A LIMNOLOGICAL STUDY OF TESLIN LAKE CANADA

by

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PREFACE

Dr. W.A. Clemens, who passed away in 1964 at the age of 77, had a close and fruitful association with Provincial fishery agencies during his long career in British Columbia as Director of the Biological Station at Nanaimo (1924-1940) and as Head of the Department of Zoology at the University of British Columbia (1940-1953). With his broad background and kindly manner, he provided much valuable counsel in both administration and technical matters.

In spite of his heavy administrative and teaching loads, Dr. Clemens, throughout his life managed to pursue independent investigations and research. In 1944, Mr. George J. Alexander, then Provincial Deputy Minister of Fisheries persuaded Dr. Clemens to make a survey of the commercial fishery possibilities of Teslin Lake in northern British Columbia. This survey was carried out by Dr. Clemens during the summer of 1944 with the aid of two field assistants who are the junior authors of the present paper. A preliminary report of the survey was published in the annual report of the Provincial Fisheries Department for 1944.

Subsequent completion of a final paper suffered many vissicitudes and delays because of the pressure of other work and the separation of the authors. Mr. Rattenbury left British Columbia and Dr. Boughton four years ago completed the manuscript and shortly afterwards passed away. The present paper received minor editing by senior members of the Fisheries Division but extensive revisions seemed inappropriate and thus some inconsistencies remain. Appendices containing detailed information on fish specimens collected are not included but are on file in the library of the Institute of Fisheries, University of British Columbia.

E.H. Vernon
April, 1968

ABSTRACT

In July and August, 1944, a limnological study was made of Teslin Lake which lies across the British Columbia - Yukon boundary line. The lake is 78 miles long and 2 miles wide on the average. The greatest depth obtained was 702 feet. It is evidently a lake with limited productiveness because of a short growing season and a large volume of cold water in the hypolimnion; probably a great run off from an extensive watershed may be a contributing factor. The summer heat budget in 1944 was 20,000 cal. $cm.^{-2}$. Plankton and bottom organisms are limited in species and quantity. Thirteen species of fish occur in the lake of which the lake whitefish, *Coregonus clupeaformis* and the broad whitefish *C. nasus* might be used commercially in a small fishery of 40,000 to 50,000 pounds annually. The lake trout, *Salvelinus namaycush* is fairly abundant but its use should be restricted for sport fishing.

INTRODUCTION

At the request of Mr. G.J. Alexander, Deputy-Minister of the Fisheries Department of British Columbia, Victoria, B.C., the authors carried out a limnological study of Teslin Lake, from July 9 to August 27, 1944, with the particular objective of investigating its fish resources. The Fisheries Department had received an application for a commercial licence to fish in the lake but the Deputy-Minister wished to have some information on the species of fish, their abundance and the general limnological conditions in the lake. The authors were engaged to carry out the survey and submitted a preliminary report which was published in 1945 (Clemens, Boughton and Rattenbury). For various reasons the final report was not completed until now.

ACKNOWLEDGEMENTS

In the course of the work much help was given by various persons, particularly Mr. G.J. Alexander, Mr. and Mrs. R. McCleery, Dr. P.A. Larkin, Dr. C.C. Lindsey, Dr. John Oughton, Dr. J. Van Oosten, Dr. W.A. Fuller, Dr. T.G. Northcote, Dr. Mildred S. Wilson and the Canadian Department of Transport.

PHYSICO-CHEMICAL CONDITIONS

Morphometry

Teslin Lake lies across the British Columbia - Yukon boundary line. It extends from 59° 30' to 60° 30' north latitude and from 132° 00' to 133° 30' west longitude. It is 78 mi.(125 km) long, averages 2 mi. (3.2 km) wide and is situated at an elevation of 2270 ft. The Alaska Highway crosses an arm of the lake, Nisutlin Bay, at the settlement of Teslin and then follows the lake shore to the north end of the lake. The drainage area, which forms part of the Yukon River drainage system is extensive, in excess of 11,000 sq. mi. (Fig. 1), and consists of gently sloping hills and mountains partly covered by small trees with pockets of denser growth at the lower levels.

Headquarters were made at the village of Teslin, Yukon Territory, about mid-length of the lake. In order to carry out the survey effectively 28 transit lines were established so that exact locations were indicated and repetitions could be made at approximately the same points at any time in the future. For purposes of record and discussion the lake was divided into four areas: N - northern portion of the lake; S - southern; M - middle; C - Nisutlin Bay. As transits were established each was assigned a code number. Thus, M2 represents the second transit line in the middle section of the lake, and M2D represents the fourth station on this transit line from the east side of the lake.

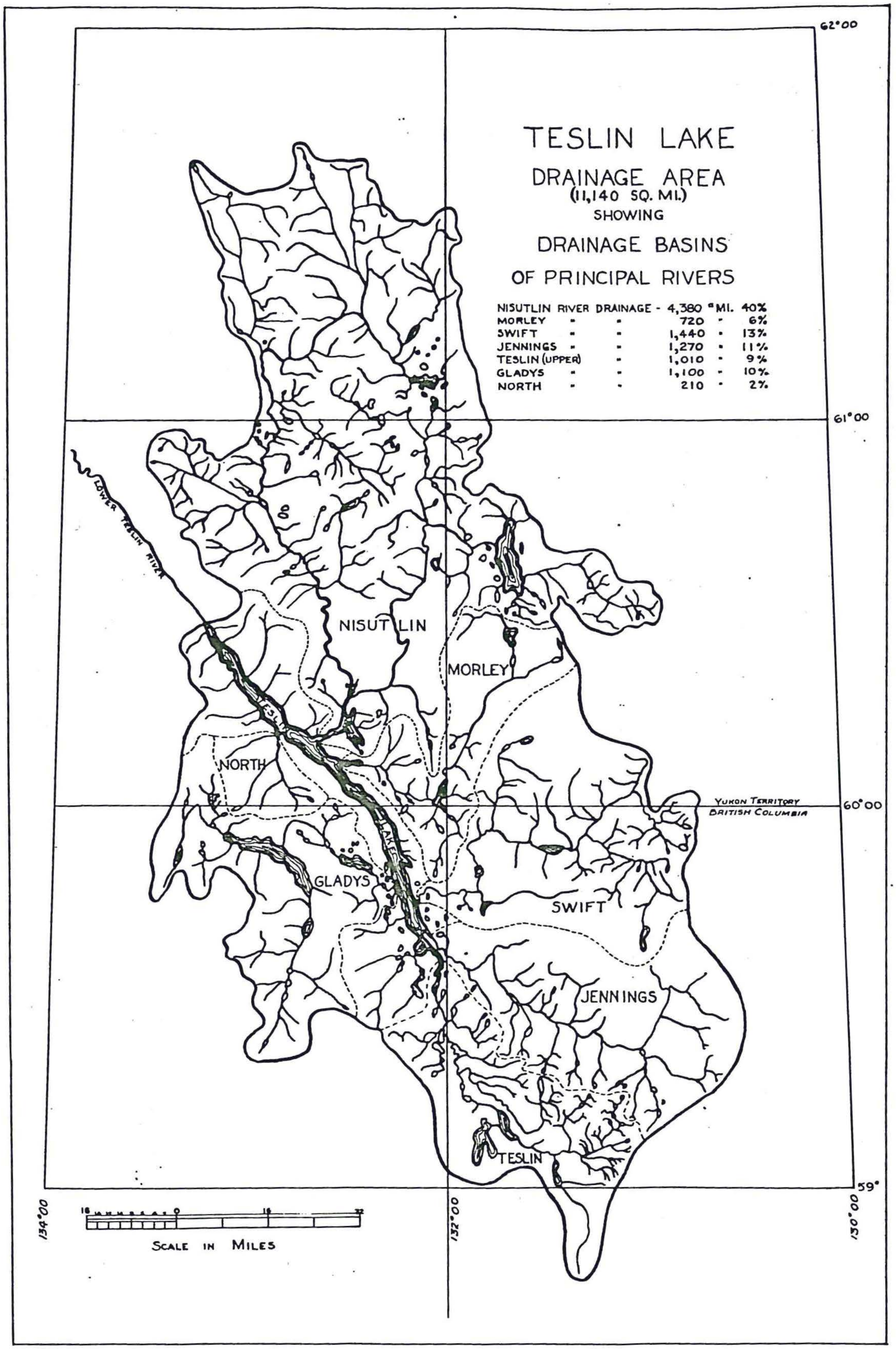

Fig. 1. Teslin Lake drainage area.

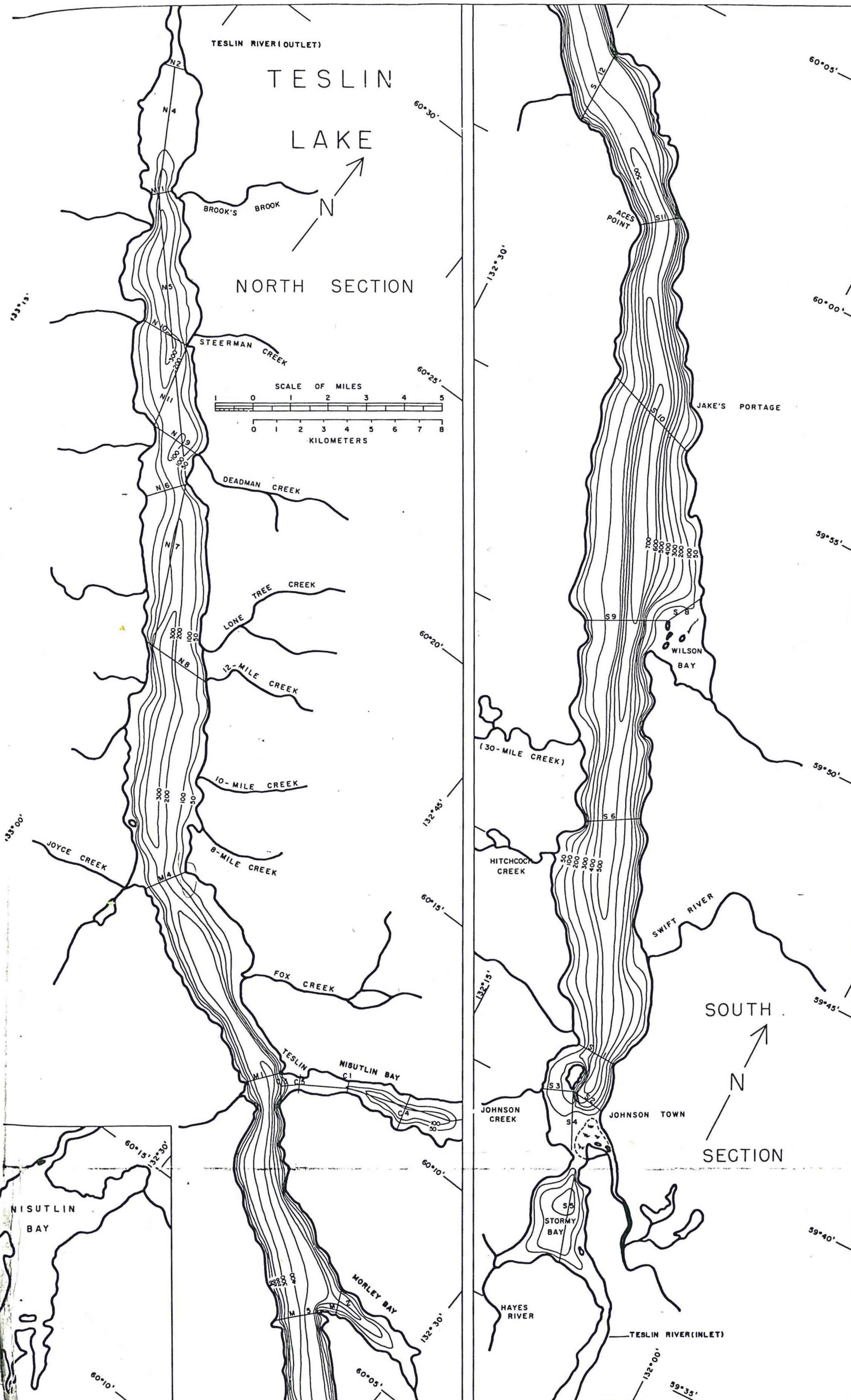

Fig. 2. Teslin Lake showing the location of the transit lines and the approximate depth contours as established.

To determine the approximate contour lines of the lake bottom 177 soundings were made along the 28 transits (Fig. 2). The northern end of the lake, where the maximum depth is 360 ft. (110 m) at station N1OD, is much shallower than the southern portion where a maximum depth of 702 ft. (214 m) was obtained at station S9C. Relatively shallow depths are present at the extreme south and north ends of the lake. A longitudinal section of the lake from north to south is shown in Fig. 3. The average depth of the lake is 194 ft. (59 m).

The approximate surface and bottom areas and volume of the lake are summarized in Tables I and II.

Volumes of the epilimnion, mesolimnion and hypolimnion were determined on the basis of the average depths of their boundaries as shown in Fig. 4. The extent and the position of the mesolimnion were so variable both with time and location that estimates of volume for the three regions cannot be very accurate.

Meteorology

The Meteorology Branch of the Federal Department of Transport kindly provided the data from September 1, 1943 to August 31, 1944, shown in Table III. From September, 1943, to September, 1944, above freezing temperatures occurred in every month with a maximum in July of 83.4°F. Below zero °F temperatures occurred during five months of the year with a minimum of minus 23.6°F in February. Below freezing temperatures occurred in every month but July. The total snowfall was

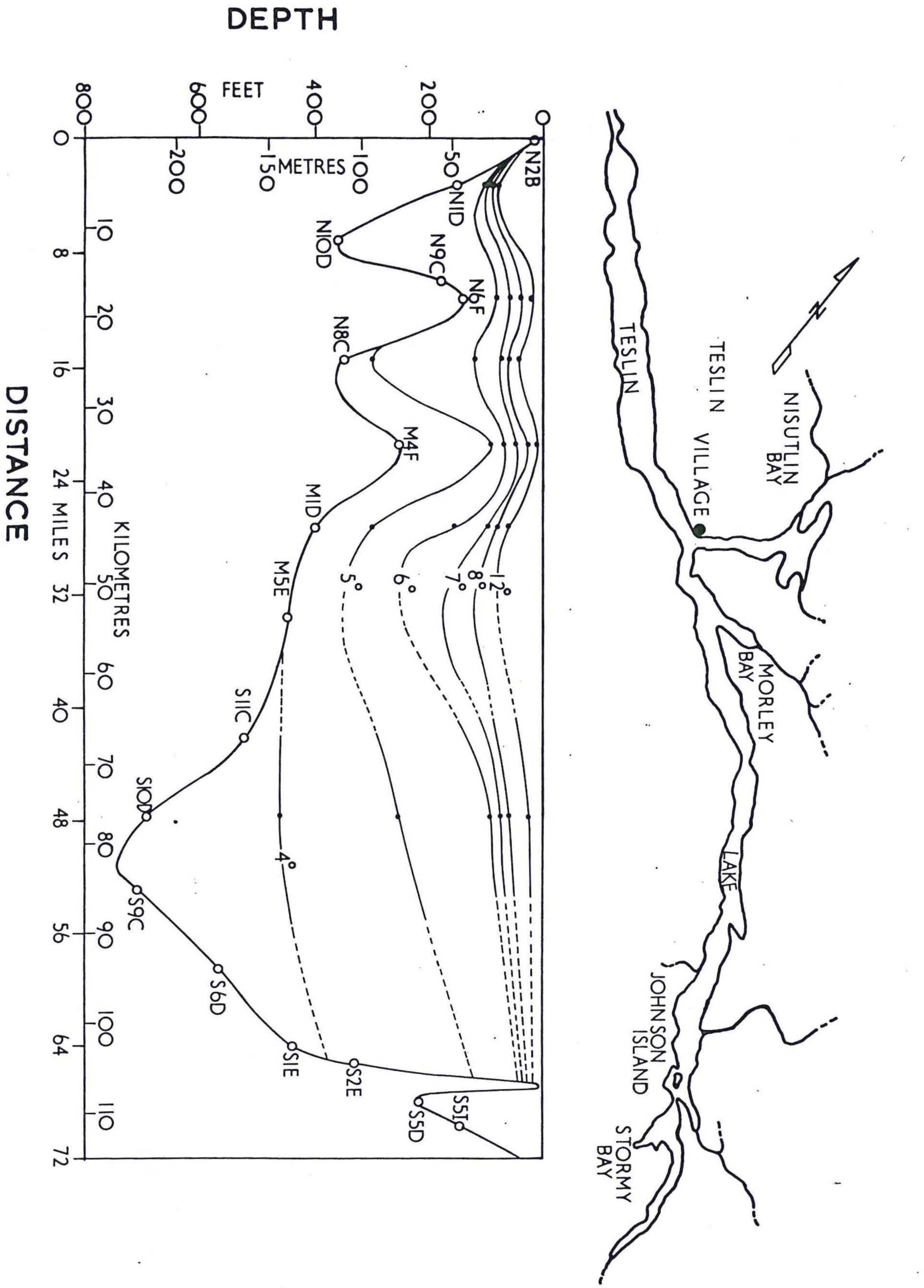

Fig. 3. Longitudinal section of Teslin Lake showing the depths and isotherms present in July and August, 1944.

TABLE I. Calculated surface and bottom areas of Teslin Lake.

	Square feet	Square miles	Square meters
Lake Surface	3820×10^6	137	354×10^6
Lake Bottom	3850×10^6	138	358×10^6
Bottom 0 to 10 ft.	223×10^6	8	21×10^6
Bottom 10 to 50 ft.	976×10^6	35	90×10^6
Bottom 50 to 700 ft.	2651×10^6	95	247×10^6

TABLE II. Calculated volumes of water in Teslin Lake.

	Cu.ft.	Cu.m.
Lake	7346×10^8	208×10^8
Epilimnion (0 to 18 ft.)	1506×10^8	43×10^8
Mesolimnion (18 to 24 ft.)	286×10^8	8×10^8
Hypolimnion (24 to 702 ft.)	5554×10^8	157×10^8

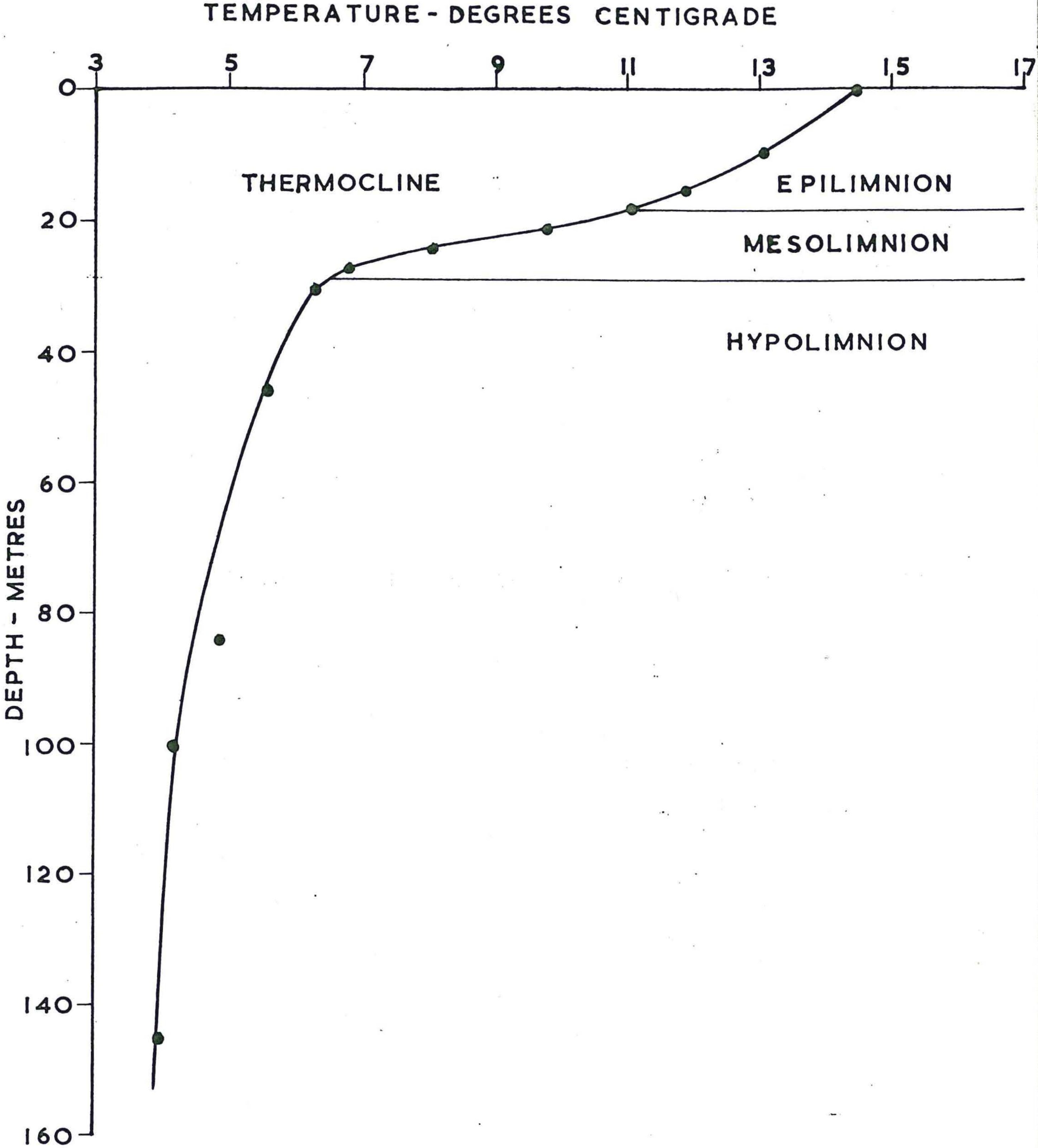

Fig. 4. Composite temperature curve for Teslin Lake, based on average values obtained during July and August 1944.

TABLE III. Meteorological data, Teslin Village, September 1, 1943 to August 31, 1944. Elevation 2270 feet. (Data supplied by Meteorological Office)

	S.	O.	N.	D.	J.	F.	M.	A.	M.	J.	J.	A.	Total
Max. Mo. Temp. (°F)	70.5	58.6	43.8	45.2	38.2	36.8	45.0	53.7	69.2	83.4	80.0	75.0	
Min. Mo. Temp. (°F)	27.3	7.6	9.1	-3.5	-10.0	-23.6	-18.5	-15.9	22.0	29.3	35.2	31.0	
Mean Max. Temp. (°F)	51.9	42.4	33.0	31.3	23.5	22.4	30.2	42.8	56.2	66.6	70.2	63.0	
Mean Min. Temp. (°F)	41.7	26.5	21.4	18.5	8.3	3.3	10.1	21.5	32.1	42.0	46.3	42.9	
Mean Mo. Temp. (°F)	46.8	39.7	27.3	25.0	16.1	16.8	20.7	32.3	45.0	54.3	58.7	52.9	
Total Precip. (in.)	2.2	1.46	0.88	1.63	0.72	0.45	1.16	0.31	1.12	1.30	0.68	1.90	13.61
Total Rainfall (in.)	2.2	0.81	0.04	0.02	-	-	0.24	0.05	1.09	1.30	0.68	1.90	7.53
No. Days Rain	15	6	3	3	-	-	1	5	14	19	12	17	95.0
Total Snowfall (in.)	-	6.5	8.4	16.1	7.2	4.5	9.2	2.6	0.3	-	-	-	54.8
No. Days Snow	-	6	15	16	18	16	16	9	3	-	-	-	99.0
Heaviest fall rain in 24 hr. (in.)	0.43	0.58	0.05	0.02	-	-	0.24	0.04	0.41	0.45	0.17	.47	
Heaviest fall snow in 24 hr. (in.)	-	2.2	3.7	6.0	1.8	0.8	5.5	1.3	0.3				

54.8 in. and the total precipitation for the area was 13.61 in.

Temperature

Temperature readings at various stations in the lake were taken by means of two Negretti and Zambra deep-sea reversing thermometers graduated to fifths of a degree centigrade and used in duplicate. Readings were made to the nearest tenth of a degree and corrections made from a Negretti-Zambra graph. The recorded temperature was the average of the two corrected thermometer readings.

Vertical temperature recordings were made at nine stations in the lake and at four of these, observations were repeated one or more times at later dates. A representative set of records is presented in Table IV. Fig. 3 shows the approximate distribution of the isotherms for the summer period. The maximum surface temperature recorded was 19.1°C at Station C1C on July 11 in Nisutlin Bay (Table IV). Meteorological data indicate that this was a period of high air temperatures with the maximum temperature for the month also occurring on July 11. The maximum surface temperature obtained in the main body of the lake was 16.8°C on August 5 at Station M1C directly off the mouth of Nisutlin Bay. The minimum surface temperature during the investigation was 12.8°C on August 18 at Station M4F and the minimum bottom temperature was 3.99°C on August 12 at Station S10D at a depth of 475 ft. Surface and near surface temperatures were continually being affected by the presence or absence of winds. For example, on July 15, the surface temperature varied from 14.1°C in the morning to 16.6°C in the afternoon at Station M1D.

Surface water temperatures of Atlin Lake, fifty mi. to the west, appear to be considerably below those of Teslin Lake. Withler (1956) found that in July, 1955, surface water temperatures ranged from 11.1°C to 5.5°C.

Sub-surface temperatures changed considerably with the force of the wind. Such short term changes in temperature may have been caused by the direct circulation of the water by wind currents or the development of seiches. Data do not appear to support the seiche theory (Table IV). A comparison of temperatures at station M1D on July 15 indicates that within a five-hour period warm surface water was distributed to a considerable depth. This circulation produced marked changes in water temperatures down to a depth of about 100 ft. Further, a comparison of vertical temperatures at station M1D on August 18 and 26 shows that temperatures at a depth of 100 ft. had risen 4.4°C while surface temperatures had dropped 1.2°C.

Temperature curves are shown in Fig. 5 for four stations on the lake and in Fig. 6 for two stations on transit M1 on four different dates. It would appear that the variation along transit M1 was greater than for the lake as a whole and this may be attributed in part to the influence of Nisutlin Bay drainage which represents 40% of that for the whole lake (see Fig. 1). A curve was constructed (Fig. 4) to represent

TABLE IV. Temperature, oxygen and hydrogen ion concentration of water from Teslin Lake for July and August, 1944.

		July 11 CIC			July 15, a.m. MID	July 15, p.m. MID			July 17 CIC			July 23 NIC	July 25 NIC	July 26 N8C
Depth ft.	Depth m.	Temp. °C	O_2	pH	Temp. °C	Temp. °C	O_2	pH	Temp. °C	O_2	pH	Temp. °C	Temp. °C	Temp. °C
0	0	19.1	96	7.9	14.1	16.6	92	8.0	16.3	86	8.0	14.9	14.5	15.2
5	1.52				14.1									
10	3.05				14.1				15.7	92	8.0			
15	4.57				14.1									
20	6.10				13.8				15.5	85	8.0			
25	7.62				13.6									
30	9.15	16.2	88	7.7	13.5				15.5	85	8.0			14.1
35	10.67				13.1									
40	12.20				13.1				12.7	85	7.9			
50	15.25	12.5	78	7.7	13.0				12.4	80	7.7	14.5		
60	18.30				12.8									12.9
65	19.82				11.6									
70	21.35				11.1									8.4
75	22.87											14.5		
80	24.40				9.2	8.3	88	7.5				14.4	13.0	7.0
85	25.92				9.0	6.9	87	7.5				11.3		
90	27.45				7.0	6.6	88	7.5				7.0		6.7
100	30.50				6.5							5.8	6.1	6.4
150	45.75													
200	61.00													
275	83.87													
300	91.50				5.6	5.0	86	7.5						
330	100.65													

TABLE IV. (Contd.)

		July 28 N6F			July 31 MIC	Aug. 5 MIC			Aug. 12 SIOD	Aug. 18 M4F	Aug. 18 Fox Pt.	Aug. 18 MID	Aug. 26 MID		
Depth ft.	Depth m.	Temp. °C	O_2	pH	Temp. °C	Temp. °C	O_2	pH	Temp. °C	Temp. °C	Temp. °C	Temp. °C	Temp. °C	O_2	pH
0	0	14.0	89	7.9	13.9	16.8	95	8.1	13.0	12.8	14.1	14.3	13.1	93	8.0
5	1.52														
10	3.05														
15	4.57														
20	6.10														
25	7.62														
30	9.15				13.4	13.1			12.2				12.1		
35	10.67														
40	12.20	9.9	88	7.7											
50	15.25				11.0	11.8			11.5	6.9	6.7	8.8	12.0		
60	18.30	7.0	87	7.6	9.7	8.8	87	7.6					12.0	87	7.9
65	19.82								8.5						
70	21.35														
75	22.87				7.0				7.5				11.7		
80	24.40														
85	25.92				6.1				6.8				11.6		
90	27.45														
100	30.50	5.6	86	7.6	5.0	7.2	88	7.6	5.7	5.1	5.0	5.4	9.8	90	7.7
150	45.75														
200	61.00														
275	83.87					4.9	87	7.6					4.8		
300	91.50														
330	100.65				4.2										

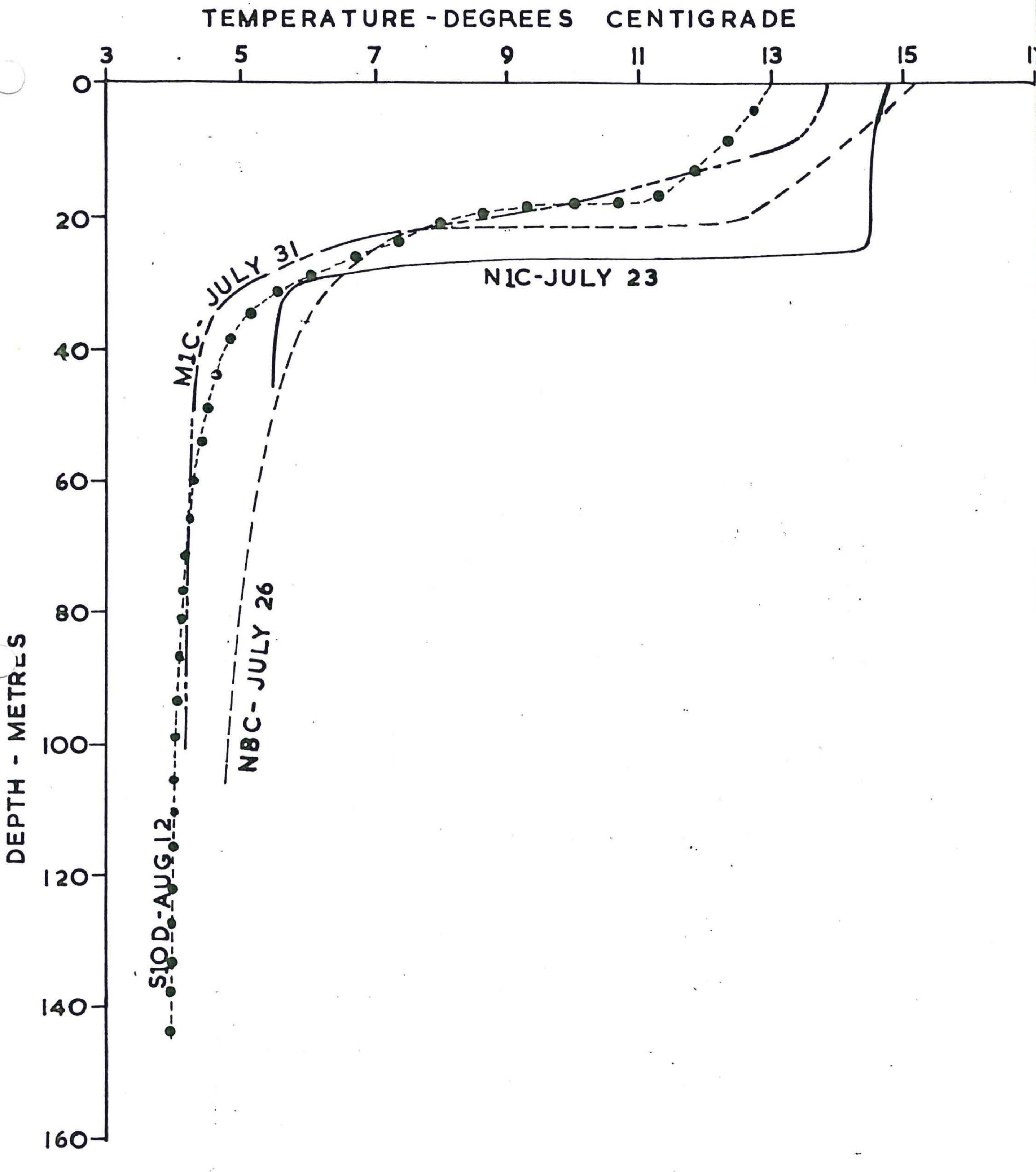

Fig. 5. Temperature curves for four stations on Teslin Lake during mid-summer, 1944.

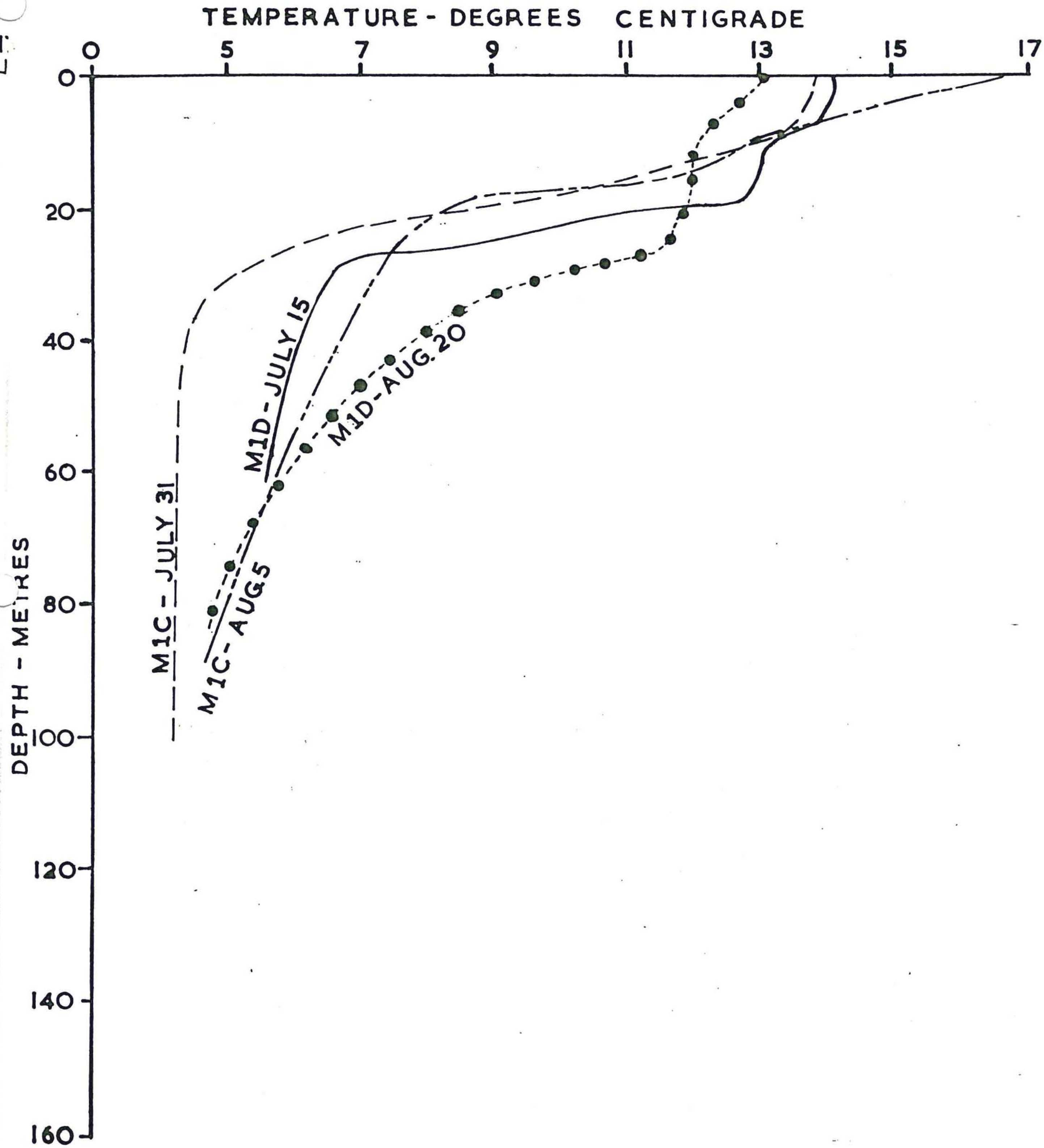

Fig. 6. Temperature curves for two stations, on Teslin Lake, at transit M1 on four dates, 1944.

the average temperatures of the lake as a whole at the height of the summer season and this was used in calculating the extent of the mesolimnion (see above) and the heat budget (see below).

The data did not provide any clear-cut evidence of a thermocline as defined by Birge (1904) as the temperature gradient only once exceeded $1C^{o}.m^{-1}$. Absence of a true thermocline may be attributed to the vertical distribution of water by winds and currents. However, there was a marked transition between the epilimnion and hypolimnion which may be referred to as the mesolimnion. The boundaries of this mesolimnion were determined, according to Hutchinson (1957), as the two points of maximum curvature of the S-shaped temperature curve (Fig. 4). The thermal properties suggest that Lake Teslin is a dimictic, first-class lake; that is, the water circulates twice a year and the lake takes up all heat climatically possible from its environment.

Heat Budget

In the determination of the summer heat budget, certain assumptions and approximations had to be made, especially as water temperature varied considerably with time and weather conditions. It was necessary to calculate areas of the lake at different depths, which was done by plotting areas obtained from the contours on the map (by means of a planimeter) against depth. Average typical values at different depths were selected from Table V and the resulting curve in Fig. 7 was used for estimating temperatures at various depths. Where several readings

TABLE V. Data for calculation of summer heat budget, Teslin Lake

Depth (z) ft.	cm.	Area (A_z) sq.mi.	sq.km.	Summer Temp. (O_{sz})	$O_{sz}-4$	$A_z(O_{sz}-4)$
0	0	137	355	14.5	10.5	3730
10	305	119	308	14.1 e	10.1	3110
20	610	109	283	13.8 e	9.8	2770
30	915	103	267	13.1	9.1	2430
40	1219	98	254	12.6	8.6	2180
50	1524	94	244	11.9	7.9	1930
60	1828	90	233	11.2	7.2	1680
70	2133	86	223	9.8	5.8	1290
80	2438	82	212	8.1	4.1	870
90	2743	79	205	6.9	2.9	595
100	3048	77	199	6.0	2.0	398
150	4572	64	166	5.6	1.6	266
200	6096	54	129	5.3 e	1.3	168
300	9144	37	96	4.8 e	.8	77
400	12,192	20	52	4.3 e	.3	15
500	15,240	10	26	4.0 e	0	0
600	18,288	5	13	4.0 e	0	0
700	21,336	2	5	4.0 e	0	0

e = estimated from composite temperature curve (Fig. 4).

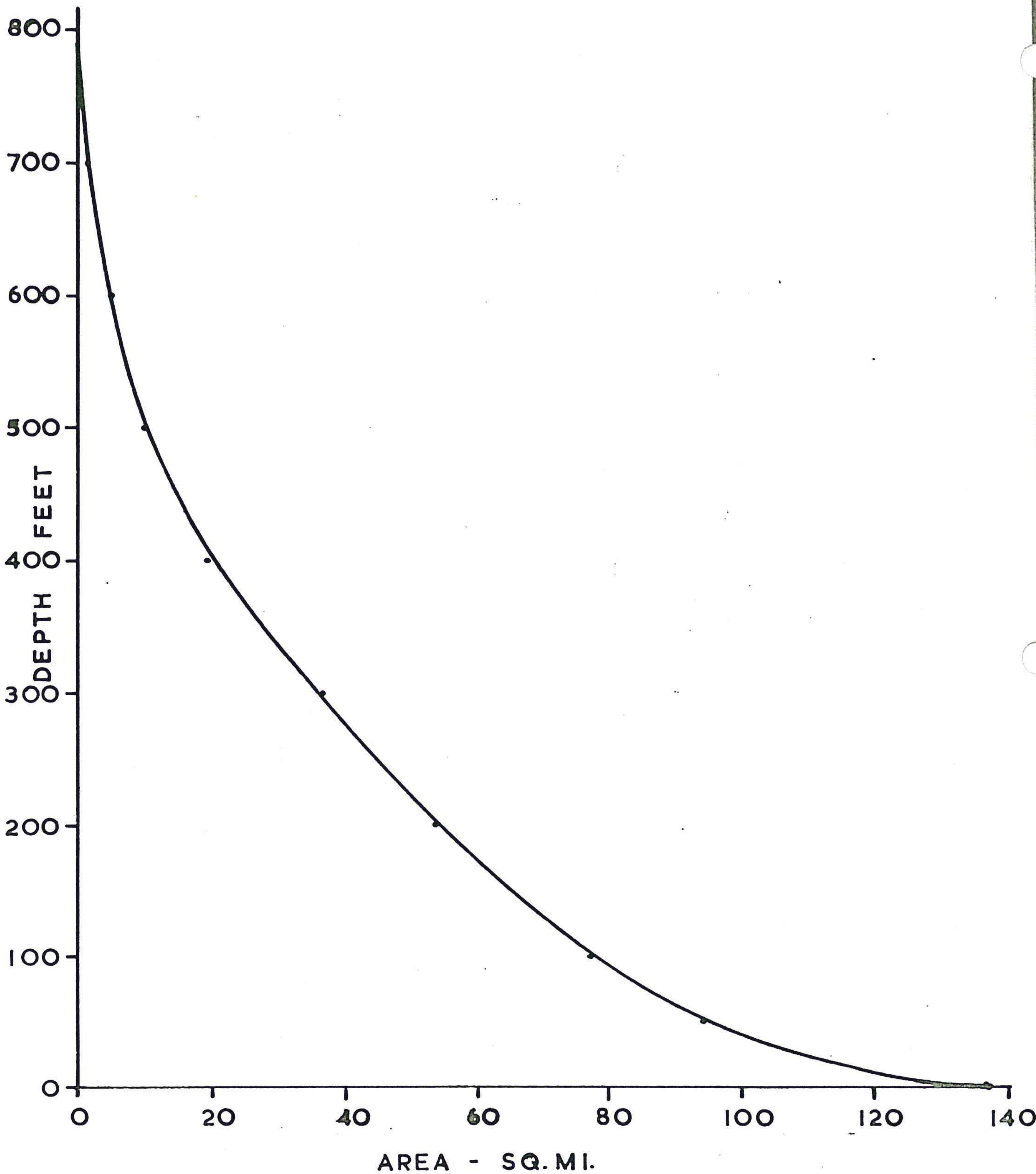

Fig. 7. Relation of area with depth, Teslin Lake, 1944.

at different times and stations were substantially in agreement for a given depth, exceptionally high or low values were excluded in determining the average value, as being the result of turbulence and mixing effects of wind action.

The method of determining the summer heat budget (H)bs was that described in Hutchinson (1957) and amounted to 20,000 cal. cm.$^{-2}$. In the absence of any water temperatures for the winter minimum period, no attempt has been made to estimate the winter heat budget. The heat budget calculations conform very well with those for other lakes of this class, size and latitude (Hutchinson, 1957).

Oxygen

The oxygen content of the water was determined by the Winkler method and the results, given in Table IV, are in per cent saturation and are not adjusted to sea level. In only one instance was the saturation below 80 per cent and this was on July 11 in Nisutlin Bay where the per cent saturation was 78. Insufficient data precluded the possibility of obtaining an accurate picture of oxygen content of the water with depth. There is a slight decrease in oxygen content with depth, which is probably due to uptake by organisms. An excess over surface oxygen content at about 3 m. on July 17 (Table IV) may have been the result of photosynthetic activity at this depth (in
140 the shallow waters of Nisutlin Bay) or of turbulence arising from wind action or river current.

Hydrogen-ion Concentration

The hydrogen-ion concentration was obtained by the use of a Taylor slide comparator. The results showed a range from 7.5 to 8.1. The surface waters ranged from 7.9 to 8.1 while the deep waters of 275 and 300 ft. were at 7.6 and 7.5 respectively.

The decrease in pH with depth is in accordance with the clinograde nature of the lake. The pH range recorded (7.5 to 8.1) conforms to that of most open lakes which vary from 6 to 9. The water of Teslin Lake is therefore slightly alkaline (Table IV).

BIOLOGICAL CONDITIONS

Plankton

To obtain some knowledge of the lake's standing crop in terms of plankton organisms, 27 series of vertical hauls were taken with a closing Wisconsin type plankton net of No. 20 bolting silk with an upper opening nine inches in diameter. The samples were obtained by taking either partial or total vertical hauls at various locations throughout the lake. The organisms secured were preserved in weak formalin or in B.C. preservative (water 20, acetic acid 2, formalin 5, methyl alcohol 73 per cent). The plankton was allowed to settle for 24 hrs. and the volumes measured in cubic centimeters (Table VI). To make comparisons between stations easier, calculations were made of the average volume of plankton in a ten-foot stratum in each vertical haul (Table VII).

TABLE VI. Summary of plankton hauls, Teslin Lake.

Date 1944	Transit	Depth in ft.	Settled Volume in cc.
July 17	C4	0- 10	0.8
		0- 24	0.7
		0- 43	0.6
		0- 50	0.4
July 19	M1	0- 30	0.3
		30- 70	0.3
		70-100	0.3
		100-200	0.2
		200-400	0.15
July 25	S10	0-143	0.5
		0- 80	1.2
		80-100	0.2
		100-143	0.1
July 27	N9	0-160	0.9
		0-184	1.5
	N8	0- 30	0.5
		30- 70	1.0
		70-295	1.4
July 31	2 mi. S of M1	0- 30	0.3
		30-100	0.2
		100-330	0.15
Aug. 4	M1	0- 50	0.7
		50-100	0.4
		100-270	0.4
Aug. 8	S5	0-200	0.9
Aug. 10	S2	0-300A	4.5
		0-300B	0.7
Aug. 11	S9	0-350A	1.3
		0-350B	0.55
		350-650	0.4
Aug. 12	S11	0-100	0.5
		100-175	0.2
Aug. 18	M4	0-100(slow haul)	0.4
		0-100(fast haul)	0.5
		0-250(slow haul)	0.8
		0-250(fast haul)	0.8
		100-250	0.8
Aug. 26	M1	0-100A	0.5
		0-100B	1.5
		0-100	0.6
		0-300	0.6
		0-300	0.9

TABLE VII. Average settled volume of plankton in ten-foot hauls, Teslin Lake.

Depth ft.	Average volume 10 ft. haul	Depth ft.	Average volume 10 ft. haul	Depth ft.	Average volume 10 ft. haul
0- 10	0.8	0-184	0.08	70-295	0.062
0- 24	0.3	0-200	0.045	80-100	0.1
0- 30	0.12	0-250	0.032	100-143	0.032
0- 43	0.16	0-300	0.056	100-200	0.02
0- 50	0.11	0-350	0.026	100-250	0.02
0- 80	0.15	30- 70	0.16	100-330	0.006
0-100	0.06	30-100	0.03	100-475	0.005
0-143	0.035	50-100	0.08	150-270	0.024
0-160	0.08	70-100	0.1	200-400	0.005
				350-650	0.013

Some of the plankton organisms are listed below:

Class Myxophyceae:	Anabaena, Aphanizomenon, Nostoc, Oscillatoria
Class Chlorophyceae:	Closterium, Dictyosphaerium, Desmidium, Pediastrum, Rhizoclonium, Staurastrum
Class Chrysophyceae:	Dinobryon
Class Bacillariophyceae:	Asterionella, Cymbella, Diatoma Fragillaria, Melosira, Rhopalodia Stephanodiscus, Tabellaria
Class Dinophyceae:	Ceratium
Phylum Rotifera:	Anuraea, Kellicottia, Keratella, Notholca
Phylum Arthropoda:	Bosmina longirostris, Chydorus sphaericus, Cyclops columbiana, Diaptomus pribilofensis, D. sicilis, Hetercope septentrionalis, nauplii, water mites, midge larvae and pupae.

The plankton appeared somewhat poorly preserved and in all probability other forms than those recorded above were present. However, certain facts are apparent;

1) the volume of plankton in any one haul was small. This may be associated in part with the large run-off from the lake. While an accurate measurement was not made, it is estimated that the drop in lake level from July 9 to August 24 was

between three and four ft. The outflow, based on an average drop of four ft., would be approximately 3500 cu. ft. per second or a total for the period of 15,000 million cu. ft. in excess of the intake of the lake from rivers which drain into it. The movement of water and therefore the passage of plankton from the lake is probably affected by winds. Southerly winds would facilitate the movement of surface plankton from the lake whereas northerly winds would facilitate the exit of deeper plankton;

2) that the plankton is limited in quality is illustrated by the crustacean fauna. Only two small species of Cladocera were observed - Bosmina longirostris and Chydorus sphaericus. No species of Daphnia was present. Only four species of Copepoda were taken - Cyclops columbiana, Diaptomus pribilofensis, D. sicilis and Heterocope septentrionalis;

3) the plankton occurs in greatest abundance in the upper 100 ft. of the lake as shown in Table VIII. The average volume in the hauls between 0-100 ft. is 0.86 cc., while that between 100-400 ft. is 0.45 cc.

Although the lake contains only one species of fish which is a plankton feeder throughout life, namely Coregonus sardinella, the young of most species subsist for some time on plankton, especially in bays and along the shoreline where the water is relatively shallow. Further, when plankton organisms die, they settle and those which reach the bottom contribute to the organic material of the bottom ooze and so indirectly contribute

TABLE VIII. Commmparison of the total volumes of eight series of vertical plankton hauls, Teslin Lake, 1944.

Station and Date	Depth in ft.	Volume in cc
M1 July 9	0-100 100-400	0.9 0.35
S10 July 15	0-100 100-143	1.4 0.1
N2 July 27	0-70 70-295	1.5 1.4
M1 July 31	0-100 100-330	0.5 0.15
M1 August 4	0-100 100-270	1.1 0.4
S11 August 12	0-100 100-175	0.5 0.2
M4 August 18	0-100 100-250	0.45 0.80
M1 August 26	0-100 100-300	0.55 0.20
Average	0-100 100-400	0.86 0.45

to the food of the whitefishes and the sucker. In these ways plankton contributes to the productivity of the lake.

Bottom organisms

A study was made on the quantity of bottom organisms available as food for fish. Eighty-four bottom samples were taken with a nine inch Ekman dredge. For the most part dredgings were taken in series from near shore line outward and on occasion extended across the lake. Samples were taken to a depth of 375 ft. In the shallow areas inorganic matter consisted largely of stones, sand and silt, with the silt content increasing progressively with depth. The material was sifted through two screens of different mesh sizes, the organisms picked off the screens, preserved in 10 per cent formalin and later counted and weighed. The molluscs were weighed after the shells were removed.

The dominant organisms were midge larvae and pupae, oligochaete worms and molluscs, Table IX. Other miscellaneous organisms were: Hydra, Nematoda, Hirudinea, Bryozoa statoblasts, Gastropoda egg masses, Hyalella, Ephemeroptera nymphs, Trichoptera larvae, Coleoptera larvae, Tipulidae larvae, Hydracarina and plant materials.

Both molluscs and non-molluscs show good correlation between mean weight times mean numbers in the different depth zones. This would indicate that either is a good measure of the amount of bottom fauna, and that there is no "dwarfing" of bottom organisms in the greater depths.

An examination of the dredging data provided in Table IX

TABLE IX. Summary of dredging data from Teslin Lake.
(All figures are averages based on a dredge area of 81 sq. in.)

		Non-Mollusca					Mollusca			
Depth in ft.	No. of samples	Midges	Oligo-chaetes	Misc.	Total	Wet wt. in gm.	No.	Wet wt. less shell	Total No.	Total wet wt. in gm.
0-15	28	28.18	14.07	2.07	44.32	0.0732	14.54	0.0349	58.86	0.1081
15-35	15	19.00	17.47	0.40	36.87	0.0678	13.87	0.0349	50.74	0.1027
35-50	9	6.77	11.55	0.78	19.11	0.0414	5.11	0.0110	24.22	0.0524
50-90	13	3.46	1.38	0.69	5.54	0.0154	5.58	0.0118	10.92	0.0272
90-160	11	6.36	10.36	1.00	17.73	0.0402	3.55	0.0145	21.46	0.0547
160-	8	10.38	9.88	0.38	20.63	0.0349	2.38	0.0008	23.01	0.0357
Totals	84	74.15	64.71	5.32	144.20	0.2729	44.83	1.079	189.21	0.3808
Means of all dredgings		15.87	11.56	1.119		0.0519	9.39	0.0228	37.97	0.0748
Mean depth zones given equal weight		12.36	10.78	0.887		0.0455	7.47	0.0180	31.53	0.0635
Total organisms		3189								
Total weight		6.2798 gr.								

brings out clearly the occurrence of relatively high productive zones in shallow (0-35 ft.) and deep water (90 + ft.). Between these zones there is a region which is relatively unproductive. This condition resembles that in Lake Nipigon where the number of organisms is highest in both shallow and deep water and lowest in the intermediate depths (Adamstone 1924). Rawson (1953) found a somewhat similar deepwater increase in benthos existed in Great Slave Lake but this was of much less magnitude and occurred approximately between the 350 and 450 ft. depths.

When the standing crop of bottom organisms in Teslin Lake is compared with that in other lakes in Canada, the number of organisms per square yard appears to be less than the average for such lakes as Slave, Athabasca, Reindeer and Nipigon but larger than in Lakes La Ronge and Wollaston and much larger than that of Cree Lake. It also appears that Teslin Lake has fewer species than have most of the above-mentioned lakes.

Fishes

Anatomical counts and proportional measurements.

Counts and measurements of parts were made on specimens of five species of fishes, for purposes of accurate identification and comparison with species in other localities. Counts and measurements employed are defined below:

Standard length	distance from tip of snout to end of vertebral column
Scales	number of scales along lateral line (not counting those on caudal fin base)
Gill rakers	total number of rakers on first left gill arch removed and counted macroscopically

Head length	distance from tip of snout to posterior point of opercular membrane
Head depth	distance from occiput vertically to ventral surface
Eye	greatest distance between the free orbital rims
Snout	distance from tip of snout to anterior margin of eye orbit
Interorbital width	horizontal width in straight line between bony orbits
Upper jaw length	straight line distance from tip of upper jaw to posterior end of maxillary bone
Caudal peduncle length	distance from point on lateral line vertically above insertion of anal fin to posterior end of vertebral column
Caudal peduncle depth	minimum vertical depth of caudal peduncle
Principal dorsal and anal rays	counted along the bases of the fins excluding any short ones at the anterior margin
Dorsal fin height	distance from the origin of the fin to its highest elevation distance from the origin of the fin to its lowest elevation
Dorsal and anal bases	greatest overall basal length, that is, from origin to insertion
Pectoral fin length	distance from origin of most anterior ray to tip of fin
Pelvic fin length	distance from origin to tip of longest ray
Adipose fin length	distance from origin to posterior tip of fin

The measurements were divided by the standard lengths and the results multiplied by 1000 to give whole numbers.

All counts and measurements were made in the field with the exception of nine specimens of _Coregonus_ _clupeaformis_ and four specimens of _C. nasus_ which were sent to the Museum of the Institute of Fisheries at the University of British Columbia.

Coregonus _clupeaformis_ and _C. nasus_. Perhaps influenced by Dymond's paper (1943) in which he expressed the opinion that only one species of whitefish existed in northwestern Canada, the authors at first recorded all whitefish taken as "lake whitefish", _Coregonus_ _clupeaformis_. However, it was soon apparent that there were two distinct forms present which were subsequently recorded as "humpback" and "sheepnose". Field counts and measurements were made on twelve specimens of each of the humpback and sheepnose. Later Dr. C.C. Lindsey supplied some data on nine additional specimens of the humpback and four specimens of the sheepnose which had been preserved and examined at the Institute of Fisheries. These data were then subjected to statistical analyses. The standard error of the difference between means for each body dimension was calculated by using small sample statistics. The "t" ratio of each dimension was then calculated and compared to a table of "t" scores as a test of significance. Of the 20 dimensions considered, 13 were found to be significantly different at the .01 level; one at the .05 level; one at the .10 level and five were found to be not significant, (Table X). The data strongly imply that the samples under consideration were from two distinct populations and consequently it may be safely assumed that the two samples comprise two different species.

TABLE X. Significance of morphometric data between *Coregonus clupeaformis* and *C. nasus*

Measurement	*C.clupeaformis*		*C.nasus*		S.E. of diff.between means	"t" score	Level of significance
	no. in sample	mean	no. in sample	mean			
Pectoral fin length	12	160.3	12	184.4	1.53	15.76	.01
Dorsal rays	20	14.0	16	12.9	.11	9.49	.01
Anal fin height	12	112.3	12	129.8	2.22	7.83	.01
Upper jaw length	21	55.3	16	47.8	1.14	6.60	.01
Pelvic fin length	12	138.4	12	152.4	2.44	5.74	.01
Head depth	12	148.8	12	169.8	3.83	5.48	.01
Interorbital width	21	57.5	16	62.8	1.00	5.27	.01
Dorsal fin height	12	150.3	12	167.2	3.36	5.04	.01
Gill rakers	21	25.1	16	23.8	.27	4.87	.01
Snout	21	50.7	16	45.3	1.24	4.40	.01
Caudal ped. length	21	121.3	16	114.1	1.70	4.25	.01
Scales lat. line	21	84.0	16	87.6	.93	3.88	.01
Caudal ped. depth	21	84.8	16	88.9	1.34	3.06	.01
Adipose fin length	12	82.7	12	91.3	4.17	2.08	.05
Branchiostegals	12	8.7	12	8.3	2.31	1.83	.10
Dorsal base	12	130.0	12	126.3	3.02	1.24	-
Head length	12	199.2	12	197.0	2.27	.96	-
Anal base	12	116.1	12	116.8	1.98	.30	-
Eye	12	42.8	12	42.8	-	-	-
Anal rays	12	13.8	12	13.8	-	-	-

Separation of the two species on statistical analyses by the authors supports Lindsey's (1962) conclusions that at least two species of whitefish occur in Teslin Lake, namely the broad (sheepnose) Coregonus nasus (Pallas) and the lake (humpback) C. clupeaformis (Mitchill). These two species live sympatrically in Teslin Lake and there appears to be little if any hybridization between them. This is probably the result of C. nasus spawning much earlier than the C. clupeaformis (Wynne-Edwards, 1952).

Coregonus sardinella. Bean (1889) described a cisco occurring in the extreme northwest of the North American continent as Coregonus pusillus. Berg (1932) stated that the Asiatic Coregonus sardinella is close to or identical with C. pusillus. Dymond (1943) observed that Leucichthys pusillus is evidently the eastern extension of the Asiatic form, that the two names are synonymous and that L. sardinella is the correct name because of priority. On the basis of the characteristics of the mouth, the coloration of the fins, the size, and other features, the cisco of Teslin Lake is identified as C. sardinella (Dymond 1943, Walters 1955, Wilimovsky 1958). Comparisons of ciscoes from other lakes are generally not possible because authors do not provide adequate data for statistical analyses.

Prosopium cylindraceum. Counts and measurements were made on 10 specimens of the round whitefish. Dymond's measurements (1943) are based on small samples and comparisons are of little value. Berg (1936) referred to this species as Coregonus (Prosopium) cylindraceum (Pallas). On the basis of the data the species is identified as P. cylindraceum.

Stenodus leucichthys nelma. The most extensive study of this species in North America is that by Fuller (1955) in which some of the present data are included. Fuller regards the inconnu of Great Slave Lake and MacKenzie River as distinct from the Siberian fish and considers the North American fish as Stenodus leucichthys mackenziei Richardson. Dymond (1943) believes that all the Arctic forms are Stenodus leucichthys nelma (Pallas). Walters (1955) likewise accepts the above designation. In view of the relatively slight variations in the body characters of the species, the present authors have adopted the subspecific name nelma.

Lota lota. An examination of six specimens seemed to indicate intergrades between the subspecies leptura and maculosa and it seems best to record the species as Lota lota at the present time (Hubbs and Schultz, 1941).

Catch data

The fish were taken mostly by a set of linen gill nets made up of 50 yd. each of 1-1/2, 2-1/8, 3, 3-1/2, 4, 4-1/2, 5 and 5-1/2 in. stretched mesh. This gang was 400 yd. in total length and 4 ft. deep and always set on the bottom, usually overnight and at right angles to the shore line. A beach seine of 1/2 in. mesh, 50 ft. long and 6 ft. deep was also used. A few fish were obtained by trolling and angling. The following species were found to occur:

Coregonus clupeaformis (Mitchill), lake whitefish; Coregonus nasus (Pallas), broad whitefish; Coregonus sardinella Valenciennes, cisco; Prosopium cylindraceum (Pallas), round whitefish; Stenodus leucichthys nelma (Pallas), inconnu; Thymallus articus (Cope), arctic grayling; Salvelinus namaycush (Walbaum), lake trout; Oncorhynchus tshawytscha (Walbaum), chinook salmon; Oncorhynchus keta (Walbaum), chum salmon; Catostomus catostomus (Forster), longnose sucker; Esox lucius Linnaeus, northern pike; Lota lota Linnaeus, burbot; Cottus cognatus Richardson, slimy sculpin.

From Atlin Lake Withler (1956) records a minnow, Hybopsis plumbea, taken in a warm water stream. He did not take Coregonus nasus, Oncorhynchus tshawytscha, O. keta, Stenodus leucichthys nelma nor Cottus cognatus.

The fish fauna of Teslin Lake has representatives of both eastern and western species. Two species are North American and are not known to occur in Asia: Coregonus clupeaformis and Salvelinus namaycush. The remainder of the species also occur in the Asian fauna and a few are circumpolar in distribution as for example the pike and the burbot.

Table XI shows the gill net catch data adjusted for comparative purposes to 14 sets. The actual catch figures are in brackets. It will be seen that Coregonus clupeaformis, C. nasus and Catostomus catostomus were the three species caught most abundantly. The above three species together with the round whitefish, Prosopium cylindraceum constitute a group of bottom

TABLE XI. Gill net catch of fish, based on 14 sets, from Teslin Lake - the numbers in brackets are the actual number of fish taken in each mesh.

Net Size	*Coregonus clupeaformis* and *nasus*	*Coregonus sardinella*	*Prosopium cylindraceum*	*Stenodus leucichthys nelma*	*Salvelinus namaycush*	*Catostomus catostomus*	*Esox lucius*	*Lota lota*
1 1/2	238 (177)	126 (97)	79 (66)	0 (0)	5 (4)	227 (173)	5 (4)	3 (3)
2 1/8	312 (245)	106 (85)	150 (137)	0 (0)	13 (13)	330 (282)	21 (15)	3 (3)
3	149 (116)	1 (1)	30 (24)	4 (3)	28 (25)	79 (68)	15 (11)	7 (6)
3 1/2	150 (111)	0	2 (1)	5 (4)	23 (20)	1 (1)	14 (10)	3 (2)
4	79 (65)	0	0	4 (4)	31 (25)	0 (0)	2 (2)	8 (7)
4 1/2	39 (28)	0	0	8 (6)	20 (14)	0	3 (2)	6 (4)
5	47 (31)	0	0	2 (1)	11 (6)	0	0	4 (3)
5 1/2	20 (9)	0	0	0 (0)	7 (2)	0	0	0 (0)
Totals	1034 (782)	233 (183)	261 (228)	23 (18)	138 (109)	637 (524)	50 (44)	34 (28)

feeding fishes. The long nose sucker appears to be the most numerous but on a poundage basis it is much less significant. The few caught by the local residents are fed to dogs or are discarded.

The cisco, Coregonus sardinella, tends to live away from the bottom, being a plankton feeder. Since the gill nets were set on the lake bottom they may not have sampled the cisco population efficiently and C. sardinella was probably much more abundant than indicated.

The gill net catches indicate that S. namaycush is the most abundant predator, others being Stenodus leucichthys nelma, Esox lucius and Lota lota.

Grayling, Thymallus arcticus, were caught in the Morley River by angling. Only one small specimen was taken in the lake proper during July and August but it is understood that many, if not all, descend to the lake in the winter months.

Two species of Pacific salmon, after travelling approximately 2,000 miles up the Yukon River, enter the lake in the late summer and early autumn and spawn in the tributary streams. The chinook salmon, Oncorhynchus tshawytscha, was observed in the Morley River in mid-August but no specimens were obtained. No chum salmon, O. keta, were seen in the lake but in the autumn Mr. R. McCleery forwarded two specimens. Both species form an important food item for the Indians and their dogs.

The sculpin, Cottus cognatus, was taken around the shores of the lake in the seine hauls. It occurred in the stomachs of lake trout and burbot and is apparently moderately abundant.

Foods

Although the quantity of bottom and plankton organisms in Teslin Lake is not large, it appears to support a fair population of fish consisting of eleven species. Ciscoes, as adults, eat plankton but also a considerable amount of midge larvae and pupae during the summer months. The lake and broad whitefishes, the round whitefish and the longnose sucker are bottom feeders. The inconnu, lake trout, northern pike and burbot are predators and feed largely upon ciscoes and whitefishes. Occasionally the pike and lake trout will take individuals of their own kind. Finally the grayling and sculpin are mostly insect eaters but will take almost any organism of the right size when available. The foods of these fishes are recorded in Appendices A to I.

The separation of the two large species of whitefishes systematically was made well on in the investigation and consequently food data are available largely for the two species combined. Appendix A summarizes the stomach contents of 50 individuals. Clams, snails and midge larvae and pupae were the most abundant food items in both the number of individuals which had eaten the above materials and the average quantity per individual. The absence of such bottom organisms as <u>Pontoporeia</u>, <u>Mysis</u>, and burrowing mayfly nymphs is noteworthy.

A summary of the food of the cisco is provided in Appendix B. It is apparent that the bulk of the food consisted of copepods and midges. The latter were particularly conspicuous during the time of their emergence in late July and August. The large percentage of midge larvae as well as pupae appears to indicate that ciscoes feed near and on the bottom of the lake at times. Conditions during the other months of the year are unknown but it may be surmised that plankton forms the major part of the diet during the rest of the year.

The round whitefish is usually caught between depths of 25 to 50 ft. and takes what is available between those depths. Appendix C indicates that the food for this species consisted largely of caddis (larvae and pupae), midges (larvae and pupae) and snails. These organisms constituted about 90% of the contents of the stomachs examined.

The stomachs of ten specimens of inconnu were examined and in all cases the contents consisted of fish remains, of which ciscoes were identified in three cases and the remains in the seven other stomachs were probably those of ciscoes (Appendix D). One individual measuring 22-1/2 in. contained eleven ciscoes ranging from 2-1/2 to 4 in. in length.

The food from the stomachs of five grayling consisted of aquatic insects - mayfly nymphs, caddis larvae, water boatmen and midge larvae; and of terrestrial insects - beetles, flies, ants and wasps. Miscellaneous food comprised - snails, traces of fresh water shrimp, water mites and some plant tissue including moss (Appendix E). These fish were taken from the Morley River.

The lake trout is the most abundant piscivorous fish in Teslin Lake. An analysis of the food from 71 stomachs indicated that the species fed upon eight different species of fish but that most of the food consisted of lake whitefish, broad whitefish, round whitefish, cisco and pike (Appendix F). One individual had eaten a burbot 17 inches in length.

The longnose sucker is a bottom feeder and midge larvae and pupae were the most common materials in the stomachs, occurring in all the stomachs examined except one. Ostracods and small clams were also abundant (Appendix G).

The pike feeds on almost any kind of fish that comes its way and is capable of being handled. In Teslin Lake its stomachs contained lake, broad and round whitefish, cisco, northern sucker, pike and sculpin. An eleven inch specimen contained two burbot, 1-1/4 and 1-1/2 in. in length. A three and a half inch specimen taken from the stomach of another pike contained mayfly nymphs, caddis pupae and midge larvae and pupae (Appendix H).

The adult burbot is a deep coldwater fish to a large extent but the occurrence of the round whitefish and the pike in the stomachs would indicate a movement into relatively shallow water at times. In addition to the round whitefish and pike present in the stomachs there were sculpins, ciscoes and lake trout. Young burbot feed on smaller items such as insects and crustaceans (Appendix I).

Age-growth relationships

The average rates of growth for all fish are summarized in

Table XII. Where data are available the age-length relationships are illustrated in Fig. 8 to 12. The ages provided throughout the text are for complete years and do not allow for scale growth in the year of capture.

Samples of scales of Coregonus clupeaformis and C. nasus were submitted to Dr. John Van Oosten at the University of Michigan. There was some disagreement in age determinations between those made by Van Oosten and the authors, but the differences in most instances were questions of single years. From Figure 8 based on data from Table XII it appears that C. clupeaformis has the slowest growth on the basis of 66 specimens; C. nasus slightly faster on the basis of 20 specimens and the undifferentiated whitefish the fastest growth rate on the basis of 124 specimens.

It was immediately apparent that the growth curve for the undifferentiated species should be between the curves for C. clupeaformis and C. nasus. Therefore the data were further analyzed and comparisons made between the average length and age of C. clupeaformis caught in Nisutlin Bay and the open lake. A similar comparison was made between the combined data for C. clupeaformis and C. nasus.

From Table XIII it is seen that in all but three out of the eighteen age groups, fish of the same age are larger in the open lake than those in Nisutlin Bay. Data graphed in Fig. 9 and 10 not only illustrate differences in growth in the same species between Nisutlin Bay and the open lake but also help to

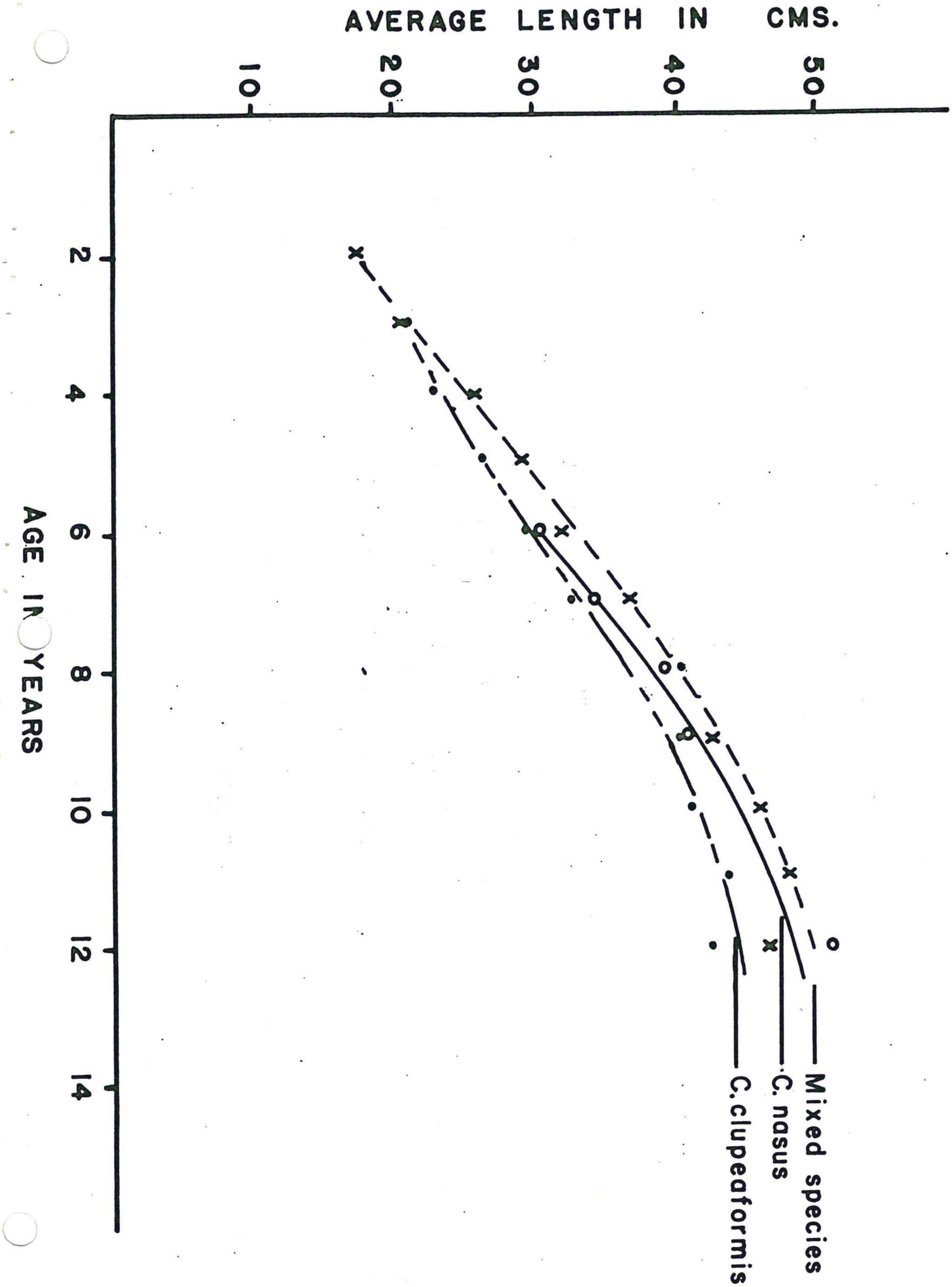

Fig. 8. Growth rates of <u>Coregonus</u> <u>clupeaformis</u>, <u>C</u>. <u>nasus</u> and of the two species undifferentiated, Teslin Lake, 1944.

TABLE XII. Average length in cm. and age in years for species of fish from Teslin Lake. Numbers in brackets are the numbers on which averages are calculated.

Age in years	0	1	2	3	4	5	6	7
Species								
<u>Coregonus clupeaformis</u>				21.0(3)	22.9(2)	26.4(7)	29.3(7)	32.6(11)
<u>C. nasus</u>							30.3(2)	34.3(7)
Mixed species of <u>C. clupeaformis</u> and <u>C. nasus</u>			17.7(10)	20.8(9)	25.9(20)	29.0(13)	32.0(7)	36.9(24)
Average for all above whitefish			17.7	20.8	25.6	28.1	30.6	35.3
<u>C. sardinella</u>		14.9(9)	18.5(54)	21.6(5)	23.9(18)	24.2(24)	25.6(6)	26.5(3)
<u>Prosopium cylindraceum</u>			18.2(6)	21.7(10)	25.8(12)	30.7(16)	32.8(9)	34.5(9)
<u>Stenodus leucichthys nelma</u>					41.5(1)	47.0(3)	50.3(3)	60.0(2)
<u>Thymallus arcticus</u>		15.8(16)	22.2(7)		29.8(1)	33.0(1)		
<u>Salvelinus namaycush</u>				26.2(4)	30.8(5)	35.4(7)	42.3(18)	45.8(18)
<u>Catostomus catostomus</u>			14.7(5)	16.1(16)	22.3(6)	23.3(11)	28.6(6)	29.7(8)
<u>Esox lucius</u>	10.7(3)	20.5(3)	37.1(3)	47.5(14)	55.0(12)	56.5(3)	64.3(6)	61.7(1)

TABLE XII. (Contd.)

Age in years	8	9	10	11	12	13–14	15	16	17
Species									
Coregonus clupeaformis	40.5(13)	40.2(9)	41.1(6)	43.6(5)	42.7(3)				
C. nasus	39.5(5)	40.8(5)			51.3(1)				
Mixed species of *C. clupeaformis* and *C. nasus*	40.7(16)	42.6(15)	46.0(4)	48.2(3)	45.7(3)				
Average for all above whitefish	39.3	41.5	43.1	45.4	45.2				
C. sardinella	24.9(1)								
Prosopium cylindraceum	36.9(6)	37.1(3)							
Stenodus leucichthys nelma	64.4(7)	76.0(1)	72.7(2)						87.5(1)
Thymallus arcticus									
Salvelinus namaycush	51.5(8)	60.9(7)	61.1(3)	69.7(1)	73.8(1)				
Catostomus catostomus	33.9(2)	26.0(1)	38.3(1)				43.0(1)		
Esox lucius	68.3(1)								

TABLE XIII. Comparisons of average lengths and ages of *Coregonus clupeaformis* and *C. nasus* in the open lake and in Nisutlin Bay.

Species	Location	AGES											Total number
		2	3	4	5	6	7	8	9	10	11	12	
Coregonus clupeaformis	Open Lake		22.4		24.6	29.9	36.0	41.3	40.2	42.9	44.6	46.1	35
	Nisutlin Bay		20.3	23.0	27.2	29.7	30.9	34.6		37.6	39.4	41.0	25
Coregonus clupeaformis and *C. nasus*	Open Lake	19.0	21.1	28.0	26.2	32.5	38.7	42.4	41.1	45.3	45.1	48.4	72
	Nisutlin Bay		20.3	25.3	26.0	32.2	33.9	38.8	41.6	38.4	42.0	41.0	99

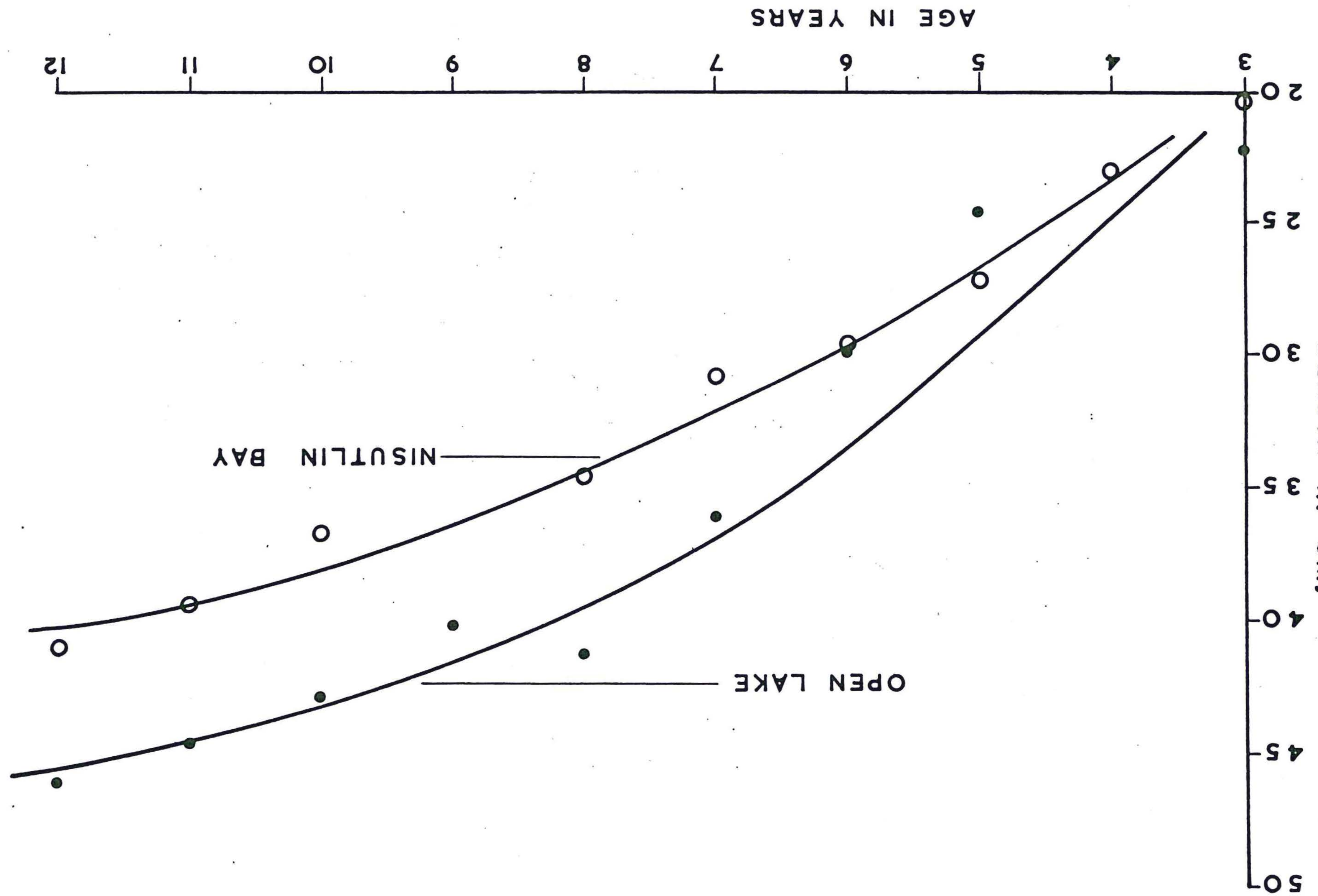

Fig. 9. Growth rates for Coregonus clupeaformis in the open lake and in Nisutlin Bay, Teslin Lake, 1944.

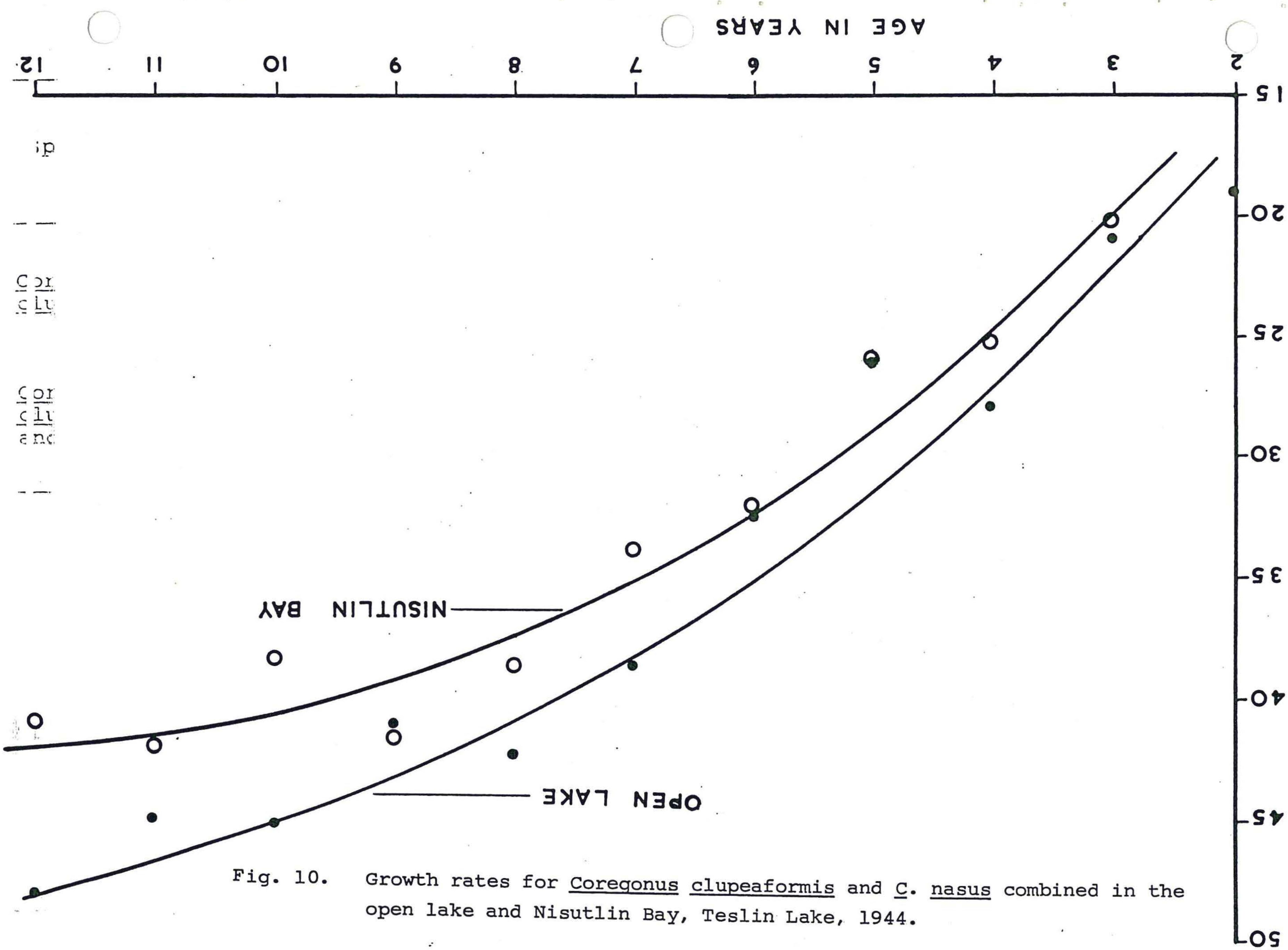

Fig. 10. Growth rates for Coregonus clupeaformis and C. nasus combined in the open lake and Nisutlin Bay, Teslin Lake, 1944.

explain why the mixed species represented in Fig. 8 had a faster growth rate than expected. Undoubtedly most of the mixed species came from the open lake. Why the bay population should grow less rapidly than that in the open lake is problematical. There are at least two possibilities:

1) Perhaps the muddy bottom of the bay makes it somewhat more difficult for the fish to search for food; and,

2) The number of fish per acre of bottom may be higher in the bay than in the open lake.

The rate of growth in length for C. clupeaformis is very similar to that of the same species in Great Slave Lake (Kennedy 1953), somewhat better than that of C. clupeaformis in Lake Nipigon (Hart 1931), slightly less than in Lac La Ronge (Rawson and Atton 1953) and considerably less than in Lake Ontario (Hart 1931), in Lake Erie (Van Oosten and Hile 1949), and in Lake Huron (Van Oosten 1939). It appears that C. clupeaformis is slower growing than in Great Bear Lake (Kennedy 1949), in Cree and Wollaston Lakes (Rawson 1959) and in Atlin Lake (Withler 1955). However, comparisons may not be very significant because measurements in length from these last three lakes were based on fork length whereas in all other lakes measurements were based on standard length (Table XIV).

The growth rate of C. clupeaformis in Atlin Lake is unusually high (Table XIV). It appears that fish at specific ages are not only much larger than those taken in Teslin Lake but are larger than those taken from nine other Canadian Lakes. The rapid growth rate is particularly difficult to explain since Atlin Lake is

TABLE XIV. Rates of growth of <u>Coregonus clupeaformis</u> in various Canadian Lakes. Many of the figures are approximate because most data are taken from graphs.

Lake	Length in cm. at 5 years	Length in cm. at 6 years	Length in cm. at 10 years
Lake Nipigon	22.7	23.8	35.8
Teslin Lake	26.6	29.5	41.0
Great Slave Lake	26.5	30.0	41.5
Lac La Ronge	28.4	31.5	41.7
Lake Erie	39.0	42.0	50.0
Lake Ontario (Belleville)	32.8	37.9	48.4
Lake Huron	42.0	45.2	55.0
Great Bear Lake *	27.9	31.6	47.8
Cree Lake	37.0	39.0	45.0
Wollaston Lake	29.7	33.0	46.0
Atlin Lake	40.8	50.5	

both deep and cold. Summer water temperatures in Atlin Lake are considerably below those in such lakes as Teslin, Cree, Wollaston and Huron. Nor does it appear that food is more abundant in Atlin Lake than in many of the lakes listed in Table XIV. Further, it should be noted that the other species of fish for which growth rates are provided by Withler all have a slower growth rate than the same species in Teslin Lake.

The average rate of growth for the cisco, Coregonus sardinella, has been compiled and the age-length relationship shown in Fig. 11. The largest specimen taken measured 27.6 cm. (11-7/8 in.), weighed 312 gr. (11 oz.) and was six years of age. The oldest fish was eight years of age, was 24.9 cm. in length and weighed 113 gr. There are apparently no published data with which the data in Fig. 11 may be compared. As stated previously the abundance of the species cannot be rightly judged on the basis of the catches since the cisco is pelagic for the most part.

Prosopium cylindraceum is intermediate in depth distribution, neither inhabiting very shallow water nor extending below about 60 ft. It spawns in the autumn like the species of Coregonus. The largest round whitefish measured 38.1 cm. (15 in.), weighed 702 gr. (1 lb. 9 oz.) at an age of 8 years. Three specimens recorded as 9 years of age averaged 37.1 cm. in length and 624 gr. in weight. No fish was taken in gill nets over three inches stretched mesh. The age-length relationship is shown in Fig. 11.

Thymallus arcticus usually inhabits northern clear, cold waters. In the Teslin Lake area it is apparently a stream fish

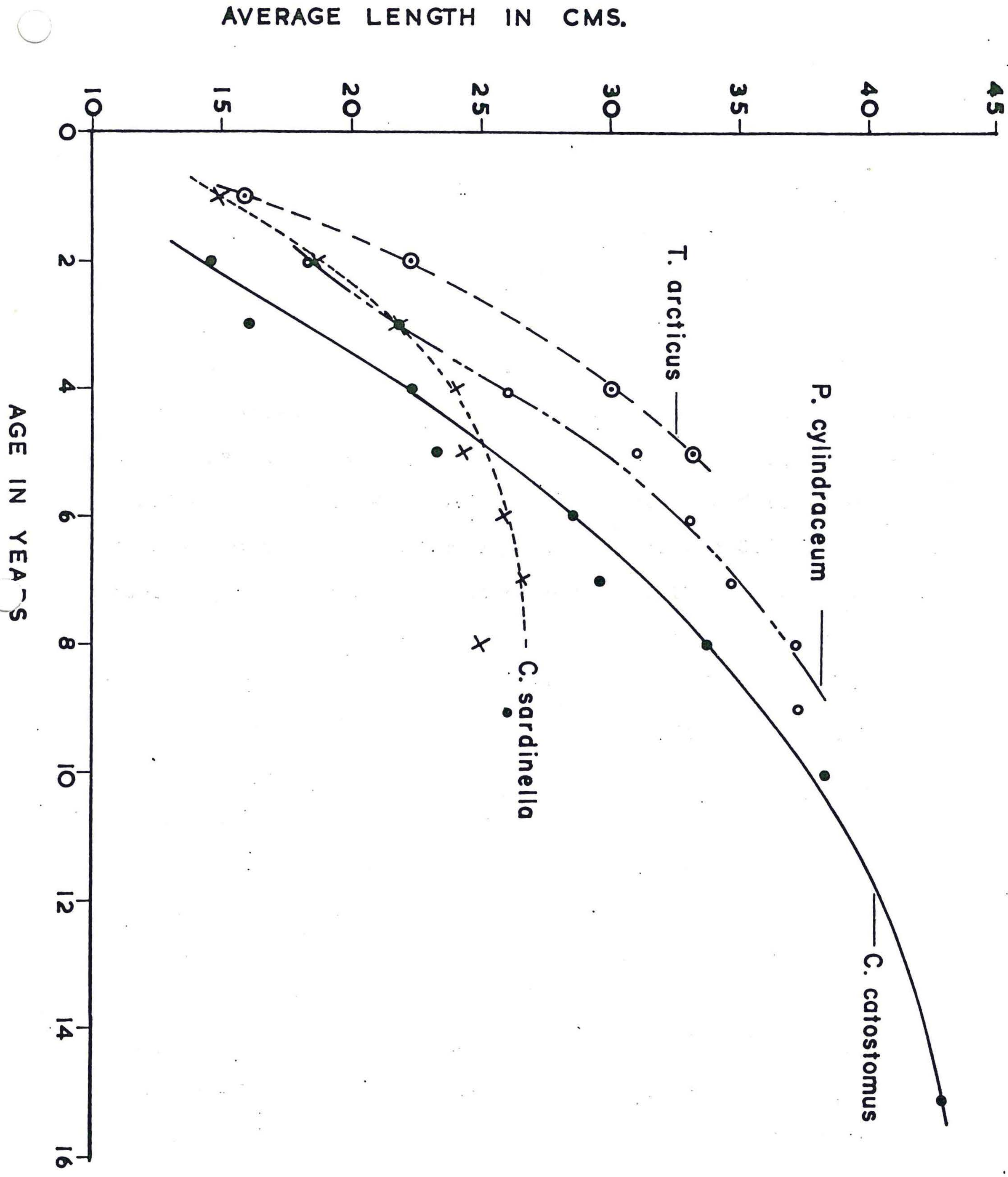

Fig. 11. Growth rates for Coregonus sardinella, Prosopium cylindraceum, Thymallus arcticus and Catostomus catostomus, Teslin Lake, 1944.

during the summer months as the only individual taken in the lake was a three-inch specimen obtained in a seine haul. Some of the streams tributary to the lake were well populated and on August 21st. 32 fish were obtained from the Morley River by angling. The individuals did not put up what was considered a good sporting fight, although generally anglers consider the species a fair fly fish. The fish ranged in length from 14.2 cm. (6.2 in.) to 33.0 cm. (14.2 in.) and in weight from 28 gr. (1 oz.) to 510 gr. (1 lb. 2 oz.). With two exceptions the fish were in their second and third summers. Age-length relationship is shown in Fig. 11. The largest fish (33.0 cm.) was in its sixth summer. The growth rate in Morley River was essentially the same as that of the grayling in Yellowstone National Park, Montana (Brown 1943).

Catostomus catostomus is widely distributed in Teslin Lake. It was very frequently taken in gill net settings in shallow as well as in deep water. The largest individual was a female 43 cm. (18 3/16 in.) in length, weighed 1021 gr. (2 lb. 4 oz.) and was 15 years old. Age-length relationship is shown in Fig. 11.

Stenodus leucichthys nelma was not very abundant in Teslin Lake as judged by the gill-net catches. Twenty specimens were available for study. Scales were submitted to Dr. W.A. Fuller for age determinations and his calculations, along with the author's, are given in Appendix U. It will be seen that agreement is fairly close. The age-growth relationship is shown in Fig. 12. The inconnu was taken throughout the lake. The largest individual was 87.5 cm. (37 1/2 in.) and weighed 6237 gm. (13 lb. 12 oz.)

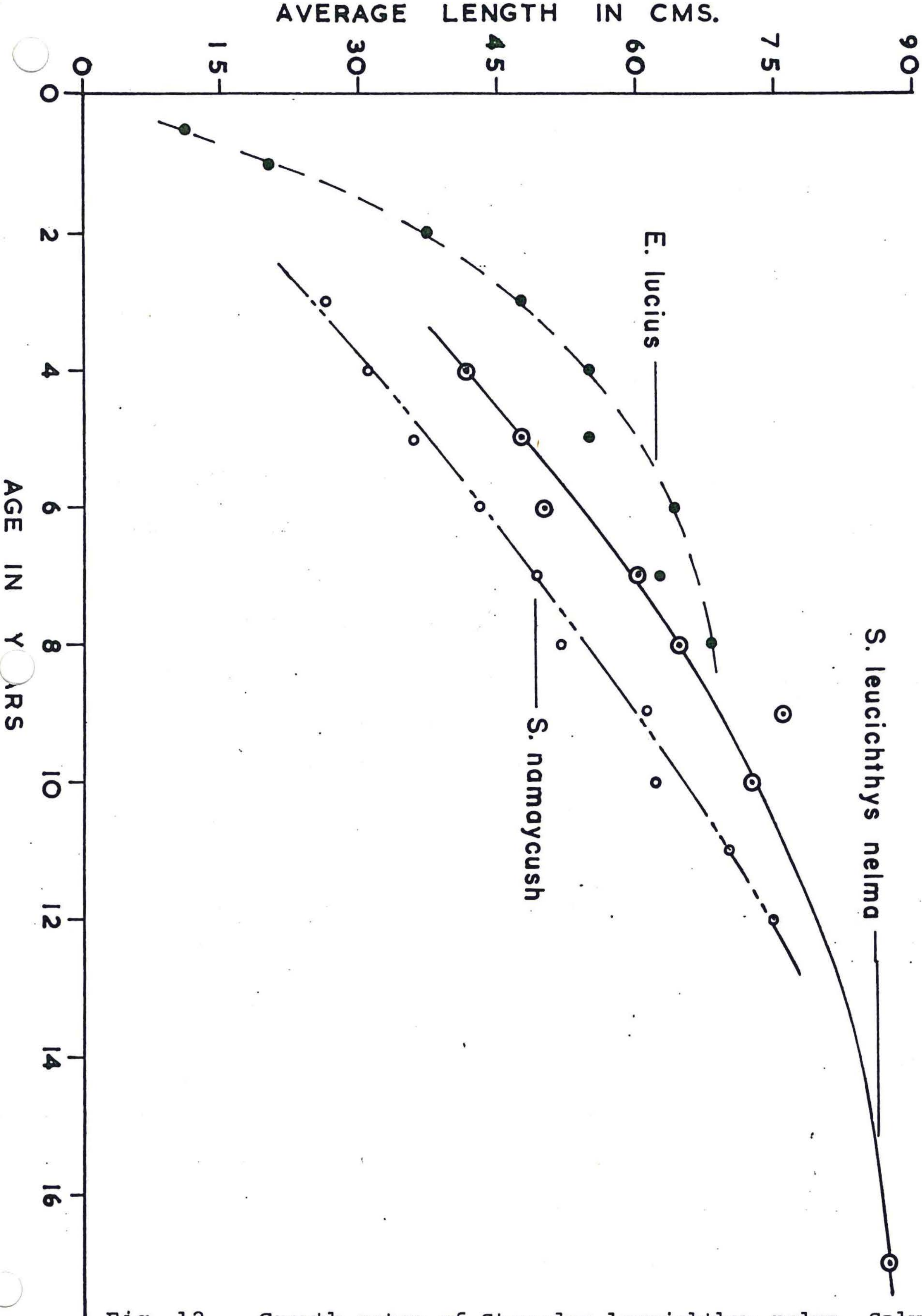

Fig. 12. Growth rates of <u>Stenodus leucichthys nelma</u>, <u>Salvelinus namaycush</u> and <u>Esox lucius</u>, Teslin Lake, 1944.

and was 17 years of age.

The population of Salvelinus namaycush may not have been sampled as well as the species of whitefishes by the bottom set gill nets. The indications, from gill net and troll catches, were that lake trout were abundant. Age-length relationship is shown in Fig. 12.

Comparison of the age-length relationship of the lake trout of Teslin Lake with that of lake trout of Great Bear Lake (Miller and Kennedy 1948) shows that the Teslin Lake fish grow at a very much faster rate than do those of Great Bear Lake. For example, at age 12 (the oldest trout obtained in Teslin Lake) the length was 73.8 cm. (31.25 in.) and the weight 5788 gr. (12.75 lb.) whereas fish from Great Bear Lake at this age were 41.2 cm. (16 in.) in length and 770 gm. (1.7 lb.) in weight. Similarly Teslin Lake fish grow much faster than do those of Great Slave Lake (Kennedy 1954). On the other hand, their growth is more like that of Lac La Ronge (Rawson 1961) and Lake Michigan fish (Van Oosten 1944).

Esox lucius usually inhabits shallow weedy areas. In Teslin Lake pike were common in Nisutlin and Morley Bays and all the material examined was taken in these two localities. The largest pike caught was 68.3 cm. (29 1/2 in.) in length, weighed 3430 gr. (7 lb. 9 oz.) and was eight years of age. Age-length relationship is shown in Fig. 12. Comparisons of the age-length relationship of the pike in Teslin Lake with data on the growth of this species in Great Bear, Great Slave, Athabasca, Lesser Slave and Waskesiu (Miller and Kennedy 1948) indicate that pike from Teslin Lake grow at a faster rate than do those in the above five lakes. Exact comparisons are not possible because the Teslin fish were measured to the end of the vertebral column and not to the fork of the caudal fin and further the data for the Teslin fish are based on actual measurements and not calculated from scale measurements. The suggestion by Miller and Kennedy (1948) that the rate of growth in length varies inversely with north latitude is not supported by the data from measurements on pike from Teslin Lake. The weight-length relationships for pike from Teslin Lake are slightly below, but almost parallel to those illustrated by Miller and Kennedy. If fork lengths had been employed it appears that weight-length relationships would have been very close.

For Lota lota the authors were unable to determine the ages from the scales and the number of otoliths taken was too few to be of use. The data for length, weight and sex are presented in Appendix J. The burbot reaches a relatively large size and probably lives for a considerable number of years. The largest specimen captured was 65 cm. (27 4/5 in.) in length and 1985 gr. (4 lb. 6 oz.) in weight.

COMMERCIAL FISH PRODUCTION

In order to establish for the whitefishs, Coregonus clupeaformis and C. nasus, a tentative annual quota which might be removed from Teslin Lake each year without seriously depleting the population, the authors have endeavoured to calculate the total annual yield which may be available to residents and possibly to commercial fishermen.

Very few investigations have been carried out which would enable one to forecast with any degree of accuracy the yearly yield of fish from a lake. The authors, however, have attempted to calculate a potential annual yield for Teslin Lake so that the figure might be employed as a starting point in an experimental program aimed at establishing a practical yearly quota for the two species of fish. It is realized, of course, that the final figure derived is a tentative one and that for any degree of accuracy many more data, including many weekly and monthly records such as those suggested by Ricker (1946), would be required.

The calculation of the annual yield has been restricted to that for Coregonus clupeaformis and C. nasus for two obvious reasons; firstly, the two species are of commercial importance because of their sizes and numbers and secondly because they feed on bottom organisms for which quantitative data have been secured.

In determining the annual whitefish production (yield) from a short term investigation of a large lake such as Teslin, several assumptions have been made:

1) The "standing crop" of bottom organisms represents the weight of the food organisms present at any given time. At present there is no way of determining what percentage of bottom organisms the fish have consumed during a year and an arbitrary figure of 50 per cent has been chosen. That is, if the standing crop of bottom organisms is 700,000 pounds

at any given time then it is assumed that the fish have consumed 700,000 pounds during the previous year for body maintenance, growth and movement.

2) Statistically it is difficult to determine a conversion factor for the transformation of wet weight of bottom organisms as shown in Table XV to that of wet weight of fish. Some of the difficulties involved in the study of the metabolism of fishes is indicated by Winberg (1960). Experiments in the laboratory under ideal conditions and with a high protein diet indicate a conversion factor as high as 2:1 may be attained but in the natural habitat the conversion is certainly much lower due to the composition of the food. In comparison with prepared foods bottom organisms would be low in calories and high in roughage. Rawson (1959) suggested a conversion factor of 10:1 and this figure has been used in calculating the annual whitefish yield for Teslin Lake. On this basis 10 lb. of bottom organisms would produce 1 lb. of whitefish.

3) Since the dredge was operated to a depth of 375 ft. the area of the bottom to a depth of 400 ft. has been calculated, namely, 120 sq. mi. out of a total bottom area of 137 sq. mi. The weight of bottom organisms on 120 sq. mi. has been calculated as the amount of food available to the bottom feeding fishes in Teslin Lake. The various bottom areas are shown in Table XV.

4) With only <u>Coregonus clupeaformis</u> and <u>C. nasus</u> under considera-

tion for commercial exploitation it was necessary to eliminate from consideration the round whitefish, *Prosopium cylindraceum*, and the longnose sucker, *Catostomus catostomus*, in determining the annual yield of whitefish under discussion. On the basis of gill-net records, *C. clupeaformis* and *C. nasus* constituted 3.4 out of a total of 4.4 for all bottom feeding fish.

With these assumptions in mind the calculation of the potential production of the two species of whitefish was derived. The 120 sq. miles of bottom was divided into 6 convenient areas based on the data in Table XV and knowing the average wet weight of bottom organisms for each area the total bottom feeding fish population per acre was determined. Then using the ratio 3.4:4.4 the longnose sucker and the round whitefish were eliminated from the production figures. This last figure represented the yearly potential yield of *C. clupeaformis* and *C. nasus*. The totals for the six areas when added together suggest a yearly potential of 63,631 lb. (Table XV). The calculation showing the method for determining the productivity of one bottom area is as follows:

Area: 0–15ft. 25 sq. mi.

Average weight of bottom organisms per sq. ft. =

$$.1081 \text{ (Table IX)} \times \frac{144}{81} = .1922 \text{ gm.}$$

No. of lb. of bottom organisms per acre =

$$\frac{43950 \times .1922}{454} = 18.56 \text{ lb.}$$

TABLE XV. Commercial whitefish productivity of Teslin Lake

Depth range in ft.	Bottom area sq. mi.	Bottom area acres	Av.wet wt. bottom org.	Lb.bottom fish per acre	Lb.comm.white-fish per acre (wet wt.)	Annual comm. whitefish production (wet wt.lb.)
0-15	27	17,280	.1922	1.86	1.43	24,883
15-35	13	8,320	.1826	1.77	1.37	11,398
35-50	6	3,840	.0930	.90	.70	2,688
50-90	14	8,960	.0484	.47	.34	3,073
90-160	18	11,520	.0972	.94	.73	8,364
160-400	42	26,880	.0635	.64	.49	13,225
Total	120	75,520	.1090			63,631

No. of lb. of bottom fish per acre =

$$\frac{18.56}{10} = 1.856$$

No. of lb. of commercial whitefish per acre (after removing the longnose sucker and round whitefish) =

$$\frac{3.4}{4.4} \times 1.856 = 1.44$$

Total annual production of commercial whitefish for this one bottom area =

$$27 \times 640 \times 1.44 = 24{,}883 \text{ lb.}$$

Reserving 20,000 lb. for the local population it would appear that 40,000 to 50,000 lb. might be taken from the lake annually in a commercial fishery.

The calculated weighted average whitefish production for Teslin Lake is 0.8 lb per acre. This figure appears to be in line with those suggested for other Canadian Lakes by Rawson (1947, 1953, 1959). However direct comparisons between the calculated production in Teslin Lake with production figures in other lakes is not possible because the figures provided are primarily based on commercial catch records, and frequently all commercial species, whereas the author's figures are for the two commercial whitefishes and the annual yield is based on the weight of bottom organisms available as food. Withler (1955), for example, suggested a commercial fish quota for Atlin Lake of one pound per acre or approximately 150,000 lb. annually but does not specify the species which he considers to be of commercial value. On the basis of lake area and possibly several species of fish, Withler's quota for Atlin Lake approximates the figure calculated for Teslin Lake.

The only other species of fish in Teslin Lake which might lend itself to exploitation is the lake trout *Salvelinus namaycush*. While lake trout are reasonably abundant in the lake, the authors do not consider that its numbers would provide a continuing and profitable commercial fishery. On the other hand, the lake trout is an excellent game fish and should be reserved for sport fishing.

If Teslin Lake is ever opened up for commercial fishing the authors suggest that it be kept under direct scientific control. Accurate catch records, length and weight measurements, scale samples for age determinations and other data on the different species of fish taken would be required to maintain a commercial fishery on a sound basis. Similar records should be obtained for lake trout so that adequate numbers may be maintained to make the lake attractive for sport fishing.

SUMMARY

1. A limnological survey was made in the summer of 1944 of Teslin Lake which lies across the British Columbia - Yukon boundary line. The lake is 78 miles long and averages 2 miles wide. The maximum depth obtained was 702 feet.

2. Teslin is a deep, cold lake with summer maximum and minimum surface temperatures in the open lake of 16.8°C and 12.8°C respectively during July and August and with a summer heat budget in 1944 of 20,000 cal. $cm.^{-2}$.

3. The thermal properties indicate that it is a dimictic lake with a summer stratification into epi-, meso-, and hypolimnion although only locally and rarely does the temperature gradient exceed 1°C per metre of depth.

4. The oxygen content of the water was never below 78% of saturation and the hydrogen-ion concentration ranged from 7.5 to 8.1.

5. The plankton was limited in numbers of species and quantity and occurred in greatest abundance in the upper 100 feet. The average volume in hauls from 100 feet to the surface was 0.86 cubic centimeters taken in a no. 20 bolting silk net having an upper opening diameter of 9 inches.

6. The bottom organisms were likewise limited in number of species and quantity as sampled by a 9 inch Ekman dredge. The total number of animals obtained in 84 samples was 3,189 weighing 6.2798 grams.

7. Detailed anatomical counts and proportional measurements were made on some species of fish for purposes of accurate identification and for comparison with species in other localities.

8. The fish taken in the lake were: Coregonus clupeaformis, C. nasus, C. sardinella, Prosopium cylindraceum, Stenodus leucichthys nelma, Thymallus arcticus, Salvelinus namaycush, Oncorhynchus tshawytscha, O. keta, Catostomus catostomus, Esox lucius, Lota lota, Cottus cognatus.

9. The ages of all species of fishes, with the exception of Lota lota and Cottus cognatus, were determined from a study of the scales.

10. Teslin Lake has limited biological production because of a short growing season, a large body of cold water in the hypolimnion and a large run-off from an extensive watershed.

11. Calculation of the quantities of bottom organisms available for Coregonus clupeaformis and C. nasus indicate a yearly potential yield of about 64,000 pounds for the two species. If 20,000 pounds are reserved for use by the local population then 40,000 to 50,000 pounds might be taken annually from the lake in a commercial fishery.

12. Salvelinus namaycush occurs in fair abundance and it seems advisable that this species be reserved for sport fishing.

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APPENDIX A. Stomach contents of 50 whitefish, Coregonus clupeaformis and C. nasus, 7 to 20½ inches, from Teslin Lake, 1944.

No. of fish	Type of food	Average quantity in per cent.	Range in per cent. among individuals
39	Sphaeridae	31.4	0– 85
37	Gastropoda	56.4	0–100
36	Midge larvae	29.6	0– 98
20	" pupae	10.2	0– 50
17	Hydracarina	5.0	0– 80
8	Plant material	7.0	0– 50
6	Ostracoda	3.0	0– 10
4	Gammarus	16.0	0– 30
4	Oligochaeta	1.0	0– 1
3	Trichoptera larvae	31.0	0– 90
3	Cladocera	34.0	0–100
3	Statoblasts	trace	
2	Misc. Diptera	trace	
2	Bryozoa	65.0	40– 90
2	Coleoptera	trace	
1	Copepoda	100.0	
1	Formicidae	trace	
1	Water Boatman (2)	95.0	
1	Gordius	2.0	
1	Trichoptera pupa	1.0	

APPENDIX B. Stomach contents of 34 ciscoes, Coregonus sardinella, 5½ to 12½ inches, in Teslin Lake, 1944.

No. of fish	Type of food	Average quantity in per cent.	Range in per cent. among individuals
30	Heterocope	70	0-100
18	Midge pupae	57	0- 97
4	" larvae	43	0- 50
3	Cladocera (Bosmina, Chydorus)	32.5	0- 96
3	Ostracoda	2.7	0- 4
3	Hydracarina	.8	0- 1
3	Misc. insects (Hemiptera, Coleoptera, Hymenoptera)	1.0	0- 2

APPENDIX C. Food of 22 round whitefish, Prosopium cylindraceum, 7½ to 16 inches, Teslin Lake, 1944.

No. of fish	Type of food	Average quantity in per cent.	Range in per cent. among individuals
11	Trichoptera larvae	64.8	0-100
11	Midge larvae	49.5	0-100
9	" pupae	26.4	0-100
6	Trichoptera pupae	42.5	0-100
6	Gastropoda	50.3	0- 98
1	Sphaeridae	10.0	
2	Hydracarina	trace	
2	Coleoptera	2.5	
3	Cladocera	trace	
2	Statoblasts	trace	
4	Plant materials	trace	

APPENDIX D. Food of 10 inconnu, _Stenodus leucichthys nelma_, 20 3/16 to 32 inches, Teslin Lake, 1944.

No. of fish	Species eaten	Average number	Greatest number
3	_Coregonus sardinella_ (size 2 1/2 to 6 1/2 in.)	6.7	18
7	Fish unidentified	1.6	3

APPENDIX E. Food of five grayling, *Thymallus arcticus*, 8 to 11½ inches, Teslin Lake, 1944.

No. of fish	Type of food	Average quantity in per cent.	Range in per cent. among individuals
5	Ephemeroptera	60	0- 99
2	Coleoptera	48	0- 50
2	Hymenoptera (ants and wasps)	20	0- 25
4	Trichoptera	8	0- 20
3	Insecta fragments	10	0- 25
2	Gastropoda	3	0- 3
2	Midge larvae	5	0- 10
1	Hyalella	trace	
1	Hydracarina	trace	
1	Plant material	trace	

APPENDIX F. Food of 72 lake trout, *Salvelinus namaycush*, 11½ to 31¼ inches, Teslin Lake, 1944.

No. of fish	Type of food	Average number	Greatest number and range in length
14	*Coregonus clupeaformis* and *nasus*	2.6	12(1 3/4-9 in.)
14	*Prosopium cylindraceum*	3.4	20 (1-4 in.)
18	*Coregonus sardinella*	2.6	15 (2-8 in.)
7	*Esox lucius*	5.9	8 (3½-6½ in.)
1	*Lota lota*	1.0	1 (17 in.)
37	Fish unidentified	2.1	25 (1-8 in.)
8	*Cottus* sp.	2.9	10 (1-3 in.)
6	Trichoptera pupae	2.2	6
4	*Salvelinus namaycush*	1.3	2 (1¼-12 in.)
1	Hirudinea	1.0	1
4	Misc. Insecta	1.0	1

APPENDIX G. Food of 14 longnose sucker, *Catostomus catostomus*, 6¼ to 15 7/8 inches, Teslin Lake, 1944.

No. of fish	Type of food	Average quantity in per cent.	Range in per cent. among individuals
13	Chironomidae larvae	45.3	0-100
9	" pupae	16.7	0- 45
9	Mollusca	34.4	0- 75
9	Ostracoda	10.0	0- 60
6	Cladocera	16.0	0- 75
3	Trichoptera larvae	3.0	0- 5
4	Algae	1.6	0- 5
5	Hydracarina	1.5	0- 5
4	Misc. (Oligochaeta, Bryozoa, Cyclops)	6.5	0- 20
1	Gammarus	50.0	
1	Coleoptera larvae	2.0	
1	Plant material	100.0	

APPENDIX H. Food of 14 pike, *Esox lucius*, 8 to 29 1/8 inches, Teslin Lake, 1944.

No. of fish	Type of food	Average number	Greatest number and range in length
3	*Coregonus sardinella*	1.3	2 (6-7½ in.)
2	*Coregonus clupeaformis* or *nasus*	1.0	1 (2 3/4-8 in.)
2	*Esox lucius*	1.0	1 (3½-4½ in.)
2	*Catostomus catostomus*	1.0	1 (2½-9 in.)
2	*Cottus sp.*	1.0	1 (2½ in.)
1	*Prosopium cylindraceum*	1.0	1 (12 in.)
2	Fish unidentified	1.5	2 (3 in.)
1	*Lota lota*	2.0	2 (1¼-1½ in.)
1	Misc. Insecta	6.0	6

APPENDIX I. Food of eight burbot, *Lota lota*, 15 to 26 3/16 inches, Teslin Lake, 1944.

No. of fish	Type of food	Average number	Greatest number and range in length
2	*Prosopium cylindraceum*	1.0	1 (3-6 in.)
2	*Cottus* sp.	1.5	2 (1¼ in.)
1	*Coregonus sardinella*	1.0	1 (2 3/4 in.)
1	*Salvelinus namaycush*	2.0	2 (2 in.)
1	*Esox lucius*	1.0	1 (6 in.)
4	Fish unidentified	3.5	5
2	Misc. Insecta	1	1
1	*Gammarus*	1	1

APPENDIX J. Data for <u>Lota lota</u> from Teslin Lake.

Length cm.	Weight gm.	Sex	Length cm.	Weight gm.	Sex
18.7	57	?	48.5	794	M
18.9	57	?	50.0	992	F
20.5	57	?	50.6	1077	M
27.0	114	F	51.7	907	F
30.0	142	?	52.6	1644	M
30.5	199	?	53.4	1106	F
35.4	340	M	55.7	1332	F
36.5	340	F	57.5	1673	F
38.8	369	M	58.3	1503	?
39.3	340	F	60.1	1758	F
41.0	425	F	60.1	1475	M
41.1	397	?	61.9	1644	F
42.2	510	F	62.0	1871	M
42.2	568	M	65.0	1985	F