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SOME FACTORS AFFECTING THE PRODUCTION OF LAKE TROUT (*CRISTIVOMER NAMAYCUSH*) IN LAKE ONTARIO

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Statistical Introduction

The lake trout is one of the most important of Canadian fresh-water fishes. In the Great Lakes and in the larger inland lakes it ranks second only to whitefish in commercial importance, while in many of the smaller lakes it is highly regarded as a game species.

The commercial catch of this fish in Canada ranges from 5,000,000 to 7,000,000 pounds per year, over 80 per cent. being taken in the Great Lakes. The catch of whitefish in Canada is from two to three times that of lake trout, but in the case of this species the catch in the Great Lakes averages under 40 per cent. of the total. It is therefore seen that so far as lake trout production is concerned the Great Lakes are of first importance.

The average catch of lake trout in the Canadian waters of each of the Great Lakes is given in table 1, from which it is seen that Lake Ontario produces 15 per cent. of the total.

Table 1—Giving in pounds the average catch of lake trout for the years 1922 to 1926 inclusive in the Canadian waters of each of the Great Lakes.

Lake Huron*	3,013,607 pounds
Lake Superior	1,877,429 "
Lake Ontario	852,686 "
Lake Erie	462 "

*Includes North Channel and Georgian Bay.

In table 2 is given the Lake Ontario catch for the years 1906 to 1926 inclusive.

TABLE 2—GIVING IN POUNDS THE CATCH OF LAKE TROUT FOR THE YEARS 1906 TO 1926 INCLUSIVE IN THE CANADIAN WATERS OF LAKE ONTARIO.

Year	*Pounds*	*Year*	*Pounds*	*Year*	*Pounds*
1906*	07,300	1913	573,403	1920	462,013
1907	105,790	1914	632,964	1921	558,845
1908	177,284	1915	555,369	1922	721,849
1909	639,798	1916	540,167	1923	754,950
1910	413,400	1917	468,724	1924	938,994
1911	384,567	1918	387,451	1925	1,063,304
1912	631,162	1919	554,103	1926	784,333

This table indicates that the catch of lake trout in Lake Ontario has been much greater in recent years than it was earlier. To what extent, if any, the actual production of fish in the lake has increased is difficult to say, but it seems quite certain that some at least of the increased catch is due to the use of more effective means of taking the fish and to a better knowledge of its habits on the part of fishermen.

MATERIALS AND METHODS

The material on which this study was based was obtained at Port Credit during the months of June, July, and August, 1927. Four or five gasoline fishing boats fish out of this port, and I was given every assistance in the securing of materials and information by the various fishermen. For this privilege and many other favours I wish to express my indebtedness.

The stomach contents of 97 ling and 272 lake trout taken in the nets of Mr. Louis Joyce were examined and the contents identified where possible. Many of the stomachs were found to be empty. During August the ovaries of many lake trout were examined, and in the case of 25 specimens, ranging

*From 1906 to 1917 inclusive the quantities of salted trout are given in the reports of the Ontario Department of Game and Fisheries in barrels. These have been converted into pounds on the basis of 200 pounds per barrel.

in weight from 6 pounds 4 ounces to 23 pounds 8 ounces, were preserved in formalin solution for use later in determining the number of eggs produced.

In estimating the number of eggs in the laboratory, the total weight of the two ovaries was determined and a representative portion of each removed and weighed, and the number of eggs was determined by count. The portion selected for counting averaged about one tenth the weight of the two entire ovaries. Unfortunately, it was impossible to secure information or material at the spawning time of the trout for the reason that all trout nets were taken out of the water before spawning occurred, because the catch had been so poor as to make it unprofitable to continue trout fishing.

DISCUSSION OF FACTORS

The factors on which depend the abundance of a species of fish in any body of water are not definitely known, but it seems obvious that among the more important are (1) the physical characteristics of the body of water, (2) the presence of enemy or competitor species, (3) the abundance of food and (4) the nature and extent of the spawning grounds. The last factor might be considered as part of the first, but for convenience it is considered separately.

Lake trout are found only in comparatively deep bodies of water. Lake Erie appears to be too shallow for them except in the eastern end, where a few occur. Here the depth reaches 210 feet, but the usual depth of the lake outside this area is about 60 feet.

Lake Ontario is the smallest of the Great Lakes, its area as given in the atlas of Canada (1915) in comparison with the others being as follows:

Lake Superior	31,800 sq. mls.	Lake Erie	10,000 sq. mls.
Lake Huron	23,200 sq. mls.	Lake Ontario	7,260 sq. mls.

Over much of its area Lake Ontario is quite deep. The greatest depth of water occurs on the United States side of the international boundary towards the eastern end of the lake, where a depth of 738 feet is recorded. In Canadian waters the greatest depth appears to be near the centre of the lake where a depth of 474 feet occurs. From this point it becomes gradually shallower both towards the west and the east. In the eastern end especially, the water is too shallow to support lake trout. On account of a smaller area of deep water, the maximum production of this species in Lake Ontario can therefore never be equal to its maximum production in either Lake Huron or Lake Superior.

The spawning habits of lake trout are little known. Many spawn in relatively shallow water, but many fishermen insist that in some lakes at least trout spawn in deep water. For instance, in Lake Nipigon (Dymond 1926, p. 68) the fishermen say that there is a race of deep water trout which do not come into water of less than 20 fathoms and which spawn at depths of 20 to 30 fathoms. Similarly in Georgian bay the fishermen "offer various reports as to very dark or pale trout, with short deep bodies, which are never taken in shallow water, and which they assume do not come in shore to spawn" (Bensley 1914, p. 29).

Whatever may be the facts in regard to the spawning of trout in deep water, it is well established that many spawn in quite shallow water. In the western end of Lake Ontario the water gradually deepens from the shore out to the centre, whereas in Lakes Huron and Superior there are numerous islands and shoals, affording much water of the depth in which trout spawn and adjacent to deep water which they require during the greater part of the year. Whether the rocky nature of the shores and islands of the upper lakes is a factor more favourable to the natural propagation of trout is of course unknown, although there is reason to believe that it may be so.

Bensley (*loc. cit.*) has drawn attention to the fact that in Georgian bay the trout seemed to be withstanding the drain of the commercial fishery much better than the white-fish and suggested a number of reasons for this. Because of its predatory habits it swims at all levels and thus escapes

to a greater extent the operations of the gill net fishermen It is probable also, he says, that it is not affected to any great extent by the pollution of the bottom through lumbering operations which would be fatal to the whitefish, which lives on bottom organisms. In the same connection it is important to note that the species on which the lake trout feeds (alewives and ciscoes) are plankton feeders and hence are not affected by types of pollution affecting the lake bottom.

FOOD OF LAKE TROUT

The food habits of lake trout were studied by examination of the stomachs of specimens taken in the fishermen's gill nets. Altogether several hundred were examined; many were empty, but whenever food material was present it consisted, in every case, of fish. In many, digestion had proceeded so far as to make identification impossible, but in the case of 128 specimens it was possible to identify the fishes that had been eaten. The results of these examinations are given in table 3.

The results before and after July 1 are given separately, because it was noticed that after that date the percentage of stomachs containing alewives was much less than before,—36.7 per cent. as compared with 75.5 per cent. On the contrary, the percentage of stomachs containing ciscoes materially increased after July 1, being 53.3 per cent. as compared with 24.5 per cent. before that date. The average number of alewives found in a stomach was 3.1, the largest number found in one stomach being 12. In the case of ciscoes the average was 2.8 and the largest number 8. For *Triglopsis thompsoni* the corresponding numbers were 5.4 and 27 and for *Cottus cognatus* 4.8 and 13.

The decreased percentage of alewives eaten by lake trout after July 1 is due to the fact that about that date the alewives began to move inshore to spawn. The trout remaining in deep water were of necessity forced to turn to the ciscoes as food. That some at least of the trout follow the alewives

TABLE 3—GIVING THE NUMBER AND PERCENTAGE OF LAKE TROUT STOMACHS, OUT OF 128 IN WHICH WERE FOUND IDENTIFIABLE FISH REMAINS, WHICH CONTAINED VARIOUS SPECIES OF FISH.

Species	June 7 to June 30		July 1 to Aug. 23			
	No. of stomachs in which found	Percentage* of stomachs in which found	No. of stomachs in which found	Percentage *of stomachs in which found	Total no. of stomachs in which found	Percentage of total in which found
Alewives (*Pomolobus pseudoharengus*)	74	75.5	11	36.7	85	66.4
Ciscoes (*Leucichthys* spp.)	24	24.5	16	53.3	40	31.2
Deep water sculpin (*Triglopsis thompsoni*)	12	12.3	4	13.3	16	12.5
Millers Thumb (*Cottus cognatus*)	1	1.0	4	13.3	5	3.9
Stickleback (*Pungitius pungitius*)	1	1.0	0	0	1	0.8
Round whitefish (*Prosopium quadrilaterale*)	0	0	1	3.3	1	0.8

*The percentages total more than 100 because some stomachs contained two or more species of fish.

inshore is suggested by the statements of the fishermen that they usually have in summer two weeks of good trout fishing near shore. All of this strongly indicates that the alewives are the favourite food of lake trout in Lake Ontario in summer.

That the ling is a serious competitor of the lake trout for food is shown by the following table giving the number of ling stomachs containing various species eaten as food.

TABLE 4—GIVING THE NUMBER OF LING STOMACHS OUT OF 64 IN WHICH WERE FOUND IDENTIFIABLE FISH REMAINS, WHICH CONTAINED VARIOUS SPECIES OF FISH.

Species	No. of stomachs in which found	Average no. per stomach	Greatest no. in one stomach
Alewives (*Pomolobus pseudoharengus*)	37	2.9	8
Crayfish (*Cambarus bartoni*)	19	1.7	6
Millers Thumbs (*Cottus cognatus*)	18	2.7	13
Deep water sculpin (*Triglopsis thompsoni*)	12	11.2	32
Sticklebacks (*Pungitius pungitius*)	4	1.2	2
Ciscoes (*Leucichthys* spp.)	3	1	1
Caddis cases	2	50	91
Mysis relicta	2	..	..
Grain of corn	1	1	1
Raisin	1	1	1

This table indicates that alewives, which are the largest item in the food of lake trout, also constitute the chief food material of the ling. All of the other staple food species of the trout are preyed on by the ling although it does not appear from these figures that the ling consumes many ciscoes. This is partly due to the fact that most of the stomachs examined were taken from specimens caught early in the season. During August and late July practically no ling were taken in the fishermen's nets. This suggests that at that time the ling are swimming well off the bottom and that ciscoes might then constitute a much larger item in their food. This inference is supported by the finding of Clemens (1924) that in Lake Nipigon ciscoes were the main item in the food of ling.

NUMBER OF EGGS PRODUCED BY LAKE TROUT

An effort was made to determine the size at which trout first spawn. From the evidence secured by examination of the ovaries in late August it was believed that few if any trout spawn under 5 pounds in weight. In larger specimens at this time the eggs are 4 to 5 millimetres in diameter, but the ovaries also contain tiny eggs of one millimetre or less in diameter which presumably will mature the following season. In the case of most specimens of 6 pounds in weight the eggs grade imperceptably in size from 1½ millimetres in diameter to those of a size which in larger specimens obviously do not mature that season. How many, if any, of these 1½ millimetre eggs would mature the same season is problematical. Specimens of 5 pounds and under in weight had the eggs so small as to preclude the possibility of their spawning the same season as examined. There is, of course, some variation in the state of development of the eggs in fish of the same weight, but from the evidence secured it seemed fairly conclusive that in the western end of Lake Ontario lake trout do not begin to spawn until they reach a weight of approximately six pounds. It may well be that the average weight of specimens spawning for the first time is well above this weight, but there is absolutely no doubt that lake trout of two pounds in weight, the present minimum legal weight in Ontario, are immature fish.

The following table gives the number of eggs found in trout of different sizes. Only the larger eggs in the ovaries were counted. The tiny eggs which would not have matured until a year later were not included in the count.

Whether, in view of the fact that lake trout do not spawn in Lake Ontario until they are approximately six pounds in weight, the taking of trout under this weight should be prohibited is a question for which no answer can at present be given. Under normal conditions very many more young trout are produced than reach maturity. The principal loss undoubtedly occurs before hatching and during the first year of life. We have no idea of the proportion

TABLE 5—GIVING NUMBER AND DIAMETER OF EGGS AND DATE KILLED OF LAKE TROUT OF VARIOUS WEIGHTS AND LENGTHS TAKEN IN LAKE ONTARIO OFF PORT CREDIT.

Weight	Length	No. of Eggs	Diameter of Eggs in millimetres	Date 1927
23 lb. 8 oz.	35¼	15,286	5	Aug. 18
19 " 2½ "	32	18,051	3	Aug. 4
15 " 8 "	30	11,043	3½	Aug. 18
11 " 14 "	29½	8,282	5	Aug. 23
11 " 4½ "	28	9,811	4½	Aug. 23
11 " 3 "	30	10,578	3½	Aug. 4
11 " 2 "	29¼	7,384	5	Aug. 18
11 " 1½ "	30½	7,433	5	Aug. 23
11 " 1 "	29	5,915	5	Aug. 23
11 " 1 "	29	9,107	3	Aug. 4
10 " 14½ "	28¾	4,646	2½	Aug. 4
10 " 7 "	29	6,117	5	Aug. 23
10 " 6 "	28⅝	8,668	4	Aug. 18
9 " 13½ "	29	7,783	3	Aug. 18
9 " 12 "	28	10,067	4½	Aug. 23
9 " 9 "	27	8,104	4	Aug. 23
9 " 9 "	28¼	5,021	3¾	Aug. 23
9 " 2 "	26¼	3,340	2	Aug. 4
9 " 1 "	26	3,661	1⅝	Aug. 18
9 " 1 "	27½	11,931	3½	Aug. 23
9 " 0 "	26½	6,891	4½	Aug. 4
8 " 15 "	29	6,697	5	Aug. 23
8 " 12 "	28½	6,205	4	Aug. 18
8 " ½ "	27	4,007	5	Aug. 23
6 " 4 "	24	2,542	4	Aug. 23

which die or are killed under normal conditions at any particular period of the life history. If there is any considerable decrease in numbers due to the struggle for existence between the age at which they reach two pounds in weight and the age at which they reach sexual maturity, it may be economically advantageous to let the fishermen take the surplus trout instead of letting them die in competition with the others.

As indicated in Table 5, fish of 20 to 25 pounds in weight produce 15,000 to 18,000 eggs, whereas those of 6 to 10 pounds produce from 3,000 to 10,000 eggs. It might be argued from this that the taking of very large trout should be prohibited. Our data are as yet far too scanty to permit us to make any very definite statement on these points. It is certain, however, that there is a limit to the amount of fish which a given body of water will produce, and if too few are left to reproduce or if their food is diminished, reduction in yield must result.

RACIAL DIFFERENCES

McGregor (1923) has shown that while there is a considerable range in the egg yield of king salmon taken from a particular river system, the fish from each system have a characteristic ova count. For instance, the range in ova counts of Klamath river fish was from 1718 to 8,406 with an average per female of 3,760. In the case of Sacramento river fish the range was 4,795 to 11,012 with an average of 7,454, almost double the average for the Klamath series. In the case of lake trout there is an average increase in ova count with increasing size of fish. This source of variation is largely eliminated in the king salmon for, although there is some range in size of spawning fish, spawning occurs only once, all individuals so far as known dying after spawning is completed.

Fishermen of the upper lakes insist that there are two or more "kinds" of lake trout. In Lake Nipigon (*loc. cit.*) they recognize a river-spawning "black trout" and a form that spawns in deep water in addition to the common form that spawns in shallow water. The very wide variation in ova counts found at Port Credit in the case of fish of the same weight (11,931 to 3,661 in fish weighing 9 pounds 1 ounce) lends support to the view that there may be racial differences in the lake trout of an individual lake.

WEIGHT OF LAKE TROUT TAKEN IN COMMERCIAL NETS

The weights of 134 lake trout taken in the commercial fishermen's gill nets were determined. The fish weighed

included those from 4½ inch nets as well as those taken in 7 inch trout nets, and the range in size selected is believed to represent the general average taken in commercial fishing on this area. The average weight of the 134 individuals was 8 pounds 10 ounces. The number of specimens of various weights is given in Table 6.

TABLE 6—GIVING THE NUMBER OF LAKE TROUT OF DIFFERENT WEIGHTS MAKING UP THE TOTAL OF 134 WHOSE WEIGHTS WERE DETERMINED AT PORT CREDIT DURING THE MONTHS OF JUNE, JULY, AND AUGUST, 1927.

Weight	*Number*	*Weight*	*Number*
2 to 3 pounds	4	12 to 13 pounds	2
3 to 4 "	6	13 to 14 "	2
4 to 5 "	9	14 to 15 "	0
5 to 6 "	14	15 to 16 "	1
6 to 7 "	14	16 to 17 "	2
7 to 8 "	16	17 to 18 "	0
8 to 9 "	16	18 to 19 "	0
9 to 10 "	19	19 to 20 "	3
10 to 11 "	11	20 to 21 "	0
11 to 12 "	12	21 to 22 "	0
		22 to 23 "	1
		23 to 24 "	1

One specimen weighed 32 lbs. 8 oz.

CONCLUSIONS

Lake trout ranks second in importance among the commercial fresh-water fishes of Canada. It is also of considerable importance as a game species.

The Canadian waters of the Great Lakes produce between 80 and 90 per cent. of the lake trout caught in Canada.

Fifteen per cent. of the lake trout taken in the Canadian waters of the Great Lakes during the past five years were taken in Lake Ontario.

Lake trout are found only in comparatively deep bodies of water.

Lake Ontario has a much smaller volume of water deep enough for lake trout than either Lake Huron or Lake Superior.

Lakes Huron and Superior, because of numerous islands and shoals, have a much larger area of water of a depth at which lake trout spawn than has Lake Ontario.

In Lake Ontario alewives are the favourite food of lake trout, at least in summer, with ciscoes ranking second in importance.

The ling is a serious competitor of the lake trout for food, preferring alewives to other species. The list of fishes eaten by ling is almost identical with that eaten by lake trout.

Lake trout in Lake Ontario spawn for the first time when about 6 pounds in weight.

Lake trout of 20 to 25 pounds in weight produce from 15,000 to 18,000 eggs, those of 6 to 10 pounds from 3,000 to 10,000 eggs.

The very wide variation in the number of eggs produced by fish of the same size lends support to the view that there are racial differences in the lake trout of an individual lake.

The average weight of lake trout taken at Port Credit during the summer of 1927 was between 8 and 9 pounds.

Reduction in the number of ling would favour lake trout production by increasing the amount of food available to the trout.

Attempts should be made to determine whether ling may be sold as food when skinned, salted, smoked, or otherwise treated.

If ling cannot be disposed of as food they should be removed from the lake and converted into fish meal and oil, if practicable, or disposed of in some other way. The removal of fish which are enemies or competitors of valuable species should be considered as much a part of the government's policy for the improvement of the fisheries, as the planting of the fry of desirable fishes.

LITERATURE CITED

Bensley, B. A. 1914. The Fishes of Georgian Bay. Contrib. Can. Biol., 1911-1914, Fasc. 11. Fresh Water Fish and Lake Biology. Biol. Board of Canada. Supp. to 47th Ann. Rept. Dept. Marine and Fisheries, Fisheries Branch, Ottawa.

Clemens, W. A., and others, 1924. Food Studies of Lake Nipigon Fishes. Univ. of Toronto Studies, Biological Series. Pub. Ontario Fisheries Research Lab., No. 25.

Dymond, J. R. 1926. The Fishes of Lake Nipigon. Univ. of Toronto Studies, Biological Series. Pub. Ontario Fisheries Research Lab., No. 27.

McGregor, E. A. 1923. A Possible Separation of the River Races of King Salmon in Ocean-Caught Fish by means of Anatomical Characters. Calif. Fish and Game, Vol. 9, pp. 138-150.

Atlas of Canada. Department of the Interior, Canada. 1915.