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The Significance of Food Habits in the Biology, Exploitation, and Management of Algonquin Park, Ontario, Lake Trout[1]

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ABSTRACT

Algonquin Park lake trout may be piscivorous or planktonivorous dependent on available food supply in the summer months. Plankton-feeding lake trout grow more slowly, do not reach as great a size or age as fish-feeders, and mature at a smaller size and younger age. Trout transferred from a plankton-feeding to a fish-feeding population grow at a faster rate and extend their life-span.

Fisheries in planktonivorous populations return larger numbers of smaller and younger fish to the angler. A higher percentage of mature fish occurs in these fisheries. The catch is dependent on fewer year classes and year-class strength is more variable. Yields in numbers per acre is higher in plankton-feeding populations but is comparable with fish-feeding populations in terms of pounds per acre.

The implications of these findings in such management practices as size limits, catch limits and quotas, lake closures, and forage fish introductions are discussed.

INTRODUCTION

Algonquin Park, Ontario, with an area of approximately 3,000 square miles, has about 150 lakes containing lake trout (*Salvelinus namaycush*) populations. These lakes range in size from 41 to 13,400 acres with about two-thirds less than 1 square mile in extent. Most support sports fisheries with angling pressure ranging from heavy to almost negligible depending upon accessibility and on the general quality of the fishing in the lakes.

A creel census has been carried out on many of these lakes since 1936. Fry (1939) and Fry and Chapman (1948) have analyzed the creel census data collected from a number of these lake trout fisheries in the period 1936–45. Great variability is evident in harvests, length composition, and availabilities of lake trout among lakes and in individual lakes over a period of years.

Martin (1952) made a detailed biological study of populations in Louisa and Redrock lakes. This indicated a great deal of the diversity in these Algonquin Park lake trout populations is a result of variability in rate of growth which in turn is a function of available food supply. If suitable forage species as yellow perch, *Perca flavescens*, lake whitefish, *Coregonus clupeaformis*, and cisco, *Coregonus artedi*, are available during the summer months, growth is relatively rapid. When such species are not available at this time the lake trout become largely planktonivorous and the growth rate is slower. Although lake trout in the largest lakes are mainly fish-feeding, there is not necessarily a relationship between lake size and food habits.

The purpose of the present paper is, by synthesis and expansion of earlier studies in Algonquin Park, to show the importance of food habits on the biology of the lake trout and their resultant effects on the character of the fisheries in this area.

FOOD HABITS AND LAKE TROUT BIOLOGY

Table 1 shows growth data for lake trout in 30 Algonquin Park lakes. These figures are based on calculated lengths of lake trout at ages as determined by the scale method.

Scales were impressed on cellulose acetate slides with a powered roller and read on an Eberbach scale projector at approximately 60× magnification. Two age determinations were made for each fish and a third reading carried out if there was disagreement in the first two. Percentage agreement in the first two determinations varied with the particular scales being aged but averaged about 75%. Criteria used for establishing annuli were essentially those used by Cable (1956). As pointed out by this author a number of indices must be used. Particularly valuable in the present aging were the spacing of the circuli, the cutting over or V mark, and the broken circuli giving a characteristic light band

[1] Contribution No. 66-3 of the Ontario Department of Lands and Forests, Research Branch, Maple, Ontario.

TABLE 1.—*Average calculated lengths (fork-inches) of lake trout at each age in 30 Algonquin Park lakes*

Lake	Length at each annulus																	Number
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Big Trout	–	6.8	12.0	9.5	12.3	14.8	15.9	18.9	19.9	20.9	22.7	25.1	–	–	–	–	–	198
Brewer	–	4.5	9.0	9.7	11.2	12.9	14.7	16.9	18.0	18.7	20.5	–	–	–	–	–	–	239
Butt	–	5.4	8.0	8.7	11.5	14.4	16.0	16.9	19.4	21.0	–	–	–	–	–	–	–	208
Cache	–	–	–	10.8	13.0	13.7	15.2	17.0	21.0	–	–	–	–	–	–	–	–	57
Canisbay	–	–	8.7	9.8	12.1	12.7	13.3	14.5	16.2	18.1	20.5	–	26.0	28.8	–	–	–	255
Cedar	–	7.5	7.9	7.8	13.4	14.6	15.6	18.3	19.0	24.3	–	26.2	27.0	–	–	–	–	58
Chicadee	–	–	–	–	12.3	14.4	15.3	15.9	16.9	15.5	–	–	–	–	–	–	–	227
Costello	–	6.8	7.6	9.9	12.2	13.3	14.8	16.9	18.6	19.9	20.9	26.3	26.3	–	–	–	–	79
Cradle	–	–	6.5	9.1	11.7	12.5	14.8	15.8	16.8	–	–	–	–	–	–	–	–	98
Godda	–	–	8.0	11.2	13.6	15.3	16.2	19.0	22.5	–	–	–	–	–	–	–	–	103
Happy Isle	–	–	8.8	10.6	12.8	14.3	15.1	16.5	18.5	20.0	22.9	25.6	26.7	31.8	32.0	–	–	2,402
Harness	–	–	–	7.7	11.0	13.4	14.8	15.8	15.5	–	–	–	–	–	–	–	–	89
Head	–	–	–	9.5	11.1	12.5	13.9	15.7	17.5	18.9	20.6	20.5	–	–	–	–	–	147
Hiram	–	–	–	12.5	13.5	15.3	16.4	16.9	17.9	21.3	–	–	–	–	–	–	–	132
Hogan	–	–	–	10.2	12.8	14.3	17.1	19.3	22.6	22.9	25.3	25.5	26.8	32.5	–	–	25.4	136
Kearney	–	6.5	8.4	10.3	12.7	14.6	15.2	18.6	18.3	19.8	21.9	25.2	32.0	–	–	–	–	84
Kenneth	–	–	–	7.5	10.3	12.2	13.8	15.4	16.2	18.0	18.6	–	–	–	–	–	–	137
La Muir	–	–	–	–	12.0	15.2	16.8	18.4	20.7	22.6	24.4	26.1	27.4	–	29.9	33.0	–	115
Lavieille	–	–	–	–	16.0	15.9	17.6	18.2	18.9	21.2	22.6	28.3	29.6	–	–	–	–	700
Lawrence	–	–	8.6	10.0	12.7	13.8	16.3	17.3	19.9	20.5	–	–	–	–	–	–	–	81
Little Island	–	–	9.1	9.8	12.7	13.6	15.1	16.0	19.4	21.1	–	–	–	–	–	–	–	117
Louisa	3.7	5.8	7.5	9.5	11.8	13.4	14.4	15.6	17.2	19.4	21.4	23.1	–	–	–	–	–	1,641
Merchants	–	–	9.9	10.5	12.5	14.5	16.0	17.3	19.4	21.9	23.5	27.1	29.0	31.6	32.6	33.1	–	2,571
Opeongo[1]	–	–	11.5	13.2	14.6	16.4	17.9	19.0	20.1	21.6	23.3	25.8	27.5	30.3	30.5	29.6	31.4	4,018
Redrock	–	6.1	8.8	10.7	13.3	15.4	16.9	18.4	19.8	21.4	24.1	25.7	30.1	–	33.0	–	–	1,608
Shirley	–	–	8.8	9.6	11.4	13.4	15.1	15.2	16.8	19.3	21.5	–	–	–	–	–	–	150
Smoke	–	–	6.9	11.4	11.3	14.4	15.2	19.6	20.1	21.5	23.1	26.9	25.0	28.7	–	–	–	90
Tanamakoon	–	–	8.9	9.5	12.8	14.1	15.3	15.9	17.3	–	–	–	–	–	–	–	–	98
White Partridge	–	–	10.2	10.8	12.2	13.9	17.2	18.9	19.8	20.8	21.8	–	–	–	–	–	–	306
Wilkins	–	–	–	8.7	10.1	12.2	13.7	14.6	16.4	19.7	–	–	–	–	–	–	–	113

[1] From Fry (1949).

around the scale, most easily seen when the image is slightly out of focus. Aging was periodically checked with other scale readers. Limited tagging work in a number of lakes generally substantiates the aging techniques. Although aging of lake trout by the scale method is admittedly difficult, the author has reasonable assurance of the determinations, particularly up to age-group X.

In Figure 1 growth is related to food habits of lake trout in these same lakes. The percentage of trout feeding on plankton has been used as an index of feeding habits. The period 15 June to 15 September was chosen for the food comparison as it represents the approximate period of thermal stratification when the availability of fish food becomes limited and the lake trout are planktonivorous. To minimize bias because of possible food preference by very small or very large fish in the samples, the comparison was further restricted to lake trout in the size range 10.0 to 19.9 inches. Age 7 was used for the comparison as it represents the main age-group in many of the fisheries thus providing the largest samples. A similar relationship was evident using other age-groups.

As the figure indicates, there is a significant correlation between plankton feeding and growth of lake trout. Average lengths at age 7 ranged from 13.6 to 17.9 inches as the percentage of trout feeding on plankton decreased from 92.5 to 0.0%. In the six heavily sampled lakes, Opeongo, Merchants, Happy Isle, Redrock Lavieille, and Louisa, the relationship was even more definite.

In Table 2 the maximum lengths, weights, and ages attained by lake trout in a series of Algonquin Park lakes are related to the dependence of the trout on plankton as food. In general, the more planktonivorous trout reach maximum lengths of 20 to 30 inches and weights of 4 to 10 pounds while those that are more exclusively fish-feeders may attain lengths of over 36 inches and weights of 25 pounds. Aging indicates plankton-feeders are shorter lived than fish-feeders. Age determinations in the oldest lake trout are particularly difficult and lack the level of accuracy of aging in younger fish. By and large, scales from the plankton-feeding populations are easier to age than those from the fish-feeders and the author feels reasonably certain of the maximum ages established for these fish. Any under-aging is most likely in the older members of the fish-feeding populations, thus emphasizing the difference in longevity in the fish of the two populations

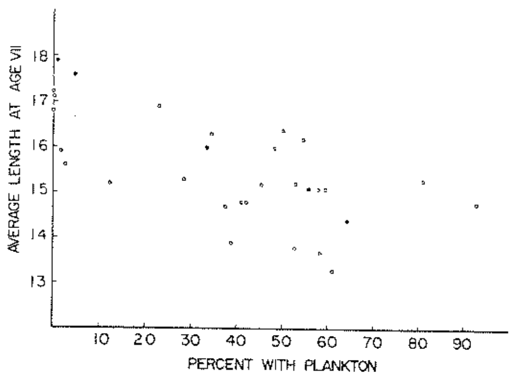

FIGURE 1.—Relationship between average fork length (inches) at age-group VII and percentage of lake trout feeding on plankton (see text). For all lakes $r = -0.65$, $P < 0.01$. For six heavily sampled lakes (solid circles) $r = -0.98$, $P < 0.01$.

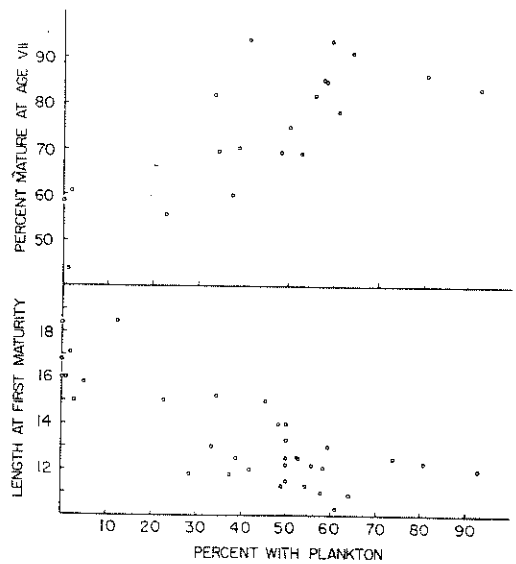

FIGURE 2.—Relationship between length at first maturity (lower panel), percentage mature at age-group VII, and percentage of lake trout feeding on plankton. For length relationship $r = -0.78$, $P < 0.01$; for age $r = 0.75$, $P < 0.01$.

Planktonivorous lake trout mature at a smaller size and in general at a younger age than do piscivorous (Figure 2). As the state of maturity of the gonads of lake trout may be difficult to determine early in the year, only maturity data after 1 July have been used for the comparison. Male lake trout may mature a year earlier than female in some cases. However, as comparable numbers of males and females occur in the samples, the sexes have been combined. Plankton-feeding lake trout reach maturity at lengths of 10 to 13 inches and in numbers at age 6 while trout more dependent on fish for food mature at lengths of 15 to 18 inches and in numbers about a year later. Furthermore, mature lake trout at age 4 have been collected only in lakes where the summer diet is chiefly plankton (Louisa, Canisbay, Godda lakes). Although these findings are anomalous to the biological principle of later maturity being associated with slower growth, the present conclusions are believed to be valid. Aging of young lake trout can be carried out with a considerable degree of certainty.

Plankton-feeding lake trout have presumably been such since glacial times, approximately 10,000 years, when the present-day fish fauna of Algonquin Park was largely established. To determine if the slow growth and relatively short life-span of these lake trout have become permanently fixed characters over this time, 303 lake trout were transferred from Lake Louisa to Lake Opeongo in 1961 and 1962. Lengths, weights, and scales were taken from these fish and they were tagged and released in the three major arms of Lake Opeongo.

To date 57 of these trout have been recaptured. They have moved freely between the largely discrete basins of Lake Opeongo. Of the 21 fish examined which contained food, 20 had fish, largely cisco, in the stomachs. As is indicated in Figure 3 the transferred lake trout responded to the new environment with marked increases in growth rate. Average annual length increments in native Louisa and Opeongo lake trout are of the order of 1 to 2 inches per year. Over comparable periods transferred fish showed increments of 2½ to 3½ inches. Longevity patterns also have been altered. Whereas approximately one in 1,000 of the lake trout in Lake Louisa reach age 10 or greater, at least one in 10 of the transferred fish have attained similar ages. The transfer program therefore indicates there has been no genetic fixation of these particular growth characteristics and they are primarily a function of environment rather than heredity.

TABLE 2.—*Maximum lengths, weights, and ages recorded for lake trout in Algonquin Park lakes. Lakes arranged in order of decreasing plankton utilization by trout. Maximum figures for individual lake not necessarily for same fish*

Lake	Percentage plankton	Maximum length (fork-inches)	Maximum weight (pounds)	Maximum age	Lake area (acres)
Cradle	92.5	16.8	2.3	9	41
Chickadee	80.7	22.0	3.0	10	67
Louisa	64.0	22.8	5.9	12	1,500
Canisbay	61.0	28.8	10.8	14	350
Little Island	59.4	28.0	–	10	123
Wilkins	58.4	19.2	–	10	569
Shirley	57.7	21.1	4.4	11	1,200
Happy Isle	55.6	35.5	26.0	15	1,452
Godda	54.4	22.5	5.8	9	143
Kenneth	52.8	19.0	2.8	11	107
Cache	52.8	28.0	8.0	–	570
Hiram	50.0	21.5	5.0	10	84
Butt	48.1	33.0	13.0	–	1,460
Kearney	45.1	25.2	7.8	11	80
Costello	41.7	28.0	–	13	96
Harness	20.9	24.0	–	–	144
Head	38.6	28.0	–	12	246
Brewer	37.4	27.6	9.5	15	109
Lawrence	34.2	26.0	–	–	224
Merchants	33.2	36.5	26.3	16	1,000
Tanamakoon	28.4	28.0	–	–	248
Redrock	22.6	36.6	21.0	15	746
Smoke	12.9	36.0	16.0	14	1,630
Lavieille	4.7	37.0	21.4	16	5,940
Cedar	2.6	34.0	10.2	13	6,400
Big Trout	1.6	34.0	–	13	3,630
Opeongo	0.9	37.5	24.0	17	13,400
White Partridge	0.0	25.0	–	–	1,408
La Muir	0.0	34.0	–	16	1,792
Hogan	0.0	34.5	15.0	17	3,072

TABLE 3.—*Summary of creel census returns for 31 Algonquin Park trout lakes for the period 1936–64. Lakes arranged in order of decreasing plankton utilization by lake trout*

Lake	Total reported caught		Average length (fork-inches)		Catch effort (number per 100 boat-hours)	
	Maximum	Mean	Range	Mean	Range	Mean
Cradle	17	–	–	14.4	–	311
Chickadee	58	35	14.3–15.9	15.2	70–214	104
Source	201	–	13.5–18.0	14.9	39–153	73
Louisa	373	206	14.0–16.8	14.9	98–354	185
Canisbay	293	218	13.6–15.7	14.3	93–181	140
Little Island	161	85	14.1–18.2	15.9	80–135	101
Happy Isle	866	252	14.2–18.5	15.0	97–183	121
Godda	37	32	14.5–16.2	14.9	147–204	177
Kenneth	125	39	14.4–15.4	14.8	93–162	134
Cache	207	107	14.7–18.4	15.7	52–118	91
Delano	146	–	12.6–15.2	14.9	125–267	172
Hiram	82	62	15.0–16.4	16.2	–	248
Two Rivers	125	–	15.6–18.0	17.1	57–124	91
Butt	338	252	16.1–19.2	17.7	170–320	235
Costello	96	68	15.3–17.3	16.9	93–103	–
Harness	64	–	14.0–18.6	14.6	99–264	171
Head	169	104	14.3–16.1	15.4	112–177	128
Whitegull	90	85	16.8–18.1	17.7	83–295	160
Brewer	30	–	14.7–18.3	16.1	57–113	84
Lawrence	96	–	14.9–19.5	16.7	119–248	166
Merchants	1,123	374	14.5–20.3	16.7	57–188	107
Tanamakoon	125	–	13.2–17.8	14.2	84–190	100
Redrock	331	195	15.4–19.6	17.5	69–153	64
Smoke	254	–	17.9–21.4	19.9	58–129	79
Lavieille	699	439	17.2–20.6	18.9	65–141	89
Cedar	255	148	15.5–20.1	17.6	80– 99	66
Big Trout	80	42	16.9–24.0	20.6	93–300	106
Opeongo	2,029	1,024	17.4–20.0	18.6	28–126	53
White Partridge	165	–	18.9–21.6	21.2	54–330	132
La Muir	142	–	19.8–24.3	21.6	66–230	124
Hogan	148	46	20.1–24.6	22.4	67–213	115

FOOD HABITS AND LAKE TROUT FISHERIES

As would be expected, this diversity in the fundamental biology of the lake trout in Algonquin Park lakes has had resultant effects on the character of the fisheries themselves. Table 3 summarizes the catch statistics collected since 1936 for a number of Algonquin Park lake trout fisheries. Although the data are of only general significance because of variability in creel census coverage and fluctuations in fishing effort over the years, they indicate a relationship between food habits and the harvest, availability, and size composition of lake trout in the fisheries. In general, harvest (number of trout per acre) and availability (number of trout caught per hour) figures are higher in the plankton-feeding populations while average length figures are lower. As White Partridge, La Muir, and Hogan are less accessible and relatively lightly fished, catch-effort figures are somewhat high for these lakes.

Figures 4 and 5 show the relationship between food habits and the average length and age of lake trout in the fisheries. In those lakes where the trout primarily feed on plankton during the summer months, a large proportion of the catch is made up of 14- and 15-inch fish at ages 6 and 7. In the more predominantly fish-feeding populations, catches are made up of a high percentage of 18- to 22-inch trout at age 7 and over. Fisheries in the former case are largely dependent on one or two year classes while in the latter they are based on a number of year classes. As is indicated in Figure 6, fisheries in planktonivorous populations exploit a higher percentage of mature fish than do those inpiscivorous (approximately 85 to 55%).

Fry and Chapman (1948), on the basis of length and catch-effort data from the creel census, suggested year-class strength was extremely variable in many Algonquin Park lake trout lakes. Populations exhibiting particularly pronounced fluctuations in their analysis were those in Louisa, Little Island,

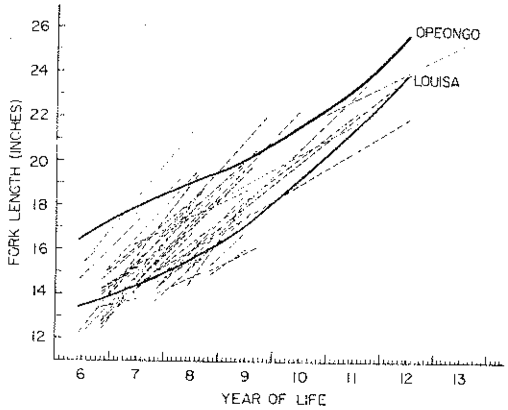

FIGURE 3.—Rate of growth of lake trout transferred from Lake Louisa to Lake Opeongo. Increments of transferred fish (dotted lines) superimposed on general growth curves for Louisa and Opeongo trout on a 12-month time scale.

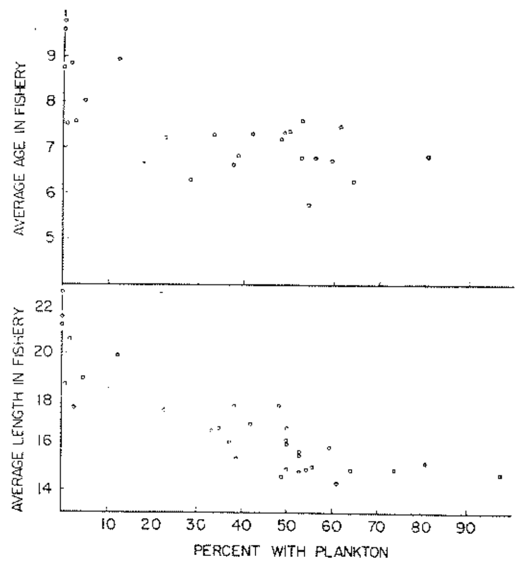

FIGURE 4.—Relationship between average length (lower panel) and average age of lake trout in fisheries and percentage of lake trout feeding on plankton. For length relationship $r = -0.83$, $P < 0.01$; for age relationship $r = -0.73$, $P < 0.01$.

Merchants, and Happy Isle lakes, all largely planktonivorous.

In Table 4 are presented estimates of year-class strength for four Algonquin Park lake trout populations over the period 1936–65 using the virtual population technique of Fry (1949). These lakes are used as they provide the most complete long-term data available from the creel census. On the basis of the general catch returns from the census for a large number of lakes and the detailed data from the four lakes, year-class strength fluctuations appear more pronounced in planktonivorous populations. In Merchants Lake (33.2% plankton) and Happy Isle Lake (55.6% plankton) year-class strength varied five- to tenfold and in Opeongo (0.9% plankton) and Redrock (22.6% plankton) fluctuations were of the order of two- to fourfold. At this point no logical explanation can be offered for this apparent relationship.

Table 5 shows the harvests of lake trout for Happy Isle, Merchants, Redrock, and Opeongo lakes for the period 1947–65. The analysis is confined to these lakes as fishing effort was greatly reduced in the war and immediate postwar years. The first three lakes have been under closure programs while Opeongo has been fished in consecutive years.

These data indicate that yields of lake trout in terms of numbers of lake trout per acre are higher in plankton-feeding populations. In Merchants and Happy Isle lakes the returns are approximately double those in Redrock Lake and Lake Opeongo. However, in terms of pounds per acre the yields of lake trout do not appear to bear any relationship to the feeding habits of the trout. Annual removals on this basis have been on the average highest in Merchants, Redrock, Opeongo, and Happy Isle lakes, in that order. In other words, although yields in terms of numbers of fish per acre are highest in lakes having plankton-feeding lake trout, total biomass figures are comparable for both planktonivorous and piscivorous populations. It is evident these yield figures approach the maximum that can be sustained on a continuing basis. Fry (1939, 1949) and Fry and Chapman (1948) have pointed out that removals in excess of these for a number of Algonquin Park lakes result in serious declines in the fisheries. Evidence from the lake closure program in Algonquin Park supports this view. The quality of the angling in Happy Isle, Merchants, and Redrock lakes remained at a reasonably constant level under an alternate-

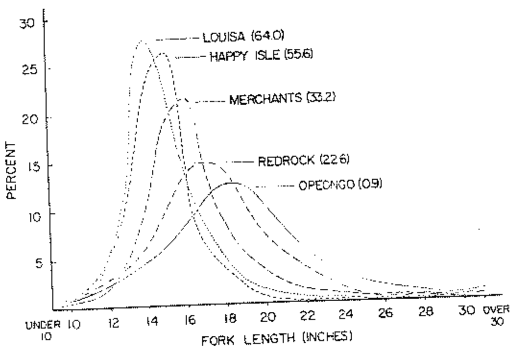

FIGURE 5.—Length composition of lake trout in five Algonquin Park fisheries for the period 1936–64. Percentage of lake trout feeding on plankton shown in brackets.

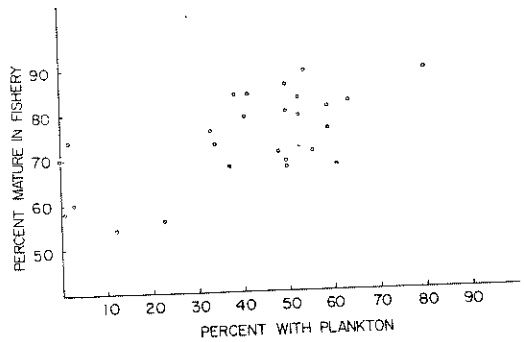

FIGURE 6.—Relationship between percentage of mature lake trout in fisheries and percentage of lake trout feeding on plankton. Coefficient of correlation, $r = 0.40$, $P < 0.05$.

year closure plan. With a 2-year-open and 1-year-closed regime there was a marked deterioration in angling quality in the second open year.

Ryder (1964, 1965) has related the chemical characteristics of Ontario lakes to their glacial history and proposed the morphoedaphic index (total dissolved solids in ppm divided by mean depth in feet) as a measure of potential fish production. His survey indicates that from the viewpoint of total dissolved solids and alkalinity the Algonquin Park area had among the lowest readings in the Province of Ontario. Most lakes average less than 40 ppm total dissolved solids and less than 15 ppm total alkalinity. Relating the morphoedaphic index to the long-term yields (pounds per acre) of lake trout only (unexploited populations of cisco, lake whitefish, perch, etc., occur in these lakes), the figures for yields and indices are, respectievly, for Merchants, Redrock, Opeongo, and Happy Isle lakes, 0.55 and 2.2, 0.37 and 1.5, 0.26 and 0.9, and 0.25 and 0.6. These data indicate a relationship between yields of lake trout and the physical and chemical characteristics of the lakes themselves. In conclusion, it appears the final production of lake trout flesh in these lakes is not influenced by different utilization of the food chain by the trout.

DISCUSSION AND CONCLUSIONS

It has been shown that food habits of lake trout in Algonquin Park lakes play an important part in determining the biological characteristics of the trout themselves. Growth, longevity, and age and size at maturity are effected by the kinds of food eaten in the various lakes. On the basis of evidence from the transfer program these characters are not genetically fixed.

In turn, this determines the character of the fisheries with respect to age and size composition of the catch, availability of the trout, year-class strength, numbers of year classes in the fisheries, and long-term yields.

It is evident this diversity has significant implications when considering the management of this species in Algonquin Park. This may best be illustrated by a discussion of some of the management practices that have been or are currently being carried out in Ontario waters for this species.

Minimum size limits

No size limits exist in Algonquin Park at present for lake trout. The present study emphasizes the impracticability of such regulations for this species. Size at first maturity has been shown to range from 11 to 19 inches in Algonquin Park lake trout. A minimum size to protect the faster-growing fish would result in many fisheries being almost entirely unavailable to the angler. The present system of nonrestrictive size limits would therefore appear desirable.

Catch limits and quotas

Plankton-feeding lake trout populations return large numbers of small lake trout to the

TABLE 5.—*Harvest of lake trout in numbers per acre and pounds per acre in Happy Isle, Merchants, Redrock, and Opeongo Lakes for the period 1947–65*

Year	Numbers per acre				Pounds per acre			
	Happy Isle	Merchants	Redrock	Opeongo	Happy Isle	Merchants	Redrock	Opeongo
1965	–[1]	0.204	–	0.074	–	0.348	–	0.339
1964	0.2111	x	0.159	0.097	0.273	x	–	0.359
1963	x[2]	0.155	x	0.053	x	0.220	–	0.208
1962	0.207	0.280	0.109	0.052	0.323	0.585	–	0.225
1961	0.317	x	0.310	0.037	0.406	x	–	0.177
1960	x	1.123	x	0.046	x	2.27	–	0.216
1959	0.196	x	0.272	0.068	0.255	x	–	0.292
1958	x	0.571	x	0.105	x	1.15	–	0.375
1957	0.367	x	0.405	0.107	0.477	x	0.936	0.353
1956	x	0.324	x	0.070	x	0.600	x	0.220
1955	0.550	x	0.310	0.069	0.621	x	0.865	0.227
1954	x	0.393	x	0.091	x	0.998	x	0.324
1953	0.600	x	0.300	0.063	0.840	x	0.611	0.190
1952	x	0.803	x	0.074	x	1.446	x	0.219
1951	0.361	x	0.231	0.090	0.570	x	0.670	0.269
1950	x	0.452	x	0.100	x	1.225	x	0.285
1949	0.131	–	0.196	0.085	0.269	–	0.459	0.243
1948	–	–	x	0.073	–	–	x	0.205
1947	–	–	0.237	0.053	–	–	0.543	0.156
Mean[3]	0.183	0.269	0.139	0.074	0.251	0.553	0.368	0.257

[1] Insufficient data.
[2] Closed to angling.
[3] Including closed years.

angler. The present daily limit of three trout permits the fisherman in Lake Louisa, for example, to keep on the average slightly over 3 pounds of fish. In Lake Opeongo, on the other hand, this limit allows a catch of over 10 pounds of trout. As has been indicated, yields in terms of pounds per acre are generally comparable for both types of lakes. The inequitable nature of present regulations in utilization of the crop is therefore apparent. The catch limit system presently in force is no doubt the most practicable from the point of view of administration. However, the use of a total inches or total weight regulation is worthy of consideration.

Quota systems for Algonquin Park lake trout fisheries would be difficult to administer because of the variability in the lake trout populations. Optimum use of the crop is particularly desirable in plankton-feeding populations where the fisheries are largely dependent on one or two year classes, the lake trout have a relatively short life-span, and year-class strength is extremely uneven. The causes of these fluctuations are not yet understood and predictions of future abundance of lake trout as a basis for setting up quotas are not yet possible.

Lake closure systems

Two lake closure practices have been carried out in Algonquin Park lakes. The first of these has been a systematic lake closure program, designed basically to increase spawning escapement. Fry (1949) has shown that in Lake Opeongo, where no closure is in effect, a positive correlation exists between spawning escapement and year-class strength. However, Martin and Baldwin (1953), and the more recent data in Table 4, indicate no clear-cut relationship between lake closure and presumably size of spawning stock, and resultant year-class strength.

This apparent contradiction may be explained on the basis of the differences in the character of the two populations. In lakes such as Happy Isle and Merchants, which have planktonivorous trout, rate of growth is slower and recruitment to the spawning stock in the closed years would be at a reduced rate. Second, year-class strength is naturally much more variable in lakes such as these. This may serve to mask possible beneficial effects of increasing size of spawning stock or indicate environmental pressures are more important than the number of spawners as factors in year-class strength. The evidence to date therefore suggests lake closure programs may be most beneficial to intensively fished lakes with faster-growing trout and more stable year-class production.

The second type of closure that has been practiced in Algonquin Park lakes has been that of winter fishing. Martin (1954) has

TABLE 4.—*Year-class contributions*[1] *to the lake trout fisheries of Opeongo, Redrock, Merchants, and Happy Isle Lakes for the period 1937–64*

Year[2] class	Lake			
	Opeongo	Redrock	Merchants	Happy Isle
1929	–	113	164	–
1930	–	126	65	–
1931	–	192	–	–
1932	1,294	163	–	–
1933	1,223	–	–	–
1934	1,132	–	–	–
1935	1,280	–	–	–
1936	1,407	–	–	–
1937	1,154	–	–	–
1938	937	–	–	–
1939	864	109	–	–
1940	768	134*	105	124
1941	1,008	80	118*	124
1942	1,203	55*	334	113
1943	1,413	58	347*	328
1944	1,470	65*	451	201
1945	1,190	112	236*	470
1946	–	84*	101	232
1947	–	88	64*	276
1948	–	83*	169	510
1949	–	115	236*	218
1950	–	204*	403	258*
1951	–	125	607*	321
1952	–	86*	468	101*
1953	–	89	159*	209
1954	–	121*	158	339*
1955	–	–	–	207
Range	768–1,470	55–204	65–607	101–510
Mean	1,167	110	246	253

[1] Based in part on Fry (1949), Martin and Baldwin (1953).
[2] Lake Opeongo based on hatching years; Redrock, Merchants, and Happy Isle on spawning years.
* Spawned in year closed to fishing.

shown that these fisheries result in larger catches and greater exploitation of small fish in many lakes than is the case with summer fisheries. This is particularly evident for those small lakes supporting slow-growing plankton-feeding trout. In these lakes productive fishing areas are more easily localized and catches in winter often exceed those in the open-water months. Summer fishing with wire line and heavy spoons serves as a self-regulatory control on the size of fish caught and spawning escapement is high. Winter fishing with set lines and live bait exploits a much higher percentage of small and immature lake trout. The faster-growing trout particularly in the larger lakes were not as vulnerable to winter fisheries either in harvest rates or in the utilization of small trout. Present evidence therefore indicates closure to winter angling may be most beneficial to the plankton-feeding populations.

Introduction of forage species

The introduction of the cisco as a forage species into Lake Opeongo has resulted in faster-growing, better-conditioned lake trout and would likely achieve the same result in plankton-feeding populations. However, such a measure would destroy the high spawning escapement currently enjoyed by these populations, although as has been previously pointed out, size of spawning stock may not be an important factor in year-class strength. The higher availability of trout in plankton-feeding populations and their superior table qualities make them desirable to many anglers and they should be preserved.

As may be readily appreciated from these examples, the fundamental variability in the character of Algonquin Park lake trout populations and the fisheries themselves may serve to complicate the effective application of many other management practices. It is likely what is biologically ideal for each of the fisheries will always have to be tempered by what is administratively feasible for the fisheries as a whole.

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LITERATURE CITED

CABLE, LOUELLA E. 1956. Validity of age determination from scales and growth of marked Lake Michigan lake trout. Fish. Bull. U. S. Fish Wildl. Serv. 57(107): 1–59.

FRY, F. E. J. 1939. A comparative study of lake trout fisheries in Algonquin Park, Ontario. Univ. Toronto Stud., Biol. Ser. 46, Pub. Ont. Fish. Res. Lab. 58:7–69.

———. 1949. Statistics of a lake trout fishery. Biometrics 5: 27–67.

FRY, F. E. J., AND V. B. CHAPMAN. 1948. The lake trout fishery in Algonquin Park from 1936 to 1945. Trans. Amer. Fish. Soc. 75: 19–35.

MARTIN, N. V. 1952. A study of the lake trout, *Salvelinus namaycush* in two Algonquin Park, Ontario, lakes. Trans. Amer. Fish. Soc. 81: 111–137.

———. 1954. Catch and winter food of lake trout in certain Algonquin Park lakes. J. Fish. Res. Bd. Canada 11: 5–10.

MARTIN, N. V., AND N. S. BALDWIN. 1953. Effects of the alternate closure of Algonquin Park lakes. Canadian Fish. Cult. 14: 1–13.

RYDER, R. A. 1964. Chemical characteristics of Ontario lakes as related to glacial history. Trans. Amer. Fish. Soc. 93: 260–268.

———. 1965. A method for estimating the potential fish production of north-temperate lakes. Trans. Amer. Fish. Soc. 94: 214–218.