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MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No.

483

Title

The Coregonine Fish of Great Bear Lake, N.W.T.

Author

W. A. Kennedy

Central Fisheries Research Station

September, 1947

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INTRODUCTION

During the summer of 1945 the author was privileged to accompany Dr. R. B. Miller to Great Bear Lake on a survey of the fisheries possibilities there, for the Fisheries Research Board of Canada. Three species of coregonines were found: whitefish, Coregonus clupeaformis, ciscoes, Leucichthys artedi and round whitefish, Prosopium cylindraceum. Our observations on availability, distribution, morphology, rate of growth, size at maturity, sex ratio, and food, are reported here. Dr. R. B. Miller has reported elsewhere on the parasites.

ACKNOWLEDGEMENTS

I take this opportunity of saying that it was a privilege and a pleasure to work with Dr. Miller. His leadership and forethought made possible a surprising amount of work in the time available especially when the remoteness of the lake and its size is considered.

I have been assisted in analysing the data by members of the staff at the Central Fisheries Research Station especially by Mr. J. J. Keleher.

TOPOGRAPHY OF GREAT BEAR LAKE

Great Bear Lake lies in the Northwest Territories on the Arctic Circle. It has an area of 11,800 square miles and is the fourth largest lake in North America. It is made up of five arms.

McTavish and Dease arms lie largely in the Precambrian shield, and have rocky and irregular shorelines with many bays and islands. Smith, Keith and McVicar arms lie in the Mackenzie lowlands and have more regular shorelines with many sandy or gravel beaches. Most of the lake is over 400 feet deep, and depths of more than 1,300 feet were found at the east end of McTavish arm.

The open lake was extremely oligotrophic, with remarkably clear water which was never much above maximum density temperature. Some of the bays which were nearly isolated from the open lake, especially when supplied by a relatively large river, tended to have entrophic characteristics.

METHODS OF COLLECTING SPECIMENS

Most of the coregonines were collected by "standard gangs" of gill nets set in representative places around the shores of the lake. These standard gangs consisted of fifty yards each of 2½-inch, 3-inch, 4-inch, 5-inch and 5½-inch mesh nets (stretched measure.) In addition, gill nets, which were not part of "standard gangs", were set on a few occasions. The nets were left in the water for an average of nineteen hours, including the short time when the sun was below the horizon. After the fish were removed from the nets, they were brought ashore, where lengths, weights, sex and sometimes stomach contents were recorded, and scale samples were taken for age determination. Detailed measurements were also made on a few for taxonomic purposes.

DISTRIBUTION AND AVAILABILITY

The localities fished appear to fall into four general groups: inshore area of the open lake: non-marshy bay; marshy bays; and river mouths.

The inshore area of the open lake comprises about 14 per cent of the total area. It is remarkably clear, cold, and almost devoid of plankton and bottom fauna. About 84 per cent of the lake is considered as offshore being much like the inshore area, although probably even more deficient in organisms including fish.

Non-marshy bays vary considerably among themselves, but typically they differ from the open lake by being slightly warmer, slightly less clear, and appreciably richer in plankton and bottom fauna. About 2 per cent of the lake is non-marshy bays.

About 0.2 per cent of the Lake is marshy bays. In them the water is noticeably warmer than in non-marshy bays and generally clear but distinctly brown in colour in contrast to the blue of the open lake and of non-marshy bays. There are rooted aquatic plants, and plankton and bottom fauna are relatively abundant.

River mouths comprise about 0.1 per cent of the area. They vary considerably among themselves but in general the water is comparatively warm and clear (but by no means as clear as the open lake) and they are comparatively rich in plankton and bottom fauna.

The number of fish per net (i. e. availability) taken in standard gangs set in each type of habitat is shown in Table 1. The Johnny Hoe River mouth is treated separately from the other

river mouths because of the greater catches made there. The percentage of each species caught by each mesh size is shown in Table 2. There was no tendency for a particular size of mesh to be relatively more successful in one type of habitat than in another.

Whitefish

The whitefish were most abundant by far at the mouth of the Johnny Hoe River, although the relative abundance may have been distorted by the fact that the spawning time was approaching when the sample was taken there. The concentration of whitefish at the Johnny Hoe River mouth at spawning time is a well known phenomenon to the Franklin Indians who go there at that time to lay in fish for the winter. A much greater concentration of fish is reported to take place at spawning time than we found. Spawning concentrations are reported to occur at the mouths of the Whitefish and Camsell Rivers which are exploited by the Rabbitskin and Dogrib Indians respectively.

It is obvious from the relative availabilities that whitefish preferred the river mouths to both the more oligotrophic open lake and non-marshy bays, and to the more eutrophic marshy bays.

Although concentrations of whitefish occur at the Johnny Hoe, Whitefish, and Camsell Rivers at spawning time, it is evident that the number of whitefish involved is small considering the size of the lake. We feel that the numbers are too small to warrant large scale exploitation. The present domestic fishery probably approaches maximum exploitation in some years.

Ciscoes

The ciscoes apparently preferred conditions slightly more oligotrophic than those preferred by the whitefish. However, they seemed to avoid the extremely oligotrophic conditions of the open lake. They were taken in the greatest numbers in Franklin Bay near the source of the Bear River. Probably the cisco population in Franklin Bay is not fully exploited by the present domestic fishery, although the Indians reported that in some years the ciscoes became scarce. However this population is found in a limited area and probably could not withstand large scale operations. There are populations of ciscoes in Echo Bay and in Lindsley Bay which apparently were sufficient for the fish requirements of the town of Cameron Bay when it existed, and which are at present not being exploited.

Round Whitefish

Round whitefish, seemed to show a preference for a condition intermediate between that preferred by whitefish and that preferred by ciscoes. In addition they appeared to prefer a current, and they were particularly abundant at the outlet of the lake where the current was about 6 miles per hour. A net set in the Bear River which was particularly successful in catching round whitefish, is not included in the calculation for Table 1, but nets set in the lake near the river which also took numbers of round whitefish were considered to be set in a non-marshy bay, (i. e. Franklin Bay).

MORPHOLOGY

Detailed measurements and counts were made on a sample of each of the three coregonine species. Standard length, head length and depth, eye diameter, snout length, interorbital width, maxillary length, caudal peduncle length and depth, dorsal fin length and base, anal fin length and base, pectoral and pelvic fin length were measured. Dorsal and anal fin rays, branchiostegal rays, scales, and gill rakers were counted. These measurements and counts were made according to the methods used by Dymond (Dymond, J. R. The Coregonine Fishes of Northwestern Canada. Transactions of the Royal Canadian Institute, Vol. XXIV, Part II, PP. 171-231). Vertebrae were also counted on some of the fish on which the measurements and other counts were taken, and on some others taken at random from the catches. All the vertebrae were counted including the urostyle.

Whenever possible the measurements and counts were made on fresh specimens, but a few whitefish and ciscoes were preserved in formalin and measured later. Twelve ciscoes and seven whitefish which had been measured while fresh were preserved at the same time and measured again with the others. The average amounts that the various measurements of these fish had changed were used to calculate the probably fresh measurements represented by the measurements taken on the preserved fish. The factors by which measurements on preserved fish were multiplied to give the probable measurements of fresh fish are shown in Table 3.

Whitefish

The sample of whitefish on which detailed measurements and counts were made consisted of three subsamples which came respectively from Smith Arm, McTavish Arm, and McVicar Arm. The sample is representative of the whitefish population in the lake, since the places where the subsamples were taken were the only places on the lake where whitefish were found or reported in any quantity, and since the numbers measured from each locality are approximately proportioned to the relative catches.

The subsample from Smith Arm was taken in Good Hope Bay and in Caribou Nest Bay which are two adjacent bays at the west end of Smith Arm. The subsample from McTavish Arm was mostly from Gunbarrel Inlet and Conjuror Bay, two adjacent bays in the southeast corner of McTavish Arm, with two fish from Lendsley Bay about 50 miles further north. The subsample from McVicar Arm was taken at the mouth of the Johnny Hoe River and from Snipe Island both of which are at the southwest end of the arm, except that two fish were taken from Bear Point, near the junction of McVicar and Keith Arms.

The subsamples were subdivided into immature and mature fish for purposes of comparing measurements. The subsamples were then compared to see if they differed among themselves with regard to the measurements, by the methods outlined in Appendix 1. These tests showed that the subsamples of mature fish differed significantly among themselves in average head length, head depth, snout length, interorbital width, caudal peduncle depth, pectoral fin length, and pelvic fin length for a given standard length, and

that subsamples of immature fish differed significantly among themselves in caudal peduncle depth, body depth, body width and dorsal fin base. In no case was there a significant difference in the rate at which the size of a body part changed with an increase in standard length.

Inspection of graphs (not shown) of logarithms of body parts plotted against logarithms of standard lengths shows that Smith Arm and McVicar Arm fish tend to be alike and that those from McTavish Arm tend to differ from them. The divergent nature of the McTavish Arm fish is probably entirely responsible for the conclusion that the above mentioned differences are significant.

The fact that Smith Arm and McVicar Arm fish tend to resemble one another and that McTavish Arm fish tend to differ from the other two suggests that environment rather than geographic separation is the cause of the differences. The Smith Arm subsample was taken about 400 shoreline miles from where the McVicar Arm subsample was taken (200 miles by the most direct route across the open lake, which a whitefish would probably not take) compared with about 100 shoreline miles between where the McTavish and McVicar Arm subsamples were taken. The subsamples from Smith and McVicar Arms were taken from similar habitats, namely at the blind ends of long narrow arms, supplied by a relatively large river, so that there was a considerable area of water which was noticeably warmer than the open lake. Although the sample from McTavish Arm was taken mostly from the vicinity of river mouths, the rivers influenced a much smaller surrounding area, and the cold water of

the open lake was much closer. So two groups of fish which were nearest to one another, but whose habitat differed, tended to be more different from one another, than two groups which were further apart but which lived in more similar habitats.

The fact that in no case did the subsamples differ significantly in rate of change in size of a body part with a change in standard length, suggests that the observed differences in average size of a body part for a given length may result from slight differences in the size at which a change in the rate occurred (During the life of many fish, at least two such changes in rate occur with respect to many body parts). Assuming that temperature influences the size at which these changes in rate occur, it is quite evident that the higher average temperatures of Smith and McVicar Arms could produce fish which would differ from those from McTavish Arm even though they were absolutely the same genetically.

The three subsamples did not differ significantly among themselves in average number of vertebrae, dorsal fin rays, anal fin rays, branchiostegal rays, scales, and gill rakers.

Since any differences among the three subsamples can be easily accounted for by environmental differences, the three subsamples are considered to be drawn from one genetically homogeneous population. The number of fish taken from each part of the lake corresponds roughly to the number present in each part of the lake. These fish were taken at random from the catches. Although one specimen was noted as "approaching the humpback form", and another from Bear Point was described by an Indian as a typical Johnny Hoe

whitefish, which he considered different from whitefish from other parts, neither these nor any other individuals appeared to differ from an "average fish" by more than would be accounted for by random variation. Therefore, the three subsamples combined are considered to be a representative sample of the whitefish population of Great Bear Lake which are considered to be one homogeneous group within which, part of the variation is produced by differences in environment from place to place.

Table 4 -- the values which are derived by the methods given in Appendix 1 -- gives a description of the whole whitefish population. The various equations in the second column give the average size of a body part for a given standard length in the sample, which is also an unbiased estimate of the average size of a body part for a given standard length in the whole mature whitefish population of Great Bear Lake. The next two columns show the average values of proportionate measurements (where proportionate measurements are defined as:- measurement of the part - standard length x 1,000 for fish of the smallest and of the largest size in the sample, which are also unbiased estimates of the average values of the proportionate measurements of all whitefish of those sizes in Great Bear Lake. Fish of intermediate size would have intermediate values of proportionate measurements. The amounts by which the true average values of proportionate measurements are likely to differ from the observed values are indicated by the values given in the next two columns (the chances are only one in

twenty that this range is not great enough to include the true value). Observed averages are more likely to differ from the true average for the largest and smallest sizes of fish, than for fish of average size, as these two columns show. Finally the last column indicates the range within which the proportionate measurements of any individual whitefish from Great Bear Lake is expected to lie.

As an example of the way in which Table 4 can be used, consider all the Great Bear Lake specimens whose standard lengths are say 532 millimeters. An unbiased estimate of their average proportionate head length is, from Table 4, 207 and we take one chance in twenty of being wrong if we say that the true average lies between 205 and 209 (207 ± 2). Also, nineteen out of twenty Great Bear Lake whitefish of that size are expected to have proportionate head lengths of between 190 and 224 (207 ± 17). Any whitefish, no matter of what origin, of that size whose proportionate head length is between 190 and 224 should not be regarded as different from a typical Great Bear Lake whitefish with respect to head length.

Table 5 is a description of the sample of immature whitefish and a probable description of all immature whitefish in Great Bear Lake whose sizes are as indicated. The explanations used in connection with Table 4 apply to Table 5.

A summary of the counts in which all the whitefish, mature and immature, are considered to belong to one sample, is shown in Table 6. The standard deviations in the last column of

Table 6 are the square roots of the sums of squares of deviations from means divided by one less than the number counted. These statistics must of course be used with caution for vertebrae, dorsal ray, anal ray and branchiostegal ray counts, especially the latter, since the range in values is small.

Dymond (Dymond, J. R. The coregonine Fishes of Northwestern Canada. Transactions of the Royal Canadian Institute, Vol. XXIV, Part II PP. 171-231) gives proportionate measurements for whitefish from several localities in Northwestern Canada, also measurements on fish which had been identified as C. kennicotti and C. nelsonii from Alaska and on a specimen of C. nasus from Siberia. A comparison of the values in Tables 4 and 6 with Dymond's Table 1, shows that, considering the effect of preservation and minor differences in measuring technique (which questions will be more fully discussed in the following section), our sample does not differ appreciably from his various samples of whitefish from Northwestern Canada. The specimens of C. kennicotti and C. nelsonii could almost have been taken from Great Bear Lake, and even C. nasus is not strikingly divergent. Our observations serve to confirm Dymond's conclusions that all whitefish from Northwestern Canada belong to one taxonomic group. They also suggest that further sampling may provide complete intergradation between C. clupeaformis and C. kennicotti, C. nelsonii and perhaps C. nasus.

Ciscoes

Detailed measurements and counts were made on ciscoes from two parts of the lake, namely from the east shore of McTavish Arm--

mostly from Echo Bay -- and from Franklin Bay at the west end of Keith Arm. Most of the ciscoes caught during the survey came from those two localities, and the size of the subsamples correspond roughly to the relative abundance. No other localities were found or reported in which there were similar concentrations of ciscoes.

The two subsamples were divided into immature and mature fish and the mature fish from Franklin Bay were further subdivided into males and females. The relative body measurements of the two sexes were compared by the methods outlined in Appendix 1, then the two sexes combined were compared with the mature fish from McTavish Arm.

The tests showed no significant difference between the sexes in the average size of any body part or a given standard length. Also there was no significant difference between the sexes in the rate at which the average size of any body part changed with a change in standard length. The two sexes of these ciscoes are seen to be remarkably similar morphologically.

The mature fish in the two subsamples differed significantly in the average size of several body parts for a given standard length. The ciscoes from McTavish Arm had significantly longer and deeper head, longer maxillaries, longer and deeper caudal peduncles, deeper and wider bodies, and longer dorsal, anal, pectoral and pelvic fins for a given standard length than did the Franklin Bay fish. The two subsamples did not differ significantly from one another in the rate at which any body part increased with an increase in body length. As in the case of the whitefish it seems

likely that the slight differences between the two subsamples are associated with differences in average temperature. The average temperature of Franklin Bay is slightly higher than that of the east end of McTavish Arm.

Eleven immature ciscoes from Franklin Bay were available for comparison with eleven immature fish from the east end of McTavish Arm. However, there was such a difference between the size ranges of the two samples--Franklin Bay 250 millimeters to 295 millimeters; McTavish Arm 40 millimeters to 65 millimeters--that it was not thought advisable to make the comparisons.

Ciscoes from Franklin Bay had an average of 59.5 vertebrae (71 fish) compared with an average of 58.7 vertebrae (19 fish) in ciscoes from McTavish Arm. The two averages are significantly different. It is assumed that this difference is related to the temperature differences. Fish from the two localities did not differ significantly in average counts of dorsal or anal fin rays, branchiostegal rays, scales, or gill rakers.

There is no characteristic or group of characteristics by which ciscoes from Franklin Bay can be readily distinguished from McTavish Arm ciscoes. The measurements of the various body parts for a given standard length overlapped to such an extent that although mathematical tests showed significant differences, the differences are scarcely noticeable even when portrayed graphically, and are certainly not apparent on gross examination. The range in vertebrae counts also almost completely overlap one another.

Further, these differences can easily be explained by the influence of different environments on one genetically homogeneous population. The number of fish taken from each part of the lake corresponds roughly to the relative abundance there. Therefore, the two subsamples are regarded as forming a representative sample of the ciscoes of Great Bear Lake, which are considered to be a homogeneous group with which part of the variation is produced by differences in environment from place to place.

A description of the mature ciscoes in the sample, and a probable description of the whole Great Bear Lake mature cisco population is given in Table 7. Table 7 corresponds to Table 4, which is explained in the previous section. No similar table has been prepared for immature ciscoes.

A summary of the average counts for the total sample is shown in Table 8. Only counts on the largest immature fish have been used since there is more chance for error in counts on small fish. The remarks made about Table 6 in the previous section apply to Table 8. Dymond (Dymond, J. R. The Coregonine Fishes of Northwestern Canada. Transactions of the Royal Canadian Institute, Vol. XXIV, Part II PP. 171-231) gives average proportionate measurements for 12 Leucichthys from Great Bear Lake and the ranges of values. Some of Dymond's values diverge noticeably from the values predicted by Table 7, unless a correction is made for the way some proportionate measurements change with preservation. When such corrections are made (using the values of Table 1) the correspondence is better, but the two sets of values still diverge noticeably in snout length, caudal peduncle length, body depth and width, and

pectoral and pelvic fin lengths. There is no reason to believe that the 12 fish reported by Dymond were from a different population than that from which the 77 fish of Table 7 were taken. The differences must be either the result of different changes in proportionate parts because of different methods of preservation, or of differences in measuring technique. Since the author used Dymond's methods of measurement throughout -- in fact learned them from Dymond -- if the latter is the cause then there was a difference in the way in which the methods were applied. Although the counts of gill rakers, scales and branchiostegals agree, the average counts of dorsal and anal fin rays given in Table 8 are appreciably greater than those given by Dymond. These discrepancies must represent differences in opinion as to what constitutes a separate fin ray.

These discrepancies serve to emphasize the need: to measure fresh specimens where possible; to be sure when comparing preserved fish that the methods of preservation are similar; to realize that different people do not make measurements and counts in exactly the same way even if they use the same methods.

Round Whitefish

Detailed measurements and counts were made on 8 fresh round whitefish. Since the sample was small, it was not treated like the samples of whitefish and ciscoes. Proportionate measurements of each individual were calculated, and they are shown in Table 9 along with the counts.

Dymond (Dymond, J. R. The Coregonine Fishes of Northwestern Canada. Transactions of the Royal Canadian Institute, Vol.

XXIV, Part II PP. 171-231) gives the averages and ranges of proportionate measurements of four Prosopium cylindraceum from Great Bear Lake. The measurements and counts given in Table 9 do not diverge greatly from those given by Dymond. There are minor discrepancies, but these are likely indicative of changes with preservation, and of differences in measuring technique.

RATES OF GROWTH AND SIZE AT MATURITY

Whitefish

Scale samples were taken from the whitefish captured. These scales were subsequently mounted dry and magnified about 50 diameters by means of a projector. The number of annuli on each projected image were counted and recorded. The inner annuli were easily distinguished, but the outer annuli on older fish tended to be so close together that often it was hard to distinguish them. Ages recorded for older fish should therefore be regarded as possibly in error, perhaps in some cases by as much as two or three years.

Table 10 shows the frequency distribution by age of the lengths of 210 whitefish whose ages were determined. The three I's (i. e. fish in their first year of life) were taken in a seine, the remainder were caught in gill nets. Certain sizes of fish are better represented than other sizes, as is expected because of the way in which gill nets fish selectively. However, the increase in length with age is well illustrated.

The sexes were approximately equally represented at all ages. There was no evident difference in growth rate between males and females.

The relationship of average length and average weight to age is shown in Table 11. Weight increases approximately as the 7.8 power of the length.

These whitefish grow faster than whitefish in some lakes and slower than whitefish in other lakes. On the whole the growth rate does not appear to differ from the growth rate in southern lakes by more than the growth rates in those lakes differ from one another. Latitude appears to have much less effect on growth rate than other factors have.

All fish in their sixth year and younger were immature. Ten per cent of those in their seventh year, 58 per cent of those in their eighth year and 97 per cent of those in their ninth year were mature as were all whitefish over nine years old.

Ciscoes

Scale samples were taken from the ciscoes captured. The scales were used to determine ages by the method described above for whitefish scales.

Table 12 shows the frequency distribution by age, of the lengths of the 311 ciscoes whose ages were determined. The smallest individuals were taken by seining and from the stomachs of predators, but most of the fish in their fifth year, and all older fish were taken in gill nets. The effect of selectivity for size is not so apparent as was the case with the whitefish, probably

because almost all of the ciscoes were caught in the $2\frac{1}{2}$ -inch mesh and 3-inch mesh gill nets. Table 12 illustrates an increase in size with an increase in age.

The sexes were approximately equally represented in each age group with the females slightly in the majority, but three-quarters of the fish over eleven years old were males. The growth rates of males and females appeared to be the same.

The relationship of average lengths and average weight to age is shown in Table 13. Weight increases approximately as the 3.3 power of length.

Like the whitefish, the ciscoes of Great Bear Lake grow more slowly than those in some southern lakes and more quickly than those in other. Latitude does not appear to be an important factor in determining rate of growth.

The smallest fish in its third year shown in Table II was a mature fish, and in view of its size this led to the speculation that it probably was a dwarf form of cisco. Except for it, all fish less than four years old were immature. Thirty-six per cent of the fish in their fifth year were mature as were 50 per cent of those in their sixth year, 95 per cent in their seventh, 97 per cent in their eighth, 94 per cent in their ninth, and 92 per cent in their eleventh. All the fish in their tenth, twelfth, thirteenth and fourteenth years were mature.

The apparent tendency for some ciscoes to never reach maturity may have resulted from classifying fish as immature when they were really mature but not spawning during the current season.

The tendency for lake trout, Cristivomer namaycush, to spawn only once in two or three years has been recorded by Miller and Kennedy (in press) and there is evidence of a similar tendency among the whitefish and ciscoes, although the evidence is not so complete.

Round Whitefish

Scale samples were taken from the round whitefish which were captured. The scales were used to determine ages by the method described above for whitefish.

Table 14 shows the frequency distribution by age of the lengths of the 74 round whitefish whose ages were determined. All were taken in gill nets. Table 14 illustrates the increase in length with age. Only the older fish are represented in the sample.

There was a predominance of females in all age groups except for fish in their sixth and eighth summers, where the sexes were about equally represented. The two sexes appeared to have the same rate of growth.

The relationship of average length and average weight to age is shown in Table 15. Weight increases approximately as the 3.8 power of the length.

Fifty per cent of the fish in their sixth year, 91 per cent of those in their seventh year and 88 per cent of those in their ninth year were mature as were all the other shown in Table 14.

STOMACH ANALYSES

Whitefish

The stomachs of 202 large whitefish were examined, of which 86 contained food and 116 were empty. The main item of food was molluscs of which sphaeriids formed the major part. Small crustacea, mostly amphipods, but including copepods and Mysis were the next most important item. Other plankton, aquatic insect larvae, terrestrial insects and horsehair worms were also eaten. These data are summarized in Table 16.

Ciscoes

The stomachs of 198 large ciscoes were examined, of which 135 contained food and 63 were empty. Various microplankters, which we did not attempt to identify, were the principle food of the ciscoes. Mysis was the principle organism which was large enough to be readily identified. Some ciscoes had eaten chironomid larvae and pupae. Terrestrial insects were also an item of diet. One cisco had eaten a small fish about an inch and a half long, which appeared to be a young cisco. These data are summarized in Table 17.

Round Whitefish

The stomachs of 72 large round whitefish were examined, of which 45 contained food and 27 were empty. The main item of diet was aquatic insect larvae, mostly caddis fly larvae, but including chironomid, mayfly and cranefly larvae. Terrestrial insects were next in importance. Plankton and molluscs were also eaten. These

data are summarized in Table 18.

SUMMARY

General

1. Three species of coregonines were found in Great Bear Lake.
2. A statistical technique is used for morphological comparisons. This technique is explained and illustrated.
3. The importance of taking account of the effect of preservatives, and of minor differences in technique when comparing measurements made by different ichthyologists is emphasized.

Whitefish

4. Whitefish were only abundant in river mouths, and were present in small numbers in protected bays. They were scarce in the open lake.
5. Although there are local concentrations of whitefish at spawning time, it seems unlikely that they could support a fishery appreciably greater than the present domestic fishery.
6. Whitefish from three localities were found to differ among themselves morphologically. These differences appear to result from differences in the environment.
7. These whitefish grow at a rate comparable with that in southern lakes, and some live a comparatively long time. The two sexes grow at approximately the same rate. They mature in their seventh, eighth or ninth year.

8. There are about equal numbers of males and females.
9. The results of stomach analyses are tabulated.

Ciscoes

10. Ciscoes were found almost exclusively in non-marshy bays and apparently avoided both the colder open lake and the warmer river mouths and marshy bays.

11. The local concentration of ciscoes in Franklin Bay could probably maintain only slightly more than the present domestic fishery. Smaller concentrations in Echo Bay and Lindsley Bay are not being exploited.

12. Ciscoes from two localities differed morphologically. These differences are assumed to be the result of different environments.

13. These ciscoes grow at much the same rate as ciscoes in southern waters. The two sexes grow at approximately the same rate. Most of the ciscoes mature in their fifth or sixth year.

14. There were about equal numbers of males and females.

15. One cisco appeared to represent a dwarf race.

16. The results of stomach analyses are tabulated.

Round Whitefish

17. Round whitefish were scarce in the open lake and marshy bays and were generally found where there was a noticeable current.

18. Round whitefish were not taken in quantity anywhere.

19. Proportional measurements of a small sample of round whitefish are tabulated.

20. Growth rate is indicated. The two sexes grow at about the same rate. Most of them mature in their sixth or seventh year.

21. There were more females than males.

22. The results of stomach analyses are tabulated.

Table 1. The average number of coregonines caught per set in different general types of habitat in Great Bear Lake during the summer of 1945.

General type of Habitat	Number of sets	Mean number of fish per set		
		Whitefish	Ciscoes	Round Whitefish
Inshore area of open lake	21	0.05	0.2	0.05
Non-marshy bays	22	0.6	14.	2.6
Marshy bays	10	1.0	0	0.2
Other river mouths	8	6.	0	2.
Johnny Hoe River mouth	3	6.0	0.3	0
Total number of fish caught		270	289	77

Table 2. The percentage of each species of coregonine caught in each size of mesh in Great Bear Lake during the summer of 1945.

Species	Mesh size				
	2"	3"	4"	5"	5½"
Whitefish	9	28	21	25	17
Ciscoes	42	55	2	1	0
Round Whitefish	57	36	4	3	0

Table 3. The factors by which measurements of preserved fish from Great Bear Lake, 1945, were multiplied to give the probable fresh measurements.

Measurement	Whitefish	Cisco
Standard length	1.08	1.04
Head length	1.04	1.00
Head depth	1.00	1.00
Eye diameter	1.00	1.04
Snout length	1.08	1.05
Maxillary length	1.00	1.00
Interorbital width	1.00	1.05
Caudal peduncle length	1.15	1.11
Caudal peduncle depth	1.00	1.00
Body depth	1.00	1.00
Body width	1.00	1.00
Dorsal fin length	1.00	1.00
Dorsal fin base	1.00	1.00
Anal fin length	1.00	1.00
Anal fin base	1.06	1.00
Pectoral fin length	1.09	1.05
Pelvic fin length	1.05	1.06

Table 4. A description of a sample of 52 mature Coregonus clupeaformis from Great Bear Lake, 1945, and a probable description of the population from which the sample was taken.

Body Parts	Relationship between standard length and average size of part within the sample where X = log standard length Y = log size of part	Average values of proportional parts as determined from the sample when standard lengths are:		The probable limits (1 chance in 20 of error) of the amounts by which:		Values of proportional parts for individual fish from the population can differ from the average values of the sample.
		360 mm	680 mm	At extremes of the size range sampled.	Average values of proportional parts in the whole population differ from the values of the sample:	
Head Length	Y = 0.973X - 0.612	208	205	+5	+2	+17
Head Depth	Y = 0.960X - 0.747	141	138	+4	+2	+13
Eye	Y = 0.545X - 0.190	44	33	+3	+1	+8
Snout	Y = 1.155X - 1.631	58	64	+4	+1	+11
Maxillary	Y = 1.263X - 1.905	59	69	+3	+1	+9
Interorbital	Y = 1.152X - 1.630	57	63	+2	+1	+7
C. P. Length	Y = 0.913X - 0.766	102	97	+7	+4	+20
C. P. Depth	Y = 0.901X - 0.826	83	78	+3	+1	+9
Body Depth	Y = 1.036X - 0.683	256	262	+11	+4	+33
Body Width	Y = 1.058X - 1.068	120	125	+7	+3	+21
Dorsal H.	Y = 0.742X - 0.108	170	145	+7	+3	+22
Dorsal B.	Y = 0.970X - 0.855	117	115	+6	+2	+17
Anal H.	Y = 0.891X - 0.634	122	114	+5	+2	+15
Anal B.	Y = 0.914X - 0.729	112	106	+4	+2	+11
Pectoral	Y = 0.910X - 0.523	176	167	+7	+3	+20
Pelvic	Y = 0.866X - 0.430	168	155	+8	+3	+22

Table 5. A description of 26 immature Coregonus clupeaformis from Great Bear Lake, 1945, and a probable description of the population from which the sample was taken.

Body Parts	Relationship between standard length and average size of part within the sample where X = log standard size Y = log size of part	The probable limits (1 chance in 20 of error) of the amounts by which:			
		Average values of proportional parts as determined from the sample when standard lengths are:		Average values of proportional parts in the whole population differ from the values of the sample:	Values of proportional parts for individual fish from the population can differ from the average values of the sample.
		210 mm	420 mm	At extremes of the size range sampled	At the average standard length 320 mm
Head Length	Y = 0.889X - 0.415	212	197	7	+17
Head Depth	Y = 1.128X - 1.193	127	138	6	+12
Eye	Y = 0.580X - 0.312	51	39	2	+5
Snout	Y = 1.0636X - 1.421	53	56	5	+12
Maxillary	Y = 0.893X - 0.961	62	58	3	+8
Interorbital	Y = 1.072X - 1.445	53	55	3	+7
C. P. Length	Y = 1.028X - 1.038	107	109	7	+18
C. P. Depth	Y = 0.990X - 1.066	81	81	3	+8
Body Depth	Y = 1.267X - 1.304	207	248	13	+32
Body Width	Y = 0.984X - 0.894	117	116	10	+26
Dorsal H.	Y = 0.800X - 0.274	182	159	12	+30
Dorsal B.	Y = 1.218X - 1.498	102	118	8	+20
Anal H.	Y = 0.911X - 0.719	118	112	7	+18
Anal B.	Y = 1.017X - 1.022	104	105	8	+21
Pectoral	Y = 0.945X - 0.662	162	156	8	+20
Pelvic	Y = 0.903X - 0.566	162	152	8	+19

Table 6. A summary of counts of body parts of whitefish from Great Bear Lake, 1945.

Body Part	Number counted	Range in count	Average count	Standard deviation = "s"
Vertebrae	49	59-64	61.8	±1.1
Dorsal Rays	78	12-16	13.7	±0.8
Anal Rays	78	12-16	13.8	±1.0
Branchiostegals	78	8-10	9.2	±0.5
Scales	57	72-85	77.8	±3.1
Gill Rakers	77	23-31	27.0	±1.5

Table 7. A description of 77 mature *Leucichthys artedii* from Great Bear Lake, 1945, and a probable description of the population from which the sample was taken.

Body Parts	Relationship between standard length and average size of part within the sample where X = log standard length Y = log size of part	Average values of proportional parts as determined from the sample when standard lengths are:		The probable limits (1 chance in 20 of error) of the amounts by which:		
		230 mm	350 mm	Average values of proportional parts in the whole population differ from the values of the sample	At extremes of the size range sampled	At the average standard length 300 mm
Head Length	Y = 0.887X - 0.405	212	203	±4	±2	±14
Head Depth	Y = 0.944X - 0.726	138	135	±4	±1	±12
Eye	Y = 0.571X - 0.271	52	43	±2	±1	±6
Snout	Y = 1.012X - 1.343	48	49	±2	±1	±6
Maxillary	Y = 0.859X - 0.804	73	69	±2	±1	±7
Interorbital	Y = 0.874X - 0.922	60	57	±2	±1	±8
C.P. Length	Y = 0.922X - 0.747	117	114	±6	±3	±21
C.P. Depth	Y = 0.879X - 0.831	76	72	±3	±1	±9
Body Depth	Y = 1.264X - 1.300	211	236	±8	±3	±28
Body Width	Y = 1.096X - 1.152	119	124	±6	±2	±19
Dorsal H.	Y = 0.833X - 0.436	147	138	±4	±2	±15
Dorsal B.	Y = 1.108X - 1.247	102	107	±6	±2	±19
Anal H.	Y = 1.001X - 1.035	93	93	±4	±2	±14
Anal B.	Y = 1.203X - 1.533	89	96	±4	±2	±14
Pectoral	Y = 0.954X - 0.735	143	140	±6	±2	±19
Pelvic	Y = 0.864X - 0.523	143	135	±5	±2	±16

Table 8. A summary of counts of body parts of ciscoes from Great Bear Lake, 1945.

Body Part	Number Counted	Range in count	Average count	Standard deviation = "s"
Vertebrae	90	56-62	59.4	±1.1
Dorsal Rays	88	12-15	13.3	±0.7
Anal Rays	88	12-15	13.5	±0.8
Branchiostegals	88	7-10	8.5	±0.6
Scales	18	73-84	78.6	±2.8
Gill Rakers	87	41-50	45.0	±2.0

Table 9. Proportionate measurements and counts of body parts of 8 fresh round whitefish taken in Great Bear Lake, 1945.

	Fish Number							
	1	2	3	4	5	6	7	8
Standard length	251	251	253	267	278	280	298	305
Head length	191	187	178	202	190	189	188	197
Head depth	120	123	107	127	126	122	121	125
Eye	40	42	40	43	41	39	40	39
Snout	46	44	43	49	50	43	45	46
Maxillary	42	42	38	45	43	39	42	46
Interorbital	52	50	47	58	52	50	54	54
Caudal Peduncle length	107	139	134	135	133	125	131	122
Caudal Peduncle depth	76	72	67	73	72	73	67	67
Body depth	179	198	170	187	205	179	187	180
Body width	131	128	130	135	126	111	128	124
Dorsal height	139	131	134	142	137	140	131	133
Dorsal base	131	123	134	124	119	122	121	118
Anal height	104	92	103	112	-	100	104	108
Anal base	92	100	87	90	90	82	87	85
Pectoral length	139	135	123	150	140	136	131	138
Pelvic length	115	115	107	124	119	118	114	124
Dorsal rays	15	14	15	14	14	15	15	13
Anal rays	13	11	11	12	12	13	12	12
Branchiostegals	7	7	7	7	7	8	7	7
Scales	86	87	102	-	-	-	-	90
Gill Rakers	21	21	18	17	20	20	18	20

Table 11. The relationship between the average length in inches, the average weight in ounces and age of whitefish taken from Great Bear Lake in 1945.

	Age											
	V	VI	VII	VIII	LX	X	XI	XII	XIII	XIV	XV	XVI
Length	11.0	11.5	14.7	16.2	17.9	18.8	19.4	20.5	20.8	21.7	22.1	22.8
Weight	9	15	26	34	46	54	61	67	65	79	88	94

Table 12. The frequency distribution by age of the lengths of ciscoes caught in Great Bear Lake, 1945.

Length to nearest inch.	Age													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
3	5	3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	3	1	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	2	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	1	2	-	-	-	-	-	-	-	-	-
8	-	-	-	-	3	-	-	-	-	-	-	-	-	-
9	-	-	-	-	9	-	-	-	-	-	-	-	-	-
10	-	-	-	-	4	6	-	-	-	-	-	-	-	-
11	-	-	-	-	-	12	7	3	1	-	-	-	-	-
12	-	-	-	-	-	13	23	43	7	1	-	-	-	-
13	-	-	-	-	-	-	25	53	17	4	4	1	1	1
14	-	-	-	-	-	-	2	6	9	12	2	3	-	-
15	-	-	-	-	-	-	-	1	2	3	1	-	-	-
16	-	-	-	-	-	-	-	-	-	-	1	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	6	3	1	18	31	57	106	36	20	13	6	2	1

Table 13. The relationship between the average length in inches, the average weight in ounces and age of ciscoes taken from Great Bear Lake in 1945.

	Age						
	V	VI	VII	VIII	IX	X	XI
Length	10.0	11.2	12.4	12.6	13.1	13.8	14.0
Weight	8	9	13	14	16	18	18

Table 14. The frequency distribution by age of the lengths of round whitefish caught in Great Bear Lake, 1945.

Length in inches	Age							
	VI	VII	VIII	IX	X	XI	XII	XIII
10	-	1	-	-	-	-	-	-
11	1	2	-	-	-	-	-	-
12	-	-	3	2	-	-	-	-
13	3	1	7	6	-	-	-	-
14	1	5	7	4	1	-	-	-
15	11	1	-	6	1	1	-	-
16	-	1	3	3	-	1	-	-
17	-	-	2	1	3	-	-	-
18	-	-	-	1	-	1	-	-
19	-	-	-	1	-	-	-	1
20	-	-	-	-	1	-	-	-

Table 15. The relationship between the average length in inches, the average weight in ounces and the age of round whitefish taken from Great Bear Lake in 1945.

	Age				
	VI	VII	VIII	IX	X
Length	12.9	13.3	13.9	14.5	16.6
Weight	14	14	16	19	32

Table 16. The frequency of occurrence of various food items in Great Bear Lake whitefish stomachs based on an examination of 86 stomachs which contained food (an additional 116 were empty).

Food item	Number which contained it exclusively	Number which contained it with or without other items
Molluscs	50	69
Small Crustacea	7	18
Unclassified plankton	1	17
Aquatic Insect larvae	1	7
Terrestrial insects	1	5
Gordiacea	0	1

Table 17. The frequency of occurrence of various food items in Great Bear Lake cisco stomachs based on an examination of 135 stomachs which contained food. (An additional 63 were empty).

Food item	Number which contained it exclusively	Number which contained it with or without other items.
Unclassified plankton	98	106
Mysis	10	21
Chironomid larvae and pupae	0	2
Terrestrial insects	12	21
Fish	0	1

Table 18. The frequency of occurrence of various food items in Great Bear Lake round whitefish stomachs based on an examination of 45 stomachs which contained food. (An additional 27 were empty).

Food item	Number which contained it exclusively.	Number which contained it with or without other items.
Molluscs	2	2
Aquatic insect larvae	21	25
Unclassified plankton	4	5
Terrestrial insects	14	17