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Author

R. H. M'Gonigle.

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R. H. M'Gonigle,

International Fact-finding Commission, Lake Champlain Fisheries.

The purpose of these remarks is to present briefly, a phase of the scientific work of the International Fact-finding Commission which was appointed jointly by the United States and Canada, to investigate certain aspects of the Lake Champlain Fisheries, with Dr. John Van Oosten of the University of Michigan, and Mr. James Rodd, of the Department of Fisheries of Canada, as Commissioners.

The field work, of which is disscussion is a portion, began following a meeting of the Commissioners and the field stagg which was held on February 10, 1930, here in Burlington, Vermont. At this meeting, arrangements for the investigation were completed and the work parcelled out to the various investigators.

The portion of the work assigned to me was a study of the winter fishery at South Hero, at the western end of the Sand Bar Bridge, at Cowbanks. In the spring, the work was transferred to Mississquoi Bay. After the field work had been completed, a special study of the Yellow Perch (Perca flavescens, Mitchill), which had been collected from all fields of investigation, was undertaken, and these remarks are concerned with some of the results of that study.

In making the collections of material, in the winter investigations, each fish was measured and weighed, The stomachs were removed, wrapped in cheesecloth in the various size-groups, the parcel tagged and preserved in formalin. During the spring investigation in Mississquoi Bay, on account of limited personnel, it

was impossible to find the time to make the measurements, but the stomachs were taken from as many as possible of each catch of perch, usually not more than fifty, when more than that number were captured. Fish of less than six inches in length were preserved round; but very few indeed of such small fish were taken, so that these do not enter into this discussion.

One of the most interesting things to be discovered, in such an investigation as this, in which several widely separated parts of a large body of water are being simultaneously studied, is how do the fish from these different parts compare one with the other. Do they differ in fatness (that is, condition)? Is the food in the various parts different in kind or quantity? These are questions which one must answer if one is to know anything about the "yield", and are of considerable importance to those administering the fisheries.

With regard to fatness, the comparison between various sections is very easily made. Since relative fatness is considered as the difference in weight for given lengths, one can, by determining the relation between the weights and lengths, use the expression of this relationship, if it differs for the various parts of the lake, as a means of making this comparison with respect to fatness. This relationship has been worked out for the fish taken in each of the six areas of lake Champlain studied in the winter investigation.

By means of grouping and averages, where the number of specimens was large, or by using all the data, where the number was small, and by employing the method of least squares to secure the best smoothed curve, a mathematical expression of

this relationship was secured for each of these groups. These expressions are called "length-weight equations", and they have been used considerably by fisheries biologists.

In these equations, the first ones indicate the better condition, as can be more readily appreciated from the graph shown herewith as figure I, and in which the curves fall in practically the same order as the equations in the table (I) below.

These equations are to be looked on as a sort of short-hand method of expressing this relationship, and it must be remembered that they are only a smoothing of averages determined from a certain amount of data.

TABLE I.

| Area | Equation |
|---------------------------------|------------------------------|
| Fort Ticonderoga (Vermont Side) | $W = 0.002757 L^{3.510}$ (1) |
| " " (New York side) | $W = 0.003728 L^{3.406}$ (2) |
| Grand Isle -- Pike Reef | $W = 0.005477 L^{3.212}$ (3) |
| Burlington -- Rocky Point | $W = 0.005684 L^{3.210}$ (4) |
| South Hero -- Milton Shore | $W = 0.012159 L^{2.940}$ (5) |
| " " Cowbanks | $W = 0.01784 L^{2.811}$ (6) |

The graph (figure 1) reveals rather clearly, that there are three definite groups, with respect to fatness; the Fort Ticonderoga groups being superior to the others, and the South Hero area having the poorest condition.

There is still another way of illustrating this matter of relative fatness, which is used even more than the graphic or equation method by the fisheries biologists, and that is the

Factor of "K" method. In this way, the weight of each fish (or group) is divided by the cube of the length, and the result multiplied by some power of 10, so that the resultant value has one figure in the units position. This method has been used chiefly for the comparison of condition of various age-groups. In the table following (II), the "K" values have been worked out for intervals of two centimetres of standard length (computed) for each of the six regions.

TABLE II

| Size | Fort Ticon- deroga | | Bur- ling ton. | Island Pike Reef | Areas Milton Shore | Cow- banks | Age (calculated) in years |
|------|-----------------------|------|----------------------|------------------------|--------------------------|---------------|---------------------------------|
| | Vt. | N.Y. | | | | | |
| 14 | 1.74 | 1.77 | 1.61 | 1.55 | 1.67 | 1.75 | 2.1 |
| 16 | 1.79 | 1.87 | 1.65 | 1.59 | 1.67 | 1.70 | 2.8 |
| 18 | 2.00 | 1.95 | 1.69 | 1.63 | 1.66 | 1.67 | 3.5 |
| 20 | 2.06 | 2.05 | 1.73 | 1.68 | 1.65 | 1.64 | 4.3 |
| 22 | 2.16 | 2.12 | 1.76 | 1.72 | 1.63 | 1.60 | 5.4 |
| 24 | 2.26 | 2.20 | 1.80 | 1.74 | 1.64 | 1.59 | 6.7 |
| 26 | 2.35 | 2.27 | 1.83 | 1.77 | 1.62 | 1.56 | 8.1 |
| 28 | 2.44 | 2.35 | 1.86 | 1.80 | 1.63 | 1.54 | 9.8 |

As already mentioned, there were very few fish under six inches in length - that is to say, fifteen centimetres, so that in the above table the "K" values are shown only for the size ranges fourteen to twenty-eight centimetres. It will be observed that those groups which have an index greater than the cube, for the L in the equation, have a steadily increasing value for "K" with increase in size. In groups in which the index is less than the cube, the "K" decreases with increase in size. This means then, that in those regions, the fish are of increasingly poor condition, with increase in size - namely the Sand Bar Bridge area; they are close to the average in the Grand Isle and in Burlington areas; and much better than average in the Fort

Ticonderoga area, assuming that the cube is about the average.

Since the length of time required to produce an animal of certain size and condition is an important one, an attempt has been made to determine this information, although in our investigations we made no collection of scales, or other means of determining the ages. The method used here has depended upon the table of age-lengths published by Schneberger (Trans. Wisc. Acad. Sci. Arts and Letters XXIX: 103-130. 1935), of the determinations by several investigators of the rate of growth of the Yellow Perch.

The sizes of the fast-growing groups to which the Lake Champlain perch most likely belong, were selected from Schneberger's table. Then by fitting a growth curve to these data, by the method of least squares (Raymond Pearl, Introduction to Medical Biometry and Statistics, 2nd. Edit. p.413, 1930), one can extrapolate and determine with a reasonable degree of probability the ages corresponding to the various size-groups. This is how the column of ages was secured, as given in the last column of Table II.

The largest group, numerically, of fish secured in the Fort Ticonderoga area, consisted of 130 individuals, of an average length of nineteen centimetres - which would mean, by these calculations that they were approximately four years old. These fish weighed on the average, eighty-five grammes each, or three ounces. Their "K" was about 2.0. Since it required four years to produce this twenty-four pounds of fish, and using McCay's conversion factor, this group has required about one hundred pounds of food. This illustrates the use made of the information

given above, and shews how it is necessary in order to give definite data or information about yields, to have such means as used here at one's disposal.

In the determination of the "K" value used in Table II, the standard length was used, to make the "K" value comparable with those reported by other workers. Since in our field work, only the total length was determined, it was necessary to calculate the standard length. This was done by using a factor determined by my colleague, Dr. M.W. Smith of the Atlantic Biological Station.

Probably it will be of interest to compare the amount of food which was found in the stomachs with this data on the length-weight relationship for the different areas. The amount of food was determined by opening the preserved stomachs, and finding the volume of fluid which this would displace. Each group of stomachs was examined separately, and each stomach in each group was tabulated. However, using collected data, and averages, we found for each of these regions, that the following amounts of food were present. In the stomachs from the Cowbanks area was found the least amount of food. This amount was put equal to unity. The other points were then calculated proportionally as follows:

TABLE III.

| Area | Amount of Food. | Index of I-- from equations. |
|---------------------------------|-----------------------|------------------------------------|
| Fort Ticonderoga (Vt.) | 85 | 3.510 |
| Fort Ticonderoga (N.Y.) | 54 | 3.406 |
| Milton Shore -- Sand-bar Bridge | 19 | 2.940 |
| Grand Isle -- Pike Reef | 8.5 | 3.212 |
| Burlington -- Rocky Point | 4.6 | 3.210 |
| Cowbanks -- Sand-bar Bridge | 1.0 | 2.811 |

With the exception of the stomachs from the Milton shore at the Sand-bar bridge, there is a definite correlation between the condition of the fish, as measured by the index of the length in the length-weight equations, and the amount of food found in the stomachs.

In the spring investigation, in Mississquoi Bay, as already stated, we took no measurements of either length or weight, so it is not possible to make a comparison of the condition of the fish from that region, with those of the winter fishery in this particular way. However, we did take as many stomachs as possible and the amounts of food in them, by areas, form the only comparison possible with the rest of the areas investigated.

For six different fishing grounds in Mississquoi bay, we found the following amounts of food in the stomachs, still using the Cowbanks value as unity:

| | |
|--------------|-----|
| Pike River | 35 |
| Desranleau | 83 |
| Millars | 94 |
| Lakewood | 167 |
| Phillipsburg | 192 |
| Jones | 245 |

Whether the Mississquoi Bay region is as much richer as seems indicated by these much higher values is possibly questionable because these fish were taken in April and May, when the waters had warmed up considerably over those of the winter fishery, which was carried out in February.

The conclusions which we seem to be justified in drawing from the above presentation are:

1. The Fort Ticonderoga area is much richer, and yields much fatter fish than the other areas investigated in the winter study.

2. It is possible that the Missisquoi Bay fish are equal to (or possibly even better) than the Fort Ticonderoga fish.

With respect to these conclusions, it is of interest that both of these areas are shallow and weedy. W. C. Muenscher in the XIX Annual Report of the New York State Conservation Department (page 175) remarks that on the western shore of Missisquoi Bay were found "the most extensive and luxuriant weed beds observed in Lake Champlain". This correlation of luxuriant weed growth and high productivity of the waters has been frequently observed, and is discussed briefly by Welch (1935).