



MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 320

AN EXAMINATION OF CLEAR LAKE, RIDING MOUNTAIN NATIONAL
PARK, MANITOBA

by

D. S. Rawson

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An Examination of Clear Lake, Riding Mountain Park.

By arrangement of the Parks Branch of the Department of Interior and the Fish Culture Branch of the Department of Fisheries the author made a brief examination of Clear lake in the Riding Mountain Park, in the period May 27-June 12, 1935. The examination included observations of the size and nature of the lake basin, certain physical and chemical conditions in the water, the nature and amounts of plankton and bottom fauna present and the various species of fish in the lake. Earlier reports on the lake by various persons were also examined with care.

In the following report the various findings are first recorded, there follows a discussion of the general situation and finally recommendations for a possible fish cultural procedure, since this was the reason for the investigation.

The Size and Nature of the Clear Lake Basin

Size and Shape.

Clear lake is shown on the accompanying sketch map to have an extreme length of 6.5 miles and a greatest width of 2.5 miles. The main part of the lake, about two miles by five has its axis in a north west direction while a narrow bay extends about two miles to the east. The area of the lake is 9.5 square miles. It should be noted that the map presented by Rajkov in his report of 1932 was inverted, the scale erroneously indicated as 1 mile = 0.5 inch and the area referred to as 22 square miles. Martin in his report of 1934 gives the area as "approximately eighteen square miles". The area is regarded as being of particular importance in planning a fish cultural procedure.

Since the lake is of considerable size and lies with its long axis in the direction of the prevailing winds most of the shores are exposed and somewhat barren, even in the narrow bay to the east. A rough examination of

this shoreline indicated that about 60% was of coarse gravel and stones, 30% of sand and 10% with emergent vegetation, chiefly Scirpus (Ballrush) beds. Most of this vegetation is found along the north margin of the north west part of the lake. The shoreline is moderately irregular, its total length being measured from the map as 19.9 miles, indicating a shore development of 1.54. (The degree of irregularity of a lake shore is expressed as shore development, the ratio of actual shore length to the perimeter of a circle of area equal to that of the lake).

Depth

Soundings were taken in five series across the lake during the process of dredging. Others were taken when setting gill nets and in exploring areas not touched in dredging. A total of 67 soundings were taken, all with a tarred cotton line graduated in metres and checked for stretching. The observations were difficult to correlate with the depth contours indicated in Bajkov's map of 1932 and drawn "after more than 100 soundings". The greatest differences were in the position of the five metre contour in the north west bay, the failure to locate any depth greater than 31 metres where Bajkov indicates 35 and the observation of depths up to 31 metres in the rather narrow neck of the east bay. In regions where our data were too meagre an attempt was made to incorporate Bajkov's figures. The resulting map will at least serve to indicate the main features of the lake bottom.

The relative areas of the depth zones indicated on the map have been calculated as follows:

0 - 5 m. zone - 25%	20 - 25 m. zone - 10%
5 - 10 m. " - 20	25 - 30 m. " - 10
10 - 15 m. " - 16	30 m. " - 6
15 - 20 m. " - 13	

It is seen that 75 per cent of the lake is less than 20 metres and 45 per cent less than 10 metres. Using the same data the average depth of the lake has been calculated as 13.2 metres or 43 feet. Bajkov 1932, states that "the average depth was calculated as 20 metres" but does not indicate the basis of the calculation.

The relative volumes of the various depth strata have been calculated as percentages of the total volume of the lake. These values are necessary for the determination of mean temperature of the lake.

0 - 5 m. stratum - 32%	29 - 25 m. stratum - 8%
5 - 10 m. " - 25	25 - 30 m. " - 4%
10 - 15 m. " - 18	30 - m. " - 1%

Although the lake is more than 30 metres in depth it will be seen that only a small amount (13%) of its volume lies below the 20 m. level. The total volume of the lake was calculated as 229 million cubic metres.

Clear lake is of similar depth but only one third the area of Waskeiu lake in the Prince Albert National Park, Saskatchewan. Since the lakes are somewhat similar in their physical and chemical conditions their comparative measurements might be recorded.

	Clear L., Man.	Waskesiu L. Sask.
Area	9.5 sq. mile	27 sq. mi.
Depth maximum	31 m.(103 ft.)	24 m.(79 ft.)
mean	13.2 m.(43 ft.)	11.1 m. (36 ft.)
Volume	229 x 10 ⁶ cu. m.	770 x 10 ⁶ cu. m.
Shore length	17 mi.	75 mi.
Shore development	1.5	2.6
Elevation	2016 ft.	1740 ft.
Mean Ann. Temp.	about 32.0°C.	32.0°C.

From this data and from that presented later with respect to temperature it would seem that Bajkov's designation of Clear lake as a "Subalpine" type is hardly justified. It is certainly not a "typical prairie lake" but it is quite comparable to certain other lakes in the well wooded part of the Canadian zone, Waskesiu lake providing an example.

Drainage and Water Level.

Clear lake has a relatively small drainage basin of about 75 square miles and the inflow of water into the lake is therefore rather limited. Of the five or six streams which enter the lake, three which flow continuously, arise chiefly from springs which are not far from the lake and the remaining streams depend chiefly on surface drainage having therefore only intermittent flow. There are also a number of springs visible along the lake shore and emptying directly into it.

The outlet, referred to as Wasemin creek, leads into the Minnedosa river and thence into the Assinaboine. From 1930 to the time of examination, June 1, 1935, there had been no outflow and the level of the lake had dropped by almost two feet. It should be noted that a low barrier had been erected across the

mouth of the creek and that the channel had become filled with sand. It is doubtful however if the level was ever sufficiently high in this period to cause an outflow even in the absence of these barriers. It is understood that during the past summer, 1955, increased precipitation resulted in a rise in level sufficient to cause a temporary outflow over the barrier.

This situation is of considerable importance to the fish of the lake. It has resulted in the cutting off of South lake which was undoubtedly the chief spawning ground of the pike. The weedy shores of the north west part of the lake have also been damaged as spawning and probably as feeding grounds. It is possible, of course, that in the event of this lower level persisting long enough the shore flora and fauna will be re-established at a new level. It is probably a more serious matter, that the absence of outflow if continued will eventually result in an undesirable increase in the already considerable salt content of the water.

It has been pointed out that any considerable increase in the level of the lake might endanger certain improvements which have been made along the shoreline, particularly in the region of the townsite. In view of this situation we could not maintain that the improvement in biological conditions resulting from raising the lake level would be great enough to warrant this procedure. It is clear, however, that an increased flow of water through the lake would be beneficial even if the present level were maintained. It is understood that the possibility of diverting additional drainage into Clear lake is being investigated.

Physical and Chemical Conditions in Clear Lake

Temperature.

The lake is frozen over for from 5 to 5 1/2 months each year, the freeze up occurring about the first of December and the ice breaking up early in May (May 10, 1935). In the present investigation temperature was observed from surface to bottom in three series at approximately weekly intervals. These observations were made at Station I in the deep water region and the instrument used was a deep sea water bottle with a Negretti and Zambra reversing thermometer. Three further series taken by Bajkov in 1932 and 1933 have been included in Table I.

The data from table I were used in plotting graph I and will be more readily interpreted in that form. Complete circulation of the water would occur when the ice went out on May 10. On May 31 the surface water was (10.5°C.) three degrees warmer than the bottom which would check circulation in some degree but in the week that followed strong winds, rain and snowstorms occurred and on June 6 the lake was again completely mixed. On June 12 the surface was again almost three degrees warmer than the bottom. It is assumed that this warming of the upper layers continued until thermal stratification was established. On July 10, 1933 Bajkov found a very marked stratification the thermocline lying between 10 and 15 metres. On August 14 of the same season the thermocline had been forced down to a position between 15 and 20 metres. It is therefore probable that a fairly definite stratification occurs in Clear lake in most years. On September 5, 1932, the lake had cooled considerably and was almost completely mixed but there still remained a slight indication of stratification in the lowest 5 meters. Whether or not the stratification will have any considerable effect on the fish life in the lake can be better judged

when the amounts of oxygen present have been discussed.

Dissolved Oxygen.

The amount of oxygen was determined by Miller's method, in water samples taken along with the temperature series of May and June 1935. There are included also Bajkov's observations of dissolved oxygen in midsummer 1933 and on September 10, 1932. The latter values are expressed in p.p.m. which is assumed to mean mgm. per litre. They have been converted to equivalent values in c.c. per litre which are used in our own results.

	Dissolved oxygen in c.c. per litre.				
	May 31'35	June 6'35	June 12'35	Midsummer '33	Sept.10'32
Surface	6.9	7.0	6.8	8.7	6.6
15 m	6.1	6.6	6.9	-	-
30 m	5.2	5.9	5.9	5.2*	4.3

* 20 m. depth but below the thermocline.

On May 31, 1935, the surface water contained 6.9 c.c. oxygen per litre which is practically saturation value for a temperature of 10.5°C. at this elevation (2016 ft.). The bottom water with 5.2 c.c. is about 70% saturated showing therefore a beginning of bottom oxygen deficiency after the spring circulation and renewal. The storms between May 1 and 4 increased the bottom oxygen to 5.9 c.c. with a saturation of more than 80%. Bajkov reports (1933) that "the surface oxygen does not drop below 12.5 p.p.m. (8.7 cc./l) even in the hottest weather". Since he records surface water temperature as 22°C. this amount of oxygen represents a supersaturation of more than 150% which seems unusually high for a minimum. In the deeper water, at a depth of 20 m. he found no less than 7.5 p.p.m. (5.2 c.c./l) which again seems very high for a lake with the degree of thermal stratification indicated above. In Waskesiu lake at a similar depth and with the same degree of stratification the oxygen of the deeper water usually falls below 30 c.c. per litre and often much lower.

Since the value quoted for Clear lake is for a depth of 20 m. it is probable that a much lower oxygen value prevailed at bottom (30 m.). On September 10, 1932, when thermal stratification had been almost destroyed Bajkov's observations show the bottom oxygen to be still as low as 6.1 p.p.m. (4.3 cc/l) which would indicate that stagnation had at least exceeded that shown by his figures for midsummer.

It is therefore impossible to say what degree of summer stagnation and oxygen deficiency exists in Clear lake but it seems probable that a considerable reduction of oxygen would take place. It is not expected that it would be as severe as that in Waskesiu lake where the bottom temperature sometime rises as high as 15°C.

The pH of Clear lake was determined colorimetrically on June 12, 1935 for the surface water 8.3 and at bottom 7.6. Bajkov 1932 indicates a determination of 8.4. This is within the usual range for lakes of this general type, the surface water of Waskesiu lake varying from 8.0 to 8.3.

The mineral analysis recorded by Bajkov 1932 indicates a total residue of 240 p.p.m. Waskesiu lake has about 200 p.p.m. and Halkett lake also in the Prince Albert Park 276 p.p.m., the latter lake having no visible outlet. The mineral constituents in the Clear lake water resemble those of Halkett lake rather closely, particularly in the comparatively large amounts of magnesium and sulphates.

The Plankton.

Plankton samples were taken on May 31 and on June 6 at Station I. The net used was an old one of number twenty bolting cloth. It had a mouth of 12 cms. diameter and was of the Wisconsin pattern, closing by means of a messenger and release. The samples taken on each date included a vertical series at 10 metre intervals, a total vertical haul and a surface tow. Since the survey was made on short notice it was impossible to obtain new nets. The efficiency of the net used was so low as to make it useless for truly quantitative sampling but a rough comparison was obtained by using the same net in Wasquesiu lake before, and in Okanagan lake after, examining Clear lake. The general impression obtained in this way was that the plankton of Clear lake at this season was somewhat meagre as compared with that of the above mentioned lakes at approximately the same season.

From a qualitative examination of the hauls it was apparent that a great variety of species were represented and that the Copepods formed the bulk of most samples. Representatives of 39 genera of plankton organisms have been identified in these collections. They are listed as abundant A, common C, occasional O or rare R. It should be remembered that these collections were made in a brief part of the season.

Copepoda			
Diaptomus spp.	A	Peridinium sp.	C
Epischura lacustris	O	Codonella sp.	O
Cyclops sp.	A	Cyphoderia sp.	R
Cladocera		Diatomaceae	
Bosmina longirostris	C	Melosira sp.	A
Daphnia longispina	O	Asterionella sp.	A
Eurycerus lamellatus	R	Stephanodiscus sp.	A
Holopedium gibberum	R	Fragillaria sp.	C
Chydorus sphaericus	R	Tabellaria sp.	O
Leptodora kindtii	R	Surirella sp.	O
		Cymbella sp.	R
		Gomphonema sp.	R
		Synedra sp.	R
		Cymatopleura sp.	R

Rotifera		Chlorophyceae	
Polyarthra platyptera	A	Pediastrum sp.	O
Notholca longispina	C	Dietyosphaerium sp.	O
Anuraea aculeata	O	Staurostrum sp.	R
Anuraea cochlearis	O	Unicellular green algae	O
Philodina sp.	O		
Triarthra sp.	O	Myxophyceae	
Asplanchna sp.	R	Microcystis sp.	R
Nerommatid form?	R	Oscillatoria sp.	R
Protozoa			
Dinobryon sp.	A		
Ceratium sp.	C		

The zooplankton forms made up the bulk of the collections. It is possible that at this early period the algae had not yet entered on their general spring "pulse" although the diatoms were already abundant. The dominant forms included three Copepods, Diaptomis, Epischura and Cyclops, two Cladocera, Bosmina and Daphnia, the rotifer Polyarthra, the colonial protozoan Dinobryon and three diatoms, Melosira, Asterionella and Stephanodiscus. Specimens of almost every form were taken in the surface tows and many of them were not found in samples from the deeper water. A few forms, notably Cyclops and the rotifer Triarthra were more abundant in the deeper water than at the surface. The deep water collections were almost completely made up of copepods, rotifers and a few diatoms.

With the exception of the Chlorophyceae and Myxophyceae (Green and Blue-green algae) the plankton of Clear lake appears to include a rich variety of forms and it is probable that these algae would be more abundant later in the season.

No quantitative data have been reported by Bajkov but in his report of 1933 he states that the plankton is "very rich" and that "many quantitative samples show that it can be placed among the richest of Manitoban lakes". As

to the identity of the organisms he indicates that they are all listed in a special report, presumably the general paper on the plankton of the Lake Winnipeg drainage area, Bajkov 1934. In this paper we find only 12 species listed as occurring in Clear lake and note also that two forms, mentioned in the report of 1932 as characteristic of Clear lake are not listed - namely the diatom Rhoicosphenia curvata and Salpina, Spinigera (sic) presumably the rotifer Salpina spinigera. The same statement occurs in a paper published earlier, Bajkov 1930.

The Bottom Fauna

The bottom fauna of the open lake was sampled with an Ekman Dredge bringing up an area of 500 sq. cms., the samples thus obtained being washed through two screens, one of wire mosquito netting and a second of silk bolting cloth of about 400 meshes to the square inch. Thirty-two dredgings were taken at various depths and in five series or lines across the lake, the location of each dredging being shown on the accompanying map. A few additional qualitative collections were made in shallow water and different places along the shoreline. The study was not sufficiently extensive to warrant minute identification of the organisms, and only a few of the dominant forms have been identified to species. The composition of the bottom fauna is indicated briefly in the following paragraphs.

INSECTA.

The aquatic stages of three insect groups were represented in the open water.

Chironomidae - Numerically more than half of the bottom population were chironomid larvae. The larger species Chironomus hyperboreus and C. plumosus were especially abundant in the deep (15-30 m.). The smaller forms included

several genera chiefly Chironomus, Cryptochironomus, Allochironomus, Poly-pedilus and Tabypus.

Ephemeroptera - The mayfly nymphs were not numerous but widespread and of large size. Most of the specimens in the open water were of the large burrowing type, Hexagenia.

Trichoptera - Caddis larvae were scattered in small numbers over the shallower water (0-10 m.). They occurred in only 5 of 32 samples.

A greater variety of insect larvae and adults have been collected in the shore area but as yet have not been identified.

MOLLUSCA

Gastropods - In the shore region the large snails Lymnaea stagnalis, Stagnicola sp. and a large species of Planorbis were common. In the dredgings Amnicola were the most common. Valvata tricarinata and a small species of Planorbis occurring in moderate numbers. Practically all the gastropods were confined to the upper 15 metres.

Pelecypods - Large clams of the genus Anodonta were common in shallow water. The minute sphaeriid form, Pisidium occurred at all depths and formed an important fraction of the bottom fauna.

CRUSTACEA.

Amphipoda - The small fresh water shrimp Hyalella azteca was found in moderate numbers in the upper 15 metres and amounted to about seven per cent of the fauna numerically.

Decapoda - Numerous specimens of the crayfish Cambarus virilis were observed along the rocky shores and in the stomachs of whitefish.

Three other groups the Oligochaeta, Hirudinea (Leeches) and Ostracoda were represented by small numbers in the open water region.

The greatest variety of organisms was found in the shallow water, all of the above groups being represented in depths of 0-10 metres. Between 10 and 20 metres there were no leeches or caddis larvae but the gastropods and mayfly nymphs were still present in fair numbers. In the deep water, 20 to 30 metres, only three forms were common, chironomid larvae, Pisidium and oligochaete worms.

The quantitative results, both numerical and gravimetical are recorded in table II. The average number of organisms per dredging is seen to be 96.5. Of this number the chironomid larvae make up about 50 per cent, Pisidium 25, gastropods 10, amphipods 7 and oligochaetes 5.

The number 96.5 organisms per dredging is equivalent to 1930 per sq. metre (1610 per sq. yard). This represents a fairly dense population which may be compared with 1363 per sq. m. in Paul lake, B.C., 875 in Lake Nipigon and 820 in Lake Simcoe, Ont. In 1933 Bajkov's report based on "several hundred dredgings" indicates 409,874,000 organisms per sq. mile in depths of 0-60 ft. which is equivalent to only 160 per sq. metre. This value seems low for a lake of this type and the discrepancy is too great to be accounted for by seasonal variation or difference in sampling technique.

The weight of each dredging was determined with a balance accurate to the nearest milligram. The mollusca were weighed separately and a percentage deducted equivalent to the weight of their shells. On this basis the average wet (equivalent to "live") weight per dredging was found to be 0.566 grams; this is the result of simply averaging the weights of all dredgings and does not take into account the greater extent of the shallow water. It was found that weighting the average according to the relative area of the depth zones resulted in only a negligible change of the simple average, 0.566 grams.

The weight of .566 gm. wet weight, with mollusc shell deducted is equivalent to .113 gm. dry weight per dredging. This is equivalent to 22.6 kilograms per hectare or 20.1 lbs. per acre. The weight of bottom organisms is regarded as a better index to the richness of the bottom population than the numbers. This weight for Clear lake may be compared with values for some other lakes as follows:

	Area sq. mi.	Av. Depth ft.	Bottom fauna lbs. dry wt. per acre
Paul lake, B.C.	1.5	112	32.5
L. Mendota, Wisc.	15.0	45	42.9
Green L., Wisc.	12.0	100	24.0
<u>Clear L., Man.</u>	<u>9.5</u>	<u>43</u>	<u>20.1</u>
Waskesiu L., Sask.	27.0	36	13.7
L. Simcoe, Ont.	280.0	50	9.6
L. Nipigon, Ont.	1750.0	180	5.2

Comparing these values it may be concluded that the quantity of bottom fauna in Clear lake is about as great as would be expected in a lake of that size and depth.

Rajkov in 1933 indicates a "rough weight" of organisms in the 0-60 ft. region of 12.380 kgm. per sq. mile. This is approximately the equivalent of 7.6 lbs. dry wt. per acre mollusc shell deducted. Again this value seems very low although the discrepancy is not so great as in the case of the numbers of organisms.

The Fish

Samples of the fish population were obtained by the use of gill nets and a seine. The gang of gill nets included five pieces, 25 yards each of meshes 1 1/2", 2" and 3" and 50 yards each of 4" and 5 1/2". This gang was set, left over night and lifted in nine locations in different depths as indicated on the map. The seine was 20 feet in length and of 1/4" mesh.

The fish taken in the gill nets were examined as to numbers, species, size and stomach contents. The scales of representative specimens were taken for age determination. The catches in the various "sets" are summarized in Table III in which they are arranged in order of depth.

The Whitefish, Coregonus sp.

In 1929 Bajkov described a whitefish from Clear lake as a new species Coregonus o'donoghuei. The 55 specimens examined by the writer are considered to be C. clupeaformis no specimens being taken which could be identified as C. o'donoghuei. The 55 individuals ranged from 17* cms. 2 oz. to 47 cms. 3 1/2 lbs. and were widely distributed since they were taken in eight of the nine settings. Table III shows that most of the specimens were from depths greater than 10 metres and that the largest catch 19 was from the deepest set 30 metres.

The white fish are not large and the scale examination of 12 specimens indicates a low rate of growth. For comparison the average weights and lengths of four year groups are indicated for Clear lake and for Waskesiu lake.

Whitefish from		3 yrs.	5 yrs.	8 yrs.	11 yrs.
Clear L.	Length	17 cms.	23 cms.	30 cms.	38 cms.
	Weight	3 oz.	7 oz.	14 oz.	2 lbs. 3 oz.
Waskesiu L.	Length	23 cms.	32 cms.	42 cms.	50 cms.
	Weight	7 oz.	1 lb. 2 oz.	2 lbs. 4 oz.	4 lbs. 2 oz.

The differences in growth rate might be due to a variety of causes, including a real difference in the identity of the white fish of the two lakes. It is at least clear that the difference is unlikely to be due to food supply since the bottom organisms of Clear lake are more abundant than those of Waskesiu.

* All lengths recorded herein are from the tip of the snout to the end of the caudal peduncle (base of tail fin).

The stomach contents of 32 specimens of all sizes and taken at various times and depths, have been examined. The average quantity (by volume) of the following organisms occurring in the stomachs is indicated as a percent of the total.

Chironomid larvae and pupae	40%
Crayfish (<u>Cambarus</u>)	20
Gastropods chiefly (<u>Amnicola</u>)	15
Pelecypods (<u>Pisidium</u>)	12
Mayfly nymphs (<u>Hexagenia</u>)	6
Amphipoda (<u>Hyalella</u>)	5

Small numbers of Hydrachnids (water mites) and Ostracods were also observed. No great differences were observed in the food of smaller and larger specimens although crayfish and the larger gastropods were found only in specimens of more than 25 cms. length. The chironomid larvae are probably the chief food of the whitefish as in Waskesiu and many other lakes. The crayfish are limited in their distribution and may not be so important as the above figures would indicate. The molluscs are probably more constant and important as food for whitefish.

About one half of the specimens examined were parasitized by the larvae of the tapeworm Trisphenophorus robustus and in about 1/5 the parasitism was very severe, 5 to 20 cysts per fish. Heavily parasitized specimens were usually soft and emaciated. In an earlier report on the suggested gill netting of whitefish of Clear Lake, (a copy of which is appended to this report) it was suggested that special care should be taken to avoid the sale of obviously parasitized fish.

The common sucker Catostomus commersoni

Eighteen suckers were taken in the gill nets and moderate numbers were seen congregated in the shallow water and attempting to move up the creeks. Apparently the suckers have difficulty in finding spawning grounds, partly because of the low water level. This belief is contributed to by the lateness of spawning

(in Waskesiu lake with similar temperature conditions spawning was practically complete by May 20) and by the unspawned condition of adults taken in the gill nets during the first week of June. Some of these adults were taken in deep water 10-20 metres and a few of the males still had nuptial tubercles on their caudal fins.

The specimens ranged from 16.0 cms. 3 oz. to 39 cms. 2 lbs. 1 oz. most of them being less than 25 cms. in length. Scales of seven were selected and their age determined. The growth rate of suckers in Clear lake, like that of the whitefish is apparently slower than that of these fish in Waskesiu lake. The difference was more marked in the older year classes, eight year old suckers in Clear lake being about 37 cms. length and 2 lbs. in weight and in Waskesiu 42 cms. - 3 lbs. 2 oz. in weight.

The stomach contents of eleven suckers varying from 16 to 39 cms. were examined and the average quantities of organisms are recorded as in the case of the whitefish.

Chironomid larvae	35%
Amphipoda (<u>Hyalella</u>)	25
Copepoda (mostly <u>Cyclops</u>)	25
Mayfly nymphs	5
Caddis larvae	5
Pelecypoda (<u>Pisidium</u>)	3

Small quantities of gastropods, ostracods, hydrachnids and cladocera were also found. Since the sample included seven small suckers the above statement is not an accurate indication of the food of the adults the chief difference being in the copepods which were not found in the larger individuals. At this season, the sucker was feeding chiefly on chironomid larvae and amphipods. Over a longer period, the molluscs and mayfly nymphs might be expected to bulk larger in its food.

Suckers are undoubtedly numerous in the lake but probably not more so than in other lakes of the region. Bajkov's statement (1933) that it is "the most common" fish in the lake seems hardly justified in view of the meagre data.

The cisco, Leucichthys sp.

The gill net catches included 107 ciscoes, a larger number than that of any other species. They were taken at depths of 2 to 30 metres but mostly in water deeper than 15 metres. They were of small size, lengths ranging only from 14.5 cms. to 17 cms. and weights from 2 to 4 oz. The specimens appeared to be sexually mature and from scale examination to be in the fourth, fifth and sixth years. It is also pointed out that a range of net meshes was used which would be expected to take larger specimens if they were present in any considerable numbers.

Ciscoes from Clear lake have been identified by Bajkov (1932a) as Leucichthys artedi tullibee. The specimens taken by the author in Clear lake are quite unlike the L. tullibee of Saskatchewan, the latter being typically a much larger and deeper fish. Bajkov (letter June 21/35) states that he used nets of only three meshes 3 1/2, 3 3/4, and 4" meshes. None of these meshes would have captured the specimens taken by the author. Of our specimens 103 were in 1 1/2" mesh and 4 in the 2" mesh. It is conceivable that there may be two species of ciscoes in the lake although we saw no evidence of the larger form.

The stomach contents of nineteen specimens 14.5 to 16 cms. in length have been examined and the following average contents determined.

Copepoda (mostly Cyclops)	85%
Cladocera (Bosmina, Daphnia and Merycerus)	10%
Chironomid larvae	4%

A few hydrachnids and some miscellaneous insect remains were also found. As usual the cisco feeds almost completely on animal plankton forms.

The ciscoes were even more severely parasitized by the larvae of Triacnophorus robustus than were the whitefish. Very few specimens were found which were free from the parasite and most individuals had from 5 to 20 cysts.

A large number of ciscoes in the lake should provide excellent food for the larger trout if a trout species can be established. A number of the specimens taken between May 31 and June 12 were in spawning condition with milt and eggs readily expressed.

An examination of the stomach contents of 19 perch resulted in the following data as to their food at this season.

Mayfly nymphs (mostly <u>Hexagenia</u>)	75
Chironomid larvae	10
Amphipods (<u>Hyaletella</u>)	8
Caddis larvae	4

Small numbers of gastropods (Amnicola), hydrachnids and terrestrial insects made up the remainder.

While the perch were numerous the writer saw no evidence of the excessive perch population cited as an important obstacle to the introduction of game fish. Neither was any evidence obtained that the perch fed on fish although large numbers of spot-tail minnows were present in some of the locations where perch were caught.

The Pike - Esox lucius

Although no pike were taken in the gill nets there was evidence of their presence in the teeth gashes found in ciscoes, whitefish and perch taken in the nets. Fish mutilated in this way were found in five of the nine settings and at all depths. It might be added that the nets used were old and the mesh probably too weak to hold a pike and that no settings were made along the north shore of the north west bay where the only remaining pike spawning grounds are located.

It is believed that the pike feed mostly on ciscoes as they do under similar circumstances in the lakes of the Prince Albert Park. It is probable that suckers and perch would also be taken. Bajkov does not discuss the food of the pike but mentions that "they eat a considerable amount of perch".

There are many reports as to the great abundance of pike in Clear lake ten or twenty years ago. Mr. E. Kelley who has fished the lake with gill nets at various times in the last twenty years believes that they are still very plentiful. The best evidence of their scarcity is found in the difficulty experienced by anglers in catching them. Although a good deal of angling is done very few fish are caught, park officials suggesting that the total number per year is probably less than one hundred. The lowered lake level and consequent restriction of the spawning grounds would seem to be the most probable reason for the existing depletion.

Of the smaller fish, the spot-tailed minnow, Notropis hudsonius appeared to be by far the most abundant. It was taken in eleven of the fourteen hauls with the small seine. In one of the hauls 600 and in another 115 individuals were taken. A number of these specimens exhibited a "pot-bellied" appearance which was found to indicate the presence of the larval flatworm Ligula.

About fifty specimens of the black-nosed dace Rhynchithys atronasus were collected in two seine hauls. They were of small size, not exceeding a length of 1 1/2". This species was not recorded by Bajkov in his reports.

Four Cottids Cottus sp. and a single specimen of the Trout Perch Percopsis omiscomaycus were taken. Bajkov 1933 records also a darter Boleosoma nigrum and the five spined stickleback Lucania inconstans. He also mentions that "there are fourteen native species" of fish in the lake although he records only ten.

Summary and General Discussion

The size and the physical and chemical conditions in Clear lake have been indicated in the foregoing sections. Its area is approximately 9.5 sq. mi., maximum depth 31 m. (102 ft.) and mean depth 13.2 m. (43 ft.). It is frozen over for more than five months of the year and undergoes the usual thermal overturning in May and probably again in September. Summer conditions indicate a thermal stratification established in July with a distinct thermocline between 10 and 15 metres (33-49 ft.) which lowers as the season progresses. The bottom oxygen is reduced at this time to an unknown degree but it seems improbable that any severe depletion exists. The salt content of the water is somewhat higher than that of Waskesiu a comparable lake in the Prince Albert Park. Drainage into the lake is from a limited area and the only permanent streams flowing into it are short and spring fed. The lake had no outflow during four years preceding the examination.

With reference to the biological conditions, the plankton exhibits no unusual features of composition but richer in animal than in plant forms. It appears to be somewhat meagre in quantity although accurate measurements were impossible with the available equipment. A more complete study of the bottom fauna indicates that it is fairly rich both in quantity and variety of organisms. The chief components of the bottom fauna are the chironomid larvae, Fisidium, gastropods, oligochaetes and mayfly nymphs in order of numerical abundance and the average population amounts to 1930 per sq. metre or 1610 per sq. yard. The average dry weight of organisms was 22.6 Kg. per hectare or 20.1 lbs. per acre. These values indicate a bottom fauna of about average richness for lakes of this area and depth. In the shore area the fauna was varied but not rich and the aquatic plants rather scarce. Neither of these last two features could be fairly estimated so early in the season.

The fish fauna includes chiefly, whitefish, cisco, sucker, perch and pike with the spot-tailed minnow most abundant of the smaller fish. Both whitefish and sucker

show somewhat slower growth than the same species in Waskesiu lake although the food supply is probably greater in Clear lake. The cisco is very numerous and feeding on plankton should be valuable in making that source of food available for the larger trout if they are introduced. The perch are numerous and compete with the sucker and whitefish especially for insect food.

We cannot be certain from these studies of the feeding habits and relations of these species in the remainder of the season. The perch is thought of as a potential enemy of fry planted in the lake but we do not know to what extent, if any, the perch in this lake take fish food. Perch in Waskesiu lake feed on insect larvae and amphipods taking much less than 5 per cent fish food. We are also without information as to the food of the pike. In Waskesiu lake the cisco provides most of the food of the pike with perch and suckers next in order. Without such information it is impossible to form any comprehensive picture of the food relationships in the lake. Such a picture is necessary in estimating the possible productivity of the lake and would be most valuable in any attempt to predict the result of introducing additional species of fish.

Basing our opinions as far as possible on the foregoing information we would recommend an attempt to introduce the Kamloops trout into this lake. Our examination has thus tended to confirm our opinion expressed in a note prepared at the request of the Fish Cultural Committee of the Biological Board in February 1935. Some of the specific considerations which have led us to this conclusion should be recorded.

The size of the lake, 9.5 sq. miles, is such that a number of fry calculated to stock it could be put in for several years at a cost which would be considerable but not prohibitive. It is also desirable that the lake should not be too large since fly fishing is rarely found in large lakes, except in very limited regions e.g. protected bays, creek mouths etc. In other words the proportion of shallow near shore area with a dense insect population decreases as the size of the lake increases.

The physical and chemical conditions seem to be suitable, especially in view

of the wide range of conditions which the Kamloops trout is known to tolerate in British Columbia. In that region it may thrive in small alkes at high altitudes, cool and unstratified as Penask lake, shallow and severaly stratified lakes such as Pinantan in the middle altitudes or in large deep and low altitude lakes such as Okanagan, to mention only three rather extreme cases. With respect to the physical conditions one point should be made clear, namely that the surface temperature of Clear lake in the midsummer period is high enough to render fly fishing at that time unlikely. Spring and fall fly fishing could be expected and trolling during the two months or more of the warm summer conditions. Although this would be a disadvantage it is pointed out that many British Columbia lakes, including such successful trout lakes as Paul, have such a season. One might speculate that such a condition would tend to lengthen the season at which Riding Mountain Park was attractive to tourists.

The available food supply appears to be adquate, both plankton for the im-mature fish and bottom organisms for the larger individuals. The absence or scarcity of the larger amphipoda Gammarus and the considerable competition for insect foods through the feeding of perch, whitefish and suckers can be mentioned as unfavorable factors.

The more general question of the effect of competitive and predatory fish on the introduction of Kamloops trout can only be speculated upon until we have experiments similar to that at Paul lake, but carried out in a lake where "coarse" and predatory fish were present. The degree of predation of perch and pike on the developing fry and fingerlings can only be guessed at. It has been pointed out that the pike cannot be very abundant in Clear lake and that the perch although numerous may not take much fish food in their diet. There is no assurance that if trout fry were available the perch would not change their feeding habits. If fingerlings were liberated the predatory effects would be much reduced. Expressed

merely as an opinion we would expect that the predatory activities of perch and pike would not be as damaging as the food competition of the species mentioned above. The only certain conclusion that can be made is that the rate of stocking per unit area in Clear lake should be much greater than that considered reasonable for a lake with no other fish present.

Consideration has been given to the question of whether the attempt to introduce Kamloops trout into lakes of this region should be made first in a smaller lake with a richer food supply and at less expense. There appears to be no lake suitable for such an experiment in the Riding Mountain Park and even on a smaller scale the project would be expensive. It seems then that the great desirability of establishing the Kamloops trout in Clear lake would completely outweigh the former argument.

In conclusion it is proposed that the Kamloops trout Salmo gairdneri is the most desirable and promising species for introduction into Clear lake. It is emphasized however that the data resulting from examination of the lake cannot assure the success of the experiment and we can only say that there are no major objections and that there seems to be fair promise of success. As an experiment which will contribute to the present knowledge of fish culture it should be of exceptional interest and value.

A. Suggested Procedure for the Introduction of Kamloops trout.

The following plan has been worked out in conference with Dr. C. McC. Mottley who has been engaged in a special study of Kamloops trout propagation and who has already expressed views on the stocking of Clear lake in a reply to Mr. J.A. Rodd's request of Jan. 15, 1935. The suggestions are based as far as possible on actual findings in production studies at Paul lake and rearing experience at the Cowichan station. Dr. Mottley has approved the following outline and further information if desired should be obtained directly from him.

General outline of procedure.

1. About 550,000 Kamloops trout eggs should be obtained as early as possible in May and shipped to Clear lake. Early egg collections are possible in Knouff lake, B.C.
2. These eggs could be held in 10 ponds, each with troughs, similar to those used at Cowichan and supplied with a mixture of spring water and water pumped from the lake.
3. The fry could be fed and held until October or November at which time about 350,000 fry of 2" size should be available for planting.
4. This procedure should be repeated for four years unless at the third season it was seen that the plantings had been unsuccessful.
5. From the third or fourth year on it should be possible to obtain breeding stock from the lake itself even though natural propagation is not expected to contribute appreciably to the stocking.

Details of the above plan and reasons underlying it.

1. The number of eggs required has been estimated on the following basis.
 - (a) Population studies at Paul lake indicate that an annual planting of 200 - one inch fry per acre supports excellent fishing.
 - (b) Since the only predatory fish in Paul lake are the trout themselves, some allowance should be made for the presence of other predatory and competitive fish in Clear lake. Lacking any definite information on the problem it is suggested that the rate be doubled i.e. 400 per acre.
 - (c) In Clear lake 400 fry per acre would be 2,500,000 fry which would be impossible to handle at reasonable cost.
 - (d) It would therefore be necessary to resort to pond culture, since a smaller number of larger fish may produce the same result.

2. Using pond culture.

(a) By obtaining the eggs as early as possible and retaining them until late in the autumn it should be possible to raise fish of at least 2" length .

This purpose would necessitate an optimum rate of feeding and regulation of the temperature of the pond by a mixture of the cold spring water with warmer water pumped from the lake.

(b) The number of 2" fish which would be approximately equivalent to 2,500,000 one inch fry can be deduced from studies of mortality of trout fry "planted" by embody (1927). He gives survival values which indicate that 340,000 two inch fish would be needed.

(c) To obtain 350,000 plantable 2" fish it would be necessary to obtain about 550,000 eggs, which should yield 500,000 eyed eggs and with a reasonable (70%) survival to the 2" stage, 350,000 fry.

(d) . This number of eggs could be handled in 10 ponds of the Cowichan type 37' x 6' x 2'6" each with two standard 18' troughs. It is believed that the available spring water supply at Clear lake is not sufficient for this purpose and that pumping from the lake would be necessary as well as advantageous in allowing temperature control. The location of the most favourable site for the ponds and checking of the water supply is essentially an engineering problem which does not come within the field of this report.

3. Approximate costs.

This plan would require the full time attention of a thoroughly trained fish culturist and an assistant. The chief expenditures would be for construction of ponds and purchase of equipment with salaries and feeding costs secondary. It is estimated that the first year's work could cost about \$10,000 and the succeeding years \$3,500 annually.

It is again pointed out that the success of this plan is not assured but that it is based as far as possible on available experience and facts.

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Memorandum Re Netting of Whitefish in Clear Lake, Riding Mountain National Park.

Submitted June 14, 1935.

D.S. Rawson

In view of the need for immediate action with reference to the netting of whitefish in Clear lake I am submitting the following recommendations in advance of my fall report. These conclusions are based upon the results of nine settings of a gill net 175 yards long and 1 1/2 to 5 1/2 in. meshes and on an inquiry into the results of previous netting in this lake.

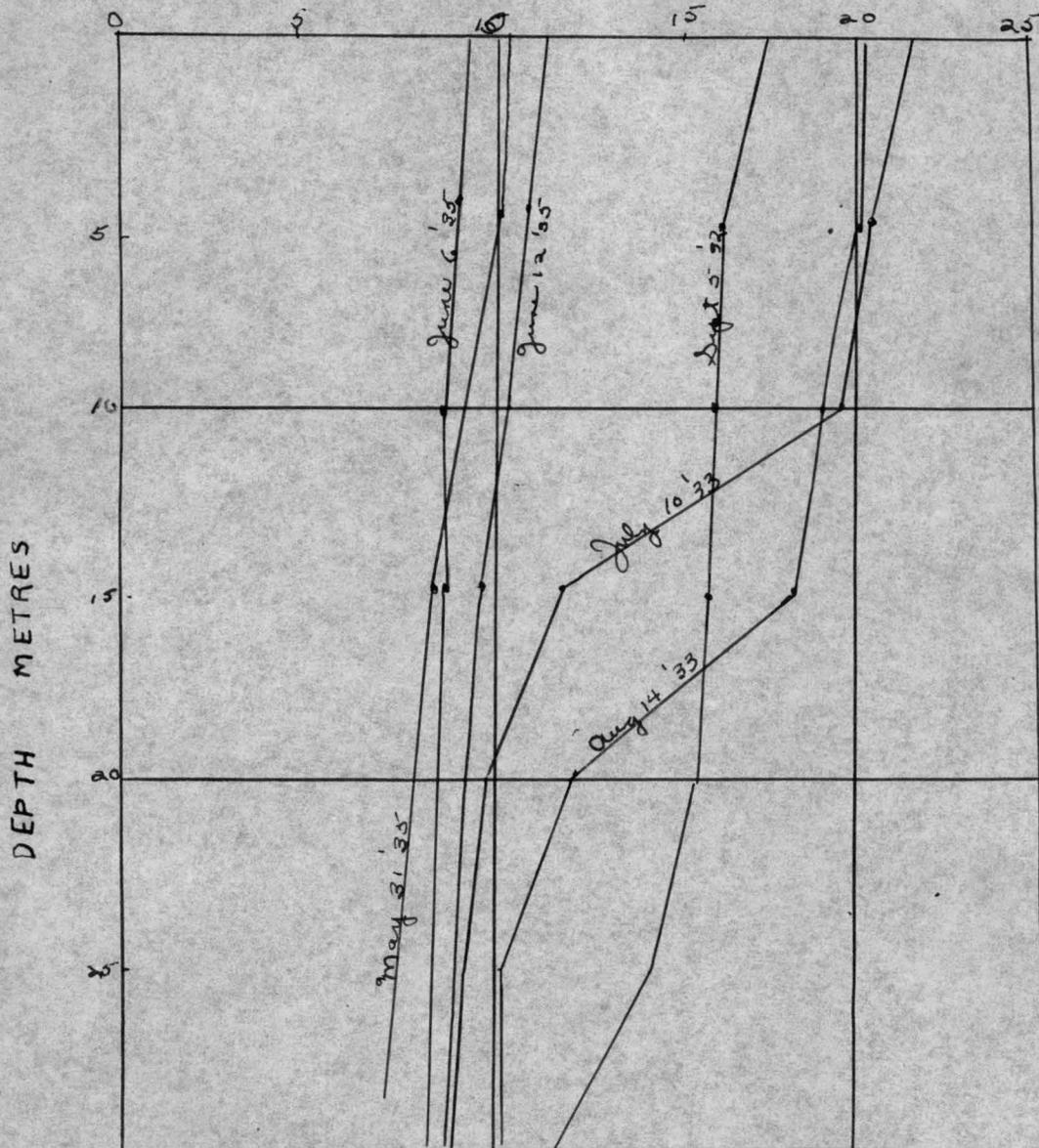
1. It is advisable that whitefish be netted in Clear lake during the tourist season.
2. That the nets used should not be smaller than 4 in. stretched mesh.
3. That the fishing should be carefully supervised by the Parks staff to ensure the following:
 - (a) That the supply of fish does not exceed the demand within the park.
 - (b) That the fish taken are handled with proper care, iced, etc.
 - (c) That the number of pike caught be kept at a minimum and that the sale of pike be not allowed (there is some evidence that in former years deliberate efforts were made to catch the pike.
 - (d) That soft fleshed, emaciated, pale or under sized fish be not sold since these are usually parasitized by harmless but unsightly tapeworm larvae.

With reference to section (d) of the above recommendation it should be explained that the larvae of the tapeworm parasite, Triacophorus robustus are found encysted in fairly large numbers in whitefish of Clear lake. This parasite is more frequently in whitefish from Clear lake than those from other lakes in the prairie provinces which the writer has examined. A small number (1 or 2) of these cysts should not prevent the sale of the fish but if larger numbers occur such fish would probably damage the market. The parasites are not usually visible externally but seen only when filleting or cutting into the muscle. The appearance of the fish however often gives a suggestion of the degree of parasitism. In 65 specimens of whitefish taken in nets at Clear lake May 31 to June 12, 1935, and examined for parasites it was found that the characters of softness, emaciation, etc. listed above were usually associated with heavy parasitism. It is therefore recommended that such fish be destroyed or examined internally before the catch is sold.

TABLE II. ANALYSIS OF CLEAR LAKE DREDGINGS

Dredging number	Depth metres	Type of bottom	Chironomid larvae	Mayfly nymphs	Caddis larvae	Oligochaetes	Amphipods (Hyalella)	Sphaeriidae (Pisidium)	Gastropods	Leeches	Total numbers	Wet weight, mollusc shell deducted. grams
SI. D1	5.5	Hard sand & chara	49	3	5	1	46	52	9	1	166	.679
D2	9.0	Sand & moll. shells	37	1	-	-	-	36	118	1	193	.760
D3	22.0	Soft clay & shells	39	-	-	-	-	24	-	-	63	.463
D4	23.0	Soft clay	47	1	-	1	-	15	-	-	64	.554
D5	30.0	Clayey ooze	105	-	-	24	-	-	-	-	130	.398
D6	30.0	Clayey ooze	61	-	-	8	-	3	-	-	72	.510
SII. D1	1.0	Gravel with sand	24	2	-	6	2	12	-	-	46	.070
D2	17.0	Soft clay	69	-	-	10	50	25	4	-	158	.916
D3	31.0	Soft clay	173	-	-	34	-	15	-	-	222	1.473
D4	21.5	Coarse sand	1	-	-	4	-	1	-	-	6	.005
D5	10.0	Gravel & coarse sand	10	-	-	-	-	2	4	-	16	.105
D6	2.0	Sand	1	-	-	-	-	-	-	-	1	-
SIII. D1	2.0	Stoney	23	1	-	10	-	1	-	-	35	.057
D2	5.5	Sand & chara	75	4	1	6	24	75	14	-	199	.467
D3	8.5	Smallstones & eladophora	41	-	6	2	3	120	76	2	250	1.560
D4	13.0	Clay ooze	50	3	-	-	-	44	36	-	133	1.040
D5	15.0	Stiff clay	49	-	-	-	9	24	3	-	85	1.594
D6	14.0	Clay ooze	69	5	-	-	6	21	8	-	109	.950
SIV. D1	1.5	Marl & sand with chara	13	1	-	-	6	15	9	-	44	.200
D2	2.5	Sand	35	7	1	-	12	24	1	-	80	.378
D3	5.0	Soft clay	15	-	-	-	26	14	5	-	60	.174
D4	7.0	Clay ooze	44	-	-	9	45	130	40	1	269	1.099
D5	14.0	Clay ooze	20	2	-	-	-	24	6	-	52	.539
D6	18.0	Clay ooze	58	-	-	8	-	23	-	-	89	.908
D7	22.0	Ooze and organic mat.	80	1	-	9	-	4	-	-	94	.595
D8	30.0	Clay ooze	117	-	-	17	-	2	-	-	136	.544
SV. D1	8.0	Gravel	26	-	4	-	2	-	13	2	47	.338
D2	17.0	Stiff clay	48	2	-	3	-	14	32	2	99	.986
D3	23.0	Clay ooze	29	1	-	2	-	13	-	-	45	.111
D4	22.0	Clay ooze	15	-	-	-	-	21	-	-	36	.099
D5	23.0	Clay ooze some sand	4	-	-	1	-	3	-	-	8	.014
D6	20.0	Clay ooze	63	2	-	3	-	16	-	-	84	.515
Totals			1490	36	17	158	231	774	378	7	3091	18.101
Average per dredging			46.5	1.1	0.5	5.0	7.2	24.2	11.8	0.2	96.5	0.566

TEMPERATURE °C.



Graph. 1. Temperature Series - Clear Lake.