UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 22

THE LIMNOLOGY OF LAKE NIPIGON IN 1923

BY

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The study of the distribution of temperatures in Lake Nipigon in 1923 was carried out during the months of July, August, and September, and the results have been rather interesting. The season in general was very cool and characterized by high winds throughout August and September. Four series of records were obtained at Station 4, which was the same location as in 1922, and these with other data obtained are given in Table 1. The surface temperatures do not give the maxima, for, during calm, sunny days in late July, the temperature of the surface water probably rose to 19.0° C., but this was only a temporary condition. In Figure I, the graphs illustrate the temperature records. The results show that during July and August conditions were rather similar to those of the two preceding years except that heat had penetrated to slightly greater depths as a result of winds. The latter part of August and the early part of September were marked by numerous storms of considerable severity, some of them almost comparable with the storm of July 30, 1921. The result was that the water of the lake was pretty thoroughly mixed down to a depth of 50 yards, as shown by the figures and the graph for September 14.

Calculations for the distribution of heat and the direct work have been made as in the two previous years. As stated previously, these are of little, if any, value for comparison with conditions in other lakes, but may be used as a basis of comparison for the several years for Lake Nipigon. The results show that in the late summer of this year the lake gained very large amounts of heat, and that a very large amount of work was involved in the distribution. The effect of this accumulation of heat on the life of the waters is

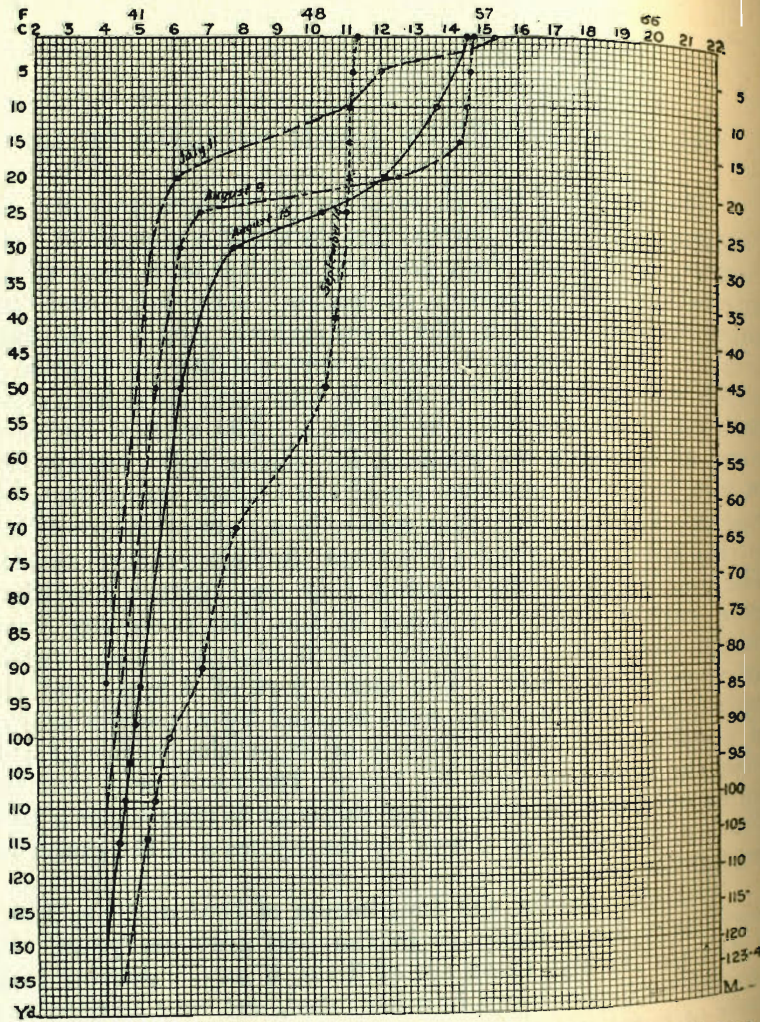

Fig. 1 Curves illustrating temperature records at Station 4, Lake Nipigon

unknown. It may have lengthened somewhat the growing period and delayed the time of spawning of the fish, but unfortunately observations could not be extended into October and November.

TABLE 1

STATION 4

	July 11							August 9							
Depth in Yards	Temperature Far.	Cent.	Ox.	%Sat.	CO_2	Bicarb.	Total Acidity	Temperature Far.	Cent.	Ox.	%Sat.	CO_2	Bicarb.	Total Acidity	pH.
0	59.5	15.3	6.9	96	1.0	107	2.0	58.5	14.7	6.8	93	0.0	110	1.5	8.3
5	53.6	12.0						58.3	14.6						
10	51.8	11.0						58.1	14.5	7.1	97	0.0	110	1.5	8.3
15	47.1	8.4	7.7	93	1.0	107	2.0	57.7	14.3						
20	43.0	6.1						54.5	12.5	7.7	101	0.0	110	1.5	8.3
25	42.0	5.6						44.2	6.8						
30								43.2	6.2	8.3	94	0.5	110	3.0	8.0
40															
50								41.9	5.5	8.5	96	0.5	104	2.0	7.8?
70															
90															
92	39.2	4.0	8.1	87	1.0	104	2.0								
98								39.7	4.3	7.85	86	0.5	106	2.0	8.0
100															
115															

TABLE 1—*Continued*

STATION 4.

	August 15		September 14							
Depth in Yards	Temperature Far.	Cent.	Temperature Far.	Cent.	Ox.	%Sat.	CO_2	Bicarb.	Total Acidity	pH
0	58.1	14.5	52.3	11.3	7.9	101	1.0	109	1.0	8.2
5			52.2	11.2						
10	56.5	13.6	52.0	11.1						
15			52.0	11.1						
20	53.8	12.1	52.0	11.1						
25	50.5	10.3	52.0	11.0	7.6	97	0.5	110	0.5	8.2
30	45.9	7.7	52.0	11.0						
40			51.3	10.7						
50	43.2	6.2	50.7	10.4	7.9	100	1.0	111	1.0	8.2
70			46.0	7.8						
90			44.2	6.8						
92										
98										
100			42.4	5.8	8.7	98	1.0	109	1.0	8.1
115	39.9	4.4								

TABLE 2

TEMPERATURES—STATION 4

	July 11		August 9		August 15		September 14	
Depth meters	Temp. C.	Av. Temp. per 5-m.l.	Temp. C.	Av. Tmp. per 5-m.l.	Temp. C.	Av. Temp. per 5-m.l.	Temp. C.	Av. Temp. per 5- m.l.
0	15.3		14.7		14.5		11.3	
5	11.8	13.55	14.6	14.65	14.1	14.30	11.2	11.25
10	10.4	11.10	14.5	14.55	13.5	13.80	11.1	11.15
15	7.5	8.95	14.0	14.25	12.7	13.10	11.1	11.10
20	5.8	6.65	10.0	14.00	11.6	12.15	11.1	11.10
25	5.5	5.65	6.4	8.20	9.0	10.30	11.0	11.05
30	5.3	5.40	6.1	6.25	7.3	8.15	10.9	10.95
35	5.2	5.25	5.9	6.00	6.8	7.05	10.75	10.82
40	5.05	5.12	5.7	5.80	6.5	6.65	10.6	10.67
45	4.95	5.00	5.5	5.60	6.2	6.35	10.45	10.52
50	4.8	4.87	5.4	5.45	6.05	6.12	10.0	10.22
55	4.7	4.75	5.25	5.32	5.9	5.97	9.3	9.65
60	4.6	4.65	5.1	5.17	5.75	5.82	8.4	8.85
65	4.5	4.55	5.0	5.05	5.6	5.67	7.7	8.05
70	4.35	4.42	4.85	4.92	5.45	5.52	7.35	7.52
75	4.2	4.27	4.7	4.77	5.3	5.37	7.1	7.22
80	4.1	4.15	4.55	4.62	5.15	5.22	6.9	7.00
85	4.0	4.05	4.40	4.47	5.0	5.07	6.55	6.72
90	4.0	4.00	4.3	4.35	4.85	4.92	6.0	6.27
95	4.0	4.00	4.15	4.22	4.7	4.77	5.65	5.82
100	4.0	4.00	4.0	4.07	4.55	4.62	5.4	5.52
105	4.0	4.00	4.0	4.00	4.4	4.47	5.20	5.30
110	4.0	4.00	4.0	4.00	4.25	4.32	5.0	5.10
115	4.0	4.00	4.0	4.00	4.1	4.17	4.8	4.90
120	4.0	4.00	4.0	4.00	4.0	4.05	4.6	4.70
123.4	4.0	4.00	4.0	4.00	4.0	4.00	4.5	4.55

TABLE 3

CALORIES ABOVE 4° C.—STATION 4

Depth m.	July 11		August 9		August 15		September 14	
0-5	4775		5325		5150		3625	
5-10	3550		5275		4900		3575	
10-15	2475		5125		4550		3550	
15-20	1325		5000		4075		3550	
20-25	825	12950	2100	22825	3150	21825	3525	17825
25-30	700		1125		2075		3475	
30-35	625		1000		1525		3410	
35-40	560		900		1325		3335	
40-45	500		800		1175		3260	
45-50	435	2820	725	4550	1060	7160	3110	16590
50-55	375		660		985		2825	
55-60	325		585		910		2425	
60-65	275		525		835		2025	
65-70	210		460		760		1760	
70-75	135	1320	385	2615	685	4175	1610	10645
75-80	75		310		610		1500	
80-85	25		235		535		1360	
85-90	0		175		460		1135	
90-95	0		110		385		910	
95-100	0	100	35	865	310	2300	760	5665
100-105					235		650	
105-110					160		550	
110-115					85		450	
115-120					25		350	
120-123.4					0	505	275	2275
		17190		30855		35965		53000

TABLE 4

DIRECT WORK—STATION 4

Depth m.	July 11	August 9	August 15	September 14
0-5	83.37	102.62	96.37	49.12
5-10	141.75	302.62	262.87	143.62
10-15	117.50	477.50	230.62	236.25
15-20	48.12	637.87	430.50	330.75
20-25	24.75	153.00	337.50	419.62
25-30	22.00	55.00	182.87	499.12
30-35	21.12	52.00	118.62	568.75
35-40	18.75	48.75	103.12	628.12
40-45	17.00	44.62	93.50	680.00
45-50	14.25	40.37	83.12	693.50
50-55	10.50	36.75	78.75	637.87
55-60	8.62	31.62	74.75	517.50
60-65	6.25	28.12	68.75	396.87
65-70	3.37	23.62	60.75	327.37
70-75	3.62	14.50	54.37	290.00
75-80		11.62	46.50	275.12
80-85		4.12	37.12	235.12
85-90		4.37	30.62	175.00
90-95			23.12	120.25
95-100			14.62	87.75
100-105			10.25	71.75
105-110			5.37	53.75
110-115				39.37
115-120				23.50
120-123.4				12.17
	540.97	2069.07	2594.06	7512.24

The results for the three years are as follows:—

	Calories	Work		Calories	Work		Calories	Work
'21 June 17,	10445	246	July 9,	16285	573	Aug. 2,	35365	2865
'22 " 27,	14775	572	" 29,	25340	1246	" 17,	31250	2023
'23			" 11,	17190	540	" 9,	30855	2069

	Calories	Work		Calories	Work
'21 Aug. 29	31490	1900			
'22 " 19,	34925	2463			
'23 " 15,	35965	2594	Sept. 14	53000	7512

DATA OBTAINED IN SHALLOW WATER

In connection with the study of the plankton of shallow, more or less protected bays, containing considerable growths of aquatic vegetation, a number of analyses were carried out and the results are given in Table 5. Included in the table is a record obtained in a small lake (Station Lake) draining into Lake Nipigon and a record for a creek tributary to Lake Nipigon in which a trap net was maintained during the greater portion of the summer of 1923. It will be seen that, in general, in these protected areas, considerably higher temperatures prevailed than in the open waters of the lake. The oxygen content was high even to a high degree of supersaturation in some cases. The hydrogen ion concentration was in the neighbourhood of 8.0 with a trace of free carbon dioxide, decreasing with increase in free carbon dioxide and increasing in its absence.

TABLE 5

DATA OBTAINED IN SHALLOW WATER

Locality, etc.	Temp. C.	Ox.	%Sat.	CO_2	Bicarb.	Total Acidity	Alk.	pH.
Station Lake, July 6, 1922 surface	17.7	5.8	86	1.5	96	5		
bottom, 5 feet	16.4	5.7	81	2.0	37	5		
Station 5, Aug. 19, 1922, open water	20.0	7.8	118	1.0	95			
among reeds	20.0	9.1	138		96		3	
Station 5, July 4, 1923, open water	24.5	6.2	102	1.0	79	1		
among reeds	24.5	6.7	110		79			
Station 5, July 12, 1923, open water	24.0	6.1	99	trace	77	1	1	
among reeds	24.0	7.1	115		77		2	
Station 5, July 19, 1923, open water	21.0	5.8	90	1.0	82	3		
among reeds	21.0	6.2	96	1.0	82	3		
Refuse bay, July 20, 1923, depth 2 yards	21.5	6.5	101	.5	107	1.5		
Station 5, July 31, 1923, open water	19.0	6.1	91	.5	88	3		
among reeds	19.0	6.2	93	trace	88	1.5		
Aviator's bay, Aug. 7, 1923	17.0	7.1	102	1.0	93			8.3
McL. bay, Aug. 10, 1923, 10.30 a.m.	14.0	6.8	92	1.0	101	2		7.9
Station 5, Aug. 13, 1923, open water	16.3	6.0	85	.5	93	2		7.8
among reeds	16.3	6.6	94	1.0	90	3		8.0
Bell's bay, Aug. 17, 1923, 4.00 p.m.	17.1	7.4	107		107		3?	8.5
Refuse bay, Aug. 18, 1923	15.4	7.1	99		106			8.4
Station 5, Aug. 19, 1923, 4 p.m., open water	17.0	6.9	99	trace	89	2		8.2
among reeds	17.0	6.9	99	"	90	2		8.2
Aviator's bay, Aug. 19, 1923, 5.30 p.m., west arm	17.0	6.7	97	"	95	4		8.0
east arm	17.0	6.6	95	"	95	4		8.0
Aviator's bay, Aug. 29, 1923, 2.30 p.m.	17.0	6.4	92	1.0	95	4		7.9
Bay, Nipigon river, Sept. 3, 1923	15.5	7.5	105	1.0	110	5		8.3
Trout Creek, Sept. 5, 1923, 3.30 p.m., near mouth, colour 118	10.5	7.8	98	3.5	93	10		7.7
Aviator's bay, Sept. 11, 1923	11.8	7.4	96	2.5	96	7		7.7
Station 5, Sept. 11, 1923, open water	15.3	7.8	109	5.0?	77	4		8.0
among reeds	16.0	10.0	141		79		4	8.8

The following temperature records were obtained in some of the bays:

BLACKWATER BAY	GULL BAY	HUMBOLDT BAY
July 14, 1921	July 23, 1922, 6.30 p.m.	Aug. 8, 1922, 5.30 p.m.
0 yds....20.9°C.	0 yds....18.9°C.	0 yds.....15.8°C.
3 " ..19.0	4 " ...18.0	B. 12 " ...10.6
B. 13 " .. 8.7	10 " ...13.6	
	B. 15 " ...11.2	

OMBABIKA BAY	OFF WHITESAND INDIAN VILLAGE	WABINOSH BAY
Aug. 9, 1922, 3.15 p.m.	July 27, 1923, 2.30 p.m.	July 28, 1923, 10.30 a.m.
0 yds....18.6°C.	0 yds....19.4°C.	0 yds....19.4.C.
B. 13 ,, ...15.6	B. 9 " ...18.0	10 " ...18.2
		B. 20 " ... 7.5

On July 20, 1922, the following temperature series was obtained in Black Sturgeon Lake, lying to the south of Lake Nipigon:

0 yds.: 20.5°C.; 8 yds.: 14.9°; B. 22 yds.: 5.8°

CHEMICAL ANALYSES

The results of the chemical analyses are given in Table 1. The oxygen is expressed in cubic centimetres per litre, and the other results in parts per million. The oxygen content was, in general, slightly higher than in the two preceding summers, while the free carbon dioxide, the bicarbonates, and the total acidity showed little variation.

Two series of hydrogen ion determinations were made using cresol red as indicator with phenol red and thymol blue as checks. The standard solutions were prepared in the Department of Biochemistry, University of Toronto, through the kindness of Professor H. Wasteneys. These determinations, as well as the other analyses, were carried out on the boat immediately after the taking of the sample.

CONCLUSIONS

In a study of a body of water of the size of Lake Nipigon, confined to a period of two or three months in midsummer, it is difficult definitely to correlate the conditions found in the physical environment with definite characteristics of the plant and animal population. That is, the relation of the combination of factors, in respect of temperatures, oxygen, carbon dioxide, bicarbonate, and hydrogen ion concentration, to the absence from the lake of certain species of fish, to the development of the eggs of the various species of fish occurring in the lake, or to the production of plankton and the various invertebrates entering into the food supply, cannot be definitely stated at the present time.

Temperature. The distribution of temperatures in the lake compares favourably with that in other large bodies of water. In all three years considerable amounts of heat were distributed to a depth of 25 yards by midsummer and late in the summer of 1923 to twice that depth. This condition is quite similar to that occurring in Cayuga and Seneca Lakes, N.Y., and possibly slightly better than in some of the Great Lakes, if we judge from the small amount of data available. Sturgeon, yellow perch, saugers, common suckers, and round whitefish live in this warmer water, while the common whitefish, ciscoes, northern sucker, pike-perch, lake trout, and ling range into deeper, cooler water to temperatures between 4° and 5° C. Dredging results show that the greatest variety and abundance of bottom organisms develop between depths of 1 and 10 yards, that is, in the region of highest temperatures. Bottom-feeding, shoreward fish feed in this region, and even adult common whitefish secure a considerable portion of their food here. *Pontoporeia hoyi*, *Oligochaeta* and certain species of *Chironomidae* larvae reach their maximum numbers in the deep water, living throughout the year at a temperature of 5° C. and lower, and forming a population almost as abundant numerically as the population of the shallow water. They constitute a vast food supply for the common whitefish and the northern sucker. The one phase of the temperature conditions in Lake Nipigon which, without doubt, limits the productivity to a considerable extent is the short summer period, as pointed out previously. This would apply especially to the shoreward population. No data have been obtained as to the relation of temperature to onset of spawning of fish or to development of the eggs.

Chemical content. As far as can be judged from experimental work by Shelford* and other investigators, the combination of high oxygen, low free carbon dioxide, and high bicarbonate contents, with a hydrogen ion concentration in the neighbourhood of 8.0 is a favourable condition for many species of fish and for the fertilization and development of whitefish eggs at least. It is possible, on the other hand, that this combination is one factor accounting for the absence of some species of fish from the lake.

Geophysical features. In conformation, Lake Nipigon is a natural fish cultural body of water. The main portion has ranges of depth down to 134 yards. Large extents of shallow areas, in addition to those along the main shore, are provided because of the many islands. Numerous expansive, fairly shallow bays with more or less narrow openings into the main body of the lake provide protected feeding areas for young fish. The numerous tributary streams bring into the lake large supplies of dissolved materials as well as considerable plant stuffs and provide adequate spawning areas for fish. Several features, on the other hand, are decidedly limiting factors in regard to the productivity of the lake. The large size makes possible the development of severe storms which keep the exposed shores almost barren, and the rocky basin results in the shore line being largely rocky or sandy. Even in the bays the amount of muddy shore line, where aquatic plants can grow, is relatively small. Large amounts of sand are brought down by some of the streams from the surrounding rocky drainage basin and create large, practically desert areas in the lake. Finally, the development of insurmountable falls in the Nipigon river has prevented the movement of fish from Lake Superior.

In spite of the limiting factors mentioned above, Lake Nipigon can be said to be a very productive body of water, and under the operation of proper conservational measures should remain so for all time to come.

*Shelford, Victor C. *The Determination of Hydrogen Ion Concentration in connection with Fresh-Water Biological Studies.* Bulletin, Article IX, Vol. XIV, Div. Nat. Hist. Survey, Dept. Reg. and Educ. Illinois, 1923.

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