	291mm 225g	13kg (0.01kg$\cdot$ha^{-1})
Whitson	1285 angler-hours (2.9 hours$\cdot$ha^{-1})	None caught	0 walleye		

Appendix 5 - Zooplankton Species

Species Names	BENNETT		BETHEL		BRODER		BRODILL		CLEARWATER		CROOKED		CROWLEY		DAISY		DILL		FAIRBANKS		FOREST		GRANT		HANNAH		JOHNNY		KELLEY		LAURENTIAN		LINTON	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
Acanthocyclops vernalis									*		x																							
Alona sp.		x																										*						
Bosmina sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	*	x	x	x	x
Ceriodaphnia sp.			*															*					x		x							x		
Chydorus sphaericus			*	x					*	*			*			x									x			x						
Cyclops scutifer																								x										
Daphnia ambigua			x										x															*						
Daphnia pulex													*												*			x	x	x	*			
Daphnia retrocurva			x				x	x			*						x	x	*	x			*		*						*			
Daphnia mendotae			x		*				*		x		x						x	x			x	x	x	x	*						*	
Daphnia sp.																	x																	
Diacyclops bicuspidatus thomasi						x	x	x	*											x				x						x	x				
Diaphanosoma birgei	x	x		x	*	x	*	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	*	x	x	x	x			x	*	*	x
Epischura lacustris																			*					x											
Eubosmina longispina																												*						
Eucyclops agilis		*																																
Eurycercus lamellatus																																		
Holopedium glacialis					x	x	x	x		x	*	x	x	x		x	x	x			x	x					x	x	x		x	*	x	x
Leptodiatomus minutus	x	x	*		x	x	x	x		x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	*		x		x	*	x	x
Leptodora kindtii							x										x																	
Macrocyclops albidus																												*						
Mesocyclops edax			x			x	x	*						x	*		x			*			x	x	x	x	*		x	x	x		x	
Orthocyclops modestus					x	*			*		x	*	x											*	*		*						x	*
Polyphemus pediculus									*												*													
Sida crystallina																												*						
Skistodiaptomus oregonensis	x	x	x	x		x			*				*					x					x	x	*	x	*		x	x	*	x		
Tropocyclops extensus						x	*			x		x		x			x	x			x	x	x	x		x		*				x	*	x
Calanoid copepodid	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	*	x	x	x	x	x	x	x	x	x	x	x	x	x
Calanoid nauplius	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	*	x	x	x	x	x	x	x	x	x	x	x	x	x
Cyclopoid copepodid	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cyclopoid nauplius	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x

x = Species present
* = Only one individual detected

Appendix 5 - Zooplankton Species

Species Names	LITTLE RAFT		LOHI		LONG		MCFARLANE		MIDDLE		MINNOW		NEPAHWIN		RAFT		RAMSEY		RICHARD		ROBINSON		SILVER		ST. CHARLES		STILL		TILTON	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
Acanthocyclops vernalis																			*				*							
Alona sp.												x																		
Bosmina sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x
Ceriodaphnia sp.		x									x	x								x	x	x				x		x		
Chydorus sphaericus		*		x		*						x							x		x	x	x		x	x		x		
Cyclops scutifer						x									x	x												*		
Daphnia ambigua														x														x		
Daphnia pulex																											*			
Daphnia retrocurva		x			x	x					x		*						*		x	x		*	x	*				
Daphnia mendotae	*				x	x	x	x	x	x	x	*	x	x	x	x	x	x	*	x	x	*		*	x			x	x	
Daphnia sp.																														
Diacyclops bicuspidatus thomasi					x	x	x	x	x	x		*	x	x	x	x	*	x	x			x		x	x					
Diaphanosoma birgei	x	x	x	x	x	x	x	x		x	x	x		*	x	x			x	x	x	x	x	x	x	x	x	x	x	x
Epischura lacustris							*						x	x	*	x	x	x							x					
Eubosmina longispina																													*	
Eucyclops agilis																						x								
Eurycercus lamellatus								*																						
Holopedium glacialis	x	x		x											x	x													x	x
Leptodiatomus minutus	x	x	x	x	x	x	x	x	x	x	*		x	x	x	x	x	x	x	x	x	x			x	x			x	x
Leptodora kindtii																						*								
Macrocyclops albidus																														
Mesocyclops edax		x			x		x	x		*				*		x		x	x	x		x					x	x		
Orthocyclops modestus				x				x																						
Polyphemus pediculus																			*											
Sida crystallina																								x		*				
Skistodiaptomus oregonensis					x		x	x		x	x	*	x				x	x		x	x	x	*		x	x	x	x		
Tropocyclops extensus		x		x			x			x				*					x	x		x		x		x				x
Calanoid copepodid	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x
Calanoid nauplius	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cyclopoid copepodid	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cyclopoid nauplius	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x = Species present
* = Only one individual detected