THE FISH POPULATION OF LAKE JESSE, NOVA SCOTIA.

M. W. SMITH,
Atlantic Biological Station, St. Andrews, N. B.

(Received May 9, 1938).

ABSTRACT.

This study is based on a sample of fish secured from Lake Jesse, Nova Scotia, following the treatment of the lake with copper sulphate (August 3, 1934) to eradicate predators and competitors of speckled trout. Practically all fish came into the shores. The fish production was estimated by counting and weighing fish from measured sections of the shore-line. The estimated population was 36,035 fish, or a production of 19.9 pounds per acre. The following species were present: *Salvelinus fontinalis, Notemigonus crysoleucas, Semotilus atromaculatus, Catostomus commersonnii, Ameiurus nebulosus, Anguilla rostrata, Fundulus diaphanus, Perca flavescens, Morone americana, Pungitius pungitius. Fundulus, Perca* and *Morone* were the most numerous species. Predator species, *Perca* and *Morone*, constituted 57 per cent of the population. Each species is discussed separately, and data on length, weight, sex and relative condition of the fish are presented. The growth rate of *Perca* and *Morone* was slower than that determined for other lakes. Females appeared to live longer, although both sexes grew at almost the same rate. The population was dominated by fish in the second, third and fourth years of age. There were few fish of the year, indicating the dominance of predators. Fish over four years of age were scarce. The dominance of certain year classes suggests a cycle in the fish production, which would determine a scarcity of fry in certain years and a scarcity of older fish in others. There are indications that some species may have migrated into and out of the lake. Fifteen thousand speckled trout fingerlings were introduced into the lake in each of the years 1929, 1931 and 1932; twenty-nine trout were secured in 1934. A fish population, predators and competitors, as found in Lake Jesse, appears inimical to successful planting with trout fingerlings.

This study is based upon a sample of fish obtained from Lake Jesse at the time that this lake was treated with copper sulphate (August 3, 1934). This treatment was for the purpose of eradicating the predators and competitors of speckled trout and was carried out under the auspices of the Fish Culture Branch of the Canadian Department of Fisheries. Accounts of the procedure are given in articles by Catt and Smith[1]. A preliminary note on the fish population of the lake has already been published[2].

[1] Catt, *Trans. Amer. Fish. Soc.*, 64, 276-280 (1934); Smith, *Trans. Amer. Fish. Soc.*, 65, 101-113 (1935).
[2] Smith, *Trans. Amer. Fish. Soc.*, 65, 297-299 (1935).

Characteristics of Lake Jesse.

Lake Jesse has an area of forty-five acres, a maximum depth of 6.6 metres, and an average depth of 2.4 metres (May 30, 1929) (Fig. I). The annual fluctuation of the water level is approximately 0.5 metre. The lake is situated on the head-waters of Salmon River, Yarmouth County, and has only one small inlet, which becomes dry in mid-summer, and

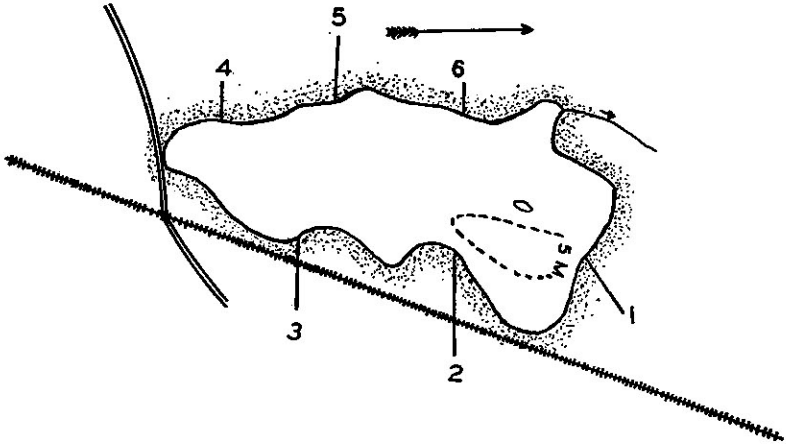

Fig. I. Sketch map of Lake Jesse. Areas over which fish were counted are indicated by numbers.

an outlet which, after a run of about a mile, empties into Lake Annis, a much larger lake than Jesse. The bottom near shore is largely composed of rocks and rubble, while in the deeper water a soft ooze, containing much organic matter, predominates.

The waters do not become stratified during the summer months and are circulated thoroughly by any strong wind during that period. Thus the temperature and chemical conditions of the bottom and surface waters are usually quite similar. The waters are soft. On August 1, 1934, the pH values were 6.5 at the surface and 6.3 at a depth of 6.5 metres.

The phytoplankton is of the Caledonian type, with a dominance of desmids. The rooted emergent aquatic vegeta-

tion occupies only a small area, and at no place is it dense. The zooplankton, as taken in mid-summer, 1934, consisted principally of *Diaphanosoma brachyurum*, *Holopedium gibberum*, *Daphnia pulex*, *Diaptomus minutus* and *Mesocyclops obsoletus*.

The reader is referred to another publication[3] by the author for additional information upon the flora and fauna of the lake, as well as for more specific data upon the hydrological conditions.

Methods.

Collection and enumeration of the fish.

Almost all the fish that were killed by the copper sulphate came either into the shallow water around the shores and died there, or were killed in the deeper water, came to the surface, and floated in. Actually a majority of the fish came into the shallow water when affected by the copper sulphate. With the aid of a water-glass, an examination of the bottom in deeper water (down to four metres) was made, and only a very few fish were noted away from the shore zone. No actual counts of the number of fish in the deeper water were made.

The presence of the fish in the shoal water at the shore made it possible to make an estimation of the total population by enumerating the number found on several areas scattered around the lake (Fig. I). The total shore-line was measured, and the areas upon which the fish were counted comprised one-eleventh of the total. For a sample all the fish from six smaller areas were preserved, with the exception of eels and bullheads, which were preserved from three such areas, as the means available for preservation of the fish were limited. All trout in the lake were enumerated as carefully as possible, since this species was of special interest. Twenty-four trout were measured as to length and then discarded.

Measurements.

The sample was preserved in ten per cent formalin from five to six months before measurements were taken. A dis-

[3] Smith, *Proc. N. S. Inst. Sci.*, 19, 253-263 (1938).

cussion of the changes of weight and length upon preservation will be given below.

Length.—Lengths were taken to the nearest millimetre and represent the distance from the snout to the shortest rays of the caudal fin (knotch of the tail). This length is used throughout the paper unless otherwise indicated. In the case of the killifish (*Fundulus*), with a truncate tail, this length is the total length. This also applies to the eel. For conversion to the standard length, where required, the following factors were used, and were based upon measurements of fish covering the entire length range of the sample. No regular change in the value of the factors was noted over this range. The species and factors are:

Notemigonus crysoleucas (golden shiner)...0.874 ($S.E._m = \pm 0.0007$)
Perca flavescens (yellow perch).....0.878 ($S.E._m = \pm 0.0008$)
Morone americana (white perch).....0.867 ($S.E._m = \pm 0.0012$)

Weight.—The fish were weighed to the nearest half-gram on a torsion balance. In the case of the yellow perch fry, however, the weight was taken to the nearest quarter-gram. The killifish were weighed in groups of one length frequency. All other fish were weighed individually.

Age determination.

Age determinations by examination of scales were made for the yellow and white perch. The scales were mounted and examined under a binocular or projection apparatus. The scales were taken from the region lying below the spinous dorsal fin, above the lateral line in the case of the white perch and below in that of the yellow perch. No trouble was experienced in making the determinations for fish up to four or five years of age, but for scales from a few older specimens in the sample a precise reading was difficult.

An examination of scales from the golden shiner was also made, but these could not be satisfactorily read. Precision was also difficult with the few speckled trout scales that were secured from fish taken in Lake Jesse.

Treatment of the data.

The standard error of the averages was calculated from the formula: $S.E._m = \frac{\sqrt{\Sigma \delta^2}}{\sqrt{N}}$.

Length-weight curves of the general form, $W = c\ L^n$, have been constructed by the method of least squares. Group averages were used in the calculations and not individual measurements.

The "condition factor" K was determined from the equation, $K = \frac{10^2 \times W}{L^3}$. Length (L) is considered in centimetres and weight (W) in grams.

The reader is referred to Hile[4] for a discussion of the "cube law", $W = cL^3$, and of the general equation, $W = c\ L^n$, in their relations to fisheries work.

Standing Crop of Fish.

The estimated crop.

From the sample of fish obtained from Lake Jesse at the time of the copper sulphate poisoning, an estimation of the total standing crop of fish has been made. The results of this estimation are presented in Table 1.

Semotilus, *Catostomus* and *Pungitius* were represented in the lake by small numbers, and did not occur on those areas from which the sample was taken, although one or two individuals of each were found on the total area counted over. *Perca flavescens* was the dominant species numerically, making up a little over forty per cent of the total population. However, *Ameiurus nebulosus* and *Morone americana*, although they comprised a smaller percentage of the population, gave, due to their larger average size, a greater production in pounds per acre, namely 5.1 and 5.5 pounds per acre respectively, as against 4.6 for *Perca*. *Fundulus diaphanus* was plentiful and constituted almost twenty-nine per cent

[4] Hile, *Bull. U. S. Bur. Fish.*, 48, 211-317 (1936).

TABLE 1.

Standing Crop of Fish in Lake Jesse.

Species	Number	Per cent of total	Number in sample	Total weight		Number per acre	Pounds per acre
				Grams	Pounds		
Salvelinus fontinalis	29	0.08	5	7,911	17.4	1	0.4
Notemigonus crysoleucas	2,611	7.45	111	41,227	90.9	58	2.0
Semotilus atromaculatus	22	0.06	.....	.....	.....	...	....
Catostomus commersonnii	22	0.06	.....	.....	.....	...	....
Ameiurus nebulosus	1,179	3.37	21	104,342	230.0	26	5.1
Anguilla rostrata	1,095	3.13	29	13,362	29.5	24	0.7
Fundulus diaphanus	10,098	28.83	325	31,910	70.3	224	1.6
Perca flavescens	14,177	40.48	497	93,006	205.0	315	4.6
Morone americana	5,781	16.51	229	113,308	249.9	128	5.5
Pungitius pungitius	11	0.03	.....	.....	.....	...	....
Totals	35,025	.....	1,224	405,066	893.0	776	19.9

of the total. Their weight averaged about three grams per fish, thus giving the comparatively small production of 1.6 pounds per acre. *Salvelinus fontinalis*, the most desirable species from the viewpoint of the angler, was scarce; twenty-nine specimens were found in the entire lake, and these represented less than one per cent of the population.

Reliability of the estimation.

The reliability of this estimation depends primarily upon the effectiveness of the copper sulphate in killing the fish and upon how well the distribution upon the areas over which the counts were made represented that on the remaining shore-line. Change of weight upon preservation in formalin might also introduce an appreciable error.

It has been concluded that the number of fish that survived the copper sulphate treatment, with the possible exception of the eel, was small. That a certain number did survive, for one cause or another, is shown by the following observations previously recorded (Smith[2], p. 110):

> "On August 5, two days after the copper sulphate had been added, a school of about twenty-five killifish were noted at the outlet from Lake Jesse, and two yellow perch and a few eels along the shore. By use of a large seine two small yellow perch were captured on August 6 in a number of hauls at various points about the lake. Catt[1] also observed killifish on August 9 at the outlet and captured one white perch in a twenty fathom gill-net. On October 3 one killifish was seen. Set-lines (25 hooks), baited with fish and earthworms, captured two eels on May 10, 1935. The same lines continued from May 16 to 21 inclusive yielded no fish. A gill-net set during the entire period of the May investigations caught nothing.
>
> Our observations indicated that a number of eels survived, for on the morning of August 4, there appeared to be a larger number of these fish alive in the shallow water at the immediate shore-line than later found dead. We anticipated that all would eventually die, so no actual count was made; thus, unfortunately we have no figures to subtantiate our observation."

The various species of fish were by no means equally distributed in the lake. Thus, for example, the greatest number of *Notemigonus* and *Morone* were found at the north

end of the lake, adjacent to the deepest water. On August 3, 1934, the day on which the lake was treated with copper sulphate, there was a steady wind blowing from the south-east, and on August 4, a light wind from the south-west. Floating fish would therefore drift toward the north end. Actually it was found, presumably owing to the proximity to the deep water and to the wind direction, that a greater number of fish were on the northern shores than elsewhere about the lake. There are no data to indicate how well the larger number found there was balanced by the smaller number at the southern end. Collection of the entire population was desirable but at the time not feasible. Although the areas counted over were kept under observation for a week comparatively few fish were found after the second day. There appeared to be no drift of fish from one area to another once the fish had become stranded in the shallow water, or washed upon the shore.

Hile[4] found a shrinkage factor for weight of 1.181 and 1.144 for ciscoes from two Wisconsin lakes. These fish were first preserved in ten per cent formalin and then in seventy per cent alcohol, and were held for about five weeks. He did not use the factors however to correct individual weights as he found the variation per fish fluctuated widely. Shrinkage factors for length have also been determined for certain species of fish preserved in formalin and alcohol [4-5].

To obtain additional information upon the change in weight we preserved specimens of several species of fish in ten per cent formalin. After a period averaging about 270 days, it was found that most of the fish gained rather than lost weight. The ratio, volume of body cavity to total body volume, appeared to be correlated with the changes observed, the larger this ratio the greater the gain in weight. Thus perciform species (*Micropterus*, *Perca*, *Morone*) showed the most gain, while pickerel (*Esox*) increased less in weight, and the eel (*Anguilla*) and killifish (*Fundulus*) lost weight. The abdomens of these fish were not incised. Neither were those

[5] Van Oosten, *Bull. U. S. Bur. Fish.*, 44, 265-428 (1929); Shetter, *Copeia*, 1936, no. 1, pp. 60-61 (1936).

in the Lake Jesse sample, since most of the specimens were small. Incising white perch (average weight about fifty grams) made a difference, although there was still considerable gain in weight. Thus, the factor, preserved weight to fresh weight, for incised perch was 1.075 and for unincised, 1.127. This factor for unincised killifish was 0.969, determined from a sample of sixty-eight fish.

If we consider the shrinkage in weight of killifish as being representative of that experienced by those in the Lake Jesse sample, we find that the total poundage of this fish as given in Table 1 should be increased from 70.3 to 72.5, which makes little difference in the poundage per acre (0.05 pounds). If we do the same for the white perch (unincised), although only a few of the larger specimens from Lake Jesse were comparable in size to those designated above, the total estimated poundage should be reduced from 249.9 to 221.7, which lowers the poundage per acre by 0.6. More data are required in order to apply general corrections in this paper, however, for it was found that there was considerable fluctuation in the individual loss or gain of weight, as for instance in the case of the pickerel, which showed individual changes from a loss of 0.04 to a gain of 0.6 per cent.

Production in other freshwaters.

The estimated standing crop of fish for Lake Jesse falls between the crops (17.0 and 36.0 pounds per acre) estimated for Boar's Back and Tedford Lakes, two other lakes which are situated in the same region of Nova Scotia and which were also treated with copper sulphate[6]. It is somewhat smaller than the standing crop (29.0 pounds per acre) estimated by Eschmeyer[7] for a small Michigan lake, which was treated with derris root, and considerably greater than that (8.4 pounds per acre) found by M'Gonigle and Smith[8] in McCormick Lake, Nova Scotia, which was also treated with derris root. Since not all the fish were recovered, Eschmeyer

[6] Smith, *Trans. Amer. Fish. Soc.*, 67, (In press).
[7] Eschmeyer, *Pap. Mich. Acad. Sci. Art. Let.*, 22, 613-628 (1937).
[8] M'Gonigle and Smith, *Prog. Fish Culturist, U. S. Bur. Fish., Mem.* 1-131, no. 38, 5-11 (1938).

considers that the standing crop for the Michigan Lake probably exceeded thirty pounds per acre. Whereas the populations of Jesse, Boar's Back and Tedford Lakes comprised several species of fish, that in the Michigan Lake was entirely yellow perch, except for a small number of introduced trout, and in McCormick Lake, entirely of speckled trout. The data for the lakes referred to are presented in Table 2.

TABLE 2.

Standing Crops of Fish in Certain Lakes.

Lake and Authority	Acreage	Number of species	Number per acre	Pounds per acre
Boar's Back (Smith)	55.8	7	498	17.0
Tedford (Smith)	52.0	7	1658	36.0
South Twin (Eschmeyer)	4.3	1	955	29.0
McCormick (M'Gonigle and Smith)	6.0	1	102	8.4
Jesse	45.0	10	776	19.9

Records of the standing crops of fish in streams show in many cases a higher production than herein recorded for lakes. In Second River, Nova Scotia, M'Gonigle and Smith[8] found that the standing crop of salmon parr and speckled trout in several sections of the stream varied from 0.7 to 573.8 pounds per acre, with an average for all sections of 112.4 pounds. From counts made on one-hundred foot sections of New York streams Greeley[9] gives estimations of the standing crops varying from 16.7 to 247.6 pounds of fish per acre. Trippensee[10] presents records for fish populations in a number of New Hampshire streams. They are based on sections of the streams that were seined, and Trippensee considers that the efficiency of the sampling varied from seventy to ninety-three per cent in numbers of fish. He gives the production for streams of the Saco drainage as varying from zero to 85.89 pounds per acre. In ten cases, that he presents, the estimation varied from 1.03 to 6.66 pounds per acre, in five others

[9] Greeley, State of N. Y., *Conserv. Dep., Biol. Survey* (1933), no. 8, pp. 53-108 (1934); Idem, *Biol. Survey* (1934), no. 9, pp. 63-101 (1935); Idem, *Biol. Survey* (1935), no. 10, pp. 45-88 (1936).

[10] Trippensee, *N. H. Fish and Game Dep., Survey Rep.*, no. 2, pp. 119-124 (1937).

from 11.55 to 17.22, and in an additional three, 29.47, 51.84 and 85.89 pounds per acre. For southern streams, Viosca[11] estimates that the total standing crop in spring-fed brooks of southern Louisiana is between 300 and 500 pounds per acre.

These data are for uncultivated waters. In rearing ponds where the fish are fed, or in fertilized carp, tench or eel ponds the production may exceed a ton of fish per acre [11-12].

Discussion on the Species of Fish.

Salvelinus fontinalis (Mitchill)—Speckled trout.

Twenty-nine speckled trout were secured from Lake Jesse after a careful search for this species had been made. The angling history of Lake Jesse indicates that in times past good catches of trout were made, but with more intensive fishing these diminished and in recent years were poor, although these waters were stocked with 15,000 number one trout fingerlings in each of the years 1929, 1931 and 1932[13]. It was of special interest, therefore, to determine the trout population as an indication of the survivals from these plantings, particularly since it was known that in late years Lake Jesse supported numbers of yellow and white perch.

One specimen of the twenty-nine trout, with a length of 40.0 cm. and a weight of 821.0 gm., was decidedly larger than the rest. The other twenty-eight individuals varied in length from 19.0 to 27.2 cm., with a mean length of 23.7 cm. ($S.E._m = 0.45$). An examination of the scales from four specimens (lengths: 20.6, 21.5, 24.1 and 24.4 cm.) placed their ages in the third year. The small number of fish involved in the age determinations made a precise reading difficult and subject to error, since there was little material from the lake for comparative purposes. We feel justified in concluding, however, that the twenty-eight fish were in their third or fourth years of age, and thus presumably represent the survivals in Lake Jesse of the 1931 and 1932 plantings.

[11] Viosca, *Trans. Amer. Fish. Soc.*, 65, 350-358 (1935).
[12] Langlois, *Prog. Fish Culturist, U. S. Bur. Fish., Mem.* 1-131, no. 7, pp. 1-7 (1935).
[13] Rodd, *Annual report on fish culture for* 1929, Dep. Fish. Can., pp. 1-78 (1931)
Annual report on fish culture for 1931, Idem, pp. 1-67 (1932);
Annual report on fish culture for 1932, Idem, pp. 1-72 (1934).

For speckled trout from streams in the Allegany State Park, New York, Kendall and Dence[14] found that sixteen fish in their third year, collected in August, 1922, had an average total length of 155.25 mm., and that nine more of the same age collected in the summer of 1921 had an average total length of 135.2 mm. Ricker[15] determined for three Ontario habitats, a cold Chara pond, a warm hard-water river, and a Laurentian Lake, that in their third year speckled trout attained an average total length of 19.05 cm., and in their fourth year an average of 26.7 cm. If we consider the trout from Lake Jesse as being in their third year, comparisons in regard to lengths show that the growth of trout from this lake was greater than that made by the fish in the Allegany streams, but was of the same order as determined by Ricker for Ontario waters.

Four individuals from Lake Jesse had an average length of 22.65 cm. and an average weight of 135.75 gm. Based on this small sample, we have calculated that the "condition factor" K has a value of 1.17. For the largest specimen (40.0 cm.) the value of K equals 1.28. Ricker[15] has calculated a "condition number" based on the length-cubed relationship: $\text{"condition number"} = \frac{\text{weight in pounds} \times 10^5}{(\text{length in inches})^3}$. Length was measured to the fork of the caudal fin as in the author's cases. Converting to a gram-centimetre relationship we secure the "condition factor" K used in this paper. Thus for trout from five Ontario habitats the value of K varies from 1.19 to 1.48.

Of the five preserved specimens from Lake Jesse, two were females and three males.

Notemigonus crysoleucas crysoleucas Mitchill—Golden shiner.

The golden shiner made up 7.5 per cent of the estimated population, and gave a poundage per acre of 2.0, ten per cent of the total.

[14] Kendall and Dence, *N. Y. State College of Forestry, Roosevelt Wild Life Bull.*, 4, 289-482 (1927).

[15] Ricker, *Univ. Toronto Stud., Biol. Ser., Publ. Ont. Fish. Res. Lab.*, no. 36, pp. 69-110 (1932).

There were 111 specimens in the sample. The length frequencies of these fish are shown in Figure VII, from which it may be seen that the total range was from 6.2 to 13.9 cm. The average length for the entire group was 10.4 cm. ($S.E._m = 0.16$).

The individual preserved weight varied from 3.0 to 36.0 gm., with a mean for the sample of 15.8 gm. ($S.E._m = 0.69$). The length-weight relationship of the fish is presented in Figure II, where the curve expressing the relationship has been

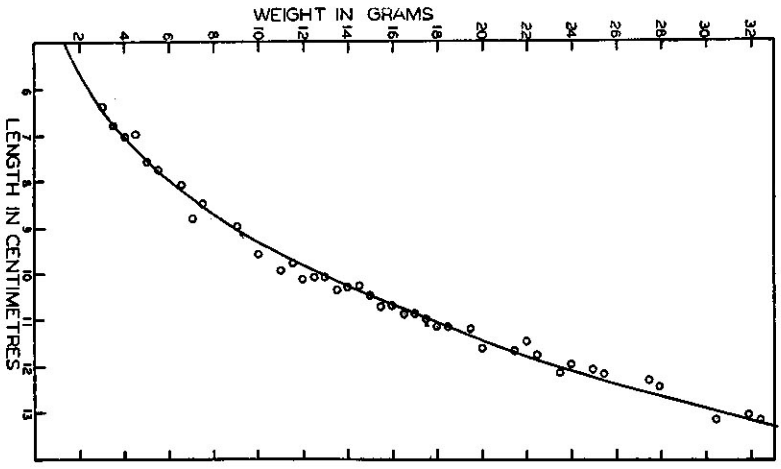

Fig. II. Length-weight relationships of *Notemigonus crysoleucas*.

calculated as $W = 0.006146L^{3.31}$. From the curve it can be shown that, within the length range of the sample, the increase in weight per unit length is quite large, particularly in the older fish. Thus between 7.0 and 8.0 cm the increase was 2.9 gm., while between 11.0 and 12.0 cm. it was 5.75 gm., or twice the rate for the smaller fish.

The "condition factor" K was determined for each five-gram interval of the weight. The determinations are set forth in Table 3. The values of K provide a measure of the relative condition or heaviness of the various groups of fish, for as Hile[4] (p. 239) states "—values of K, by reason of their calculation from the cube relationship; are direct and quanti-

tative measures of form or relative heaviness, and in this sense are directly comparable between fishes of any length." The value of K, however, would appear to be affected by certain factors. Ricker[15] found that for large trout heavy feeding considerably increased the value of the constant, as well as the approach of the spawning season in the females, but not in the males. Clark[16], in the case of *Sardina*, and Schneberger[17], in the case of the yellow perch, concluded that undigested food had no appreciable effect. These latter fish would be of the same order of size as the golden shiners from Lake Jesse. The youngest golden shiners from Lake Jesse were not mature, while the greater proportion of the older females were spent, although some were still gravid. The average value of K for five gravid females, averaging 11.0 cm. in length, was 1.32 as compared to a value of 1.28, the average for the weight group to which they belonged. With the Lake Jesse shiners, the variation is apparently not very large, and so males and females, immature and mature, are lumped together in the calculations for the results shown in Table 3.

TABLE 3.

Values of K for Notemigonus Crysoleucas.

Weight in grams	Number of fish	Average value of K
3.0– 7.5	18	1.17
8.0–12.5	15	1.18
13.0–17.5	41	1.28
18.0–22.5	19	1.35
23.0–27.5	6	1.43
28.0–32.5	8	1.36
33.0–37.5	1	1.34

The data show that the value of K increases as the fish become older, except for the last two groups which comprise a small number of specimens. This increase perhaps shows that Lake Jesse was as suitable, if not a better habitat for

[16] Clark, *Div. Fish and Game California, Fish. Bull.*, no. 12, pp. 1-59 (1928).
[17] Schneberger, *Trans. Wis. Acad. Sci. Art. Let.*, 29, 103-130 (1935).

the larger fish as for the small. *Notemigonus* feeds upon a variety of invertebrate forms, both of the plankton and of the bottom fauna, and in some cases algae[18]. The data appear to indicate that the species is an efficient converter of basic fish foods.

Scales from the Lake Jesse specimens were mounted and examined but they could not be satisfactorily read. Cooper[19] was able to determine the age by scale reading of the subspecies *auratus* from Michigan and of the typical form from New York. From a comparison between the standard lengths of the Lake Jesse fish on the one hand and of the Michigan and New York fish on the other, we would conclude that only a few of the fish from Lake Jesse were five years old, and that the dominate group of the population was three years of age.

The sex was not determined in the smallest fish (5.6 to 6.9 cm. standard length). Of the remainder in the sample, forty-four were males and forty-nine females, a ratio of 1:1.11. If this sample is divided into two groups at 10.0 cm. of length (standard), the ratio of males to females is 1: 0.68 under this length, but 1: 3.83 over it. In fact all fish over 10.5 cm. were females. Cooper[19] also found for *auratus* that females predominated among the older fish, in other words lived longer.

Notemigonus is usually considered a late spring and summer spawner. Thus Wright and Allen[20] give the spawning period for New York waters as May to July 1. Hubbs and Cooper[21] state that they have observed spawning in Michigan from June into August, with indications that in some waters it may begin in May. In Lake Jesse, 26.5 per cent of the females were considered gravid, i.e quite a number had not spawned by August 3. These individuals occurred over the entire length range of the mature fish. Below the 10.0 cm. length nineteen per cent of the females were gravid, while above this size thirty-five per cent were considered

[18] Ewers, *Trans. Amer. Fish. Soc.*, 63, 379-390 (1933); Forbes and Richardson. *Nat. Hist. Surv.* Ill., 3, 1-357 (1909); Moore, *U. S. Bur. Fish., App. Rep.* 1922, pp. 1-60 (1922).
[19] Cooper, *Pap. Mich. Acad. Sci. Art. Let.*, 21, 587-597 (1936).
[20] Wright and Allen, "*The fauna of Ithaca, N. Y.: Fishes.*" Zool. Field Notebook, Ithaca, pp. 4-6 (1913).
[21] Hubbs and Cooper, *Bull. Cranbrook Inst. Sci.*, no. 8, pp. 1-95 (1936).

ready to spawn. The absence of golden shiner fry in Lake Jesse at the time the waters were poisoned is explained by the fact that the treatment was carried out in the midst of of the shiners' spawning period.

As shown by the distribution of the dead fish along the shores, following the copper sulphate treatment, the golden shiners were largely confined to the deepest water at the north end of the lake and in a region free from aquatic vegetation. As a rule this species prefers shallow waters which contain an abundance of aquatic plants. Adams and Hankinson[22] found the majority of this fish in this type of habitat in Oneida Lake, New York, although they did take larger individuals in more open waters without vegetation. Hankinson[23] indicates that, in Michigan lakes, *Notemigonus* occurs most plentifully in the vegetal shallows, with a secondary preference for the *Potamogeton* zone. Their occurrence in the open water is not listed.

Semotilus atromaculatus (Mitchill)—Horned dace or creek chub.

Two specimens of this species were secured from Lake Jesse, measuring in length 8.7 and 17.0 cm.

Semotilus is typically a fish of brooks and streams. Evermann, according to Adams and Hankinson[22], indicates that the species may be found in larger creeks and rivers, and more rarely in lakes and ponds. It is apparently distributed throughout New Brunswick and Nova Scotia, and was recorded in 1852 by Perley[24a] under the name *Leuciscus cephalus* as being common in rivers and streams of the two provinces. The writer has taken the species in the Tusket river system (Sullivan's flowage), Nova Scotia.

Catostomus commersonnii (Lacépède)—Common or white sucker.

A few fairly large suckers were found in Lake Jesse. Three specimens were preserved and these had lengths of

[22] Adams and Hankinson, *N. Y. State College of Forestry, Roosevelt Wild Life Ann.*, 1, 235-548 (1928).
[23] Hankinson, *Pap. Mich. Acad. Sci. Art. Let.*, 17, 553-574 (1932).
[24] Pearse, *Bull. U. S. Bur. Fish.*, 38, 249-292 (1918).
[24a] Perley, "*Reports on the sea and river fisheries of New Brunswick.*" 2nd. ed., Fredericton, pp. 1-228 (1852).

35.8, 47.0 and 51.0 cm. The smallest of these (35.8 cm.) weighed 684.0 gm.

The only suckers present in Lake Jesse were mature fish. This indicates that either all the fry of this species that might have been in the lake fell prey to other fish, or that these larger individuals represented a few strays from the waters below. Lake Jesse is a head-water lake with no tributaries, except the outlet, in which suckers might spawn. Actually the outlet presents few gravel beds and other areas suitable for spawning. Thus, it is concluded that the absence of small suckers in Lake Jesse was due to a lack of spawning facilities, and that those present were strays which had penetrated into Lake Jesse from Lake Annis, while seeking spawning grounds in the outlet. Conversations with fishermen familiar with Lake Annis revealed that suckers are plentiful there.

Ameiurus nebulosus (LeSueur)—Bullhead or Horned pout.

The estimated number of *Ameiurus* in Lake Jesse constituted 3.4 per cent of the total population, but, due to the comparatively heavy individual weight, the poundage per acre, 5.1, was second largest for the lake. This poundage was 25.6 per cent of the total.

Twenty-one specimens made up the sample for this species. The length range of the sample was from 8.1 to 23.7 cm., the mean of which was 18.4 cm. ($S.E._m = 0.67$). The average weight was 89.7 gm. ($S.E._m = 7.89$). One specimen was decidedly smaller than the rest. It measured 8.1 cm. in length and had a weight of 7.0 gm. If we exclude this individual, the remainder were grouped fairly close together in size around a mean length of 19.9 cm. ($S.E._m = 0.46$).

Data for the length-weight relationship have been plotted in Figure III. The curve expressing this relationship is $W = 0.009109\ L^{3.125}$.

Anguilla rostrata LeSueur—Eel.

The eels killed in Lake Jesse were, as a whole, small. In the sample one specimen measured 75.0 cm. in length

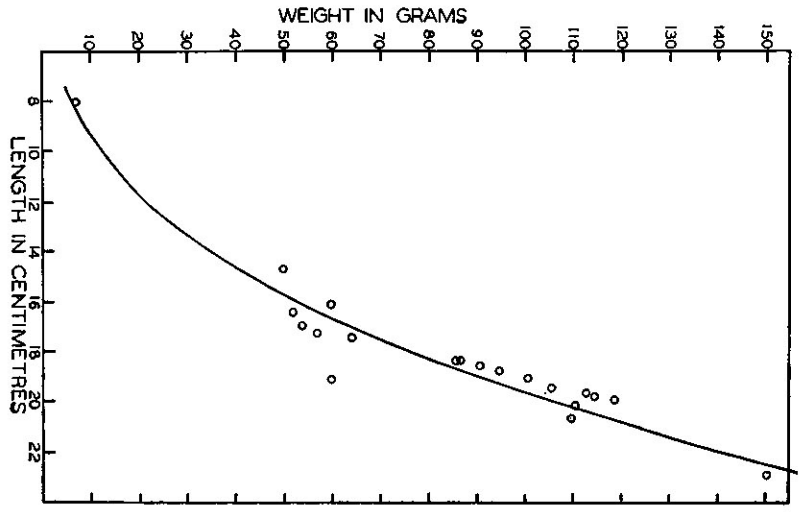

Fig. III. Length-weight relationships of *Ameiurus nebulosus*.

and weighed 840.0 gm. The remainder, however, had a much smaller average length of 19.4 cm. ($S.E._m = 3.7$), and an average weight of 12.75 gm.

In such species of fish as *Notemigonus*, *Perca* and *Morone*, the "condition factor" K $\left\{\frac{10^2\ W}{L^3}\right\}$ usually has a value greater than one, indicating that the weight is increasing out of proportion to the cube of the length. When we calculate the K values for the eel we find the reverse relation, namely that the cube of the length is increasing out of proportion to the weight. Thus the average K value for the eels from Lake Jesse was 0.161. For the single large specimen in the sample it was 0.198, and for the remainder 0.157 (average). The values of K for the Lake Jesse eels are compared in Table 4 with values for eels from two other lakes of the same region of Nova Scotia. As a whole the values are smaller for Lake Jesse, showing a less robust condition of the eels from this lake.

TABLE 4.

Values of K for Eels from Three Nova Scotian Lakes.

Lake	Number of fish	Length range, cm.	Range of K values	Average value of K
Boar's Back	12	17.2–26.5	0.142–0.217	0.176
Tedford	19	9.1–24.9	0.134–0.227	0.173
	89	25.0–51.0	0.173–0.246	0.207
Jesse	28	18.7–23.4	0.144–0.175	0.157
	1	75.0	0.198	0.198

As noted above, most of the eels from Lake Jesse were small. We have indicated before that a certain number of eels apparently survived the copper sulphate treatment. There is, however, no evidence at hand that the poison was selective in its action, killing a greater proportion of the smaller than of the larger individuals.

The eel is a catadromous species. As the fish become older and approach maturity, they migrate to lower waters on their way to spawn in salt water. Lake Jesse, as with the other lakes indicated in Table 4, is a head-water lake. The comparative absence of larger eels in these lakes could be explained by postulating that during the last few years of their life in fresh-water the eels gradually drop down from the head-waters into deeper basins nearer the sea. The three lakes in question do in fact have deeper and larger lakes lying immediately below them.

Fundulus diaphanus (LeSueur)—Killifish.

Killifish constituted almost twenty-nine per cent of the fish population in Lake Jesse. It is a small species, however, and, with its average weight of 3.2 gm., gave 1.6 pounds per acre, only a little over eight per cent of the total poundage for the lake. There were 325 specimens in the sample.

The length frequencies for the fish in the sample are presented in Figure VII. No satisfactory results were secured from attempts to determine the age of this species from the scales, but it is apparent that the population was very poorly

represented by fish of the year, which condition likely reflects the predator action of the dominant perch. Further, the length frequencies define a group, with an average length of about 5.5 cm., which is considered to consist of fish one plus years of age. Above a length of 6.1 cm., the length frequencies are bunched together. Without corroboration it is impossible to say whether we are dealing with a group predominately two plus years of age, and a few older fish, or with two groups, one of two plus and the other of three plus years, and a few older fish.

The entire length range of the sample was from 2.5 to 9.2 cm. The average length was 6.9 cm. ($S.E._m = 0.06$). Adams and Hankinson[22] give a maximum length of 11.4 cm. (4.5 in.) for specimens of the subspecies *menona* collected by them in Oneida Lake, New York. The length-weight relationship is shown in Figure IV. The curve expressing this relationship has been calculated as $W = 0.005411\ L^{3.25}$.

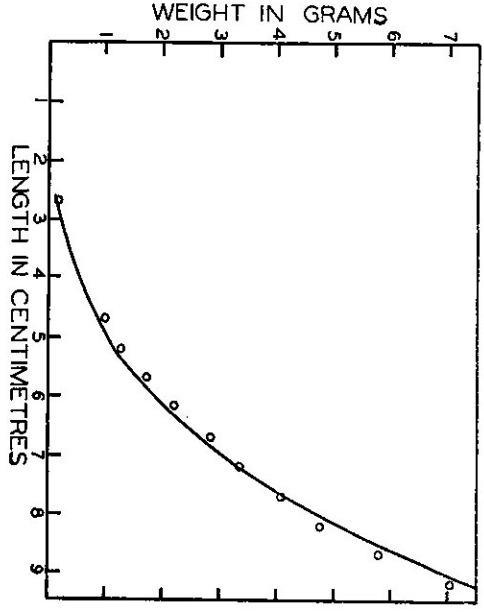

Fig. IV. Length-weight relationships of *Fundulus diaphanus*.

The values of K, based on the total lengths, for the Lake Jesse killifish have been determined for each five millimetres of length (Table 5). Leaving out of consideration the two fish of the year, and by taking moving averages for the K values, it is shown that the K values, as a whole, decrease as the fish become older, or in other words the fish appear to lose condition or comparative heaviness. The food of killifish comprises a wide selection of organisms, but entomostracans and insect larvae constitute a large proportion of their diet[24]. Such foods were not scarce in Lake Jesse. No evidence seems available to explain the trend of the K values.

TABLE 5.

Values of K for Fundulus Diaphanus from Lake Jesse.

Length, cm.	Number of fish	Value of K	Moving average
2.5–2.9	2	0.635	.....
4.5–4.9	14	0.934	.....
5.0–5.4	26	0.889	0.910
5.5–5.9	26	0.907	0.902
6.0–6.4	23	0.911	0.917
6.5–6.9	63	0.934	0.909
7.0–7.4	53	0.881	0.900
7.5–7.9	61	0.885	0.873
8.0–8.4	40	0.854	0.871
8.5–8.9	14	0.873	0.875
9.0–9.4	3	0.899	.....

Perca flavescens (Mitchill)—Yellow perch.

The yellow perch is common to abundant in many freshwaters of the Maritimes. In Lake Jesse it was numerically the dominant species, comprising a little over forty per cent of the estimated population. The poundage per acre was estimated at 4.6, or 24.2 per cent of the total. In poundage per acre, however, the yellow perch was surpassed by the less abundant, but individually heavier, bullheads and white perch. There were 497 yellow perch in the sample.

The length frequencies for the yellow perch in the sample are presented in Figure VII. In this figure there is shown

a well defined group of frequencies around an average length of 3.6 cm. segregated from the others. This group represents the fish of the year, as might be judged from viewing the figure, and as determined from scale readings. These fish made up 8.5 per cent of the population of yellow perch. From age determinations by scale readings the two groupings of frequencies around 7.6 and 9.2 cm. are shown to represent fish one plus and two plus years of age. These two year classes dominated the perch population, particularly that of one plus years of age, which comprised 63.9 per cent of the total. There were few fish three plus and four plus years of age. Four fish, still older, are not indicated in Figure VII. No precise determination of their ages was made, although they are considered to be in their eighth or ninth years. These fish had lengths of 16.3, 16.7, 18.0 and 20.3 cm.

Average lengths and weights for the yellow perch in the sample from Lake Jesse are given in Table 6. These data are presented for each year of age, up to four plus years, and by sexes, except for fish of the year, in which cases the males and females are not separated. The average lengths (standard) and increments of length for each year of age for the Lake Jesse perch are compared in Table 7 with similar data obtained from a number of lakes by other investigators.

TABLE 6.

Average Lengths and Weights for Perca Flavescens from Lake Jesse.

Age in years	Sex	Number of fish	Average length, cm.	S.E.m	Average weight, gm.	S.E.m
0+	?	42	3.6	0.059	0.5	0.053
1+	♀	140	7.8	0.038	5.5	0.074
1+	♂	176	7.7	0.042	5.4	0.075
2+	♀	74	9.3	0.060	8.3	0.174
2+	♂	34	9.1	0.063	8.15	0.166
3+	♀	19	10.8	0.135	13.8	0.135
3+	♂	2	10.8	.....	13.75	.....
4+	♀	1	12.8	.....	23.0	.....
4+	♂	2	12.4	.....	21.5	.....

TABLE 7.

Comparison of Lengths and Increments in Length by Age of Perca Flavescens from Several Habitats. Standard Length.

I. Length in millimetres.

Lake and Authority	Age					
	0+	1+	2+	3+	4+	5+
Erie (Jobes[25])	69	150	178	197	316	250
Nebish (Schneberger[17])	56	124	157	173	209	245
Erie (Harkness[27])	44	...	144	168	187	217
Wawasee (Hile[26])	39	86	129	167	198	220
Weber (Schneberger[17])	53	95	130	158	174	191
Silver (Schneberger[17])	45	77	109	120	145	173
Winona (Bolen[28])	..	79	111	137	175	...
South Twin (Eschmeyer[7])	..	87	86	118	129	...
Jesse	32	68	81	95	111	...

II. Increments of length in millimetres.

Erie (Jobes)	69	81	28	19	19	34
Nebish (Schneberger)	56	68	33	16	36	34
Erie (Harkness)	44	..	..	24	19	30
Wawasee (Hile)	39	47	43	38	31	22
Weber (Schneberger)	53	42	45	28	16	17
Silver (Schneberger)	45	32	32	11	25	28
Winona (Bolen)	..	..	32	26	38	..
South Twin (Eschmeyer)	..	..	1 (-)	32	11	..
Jesse	32	36	13	14	16	..

In general, the perch from Lake Jesse were decidedly smaller for their age than determined for the fish from the other lakes indicated in the tables. The data for the Lake Jesse perch most closely agree with those from South Twin Lake[7]. In Lake Jesse, the fish were killed on August 3, 1934, and in South Twin Lake on September 20, 1934. Thus it may be assumed that the Lake Jesse perch, if they had been allowed to grow until the latter date, would have more nearly

[25] Jobes, *Pap. Mich. Acad. Sci. Art. Let.*, 17, 643-652 (1933).
[26] Hile, "*Investigations of Indiana Lakes*," no. 2, Publ. no. 107, Dep. Consrve Ind., pp. 7-55 (1931).
[27] Harkness, *Univ. Toronto Stud., Biol. Ser., Publ. Ont. Fish. Res. Lab.*, no. 20, pp. 87-95 (1922).
[28] Bolen, *Proc. Ind. Acad. Sci.*, 33, 307-309 (1923).

approached in size those from South Twin Lake. The fish in the other lakes were taken from spring until fall.

As shown by the data in the second part of Table 7, the perch in Lake Jesse grew most rapidly in length during the first two years of life. In the third year there was a sharp drop in this increase in length, which, however, was then maintained almost on the same level during the fourth and fifth years. This sharp drop in length growth is in agreement with the findings of Jobes[25] for perch from Lake Erie, and also of Schneberger[17] for perch from Nebish Lake, Wisconsin. Jobes indicates that this radical change in growth may be associated with the attainment of sexual maturity in the fish. Yet, in other lakes there may be no manifestation of this sudden decrease in length growth in the third year. According to Hile's[26] data, for instance, the growth rate of perch in Wawasee Lake, Indiana, is gradual in its decline, or comparatively so, as the fish became older. It would appear that the attainment of sexual maturity does not always cause a sudden decline in the increase of length, although it may remain a potential factor. Good growing conditions at the time the fish reach sexual maturity might overshadow possible adverse effects of this physiological change. Examination of the ovaries of the Lake Jesse perch indicated that the fish spawned during the spring that they reached two complete years of age. Aside from the sudden drop in length growth in the third year, it was found for the Lake Jesse perch that there was also a drop in the weight increment (Table 6), which thereafter increased, and, further, a drop in the value of the factor K for the third year (Table 8). These observations appear to substantiate Jobes' postulation.

Average values for the factor K are given in Table 8, for the various ages and for both sexes, when determined. In Table 9 we have compared the values of K for the Lake Jesse perch with those determined by Hile[26] for Wawasee Lake, Indiana, by Schneberger[17] for Nebish, Weber and Silver Lakes, Wisconsin, and by Eschmeyer[7] for South Twin Lake, Michigan. Much of these data are the same as used by Eschmeyer[7] (Table VI, p. 623).

TABLE 8.
Values of K for Perca Flavescens from Lake Jesse.
(Standard Lengths used.)

Age in years	Sex	Number of fish	Average values of K by years and sex	Average values of K by years
0+	♀ and ♂	42	1.62	1.62
1+	♀	140	1.70	
1+	♂	176	1.72	1.71
2+	♀	74	1.61	
2+	♂	34	1.61	1.61
3+	♀	19	1.61	
3+	♂	2	1.61	1.61
4+	♀	1	1.62	
4+	♂	2	1.66	1.64

TABLE 9.
Comparison of Values of K for Perca Flavescens from Several Lakes.

Lake and Authority	Age				
	0+	1+	2+	3+	4+
South Twin (Eschmeyer)	....	1.49	1.49	1.43	1.42
Wawasee (Hile)	....	1.51	1.63	1.60	1.77
Nebish (Schneberger)	....	1.67	1.64	1.63	1.72
Weber (Schneberger)	....	1.65	1.44	1.54	1.61
Silver (Schneberger)	....	....	1.57	1.60	1.61
Jesse (Smith)	1.62	1.71	1.61	1.61	1.64

The perch in Lake Jesse apparently found the conditions more suitable for their well-being in the second year than at any other time of their life. This is indicated by the higher value for K of 1.71 than for the other fish, for which the value of K averaged 1.62. On the whole, the values of K for the Lake Jesse perch are of the same order as found by Hile and Schneberger, but greater than those determined by Eschmeyer for the perch from South Twin Lake.

In the latter case, Eschmeyer considers that the fish in South Twin Lake represented a population of stunted perch. He bases his contention upon the small size of the fish for their age and on the lower values of K as compared to perch from other lakes. The perch in Lake Jesse grew slower but

had higher K values, i.e. were relatively stouter fish, than those from South Twin Lake. This seemingly presents an anomalous situation, which, however, might be explained on the following basis. If a lake has a higher temperature and a poorer food supply than another lake, then the fish in the first lake will grow faster, but will be of a poorer condition, than those in the second lake, with its cooler temperatures and relatively better food supply. In other words, in the first lake the food supply is not adequate to meet the physiological requirements of the fish, while in the second these demands are fulfilled. Actually South Twin is a smaller lake than Jesse (4.3 acres as compared to 45 acres), and thus

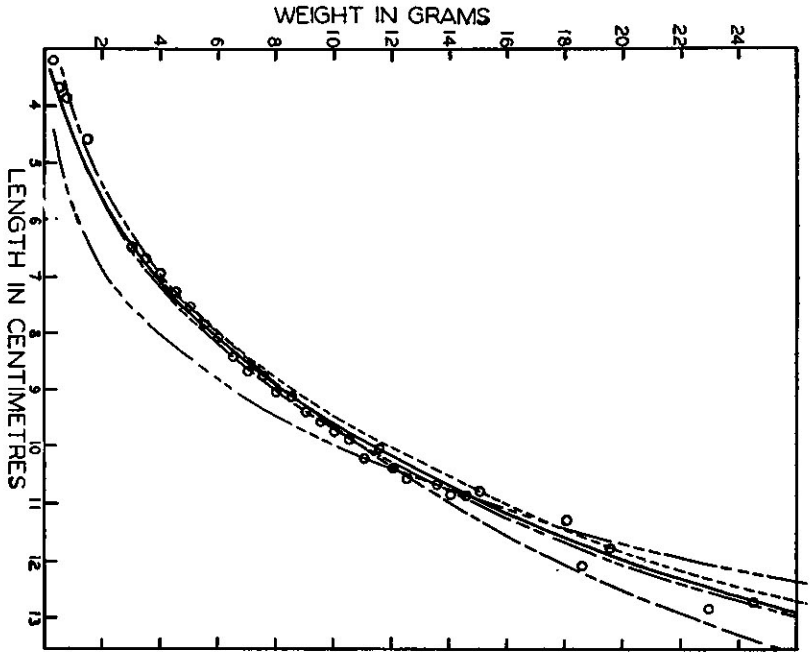

Fig. V. Length-weight relationships of *Perca flavescens*.
– – – – – – one plus years, females;
—— – —— one plus years, males;
—— – – —— two plus years, males;
– – – – – – three plus years, females;
———————— all fish, males and females.

might be expected to be warmer over a longer season. Further, Eschmeyer considers that there was a scarcity of food organisms for perch of intermediate size in South Twin Lake.

On the other hand, although the growth rate of perch in Lake Jesse was low when compared to the lakes investigated by Hile and Schneberger, the values of K were quite similar. For three Wisconsin lakes, Schneberger concludes that the rate of growth was in inverse proportion to the relative abundance of fish. Hile states that the food conditions in Lake Wawasee, Indiana, were excellent. Since all these lakes in question may have comparable water temperatures, at least less difference in this regard between these lakes and Jesse than between Jesse and South Twin, it may be possible to ascribe the low growth rate of the perch in Lake Jesse to a *relatively* poor food supply or a *relative* abundance of fish.

Expressions of the length-weight relationships by the function $W = CL^n$ for perch of various ages and both sexes, as well as for the population as a whole, are plotted in Figure V. Constants for this function for the perch are tabulated in Table 10. The equation expressing the length-weight relationship of female fish two plus years of age ($W = 0.008405\ L^{3.12}$) is not shown in Figure V since over the range of the curve that would be illustrated in the figure, it coincides with the equation for the entire population ($W = 0.009596\ L^{3.07}$).

For the perch population it is seen that the value of the exponent of the length (n) varies considerably in value, not

TABLE 10.

Constants of the Function $W = CL^n$ for Perca Flavescens from Lake Jesse. W = Weight in Grams. L = Length to the Shortest Rays of the Caudal Fin.

Age	Sex	Value of C	Value of n
1+	♀	0.009632	3.08
1+	♂	0.002039	2.72
2+	♀	0.008405	3.12
2+	♂	0.007297	3.17
3+	♀	0.0004581	4.34
All ages	♀ and ♂	0.009596	3.07

only from one year class to another, but also within one year class when the sex is differentiated. As illustrative of the difference in the value of the constants, consider the perch one plus years of age. For the females the value of n is 3.08, while that for the males is considerably lower at 2.72. Hile[4], dealing with the cisco, has also remarked that the values of n are not constant for a species or a population. He says in part (p. 246): "—the values of n determined for a single year's sample apply only to the length intervals for which the equations are fitted and do not hold for fish whose lengths lie outside these length ranges."

Sex was not determined for fish of the year, but was for all older fish. An analysis of the sex ratio, considering the perch population by years and as a whole, is given in Table 11. Considering the population as a whole, insofar as the sex was determined, females were somewhat more numerous than males, the actual proportions being 52.7 per cent females and 47.3 per cent males. For the perch one plus years of age, males were more plentiful. In this year class, 55.7 per cent were males. In the older fish, females began to predominate, and in the case of the fish two plus years of age the females constituted 68.5 per cent, and of the three plus, 86.4 per cent.

TABLE 11.

Sex Ratios for Perca Flavescens from Lake Jesse.

Age	Sex	Number of fish	Per cent by years of age	Per cent of the total
0+	?	42	.....	8.5
1+	♀	140	44.3	28.3
1+	♂	176	55.7	35.6
2+	♀	74	68.5	15.0
2+	♂	34	31.5	6.9
3+	♀	19	86.4	3.8
3+	♂	2	13.6	0.4
4+	♀	1	33.3	0.1
4+	♂	2	66.7	0.4
Older fish	♀	4	100.0	0.8
All ages except fish of the year	♀	238	52.7	....
	♂	214	47.3	....

Eschmeyer[7] found for the South Twin Lake, Michigan, that for the entire perch population the sex ratio was 74 females per 100 males, a ratio very close to that ascertained for the Lake Jesse perch one plus years of age. Eschmeyer indicates, as we have found for Lake Jesse, that the males are more abundant among the younger fish. Schneberger[17], for Wisconsin Lakes, found a ratio of females to males of 1:1.26 in Nebish Lake, but in Weber and Silver Lakes, ratios of males to females were 1:1.31 and 1:1.40 respectively. As pointed out by Eschmeyer, Schneberger was dealing with netted fish, and thus had comparatively few young fish in his samples. If he had had a larger number of young fish possibly males would have made up a greater proportion of the population. He did find that males were more plentiful among the younger fish.

Eschmeyer interprets his data as indicating that females live longer than males. The data for the Lake Jesse yellow perch seem to corroborate this view. Although there appeared to be a difference in the length of life between the two sexes, yet male and female perch grew at practically the same rate in Lake Jesse.

Morone americana Gmelin—White perch.

The general distribution of this species, according to Bigelow and Welsh[29], is along the Atlantic coast from the Gulf of St. Lawrence and Nova Scotia to South Carolina. These authorities say (p. 258): "Apparently it does not occur at all in salt water in the Bay of Fundy." The white perch is reported to breed either in brackish or fresh water. In the more northern part of its range, the species occurs in many lakes, and these populations, at least in part, are considered to be land-locked.

There were 229 specimens of white perch in the sample from Lake Jesse. There it made up 16.5 per cent of the fish population by number and 27.6 per cent by weight. This species and the yellow perch constituted the greater part of the predator fish population in Lake Jesse.

Bigelow and Welsh, *Bull. U. S. Bur. Fish.*, 40, 1-567 (1924).

The length frequencies found in the sample, as illustrated in Figure VII, show quite definite groupings, which coincide closely with the various year classes. The dominant year classes were composed of fish in their second, third and fourth years of age. Thus fish in their second year constituted 32.7 per cent of the white perch population, in their third year, 35.4 per cent, and in their fourth year, 21.4 per cent. Two perch, not indicated in Figure.VII, were either in their ninth or tenth year of age, and measured 27.2 and 29.9 cm. in length.

A peculiarity of the white perch population in Lake Jesse was the absence of fish of the year. In the case of the other dominant species, killifish and yellow perch, specimens of fish of the year were secured, although they were relatively scarce. White perch fry, however, appeared to be completely absent. Certain possibilities might account for the phenomenon. First, any spawning in Lake Jesse in 1934 may have been a complete failure. Spawning takes place in southern New England in April, May and June[29], and in the Chesapeake Bay region in April and May, and possibly during the winter[30]. Cameron[31] secured white perch fry from Wheaton's Lake, New Brunswick, on July 17, 1929. These fish ranged in length (standard) from 1.5 to 2.1 cm. Thus, it would seem probable that any surviving fry from a 1934 spawning in Lake Jesse would have been noted, particularly since a search was made for them. The second possibility is that no spawning by white perch took place in Lake Jesse and that the population of this species was represented by immigrants into the lake. Although the sample has not yet been fully analysed, the same situation apparently obtained in neighbouring Tedford Lake, which was also treated with copper sulphate. There is not sufficient evidence, however, to give a more precise explanation of this peculiarity.

Considering the white perch sample from Lake Jesse as a whole, the average length was 11.2 cm. ($S.E._m = 0.16$). The average length of the fish by year classes and sex and the average weight by year classes are given in Table 12.

[30] Hildebrand and Schroeder, *Bull. U. S. Bur. Fish.*, 43, 1-366 (1927).
[31] Cameron, *Biol. Bd. Can., Mss. Rep. Biol. Sta.*, no. 61 (1929).

TABLE 12.

Lengths and Weights of Morone Americana from Lake Jesse.

Age	Sex	Number of fish	Average length, cm.	S.E.$_m$	Average weight, gm., by years	S.E.$_m$
1+	♀	39	9.2	0.056	....	.....
1+	♂	36	9.1	0.081	9.1	0.128
2+	♀	48	11.1	0.042	....	.....
2+	♂	33	10.9	0.063	17.2	0.139
3+	♀	26	12.8	0.117	....	.....
3+	♂	23	12.55	0.117	25.1	0.361
4+	♀	7	13.9	2.15	....	.....
4+	♂	8	13.65	1.83	32.7	0.257
5+	♀	4	15.6	.....	....	.....
5+	♂	3	15.4	.....	47.1	.....

Concerning the rate of growth of this species, Hildebrand and Schroeder[30], writing in 1928, say (p. 246): "Virtually nothing is known of the rate of growth of the white perch." They indicate that fish taken in April, ranging in length from 7.4 to 14.0 cm., may have been one year old. Another sample of white perch, length range from 5.5 to 6.5 cm., taken in the lower Rappahannock River on July 25, is considered by them to consist of fish of the year. Cameron[31] presents data on length and age for white perch secured on June 25, July 17 and August 7 from Wheaton's Lake, New Brunswick. She obtained no fish in their second year of age, which may have been a result of the method of netting the samples. For white perch in their third, fourth and fifth years, the average standard lengths, male and female grouped together, were 12.25, 14.01 and 16.04 cm. respectively. For the Lake Jesse white perch the corresponding standard lengths were 9.6, 11.0 and 11.9 cm. Thus, comparing the two perch populations, it is seen that the fish from Lake Jesse grew at a decidedly lower rate. This is in agreement with the growth characteristics of the yellow perch from Lake Jesse when compared to most other habitats examined.

Length-weight relationships for the white perch in the sample are shown in Figure VI. Curves have been developed for this relationship for each year of age, males and females

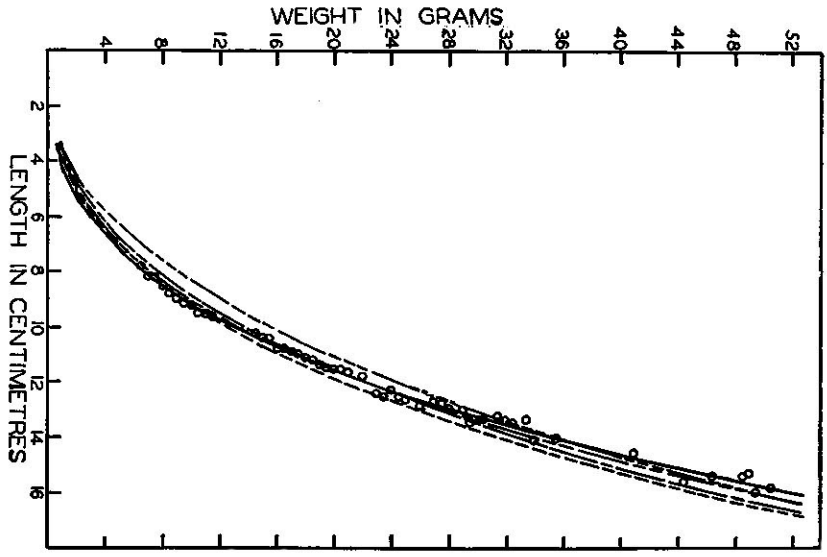

Fig. VI. Length-weight relationships of *Morone americana*.
- - - - - - - one plus years;
—— - —— two plus years;
—— - - —— three plus years;
—— - - - —— four plus years;
———— all fish.

grouped together, as well as for the entire sample. The curve for the perch over four plus years of age ($W = 0.01367\ L^{2.98}$) coincided so closely with that for the entire sample ($W = 0.01247\ L^{3.02}$) over the range shown in Figure VI that it could

TABLE 13.

Constants of the Function $W = CL^n$ for Morone Americana from Lake Jesse. W = Weight in Grams. L = Length in Centimetres to the Shortest Rays of the Caudal Fin.

Age	Value of C	Value of n
1+	0.02003	2.79
2+	0.03229	2.63
3+	0.02109	2.80
4+	0.05333	2.47
Older fish	0.01367	2.98
All ages	0.01247	3.02

not be illustrated. The constants for the function expressing the length-weight relationships are presented in Table 13.

It may be seen, as was also the case with the yellow perch, that the value of the exponent of length (n) varies in value from year class to year class. The use of this type of curve, based on fish in one year class or on a restricted group of fish, for the purpose of extrapolating lengths and weights from those portions of the curves lying outside the range of data to which the curves were fitted, may lead to considerable error. Further, the use of the constant C, determined empirically from the function, $W = CL^n$, rather than from the cube relationship, $W = CL^3$, as a coefficient of the condition of the fish gives an erratic and erroneous result. This has already been pointed out by Hile[4].

The "condition factor" K for the various ages of white perch from Lake Jesse showed little variation. Thus the average values of K (males and females together) for the fish in their second year was 1.22, in their third year, 1.29, in their fourth year, 1.23, and in their fifth year, 1.24. No other data seem available for comparison in this regard.

Cameron[31] found that a small sample of white perch taken on June 25 in Wheaton's Lake consisted of 66.7 per

TABLE 14.

Sex Ratios for Morone Americana from Lake Jesse.

Age	Sex	Number of fish	Per cent by years of age	Per cent of total
1+	♀	39	52.0	17.0
1+	♂	36	48.0	15.7
2+	♀	48	59.3	21.0
2+	♂	33	40.7	14.4
3+	♀	26	53.0	11.4
3+	♂	23	47.0	10.0
4+	♀	7	46.7	3.1
4+	♂	8	53.3	3.5
5+	♀	4	57.1	1.7
5+	♂	3	42.9	1.3
Older fish	♀	2	100.0	0.9
All ages	♀	126	55.0	....
	♂	103	45.0	....

cent females. Larger samples taken on July 17 and August 7 gave the percentages of females as 65.4 and 51.2. For the entire sample from Lake Jesse, 55.0 per cent were females. Table 14 outlines the distribution of sex by year classes. Females were somewhat in excess for the year classes most plentifully represented in the lake, i.e. one plus, two plus and three plus. Unlike the yellow perch from Lake Jesse, female white perch were more abundant than males in their second year of age. There is some indication, however, that female white perch live longer than males, since the two older fish indicated above were females.

Pungitius pungitius (Linnaeus)—Nine-spined Stickleback.

Only one specimen of this stickleback, which is common in many fresh-waters of New Brunswick and Nova Scotia, was secured from Lake Jesse.

Discussion.

Size of fish.

The fish population in Lake Jesse was dominated by fish in their second, third and fourth years. In the case of the yellow perch it was fish one plus and two plus years of age, while with the white perch these two year classes, along with fish three plus years, were fairly equally represented. With the killifish it was also these classes that were most plentiful. Thus, considering the population as a whole, there was a scarcity of fish of the year, and also a scarcity of older fish, of four or more years of age.

In the population as it existed in 1934, although the yellow and white perch were potential predators of the killifish, for instance, little predator action was apparently possible, since, in general, the size of all the most abundant species was quite similar (Fig. VII). The abundance of these predators in the lake would, however, explain the failure of the 1934 class of fish, due to the predator action of the dominant year classes against spawn and fry. Golden shiner fry were not taken since the fish were killed at the time of spawning. The

absence of white perch fry might require a further explanation, as noted above.

The scarcity of older fish is not so easily explained. In the case of the killifish it seems possible that the fish complete a normal life span in the lake. Jordan[32] gives the usual maximum size of this species as four inches, and the largest specimens taken by Adams and Hankinson[22] in Oneida Lake were

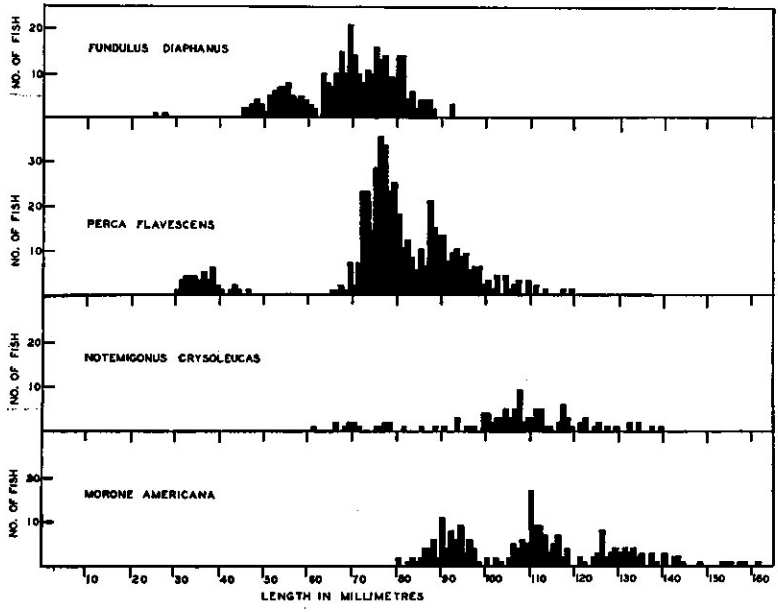

Fig. VII. Length frequencies for *Fundulus*, *Perca*, *Notemigonus* and *Morone*.

4.5 inches in length. The largest individuals taken in Lake Jesse measured 3.6 inches (9.2 cm.). The yellow perch definitely reach larger sizes than was found for the general run of this species in Lake Jesse, and fish over four years of age may constitute a good proportion of yellow perch populations[17,25,27]. With white perch it is also known that the species

[32] Jordan, "*Manual of the vertebrate animals of the northeastern United States*," New York, pp. 1–446 (1929).

grows to a much larger size than encountered in Lake Jesse, although most of the records are for fish from brackish or salt water[29,30]. We are aware that larger specimens of white perch are found in Lake Annis, which receives the drainage from Lake Jesse, but there is no information upon the abundance of these larger fish. The golden shiner may likewise attain larger sizes than found in Lake Jesse, although Hubbs[33] states that in small bodies of water the shiner may remain dwarfed. Thus, in summary, it seems indicated that for some species the scarcity of old fish may be attributed to a completion of the life span at a small size. Other species, as yellow and white perch, might be expected to grow larger. Food cannot be ascribed as the factor determining the size attained by these fish in Lake Jesse, for there was no apparent paucity of invertebrate fish foods in the lake, and there were plenty of fish, one and two years of age, to serve as a source of food for larger predator species. Schneberger[17], for Wisconsin yellow perch, has postulated that slow growing fish live a longer span of life than fast growers. Lake Jesse perch, as compared to those from the Wisconsin Lakes, were definitely slow growers, and from this viewpoint we might have expected a larger number of older fish than was actually observed.

There may be the possibility that the older fish in certain cases had migrated from Lake Jesse into the deeper and larger Lake Annis and waters below. We have already suggested that the suckers found in Lake Jesse were immigrants in the reverse direction. We have also postulated that the scarcity of large eels in Lake Jesse was due to migration downstream in connection with the seaward spawning run, although taking place sometime before the fish were mature. Further, if it was the case that the white perch in Lake Jesse were immigrants from elsewhere, it is logical to expect that spawning fish would migrate from the lake.

Cycle in the fish production.

The dominance of certain year classes suggests a cycle in the fish production of Lake Jesse. It is apparent that fry,

[33] Hubbs, *Trans. Ill. State Acad. Sci.*, 11, 147-151 (1921).

of most species present in the lake, produced in 1931, 1932 and 1933 were able to survive in good numbers. Since there were comparatively few large predator fish to prey upon these year classes, it might be assumed that they would have continued to dominate the fish population in Lake Jesse until a large percentage of them had completed their normal life span in the lake, i.e. either died or migrated. The 1934 year class of the entire population was a near failure. The cause for this may largely be attributed to the predator action of the 1931, 1932 and 1933 year classes of both yellow and white perch. If the fish population had been unmolested, probably the year class of 1935 would also have been a failure, and this would have continued in successive years, with diminishing intensity, until the classes of 1931, 1932 and 1933 had largely disappeared.

We have suggested above that the scarcity of fish four years of age and older was due to migration from the lake. A cycle in the fish production would also provide an explanation. The existence of dominant year classes during the few years before 1931 would determine a scarcity of fish four, five, and six years of age, and perhaps older, in 1934. By 1931 these fish would have become less plentiful, and thus would permit the year classes of 1931, 1932 and 1933 to build up, which in their turn would check the population in 1934. The presence of a few yellow and white perch about eight years of age in Lake Jesse in 1934 may well indicate the remnants of a dominating population prior to 1931.

We cannot say how long the 1931, 1932 and 1933 year classes would have continued to dominate the fish population in Lake Jesse, and thus no definite period to the suggested cycle can be given.

Eschmeyer[7] states that presumably a cycle of three years occurred in the yellow perch of South Twin Lake. He believes that in this lake the fish largely died of starvation in their third year. Huntsman[34] points out a cycle, averaging 9.6 years, in the scarcity of Atlantic salmon in the waters of the Maritime

[34] Huntsman, *Trans. Roy. Soc. Can.*, 3rd. Ser., 31 (sec. V), 17-27 (1937).

Provinces of Canada. He considers the scarcity is determined during the fresh-water stage of the salmon's life. He says (p. 26): "It develops that low water could be a factor causing scarcity through making the large parr, on which kingfishers and mergansers feed, easily available to these birds." Thus, during the dry summers the fry and small parr, due to the removal of the larger competing parr, would survive in greater numbers, and the year classes that these small fish represent would be favoured.

Fish culture implications.

Under the discussion on the brook trout we indicated that Lake Jesse had been stocked with 15,000 fingerlings of this species in each of three years, 1929, 1931 and 1932. Only twenty-nine trout were secured when the lake was treated with copper sulphate in 1934. The survival from these plantings was very low. It is generally considered that perch populations are inimical to success in planting trout fingerlings. The perch population as it existed in Lake Jesse in 1934 is considered to have destroyed a very large proportion of the fry of almost all species, and if plantings of trout fingerlings had been made in that year, it is natural to expect that the survival would have been poor. However, in 1931 and 1932, when the plantings were made, the situation was different. Since the fry of several species were quite successful in those years, it is probable that larger predator perch were scarce, and that introduced trout fingerlings would have encountered not so much predator action as competition for food and space from a large number of small fish of different species, of which fish of the year would constitute a good proportion. If the fish cycle, as postulated above, operated in Lake Jesse, then the planting of trout in 1929 did, on the other hand, encounter a perch population consisting in large part of older individuals, and the poor survival of trout could be ascribed to the predator activities of these perch.

During the years in question angling was poor in Lake Jesse. In fact, it was the scarcity of trout in this lake, follow-

ing the plantings already indicated, that prompted the treatment of the lake with copper sulphate in order to rid it of the undesirable species.

These observations would seem, therefore, to warrant the conclusions that not only are plantings with trout fingerlings unsuccessful in waters maintaining fish of sufficient size to prey upon the fingerlings, but also in waters, where predator action is comparatively slight, but competition by small fish heavy. This perhaps explains the lack of success in stocking waters with trout fingerlings which do not appear to contain trout predators, but there does exist direct competition for food, etc., on the part of other small species.

Acknowledgments.

This study was only made possible through the activities at Lake Jesse of the Fish Culture Branch of the Department of Fisheries. The author wishes to acknowledge the cooperation and assistance of Mr. James Catt, District Supervisor of Fish Culture, in carrying out the work at the lake. The author's colleagues on the staff of the Atlantic Biological Station gave valuable assistance in the preparation of this paper. The paper is published with permission of the Fisheries Research Board of Canada.