Investigation in connection with the whitefish

CORECONUS CLUPEAFORMIS(Mitchil.)

A. Bajkov.

1930.

TABLE OF CONTENTS.

Sources of food of deep water organisms.

Productivity of whitefish grounds in Lake Winnipeg.

Bottom Fauna of other lakes.

FIRST PART.

INTRODUCTION

When the fisheries resources of a certain body of water are exploited too much and the industry after reaching its maximum begins to decrease it is necessary to make detailed investigations in order to find means for preserving the industry and keeping it in a healthy condition. The main problem of such investigations is to determine those specific conditions under which productiveness on one side and resisting forces on the other keep the fish population in balance.

The total quantity of commercial fishes of a lake we can divide into two large groups: (a) fishes which have reached commercial size, and (b) fishes less than this size. It is not sufficient to investigate only individuals of the first group, i.e., adult commercial fishes, the total amount of these being dependent very often not so much on the intensity of fishing and over-fishing, as on the regularity and constancy with which their numbers are augmented every year by individuals from the second group. And here, the main problem of the investigations is the study of the conditions which regulate the total amount of young fishes. Two factors are at work here, (1) quantity of fertilized eggs, and (2) the mortality of eggs and fry. It is very easy to understand that the intensity of fishing has no influence on the second factor, i.e., on mortality of fertilized eggs and fry, and can only cause a decrease in quantity of the eggs.

Studying the reasons of abnormally low production of young fish, we cannot always connect this phenomenon with poor spawning, but we must look for the cause in a great mortality of very young fry. It seems to the author that one of the causes of great mortality is a lack of food, mainly plankton organisms. As a rule, the development of plankton, especially early in the spring, is periodical, and if these sudden developments of plankton do not take place until some time after the fry have hatched the result may be a very poor crop of fry, and after a certain number of years the catch of fish will be very poor. On the other hand, if there is a very plentiful crop of plankton at the right time, the catch, despite intensive fishing, may be very good. It seems to the author that this is a cause of puzzling periodical increase and decrease in catches.

The above considerations apply very well to the whitefish industry in the large lakes of western Canada. Therefore we must investigate every phase of development of whitefish, and especially those specific conditions under which the fry hatch and live. Artificial propagation and hatchery work cannot be based only on a large quantity of introduced fry but must be in accordance with those hydrological and hydrobiological conditions. In this way tens and hundreds of millions of fry would be kept from perishing. Only thus can hatchery work give good results.

Recently many investigators have found that the catches of adult fish continue to diminish in spite of increased introduction of fry, and as a result have criticized strongly the practice of fish-culture in general and have concluded that it is useless to build new hatcheries when we cannot see any results.

Although absolutely in disagreement with this opinion, the author, however, thinks that the hatchery work will be useful only in the event of all conditions being favorable for planting fry. The main thing in whitefish propagation in big lakes is to find the time and place for planting fry most favorably. Hatchery problems not only consist of artificial fertilization and hatching of the fry, but also the protection of this fry from unfavorable natural conditions, otherwise the result will be only an increase of mortality of the fishes of the second group, i.e., fishes less than commercial size.

Therefore, an examination of hydrological and hydrobiological conditions, rates of growth and food of fry should be a first consideration.

The investigations were made [illegible] during the years 1926-1929 at the request of the Biological Board of Canada to which the author would like to express his thanks.

The author also desires to express his sincere thanks to Mr. J. A. Rodd, Superintendent of Fish-culture, and Mr. G. Butler, Superintendent of Lake Winnipegosis Hatchery, for their kind assistance and many helpful suggestions.

Thanks are also due to Mr. F. Neave and all other members of the parties for generous assistance and co-operation.

PHYSIOGRAPHY OF THE LAKES

In order that the distribution of whitefish and its food in the various lakes examined may be fully understood it is necessary to give a short description of the physiography of these lakes.

Lake Winnipeg. (pH 7.7 - 8.4)

Lake Winnipeg is the largest and, from the standpoint of fisheries, the most important lake in western Canada. It is 280 miles in length and the greatest width is 70 miles. The area is approximately 9,460 square miles. A large number of important rivers flow into Lake Winnipeg, the principal being: Great Saskatchewan River with its drainage area of more than 100,000 square miles, Winnipeg River with 53,500 square miles, Red River with 116,347 square miles, and Dauphin River. Numerous smaller, but still large, rivers including the Berens, Pigeon, Manigotagan, Brokenhead and others, also contribute to Lake Winnipeg. All these immense rivers running into Lake Winnipeg empty by one outlet, the Nelson River, which has a drainage area of approximately half a million square miles and flows into the southwest end of Hudson Bay.

Lake Winnipeg lies on the boundary of the Archaen and Palaezoic deposits. The eastern shores are composed of granite with many rapid streams leading from the eastern forested area. The western shores on the other hand are built of Palaezoic limestones and dolomites, with a few large comparatively alkaline tributaries from the western plains. With this is associated an important difference in hydrogen-ion concentration, which is of importance in connection with whitefish distribution and of some significance in connection with other aquatic fauna and flora, with the exception of Saskatchewan River where pH is somewhat lower than in Lake Winnipeg proper.

This lake is readily divisible into two portions from the standpoint of fisheries. The shallow southern end (average depth 6½ fath.) in which pike, pickerel and sucker are the dominant species of fish, and the deeper more extensive northern portion, with average depth 9 - 9½ fathoms, in which whitefish are abundant and in which large individuals of lake trout (Cristivomer namaycush) are occasionally caught. The essential differences between these two parts are those of temperature, dissolved oxygen, composition of the bottom and distribution of whitefish food. Lake Winnipeg is a shallow lake with a flat muddy bottom which supports an extremely rich fauna, insect larvae, mollusks and amphipods being the dominant forms. In this way it is admirably suited for whitefish culture.

Character of Water.

The average salinity for the whole of Lake Winnipeg is approximately 220 parts per million or 0.22%. It is interesting for comparison to note that in ocean it is 35% and in certain alkaline lakes of Saskatchewan, 17%.

In different parts of the lake the salinity is not the same. The freshest water is distributed along the eastern shore due to the influence of tributaries flowing from the granite plateau. Along the western shore the sources of such water are comparatively small and the total solids in some places reach even 0.56%.

Results of analyses of water from Lake Winnipeg and certain of its tributaries and also from the Nelson River in parts per million are given below.

TABLE I.

Analyses of water from Lake Winnipeg and certain connecting waters (by Dr. Paul Hiebert, University of Manitoba)

Locality,	date	Total solids	Mineral	Organic	CO_3	Cl	Ca	Mg	SO_4	N as NO_3	Fe
Red River near Lockport,	12.vi.28	564	160	404	193	23	33.8	17.21	125.2	.08	.3
Mouth of Red River,	14.vi.28	480	330	150	128.1	27.5	62.8	33.7	118.5	.16	.14
Icelandic River,	17.vi.28	556	270	286	217.4	4.5	15.8	20.1	44.8	.10	.14
Traverse Bay,	4.vii.28	100	26	74	28.2	none	13.7	2.75	3.90	.04	.5
Winnipeg Beach,	15.vi.28	160	92	68	50.32	8.0	23.8	11.0	16.52	.10	.34
2 miles east off Drunken Pt.	15.vii.28	130	62	68	40.5	4.5	21.7	8.24	14.0	.02	1.4
Middle of Southern Portion 11 mt.	15.vii.28	142	98	44	47.5	6.0	25.7	7.45	23.8	.05	.8
Middle of Southern Portion Surface,	15.vii.28	124	90	38	44.3	4.5	23.9	9.90	18.0	.02	1.6
Black River,	14.vii.28	80	26	54	7.92	2.5	5.14	2.29	1.64	--	.8
Bloodvein River,	28.vii.28	46	12	34	7.24	Trace	6.0	Trace	Trace	--	.2
George id.	9.viii.28	152	60	92	43	14.0	14.6	18.8	20.1	--	.14
Pigeon Bay, Surface,	16.viii.28	100	46	54	24.5	Trace	17.6	5.82	15.8	--	.6
Pigeon Bay, Bottom,	16.viii.28	62	18	44	15.2	none	11.1	3.24	4.35	--	.4
Pigeon River,	15.viii.28	50	10	40	10.8	none	8.58	2.10	Trace	--	.5
Eagle id.	11.viii.28	200	86	114	67.1	11.0	35.7	13.7	28.7	--	.5
Berens River,	12.viii.28	40	14	26	12.0	none	7.72	2.10	none	--	.4
Saskatchewan River, near The Pas,	30.viii.28	250	96	154	74.0	none	39.3	13.0	27.4	--	.4
Saskatchewan River, Grand Rapids,	11.viii.28	214	152	62	74.0	2.5	36.75	13.8	29.7	--	2.0
Kettle River,	2.ix.28	156	66	90	39.9	none	31.6	6.84	Trace	--	Trace
Nelson River, near Kettle Rapids,	3.ix.28	252	160	92	59.5	13.0	35.3	11.5	24.1	--	.1
Cedar Lake	ix.28	272	---	--	87.3	7.5	----	----	----	--	--

TABLE II.

(by courtesy of Professor R. C. Wallace)

	SiO_2	R_2O_3	Ca	Mg	Na	K	CO_3	SO_4	Cl	Total solids	Suspended matter
Red River at River Park, Man.											
1925 VI	18.4	2.6	47.9	30.3	12.2	0.5	110.4	44.7	19.0	297.6	990.2
VII	22.0	3.6	54.5	25.3	40.1	8.9	115.6	52.9	23.7	328.8	142.6
VIII	23.6	2.2	68.3	30.6	60.8	4.5	156.9	96.0	49.9	458.8	99.4
IX	20.8	3.8	65.2	26.4	65.5	11.9	149.3	99.3	61.2	487.0	26.2
X	11.1	6.1	76.7	27.9	80.1	10.9	165.3	131.2	64.6	570.0	35.9
1926 I	21.6	22.8	62.0	38.8	76.2	4.8	166.9	130.1	33.2	561.0	25.8
Red River at Selkirk.											
1925 VI	14.8	1.4	63.1	32.7	46.5	6.5	135.6	97.6	32.8	425.7	225.4
VII	23.0	9.2	65.0	22.7	41.0	7.8	119.1	85.8	38.5	415.0	102.4
VIII	28.8	0.6	69.1	29.4	60.6	6.1	126.9	121.6	52.3	504.8	118.4
IX	36.0	18.0	70.2	29.5	65.6	4.5	139.6	125.8	62.0	559.6	111.2
X	16.6	--	67.5	31.6	75.1	7.8	135.6	135.2	85.6	546.2	172.6
1926 I	12.6	16.6	80.0	40.3	71.2	8.2	182.4	144.8	58.0	640.4	17.5
Red River at its Mouth, Man.											
1925 VI	7.0	6.8	47.5	27.0	63.8	7.0	113.0	109.9	38.0	409.9	629.8
VII	23.5	7.4	37.0	35.5	59.1	8.4	113.0	115.2	23.8	447.2	78.8
VIII	18.8	1.2	48.8	23.5	26.3	4.2	95.6	109.5	23.8	343.2	64.0
IX	9.8	0.2	55.5	20.8	27.6	6.2	101.7	102.5	23.8	357.6	37.0
X	10.0		56.9	34.7	44.5	6.7	124.3	97.0	69.9	437.0	12.4
1926 I											
Lake Winnipeg 4 miles out from Red River.											
1925 VI	16.4	12.0	27.5	13.8	54.4	2.9	50.4	47.0	14.3	224.0	296.0
VII	27.8	8.2	36.4	14.4	13.0	2.8	43.9	49.4	29.0	223.8	81.8
VIII	5.4	1.4	25.4	16.6	18.3	3.6	59.1	34.7	20.9	189.6	17.2
IX	9.4	0.2	26.1	10.8	11.6	3.8	56.5	21.2	14.3	156.4	36.4
X	8.0	0.8	26.8	14.3	17.7	4.2	63.0	25.8	19.0	200.2	26.2
Lake Winnipeg at Black Island.											
1925 VI	16.3	11.3	15.1	13.4	11.6	1.2	48.3	36.8	7.3	160.6	6.3
VII	15.2	9.6	17.2	9.1	12.4	0.4	25.2	44.7	9.5	158.9	8.4
VIII	15.0	3.6	20.3	13.3	17.2	4.0	25.2	31.8	11.9	169.8	18.0
IX	1.8	0.2	31.6	11.3	3.5	5.4	67.8	18.8	16.6	166.4	31.0
X	6.8	0.8	32.1	12.6	6.1	1.6	65.2	17.6	17.9	160.8	33.2
1926 I	29.2	17.2	32.6	18.3	6.4	1.1	90.4	16.4	29.7	246.0	30.7
Nelson River (Outlet of Lake Winnipeg).											
June 1925	6.8	0.2	31.6	4.6	15.5	2.4	36.5	49.4	14.3	160.1	4.5

Color and light penetration.

The color of the water in the southern portion of Lake Winnipeg is dirty from the large amount of small particles of mud which are brought in by the Red River ("Winnipeg" is Indian for "Muddy water"). But further northward this mud is slowly precipitated, the color begins to be more greenish-brown (influence of numerous diatoms as Asterionella formosa, Stephanodiscus niagarae, etc.) and at last in the northern part of the lake, north of Georges id. the water is so clear that it appears green. The clearest water is in the deepest places and in well protected bays (Limestone Bay and others). In many bays near the mouths of eastern tributaries (Pigeon, Berens, Black, Manigotagan, etc.) the water has a reddish-brown color as a result of the influence of many peaty bogs situated along the shores of these rivers.

The color of the water depends on the penetration of the light or transparency, which has an important influence on aquatic inhabitants, especially plankton vegetation, those primary elements of productivity of the lakes. In connection with this we find in many well protected bays extremely rich phyto- and zooplankton, a richer bottom fauna and as a result a more abundant ichthyofauna than in the open lake. From the same point of view we can say that the northern part of Lake Winnipeg is more productive than the southern part.

Secchi disk.

Traverse Bay ------------------------ 1.00 mt.
Middle of Southern Portion ----------- 1.50 mt.
Narrow place near Gull Harbor -------- 1.75 mt.
Northern Portion --------------------- 1.75 mt.
Northern Portion in Asterdonella fields 1.50 mt.
Pigeon Bay -------------------------- 1.15 mt.

HYDROGEN ION CONCENTRATIONS IN LAKE WINNIPEG

pH	locality	t°	date	pH	locality	t°	date
8.4	Mouth of Red River	17.2	14.vi.28	6.8	Black River	22.0	12.vii.28
8.2	Winnipeg Beach	16.5	16.vi.28	8.0	Grindstone Pt.	17.0	24.vii.28
8.25	Gimli	15.2	17.vi.28	8.0	Mathesson id.	20.1	25.vii.28
8.3	Riverton Bay (Riv.	16.1	17.vi.28	8.0	Whiteway Pt.	19.4	27.vii.28
8.5	Mouth of Icelandic	17.0	18.vi.28	7.6	½ mile off mouth at Bloodvein R.	20.0	28.vii.28
8.2	Gimli (Gimli	17.8	4.vii.28				
8.2	2 miles east off	17.9	4.vii.28	7.2	Bloodvein River	23.0	28.vii.28
8.2	4 miles " " "	18.0	4.vii.28	8.0	Mouth of Pigeon	20.1	8.viii.28
7.9	Traverse Bay	19.0	5.vii.28	7.4	Pigeon River	24.5	17.viii.28
8.3	Middle of Southern Part	24.5	11.vii.28	7.45	Berens River	23.0	14.viii.28
				7.5	Mouth of Berens	23.0	14.viii.28
8.0	½ mile west off Mouth at Black River	22.0	14.vii.28	7.9	Pigeon Bay	18.0	9.viii.28
8.2	2 miles off Black River, Surface	23.0	14.vii.28	7.5	Manigotagan R.	19.2	28.vi.28
7.9	" " " mt.depth	18	14.vii.28	7.5	Winnipegow R.	17.9	27.vi.28
8.2	4 miles off Black R. Surface	24.0	14.vii.28	8.0	Winnipeg River	16.4	27.vi.27
8.0	" " " 11 mt. d.	16.0	14.vii.28	6.5	Whiteshell R.	18.0	12.vi.27

Temperatures and dissolved gases.

As a result of the north and south direction in which Lake Winnipeg lies, different parts of it have different temperatures for about half the year. At the time when the southern portion of the lake is free from ice, usually at the end of May, the northern portion still contains plenty of floating ice, which is brought from the northern shore by the cold "Hudson's Bay" wind. While in the southern portion the temperature of the water is running up and many signs of a "hydrobiological spring" appear certain, e.g., plankton organisms, along the northern shore the lake is covered by ice and there is still a "hydrobiological winter". Besides the difference in latitude, the distribution of heat is largely influenced by the difference in depth of these two portions. The shallow southern portion heats more quickly in spring and grows cold more quickly in autumn, than the deep northern portion. The first ice appears always in the shallower bays of the southern portion. The lake freezes usually in the middle of November, several days after the appearance of the first ice in shallow bays. The thickness of the ice in cold winters reaches 1.25 mt. The freezing point of water in Lake Winnipeg will be between -0.1° C to -0.3°C., depending on salinity. The highest temperature observed near the surface was 28.5°C (31.vii.28) ~~near~~
The following graph shows the average daily surface temperatures based on three readings per diem, at 8 a.m., noon, and 8.p.m. during the summer. As a result of shallow water and turbulence the thermoclone disappears early in summer and even in the deeper places we cannot find any big difference between temperatures at the surface and at the bottom.

The following table shows the distribution of temperatures and dissolved oxygen in parts per million in Lake Winnipeg.

TABLE III.

Depth	Between Berense id. and Berense Bank 10.viii.27 1 p.m.		Middle of Southern Portion 4.vii.28		Black River Drunken Pt. 12.vii.28 5 p.m.		Georges id. 11.viii.28 3 p.m.		Georges id. 7.viii.28 9 p.m.		Marrow place		Depth
	t°C	O2	t°C	O_2	t°C	O_2	t°C	O_2	t°C	O_2	t°C	O_2	
0	17.4	10.6	18.8	9.5	23.8	10.3	18.5	10.5	15.5	10.0	-0.1	25.6	0
1	17.2	10.6	18.0	9.5	20.4	10.1	18.4	10.5	15.6	--	+0.5	25.0	1
3	17	10.6	17.6	9.9	19.6	10.0	18.0	--	16.0	--	--	--	3
5	16.4	10.6	17.2	--	17.2	--	17.8	--	16.4	--	--	24.2°C	5
7	16.3	10.6	13.3	10.0	16.8	--	17.8	--	16.0	--	--	--	7
9	15.9	10.6	13.0	--	16.4	--	17.8	--	16.0	--	--	--	9
11	15.5	10.6	13.0	--	16.2	--	17.8	10.9	16.0	--	--	--	11
13	15.3	10.6	12.5	10.1	16.0	11.1	17.7	--	--	--	--	--	13
15	--	--	--	--	--	--	17.7	--	--	--	+2.0°	14.0	15
17	--	--	--	--	--	--	17.7	11.0	--	--	--	--	17

12

1928

Temperature of Lake Winnipeg. 1928

[Surface, Southern Portion of the Lake]

Temperature of Lake Winnipeg.

Surface.

1929.

The carbon-dioxide content of the water of Lake Winnipeg and certain eastern tributaries is nearly constant and varies between about 1.0 and 1.1 per million.

During the work two deep sea reversing termometers "Negretti and Zambra" were used. Determinations of oxygen were made by Winkler's method and of carbon dioxide by the standard method of titration with $\frac{N}{22}$ sodium carbonate solution and phenolphtalein as indicator. Determinations of carbon dioxide were made by Miss B. Sharman in 1928.

Changing of Level, currents, action of wind and waves.

In the southern portion we can remark only a very weak current from south to north, it is mixed water from Red and Winnipeg Rivers. This scarcely perceptible current becomes quite strong in the narrows near Whiteway Pt. reaching in places 3 miles per hour. Another strong current can be observed near Norway House at the beginning of the Nelson River.

During northern winds, particularly in autumn, the level of the southern portion of the lake rises 2 meters, as a result of influx from the extensive northern part to the southern part. This reversed current is sometimes quite considerable in narrow places.

These currents have their effects on the distribution of temperatures, dissolved gases and other hydrological changes, and have an influence on the migration of whitefish.

The water level in the northern part does not change very much, even during strong winds. As a result of its meridional situation Lake Winnipeg is well open to northern winds, and in September and October is always very liable to storms. The waves are so short and steep that not only fishermen are unable to go out with their 30-40 feet boats for several days, but big steamers must take shelter in well protected bays.

In general, stormy weather on Lake Winnipeg has an essential influence on the whitefish industry.

Character of bottom.

Along the eastern shore of Lake Winnipeg is a narrow strip of Precambrian plateau running down and forming many reefs and small islands, alternating with considerable depths. Not far from the shore this granite plateau passes under the ordovician limestone, which runs under the water and forms the bed of the lake. Most of the limestone bed is covered with alluvial materials which may be roughly divided into the following categories, gradually intergrading from one to another:

(1) Boulder areas. This kind of bottom occurs in narrow and broken strips in many places for quite a distance along the shore and islands. There are broken pieces and washed boulders of limestone along the western shore and granite rock along the eastern shore. This area never reaches considerable depths and represents a comparatively small part in comparison with the rest of the lake.

(2) Gravel areas. These lie next to the boulder areas descending deeper and covering more space than the latter. This kind of bottom is interesting because in many parts it forms spawning grounds for whitefish and on it the whitefish fry passes its first and most dangerous stage of life. These areas are composed of different sizes of small stones and gravel. They run in narrow strips along the shore to the depth of 4-5 mt.

(3) Sand areas. These areas are scattered over many parts of the lake very often representing continuations of the sand beaches. They usually run from 0 to 2 mt. often near the mouths of the rivers and occasionally they occur in the deeper places down to 12 mt. This sand is yellow or yellowish gray, the particles having a diameter of 0.05 - 0.25 mm., composed of nearly pure silica. The whole of these sand areas form a comparatively small part of the whole lake.

(4) Humus areas. These areas of deposited vegetable matter are always in connection with river mouths or with a breaker zone and reach in some places a depth of 6 mt. They are rich in organic stuff, rotten pieces of vegetation, etc., populated by a great many bottom organisms. Often such bottom alternates with rock and sand. The total amount of such places represents a greater part of the lake than the sand areas.

(5) Mud bottom area. This area covers the largest portion of the bottom of Lake Winnipeg, taking up about 7,570 square miles. It is relatively flat situated from 5-6 mt. at the deepest places. It consists of soft, very fine black or dark grey mud, the particles of which measure 0.001 - 0.005 mm., together with a considerable amount of organic matter from dead plankton. In places this mud is mixed with sand and clay.

(6) Clay areas. Clay bottom occurs in a few places in the Northern part of the lake always at a considerable depth and in patches of varying size, among extensive mud bottom. In some places clay occurs at a depth of 18 mt.

LAKE WINNIPEGOSIS (pH. 8.4 - 8.6).

From the point of view of whitefish production, Lake Winnipegosis ranks second in importance in the western Canadian lakes. In the province of Manitoba this lake ranks next in size to Lake Winnipeg. It is a large shallow lake with an area of 2,086 square miles, and is relatively saline as compared with Lake Winnipeg, although the alkalinity does not approach the limit of tolerance of the common fish.

The most important whitefish grounds are found principally in the deeper northern portion of the lake, thus forming an interesting analogy with the distribution of the same species in Lake Winnipeg. In the northern part of the lake from Cormorand Island to Dawson Bay a common sounding is 35 feet or slightly more. North of Whiskey Jack Island the lake is about 60 feet in depth. The southern portion of the lake is very much shallower, usually about 15 feet deep. The conditions in the southern part of the lake appear to be quite definitely unfavorable for whitefish during the period of warm weather. As a result of the high temperature, the dissolved oxygen content of the water is very low, and a number of dead whitefish and cisco were found floating on the surface between the Meadow Portage and the town of Winnipegosis. But in autumn, when the water is cold, a number of whitefish come from deeper places to spawn near the mouth of Waterhen River.

Character of Water.

There is also a distinct difference in the nature and amount of the dissolved salts in the northern and southern parts of the lake. The water in the northern portion of the lake has about 1200 parts per million of dissolved solids, while the waters of the southern part have about one half this amount. This is to some extent the result of the dilution of the solution by the waters by Mossy River, an important stream which empties into the lake at the town of Winnipegosis, and has a drainage area of about 4,000 square miles. The total solid content of the water of this river is about 300 parts per million. There are numerous salt springs draining into the lake.

Analyses of Water from Lake Winnipegosis,
and certain connecting waters.

TABLE IV. (by Miss B. Sharman).
(in parts per million).

	SiO_2	Fe	Ca	Mg	other solids	Cl	SO_4	Total Solids	Alkalinity as $CaCO_3$
Lake Winnipegosis, 22.VI.27 near Snake id. Surface.	8.8	2.61	46.04	0.65	366.54	16 168.0	47.35	600.0	149.9
Lake Winnipegosis, 22.VI.27 near Snake id. 3 metres	9.0	2.61	44.8	—	.	166.0	55.5	720.	149.9
Lake Dauphin, 30.VIII.27 near the source of the Mossy River	1.0	3.5	42.0	1.0		15.	49.3	280.0	139.9

TABLE V.
(in parts per million).

Lake Winnipegosis, near Dog Island, 5.III. 28.

Colour	14 (approx)	cl	427.0
Turbidity	7 (approx)	So_4	138.0
Total solids	1265.00	CO_3	194.0
Ca	107.0	Alkalinity	324.0
Mg	54.0	SiO_2	6.0
Na	270.0	Fe + Al.	2.3

TABLE IV.

(by Dr. P. G. Hiebert, in part per million).

Locality	Date	Total Solids	Mineral	Organic	CO_3	Cl	Ca	Mg	SO_4	N as NO_3	Fe
Near Snake id.	25.V.22	550	336	184	95.4	164	52.5	25.5	70.6	.01	0.1
Near Red Deer Pt.	27.VI.23	558	336	224	81.6	207	43.2	21.8	60.6	.01.	.05.
Near Salt Pt.	27.V.24	656	192	464	85.4	1965	42.0	23.0	77.1	.01.	.16.
Between Long Pt. and Cormorant id	1X.25	708	292	416	82.3	226	46.1	26.3	74.6	.1	.1.
Near Whiskey Jack	IX.28	636	254	382	82.9	208	47.9	24.00	69.5	–	.4
Between Fox Pt. and Pemmican id.	IX.28	640	270	370	81.0	204	48.6	26.0	72.1	–	Trace

Other conditions.

The water in Lake Winnipegosis is clearer than in Lake Winnipeg. Average of Secchi Disk is about 1.75 mt.

Temperatures and dissolved gases in Lake Winnipegosis do not differ very much from Lake Winnipeg. The following Table will explain these hydrological conditions.

TABLE VII.
Temperature and Dissolved Oxygen.

Lake Winnipegosis.

3 miles east of Snake Island. 22.VIII.27 12 noon		2 miles west of Snake Island 24.VIII.27 1 p.m.		2 miles N.W. of Snake Island. 28.VIII.27 12 midnight.	
pth mt.	Temp.	Depth	Temp.	Depth	Temp.
	27.2°C	0 mt.	29.0°C	0 mt	22.9°C
	22.5	1	22.6	1	22.9
	21.8	2	22.4	2	22.9
	21.3	3	22.3	3	23.0
	21.2	4	22.2	4	23.0
r temp	27.8°C	Air temp.	38.0°C	Air temp.	20.0°C

TABLE VII (contd).

Oxygen at surface -24. VII. 27. - 10.2 p. p. m.
Oxygen at bottom (4.5 mt) 24. VII. 27.- 3 p.p.m.

Whiskey Jack (Surface).

	8 a.m.	12 noon	8 p.m.	O_2 at noon
9.XX.28	10.0°C	11.4°C	10.2°C	11.4
10.IX.28	11.7	17.2	13.0	11.4
12.IX.28	13.1	14.9	15.9	11.3
Devils Id. (Surface)				
16.IX.28	11.0	14.4	16.2	10.2
Snake Id. (Surface)				
29.X.28	-0.1°C	+0.3	-0.1	16.8

The bottom of Lake Winnipegosis has a different character from Lake Winnipeg. There are no big rivers to bring in large quantities of mud humus. As a rule the bottom of Lake Winnipegosis is somewhat harder, covered by dead mollusca shells and Chara, although we can find in many places a very soft mud, similar to that of Lake Winnipeg.

LAKE MANITOBA. (pH: 8.3 -8.6.)

This is the next in order of size and importance after the two previous lakes. The area of Lake Manitoba is 1,775 square miles. It is situated between Lakes Winnipeg and Winnipegosis and connected with them by Fairford and Waterford Rivers. Lake Manitoba is very shallow with an average of about 5-6 mt. (maximum 7 mt.).

The whitefish industry stands third in importance following the pickerel and tullibee fisheries.

Hydrological conditions in this lake differ from both the previous lakes as a result of shallower water, but in general are similar to the southern portions of Lakes Winnipeg and Winnipegosis. The transparency of the water is higher than in Lake Winnipeg and less than in Lake Winnipegosis. Secchi disk disappears at the depth of 1.62 mt. The bottom of Lake Manitoba is very similar to Lake Winnipegosis.

The following tables will show the chemical composition of water, temperatures, and dissolved oxygen.

TABLE VIII.

Analyses of Water from Lake Manitoba, in parts per million.

Locality.	Date.	Total solids	Mineral	Organic	CO_3	Cl	Ca	Mg	SO_4	N as NO_3	Fe
The Narrow	viii.28	628	200	428	90.5	204	11.1.	37.4	90.5		[illegible]
Walchorn Bay	viii.28	628	234	394	136.7	154	45.0	48.7	72.9		[illegible]
Step Rock Bay	10.viii.28	614	186	428	87.9	196.0	38.2	35.1	87.9		[illegible]
Elm Bay	25.viii.28	614	194	420	84.8	201.5	37.2	39.2	87.8		[illegible]
Oak Point	4. ix. 28	758	392	366	113.3	113.3	32.6	51.9	110.4		none
Between Elm Pt. and Long Pt.	15.viii.28	752	424	328	115.8	214.5	33.6	50.8	115.6		none

Temperature and Dissolved Oxygen.

Lake Manitoba. (Surface).

Date, Place		8A.M.	12 noon	8P.M.	O_2 noon
Fairford, 7. VIII	Air	24.7	24.8	20.0	
	Water	21.8	22.0	21.0	9.8
Steprock Bay 9 VIII	Air	21.0	24.1	19.6	
	Water	21.0	23.5	21.9	
10, VIII	Air	21.2	26.2	22.0	
	Water	21.6	24.5	21.1	10.9
11, VIII	Air	22.6	24.6		
	Water	20.2	23.2		
12, VIII	Air	23.9	26.0	21.0	
	Water	21.8	24.0	22.6	9.9
13, VIII	Air	21.5	23.6	21.4	
	Water	22.6	23.7	23.5	
14, VIII	Air	18.7	21.6	19.5	
	Water	22.1	23.0	23.2	10.0
Elm Pt. 15, VIII	Air	14.6	19.6	20	
	Water	20.2	21.0	21.9	10.1
Garlson Bay 27, VIII	Air	12.2	14.7	14.9	
	Water	14.2	15.0	15.4	10.6
Dog Creek Bay, 28, VIII	Air	13.2	21.0	15.8	
	Water	14.1	14.5	16.9	10.2
29, VIII	Air	12.0	14.0	9.2	
	Water	15.5	16.9	14.5	
Elm Pt. 30, VIII	Air	12.5	15.1	11.0	
	Water	12.6	14.6	15.4	11.4

Date, Place	8A.M.	12 noon	8 P.M.	O_2 noon.
Elm Bay 16 VIII		19.0	21.0	
		20.0	22.0	10.1
Watchorn Bay 17, VIII	21.5	21.4	21.0	
	20.0	20.6	22.3	9.0
19, VIII	16.5	16.8		
	20.0	20.5		
Mathison Bay	13.5	19.0	16.9	
20, VIII	17.0	19.6	19.9	
Dolly Bay 21, VIII	14.2	19.1		
	16.8	19.2		9.1
24, VIII	12.0	16.0	13.4	
	13.8	15.3	16.2	11.0
25, VIII	13.9	16.8	15.5	
	15.9	16.5	16.7	10.6
26, VIII	11.4	15.5		
	14.0	15.0		10.2
Sugar Bay 31, VIII	12.5	17.8		
	12.1	14.8		
1, IX	12.5	16.2	13.4	
	13.5	17.5	15.2	10.4
Swan Creek 2, IX.	11.6	15.5	10.5	
	13.6	14.8	14.5	10.8
Swan Creek Bay	10.8	16.2	13.6	
	14.0	15.0	15.6	8.0

Remarks: at the bottom 3-3½ mt. the temperature never varies from that of the surface by more than three degrees.

Fairford (near shore)		
27,VIII. 27 1 p.m.		
Surface	19.8°c	O_2-10.6
1 mt.	19.5	
2 mt.	18.6	
3 mt.	18.8	O_2 - 9.9

Fairford (5 miles from shore)		
27,VIII. 27 1 p.m.		
Surface	19.6°c	O_2 - 9.0
1 mt.	19.6	
2 mt.	19.45	
3 mt.	19.4	
4 mt.	19.4	O_2 - 9.9

Lake St. Martin. (ph. - 8.45.)

This lake is situated between Lake Manitoba and Lake Winnipeg and connected with them by Fairford and Dauphin rivers. This is a smaller lake with an area of 125 square miles. Chemical composition of the water, alkalinity, temperatures, dissolved gases, and also fauna of this lake are intermediate between lakes Winnipeg and Manitoba. This is a shallow lake with large areas of hard bottom, which forms good spawning grounds for whitefish. This lake is important and interesting because large shoals of whitefish migrate there every year, at the end of October, from Lake Winnipeg, through Dauphin river, and spawn in a narrow place in Lake St. Martin, at a depth of 2-6 feet.

Waterhen Lake. (ph. - 8.4.)

This small lake, with an area of about 100 square miles, lies between Lake Winnipeg and Lake Manitoba. All hydrological and hydrobiological conditions are very similar to Lake Winnipegosis. The water is quite clear, (seechi disk - 1.25 mt.); pH - 8.45-8.5. The lake is quite deep in the middle, where whitefish find a good feeding ground. This lake is very rich in amphipods and insect larvae. The amphipods are so common that they very often destroy gill nets. This is a very productive lake.

Analysis of water from Waterhen Lake. October 28, 1923. in parts per million.

Total solids	Mineral	Organic	CO_3	Cl.	Ca.	Mg.	SO_4	Fe.
580.	290.	290.	63.3	185.	45.7	24.8	73.5	.1

Dauphin Lake. (ph. 8.35.)

This shallow lake with an area of nearly 200 square miles, is situated twenty miles south of Lake Winnipegosis, to which it has an outlet.

Hydrological conditions are somewhat similar to the southern part of Lake Winnipegosis and are not very favorable for whitefish. The water is very muddy. The lake is not important for whitefish industry and is stocked artifically with whitefish fry from Winnipegosis hatchery.

Atikameg and Cormorand Lakes.

Atikameg lake is situated on the Hudson Bay Railway, seventeen miles north of the Pas. It is quite a large, very clear and deep lake, being about twenty miles in length and twelve miles wide. The maximum depth found was somewhat more than sixty feet. It has one outlet of moderate size into Comorant lake, a more or less similar lake, situated a few miles to the north.

As a result of its northerly situation, and the nature of the surrounding country, Atikameg lake differs very much from lakes of the prairies, and is of a distinctly northern or alpine type. The water is very clear and has a faint blue color. The fish fauna is of a type characteristic of such lakes, whitefish and lake trout being the characteristic species. The forest comes very close to the water's edge. There are very few sandy beaches along the shore line, and the shores mostly consist of limestone and dolomite rock and stones. The western shore is as yet unexplored but doubtless has the same character as the rest of the shore line. No change of level was noticed on the lake.

The bottom of the lake is mainly stony, in deep places covered by a thin stratum of mud. In many parts of the bottom there are big pieces of limestone which are quite easily seen even in deep places. Some of these stones are of such a regular, rectangular shape, that they appear as if made artificially. These stones are brought by floating ice. In some places near shore, the bottom is covered with gravel and sand, which form good spawning places for whitefish and lake trout. Only a few places in shallow bays are covered with water plants (Potamogeton and Myriophyllum) and near shore with water moss, Amblystegium riparium L.

Chemical composition of water, Dissolved Oxygen and Temperatures.

The small percentage of chlorine occurring in Atikameg Lake is very characteristic.

The results of water analysis are given below, in grams per one million c.c. of water:

SiO_2	-	7.0
Fe	-	4.702
Ca	-	19.208
Mg	-	14.662
K, Na, Li	-	41.370
SO_4	-	47.29
Cl	-	8.0
Alkalinity (as $CaCO_3$	-	138.27
pH	-	8.4

The temperatures of the water in the lake were as follows:

19,VII,27. 6 P.M. Sunshine, quite.

Air	21.4 C.	8 m.	15.8 C.
Surface	17.9 C.	10 m.	15.7 C.
1 m.	17.4 C.	12 m.	15.0 C.
3 m.	17.0 C.	18 m.	13.6 C.
5 m.	16.7 C.	20 mt.	13.6 C.

Distribution of dissolved oxygen was as follows:

Surface	14.6 parts per million.
20 mt.(near bottom)	9.0 parts per million.

As a result of the very clear water, (Sechi's disk - 14.5 m.) the light penetration is very great so the thermocline was not found in the lake in the middle of July. (A similar condition has been found in the alpine lakes of Jasper Park.)

Clear Lake. (pH. 8.4.)

Clear Lake is situated in Riding Mountains, Manitoba. This small lake has an area of about 22 square miles and is interesting for comparison with the other lakes of the Prairie Provinces. As a result of its high altitude, and the nature of the surrounding country, clear Lake differs very much from the lakes of the prairies and tends rather towards an alpine type.

It is a deep lake with maximum depth in the southern portion of somewhat more than eighty feet, the northern portion being less deep and well covered with Potamogeton. The water is very clear, Secchi disk disappearing at a depth of 6 mt. This lake has one fairly good sized outlet and several inlets.

Analysis of water.

August 1928. Parts per million.

Total solids	Mineral	Organic	CO_3	Cl	Ca.	Mg.	SO_4	Fe.
240	136.	104.	96.8	3.0	32.6	28.3	35.8	.1

Whitefish are very common in this lake, but have no commercial value. From the ichthyological stand point this fish is very interesting and represents a different geographical subspecies.

Plankton.

Taking into consideration the great importance of plankton in the biology of whitefish we undertook extensive studies of plankton in the Prairie Lakes. The investigations of the larger lakes dealt in more detail with the plankton of Lake Winnipeg, while the observations on the other lakes were made for purposes of comparison. As a sample of the Northern Lakes, situated between Lake Winnipeg and Hudson Bay, we chose Atikameg Lake (near The Pas) as a typical whitefish lake.

Plankton play a great part in the life history of whitefish. Firstly these organisms represent direct food for whitefish fry, as young fishes, during their first, and to some extent, second years, are chiefly plankton-feeders. Secondly adult fish, being bottom-feeders, feed on those animals which are themself mainly plankton-feeders. From this standpoint we can see that plankton studies should form an important part of whitefish investigations.

Collection samples, apparatus, methods.

The collections were obtained from Lakes Winnipeg, Manitoba, Winnipegosis, Dauphin, St. Martin, Waterhen, Cedar, Atikameg, Cormorand, Clear, and other lakes and rivers, including Nelson and Saskatchewan rivers. The largest collections were secured from the three most important lakes in the Prairie Provinces, i.e. Lakes Winnipeg, Manitoba and Winnipegosis. The total number of samples taken from these lakes, during all the seasons, is over six hundred.

All plankton for quantitative work was collected with two special galvanized iron plankton cylinders, volume ten liters each. These cylinders were each fitted with a lid, and a bottom, in the form of two semicircles hinging in the middle and acting as valves, which open as the apparatus descends, allowing the water to pass freely, but close as soon as the cylinder stops or is drawn up. The water collected (usually 50-100 liters) from the desired depth in this way, was then strained through an Apstein plankton net and carefully drained from the bucket into vials. All plankton was preserved in 3% formalon. Temperatures were always taken with plankton samples at all depths. Water samples for determination of oxygen were taken when possible at the same time. For volumetric determination of plankton use was made of special, graduated tubes, half a meter in length and with a diameter of 5 mm., in which the plankton was allowed to settle for 24 hours.

Our experiments show that the volume of plankton in such tubes does not change, or changes very little, during the period from the first 24 hours to one year.

In addition to settling tubes a hand centrifuge was used for quick determination of volume of the plankton. The volumetire estimation of different species has been already discribed by the author, in his former report on "Quantitative and Qualitative study of the plankton of Jasper Park Lakes", (1927), and several new experiments for separation of different animals, by means of different specific gravity, (in NaCe solution) and washing out small diations from larger copepods and phyllopods were performed.

All samples obtained have been carefully worked through and as many different species as possible identified in each collection.

In connection with the study of the circulation of the organic and mineral matter in whitefish biology, several chemdcal analysis of the most characteristic plankton samples, as well as of different species, have been made by Dr. Paul Hiebert, at the University of Manitoba.

Composition of Plankton in Prairie Lakes.

Generally speaking, the plankton of the Prairie Lakes is very rich, both in species and individuals. About 200 different species of plankton organisms have been identified in the lakes examined. The number of species of phytoplankton is only a little greater than the number of species of Zooplankton. Of course not all species of the plankton organisms have the same importance in the biology of the whitefish, many species of Myxophyceae and Chlorophyceae being useless or almost useless and hence not forming a part of that circle of organic matter which includes the whitefish. Nevertheless the most abundant and widely distributed plankton organisms, such as diatoms, phyllopods, and copepods are of first importance in the life history of the whitefish. It is very difficult to estimate the importance of green and bluegreen algae, many of which undoubtedly represent food supplies for small crustacea. The importance of small crustacea as food for whitefish fry, we can see from the second part of this paper. As is shown by chemical analysis of these plankton organisms, they represent an extensive source of phosphorus and albumens - the foundation stones on which the development of the skeleton and muscles of the fishes are based. The most important for whitefish fry are the genera: Bosmina, Daphnia, Alona, Chydorus, Leptodora, Cyclops, which contain all the necessary elements for building up the body of young fishes and are extremely common organisms in all the lakes examined.

The part played by diations consists principally in the feeding of certain insect larvae and amphipods, which represent food of adult whitefish. The stomachs of Chironomidae, Hexagenia and Phryganidae are full of Stephanodiscus niagaise, Asterionella formosa, Melosira, Tabellaria, Fragilaria, etc., and these diatoms, together with small crustacea compose about 90% of all the plankton.

The three large prairie lakes: Winnipeg, Manitoba, and Winnipegosis, each possess a distinctive plankton, fauna and flora, while in the best whitefish lakes, i.e. Winnipeg and Winnipegosis, the plankton consists chiefly of diatoms, copepods and phyllopods, in Lake Manitoba, which is not so important as a whitefish lake, green and blue-green algae predominate.

Horizontal and vertical distribution of plankton organisms.

The horizontal distribution of the plankton depends mainly on depth and accompanying hydrological conditions. Many Cladocera which are abundant above deep waters do not occur in shallow places. This can be explained by the vertical migration of the plankton. For instance, Leptodora, Daphnia, Limnocalanus and partly Epischura, being negatively-heliotropic animals, and living in deep places in Lake Winnipeg, often during gloomy weather, rise near the surface, even during the day time.

On the other hand such organisms as Chlorophyceae and Myxophyceae are distributed mostly near the surface and only sink down at night.

There is a very interesting "insular" distribution of certain plankton organisms. For example the alga Aphanizomenon flos-aquae, which very abundant in the southern portion of the Lake Winnipeg, is not equally distributed over all this area. In places it forms a carpet on the water and in other places does not occur, although all conditions seem to be the same. This is well shown on fig. III and IV.

A considerable influence on the distribution of plankton organisms is exerted by the chemical composition of the water and particularly the alkalinity. Thus, many species, which are widely distributed and common along the eastern shore of Lake Winnipeg, hardly occur along the western shore. In shallow bays the plankton is richer, both in species and in individuals. There are many Phyllopoda and Chlorophyceae, which do not occur in the open lake, and though of minor importance to the whitefish, these often form a source of food to other species of fish.

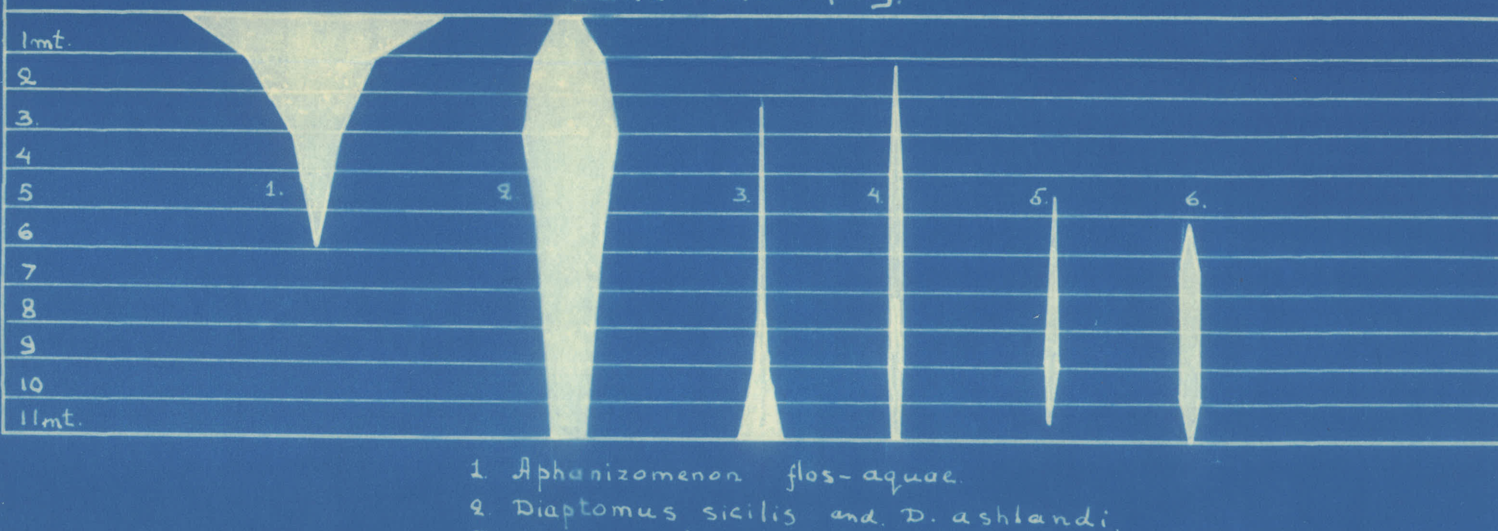
The following graphs illustrate the vertical and horizontal distribution of the most important plankton organisms in Lake Winnipeg.

The Vertical Distribution of certain Planktonic Organisms at the Whitefish Ground near George Id. 11.VIII.28.
Lake Winnipeg.

1. Asterionella formosa.
2. Stephanodiscus niagaroe,
3. Daphnia longispina hyallina
4. Cyclops (sev. species)
5. Leptodora Kindtii.
6. Limnocalanus and Epischura.
7. Diaptomus sicilis and Ashlandi.

Scale: 1 inch = 1 c.c. per 60 liters of water.

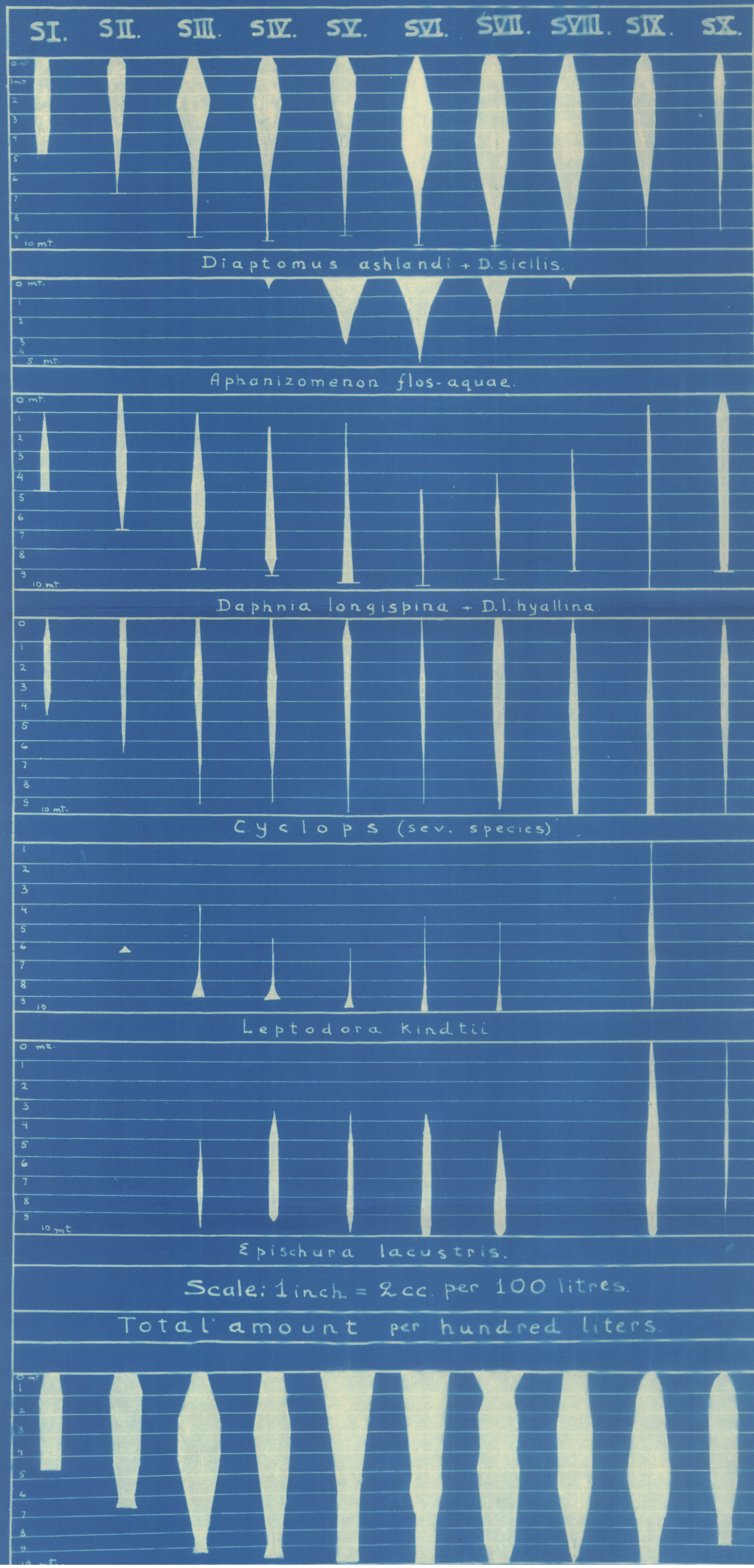
The Vertical Distribution of certain Planktonic Organisms at the Whitefish Ground near Black Id. 31.VII.28.
Lake Winnipeg.

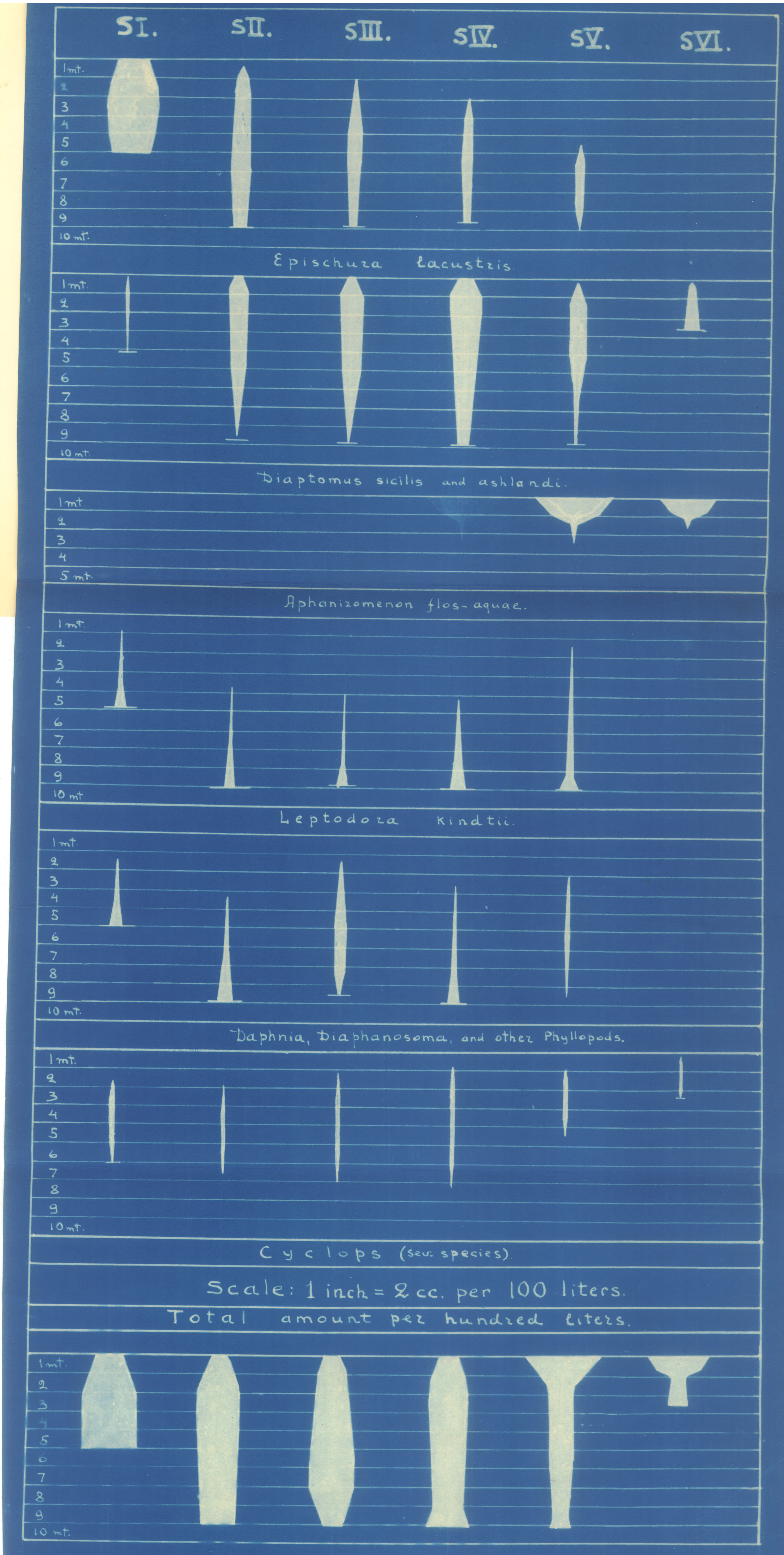


1. Aphanizomenon flos-aquae.
2. Diaptomus sicilis and D. ashlandi.
3. Daphnia longispina.
4. Cyclops (sev. species)
5. Epischura lacustris.
6. Limnocalanus macrurus.

Scale: 1 inch = 1 cc. per 60 liters of water.

Cross Section of Lake Winnipeg from Gimli to Traverse Bay showing the Distribution of certain Planktonic organisms. 4.VII.28.





S I.
S II.
S III.
S IV.
S V.
S VI.
1 mt.
10 mt.
Epischura lacustris.
Diaptomus sicilis and ashlandi.
5 mt.
Aphanizomenon flos-aquae.
Leptodora kindtii.
Daphnia, Diaphanosoma, and other Phyllopods.
Cyclops (sev. species).
Scale: 1 inch = 2 cc. per 100 liters.
Total amount per hundred liters.

Seasonal variations of plankton.

From the point of view of fishculture the study of seasonal variation of plankton is one of the most important problems. During the latter part of winter and early in spring, just before the hatching of whitefish fry, in Lake Winnipeg and many other Prairie Lakes, the plankton is not rich, either in species or individuals, and is composed chiefly of copepods and diatonus. The principal species are: Diaptomus sicilis, Diaptomus ashlandi, several species of Cyclops, many naupliis, Melosira, Stephanodiscus, Gomphonema and Surirella. This plankton is distributed almost equally through the lakes, becoming less rich near shores.

As soon as warm weather comes and the ice begins to go back from the shore a very rich fauna of small phyllopods and other small crustaceans begin to appear, and spread out farther and deeper from the shore as the ice melts and the temperature of the water rises. This begining of the "hydrological spring" usually occurs early in May, when the hatching of whitefish fry takes place. The characteristic plankton animals, at this time, are Bosmina, Chydorus, Eurycercus, Pleuroxus, Acropterus, Alona, Alonella, Moina, Cyclops, Diaptomus and Ostracoda. All these animals represent food for whitefish fry. On the early and incolent development of the plankton depends the crop of whitefish fry.

If an early and cold autumn is followed by a late, cold spring, the whitefish fry may not find enough food. Through the summer these small crustacea are always quite plentiful. Daphnia longispona, which probably forms also one of the most important foods of young whitefish, reaches its maximum abundance in the middle and latter part of the summer. At the time greenalgae and diatoms(especially Asterionella, Tabellaria, Stephanodiscus) reach their maximum abundance and support certain insect larvae, which are faod for adult whitefish.

Later in the summer and autumn Leptodora Kindtil, Limnocalanus macrurus and Epischura lacustris seem to be more abundant.

In different lakes of the Prairie Provinces we find a great variability in maximum abundance of different species.

Thus Aphanifomenon flos-aguae - the most abundant alga in Lake Winnipeg, from July to September, does not occur at all in Lake Manitoba, but is replaced there by another alga Rivularia pisum.

The plankton samples obtained from all the various stations have been carefully worked through and as many species as possible identified in each collection. The following letters are placed in the Table opposite the name of the species and under the locality in which they were obtained.

LIST OF SPECIES.

Myxophyceae.

A - abundant; VC -very common; C - common; LC - less common - R - rare.

	Lake Winnipeg	Lake Manitoba	Lake Winnipegosis.	Lake Atikameg
Aphanizomenom flos-aque Ralfs	A			
Anabaena circinalis Raben	LC			
Anabaena flos-aquae Bree	A	C	LC	
Anabaena lemmermanni Richt.				R
Aphanocapsa elachista West	C	?	?	C
Chroococcus limneticus Lemm.	C	C	C	C
Chroococcus turgidus Nag.	R		R	LC
oclosphaerium Kuzingianum Nag m	LC			
loeothece linearis Nag.			R	
erismopedia glauca Nag.	C	LC	?	
icrocystis aeruginosa (Kutz)	LC	C	LC	LC
ostoc commune Vauck	C	C	C	C
scillatoria agardhii Gom.	LC		LC	LC
scillatoria limosa Ag.	C			
yngbia major Uneg.			LC	R
vularia pisum (Ag.)	LC	A	C	

Chlorophyceae.

	Lake Wpg.	Lake Manitoba	Lake Winnipegosis	Lake Atikameg.
Actinastrum hantzschii Lager.			LC	
Actinastrum gracillimum G.M. Smith.	LC	L C	L C	
Botryococcus Brauni KutzV	C	C	L C	L C
Cladophora sp.	L D	R	R	
Closterium moniliferum Ehr.	C	C	L C	L C
Closterium sp.	R	R	R	
Coelastrum microsporum Nag.	C	L C	L D	
Cosmarium menghinii Breb	L C	L C	R	
Cosmarium Botrytis Uneg.	C	L C	L C.	
Cosmarium sp.	L C	L C	L C	
Crucigenia quadrata Morren	L C	C		
Crucigenia rectangularis (Nag.)			L C	
Cosmarium reniforme (Ralfs)	L C	L D	R	
Distyosphaerium pulchellum Wood.	A	V C	V C	C
Draparnaldia glomerata Ag.	R			
Euastrum sp	R	R		
Eudorina elegans Ehrb.	C	C	L C	
Hydrodiction reticulatum (L)	L C			

Chlorophyceae cont'd.

	Lake Wpg.	Lake Manitoba	Lake Winnipegosis	Atikameg Lake.
Kirchneriella obesa (West).	L C			
Micrasterias sp.	L C		L C	
Microspora sp.	L C	L C	L C	
Mougestia sp.	R	R	R	
Oocystis lacustris Chad.	C	C	L C	
Oocystis solitaria Wittr.	L C			L C
Pediastrum Boryanum Uneg.	V C	V C	V C	C//
Pediastrum duplex Uneg.	V C	V C	V C	C
Pediastrum duplex Meyen. var.	V C	V C	V C	
Pediastrum Biradiatum Uneg.			C	
Pediastrum integrum Nag.	C	R	R	
Pediastrum tetras(ehrb.)	C	C		
Pediastrum simplex Meyer.	C	C	C	R
Pediastrum simplex Meyer. var.	C	C	C	
Rhizoclonium hiero-gliphicum Kutz.	C	C		
Scenedesmus Bijugatus Kutz.	L C			
Scenedesmus quadricanda Breb.	A	A	A	

Chlonophycaae cont'd.

	Lake. Wpg.	Lake Manitoba	Lake Winnipeg-osis	Atikameg Lake.
Stigeoclonium sp.	L C			
Selenastrum sp.	C	L C	L C	
Sphaerocystis schraeteri Chodat.	L C			
Staurastrum brevispinum Breb.	L C	R	L C	
Staurastrum leptocladum Nordst.	R	R	?	
Staurastrum sp	L C	L C	L C	
Spirogyra sp.	R	R		
Tetraspora gelatinosa (Vauch)	C	C	C	
Tribonema sp.	R	R		
Ulothrix zonata Kutz.	L C	L C	L C.	
Zygnema sp.	C	L C	L C	

Bacillariaceae.

	Lake. Wpg.	Lake Manitoba	Lake Winnipeg-osis	Atikameg Lake.
Amphiprora ornata, Bail.	C		C	
Amphora ovalis Ehrb.		L C	L C	L C
Asterionella formosa Hass	A	R	C	A
Campylodiscus sp.			L C	
Cocconema sp.				C
Cyclotella antiqua, W.Sm.	C	C	C	
Cymatopleura sp.	C	C	C	

Bacillariaceae cont'd.

	Lake Wpg.	Lake Manitoba	Lake Winnipeg-osis.	Lake Atikameg.
Cymbella sp.	C			
Denticula infanta Smith.	C			L C
Diatoma elongatum Sg.	C		C	
Epithemia gibba Kutz.				L C
Epithemia turgida(Ehrb)	C	C	C	C
Eunotia sp.	L C	L C	L C	L C
Fragilaria crotonensis Kitton	A	V C	A	A
Fragilaria capucina Desmaz.	R			
Gomphonema acuminatum Ehrb.	L C			L C
Melosira granulata Ehrb.	V C	V C	V C	
Melosira varians (Ag.)	V C	V C	A	C
Navicula exilis Grun.	L C			
Navicula radiosa Kutz. var. acuta.W Smith	V C	C	L C	
Navicula viridis Kutz.	L C			L C
Navicula sp.	L C	L C	L C	C
Nitzschia linearis Smith	R			R
Pleurosigma attenuatum W.Sm.	C	C	L C	C
Rhizosolenia morsa W.& G.West.	V C	R	R	?

Bacillariaceae cont'd.

	Lake Wpg.	Lake Manitoba	Lake Winnipeg-osis.	Atikameg. Lake.
Rhopalodia gibba O.F. Mull.	L C			L C
Stephanodiscus niagaroe Ehrb.	A	L C	L C	L C
Surirella ovalis Breb. var. ovata Kutz.	L C	L C	L C	L C
Surirella spiralis?	L C			
Surirella sp.	L C	L C	L C	L C
Synedra salina W.Smith.	L C	R	L C	C
Synedra sp.	C	L C	C	L C
Tabellaria fenestrata Kutz.	A	V C	V C	A
Tabellaria flocculosa Kutz.	C	L C	L C	L C
Flagellata.				
Ceratium hirundinella O.F. Mull	L C	L C	L C	L C
Dinobryon sertularia Ehrb.	V C	C	C	C
Dinobryon stipitatum Stein.	C	L C	L C	C
Glenodinium pulvisculus Stein.	C	L C	L C	
Peridinium tabulatum Ehrb.	R	R	R	C
Trachelomonas sp.	L C		R	
Rotatoria.				
Anuraea aculeata Ehrb.	V C	V C	V C	

Rotatoria cont'd.

	Lake Wpg.	Lake Manitoba	Lake Winnipegosis.	Atikameg Lake.
Anuraea cochlearis Gosse.	A	V C	V C	V C
Anuraea cochlearis Gosse var. Tecta				
Asplanchna priodonta Gosse	R	V C	L C	
Asplanchnopus myrmeleo Ehrb.	R			
Brachionus angularis Gosse	C			
Brachionus bakeri Mull	L C	L C	L C	
Brachionus bakeri Mull. var. entzii (Frande)	L C	C		
Brachionus bakeri Mull. var. brevispinus Ehrb.		C		
Brachionus pala Ehrb.	C		L C	
Cathypna luna Ehrb.	C	C	C	
Cathypna ungulata ?	C			
Colurus grallator Gasse	L C	C		
Colurus sp.	C			
Cochleare turbo Gosse.			L C	
Conochilus unicornis Roussel				R
Diplax sp.				A
Diplois daviesiae Gosse	C			

Rotatoria cont'd.

	Lake Wpg.	Lake Manitoba	Lake Winnipeg-osis.	Atikameg Lake.
Distyla inermis Bryce.				L C
Monostyla quadri-dentata Ehrb.		C		
Monostyla lunaris Ehrb.	C		L C	
Noteus quadricornis Ehrb.	C	?	L C	
Notholca longispina Kellic	A	A	A	A
Pterodina patina Ehrb.	R			R
Ploeosoma lentic-ulare Kerrick.				R
Polyarthra platyptera Ehrb.	A	A	A	A
Rattulus cilindricus Imhof.	L C			
Rattulus longiseta. Schrauk.	L C			
Rattulus sp.	C			
Tetramastix apoliensis Zach.	V R			
Triarthra terminalis Plate	R		R	
Triarthra sp.	L C	A	C	
Salpina macracantha Hosse				L c
Scardinium longicaud-atum Ehrb.				L C

Copepoda.

C	Lake Wpg.	Lake Manitoba	Lake Winnipegosis.	Atikameg Lake.
Canthocamptus sp.	C	V C	C	
Cyclops Bicolor Sars.	R		R	L C
Cyclops bicuspidatus Claus.	V C	L C	C	V C
Cyclops fimbriatus Fish	L C		L C	R
Cyclops pracinus ?		C		
Cyclops sp.	C	C	C	
Diaptomus ashlandi Marsh.	A			
Diaptomus tenuicaudatus Marsh			C	
Diaptomus Sicilis Forbes.	A			A
Diaptomus Siciloides Lilljeb.			C	
Diaptomus leptopus Forbes.	C			
Diaptomus shoshone Forbes.		V C		
Diaptomus sp.		C	C	
Epischura lacustris Forbes.	A		C	A
Limnocalanus macrurus Sars.	V C			

Phyllopoda.

Acropterus harpae Baird	C	C	L C	
Alona affinis Leydig.	R			

Phyllopoda contʼd.

	Lake Wpg.	Lake Manitoba	Lake Winnipegosis	Atikameg Lake.
Alona quadrangularis O.F. Mull	C	C	C	L C
Bosmina longispina Leydig.				R
Bosmina longirostris O.F. Mull.	C	C	C	A
Ceriodaphnia pulchella Sars.	C			
Ceriodaphnia sp.	C	C	C	
Chydorus sphaericus O F Mull	C	C	C	C
Chydorus gibbus Lilljeb.				R
Daphnia pulexx de Geer.	C	C		
Daphnia longispina O.F.Mull	V C	V C	V C	A
Daphnia longispina O.F. Mull var. hyalina	A	A	A	A
Daphnia retrocurva Forbes.			L C	
Diaphanosoma leuchtenbergianum Fish	C	L C	C	
Diaphanosoma brachyurum Lieven	C	C		
Eurycercus lamellatus O.F. Mull	C			
Estheria mexicana Claus.	A			
Kurzia latissima Kuzz	L C	C		

Phyllopoda cont'd.

	Lake Wpg.	Lake Manitoba	Lake Winnipegosis	Atikameg Lake
Leptodora Kindtii Focke	A		A	C
Limnetis gouldii Baird	A			
Moina sp.	R	L C	C	
Pleuroxus denticulatus Birge.	V C			
Pleuroxus procurvatus Birge	L C		C	
Polyphemus pediculus (L)	L C			
Sida crystallina O.F.Mull	C	C	C	
Scapholeberis mucronata O.F. Mull.	L C		L C	
Simocephalus serulatus Koch	C			
Simecephalus vetulus O.F.Mull	L C	L C	L C	
Ostracoda.				
Limnocythere reticulata Sharpe.	L C	L C	R	
Cypria sp.	C	C	C	C
Candona sp.	L C	R		
Protozoa				
Actonosphaerium sp.				L C
Arsella vulgaris Ehrb.	R			
Difflugia corona Wallich	R			
Difflugia piriformis Perty.	R			
Diffulgia lobostoma Leidy.				L C

Protozoa, cont'd.

	Lake Winnipeg	Lake Manitoba	Lake Winnipegosos	Atikameg Lake.
Diffulgia sp.	R			C
Splen[illegible]eria sp.	LC			
Tintinopsis sp.	C	C	C	C

Chemical Composition of Plankton in Lake Winnipeg.

Several chemical analyses of quantitative samples of plankton from whitefish grounds have been made during the winter of 1928-29. The results are as follows:

(In Grams)

	Rough Weight	Dry Weight	Ash	% Ash in dry weight
10 cc. of Diatom's plankton from Goose Is.	--	.1128	.0673	59.[illegible]
2 cc. of copepod's plankton from Southern portion of the lake.	.45	.0486	.0053	1.09
13 cc. of Phyllopod's plankton (Daphnia longispina)	2.49	.2408	.0795	33.03
Aphanizomenon flospaquae, (in 60 litres of water)	--	.0684	.0050	7.31

THE PLANKTON OF LAKE WINNIPEG.

There are great variations in the total amount of the plankton in Lake Winnipeg during different seasons. The following graph illustrates such variations, during 1929. The average amount of plankton estimated from about five hundred samples, during August is about 22.52 cubic centimeters per one cubic meter of water, as measured after settling. The maximum depends chiefly on the maximum of blue-green algae such as Aphanizomen and Anabaena, etc. Assuming that the whole of Lake Winnipeg contains about 245.014.000.000 cubic meters of water we can say roughly that in August there are 5,512,500 cubic meters of plankton containing approximately:

1,147,500,000 kg. of rough weight,
114,750,000 kg. dry weight,
76,500,000 kg. organic matter,
38,250,000 kg. mineral salts,
30% ash in dry weight.

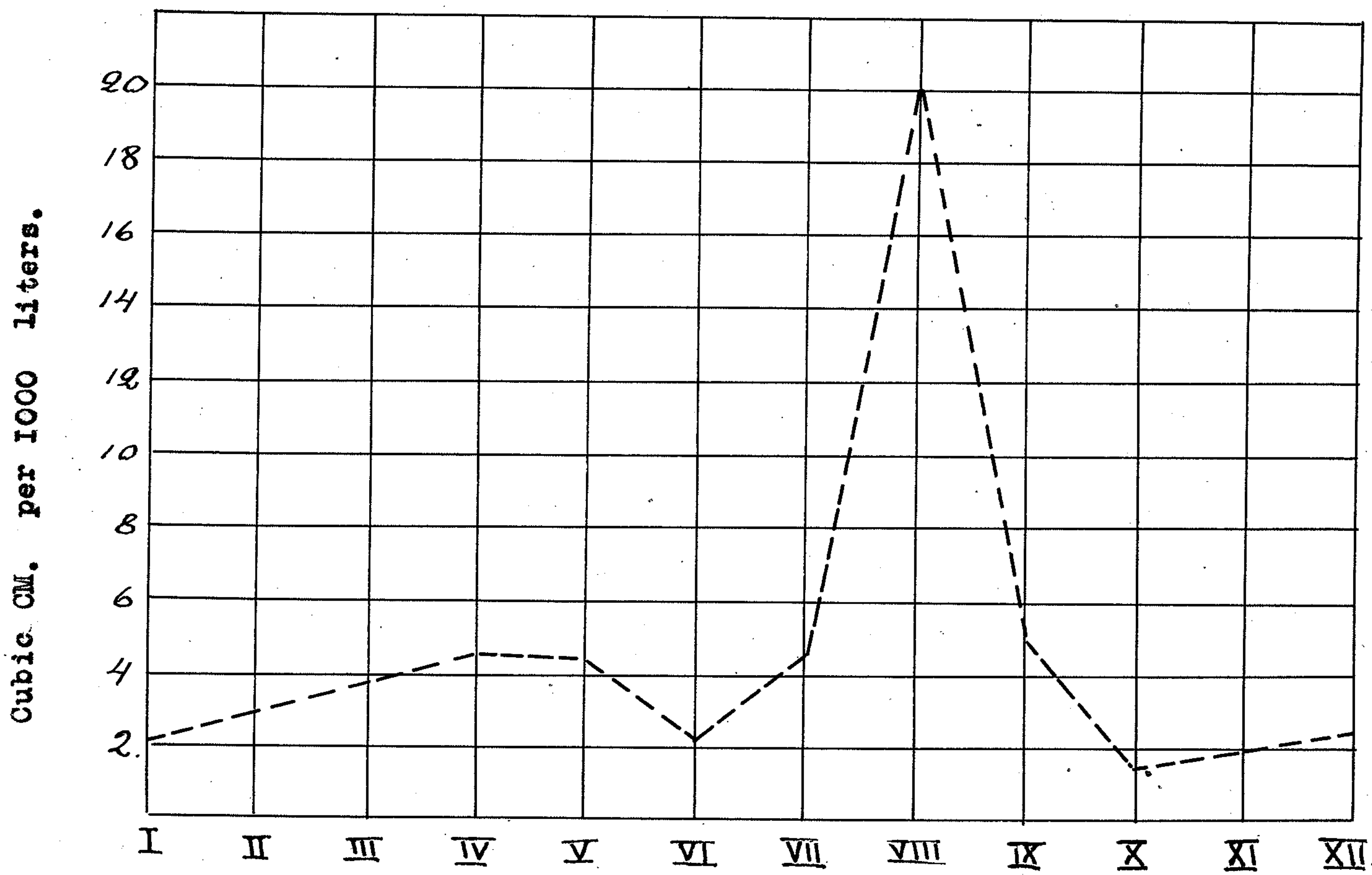
PLANKTON OF OTHER LAKES EXAMINED.

Lake Waterhen. The plankton of this lake is composed of the same species as occur in Lake Winnipegosis, Asterionella formosa, Fragilaria crotonensis, Stephanodiscus niagaioe, Melosira, Talellaria, several species of Pediaotorum, Anuiaea, Notholea, etc., are common in this lake. Also Copepoda and Phyllopoda not uncommon. Not very many samples have been secured from t is lake, but judging from the similar conditions which prevail in Lake Winnipegosis, we cannot expect to find a great many plankton organisms which do not occur in Lake Winnipegosis or Lake Manitoba.

Lake St, Martin. About twenty quanttitative and qualitative samples were secured from this lake in August 1927. The following species have been found: Asterionella formosa, Fragilaria crotonensis, Melosira granulata and varians, Bosmina longirostris, Daphnia loggispina Chydorus sphaericus, Alona sp, Pleuroxus sp. Diaphanosama, several species of Cyclops and Diaptomus, Anuraea cochlearis and aculeata, Polyaithia platyptera, Notholca longispina, Cathypna luna, several speciea of Pediastrum, Staurastrum, and many others Chlorophyceae and Myxophyceae.

Cedar Lake. Two samples from this Lake were collected in September 1928. The plankton of Cedar Lake is quite similar to the plankton of the northern portion of Lake Winnipeg. Asterionella formosa Fragilaria crotonensis, Pediastrum coryanum, duplex and simplex, Staurastrum sp. Polyarthra platypera, Epischura lasustris, Diaptonus sicilis and cyclops sp. are common species.

Clear Lake. Several quantitative and qualitative samples were collected from this lake in 1927 and 1928. The plankton of this lake is somewhat different from other prairie lakes. Several planktonic organisms such as Hollopedium gibberum, Rhoicosphenia currata, Salpina, Spinigera, etc., which do not occur in other lakes examined, are present in Clear Lake. On the other hand many common species of plankton organisms in Lake Winnipeg, Winnipegosis and Manitoba, have not been observed in Clear Lake. The most important species for whitefish fry,



Graph showing seasonal variations in amount of plankton present in Lake Winnipeg.

sch as Bosmina longirostris, Daphnia longispina, Diaptomous sicilis, Cyclops bicuspidatus and other small Crustacea, as well as Leptodora Kindtii, are abundant in Clear Lake.

Nelson River. A few samples of plankton from several bays in the Nelson River, near Kettle Rapids, were taken, in September 1928. The following species have been found: Asterionella formosa, Melosina granulata, Melosina varians, Gomphonema constrictum, Stephanodiscus niagaroe, Fragilaria crotonensis, Rhizosolenia morsa, Pediastrum coryanum, simplex and duplex, Ulothrix sp. Euchlanis macrura, Bosmina sp. (remains) and Diaptomus sp. (remains.

COMPOSITION OF THE BOTTOM HABITATS OF LAKE WINNIPEG.

As the adult whitefish is a bottom feeder, so the study of bottom fauna, both quantitative and qualitative, must be one of the most important problems in the biological investigations of the species. During 1927, 1928, and 1929, some fifteen hundred bottom samples were collected and a considerable attention was given to whitefish grounds.

Methods and instruments:

At each station, where quantitative plankton was taken, together with depth and temperatures, from five to ten bottom samples with the Ekman dredge were collected. This dredge cutting out sixty four square inches of bottom with all the animals therein, works very well on soft ground but is nearly useless on hard stony bottom, where in addition to this instrument, several different sizes (1-3") of simple zoological dredges were used.

Samples were washed through metal sieves and riddles. The most convenient sieves were found 2½ ft in diameter with 1/20 inch mesh. After washing, all organixms were carefully collected into vials and preserved with 3% alcohol or formaldehyde or counted and recorded.

nThe material was worked through in the laboratory of the Prairie Lakes Investigation in Winnipeg, where all bottom organisms were counted, identified, and "rough weight" of certain species was determined.

This"rough" or "formalin" weight gives a general quantitative idea of the total productivity of certain spots. The samples, after being preserved for a long time in formalin, usually increase in weight by about0.25-0.75% in consequence of becoming saturated and possibly also, certain chemical reactions, while the "alcohol" weight, as a result of extraction, shows a considerable decrease, (to 2-3%). Determination of"dry weight" was made after preliminary drying at 60°C. and full drying at 100°C. until a constant weight was obtained. Chemical analysis of the organisms which are most important in the biology of the whitefish, were made.

Distribution of bottom fauna in horizontal and vertical direction.

As the quantitative and qualitative compositions of the bottom fauna depends on the depth and character of the tround, it will be correct to divide it into zones which correspond to bottom areas .

1. Benthos of Boulder and Gravel bottoms.

This area is preferred by mollusks: *Physa gyrina*, *Physa integra*, *succinea ovalis*, *Succinea avara*, *Lymnaea stagnalis appressa*, *Planorbis exacuous*, *Planorbis parvus*, *Valvata tricarinata*, *Pisidium spp.*, *Sphaerium spp.* and several species of Anodonta and Lampsilis. There are also present in abundance the larvae of Ephemeridae, Trichoptera, Coleoptera, amphipods, (Hyalella knickerbockerii, Gammarus spp.) Cambarus, and small crustacear (Sida crystallina, Eurycercus lamellatus, Simocephalus, Alona, Chydorus, Bosmina, Canthocamptus, etc) Many species of Hirudinea, Oligochaeta and Hydrocarina are also common.

m This zone is very rich in aquatic vegetation and shows most diversity in number of species. On the deeper border of this area, about 1½ - 2 mt. spaqning of whitefish takes place and the whitefish fry pass the first stadia of their life.

The quantitative investigation of the benthos of this area is very difficult, because the development of the organisms, which are most important for whitefish, is regulated by different circumstances, such as changes in temperature, winds, etc. The Ichthy or fauna of this area is very rich. There are many different species of minnows (Notropis hudsonius, Notropis spp. Percopsis, omisco-maycust, etc) and fry of certain commercial fishes, such as pickerel, pike, perch and others.

Along the western shore of Lake Winnipeg there are absent quite a number of aquatic organisms which are more or less characteristic of the eastern shore as Campeloma decisum (Say) Lymnaea megassoma (Say) and several other mollusks, also lake sturgeon (Acipenser fulvescens) during the spring.

2. Benthos of Sand bottom areas.

As these areas are situated in different parts of the lake their fauna is also quite different. In general, if such areas are not covered with aquatic vegetation, their fauna is comparatively poor. The bottom samples from such areas include a few species of mollusks, especially Pelecypoda, amphipods and insect larvae. The contents of alimentary tracts of fishes taken from such places show the presence of small phyllopods. Such sand areas are populated by young pickerel, perch, and different minnows, but in limited quantity. The role played by these areas , in the biology of whitefish, is not very clear to us, but it ispossible to say that if they are not very important it is because they are not large in comparison with other part of bottom.

3. Humus Areas.

As these areas are distributed near the mouths of the rivers, along the western, as well as the eastern, shore, where the chemical conditions of the water are very different, their bottom fauna has a considerable influence and shows an admixture of river forms. Along the more alkaline western shore, as for instance, Riverton bay, such areas are populated with Hyalella knickerbockery, larvae of Phryganidae, Chironomidae, several species of Sphaerium and Pisidium and comparatively few species of fishes. In many places they are covered with Potamogeton interior, Potamogeton richardsoni, and Myriophyllum spicatum.

On the other hand, similar areas near the eastern shore of Lake Winnipeg are populated much more ichly. Crustacea are especially plentiful there, being represented by many species: Gammanus spp, Pontoporeia Hoyi, Mysis relicta, Estheria mexicana, Limnetis gouddii, Leptodora Kindtii, Epischura lacustris, Limnocalanus macrurus, and many other species of small Crustarea, as well as Cambarus viridus. Mollusks are also extremely abundant and represented by many species of Sphaerium, Musculium, Pisidium, Physa, Lymnaea, Planorbis, Anodonta and Lampsilis. Many species of Phryganidae, Ephemeridae and Chironomidae, also are not uncommon.

Many species of fish and fish fry find a good feeding ground on these areas. Several spawning grounds for whitefish are situated near such areas, along the eastern shore of Lake Winnipeg, and it is very possible that whitefish fry can find a good feeding ground here. Adult whitefish do not occur on such bottom, except at spawning time, when they pass through them to the spawning grounds.

Benthos of Mud Bottom Areas.

These, the most extensive areas, covering approximately 85% of all Lake Winnipeg, are the places where the whitefish spend the greater part of their lives, where they grow, feed and where the main whitefish industry is carried on. They are the so-called "Whitefish grounds".

The Benthos of these areas is rather poor in number of species, but individuals are present in such large numbers that undoubtedly they can feed a much larger quantity of whitefish than are present in the lake, at the present time, With few exceptions all these organisms are useful from the standpoint of whitefish production. The investigation of the benthos of these grounds was given considerable attention, and quite a number of bottom samples were taken from different whitefish grounds.

The most characteristic organisms of this zone are:

Crustacea	%	Mollusca	%	Insect larvae	%
Pontoporeia hoyi	63	Valvata tricarinata	0.3	Hexagenia limbata	10
Hyalella knickerbockeri	0.6	Valvata sp.	0.2	Ephemeridae (larvae)	0.5
Gammarus sp.	0.3	Amnicoda spp.	3.3	Phryganea sp.	2.2
Mysis relicta	1.0	Pisidium sp.	4.5	Molana sp	1.5
Estheria mexicana	3.7	Spharium sp.	4.0	Other Trichoptera	0.9
Limnaetis gouldii	0.95	Musculium sp.	0.5	Chironomidae larvae	0.4

Rest -------------3.05%

Before the consideration of this area, which is of such importance for the whitefish induesty, it seems well-timed to examine thoroughly, several questions, in connection with the biology of these organisms, as it will throw great light on the biology and local distribution of whitefish.

1. Sources of food of deepwater organisms. The investigations of the alimentary tracts of different species, which provide food for whitefish, shows that most of them feed on living, as well as, dead plankton organisms, and uninterrupted rain of which, keeps alive such, as are more removed from the surface and upper strata of the water, and the illumination and heat of beneficial sun rays.

The most important plankton organisms, which provide food for insect larvae (Hexagenia, Phryganidae, Chironomidae etc), are small diatoms, such as Asterionella formosa, Stephanodiscus niagarve, Tabellaria fenestrata and floculosa, Melosira granulata and variaas, etc. The food of small amphipods (Hyalella knickerbockeri, Pontoporeia hoyi, Gammarus spp.) consists of Asterionella, Stephanodiscus, Tabellaria, Melosira, Meridion sp., Synedra spp., Chroococcus

Turgidus and limneticus.

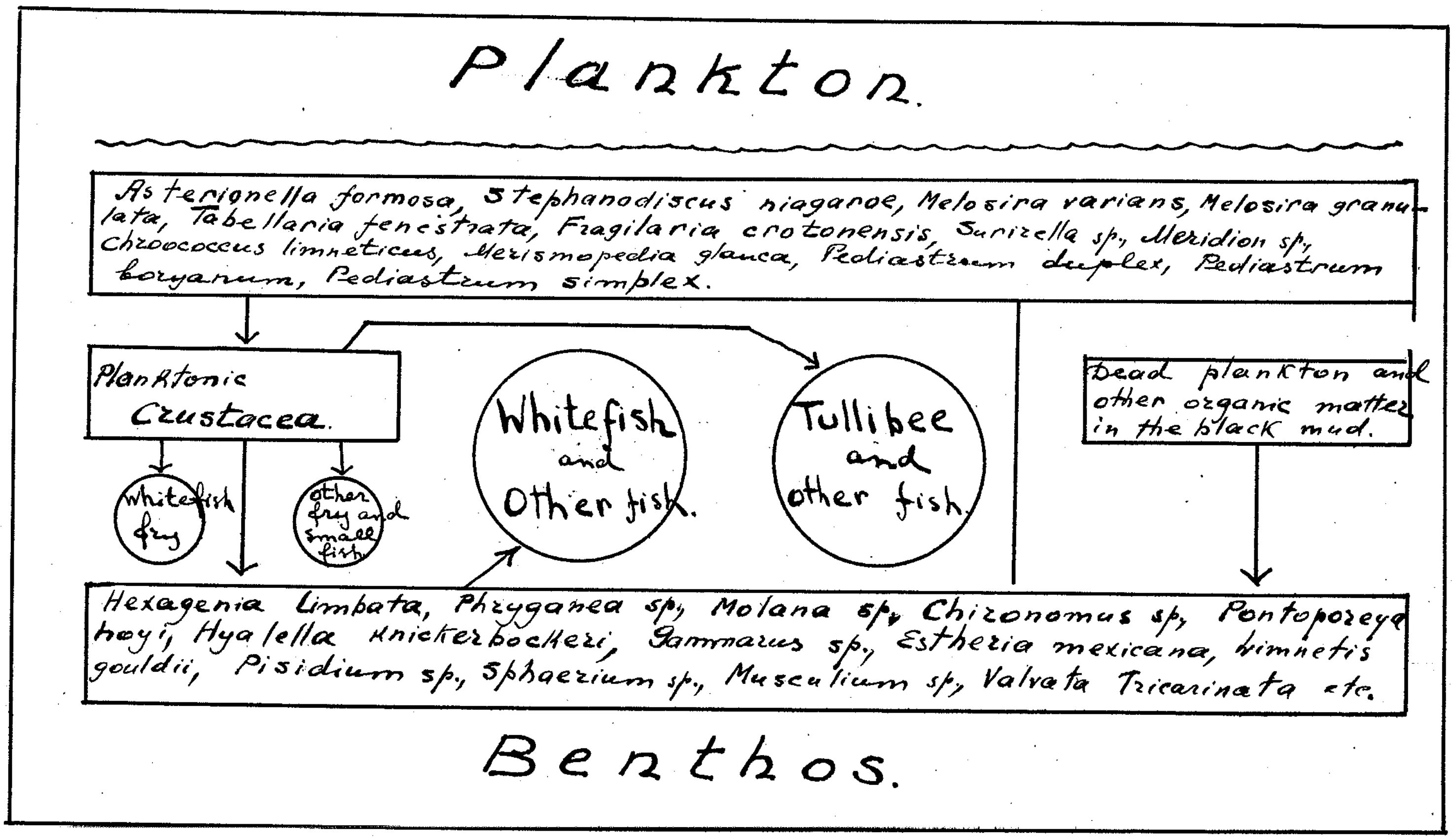
The food of small mollusks (Sphaerium spp. Pisidium spp., Amnicola sp Valvata tricarianta and sp., Lymnaea sp.) is chiefly Tabellaria, Stephan-odiscus, Fragilaria, Asterionalla, Chrooesccus, Scenedesmus, Pediastrum Coryanum and duplex, Cocconema lanceolatum, Merismopedia glaucum.

The following scheme shows this cycle of exchange of organic matter. (See p. 48.)

2. On the basis of our examination of the bottom fauna of the whitefish grounds in Lake Winnipeg, we conclude that the larger proportion of different animals, such as mollusks, insect larvae, amphipods, etc., are distributed irregularly being congragated in spots on the whole bottom area. It is true, now only for mollusks, and other sedentary organisms, but also to different quick-moving forms, such as Amphipoda, Mysis relicta etc. As the depth, temperatures, dissolved gases, and chemical composition of the water were in many cases similar, such differences in distribution depend, probably onthe different composition and structure of the bottom and other specific conditions, which may easily pass undected by investigators.

As an illustration the following table shows the number of Amphipods secured in ten dredges at five different stations situated within one mile near George Is. on whitefish ground. The depth, temperature, nature of bottom, etc., appeared quite similar

Dredges.	St. 1.	St. 2.	St. 3.	St. 4.	St. 5.
1	39	22	39	6	4
2	32	26	30	3	0
3	33	26	25	12	0
4	39	38	23	3	0
5	47	24	28	6	0
6	43	32	19	5	0
7	35	40	34	4	0
8	43	15	28	0	1
9	26	18	32	2	0
10	40	50	22	8	0
tal	377	291	280	49	5


Plankton.
Asterionella formosa, Stephanodiscus niagarae, Melosira varians, Melosira granulata, Tabellaria fenestrata, Fragilaria crotonensis, Surirella sp, Meridion sp, Chroococcus limneticus, Merismopedia glauca, Pediastrum duplex, Pediastrum boryanum, Pediastrum simplex.
Planktonic Crustacea.
Whitefish fry
other fry and small fish
Whitefish and Other fish.
Tullibee and other fish.
Dead plankton and other organic matter in the black mud.
Hexagenia Limbata, Phryganea sp, Molana sp, Chironomus sp, Pontoporeya hoyi, Hyalella knickerbockeri, Gammarus sp, Estheria mexicana, Limnetis gouldii, Pisidium sp, Sphaerium sp, Musculium sp, Valvata Tricarinata etc.
Benthos.

Examination of stomach contents of whitefish and other species, even from the same locality, shows also similar differences and, as will be shown below, some stomachs are full of Hexagenia, while in others we found only Chironomidae or Mollusca.

In addition to these, great differences in quality and quantity are regulated by depth, chemical and mechanical composition of the bottom, chemistry of water, pH, temperature, bottom flora, etc.

PRODUCTIVITY OF WHITEFISH GROUNDS IN LAKE WINNIPEG, DURING THE SUMMERTIME.

The following estimations are based on the sum of all dredges taken from whitefish grounds, mostly during the summers of 1928-29. As these dredgings have been taken in different parts of the lake, they will give the average abundance of the various organisms, despite their distribution in "spots", as the accuracy depends solely on the number of samples.

Of course, the abundance of different organisms, as for instance the amphipods, is not the same during a period of several years, but shows periodical decrease and increase in connection with decrease or increase of other aquatic organisms. Nevertheless, the results obtained during the first two years, will be useful for comparison with future work, as well as with other lakes which have been investigated in a similar manner.

The following tables show the average number of seven of the most important food organisms for whitefish, per one square mile (unit area) being estimated from all dredgings taken from whitefish ground:

1928.

	Thousands 1 sq.mile	Rough weight in Kilograms	Dry weight in Kilograms	Organic matter in Kg.	Mineral matter in Kg
Estheria mexicana	32.900	2,211.0	182.4	166.05	16.35
Amphipods	595.020	19,634.6	6515.47	65475.72	39.75
Mysis relicta	13,630	219.6	44.8	40.32	4.48
Hexagenia limbata	96,820	7,674.5	1696.0	1383.69	312.31
Phryganeidae	46,530	3,615.2	903.8	450.0	453.8
Chironomidae	39,890	780.0	312.0	215.28	96.72
Mollusks.	130,190	3,120.0	60.04	17.4	42.65
Total	954,980	37,255.0	9714.5	8,748.46	966.06

1929

	Thousands per 1 sq. mile.	Rough weight in kilograms	Dry weight in kilograms	Organic matter in kilograms	Mineral matter in kilograms.
Estheria mexicana	2,800	188.0	15.5	14.1	1.4
Amphipods	647,000	21,400.0	7160.0	7060.0	40.0
Mysis relicta	1.200	19.4	4.0	3.6	0.4
Hexagenia limbata	230,000	18,250.0	4030.0	3290.0	740.0
Phyganeidae	19,000	1,472.0	368.0	178.0	190.0
Chizonomidae	67.000	1,310.0	537.0	370.0	167.0
Mollusks	91.000	2,180.0	41.9	12.1	29.8
Total	1,058.000	44,819.4	12,096.4	12,927.8	1.168.6

Average amount of rough weight is 41,000 kg. per one square mile.

Counting the whole whitefish ground area as 8,000 square miles we cam say roughly that this bottom represents 328 million kg. of white-fish food, containing about 60 million kg. dry weight.

The analysis of over 500 stomachs of whitefish show that the average stomach content is ten grams of rough weight for one adult fish, per 24 hours, (or 3.28 kg. per one year.)

So if in Lake Winnipeg the only fish were whitefish (no other fish competttors)- we can say that approximately 90,000.000 whitefish could feed on this area (leaving the rest of the total amount of available fish food for reproduction). Estimating approximately from the statistics that the total amount of whotefish caught in Lake Winnipeg equals about one third of the total production of this lake, we can say that 30,000.000 of whitefish could feed on whole whitefish ground in Lake Winnipeg, without any competition from other commercial fishes present in the lake. If Lakes Winnipegosis and Manitoba have the same relative productivity as Lake Winnipeg, we can say that 15,000.000 and 5,000.000 whitefish can live in these lakes respectively.

As can be seen from the second part of this work there are only six or seven million whitefish in Lake Winnipeg at the present time. In other words, there is a reserve food supply which can support five times the number of whitefish which are now present in Lake Winnipeg.

BOTTOM FAUNA OF OTHER LAKES.

The bottom fauna of Lake Winnipegosis and Lake Manitoba differs somewhat fromtthe bottom fauna of Lake Winnipeg, chiefly in the percentage of different species.

Generally speaking the benthos of these two lakes is very much richer is small mollusks as : Valvata tricarinata, Valvata sp., Planor-bis antrosus, Physa gyrins, Lymnaea sp. Pisidium spp., Sphaerium sp. and Musculium sp. Several species of Crustacea as Mysis relicta, Estheria mexicana, Limnetis gouldii, etc., which are abundant in Lake Winnipeg, have not been found in Lakes Winnipegosos and Manitoba. Larvae of Hexagenia limbata, are also not so abundant as in Lake Winnipeg. Amphipods are no abundant in both these lakes that they destroy many gill nets, used for whitefish.

The benthos of Lakes St. Martin and Waterhen is quite similar to that of Lakes Winnipegosis and Manitoba. Although we have not enough quantitative samples for determination of the bottom productiveness of these lakes, as far as our observations go all these lakes, as well as many others in the Prairie Provinces, have about the same relative productiveness of bottom fauna as Lake Winnipeg..

The quantity of different bottom animals is not the same throughout the year. Great variations in the total number and size of different insect larvae during different seasons. For instance, the larvae of Hexagenia limbata reach a maximum size (dry weight) in the middle of summer, and in autumn are comparatively very small. The larvae of Chironomus reach their maximal size in spring and being scarce, after the hatching,of imago about the end of June, when clouds of these insects like smoke from a steamer, can be observed in the evenings along the shores of Lake Winnipeg and Lake Winnipegosis.

Other bottom organisms, such as amphipods and mollusks, also show seasonal increase and decrease in number and size.

There is every reason to believe that if the weather, during the hatching period of some aquatic insects, is suitable, a big crop of larvae should be expected next season, and in connection with the productiveness of the lake will be increased several times. This re-lation between meterological factors and abundance of different insect larvae must be one of the main problems of the aquatic insect investi-gation.

Results of Dredging

Locality. Date. Bottom. Depth.	Number of Dredges.	Amphipods	Mysis relicta	Hexagenia limbata.	Phryganea sp.	Molana sp.	Chironomus sp.	Hirudinea	Amnicola sp.	Valvata sp.	Valvata tricarinata	Physa sp.	Sphaerium sp.	Lampsilis sp.
3 miles South off Grindstone Pt. 10. VII. 29. Sand 11 m.	10	241		82	1		18	2			2			
Whiteway Pt. 11. VII. 29. sand 8 m.	10	159		31			20		1	1	3	1	24	1
1/2 mile East off George Is. 27. VII. 29 sand 8 m.	20	300												
5 miles East off George Is. 15. VII. 29 Sand 16 m.	30	522	1			6	1			2	1			
Total.	70	1222	1	114	1	6	39	2	1	3	6	1	24	1
6 miles North off Reindeer Hrb. 12. VII. 29. clay 4 m.	10							1		1				
3 miles North off Poplar Reef 15. VII. 29. clay 14 m.	5	2			3									
2 miles South off Rabbit Pt. 22. X. 29. clay 7 m.	10	273		12			2	1						
Total.	25	275		12	3		2	2		1				

Results of Dredging. (near Gimli; 25-26. vi. 1930.)

Station	Bottom	Depth in Metres	Number of Dredges	Esteria mexicana	Amphipods.	Hexagenia limbata	Phryganea sp.	Chironomus spp.	Hirudinea	Oligochaeta	Amnicola spp.	Valvata sp.	Lymnaea spp.	Physa gyrina	Sphaerium spp.	Pisidium spp	Lampsilis sp.
1	Gravel	2	5														
2	"	2	5													1	
3	Sand	2.3	5		24			2		1					2	1	
4	"	2	5		22			1						4	1	2	1
5	clay	3.5	5														
6	Gravel	4	5		50	2		1		5		1	4	1	3	5	
7	"	4.5	5		13												
8	Silt	1.5	5		54			3								1	
9	Sand	3.5	5		5	2											
10	Mud & silt	5.5	5	1	248	10		4	3	1	4					5	
11	Mud	5.5	5	1	121	14		4	3	2	7		1			10	
12	"	6	5	2	109	3		5	2	1			1				
13	"	6	5		175	2	1	10	2	2			1			4	
14	"	5	5		90	4		5		2	2	2				2	
15	"	7	5		276	23		8	3		8					5	
16	"	7	5		218	12		5	5					1		4	
17	"	7.5	5	1	128	7		6								2	
18	"	6.5	5		197	3	1	6	4		6			4		2	
19	"	3	5		207	6		29	3	4	23				3	30	
20	"	6	5		170	35		3	2	1	6					5	
21	"	7.5	5		218	34		6						1			
22	"	7	5		108	16		7			1			1		4	
23	"	7.5	5		34	9		12									
24	"	7.5	5		63	25		16									
25	"	8.5	5		44	18	2	14	1								
26	"	8	5		41	16			2								
Total			130	5	2615	241	4	147	30	19	57	3	7	12	9	83	1

Locality. Date. Bottom. Depth.	Number of Dredges.	Esteria mexicana	Amphipods.	Mysis relicta	Hexagenia limbata	Phryganea sp	Molanna	Sialidinae	Chironomus spp.	Hirudinea	Oligochaeta	Amnicola spp.	Valvata sp.	Valvata tricarinata	Lymnaea spp.	Physa sp	Sphaerium spp.	Pisidium spp.	Lampsilis sp.
1 mile South off Clements Pt. 4.VI.29. Mud 5m.	6				177	2	1		28										
5 miles W.S.W. off Clements Pt. 4.VI.29 Mud 8.5m.	6				156	2			9										
5 miles East off Hecla 4.VI.29. Mud 9m.	6				205				6										
White Fish Ground Hecla-Black Is. 21.VI.29 Mud 9m.	20	1	78		72				1	1									
Wells Harbor. 22.VI.29. Mud. 3m.	5	1			4			2							2		4	9	
8 miles N.E. off Drunken Pt. 9.VII.29. Mud. 9m.	10	1	640		7	3	1		4		2								
1 mile North off Berry Is. 11.VII.29. Mud. 9m.	10		309		168				2	7									
14 miles S.W. off George Is. 18.VII.29. Mud. 17m.	10					3			2		20	15	32	114		1	90	10	
1 mile North off Cox Reef. 13.VII.29. Mud. 11m.	10	1	40		116				78	3	1								
8 miles West off Leaf Pt. 14.VII.29. Mud. 16m.	10		182		1	1			27		6	5		4					
8 miles. S.W. off George Is. 18.VII.29. Mud. 17m.	10					1			5	2	3			2			2	2	
12 miles S.W. off George Is. 18.VII.29. Mud. 17m.	10					2			1		40		3	2			12	10	
10 miles S.W. off George Is. 18.VII.29. Mud. 17m.	10					1			5		33	2		7		1	31	14	
Whitefish Ground Hecla-Black Is. 21.VII.29. Mud. 8m.	20		160		77				20	1	2	1						1	
2 miles South off George Is. 4.VIII.29. Mud. 16m.	50		1004	3	24	29	1		43	5	145	20		10			10		
George Is. 23.-24.VII.29. Mud. 20m.	50		1590	1	13	10	30		21	6	50	10		2			2	2	
1 mile Eeast off Gimli. 14.VIII.29. Mud. 8m.	10	4	22		137	1			5	1									
4 miles E. off Gimli. 14.VIII.29. Mud. 8m.	10	2				1			14		2								2
8 miles E. off Gimli 14.VIII.29. Mud. 9m.	14	3			9				20	1		4	1			2		1	
6 miles west off Vict. Beach. 14.VIII.29. Mud. 9m.	10		1		28	1			4		2	3				1		3	
2 miles West off Vict. Beach 14.VIII.29. Mud. 7m.	10		72	1	75	3				2		1						4	
Wells Harbor. 24.VI.29. Mud. 4m.	3				18			4	7										
Wells Harbor 24.VI.29. Mud. 6m.	4		270		13				1										
Whitefish Ground Hecla-Bla[ck] Is. 23.VIII.29. Mud. 9m.	10	1	104	1	401					1									
Total	314	14	4472	6	1701	60	33.	6	335	30	306	61	36	141	2	5	151	56	2.

Locality. Date. Bottom. Depth.	Number of Dredges	Esteria mexicana	Amphipods	Mysis relicta	Hexagenia limbata	Phryganea sp.	Molana sp.	Other Trichoptera	Chironomus spp.	Hirudinea	Corethra	Oligohaeta	Amnicola spp.	Valvata sp	Valvata tricarinata	Lymnaea spp.	Physa sp.	Sphaerium spp.	Pisidium spp.	Lampsilis sp.
4. VII. 28 Gimli Fine mud 5m.	3		10		8	5			2	1			28			3			16	
2 miles East off Gimli Fine mud 6m.	5				10	2							10						1	
4 miles East off Gimli Fine mud 11m.	10	1	124		7	2			8	3			1						16	
6 miles East off Gimli Fine mud 11m.	6	8		3	26				8	2	2		20			2		12		
8 miles East off Gimli Fine mud 11m.	10	2			7		2		2										2	
10 miles East off Gimli Fine mud 11m.	3	1				14					1	2	1						2	
12 miles East off Gimli Fine mud 11m	3	4							4		2		1							
200m. West off Victoria Beach mud-sand 9m.	3		1		1	1			4									1		
Travers Bay sand-mud 8m.	3		4	2	21	2			2									1		
26. VII. 28 Mathison Is Fine mud 8m.	5	1	60		43	5		8	1	1		2	1					1	2	
31. VII. 28. 2 miles off Hecla mud 12m.	3		70		11			1		1										1
26. VII. 28. Mathison Is. mud 10m.	5		28		18	2		6	2	1									5	
31. VII. 28. 2 miles off Hecla mud 12m.	1		20		6	1			1											
23. VII. 28. Riverton Bay mud-sand 4m.	6				3		6		1	1							5	75	50	
12. VIII. 28. George Is. Fine mud 11m.	5		330	1	22		6		18			3	1	5	7					
12. VIII. 28. George Is. mud 15m.	10		572		14		4													
12. VIII. 28 near Black R. Fine mud 9m.	3	2			1				3	1										
12. VII. 28 Drunken Pt. mud sand 6m	3	1	15		3				12											
14. VII. 6 miles West off Black R mud 11m.	3	1							1		6	3	1							
14. VII. Middl of the Southern Portion mud 8m	3		5		1				12		2	3					1	7	1	
28. VII. 28. Near Mouth of Berens R. mud 8m.	5	38			5	10	7	15	6		1							41	5	1
10. VIII. 27. Midway Berens Is and Berens R. mud 12m.	2	10	8	25	11															
Total	100	69	1247	31	218	44	25	30	87	11	14	13	64	5	7	5	6	138	100	2

S E C O N D   P A R T

SECOND PART.

SYSTEMATICAL SKETCH.

The common whitefish, Coregonus clupeaformis (Mitch) belongs to the extensive gfoup of Coregonus lavaretus (Linne).

This group of whitefishes being widely distributed throughout all the circumpolar region includes several well marked species with a great many local varieties.

In many different places, under similar conditions, forms have originated which are so similar that it is very difficult, and sometimes even impossible, to distinguish one from another. Generally speaking, these fishes represent one of the most difficult systematical groups.

All this group can be divided into anadromous and fresh water fishes, Anadromous fish spend a part of their life in brackish water, usually not far from river mouths, and enter the rivers for spawning purposes. The second ones, entirely fresh water fish, represent a younger subgroup, which departed from the anadromous condition, after the ice period.

The following is the schematic representation of this group:

Group Coregonus lavaretus.

North Europe	North Asia	North America.
Coregonus lavaretus (Linne). Anadromous, Baltic Sea. D. III, IV G-11; A. IIImIV, 11-13(14); 11.84,98; Gill rakers -24-39.	Coregonus lavaretus (Gmelin) Pidschian. Anadromous Artic Sea. DIII-IV 10-14; AIII-IV 12-14; 11.74-94 Gill rakers 18-24.	Coregonus clupeaformis (Mitch) var. Anadromous. Hudson Bay. D IV 9; AIII-IV 10; 11.74-76. Gill rakers 26-27.
C. lavaretus lavaretoides (Poljakov) Lacustrine. Ladoga & Onega Lakes. D. III, IVG-11; AIII-IV 11-13; 1184-98 Gill rakers - 29-40. Several varieties.	C. L. p. natio Smitti Warpachowski. Lacustrine. Lake Teletskoge. (Siberia) DIII-IV 10-11; AIII 11-12; 1180-86. Gill rakers 24-25. C. L. p. natio Baikalensis Dybowski. Lacustrine Lake Bajkal (Siberia) DIII-IV 9-12; AIII-IV 10-11; 11.88-107. Gill rakers 20-28. (and other varieties)	Coregonus clupeaformis (Mitch) Lakes of N. Amer. D III-IV 8-12; A II-Iv 8-12; 11 71-87 Gill rakers 24-29 (Several varieties)

In its systematic characters the American whitefish is quite similar to the Siberian lake whitefish and nay be placed between Coregonus lavaretus pidschian nation Smitti and Coregonus lavaretus pidschian nation Baicalensis.

According to the key of L.S. Berg, Fishes of Russia, the American whitefish does not differ from Coregonus lavaretus pidschian.

By taking the characters of a sufficient number of individuals from the standpoint of variation statistics by the method of mean squares, we can compare different varieties of whitefish on this continent. If the difference between means is much greater than the mean error, we can tell that we have two different species.

In the case of Coregonus clupeaformis and Coregonus lavaretus pidschian in many characters the difference between the means does not exceed the mean error, and in general, both fish are so similar that if they occurred togehher no ichthyologist would distinguish them as different species. On the Casis of small differences in the number of scales in the lateral lone and the geographical distribution of these two fish, it may be more accurate to consider the Americam fish as a subspecies of Coregonus lavaretus(Linne) 1758. Taking into consideration, however, the fact that the name Coregonus clupeaformis (Mitchell) 1818, is well established on this continent, we shall continue to use this name.

The comparative neasurements of this fish are given in the following tables;

%	Coregonus lavaretus pidschian Mean	mean error	Coregonus clupeaformis Mean	mean error	Difference between means and their mean error
Base of dorsal; length of body (Smitt)	12.725	- 0.25	12.33	- 1.23	0.39-0.74
Height of dorsal; length of body	17.90	- 0.27	17.31	- 1.55	0.59 -091
Base of Anal; Length of body.	11.789	- 0.15	11.31	- 2.15	0.47-1.15
Height of Anal; Length of body	11.70	- 0.22	12.55	- 0.9	0.85-0.56
Length of Pectoral; length of body	15.306	- 0.14	16.71	- 1.36	1.41-0.75
Length of ventral; length of body.	15.25	- 0.18	15.48	- 1.96	0.23-1.07
Length of caudal Peduncle. Length of body	11.945	- 0.14	12.97	-0.88	1.02-0.50
Length of Maxillary. Length of head	23.475	- 0.65	25.17	- 3.8	1.69-2.2
Scales in lat. line	82.0	- 0.57	77.7		4.3-

%	C. clupeaformis Lake Winnipeg Mean	Mean error	C. clupeaformis Lake Winnipegosis Mean	Mean error	Difference between mean and their mean error.
Base of dorsal; L. of body	11.6	-1.17	13.06	-1.29	1.46-1.23
Height of dorsal; L. of body	16.0	-1.6	18.63	-1.51	2.63-1.55
Base of Anal; L. of body	11.2	-1.41	11.42	-2.9	0.22-2.15
Height of Anal; L. of body.	12.35	-1.19	12.76	-0.71	0.41-0.9
L. of Pectoral; L. of body	16.3	-1.59	17.12	-1.12	0.82-1.36
L. of ventral; L. of body	14.9	-1.00	16.06	-2.91	1.16-1.96
L. of caud. peduncle. L. of body	13.2	-0.65	12.92	-1.12	0.28-0.88
L. of mexillary. L. of head	24.1	-3.33	26.25	-4.275	2.15-3.8
Scales in lat. line	79.7		75.8		3.9-

MEASUREMENTS OF WHITEFISH (Coregonus clupeaformis) from Lake Winnipegosis.

In % of Length of Body (Smitt)	1	2	3	4	5	6	7	8	9	10
Length of head	20.0	19.3	18.8	19.2	19.2	19.0	20.7	19.5	19.4	20.0
Height. of body	27.4	21.7	32.0	30.8	30.2	28.0	30.5	30.5	30.6	31.3
Height . of caud. peduncle	9.43	9.43	9.50	10.00	9.60	9.00	9.76	9.76	10.5	10.0
Snout to ventral	45.7	48.1	50.7	48.7	46.6	48.0	48.8	47.6	48.7	47.5
Snout to anal	6.85	7017	72.5	71.8	71.2	72.0	74.3	73.3	75.0	713
Snout to dorsal	42.8	44.7	43.7	43.6	41.1	43.0	43.9	41.5	44.5	45.1
Length of caud. peduncle	12.8	13.1	13.7	15.4	12.6	13.0	14.6	12.2	13.3	12.5
Base of anal	10.0	11.3	10.2	11.5	10.9	12.0	11.0	13.4	12.5	11.3
Base of Dorsal	10.8	12.8	12.0	11.5	13.7	12.0	13.4	14.6	16.1	13.5
Length of pectoral	15.7	18.3	17.8	17.7	15.6	19.2	17.1	17.1	18.1	16.3
Length of ventral	5.7	166	17.5	16.7	15.9	16.0	14.0	17.1	18.1	15.5
Height of dorsal	17.4	18.1	20.2	21.0	17.8	17.6	1711	17.6	18.1	18.8
Height of Anal	12.9	12.3	14.5	14.4	12.9	12.0	12.2	13.4	12.5	12.5
In % of length of head.										
Median port. of head	50.0	58.8	56.0	60.0	57.2	63.2	51.8	62.5	57.2	62.5
Length of Pectoral	78.5	95.0	99.8	92.0	81.5	101.0	82.4	87.5	92.9	81.3
Length of Eye	17.2	16.7	17.4	18.7	20.0	18.9	17.7	18.8	20.0	16.3
Length of snout	25.8	29.4	29.4	37.0	22.9	26.3	26.7	25.0	31.4	31.3
Length of Maxillary	21.5	29.4	26.7	28.0	27.2	22.1	23.5	25.0	35.8	36.3
Interorbital width	27.1	24.5	37.6	33.4	28.6	31.6	27.1			

MEASUREMENTS OF WHITEFISH (Coregonus clupeaformis) from Lake Winnipeg.

In % of length of body(Smitt)	1	2	3	4	5	6	7	8	9	10	M
Length of head	17.4	17.1	18.5	18.7	18.9	19.0	19.2	19.4	21.0	17.8	18.70
eight of body	21.7	26.8	27.1	29.1	30.0	27.5	26.6	26.7	26.7	31.1	27.33
eight of caud. peduncle	8.5	9.0	8.5	8.9	8.9	8.8	9.6	7.9	9.5	8.9	8.85
nout to ventral	47.2	48.8	46.4	49.4	48.9	49.0	49.7	48.5	49.6	48.9	48.58
out to anal	67.9	73.4	73.2	72.1	73.3	69.7	69.3	69.4	68.7	72.3	70.93
nout to dorsal	43.4	47.1	44.6	48.1	45.8	41.9	44.3	41.6	41.9	44.4	44.31
ength of caud. peduncle	12.3	13.4	14.6	12.7	13.3	13.1	12.5	12.9	12.9	13.3	13.10
ase of anal	11.3	11.7	9.8	11.4	10.7	10.8	10.4	10.3	10.5	10.0	10.69
se of dorsal	10.0	11.0	11.0	11.4	11.5	11.8	11.5	11.5	11.8	11.1	11.26
ength of pectoral	15.1	13.8	15.8	16.2	15.8	1912	18.9	18.8	19.1	16.7	17.94
ength of ventral	13.4	13.9	16.3	14.7	15.6	14.7	15.0	15.8	16.2	14.4	15.00
eight of dorsal	15.9	17.1	17.1	16.2	16.2	15.7	15.8	14.9	15.2	16.7	16.05
eight of anal	12.3	10.7	12.4	11.9	12.0	12.1	13.5	11.9	13.0	11.1	11.[illegible]
% of length of head.											
edian port. of ead.	64.2	61.5	62.7	60.8	64.8	63.9	62.0	61.2	59.2	75.1	[illegible].6
ength of pectoral	87.0	80.0	85.6	86.5	83.5	100.	98.0	97.0	90.9	93.9	90.24
ength of eye	17.4	18.6	17.1	17.6	15.3	17.5	16.0	18.4	16.4	18.8	16.61
ength of snout	30.4	31.4	23.7	28.4	29.4	26.8	30.0	26.5	27.3	32.5	28.64
ength of Maxillary	21.8	34.3	23.7	24.3	22.4	22.7	18.0	20.4	20.0	22.5	23.10
ength of Mandible											
nterorbital width.	27.2	32.8	29.0	33.8	30.6	28.9	30.00	27.6	26.3	33.8	30.00

11	12	13	14	15	16	17	18	19	20	Mean.	Error of Mean square (Standard deviation)
204	18.8	18.5	18.4	18.1	20.0	20.2	18.4	19.6	20.0	1914.	0.718
30.7	30.00	29.5	29.0	29.3	32.6	28.0	27.6	29.6	26.8	29.3	2.31
9.09	9.50	9.50	10.0	9.27	10.65	8.90	8.98	9.0	9.4	9.56	0.475
50.0	4.75	4.75	46.1	46.3	48.0	49.6	50.0	47.7	48.1	48.0	1.31
72.8	70.0	71.8	72.5	73.2	70.0	73.0	77.7	71.3	69.4	72.1	2.01
45.5	47.6	43.6	44.8	42.0	43.2	45.6	44.9	45.1	45.0	44.06	1.51
12.5	13.8	12.8	13.2	14.6	13.3	11.6	11.2	11.3	11.1	12.9	1.12
11.4	12.5	11.5	13.2	12.2	12.0	9.96	11.0	10.7	11.0	11.5	2.97
13.6	13.8	14.4	13.2	13.4	14.4	12.7	11.2	13.7	11.3	13.1	1.29
18.6	15.5	16.7	17.1	14.6	17.3	17.4	17.4	16.7	18.1	17.1	1.12
15.9	15.5	15.9	14.8	15.1	17.1	16.8	16.1	15.0	15.3	16.06	2.91
18.2	16.3	18.7	18.4	17.1	21.6	19.1	18.2	16.1	15.3	18.1	1.51
12.7	12.5	12.8	13.2	12.7	12.0	11.6	12.6	12.3	13.4	12.8	0,717
51.1	60.0	59.7	57.2	60.8	60.0	63.2	66.7	59.0	59.1	59.3	3.74
91.2	82.6	90.4	93.0	81.1	86.7	86.4	94.5	85.7	91.3	88.5	5.86
16.7	20.0	19.5	17.1	18.9	20.0	17.9	18.9	16.3	16.8	18.3	1.29
27.8	29.4	29.2	29.6	28.4	29.4	28.4	27.8	33.3	33.0	29.0	2.68
24.5	29.4	29.2	27.2	24.4	24.0	25.3	25.6	20.0	20.0	26.25	4.275
				27.0	24.0	27.4	30.0	30.5	28.8	29.0	3.49

11	12	13	14	15	16	17	18	19	20	Mean	Error of mean square on standard deviation.
19.3	17.1	15.9	18.3	16.8	18.7	20.1	19.5	18.8	19.2	18.5	1.19
30.8	28.6	31.4	26.5	31.8	32.4	36.9	32.8	32.3	31.6	29.42	4.07
10.3	8.20	2.10	8.44	8.65	8.73	10.2	10.1	9.53	8.35	9.03	0.637
48.7	46.7	47.7	48.2	50.0	50.4	51.3	51.1	46.4	50.3	48.9	1.41
48.8	43.8	45.4	43.4	44.1	47.9	48.6	44.0	46.2	47.2	45.1	2.20
13.3	12.9	12.5	14.5							13.2	0.657
10.3	10.5	91.0	9.16	12.3	12.7	12.9	12.9	14.4	12.7	11.2	1.41
11.0	9.55	11.8	10.8	13.2	12.7	13.5	13.4	13.8	13.3	11.6	1.17
74.	15.3	15.9	15.7	13.9	15.2	16.5	16.8	15.6	15.0	16.3	1.59
14.4	13.3	13.7	15.7	13.7	14.9	16.5	16.6	16.1	14.8	14.9	1.00
16.7	14.3	15.9	10.8	1.60	15.2	17.1	12.9	17.0	18.9	16.0	1.60
11.5	11.4	11.4	10.8	12.5	13.0	13.2	15.4	12.1	14.8	12.35	1.19
in % of length of head											
54.0	6.12	18.6	59.3							64.2	5.48
90.8	88.0	10.9	85.6	82.5	81.3	82.0	86.5	83.1	78.5	88.1	6.51
18.7	17.8	21.4	13.4	17.6	13.7	24.6	18.7	21.5	20.0	18.5	2.08
26.7	33.3	35.7	26.3	29.8	26.0	26.2	25.9	30.8	23.1	28.5	3.31
2.27	24.4	24.3	23.7	27.1	26.7	27.9	25.2	26.2	24.6	24.1	333
33.3	28.9	37.2	32.9	35.2	32.0	32.8	33.8	30.8	29.2	31.3	2.82

As is the case in almost all North American lakes this species has several well marked varieties in Lake Winnipegosis and Lake Winnipeg. The following forms should be distinguished:

The deep form, Coregonus clupeaformis morpha elata (depth in length: females 3.3-3.4; males 3.7 - 3.8)

The long form, Coregonus clupeaformis morpha elongata(depth in length: females 3.7 - 3.9; males 4.8 - 5.1)

In addition to these, two colour variaties are to be distinguished.. These exist among both of the above mentioned morphae. They are as follows:

Fish with bright red fins, with the sides a faintly golden colour, and with gold pigment around the pupil.

Fish of the usual silver colour, with grey or nearly colourless fins, and silver pigment around the pupil.

The first of these appears to be the more vigorous and is usually found to be alive when the nets are raised, whereas those of the second colour variety die soon after being caught. This difference is well known to all fishermen on the lakes. There appears, however, to be little or no difference in the habits or distribution of any of these varieties.

Anadromous whitefish.

Until the present time American ichthyologists have considered that the common whitefish (Coregonus clupeaformis) is essentially a lake fish. According to information obtained from several fishermen whitefish enter The Churchill and Nelson Rivers in great numbers, from Hudson Bay. This is to be expected from a comparison with European and Siberian members of this group. We obtained several specimens of anadromous whitefish from the lower Nelson River near Hudson's Bay.

This fish differs from the lacustrine form inits slender body, and very dark colour, all the fins are colored black, back black, black pigmentation on the sides, head, operculum and maxillary. Head is larger than in freshwater fish. Operculum is somewhat further back. Caudal peduncle short. The form of the head, which, in the freshwater fish, is slightly concave dorsally, is nearly flat in the anadromous form.

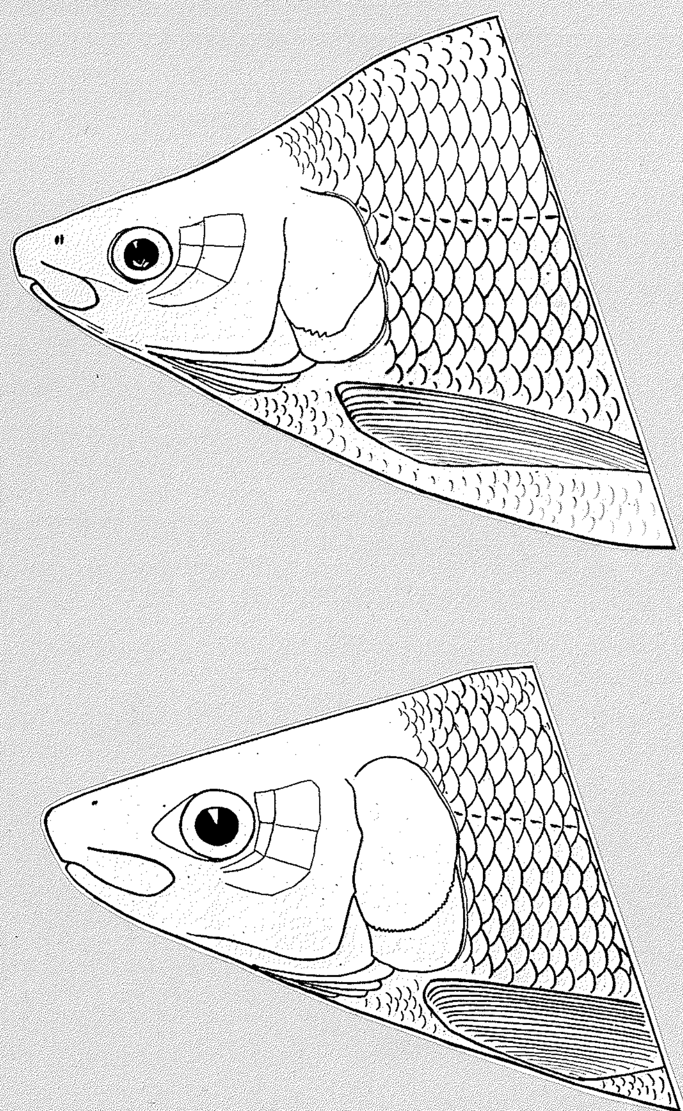
MEASUREMENTS OF ANADROMOUS FORM.

In % of length of body.

1.	Length of head	21.3
2.	Height of body	28.9
3.	Height of caud. peduncle	9.0
4.	Snout to ventral	49.2
5.	Snout to anal	70.3
6.	Snout to dorsal	47.0
7.	Length of caud. peduncle	11.7
8.	Base of anal	12.7
9.	Base of dorsal	11.7
10.	Length of Pectoral	18.7
11.	Length of ventral	17.7
12.	Height of dorsal	18.5
13.	Height of anal	14.4

In % of length of head.

14.	Median portion of head	76.2
15.	Length of pectoral	87.9
16.	Length of eye	17.8
17.	Length of snout	26.9
18.	Length of maxilary	29.2
19.	Interorbital width	26.6



Whitefish 470 mm., Female; 7 years old, Lake Winnipeg.
Whitefish 470 mm., Female; 7 years old, Hudson Bay.

THE AGE COMPOSITION OF CATCHES.

At the present time the average weight of whitefish, in catches in the lakes of Prairie Provinces, is three pounds. The largest fish caught during the last two years was a female of 16 pounds. Twenty or even fifteen years ago specimens weighing twenty and twenty five pounds were not rare. We have no data concerning the average weight of whitefish twenty years ago, but undoubtedly it was somewhat more than now.

Usually the decrease of the industry is accompanied by a decrease in the average weight of catches, but it would be wrong to connect decreasing of average weight with decreasing number of fish.

Together with a development of industry and the developing of fish culture we can observe a decrease of average weight in connection with a more rapid destruction and replacement which makes the average life of the fish very much shorter.

The main bulk of the catch is quite compact in age. From the total amount of fish 65% are composed of individuals over five years old.

FOOD OF WHITEFISH IN PRAIRIE LAKES.

Whitefish begin to take food on the spawning gfounds, a short time after hatching, several days before the yolk sac is fully absorbed. The gravel bottom on which are situated the most important spawning places is quite rich in food.

The young fish, during the first summer, feed mostly on plankton, although, quite soon, even during the first month, they begin to hunt for small Diptera larvae, getting them from the bottom. Whitefish fry therefore are not entirely plankton feeders. We were unable to get a great many whitefish from the examination of the stomachs. The following table shows, notwithstanding, the main food of whitefish fry during the first three months:

As we can see from this table the main food of whitefish fry is composed of Phyllopoda, Chironomidae (larvae) and Copepoda.

By the month of August, if the fry have enough food, the young fish reach ten centimeters in length. The fry at first keeps in schools together with tullibee fry, and only later in the season go into deeper places.

In the second year the young fish feed mostly on bottom fauna. We examined six whitefish, one and a half years old, from Lake Winnipegosis, which were caught in trapnets on the whitefish spawning ground, 17 miles north of Snake Island. The stomach contents of these fish were as follows: Chironomidae (larvae) - 30%: Amphipods - 40% Small Mollusks (Pisidium and Amnicola) - 20%: Hydrachnidae and small Hexagenia - 10%.

Number	Length	Date	Bosmina longirostris	Chydorus sphaericus	Pleuroxus sp.	Moina sp.	Alona sp.	Cyclops bicuspidatus and sp.	Diaptomus sp.	Canthocamptus minutus.	Chironomus sp.	Diatoms.
1	19 mm	25vi28	30	2	1	1						
2	14	"	20	1				5	3		10	3
3	25	"	40					4			12	
4	25	"	10							1	5	1
5	26	"	100	5			1					
6	20	"	25									
7	18	28vi23	3		3	1		6			10	1
8	22	"	21	2				4	1			
9	20	"	75								5	
10	20	"		10	5				2		3	
11	28	"	4					3		3	1	20
12	15	"	15	3			2					
13	19	"	27	1							3	
14	17	"	40	1								
15	17	"	2					11		1	1	
16	25	"			1	8			10		2	
17	18	"	34	1			1	4			1	
%			70.	4.1	1.5	1.5	0.7	5.8	2.6	0.6	10.1	3.1

From the third year the young fish keep in deep places together with the adult fish, and feed on the same food as the latter. Examination of five two-year old whitefish, obtained with small mesh gill nets in Lake Winnipeg, near Black Id, as well as five specimens from Lake Winnipegosis, shows that the fish feed at this time on Amphipods, small mollusks, larvae of Hexagenia limbata, Chironomidae, small Phryganeidae, Hydrachnidae and Corixa. Vegetable matter probably does not play an important role, as it only occurs occasionaly in comparatively small amounts in the digestive tract of young fish.

The food of adult fish consists mainly of Amphipoda, Chironomidae larvae, Hexagenia limbata, Phyganeidae and different small mollusks. The vegetable food also can not be taken into consideration, although, in the stomachs of adult fish we can sometimes find remains of Chara, Cladophora and other algae, swallowed, very likely by chance, together with sand, small stones and detritus. No remains of small fish were found in stomachs of whitefish.

In different lakes of the Prairie Provinces the food of whitefish varies. For example, in Lake Winnipeg the main food of the whitefish is small <u>Amphipods</u> (mostly <u>Pontoporeia hoyi</u>) but in Lake Winnipegosis and Lake Manitoba the main food consists of different small mollusks. In some places, as for instance, in the northern portion of Lake Winnipegosis, during the second part of winter, the stomachs of some whitefish are full of big green <u>Chironomus</u> largae.

We must take into consideration the fact that the food of the whitefish is subject to change during different seasons.

In August the stomachs of whitefish are not so full as at other times of the year, depending probably partly on higher temperature of deep water and partly on the circumstance that the larger part of the larvae of different water insects are hatched out. As a rule <u>Hexagenia limbata</u> is a very important food animal for whitefish, during the first part of the summer, when the larvae are of large size.

The following tables show the analysis of the stomach contents of adult whitefish from different lakes, during different months.

Lake Winnipeg. George id. August. 10, 1928.

…ber …gth in m.m. …, Age.	Mysis relicta	Estheria mexicana	Limnetis gouldii	Pontoporeia hoyi	Other Amphipods	Amnicola sp.	Valvata tricarinata	Valvata sp.	Spaerium sp.	Pisidium spp.	Lampsilis sp.	Chironomidae	Hexagenia limbata	Molana sp.	Phryganeidae	Parasites Cestodes.
0 m. 8																
0 M. 8				8		3				20				2	2	
5 M. 5				5							1					
5 M. 5		1												12		
3 M. 7							3	11						5	3	
5 M. 7													1			
4 F. 7				15				3								
3 F. 6												3				
5 M. 5				49						10		5				
0 M. 5				35												
5 F. 4																
3 M. 3																
3 F. 6																
7 F. 5				15	1											
0 F. 9			1		5										1	
0 M. 13												4			10	X
7 F. 8				50											6	x
3 M. 9				100												
												3			9	
				277								15			32	

Lake Winnipeg,

George Id.

August 10, 1928. cont'd.

Number ngth in mm. x Age.	Mysis relicta	Estheria Mexicana	Limnetis gouldii	Pontoporeia hoyi	Other Amphipod.	Amnicola sp.	Valvata Tricarinata	Valvata sp.	Sphaerium sp.	Pisidium spp.	Lampsilis sp.	Chironomidae	Hexagenia limbata	Molana sp.	Phryganeidae	Parasites Cestodes.
476 M.8																
481 M.10				42												
407 F.6		Sand about 2 cc. in intestine.														
507 M.10				25								5			16	
443 F.7				180									1		5	
430 M.7				10	2							8			10	
425 F.7															5	
413 M.7				20												
460 F.8																
373 M.5				500								20			1	
436 M.7									1	1					35	
398 F.6																
462 F.7				200								15				
471 - 8																
414 M.6															4	
395 M.5				550								20				
420 F.8																x
377 F.6																X
410 F.7				72						1						
440 F.8				348												
450 M.8																
410 M.7																
448 M.8				50								1				
415 M.6				25											14	
472 M.10				300								69				
455 F.8																
486 F.9				140											5	
430 M.7																
4[illegible] M.7															95	
419 M.7				15												X
421 M.8																
				2135												

Number, Length in mm., Sex, Age	Mysis relicta	Estheria mexicana	Limnetis gouldii	Pontoporeia hoyi	Other Amphipods	Amnicola sp.	Valvata Tricarinata	Valvata sp.	Sphaerium sp.	Pisidium spp.	Lampsilis sp.	Chironomidae	Hexagenia limbata	Molanna sp.	Phryganeidae.	Parasites cestodes.
50 533 M. 12																
51 447 M. 8															5	X
52 445 F.8				5												
53 434 M.7															5	
54 450 F.8				50												
55 412 M.6				600											2	
56 445 M.7				50								3				
57 394 F.5	1															
58 390 M.5																
59 400 F.6																
60 416 F.7				20								5				
61 350 M.4										3		5				
62 410 M.5																
62 330 F.3																
64 348 F.4																
65 370 -.6															1	
66 530 M. 14																
67 515 F. 11																
68 442 M.8																
69 450 F.9																
70 405 F.6				150	30	12			10							
71 412 F.6												4	1		9	
72 485 F. 10			8	200												
73 364 M.5				100						3		11	2		18	
74 458 M.8												3			5	
75 460 M.9				50				1					1		1	
76 455 M.8															3	
77 346 -.5															1	
78 365 M.5				122												
79 410 M.8 [illegible]																
				1347											59	X

Number	Length in mm.	Sex, age.	Mysis relicta	Estheria mexicana	Limnetis gouldii	Pontoporeia hoyi	Other Amphipods.	Valvata Tricarinata	Valvata sp.	Sphaerium sp.	Pisidium spp.	Lampsilis sp.	Chironomidae	Hexagenia limbata.	Molana sp.	Phryganeidae	Parasites cestodes.
80	380	F6				10							2			15	
81	450	F 8				550		10									
82	400	M 6							3		40						
83	390	F 6	1		1	60									12	10	
84	420	M 7				20										2	
85	400	F 6		2													
86	500	F 11				300					5			3		16	
87	448	M 9				10	1										
88	363	M 5							1		2						
89	340	M 4				50										1	
90	405	F 5										1					X
91	400	M 5				50											
92	420	F 7	3			180											
93	320	F 3				500		2						1	6		
94	415	M 7															X
95	408	F 7		1		550								1		7	
96	412	M 7				30					4						
97	360	F 6															
98	345	F 5				8											
99	425	F 7															
100	400	F.6				20		1								19	
101	375	M.6				20				1						2	
102	355	M.5														22	
103	430	M.7				5										14	
Total						2363										108	

Lake Winnipeg,

George Id.

August 7, 1927.

Number Length in mm. Sex and Age	Esthezia mexicana	Limnetis gouldii	Pontoporeia hoyi and other Amphipods	Amnicola sp.	Valvata tricarinata.	Valvata sp.	Sphaerium and Musculium spp.	Pisidium spp.	Chironomidae	Molana sp.	Phryganidae	Corixa sp.	Nematodes	Hexagenia limbata	Parasites cestodes.
430 F 6											6				
510 M 8						1		4	4						
510 F 8															
450 M 7															X
610 F 15											1				X
540 F 10															
460 F 8															
460 M 8		1	400			1		2	8		15	1			
530 M 9									3		52				X
580 M 12			20				1		5		10				
500 F 10			5					22	3		3				
510 M 10			80					40	35		16		2		
500 M 9			100						1				1		
470 M 8															X
460 F 7			20					1	9		15				
490 F 7	1			4		49		25	20		15				
630 M 17															X
630 F 16															X
490 F 8							2	14			3				
															X
															X
															X
5											2				
															X
			15						2		2				
		1									1				

Number. Length in mm. Sex Age.	Esthezia mexicana	Limnetis gouldii	Pontoporeia hoyi and other Amphipods.	Amnicola sp.	Valvata tricarinata.	Valvata sp.	Sphaerium and Musculum spp.	Pisidium spp.	Chironomidae	Molana sp.	Phryganeidae	Corixa sp.	Nematodes	Hexagenia limbata	Parasites cestodes.
29											1				
30			4				1	24	7		4				
31															X
32				6	7		2	21	5		7				
33															
34		2	50	2			4	16	9		11				
35			40						8	3				1	
36															
37			100												
38											32				X
39			300						8		55				
40			5						10		3				
41			3					6	4		21				
42				68		127	14	7			3				
43	1		35			5		10	6		6				
								84			143				

LAKE WINNIPEG

3 miles from Hecla.

June 26, 1928.

Number	Length in mm.	Sex	Age.	Pontoporeia hoyi and Hyalella knickerbockeri	Hexagenia limbata	Phryganea sp	Chironomus sp.	Pisidium sp.	Parasites cestodes.
1	440	F	7	5	4				X
2	401	F	6		60				
3	303	M	3		1				
4	357	M	4	790	1		10		
5	347	M	4	1	10			5	
6	339	F	6	14	6	2	20		

LAKE WINNIPEGOSIS

Cormorand Id.

Sept. 1, 1928.

	Amnicola sp.	Valvata tricarinata	Valvata sp.	Musculium sp	Sphaerium sp	Planorbis antrosus	Pisidium sp.	Physa sp (gyrina ?)	Lymnaea sp	Amphipods	Cambarus viridis	Chironomus sp.	Nematodes	Parasites cestodes.
1	8	207 (35)	12 (6)				50 (5)	1	2					
2											22			
3										1				
4			1				4							
5														
6		3	3											
7		10	21				4			10				
8	30	10					14							
9			16				2	2		5				
10												1		
11		25	28				11							
12														X
13			1											
14	6	20	9				5							
15		100	50				5	2						
16	12	5					23							
17		20	30				20	1						
18		47	60				25	5						
19														
20	10	28	6				15							
21	3	8	6				21			20				
22	10	3	3				3	1		11				
23	40	60	40				12			10				X
24		16	8					1				3 1		
25		20	25				40			1				
26	12	30	28				18			10			2	

LAKE WINNIPEGOSIS

Skunk Bay,

August, 28, 1927.

No.	Length	Sex	Age	Amnicola sp.	Valvata tricarinata	Valvata sp.	Musculium sp	Sphaerium sp.	Planorbis antrosus	Pisidium spp.	Physa sp (gyrina?)	Lymnaea spp (vahlii?)	Hexagenia limbata	Molana sp.	Chironomus spp.	Hemiptera	Phryganea sp.	Amphipods (Hyalella etc.)
1	380	M	4	150	47	6	1		2	15								
2	360	F	4															
3	405	M	5	50	10	15			1	9								
4	475	F	7	5									6					
5	375	M	4															
6	440	M	6	320	42		3		11	12			1					
7	350	F	3	120			2			6	1		1					
8	375		4	57								3	2					
9	380	M	4	15	2			5		10		110						
10	525	F	8	25	41	49		8	1	15		480	1					
1	475	F	7	15	37				2		5	424						
2	430	F	6		90					50		110						
3	430	F	6									2	1		1	50		
4	505	F	8		3													
	400	F	5	19	50				2				1	3	2			
	375	M	5	200	142	15			25	17		6						
	435	M	6	24	3						1	81						
	460	F	7		650		3	2	47	9		30						
	500	M	8	10					1			200	3					
	375	M	4		5							33	1					
	470	F	8						2					1	16			
	480	F	8		150			3				40						
	475	M	8	20												1	2	
	380	M	5															
	400	F	5		60				1			300			8			
	450	F	6										10				4	
	350	M	4															
										12					2		1	
				3		5				84					2			150
								5			1							60
					69	66			1									
					11	12				9								
				20		2				55					16		2	90

LAKE WINNIPEGOSIS,

Whiskey Jack.

March 3, 1928.

Number	Length in mm.	Sex	Age.	Hyalella knickerbockeri and other Amphipods.	Chironomus spp.	Hexagenia limbata	Pisidium spp.	Musculium spp.	Amnicola sp	Lymnaea sp.	Valvata tricarinata	Valvata sp.	Physa sp	Nematodes	Corixa sp.	Cestodes Parasites
1	420	F	5	10	200		35									
2	475	F	7		300		9									
3	540	M	10	9	110	12	560	1								
4	360	M	5		6	50										
5	390	F	5		11		8									
6	360	F	4												3	
7	600	F	15													X
8	430	F	5		15	5	70									X
9	360	F	4													
10	570	F	12	2	10	1	150		10							X
11	400	M	5			24	3			2						
12						100										
13																
14				20	10		15									X
15						30										
16				50	40	32	100									
17				65			20				5	1	1			
18				510	950		100									X
19	375	F	4		1000		15									
20	580	M	14		450		50				1					
21	430	F	6		300		5									
22	435	M	6		650		22	2								
23	390	F	5		700		30							1		
24	540	M	10		300		10									
25	450	F	6		50		40							1		
26	400	M	6		1000		25							5		
27	400	M	5		200		5							6		
28	435	M	7		60		28							50		
29	480	M	8		500		80									
30	430	F	7		380											
				666	7242	244	880									
					6226		268									
					13468		1148									

Number	Length in mm.	Sex	Age	Hyalella knickerbockeri and other Amphipods.	Chironomus spp.	Hexagenia limbata	Pisidium spp.	Musculium spp.	Amnicola sp.	Lymnaea sp.	Valvata tricarinata	Valvata sp.	Physa sp.	Nematodes.	Corixa sp.	Cestodes Parasites.
31	420	F	7		856		30				1					
32	410	F	6		190											
33	440	F	1?		600		14									
34	407	F	5		480		6									
35	500	F	8		100		45									X
36	515	M	9		400		100									
37	572	F	14		500		10									
38	553	M	12		900		30									
39	522	F	10		400		8									X
40	500	F	9		700		25									
41	360	M	4		200											
42	400	M	5		100											
43	410	M	5		800											

LAKE WINNIPEGOSIS,

Whiskey Jack,

Sept. 12, 1923.

				Amnicola sp.	Valvata tricarinata	Valvata sp.	Musculium sp.	Sphaerium sp.	Pisidium spp.	Physa sp (gyrina)	Lymnaea sp.	Amphipods.	Chironomus sp.	Corixa sp.	Phryganidae.	Hexagenia limbata	Parasites cestodes.
				2	12				25			4	2				
									10			30	1				
									8			40					
					2	4			24			27					X
				1	5	12			21		1	7		9			
									30			1		4			
				16					32								X
															1		X
				8	30	27			120			20				1	
0				11	5	3			60		5	10					X
1									10			8		2			
2				4		1			20			45					
3	395	F	5						10			30					
4	405	F	5	4	6	3		1	15	1		19	2				
5	420	M	6	6			1		30		2	5					
6	360		4	Stomachs empty.													

LAKE MANITOBA.

St. Laurent,

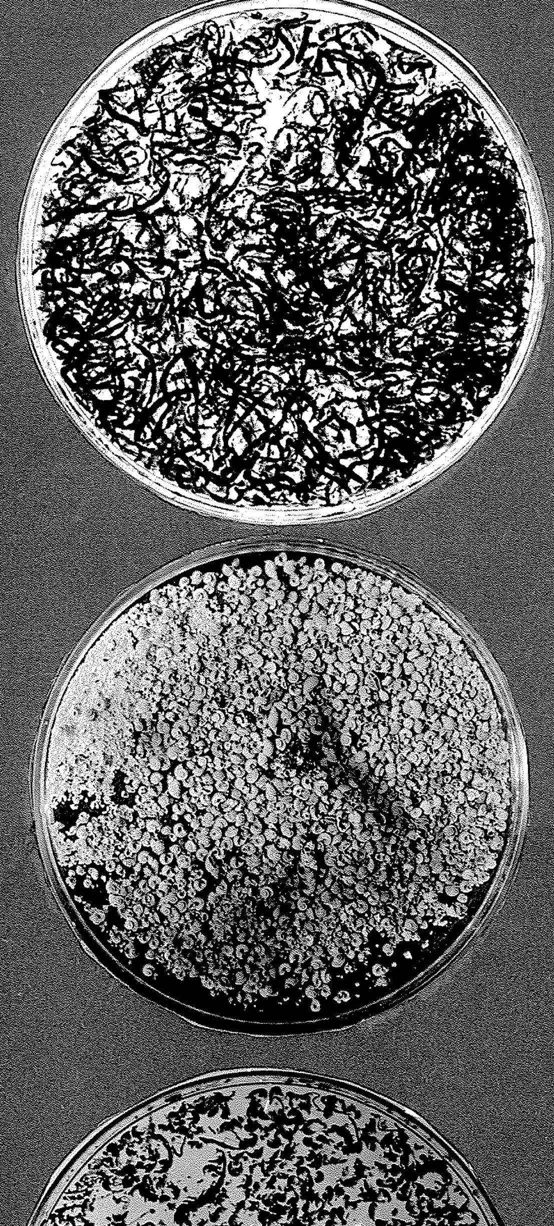
February 25, 1927.

Number	Length in mm.	Age sex.		Amphipoda	Lymnaea sp.	Amnicola sp.	Pisidium spp.	Sphaerium sp.	Musculium sp.	Chironomus sp.	Parasites cestodes.
1	435	F	8		15	200	60			10	X
2	195	M	3								X
3	295	M	4		38	50	7	1			
4	280	M	4	10	20	24	94	6	1	2	X
5	270	F	4	5	40	63	5				
6	300	F	4	2	3	10		1		4	

CLEAR LAKE,

October 1928.

Length. in mm. Age Sex.	Chironomus sp. (larvae)	Phryganidae	Hexagenia sp.	Corixa sp.	Pisidium sp	Planorbis companulatus	Planorbis parvus	Lymnaea emarginata	Hyalella knickerbockeri	Whitefish eggs.
340, M 5	5	1			1					
430, F 8				1000	3					10
400, F 6		3		600						
435, F 10		1		20	3		7	125		
385, M 6		10	5	60	1					
405, M 7				10						
410, F 7		60		15						30
450, F 10				600						50
290, M 4				100					2	
240, 3				40						
				2445						



Typical stomach contents of whitefish:

1. Lake Winnipegosis, (March) larvae of Chironomus sp.
2. Lake Winnipegosis, (August) Mollusks.
3. Lake Winnipeg, (August) Amphipods.

In the stomachs of whitefish from Atikameg Lake mollusks (Posidium, Musculium, Sphaerium, Lymnaea, Amnicola and Planorbis) were the chief items found. A very few larvae of Chironomus: Several spherical colonies of Nostoc commune and fertilized whitefish eggs were also observed.

The stomach contents of two whitefish caught in September 1929, in the Nelson River near Hudson Bay, were as follows:

1. Female: 500 mm: Corixa sp - 120: Limnadia sp - 1: Limnitis gculdii - 29: Hyalella knickerbockeri - 3: Phryganea sp (larvae) - 7; Notonecta sp - 2; Haliplus sp - 4.
2. Male; 290 mm: Corixa sp - 50; Estheria mexicana 3; Limnetisgouldii - 1.

It is interesting to compare this with the average percentage of the various food material found in the alimentary tracts of six adult whitefish from Quill lakes Saskatchewan, where this fish was introduced artificially. The stomachs were examined early in the winter and were found to contain Corixa sp - 99%, and Hyalella knickerbockeri - 1%.

One very interesting point was observed, vis: that fish which were infected by internal parasites contained little, if any, food. On the other hand the stomachs of fish which were free from parasites nearly always contained a quantity of food. In the case of the infected fish the growth rate will be different and this fact must be taken into consideration in determining the age by scales. The total amount of fish infected by internal parasites (Cestodes) is about 10%.

For several days before spawning the whitefish takes little food, and often does not take any at all, but immediately after spawning the fish feeds heavily and often devours a great deal of its own spawn.

DAILY CONSUMPTION OF FOOD BY WHITEFISH.

The average stomach content of adult white fish in different Prairie lakes will be as follows:

In Lake Winnipeg.

	Number	%		Number	%
Pontoporeia hoyi	80	82.4	Amnicola sp	1.0	1.1
Phryganeidae (larvae)	5.6	5.7	Hexagenia limbata	1.0	1.1
Chironomidae (larvae)	3.0	3.1	Molana sp	0.4	0.4
Pisidium sp	3.0	3.1	Other Mollusks	0.4	0.4
Valvata tricarinata and sp.	2.3	2.4	Other Crustacea	0.3	0.3

Crustacea - 82.7%; Insect larvae - 10.3; Mollusks - 7%.

In Lake Winnipegosis.

	Number	%		Number	%
Chironomus sp (larvae)	133.0	61.1	Planorbis antrosus	1.0	9.46
Pisidium sp	19.3	9.3	Nematodes (free Living.)	0.6	0.25
Lymnaea vahlii	17.4	8.0	Sphaerium sp	0.2	0.1
Valvata tricarinata	11.7	5.4	Physa gyrina	0.2	0.1
Amphipods	11.9	5.5	Cambarus viridis	0.2	0.1
Amnicola sp	11.7	5.4	Phryganea sp	0.1	0.06
Valvata sp	5.5	2.5	Musculium sp	0.1	0.05
Hexagenia limbata	3.4	1.6	Corixa sp	0.1	0.06
			Molanna sp	0.04	0.02

Insect larvae - 63.1%; Mollusks - 31.3%; Crustacea - 5.6%

In Lake Manitoba.

	Number	%		Number	%
Amnicola sp.	69.30	51.6	Amphipods	3.2	2.5
Pisidium sp	33.0	24.7	Sphaerium sp	1.6	1.2
Lymnaea sp	22.8	17.3	Musculium sp	0.2	0.2
Chironomus sp (larvae)	3.2	2.5			

Mollusks - 95%; Insect larvae - 2.5%; Crustacea - 2.5%

Figures in the second column indicate merely percentage of number of individuals without reference to size or food value.

As whitefish feed mainly at night, and are caught during this period, the average stomach contents should represent half of a 24 hour food supply. Exactness will depend on number of specimens examined. Thus, on this view we can estimate a daily consumption of whitefish food in the Prairie Lakes, as follows:

	Amphipods and other crustacea	Mollusks (small)	Insect larvae	Rough Weight. in gr.
In Lake Winnipeg	160.0	14	20.0	9.0
In Lake Winnipegosis	23.8	135.4	274.0	10.0
In Lake Manitoba	6.4	254.0	6.4	7.6
Average in Prairie Lakes	63.4	144.5	100.0	8.7

This will be 3.28 kg. rough weight per year, which accords quite well with the average increase in weight of whitefish of 200 gr. per year. Of course the quantity of 3.28 kg. we must count as a minimum, without including all other foodstuff which the whitefish takes, as, Oligohaeta, Hirudinea, Acarina, larvae of Odonata, Corixa and other food of secondary importance, which cannot be estimated exactly, also some vegetable matter, rotten pieces of food, detritus, humus, mud, and other stuff containing organic matter.

The amount of 5-10 gr. of food per day may seem to be too small, but we must not forget that the fish expends very few calories for keeping up the normal temperature of its body.

COMPETITORS.

As food competitors of whitefish fry may be noticed many different species of minnows, especially the genus Notropis, young tullibee and fry of pickerel, perch, goldeyes, etc. which feed on plankton food.

The following species are the competitors for food with the adult whitefish.

1. Ling (Lota lota maculosa). The stomachs of several ling examined contained many larvae of Hexagenia limbata.
2. Pickerel (Lucioperca vitreum) and sauger (Lucioperca canadense). The stomachs of these species together with remains of small fish contained many larvae of Chironomidae, Phryganeidae, Hexagenia and Amphipoda.
3. Northern sucker (Catostomus catostomus). Examination of the stomachs of this sucker taken from different whitefish grounds in the Prairie Lakes, shows that its food consists of:

40% of larvae of Hexagenia limbata.
20% of Pontoporeia hoyi and other Amphipods.
2% of larvae of Phryganeidae.
16% of small Mollusca.
12% of vegetable matter.
10% of miscellaneous

4. Common sucker (Catostomus commersonnii). Although this fish living mostly in shallow places is not common on the typical whitefish gfound it must be ranked among the competitors of whitefish. Its stomach content comprizes diffeent insect larvae, small mollusks, amphipods, plankton and vegetable matter.
5. Sunfish (Aplodintus grunniens). The food of adult sunfish taken from whitefish grounds in Lake Winnipeg, near Black Id. is as follows:

Hexagenia limbata -	60%
Chironomus sp. larvae	12%
Amphipoda	3%
Cambarus viridis	20%
Mollusca	5%

6. Sturgeon (Acipenser fulvescens). The distribution of this species in Lake Winnipeg, differs from the distribution of whitefish. Very few sturgeons are caught on

the whitefish grounds in the northern portion of the lake. But, nevertheless, stomachs of sturgeon are full of small mollusks, amphipods, and larvae of Hexagenia limbata. The last species, as well as many other larvae of aquatic insect, produce imajines, which can lay the eggs over the whole water area. Therefore, by feeding on such forms, even in a locality from which whitefish are absent, there will be a certain effect on the whitefish food supplies.

RATES OF GROWTH.

A. Fry.

Observation on the rates of growth of the fry were carried on mainly in hatcheries.

When just hatched from the egg, after several months incubation, the fry of whitefish is essentially a larvae, which must have a period of postembryonic development before attaining specific characters.

The food sac is absorbed from 6 to 12 days after the fry have hatched, the time varying somewhat with temperature, food and period of incubation.

The size of fry just hatching is 6-9 mm. During the first few days the fry grow quickly. The generations hatched from different sets of spawn are not the same in size and rate of growth, but always nearly double their length during the first week (11 - 17 mm.) and are then able to search for food. The rates of growth in different lakes, depend on temperature of water and food supply.

During the first month fry reach 15-30 mm. in length. We can remark some periodicity in rates of growth of whitefish fry.

After absorption of the food sac, the fry eat plankton ravenously and grow on an average to 22 mm. and after this we can remark some delay in further growth. This is probably in connection with the formation of internal organs. After this the young fish grow again more quickly and by August they reach a length of from 45 to 75 mm.

As is shown by the study of whitefish scales, in autumn and winter of their first year, the rates of growth of young fish again begin to be somewhat slow and only in the second spring does the fish start to grow more quickly.

The rates of growth of whitefish fry are not the same for all fry and we can always find among one generation individuals twice the size of others.

GROWTH OF ADULT FISH

The rate of growth of adult fish was determined by means of the scales. These were taken from different parts of the body in the dorsolateral and ventrolateral regions. The best scales for this purpose were found to be from the dorsolateral region. Scales were collected in paper envelops and kept dry. Several scales (usually six to ten) were examined from each fish. They were examined dry under the microscope using transmitted light, but without the use of a substage condenser. The best multiplications were found to be from ten to sixteen.

In the center of the scale is a small area without striations. This clear area, the socalled "focus", represents the original scale of the young whitefish, before the first winter. Around this area are numerous concentric striations, "circuli" which form all the time, during the growth of the scale at its periphery. In summer the distances between the circuli are greater than in winter, when the fish grow comparatively slowly. Under the microscope we can see a series of consentric rings, composed of circuli, which represents winter and summer rings, like the rings of growth in a tree. The outlines of these rings show the sizes of the scales of the fish in a certain year. During the spawning time these circuli are broken and have an irregular zigzag form, so it is possible to determine by the scale, not only the age of the fish, but also how many times the fish has spawned, and in which years of its life.

Very often scales occur on which winter and summer rings are not clear and are so badly defined that it is impossible to determine the age by them. In such cases it is necessary to examine not less than ten scales.

In a few cases all the scales are rather indefinite or show different numbers of annual rings. In such cases the age of the fish cannot be determined.

In addition to these difficulties, it is easy, especially if the fish is very old, to make a mistake of one, or even two year, but if we have a large number of specimens these small mistakes will cancel out, and the results will give a correct idea of the growth of the fish.

As the growth of the fish and the growth of the scales is nearly proportional, it is not different to find the length of the fish at the end of any year of its life by the following formula:

$$\frac{l}{d} = \frac{L}{D} \quad \text{or} \quad l = \frac{d\,L}{D}$$

Where: l = length of fish at the end of n = years.
L = length of fish.
d = diameter of ring at the end of n = years.
D = Diameter of scale.

About four hundred fish were examined from different lakes of the Province of Manitoba. As is shown in the accompanying graphs, the whitefish in Lake Winnipeg and Lake Winnipegosis grow at nearly the same rate, and somewhat faster than those in Lake Erie (see J.M. Couch: Rate of growth of Whitefish). This is certainly a result of the abundance of food, in the form of mollusks and insect larvae, which is available in Lakes Winnipeg and Winnipegosis.

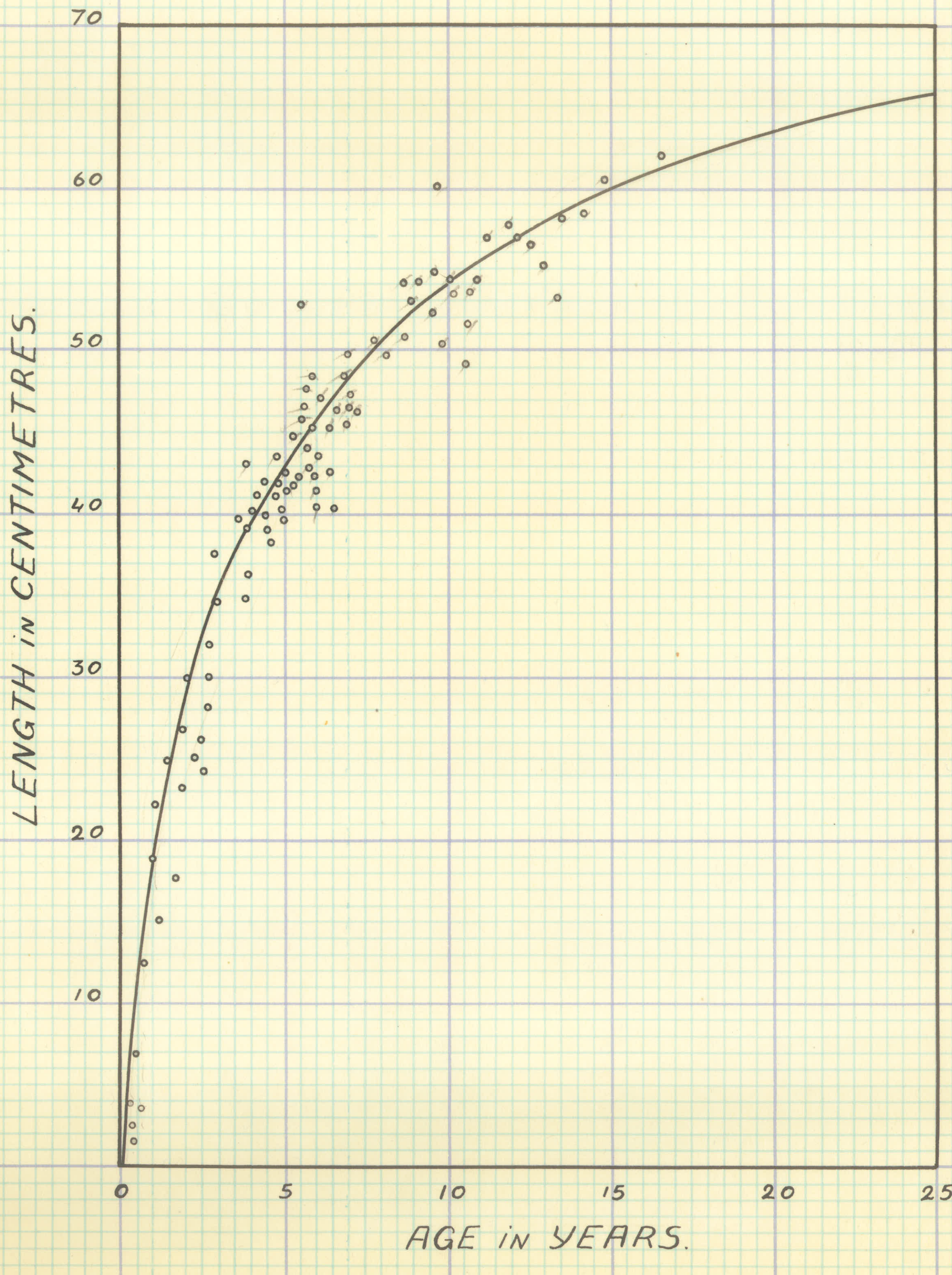
It is very interesting to note that in the Alkaline water of Quill Lake, Saskatchewan the Whitefish grow very much faster than in Lake Winnipeg (approximately one pound per year), which is due probably to the higher summer temperature of the water and to the abundance of planktonic crustacea early in the spring, during the period when the whitefish fry need plenty of food.

As a rule, during the first three to five years, the whitefish develops rapidly in length with comparatively small increase in weight, but after this age the fish begins to grow fat and increases in weight. Very old fish have also a deeper body, often with a fleshy hump behind the occiput, and are called by fishermen "Jumbo".

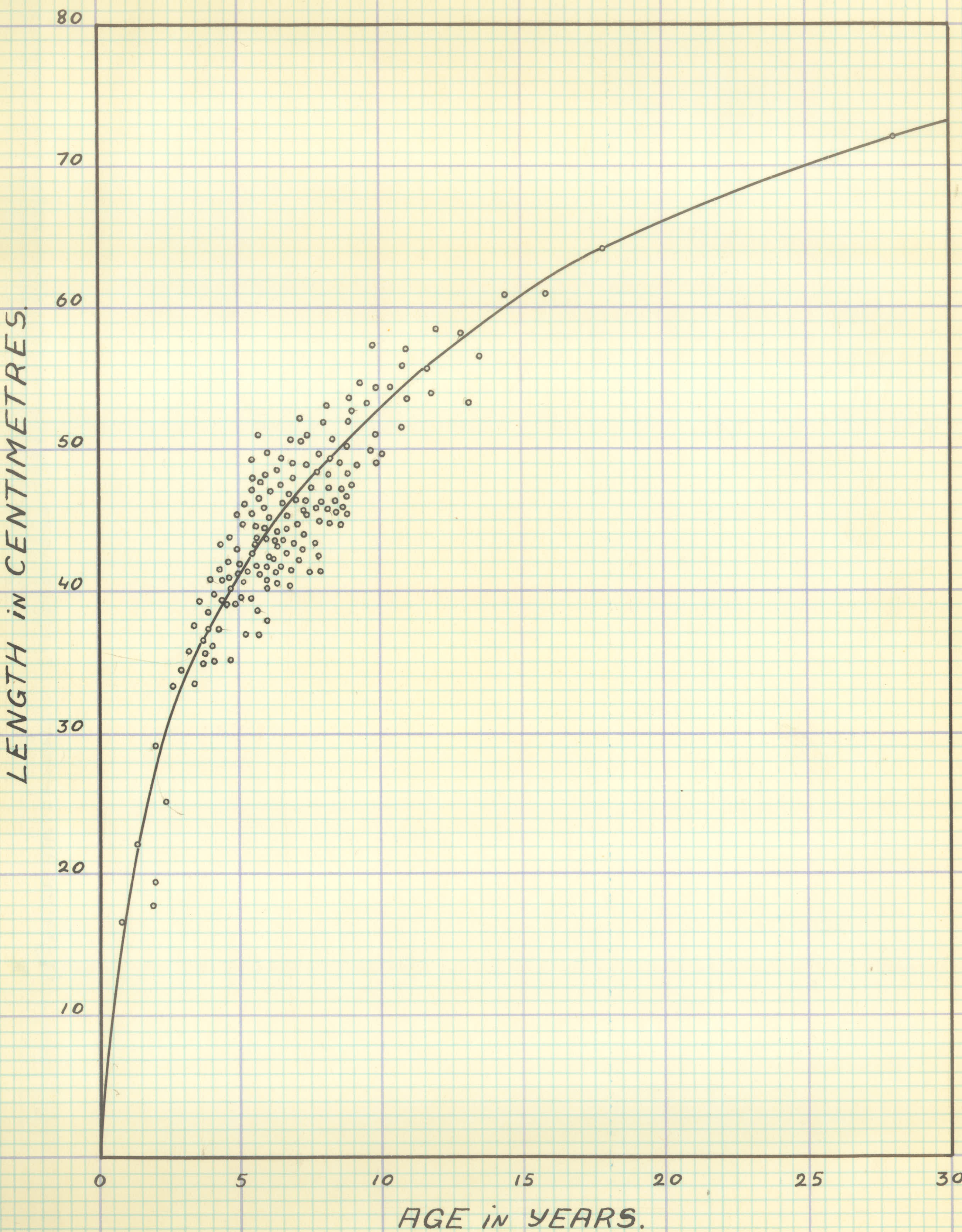
The following graphs illustrate rate of growth in different lakes of the Prairie Provinces.

The increase in length both in males and females proceeds more and more slowly every year but doesn't stop even in very old fish.

Graph illustrating rates of growth of whitefish from Lake Winnipegosis.



Graph illustrating rates of growth of whitefish from Lake Winnipeg.



The curves illustrating the rates of growth for the sake of simplicity are shown as simple parabolic lines, but in reality these curves should be represented as undulating lines, because the rates of growth are periodically slowed down and probably break off during the winter time, and on the other hand become very rapid in summer.

CORRELATION OF SEXES.

The analysis of the catches show that there are about equal proportions of males and females. As there is very little difference in length and height of males and females of the same age, gill nets can not play the role of a filter between these two sexes. It shows also that the habits of both sexes are similar and that both sexes live together and feed on the same food. From this we can consider that whitefish shoals in the Prairie Lakes consist of equal number of males and females.

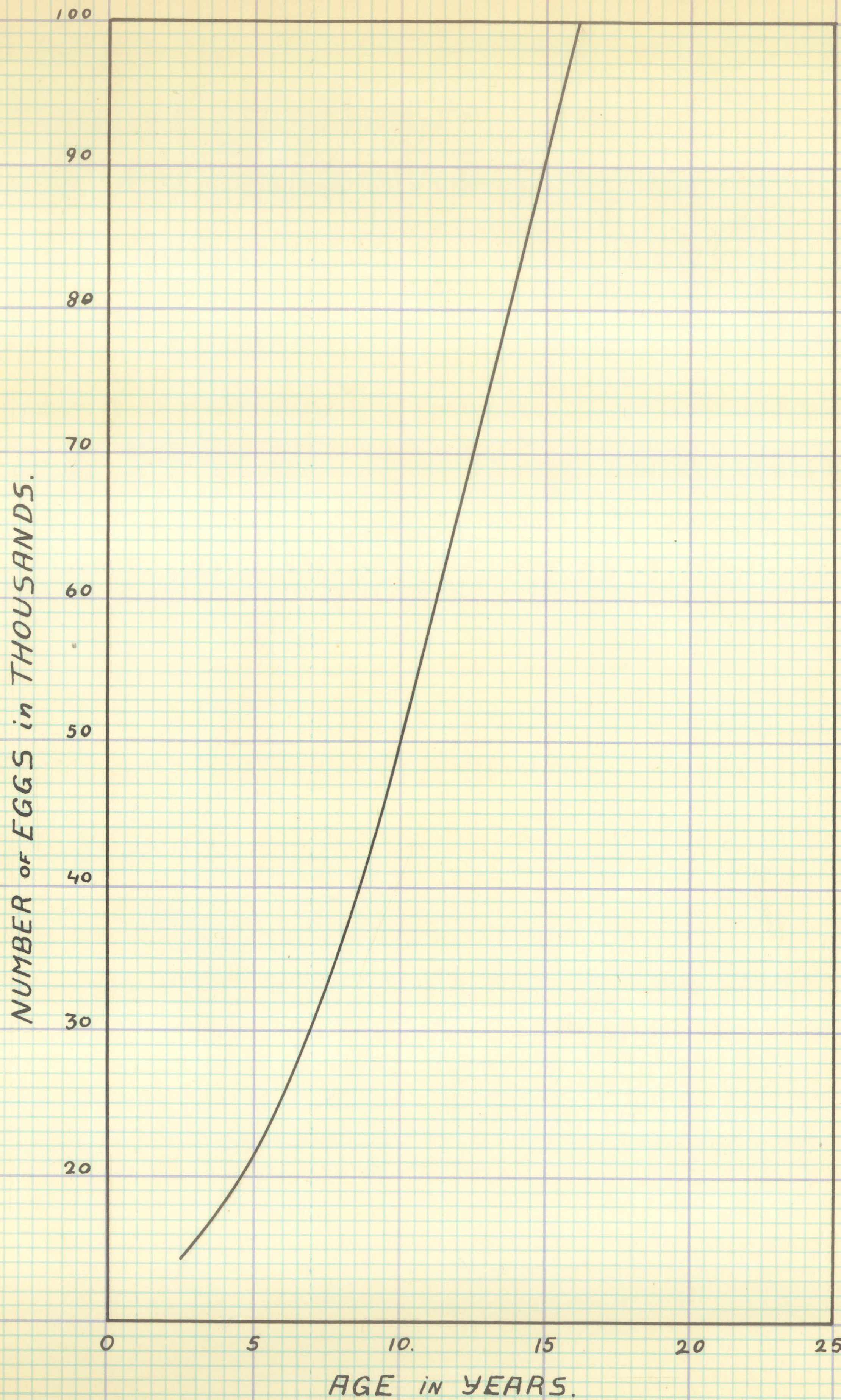
FERTILITY.

We have very little data from literature about the fertility of whitefish. Different American investigators estimate the average fertility of whitefish as 35.000 eggs. This data is more or less accurate. After examining several different sizes of ripe females from Lake Winnipegosis, the following graph was constructed, showing the number of eggs in relation to age of fish.

With increase of weight beginning from 3 to 6 pounds, the number of eggs increases approximately 14.000 per each pound, but later this begins to decrease.

Roughly speaking the fertility of a whitefish will be proportional to its weight.

Downing (p. 627) says, that the greatest number of whitefish eggs 150.000 from a 11 pound fish, but we cannot admit this as a limit, because whitefish sometimes reach a greater weight.



Graph showing the relative fertility of whitefish from Lake Winnipegosis.

The oldest fish examined from Lake Winnipegosis was an eight pound female of 17 years, the number of eggs was approximately 100.000.

In general, the fertility of whitefish fairly hight and very much higher than the fertility of Acipenseridae, Salmonidae and other fish, but less than Gadidae, Percidae, Clupeidae and Cyprinidae.

Whitefish spawn every year after reaching four years. Taking the average duration of the life of a whitefish as 10 years we may say that it can lay about 250,000 eggs.

RIPENING.

Only in the third year can the ovaries be microscopically distinguished from the testes. The ovaries, at the beginning of the third year, have the form of long ribbons. The eggs having a diameter of 0.12 mm. The weight of such ovaries is relatively very small.

As a rule whitefish reach maturity in the fourth year. The ripe eggs are about $2\frac{1}{2}$ mm. in diameter and are of an amber color. After the first spawning, as a rule, the other spawnings take place every year.

In September the adult females have well developed ovaries in which it is possible to observe two stages of development in the eggs. The first consists of more or less ripe eggs, which are to be laid during that autumn, and there are also very small eggs like white spots in the oscyte or perhaps the oogonia stage. These sexual cells must have one year's further development.

As is shown by experiments with artificial fertilization, not all females and males ripe at the same time, i.e. practically the period of spawning extends over one month. We have no data as to whether the females which ripe first are old ones or small fish.

The length of life of the whitefish sperm varies varies considerably and depends on the ripeness of the male. The most viable sperm is from very vipe males, from which it is obtained by easy pressure on the belly of the fish.

The maximum length of life of very ripe sperm which has been observed on Lake Winnipegosis, was 30 minutes. The following table shows the average length of life of the sperm in water and in air, taken from 26 male whitefish in Lake Winnipegosis, October 29, 1923. The temperature of the water was -0.1°C., air temperature +0.5°C. and dissolved oxygen 10.8 parts per million.

Length of fish in cm.	Age	Life in Air	Life in Water.	Length of fish in cm.	Age	Life in air	Life in water.
350	4	2-00	2-30	466	7	10-00	15-00
380	4	6-00	7-50	410	5	6-25	10-20
390	5	4-30	8-00	530	11	9-40-	19-30
460	7	3-40	7-15	420	5	3-20	4-30
460	8	5-10	10-00	440	6	5.00	8-10
550	14	6-10	12-00	470	7	4.50	6-00
540	9	7-50	9-00	330	4	5.00	6-00
420	5	6-00	8-20	450	6	6.00	9-00
460	7	6-00	9-00	500	8	5.20	8-50
460	7	7-10	10-00	420	6	4-30	9-00
380	4	5-00	6-30	460	7	6-00	8-30
440	5	8-30	12-00	370	4	3-40	5-00
420	6	5-20	8-00	350	4	1-00	2-30

The average life in air is 6 minutes, in water 16 minutes, i.e. more than twice as long. This indicates that "wet" method of fertilizing is preferable to the "dry" method, but the sperm should not be diluted so much as to impair the chances of reaching all the eggs.

During the spawning period the color of the fish begins to be very much darker, males have small black spots on dorsal and adipose fins. On the scales and head of males appear many white epithelial tubercles. Females have also such tubercles but in comparatively smaller numbers.

SPAWNING NOTES.

In October and November the adult whitefish gathers into large shoals, leaving the deepest places of the lakes and coming towards shore in shallow places for spawning purposes. We must distinguish among the whitefish two groups which are different in their spawning habits, i.e. one spawns in the lakes proper, the other group enters rivers for this purpose. So, for instance, a great number of whitefish pass from Lake Winnipeg up the Saskatchewan, Dauphin and Fairford Rivers where they spawn in the currents. To the first group belong the wholly lacustrine fish which never leave the lake, although they sometimes come to the river mouths. It is possible, that these two groups differ somewhat, one from the other, taxonomically, but we have not enough material to make a definite conclusion. The time of spawning of whitefish in the Prairie Lakes usually falls at the end of October and beginning of November, but may be delayed by warm weather. The character of the spawning gfounds has already been considered in the description of bottom areas. These spawning places are more or less constant in all the Prairie Lakes. The most important of them in Lake Winnipegosis, are situated along the northern shore between Ami Id. and Shannon Id. There the whitefish spawns at a depth of from three to six feet and comes in such large numbers that 400 fish have been caught in one night with 100 yards gill net. Other important whitefish spawning grounds in Lake Winnipegosis are situated near the outlet from this lake, where the fish from the deepest places of the southern portion of the lake, and also whitefish from Waterhen Lake congregate. Beside this several spawning grounds are situated along the eastern shore of Lake Winnipegosis.

There is a widespread opinion among the fishermen that a considerable migration of whitefish takes place annually, from Lake Winnipeg to Lake Winnipegosis, via the Dauphin River and Lake Manitoba. It is true that some migration takes place from Lake Winnipeg, up the Dauphin River, at least as far as Lake St. Martin, and Fairford River. A large Number of whitefish spawn in the narrow part of this lake situated 17 miles northeast of Fairford, others spawn in the Fairford River. Apart from this it is doubtful whether any extensive migration takes place. The chief evidence against the current opinion lies in the morphological difference between the whitefish in Lake Winnipeg and Lake Winnipegosis, which are summarized below:

Number of scales in Lateral Line.	Arithmetic Mean	Maximum Number	Minimum Number	Percent of total less than 75	Percent of total over 81
Lake Winnipeg	79.7	85	75	0	28.5
Lk. Winnipegosis	75.6	81	71	365	0

It also appears unlikely that any extensive migration for spawning purposes would take place over such a route without the presence of a great many whitefish being noted in Lake Manitoba and the Southern end of Lake Winnipegosis. As a matter of fact whitefish are somewhat rare in these two places.

Many whitefish enter the Big Saskatchewan River, where they spawn, not far from Grand Rapids. Into certain rivers, as for example, Icelandic River, whitefish do not come at all, in fact they do not even approach the mouth of this river. It is very interesting to note also, that whitefish do not enter such a big river as the Winnipeg River. However a large quantity of whitefish come to the mouth of several rivers along the eastern shore, such as Bloodvein Bay, Pigeon Bay, etc.

The process of spawning takes place at night and begins shortly after sunset. The fish rise to the surface and make heavy splashes, like a flock of wild ducks. The author has observed such splashes on Lake Winnipegosis.

This "play", quick motions and rising to the surface are an effect of sexual excitement. It is possible that some eggs are emitted at the surface.

Mr. C.C. Leach (p.4) describes the spawning habits of whitefish confined in pens, as follows: the fish rise to the surface, occassionally in pairs, and rarely in trios of one female and two males, The female emitted a quantity of spawn at each rise. The males, always the smaller first, persistently follow the female and discharge milt at the same time the eggs are emitted.

It seems to the author that most of the eggs and milt are emitted near the bottom, otherwise the percentage of fertilized eggs would be very poor. The rising of the fish to the surface should be explained as reflex movements, easily performed since the depth of the spawning places does not exceed 5-6 feet.

The writer's investigations seem to indicate that the whitefish lays its eggs in small batches over a period of about 10 days. This habit would give the spawn a much better chance of survival than if all the eggs were laid together.

DEVELOPMENT OF EGGS.

Under natural conditions, in a mean water temperature of 1.7°c (= 35°F.) eye spots appear on the fertilized eggs, after about one and a half months, and the full incubation period is about 140 days. T This is of course regulated by temperature as is shown by our experiments with hatching eggs in the alkaline water of Little Quill Lake, Saskatchewan, (total solids about 11,000 parts per million) fertilization and further development of whitefish eggs is possible even in such water. This solinity is not ruinous for whitefish sperm, which can live in this water for 20 minutes.

DESTRUCTION OF WHITEFISH SPAWN IN NATURE.

There are indications in literature that whitefish eggs are subjected to the attacks of many enemies, such as yellow perch (Perca flavescens), common sucker (Catostomus commersonnii) various smaller Cyprinidae and some other fish, crawfish, and wild fowl. All these suggestions must be strongly criticized. We have carefully examined one hundred stomachs of common sucker taken from whitefish spawning gfounds, in the southern portion of Lake Winnipegosis, during the spawning time of whitefish, and for two weeks afterward. No whitefish eggs have been observed in the stomachs of those suckers. Several stomachs of suckers were examined from different spawning grounds in other lakes and no whitefish spawn has been observed.

It is concluded, on this basis, that the common sucker does not destroy whitefish spawn in nature. This fish feeds on different insect larvae, mollusks, small amphipods, plankton and vegetable matter. It may be classed rather as a competitor of the whitefish for food.

Many small Cyprinidae, such as Notropis etc., are too small to take whitefish eggs, and wild water fowl also cannot be ranked among the destroyers of whitefish spawn in the Prairie lakes, because spawning takes place at a time when most of the wild ducks and other aquatic birds are going away, and soon after the spawning the lakes are frozen.

A certain number of whitefish eggs have been observed by us in the stomachs of perch, and a few in the stomachs of Tullibee. Several whitefish eggs were found in the stomachs of ling (Lota lota maculosa) Only six specimens of this species have been examined from natural spawning grounds in Lake Winnipegosis.

Nevertheless, undoubtedly, a great many whitefish eggs are destroyed by whitefish themselves and only the circumstance that the whitefish returns at once to deeper water after spawning, saves many fertilized eggs in nature. We found several fertilized eggs of whitefish in the stomachs of those fish from Atikameg Lake, in the winter of 1927. The same Phenomenon was observed in Clear Lake in 1928. During the spawning time in 1928 five stomachs of whitefish from Waterhen Lake and ten from Lake Winnipegosis were examined. Nearly all these stomachs contained whitefish eggs in different quantities. In one stomach of a $3\frac{1}{2}$ pound male 1,200 eggs were found. A photograph of this stomach is given below.

How many eggs of whitefish are fertilized and hatched.

Downing estimates the number of eggs fertilized under natural conditions as not more than one percent. He estimates that only 350 eggs are fertilized from a whitefish of average size and only 11 young fish will result from each pair of parents.

Professor E.E. Prince doubts that the percentage of fertilized eggs under natural conditions is so small and gives, among others, the following example, regarding Sockeye Salmon, in British Columbia. He gathered quantities of natural fish spawn in the beds and failed in some thousands of eggs, to get one single egg that was not fertilized, which showed how scrupulously nature accomplishes the fertilization of eggs, under natural conditions. He says, that as far as his observations go, the eggs which were deposited by the parent fish are almost to an egg fertilized.

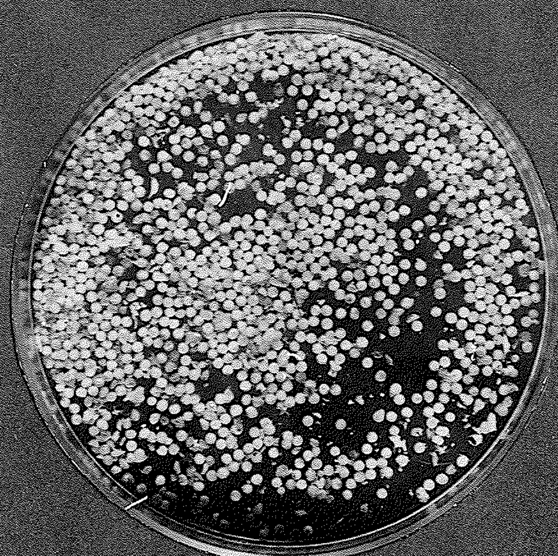
Mr. Fryer, has collected salmon and trout and fertilized naturally, under normal conditions, and has not found 5% of the eggs unfertilized, so that, he says, there seems very great reason to doubt that the proportion of unfertilized eggs in the case of the whitefish can possibly be 99% as suggested.

The observations of Capt. Lambson on the Sacramenta river on the natural fertilization of the salmon eggs, show that about 75% are fertilized under natural conditions, but further observations show that of the 75% which are naturally fertilized, fully 25% are smothered in the sand, so that eventually only a few hatch. Under artificial conditions from 90 to 95% were fertilized, and from 90 to 95% of the eggs fertilized hatched and developed as fry.

We must remember that this observation was on trout and salmon eggs. Mr. Stranahan was instructed by U.S. Commiss. of Fisheries to make dredgings on the reefs with a steamer. He did so for several days, during the latter part of November and early in December. He had an inch hose and rotary pump and took up several thousand eggs. He cannot give the exact percentage, but it was somewhere in the vicinity of one egg out of 300 or 400, and as he remembers, he got only 11 or 12 impregnated eggs, during the two or three days' work.

Mr. Samuel F. Fulerton has been at it eighteen years, and has taken eggs off the bottom rocks and off the sand and brought them to the hatchery and hatched them, but he never got 1% of fry.

Our examination of whitefish eggs found in stomachs of whitefish in Lake Winnipegosis, 1928, shows that 85% were fertilized under natural conditions. About 30% of fertilized eggs have been found in stomachs of whitefish from Atikameg Lake (1928).



Whitefish eggs found in the stomachs of whitefish.

(Lake Winnipegosis, November.)

The author's opinion is that the percentage of fertilized eggs may fluctuate very considerably, depending on spawning conditions, age of fish, fertility of males, temperature, dissolved gases, etc.

MIGRATION OF WHITEFISH

As regards the migrations of whitefish in the Prairie Lakes, they may be grouped as follows: Migrations for spawning purposes, about which we have spoken previously, and migrations depending on the currents. There is a wide-spread opinion among the fishermen, that the wind "brings on" the fish into nets. This phenomenon can be explained by the fact that the whitefish shoals, like shoals of any other commercial fish, are very sensitive to weak currents, originated by strong and constant wind, and move against these currents. As the direction of such currents is always opposite to the direction of wind, so the impression is created that the fish, which is really keeping against the stream, is being "brought on" into the nets by wind. This opinion is so firmly implanted among the fishermen that they believe wind can "bring on" fish, even during winter, when the lake is covered with ice.

Deep water currents are connected also with the vertical migrations of whitefish, which explains, very often, poor catches during windy weather. Fish trying to keep against the current rize up for several feet and pass through above the nets. This is confirmed by the circumstance that during poor fishing some of the fish are caught in the upper meshes of gill nets, but during very good fishing most of the fish are caught in the lower part of the net.

In October 1927, Mr. Butler, superintendent of Lake Winnipegosis hatchery, marked 2655 whitefish with special tags, and put them into the lake near Snake Id. Several hundred of these fish were recaptured next year within a radius of about 30 miles. This shows a comparatively small migration of whitefish.

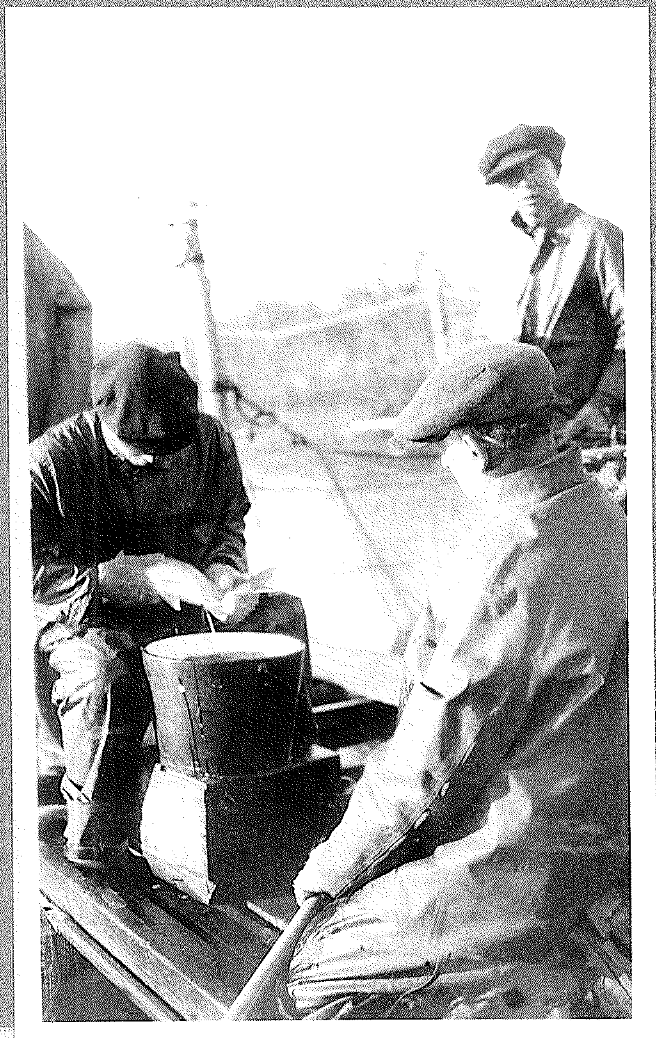
WHITEFISH CULTURE IN THE PRAIRIE LAKES.

In the Lake Winnipeg system there are at the present time, three large and excellent hatcheries, capable of dealing with approximately 200 million whitefish fry, but it is not every year that the hatchery people can collect such an amount of eggs.

Two of these hatcheries, with capacity of 90 million eggs each, are situated on Lake Winnipeg at Gull Harbor and on Lake Winnipegosis at Snake Id. The third hatchery is situated at Fort Qu'Appelle, S Saskatchewan.

The water for these hatcheries is pumped from the lake by means of steam power. As the work and adaptation of these hatcheries are more or less similar, it will be sufficient to give a short description of the Lake Winnipegosis hatchery.

Fish for this hatchery are obtained from Waterhen River, about 10-15 miles from Snake Id., by pond nets, and transported in special boats to the hatchery. There fish are kept in a lagoon in big square nets until fully ripe, i.e. usually until the end of October. Artificial fertilization is carried out on the special boat by the following method: The spawntakers sit on boxes, holding between their knees wooden pails, of 3 gallon capacity, painted white in the inside. Helpers give the fish to the spawntakers, using shallow hand nets. For convenience spawntakers have woolen mits. The fish is held in the left hand near the candle peduncle, if possible horizontally, belly down, 6-10 inches from the bottom of the pail. The fish are squeezed out by the right hand by applying a gentle pressure. For each 3-4 females one male is quite enough, although, as experiments show, if the males are scarce, 2-3 good males are quite enough for fertilization of a full pail with 2,000,000 eggs. As soon as new portions of eggs and milt come into the pail the contents are mixed very gently by hand without mits, or if with mits, at the surface. Usually the "dry method" is used, but the "wet method"is also often used. The quantity of eggs depends on the size of the fish, but the quantity of milk is about 1-2 teaspoonsfull. If the fish is ripe, both the eggs and milt are squeezed out very easily. If the fish is not ripe enough it goes back to the pens. The fish, after being squeezed, are put in the lake. A few thousand fish are marked every year, by means of small metal tags, placed near the caudal fin. When the pail is full of fertilized eggs, each spawn-taker carries his pail to the hatcher, transfers the contents into big wooden kegs, $\frac{3}{4}$ mt. in diameter and $\frac{1}{2}$ mt. high, and puts therein as much water as is necessary to cover the eggs to a depth of 8 inches. After this the spawn-takers put a label on the keg, in order to distinguish it from the kegs of other spawntakers. The eggs of each spawntaker are placed in separate jars.



Taking the spawn.

Distribution of fry.

The spawn remains in these kegs for about 10 minutes, after which, by means of a rubber tube, $\frac{3}{4}$" in diameter, a strong current of water is passed into the keg. The eggs remain in these kegs for 48 hours, being raked several times. After this the eggs are placed in open-top Downing hatching jars. Subjecting the eggs for a period of 48 hours to running water in the kegs keeps them from sticking together. Hardening of the eggs also takes place in the kegs and is completed after about 3-5 hours.

After transferring the eggs into hatching jars, they are again raked gently, by means of soft goose feathers, to keep them from sticking.

Each hatching jar contains from 100 to 150 thousand whitefish eggs, and is about two thirds full of eggs. The number of hatching jars in the Lake Winnipegosis hatchery is about 700. In these jars the fry hatch in spring. The temperature of the water in the hatching jars is somewhat higher than in the lake.

The fry are planted in the lake shortly after hatching, without being kept or fed for any time. Most of the fry for a long period has been distributed near the hatchery in the southern portion of Lake Winnipegosis. Transportation of the fry to the Northern portion of the Lake, early in spring, is very inconvenient.

MARKING OF WHITEFISH FRY.

In May 1923 a short visit was paid to the Winnipegosis Hatchery for marking whitefish fry. This can be done only with the help of a binocular microscope. The actual marking operation may be summarized as follows: One or more fry (the number depending on their activity or vigor at the time) were picked up in the watch glass from a dipperful on the work table, and the watchglass placed on the stage of the microscope. For some seconds they usually swam excitedly around the watch glass, and during this time the forceps were grasped in the right hand and held ready over the fry while the watch glass was manipulated by the fingers of the left hand. As soon as the young whitefish momentarily ceased its struggles and one got a clear view, the pectoral fin on the side desired, was quickly and firmly grasped with the forceps between the center and b base. This requires rather careful manipulation, but with practice one can judge the thrust required to a nicety in spite of the quickness of action required.

Once the young fish is grasped in the forceps the dissecting needle is picked up in the left hand and the point carefully run down between the two arms of the forceps until it touched the watch glass. The animal was then released and the extent of the injury observed. If it was found that not all the distal portion of the fin had been removed, the above operation was repeated. But if it was necessary to repeat this more than three times, or if the fish was injured even slightly, in any way, it was discarded and a fresh one taken. The newly marked fry were placed in a syracuse watch glass, and when five had been marked this was put aside. By the use of two of these watch glasses alternately the marked fry are readily kept under observation for five or ten minutes while others are being marked. If at the end of this time any of the fry were lying on their backs on the bottom of the watch glass, as was ocassionally the case, they were discarded and other fry marked. After this they were transferred to one of the hatchery jars, through which there was a constant flow of water.

It is worth while noting that when this method is used the fry are at no time taken out of the water, and also that none but the part to be amputated are touched or injured in any way. This is doubtless the reason for the low mortality.

Some care is necessary if the fry are to be marked without injury to other parts than the fin cut off, so that the process is rather slow. At the same time the recovery of the fry from this operation was excellent, and judging from several lots kept under observation in the hatchery for twenty-four hours or longer, it appears that the loss resulting from the operation was comparatively small, probably not more than ten per cent (quite possibly less in several lots). This applies to fry marked shortly after the absorption of the egg sac.

WHITEFISH FRY MARKED AT THE WINNIPEGOSIS HATCHERY, 1928.

Date of Marking	Right or Left Pectoral Fin	Number Marked	Date of Planting	Where Planted	Temperature when planted	Loss up to time of Planting.
18/V/28	Right	50	20/V28	A sheltered bay about 1 mle. north of Bickle's Island.	Air - 21°C. Surface - 10.8° Bottom (4') -8.0° Water in cans just before planting - 10.3°	Not more than 10%. Fry in very good condition.
19/V/28	Right	340	20/V/8	as above		
20/V/28	Right	100	20/V/28	as above		
20/V/28	right	130	22/V/28	East shore of Long Island, 2 mls. from south end.	surface - 44°	
21/V/28	Right	370	22/V/28	as above		
21/V/28	Right	30	23/V/28	West shore 4 mls. north Bachelors Island. ¼ ml. off shore.		
22/V/28	Right	170	23/V/28	as above		
22/V/28	Right	225	23/V/28	as above		
24/V/28	Left	500	25/V/28	In channel between Northern end of Red Deer Peninsula & Devils Id.	Air - 13.4° Surface - 7.4° Bottom (15') -5°	About 40% Fry in poor condition.
26/V/28	Right	100	26/V/28	Off Armstrongs Creek in Bay east of Salt Point.		

F I S H E R Y.

Commercial fishing of whitefish in the Prairie-Lakes is about 60 years old and is one of the most important branches of industry in the Prairie Provinces. At the present time, in Manitoba, about 4 million pounds of whitefish are obtained, representing $350,000. In three of the most important lakes, the catches have been as follows:

	Lake Winnipeg	Lake Winnipegosis	Lake Manitoba.
1906	5,000,000	600,000	200,000
1908	2,000,000		
1909 - 10	3,000,000	861,700	753,400
1911 - 12	3,123,300	953,600	258,700
1912 - 13	3,297,500	1,101,400	178,000
1914-15	2,247,000		
1915-16	2,637,300	576,000	223,800
1917	2,815,100	962,000	262,000
1918	3,052,500	1,000,000(?)	200,000(?)
1919	2,975,500	1,240,400	471,900
1920	3,000,000(?)	700,000(?)	100,000(?)
1921	3,143,000	941,100	74,600
1922	2,637,100	722,200	77,600
1923	1,626,400	639,000	78,000
1924	1,591,000	690,800	99,000
1925	2,559,000	621,500	117,000
1926	3,741,700	833,700	136,500
1927	2,826,000	718,700	189,400
1928	3,094,300	674,500	179,800

The following graph shows the production of whitefish for the whole Province of Manitoba for the last thirty-six years.

In Lake Winnipeg and Winnipegosis both summer and winter fishing is allowed, in Lake Manitoba only winter fishing.

The whitefish fishing is carried on mostly in the northern parts of Lakes Winnipeg and Winnipegosis, from where fish are transported to the main bases, situated at Selkirk, Gimli and Winnipegosis, and also to certain railway stations. Most of the whitefish are shipped to Chicago, New York and other U.S. markets.

Whitefish are obtained only with gill nets, on sail and motor-sail boats, about 30 feet long, operated by two or three men. At the shipping station the fish are dressed and packed into 100 pound boxes, with crushed ice.


Whitefish production of
Manitoba
for the period 1892 - 1928.
Millions of Lbs.
10
8
6
4
2
1892
1897
1902
1907
1912.
1917
1922
1927.

Formerly only winter fishing was permitted on Lake Winnipegosis, recently however, summer fishing has been allowed, for a period of one month (Sept. 15th to October 15th). This innovation has brought about an undesirable condition, in that a great many small whitefish (about one pound in weight) are caught in the summer. As these small fish decompose very rapidly in hot weather, - the majority of them are not fit for sale and are burned. This is the direct result of the use of 4¼ inch gill nets, in the summer fishing, and will undoubtedly have very serious consequences if remedial measures are not taken at once.

WHITEFISH POPULATION IN THE PRAIRIE LAKES.

The diversity in size and weight of whitefish, obtained from the Prairie Lakes, shows the variety in age of these fish. The direct determination of age of a great number of individuals, obtained from Lakes Winnipegosis and Winnipeg, gives the following percentages of each group.

Lake Winnipegosis				Lake Winnipeg.			
Age	Average Length	Average weight	%	Age	Average Length	Average weight	%
3 yrs.	350mm	1.4	5	3 yrs.	325	1.3	2
4 "	390	1.8	10	4 "	380	1.7	6
5 "	420	2.3	24	5 "	420	2.3	20
6 "	450	2.5	16	6 "	450	2.5	17
7 "	480	3.	10	7 "	480	3.	16
8 "	500	3.3	7	8 "	500	3.3	15
9 "	520	3.7	6	9 "	520	3.7	10.638
10 "	540	4.2	5.5	10 "	540	4.2	6
11 "	560	4.8	5	11 "	560	4.8	2
12 "	575	5.3	3.5	12 "	575	5.3	2
13 "	585	5.8	3.	13 "	585	5.8	1.5
14 "	592	6.5	2	14 "	592	6.5	1
15 "	600	7.	1.5	15 "	600	7	0.5
16 "	610	7.6	1	16 "	615	8	0.2
17 "	620	8.	0.5	17 "	630	10	0.2

The rates of growth, both in males and females, are about the same.

As the mesh of gill nets plays the role of a filter, for fish of a certain size, so on the case of this analysis of catches we can make a curve of the relative number of whitefish of different age i.e. the curve of whitefish population in Lake Winnipeg and Lake Winnipegosis.

The following graph illustrates this illustration.

We can see that in Lake Winnipegosis the relative number of adult whitefish is somewhat less than in Lake Winnipeg. This circumstance is quite understandable if we remember that the rates of growth of whitefish are about the same in both of these lakes. But the catches in these lakes, during the last eight years, (1921 0 1928 inclusive) were not proportional. The catches during this period are as follows:

In Lake Winnipeg	In Lake Winnipegosis.
(total area 9,400 sq.mls.)	(total area 2036 sq. mls.)
21,218,500 pounds	5,841,500 pounds.
or per one square mile	
2,243 pounds	2,800 pounds
or approximately:	
748 individuals	933 individuals.

This disproportion will be even greater if we take into consideration that the relative area of whitefish grounds in Lake Winnipeg and in Lake Winnipegosis is more than 9400/2036.

The comparative decrease of the whitefish population in Lake Winnipegosis is the direct result of more intensive fishing than in Lake Winnipeg.

It is very important from the standpoint of the fish industry to estimate the total amount of whitefish in the different lakes. Of course to estimate the exact total amount of fish is possible only in comparatively small ponds, drained annually, when we know the total number of fry distributed artifically every year, as for instance in certain carp culturing in Europe.

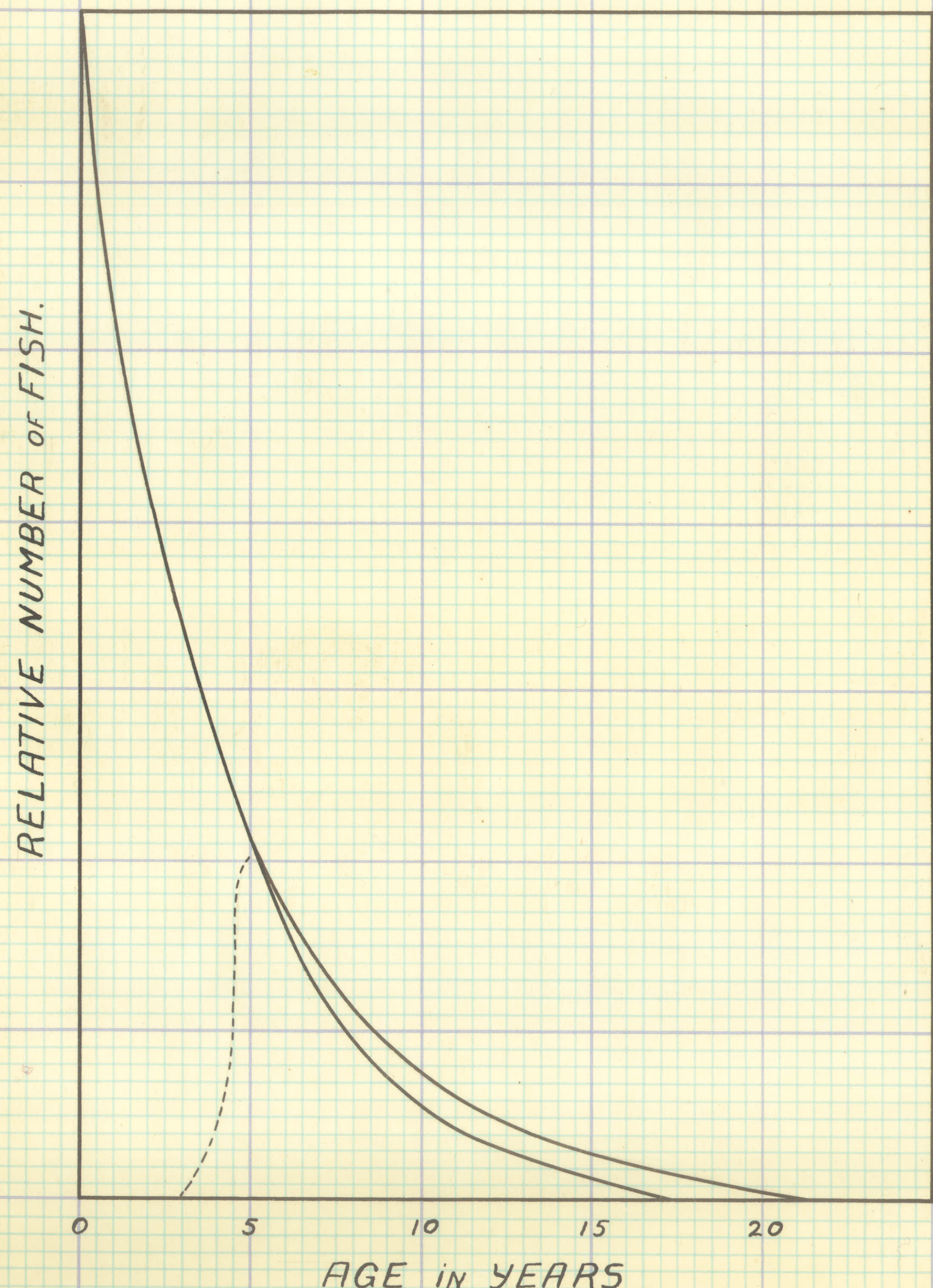
Nevertheless, it is possible to estimate approximately the number of commercial fish of every species, for each body of water, where regular industry taxes place#

such calculations have been used for estimating the number of some commercial fish in the Caspian Sea.

See: Dergawin A.N. "The Stellated sturgeon.....

(refer. p. 122 of this report) A.B.

Graph showing whitefish population in Lakes Winnipeg and Winnipegosis.



This is possible only if we know the maximum age attained by the fish, the age of the fish in the catches, and the constitution of the catches for a period of years, not less than the age of the fish. It is taken for granted that the numerical composition of the fish fauna remains constant during the time of investigation.

It is necessary to add a reservation that we cannot estimate the total number of fish perishing every year under natural conditions. But this does not invalidate our estimate because in the Prairie Lakes there appears to be a very low mortality of the adult whitefish, from epidemics and there are many big fish which eat the small whitefish, also there are few chances that an adult whitefish will live until it dies naturally. Therefore the following estimate gives us an idea only of those fish which will eventually be caught by the fishermen, i.e. the only important parts of the fish population from our point of view.

The total number of individuals of a given commercial fish, in a given body of water, is equal to the sum of a series of generations, the number of which equals the maximum age of this species with discount of those fish which were caught during this time.

The quantity which remains of each age group gives the catches of the following years, during which one generation after another will be destroyed. Therefore the number of fish in each body of water, where regular industry takes place, will be as follows.

$$n=C_n(1-y)+C_{n+1}(1-y-y_1)+C_{n+2}(1-y-y_1-y_2)\ldots\ldots C_{n+l-1}(1-y-y_1-y_2-\ldots y_{l-1})$$

where

Xn- number of individuals at the beginning of the nth year.

l - maximum age of fish.

Cn, Cn-i, etc - catches of following years.

y - percent of fry hatched in nth years.

y_1 - percent of individuals of one year old.

y_2 - percent of individuals of two year old.

y_3 - percent of individuals of three years old.

If we use this formula for estimating the whitefish population, in Lakes Winnipeg, Winnipegosis and Manitoba, it will consist of fourteen terms, if we take fourteen years at the period of whitefish life. The amount of older fish (somewhere about two percent) we do not take into consideration. On the other hand there are scarcely any fish less than three years old. Therefore the whitefish population in Lake Winnipeg will be as follows:

X= 100% C16 - 100% C17 - 100C18 - 98% C19 - 92% C20 - 72% C21 - 55% C22 - 39% C23 - 24%C24 - 13.4%C25 - 7.4% C26 - 5.4% C 27 - 3.4% C28 ==

6,000,000 (approximately)
(Average weight = 3,040 pounds)

Year	Catches in pounds	Numbers of individuals	% of Cn.
1916	1,300,000	433,000	433,000
1917	2,815,000	937,000	937,000
1918	3,052,000	1,000,000	1,000,000
1919	2,975,000	990,000	970,200
1920	3,000,000(?)	1,000,000	920,000
1921	3,143,000	1,000,000	720,000
1922	2,637,400	879,000	483,450
1923	1,626,400	562,000	219,180
1924	1,591,000	530,000	124,200
1925	2,559,000	853,000	114,300
1926	3,741,700	1,245,000	67,800
1927	2,826,000	942,000	50,870
1928	3,094,300	1,000,000	34,000

The total number of whitefish in lake Winnipeg in 1916 6,073,705.

X = 100%C16 - 100%C17 - 100C18 - 95%C19 - 85%C20 - 61%C21 - 45% C 22 - 35% C 23 - 28% C 24 - 22% C 25 - 16½% C26 - 11.5% C 27 - 8% C 28 =

1,922,000 (Approximately)

(Average weight 3,122 pounds)

Year	Catches in pounds	Number of individuals	% of Cr.
1916	288,000	96,000	96,000
1917	962,000	321,000	321,000
1918	1,000,000(?)	333.000	333,000
1919	1,240,400	410,000	339,500
1920	700,000 (?)	233.000	193.000
1921	941,100	314,000	191.500
1922	722,200	240,700	109,320
1923	639,000	333,000	81.550
1924	690,000	230,300	64.500
1925	621,500	207,200	45.700
1926	833,700	277,900	45.850
1927	718,700	239,600	27,550
1928	674,500	224,300	18,000

The total number of whitefish in lake Winnipegosis in 1916 1,921,500.

Taking the same formula as for Lake Winnipegosis, we obtain for Lake Manitoba a total number of whitefish of about half a million (400,000)

average weight - 3 pounds.

Year	Catches in pounds	Numbers of individuals	% of Cn.
1916	112.000	37.300	37.300
1917	262.000	87.300	87.300
1918	200.000(?)	36.600	86.600
1919	471.900	157.300	149.440
1920	100.000(?)	33,300	28.300
1921	74.700	24.800	13.130
1922	77.600	25.500	11.480
1923	78.000	26.000	9.100
1924	99.000	33.000	7.920
1925	117.000	39.000	8.580
1926	136.500	43.500	6.960
1927	189.400	69.130	6.950
1928	179.800	59.600	4.210

The total number of whitefish in Lake Manitoba in 1916 457.270

All these amounts represent a minimum number of whitefish in the three largest lakes of the Prairie Provinces.

Taking into consideration the circumstance that the catches, during the last four years are about the same as in the four years before 1916 but that the number of fishermen has increased, it seems evident that the whitefish population has decreased somewhat during this period. At the same time the industry is not in immediate danger.

SUMMARY AND GENERAL CONCLUSIONS.

1. The common whitefish (Coregonus clupeaformis) is not specifically distinct from the Siberian whitefish.

At the present time the Prairie Lakes are an important region for the propagation of whitefish. This species keeps principally to the northern, deeper portions of Lakes Winnipeg and Winnipegosis.

2. No considerable migration of whitefish takes place from one lake to another.

3. Whitefish in the first year are mostly plankton feeders, but from the second year they feed entirely on the bottom fauna. The food of the adult whitefish consists mostly of mollusks, insect larvae, and small Amphipoda.

4. The daily consumption of food by the whitefish is about 10 gm. per individual. The whitefish feeds chiefly at night.

5. The total amount of food supply in Lake Winnipeg is quite enough for 30,000,000 fish.

6. It is possible with the help of statistical methods, and with a knowledge of the age of the fish in the catches, to calculate the number of whitefish in the different Prairie Lakes.

During the last few years the number of whitefish in the lakes of the Prairie Provinces has kept at the same height, and is about:

6,000,000 in Lake Winnipeg.
2,000,000 in Lake Winnipegosis.
500,000 in Lake Manitoba.

7. The average weight of whitefish in the Prairie Lakes, at the present time is about 3 pounds.

Whitefish shoals in the Prairie Lakes, consist of equal numbers of makes and females. The average duration of whitefish life, in the Prairie Lakes, is ten years.

8. The whitefish can lay about 250,000 eggs during its life. With increase of weight the number of eggs increases, approximately 14,000 per each pound.

9. The percentage of fertilized eggs may fluctuate very considerably, depending on spawning conditions, and may reach 85%.

10. Fully ripe sperm can live 30 minutes. The average life in air is 6 minutes, in water 16 minutes, i.e. more than twice as long. This indicates that the "wet method" of fertilizing is preferable to the "dry" method, but the sperm should not be diluted so much as to impair the chances if reaching all the eggs.

11. A great many whitefish eggs are destroyed by whitefish themselves, and only the circumstance, that the whitefish returns at once to deeper water, after spawning, saves many fertilized eggs in nature. Eggs are also eaten by perch and tullibees.

12. The percentage of mortality of the fertilized eggs and fry, under natural conditions, is very great, somewhere about 99%.

13. The production of the Prairie Lakes can be increased very considerably by means of artificial fish culture, but only if the whitefish fry are cared for. Fry should be kept in special cages or enclosed areas and artificially fed for a period of one month at least.

14. If Lakes Winnipegosis and Manitoba have the same relative productivity as Lake Winnipeg, we can say that approximately 20,000,000 and 10,000,000 whitefish can live in those lakes respectively.

LITERATURE.

Adamstone, F.B. Bottom fauna of Lake Nipigon. (University of Toronto Studies). Publ. of the Ont. Fish Res. Lab. No.25. Toronto, 1924.

ajkov, A.D. A preliminary report on the fishes of the Hudson's Bay Drainage System. The Canadian Field Naturalist. Vol. XIII, April, Ottawa, 1928.

ajkov, A.D. A Qualitative and Quantitative study of Plankton of Jasper Park Lakes. (Contrib.. to Can. Biology and Fisheries.) (In press).

erg, L.S. Fisheries of Russia, Moscow, 1923.

irge, A. and Juday, Ch. The Inland Lakes of Wisconsin. The Plankton its **Quantity and Chemical** Composition. Madison, 1922.

arbonell, E. T. Fisheries of Manitoba. (Commission of Conservation Canada) 1911, Lands, Fisheries and Game. Minerals. p. 164-176. Ottawa, 1911.

emens, W. A., Dymond, J.R., and Bigelow, N.K. Food studies of Lake Nipigon Fishes. (University of Toronto Studies) Publ. of the Ont. Fish. Res. Lab. No. 25, Toronto, 1924.

emens, Wilbert A. The limnology of Lake Nipigon. (University of Toronto Studies). Publ. of the Ont. Fish Res. lab. No.11, pp. 1-31. Toronto, 1923.

emens, Wilbert A. The limnology of Lake Nipigon in 1923. ibid. No.22 Toronto, 1924.

eau, N.A. Report on the fisheries expedition to Hudson's Bay in the Auxiliary schooner "Burleigh" 1914. (Appendix to the annual report of the Dept. of the Naval Service.) Ottawa, 1915.

ch, J.H. The rate of growth of the whitefish (Coregonus albus) in Lake Erie. (University of Toronto Studies. Publ. of the Ont. Fish Res. Lab. No.7. Toronto, 1922.

rk, F.N. A plan for promoting the whitefish production of the Great Lakes. (Proceeding of the Fourth Internat. Fish Congress. Part I, p. 637) Washington, 1910.

~~gawin, A. N. The stellated sturgeon (Acipenser stellatus Pallas) a biological sketch. Bull. of Ichthyol. Lab. of Baku, 1922.~~ X

hing, S. W. A plan for promoting the whitefish production of the Great Lakes. (Proceeding of the Fourth Internat. Fish Congress, Part. I, p.627) Washington, 1910.

Dymond, John Richardson,
The Fisheries of Lake Nipigon. (University of Toronto Studies) Publ. of the Ont. Fish. Res. Lab. No. 27, Toronto, 1927.

Dymond, John Richardson, and J.L.Harte.
The fishes of Lake Abitibi (Ontario) and adjacent waters (University of Toronto Studies, Publ. of the Ont. Fish Res. Lab. N. 29. Toronto, 1927.

Evermann, B.W. and Goldsborough, E.L.
The Fishes of Alaska; Bul. U.S. Bureau of Fisheries, Vol. XXVI, 1906, Washington, 1907.

Evermann, B.W. and Latimer, H.B.
The Fishes of the Lake of the Woods and connecting waters. Proceeding U.S. Nat. Mus. Vol. 39, Washington 1910.

Forbes, S.A.
The food of young whitefish - Coregonus clupeiformis. Bull. U.S. Fish Commission, Vol. I, 1881, p. 19-20. Washington, 1881.

Forbes, S.A
The First Food of the common Whitefish (Coregonus clupeiformis). Bull. No. 6, IV, Illinois State Lab. of Nat. Hist., Peoria, Illinois, 1883.

Forbes, S.A. and Richardson, R.E.
The Fishes of Illinois, Vol. III. Natural History Survey of Illinois. State Laboratory of National History, Danville, 1808.

Hankinson, T.L.
Young Whitefish in Lake Superior, (Science, N.S. Vol. XI, No. 1024, p. 239 - 240.)

Hubbs, C. L.
A check list of the fishes of the Great Lakes and tributary waters, with nomenclatorial notes and analytical keys. University of Michigan, Museum of Zoology, Miscellaneous Publ. No. 15. Ann Arbor, 1926.

Isatschenko, W. L.
Eine neue Art der Gattung Coregonus aus dem Stromgebiete des Jenissei. (Arbeiten des Sibeirischen ichtyologischen Laboratorium, Bank II, Keft 2,) Krasnojarsk, 1925.

Jordan, D.S. and Evermann, B.W.
The Fishes of North and middle America. Bul. U.S. Nat. Mus. No. 47, Washington, 1896 - 1900.

Jordan D. S. and Evermann, B. W.
American Food and some game fishes. New York 1902.

Jordan, D. S. and Evermann, B.W.

Descriptions of the new species of cisco, or lake hering (Argyrosomus), from the Great Lakes of America with a note on the species of whitefish. Proceedings U.S.Nat. Mus. Vol. XXXVI, Washington, 1909.

Jordan, D. S. and Snyder, J.O.

Description of a new whitefish (Coregonus oregonensis) from the McKenzie River, Oregon. Proceedings U.S. Nat. Mus. Vol. XXXVI, Washington, 1909.

Jordan, D.S. and Evermann, B. W.

A review of the Salmonsid Fishes of the Great Lakes with notes on the whitefishes of other regions. Bull. U.S. Bureau of Fish. Vol. XXIX, Doc. 737. Washington 1911.

Kendall, W. C.

The Rangeley Lakes, Me., with special reference to the habits of the fishes, fish culture and angling. Bull. U.S. Bureau of Fisheries, Vol. XXXV, Washington 1918.

Koelr, W.

Fishing industry of the Great Lakes, Appendix XI. Report U.S. Commissioner of Fisheries for 1925 (26), Bureau of Fisheries Document No. 1001, Washington, 1926.

Koelr, W.

Coregonid fishes of the Great Lakes. Bull. U.S. Bureau of Fisheries, Vol. XLIII, 1927, Part II, Doc. No. 1048, Washington, 1929.

Leach, G.C.

Artificial propagation of whitefish, grayling and lake trout. Appendix III to the report of the U.S. Commissioner of Fisheries for 1923, Washington, 1923.

Lowe, C.W.

The Freshwater Algae of Central Canada. Transaction of the Royal Society of Canada, Vol. XVIII, Ottawa 1924.

Mellen, Ida M.

The whitefishes (Coregonus clupeaformis) reared in the New York Aquarium. Zoologica, Vol. II, No. 17, New York, 1923.

[illegible] A.

A biological investigation of the Athabaska - Macdonald region. (Fishes). North American Fauna No 27, U. S. Dept. of Agriculture, Washington, 1908.

Reighard, R.

A plan for promoting the whitefish production of the Great Lakes. (Proceeding of the fourth Internat. Fish. Congress, Part I, p. 643.

Richardson, J.

Fauna Boreali - Americana, III. The Fish, London. 1836.

Skaptason, J.B.

The Fish Resources of Manitoba (Industrial Development B.ard of Manitoba.) Winnipeg, 1926.

Tchugunov, N.L.

Essay on the quantitative exploration of the benthos-production in the north part of the Caspian Sea. Report of the Ichthyol. Lab. in Astrachan, Vol. V, No. 1. Astrachan, 1923.

Van Oosten, J.

The whitefishes (Coregonus clupeaformis). A study of the scales of whitefishes of known ages. Zoologica, Vol. II, No. 17, New York, 1923.

Van Oosten, J.

Life History of the Lake Herring (Leucichthys artedi Le Sueur) of Lake Huron as revealed by its scales, with a critique of the scale method. Bull. U.S. Bureau of Fisheries, Vol. XLIV, pp. 263-428, Washington, 1929.