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A Biological Survey of the Rangeley Lakes, with Special Reference to the Trout and Salmon

BY

GERALD P. COOPER
Assistant Professor of Zoology
University of Maine

Fish Survey Report No. 3

TO

Maine Department of Inland Fisheries and Game

GEORGE J. STOBIE, *Commissioner*
ARCHER L. GROVER, *Deputy Commissioner*

S. Williams

MAINE DEPARTMENT OF INLAND FISHERIES AND GAME

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Published by
The Augusta Press, Augusta

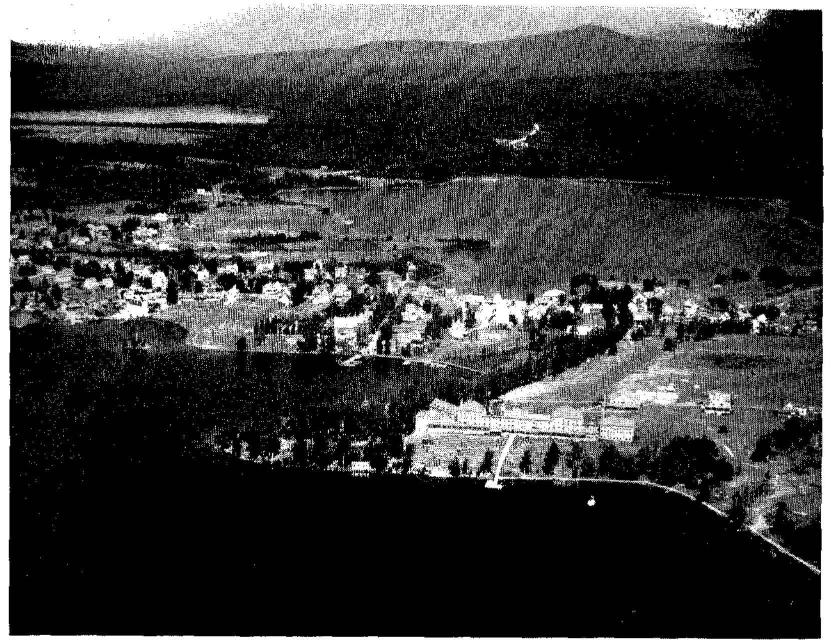
November 7, 1940

ANNOUNCEMENT

This is the third of a proposed series of reports on biological surveys of fresh waters of Maine. These surveys are being conducted by the Maine Department of Inland Fisheries and Game in cooperation with the Zoology Department of the University of Maine. The first two reports, published in 1939, dealt with streams, ponds and lakes in the extreme southwestern part of the state, in York County and parts of Cumberland and Oxford counties. The present report deals with a survey of the six large lakes of the Rangeley region collectively known as the Rangeley Lakes. Umbagog Lake, about two-thirds of which is in New Hampshire, is not included. These six large lakes in the Rangeley chain in western Maine together with numerous smaller ponds make up the headwaters of the Androscoggin River drainage. This river leaves Maine through Umbagog Lake on the border, loops southward through New Hampshire and again enters Maine near Rumford.

The present survey was made during the summer of 1939. In the announcement in the second report of the present series (Fish Survey Report No. 2) it was stated that plans for the 1939 survey were to begin the study of the Androscoggin River system at its lower end and to continue on northward. It seemed advisable, however, to begin the study of the Androscoggin system with the Rangeley lakes themselves. The 1940 survey will be carried on in the lower and central parts of the Androscoggin and Kennebec river drainages.

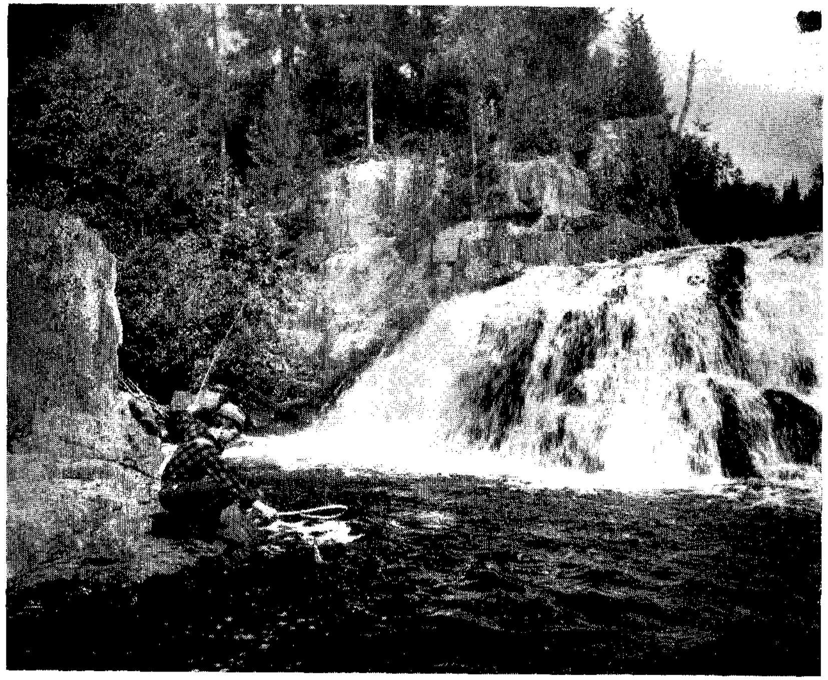
The two previous reports on lake and stream surveys in Maine were as follows: Fish Survey Report No. 1, "A Biological Survey of the Waters of York County and the Southern Part of Cumberland County, Maine," 1939; and Fish Survey Report No. 2, "A Biological Survey of Thirty-one Lakes and Ponds of the Upper Saco River and Sebago Lake Drainage Systems in Maine," August, 1939.



COURTESY OF THE PORTLAND PRESS HERALD

Aerial view of Village of Rangeley, with City Cove of Rangeley Lake in the foreground and Haley and Gull ponds in the background

The lower end of Mooselookmeguntic Lake from the southeast, looking toward Toothaker and Students' islands



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Survey Report No. 3

By Gerald P. Cooper

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INTRODUCTION

The Rangeley lakes are located in the extreme western part of the state, in Oxford and Franklin counties, near the Maine-New Hampshire border, and about 30 miles south of the international boundary line. They constitute a well defined lake unit comparable in size and in importance of fishing to such other unit areas in the state as Sebago Lake, the Belgrade chain, Moosehead Lake, the Grand Lake Stream section, and the Fish River chain. The six larger lakes of the Rangeley chain with which this report is concerned have a combined area of approximately 38,000 acres. The Rangeley region is readily accessible by automobile from the larger cities in Maine. U. S. Route 2, which is one of Maine's most important highways running east and west across the state, passes about 30 miles south of the lakes, and from this highway there are three good roads which lead into the Rangeley region, the best being Route 4 running northwest from Farmington from which the distance is about 45 miles. Another newly improved road is Route 5 to South Arm at the lower end of Lower Richardson Lake. The third entry into the Rangeley region is by way of Berlin and Errol, New Hampshire on Route 16 to Wilson's Mills at the foot of Aziscoos Lake.

The Rangeley lakes have long been one of the most important fishing regions in the more remote portions of Maine. It was estimated from reports by local fish and game wardens that the six large lakes considered in the present report had a total fishing intensity during the 1939 season of over 8,000 fisherman-days; records of the sale of fishing licenses indicated that the figure was actually much greater. A considerable proportion of the fishermen in the region are out-of-state people, and another large proportion are non-resident fishermen from other parts of Maine. The revenue brought by tourist-fishermen into this section of the state, to the local merchants, guides, boat renters, etc., constitutes a large proportion of the total annual income of the local people. The roads into the Rangeley region are continually being improved and the number of tourists coming into the region is continually increasing; therefore it seems safe to predict that the importance of the fishing to the Rangeley people will continue to increase, at least as long as the fish supply is maintained. To meet the continual drain which the large numbers of fishermen are putting on the Rangeley lakes, the State Fish and Game Department is stocking the lakes heavily with trout and salmon. The purpose of the present survey has been to study the fish populations and the various conditions which affect them in these lakes, in order to have an inventory of the present status of the fish fauna and to make recommendations on ways in which the fishing can be maintained and improved.

The present biological survey of the Rangeley lakes was made by Messrs. M. A. Marston and G. E. Spofford, Wildlife Students at the University of Maine, and the writer. The survey was a continuation of the general survey program initiated in the summer of 1937 by the Maine Department of Inland Fisheries and Game, cooperating with the Zoology Department at the University of Maine. The field survey was financed by the Fish and Game Department. Valuable assistance and information were obtained in the field work from the following local Fish and Game Wardens: Chief Warden Roy Gray and Deputy Wardens Alston Robinson, Frank Phillips, Charles Smart, Fernald Philbrick, and Norman Buck.

The survey was confined mostly to the six large lakes in the Rangeley region (not including Umbagog Lake on the Maine-New Hampshire line), namely: Lower Richardson, Upper Richardson, Mooselookmeguntic and Cupsuptic, Rangeley, Kennebago, and Aziscoos. Parmachenee Lake in the headwaters of the Magalloway River drainage, the numerous ponds in the headwaters of the Kennebago River drainage, and the numerous ponds draining into Rangeley Lake were not included in the present study.

The actual field survey work was carried on from the first part of July to the middle of September, 1939. The procedure was essentially the same as that used in the study of the lakes in Cumberland and southern Oxford counties in the summer of 1938; these methods have been described in Survey Report No. 2.[1] The procedure in lake surveys in Maine in the past has included the sounding of lakes in order to evaluate the water for trout and salmon. Previous sounding surveys had already been made on five of the six Rangeley lakes, and it was, therefore, necessary for the present survey to sound only Aziscoos. The other five lakes had been sounded by the United States Geological Survey in cooperation with the Maine State Water Storage Commission as follows: Mooselookmeguntic and the Richardson lakes in 1909, and Rangeley and Kennebago lakes in 1910. The original maps by the Maine State Water Storage Commission giving these soundings were copied by Kendall (1918)[2] in his report on the Rangeley Lakes. The original Maine State Water Storage maps, and also Kendall's maps published by the Bureau of fisheries, have been used with their permission in the present report.

Tests were made on the vertical distribution of temperature, oxygen and pH of the water in each of the lakes at one or more times during the middle or late part of the summer. Studies were made on the type of bottom soil and the abundance of bottom food organisms in each lake. Studies were made on the abundance of plankton organisms which constituted a very important link in the food chain of the fishes present. The kinds and abundance of fishes were determined by seining along the shores and by fishing with gill nets in different parts of each lake. Stomach contents of the game fishes were analyzed for food habit studies, and studies on age and growth by the scale method were made on all trout and salmon which were available. Comparative data on food habits and age and growth of trout and salmon from several other localities in Maine have been included for a comparison with the Rangeley material. The present survey has also included an analysis of the records of previous stocking of fishes in the Rangeley lakes by the State Fish and Game Department, and an analysis of a 1939 census by the State Fish and Game Wardens on the numbers of trout and salmon taken by fishermen from the lakes. All of these survey data are presented in the present report and are the basis for the recommendations that are given.

The most extensive of previous surveys which have been made on the fishes and fishing in the Rangeley region is the report by the late Dr. W. C. Kendall (1918), "The Rangeley Lakes, Maine; with special reference to the habits of the fishes, fish culture, and angling," United States Bureau of Fisheries Document No. 861. This report was based on a field survey, made by a United States Bureau of Fisheries investigating party under the direction of Dr. Kendall, of Umbagog Lake during the summer of 1905. Dr. Kendall had also made numerous observations on conditions in the Rangeley lakes, and these were included in his 1918 report. The chief emphases of the report were on the physical descriptions of the lakes, the kinds, abundance, and habits of the fishes present, and the history of stocking, of fish abundance, and of catch records. Numerous references are made throughout the present report to Dr. Kendall's survey and report of 1918.

[1] Cooper, G. P.: 1939. A biological survey of thirty-one lakes and ponds of the Upper Saco River and Sebago Lake drainage systems in Maine. Fish Survey Report No. 2, Maine Department of Inland Fisheries and Game.

[2] Kendall, W. C.: 1918. The Rangeley Lakes, Maine; with special reference to the habits of fishes, fish culture, and angling. Bull. U. S. Bur. Fish., vol. 35, pp. 485–594. U. S. Bur. Fish. Doc. No. 861.

GENERAL CHARACTERISTICS OF LAKES[3]

Physical and chemical characteristics. Temperate lakes undergo seasonal changes in their physical, chemical, and, to some extent, biological conditions. These changes are of utmost importance to fish life. A discussion of these changes is given at this time in order to aid the reader in evaluating the water analysis data which are given in a later part of this report. Seasonal changes in temperature are the most striking of all the changes in physical conditions in lakes, and these changes in temperature are very important to all of those fishes (including trout and salmon) which need cold water. Most seasonal changes in chemical conditions are dependent upon the water temperature cycle. The water temperature cycle is largely dependent upon two facts: (1) the maximum density of water occurs at a temperature of 4° C. (39° F.), that is, a unit volume of water is heavier at 4° C. than at either a colder or warmer temperature; and (2) water in lakes is heated mostly by contact with the air at the surface.

Each year, lakes in Maine pass through four distinct stages with respect to water temperature. In a large (over 1,000 acres) and deep (100 feet or more) lake, the distribution of temperature during these four stages is approximately as follows:

1. *Mid-winter stagnation stage:* Lasting from December until the ice "goes out" in early spring. Water temperature 32° F. just below the ice and becoming gradually warmer toward the bottom; seldom warmer than 39° F. on the bottom and usually not over 36° to 38° F. During this period there is practically no movement of the water.

2. *Spring turnover stage:* Begins usually only a few days after the ice disappears in the spring, and lasts only a few days depending upon the amount of wind and the air temperature. Water temperature uniform from top to bottom and at or near 39° F. Wind action produces water currents which roll and mix the water completely from top to bottom.

3. *Summer stagnation stage:* Commences immediately after the spring turnover stage and continues as long as warm weather lasts, usually into September. During this period the lake water may be divided into three distinct depth regions on the basis of temperature: (a) An upper layer (epilimnion) in which the water is quite uniformly warm (in large lakes this layer extends down about 18 to 25 feet or more; the temperature at 20 feet would be perhaps 2 or 3 degrees colder than at the surface); (b) a middle layer (mesolimnion or thermocline), extending from a depth of about 20 feet to 30 or 35 feet, through which there is a very sharp drop in temperature with increase in depth (for example: the temperature might be 76° F. at 20 feet, and 50° F. at 35 feet); and (c) a lower layer (hypolimnion), extending from 30 or 35 feet to the bottom, through which the drop in temperature is very slight compared to depth (for example: 50° F. at 35 feet, and 44° F. at 100 feet). During this summer stagnation period, the warmer water is on top because it is the lighter, and this difference in weight between the upper warm and deep cold water is very great. Summer wave action and water currents tend to force the warm water down to mix with the cold water below, while the greater weight of the cold water tends to work against this mixing. The warm water extends down farther as the summer progresses and the depth to which it does finally descend depends upon the strength of the waves and water currents which in turn depend upon the size and shape of the lake and the amount of wind action.

4. *Fall turnover stage:* Commences after the lake water has cooled down to 40° to 45° F. in the fall and lasts for several days to a week or more (in October or November) depending upon weather conditions of air temperature and wind. Water temperature uniform from top to bottom until the water cools to 39° F. or slightly less. Water "rolls" and mixes from top to bottom due to wind action.

The change from one to another, of these above stages in lakes, is mostly quite gradual due to the high specific heat of water. After the ice disappears in the spring, the 32° F. water at the surface in contact with warmer air begins to heat up. As it does so, it becomes heavier and sinks to mix with and displace the colder water below. This process continues until all the water in the lake is at 39° F. and at its maximum density. Since there is then no difference in weight between different layers of the water, a moderate wind can roll the water from top to botom. As the surface water now comes in contact with the warmer air, its temperature rises above 39° F. and its weight per unit volume decreases. This warm water now stays on top, and continues to do so as the lake warms up during the summer. There is then the summer stagnation stage as described under "3" above. When the water begins to cool in the fall the process is reversed.

[3] The following two sections of this report, namely "General Characteristics of Lakes" and "Requirements of Trout, Salmon, and Smelt" have been extracted, with slight alterations, from Survey Report No. 2. The sections are repeated here because the information is of considerable aid in interpreting the survey data on water analyses, and because the supply of Survey Report No. 2 is nearly exhausted and therefore not generally available to the fishermen in the Rangeley region. For a much more complete discussion of the physical and chemical characteristics of lakes, see Welch, Paul S.: 1935. Limnology. McGraw Hill Book Co., New York. 471 p.

The water cooling at the surface becomes heavier and sinks to displace the warmer water just below. This continues until all the water is of a uniform temperature from top to bottom. The water will then remain uniform in temperature from top to bottom until it cools to 39° F. Thereafter, as the surface water cools below 39° F., it becomes lighter than the warmer water just below and therefore stays on top; this process continues until ice forms on the lake and conditions are as described under "4" above.

The yearly cycle of dissolved oxygen, pH ("acidity"), and free carbon dioxide content of lake water depends upon the temperature cycle, and also upon other factors, namely:

1. The inherent ability of cold water to contain more dissolved oxygen than warm water.
2. The production of oxygen in water by aquatic plants, and largely by the plant plankton in most Maine lakes since the higher plants are generally rare.
3. The absorption of oxygen from the air by water at the surface.
4. The liberation of carbon dioxide into the air by water at the surface.
5. The amount and rate of decomposition of organic mud on the bottom and suspended in the deep water; this decomposition at the bottom removes oxygen and produces carbon dioxide.
6. The removal of oxygen from water by both animal and plant life, including bacteria.
7. The liberation of carbon dioxide into water by both animals and plants.

Of the above factors, Nos. 1, 3, 4, and 5 are probably the most important in the changes of the chemical properties of lake water in most Maine lakes. When water comes in contact with air at the surface it rapidly becomes saturated with oxygen and rapidly loses most of its carbon dioxide. Thus, when lake water is being mixed from top to bottom during the spring and fall turnover stages, the oxygen content of the water from the surface to the bottom is high and the carbon dioxide content is low. Following the spring turnover, however, temperature stratification makes it impossible for the deeper water to come in contact with the surface. Whether or not this deeper water will retain enough oxygen for trout and salmon throughout the summer, and not accumulate too much carbon dioxide, depend mostly upon the amount of water in the hypolimnion and the rate of decomposition of the bottom material. In a deep lake a moderate amount of decomposition might not be very serious because of the presence of a large amount of deep cold water; in a more shallow lake, the same amount of bottom decomposition might be sufficient to make all of the deep water unsuitable for fishes.

Under natural conditions in lakes, the oxygen content and carbon dioxide content tend to be complementary in their vertical distribution, since those processes which take up oxygen liberate a somewhat corresponding amount of carbon dioxide. Thus, where the oxygen content is high, the carbon dioxide is usually low; and vice versa.

Tests made during the past three years on about fifty Maine lakes have indicated that most of the natural lakes in southern Maine are more or less acid, even the upper water in the epilimnion. Summer tests on all of these lakes indicated that the deep water during summer is much more "acid" (a higher hydrogen-ion concentration) than the upper water. This variation in vertical distribution of pH reflects the variation in vertical distribution of carbon dioxide; that is, the deeper water is more acid due to the presence of more carbon dioxide produced by decomposition of bottom material and of organic material suspended in the hypolimnion. Thus, comparative pH tests are regarded, for most lakes of Maine, as a fairly good general index of the amount of carbon dioxide in the deeper water.

The depth to which warm surface water will be driven in lakes by the end of the summer depends mostly upon the size and shape of the lake and the amount of wind and wave action. Thus, the warm water will be driven down to about the same depth in all large lakes whether they are shallow or deep. This makes the factor of depth in large lakes very important in determining whether or not a lake will have cold water for trout or salmon during the hot part of the summer. Warm water is driven down to a greater depth in large lakes than in small ones, and this makes the size of the lake and the amount of protection which it has against the wind of considerable importance in determining the amount of trout water. In brief, it might be stated that the ratio of size to depth is the most important factor in determining how deep the warm water will be driven during the summer time and, therefore, how far down the trout and salmon will have to go to find a suitable temperature. Some information on this relationship between size and depth of lake or pond and depth to which the warm water (mostly the lower limit of the epilimnion) does descend is available from the 1938 and 1939 lake surveys. Judging from analyses made during June, July, and August in 1938 on lakes and ponds of southern Maine (Survey Report No. 2), it was estimated that during late summer the warm water (above 70° F.) extended to a depth of:

17 feet in ponds of 56 to 100 acres in area (average for 5 ponds)
18.7 feet in ponds of 101 to 500 acres in area (average for 15 ponds)
23.3 feet in ponds of 501 to 1,000 acres in area (average for 3 ponds)
25.3 feet in ponds of 1,001 to 2,000 acres in area (average for 4 ponds)
25 feet in one lake of 4,867 acres
30 feet in one lake of 28,771 acres

On the basis of the 1939 survey, it was concluded that the upper warm-water layer in the Rangeley lakes had extended to depths of 30 to 35 feet by the middle of August. These figures indicate for lakes of various sizes the approximate extent of the upper water layer which is too warm for trout or salmon during late summer.

The type of pond and consequently the amount of decomposition of bottom mud and organic material suspended in the deep water are the most important factors determining whether or not the deep water will keep enough of its oxygen during the summer to support fish life. The ratio of size of the lake to its depth is important to the oxygen content only indirectly in that it determines the amount of the deep water; if the amount of deep cold water is large, then a large amount of decomposition of the bottom mud might still not be sufficient to remove all of the oxygen and there might still remain some suitable trout and salmon water. One fact of particular interest at this point is that temperature, oxygen content, and pH content in water in lakes (except during spells of very windy weather) are quite uniformly stratified; that is, temperature, oxygen, and pH are each usually about the same at the same depth over the whole lake.

Stability of lakes and ponds. The physical, chemical, and, to some extent, biological conditions in lakes and ponds change from year to year only in proportion to the rate at which bottom material accumulates in the basin of the lake.

From the geologist's point of view, all lakes are in the process of rapid extinction by filling in of the lake basins with eroded soil and organic materials from aquatic plants and animals. In deep and relatively unproductive lakes with little plant life, this process of filling in is, by ordinary standards of time, extremely slow; but in the final stages in very shallow lakes, the process is much more rapid. Fortunately most of Maine's good trout and salmon lakes are of the former type, and are changing very little from year to year. Probably such bodies of water as Sebago Lake and the Rangeley lakes have not changed appreciably in their physical and chemical properties for the past several hundred years or much longer. Probably, also, such bodies of water will not change much for centuries to come, assuming that no large amount of organic pollution will enter the lakes. Therefore, the temperature, oxygen, and pH data obtained during the 1939 survey on the Rangeley lakes should be applicable to these lakes for many years in the future, and the lakes which are now good trout waters from the standpoints of temperature and oxygen will probably continue to be so for centuries. The fish populations in lakes, on the other hand, are subject to much more rapid changes, especially when new species are introduced. A continual knowledge of these changes in each lake is necessary for efficient fisheries management.

Classification of lakes. European limnologists have classified lakes[4] according to their physical, chemical, and biological characteristics into three types: *oligotrophic*, *eutrophic*, and *dystrophic*. Some of the important characteristics of these three types of lakes are as follows:

Oligotrophic lakes

- Relatively large amount of deep cold water.
- Water blue to green and very transparent.
- Little or no organic material on the bottom in deep water.
- Oxygen content high at all depths and at all seasons.
- Aquatic plants rare.
- Basic fertility: low in plankton, fairly rich in bottom food organisms.
- Excellent for trouts and salmons and other "cold-water" fishes.

Eutrophic lakes

- Lake shallow with relatively small amount of deep cold water.
- Water green to yellow or brownish green and not very transparent.
- Large quantity of organic material on the bottom and suspended in the water.
- Little or no oxygen in deep water during the summer.
- Aquatic plants abundant.
- Basic fertility: very rich in both plankton and bottom food organisms.
- Usually not good trout or salmon water.

Dystrophic lakes

- Deep to shallow; in bog surroundings or in old (geologically speaking) mountains.
- Water yellow to brown and with low transparency.
- Large quantity of organic mud on the bottom.
- Little or no oxygen in deep water during the summer.
- Aquatic plants rare.
- Basic fertility: low in both plankton and bottom food organisms.
- Occasionally trout (probably never salmon) in deep *dystrophic* lakes; never trout or salmon in shallow or advanced *dystrophic* lakes.

Five of the six Rangeley lakes which were studied by the 1939 survey (namely: Lower Richardson, Upper Richardson, Mooselookmeguntic, Rangeley, and Kennebago) are distinctly of the *oligotrophic* type. They were found to possess the above-mentioned characteristics of this type of lake in every detail, with the exception that they had a

[4] See Welch: 1935. Limnology, pp. 310–315.

genera scarcity of bottom fauna. They are definitely the direct opposite of the *eutrophic* type, as characterized above, in every detail; and they are distinctly not of the *dystrophic* type. Aziscoos Lake appeared to have several characteristics of both the *oligotrophic* type and *eutrophic* type, and this may be attributable to the fact that the lake is an artificial body of water of relatively recent origin.

REQUIREMENTS OF TROUT, SALMON, AND SMELT

The development of a scientific stocking policy must of necessity consider the requirements of the fish species concerned. These basic requirements of individual species naturally vary somewhat in different parts of the country, as, for example, the requirements of the Brook Trout in Maine waters are probably somewhat different from those of Brook Trout in states farther south and west. The requirements of our game species are not completely known by any means. Many of the basic requirements, however, are understood in a general way; and these are summarized (based largely on the literature; to some extent on survey results) for trout and salmon in the present section. The discussion applies equally well to the Brown Trout and Rainbow Trout. The requirements of trout and salmon are much the same in lakes and ponds as in streams. The most important of these requirements are:

1. *Cold water*: at least below 75° Fahrenheit, preferably below 70° F. There is considerable evidence that Brook Trout, at least, will live and do well in water 75° F. and warmer in shallow ponds where competing warm-water game fishes, such as the perches, bass and pickerel, are not present. It appears that in most of the lakes of southern Maine, trout and salmon occupy the deep and cold water partly because of preference but also partly because they will not tolerate the competition of the warm-water species which live mostly in the upper water. The maximum temperature limit of 70° F., therefore, has been tentatively set for those lakes of the southern part of Maine where warm-water game fishes are present. In more northern waters, such as the Rangeleys, which lack the warm-water game fishes, water of 70° to 75° F. has been tentatively characterized as marginal trout water.

2. *Oxygen*: at least 5 parts per million (p.p.m.) of dissolved oxygen in the water. The minimum oxygen requirement is set by some investigators at 4 p.p.m.; however, our studies on Maine lakes have indicated that trout and salmon do best in water with much more than 5 p.p.m. of oxygen. In determining the amount of trout or salmon water in a lake during late summer, it would make little difference whether the minimum was set at 5 p.p.m. or 4 p.p.m., because, in those regions where oxygen is as low as 5 p.p.m., the oxygen content usually varies markedly with slight change in depth.

3. *pH* (*acid intensity*): of approximately 5.0 to 9.0 for trout, best above 6.0 for salmon. Trouts can tolerate much more acid water than many other game fishes. However, a low pH in deep water reflects low oxygen and high carbon dioxide which trout and salmon can not tolerate.

4. *Adequate food supply*: Trout and salmon up to a length of about eight inches feed mostly on insects. These must be mostly bottom insects when trout and salmon are confined to the deep water in lakes during the summer months. Thus, the amount of bottom area available to these fish, and the abundance of bottom food organisms are important. Larger trout and salmon feed mostly upon small fishes; and, in Maine lakes, the Smelt is the only small fish which is very abundant in deep water during the summer. Thus the Smelt is an absolute necessity to the production of large Land-locked Salmon,[5] and is also important to large Brook Trout and Togue (Lake Trout).

5. *Spawning grounds*: Brook Trout and salmon are inherently stream spawners. (Possibly they do spawn in lakes under certain conditions, but this occurs rarely and is of little general importance.) Therefore, if stocking of a lake is done with the idea of establishing a partially or entirely self-sustaining population of trout or salmon, the lake should have tributary streams which offer suitable spawning conditions for the adults and conditions favorable for good growth of the young for at least two years.

6. *Stream habitats*: Young Brook Trout and salmon (also Browns and Rainbows, but not Togue) normally live in streams for two years or more and until they reach a length of at least six to eight inches. It is biologically unsound to plant trout and salmon fry (not Togue) in lakes and ponds. Fry should be planted only in suitable tributary streams. If the lake has no such streams, the fish should be reared in the hatchery to a length of at least six to eight inches before they are planted in a lake.

Smelt. Smelt, like the trouts and salmon, live in deep cold water during most of the summer at temperatures mostly less than 60° F. However, there are some authentic records which indicate that smelts

[5] Kendall, W. C.: 1935. The fishes of New England. The Salmon family. Part 2. The Salmons. Memoirs Boston Society Natural History, Vol. 9, No. 1, see p. 146.

do occasionally school at the surface of lakes during the warm summer months. Judging from the distribution of smelts in the lakes covered by the 1938 and 1939 surveys, it is believed that their oxygen requirement is similar to that of trouts and salmon, presumably at least 5 p.p.m. The adults of the larger race of smelts feed mostly on small fish; on the other hand, the young smelts and the adults of the small race feed largely on plankton (or micro-organisms) in the water.

Smelt spawning occurs mostly in streams; however, smelts are known to spawn normally in some lakes, as for instance Lake Champlain on the New York-Vermont line. Possibly also some populations of our smallest race of smelts here in Maine spawn only in lakes. Smelts spawn from late March to early May and the larger race usually spawns earlier than the smaller one. The eggs are adhesive and are stuck on sticks and stones on gravel or rubble bottom.

GENERAL DESCRIPTION OF THE RANGELEY LAKES

The various physical features of the Rangeley lakes have been discussed in considerable detail in early reports of the Maine State Water Storage Commission.[6] The data given in these reports have been treated extensively by Kendall in his 1918 paper, and are largely extracted from Kendall's report for the present account. Some of these data on the physical features of the Rangeley lakes are summarized in Table I.

The names of the six Rangeley lakes have been subject to some change in the recent past, apparently in an attempt to avoid rather cumbersome names of Indian derivation. The present tendency of changing the names of lakes throughout much of the state of Maine in order to adopt names which are more pronounceable is perhaps somewhat justified for that reason alone, but on the other hand seems somewhat regrettable from the standpoint of sentiment and also from the standpoint of individuality. One of the most confusing problems at the present time is the fact that there are so many lakes and ponds with such names as Mud, Round, Beaver, etc. that a knowledge of the exact location of a pond is a necessary part of its identity. The names now in use for the Rangeley lakes are not likely to be confused with lakes in any other part of the state, and perhaps the tendency for a change is justified in this instance. The names of the lakes which have been used in the present report are those which are in common use by the majority of the local residents The most commonly used names and also the older and less commonly used ones for the six lakes are as follows:

[6] See First Annual Report, Maine State Water Storage Commission, January, 1911.

Lower Richardson Lake, originally known as Wellekennebacook.

Upper Richardson Lake, originally known as Molechunkamunk.

Mooselookmeguntic Lake, also spelled Mooselucmaguntic, also known as Lower Rangeley Lake or Lower Oquossoc Lake.

Cupsuptic Lake, originally a lake separated from Mooselookmeguntic but subsequently joined to it by a raising of the dam at Upper Dam.

Rangeley Lake, formerly known as Oquossoc, Upper Oquossoc and Upper Rangeley.

Kennebago Lake, no other names.

Aziscoos Lake, also spelled Aziscohos, also known as Sawyer Lake.

Aziscoos or Sawyer Lake is entirely an artificial body of water produced by flooding the original Magalloway River by a dam located at Wilson's Mills. The small dam first located at Wilson's Mills produced a flowage about one-half the present size of the lake. Subsequently the dam was raised so as to produce the present lake of

TABLE I. Data on the physical features of the six Rangeley lakes

Lake	Elevation above sea level: feet	Area: acres (approximate)	Maximum depth*: feet	Total volume of water: acre feet (approximate)	Critical temperature and oxygen conditions during August (estimated from results of water analyses): Water 70°F. or warmer extends down to depth of: feet	Oxygen more than 5 p.p.m. extends down to depth of:
Lower Richardson	1,449	2,900	100**	124,000	35	bottom
Upper Richardson	1,449	4,200	108**	134,000	30	"
Mooselookmeguntic and Cupsuptic	1,467	16,300	132**	549,000	35	"
Rangeley	1,518	6,000	149**	328,000	35	"
Kennebago	1,777	1,700	116	105,000	30	"
Aziscoos (Sawyer)	1,517	6,700***	60**	181,000	30	30 ft.

* Maximum depths somewhat variable due to changes in water level.
** Maximum depth as found by present survey.
*** Data on area and water volume in Aziscoos based on a total area of 10.5 square miles as given by Kendall: 1918.

about 10.5 square miles in area. The present lake is about 30 years old. The other five Rangeley lakes are natural bodies of water, but all contain dams at their outlets and the dams are operated in controlling the flow of water in the Androscoggin River. The present dams[6] controlling the levels of the lakes are as follows: The one at Middle Dam controlling the level of the two Richardson lakes is 22 feet high with a 21-foot head. The dam at Upper Dam controlling Mooselookmeguntic is 20 feet high with a 14-foot head. The dam on Rangeley stream controlling Rangeley Lake is 10 feet high with a 4-foot head. The dam controlling the level of Kennebago Lake is on Kennebago River a short distance below the lake outlet. This dam has a head of about 20 feet. The dam on the Magalloway River at the foot of Aziscoos Lake is about 80 feet high with a 47-foot head. All of the dams controlling the five Rangeley lakes (except Aziscoos) are over 70 years old.

Rangeley, Mooselookmeguntic, Upper Richardson, and Lower Richardson lakes lie in a closely connected series extending in a northeast-southwest direction. Rangeley Lake at the head of the series drains through Rangeley Stream into the north end of Mooselookmeguntic; this connecting stream drops 50 feet in its two and one-half mile course. The outlet of Mooselookmeguntic Lake at its southeast end at Upper Dam empties immediately into Upper Richardson Lake near the middle of its east shore. The two Richardson lakes are connected by a "narrows" which maintains essentially lake conditions. Rapid River, the outlet of Lower Richardson Lake, leaves the lake near the middle of its west shore and drops about 200 feet in its six-mile course to Umbagog Lake. Kennebago Lake and especially Aziscoos Lake are somewhat segregated from the main Rangeley chain. Kennebago Lake has its outlet in the Kennebago River which drops about 310 feet in its 12-mile course to Mooselookmeguntic Lake. Aziscoos Lake is a flowed area on the Magalloway River which empties into the Androscoggin River at the foot of Umbagog Lake; it is, therefore, quite independent in drainage from the other lakes of the Rangeley region. (See maps, Figures 2 to 6.)

The general elevation above sea level of the Rangeley region is considerably higher than that of much of the rest of the state of Maine. The elevation of the two Richardson lakes is 1,449 feet above sea level, Mooselookmeguntic is 1,467 feet, Rangeley is 1,518 feet, Aziscoos is 1,517 feet, and Kennebago is 1,777 feet.

In actual area Mooselookmeguntic and Cupsuptic lakes together are nearly as large as the other five lakes combined. Next in order as to size are Aziscoos, Rangeley, Upper Richardson, Lower Richardson, and Kennebago, respectively. The actual areas and approximate

[6] See footnote p. 20.

capacity of water volume of each of these Rangeley lakes as quoted by Kendall from the Maine State Water Storage Commission Report are as follows:

Lake	Area in square miles	Volume of water
Lower and Upper Richardson (together)	13.08	5¼ billion cubic feet
Mooselookmeguntic and Cupsuptic	28.27	10 " " "
Rangeley	9.76	2½ " " "
Kennebago High level	4.13	
Low level	2.74	50 million " "
Aziscoos	10.5	8 billion " "

For the purpose of evaluating each lake with respect to the amount of trout and salmon water present, the areas of each lake were calculated by using a planimeter on our own prepared maps. These areas are given in acres in Table I. They agree approximately with the figures given by the Maine State Water Storage Commission. Likewise, for the present survey, the actual volume of water in each lake was calculated by drawing depth contour lines on the available maps and determining the area within each depth contour by planimeter reading. Our own figures on water volume as calculated in this way are given in Table I; these also agree fairly well with the figures as given by the Water Storage Commission. The discrepancies which do exist between our own figures and those given by the Water Storage Commission are of very little if any significance, in the present survey procedure of calculating the relative amounts of water suitable and not suitable for trout and salmon in these lakes.

All of the Rangeley lakes except Aziscoos are comparatively deep. Soundings during the present survey revealed water depths greater than those indicated by the Water Storage Commission maps on four of the five lakes which had been sounded. These maximum depths for the various lakes are as follows: Lower Richardson, 100 feet; Upper Richardson, 108 feet; Mooselookmeguntic, 132 feet; Rangeley, 149 feet; Kennebago, 116 feet; Aziscoos, 60 feet. It is, of course, possible that there is somewhat deeper water in some or all of these lakes than indicated by these maximum depths, but the possibility is slight that the difference is more than a few feet in each instance.

Most of the shore line on the Rangeley lakes is rocky. Areas of protected shores with an accumulation of mud in the shallow water are generally very scarce. Stretches of sandy beaches and sandy shoal areas are fairly prevalent in the Richardson lakes but are very limited or absent in the others. The raising of the levels from a few to several feet by the present dams produced only a small amount of submerged and dead timber, or "dry-ki," because immediate shores of the lakes are quite precipitous and the raising of the lake levels has flooded only a relatively small amount of land.

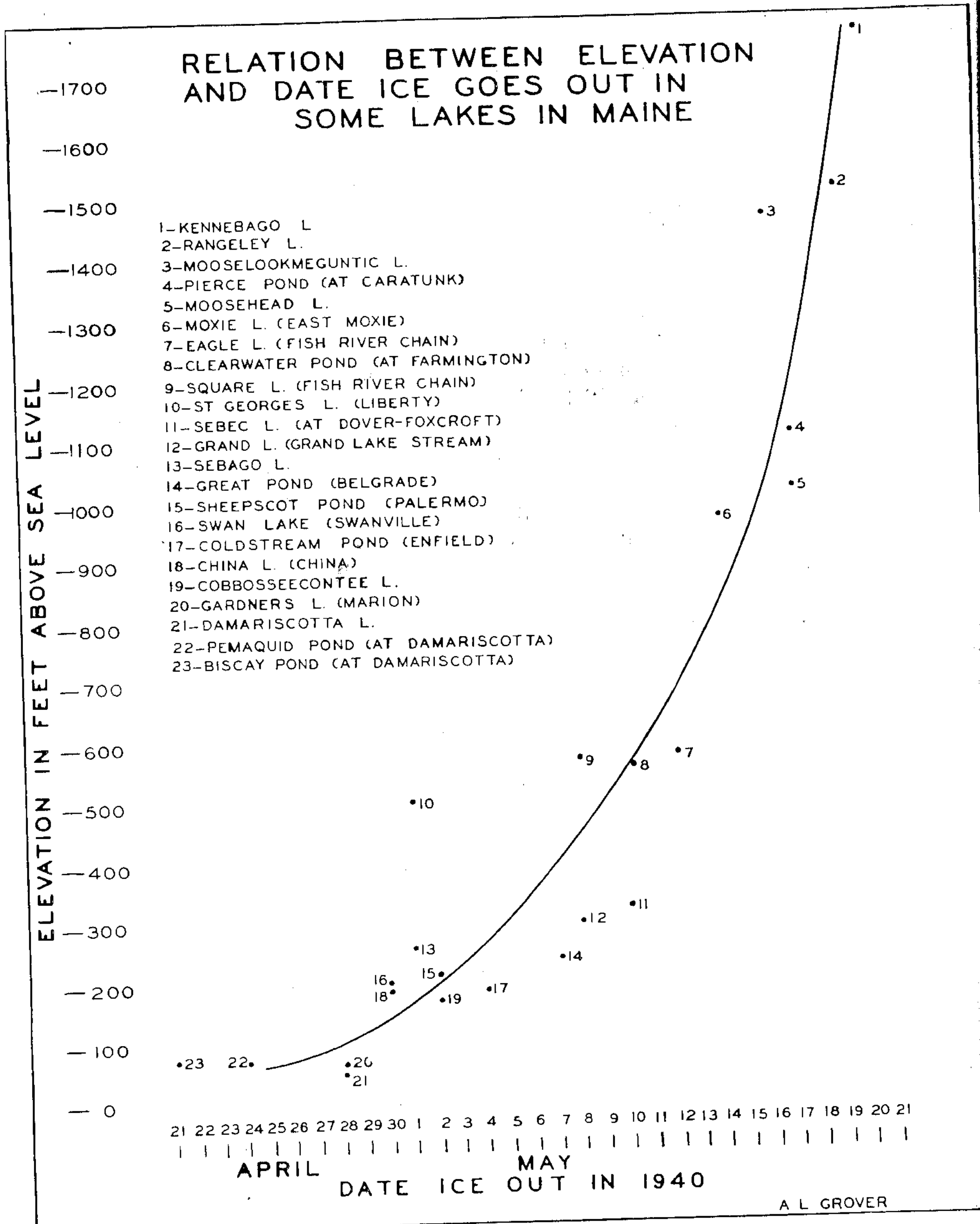

Figure 1. Relation between elevation and the date on which the ice "went out" in the spring of 1940 for some lakes and ponds in Maine. Data compiled by Mr. Archer L. Grover, Deputy Commissioner of the Maine Department of Inland Fisheries and Game.

Rooted vegetation, both submergent and emergent, is generally very rare in all of the six lakes. This is undoubtedly associated with and in part due to the fact that much of the lake bottom in the shoal areas is either very rocky or composed of shifting sand. Probably also the continual fluctuation in water levels, caused by drawing water from the lakes at certain seasons, has played an important role in preventing the establishment of vegetation.

The Rangeley lakes freeze to a depth of about two to two and one-half feet and occasionally to a depth of three feet. The date on which the ice leaves the lakes varies from year to year depending upon the weather. The ice leaves the lakes of the Rangeley region somewhat later than in other parts of the state. According to data collected by Mr. Archer L. Grover, Deputy Commissioner of the Department of Inland Fisheries and Game, the dates in 1940 on which ice "went out" of lakes in different parts of the state were quite definitely correlated with altitude (See Fig. 1). According to data compiled by Kendall (1918), the date on which the ice went out of the Rangeley lakes as a whole for the years from 1875 to 1915 varied from April 19 to May 28. From the data given by Kendall, it was calculated that the mean date on which the ice "went out" in the years from 1875 to 1888 was May 15; for 1889 to 1902, it was May 8; for 1903 to 1915, it was May 6. The fact that the mean date for these three periods was progressively earlier may or may not have some significance. The mean date for the entire period from 1875 to 1915 was May 10. In the spring of 1940 the ice went out of Mooselookmeguntic on May 16, Rangeley on May 19, and Kennebago on May 20 (See Fig. 1).

SUITABILITY OF THE WATER IN THE RANGELEY LAKES FOR TROUT AND SALMON

Analyses on the temperature, dissolved oxygen, and pH (acid intensity) were made on the water at various depths in these six Rangeley lakes at various times during the summer of 1939. At least part of the analyses on each lake was made during the most critical period (for trout and salmon) during the month of August. Also, at least one set of analyses on each lake was made at a point near the deepest water; such analyses gave the range of conditions of temperature and oxygen throughout the entire depth range of the lake. Analyses on each lake were sufficient to indicate the general suitability of the water at various depths during this late summer period, for trout and salmon.

Temperatures were taken with a Negretti and Zambra deep sea reversing thermometer. Water samples were collected with a Foerst improved water sampler, analyzed for oxygen by the Winkler method and for pH with LaMotte color standard solutions and LaMotte indicator solutions. Plankton samples were collected at each water analysis station. All equipment was operated on specia water resistant ropes. The complete water analyses data are given in Table II. All water analysis stations are indicated on the accompanying individual maps of each lake.

The vertical distribution of temperature was fairly similar in the six lakes. The upper warm-water layer of fairly uniform temperature (epilimnion) extended to about the same level by the end of August in each of the lakes — about 35 feet in Lower Richardson, Mooselookmeguntic and Rangeley; and about 30 feet in Upper Richardson, Kennebago, and Aziscoos. The depths to which this warm water extended in these various lakes were somewhat less in early July and somewhat greater by September; this was to be expected, since the upper warm-water layer during the summer is extended downward by the agitation of surface water due to wind and waves. This vertical depression of the warm surface waters not only varies with the season but also may vary at different locations on the same lake at any one time, due to direction and intensity of the wind and wave action. The September 6 temperatures on Rangeley Lake, taken after a hard west wind had been blowing for several hours piling waves four to five feet high along the east shore, were a good example of this local effect of wind action. Near the east end of the lake, at a point about one mile northeast of Dickson Island, 67.8°F. water was being driven down from the surface to a depth of 52 feet, with a very sharp break in temperature between 52 and 55 feet. Four hours later with this west wind still blowing,

temperatures were taken at a station about four miles farther west and just off the mouth of Smith's Cove (see map, Figure 4). These temperatures revealed much colder water (62.6° F.) at the surface, a fairly uniform temperature down to a depth of only 25 feet, and a marked drop in temperature between depths of 25 and 30 feet. Thus, this strong west wind producing waves four to five feet high had tipped the thermocline from a depth of 25 feet at one end of the lake to a depth of 52 feet near the other end. Effects of wind and wave action on vertical distribution of temperature were noticed at certain times on other of the Rangeley lakes, but none were quite so striking as these conditions on Rangeley Lake on September 6.

The maximum surface water temperatures which were found in the Rangeley lakes during the summer were strikingly low as compared to temperatures in those lakes in the more southern part of the state which were studied in 1938 (Maine Fish Survey Report No. 2). The surface temperatures at the time of analyses on the Rangeley lakes were:

Lower Richardson
69.1° F. on Aug. 1, dropped to 64.8° F. by Sept. 13.

Upper Richardson
72.9° F. on July 28, dropped to 62.2° F. by Sept. 12.

Mooselookmeguntic and Cupsuptic
67.3° F. on July 19, 67.6° F. and 66.2° F. on July 20, 70.0° F. and 66.9° F. on July 21, dropped to 62.4° F. and 62.6° F. by Sept. 11.

Rangeley
70.0° F. on July 7, 74.1° F. on July 10, 72.0° F. on Aug. 15, 72.7° F. on Aug. 16, dropped to 67.8° F. and 62.6° F. by Sept. 6.

Kennebago
69.3° F. and 69.8° F. on Aug. 14.

Aziscoos
73.9° F. and 73. 0° F. on Aug. 25, 75.4° F. on Aug. 28, 76.0° F. on Aug 29.

The differences between the above temperatures were undoubtedly due more to such seasonal and variable factors as air temperature, wind disturbances of the water, time of day, etc. than to inherent differences between the various lakes, because the above temperatures were taken under a variety of conditions and at different times. It appears from these surface temperature readings that the maximum summer surface temperatures of these lakes were usually near or slightly above 70 degrees F. or somewhere between 70 and 75 degrees F. Fairly uniform temperatures of near 70° F. were maintained by frequent strong wind action down to depths of about 30 to 35 feet during late July and August. By September this uniform temperature layer was enlarged and pushed downward to depths near 40 feet, but by this time the actual water temperature of this uniform surface layer had dropped to the low sixties and within the optimum range for trout and salmon. Since the upper warm-water layer was not in excess of 75° F. and usually much less, during August this upper layer can not be regarded as entirely unfavorable for trout and salmon during this season. Our gill net catches gave some indication that trout and salmon were much more abundant in the colder waters below the epilimnion, and reports by numerous fishermen in this region indicated that trout and salmon were more readily caught in summer months by trolling in deep water. However, our gill nets set in the shallow warm water did catch some trout and salmon, and salmon jumping at the surface during the middle of the summer were occasionally seen. Thus, this upper warm-water layer in the Rangeley lakes, which averages about 70° F. in temperature, is regarded as marginal or not particularly good trout and salmon water during the summer, and is probably utilized only occasionally by these fish.

The dissolved oxygen content of the water at different depths was found to be generally favorable in all of the lakes except in the deep water of Aziscoos. In the five lakes other than Aziscoos there were variations in the oxygen content worthy of note. There were variations between the different lakes, in the same lake at different dates, and between different parts of the same lake on the same date. The oxygen at the surface and throughout the epilimnion in all of the lakes was close to saturation and adequate for all fish life. There had been some depletion of oxygen in the deeper waters of all the lakes by the middle of the summer, very slight by the time of the July analyses on Rangeley Lake and more pronounced in the deep waters of Rangeley by the middle of August. The oxygen values for the deep waters of the Richardsons were moderately low by July and August and still lower by September, but were still at least 5 p.p.m. at all depths. In Mooselookmeguntic the oxygen in the deep water was somewhat depleted by July 20, but in the main part of the lake the change was only very slight from July 20 to September 11. However, the deep pocket of water just southwest of Student's Island in Mooselookmeguntic Lake lost considerable of its oxygen between July 20 and September 11, this being in sharp contrast with the main body of the lake north of Student's Island. In Kennebago Lake there had been some oxygen depletion by August 14 in deep water, but the oxygen supply was still adequate for trout and salmon at all depths. The conditions of oxygen in the deep water of Aziscoos Lake were in sharp contrast to the conditions in the other five lakes. The oxygen was near saturation at the surface and in the epilimnion where the water was continually in circulation and in contact with

the air at the surface; but starting at the lower limit of the epilimnion or at the upper limit of the thermocline the oxygen was greatly depleted. There was no oxygen at all present at depths of 40 feet or more and there was very little oxygen below 30 feet. It was estimated from these analyses on Aziscoos in late August that even a month earlier during July there would be too little oxygen for trout or salmon below a depth of about 30 feet. By the middle of August the oxygen depletion extending up from the bottom had reached the lower limit of the upper warm-water layer and thus completely eliminated any good trout and salmon water in the lake.

To summarize the conditions of oxygen in the deep water of these six Rangeley lakes, it can be stated that the five natural lakes in the chain, namely, the two Richardsons, Mooselookmeguntic, Rangeley, and Kennebago, have adequate oxygen supply for trout and salmon at all depths during the entire summer. Of these five lakes, Rangeley, Mooselookmeguntic, and Kennebago are slightly better in oxygen supply than the two Richardsons, and the oxygen supply in Rangeley is perhaps slightly better than that of Mooselookmeguntic and Kennebago. The deep water of Aziscoos Lake is so depleted of oxygen by August as to be entirely inaccessible to trout and salmon. This extreme oxygen depletion automatically relegates Aziscoos to a category entirely separate from the other five Rangeley lakes.

Data on temperature and oxygen supply of the water at different depths in the lakes were used to calculate the amount of water and amount of bottom area within the upper warm-water zone of marginal trout and salmon water, the amounts within the lower deep-water zone of good trout and salmon water, and in the case of Aziscoos, the amounts within the deep-water zone of oxygen depletion. In making these calculations the upper temperature limit of good trout and salmon water was set at 70° F. and the minimum oxygen requirement was set at 5 p.p.m. The calculations were based on conditions as they occurred during the month of August. The critical temperature and oxygen depths of these six lakes are given in Table I. By drawing contours on the outline maps of each lake and using the soundings given on the United States Geological Survey and Maine Water Storage Commission maps and our own soundings on Aziscoos, the areas within the different depth contours were determined by planimeter. The areas within these depth contours were assumed to be the same as the actual bottom areas, and the volume of water between the different depth contours were calculated by assuming the lake to be a series of frustums. The aforementioned depths for the lower limits of the upper warm-water zone were used, namely: 35 feet for Lower Richardson, Mooselookmeguntic, and Rangeley; and 30 feet for Upper Richardson, Kennebago, and Aziscoos. Oxygen was considered to be adequate at all depths for all except Aziscoos; oxygen depletion was estimated to extend up to

TABLE II. Water Analyses. Vertical distribution of temperature, oxygen and pH in the six Rangeley Lakes, from analyses* made during the summer of 1939

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature ° F.	Oxygen: p.p.m.	pH
LOWER RICHARDSON LAKE, C Twp.,	Surface	69.1	8.6	6.9
Oxford Co.	5	69.1	...	...
August 1, 1:30 to 2:30 P.M.	10	68.9	...	...
Station: ¾ mile west of	15	68.9	...	...
Hardscrable Point.	20	68.9	...	...
Depth of water: 100 ft.	25	68.7	8.5	6.9
Strong west wind.	30	68.5	...	...
Waves: 3½ ft. high.	35	61.5	7.9	6.5
	40	58.1	...	...
	45	55.0	...	...
	50	52.5	8.5	6.2
	60	49.1	...	...
	70	48.0	...	...
	80	47.7	8.5	6.1
	90	46.7	...	...
	100	46.4	8.0	6.1
LOWER RICHARDSON LAKE, Magal-	Surface	69.1	8.5	6.9
loway Twp., Oxford Co.	5	69.1	...	...
August 1, 3:30 to 4:30 P.M.	10	69.1	...	...
Station: ½ mile south of	15	69.1	...	...
Jackson Point.	20	68.9	...	...
Depth of water: 80 ft.	25	67.1	8.1	6.7
West wind. Waves: 15 inches.	30	61.9	...	...
	35	59.0	7.8	6.4*
	40	57.0	...	...
	45	54.1	...	...
	50	50.9	8.5	6.2
	60	49.1	...	...
	70	47.8	...	...
*pH 6.4 with Bromcresol Purple.	80	47.1	8.5	6.1
LOWER RICHARDSON LAKE, C Twp.,	Surface	64.8	9.0	6.8
Oxford Co.	5	62.2	...	...
Sept. 13, 2:00 to 3:20 P.M.	10	62.2	...	...
Station: 1 mile east of Middle Dam.	15	62.2	...	...
Depth of water: 97 ft.	20	62.2	...	...
No wind or waves.	25	61.9	9.0	6.8
	30	61.7	...	...
	35	61.7	8.9	6.8
	40	61.7	...	...
	45	61.0	...	...
	50	53.4	7.1	6.2
	60	49.5	...	...
	70	48.4	...	...
	80	47.9	6.4	6.1
	90	47.5	...	...
	95	47.3	5.8	6.0

* All temperatures were taken with a Negretti and Zambra Deep Sea Reversing Thermometer. With three exceptions, all pH values of 5.5 to 6.3 inclusive were from tests made with Bromcresol Purple indicator, and all pH values of 6.4 to 7.2 were from tests made with Bromthymol Blue indicator; the exceptions are so indicated in the table. Each water analysis station is indicated by an ⊗ on the accompanying outline maps of these lakes.

TABLE II. Water analyses—Continued

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: °F.	Oxygen: p.p.m.	pH
UPPER RICHARDSON LAKE, Richard-	Surface	72.5	8.7	6.9
sontown Twp., T.4, R.1, Oxford Co.	5	72.3	...	...
July 28, 1:00 to 2:15 P.M.	10	70.7	...	...
Station: between Black Point and Half Moon	15	66.9	...	...
Cove.	20	64.8	...	...
Depth of water: 69 ft.	25	62.2	8.2	6.5
South wind. Waves: 20 inches.	30	57.2	...	...
	35	54.9	7.9	6.3
	40	54.1	...	...
	45	53.2	...	...
	50	52.1	7.7	6.3
	60	51.4	...	...
	69	50.9	7.2	6.1
UPPER RICHARDSON LAKE, Richard-	Surface	72.9	8.6	6.9
sontown Twp., T.4, R.1, Oxford Co.	5	72.9	...	...
July 28, 3:00 to 4:15 P.M.	10	72.9	...	...
Station: 1 mile east of Big Beaver Island.	15	72.5	...	..
Depth of water: 108 ft.	20	66.0	...	...
South wind. Waves: 20 inches.	25	64.0	8.2	6.6
	30	62.2	...	...
	35	59.7	7.9	6.3
	40	55.6	...	...
	45	54.1	...	...
	50	52.5	7.7	6.2
	60	52.0	...	...
	70	51.4	...	...
	80	50.9	7.7	6.1
	90	50.9	...	...
	100	50.9	7.3	6.1
	108	50.7	7.1	6.1
UPPER RICHARDSON LAKE, Richard-	Surface	62.2	8.9	6.8
sontown Twp., T.4, R.1, Oxford Co.	5	62.2	...	...
Sept. 12, 10:30 A.M. to 12:00 M.	10	62.2	...	...
Station: half way between Black Point and	15	62.2	...	...
Half Moon Cove.	20	62.2	...	...
Depth of water: 56 ft.	25	62.2	8.7	6.8
Strong northwest wind.	30	62.1	...	...
Waves: 2 ft. high.	35	62.1	8.7	6.8
	40	62.1	...	...
	45	61.7	...	...
	50	59.2	...	...
	55	54.1	5.3	6.2

TABLE II. Water analyses—Continued

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: ° F.	Oxygen: p.p.m.	pH
UPPER RICHARDSON LAKE, Richardsontown Twp., T.4, R.1, Oxford Co. Sept. 12, 1:30 to 3:00 P.M. Station: 1 mile west of Upper Dam. Depth of water: 85 ft. Strong northwest wind. Waves: 3 ft. high.	Surface	62.2	8.7	6.9
	5	62.2	...	...
	10	62.2	...	...
	15	62.2	...	...
	20	62.2	...	...
	25	62.2	8.7	6.9
	30	62.2	...	...
	35	62.1	8.7	6.9
	40	61.3	...	...
	45	60.3	...	...
	50	59.4	6.6	6.4
	60	56.3	...	...
	70	55.2	...	...
	80	53.4	5.0	6.1
	85	53.2	...	...
MOOSELOOKMEGUNTIC LAKE, Rangeley Twp., Franklin Co. July 19, 1:00 to 2:30 P.M. Station: ¾ mile west of Bugle Cove. Depth of water: 110 ft. Slight north breeze. Waves: 8 inches.	Surface	67.3	8.8	6.8
	5	66.6	...	...
	10	64.9	...	...
	15	64.8	...	...
	20	64.6	...	...
	25	64.6	8.8	6.8
	30	61.2	...	...
	35	56.7	8.6	6.3
	40	53.8	...	...
	45	52.2	...	...
	50	49.1	...	...
	60	47.5	9.2	6.3
	70	46.4	...	...
	80	46.0	9.5	6.2
	90	45.1	...	...
	100	44.8	9.4	6.2
	105	44.6	...	...
	110	44.1	...	...
MOOSELOOKMEGUNTIC LAKE, Rangeley Plantation Twp., Franklin Co. July 20, 12:00 M. to 12:45 P.M. Station: 1 mile north of the eastern tip of Toothaker Island. Depth of water: 38 ft. Moderate wind. Waves: 10 inches.	Surface	67.6	8.8	6.9
	5	67.3	...	...
	10	66.2	...	...
	15	66.0	...	...
	20	65.7	...	...
	25	65.3	8.7	6.9
	30	64.9	...	...
	35	56.1	8.2	6.4

TABLE II. Water analyses—Continued

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: ° F.	Oxygen: p.p.m.	pH
MOOSELOOKMEGUNTIC LAKE, Richardsontown Twp., T.4, R.1, Oxford Co. July 20, 2:45 to 4:15 P.M. Station: ¼ mile south of Student's Island and ½ mile east of Brandy Point. Depth of water: 97 ft. No wind or waves.	Surface	66.2	8.9	6.9
	5	65.3	...	...
	10	64.9	...	...
	15	64.9	...	...
	20	64.9	...	...
	25	64.7	8.7	6.9
	30	62.8	...	...
	35	58.5	8.4	6.5
	40	57.0	...	...
	45	54.7	...	...
	50	53.6	...	...
	60	51.4	8.1	6.3
	70	50.9	...	...
	80	50.7	8.1	6.2
	90	50.5	...	...
	95	50.5	7.9	6.2
MOOSELOOKMEGUNTIC LAKE, Adamstown Twp., T.4, R.2, Oxford Co. July 21, 2:15 to 3:00 P.M. Station: 1 mile east of Farrington Island. Depth of water: 70 ft. No wind or waves.	Surface	70.0	8.8	6.9
	5	66.0	...	...
	10	65.5	...	...
	15	65.3	...	...
	20	65.1	...	...
	25	64.9	8.8	6.9
	30	59.9	...	...
	35	56.3	8.4	6.3
	40	53.2	...	...
	45	51.6	...	...
	50	50.4	...	...
	60	48.9	8.9	6.3
	70	47.1	8.8	6.2
MOOSELOOKMEGUNTIC LAKE, Rangeley Twp., Franklin Co. Sept. 11, 9:30 to 11:00 A.M. Station: 1 mile west of Bugle Cove. Depth of water: 117 ft. Strong northwest wind. Waves: 3 ft. high.	Surface	62.4	8.8	6.9
	5	62.8	...	...
	10	62.8	...	...
	15	62.8	...	...
	20	62.8	...	...
	25	62.8	8.7	6.9
	30	62.8	...	...
	35	62.8	8.7	6.9
	40	62.8	...	...
	45	62.8	...	...
	50	52.9	7.2	6.4
	60	49.8	...	...
	70	47.5	...	...
	80	46.0	7.9	6.2
	90	46.0	...	...
	100	45.3	7.8	6.2
	110	45.3	...	...
	117	45.3	7.3	6.2

TABLE II. Water analyses—Continued

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: ° F.	Oxygen: p.p.m.	pH
MOOSELOOKMEGUNTIC LAKE, Richardsontown Twp., T.4, R.1, Oxford Co.	Surface	62.6	9.0	6.9
Sept. 11, 2:15 to 3:45 P.M.	5	62.6	...	...
Station: ¼ mile southwest of Student's Island.	10	62.6	...	...
Depth of water: 110 ft.	15	62.6	...	...
Strong northwest wind.	20	62.6	...	...
Waves: 3 ft. high.	25	62.6	8.8	6.9
	30	62.6	...	...
	35	62.6	8.8	6.9
	40	62.6	...	...
	45	62.4	...	...
	50	56.8	5.2	6.4
	60	52.7	...	...
	70	52.2	...	...
	80	51.8	4.5	6.2
	90	51.8	...	...
	100	...	4.3	6.2
	110	...	4.3	6.1
CUPSUPTIC LAKE, Adamstown Twp., T.4, R.2, Oxford Co.	Surface	66.9	8.5	6.9
July 21, 11:00 A.M. to 12:15 P.M.	5	65.3	...	...
Station: about halfway between Brown's Islands and Pleasant Island Camps.	10	64.7	...	...
Depth of water: 53 ft.	15	64.4	...	...
No wind or waves.	20	64.4	...	...
	25	64.0	8.5	6.7
	30	58.6	...	...
	35	55.6	7.4	6.2
	40	53.8	...	...
	45	52.3	...	...
	50	52.1	7.3	6.1
RANGELEY LAKE, Rangeley Twp., Franklin Co.	Surface	70.0	9.6	6.9
July 7, 2:00 to 3:00 P.M.	5	68.5	...	...
Station: 1/3 mile out from mouth of Hunter Cove.	10	68.2	9.6	6.9
Depth of water: 81 ft.	15	63.5	...	...
Slight west breeze.	20	61.2	...	...
Waves: 4 inches.	25	59.2	9.8	6.8
	30	57.0	...	...
	35	54.0	10.0	6.6
	40	53.6	...	...
	50	50.0	10.0	6.5
	60	49.8	...	...
	70	48.2	10.0	6.4
	75	47.7	9.7	6.3
	80	47.7	9.7	6.3

TABLE II. Water analyses — Continued

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: ° F.	Oxygen: p.p.m.	pH
RANGELEY LAKE, Rangeley Twp., Franklin Co.	Surface	74.1	9.9	6.9
July 10, 12:15 to 3:45 P.M.	5	73.6	...	...
Station: ¾ mile east of Dickson Island.	10	70.3	9.5	6.9
Depth of water: 132 ft.	15	67.6	...	...
Strong west wind.	20	62.2	...	...
Waves: 2 ft. high.	25	59.9	10.1	6.8
	30	58.8	...	...
	35	56.5	10.1	6.7
	40	55.0	...	...
	45	52.5	...	...
	50	51.9	10.4	6.5
	60	49.6	...	...
	70	48.2	...	...
	80	47.7	10.4	6.5
	90	47.1	...	...
	100	46.4	...	...
	110	46.0	10.5	6.3
	120	45.3	10.3	6.3
	125	45.1	10.2	6.2
	130	44.9	10.1	6.2
RANGELEY LAKE, Rangeley Twp., Franklin Co.	Surface	72.0	8.8	6.9
August 15, 1:40 to 3:20 P.M.	5	71.6	...	...
Station: 1/3 mile out from Hunter Cove.	10	69.9	8.8	6.9
Depth of water: 77 ft.	15	69.4	...	...
Light west breeze.	20	69.3	...	...
Waves: 5 inches high.	25	68.9	8.6	6.9
	30	67.6	...	...
	35	61.3	8.5	6.6
	40	59.9	...	...
	50	50.5	9.7	6.4*
	60	49.1	...	...
	70	48.7	8.9	6.2
	75	48.6	8.4	6.2
*pH 6.4 with Bromcresol Purple	77	48.6	...	...
RANGELEY LAKE, Rangeley Twp., Franklin Co.	Surface	72.7	8.5	7.0
August 16, 10:45 A.M. to 1:00 P.M.	5	72.7	...	...
Station: ¾ mile east of Dickson Island.	10	72.1	...	...
Depth of water: 149 ft.	15	72.0	...	...
Light west breeze.	20	70.7	...	...
Waves: 7 inches high.	25	69.9	8.5	6.9
	30	65.8	...	...
	35	60.9	8.2	6.7
	40	59.0	...	...
	45	56.3	...	...
	50	53.6	8.7	6.3
	60	50.2	...	...
	70	49.1	...	...
	80	48.9	8.8	6.3
	90	48.0	...	...
	100	47.5	...	...
	110	46.8	8.9	6.3
	120	46.4	8.7	6.2
	130	46.0	8.3	6.3
	140	45.9	8.2	6.1
	149	45.9	8.2	6.1

TABLE II. Water analyses—Continued

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: ° F.	Oxygen: p.p.m.	pH
RANGELEY LAKE, Rangeley Twp., Franklin Co.	Surface	67.8	...	...
Sept. 6, 11:00 A.M. to 12:00 M.	5	67.8	...	...
Station: 1 mile northeast of Dickson Island; ¾ mile north of Haines Point.	10	67.8	...	...
Depth of water: 145 ft.	15	67.8	...	...
Strong west wind.	20	67.8	...	...
Waves: 4 ft. high.	25	67.8	...	...
	30	67.8	...	...
	35	67.8	...	...
	40	67.8	...	...
	45	67.8	...	...
	50	67.8	...	...
	52	67.8	...	...
	55	58.6	...	...
	60	51.8	...	...
	65	50.7	...	...
	70	50.2	...	...
	80	48.9	...	...
	100	48.2	...	...
	120	47.5	...	...
	145	46.4	...	...
RANGELEY LAKE, Rangeley Twp., Franklin Co.	Surface	62.6	...	...
Sept. 6, 3:00 to 4:00 P.M.	5	62.6	...	...
Station: ¼ mile out from the mouth of Smith's Cove, ¼ mile southeast of Bonney Point.	10	62.6	...	...
Depth of water: 80 ft.	15	62.6	...	...
Strong west wind.	20	61.9	...	...
Waves: 2½ ft. high.	25	61.2	...	...
	30	56.5	...	...
	35	54.7	...	...
	40	53.4	...	...
	45	52.7	...	...
	50	51.4	...	...
	60	49.5	...	...
	70	49.3	...	...
	80	48.6	...	...
KENNEBAGO LAKE, T.3, R.4, Franklin Co.	Surface	69.3	8.5	6.7
August 14, 10:40 A.M. to 1:00 P.M.	5	69.1	...	...
Station: ½ mile east of Grant's Camps.	10	68.0	...	...
Depth of water: 84 ft.	15	66.9	...	...
Northwest breeze.	20	66.2	...	...
Waves: 6 inches.	25	61.7	7.7	6.5
	30	60.3	...	...
	35	58.1	7.7	6.3
	40	53.1	...	...
	45	49.6	8.3	6.2
	50	48.6	...	...
	60	47.7	8.3	6.1
	70	46.8	...	...
	80	46.4	...	...
	83	46.2	8.2	6.0

TABLE II. Water analyses—Concluded

Lake, location, date, time, station, water depth, etc.	Depth in feet	Temperature: ° F.	Oxygen: p.p.m.	pH
KENNEBAGO LAKE, Davis Twp., T.3, R.3, Franklin Co.	Surface	69.8	8.4	6.9
August 14, 2:00 to 4:00 P.M.	5	69.8	...	...
Station: ½ mile south of Skedaddle Cove.	10	69.8	...	...
Depth of water: 107 ft.	15	69.8	...	...
Northwest breeze.	20	69.8	...	...
Waves: 8 inches.	25	69.6	8.3	6.9
	30	65.7	...	...
	35	53.8	8.1	6.3
	40	50.2	...	...
	45	48.6	8.5	6.2
	50	47.7	...	...
	60	46.6	8.3	6.1
	70	46.2	...	...
	80	46.2	...	...
	90	45.8	8.1	6.1
	100	45.8	...	...
	107	45.8	7.8	6.1
AZISCOOS (SAWYER) LAKE, Parkertown Twp., Oxford Co.	Surface	73.9	9.3	7.1
Aug. 25, 1:00 to 2:15 P.M.	5	73.8	...	...
Station: off mouth of North Fork Stream.	10	72.7	...	...
Depth of water: 41 ft.	15	72.3	...	...
No wind or waves.	20	69.1	4.5	6.2
	25	64.9	...	...
	30	60.1	0.4	5.9
	35	55.6	...	...
*pH 6.4 with Bromcresol Purple	40	53.2	0.0	6.4*
AZISCOOS (SAWYER) LAKE, Lincoln Twp., Oxford Co.	Surface	73.0	9.6	7.2
Aug. 25, 3:50 to 5:00 P.M.	5	72.5	...	...
Station: ½ mile east of Aziscoos Dam.	10	72.1	...	...
Depth of water: 60 ft.	15	70.9	...	...
South Breeze.	20	69.6	9.0	6.6
Waves: 4 inches high.	25	66.0	...	...
	30	60.6	4.0	6.1
	35	56.8	...	...
	40	54.7	0.0	6.1
	45	54.1	...	...
	50	54.1	...	...
	60	50.9	0.0	6.3
AZISCOOS (SAWYER) LAKE, Parkertown Twp., Oxford Co.	Surface	75.4	8.8	7.0
August 28, 3:10 to 4:00 P.M.	5	72.3	...	...
Station: 1 mile southwest of mouth of Lincoln Brook.	10	71.8	9.0	7.0
Depth of water: 54 ft.	15	71.6	...	...
No wind or waves.	20	70.3	7.8	6.6
	25	67.8	...	...
	30	61.3	2.1	6.0
	35	58.1	...	...
	40	57.9	0.0	6.0
	45	55.9	...	...
	50	55.9	0.0	6.0
	54	55.9	...	...
AZISCOOS (SAWYER) LAKE, Lynchtown Twp., T.5, R.4, Oxford Co.	Surface	76.0	9.1	6.3
August 29, 4:00 to 4:30 P.M.	5	73.6	...	...
Station: in Big Eddy at upper end of lake.	10	71.6	8.0	6.8
Depth of water: 27 ft.	15	68.7	...	...
No wind or waves.	20	68.2	8.3	6.9
	24	68.2	...	...
	27	59.3	6.1	6.7

TABLE III. An evaluation of the six Rangeley lakes with respect to the suitability of temperature and of oxygen content of the water for trout and salmon during the most critical, late summer period, in August. (The figures are only approximately accurate because of limitations in the methods of computation.)

Name of Lake	How much* of lake is, and is not, good trout or salmon water during most critical, late summer period, in August					
	Upper layer: not good trout or salmon above 70° F.	Middle layer: good trout or salmon water	Lower layer: no trout or salmon oxygen deficient	Upper layer: not good trout or salmon above 70° F.	Middle layer: good trout or salmon water	Lower layer: no trout or salmon oxygen deficient
	VOLUME OF WATER					
	Acre feet			% of total		
Lower Richardson	74,000	50,000	0	60	40	0
Upper Richardson	96,000	38,000	0	72	28	0
Mooselookmeguntic and Cupsuptic	388,000	161,000	0	71	29	0
Rangeley	169,000	159,000	0	52	48	0
Kennebago	43,000	62,000	0	41	59	0
Aziscoos	154,000	0	27,000	85	0	15
	AREA OF LAKE BOTTOM					
	Acres			% of total		
Lower Richardson	1,400	1,500	0	48	52	0
Upper Richardson	1,900	2,300	0	45	55	0
Mooselookmeguntic and Cupsuptic	9,700	6,600	0	60	40	0
Rangeley	2,300	3,700	0	38	62	0
Kennebago	500	1,200	0	29	71	0
Aziscoos	3,200	0	3,500	48	0	52

* Based on estimated depths above which water is too warm (above 70° F.) and below which oxygen is deficient (less than 5 p.p.m.) for trout and salmon

a depth of 30 feet in Aziscoos. The calculated volume of water and area of the bottom within each zone of each lake are given in Table III. The upper zone indicated as not good trout and salmon water is that portion of each lake above the thermocline where the water temperature is mostly above 70° F. during the late summer and this zone is regarded as marginal trout and salmon water. The theoretical middle zone is that layer between the warm water above and oxygen-deficient water below, and is suitable for trout and salmon. The theoretical lower zone is the region of oxygen depletion in the deepest water. In the case of Aziscoos the theoretical middle zone is absent, and in the other five Rangeley lakes the theoretical lower zone is absent. The bottom area given for each zone is only that part of the total bottom area of the lake which is directly in contact with the water of that zone. The figures given in Table III are presumably only approximately accurate because of various limitations of the methods used in setting the limits of the zones and in computing the actual figures.

It was calculated that Mooselookmeguntic, for example, had 388,000 acre feet or 71 per cent of its water in the upper warm-water layer in August, and 161,000 acre feet or 29 per cent good trout and salmon water in the middle zone, with no lower zone of oxygen depletion. Also in Mooselookmeguntic the upper and warm-water zone covered approximately 9,700 acres or 60 per cent of the lake bottom; the middle or good trout and salmon zone covered 6,600 acres or 40 per cent of the bottom. If these figures on the actual amount of water in the good trout and salmon zone in each lake during late summer are compared, the lakes ranked in the following order: Mooselookmeguntic had the most good trout and salmon water, followed by Rangeley, Kennebago, Lower Richardson, and Upper Richardson; Aziscoos had none. If the lakes are ranked on the basis of bottom area within the good trout and salmon zone, the order was Mooselookmeguntic, Rangeley, Upper Richardson, Lower Richardson, and Kennebago. If they are ranked on a percentage basis of the total water volume and bottom area within the trout and salmon zone, the order was much different, with Kennebago the best, followed by Rangeley, Lower Richardson, Upper Richardson, and Mooselookmeguntic, respectively.

Maps of the Rangeley Lakes. The accompanying outline maps of the lakes give depth soundings, and the survey's evaluation of the suitability of the water in the lakes for trout and salmon during late summer. Those soundings copied from Kendall's (1918) report were checked against the original maps now in possession of the Maine State Water Storage Commission. Permission by the United States Bureau of Fisheries and the Maine State Water Storage Commission to copy these soundings is gratefully acknowledged. A partially descriptive key to the maps is as follows:

All numerical figures within outline of lake represent soundings in feet

Water analysis stations indicated by an ⊗

In the cross-section diagrams headed by "suitability for trout and salmon during late summer"

- "Suitability" means only from the standpoint of temperature and oxygen
- "Late summer" means mostly during August
- "Water volume" refers to all water in the lake
- "Bottom area" refers to entire lake bottom
- "Warm" means above 70° Fahrenheit
- "Trout" means suitable for both trout and salmon
- "Low oxygen" means less than 5 p.p.m. of dissolved oxygen in the water
- Stippled area represents proportionate amount of water volume and bottom area in the "marginal" trout and salmon zone
- White area represents amount of water volume and bottom area in the good trout and salmon zone.

Direction arrows indicate true north

All maps by Mr. Gerald E. Spofford

PLANKTON OF THE RANGELEY LAKES[7]

Plankton consists of minute or microscopic organisms, both plants and animals, which are free living in the water. Because of their small size, they are unable to make headway against currents. In size they range from microscopic forms up to those which attain a length of a tenth of an inch or more. Those forms which are large enough to be collected by a plankton net of No. 20 silk bolting cloth are referred to as net plankton. The young individuals of most species of fishes and the adults of many of the smaller species, including the Smelt, feed mostly on plankton and particularly on the water-fleas (copepods and cladocera). Therefore, the planktonts occupy an important position in the food chain of adult game fishes, and the abundance of plankton determines, to a large degree, the fish producing capacity of any lake. The large crustaceans of the plankton feed on the smaller algae forms, and thereby are the first step in converting the plant life of a lake into a form useable by most fishes. The plankton populations of lakes vary considerably with the season of the year, both in types of organisms and in their numerical abundance; in general, the peaks in total abundance appear in the spring and in the fall, and the greatest depressions in abundance occur during mid-summer and mid-winter. The plankton also varies greatly in kind and abundance of organisms at different depths, and this is probably of great importance to lake fishes.

Plankton samples were collected at several stations on each of the six Rangeley lakes. The samples were collected with a Birge Closing Net drawn vertically through the water between two chosen depths and at a rate of ½ meter per second. At most stations hauls were made from 15 feet to the surface, 35 feet to 15 feet, 75 feet to 35 feet,

[7] Laboratory analyses of the plankton samples, and the initial writing of this report on the plankton of the Rangeley lakes, were done by Mr. H. A. Goodwin, graduate student in Wildlife Conservation at the University of Maine.

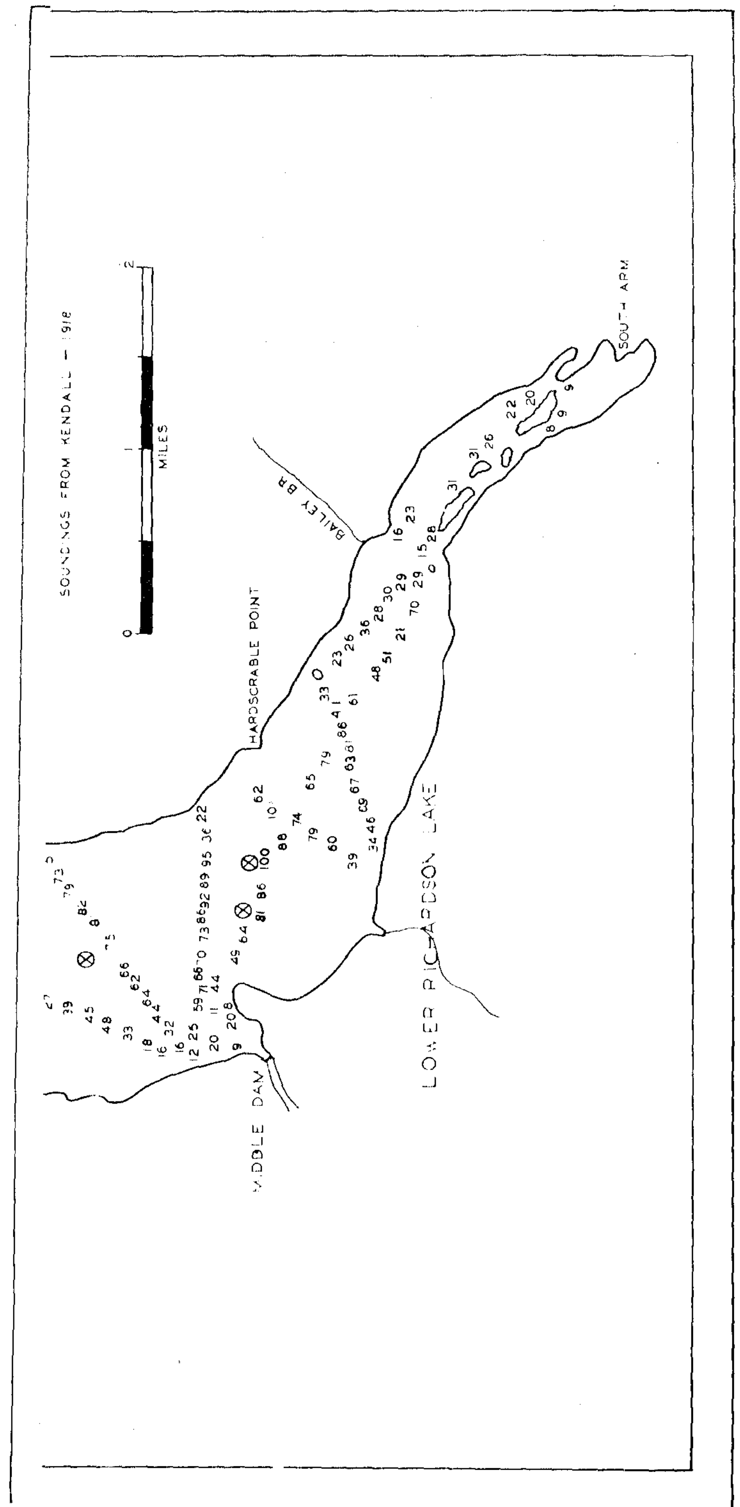

Figure 2. Lower and Upper Richardson lakes. Soundings in feet, and suitability of the water for trout and salmon.

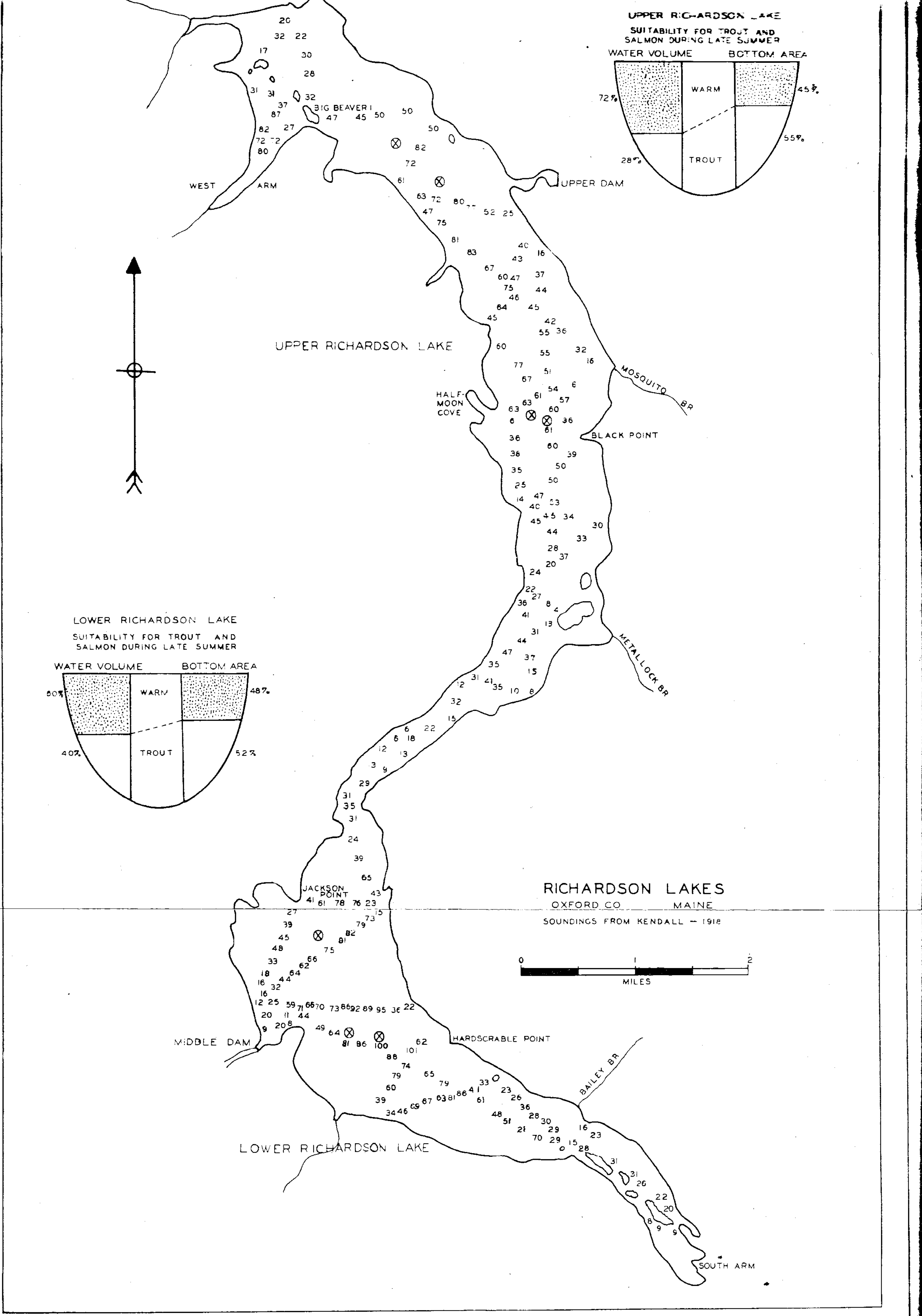

Figure 2. Lower and Upper Richardson lakes. Soundings in feet, and suitability of the water for trout and salmon.

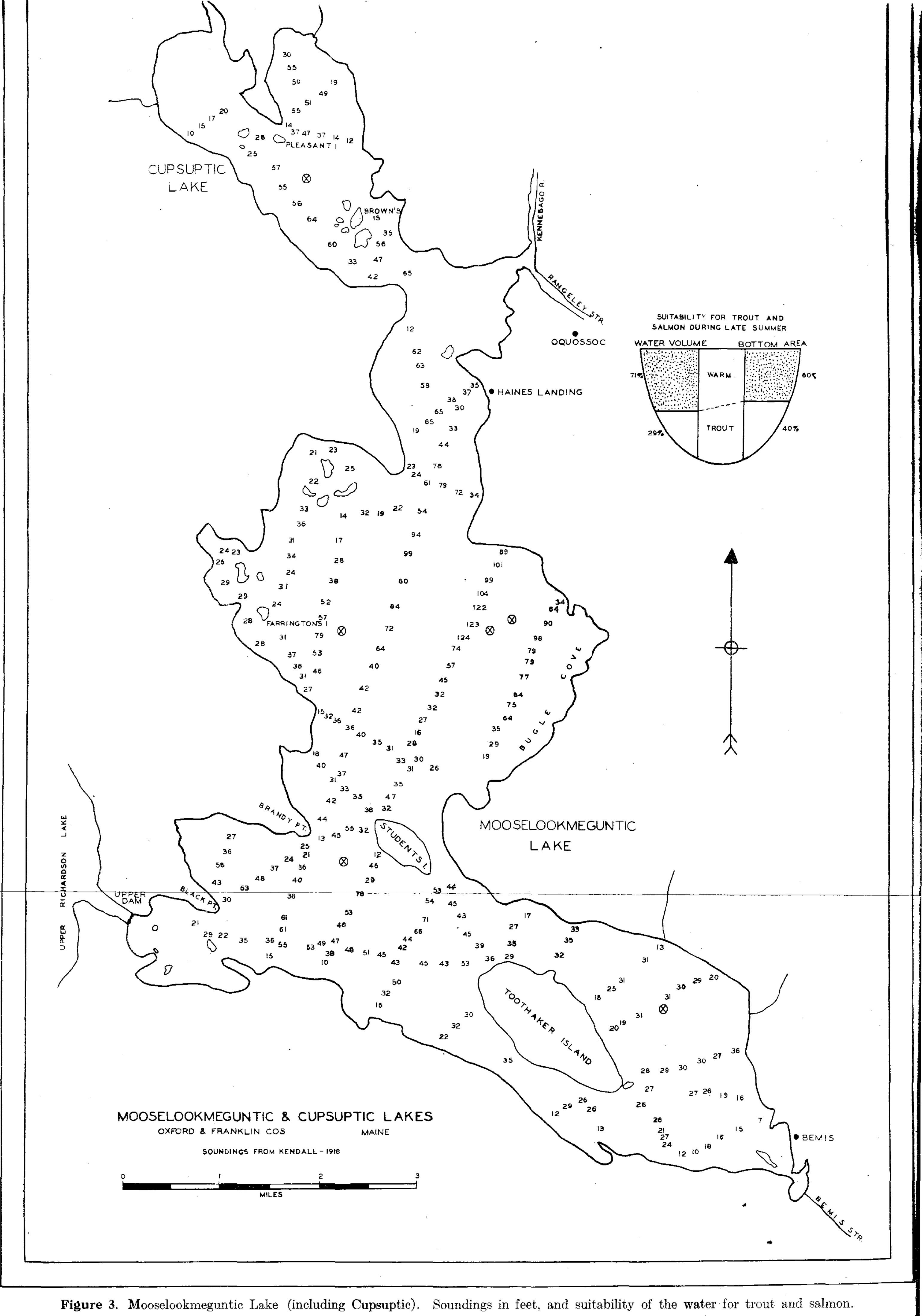

Figure 3. Mooselookmeguntic Lake (including Cupsuptic). Soundings in feet, and suitability of the water for trout and salmon.

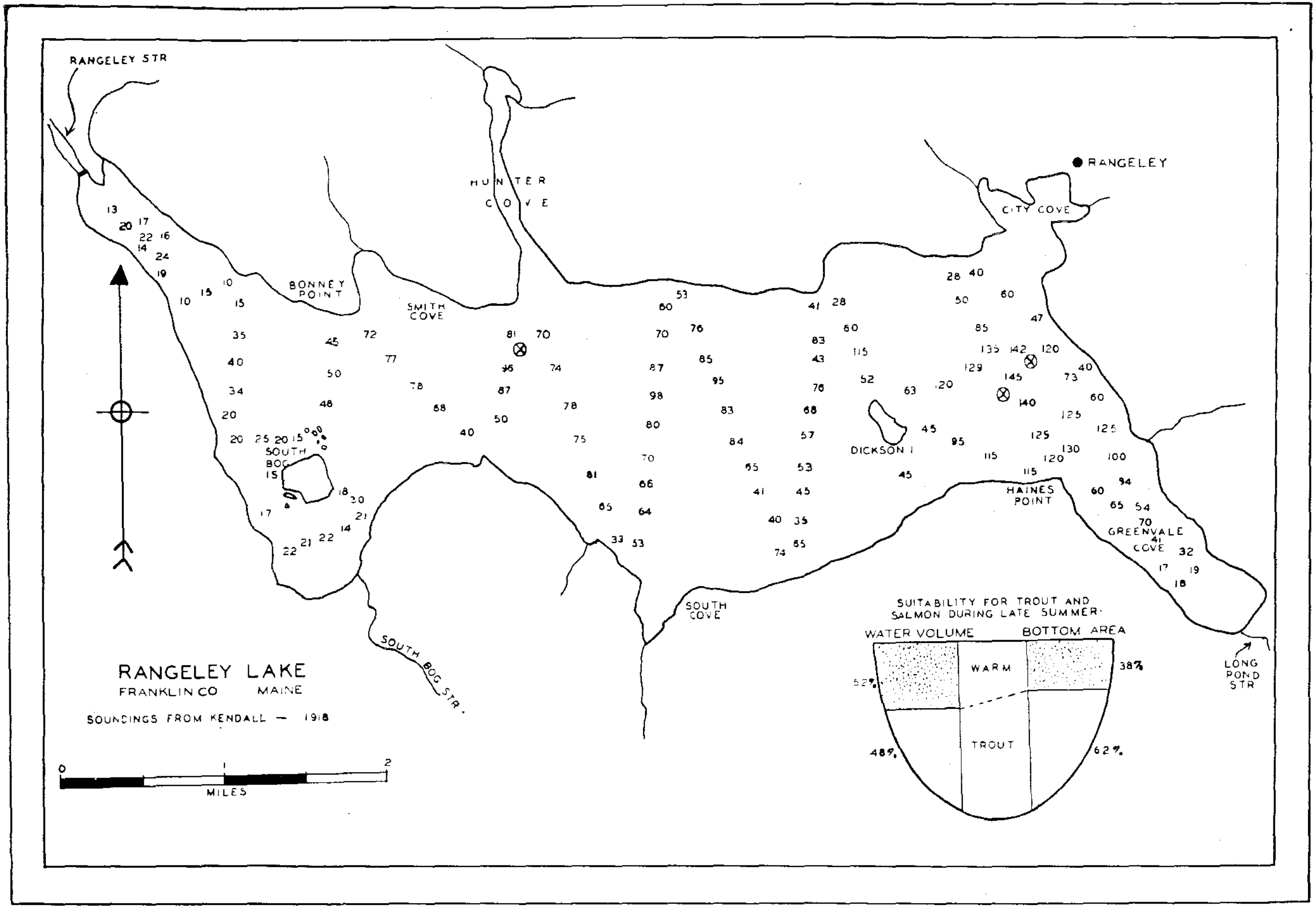

Figure 4. Rangeley Lake. Soundings in feet, and suitability of the water for trout and salmon.

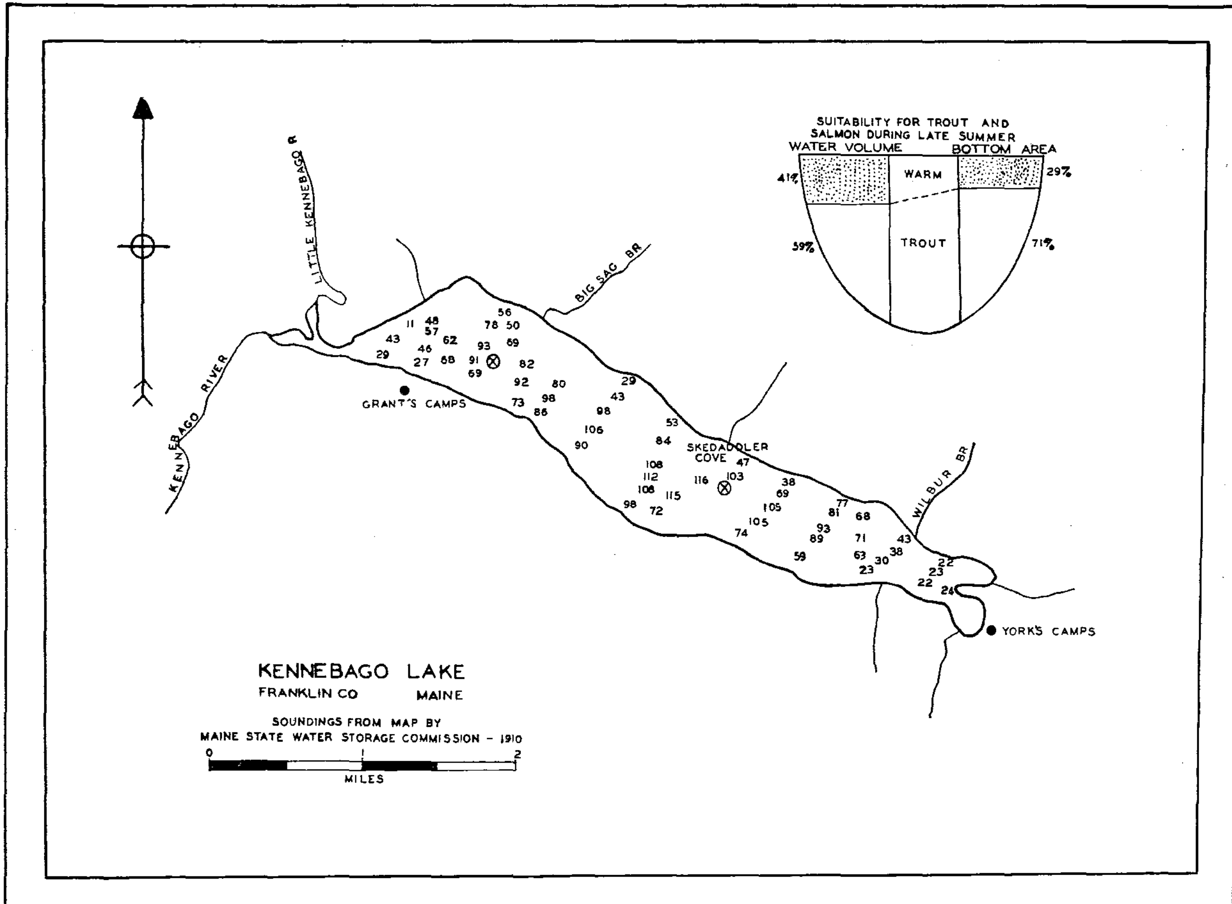

Figure 5. Kennebago Lake. Soundings in feet, and suitability of the water for trout and salmon.

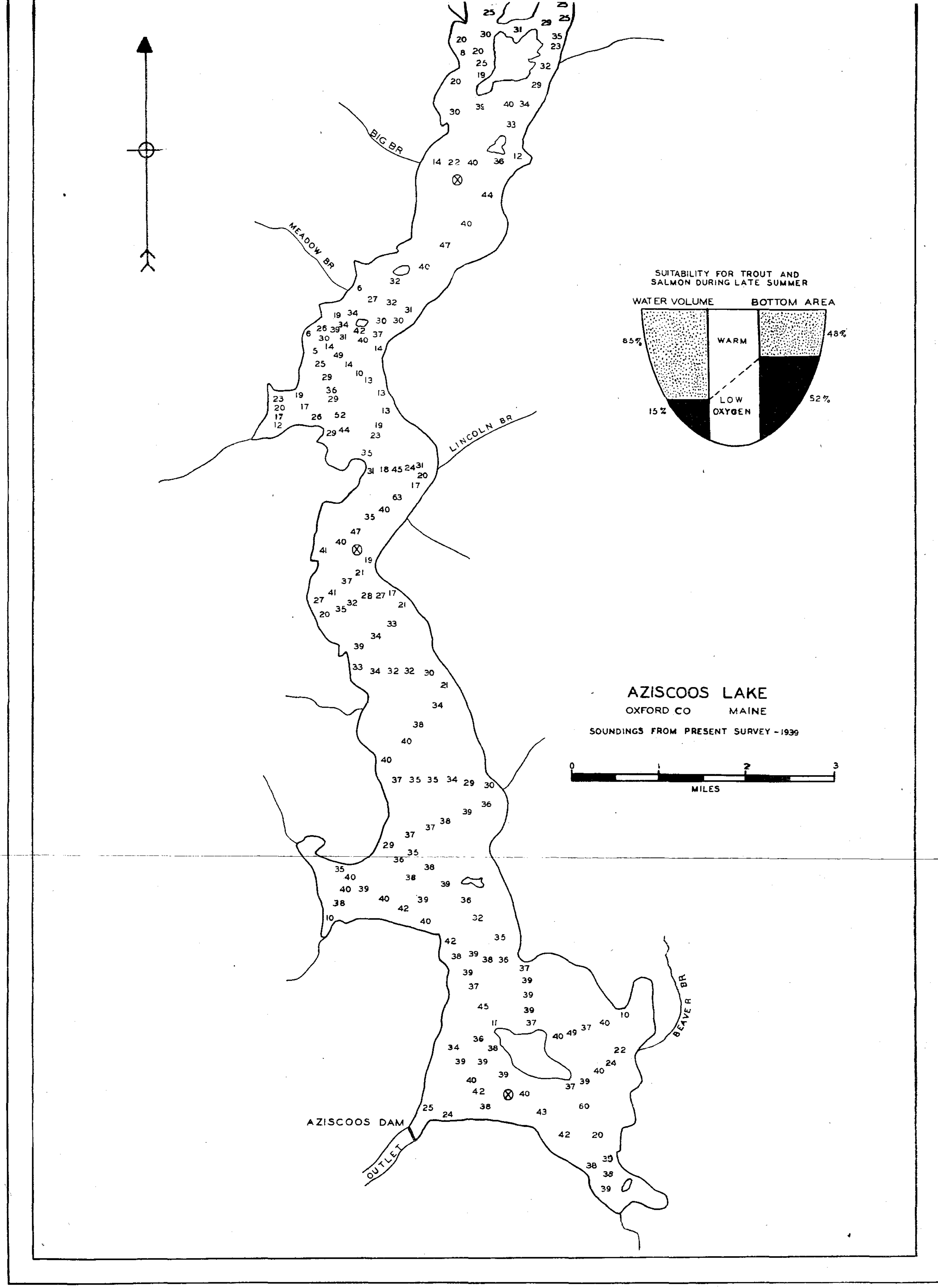

Figure 6. Aziscoos Lake. Soundings in feet, and suitability of the water for trout and salmon.

and from the bottom up to 75 feet. At each station two samples were taken within each depth range. The samples were preserved in 5 per cent formalin, and were analyzed in the laboratory. With the exception of one alteration[8] the methods of analysis were the same as given in "Field and Laboratory Methods of Lake Survey," Appendix B to Fish Survey Report No. 2.[1]

The vertical distributions of kinds and abundance of plankton forms at the various survey stations are given in Table IV and summarized by lake in Table V and Figure 7. The organisms collected were found to represent nine major taxonomic groups of animals and plants, and these groups together with certain of the more important genera are discussed in the following:

Copepoda. The copepods, commonly called water-fleas along with the following group, are of fundamental importance as food for adults of some species of fish and for the young of most species. These two groups comprise the macroplankton of fresh-water lakes, and due to their large size and to their dependence upon the microplankton for food they are not present in the profusion of the smaller forms. In many samples the immature forms (*nauplii*) were more abundant than the mature forms. The two most common genera were *Cyclops* and *Diaptomus*. The maximum abundance of copepods was encountered in Aziscoos Lake; at one station a concentration of 417 per cubic foot was present in the surface layers of water. The greatest abundance was consistently in the upper layers of water in each lake, and the numbers decreased as the depth increased. As a whole, the Rangeley lakes showed a meager population of copepods when compared with some of the lakes and ponds of the upper Saco River and Sebago Lake drainage systems in Maine.[1]

Cladocera. This group, also called water-fleas, is also important from the standpoint of the fish producing capacity of lakes. The cladocerans were slightly less abundant than the copepods. The greatest abundance was encountered in Aziscoos Lake, where surface waters at one station had a concentration of 521 individuals per cubic foot. The abundance of these organisms in the other lakes was fairly uniform. Some of the genera commonly encountered were *Daphnia*, *Bosmina*, *Macrothrix*, and *Holopedium*. *Leptodora* and *Polyphemus* were present but rare. As with the copepods, the greatest concentrations of cladocerans were almost invariably near the surface, and the numbers decreased as the depth increased. These

[8] In quantitative analysis of the macroplankton (copepods and cladocerans) ten random samples of 1 c. c. were taken from each of the field collections, placed in a standard counting cell (50 x 20 x 1 mm.), and the total numbers counted in each 1 c. c. sample.

[1] See footnote p. 10.

TABLE IV. The average numbers of different types of planktonts, and the average volume of all plankton, per cubic foot of lake water within different lake strata and at different dates, as calculated from survey collections

Name of Lake	Date: 1939 Time: A=A.M. P=P.M.	Depth Range of sample in ft.	Average vol. of plankton per cu. ft. of lake water in c.c.	Average number of plankton organisms per cu. ft. of lake water									
						In thousands — add ,000							
				Copepoda (water-fleas)	Cladocera (water-fleas)	Rotifera	Protozoa	Zoophyta	Desmidiaceae (desmids)	Chlorophyceae (other green algae)	Bacillarieae (diatoms)	Myxophyceae (blue-green algae)	All Planktonts
Lower Richardson	Aug. 1 2:30 P	15–0 35–15 75–35 100–75	0.47 0.39 0.09 0.06	185 28 20 17	24 92 14 11	.. ..	5 4 4 ..	.. ..	.. ..	.... 4 14	161 64 7 3	9 4 4	176 75 14 18
	Aug. 1 4:30 P	15–0 35–15 75–35	0.62 0.14 0.05	256 46 25	142 21 20	5 4 2	19 4 2	.. .. ..	.. .. ..	5 7	128 21 9	....	157 36 12
	Sept. 13 3:00 P	15–0 35–15 75–35 95–75	0.52 0.39 0.07 0.11	161 32 7 60	152 50 2 14	5	14 14 .. 4	.. .. 2 4	.. ..	14 4	152 142 30 25	24 7	209 163 32 36
Upper Richardson	July 28 1:45 P	15–0 35–15 69–35	0.14 0.14 0.10	147 39 10	199 21 13	.. 4 ..	28 7 4	.. .. ..	5	.... 4 4	71 21 6	.... 4	105 39 15
	July 28 3:30 P	15–0 35–15 75–35 100–75	0.71 0.25 0.18 0.14	199 50 69 42	161 25 7 31	.. 4 2 ..	.. 11 2 11	57 .. 4 ..	 3	5 .... 5 3	38 18 5 11	5 7 6	105 39 18 34
	July 29 9:00 A	15–0 35–15 50–35	0.71 0.21 0.14	156 71 19	151 32 14	5 7 ..	28 7 ..	5	.. .. ..	.... 4	28 18 9	....	67 36 10
	July 29 9:45 A	15–0 35–15 65–35	0.71 0.25 0.05	161 160 2	185 57 28	9 4 2	9 .. 5	.. 7 ..	5	5 2	28 14 7	5 2	62 25 19
	Sept. 12 11:30 A	15–0 35–15 55–35	0.71 0.25 0.14	76 25 11	171 28 4	 4	5 4 4	.. .. ..	5 4 ..	9 7	142 28 39	.... 7	161 50 46
	Sept. 12 2:30 P	15–0 35–15 75–35	0.47 0.18 0.16	114 32 46	85 25 5	.. 4 2	.. .. ..	.. .. ..	38	5 11 7	80 42 30	9 2	132 57 41

Name of Lake	Date: 1939 Time	Depth Range of sample in ft.	Average vol. of plankton per cu. ft. of lake water in c.c.	Copepoda (water-fleas)	Cladocera (water-fleas)	Rotifera	Protozoa	Zoophyta	Desmidiaceae (desmids)	Chlorophyceae (other green algae)	Bacillarieae (diatoms)	Myxophyceae (blue-green algae)	All Planktonts
Mooselookmeguntic	July 19 3:00 P	15–0 35–15 75–35 100–75	1.18 0.11 0.18 0.14	156 63 28 37	209 7 27 62	9 7 5 11	5 .. 2 ..	.. ..	5	.... 2 3	14 7 2 6	9 .... 2	43 14 13 20
	July 20 12:30 P	15–0 35–15	0.95 0.14	114 39	161 25	19 4	5 ..	.. ..	.. 4	5	9 18	19 7	57 32
	July 20 4:30 P	15–0 35–15 75–35 95–75	1.42 0.14 0.11 0.07	242 35 34 11	237 14 28 7	.. 4	.. .. 2 ..	.. ..	5 4	14 4 5 11	19 14 5 14	28 4 2	67 28 14 25
	July 21 3:00 P	15–0 35–15 70–35	0.47 0.18 0.10	100 25 8	137 32 14	9 7 4	14 .. 2	.. .. ..	5 4 ..	5 4	5 14 10	9 4	48 32 16
	July 21 4:00 P	15–0 35–15 75–35	0.95 0.18 0.41	24 113 4	156 14 7	.. .. ..	33 11 ..	.. .. ..	 2	 14	14 11 12	9 7	57 28 28
	Sept. 11 10:30 A	15–0 35–15 75–35 110–75	0.47 0.39 0.07 0.20	81 11 23 93	81 18 5 49	5 4	5	.. ..	.. ..	.... 14 4 8	100 64 23 57	.... 4 7 6	109 82 34 75
	Sept. 11 3:30 P	15–0 35–15 75–35	0.66 0.36 0.18	104 25 53	85 18 25	9 .. 2	9 7 2	.. .. ..	.. .. ..	9 14 2	232 110 71	28 18 7	289 149 84
Cupsuptic	July 21 12:00 Noon	15–0 35–15 53–35	0.90 0.14 0.04	161 50 27	133 60 19	9	33 46 19	.. .. ..	5 4 4	 4	52 14 15	....	100 64 41
	July 21 1:15 P	15–0 35–15 62–35	0.90 0.11 0.05	194 35 37	156 28 21	9	19 7 8	.. .. ..	.. .. ..	5 7 3	9 14 11	14	57 28 21

TABLE IV. Numbers and volume of planktonts—Continued

Name of Lake	Date: 1939 Time: A=A.M. P=P.M.	Depth Range of sample in ft.	Average vol. of plankton per cu. ft. of lake water in c.c.	Average number of plankton organisms per cu. ft. of lake water — In thousands — add ,000: Copepoda (water-fleas)	Cladocera (water-fleas)	Rotifera	Protozoa	Zoophyta	Desmidiaceae (desmids)	Chlorophyceae (other green algae)	Bacillarieae (diatoms)	Myxophyceae (blue-green algae)	All Planktonts
Rangeley	July 7 3:30 P	15–0	1.42	47	260	28	5	..	5	....	14	9	62
		35–15	0.11	25	32	4	..	..	4	4	21	4	36
		75–35	0.02	4	2	..	..	..	2	2	4	....	7
	July 10 3:45 P	15–0	0.71	47	171	33	..	..	..	9	....	14	57
		35–15	0.11	21	14	4	4	..	..	....	11	7	25
		75–35	0.18	130	25	4	2	..	..	4	11	....	20
		130–75	0.18	76	21	3	1	..	..	4	5	....	13
	July 12 2:00 P	15–0	0.95	71	123	9	..	..	5	14	9	28	67
		35–15	0.18	25	14	7	..	4	..	4	11	11	36
		75–35	0.09	57	14	..	2	2	4	....	2	....	9
	July 12 3:30 P	15–0	1.42	14	175	85	..	..	..	28	57	24	195
		35–15	0.14	18	14	4	..	..	..	....	4	21	28
		75–35	0.18	59	7	..	..	..	..	4	4	4	11
	July 12 4:30 P	15–0	0.95	14	114	9	..	..	..	9	9	24	52
		35–15	0.18	25	25	11	..	7	..	4	7	11	39
	Aug. 15 3:00 P	15–0	0.24	28	76	..	5	..	..	9	....	19	33
		35–15	0.71	14	14	..	7	..	..	11	4	....	21
		75–35	0.02	32	4	..	..	..	..	5	....	....	5
	Aug. 15 3:50 P	15–0	0.28	114	142	5	..	..	5	....	5	14	29
		35–15	0.11	32	....	..	..	..	..	4	4	14	21
		75–35	0.02	10	2	..	..	..	..	7	5	....	12
	Aug. 15 4:30 P	15–0	0.24	240	114	9	..	..	5	5	....	5	24
		35–15	0.11	11	32	4	..	..	..	....	7	18	28
		75–35	0.14	41	5	..	4	..	2	4	2	....	11
		110–75	0.04	37	2	2	2	..	..	8	....	....	12
	Aug. 16 12:45 P	15–0	0.47	223	194	14	..	..	..	9	....	14	38
		35–15	0.11	21	32	..	..	..	4	11	4	7	25
		75–35	0.05	71	....	2	..	..	2	4	2	9	18
		130–75	0.03	40	26	1	..	..	..	3	1	3	8
Kennebago	Aug. 14 1:00 P	15–0	0.71	147	95	9	24	9	53	14	14	5	129
		35–15	0.18	64	25	..	32	..	7	11	11	....	60
		75–35	0.04	32	7	2	2	11	..	....	....	....	14
	Aug. 14 3:30 P	15–0	0.47	166	147	9	33	24	43	....	52	38	199
		35–15	0.07	11	14	..	..	7	7	7	7	4	32
		75–35	0.05	30	7	..	2	9	2	....	....	2	14
		100–75	0.06	73	....	..	3	..	..	....	6	3	11
	Aug. 17 3:00 P	15–0	0.43	104	81	5	43	14	24	19	28	14	147
		35–15	0.11	50	7	..	14	..	32	....	21	....	67
		75–35	0.04	16	5	..	11	..	2	....	....	11	23
	Aug. 17 3:15 P	15–0	0.43	95	118	5	43	9	100	19	33	19	228
		35–15	0.07	18	14	..	21	7	..	....	18	....	46
		65–35	0.05	5	69	2	..	2	..	7	2	....	14
	Aug. 17 3:45 P	15–0	0.71	223	....	5	66	5	71	5	33	....	185
		35–15	0.07	35	4	..	14	..	4	7	18	....	43
		65–35	0.05	45	....	..	5	5	5	3	5	....	21
Aziscoos	Aug. 25 2:15 P	15–0	0.43	237	161	5	47	..	14	....	14	....	81
		35–15	0.07	21	14	4	14	..	..	7	14	4	43
	Aug. 25 4:45 P	15–0	0.43	137	109	14	422	..	..	5	14	....	455
		35–15	0.21	99	117	7	135	..	4	4	7	....	156
		55–35	0.11	11	....	..	67	..	4	7	4	4	85
	Aug. 28 3:30 P	15–0	0.24	147	114	5	19	19	5	14	5	....	67
		35–15	0.07	43	11	..	18	..	..	....	7	....	25
		50–35	0.03	6	3	3	6	..	..	3	6	....	17
	Aug. 29 4:30 P	15–0	0.43	417	521	..	71	..	5	5	28	....	110

TABLE V. The average numbers of different types of planktonts, and the average volume of all plankton, per cubic foot of lake water within different depth strata during the summer of 1939 (Data condensed from Table IV)

Name of lake	Depth range in feet	Average vol. of plankton per cu. ft. of lake water in c.c.	Average number of plankton organisms per cu. ft. of lake water: Copepoda (water-fleas)	Cladocera (water-fleas)	In thousands, add ,000: Rotifera	Protozoa	Zoophyta	Desmidiaceae (desmids)	Chlorophyceae (other green algae)	Bacillarieae (diatoms)	Myxophyceae (blue-green algae)	All planktonts
Lower Richardson	15–0	0.54	201	106	3	13	..	..	6	147	11	181
	35–15	0.31	35	54	1	7	..	..	4	76	4	91
	75–35	0.07	17	12	1	2	1	..	..	15	1	18
	100(95)–75	0.08	38	12	..	2	2	..	9	14	..	27
Upper Richardson	15–0	0.57	142	159	2	11	10	9	4	64	3	105
	35–15	0.21	63	32	4	5	1	1	4	23	3	41
	55(50)–35	0.14	15	9	2	2	..	..	..	24	..	41
	69(65)–35	0.08	6	20	1	4	..	..	3	7	1	17
	75–35	0.17	57	6	2	1	2	..	6	17	1	29
	100–75	0.14	42	31	..	11	..	3	3	11	6	34
Mooselookmeguntic and Cupsuptic	15–0	0.87	132	150	8	14	..	2	4	50	12	91
	35–15	0.19	44	24	2	9	..	2	43	29	5	51
	62(53)–35	0.05	32	20	..	14	..	2	4	13	..	31
	75(70)–35	0.17	25	17	2	1	..	1	4	19	3	31
	110(100) (95)–75	0.13	43	39	5	..	..	..	7	25	2	40
Rangeley	15–0	0.74	88	141	21	1	..	2	9	9	17	42
	35–15	0.18	21	19	3	1	1	1	4	8	10	29
	75–35	0.09	50	7	1	1	1	1	3	3	1	11
	110–75	0.04	37	2	2	2	..	..	8	..	..	12
	130–75	0.10	58	24	2	1	..	..	4	3	1	11
Kennebago	15–0	0.55	147	88	6	42	12	58	11	32	15	158
	35–15	0.10	36	12	..	14	3	10	5	13	1	49
	65–35	0.05	25	34	1	3	4	2	..	4	..	18
	75–35	0.04	26	6	1	5	7	1	..	..	4	17
	100–75	0.06	73	..	..	3	..	..	..	6	3	11
Aziscoos	15–0	0.38	269	226	6	139	5	6	6	15	..	176
	35–15	0.12	54	47	4	55	..	1	4	9	1	74
	55(50)–35	0.07	9	2	2	37	..	2	5	5	2	51

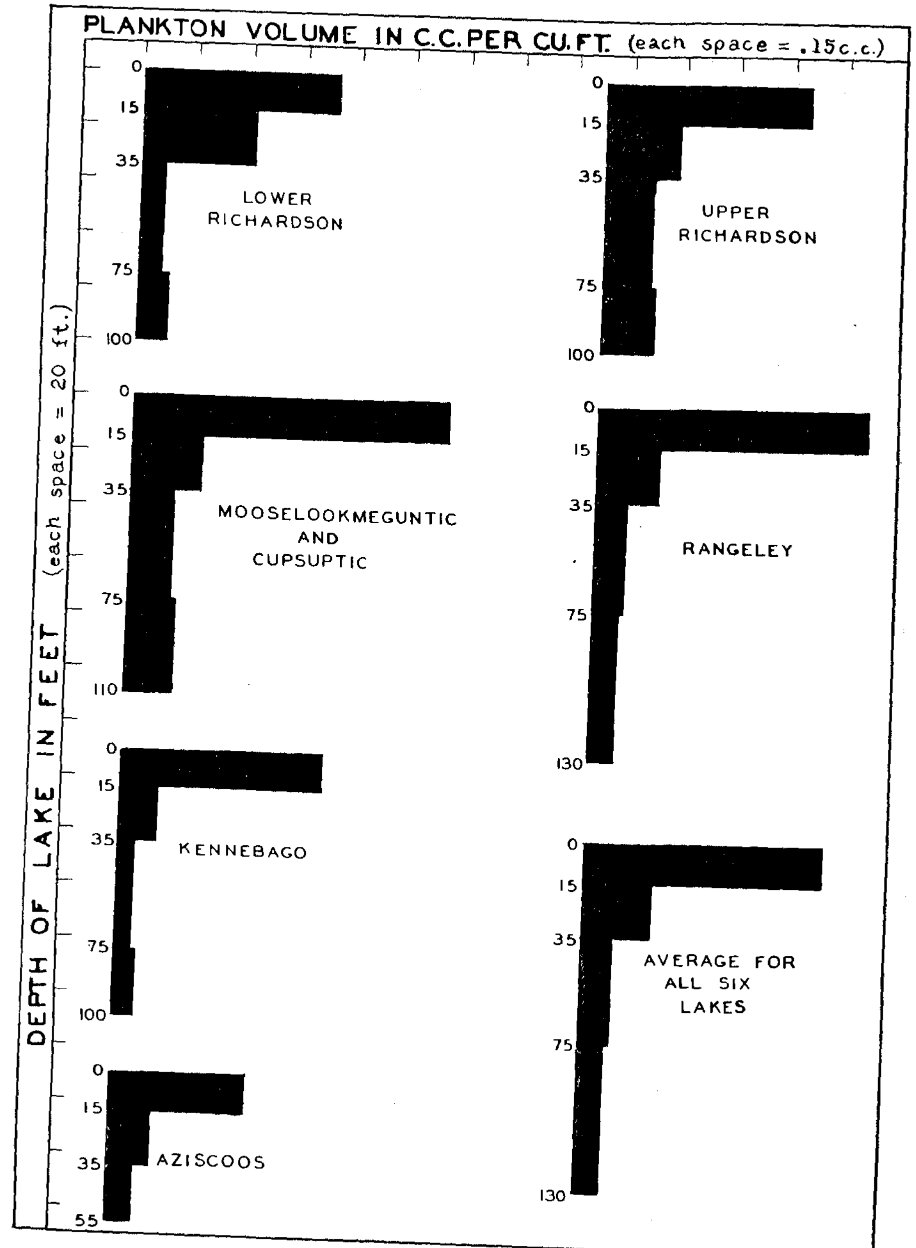

Figure 7. Average summer vertical distribution of volume of plankton in the six Rangeley lakes based on 1939 survey collections. Data are from Tables V and VI.

large and relatively cold-water lakes did not appear to have so great an abundance of cladocerans as was found in the warm-water lakes of southern Maine by the 1938 survey.[1]

Rotifera. The rotifers are minute but highly organized animals and are characteristic of fresh water. Their most outstanding feature is the *corona*, a ciliated area near the anterior end adapted for locomotion and for obtaining food. The greatest abundance of these organisms was found in Rangeley Lake. Some of the genera encountered were *Notholca, Polyarthra, Conochilus, Anuraea,* and *Philodina.*

Protozoa. The protozoans are microscopic, unicellular animals. Some move about by means of appendages and are classified into major groups according to the type of locomotor organs they possess. The greatest abundance of protozoans was found in Aziscoos Lake. Protozoans were also found in great numbers in Kennebago Lake. The concentration of protozoans found at one station in Aziscoos Lake was numerically the greatest of any one group of organisms in any lake during the summer. Some of the common genera were *Dinobryon, Ceratium, Synura,* and *Actinophrys.*

Zoophyta. Those organisms which are often claimed by both Zoologists and Botanists are designated as *Zoophyta* in this report. Their greatest general abundance was recorded in Kennebago Lake. None were recorded from Mooselookmeguntic and Cupsuptic lakes, and the group was, in general, the least abundant of all groups of planktonts. Among the genera present, *Volvox* and *Eudorina* were the most common.

Desmidiaceae. These unicellular plants are a family of the green algae. They were most abundant in Kennebago Lake. They were not recorded in Lower Richardson Lake, but were present in fair numbers in the remainder of the lakes. Of the desmids the genus *Staurastrum* was by far the most common. Some of the other common genera were *Closterium, Cosmarium, Sphaerozosma, Xanthidium,* and *Micrasterias.*

Chlorophyceae. This group includes, in this report, all of the green algae, with the exception of the family *Desmidiaceae*. They are grass-green in color due to the presence of plastids which contain a high concentration of chlorophyll. The green algae contribute a great number of species to fresh-water plankton. They were found quite abundantly in all of the lakes surveyed. The greatest numbers were recorded from Mooselookmeguntic and Cupsuptic lakes. Some of the more common genera were *Ulothrix, Scenedesmus, Pediastrum, Micractinium, Zygnema,* and *Dictyosphaerium.*

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1 See footnote p. 10.

Bacillarieae. Diatoms are widely distributed in fresh water. Of all the planktonts encountered, two genera of diatoms (*Tabellaria* and *Asterionella*) were recorded most frequently. The greatest abundance of these organisms was found in Lower Richardson Lake. In general, this was the most abundant group of planktonts in the lakes as a whole.

Myxophyceae. Members of the blue-green algae are invariably present in the plankton of fresh-water lakes. The greatest general abundance was recorded from Rangeley Lake. This group was third in numerical abundance in the lakes as a whole. Some of the common genera were *Microcystis, Anabaena, Aphanocapsa, Coelosphaerium, Merismopedia,* and *Nostoc.*

All Plankton. The greatest concentration of plankton was recorded from Aziscoos Lake. At one station near Aziscoos Dam, in the upper warm water, there was a population of 455,000 planktonts per cubic foot. Of this number 422,000 were protozoans, chiefly *Synura, Ceratium,* and *Dinobryon.* The least abundance of plankton was recorded from the deep water in Rangeley Lake. At three separate stations on Rangeley Lake, in the deep water hauls, the total plankton populations amounted to less than 9,000 individuals per cubic foot. The greatest concentration of plankton in each lake was in the warm surface water (see Table IV and Figure 7); and the decrease toward the minimum abundance, with few exceptions, was in relation to increase in depth. The averaged total numbers in the 15-foot-to-surface hauls in the different lakes varied from 42,000 planktonts per cubic foot in Rangeley Lake, to 181,000 planktonts per cubic foot in Lower Richardson Lake.

A general comparison may be made between the basic fertility of the Rangeley lakes (Table VI) and the basic fertility of lakes in adjacent parts of the country, on the basis of plankton abundance. The samples collected from the Rangeley lakes were taken during that part of the summer when plankton populations in lakes are usually on the decline or at their mid-summer minimum in numerical abundance. The samples, therefore, probably do not constitute a measure of the maximum plankton production. Both seasonal variations and variations in depth distribution have been taken into account in making the following general comparisons.

In a survey of 15 comparatively small and shallow lakes selected as representative of the St. Lawrence watershed during June, July, and August of 1930, Muenscher[9] (1931) found populations of copepods varying from about 500 to nearly 3,000 individuals per cubic

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9 Muenscher, W. C.: 1931. Plankton studies in some northern Adirondack Lakes. *In* A biological survey of the St. Lawrence Watershed. Suppl. to 20th Ann. Rept., N. Y. S. Conservation Dept., Albany.

TABLE VI. The average numbers of different types of planktonts, and the average volume of all plankton, per cubic foot of lake water within different depth strata of all six Rangeley lakes combined during the summer of 1939 (Data condensed from Table V)

Depth range in feet	Average vol. of plankton per cu. ft. of lake water	Average number of plankton organisms per cu. ft. of lake water									
				In thousands, add ,000							
		Copepoda (water-fleas)	Cladocera (water-fleas)	Rotifera	Protozoa	Zoophyta	Desmidiaceae (desmids)	Chlorophyceae (other green algae)	Bacillarieae (diatoms)	Myxophyceae (blue-green algae)	All planktonts
15–0	0.66	163	145	8	37	5	13	7	53	10	125
35–15	0.19	42	31	2	15	1	3	10	26	4	56
75–35	0.09	26	13	1	7	2	1	3	11	1	26
130–75	0.08	49	18	1	3	1	1	5	10	2	22

foot of water, and populations of nearly 3,000 cladocerans per cubic foot, in the surface waters. The greatest abundance of copepods found in the Rangeley lakes was slightly more than 400 per cubic foot, recorded from one station on Aziscoos Lake in a sample taken in late August; the greatest abundance of cladocerans was 521 per cubic foot recorded from the same sample. The average numbers of copepods and cladocerans in the surface waters of all of the Rangeley lakes were 163 and 145, respectively. The microplanktonts in the lakes of the St. Lawrence watershed were also much more numerous than in any of the Rangeley lakes. This apparently greater fertility of these northern New York lakes in plankton production may be partly attributable to seasonal variations, but a significant difference in basic fertility appears obvious from the comparison. The Rangeley lakes compared more favorably in plankton production with Lake Champlain, judging from Muenscher's[10] study on this lake in 1929. This author's analyses on samples from one station on Lake Champlain revealed about the same numbers of copepods and cladocerans as were found by the 1939 survey on the Rangeley lakes, a smaller population of protozoans and rotifers, and a greater population of other plankton forms. Studies by Burkholder and

[10] Muenscher, W. C.: 1930. Plankton studies in the Lake Champlain Watershed. *In* A biological survey of the Champlain Watershed. Suppl. to 19th Ann. Rept., N. Y. S. Conservation Dept., Albany.

Tressler[11] (1932) on lakes of the Oswegatchie and Black river systems in northern New York revealed plankton populations, in comparison to which the Rangeley lakes have a comparative paucity of plankton. If a comparison is made on the basis of average volume of plankton in the upper waters, with lakes of the Merrimack Watershed in New Hampshire,[12] the Rangeley lakes are apparently much more abundantly supplied with plankton. On the basis of the limited number of brief comparisons just made, it appears that plankton production in the Rangeley lakes is quantitatively rather low as compared to lakes in general. The total quantity of plankton present in these large Rangeley lakes, on the other hand, is very great, and represents a far greater potential productivity than does the bottom fauna. Another important fact is that certain of the larger plankton forms were abundant in the deep and cold water where they were available to the Smelt populations.

Three features of the plankton which are measures of general abundance and importance to fishes are: (1) volume of plankton, (2) abundance of micro-crustaceans, and (3) total number of planktonts. If the six Rangeley lakes are compared on the basis of these three features of the plankton populations, the lakes may be ranked approximately in the following order: Lower Richardson Lake was at or near the top in plankton production, followed by Upper Richardson Lake, Aziscoos Lake, Mooselookmeguntic and Cupsuptic lakes, Rangeley Lake, and Kennebago Lake, respectively.

[11] Burkholder, P. R. and W. L. Tressler: 1932. Plankton studies in some northern New York waters. *In* A biological survey of the Oswegatchie and Black river systems. Suppl. to 21st Ann. Rept., N. Y. S. Conservation Dept., Albany.

[12] Hoover, Earl E.: 1938. Stocking policy for the streams and lakes of the Merrimack watershed. *In a* Biological survey of the Merrimack watershed. New Hampshire Fish and Game Dept., Survey Report No. 3.

BOTTOM SOIL AND BOTTOM FAUNA OF THE RANGELEY LAKES

Studies on the bottom soil and bottom fauna of the Rangeley lakes were based on an examination of 236 bottom samples collected with an Ekman dredge of a 9-inch by 9-inch bottom area. The distribution of these samples by lake and date (in 1939) was as follows:

Lower Richardson, 21 samples, Aug. 10 to 11
Upper Richardson, 32 samples, Aug. 7 to 9
Mooselookmeguntic and Cupsuptic, 53 samples, July 25 to 26 and Aug. 14 to 15
Rangeley, 61 samples, July 13 to 19
Kennebago, 42 samples, Aug. 21 to 25
Aziscoos, 27 samples, Aug. 29 to 31

All samples were taken in the daytime, mostly between 9 A.M. and 5 P.M. The samples were from localities scattered fairly uniformly over each lake. The depth of water and the type of bottom soil material were noted for each sample. In each the entire sample was passed through brass sieves with No. 20 or No. 40 mesh. The No. 20 mesh sieve was used only when it was evident that very small organisms were not passing through it. The organisms were preserved in 70 per cent alcohol, and the samples were analyzed in the laboratory. Identification of the bottom organisms[13] was made mostly only to orders and families. The total number of each type of organism was counted and the total volume of each type was determined by water displacement. In the measurements on volume the excess water was drained off from the organisms and the volume readings were made in graduated test tubes with tapered bottom. On volume quantities of less than one cubic centimeter (c. c.), the volume was read with a fair degree of accuracy to the nearest 0.02 c. c. With lesser quantities the volumes were estimated. With volumes over 1 c. c. accurate measurements were made to the nearest 0.1 c. c.

Bottom Soil. Bottom soils in the samples were classified according to distinct soil types and combinations of soil types into 12 different categories (given in Table VII). Most categories are self-explanatory; two, however, may need further explanation. The material referred to as mud was mostly very fine and light inorganic silt, and contained very little coarse organic detritus. The material referred to as mineral concretions was encountered in bottom samples from Rangeley and Kennebago lakes and was also collected from Mooselookmeguntic.

[13] The identifications of most of the organisms in these bottom samples were checked by Dr. C. O. Dirks, Associate Professor of Entomology, University of Maine.

TABLE VII. Frequency of each type of bottom soil material in the 236 bottom samples from the six Rangeley lakes arranged according to lake and depth of water

	Name of lake, and depth of water in feet	Type of bottom soil											
		Gravel	Gravel, sand	Sand	Mineral concretions	Clay	Wood debris	Sand, wood debris	Mud, clay	Mud, sand	Mud, wood debris	Mud, mineral concretions	Mud
All depths	Lower Richardson	3	..	5	..	..	..	..	..	..	..	..	13
	Upper Richardson	1	..	4	..	..	..	..	..	..	..	..	27
	Mooselookmeguntic and Cupsuptic	2	3	6	..	1	..	..	..	..	9	..	32
	Rangeley	5	1	6	4	1	..	..	..	5	1	..	38
	Kennebago	3	1	6	2	..	..	..	3	2	..	4	21
	Aziscoos	..	1	3	..	..	11	5	..	..	6	..	1
All lakes	6–20	4	2	16	..	..	1	..	3	..	1	..	8
	21–40	5	3	10	3	..	6	3	..	7	13	..	10
	41–60	4	1	3	1	2	4	2	..	..	2	..	48
	61–80	1	..	..	2	..	..	..	..	..	..	1	38
	81–100	..	..	1	..	..	..	..	..	..	..	3	17
	101–120	..	..	..	..	..	..	..	..	..	..	..	6
	121–138	..	..	..	..	..	..	..	..	..	..	..	5

lookmeguntic. These concretions appeared to be materials which had precipitated from the lake water itself around stones or other types of soil. The size of these concretions varied from the size of a pea to that of a hen's egg. Six bottom samples contained concretions entirely and four others contained a mixture of concretions and mud. Analyses were made on four samples of these concretions by the Maine Soil Testing Service at the University of Maine. The analyses which were employed gave the amount of each element, in parts per million of air dry material, as liberated in a soil extractant at pH 3.0. Of the samples of mineral concretions which were analyzed, two were from Mooselookmeguntic, one from Rangeley, and one from Kennebago. The analyses were as follows:

Elements	Mooselook-meguntic Summer 1939	Mooselook-meguntic Spring 1940	Rangeley Summer 1939	Kennebago Summer 1939
pH reaction	6.50	6.32	6.48	6.53
Nitrates	5	1	5	50
Ammonia	50+	2	10+	100
Phosphorus	5	5+	12	5-
Potassium	50	25	25	50
Calcium	500	375	1000	1500+
Magnesium	50	25	5	100+
Manganese	37	50+	50+	25
Iron	2	5+	50+	26-
Aluminum	25	25+	250+	125

According to Dr. Delmar S. Fink of the Maine Agricultural Experiment Station of the University of Maine, who made the analyses, the above values for mineral elements are generally very high as compared to ordinary soil samples; also the variations between the samples from the different lakes are unusually great. According to Dr. Fink, these elements in concretion form on the lake bottom would be available to the lake water by slow reabsorption under acid conditions.

Of the 12 types of bottom soil material which were recorded, mud was by far the most prevalent in the bottom samples from all except Aziscoos Lake. Of the 236 samples, 132 contained only mud. Various mixtures containing sand or gravel were present in 62 samples. Fine wood debris was confined mostly to Aziscoos and to restricted areas of Mooselookmeguntic. Gravel and sand were confined mostly to water less than 40 feet deep. Below 60 feet, the bottom of all the lakes was mostly mud. (See Table VII.)

Bottom Fauna. The animals taken in these 236 bottom samples were classified into 14 separate taxonomic groups. The volumes and numbers of each type of bottom organism are summarized by lake and depth of water in Table VIII. Of the 14 groups of organisms, the round worms (Nematoda) were represented by only one individual in one sample, and water-fleas (Cladocera) were taken in only one sample. Of the annelid worms, the leeches (Hirudinia) were taken in several samples from Kennebago but in only one sample from the other lakes; the aquatic earthworms (Oligochaeta) were taken from five of the six lakes and were third in general abundance of all 14 groups. Fresh-water shrimp (Amphipoda) were found in three lakes but were generally quite rare. Of the nine remaining groups, six were insects. These included the midge larvae (Chironomidae), Mayfly nymphs (Ephemerida), alder-fly larvae (*Sialis*), dragonfly nymphs (Anisoptera), caddisfly larvae (Trichoptera), and mosquito larvae (*Corethra*). The midge larvae were by far the most abundant numerically, and represented a greater volume than all other bottom organisms combined. There were apparently four dis-

tinct types of these chironomids, of which *Ceratopogon* was one of the least abundant; the other types were not identified to genera. Mayfly nymphs were fairly common. Alder-flies, dragonflies, caddisflies, and *Corethra* were rare. Of the mollusks present in the bottom samples, the pill clams (Sphaeridae) were second in abundance of all bottom organisms, both numerically and in terms of volume; snails (mostly Amnicolidae) were rare.

The numbers and volumes of all bottom organisms for all six lakes combined have been averaged according to type of bottom and depth of water in Table IX. The number of samples is inadequate for a detailed comparison of the quantities of organisms in different types of bottom soil within different depth ranges. If, however, the organisms from the entire depth range are considered as a unit, there is an adequate number of samples for a general comparison of the productivity of different types of bottom. The figures at the bottom of Table IX are a summary for each bottom type for all depths. The 236 bottom samples from all of the lakes contained an average of 6.7 organisms or an average volume of 0.043 c. c. per 9-inch by 9-inch bottom sample. The 132 samples on entirely mud bottom had an average of 9.6 organisms with a volume of 0.060 c. c. The 14 samples on a gravel bottom had an average of 1.8 organisms or 0.012 c. c. per sample; the six samples from gravel and sand (mixed) had 0.3 organism or 0.002 c. c.; 30 samples on entirely sand bottom had an average of 1.4 organisms or 0.019 c. c. per sample. The 50 samples on gravel, gravel and sand, and sand together had an average of 1.4 organisms or 0.015 c. c. per sample. From these data it seems to be a safe conclusion that in these Rangeley lakes mud bottom is the richest in production of bottom food organisms, and at least several times as productive as gravel or sand.

An examination of the data given in Table VIII reveals certain differences in depth distribution of these 14 different groups of bottom organisms. The aquatic earthworms, midge larvae, and pill clams were found in fair abundance throughout the entire depth range from shallow to very deep water. The other groups were found mostly in the more shallow half of the depth distributions of the various lakes.

For a comparison of the production of bottom organisms in individual lakes, the data given in Table VIII have been summarized according to total number and volume of each type of bottom organism in all samples from each lake. These data (Table X) reveal that the predominance of certain groups in the bottom fauna of the lakes as a whole (as mentioned above) holds true for the lakes individually. Midge larvae predominated both in volume and in numbers in each of the six lakes; pill clams were mostly second in importance; and aquatic earthworms were about third. The comparative

TABLE VIII. Volumes and numbers of each type of organism in 236 bottom samples taken from the Rangeley lakes during 1939 with an Ekman Dredge (9″ x 9″), arranged according to lake and depth of water

Name of Lake and data on samples: Depth range in feet	Number of samples	Volumes in cubic centimeters and numbers (in parentheses) of aquatic organisms in samples: Round worms (Nematoda)	Leeches (Hirudinia)	Aquatic earthworms (Oligochaeta)	Water-fleas (Cladocera)	Fresh-water shrimp (Amphipoda)	Mayfly nymphs (Ephemerida)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Pill clams (Sphaeridae)	Snails (Amnicolidae)	Other snails (Gastropoda)	All organisms
Lower Richardson Lake													
12–20	2	......	......	......	......	......	0.03 (1)	......	......	......	......	......	0.03 (1)
21–40	3	......	......	......	......	......	......	......	0.001 (1)	......	......	......	0.001 (1)
41–60	5	......	......	......	......	......	......	......	0.045 (4)	0.035 (2)	......	......	0.08 (6)
61–80	7	......	......	......	......	......	......	......	0.157 (27)	0.008 (4)	......	......	0.165 (31)
81–96	4	......	......	......	......	......	......	......	0.198 (21)	0.022 (2)	......	......	0.22 (23)
Upper Richardson Lake													
6–20	5	......	......	......	......	......	......	......	0.001 (1)	......	0.029 (3)	......	0.03 (4)
21–40	7	......	......	......	......	......	......	......	0.003 (1)	0.01 (2)	......	......	0.013 (3)
41–60	15	......	......	......	......	......	......	......	0.185 (22)	0.075 (10)	......	......	0.26 (32)
61–80	3	......	......	0.02 (1)	......	......	......	......	0.09 (12)	0.14 (10)	......	......	0.25 (23)
81–85	2	......	......	0.07 (4)	......	......	......	......	0.06 (8)	0.02 (3)	......	......	0.15 (15)
Mooselookmeguntic and Cupsuptic lakes													
8–20	7	......	0.02 (1)	......	......	0.04 (6)	0.2 (7)	......	0.057 (10)	0.023 (5)	0.04 (6)	......	0.38 (35)
21–40	15	......	......	......	......	......	0.04 (2)	......	0.131 (16)	0.244 (19)	......	......	0.415 (37)
41–60	14	......	......	0.015 (1)	......	......	......	......	0.284 (32)	0.126 (10)	......	......	0.425 (43)
61–80	14	0.002 (1)	......	0.09 (10)	......	......	......	......	0.451 (56)	0.17 (16)	......	......	0.713 (83)
81–100	2	......	......	......	......	......	......	......	0.053 (13)	0.007 (2)	......	......	0.06 (15)
101–120	0	......	......	......	......	......	......	......	......	......	......	......	......
121–132	1	......	......	......	......	......	......	......	0.03 (2)	0.01 (1)	......	......	0.04 (3)
Rangeley Lake													
11–20	9	......	......	......	0.002 (3)	......	0.103 (3)	......	0.208 (16)	0.009 (2)	......	......	0.322 (24)
21–40	15	......	......	......	......	......	0.047 (4)	......	0.63 (58)	0.002 (2)	......	......	0.679 (64)
41–60	15	......	......	......	......	......	......	......	0.244 (49)	0.031 (3)	......	0.02 (1)	0.295 (53)
61–80	9	......	......	......	......	0.002 (2)	......	......	0.186 (26)	0.048 (6)	......	......	0.236 (34)
81–100	6	......	......	......	......	......	......	......	0.302 (43)	0.021 (5)	......	......	0.323 (48)
101–120	3	......	......	0.015 (2)	......	......	......	......	0.046 (11)	0.029 (2)	......	......	0.09 (15)
121–138	4	......	......	0.005 (3)	......	......	......	0.004 (1)	0.25 (41)	0.011 (2)	......	......	0.27 (47)

Table VIII. Organisms in bottom samples — Concluded

Name of lake and data on samples: Depth range in feet	Number of samples	Volumes in cubic centimeters and numbers (in parentheses) of aquatic organisms in samples: Leeches (Hirudinia)	Aquatic earthworms (Oligochaeta)	Fresh-water shrimp (Amphipoda)	Alder-fly larvae (*Sialis*)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Mosquito larvae (*Corethra*)	Pill clams (Sphaeridae)	All organisms
Kennebago Lake												
6–20	10	......	0.005 (1)	0.025 (7)	0.07 (3)	0.09 (1)	0.13 (1)	......	......	......	0.01 (3)	0.33 (16)
21–40	4	......	......	0.01 (1)	0.005 (1)	......	......	......	0.005 (1)	......	0.01 (2)	0.03 (5)
41–60	9	0.08 (2)	0.047 (4)	0.04 (1)	......	......	......	0.02 (1)	0.33 (112)	......	0.243 (43)	0.76 (163)
61–80	9	0.15 (4)	0.01 (1)	......	......	......	......	......	0.768 (301)	......	0.492 (73)	1.42 (379)
81–100	7	......	0.06 (5)	......	......	......	......	......	1.04 (212)	......	0.38 (51)	1.48 (268)
101–109	3	......	0.05 (5)	......	......	......	......	......	0.36 (66)	......	0.14 (29)	0.55 (100)
Aziscoos Lake												
12–20	2	......	......	......	......	......	......	......	......	......	......	......
21–30	5	......	0.01 (1)	......	......	......	......	......	0.01 (1)	......	......	0.02 (2)
31–40	11	......	0.01 (1)	......	......	......	......	......	0.007 (2)	0.005 (1)	......	0.022 (4)
41–50	7	......	0.035 (6)	......	......	......	......	......	0.07 (8)	......	......	0.105 (14)
51–53	2	......	......	......	......	......	......	......	......	......	......	......

TABLE IX. The average volumes in cubic centimeters and numbers (in parentheses) of bottom organisms per 9″ x 9″ sample for the six Rangeley lakes combined, arranged according to depth and type of bottom soil, and based on a total of 236 samples. The numbers of samples upon which the averages are based are given in the second part of Table VII. Averages based on five or more samples are given in heavy type

Depth in feet	Type of bottom: Gravel	Gravel, sand	Sand	Mineral concretions	Clay	Wood debris	Sand, wood debris	Mud, clay	Mud, sand	Mud, wood debris	Mud, mineral concretions	Mud	All bottom types
6–20	0.005 (1.8)	0.0 (0)	**0.033 (2.2)**	......	......	0.0 (0)	......	0.03 (0.3)	......	0.02 (2)	......	**0.055 (4.4)**	**0.031 (2.3)**
21–40	**0.003 (0.6)**	0.0 (0)	**0.002 (0.4)**	0.0 (0)	......	**0.003 (0.3)**	0.0 (0)	......	**0.007 (2.1)**	**0.033 (3.1)**	......	**0.065 (5.2)**	**0.020 (1.9)**
41–60	0.033 (2.8)	0.01 (2)	0.01 (1)	0.0 (0)	0.015 (1.5)	0.0 (0)	0.0 (0)	......	......	0.053 (7)	......	**0.034 (5.8)**	**0.029 (4.6)**
61–80	0.005 (4)	......	......	0.05 (2.5)	......	......	......	......	......	......	0.26 (83)	**0.064 (12.1)**	**0.066 (13.1)**
81–100	......	......	0.003 (1)	......	......	......	......	......	......	......	0.127 (31.7)	**0.109 (16.1)**	**0.106 (17.6)**
101–120	......	......	......	......	......	......	......	......	......	......	......	**0.107 (19.2)**	**0.107 (19.2)**
121–138	......	......	......	......	......	......	......	......	......	......	......	**0.062 (10.0)**	**0.062 (10.0)**
All samples, all depths	**0.012 (1.8)**	**0.002 (0.3)**	**0.019 (1.4)**	**0.017 (0.8)**	0.015 (1.5)	**0.002 (0.2)**	0.0 (0)	0.03 (0.3)	**0.007 (2.1)**	**0.035 (3.5)**	0.160 (44.5)	**0.060 (9.6)**	**0.043 (6.7)**

TABLE X. Total volumes and numbers of each type of organism in the 236 bottom samples, for each of the Rangeley lakes. Summary of data given in Table VIII

Name of lake	Depth of water in feet	Number of samples	Volumes in cubic centimeters and numbers (in parentheses) of organisms in all samples: Round worms (Nematoda)	Leeches (Hirudinia)	Aquatic earthworms (Oligochaeta)	Water-fleas (Cladocera)	Fresh-water shrimp (Amphipoda)	Alder-fly larvae (*Sialis*)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Mosquito larvae (*Corethra*)	Pill clams (Sphaeridae)	Snails (Amnicolidae)	Other snails (Gastropoda)	All organisms
Lower Richardson	12–96	21	......	......	......	......	......	......	0.03 (1)	......	......	0.401 (53)	......	0.065 (8)	......	......	0.496 (62)
Upper Richardson	6–85	32	......	......	0.09 (5)	......	......	......	......	......	......	0.339 (44)	......	0.245 (25)	0.029 (3)	......	0.703 (77)
Mooselookmeguntic and Cupsuptic	8–132	53	0.002 (1)	0.02 (1)	0.105 (11)	......	0.04 (6)	......	0.24 (9)	......	......	1.006 (129)	......	0.58 (53)	0.04 (6)	......	2.033 (216)
Rangeley	11–138	61	......	......	0.02 (5)	0.002 (3)	0.002 (2)	......	0.15 (7)	......	0.004 (1)	1.866 (244)	......	0.151 (22)	......	0.02 (1)	2.215 (285)
Kennebago	6–109	42	......	0.23 (6)	0.172 (16)	......	0.075 (9)	0.075 (4)	0.09 (1)	0.13 (1)	0.02 (1)	2.503 (692)	......	1.275 (201)	......	......	4.57 (931)
Aziscoos	12–53	27	......	......	0.055 (8)	......	......	......	......	......	......	0.087 (11)	0.005 (1)	......	......	......	0.147 (20)
All six lakes	6–138	236	0.002 (1)	0.25 (7)	0.442 (45)	0.002 (3)	0.117 (17)	0.075 (4)	0.51 (18)	0.13 (1)	0.024 (2)	6.202 (1,173)	0.005 (1)	2.316 (309)	0.069 (9)	0.02 (1)	10.164 (1591)

potential values of the different types of bottom organisms in the six Rangeley lakes as food for fishes, were more clearly indicated by the calculated average volumes *per 100 square feet* of bottom area in each lake (Table XI). The same order of abundance, namely, midge larvae, pill clams, aquatic earthworms, and Mayfly nymphs, is apparent in these figures.

The calculated volumes and numbers of organisms per square foot according to depth for each lake (Table XII) reveals for most of the lakes, and for all of the lakes combined, a general tendency towards a greater volume and number of bottom organisms in the deeper water, starting at the depth class of 41 to 60 feet, and being especially evident within the depth range of 61 to 100 feet. This somewhat greater abundance of the bottom organisms in the deeper water was apparently due to the preponderance of the more productive mud bottom at these greater depths and, to some extent, to the preponderance of the midge larvae over the other types of bottom organisms in the deep waters (see Table VIII). The lower values of volumes and numbers of bottom organisms within depths of 6 to 40 feet were largely due to the presence of more sand and gravel and other less productive types of bottom in the shallow water (see Table IX).

The six Rangeley lakes varied considerably in terms of productivity of bottom organisms available as food for bottom-feeding fishes. The summary figures in Tables XI and XII are the calcu-

TABLE XI. Calculated volume of each type of bottom organism *per 100 square feet* for each of the Rangeley lakes, based on data given in Table X

Name of lake	Calculated volumes in cubic centimeters of organisms *per 100 square feet*														
	Round worms (Nematoda)	Leeches (Hirudinia)	Aquatic earthworms (Oligochaeta)	Water-fleas (Cladocera)	Fresh-water shrimp (Amphipoda)	Alder-fly larvae (*Sialis*)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Mosquito larvae (*Corethra*)	Pill clams (Sphaeridae)	Snails (Amnicolidae)	Other snails (Gastropoda)	All organisms
Lower Richardson	....	....	....	....	....	....	0.25	....	....	3.38	....	0.6	....	....	4.23
Upper Richardson	....	....	0.5	....	....	....	....	....	....	1.85	....	1.35	0.16	....	3.86
Mooselookmeguntic and Cupsuptic	0.01	0.1	0.4	....	0.1	....	0.8	....	....	3.4	....	1.9	0.1	....	6.81
Rangeley	....	....	0.05	0.01	0.01	....	0.44	....	0.01	5.44	....	0.44	....	0.05	6.45
Kennebago	....	0.9	0.7	....	0.32	0.32	0.4	0.56	0.1	10.6	....	5.4	....	....	19.3
Aziscoos	....	....	0.36	....	....	....	....	....	....	0.58	0.03	....	....	....	0.97

lated averages of volumes and numbers of organisms for all samples in each lake. These averages apply to conditions in each lake as a whole, since the samples were originally taken at stations scattered at random over each lake irrespective of depth of the water. The calculated volumes of organisms per square foot and the order of relative productivity of the different lakes are as follows: Kennebago was by far the richest with 0.193 c. c. per square foot; Mooselookmeguntic and Rangeley were of about equal productivity, Mooselookmeguntic having 0.068 c. c. per square foot and Rangeley having 0.065 c. c.; the two Richardsons were also quite similar with Lower Richardson having 0.042 c. c. and Upper Richardson having 0.039

TABLE XII. Calculated volumes and numbers of all bottom organisms per square foot in the Rangeley lakes according to lake and depth of water, based on data given in Table VIII

Depth range in feet	Volumes in cubic centimeters and numbers (in parentheses) of bottom organisms per square foot						
	Lower Richardson Lake	Upper Richardson Lake	Mooselookmeguntic and Cupsuptic lakes	Rangeley Lake	Kennebago Lake	Aziscoos Lake	Average for all six lakes
6–20	0.027 (0.89)	0.011 (1.4)	0.097 (8.9)	0.064 (4.7)	0.059 (2.8)	0.0 (0)	0.043 (3.12)
21–40	0.001 (0.59)	0.003 (0.76)	0.049 (4.4)	0.080 (7.6)	0.013 (2.2)	0.005 (0.67)	0.025 (2.70)
41–60	0.028 (2.1)	0.031 (3.8)	0.054 (5.5)	0.035 (6.3)	0.150 (32.2)	0.021 (2.8)	0.053 (8.78)
61–80	0.042 (7.9)	0.148 (13.6)	0.091 (10.5)	0.047 (6.7)	0.280 (74.9)	......	0.122 (22.72)
81–100	0.098 (10.2)	0.133 (13.3)	0.053 (13.3)	0.096 (14.2)	0.376 (68.1)	......	0.151 (23.82)
101–120	......	......	......	0.053 (8.9)	0.326 (59.3)	......	0.190 (34.10)
121–138	......	......	0.071 (5.31)	0.120 (20.9)	......	......	0.096 (13.10)
Average for entire lake	0.042 (5.25)	0.039 (4.28)	0.068 (7.25)	0.065 (8.31)	0.193 (39.41)	0.010 (1.32)	0.070 (10.97)

c. c.; Aziscoos was by far the lowest in productivity with 0.010 c. c. per square foot. The comparison is practically identical if made on the basis of numbers instead of volume (see Table XIII). The richer lakes in terms of total numbers and volumes of bottom organisms were also richer in variety of bottom fauna. Of the 14 groups of bottom organisms from the six lakes, nine were represented in the bottom fauna of Kennebago, eight in the bottom fauna of Mooselookmeguntic and Cupsuptic, eight in Rangeley, four in Upper Richardson, three in Lower Richardson and three in Aziscoos (Table XI).

Data were available for a comparison of the average productivity of the bottom organisms of these six Rangeley lakes with six other lakes in Maine (Table XIII). The data for Burnt Meadow, Quimby,

TABLE XIII. Comparative data on volumes and numbers of bottom organisms in twelve lakes and ponds in Maine, based on bottom samples. Data for Burnt Meadow, Kezar, Sebago, Adams and Quimby ponds are from Cooper, 1939*

Name of Lake	Number of samples	Total organisms in samples		Organisms per square foot (calculated)	
		Vol. in c.c.	Number	Vol. in c.c.	Number
Burnt Meadow Pond	20	1.53	134	0.14	11.9
Kezar Lake	17	0.79	67	0.08	7.0
Sebago Lake	28	0.07	18	0.004	1.1
Adams Pond	20	1.89	51	0.17	4.5
Quimby Pond	13	7.49	2,187	1.02	299.1
Horseshoe Pond	23	2.97	412	0.229	31.8
Lower Richardson Lake	21	0.496	62	0.042	5.25
Upper Richardson Lake	32	0.703	77	0.039	4.28
Mooselookmeguntic and Cupsuptic lakes	53	2.033	216	0.068	7.25
Rangeley Lake	61	2.215	285	0.065	8.31
Kennebago Lake	42	4.57	931	0.193	39.41
Aziscoos Lake	27	0.147	20	0.010	1.32

* Cooper, Gerald P.: 1939. A biological survey of thirty-one lakes and ponds of the Upper Saco River and Sebago Lake drainage systems in Maine. *Maine Dept. Inland Fisheries and Game, Fish Survey Report No. 2.*

and Adams ponds and Kezar and Sebago lakes are from Survey Report No. 2 (see footnote to table). The data on Horseshoe Pond in West Bowdoin College Grant are given in Appendix A of the present report. On the basis of these figures in Table XIII, in production of bottom food organisms the Rangeleys as a group with 0.070 c. c. or 10.97 organisms per square foot (see Table XII) compared favorably with Kezar Lake (0.08 c. c. or 7.0 organisms), and were much richer than Sebago Lake (0.004 c. c. or 1.1 organisms). If, however, the Rangeleys are compared with the four smaller ponds, the average productivity of the Rangeleys was considerably less; the best of the Rangeleys (Kennebago, with 0.193 c. c.) was about the same in productivity as Burnt Meadow (0.14 c. c.), Adams (0.17 c. c.), and Horseshoe (0.229 c. c.), and considerably less than Quimby Pond, an apparently quite rich pond with 1.02 c. c. of bottom organisms per square foot. The above comparison is at least partially valid from the standpoint of date, since all of the samples were taken during the summer months of June to the middle of September and mostly during July and August.

In general the productivity of bottom fauna of the Rangeley lakes is low. This fact is particularly obvious if the summary figures given in Table XI are converted into weight of bottom organisms per acre. If the actual live weight of the organisms is assumed to be approximately the same as that of water, or 1 gram per c. c. (the weight of the organisms is actually somewhat greater than that of water), the average weight of bottom organisms per acre for each lake was approximately as follows:

Lower Richardson	4.1	pounds	per	acre
Upper Richardson	3.7	"	"	"
Mooselookmeguntic and Cupsuptic	6.5	"	"	"
Rangeley	6.2	"	"	"
Kennebago	18.5	"	"	"
Aziscoos	0.9	"	"	"

The extent to which these amounts of bottom organisms in the various Rangeley lakes could be converted into pounds-per-acre of trout and salmon available for the angler would depend upon, and be limited by several factors. First of all, all of the bottom fauna could not be eaten by fish as obviously the bottom organisms themselves would be exterminated. Not all of the organisms are available to fish at all seasons, as for example in the deep-water area of Aziscoos Lake during the summer where extreme oxygen deficiency undoubtedly results in an unsuitable habitat for trout and salmon. The organisms in especially deep water, such as at depths of over 100 feet in Rangeley and Mooselookmeguntic, are probably not nearly so accessible to trout and salmon as are organisms in shallower water, because trout and salmon apparently do not frequent this exceptionally deep water to any great extent. Also the bottom organisms in very shallow water during the summer time, when trout and salmon are mostly in the deeper water below the thermocline, probably are not as available as at other seasons of the year. Another factor is that other species of fishes besides trout and salmon are present in the lakes and are potentially bottom feeders. There are several species of minnows present in all of the Rangeley lakes, and two species of suckers present in all except Kennebago; thus trout and salmon could get only a portion of the bottom organisms that were eaten by fishes as a whole. It would, also, take at least several pounds of bottom food organisms to produce a pound of trout or salmon. Thus the pounds-per-acre of trout and salmon which would normally be produced from the bottom fauna would be only a fraction of the weight of the bottom food present. The potential productivity of the bottom fauna in the Rangeley lakes is obviously much less than one pound of fish per acre for all of the lakes, with the possible exception of Kennebago. The actual value of the bottom fauna in the summer diet of trout and salmon is relatively very small in Kennebago and practically negligible in the other five Rangeley lakes (see a later section of this report on "Food Habits of Trout and Salmon").

FISHES OF THE RANGELEY LAKES

Methods of Collection. The kinds and abundance of fishes in the Rangeley lakes were determined by fishing the lakes with gill nets in fairly shallow to deep water and by operating seines in the shoal areas and in the tributaries of the lakes. All of the survey collections discussed in this section were made during the summer of 1939. The validity of the discussions on size and age frequency distributions of the fishes, and on the relative abundance of the different species, is directly dependent on whether or not the collections took random samples of the fish populations that were present. The types of both gill nets and seines which were used and their operation were both designed to take such random samples.

In the operation of gill nets, the size of fish which a net will catch is dependent to a large extent on the size of the mesh of the netting itself. Fish are caught in gill nets by attempting to swim through the net, in which process they get part way through, are caught and are unable to swim completely through the net or to back out. Thus small fish can swim through a large-mesh net, and large fish may run up against a small mesh which is too small to catch them. By using a net with a variety of mesh sizes, fishes of various sizes are readily captured. The net which was operated during the present survey and which caught the majority of fishes which were obtained was of an experimental type and made up as follows: net 375 feet long by

6 feet deep and made up of five sections each 75 feet long; each of these five sections was of different size mesh, namely, 4-inch, 2 inch, 6-inch, 3-inch, and 5-inch stretched measure or 2-inch, 1-inch, 3-inch, 1½-inch, and 2½-inch bar measure, and the units were tied together in the above order; to this 375-foot unit was added a 70-foot by 6-foot section with 2 3/8-inch stretched mesh making a net 445 feet by 6 feet; and an additional section 30 feet by 6 feet with 2¾-inch stretched mesh was added making the net 475 feet by 6 feet. These three net units (475, 445, and 375 feet long) were used at different times during the summer. A second gill net 150 feet by 12 feet with 5-inch stretched mesh was also used. These two nets, 150-foot and 475-foot (or 445-foot, or 375-foot), were used as a pair and were set in the same lake, at about the same depth, near each other, and at the same time.

In the operation of these nets it was the general rule that small fish were usually caught in the small meshes and large fish were caught in the large meshes. There was, however, a fair percentage of overlapping, with large fish caught in the smaller meshes, and vice versa. These fishes, and especially trout and salmon, got their teeth and jaws entangled in the netting and were caught irrespective of the size of mesh. A few 8- to 10-inch trout, for example, were caught in 4- and 5-inch mesh, and a considerable number of smelts in Kennebago were caught in the gill net. These 6- to 8-inch smelts were of a sufficiently small size that they might have passed through the one-inch bar mesh of the gill net quite easily, but they apparently had their mouths open at the time of striking the net and were caught by their teeth. The fact that five different mesh sizes of gill-netting were used, plus the fact that there was some overlapping between the size of mesh and size of fish caught, are believed to be adequate evidence that the nets themselves were capable of catching fish of a size range representative of the size range of the larger fishes (over seven to eight inches) in these lakes. For further evidence that these two nets took fairly representative samples of fish present, data on the total lengths of trout and salmon taken from all the Rangeley lakes are presented at this time. These two gill nets were set for a total of approximately 1,200 hours each in the six lakes, and they caught a total of 252 Brook Trout and 57 Land-locked Salmon. Of these 309 fish, length measurements were taken on 239 trout and 50 salmon. (Twenty of the smaller trout and salmon were not measured.) The length frequencies of these 289 trout and salmon are given by species and by net in Table XIV. This compilation of the length measurements reveals that these nets took fish ranging from the 7-inch class to the 24-inch class. The size frequency distribution of the trout caught by the experimental net of the five mesh sizes resembles somewhat a curve of normal distribution, with some variations attributable to the character of the trout populations. A low point at the

TABLE XIV. Frequencies of total lengths in inches of Land-locked Salmon and Brook Trout taken by gill nets from all six Rangeley lakes during the summer of 1939

Net	Fish	7–7.9	8–8.9	9–9.9	10–	11–	12–	13–	14–	15–	16–	17–	18–	19–	20–	21–	22–	23–	24–
		Length classes — total length in inches																	
475′ (445′ and 375′) net	Salmon	:	1	4	2	3	2	3	:	5	1	5	1	2	1	1	3	2	1
	Trout	4	19	32	35	38	39	31	5	10	8	6	2	1	1	1	:	:	:
	Salmon and Trout	4	20	36	37	41	41	34	5	15	9	11	3	3	2	2	3	2	1
150′ x 12′ net	Salmon	:	:	:	:	:	:	:	:	:	1	:	:	1	9	1	1	:	:
	Trout	:	:	:	:	:	:	1	:	1	1	1	2	1	:	:	:	:	:
	Salmon and Trout	:	:	:	:	:	:	1	:	1	2	1	2	2	9	1	1	:	:
Both nets	Salmon	:	1	4	2	3	2	3	:	5	2	5	1	3	10	2	4	2	1
	Trout	4	19	32	35	38	39	32	5	11	9	7	4	2	1	1	:	:	:
	Salmon and Trout	4	20	36	37	41	41	35	5	16	11	12	5	5	11	3	4	2	1

14-inch size of trout and salmon caught by the 475-foot net could hardly be attributed to the inability of the net to cath fish of this size, in view of the large numbers of 13- and 15-inch fish and the fact that the 13- to 15-inch fish were in the size range readily caught by 2 3/8-inch, 2¾-inch and 3-inch mesh netting, which together made up over one-third of the entire length of the net. The low numbers of 7-inch fish might have been in part due to selectivity, but, on the other hand, other evidence indicates this to be approximately the size at which trout move from the tributary streams out to the open water of the lakes where they might be caught by the nets. If 4- to 7-inch trout were present in the lakes in considerable numbers, some should have been taken either by seining or from the stomachs of adult trout and salmon, but none were taken in these ways.

The 150-foot net (5-inch stretched mesh) was obviously selective for larger fish between the lengths of 15 to 22 inches. This net was used to compensate for the extra one hundred feet of 2 3/8-inch and 2¾-inch mesh netting used on the long net. The comparatively large number of 20-inch salmon caught in this large-mesh net might have represented size selectivity to some extent, but it obviously did not represent extreme selectivity because the net also took Brook Trout of lengths of 13 to 19 inches.

In the operation of the two nets as a whole they captured fish scattered fairly uniformly over the size range of fishes known to be present in the lakes, and it is believed that fairly random samples of the fish populations present were obtained (see Table XIV and Plates I to III). It is believed that the same conclusions apply to the populations of the two species of suckers and the Fallfish, and that random samples of these species were obtained for individuals above approximately seven inches in length. The smelts taken from the lakes by gill net were obviously only the larger individuals present in each lake. Only a few of the smelts which were taken were large enough to be caught in the one-inch mesh gill net in a normal way. The other smelts taken in the gill net were small enough to have readily passed through the smallest mesh netting, but had been caught solely by getting their teeth and jaws entangled in the thread.

The gill nets were operated within various depth ranges in each of the lakes, and approximately within the same depth ranges (see Figure 8) in the different lakes. In examining the data in Figure 8 it should be kept in mind that the gill nets in their normal position sat directly on the bottom. The depths given in this figure refer to the depths of water to the bottom of the nets. The 475-foot net sat with the top of the net six feet above bottom, and the 150- by 12-foot net sat with the top of net 12 feet above the bottom. The locations of the net sets within each lake were scattered with some degree of uniformity over the entire area of the lake, and without regard to the known locations of certain of the better fishing grounds.

The possibility of trout and salmon living at various depths in the open water over the deep parts of the lakes and considerably above the bottom was checked by setting the 475- by 6-foot gill net in the main part of Rangeley Lake over water 125 to 132 feet deep for five consecutive days, from August 23 to August 28. At the beginning of the set the net was suspended horizontally at a depth of 11 feet, from floats at the surface, and after each 24-hour interval the net was lowered to a new position. The depths to the bottom of the net for these five consecutive sets were 11, 21, 31, 36, and 46 feet, respectively. The net in these five sets took the following fishes:

at 11 feet...............	1 Fine-scaled Sucker
at 21 feet...............	8 Fine-scaled Suckers
	1 Land-locked Salmon
at 31 feet...............	14 Fine-scaled Suckers
at 36 feet...............	1 Fine-scaled Sucker
	3 Land-locked Salmon
at 46 feet...............	2 Brook Trout
	1 Land-locked Salmon

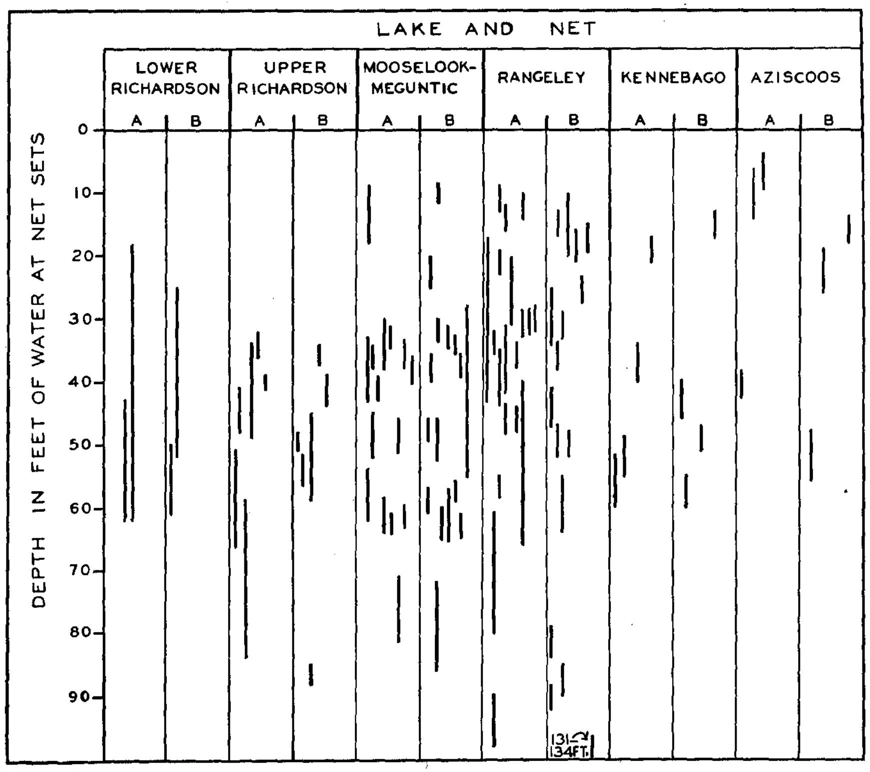

Figure 8. The ranges in depth of water at gill net sets in the Rangeley lakes during the 1939 survey. Net A was the 475-foot by 6-foot experimental net of seven sizes of mesh; Net B was the 150-foot by 12-foot net with 5-inch mesh.

The results of this set indicated at least that trout and salmon were present in the upper layers of this deep water; and that there was no great concentration of trout and salmon present in this region, and which were being missed by the gill nets set in their normal position on the bottom in shallower water. The presence of considerable numbers of Fine-scaled Suckers in this somewhat pelagic habitat was of interest, since suckers are usually considered to be bottom forms.

Seines of various lengths from 6 to 50 feet, and of various mesh sizes from Common Sense to 3/8 inch, were used in collecting small fishes in shallow water. The seining operations were designed to take a fairly representative sample of all of the smaller fishes on the lake shallows.

Fish Fauna. The fish fauna of the Rangeley lakes is a very limited one in number of species. The fauna of the six lakes studied by the present survey (not including Umbagog), as indicated by our collections, includes 19 species representing six families.[14] Of these 19 species, 5 are forms which have been introduced into the Rangeley region:

- Smelt (*Osmerus mordax*)
- Land-locked Salmon (*Salmo sebago*)
- Brown Trout (*Salmo trutta*)
- Rainbow Trout (*Salmo gairdnerii irideus*)
- Horned Pout (*Ameiurus n. nebulosus*)

The other 14 species are indigenous to the Rangeley region:

- Family Salmonidae
  - Brook Trout (*Salvelinus f. fontinalis*)
- Family Catostomidae
  - Common Sucker (*Catostomus c. commersonnii*)
  - Fine-scaled Sucker (*Catostomus c. catostomus*)
- Family Cyprinidae
  - Lake Chub (*Couesius plumbeus*)
  - Black-nosed Dace (*Rhinichthys a. atratulus*)
  - Fallfish (*Leucosomus corporalis*)
  - Creek Chub (*Semotilus a. atromaculatus*)
  - Northern Dace (*Margariscus margarita nachtriebi*)
  - Fine-scaled Dace (*Pfrille neogaea*)
  - Red-bellied Dace (*Chrosomus eos*)
  - Black-nosed Shiner (*Notropis h. heterolepis*)
  - Common Shiner (*Notropis c. cornutus*)
  - Fat-headed Minnow (*Pimephales p. promelas*)
- Family Cottidae
  - Fresh-water Sculpin (*Cottus cognatus*)

[14] The identifications of fishes in part of the survey collections, including some individuals of all of the non-game species, have been checked by Dr. Carl L. Hubbs, Curator of Fishes, Museum of Zoology, University of Michigan.

The distributions of these 19 species of fishes in the Rangeley lakes, according to our collections, are given in Tables XV and XVI.

To the above list of 19 species for these six lakes can be added Kendall's[2] (1918) records for the Eel (*Anguilla bostoniensis*) in the Richardson lakes, and for the Blueback Trout (*Salvelinus oguassa*) in Rangeley, Mooselookmeguntic, and the Richardson lakes. There is a record of a planting of the Golden or White Trout (*Salvelinus aureolus*) in Mooselookmeguntic Lake in 1903 or 1904 but the accuracy of the record is doubted by Kendall. There are also records of early plantings of large numbers of the Sea Salmon (*Salmo salar*), but the extent to which these fish may have survived in the region is not known. Thus the total known fish fauna of 23 species in the Rangeley lakes (not including Umbagog) includes 7 introduced forms of which the introduction of one (the Golden Trout) is doubtful, and 16 native species of which one (the Blue-back Trout) is apparently extinct in this region.

To our records of occurrence of the different species in each of the Rangeley lakes and tributaries may be added Kendall's[2] (1918, p. 507) record of the Horned Pout (*Ameiurus n. nebulosus*) for Rangeley Lake. Of the 19 species of fish found in the six lakes by the present survey, eight species are here reported as new either to the entire Rangeley chain or to those lakes of the chain above Umbagog. They include the Brown and Rainbow trouts which were not reported as being present by Kendall in 1918 and which, according to local reports, were introduced accidentally into some of the Rangeley lakes within the last few years; the Black-nosed Dace (*Rhinichthys a. atratulus*) and Fine-scaled Dace (*Pfrille neogaea*), reported by Kendall from Umbagog but not from the other Rangeley lakes; and 4 other species of minnows, namely: the Northern Dace (*Margariscus m. nachtriebi*), Red-bellied Dace (*Chrosomus eos*), Black-nosed Shiner (*Notropis h. heterolepis*), and the Fat-headed Minnow (*Pimephales p. promelas*). Further notes on each of the species of fishes in the Rangeley lakes fauna are given in the following:

Smelt (*Osmerus mordax*). According to Kendall[2] the Smelt was first introduced into the Rangeley lakes about 1895 or possibly as early as 1891. The first smelt plantings in the lakes were obtained from Weld Pond and later plantings were obtained from Swan Lake near Belfast. Within four years after the first introduction, they appeared in considerable numbers. By 1900 the species was abundant in Rangeley, Mooselookmeguntic, and the Richardson lakes.

Judging from our survey seine and gill net collections, from the contents of trout and salmon stomachs, and from Warden's records of smelt dipping in the spring, the Smelt is still abundant in the six

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[2] See footnote p. 11.

Rangeley lakes. The pertinent question from the standpoint of trout and salmon fishing is just how abundant the smelt population is in each of the lakes. This is discussed in a later section of this report.

The smelts which were first introduced into the Rangeley lakes were reportedly of a small race; a larger race was introduced somewhat later into Mooselookmeguntic (Kendall: 1918, p. 577). At present there seems to be a wide size range of the smelts in the various lakes. Two fish taken in the gill net in Lower Richardson were 8 to 8½ inches long, two in Mooselookmeguntic were 9 to 11½ inches long, one from Rangeley was 7¾ inches long, and 22 from Kennebago were 6½ to 9 inches long. The above lengths of these smelt are presumably more indicative of the maximum lengths than of the average lengths attained by the Smelt in these lakes. The smelts which were recovered from the stomachs of trout and salmon were of the following lengths: from Kennebago, 4.1 to 6.9 inches; from Mooselookmeguntic, 2.0 to 6.1 inches; and from Rangeley, 1.6 to 4.9 inches in total length. The average lengths were approximately in the same order: the largest were from the stomachs of trout and salmon in Kennebago, smelts intermediate in size were from fish in Mooselookmeguntic, and the smaller smelts in the fish from Rangeley Lake. Data on size of the smelts from the Richardsons and Aziscoos lakes were inadequate for comparison.

There are known to be two size classes of spawning Smelt in Mooselookmeguntic Lake: an early run of large fish averaging over 10 inches in length and a later run of 7- to 8-inch fish. According to local reports the run of the larger fish has been greatly depleted, probably by net dipping on the spawning grounds. Judging from the stomach contents of the trout and salmon, the smaller sized smelts of lengths from 2 to 5 inches were much more abundant in the lakes as a whole than were smelts of the 7- to 11-inch size which were taken only by the gill nets.

Smelt fry, 1½ to 2 inches long, were encountered in fair numbers in shallow water in the two Richardson lakes and in Mooselookmeguntic Lake in late July and early August, but nowhere were they found to be very abundant. No fry were encountered in the shallow water of the other lakes, although the dates at which the seinings were made may have been a deciding factor. Also no smelts were found in any of the streams tributary to the lakes during the survey (in the months of July to September).

Sea Salmon (*Salmo salar*). The Sea Salmon was first planted in the Rangeley lakes in 1873 with 10,000 fry; 99,000 fry in 1881; 194,-600 fry in 1882; and 1,000 yearlings in 1900-1901 (Kendall: 1918,

TABLE XV. Fishes taken by gill nets from the Rangeley lakes during the present survey, and the relative abundance of the different species as indicated by the catch per unit of fishing effort

The figures given in the table are the calculated numbers of fish caught per 24 hours per 500 feet of net, and (in parentheses) the actual numbers of fish caught by the nets. For explanation see text

Kind of fish		Lower Richardson Lake	Upper Richardson Lake	Mooselookmeguntic and Cupsuptic lakes	Rangeley Lake	Kennebago Lake	Aziscoos Lake*	All six lakes
	Number individual net sets	2	6	15	19	4	3	49
	Total hours fished with experimental gill nets: 375, 445, and 475 feet long	43¾	158	415¾	370½	89½	68¼	1,145¾
Smelt *Osmerus mordax*		1.3 (2)	...	0.1 (2)	0.1 (1)	6.2 (22)	...	0.6 (27)
Land-locked Salmon *Salmo sebago*		0.6 (1)	0.2 (1)	0.6 (9)	1.4 (19)	0.6 (2)	2.0 (5)	0.8 (37)
Brown Trout *Salmo trutta*		...	...	...	0.1 (1)	0.6 (2)	...	0.07 (3)
Brook Trout *Salvelinus f. fontinalis*		5.8 (9)	2.4 (15)	2.4 (39)	6.0 (83)	22.6 (80)	5.5 (14)	5.5 (240)
Common sucker *Catostomus c. commersonnii*		6.5 (10)	6.6 (41)	5.9 (96)	3.4 (47)	...	9.1 (23)	5.0 (217)
Fine-scaled Sucker *Catostomus c. catostomus*		0.6 (1)	0.3 (2)	1.7 (28)	3.9 (54)	...	0.8 (2)	2.0 (87)
Fallfish *Leucosomus corporalis*		...	0.3 (2)	1.2 (19)	1.9 (26)	...	2.4 (6)	1.2 (53)
Creek Chub *Semotilus a. atromaculatus*		...	...	...	...	...	0.3 (1)	0.02 (1)
Kind of fish	Number individual net sets	2	6	16	16	4	3	47
	Total hours fished with gill net 150 x 12 feet, 5-inch mesh	43¾	230½	439	370	89½	67¼	1,240
Land-locked Salmon *Salmo sebago*		...	...	1.1 (6)	1.5 (7)	...	...	0.8 (13)
Brown Trout *Salmo trutta*		...	...	...	0.2 (1)	...	...	0.06 (1)
Brook Trout *Salvelinus f. fontinalis*		...	...	0.9 (5)	...	2.7 (3)	...	0.5 (8)

* Nets set in Aziscoos Lake caught fish only off the mouths of Meadow and Big brooks, and not in the open part of the lake.

TABLE XVI. The distribution of different species of fishes in the Rangeley lakes and their tributaries, as determined from seine collections made by the present survey. An X indicates that the species was found to be present

Kind of fish		Lake and tributaries				Lake and tributaries					Lake and tributaries				Lake and tributaries				Lake and tributaries		
	Lower Richardson Lake	Upper Richardson Lake	Metallock Bk.	Mosquito Bk.	Beaver Bk.	Mooselookmeguntic and Cupsuptic lakes	Bemis Stream	Cupsuptic R.	Toothaker Bk., trib. of Cupsuptic R.	Kennebago R.	Rangeley Lake	South Bog Stream	Dodge Pond Stream	Long Pond Stream	Kennebago Lake	Wilbur Br.	Big Sag Bk.	Little Kennebago R.	Aziscoos Lake	Little Magalloway R.	Magalloway R.
Smelt *Osmerus mordax*	X	X	...	...	...	X	...	...	...	...	X	...	...	...	...	...	...	...	X	...	...
Land-locked Salmon *Salmo sebago*	...	...	X	...	...	...	...	...	...	X	X	...	X	...	...	...	...	X	...	...	...
Brook Trout *Salvelinus f. fontinalis*	...	...	X	X	...	...	X	X	X	X	...	X	...	X	...	X	X	X	...	...	...
Common Sucker *Catostomus c. commersonnii*	X	X	...	...	X	X	...	...	...	X	X	X	X	...	...	...	...	...	...	X	X
Fine-scaled Sucker *Catostomus c. catostomus*	...	...	...	...	...	...	...	...	...	...	X	X	...	...	...	...	...	...	...	...	...
Lake Chub *Couesius plumbeus*	X	X	...	...	...	...	...	...	...	...	X	X	X	...	X	...	...	X	X	...	X
Black-nosed Dace *Rhinichthys a. atratulus*	...	...	...	...	...	...	...	X	...	X	X	X	X	...	X	...	X	X	X	X	X
Fallfish *Leucosomus corporalis*	X	X	X	...	X	...	X	...	...	X	X	...	X	...	...	...	...	...	X	...	X
Creek Chub *Semotilus a. atromaculatus*	...	...	...	...	X	...	...	...	...	X	...	...	X	...	...	...	...	...	...	X	...
Northern Dace *Margariscus m. nachtriebi*	X	X	...	...	...	X	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fine-scaled Dace *Pfrille neogaea*	...	X	...	...	X	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Red-bellied Dace *Chrosomus eos*	...	X	...	...	X	X	...	...	...	...	...	...	X	...	...	...	...	...	X	X	X
Black-nosed Shiner *Notropis h. heterolepis*	...	...	...	...	...	...	...	...	...	...	X	...	X	...	...	...	...	...	...	...	...
Common Shiner *Notropis c. cornutus*	...	X	...	...	X	...	...	...	...	X	X	X	X	...	...	...	...	...	...	...	...
Fat-headed Minnow *Pimephales p. promelas*	X	X	...	...	...	X	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bullhead or Horned Pout *Ameiurus n. nebulosus*	...	X	...	...	X	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fresh-water Sculpin *Cottus cognatus*	...	...	...	...	...	...	...	...	...	...	...	X	...	...	...	...	...	...	...	X	...

p. 522-523). Some salmon were caught shortly after the first planting and these fish may possibly have been Sea Salmon, but there is an element of uncertainty involved because of the fact that Land-locked Salmon were first planted in the Rangeley lakes at about the same time. The extent to which the introduction of Sea Salmon may have affected the early stock of the Land-locked Salmon (*Salmo sebago*) is not known.

Land-locked Salmon (*Salmo sebago*). The Land-locked Salmon was originally restricted in its distribution in Maine to four widely separated regions: Grand Lake and other lakes on the western branch of the St. Croix River in Washington County; Green Lake or Reed's Pond, tributary of Union River in Hancock County; Sebec Lake, tributary to the Piscataquis and Penobscot rivers in Piscataquis County; and Sebago Lake, tributary to the Presumpscot River in Cumberland County. The Land-locked Salmon was first introduced into the Rangeley lakes in 1875. Stocking of this species from 1875 to 1900 was done at irregular intervals. Since about 1900 plantings were made each year. The early plantings (before 1900) were mostly fry, but in later years the majority were either yearlings or fingerlings. The Land-locked Salmon was apparently established in the Rangeley lakes by the first planting in 1875, and the species increased rapidly and was described as very abundant by 1900. (Kendall:[2] 1918.)

Land-locked Salmon are at present abundant in the Rangeley region, with considerable variation between the different lakes. Our gill nets took salmon from all six lakes. In seining, salmon were found in Metallock Brook, a tributary of Upper Richardson Lake; Kennebago River, tributary of Mooselookmeguntic; Little Kennebago River above Kennebago Lake; and Dodge Pond stream, tributary of Rangeley Lake. Fairly extensive seining in the shallow water in the lakes themselves produced three fingerling salmon in Rangeley Lake and none in the other five lakes.

Brook Trout (*Salvelinus f. fontinalis*). The Brook Trout or "Square Tail" is probably the most widely distributed and abundant fish in the Rangeley region. It was found in all of the lakes and found abundantly in most of the streams which were examined. The Brook Trout is native to the region. (A more complete discussion of this species is given later, see page 146.)

Blueback Trout (*Salvelinus oquassa*). The Rangeley lake region was one of two sections of Maine to which the Blueback Trout was known to be native. It occurred abundantly in Rangeley, Mooselookmeguntic and the Richardson lakes, according to past reports.

[2] See footnote p. 11

It was seldom seen except when it entered streams in October to spawn. One of the largest spawning runs was in the outlet of Quimby Pond, tributary to Rangeley Lake. The Blueback was a deep-water fish. It was generally small as compared with other trouts, ranging from about 6 to 9 inches in length. In the latter years of the Blueback's existence in the Rangeley lakes it reached a larger size, and this has been attributed by some to smelts which were present as food for the Blueback only during the latter part of its existence. According to early reports, the Blueback was an important food of trout and salmon. The Blueback greatly decreased in numbers in the early 1890's and apparently became extinct about 1905, coinciding with the increase in abundance of salmon. No Bluebacks were encountered during the present survey. Although this species has apparently become extinct in the Rangeley region, it is still known to occur in Rainbow Lake on the headwaters of the west branch of the Penobscot River in Piscataquis County, Maine. There is also the possibility that some undiscovered populations of the Blueback Trout may occur in some waters in the more northern parts of the state.

Brown Trout (*Salmo trutta*). The Brown Trout was native to Europe and not to any part of Maine. It has been introduced into many localities in southern Maine, and is now also present in at least some of the Rangeley lakes. It was reported to the writer by local residents of the Rangeley region that the Brown Trout was accidentally introduced into these lakes a few years ago. Two Browns were taken by gill net from Rangeley Lake, and two from Kennebago. The species was also found in Quimby Pond which is located on a tributary of Rangeley Lake, and it seems likely that the Brown Trout may be present in still other lakes in the region. The species is still very rare in the area but there is the possibility of it becoming permanently established. There is no evidence as yet, however, that the spawning of the Brown Trout in the region has been successful, since no young Browns were found by our seining in the shallow waters of the lakes or in any tributaries.

Rainbow Trout (*Salmo gairdnerii irideus*). The Rainbow Trout was native to the western coast of North America. It has been planted in some localities in southern Maine but not so extensively as the Brown Trout. It is reported as having been introduced accidentally into the Rangeley lakes along with the Browns a few years ago. One adult Rainbow Trout was given to the survey party by a fisherman who reported that he caught it in Upper Richardson Lake. There is also a report of one Rainbow being caught in Kennebago Lake. None were taken by any of our gill net sets in any of the lakes, and no young were taken by seines in the region. The species is apparently very rare and there is no indication that it has as yet successfully spawned or become permanently established.

Common Sucker (*Catostomus c. commersonii*). The Common Sucker is one of the most abundant of the non-game species in the Rangeley region, as well as in the whole state of Maine. Adult suckers were taken by gill nets from all of the six Rangeley lakes except Kennebago. Neither of the two suckers (the Common or the Fine-scaled) were found in Kennebago Lake or any of its tributaries, and all reports by local fishermen were to the effect that suckers were absent in this section of the Rangeley region. Young Common Suckers were found to be generally common in our seine collections from the shallow waters of the lakes and the tributary streams. The adult Common Suckers taken from the gill nets were generally small as compared to average size of suckers in lakes in Maine as a whole. Most individuals were 8 to 12 inches long, a very few were up to 16 inches, and one individual was 28 inches long.

Fine-scaled Sucker (*Catostomus c. catostomus*). Adults of the Fine-scaled Sucker were taken in all of the lakes except Kennebago. Fine-scaled Suckers of the fingerling size were taken by seines in South Bog Stream, tributary to Rangeley Lake, and also in the shallow water of Rangeley Lake itself. The Fine-scaled Sucker was found to be somewhat more abundant in Rangeley Lake than the Common Sucker, but less abundant in the other four lakes in which it occurred. The Fine-scaled Sucker of the Rangeley lakes is somewhat smaller than the Common Sucker. The great majority of those caught by the gill nets were 8 to 10 inches in length, and the largest one was about 11 inches. One of the most interesting of our records was the finding of considerable numbers of this species living an apparently pelagic existence nearly a mile from shore in Rangeley Lake; gill nets fished in the upper strata of water from the surface down to a depth of 46 feet and over a depth of 132 to 135 feet, took a considerable number of this species (see page 70). Both species of suckers are usually considered as bottom forms.

Minnows (Cyprinidae). There are about as many species of minnows in the fish fauna of the Rangeley region as all other species of fishes combined. The minnows included the majority of small fishes in the shallow waters of the lakes. At present the minnows are of some importance as food for trout and salmon in the Rangeley lakes, and particularly for trout in Rangeley and Kennebago lakes; but in the region as a whole the minnows are not nearly as important as the introduced Smelt. The Minnows are otherwise of very little or almost no direct economic importance, with the possible exception of the Fallfish. Past records indicated that the minnows were of considerable value as food for trout in the Rangeley lakes before the Smelt was introduced.

Even though the number of individual species of minnows in the region is quite large, the total minnow populations in terms of numbers of individual fish, are not at all abundant. Judging from early reports of great abundance of minnow life in the region, it might appear that the minnow populations of these lakes have decreased somewhat during the past half century, but it is the present writer's opinion that these early reports were misleading, that minnows were not unusually abundant in the past, and that there has been no great decrease in the minnow populations. There are no apparent reasons for explaining such a change. The trout and salmon reportedly changed their diet from minnows to Smelt when the latter was introduced about 1900, and this should have favored a building up of the minnow populations. Also the several species of minnows now present in the Rangeley lakes are species of diversified habits and should be adequate to build up large minnow populations under favorable conditions. Minnows are not abundant in these lakes at present obviously because of the general absence of vegetation and shelter and the scarcity of food in shallow water, and there is no reason to believe that these conditions were much more favorable for minnows in the past.

Lake Chub (*Couesius plumbeus*). The Lake Chub is one of the most abundant of the smaller species of minnows in the Rangeley lakes. The maximum length of Lake Chubs taken from this region was about 5 inches. The species was found abundantly in the shallow water of both Richardson lakes, Rangeley, Aziscoos, and particularly in Kennebago Lake. This fish was of more importance than any other species of minnow in the food of trout from Kennebago and Rangeley lakes. An abundant breeding population of the Lake Chub was found in South Bog Stream, tributary to Rangeley Lake, on July 9.

Black-nosed Dace (*Rhinichthys a. atratulus*). The Black-nosed Dace is one of the smallest species of minnows of the region, with a maximum length of about 3 inches. It was found in Rangeley, Kennebago, and Aziscoos lakes in shallow water, and in tributaries of Rangeley, Mooselookmeguntic, Kennebago, and Aziscoos. The species was found to be generally common in the whole Rangeley region and somewhat more abundant in the streams than in the shallow water of the lakes.

Fallfish (*Leucosomus corporalis*). The Fallfish was found to be generally common in all of the lakes or their tributaries except Kennebago Lake. This large minnow was taken commonly in the gill nets. Most individuals were about 8 to 12 inches long but a few individuals up to 16 inches long were taken. Fallfish in the Rangeley lakes feed to a large extent on smelts and thus compete with trout and salmon for their food supply. On the other hand, small Fallfish were fed upon to some extent by the trout.

Creek Chub (*Semotilus a. atromaculatus*). The Creek Chub was found scattered fairly generally, but rarely, over the Rangeley region in tributaries of Upper Richardson, Mooselookmeguntic, Rangeley, and Aziscoos lakes. One particularly large individual 9¼ inches long was taken by gill net from Aziscoos Lake. No other individuals of this species were taken in any of the lakes.

Northern Dace (*Margariscus m. nachtriebi*). The Northern Dace was found in both of the Richardson lakes and in Mooselookmeguntic. It was not found in any streams in the area. The individuals found were mostly fry, and the species was generally rare. The maximum length of the Northern Dace is about 4 inches.

Fine-scaled Dace (*Pfrille neogaea*). The Fine-scaled Dace was found in Upper Richardson Lake and one of its tributaries but nowhere else. Most of the individuals were fry and the species was found to be rare. It has a maximum length of about 3 inches.

Red-bellied Dace (*Chrosomus eos*). The Red-bellied Dace was found to be generally common over the region as a whole (in Upper Richardson, Mooselookmeguntic, Rangeley, and Aziscoos lakes or their tributaries). Especially large schools of several thousand individuals of this species were encountered in Mooselookmeguntic and Aziscoos. The species has a maximum length of about 2½ inches. *Chrosomus eos* and *Pfrille neogaea* were found together in four collections on Upper Richardson Lake, yet no individuals of the common hybrid between the two species were found; also no *Chrosomus X Pfrille* hybrids were found among the other collections of *Chrosomus*.

Black-nosed Shiner (*Notropis h. heterolepis*). The Black-nosed Shiner was found in Rangeley Lake, and in Dodge Pond Stream, tributary to Rangeley Lake, but nowhere else in the region. It was one of the rarest species of minnows present; a total of only 5 individuals were collected by seine and one was picked up dead. The species has a maximum length of about 2½ inches. It is of no economic importance in the region.

Common Shiner (*Notropis c. cornutus*). The Common Shiner was found in Rangeley, Mooselookmeguntic, and Upper Richardson lakes or their tributaries. The species was generally rare in the lakes but considerably more abundant in the streams. It has a maximum length of about 6 inches in this region.

Fat-headed Minnow (*Pimephales p. promelas*). This species was found in the two Richardsons and Mooselookmeguntic lakes but

not in any tributaries. Most of the individuals taken were fry and the species was generally very rare. It has a maximum length of about 3 inches, and is of little or no economic importance here.

Horned Pout or **Bullhead** (*Ameriurus n. nebulosus*). The Horned Pout, according to Kendall[2] (1918, p. 508), was not native to the Rangeley lakes but was reported to have been brought into the region about 35 years ago, at least, to a small pond from which it escaped into the lakes. In the present survey a few young were found in an isolated pool on the shore of Upper Richardson, and in Beaver Brook, tributary of Upper Richardson Lake. Kendall (p. 508) records the taking of several small Horned Pouts in a wire minnow trap from Rangeley Lake in 1904. No Horned Pout were taken in our gill nets. Local residents reported that a few of this species are present in the region but that they are generally very small. The Horned Pout commonly reaches a length of 10 to 12 inches in more favorable habitats; but in the Rangeleys, according to reports, 6 to 8 inches is a large size for the species. The Horned Pout, obviously, has been only barely maintaining itself in the Rangeley region over the past 35 years, and the reason is particularly obvious in that the lakes are not at all suitable to the species. At present the species is not abundant enough to be of any importance or to have any pronounced effect on the trout and salmon populations in the lakes.

Fresh-water Sculpin (*Cottus cognatus*). The Fresh-water Sculpin is typically found in good trout waters, usually in streams. It has a maximum length of about 3 to 4 inches. It was found in South Bog Stream, tributary to Rangeley Lake, and in Little Magalloway River, tributary to Aziscoos. Also two individuals of this species were taken from the stomachs of trout from Rangeley Lake. The species is generally rare in the region; only 6 fish were taken in the above two localities.

Present Relative Abundance of Fishes in the Rangeley Lakes. The numbers of the different kinds of fishes caught by gill nets from the various lakes offer a basis for a comparison of the relative abundance of any given species in the different lakes and of the various species in any one lake. The validity of these comparisons depends on whether or not the nets took random samples of the total fish populations present in each lake and in all the lakes combined. It is believed, from the size range of net mesh (see page 66), the depth range of the gill net sets (Figure 8), and the size range of the trout and salmon caught (see Table XIV), that the nets took a fairly representative sample of the larger fishes present in the various lakes.

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[2] See footnote p. 11.

Other factors affecting the type of sample taken by the nets would be the number of separate localities at which the nets were set in each lake and the total number of hours fished by the nets. There was probably adequate fishing effort to get representative samples for Mooselookmeguntic and Rangeley, possibly also for Kennebago and Upper Richardson, possibly not for Lower Richardson and Aziscoos. Also the scattering of the localities of the net sets appeared to be adequate for most of the lakes. Certain general comparisons on the abundance of several species seem justified. The number of individual net sets and the total number of hours fished are given for each of the two nets and for each lake in Table XV; also in this same table are given the total number of each fish species caught by the nets, and the calculated number of each species caught per 24 hours per 500 feet of net, for each lake. These figures on the number of fish caught per unit of fishing effort are presumably fairly reliable indices of the relative abundance of the different species per unit area — they are not presumed to be in proportion to the total number of fishes present in the different lakes. The figures should be interpreted as for the following example: The Brook Trout occurred in the followng relative abundance per unit area in each lake: Kennebago Lake, 22.6; Rangeley, 6.0; Lower Richardson, 5.8; Aziscoos (only near stream mouths — the figure has little significance for the lake as a whole) 5.5; Mooselookmeguntic, 2.4; and Upper Richardson, 2.4. The similar figures for Land-locked Salmon are based on inadequate numbers of fish for all lakes with the possible exception of Rangeley and Mooselookmeguntic, for which the values are: Rangeley, 1.4; and Mooselookmeguntic, 0.6.

Further generalizations which would seem warranted from the data on catch per unit of fishing effort are as follows: The Common Sucker maintained a fairly dense population in all lakes except Kennebago where suckers were absent. There was a greater population of Common Suckers than Fine-scaled Suckers in all the lakes except Rangeley where the latter predominated. In connection with the Common and Fine-scaled suckers the data revealed a tendency for the two species to be complementary in their abundance: in Mooselookmeguntic the catch per unit effort was 5.9 Common Suckers and 1.7 Fine-scaled Suckers, or a total of 7.6 for both species; in Rangeley, 3.4 Common Suckers and 3.9 Fine-scaled Suckers, or a total of 7.3 for both species. The total catches per 24 hours of the two species of suckers combined for the six lakes reveal less variation than do the catches for each species separately; the total catches were 7.1, 6.9, 7.6, 7.3, and (Aziscoos, in stream mouths) 9.9. The total figures for the 49 sets of the 475-foot net for a total of 1,145¾ hours indicated the following relative abundance of the different species of fishes in the six lakes as a whole: the Brook Trout was the most abundant of the larger species of fishes (not including the Smelt)

with a value of 5.5; the Common Sucker was nearly as abundant with 5.0; the Fine-scaled Sucker third with 2.0; the Fallfish, 1.2; and Land-locked Salmon, 0.8.

The comparison of catch per 24 hours of trout and salmon for the various lakes is of less direct interest than figures representing relative abundance for each lake as a whole. By multiplying the catch-per-24-hour figures given in Table XV by lake areas in square miles (omitting Aziscoos), the following indices of total abundance of trout and salmon were obtained:

Lake	Approximate area: square miles	Trout	Salmon
Lower Richardson	4.5	26	2.7
Upper Richardson	6.6	16	1.3
Mooselookmeguntic and Cupsuptic	25.5	61	1.3
Rangeley	9.4	56	13.2
Kennebago	2.7	61	1.6

These figures are supposedly in proportion to the actual numbers of trout and salmon (of the entire size range above about 7 to 8 inches) in the various lakes. Assuming the figures are approximately accurate, Mooselookmeguntic and Kennebago have the most trout, and they have about the same numbers of trout even though Mooselookmeguntic is about ten times as large as Kennebago; Rangeley Lake has nearly as many trout as Mooselookmeguntic even though Mooselookmeguntic is nearly three times as large; data on the two Richardsons together are perhaps adequate to indicate that they have fewer trout than any of the other three lakes. The similar computations of figures for Land-locked Salmon show Mooselookmeguntic with the greatest population but Rangeley Lake with nearly as many salmon in spite of its much smaller size.

The seining collections of minnows and other small fishes in the shallow waters of the Rangeley lakes revealed the most abundant species to be the Lake Chub (*Couesius*), the Fallfish (*Leucosomus*), and the Smelt (fry). Common Suckers, Red-bellied Dace (*Chrosomus*), and Black-nosed Dace (*Rhinichthys*) were somewhat less in abundance than the above. The other species, namely: the Fat-headed Minnow (*Pimephales*), Northern Dace (*Margariscus*), Common Shiner (*Notropis c. cornutus*), Fine-scaled Dace (*Pfrille*), Black-nosed Shiner (*Notropis h. heterolepis*) and Fine-scaled Sucker (*Catostomus c. catostomus*) were generally more or less rare in the lakes as a whole. The total minnow populations of the larger lakes in this Rangeley region are certainly no greater and apparently somewhat less than the minnow populations of lakes of similar size in other parts of Maine, judging from past observations by the present writer.

FOOD HABITS OF TROUT AND SALMON

The stomach contents of the Brook Trout and Land-locked Salmon obtained by survey collections from the Rangeley lakes were analyzed for data on food habits. Since the collections were made only during the period of July to September, the results apply to food habits, only for these summer months. Comparative data on stomach analyses on trout and salmon from several other lakes and ponds in Maine have been obtained and are here presented. The data presented below are based on an examination of the stomachs of 511 trout of which 390 contained food in their stomachs, and 61 salmon of which 44 contained food. Of the 511 trout, 221 were from the six Rangeley lakes and 290 were from eight other ponds in Maine. Of the 61 salmon, 40 were from the Rangeley lakes and 21 from four other Maine lakes. All stomachs were preserved and their contents analyzed in the laboratory.[15] The stomach contents were readily indentifiable except for a few organisms where digestive action had made identification difficult or impossible. The individuals of each type of organism in the stomachs were counted, and the volume of each type was measured by water displacement. (Volume measurements of stomach contents were made with the same degree of accuracy as in the case of bottom organisms, see page 54.) The total lengths of the small fish found in the stomachs were measured, when possible. The detailed results of the analyses, and summaries of the data, are given in Tables XVII to XXIII. The results of the analyses are given separately for each species and each lake in the following:

Stomach Contents of Brook Trout (See Tables XVII to XIX and Plate IV)

Lower Richardson Lake

The Brook Trout stomachs from Lower Richardson Lake which were analyzed were taken from the fish in two gill net collections on August 10 and 11, 1939. Of nine fish ranging from 10.2 to 13.3 inches in total length, six had some food material in their stomachs. The volume of food in these six stomachs, all of which was remains of smaller fish, was 9.7 c. c. A single large Smelt, 5.1 inches long, made up 7.8 c. c. of this total volume. The food consisted (by volume) of 86.6 per cent smelt, 10.3 per cent minnows, and 3.1 per cent unidentified fish remains.

Upper Richardson Lake

The Brook Trout stomachs from Upper Richardson Lake were taken from the fish in four gill net collections taken from August 1 to 11, 1939. Of 11 fish ranging from 8.9 to 17.1 inches in length only four had food in their stomachs. The total volume of food in these four stomachs was 4.2 c. c. and was wholly small fish remains: 28.6 per cent smelt, 69.0 per cent minnows, and 2.4 per cent unidentified fish.

Mooselookmeguntic Lake

The Brook Trout stomachs from Mooselookmeguntic Lake were taken from July 19 to 31 and on August 15, 1939. Of 22 fish ranging from 8.2 to 18.5 inches in length, 16 had food in their stomachs. The total volume of food in these stomachs was 57.5 c.c. of which all except a trace of insect remains was remains of small fish: 94.4 per cent smelt, 5.5. per cent unidentified fish remains, and 0.1 per cent terrestrial insects.

Cupsuptic Lake

The Brook Trout stomachs from Cupsuptic Lake (a part of Mooselookmeguntic) were taken from fish in five gill net collections made from July 22 to 24 and on September 11 and 12. Of 19 fish, ranging from 10.2 to 18.0 inches in length, only five contained food. The total volume of food in the five stomachs was 9.4 c. c. which was wholly the remains of forage fish: 98.9 per cent smelt, and 1.1 per cent unidentified fish remains.

Rangeley Lake

The Brook Trout stomachs from Rangeley Lake were from the fish in 13 gill net collections taken from July 7 to 14 and from August 28 to September 10. The fish ranged from 7.5 to 20.2 inches in length, and of the 79 stomachs examined, 55 contained food material. The total volume of food in these stomachs was 147.56 c. c. of which 78.9 per cent was smelts, 15.6 per cent minnows and Fresh-water Sculpins (*Cottus cognatus*), 5.0 per cent unidentified fish remains, 0.3 per cent terrestrial insects, and 0.2 per cent aquatic insects. The aquatic insects were Mayfly nymphs, dragonfly nymphs, midge larvae, and beetle larvae. These data indicate quite clearly the importance of smelt, as well as the unimportance of insect life, as food for trout in Rangeley Lake during the summer.

Kennebago Lake

The Brook Trout stomachs from Kennebago Lake were from fish in seven gill net collections taken from August 17 to 23. The fish ranged from 8.5 to 21.7 inches in total length; and, of 71 stomachs examined, 35 were found to contain food. The total volume of food in these stomachs was 128.3 c. c. of which 61.6 per cent was smelt remains, 24.6 per cent minnow remains, 7.8 per cent unidentified fish remains, 3.6 per cent terrestiral insects, 1.4 per cent aquatic insects, 0.4 per cent water-fleas (Cladocera), 0.1 per cent other invertebrates, and 0.5 per cent remains of a bird. The aquatic insects

[15] Stomach analyses were made by Mr. M. A. Marston, graduate student in Wildlife Conservation at the University of Maine, and the writer.

TABLE XVII. Stomach contents of Brook Trout (*Salvelinus f. fontinalis*) collected from the Rangeley lakes during the summer of 1939

Locality, date, time	Fish examined: Number, and number containing food in ( )	Fish examined: Range in total length in inches	Food organisms in stomachs: Terrestrial insects: Vol. in c. c.	Fish: Smelt: Number	Fish: Smelt: Total volume in c.c.	Fish: Unidentified fish remains: Number	Fish: Unidentified fish remains: Total volume in c.c.	Fish: Other fish: Kind	Fish: Other fish: Number	Fish: Other fish: Total volume in c.c.
Lower Richardson Lake Aug. 10, 4:30 P.M.	4(2)	11.1–12.9	....	....	....	1	0.1	Minnow	1	1.0
Aug. 11, 10:30 A.M.	2(2)	10.2–10.5	....	1	0.6	1	0.1	....	....	....
Aug. 11, 10:30 A.M.	2(1)	12.5–13.3	....	1	7.8	....	....	....	....	....
Aug. 11, 4:15 P.M.	1(1)	12.2	....	....	....	1	0.1	....	....	....
Upper Richardson Lake Aug. 1, 9:30 A.M.	1(0)	11.9	....	....	....	....	....	....	....	....
Aug. 8, 7:00 A.M.	1(1)	8.9	....	1	0.2	....	....	....	....	....
Aug. 8, 7:00 A.M.	3(2)	11.9–13.7	....	....	....	1	0.1	*Chrosomus*	1	2.9
Aug. 8, 7:00 A.M.	1(0)	17.1	....	....	....	....	....	....	....	....
Aug. 8, 5:30 P.M.	2(0)	10.6–11.1	....	....	....	....	....	....	....	....
Aug. 9, 5 P.M.	1(1)	9.1	....	1	1.0	....	....	....	....	....
Aug. 9, 5 P.M.	1(0)	13.4	....	....	....	....	....	....	....	....
Aug. 11, 7:30 P.M.	1(0)	12.2	....	....	....	....	....	....	....	....

Locality, date, time	Number (food)	Range	Terrestrial insects	Smelt Number	Smelt Total volume	Unidentified Number	Unidentified Total volume	Other fish Kind	Other fish Number	Other fish Total volume
Mooselookmeguntic Lake July 19, 4 P.M.	5(5)	10.4–13.2	....	9	36.9	....	....	....	....	....
July 20	2(2)	9.5–10.7	0.1	2	2.7	....	....	....	....	....
July 20	4(2)	11.7–13.9	....	2	1.7	1	1.4	....	....	....
July 20	3(1)	14.6–16.7	....	....	....	1	0.7	....	....	....
July 24, 5 P.M.	1(1)	13.2	....	1	1.0	....	....	....	....	....
July 25, 9:30 A.M.	1(1)	8.2	....	1	0.5	....	....	....	....	....
July 25, 8:30 P.M.	1(1)	13.9	....	3	6.4	....	....	....	....	....
July 25, 8:30 P.M.	1(1)	17.9	....	1	4.6	....	....	....	....	....
July 26, 10 A.M.	1(1)	16.5	....	....	....	1	1.1	....	....	....
July 31, 2 P.M.	1(0)	18.5	....	....	....	....	....	....	....	....
Aug. 15, 4:30 P.M.	1(1)	10.0	....	1	0.4	....	....	....	....	....
Aug. 15, 4:30 P.M.	1(0)	14.9	....	....	....	....	....	....	....	....
Cupsuptic Lake July 22, 8 P.M.	2(2)	11.2–11.4	....	1	1.3	1	0.1	....	....	....
July 22, 8 P.M.	1(0)	14.7	....	....	....	....	....	....	....	....
July 23, 9 A.M.	1(1)	12.9	....	1	2.0	....	....	....	....	....
July 23, 7:30 P.M.	6(2)	10.2–11.6	....	3	6.0	....	....	....	....	....
July 24, 9 A.M.	3(0)	10.5–13.7	....	....	....	....	....	....	....	....
Sept. 11, 10:30 A.M.	1(0)	13.7	....	....	....	....	....	....	....	....
Sept. 11, 5:30 P.M.	1(0)	18.0	....	....	....	....	....	....	....	....
Sept. 12, 9:45 A.M.	4(0)	13.0–16.5	....	....	....	....	....	....	....	....

TABLE XVII. Stomach contents of Brook Trout — Continued

Locality, date, time	Fish examined: Number, and number containing food in ( )	Fish examined: Range in total length in inches	Food organisms in stomachs — Insects: volume in c.c.: Aquatic insects	Insects: Terrestrial insects	Fish — Smelt: Number	Smelt: Total volume in c.c.	Unidentified fish remains: Number	Unidentified fish remains: Total volume in c.c.	Other fish: Kind	Other fish: Number	Other fish: Total volume in c.c.
Rangeley Lake July 7, 5 P.M.	8(7)	9.3–12.7	0.02	....	2	1.7	3	1.4	*Leucosomus*	2	1.1
July 8, 5:30 A.M.	1(0)	16.0	....	....	......	....	......	....	....	......	....
July 8, 5:30 A.M.	3(3)	9.9–11.8	....	....	......	....	3	1.5	*Couesius*	2	5.4
July 10, 7 A.M.	5(4)	11.9–15.4	....	....	5	13.2	2	2.1	....	......	....
July 10, 7 A.M.	5(3)	7.8–10.4	0.2	0.05	......	....	......	....	*Cottus* Minnow	1 1	0.5 1.35
July 10, 7 A.M.	1(0)	19.5	....	....	......	....	......	....	....	......	....
July 10, 7:15 P.M.	2(1)	8.9–10.4	....	....	2	4.3	......	....	....	......	....
July 10, 7:15 P.M.	3(2)	12.1–13.1	....	....	2	5.6	......	....	....	......	....
July 11, 6 A.M.	10(8)	11.1–13.7	....	....	12	32.1	1	0.4	*Couesius*	1	4.0
July 11, 6 A.M.	1(0)	17.5	....	....	......	....	......	....	....	......	....
July 11	3(3)	8.1–10.3	....	....	2	5.6	......	....	*Cottus*	1	6.0
July 11	6(6)	11.7–14.1	....	0.05	5	8.5	2	1.1	....	......	....
July 13	4(4)	7.6–9.2	0.05	0.25	4	5.2	......	....	....	......	....
July 13, 4 P.M.	2(2)	7.9–8.2	....	0.05	2	5.0	......	....	*Leucosomus*	1	4.7
July 13, 4 P.M.	6(4)	10.9–15.2	....	....	8	21.0	......	....	....	......	....

Locality, date, time	Number, and number containing food in ( )	Range in total length in inches	Aquatic insects	Terrestrial insects	Smelt: Number	Smelt: Total volume in c.c.	Unidentified: Number	Unidentified: Total volume in c.c.	Other fish: Kind	Other fish: Number	Other fish: Total volume in c.c.
Rangeley Lake (concluded) July 14, 9 A.M.	2(2)	9.8–12.5	....	....	1	2.0	1	0.8	....	......	....
July 14, 7:30 P.M.	3(2)	8.5–9.2	....	....	4	6.5	......	....	....	......	....
July 14, 7:30 P.M.	1(1)	11.4	....	....	2	3.3	......	....	....	......	....
Aug. 28, 9:30 A.M.	2(0)	16.2–18.2	....	....	......	....	......	....	....	......	....
Sept. 2, 9:30 A.M.	1(0)	11.5	....	....	......	....	......	....	....	......	....
Sept. 7, 9:30 A.M.	1(1)	7.5	....	0.09	......	....	......	....	....	......	....
Sept. 7, 9:30 A.M.	3(1)	10.0–10.7	....	....	1	2.4	......	....	....	......	....
Sept. 7, 9:30 A.M.	2(0)	16.9–17.7	....	....	......	....	......	....	....	......	....
Sept. 8, 8 A.M.	2(1)	9.4–10.6	....	....	......	....	1	0.05	....	......	....
Sept. 10, 1 P.M.	1(0)	20.2	....	....	......	....	......	....	....	......	....
Sept. 10, 1 P.M.	1(0)	18.9	....	....	......	....	......	....	....	......	....

TABLE XVII. Stomach contents of Brook Trout— Concluded

Locality, date, time	Fish examined: Number, and number containing food in ( )	Fish examined: Range in total length in inches	Arthropods: volume in c.c.: Water-fleas (*Leptodora*)	Arthropods: Fresh-water shrimp (Amphipoda)	Arthropods: Aquatic insects	Arthropods: Terrestrial insects	Fish: Smelt: Number	Fish: Smelt: Total volume in c.c.	Fish: Unidentified fish remains: Number	Fish: Unidentified fish remains: Total volume in c.c.	Other fish: Kind	Other fish: Number	Other fish: Total volume in c.c.
Kennebago Lake													
Aug. 17, 4 P.M.	1(0)	9.2	....	....	....	....	......	....	......	....	....	......	....
Aug. 17, 4 P.M.	4(1)	11.2–13.[illegible]	....	....	....	....	1	13.8	......	....	....	......	....
Aug. 17, 4 P.M.	3(1)	16.2–21.7	....	....	....	....	......	....	1	2.0	....	......	....
Aug. 18, 9 A.M.	3(1)	8.5–11.0	....	....	....	....	......	....	1	1.2	....	......	....
Aug. 18, 9 A.M.	1(0)	15.7	....	....	....	....	......	....	......	....	....	......	....
Aug. 18, 4:45 P.M.	1(0)	12.7	....	....	....	....	......	....	......	....	....	......	....
Aug. 19, 9:30 A.M.	3(3)	9.7–12.0	....	....	....	2.0	......	....	......	....	....	......	....
Aug. 21, 5 P.M.	11(8)	9.1–11.4	0.5	....	0.4	0.1	......	....	1	2.0	*Couesius*	2	8.8
Aug. 21, 5 P.M.	5(2)	12.2–12.8	....	....	....	....	1	0.9	......	....	*Couesius*	1	3.3
Aug. 21, 5 P.M.	2(2)	15.2–16.4	....	....	0.5	....	......	....	......	....	*Couesius*	2	6.5
Aug. 21, 5 P.M.	2(0)	17.5–18.9	....	....	....	....	......	....	......	....	....	......	....
Aug. 22, 9:30 A.M.	21(9)	10.9–13.9	....	....	....	0.2	2	12.0	2	4.2	*Couesius* Leg of bird	3 1	13.0 0.6
Aug. 22, 9:30 A.M.	6(1)	15.1–17.5	....	....	....	....	2	38.0	......	....	....	......	....
Aug. 22, 4 P.M.	1(1)	8.5	....	0.1	0.6	....	......	....	......	....	....	......	....
Aug. 22, 9:30 A.M.	1(1)	19.5	....	....	....	....	1	11.0	......	....	....	......	....
Aug. 22, 4 P.M.	1(1)	13.5	....	....	0.3	....	1	3.4	......	....	....	......	....
Aug. 23, 10:45 A.M.	4(3)	9.7–10.7	....	....	....	2.3	......	....	1	0.5	....	......	....
Aug. 23, 10:45 A.M.	1(1)	13.0	....	....	....	....	......	....	1	0.1	....	......	....
Aziscoos Lake													
Aug. 31, 3 P.M.	8(2)	10.2–13.0	....	....	....	0.1	......	....	3	0.5	....	......	....
Aug. 31, 3 P.M.	2(0)	15.0–15.9	....	....	....	....	......	....	......	....	....	......	....

TABLE XVIII. Stomach contents of Brook Trout (*Salvelinus f. fontinalis*) from six ponds in Maine

Locality, date	Fish examined: Number, and number containing food in ( )	Fish examined: Range in total length in inches	Fish examined: Total vol. stomach contents in c.c.		Leeches (Hirudinia)	Water-fleas (Cladocera)	Fresh-water shrimp (Amphipoda)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Damselfly nymphs (Zygoptera)	Caddisfly larvae (Trichoptera)	Midge larve (Chironomidae)	Mosquito larvae (*Corethra*)	Other aquatic insects	Snails (Amnicolidae and others)	Pill clams (Sphaeridae)	White Perch
Adams Pond, P. 307, Bridgton Twp. July 2, 1933	39 (39)	7.9–12.6	19.63	No. fish containing organisms	....	31	2	1	1	....	1	8	31	3	6	2	1
				Tot. No. organisms	....	25,660	4	1	1	....	1	20	322	7	72	18	25 (fry)
				Tot. vol. organisms in c.c.	....	13.63	0.02	0.04	0.15	....	0.03	0.17	3.23	0.22	0.99	0.15	1.0
				Vol. by % of total	....	69.4	0.1	0.2	0.8	....	0.2	0.9	16.4	1.1	5.0	0.8	5.1
Quimby Pond, Rangeley Twp. July 23 and 24, 1938	22 (21)	7.9–14.8	24.69	No. fish containing organisms	1	......	4	1	21	1	2	.....	.....	....	1	....	....
				Tot. No. organisms	5	......	15	2	112	1	2	.....	.....	....	1	....	....
				Tot. vol. organisms in c.c.	1.5	......	0.4	0.01	22.7	0.03	0.04	.....	.....	....	0.01	....	....
				Vol. by % of total	6.1	......	1.6	0.1	91.9	0.1	0.1	.....	.....	....	0.1	....	....

TABLE XVIII. Stomach contents of Brook Trout — Continued

Locality, date	Fish examined: Number, and number containing food in ( )	Range in total length in inches	Total vol. stomach contents in c.c.		Leeches (Hirudinia)	Water-fleas (Cladocera)	Fresh-water shrimp (Amphipoda)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Damselfly nymphs (Zygoptera)	Water boatmen (Corixidae)	Caddisfly larvae (Trichoptera)	Midge larvae and pupae (Chironomidae)	Other aquatic insects	Terrestrial insects	Spiders (Arachnida)	Water mites (Hydracarina)	Snails (Amnicolidae and others)	Pill clams (Sphaeridae)	Frog tadpole	Newt (*Triturus*)	Snake
Horseshoe Pond, West Bowdoin College **Grant. June** 2, 1939	57 (57)	6.9–10.6	40.6	No. fish containing organisms	4	26	15	16	20	11	3	5	48	5	28	4	....	19	4	....	....	....
				Tot. No. organisms	5	20,360	145	208	29	14	15	26	2,493	6	187	7	....	99	10	....	....	....
				Tot. vol. organisms in c.c.	0.44	7.87	0.47	4.65	7.52	1.31	0.1	1.13	9.19	0.2	6.51	0.2	....	0.96	0.05	....	....	....
				Vol. by % of total	1.1	19.3	1.2	11.5	18.5	3.2	0.2	2.8	22.7	0.5	16.0	0.5	....	2.4	0.1	....	....	....
Horseshoe Pond, **West** Bowdoin College **Grant. June** 3, 1939	58 (58)	6–10	41.24	No. fish containing organisms	7	21	30	24	33	18	3	7	36	5	27	4	4	13	12	1	1	....
				Tot. No. organisms	9	10,135	320	203	45	36	32	14	565	14	185	5	–26	274	46	1	1	....
				Tot. vol. organisms in c.c.	1.97	4.05	1.36	4.83	11.17	2.34	0.16	0.3	2.06	0.81	3.69	0.06	0.06	1.18	0.2	1.5	5.5	....
				Vol. by % of total	4.8	9.9	3.3	11.7	27.1	5.7	0.4	0.7	5.0	2.0	8.9	0.1	0.1	2.9	0.5	3.6	13.3	....
Baker Mountain Pond, **West Bow**doin College **Grant. June 4**, 1939	44 (44)	8–11	26.32	No. fish containing organisms	1	17	20	15	15	11	5	9	36	16	5	1	....	5	2	....	....	1
				Tot. No. organisms	1	13,230	596	46	21	19	5	12	433	65	5	1	....	16	6	....	....	1
				Tot. vol. organisms in c.c.	0.25	4.63	2.69	4.27	5.48	1.83	0.15	1.08	1.51	2.66	0.19	0.01	....	0.16	0.01	....	....	1.4
				Vol. by % of total	0.9	17.6	10.2	16.2	20.8	7.0	0.6	4.1	5.7	10.1	0.7	0.1	....	0.6	0.1	....	....	5.3

TABLE XVIII. Stomach contents of Brook Trout — Concluded

Locality, date	Fish examined: Number, and number containing food in ( )	Range in total length in inches	Total vol. stomach contents in c.c.		Leeches (Hirudinia)	Water-fleas (*Leptodora*)	Other water-fleas (Cladocera)	Fresh-water shrimp (Amphipoda)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Midge larvae (Chironomidae)	Mosquito larvae (*Corethra*)	Other aquatic insects	Terrestrial insects	Brook Trout
Tim Pond T. 2, R. 4, Franklin Co. Sept. 13, 1939	38 (23)	8.6–11.2	4.47	No. fish containing organisms	1	3	6	2	8	1	8	7	4	1	1
				Tot. No. organisms	1	145	3,205	2	12	2	44	205	18	1	1(3" long)
				Tot. vol. organisms in c.c.	0.2	0.31	1.75	0.02	0.32	0.4	0.19	0.60	0.26	0.02	0.4
				Vol. by % of total	4.5	6.9	39.1	0.5	7.2	8.9	4.3	13.4	5.8	0.5	8.9

Locality, date	Fish examined: Number, and number containing food in ( )	Range in total length in inches	Total vol. stomach contents in c.c.		Mayfly nymphs (Ephemerida)	Mayfly adults (Ephemerida)	Damselfly nymphs (Zygoptera)	Water boatmen (Corixidae)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Insect remains	Snails (Amnicolidae)	Fallfish (*Leucosomus*)	Minnow	Fish remains
Abacotnetic Bog T. 6, R. 17 Somerset Co. July 18, 1937	25 (24)	9–12	17.59	No. fish containing organisms	6	3	1	1	9	1	8	1	1	1	4
				Tot. No. organisms	20	45	1	2	15	1	10	1	1	1	4
				Tot. vol. organisms in c.c.	0.71	1.25	0.1	0.03	0.93	0.01	0.85	0.01	11.5	0.4	1.8
				Vol. by % of total	4.1	7.1	0.5	0.2	5.3	0.1	4.8	0.1	65.4	2.2	10.2

TABLE XIX. Summary of stomach analyses on 511 Brook Trout (*Salvelinus f. fontinalis*) **from fifteen lakes and ponds in Maine**

Name of lake or pond	Number of fish examined and number containing food in ( )	Total volume of stomach contents in c. c.	Stomach contents: volume by per cent of total									
			Aquatic insects	Terrestrial insects	Water-fleas (Cladocera)	Other invertebrates	Smelt (*Osmerus*)	Unidentified fish remains	Brook Trout	Minnows and *Cottus*	White Perch	Frog, tadpoles, newts, snakes, birds
Lower Richardson	9(6)	9.7	....	....	....	....	86.6	3.1	....	10.3	....	....
Upper Richardson	11(4)	4.2	....	....	....	....	28.6	2.4	....	69.0	....	....
Mooselookmeguntic	22(11)	57.4	....	0.1	....	....	94.4	5.5	....	....	....	....
Cupsuptic	19(5)	9.4	....	....	....	....	98.9	1.1	....	....	....	....
Rangeley	79(55)	147.56	0.2	0.3	....	....	78.9	5.0	....	15.6	....	....
Kennebago	71(35)	128.3	1.4	3.6	0.4	0.1	61.6	7.8	....	24.6	....	0.5
Aziscoos	10(2)	0.6	....	16.7	....	....	....	83.3	....	....	....	....
Adams	39(39)	19.63	19.6	....	69.4	5.9	....	....	....	....	5.1	....
Abacotnetic	25(24)	17.59	15.0	7.1	....	0.1	....	10.2	....	67.6	....	....
Sabbathday	3(3)	0.23	43.5	....	8.7	26.1	....	21.7	....	....	....	....
B Pond	4(3)	11.3	....	....	....	....	92.0	8.0	....	....	....	....
Quimby	22(21)	24.69	92.2	....	....	7.8	....	....	....	....	....	....
Horseshoe	115(115)	81.84	56.0	12.4	14.7	8.5	....	....	....	....	....	8.4
Baker Mt.	44(44)	26.32	64.5	0.7	17.6	11.9	....	....	....	....	....	5.3
Tim	38(23)	4.47	39.6	0.5	46.0	5.0	....	....	8.9	....	....	....

included Mayfiy nymphs, dragonfly nymphs, caddisfly larvae, and midge larvae. The terrestrial insects included crickets, sawflies, winged ants, spittle bugs, ichneumon flies, true flies, leaf hoppers, and locusts. Only one trout contained water-fleas and these were entirely of the genus *Leptodora*.

Aziscoos Lake

The Brook Trout stomachs from Aziscoos Lake were from the fish in one gill net collection taken on August 31, 1939. Of the ten fish ranging in length from 10.2 to 15.9 inches, only two contained food. The food of these two fish consisted of 83.3 per cent unidentified fish remains and 16.7 per cent terrestrial insects.

Adams Pond (Bridgton Twp.)

The Brook Trout stomachs from Adams Pond were collected on July 2, 1938. All of the 39 fish ranging in length from 7.9 to 12.6 inches had food in their stomachs, which made up a total volume of 19.63 c. c. This total volume consisted of 69.4 per cent water-fleas

(Cladocera), 0.1 per cent fresh-water shrimps (Amphipoda), 0.2 per cent Mayfly nymphs, 0.8 per cent dragonfly nymphs, 0.2 per cent caddisfly larvae, 0.9 per cent midge larvae, 16.4 per cent mosquito larvae (*Corethra*), 1.1 per cent other aquatic insects, 5.0 per cent snails, 0.8 per cent pill clams, and 5.1 per cent White Perch fry.

The water-fleas, which made up the great bulk of the food of these trout, were present in 31 of the 39 trout; a total of approximately 25,660 of these minute organisms were present.[16] One trout contained approximately 4,000 Cladocera, three other trout had over 2,000 Cladocera, and 10 others had over 1,000. The trout containing the 4,000 water-fleas was one of the largest fish in the collection. Mosquito larvae (*Corethra*) were second in importance in the trout stomachs; they were present in 31 stomachs and to the extent of 322 individuals. *Corethra* larvae are plankton forms at night, and the trout were taken by an overnight gill net collection; the supposition is that both *Corethra* and the water-fleas may have been taken as plankton rather than from the bottom of the pond. Of 72 snails in these trout stomachs, 70 were of the family Amnicolidae. At the time these trout were caught in Adams Pond, plankton organisms were furnishing about five-sixths of the food of the trout.

Abacotnetic Bog (Somerset Co.; T.6, R. 17)

The Brook Trout stomachs from Abacotnetic Bog were taken from 25 fish collected on July 18, 1937. These fish ranged approximately from 9 to 12 inches in length and all but one of the 25 had food in their stomachs. The total volume of food present was 17.59 c. c. and included the following: Mayfly nymphs, Mayfly adults, damselfly nymphs, water boatmen, caddisfly larvae, midge larvae, other insect remains, snails, minnows, and unidentified fish remains. The total volume was made up as follows: 67.6 per cent minnows, 10.2 per cent unidentified fish remains (probably minnows), 15 per cent aquatic insects, 7.1 per cent terrestrial insects, and 0.1 per cent other invertebrates.

Sabbathday Lake (New Gloucester Twp.)

The three Brook Trout stomachs from Sabbathday Lake were from the fish taken in two gill net collections on August 14 and 18, 1937; the fish were 9.4 to 12.7 inches in length. The total amount of food was only 0.23 c. c.; it consisted of 8.7 per cent water-fleas (Cladocera), 43.5 per cent midge larvae (Chironomidae), 21.7 per cent spiny-rayed fish, and 26.1 per cent other invertebrates including water mites (Hydracarina) and snails (Amnicolidae).

[16] Estimates on numbers of water-fleas were made by the partial count and total volume method. The number in one c. c. was counted and this figure was multiplied by the total number of c. c.

B Pond (Upton Twp.)

The Brook Trout stomachs from B Pond were taken on July 2, 1937. Of the four trout ranging in total length from 14.4 to 18.7 inches, three had food material in their stomachs, including 5 smelt, having a volume of 10.4 c. c. (92 per cent), and one unidentified fish with a volume of 0.9 c. c. (8 per cent).

Quimby Pond (Rangeley Twp.)

The Brook Trout stomachs from Quimby Pond were taken on July 23 and 24, 1938. Of the 22 fish collected, ranging in length from 7.9 to 14.8 inches, 21 had food in their stomachs totaling 24.69 c. c. in volume. This food consisted of 6.1 per cent leeches, 1.6 per cent fresh-water shrimps, 0.1 per cent Mayfly nymphs, 91.9 per cent dragonfly nymphs, 0.1 per cent damselfly nymphs, 0.1 per cent caddisfly larvae, and 0.1 per cent snails.

Horseshoe Pond (West Bowdoin College Grant)

The Brook Trout stomachs from Horseshoe Pond were from fish taken by hook and line on June 2 and 3, 1939. All of the 115 fish collected, ranging in length from 6 to 10.6 inches, had food in their stomachs totaling 81.84 c. c. in volume. The food consisted of the following types of organisms: leeches, water-fleas (Cladocera), fresh-water shrimps (Amphipoda), Mayfly nymphs, dragonfly nymphs, damselfly nymphs, water boatmen, caddisfly larvae, midge larvae and pupae, other aquatic insects, terrestrial insects (Hymenoptera, Coleoptera, Hemiptera, and Diptera), spiders, water mites, snails (6 *Physa* and 367 Amnicolidae), pill clams, a frog tadpole, and a newt. The volume of food material in these stomachs was made up of 56.0 per cent aquatic insects, 12.4 per cent terrestrial insects, 14.7 per cent water-fleas, 8.5 per cent other invertebrates, and 8.4 per cent frog tadpole and newt. These figures quite definitely indicate that aquatic insects were of primary importance as early summer trout food in this pond. Of particular interest was the inclusion of over thirty thousand individual water-fleas (14.7 per cent) in the stomachs of 47 of these 115 trout. One trout had approximately 3,400 water-fleas in its stomach, and 12 fish had over 1,000.

Baker Mountain Pond (West Bowdoin College Grant)

The Brook Trout stomachs from Baker Mountain Pond were taken from fish caught by hook and line on June 4, 1939. All of the 44 fish, ranging from 8 to 11 inches in length, had food in their stomachs representing a total volume of 26.32 c. c. The food consisted of the following types of organisms: leeches, water-fleas (Cladocera), fresh-water shrimps. Mayfly nymphs, dragonfly nymphs, damselfly nymphs, water boatmen, caddisfly larvae, midge larvae, other aquatic insects (including *Corethra*), terrestrial insects, spiders, snails (mostly Amnicolidae), pill clams, and a snake. The volume of food in the stomachs included the following: 64.5 per cent aquatic insects, 0.7 per cent terrestrial insects, 17.6 per cent water-fleas (Cladocera), 11.9 per cent other invertebrates, and 5.3 per cent snake. One trout had approximately 2,500 cladocerans and six others had over 1,000. The maximum numbers of midge larvae and pupae per trout were 109, 69, 43, and 23; the maximum numbers of fresh-water shrimp per trout were 249, 86, 57, 52, and 51. The above figures indicate that, as in the case of Horseshoe Pond, aquatic insects were the chief early summer food of the trout in this pond, with other invertebrates second in importance.

Tim Pond (Franklin Co.; T. 2, R. 4)

The Brook Trout stomachs from Tim Pond were taken from the fish in one gill net collection on September 13, 1939. Of the 38 fish in the collection, ranging from 8.6 to 11.2 inches in length, 23 had food in their stomachs representing a total volume of 4.47 c. c. The fact that these 38 fish had such a small total volume of food in their stomachs was probably due to the fact that they were all adult and ripe fish concentrated near the mouth of a tributary stream just prior to the beginning of a spawning run. The following types of organisms were found in the stomachs: leeches, water-fleas (Cladocera), fresh-water shrimps, Mayfly nymphs, dragonfly nymphs, midge larvae, mosquito larvae (*Corethra*), other aquatic insects, terrestrial insects, and one small Brook Trout. The volume of food material was made up as follows: 39.6 per cent aquatic insects, 0.5 per cent terrestrial insects, 46.0 per cent water-fleas, 5.0 per cent other invertebrates, and 8.9 per cent Brook Trout. One trout contained approximately 2,400 water-fleas; another had 750. One trout had 105 *Corethra*; and two trout had 70 and 60 of the large water-fleas, *Leptodora*. These analyses revealed that water-fleas and aquatic insects were of leading and probably approximately equal importance in the late summer food of the Brook Trout in Tim Pond.

Summary for the Rangeley Lakes (see Table XIX)

The summer food of Brook Trout in the large Rangeley lakes, according to these analyses was almost entirely forage fish, of which the Smelt was by far the most important, and native minnows made up the balance. The data on Aziscoos and the Richardson lakes are inadequate for comparison. In Mooselookmeguntic and Cupsuptic the dependence of trout on Smelt for food was complete. In Rangeley Lake their food was almost entirely fish, but native minnows constituted about one-sixth of the food, thus supplementing the Smelt to some extent. In Kennebago forage fish made up 94.0 per cent of the stomach contents, of which over one-fourth was the native minnow *Couesius*. Only in Kennebago Lake were considerable numbers of trout feeding on insects and other invertebrates, and here only to the extent of 5.5 per cent. Of this 5.5 per cent, only 1.9 per cent represented aquatic organisms and only 1.5 bottom food organisms.

The extremely small extent to which the trout of Kennebago and other Rangeley lakes fed on aquatic insects and other invertebrates is partly but not entirely attributable to paucity of the bottom fauna, judging from the following (figures on abundance of bottom fauna from Table XIII): In Adams Pond with a bottom fauna of 0.17 c. c. per square foot, the trout contained 9.1 per cent bottom fauna, or, if *Corethra* (periodically a bottom form) is included, 25.5 per cent bottom fauna; in Horseshoe Pond with a bottom fauna of 0.229 c. c., the trout had 64.5 per cent bottom organisms; in Quimby Pond with 1.02 c. c. of bottom organisms per square foot, the trout had fed 100 per cent on this bottom food; but in Kennebago Lake with 0.193 c. c. per square foot, the trout contained only 1.5 per cent bottom food; and in Mooselookmeguntic and Rangeley lakes with 0.068 and 0.065 c. c. of bottom fauna, the trout contained no bottom organisms and only 0.2 per cent bottom organisms, respectively. Differences in size of fish and season of the year were not sufficient to explain the above differences in food habits. The differences were more readily explainable on the basis of food availability. In the Rangeley lakes smelts were abundant; in Adams Pond there were no smelts and very few other small fishes available to trout; in Horseshoe Pond there were no fishes present other than trout. Smelt have been reported to be present in Quimby Pond, but were presumably rare, if present at all, at the time the trout were obtained. Thus it appears that the almost complete dependence of trout on smelts and minnows in the Rangeleys is partly a matter of choice on the part of the fish due to the greater size and availability of these forage fishes as compared to the bottom fauna. In the case of at least Kennebago Lake among the Rangeleys, the trout presumably would use the bottom fauna more extensively if the abundant smelt population were not present.

Summary for Other Lakes (See Table XIX)

In general the food habits of Brook Trout in the several other ponds considered in this section, namely Adams Pond, Abacotnetic Bog, B Pond, Quimby Pond, Horseshoe Pond, Baker Mountain Pond, and Tim Pond, differed widely among these various ponds, as well as from the habits of trout in the large Rangeleys. In B Pond the trout were eating 100 per cent forage fish, of which at least 92 per cent was smelt. In all the other ponds, insect and invertebrate forms were eaten for the most part. Certain differences in trout food habits among these ponds have been partially explained on the basis of available food, in the preceding paragraph. The variations in food habits among these ponds were apparently mostly the result of differences in the amount of different types of food organisms available and the size of the organisms. In the Rangeleys the trout were

feeding almost entirely on the abundant smelt populations; in Quimby Pond with an abundant bottom fauna and apparently no smelts at the time, the trout were selecting mostly the largest item (dragonfly nymphs) in the bottom fauna; in Horseshoe Pond, with only a moderately rich (for Maine lakes) bottom fauna and no forage fish, an abundant trout population was feeding on the various types of bottom organisms in somewhat the same proportion as the relative abundance of the different types of this food supply; in Adams Pond, with bottom food somewhat less than in Horseshoe and in the presence of competing warm-water game fishes, the trout were feeding to some extent on a variety of bottom organisms but to a large extent on plankton forms (see Tables XIX and XX and Figure 9.)

The inclusion of water-fleas (Cladocera), and of *Corethra* which is periodically also a plankton form, in the diet of trout, was obviously related to availability of food, density of the trout populations, and the growth of the trout. The trout from the Rangeleys with abundant smelts for food contained no water-fleas (except rarely in Kennebago) although water-fleas were fairly abundant. The fact that one trout in Kennebago had fed on *Leptodora* may be of no significance. In Quimby and Adams ponds the concentration of water-fleas was about the same; but in Quimby Pond the trout were feeding entirely on an abundant bottom fauna, while in Adams Pond trout were feeding to a small extent on a much smaller bottom fauna and to a large extent on the water-fleas. Horseshoe, Baker Mountain, and Tim ponds all had abundant trout populations. In Horseshoe, with a bottom fauna much smaller than in Quimby, trout were supplementing their diet of bottom organisms with 14.7 per cent water-fleas. In Baker Mountain and Tim ponds, trout were adding 17.6 and 46.0 per cent water-fleas to their diet. Of the trout (from the six ponds) which contained water-fleas, many contained over 1,000 individuals in their stomachs; one trout contained approximately 4,000. The trout feeding on these minute water-fleas were not merely the smaller fish; the greatest numbers of water-fleas were often in the larger fish. Also, these water-fleas (Cladocera) were either in a clear culture in the trout stomachs or often mixed with bottom organisms, but no Copepods were found in any of the stomachs. The extensive feeding by trout on water-fleas must entail a considerable amount of time and effort, for trout apparently have no well-adapted structure for straining these organisms from the water, as is found in such fishes as the cisco and mackerel. Judging from conditions in the various lakes and ponds mentioned above and the food habits of the trout in these waters, it appears that trout feed on water-fleas only when other food is generally rare, or in ponds where trout are very abundant in proportion to the food supply. If this generalization holds true for trout lakes in general, then a

TABLE XX. A comparison of the kinds and amounts of available bottom food organisms with the relative amounts of the different types found in stomachs of Brook Trout, in three ponds in Maine

Data on bottom samples from Adams and Quimby ponds are from Cooper (1939). Maine Fish Survey Report No. 2; other data from Tables XVIII and XL. The figures given in this table are the percentages by volume of each type of bottom organism to all bottom organisms in the trout stomachs, and the volume percentage composition of the bottom fauna itself as determined by sampling

Locality	Volume by per cent in	Leeches (Hirudinia)	Aquatic earthworms (Oligochaeta)	Fresh-water shrimp (Amphipoda)	Alder-fly larvae (*Sialis*)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Damselfly nymphs (Zygoptera)	Water boatmen (Corixidae)	Beetle larvae (Coleoptera)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Mosquito larvae (*Corethra*)	Other aquatic insects	Water mites (Hydracarina)	Snails (Amnicolidae)	Other snails	Pill clams (Sphaeridae)
Adams Pond	Trout stomachs	.....	......	0.4	......	0.8	3.0	......	......	......	0.6	3.4	64.6	4.4	......	19.8	......	3.0
	Bottom samples	.....	......	5.9	5.9	29.4	29.4	......	......	......	......	29.4	......	......	......	......	......	......
Quimby Pond	Trout stomachs	6.1	......	1.6	......	0.1	91.9	0.1	......	......	0.1	......	......	......	......	0.1	......	......
	Bottom samples	2.9	1.0	36.3	......	......	14.7	......	......	......	4.9	39.2	......	......	......	......	1.0	......
Horseshoe Pond	Trout stomachs	4.6	......	3.5	......	18.1	35.6	7.0	0.5	......	2.7	21.4	......	1.9	0.1	4.1	......	0.5
	Bottom samples	.....	2.2	28.8	0.9	18.8	14.4	3.1	......	0.4	5.2	7.9	12.6	......	......	0.9	0.9	3.9

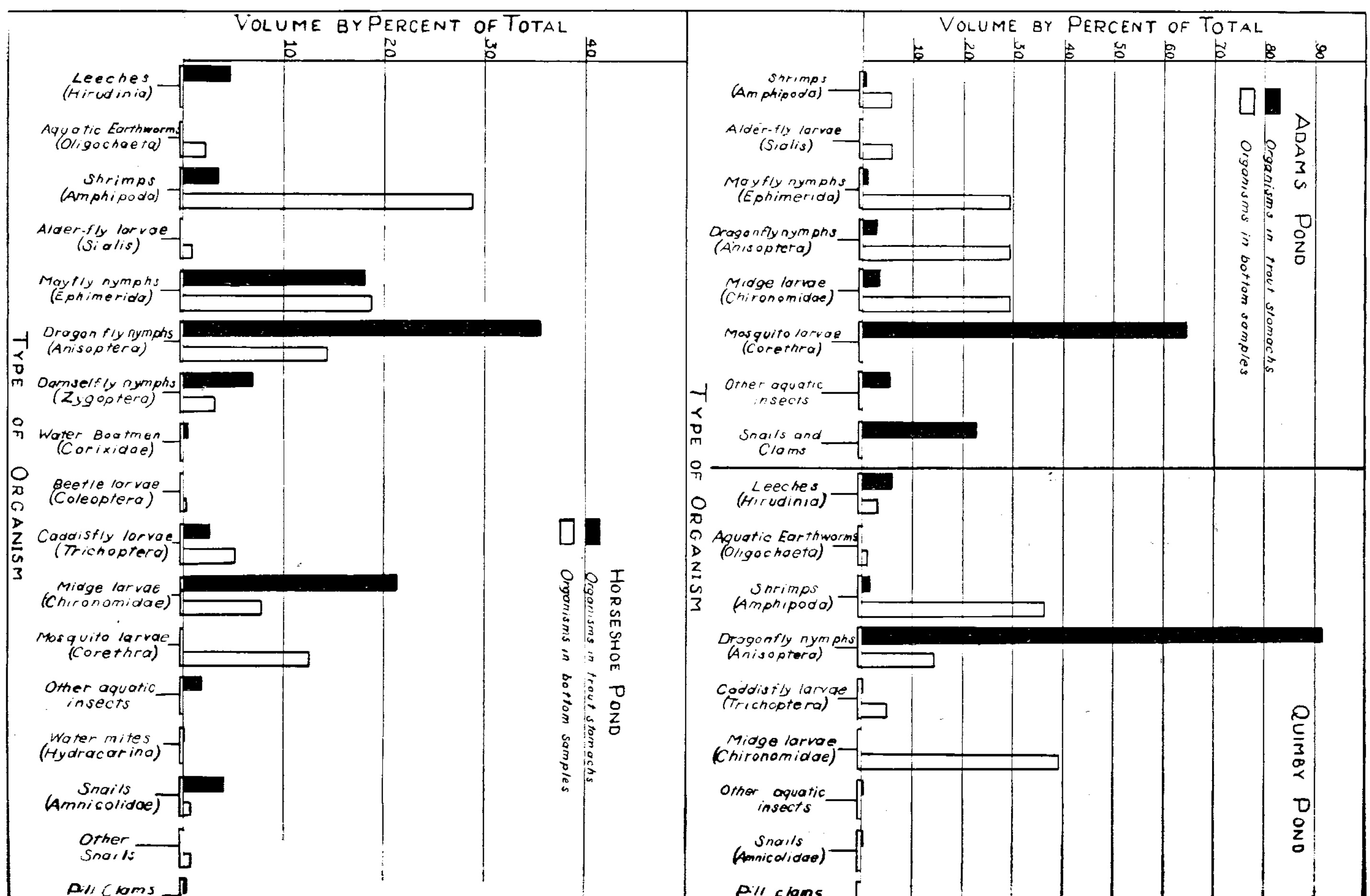

Figure 9. A comparison of the per cent by volume of each type of bottom food organism to all bottom organisms in Brook Trout stomachs with the per cent by volume of each type of organism in the bottom fauna, for three ponds in Maine. Data are from Table XX.

recognition of the presence of water-fleas in trout stomachs might be of considerable value in trout management in indicating a scarcity of food or an overcrowded trout population.

Stomach Contents of Land-locked Salmon (see Tables XXI to XXIII)

Mooselookmeguntic Lake

Land-locked Salmon stomachs from Mooselookmeguntic Lake were from the fish in eight gill net collections taken from July 20 to 27, 1939. Of the 12 salmon, ranging from 11.6 to 21.9 inches in total length, seven had food in their stomachs making up a total volume of 51.55 c. c. This volume consisted of 84.8 per cent smelts, 6.0 per cent unidentified fish remains, 9.1 per cent Lake Chub (*Couesius*), and 0.1 per cent aquatic insects.

Cupsuptic Lake

Land-locked Salmon stomachs from Cupsuptic Lake were taken from fish in two gill net collections on July 24 and September 12, 1939. Of the seven fish, ranging from 15.1 to 23.4 inches in length, only two had food in their stomachs. The total volume of this food was 23.2 c. c. and consisted of 100 per cent smelts.

Rangeley Lake

The Land-locked Salmon stomachs from Rangeley Lake were taken from the fish in 11 gill net collections taken from July 8 to 13 and August 25 to September 10, 1939. Of the 21 salmon, ranging from 9.1 to 24.1 inches in length, 18 had food in their stomachs making up a total volume of 100.0 c. c. This volume consisted of 82.8 per cent smelts, 1.2 per cent unidentified fish remains, and 16.0 per cent remains of one sucker.

Kennebago River spawning run

Sixteen Mooselookmeguntic Lake salmon were obtained from the Kennebago River spawning run at Canoe Pool at 12 Noon on September 12. These fish were 14.7 to 22.6 inches in length, and were all adult fish. There was not a trace of food in any of their stomachs. The analyses are of interest in supporting the general belief that salmon in spawning runs feed very little if any.

Sebec Lake

The Land-locked Salmon stomachs from Sebec Lake were taken from fish collected by hook and line on May 9, 1937. All six salmon, ranging from 14.9 to 21.9 inches in length, had food in their stomachs making up a total volume of 58.5 c. c. This volume consisted of 88.4 per cent smelts, 8.4 per cent unidentified fish remains, and 3.2 per cent aquatic insects.

Moosehead Lake

The Land-locked Salmon stomachs from Moosehead Lake were collected on May 18 and 29, 1937. Of the three fish, ranging from 16 to 21.2 inches in length, two had food in their stomachs making up a total volume of 3.55 c. c., or 98.6 per cent smelt and 1.4 per cent terrestrial insects.

Kezar Lake

The Land-locked Salmon stomachs from Kezar Lake were collected on July 19, 1938. Of the four fish, ranging from 9.8 to 21.5 inches in total length, 3 had food in their stomachs making up a total volume of 84.0 c. c. This volume consisted of 16.7 per cent smelt, 0.6 per cent unidentified fish remains, and 82.7 per cent Yellow Perch.

Sebago Lake

Stomachs of Land-locked Salmon from Sebago Lake were collected on May 25 and August 6 to 11, 1938. Of the eight fish, 9.1 to 23.0 inches in length, seven had food in their stomachs making up a total volume of 46.9 c. c., including 69.1 per cent smelts, 27.7 per cent terrestrial insects, and 3.2 per cent Yellow Perch.

Summary for Salmon (see Table XXIII)

In the three Rangeley Lakes from which stomachs containing food were obtained for analysis (Mooselookmeguntic, Cupsuptic, and Rangeley), Land-locked Salmon were found to be feeding almost exclusively on smelts. The 40 salmon which were examined contained a total of 49 smelts, one sucker, one Lake Chub (*Couesius*), and 5 unidentified fish which probably were mostly smelts. In the other four lakes from which salmon stomachs were examined the principal food was also mostly smelts or (in Kezar Lake) Yellow Perch. These rather limited data on food habits of the salmon substantiate the already established and well known fact that the Smelt is the chief food of Land-locked Salmon in Maine lakes.

TABLE XXI. Stomach contents of Land-locked Salmon (*Salmo sebago*) collected from the Rangeley lakes during the summer of 1939

Locality, date, time	Fish examined: Number examined and number containing food in ( )	Fish examined: Range in total length in inches	Food organisms in stomachs: Caddisfly larvae (Trichoptera) Vol. in c. c.	Fish: Smelt: Number	Fish: Smelt: Total volume in c.c.	Fish: Unidentified fish remains: Number	Fish: Unidentified fish remains: Total volume in c.c.	Fish: Other Fish: Kind	Fish: Other Fish: Number	Fish: Other Fish: Total volume in c.c.
Rangeley Lake										
July 8, 5:30 A.M.	3(3)	9.1–10.0	...	3	2.9	...	...	...	...	...
July 8, 5:30 A.M.	1(1)	20.6	...	3	8.0	...	...	...	...	...
July 10, 7:15 P.M.	2(2)	17.9–19.5	...	4	15.5	...	...	...	...	...
July 11, 6 A.M.	1(1)	13.1	...	5	13.8	...	...	...	...	...
July 11, 6 A.M.	1(1)	17.7	...	3	5.0	...	...	...	...	...
July 11, 6 A.M.	1(1)	22.4	...	1	1.7	...	...	*Catostomus* (sp.?)	1	16.0
July 11, 6 A.M.	4(2)	19.2–20.8	...	6	12.4	...	...	...	...	...
July 11, 8 P.M.	1(1)	24.1	...	1	1.8	...	...	...	...	...
July 13, 9 P.M.	1(1)	15.4	...	2	1.8	...	...	...	...	...
Aug. 25, 7 A.M.	1(1)	22.4	...	2	5.2	...	...	...	...	...
Aug. 28, 9:30 A.M.	1(0)	21.5	...	...	...	...	...	...	...	...
Sept. 1, 7:30 P.M.	1(1)	17.7	...	...	...	1	0.1	...	...	...
Sept. 7, 9:30 A.M.	1(1)	9.7	...	...	...	1	0.1	...	...	...
Sept. 8, 8 A.M.	1(1)	22.5	...	3	14.7	...	...	...	...	...
Sept. 10, 1 P.M.	1(1)	20.7	...	...	...	1	1.0	...	...	...
Mooselookmeguntic Lake										
July 20, 8:30 A.M.	1(1)	15.0	...	2	7.5	...	...	...	...	...
July 21, 9:30 A.M.	1(1)	13.4	0.05	...	...	1	0.1	...	...	...
July 25, 9:30 A.M.	2(0)	20.2–20.9	...	...	...	...	...	...	...	...
July 25, 9:30 A.M.	1(1)	11.6	...	1	0.1	...	...	...	...	...
July 25, 9:30 A.M.	2(0)	13.9–19.6	...	...	...	...	...	...	...	...
July 25, 8:30 P.M.	1(1)	21.9	...	...	...	1	3.0	...	...	...
July 26, 2:30 P.M.	1(1)	20.7	...	2	7.0	...	...	*Couesius*	1	4.7
July 27, 5:30 P.M.	1(1)	16.1	...	2	7.6	...	...	...	...	...
July 27, 5:30 P.M.	2(1)	20.5–20.9	...	6	21.5	...	...	...	...	...
Cupsuptic Lake										
July 24, 9 A.M.	1(1)	17.2	...	2	22.8	...	...	...	...	...
Sept. 12, 9:45 A.M.	3(0)	15.1–18.6	...	...	...	...	...	...	...	...
Sept. 12, 9:45 A.M.	3(1)	22.0–23.4	...	1	0.4	...	...	...	...	...
Aziscoos Lake										
Aug. 31, 3 P.M.	3(0)	15.0–17.5	...	...	...	...	...	...	...	...
Kennebago River at Canoe Pool										
Sept. 12, 12 Noon	16(0)	14.7–22.6	...	...	...	...	...	...	...	...

TABLE XXII. Stomach contents of Land-locked Salmon (*Salmo sebago*) from four Maine lakes

Locality, date	Fish examined: Number examined and number containing food in ( )	Fish examined: Range in total length in inches	Food organisms in stomachs — Insects: volume in c. c.: Aquatic insects	Insects: Terrestrial insects	Fish — Smelt: Number	Smelt: Total volume in c.c.	Unidentified fish remains: Number	Unidentified fish remains: Total volume in c.c.	Yellow Perch: Number	Yellow Perch: Total volume in c.c.
Sebago Lake May 25, 1938	1(1)	14.8	....	13.0	1	2.5	......	......	......	......
Aug. 6, 1938	1(0)	19.7	....	....	......	......	......	......	......	......
Aug. 10, 1938	1(1)	18.7	....	....	......	......	3	0.4	......	......
Aug. 11, 1938	4(4)	9.1–19.4	....	....	22	12.4	......	......	1	1.5
Aug. 11, 1938	1(1)	23.0	....	....	7	17.5	......	......	......	......
Kezar Lake July 19, 1938	4(3)	9.8–21.5	....	....	4	14.0	2	0.5	10	69.5
Sebec Lake May 9, 1937	6(6)	14.9–21.9	1.9	....	8	51.7	5	4.9	......	......
Moosehead Lake May 18, 1937	2(1)	16–18	....	0.05	......	......	......	......	......	......
May 29, 1937	1(1)	21.2	....	....	8	3.5	......	......	......	......

TABLE XXIII. Summary of stomach analyses on Land-locked Salmon (*Salmo sebago*) from seven lakes in Maine

Name of lake	Number of fish examined and number containing food in ( )	Total volume of stomach contents in c.c.	Stomach contents: volume by per cent of total — Aquatic insects	Terrestrial insects	Smelt (*Osmerus*)	Unidentified fish remains	Minnows	Suckers	Yellow Perch
Mooselookmeguntic	12(7)	51.55	0.1	...	84.8	6.0	9.1	...	...
Cupsuptic	7(2)	23.2	...	...	100.0	...	...	...	...
Rangeley	21(17)	100.0	...	...	82.8	1.2	...	16.0	...
Sebago	8(7)	46.9	...	27.7	69.1	...	...	...	3.2
Kezar	4(3)	84.0	...	...	16.7	0.6	...	...	82.7
Sebec	6(6)	58.5	3.2	...	88.4	8.4	...	...	...
Moosehead	3(2)	3.55	...	1.4	98.6	...	...	...	...

AGE AND GROWTH OF SALMON AND TROUT

The present section on age and growth of Land-locked Salmon (*Salmo sebago*) and Brook Trout (*Salvelinus f. fontinalis*) is based on an examination of the scales and on measurements of lengths and weights of 374 salmon (mostly adults) and 408 trout. Of the above fish, 105 of the salmon and 242 of the trout were from the Rangeley lakes and the Kennebago River spawning run of salmon. The data on age and growth of salmon and trout from twelve other lakes and ponds in Maine are offered here for comparison with the data for the Rangeleys. These trout and salmon were collected mostly by nets from the Rangeley lakes; and by either nets or hook and line from the other waters, or (in the case of salmon from three localities) they were obtained from spawning runs. The collections are believed to represent random samples of the fish populations in the various waters or in the spawning runs, except as indicated below.

Lengths of almost all of the fish were taken to the nearest millimeter or the nearest 1/16th inch or the nearest ¼th inch; all lengths have been changed to the nearest 0.1 inch for use in this report. All weights, except that of the largest single individual trout, were taken to the nearest gram and subsequently changed to the nearest 0.1 ounce. All lengths and weights were taken from the fish while in a fresh condition and shortly after they were taken from the water. Scales of all fish were mounted in glycerine-gelatin on slides and examined by microscope to determine age and spawning and growth history. No calculations on lengths of fish were made on the basis of scale measurements.

Age and Growth of Land-locked Salmon (See Tables XXIV to XXIX and Plates V and VI)

Of the 105 salmon from the Rangeley lakes, 45 were from the lakes themselves and collected during the summer months, 22 were from two samples taken from the spawning run on the Kennebago River during September, and 38 individuals were a partially selected sample from the Kennebago River spawning run taken from hatchery holding boxes on December 4, 1939. In taking this latter sample from the spawning run, individuals of all sizes were selected, but with preference for females and for the larger individuals of both sexes. Eight of nine salmon from Sebago Lake, and the five salmon from Kezar Lake in Lovell were taken by the experimental gill net (same net as used on the Rangeley lakes) during the summer of 1938. The 82 salmon from Cold Stream Pond at Enfield on November 11, 1936 were all spawning adults and they represented a random sample of each sex separately of an almost completed spawning run down the outlet from the pond; they were collected at a trap at the fish hatchery. The 71 salmon from the same place on Cold Stream Pond on November 10, 1937 were also a random sample of each sex separately of salmon in an almost completed spawning run. In the spawning runs of salmon at Cold Stream Pond in both years there was an almost equal sex ratio of fish in the entire runs. The 40 salmon from Cross Lake Thoroughfare at Guerette in T. 17, R. 5 on October 30, 1936 represented a random sample, taken for the two sexes separately, of all fish in the spawning run. According to a report by local fish hatchery men, the salmon spawning in the Cross Lake Thoroughfare came from two directions in the Fish River chain; some came up from Cross Lake, and others came down the stream from Mud and Long lakes. The seven salmon from this same Cross Lake Thoroughfare on November 6 to 13, 1938 were a selected few of the largest salmon in the entire run for that year. The 46 salmon from Grand Lake on October 31, 1936 were a random sample, of each sex separately, of all fish in the spawning run; the fish were being held in enclosures prior to stripping. The Grand Lake from which these 46 salmon were obtained is located in T. 6 of Washington County. The spawning salmon had run from Grand Lake down to the outlet where they were trapped. The nine salmon from Sebec Lake on Piscataquis County on May 9, 1937 were taken by fishermen on hook and line.

The determination of age of fishes by an examination of their scales is a well established science. The method is applicable to most species of fish living in temperate climates where waters undergo a

drastic seasonal change in temperature which affects the fish's growth. Often there are certain difficulties in age determination, resulting from such factors as stunting in growth and scale erosion, and one investigator[17] has found Land-locked Salmon which had made no scale growth at all in certain years. In most of the lakes from which the salmon considered in the present report were taken, this fish was growing fairly rapidly, with neither extreme crowding of the year marks nor unusual marginal erosion (see Plates V and VI). Therefore, it is the writer's belief that the present age determinations are mostly accurate in indicating the actual ages of the fish.

The characteristics of scale growth in salmonid fishes are well known to fish investigators. The most important diagnostic feature of the annulus or winter mark in salmon scales is the crowding of the circuli of slow growth in the fall, followed by a wide-spacing of the circuli of rapid growth in spring and early summer. Another characteristic of salmon scales is the result of the fact that salmon usually spend their first one, two, or more years in a stream where they grow very slowly, and subsequent years in a lake (or ocean in the Sea Salmon) where they grow very rapidly. The change from the one habitat to the other usually is registered clearly on the scales. It has been customary in studies on growth of salmon to differentiate between stream and lake (or ocean) growth and to record the number of years of each. In the present study, the salmon scales have invariably revealed this phenomenon of differential growth, but it does not seem safe to state that all of the slow years of growth during the early life of each fish have been made either in a hatchery or in a stream. At the Rangeley lakes, at Cold Stream Pond, and at most of the other lakes from which salmon have been collected for this study, salmon are liberated as fry from hatcheries directly into the lakes, others as 2- to 4-inch fingerlings, and others when they are 6 inches or more in length and over one year old. Furthermore, it has been impossible in the present studies to differentiate between hatchery-reared fish and fish which may have come from natural reproduction in tributary streams. It is also not known whether or not these young salmon, which are planted directly into the lakes, enter one of the tributary streams and complete their normal stream growth there before again returning to the lake, or whether they remain in the lake where they are planted and continue to grow at a very slow rate (as they would in streams) for their first one, two, or three years. Regardless of whether or not the young salmon did make their first few years of slow growth in streams, the fact remains that all of them showed at least one or two years of slow growth, and the change from the period of slow growth to the period of rapid

[17] Blair, A.A.: 1937. The validity of age determinations from scales of land-locked salmon. Science, Vol. 86, No. 2240, pp. 519–520.

growth was very marked as indicated by the spacing of the circuli on the scales.

Another feature well known for scales of salmon is the eroding away of portions of the scale during the breeding season. The amount of scale erosion observed in the present study varied greatly between the two sexes and also varied greatly between the different localities. Scale erosion was generally more severe among the males than among the females, and the scales of the females from Grand Lake showed practically no erosion at all. Scale erosion was quite severe in salmon from the Rangeley region; however, several of the 38 salmon from the Kennebago River spawning run on December 4 showed no scale erosion at all. Several salmon taken from Mooselookmeguntic Lake in early September had a slight amount of marginal erosion on their scales, indicating that this erosion might start before the spawning salmon have left the lake. Scale erosion on the males from Cross Lake Thoroughfare and Cold Stream Pond was very severe, praticularly among the older individuals, and usually so severe as to make age determinations rather difficult. However, scale erosion was found to be so variable among the different scales on an individual fish that presumably reliable age determinations could be made by examining a large number of scales from each fish. There was considerable evidence that the erosion of Land-locked Salmon scales is largely a matter of physiological absorption, at least among the males on which the scales during the breeding season are completely embedded under a thick layer of epidermis, and on which erosion takes place to some extent along the anterior or embedded margin of the scales and in scattered patches over the entire surface of the scales.

The spawning mark is another feature well known on scales of salmon and is the result of the scale being eroded away during the spawning season and subsequently patched up during growth of the following spring. Scale erosion during the spawning season tends to be more severe along the posterior and lateral margins of the scale, with the result that the posterior margin of the scale changes from the usual round shape to a sharp triangular point. Thus the erosion tends to cut sharply across the posterior ends of circuli which had been laid down during one or more previous years of growth. When growth resumes the following spring the new circuli tend to round off the posterior margin of the scale by growing more completely around it and thus cutting across the eroded ends of the circuli representing previous growing seasons. In many of those instances in the present study where the fish had spawned two or more times, the scale erosion of the second or third spawning often completely obliterated the history of the first spawning on many of the scales. The complete history was evident, therefore, on only a few scales on some fish; and was possibly absent on all scales of a few

fish. Possibly, therefore, some of the fish had spawned more times than was accredited to them in the present study, but it is believed that the number of errors made in this respect was small.

The results of the present studies on age and growth of Land-locked Salmon are summarized in table form, as follows: Lengths, weight, age, etc. are given for individual salmon from the Rangeley region in Table XXIV, and for individual salmon from Sebago and Kezar lakes in Table XXV. Data are not given for individual fish from the other four localities. Average lengths and weight by sex and age group for only certain age groups of each locality are given in Table XXVI. Average lengths and weight are given for each age group in each locality in Tables XXVII and XXVIII. Average lengths of salmon of different growth types and by age groups and sex are given for three lakes in Table XXIX.

Growth according to sex. The data on lengths of salmon in all of the collections are valid for a comparison of average lengths of the two sexes in those age groups having adequate numbers of fish. Among all of the salmon collected, there were 20 separate age groups from individual localities in which five or more fish, including both sexes, were represented. If the body or standard lengths of the two sexes in these 20 groups are compared (Table XXVI), the males exceeded the females in length in 16 of the 20 groups. Of the nine groups in which there were at least five individuals of each sex present, the males exceeded the females in length in six groups. Also, the males were the largest in the three groups containing the greatest numbers of fish, namely: the V-group, containing 27 males and 27 females, from Cold Stream Pond in November, 1936; the IV-group, containing 24 males and 16 females, from Cold Stream Pond in November, 1937; and the IV-group, containing 13 males and 11 females, from Grand Lake in October, 1936. In these three instances the males exceeded the females in length by about one inch or somewhat less. The present data, therefore, seem to indicate that in salmon of a given age, the males are usually slightly longer than the females. The point needs further confirmation, however. The difference, if it is real, is so small as to be of comparatively little or no economic significance.

Growth of salmon in different lakes. The average lengths and weight of salmon in each age class from each locality are given for the Rangeley waters in Table XXVII, and for other lakes in Table XXVIII, and are represented graphically in Figure 10. The unweighted averages for standard or body length in inches of salmon at or near the end

TABLE XXIV. Lengths, weight, sex, age, and growth history of individual Land-locked Salmon (*Salmo sebago*) from the Rangeley lakes

Lake and date: 1939	Sex and maturity*	Body length in inches: S.L.	Total length in inches incl. tail: T.L.	Weight in ounces	Age in growing seasons**	Growth history***
Lower Richardson Aug. 11	M.im.	8.9	10.6	6.1	III	1–II
Upper Richardson Aug. 10	M.im.	7.9	9.2	4.1	III	2–I
Mooselookmeguntic and Cupsuptic July 20	M.im.	13.0	15.0	17.1	V	2–III
July 21	M.im.	9.6	11.3	7.4	IV	2–II
	M.im.	11.3	13.4	14.6	V	2–III
July 24	M.ad.	14.6	17.3	31.0	VI	2–IV
July 25	M.im.	9.8	11.6	7.1	V	3–II
	F.im.	9.8	13.9	13.9	V	2–III
	F.ad.	16.4	19.6	47.4	VI	2–IV
	M.ad.	17.3	20.3	48.9	VII	2–V
	F.ad.	18.0	20.9	60.5	VI	2–IIIS–I
	F.ad.	19.4	21.3	65.7	VI	2–IIIS–I
July 26	M.ad.	17.6	20.8	53.2	VI	2–IV
July 27	M.ad.	13.9	16.1	27.0	V	2–III
	F.ad.	18.3	20.5	60.3	VII	2–V
	F.ad.	18.4	20.9	54.9	VIII	3–V
Sept. 12 (spawning run at mouth of Kennebago R.)	M.ad.	13.3	15.1	21.2	V	2–III
	M.ad.	14.1	16.6	23.3	V	2–III
	F.ad.	16.1	18.6	37.4	VI	2–IV
	F.ad.	19.3	22.0	67.3	VII	3–IV
	M.ad.	20.5	23.3	94.2	VII	2–IIIS–II
	F.ad.	20.4	23.4	85.4	VI	2–IV
Kennebago River, Trib. of Mooselookmeguntic (spawning run) Sept. 12	M.ad.	12.5	14.8	15.2	VI	2–IV
	M.ad.	12.5	14.8	16.5	V	2–III
	F.ad.	13.0	15.1	17.3	V	2–III
	F.ad.	13.5	15.6	18.3	VI	2–IV
	F.ad.	13.6	16.0	17.5	VI	2–IV
	F.ad.	14.3	16.3	21.7	VI	2–IV
	F.ad.	15.3	17.4	30.4	VI	2–IV
	F.ad.	15.8	17.9	31.1	VI	2–IV
	F.ad.	16.8	19.0	39.8	VI	2–IV
	M.ad.	18.5	20.8	44.8	VII	2–IVS–I
	F.ad.	18.8	20.4	53.5	VIII	2–IVS–II
	F.ad.	19.6	21.3	61.4	VIII	2–IVS–II
	M.ad.	19.8	21.9	56.6	VI	2–IV
	M.ad.	19.8	22.0	54.8	VIII	2–IIIS–I S–II
	F.ad.	20.1	22.4	71.5	VIII	2–IIS–I S–IS–II
Sept 22 (at mouth of Kennebago R.)	M.ad.	18.5	21.5	53.6	VI	2–IIIS–I

* In describing sexual maturity, im. means immature; ad. means adult; M. means male; F. means female.

** The 1939 growing season has been counted as a completed growing season for all fish included in this table; thus a III-year fish is one hatched in the spring of 1937, a VI-year fish is one hatched in the spring of 1934, etc.

*** Growth history indicates the number of years of very slow growth as a young fish (possibly all growth in a stream), the number of years of rapid growth in the lake, and the number of spawning marks on the scales. Spawning salmon usually, if not always, develop a spawning mark on their scales. A fish with a growth history of 2-III is a V-year-old which had 2 years of slow growth in a stream, followed by three years of rapid growth in a lake, and had not yet spawned. A 2-IIIS-IS-II fish is an VIII-year-old which had 2 years of slow, stream growth followed by 3 years of rapid growth in the lake, then spawning, then one year of lake growth, then spawning, and then 2 years of lake growth.

TABLE XXIV. Age of salmon—Continued

Lake and date: 1939	Sex and maturity*	Body length in inches: S.L.	Total length in inches incl. tail: T.L.	Weight in ounces	Age in growing seasons**	Growth history***
Kennebago R. (spawning run) Dec. 4	F. ad.	12.0	13.6	10.9	V	2–III
	" "	12.4	13.9	15.3	"	2–III
	" "	13.0	14.6	23.1	"	2–III
	" "	15.6	17.4	37.5	"	2–III
	F. ad.	13.1	14.6	13.7	VI	2–IV
	" "	13.9	15.8	18.0	"	2–IV
	" "	14.3	16.3	18.6	"	2–IV
	" "	14.3	16.3	21.7	"	2–IV
	" "	14.3	16.3	23.7	"	2–IV
	" "	14.3	16.3	30.2	"	2–IV
	" "	14.4	16.1	20.5	"	2–IV
	" "	15.0	16.9	23.2	"	2–IIIS–I
	" "	15.4	17.3	26.9	"	2–IV
	" "	15.5	17.1	25.5	"	2–IV
	" "	15.5	17.4	31.7	"	2–IV
	" "	15.9	17.8	29.7	"	2–IV
	" "	16.0	18.0	32.4	"	2–IIIS–I
	" "	16.5	18.5	32.4	"	2–IV
	" "	16.5	18.6	33.1	"	2–IV
	" "	17.4	19.5	39.0	"	2–IV
	M. ad.	14.6	16.4	20.8	VI	2–IV
	" "	16.3	18.1	34.7	"	2–IV
	" "	17.4	19.3	43.0	"	2–IIIS–I
	" "	17.4	19.8	48.6	"	2–IIIS–I
	F. ad.	16.0	18.0	38.2	VII	2–V
	" "	16.5	18.4	42.7	"	2–V
	" "	16.5	18.5	38.2	"	2–IVS–I
	" "	17.4	19.4	46.6	"	2–IVS–I
	" "	18.1	20.4	51.4	"	2–IIS–IS–IS–I
	M. ad.	18.5	20.6	48.3	VII	2–IVS–I
	F. ad.	18.5	21.3	54.5	VIII	2–IIIS–I S–IS–I
	" "	19.9	22.1	58.8	"	2–IVS–II
	M. ad.	19.8	22.3	57.6	VIII	2–IVS–II
	" "	20.0	22.4	64.5	"	2–IVS–II
	" "	21.8	23.5	57.2	"	2–VS–I
	F. ad.	20.0	22.5	64.2	IX	2–IVS–III
	" "	20.3	22.5	68.8	"	2–IIS–I S–IS–II S–I
	" "	20.4	23.0	76.3	"	3–IVS–II

TABLE XXIV. Age of salmon—Concluded

Lake and date: 1939	Sex and maturity*	Body length in inches: S.L.	Total length in inches incl. tail: T.L.	Weight in ounces	Age in growing seasons**	Growth history***
Rangeley July 8	M.im.	7.6	9.1	3.7	III	2-I
	F.im.	7.7	9.2	4.0	III	2-I
	M.im.	8.4	10.0	5.1	III	2-I
	F.ad.	17.7	20.6	48.7	VI	2-III S-I
July 10	M.ad.	15.7	17.9	37.7	V	2-III
	F.ad.	17.2	19.5	53.2	V	2-III
July 11	M.im.	11.3	13.1	13.4	IV	2-II
	M.ad.	15.6	17.8	34.6	V	2-IIS-I
	M.ad.	16.9	19.3	51.0	V	2-IIS-I
	F.ad.	17.7	20.1	55.2	V	2-III
	F.ad.	17.8	20.4	56.8	V	2-III
	F.ad.	18.1	20.8	54.7	V	2-III
	M.ad.	19.6	22.4	81.2	V	2-IIS-I
	M.ad.	21.1	24.1	77.7	VII	2-IIS-II S-I
July 13	M.im.	13.2	15.4	18.1	IV	1-III
Aug. 25	F.ad.	20.0	22.4	68.6	VI	2-IIIS-I
Aug. 28	M.ad.	19.4	21.5	72.9	V	2-III
Sept. 1	F.im.	15.3	17.4	33.7	V	2-III
Sept. 7	M.im.	8.9	9.8	5.5	IV	3-I
Sept. 8	F.ad.	20.0	22.5	82.6	V	2-IIS-I
Sept. 10	F.ad.	18.9	20.8	60.8	VI	3-III
Kennebago L. Aug. 22	M.im.	7.5	8.3	3.3	IV	2-II
	F.im.	11.1	12.3	12.6	IV	2-II
Aug. 25	?	?	18.3	34.0	V	2-IIS-I
Aziscoos Aug. 31	M.im.	10.0	11.5	7.6	IV	2-II
	M.ad.	11.0	12.5	11.9	IV	1-III
	?	13.3	15.0	15.9	VI	2-IV
	M.ad.	13.8	15.3	22.1	VI	2-IV
	M.ad.	15.3	17.5	28.1	VI	2-IIIS-I

TABLE XXV. Lengths, weight, sex, age, and growth history of individual Land-locked Salmon (*Salmo sebago*) from Sebago and Kezar lakes in Maine

Lake and date	Sex and maturity	Body length in inches: S.L.	Total length in inches incl. tail: T.L.	Weight in ounces	Age in growing seasons*	Growth history
Sebago Lake May 25, 1938	F. im.	12.8	14.8	17.3	IV+	1-III
Sebago Lake Aug. 5 to 11, 1938	M. im.	8.0	9.1	4.0	III	2-I
	M. ad.	14.2	16.3	28.5	IV	2-II
	F. ad.	14.5	16.5	23.8	V	2-III
	F. ad.	15.4	18.2	32.8	V	2-III
	M. ad.	16.8	19.4	42.0	V	2-III
	F. ad.	16.7	18.7	45.8	VI	2-IV
	M. ad.	17.4	19.7	51.4	VI	2-IV
	F. ad.	20.5	23.0	81.4	VII	2-III S-II
Kezar Lake July 19 and 20, 1938	M. im.	8.5	9.8	5.7	III	2-I
	M. im.	13.5	15.6	23.2	IV	2-II
	M. im.	14.3	16.8	23.4	IV	2-II
	M. ad.	18.2	20.6	69.5	VI	2-II S-I S-I
	F. ad.	19.1	21.5	72.8	VI	2-III S-I

* Age in growing seasons includes the year of 1938 for all except the one salmon from Sebago Lake on May 25.

TABLE XXVI. Average lengths and weight (in part) according to sex and age of Land-locked Salmon for those age groups from each locality in which a total of five or more fish are represented

Lake and date	Sex	Age in growing seasons*	Number of fish	Body length in inches: S.L.	Total length in inches, incl. tail: T.L.	Weight in ounces
Mooselookmeguntic and Cupsuptic July 20 to 27, 1939	Male	V	4	12.0	14.0	16.5
	Female	V	1	9.8	13.9	13.9
	Male	VI	2	16.1	19.1	42.1
	Female	VI	3	17.9	20.6	57.9
Kennebago River (spawning run from Mooselookmeguntic) Sept. 12 and 22, 1939	Male	VI	3	16.9	19.4	41.8
	Female	VI	8	15.7	18.0	35.2
Kennebago River (spawning run from Mooselookmeguntic) Dec. 4, 1939	Male	VI	4	16.4	18.4	36.8
	Female	VI	16	15.1	17.1	26.3
	Male	VII	1	18.5	20.6	48.3
	Female	VII	5	16.9	18.9	43.4
	Male	VIII	3	20.5	22.7	59.8
	Female	VIII	2	19.2	21.7	56.7
Rangeley Lake July 8 to Sept. 10, 1939	Male	V	5	17.4	19.8	55.5
	Female	V	6	17.7	20.1	56.0
Cold Stream Pond Nov. 11, 1936	Male	III	4	14.4	17.0	....
	Female	III	1	13.5	15.8	....
	Male	IV	5	16.4	19.1	....
	Female	IV	11	16.8	19.6	....
	Male	V	27	18.7	21.9	....
	Female	V	27	17.6	20.4	....
	Male	VI	1	19.3	22.3	....
	Female	VI	6	18.7	21.7	....
Cold Stream Pond Nov. 10, 1937	Male	IV	24	17.5	20.4	....
	Female	IV	16	16.7	19.5	....
	Male	V	13	18.0	20.9	....
	Female	V	6	17.8	20.5	....
	Male	VI	4	20.4	23.8	....
	Female	VI	5	19.4	22.6	....
Cross Lake Thoroughfare Oct. 30, 1936	Male	V	8	17.7	20.8	....
	Female	V	10	18.1	21.2	....
	Male	VI	3	24.0	28.0	....
	Female	VI	4	19.6	22.7	....
	Male	VII	6	24.7	29.0	....
	Female	VII	6	23.0	26.3	....
Grand Lake Oct. 31, 1936	Male	IV	13	17.6	20.3	....
	Female	IV	11	17.1	19.4	....
	Male	V	9	19.6	22.4	....
	Female	V	11	17.7	20.5	....
Sebec Lake May 9, 1937	Male	V	1	18.5	21.3	....
	Female	V	4	14.8	17.3	....

* Ages include the calendar year in which fish were collected for all except the fish from Sebec Lake.

TABLE XXVII. Average lengths and weight, and range in lengths and weight of different year classes of Land-locked Salmon (*Salmo sebago*) from the Rangeley lakes

Lake and date: 1939	Age in growing seasons*	Number of fish	Body length in inches: S.L.	Total length in inches, incl. tail: T.L.	Weight in ounces
Lower Richardson Aug. 11	III	1	8.9	10.6	6.1
Upper Richardson Aug. 10	III	1	7.9	9.2	4.1
Mooselookmeguntic and Cupsuptic July 20 to 27	IV	1	9.6	11.3	7.4
	V	5	11.6 (9.8–13.9)	14.0 (11.6–16.1)	15.9 (7.1–27.0)
	VI	5	17.2 (14.6–19.4)	20.0 (17.3–21.3)	51.6 (31.0–65.7)
	VII	2	17.8 (17.3–18.3)	20.4 (20.3–20.5)	54.6 (48.9–60.3)
	VIII	1	18.4	20.9	54.9
Kennebago River (spawning runs) Sept. 12 and 22	V	4	13.2 (12.5–14.1)	15.4 (14.8–16.6)	19.6 (16.5–23.3)
	VI	11	16.1 (12.5–20.4)	18.4 (14.8–23.4)	37.0 (15.2–85.4)
	VII	3	19.4 (18.5–20.5)	22.0 (20.8–23.3)	68.8 (44.8–94.2)
	VIII	4	19.6 (18.8–20.1)	21.5 (20.4–22.4)	60.3 (53.5–71.5)
Kennebago River (spawning run) Dec. 4	V	4	13.3 (12.0–15.6)	14.9 (13.6–17.4)	21.7 (10.9–37.5)
	VI	20	15.4 (13.1–17.4)	17.3 (14.6–19.8)	28.4 (13.7–48.6)
	VII	6	17.1 (16.0–18.5)	19.2 (18.0–20.6)	44.2 (38.2–51.4)
	VIII	5	20.0 (18.5–21.8)	22.3 (21.3–23.5)	58.5 (54.5–64.5)
	IX	3	20.2 (20.0–20.4)	22.7 (22.5–23.0)	69.8 (64.2–76.3)
Rangeley Lake July 8 to Sept. 10	III	3	7.9 (7.6–8.4)	9.4 (9.1–10.0)	4.3 (3.7–5.1)
	IV	3	11.1 (8.9–13.2)	12.8 (9.8–15.4)	12.3 (5.5–18.1)
	V	11	17.6 (15.3–20.0)	20.0 (17.4–22.5)	55.8 (33.7–82.6)
	VI	3	18.9 (17.7–20.0)	21.3 (20.6–22.4)	59.4 (48.7–68.6)
	VII	1	21.1	24.1	77.7
Kennebago Lake Aug. 22 and 25	IV	2	9.3 (7.5–11.1)	10.3 (8.3–12.3)	8.0 (3.3–12.6)
	V	1	?	18.3	34.0
Aziscoos Lake	IV	2	10.5 (10.0–11.0)	12.0 (11.5–12.5)	9.8 (7.6–11.9)
	VI	3	14.1 (13.3–15.3)	15.9 (15.0–17.5)	22.0 (15.9–28.1)

* Includes the 1939 growing season.

TABLE XXVIII. **Average lengths and average weight (in part) of different year classes of Land-locked Salmon (*Salmo sebago*) from six Maine lakes, not including the Rangeleys**

Lake and date	Age in growing seasons*	Number of fish	Body length in inches: S.L.	Total length in inches, incl. tail: T.L.	Weight in ounces
Sebago Lake May 25, 1938	IV	1	12.8	14.8	17.3
Sebago Lake Aug. 5 to 11, 1938	III	1	8.0	9.1	4.0
	IV	1	14.2	16.3	28.5
	V	3	15.6	18.0	32.9
	VI	2	17.1	19.2	48.6
	VII	1	20.5	23.0	81.4
Kezar Lake July 19 and 20, 1938	III	1	8.5	9.8	5.7
	IV	2	13.9	16.2	23.3
	VI	2	18.7	21.1	71.2
Cold Stream Pond Nov. 11, 1936	III	5	14.2	16.8	....
	IV	16	16.7	19.5	....
	V	54	18.1	21.1	....
	VI	7	18.8	21.8	....
Cold Stream Pond Nov. 10, 1937	III	2	15.0	17.4	....
	IV	40	17.2	20.0	....
	V	19	17.9	20.8	....
	VI	9	19.8	23.1	....
	VII	1	20.5	24.0	....
Cross Lake Thoroughfare Oct. 30, 1936	IV	3	14.8	17.1	....
	V	18	17.9	21.0	....
	VI	7	21.5	25.0	....
	VII	12	23.9	27.6	....
Grand Lake Oct. 31, 1936	IV	24	17.3	19.9	....
	V	20	18.5	21.4	....
	VI	2	21.4	24.9	....
Sebec Lake May 9, 1937	III	1	12.6	14.9	....
	IV	2	14.1	16.6	....
	V	5	15.5	18.1	....
	VI	1	19.2	21.9	....

* The May 25 salmon from Sebago Lake had made only very little scale growth in 1936, and the May 9 fish from Sebec Lake had made little or no growth in 1937; therefore their ages as given above do not include the calendar years in which the fish were taken. For all other fish their ages as given above include the calendar year in which the fish were collected. The fish taken from Kezar Lake and the August fish from Sebago Lake had made at least more than half of a normal year's scale growth; and those fish taken in the months of October and November presumably had completed their growth for the year.

TABLE XXIX. **Average standard (body) and total lengths for salmon of different growth types, according to age group, sex, and locality for three lakes**

Data are given for only those age groups of each sex containing at least five individuals in two growth types

Locality and date	Sex	Age in growing seasons	Growth type*	Number of fish	Body length in inches: S.L.	Total length in inches, incl. tail: T.L.
Cold Stream Pond Nov. 11, 1936	Male	IV	1–III	2	16.9	19.8
	Male	IV	2–II	3	16.0	18.7
	Female	IV	1–III	8	17.4	20.2
	Female	IV	2–II	3	15.3	18.3
	Male	V	1–IV	10	18.6	21.9
	Male	V	2–III	12	18.8	21.8
	Female	V	1–IV	4	17.8	20.6
	Female	V	2–III	15	17.5	20.2
Cold Stream Pond Nov. 10, 1937	Male	IV	1–III	21	17.6	20.6
	Male	IV	2–II	3	16.4	18.8
	Female	IV	1–III	15	16.7	19.5
	Female	IV	2–II	1	16.5	19.3
	Male	V	1–IV	5	18.5	21.5
	Male	V	2–III	3	18.5	21.6
	Male	V	3–II	5	17.2	20.0
Cross Lake Thoroughfare Oct. 30, 1936	Male	V	1–IV	2	19.9	23.6
	Male	V	2–III	6	16.9	19.8
	Female	V	1–IV	1	17.5	20.3
	Female	V	2–III	9	18.1	21.3
Grand Lake Oct. 31, 1936	Female	V	1–IV	10	17.8	20.7
	Female	V	2–III	1	16.5	19.0

* Numbers in Arabic represent years of very slow growth, presumably in a stream; Roman numerals represent years of very rapid growth, presumably in a lake.

of consecutive growing seasons, from all of the Rangeley waters combined, all other lakes combined, and all localities, are:

Age group:	III	IV	V	VI	VII	VIII	IX
Rangeleys	8.2	10.1	14.8	16.5	19.1	19.1	20.2
Other lakes...	10.9	15.1	17.1	19.5	21.6	....	....
All lakes	9.8	13.1	16.1	18.3	20.4	19.1	20.2

Similar figures for total length in inches (that used by fishermen) of salmon from these waters are:

Age group:	III	IV	V	VI	VII	VIII	IX
Rangeleys	9.7	11.6	16.9	18.8	21.7	21.4	22.7
Other lakes...	12.7	17.5	19.9	22.4	24.9	....	....
All lakes	11.4	15.2	18.6	21.0	23.3	21.4	22.7

Data on average weight in ounces of salmon by age groups are available for the Rangeley waters and Sebago and Kezar lakes, as follows:

Age group:	III	IV	V	VI	VII	VIII	IX
Rangeleys	4.8	9.4	31.6	41.4	62.9	57.2	69.8
Rangeleys plus Sebago and Kezar........	4.8	14.0	31.9	47.6	67.6	57.2	69.8

Certain of the above differences between different localities in lengths of salmon at given ages may be ascribed, at least in part, to differences in time and methods of collecting the fish. However, the general trend in growth of these Land-locked Salmon was toward a fairly uniform added increment of growth in length for each year up to the sixth or seventh years of life, or to a length of about 18 to 20 inches; after this age and length were attained there was little increase in size with increase in age. Judging from scale diameters (not measured) the length growth of these older fish was greatly retarded. The apparent decrease in growth rate, as indicated by the above figures, might also have been partially due to differential mortality with age, a phenomenon well known for some other species of fishes. The average Rangeley salmon reached the legal length of 14 inches at about four and one-half years of age, in the other lakes at about three and one-half years of age. The average lengths of salmon of the various age groups were considerably less in the Rangeleys as a whole than in the other lakes. While these differences in terms of length of fish were not particularly great, they represent a far greater difference in average weight.

The variation in growth of salmon between the different localities is shown graphically in Figure 10. The most rapidly-growing fish were from Grand Lake and Cross Lake Thoroughfare. The seven lakes represented in this figure rank on the basis of salmon growth approximately in the following order: Grand Lake, Cross Lake Thoroughfare (Cross Lake and Mud and Long Lake fish), Cold

Stream Pond, Rangeley Lake, Sebago Lake, Sebec Lake, and Mooselookmeguntic Lake (including Mooselookmeguntic Lake spawning fish in the Kennebago River). The growth of salmon in Rangeley Lake was about average for the seven lakes; the growth of Mooselookmeguntic Lake salmon was considerably below that of all other lakes. This difference in growth of salmon from Rangeley and Mooselookmeguntic lakes is striking if average weights are compared, as for example: the 11 V-year fish from Rangeley had an average weight of 55.8 ounces: while the five V-year fish from Mooselookmeguntic, the four V-year fish from the Kennebago River spawning run (new fish) in September, and the four V-year fish from the Kennebago River spawning run taken on December 4, had average weights of 15.9, 19.6, and 21.7 ounces, respectively. A similar comparison of the VI-year-old fish also reveals a greater growth of Rangeley Lake salmon over Mooselookmeguntic Lake fish, but the difference is not so striking as in the V-year-olds. No comparison is possible from the data on salmon from the Richardson lakes. The few salmon obtained from Kennebago and Aziscoos lakes were small for their age.

A critical explanation for the differences in rate of growth of salmon in the seven localities listed above, would require a detailed study of prevailing conditions in each lake. Such studies have not been completed as yet for all of these lakes. One of the factors which might be expected to have an effect on salmon growth is the length of the growing season available to the fish. The length of the growing seasons in the various large lakes in Maine, as indicated by the date on which the ice "goes out" in the spring (see Figure 1), varies more than a month. This additional month of time in early spring available for fish to grow in some of the lakes must be of some importance, especially since the average growing season is short. However, the differences in growth of salmon between these seven lakes were not entirely attributable to differences in length of growing season. In fact, the correlation between rapid growth of salmon (Figure 10) and an early disappearance of ice in the spring (Figure 1) was very poor.

Size as related to growth history. It has already been mentioned that salmon vary considerably in their growth history or in the number of early years of slow growth, and that the change in growth rate is usually very marked and is evident in the spacing of the circuli on the scales. The great majority of the salmon from the Rangeley region had the first two years of slow growth followed by rapid growth. There was more variation, however, in the growth history of salmon from Cold Stream Pond and Cross Lake Thoroughfare, and this variation afforded an opportunity to compare the size attained by fish of different growth types. Average lengths for each sex in each age group having at least five individuals represented in two different growth types are given in Table XXIX. All salmon, scales of which indicated that the fish had spawned one or more times previous to the time of collection, were not included in this table; therefore, the comparison is based on only those individuals which had a period of slow, presumably stream, growth followed by rapid lake growth, and not interrupted by an alteration in the growth rate due to development of maturity. Among these salmon from Cold Stream Pond and Cross Lake Thoroughfare, there was a marked tendency toward growth compensation; for those salmon which had spent two years of slow growth and then started a rapid growth presumably in a lake, attained about the same size at a given age as did those individuals which had spent only one year of slow growth. As an example the IV-year-old females from Cold Stream Pond on November 11, 1936 included eight individuals which had spent one year of slow growth and three years of rapid growth, and three individuals which had had two years of slow growth and two years of rapid growth. The 1-III fish averaged 17.4 inches whereas the 2-II fish were nearly as long at 15.3 inches. Also, among the V-year males from this same collection the average lengths of fish in the two growth types were nearly the same, or 18.6 and 18.8 inches. Thus it might be concluded for Cold Stream Pond and Cross Lake Thoroughfare that, from the practical standpoint of fish culture, it does not make much difference with respect to ultimate growth of those fish which do survive, whether they are held in hatchery rearing ponds for one year and then liberated into a lake or whether they are held for two or more years in the rearing ponds, giving them a slight advantage in size, and then liberated into the lake. This applies only to the growth of those fish which do survive and does not take into account the fact that there might be a much greater rate of survival of those fish which are held in hatchery ponds for more than one year.

Of the 105 salmon examined from the Rangeley region, 102 fish had the first two or three years of very slow growth, and only three fish had started a rapid (lake?) growth after one year of slow growth. The majority of the salmon planted by Maine state hatcheries in the Rangeley lakes during the past five years were one year of age or somewhat less, and, judging from the present growth studies, the majority of these planted fish did not begin, immediately, a rapid growth in the open waters of the lakes. Rather, it appears that conditions in the Rangeley region are conducive to a slow growth for the first two years (one year after planting) before the salmon enter the open waters of the lakes and begin a rapid growth on a smelt diet.

Age of salmon. The maximum age found by the present scale examinations on 374 salmon was nine years, attained by three Mooselookmeguntic Lake fish in the Kennebago River spawning run. There was no reliable indication of a sex difference in maximum age, but the data were inadequate. The maximum ages of salmon from the other lakes were mostly seven and eight years, but these differences between localities are not considered particularly significant.

For the following data on relation of mortality to age, the December 4 Kennebago River fish and the fish from Cross Lake Thoroughfare on November 6 to 13, 1938 have been excluded because the samples were obviously selective. The remaining 329 salmon from all localities taken by random sampling from lakes and from spawning runs were divided according to number of fish in each age group as follows:

Age group:	III	IV	V	VI	VII	VIII
Number of fish:	15	97	140	52	20	5

The variation in the above numbers was obviously the result of several factors. The low number of III-fish was due in part to the scarcity of this age class in spawning populations. Normal variation in abundance of year classes might have been involved; of the 20 VII-fish, 12 were from the Cross Lake Thoroughfare collection in 1936. The "take" of fish by fishermen would also affect the age-class distribution, but it could not fully explain the above differences. On the average the above salmon reached the legal length of 14 inches at about four years of age, and the abundant V-year group included mostly legal fish available to the angler. The data indicate that IV-, V-, and VI-year fish make up the greatest part of salmon populations available to the fishermen. The great and continual decrease in numbers of fish after the V-group might be attributable either to fishing intensity or normal mortality; most likely it should be attributed to both.

The data on age at maturity of salmon in the Rangeley lakes are given for individual fish in Table XXIV. The 60 fish from the Kennebago River spawning run were all V-year fish or older; and the scales of only three salmon had spawning marks to indicate spawning of fish at four years of age in earlier years. Of the III- and IV-year fish taken from the various Rangeley lakes during the summer, only one IV-year male had adult-sized gonads. In four out of 11 V-year salmon and in one VII-year salmon from Rangeley Lake, however, the scales indicated previous spawning at four years of age. Of the III- and IV-year salmon from Sebago and Kezar lakes, only one IV-year male was mature, and only one had a spawning mark indicating previous spawning at four years of age. In the spawning runs of salmon in Cold Stream Pond there were several III-year fish and a large percentage of IV-year fish; in the Cross Lake Thoroughfare spawning run there were no III-fish and a few IV-fish; and in the Grand Lake spawning run there were no III-fish but a majority of IV-fish. From these data it is concluded that age composition of spawning populations varies considerably between different localities and within any one locality from year to year, and the age of salmon at first maturity is mostly five years in the Rangeley region and mostly at four years in some of the other lakes.

Survival after spawning. Most of the V- and all of the VI-, VII- and VIII-year salmon taken from the Rangeley lakes during the summer were adult fish apparently maturing for spawning in that fall; by July the females had eggs approximately of mature size. Since a certain percentage of the V-fish were not mature it should necessarily follow that some of the VI-fish would not have spawning marks on their scales. This was verified by scale examinations. The records for survival after spawning, as based on identification of spawning marks on scales, and based only on fish which had spawned or were maturing to spawn in the year of capture, were as follows:

Mooselookmeguntic Lake and Kennebago River:
- Of 9 V-year salmon, all were spawning for their first time.
- Of 36 VI-year salmon, 7 were spawning for the 2nd time.
- Of 11 VII-year salmon, 5 were spawning for the 2nd time, and 1 was spawning for the 4th time.
- Of 10 VIII-year salmon, 6 were spawning for the 2nd time, 1 for the 3rd time, and 2 for the 4th time.
- Of 3 IX-year salmon, 2 were spawning for the 2nd time, and 1 for the 5th time.

Rangeley Lake:
- Of 10 V-year fish, 4 were maturing to spawn for the 2nd time.
- Of 3 VI-year fish, 2 were maturing to spawn for the 2nd time.
- The 1 VII-year fish was maturing to spawn for the 3rd time.

Aziscoos Lake:
- The 1 IV-year fish was maturing to spawn for its first time.
- Of 2 VI-year fish, 1 was maturing to spawn for the 2nd time.

Sebago Lake:
- One IV-year, 3 V-year, and 2 VI-year fish were maturing to spawn for the first time.
- One VII-fish was maturing to spawn for the 2nd time.

Kezar Lake:
- Of 2 VI-year fish, 1 was maturing to spawn for the 2nd time, 1 for the 3rd time.

Cold Stream Pond (November 11, 1936):
- Of 27 V-year males, 5 were spawning for their 2nd time, and 2 were spawning for their 3rd time.
- Of 27 V-year females, 7 were spawning for their 2nd time, and 1 was spawning for its 3rd time.
- Of 6 VI-year females, 2 were spawning for their 2nd time, and 3 were spawning for their 3rd time.

Cold Stream Pond (November 10, 1937):
- Of 4 VI-year males, 2 were spawning for their 2nd time, and 1 was spawning for its 3rd time.
- Of 5 VI-year females, all were spawning for their 2nd time.
- The 1 VII-year male was spawning for its 3rd time.

Cross Lake Thoroughfare (October 30, 1936):
- Of 3 VI-year males, 1 was spawning for its 2nd time.
- Of 4 VI-year females, 1 was spawning for its 2nd time.
- Of 6 VII-year males, 5 were spawning for their 2nd time.
- Of 6 VII-year females, 3 were spawning for their 2nd time, and 1 was spawning for its 4th time (this fish was 29.75 inches in total length).

Grand Lake Stream:
- Of 9 V-year males, 1 was spawning for its 2nd time.
- The 1 VI-year male was spawning for its 2nd time.

Sebec Lake:
- The 1 VI-year female had spawned twice.

The data on survival after spawning are summarized below for all localities. Of the 374 salmon on which scale examinations were made, 349 were adults, including spawning fish taken from spawning runs, and summer fish maturing for spawning in the fall. The dis-

tribution of these 349 adult salmon according to age group and frequency of spawning was as follows:

Age group:	III	IV	V	VI	VII	VIII	IX	III to IX
Number of adult fish:	7	87	138	73	31	10	3	349
Number spawning 1st time	7	87	118	43	8	1	..	264
" " 2nd "	..	..	17	25	17	6	2	67
" " 3rd "	..	..	3	5	4	1	..	13
" " 4th "	..	..	..	..	2	2	..	4
" " 5th "	..	..	..	..	..	..	1	1

From the above it is apparent that the spawning populations of salmon in these lakes were composed largely of IV-, V-, and VI-year-old fish; and these spawning populations were also made up largely of "maiden" fish, or salmon spawning for their first time. Of the 349 salmon, 264 or 76 per cent were spawning for the first time, and only 24 per cent had spawned at least once before. Of those salmon which lived to spawn twice, only about one-fifth lived to spawn a third time.

The 24 per cent (85 fish) survival to two or more spawnings, when divided into component parts, reveals a striking difference between salmon in the Rangeley region and those in other waters. Of the 86 adult fish from the Rangeleys, 33 fish or 38 per cent were spawning for at least the second time; of the 263 fish from all other localities, 52 fish or only 20 per cent were spawning for at least the second time. Judging from the above figures, the Land-locked Salmon gives much better returns of post-spawning fish for the angler than does the Sea Salmon (*Salmo salar*); Dahl[18] (1910), for example, found that, among the Sea Salmon in Norway, only about five per cent lived to spawn for a second time.

The second-, third-, and fourth-spawning salmon were mostly the larger individuals of each population; and correspondingly, most of the large individuals had spawned previously. While the number of these larger fish in any one locality is relatively small, nevertheless, the value of these large individuals is far out of proportion to their relative numbers, chiefly because they are such coveted prize to the fishermen. Therefore, it is important that the spawning fish are handled with care and everything possible is done to favor their survival after spawning.

A selected group of seven large salmon was obtained from the Cross Lake Thoroughfare spawning run during the period of November 6 to 13, 1938. They were included among the fish previously mentioned, but are listed separately here because they revealed

[18] Dahl, Knut: 1910. The age and growth of salmon and trout in Norway as shown by their scales. 141 p. London: The Salmon and Trout Association.

variety of growth histories, and because they give further supporting evidence to the conclusion that most of the larger salmon had spawned two or more times. Data on these seven fish are as follows:

Sex	Age in growing seasons	Growth history	Body length: inches	Total length: inches	Weight: ounces
Male	VI	2–IIIS–IS	27.8	32.3	164
Female	VI	1–VS	20.5	23.7	62
Male	VII	1–IVS–IS–IS	28.2	31.9	188
Male	VII	2–IIIS–IIS	26.2	29.4	163
Male	VII	2–IIIS–IS–IS	26.5	30.2	144
Female	VII	1–IVS–IIS	23.0	26.2	88
Female	VII	2–IIIS–IIS	27.1	30.8	174

The high mortality of Sea Salmon after spawning might be attributable, in small part at least, to the strain of the spawning migration and the distance which the fish must travel after spawning to get back to a suitable food supply. These factors must be of little or no importance to the mortality of Land-locked Salmon in Maine. In Cold Stream Pond, for example, the fish have almost no spawning migration at all, and they are put back into the lake in apparently excellent condition after being stripped. The stream spawning runs of the Land-locked Salmon in Maine waters in general are rarely over a distance of six to eight miles and are mostly much less.

Age and Growth of Brook Trout (see Tables XXX to XXXII)

The 408 Brook Trout on which the present study on age and growth has been based included 242 fish from the six Rangeley lakes as follows: 25 from the Richardson lakes, 45 from Mooselookmeguntic and Cupsuptic lakes, 78 from Rangeley Lake, 80 from Kennebago Lake, and 14 from Aziscoos Lake. All Rangeley fish, except one, were taken by gill nets and presumably represent random samples (see page 66), and all were taken from the lakes themselves and not from tributary streams. The remaining 166 trout were from six lakes and ponds in other parts of the state, as follows: 41 from Adams Pond in Bridgton, 3 from Sabbathday Lake in New Gloucester, 22 from Quimby Pond in Rangeley, 57 from Horseshoe Pond in West Bowdoin College Grant, 39 from Tim Pond in T. 2, R. 4 of Franklin County, and 4 from B Pond in Upton. The trout from Horseshoe Pond and B Pond were taken by hook and line, those from the other ponds by the experimental gill net (same as used on the Rangeley lakes); all collections were presumably random samples.

The age determination of Brook Trout by the scale method is somewhat more difficult than that of Land-locked Salmon. Under sufficient magnification, however, the scales are "readable," and the

great majority of the present age determinations are believed to be accurate. The same characterization of the winter mark, as previously indicated for salmon scales, holds true for trout, namely: a marked crowding or narrow spacing of the circuli of fall growth, followed by a wide spacing of the circuli of spring and early summer growth. In contrast to the salmon scales, however, the trout scales did not show the extreme and consistent demarcation between scale areas representing very slow growth in early years and scale areas representing rapid growth in lakes after the first two or three years of life. Also, no trout scales revealed any signs of spawning marks; however, there was no question but that many of the trout had spawned in years prior to the date of sample.

Growth according to sex. Average lengths and weight, by sex and age group, of all of the trout in each locality are given in Table XXX. Both sexes are represented in 33 separate age groups. If the average body lengths of the two sexes in each age group are compared, the males exceeded the females in length in 18 age groups, the females exceeded the males in 14, and the two sexes were of the same length in one age group. The present data, therefore, do not appear to indicate any significant sex difference in rate of growth.

Growth of trout in different lakes. The average lengths of trout by age groups (sexes combined) for the various localities revealed a striking similarity in the rate of growth of the Brook Trout in the different Rangeley lakes (Tables XXXI and XXXII and Figure 11). The growth curves for Mooselookmeguntic, Rangeley, and Kennebago lakes are practically identical, but with some variations among the different year classes. The curves for trout in the Richardsons and Aziscoos lakes reveal average Rangeley growth of the II-, III-, and IV-fish but a slightly smaller size for V-year fish; the numbers of trout from the Richardsons and Aziscoos were inadequate for detailed comparison, however. The somewhat greater numbers of fish in the older age groups together with a slightly faster average growth explains the greater average length and weight of trout from Mooselookmeguntic Lake (Table XXXII). On the average, the body lengths of consecutive age groups of trout in the Rangeley lakes as a whole were approximately as follows: 7½ inches at 2 years, 8¾ inches at 3 years, 10¾ inches at 4 years, 13½ inches at 5 years, 16 inches at 6 years, and 18½ inches at 7 years. The average total lengths (length used by fishermen) of all Rangeley trout by year classes were as follows (from Table XXXII): 8.4 inches at 2 years, 10.0 at 3 years, 12.1 at 4 years, 14.8 at 5 years, 18.1 at 6 years, and 20.7 at 7 years. Similar data on average weight for these six age groups were: 4.8, 5.9, 11.4, 22.7, 47.2, and 60.1 ounces, respectively. Thus, while the growth curve in length of Rangeley trout follows closely a straight line, the growth curve in weight swings sharply

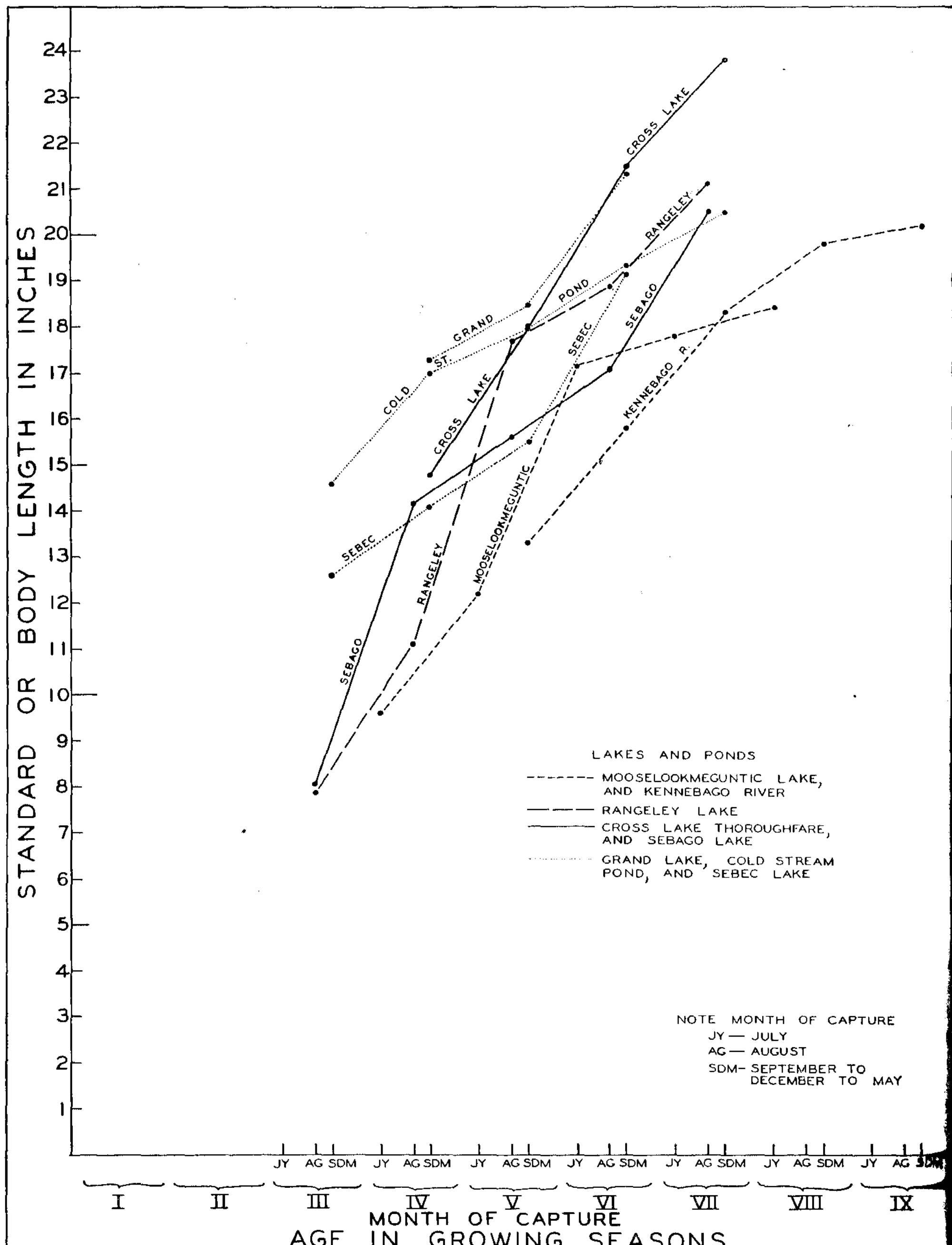

Figure 10. Age-length curves for Land-locked Salmon (*Salmo sebago*) from seven lakes and ponds in Maine. Data are from Tables XXVII and XXVIII.

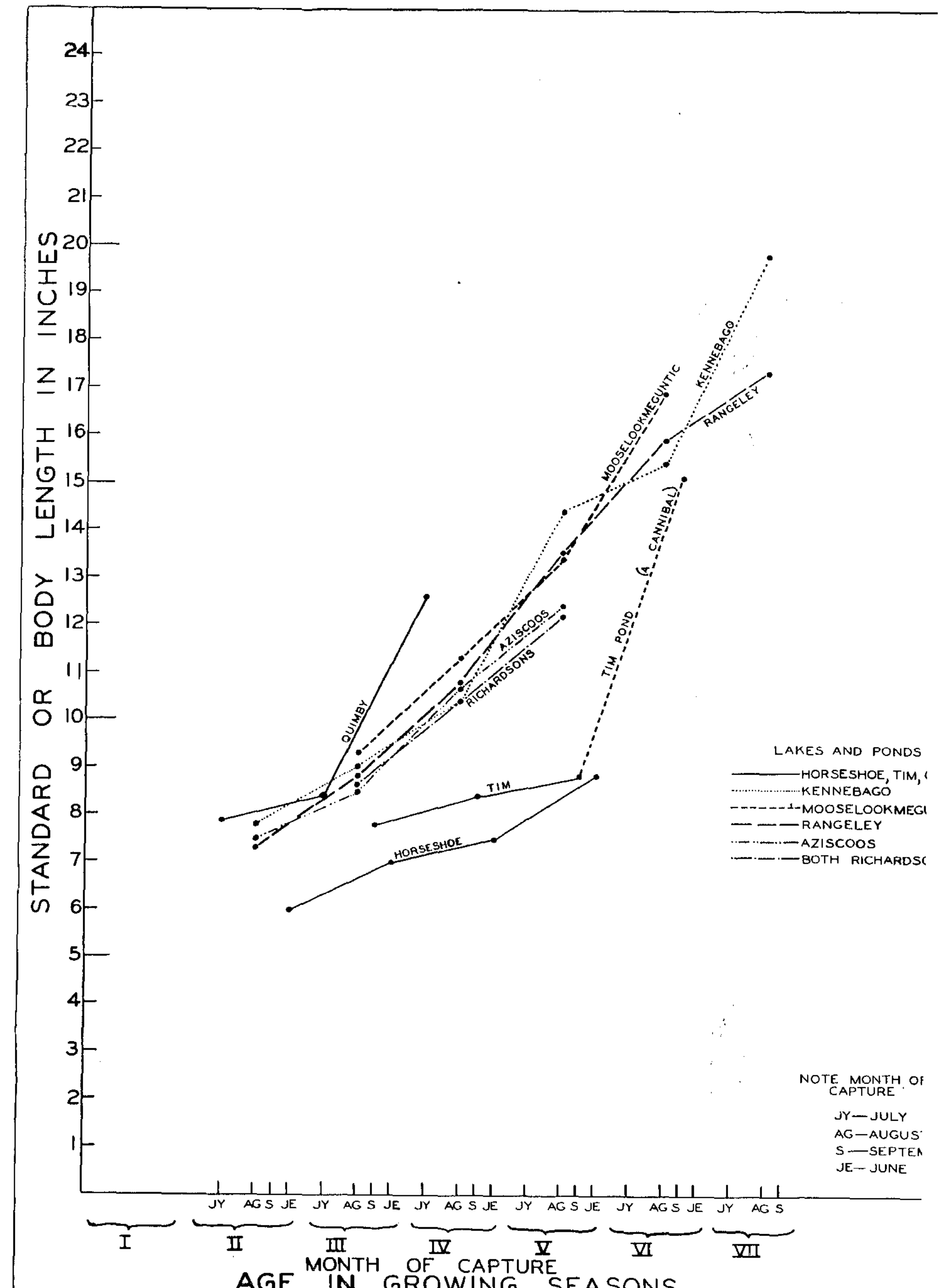

Figure 11. Age-length curves for Brook Trout (*Salvelinus f. fontinalis*) from the six Rangeley lakes and three other ponds in Maine. Data are from Table XXXI.

TABLE XXX. Average standard or body length (does not include tail) and average weight for each sex of each age group of Brook Trout (*Salvelinus f. fontinalis*) from twelve lakes and ponds in Maine

Lake, and date of collection	Sex	Number of growing seasons (summers of life) completed or partially completed (Includes the season or year in which fish were caught for all except those marked by an asterisk)																	
		II			III			IV			V			VI			VII		
		No. fish	Body length in inches	Weight in ounces	No. fish	Body length in inches	Weight in ounces	No. fish	Body length in inches	Weight in ounces	No. fish	Body length in inches	Weight in ounces	No. fish	Body length in inches	Weight in ounces	No. fish	Body length in inches	Weight in ounces
Lower Richardson Aug. 10 to 11, 1939	Male	..	....	.....	..	....	.....	4	10.9	12.8	..	....	.....	..	....	.....	..	....	.....
	Female	..	....	.....	..	....	.....	4	9.9	9.8	1	11.8	14.1	..	....	.....	..	....	.....
Upper Richardson Aug. 1 to 11, 1939	Male	..	....	.....	2	9.1	7.2	3	10.7	10.1	..	....	.....	..	....	.....	..	....	.....
	Female	..	....	.....	7	8.5	5.8	1	9.6	7.9	3	13.0	23.3	..	....	.....	..	....	....
Mooselookmeguntic and Cupsuptic lakes July 19 to 31, 1939	Male	..	....	.....	4	9.8	7.9	4	11.5	14.8	7	13.8	28.1	..	....	.....	..	....	.....
	Female	..	....	.....	7	9.2	7.0	8	10.6	11.0	3	12.2	18.1	2	17.2	84.9	..	....	.....
Mooselookmeguntic and Cupsuptic lakes Aug. 15 to 17, 1939	Male	..	....	.....	1	8.8	6.0	..	....	.....	1	13.5	21.7	..	....	.....	..	....	.....
	Female	..	....	.....	1	8.9	4.5	..	....	.....	..	....	.....	..	....	.....	..	....	.....
Mooselookmeguntic and Cupsuptic lakes Sept. 11 to 12, 1939	Male	..	....	.....	..	....	.....	2	13.5	24.9	1	14.8	30.3	1	16.3	42.1	..	....	.....
	Female	..	....	.....	..	....	.....	2	11.7	13.1	1	12.9	16.3	..	....	.....	..	....	.....
Rangeley Lake July 8 to 14, 1939	Male	4	7.0	3.3	5	8.4	5.6	13	10.9	12.6	4	12.7	22.9	..	....	.....	..	....	.....
	Female	2	8.1	5.2	11	8.8	5.4	22	10.9	12.9	2	11.6	15.5	1	15.6	42.4	1	17.3	69.6
Rangeley Lake Aug. 28 to Sept. 10, 1939	Male	1	6.8	2.4	4	9.1	6.0	..	....	.....	2	14.8	30.4	1	16.1	32.7	..	....	.....
	Female	..	....	.....	1	9.5	7.2	1	9.8	8.4	1	18.3	56.7	1	16.0	37.7	..	....	.....
Kennebago Lake Aug. 17 to 23, 1939	Male	1	7.8	6.3	12	9.3	6.3	18	10.7	10.4	4	14.3	27.5	3	16.1	38.5	1	19.8	50.6
	Female	..	....	.....	16	8.8	5.5	20	10.2	8.7	3	14.5	27.1	2	14.2	26.1	..	....	.....
Aziscoos Lake Aug. 31, 1939	Male	1	7.5	4.4	3	8.5	5.1	5	11.1	12.4	1	11.8	14.9	..	....	.....	..	....	.....
	Female	..	....	.....	..	....	.....	2	9.9	7.8	2	12.8	22.5	..	....	.....	..	....	.....
Adams Pond Bridgton Twp. July 1 to 2, 1938	Male	24	7.9	5.1	1	10.7	11.4	..	....	.....	..	....	.....	..	....	.....	..	....	.....
	Female	14	7.8	4.7	1	10.6	12.1	1	11.5	13.5	..	....	.....	..	....	.....	..	....	.....
Sabbathday Lake New Gloucester Twp. Aug. 14 to 18, 1937	Male	..	....	.....	..	....	.....	1	8.2	4.9	..	....	.....	..	....	.....	..	....	.....
	Female	..	....	.....	1	9.6	7.2	1	11.0	12.1	..	....	.....	..	....	.....	..	....	.....
B Pond Upton Twp. July 1 to 2, 1937	Male	..	....	.....	..	....	.....	1	12.5	17.5	..	....	.....	..	....	.....	..	....	.....
	Female	..	....	.....	..	....	.....	..	....	.....	3	15.0	33 1	..	....	.....	..	....	.....
Quimby Pond Rangeley Twp. July 23 to 24, 1938	Male	5	8.0	6.1	3	8.1	5.8	3	12.9	22.1	..	....	.....	..	....	.....	..	....	.....
	Female	10	7.9	5.4	1	9.3	8.9	..	....	.....	..	....	.....	..	....	.....	..	....	.....
Horseshoe Pond West Bowdoin College Grant June 2, 1939	Male	3*	6.0	.....	21*	7.1	.....	3*	8.0	.....	1*	8.5	.....	..	....	.....	..	....	.....
	Female	..	....	.....	24*	6.9	.....	4*	7.2	.....	1*	9.0	.....	..	....	.....	..	....	.....
Tim Pond T. 2, R. 4, Franklin Co. Sept. 13, 1939	Male	..	....	.....	13	7.8	3.9	5	8.3	4.7	2	8.3	4.2	1	15.1	30.4	..	....	.....
	Female	..	....	.....	3	7.9	4.1	12	8.4	4.7	3	9.1	5.5	..	....	.....	..	....	.....

TABLE XXXI. Average, and range (in parentheses) of standard (body) length, total length (including the tail), and weight for each age group of Brook Trout (*Salvelinus f. fontinalis*) from twelve lakes and ponds in Maine

Lake, and date of collection	Age in growing seasons or years*	Number of fish	Standard (body) length in inches	Total length (includes tail) in inches	Weight in ounces
Lower Richardson Aug. 10 to 11, 1939	IV	8	10.4 (9.0–12.3)	11.8 (10.3–13.9)	11.3 (6.8–20.2)
	V	1	11.8	12.9	14.1
Upper Richardson Aug. 1 to 11, 1939	III	9	8.6 (7.6–10.3)	10.0 (8.9–11.9)	6.1 (3.6–10.3)
	IV	4	10.4 (9.6–11.1)	11.9 (11.1–12.3)	9.6 (7.9–10.6)
	V	3	13.0 (12.0–15.0)	14.8 (13.4–17.1)	23.3 (13.9–38.3)
Mooselookmeguntic and Cupsuptic July 19 to Sept. 12, 1939	III	13	9.3 (7.5–10.1)	10.5 (8.3–11.5)	7.0 (3.6–9.0)
	IV	16	11.3 (8.2–14.6)	12.8 (9.5–16.5)	14.0 (4.5–31.5)
	V	13	13.4 (11.5–16.7)	15.1 (13.3–18.5)	24.6 (13.8–46.4)
	VI	3	16.9 (16.0–18.4)	18.9 (17.8–20.9)	70.6 (42.1–124)
Rangeley July 8 to Sept. 10, 1939	II	7	7.3 (6.7–8.8)	8.2 (7.5–10.1)	3.7 (2.4–6.2)
	III	22	8.8 (6.6–9.9)	9.6 (7.8–11.1)	5.6 (3.2–9.7)
	IV	36	10.8 (8.8–13.7)	12.2 (9.9–15.4)	12.6 (6.5–23.2)
	V	9	13.5 (10.9–18.3)	15.3 (12.4–20.3)	26.6 (12.2–56.7)
	VI	3	15.9 (15.6–16.1)	17.9 (17.5–18.3)	37.6 (32.7–42.4)
	VII	1	17.3	19.5	69.6
Kennebago Aug. 17 to 23, 1939	II	1	7.8	8.5	6.3
	III	28	9.0 (7.3–11.5)	10.2 (8.3–12.8)	5.8 (3.5–10.4)
	IV	38	10.4 (8.0–13.3)	11.9 (9.4–15.3)	9.5 (4.3–22.4)
	V	7	14.4 (13.0–16.5)	16.4 (15.1–18.9)	27.4 (16.9–51.4)
	VI	5	15.4 (13.8–17.1)	17.4 (16.3–19.5)	33.5 (26.1–49.0)
	VII	1	19.8	21.8	50.6

* Age in growing seasons means the number of growing seasons or summers of life completed or partially completed by the fish at the time they were collected. The June 2 fish from Horseshoe Pond had made no scale growth in 1939; therefore the 1939 growing season is not included in their age. The trout from all of the remaining ponds had made more than half of a normal year's scale growth during the summer in which they were collected; their age, therefore, includes the year of capture.

TABLE XXXI. Age of Brook Trout—Concluded

Lake, and date of collection	Age in growing seasons or years*	Number of fish	Standard (body) length in inches	Total length (includes tail) in inches	Weight in ounces
Aziscoos Aug. 31, 1939	II	1	7.5	8.5	4.4
	III	3	8.5 (8.0–9.0)	9.6 (9.0–9.9)	5.1 (4.4–5.7)
	IV	7	10.7 (9.0–13.8)	12.0 (10.3–15.0)	11.1 (6.5–23.1)
	V	3	12.4 (11.5–14.0)	14.0 (13.0–15.9)	20.0 (14.1–30.9)
Adams Pond Bridgton Twp. July 1 to 2, 1938	II	38	7.9 (6.8–9.1)	9.0 (7.9–10.5)	4.9 (3.4–9.1)
	III	2	10.7 (10.6–10.7)	12.0 (12.0–12.0)	11.8 (11.4–12.1)
	IV	1	11.5	12.6	13.5
Sabbathday New Gloucester Twp. Aug. 14 to 18, 1937	III	1	9.6	10.8	7.2
	IV	2	9.6 (8.2–11.0)	11.1 (9.4–12.7)	8.5 (4.9–12.1)
B Pond Upton Twp. July 1 to 2, 1937	IV	1	12.5	14.4	17.5
	V	3	15.0 (14.0–16.4)	17.2 (16.3–18.8)	33.1 (28.6–40.8)
Quimby Pond Rangeley Twp. July 23 to 24, 1938	II	15	7.9 (6.9–8.5)	9.2 (7.9–9.8)	5.7 (3.7–7.3)
	III	4	8.4 (7.6–9.3)	9.6 (8.8–10.6)	6.6 (5.0–8.9)
	IV	3	12.6 (12.0–13.0)	14.4 (13.8–14.8)	22.1 (21.7–22.7)
Horseshoe Pond West Bowdoin College Grant June 2, 1939	II	3	6.0 (5.9–6.2)	7.0 (6.9–7.3)	....
	III	45	7.0 (6.2–8.0)	8.2 (7.2–9.3)	....
	IV	7	7.5 (6.6–8.6)	8.8 (7.7–9.9)	....
	V	2	8.8 (8.5–9.0)	10.2 (9.8–10.6)	....
Tim Pond T.2, R.4 Franklin Co. Sept. 13, 1939	III	16	7.8 (7.3–8.3)	9.1 (8.6–9.8)	3.9 (3.4–4.5)
	IV	17	8.4 (7.8–8.9)	9.7 (9.1–10.3)	4.7 (3.6–6.2)
	V	5	8.8 (8.3–9.8)	10.1 (9.6–11.3)	5.0 (4.1–6.2)
	VI	1	15.1	17.5	30.4

TABLE XXXII. Average total length and average weight for each age group, and for all age groups combined, of Brook Trout (*Salvelinus f. fontinalis*) from twelve lakes and ponds in Maine, and for the six Rangeley lakes combined, based on survey collections

The number of specimens upon which each average is based is given in Table XXXI from which the figures in this table have been extracted for comparison. All figures given in heavy type are averages based on five or more specimens.

	Age in growing seasons*	Lower Richardson	Upper Richardson	Mooselookmeguntic and Cupsuptic	Rangeley	Kennebago	Aziscoos	All six Rangeley lakes (average)**	Adams Pond	Sabbathday Lake	B Pond	Quimby Pond	Horseshoe Pond	Tim Pond
Total length in inches	II	....	....	....	**8.2**	8.5	8.5	**8.4**	**9.0**	....	....	**9.2**	7.0	....
	III	....	**10.0**	**10.5**	**9.6**	**10.2**	9.6	**10.0**	12.0	10.8	....	9.6	**8.2**	**9.1**
	IV	**11.8**	11.9	**12.8**	**12.2**	**11.9**	**12.0**	**12.1**	12.6	11.1	14.4	14.4	**8.8**	**9.7**
	V	12.9	14.8	**15.1**	**15.3**	**16.4**	14.0	**14.8**	....	....	17.2	....	10.2	**10.1**
	VI	....	....	18.9	17.9	**17.4**	....	**18.1**	....	....	....	....	....	17.5
	VII	....	....	....	19.5	21.8	....	20.7	....	....	....	....	....	....
	All age classes	**11.9**	**11.4**	**13.2**	**11.8**	**12.1**	**11.6**	**12.0**	**9.3**	11.0	16.5	**10.0**	**8.3**	**9.7**
Weight in ounces	II	....	....	....	**3.7**	6.3	4.4	**4.8**	**4.9**	....	....	**5.7**	....	....
	III	....	**6.1**	**7.0**	**5.6**	**5.8**	5.1	**5.9**	11.8	7.2	....	6.6	....	**3.9**
	IV	**11.3**	9.6	**14.0**	**12.6**	**9.5**	**11.1**	**11.4**	13.5	8.5	17.5	22.1	....	**4.7**
	V	14.1	23.3	**24.6**	**26.6**	**27.4**	20.0	**22.7**	....	....	33.1	....	....	**5.0**
	VI	....	....	70.6	37.6	**33.5**	....	**47.2**	....	....	....	....	....	30.4
	VII	....	....	....	69.6	50.6	....	60.1	....	...	....	....	....	....
	All age classes	**11.6**	**10.2**	**18.8**	**13.2**	**11.8**	**11.2**	**12.8**	**5.5**	8.1	29.2	**8.1**	....	**5.1**

* See footnote to Table XXXI.

** Averages of the values given in this table for the individual lakes.

upward after the third year. The rate at which fish add length and weight to the body gives a clearer picture of rate of growth. The 8.4-inch fish at 2 years add 1.6 inches during their third year, 2.1 during the 4th year, 2.7 during the 5th, 3.3 during the 6th, and 2.6 during the 7th year. In weight, on the other hand, the 4.8-ounce fish at 2 years add 1.1 ounces during their third year, 5.5 ounces during the 4th, 11.3 during the 5th, 24.5 during the 6th, and 12.9 ounces during the 7th year.

The trout from Adams and Quimby ponds were fairly fast-growing fish, as compared to trout in the Rangeleys; the trout from Horseshoe and Tim ponds were definitely very slow-growing fish. The few fish from Sabbathday Lake and B Pond were considerably above average in size for their age.

Certain of the locality differences in growth of these trout are explainable on the basis of known facts concerning available food and density of the trout populations. It has been pointed out by several investigators[19] that trout living strictly on an insect diet do not reach so large a size as do trout living on a diet of fish. The present findings are consistent with this statement. Horseshoe and Tim ponds were reported by local residents to contain no fish except trout; and no fish, except one small Brook Trout, were found in stomachs of trout from these ponds (Table XVIII). On a diet almost strictly of insects, water-fleas, and other invertebrates, these trout were growing to a maximum length of about 11 inches. (The single 15-inch trout from Tim Pond was reportedly the largest one ever seen in the pond by local residents, and was presumably a cannibal.) Trout in Baker Mountain Pond were feeding mostly on insects and other invertebrates and no fish (Table XVIII), and local residents reported that trout seldom exceeded 12 inches in this pond. Trout in Quimby Pond, feeding entirely on insects and other invertebrates, had made fairly rapid growth, but reportedly rarely exceeded 13 inches in length. The difference in growth of trout in Quimby and Horseshoe ponds was attributable to food and trout abundance. Quimby was much richer in bottom food organisms (Table XIII), was fished much more heavily, and, according to our observations, had a less dense trout population. The fairly fast-growing trout from Adams Pond were presumably all hatchery fish. The trout which had been stocked in Adams were mostly legal-sized fish, and there was, therefore, an element of uncertainty as to how much of their growth had been made in the pond itself; the largest trout taken from the pond was 12.6 inches long, and all had been feeding mostly on plankton and bottom insects. In comparison to the slow growth and/or short life span of the trout in Horseshoe, Tim, Quimby,

[19] Kendall, W. C., 1918: The Rangeley Lakes, Maine; etc., see p. 579. *Also* Ricker, William E., 1931: Feeding habits of speckled trout in Ontario waters. Trans. Amer. Fish. Soc., Vol. 60 (1930), see p. 68.

Baker Mountain, and Adams ponds, the trout in all of the Rangeley lakes, on a fish diet, grow more rapidly and/or live to a greater age.

Age of Brook Trout. The maximum age among the 408 trout on which scale examinations were made was seven years, or two years less than that found for the Land-locked Salmon. The individual records for some of the oldest and largest trout obtained were as follows:

Mooselookmeguntic Lake:
- Female, 20.9 inches, 7¾ pounds, age 6 years
- Male, 18.0 inches, 2 pounds 10 ounces, age 6 years

Rangeley Lake:
- Female, 17.5 inches, 2 pounds 10 ounces, age 6 years
- Female, 17.8 inches, 2 pounds 6 ounces, age 6 years
- Female, 19.5 inches, 4 pounds 6 ounces, age 7 years

Kennebago Lake:
- Male, 17.3 inches, 2 pounds 3 ounces, age 6 years
- Male, 19.5 inches, 3 pounds 1 ounce, age 6 years
- Male, 21.8 inches, 3 pounds 3 ounces, age 7 years

It is of some interest that the heaviest trout was neither the longest nor the oldest.

The age frequency distributions of trout from the Rangeley lakes and from the six other ponds concerned were as follows:

Age group:	II	III	IV	V	VI	VII
Number from Rangeley lakes..........	9	75	109	36	11	2
Number from other ponds.............	56	68	31	10	1	..

Net selectivity among II-year fish, scarcity of II-year fish in the lakes, variations in abundance of year classes, and fishing intensity, probably all had some effect on the above age distribution. Trout in the Rangeleys reach the legal length of 10 inches in the two Richardsons, Mooselookmeguntic, and Rangeley lakes by their third year, and the legal lengths of 8 and 7 inches in Aziscoos and Kennebago lakes somewhat sooner. Therefore the great majority of the trout which the survey found to be present in these lakes were available to the angler. The legal size limits of 7 and 8 inches for Tim, Horseshoe, and Quimby ponds also makes most fish in the above age classes for these ponds available to fishermen. The above figures indicate that trout in the Rangeleys live longer, on the average, than do trout in the smaller ponds. The decline in numbers of fish after the IV-group in the Rangeleys and the III-group in the smaller ponds is attributable partly to normal mortality (see data for the very lightly fished Horseshoe Pond — Table XXXI) and probably partly to fishing intensity.

Records of maturity of individual trout from the Rangeley lakes are summarized only for the females, as follows (data for males are unsatisfactory): 33 out of 43 III-year fish were maturing to spawn in the fall; 11 out of 20 IV-year fish from Kennebago Lake and all IV-year fish from the Richardsons, Mooselookmeguntic, and Rangeley lakes were mature; and all fish older than IV years were mature.

Since all IV-year fish from the lakes except Kennebago, and all V-, VI- and VII-year fish from all of the lakes were developing eggs for spawning in 1939, it is concluded that all of these older trout in the Rangeley lakes spawn probably every year.

TRIBUTARIES OF THE RANGELEY LAKES

Information on water temperatures, amount of water, abundance of insect food, the extent of pools and cover for fish, and the fish populations of most of the larger tributaries of the Rangeley lakes was obtained by the 1939 survey. A partial summary of this information, and an evaluation of these waters as breeder streams for trout and salmon, are given in this section.

Tributaries of the Richardson lakes

Metallock Brook. This brook was examined on August 10. The water temperature was 66 degrees Fahrenheit at 12 Noon. The water flow was approximately 4 cubic feet per second (c. f. s.). The pools were found to be of low carrying capacity and were given a C grade. Bottom food organisms were quite rare, and the stream was graded as III for food. Young trout were much more abundant than young salmon.

Mosquito Brook. August 10. Water temperature 66. Water very dark brown and acid. Flow 1 c. f. s. Pools A. Food III. Suitable for stocking with trout, but not salmon.

Beaver Brook, the outlet of Big Beaver Pond. August 10. Water temperature 77, with air temperature 72; stream decidedly too warm for stocking either trout or salmon. Flow 1½ c. f. s.

Tributaries of Mooselookmeguntic Lake

Cupsuptic River. September 13. Water temperature 56. Flow estimated at 70 to 90 c. f. s. Pools B. Good III. Trout abundant. The most important breeding stream of the trout in Mooselookmeguntic.

Toothaker Brook, tributary to Cupsuptic River. September 13. Water temperature 54. Flow 5 c. f. s. Pools B. Food III. Young trout very abundant.

Kennebago River, below Oquossoc Light and Power Company dam. September 12. Water temperatures 56, 59, and 61. Flow estimated at 80 c. f. s. Pools B. Food III. Young salmon more abundant than trout. The most important breeding stream of the salmon.

Bemis Stream. August 12. Water temperature 62. Flow 300 gallons per minute (g. p. m.). Pools B. Food III. Brook Trout abundant; no salmon seen. A good trout breeder stream.

Tributaries of Rangeley Lake

South Bog Stream. July 9. Water temperatures 68 and 72; temperatures approaching upper limit for trout. Flow 4 c. f. s. Pools B. Food grade III. Trout abundant; no young salmon seen. A very large population of minnows and suckers present, undoubtedly seriously competing with the trout for food. The best trout feeder stream on Rangeley Lake.

Dodge Pond Stream. September 7. Water temperature 54. On September 7 there was no water running out of Dodge Pond, and the stream was dry to pools. Young salmon were abundant in these few pools between Dodge Pond and Rangeley Lake. No trout seen. Competing minnows abundant. The stream is a breeding ground for Rangeley Lake salmon, but it has very low carrying capacity for the young.

Long Pond Stream. September 7. Water temperature 58 with air temperature 54 (temperatures of little significance). Flow 100 g. p. m. in lower section. Upper section nearly dry to pools, with a flow of 25 g. p. m. out of Long Pond. Pools B. Food II. Trout common; no salmon seen. A fair feeder stream but of low carrying capacity.

Hatchery Brook. September 7. Water 54. Flow 75 g. p. m. Stream very small.

Quimby Brook. September 7. Water 50. Flow 40 g. p. m. Stream very small.

Tributaries of Kennebago Lake

Flatiron Brook. August 24. Water temperature 67. Flow 100 g. p. m. Pools C. Food III. Lower section of stream precipitous, and filled with large boulders. Stream not accessible for trout from the lake.

Wilbur Brook. August 24. Water temperature 60. Flow 150 g. p. m. Pools B. Food II. Young trout very abundant; no other fish seen. Stream small but accessible to fish from the lake, and is of some value as a feeder stream.

Big Sag Brook. August 24. Water temperature 76, or near the maximum for trout, with an air temperature of 82. Flow 5 c. f. s. Pools B. Food II. Young trout rare; no salmon seen. The lower section of the stream is of some value as a trout feeder stream for the lake, but is limited because of high temperature.

Little Kennebago River, up to Little Kennebago Lake. August 24. Water temperature 76, with an air temperature of 80. Flow 20 c. f. s. Pools B. Food II. Young salmon much more abundant than young trout. The two-mile section of this stream has a large

carrying capacity for young fish, but apparently is much better suited to salmon than to trout. It was reported that salmon have been in Kennebago Lake for about 30 years, but are still not nearly as abundant as trout. It appears, therefore, that the present preponderance of young salmon over trout in the Little Kennebago River does not necessarily mean that the salmon is on the verge of outnumbering the trout in Kennebago Lake.

Tributaries of Aziscoos Lake

Magalloway River. September 8. Water temperature 60. Flow estimated at 50 c. f. s. Pools B. Food III.

Little Magalloway River. September 8. Water temperature 54. Flow 11 c. f. s. Pools C. Food III.

Meadow Brook. September 9. Water temperature 55. Flow 1 c. f. s. Pools C. Food III.

Twin Brook. September 1. Water temperature 54. Flow 4 c. f. s. Pools B. Food II.

Lincoln Brook. September 8. Water temperature 53. Flow 1 c. f. s. Pools B. Food II.

Big Brook. September 8. Water temperature 52. Flow 5 c. f. s. Pools C. Food II.

In addition to the above survey data on the tributaries of Aziscoos Lake, water temperatures taken during the summer of 1937 by Deputy Warden Charles Smart were available, as follows:

Big Magalloway River: (fast water, below Parmachenee L.)	July 29 — 65° F. Aug. 3 — 68° F. Aug. 8 — 72° F.
Big Magalloway River: (fast water, above Parmachenee L.)	July 29 — 64° F. Aug. 3 — 65° F. Aug. 14 — 64° F.
Little Magalloway River (fast water):	July 25 — 68° F.
Hurricane Brook (fast water):	July 24 — 58° F. July 26 — 60° F. Aug. 9 — 60° F. Aug. 13 — 60° F.
Meadow Brook (fast water):	July 25 — 60° F. Aug. 14 — 58° F.
Big Brook:	Aug. 3 — 65° F. Aug. 14 — 64° F.
Twin Brook:	Aug. 13 — 56° F. Aug. 14 — 56° F.
Lincoln Brook:	Aug. 14 — 64° F.

The above data on the tributaries of the Rangeley lakes may be summarized briefly as follows: Mooselookmeguntic and Aziscoos lakes have tributaries with more extensive spawning grounds and a much greater potential capacity for the production of young trout and salmon than do the other four lakes; and these two lakes should be the more self-sustaining in fish production under heavy fishing intensity. The potential capacity of the tributaries of Kennebago Lake and the Richardson lakes is considerably less, and apparently insufficient to support intensive fishing on the lakes over a period of years without some aid by artificial propagation. Rangeley Lake is the most poorly supplied with good tributaries, unless the five small surrounding ponds and their tributaries are considered as a source of natural stocking for the lake.

THE FISH POPULATIONS AND FISHING INTENSITY IN THE RANGELEY LAKES

The results of the present survey on the Rangeley lakes as described on preceding pages of this report have much more significance and greater applicability when considered in connection with a knowledge of the present and past fishing intensity and a knowledge of certain changes in size and abundance of trout and salmon in the lakes. The late Dr. W. C. Kendall,[2] in his 1918 report on these lakes, included a great deal of information on the history of fishing, of catch records, of size of fish, of relative abundance of trout and salmon, and of other factors; most of this information was obtained by Kendall from reports (presumably mostly reliable) in early sporting magazines, books, and newspapers, and from records in local sporting camps and hotels. Historical data on fish and fishing have been extracted from Kendall's report, and some information has also been otbained from other sources. Information on present fishing intensity and on the numbers of trout, salmon, and smelt taken from the Rangeley lakes per year have been obtained from records kept by the local Fish and Game Wardens. Some information has also been obtained from local guides and fishermen. Information on past and present stockings of fish, and other data on the fish populations, have been obtained from members of the fish hatchery service. The purpose of this section of the present report is to present a summary of this available information on the history of the fish populations and of the intensity of fishing, and to correlate it with the results of our 1939 survey as a basis for various fish management recommendations.

Early Fishing. The Rangeley lakes have furnished excellent Brook Trout fishing since the days of the first local settlers and visiting sportsmen. Perhaps some of the accounts of this early trout fishing

[2] See footnote p. 11.

which have been passed along by word of mouth for two generations have "stretched" the actual facts somewhat. On the other hand, there are numerous and apparently reliable reports in many early books and sport magazines which do give a picture of fishing conditions in the past. There is good reason to believe the current reports by the older sportsmen now fishing the Rangeleys that in years past there were hundreds of pounds of trout dumped into the garbage can because the supply of fish and the fisherman's appetite for fishing were far greater than his capacity to consume his catch.

One of the earliest books on fishing in the Rangeleys, which has come to the writer's attention, contains considerable information which is of interest when compared with the findings of the present survey. The book in question is by R. G. Allerton[20] (1869), one of eleven members of the Oquossoc Angling Association who made a "trout fishing excursion" to the Rangeley lakes in the month of June, 1869; the book is a description of that trip. The Oquossoc Angling Association's camp was located at the mouth of the Kennbago River and it seems probable that the Association members fished on Mooselookmeguntic and Rangeley lakes, and Kennebago, Cupsuptic, and Rangeley streams, if not more extensively. (The author does not state exactly where the fishing was done, but merely that it was a fishing trip to the Rangeley lakes.) The extensive detail of the fishing records given by Allerton is quite unusual and supports the present writer's belief that the records are reliable. Allerton's records are of some interest in connection with the number of fishermen visiting the Rangeley region during a portion of June, 1869. He states that, in addition to the eleven members of the Oquossoc Angling Association, "Numerous other angling parties visited the fishing grounds during the stay of the Oquossocs, and all were very successful in taking trout. Below will be found the names of a few of the angling gentlemen present:" (The author then lists the names of eleven visiting fishermen.) If eleven constituted "a few" of "numerous other angling parties," it seems safe to assume that there were at least 50 to 100 fishermen (and possibly more) present during this month. This represents a fairly heavy concentration of fishermen for that time, considering the fact that fishermen had to travel by stage or buckboard and over poor roads for a distance of about 25 miles in order to reach the lakes from the nearest railroad. The number of fishermen at that time, however, was hardly comparable to the present fishing intensity of over 8,000 fishermen-days per year on the Rangeley lakes (Table XXXIII).

The most instructive part of Allerton's book is the section giving

[20] Allerton, R. G.; 1869. Brook trout fishing. An account of a trip of the Oquossoc Angling Association to northern Maine, in June, 1869. Printed by Perris and Browne, 164 Fulton Street, New York.

records of the number and weight of Brook Trout caught in 1869 by the eleven members of his party. It follows:

Following is an exact account of the numbers and weights of thirty brook trout taken by eight of the party; average time of fishing about six days each. In this list none are mentioned under four pounds each, although an immense quantity of smaller ones were taken. It is, without doubt, the greatest catch of large brook trout by any one party, in the same time, ever known; and the world is challenged to produce a record that will surpass or even equal the following:

WEIGHTS AND NUMBERS OF THIRTY LARGE BROOK TROUT

3	Brook	Trout	4	pounds	each.
1	"	"	................$4\frac{1}{4}$	"	
1	"	"	................$4\frac{1}{2}$	"	
2	"	"	................$4\frac{3}{4}$	"	each.
3	"	"	5	"	"
1	"	"	................$5\frac{1}{4}$	"	
4	"	"	................$5\frac{1}{2}$	"	each.
2	"	"	6	"	"
2	"	"	................$6\frac{1}{2}$	"	"
2	"	"	................$6\frac{3}{4}$	"	"
2	"	"	7	"	"
1	"	"	................$7\frac{1}{4}$	"	
1	"	"	................$7\frac{1}{2}$	"	
3	"	"	8	"	each.
1	"	"	................$8\frac{1}{2}$	"	
1	"	"	9	"	

Making 30 Trout, total weight $181\frac{1}{4}$ lbs., averaging over 6 lbs. each.

The "taking" was pretty fairly divided among the party; but a few items of individual skill will be of interest.

Mr. Cooke was fortunate enough to return to camp on the evening of June 2nd, with a magnificent seven-and-a-half-pounder alive in his car, and two or three days later took this beautiful specimen of the finny tribe to his home near Philadelphia, where upon his arrival he gave a grand dinner, at which the "giant captive" was the attractive dish. The Press of Philadelphia was well represented on the occasion. Mr. C. on another day captured one of 3 lbs. and one of 4 lbs.

Mr. Reed took one $3\frac{1}{4}$ and one $7\frac{1}{4}$ lbs.

Mr. Page one 3, one 4 and one 6 lbs.

Mr. Baker one $2\frac{1}{2}$, and one $4\frac{3}{4}$ lbs.

Mr. Gilbert one 3, one $3\frac{1}{4}$, one $4\frac{1}{4}$, one $5\frac{1}{4}$, and one $6\frac{3}{4}$ lbs.

Mr. Fahnestock one $2\frac{1}{2}$, one $3\frac{1}{2}$, one $4\frac{3}{4}$, and one 5 lbs.

Mr. Badgley two of $5\frac{1}{2}$ lbs. each, one $6\frac{3}{4}$ lbs., one 8 lbs., and one 9 lbs., making five trout, averaging nearly 7 lbs. each.

Mr. Badgley's nine pounder ranks as the largest trout taken this year. Mr. B. caught during one day, in less than two hours, three of those given in his list weighing $6\frac{3}{4}$, 8, and 9 lbs.; total weight $23\frac{3}{4}$ lbs.

Mr. Allerton, who remained considerably longer than any of the other gentlemen, caught as follows:

Two of 5 lbs. each, two of $5\frac{1}{2}$, one of 6, two of $6\frac{1}{2}$, two of 7, one of $7\frac{1}{2}$, two of 8, and one of $8\frac{1}{2}$, making thirteen trout, weighing 86 lbs. and averaging 6 lbs. 10 oz. each. Mr. A. caught, in addition to the above, twenty-seven trout, weighing 61 lbs., from one lb. up to five lbs. each, averaging $2\frac{1}{4}$ lbs.; also, 207 weighing $87\frac{1}{4}$ lbs., under one lb. each, averaging $6\frac{3}{4}$ ozs.; total catch, 247 trout weighing $234\frac{1}{4}$ lbs., averaging nearly one pound each.

The best twenty trout of the last-mentioned angler's taking, averaged $5\frac{1}{2}$ lbs. each, and the best forty 3 lbs. 11 oz. each. Of these trout he caught four in three-quarters of an hour on the afternoon of June 22d, that being

his last half day's fishing, as he left for home next morning. The four weighed respectively 5, $5\frac{1}{2}$, 6, and 8 lbs., making a total of $24\frac{1}{2}$ lbs. of trout caught in three-quarters of an hour, a very satisfactory "wind up" to the grandest fishing excursion confessedly ever made by him.

The trout caught this season of 7 to 9 lbs. measured from 25 to 28 inches in length, and from 14 to 20 inches around. The tails, when spread, measured from $5\frac{1}{2}$ to 8 inches across.

It appears from Allerton's records that the 30 large Brook Trout which he lists in table form included all of the fish weighing 4 pounds or more which were caught by his party. Of particular interest then is the fact that these large trout were so evenly distributed over the weight range of 4 to 9 pounds. A more normal abundance curve with many more 4 to 6 pound fish might have been expected.

The total catch of Brook Trout by Mr. Allerton himself over a period of about three weeks (judging from dates given at various places in his book) is of particular interest. It included:

207 trout, each less than 1 lb., total wt. $87\frac{1}{4}$ lbs., average weight $6\frac{3}{4}$ ozs.
27 trout, each 1 to 5 lbs., total wt. 61 lbs., average weight $2\frac{1}{4}$ lbs.
13 trout, each 5 to $8\frac{1}{2}$ lbs., total wt. 86 lbs., average weight 6 lbs., 10 ozs.

Total 247 trout, up to $8\frac{1}{2}$ lbs., total wt. $234\frac{1}{4}$ lbs., average weight 15 1/6 ozs.

These fish represent Allerton's total catch for a period of three weeks, and judging from his own account he caught about half of the 30 fish weighing 4 pounds or more, which were taken by the entire fishing party of 11 men. From Allerton's own statement that the catch of 30 large trout taken by his party "is, without doubt, the greatest catch of large brook trout by any one party, in the same time, ever known," it may be concluded that Allerton's own catch was unusual or somewhat above the average in numbers of large fish.

The history of trout and salmon fishing in the Rangeley lakes as treated extensively by Kendall[2] (1918) was concerned mostly with the period from about 1870 to 1914. The following accounts of the histories of the Land-locked Salmon, Brook Trout, Blueback Trout, and Smelt, have been extracted entirely from Kendall's report. Kendall cited the original sources for most of his information; but these original sources have not been included in the present discussion. The histories of the Smelt and Blueback Trout are given first, because of the importance of the populations of these two species to the trout and salmon.

History of the Smelt. The Smelt was first introduced into the Rangeley lakes in 1895 or possibly as early as 1891. The first smelts were of a type which matured at about three inches in length. Later a larger race of Smelt was planted in Mooselookmeguntic Lake. Smelts were described by local residents, visiting fishermen, etc., as "appearing in considerable numbers within four years" (or about

[2] See footnote p. 11.

1900); as "running up Dodge Stream 'in bushels' " in 1904 (Dodge Stream or Dodge Pond Stream is a tributary of Rangeley Lake; as "plenty in all the lakes from Rangeley down" in 1907) as "seen in great numbers" in the spawning run in Kennebago River at Indian Rock in 1907; as "One man dipped 4 bushels of smelts" in 1907; and "the quantity is said to be unlimited" in 1910. It would appear, without doubt, from the above that the Smelt was well established and rapidly increased in abundance in these Rangeley lakes from this first planting.

The immediate reaction of many fishermen to this establishment of the Smelt was that it was ruining the fishing. These fishermen maintained that trout were gorging themselves with smelts and consequently would not bite. A report by a Rangeley lakes correspondent in Forest and Stream for June 12, 1897, said:

> Perhaps the poor fishing in Mooselucmaguntic and Richardson Lakes is due to the smelts, which have appeared in great numbers for the first time this spring. Perfectly reliable guides say that the water has been alive with these smelts. Later they have died by the thousands and have been seen floating on the surface dead or dying. Every trout caught has been simply gorged with these smelts. This I saw myself in the case of trout being dressed. The question of these smelts ever having been introduced into the Rangeley waters is a very grave one. Guides and sportsmen who have watched and fished these waters for years are in doubt, to say the very least, and some of them are mad all through. I heard it freely expressed that the most wonderful brook-trout fishing of the world — at the Rangeleys — has been ruined by putting in smelts for land-locked salmon food — land-locked salmon that can, at the very best, never equal what the brook trout have been to these waters. As for myself, I have no opinion at present. The smelts in the maw of the trout I have seen and have seen the dead smelts on the water. I have also seen the remarkably fattened condition of the trout as compared with the fish of the past 20 years, with which I have been familiar, catching and examining them each year in greater or less numbers. . . .

Another report in the same paper for May 20, 1899:

> The fishing has not been up to former seasons, since the water is the highest ever known, and in both Richardson and Mooselucmaguntic Lakes are millions of smelts, many of them dead from spawning. The trout are "just gorging" on these smelts and will not take artificial flies or other bait till the smelts are gone. Still a few trout are taken.

Still another report, entitled "Rangeley trout and the smelts," in the same paper for August 30, 1902, refers to the overabundance of the Smelt:

> Boston, August 23: Mr. Henry W. Clarke, of Boston, a veteran angler in the Rangeley waters, has just returned from a stay of seven weeks at the Mountain View, foot of Rangeley Lake. This was Mr. Clarke's twenty-eighth successive annual trip to those waters, and his opinions naturally carry a good deal of weight on angling subjects. He says that of all the seasons he has ever spent there the past has shown the poorest fishing. His idea is that the poor fishing is largely due to the putting of smelts into the Rangeleys. He says that the smelts are in deep water the most of the season, only going up into the streams to spawn in the spring. The trout have found them better eating than the old-time minnows, for which the Rangeleys have always been noted, and, like the salmon, they follow the smelts into deep water. Mr. Clarke says that he caught one trout, hardly 3 pounds' weight, which had in its throat and maw 53 smelts. He adds: "It must have taken my hook out of idle curiosity. There could have been no other reason for its biting." Mr. Clarke regards the stocking of the Rangeleys with smelts as a dangerous experiment at the best. He believes that the trout fishing has been greatly injured thereby. Mr. C. P. Stevens, another veteran angler at the Rangeleys, has the same idea. He says never has the trout fishing been so poor in the vicinity of his cottage, in the narrows, Richardson Lake. It is the opinion of other "old timers" at the Rangeleys that the big trout of that region are done for, and it is certain that not half the usual number have been caught the past season, while the catch of salmon has been greater.

Other accounts refer to the finding of large numbers of smelts in trout stomachs. There can be no doubt, judging from the above that trout made use of the smelt food supply as soon as it was established. These early fishermen may have been partially correct in concluding that the abundance of Smelt was spoiling their fishing, at least by making it more difficult to catch the trout that were present. The abundance of smelts may have made it more difficult to catch trout, but there is no reason to believe that it caused a decrease in the trout population; rather, it appears obvious from all data available that the added smelt food supply, plus the possible fact that the well-fed trout were more difficult to catch, resulted in a building up of the trout population (see Figure 12). It is the present writer's opinion on the basis of the 1939 survey, that the Smelt is a distinct asset to trout and salmon fishing in the Rangeley lakes. Kendall[2] (p. 580), on the basis of his studies, expressed the same opinion, when he wrote:

> It may be affirmed that the only fish that has been wisely introduced into Rangeley Lakes is the smelt. It has directly or indirectly been the savior of the trout by affording the trout requisite food and detracting to some extent the attention of the salmon from trout by furnishing sufficient natural food.

History of the Blueback Trout. The Blueback Trout (*Salvelinus oquassa*) was native to certain of the Rangeley lakes, namely: Rangeley, Mooselookmeguntic, and the Richardsons. It was mostly 6 to 9 inches long, was a deep-water fish, but migrated into streams in October to spawn. Reports indicate that it was occasionally caught by bait fishing in fairly deep water, but was caught mostly on the spawning grounds. The usual method of capture was by net, such as a bag hung on a wooden hoop. Some were also taken by hook and line on the spawning grounds; one man reported catching 1½ bushels in one day with a baited hook (this catch must have been over 500 fish). Starting before 1850, bluebacks were taken in large quantities. One report stated that the usual catch by net was several bushels per man in one night. Another report referred to the fish having been hauled away in barrels and cartloads. The surprising fact is that the blueback appeared to maintain its abundance for 30 to 40 years in spite of this slaughter. There was some justification

[2] See footnote p. 11.

for the local residents taking the Blueback, as the fish constituted an important part of their food supply. The fish were either salted, dried, or smoked, and used as food from one fall season to the next. Bluebacks were also marketed to some extent. When the first law was passed in 1869 giving some protection to the Brook Trout in the Rangeleys, the Blueback Trout was exempted because of its importance to the local residents.

One of the first recognitions of the possible importance of the Blueback to trout fishing in these waters was a statement in the Maine Fish Commissioner's Report for 1874 to the effect that it was a mistake to allow the Blueback to be taken at all as they were an important food of the Brook Trout and were responsible for their large size. There were other early references to the importance of the Blueback to Brook Trout, and to the finding of Bluebacks in their stomachs.

The decline of the Blueback Trout in the Rangeleys started in the early 1890's. A special law was passed in 1899 giving them protection; it read that "it be unlawful to fish for, take, catch, or kill any blueback in any waters of the State at any time." The law was too late. A few large bluebacks were taken for fish culture in 1902; five were taken in 1903; three in 1904; but none have been reported since then. The last of the bluebacks were unusually large in size (up to 2 or 2½ lbs.), and this fact was believed by Kendall to have been due to these few remaining fish feeding on the Smelt which was introduced in 1895 and had become abundant by 1900. The great decline of the Blueback in the early 1890's coincided with the great increase in abundance of the salmon (introduced in 1875). It may have been that over fishing of bluebacks on the spawning grounds was, in part, responsible for their depletion, but it was Kendall's opinion that predation by salmon was the most important factor.

History of the Brook Trout. The records compiled by Kendall from Forest and Stream, the American Angler, and Maine Woods were considered by that author as fairly complete for the larger trout taken from the Rangeley lakes. The largest Brook Trout taken, for which the record is authentic, was one of 12½ pounds caught in 1867; and there is an element of uncertainty as to its exact weight. There is an authentic record of a 12-pound trout taken in 1878. There are two other records of fish in this 12-pound class, one of a 12-pounder and one of a 12½-pounder, but neither records are free from doubt. There are authentic records of about 20 fish of 10 pounds or more in weight. The complete records of numbers of Brook Trout eight or more pounds in weight for the 45 years from 1867 to 1911 were summarized by weight class and by year, as follows:

Year:	67	72	73	77	78	79	83	84	85	86	87	88	90	96	97	98	01	03	06	07	08	10	11
12–12½ lbs.	1?	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11–11.9	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
10.5–10.9	1	.	.	.	1	.	.	.	1	1	.	1	1	.	1	.	.	.	.	.	.	.	.
10–10.4	1	.	1	.	2	.	.	.	1	.	.	.	.	.	.	1	.	1	.	1	1	.	.
9.1–9.9	1	1	1	1	2	.	1	2	2	1	2	.	1	1	3	.	1	.	1	.	.	1	1
9	A total of 11 nine-pound fish in these 45 years																						
8–8.9	A total of over 60 fish from eight up to nine pounds																						

The great majority of the fish over 10 pounds were taken from the spawning grounds by hatchery men. The majority of the 8- to 10-pounders were taken by anglers. A total of the above figures gives 28 trout of over nine pounds in weight for the 22 years from 1867 to 1888, and 15 trout over nine pounds in weight for the 23 years from 1889 to 1911. This 46 per cent drop in numbers of large trout reported, occurred in spite of the fact that fishing intensity probably was at least doubled in the second period over that of the first. The figures indicate a definite tendency towards a decrease in both maximum size and numbers of these exceptionally large trout over the 45-year period.

The early records leave no doubt of the fact that the average angler sixty years ago took a considerable quantity of trout from the Rangeley lakes. Those catches which were reported in magazines and newspapers usually contained relatively few fish of large size, rather than a large number of small fish. The fishermen probably caught considerable numbers of smaller fish (see Allerton's catch — p. 143) but usually released them. The following are a few (probably better than average) catches which were reported:

First week in August, 1884: one man took eight trout, weight 38 pounds.

One day in August, 1884: one man took five trout, weight 28 pounds.

A one-day trolling record in April, 1896: one man caught one 9-pound and one 9¼ pound trout. "This spring hundreds were caught this way ranging from 1 to 5 pounds."

One man's six-day trolling record in June: 32 trout from 1 to 7 pounds each, total weight 85 pounds.

On August 6, 1874: two fishermen on Mooselookmeguntic took 26 trout, weight 30 pounds.

On August 20, 1880: two fishermen in four hours on Mooselookmeguntic Lake took 17 trout, weight 52 pounds, as follows: one, 8½; one, 5½; one, 5; one, 4½; two, 4; one, 3½; three, 3; one, 2; and six 1-pound fish.

The following is a list of trout reported to have been caught on flies at Upper Dam by all fishermen during the period of August 29 to September 30, 1890; one, 9 1/8 pounds; one, 8 7/8; one, 8 3/16; two, 7 12/16; one, 7 7/16; one, 7 5/16; one, 7 3/16; one, 6 7/8; two, 6¾; three, 6½; one, 6 5/16; two, 6¼; three, 6 3/16; one, 6 1/16; two, 5 5/16; one, 5; one, 4 7/8; one, 4½; and 1 trout, 4 pounds. Presumably many smaller fish were caught, not recorded, and probably mostly released.

Hook and line was not the only method commonly used in taking Rangeley trout. Spearing was a common practice among local residents who salted down a supply for winter use, and also sold them on the market. A record for the fall of 1854 stated that two men spearing on Trout Cove took in one night 100 trout weighing 600 pounds. In a letter written in 1879 by H. O. Stanley, then Fish Commissioner of Maine, to a Mr. Rich, Stanley stated that he could well remember the time, some 20 years prior (or about 1859) when it was very common to take 100 pounds of trout in one-half day's fishing, but since that time the practice of taking them with grapnel, spears, and nets had become common, and the fish were greatly diminished.

The above statement by Stanley that trout were greatly diminished by intensity of fishing was an opinion shared by other anglers. An article in Forest and Stream in 1888 refers to the poor fishing in the Rangeley lakes and attaches most of the blame to workingmen at the dams using spears and dynamite on the trout spawning grounds. All published reports reveal a rapid increase in numbers of fishermen, even before the first railroad was extended to the Rangeley area in 1891, but accurate data on the numbers of fishermen which were present are extremely meager. From Allerton's book (see p.141) it might be inferred that the total number of anglers visiting the area during 1869 was certainly not over several hundred, and probably much less. Furthermore, each of these men apparently fished only a few days, as Allerton, in three weeks, caught about as many fish as were caught by the other ten members of the Oquossocs combined. There was a report for 1883 that 3,000 annual visitors came to the Rangeley region. In a more recent statement by the proprietor of the Mountain View House on Rangeley Lake, it was pointed out that most July and August guests came to the region for activities other than fishing. The 3,000 annual visitors in 1883, therefore, were probably not all fishermen. A correspondent to a sportsmen's journal for June 8, 1889 estimated that there were 1,000 people on the Rangeley lakes during the previous week.

The records for the total number of trout taken by anglers from the region are very incomplete, largely because no records were kept of many anglers' catches. The figures available are more reliable in indicating trends than in revealing total numbers of fish caught. The records, in part, of numbers of trout reported, as compiled by Kendall for the Rangeley chain, including Rangeley, Mooselookmeguntic, the Richardsons, and Pond-in-the-River, but not Umbagog, Kennebago, or Aziscoos lakes, were:

1895	186	1902	56	1909	92
1896	10	1903	207	1910	163
1897	75	1904	13	1911	237
1898	242	1905	83	1912	170
1899	45	1906	95	1913	99
1900	29	1907	150	1914	124
1901	16	1908	80	1915	96

Kendall further summarized his data on number of trout reported

from all of these Rangeley waters, into 13 periods of six years each, and overlapping three years, as follows:

1873–1878	1,092	1894–1899	589
1876–1881	356	1897–1902	464
1879–1884	945	1900–1905	415
1882–1887	1,017	1903–1908	654
1885–1890	521	1906–1911	832
1888–1893	451	1909–1914	885
1891–1896	257		

and he presented this summary data in graph form, see Figure 12. On the basis of the above data, Kendall stated:

> . . . . the inference is that the number of trout greatly decreased until the nineties, when they increased again, but the highest later numerical record, 1914, did not attain to the quantity recorded in the seventies and early eighties. However, there appears to be but little change in the general average weight, and really large fish were taken every year, but not quite so many in any one of the later years as in the earlier years represented by the records.

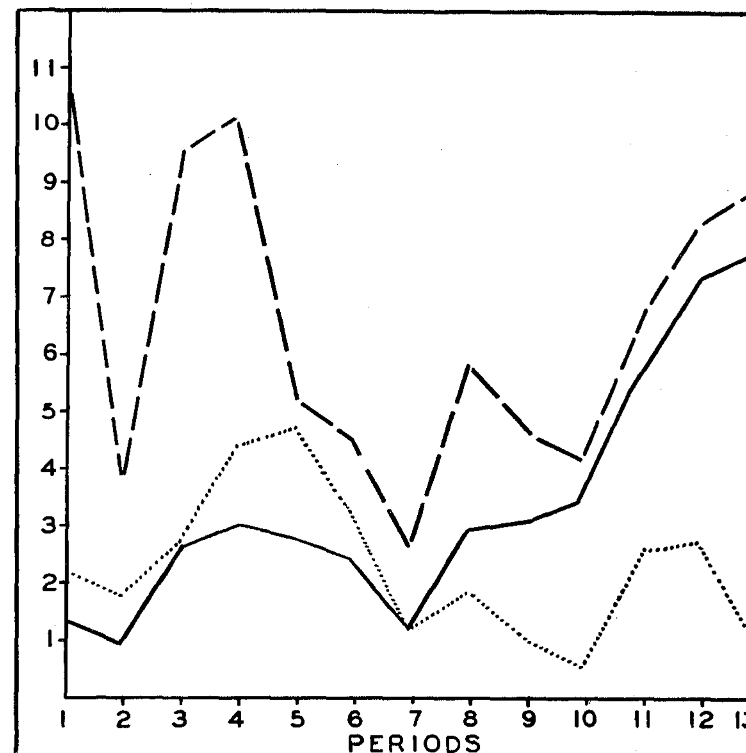

Figure 12. Numbers of trout recorded from the Rangeley lakes in 13-year periods of 6 years each, overlapping 3 years. Broken line, all trout, numbers in hundreds; solid line, 2 pounds and over, numbers in hundreds; dotted line, 8 pounds and over, numbers in units. Data are for the period from 1873 to 1914. (From Kendall, 1918, p. 571.)

Records were kept by the principal hotels and camps in the Rangeley region for the entire open season of 1915. They reported 345 anglers whose catches were definitely recorded, with a total of 96 trout and 549 salmon. This represented an average catch per fisherman per season of 0.28 trout and 1.59 salmon, or a total of 1.87 for the two species. (It seems reasonable to assume that each of these 345 anglers fished, on the average, for more than one day; this would leave an average catch of less than one fish per person per day.) The trout ranged from 1 to 8½ pounds, with an average of 4.09; the salmon ranged from 1 to 8½ pounds, with an average of 3½ pounds.

History of the Land-locked Salmon. The Land-locked Salmon was introduced into the Rangeleys in 1875. It reportedly became established from this first planting; and, with continued yearly plantings and in a very suitable habitat, it continued to increase in abundance and to spread throughout the Rangeley chain from Rangeley Lake down. Reports of the capture of salmon began to appear about 1880. Some of these reports on the number, size, and abundance of salmon were as follows:

> In 1880: 5 salmon reported, largest 4 pounds.
>
> In 1882: 1 salmon, weight 4 pounds.
>
> In the spawning run of 1882: several salmon, 4 to 10 pounds.
>
> In 1883: many salmon, 5 to 10 pounds.
>
> In 1886: 4 salmon; weight 3, 8, 9, and 11 pounds.
>
> In 1887: report trout catches sprinkled with salmon. Hardly a day passed without one or two being brought into camp. One 7½-pound salmon caught in Greenvale cove of Rangeley Lake.
>
> In 1888: one of 5 pounds; one of 6½ pounds; large numbers of smaller ones. Stated that most salmon were caught in Rangeley Lake; few in other lakes.
>
> "The report of each succeeding year indicated an increase in the number and size of salmon, and their gradual appearance successively down the chain of lakes" from Rangeley Lake down (Kendall).

In 1891, it was stated definitely that the introduction was going to be a success. In 1896, a correspondent wrote for Forest and Stream, as follows:

> The landlocked-salmon record at Rangeley, already referred to, is a remarkable one. The first 21 salmon taken by guests of the Rangeley Lake House, and almost within sight of the house, actually weighed 135 pounds 2 ounces, an average of 6 pounds 7 ounces to the fish. Fifteen of the same fish weighed 112 pounds 14 ounces, an average of 7 pounds 8 ounces. The catch of the above fish began May 7 and ended June 4. A great many large salmon have also been taken since.

In 1900 a correspondent for Forest and Stream stated that "Never before has Rangeley Lake seen such excellent fishing." The statement was perhaps somewhat too enthusiastic. The fish caught were all salmon. In 1901 a note from Upper Dam read "A remarkable feature is that almost as many salmon are being taken as trout. . . While the supply of trout has scarcely lost anything, a supply of salmon has been added." The correctness of the statement "while the supply of trout has scarcely lost anything" may be doubted (see Fig. 12). Further records were given as follows:

> On June 5, 1901: guests at Rangeley House caught 17 salmon but no trout.
>
> In 1905, two weeks fishing during the last of May and first of June: guests at Rangeley House took 53 salmon and trout, of 3 to 8¼ pounds.
>
> In 1906, same period as in 1905: guests of Rangeley House took 69 salmon and 5 trout. The largest salmon was 9 pounds; the largest trout was 5½. These 1905 and 1906 catches were reported at the time to be the best catches made by guests of the Rangeley House.

The average weight of salmon caught and reported for the years 1903 to 1912 was 4¼ pounds. The records kept by the principal hotels and camps of the region, and previously cited under trout, indicated an average weight of 3½ pounds for the 549 salmon caught in 1915. This drop of ¾ of a pound in average weight probably was partly due to an actual decrease in size of fish caught, while it may have been partly due to the failure of fishermen to keep or report smaller fish during the earlier period.

The records of capture of fish over 10 pounds in weight reveal a gradual increase in maximum size of the salmon and an increase in numbers of these larger fish, between 1880 and 1912. The following gives the distribution by year of the 18 salmon, of 10 pounds or more in weight, from the Rangeley lakes during this period:

Year:	82	86	90	96	97	98	99	01	02	03	05	07	08	10	11	12
17.5–18.5 lbs.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.
16.5	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
13.5	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.
12.5–12.6	.	.	.	.	.	1	.	.	1	1	.	.	.	1	.	.
12.0–12.1	1	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.
11–11.5	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.
10–10.8	.	.	.	1	.	.	1	1	.	.	.	.	1	.	.	.

The 17½- and 18½-pound salmon were taken by fish culturists in 1905; the 16½-pounder was taken by an angler in 1903. Of the above 18 salmon, 3 were taken during the 10 years from 1882 to 1891; 5 from 1892 to 1901; and 10 from 1902 to 1911. It is of particular interest that the largest of 549 salmon reported in 1915 was only 8½ pounds in weight. Also of interest is the fact that the Blueback Trout became extinct about 1905, or near the peak of abundance of these large salmon; the extinction of the Blueback was attributed by Kendall to the salmon.

The numbers of salmon reported for each year revealed a continual and rapid increase up to 1915; in comparison, the catch of trout declined considerably up to about 1905, after which it increased. Prior to 1895 there were records of approximately 100 salmon, and, by far, fewer salmon than trout. The recorded catches of salmon and trout by three-year periods, starting with 1895, were as follows:

1895–1897	65 salmon,	271 trout
1898–1900	231 "	, 316 "
1901–1903	552 "	, 279 "
1904–1906	1,053 "	, 191 "
1907–1909	1,078 "	, 322 "
1910–1912	1,431 "	, 570 "
1913–1915	1,377 "	, 319 "

The totals of the above figures are 5,787 salmon reported as against 2,268 trout, or 2½ times as many salmon.

The total number of trout and salmon caught by all anglers and the average number caught by individual anglers may have been somewhat less in 1939 than it was in the early thirties; this seemed to be the opinion of the majority of ten local guides and fishermen who responded to a questionnaire which was distributed generally in the Rangeley area during 1939. In answer to the question for their opinion as to the trend in trout and salmon fishing, seven men stated that trout fishing was getting worse, and three stated it was getting better; six said salmon fishing was getting worse, two said it was the same, and two said it was getting better; eight said trout in their catch were getting smaller, while two said larger; nine said that salmon were getting smaller, and one said they were about the same in size. Mr. C. C. Turner of Bald Mountain, Maine, was the only guide who offered the records of his catch from Mooselookmeguntic Lake as evidence supporting his belief that trout and salmon fishing had been getting worse during the ten years previous to 1939. Mr. Turner stated in his letter:

I am enclosing a record of all the fish that have come to my boat since 1938 and also for the months of July and August, 1928:

Year	Days	Trout	Salmon	Total	Average per day
1928	53	40	98	138	2.6
1929	51	94	277	371	7.3
1930	32	60	71	131	4.1
1931	63	50	213	263	4.2
1932	41	64	113	177	4.3
1933	43	28	128	156	3.6
1934	43	31	109	140	3.3
1935	46	16	72	88	1.9
1936	73	42	107	149	2.0
1937	47	15	60	75	1.6
1938	43	10	34	44	1.0
1939	20	3	13	16	0.8

Mr. Turner's average catch of 0.8 fish per day in 1939 was almost identical to the average catch of 0.88 trout and salmon by the total 3,200 fisherman-days by all fishermen on Mooselookmeguntic Lake during 1939, according to a census by the Fish and Game Wardens (see Table XXXIV). Mr. Turner's records were apparently adequate to indicate a downward trend in fishing in Mooselookmeguntic during this period. His records, however, could not be regarded as indicating a new and permanent downward trend of the fishing in the Rangeley region as a whole, for there have been previous low points in the fishing as indicated by the 1915 checkup by the principal hotels and camps in the region. In that season, a check on 345 anglers revealed a total catch of 96 trout and 549 salmon, or an average catch of 1.87 fish per person per season, or, presumably, considerably less than one fish per person per day. The drop in numbers of fish caught per day by Mr. Turner over the period from 1928 to 1939 might be partly attributed to increase in fishing intensity and the fact that the fish which were being caught during the latter years were distributed among a greater number of fishermen. During this 12-year period the number of resident licensed-fishermen in Maine remained about the same. The number of non-resident fishermen, on the other hand, was almost exactly doubled, and the Game Warden census revealed that nearly half of the fishing on Mooselookmeguntic in 1939 was done by non-residents.

Present Fishing Returns from the Rangeley Lakes. Information on the number of fishermen, and the kinds and numbers of game fishes taken from the Rangeley lakes during the 1939 season was obtained from the local wardens[21] of the Inland Fish and Game Department. As part of their daily routine, the Fish and Game Wardens visit the waters in their area at irregular intervals to determine the number of fishermen on each body of water and the kinds and numbers of fish which are being caught. The records kept by the wardens in the Rangeley area were on daily diaries. The information given in the following account has been compiled from these daily records. In estimating the total numbers of fish and fishermen from this partial census, allowances were made for the unequal distribution in number of fishermen over the different days of the week, and for the time of day at which each individual census was made, as for examples: If a census was not made on a given Saturday or Sunday, it was figured that the number of fishermen on the lake on that day and the number of fish caught were similar to the records for the preceding and following Saturdays or Sundays. If the census was made on a lake during the middle of the day, an allowance was made for fish which fishermen might have been expected to catch during the remainder of that day. The results obtained from this fishing census by the wardens are summarized in Tables XXXIII and XXXIV. It is the present writer's opinion that the data on ratios of trout to salmon in the catch, average catches per fisherman per day, and ratios of non-resident to resident fishermen, are reliable

[21] Creel census data were obtained from Chief Warden Roy Gray and Deputy Wardens Norman Buck, Fernald Philbrick, Frank Phillips, Alston Robinson, and Charles Smart.

TABLE XXXIII. The numbers of all fisherman-days and of non-resident fisherman-days, and the numbers of trout and salmon taken by them, as checked by the Fish and Game Warden census, and as calculated for total fishing intensity, for each of the Rangeley lakes during the season of 1939*

Lake Date (1939) and number of census days** (in parentheses)	Fisherman-days***				Fish****			
	Checked by wardens		Calculated total for the season*****		Checked by wardens		Calculated total for the season*****	
	All fishermen	Non-residents	All fishermen	Non-residents	Trout	Salmon	Trout	Salmon
Both Richardson lakes May 22 to Aug. 4 (7 days)	**18**	**5**	**250**	**70**	**14**	**2**	**300**	**25**
Mooselookmeguntic and Cupsuptic lakes May 14 to June 30 (44 days)	877	331	2,100	790	258	250	1,150	1,100
July 1 to Aug. 31 (30 days)	329	180	1,100	600	42	34	310	250
Total: May 14 to Aug. 31 (69 days)	**1,206**	**511**	**3,200**	**1,390**	**300**	**284**	**1,460**	**1,350**
Rangeley Lake May 18 to June 30 (19 days)	249	60	1,840	440	248	46	2,350	440
July 1 to Aug. 12 (12 days)	107	46	1,100	470	115	15	1,400	170
Total: May 18 to Aug. 12 (31 days)	**356**	**106**	**2,940**	**910**	**363**	**61**	**3,750**	**610**
Kennebago Lake May 15 to June 30 (25 days)	233	134	1,000	575	321	16	1,670	105
July 4 to Sept 9 (18 days)	86	57	900	595	63	4	830	15
Total: May 15 to Sept. 9 (43 days)	**319**	**191**	**1,900**	**1,170**	**384**	**20**	**2,500**	**120**
Aziscoos Lake May 8 to June 30, 1938* (35 days)	96	?	170	?	96	10	300	30
July 1 to Sept. 10, 1938* (39 days)	96	?	150	?	55	12	150	30
Total: May 8 to Sept. 10, 1938* (74 days)	**192**	**?**	**320**	**?**	**151**	**22**	**450**	**60**
Total: All six Rangeley lakes for one year	**2,091**	**813**	**8,610**	**3,540**	**1,212**	**389**	**8,460**	**2,165**

* Data on Aziscoos are given for 1938, as figures for 1939 were not available.

** Number of census days includes every day on which a census was made, regardless of whether it was a partial one or complete.

*** Not the same as number of individual fishermen; if one man fished ten days, his fishing would be counted as 10 fisherman-days.

**** All salmon 14 inches or more in length; trout in Kennebago Lake 7 inches or more; trout in Aziscoos 8 inches or more; trout in other lakes 10 inches or more in length.

***** Presumably much too low; see text.

TABLE XXXIV. The proportion of non-resident fisherman-days to all fisherman-days, the catch per fisherman-day of trout and salmon, and the ratio of trout to salmon in the catch, by parts of the fishing season, for the Rangeley lakes during 1939* (Figures calculated from data given in Table XXXIII)

Lake, Parts of 1939* season	Fisherman-days		Fish caught per fisherman-day			Ratio of trout to salmon
	All fisherman-days by per cent	Ratio of non-resident to all fishermen by per cent	Trout	Salmon	Trout and salmon	
Both Richardson lakes May to September	100	28	1. 20	0. 10	1. 30	12 to 1
Mooselookmeguntic and Cupsuptic lakes May and June	66	38	0. 55	0. 52	1. 07	1.05 to 1
July and August	34	55	0. 28	0. 23	0. 51	1. 24 to 1
Total for season	100	43	0. 46	0. 42	0. 88	1. 08 to 1
Rangeley Lake May and June	63	24	1. 28	0. 24	1. 52	5. 3 to 1
July and August	37	43	1. 27	0. 16	1. 43	8. 2 to 1
Total for season	100	31	1. 27	0. 21	1. 48	6. 1 to 1
Kennebago Lake May and June	53	58	1. 67	0. 11	1. 78	16 to 1
July and August	47	66	0. 92	0. 02	0. 94	55 to 1
Total for season	100	62	1. 32**	0. 06	1. 38**	21 to 1
Aziscoos Lake May and June	53	?	1. 76	0. 18	1. 94	10 to 1
July to September	47	?	1. 00	0. 20	1. 20	5. 0 to 1
Total for season	100	?	1. 40	0. 19	1. 59	7. 5 to 1
Total: all six lakes May and June	61	36	1. 08	0. 32	1. 40	3. 33 to 1
July to September	39	53	0. 84	0. 14	0. 98	5. 95 to 1
Total for season	100	43	0. 98	0. 25	1. 23	3. 91 to 1

* Data on Aziscoos Lake are for 1938.

** The figures given in this table are for fish killed by the angler; the wardens reported that, in the case of Kennebago Lake, fishermen killed only about half of the trout which they caught; therefore the average catch per fisherman-day was approximately 2.6 fish for the entire season and 3.5 fish for May and June. In the case of the other lakes, it was reported that fishermen killed most of the fish which they caught.

for four of the six lakes. The data for the two Richardson lakes were probably not reliable, since the number of fishermen contacted by the wardens was too few.

The accuracy of the figures on total fishing intensity and total numbers of trout and salmon caught during 1939 was dependent upon the warden's individual estimates of the proportion of total fishing effort which he checked. In the present writer's opinion these estimates were very conscientious. Records of the number of fishing licenses issued to fishermen in the Rangeley region, however, seem to indicate definitely that the wardens' estimates of total fishing intensity were much too low. The most reliable check on the number of fishermen in the Rangeley region can be made for the non-residents (out-of-state fishermen). Of 41,454 non-resident fishing licenses sold in 1939 by the State of Maine, 37,985 were sold by agents in Maine and 3,469 were sold by agents outside of Maine. Of the 37,985 sold by agents in Maine, 2,881 (7.6 per cent) were sold in the Rangeley region. Since 7.6 per cent of all non-residents who bought fishing licenses in Maine did so in the Rangeley region, it seems safe to assume that, of those 3,469 non-residents who bought their licenses outside of Maine, approximately 7.6 per cent, or 264 fishermen, also came to the Rangeleys. The total number of non-resident fishermen who fished in the Rangeley region was, therefore, approximately 3,145 (2,881 plus 264); and the great majority of these fishermen fished on the six large Rangeley lakes or their tributaries. It was estimated on the basis of the census by the Fish and Game Wardens that the total non-resident fishing intensity on these six lakes was 3,540 fisherman-days. If this figure were correct, it would mean that the average non-resident fished only 1.1 days during the season. That the non-residents fished much more than 1.1 days, on the average, may be inferred from the types of 1939 fishing licenses which they purchased, as follows:

Type of license	Number sold at Rangeley	Number sold by all out-of-state agents
Season	227	613
30-day	722	909
15-day	525	544
3-day	1,188	1,187
Exchange	89	113
Junior	130	103
Total	2,881	3,469

Thus, considerably more than half of the non-residents purchased licenses allowing them to fish for 15 days or more, rather than the 3-day license. The inference is that the 3,145 non-resident fishermen in the Rangeley region fished considerably more than the 3,540 fisherman-days as estimated from the warden census; likewise, the total number of all fisherman-days and the total numbers of trout

and salmon which were caught were considerably greater than the figures (given in Table XXXIII) estimated from the census. The low estimate of fishing intensity and total number of fish which were caught presumably did not affect the figures on ratios of trout to salmon, ratios of non-resident to resident fishermen, and average catches per fisherman-day; for these latter figures were based on the actual records obtained by the wardens for the individual fishermen which they contacted.

Fish caught. The figures as estimated from the warden's census (these figures presumably are much too low; see above) indicated that there were approximately 8,610 fisherman-days of fishing on the six large Rangeley lakes during the season; and 10,625 Brook Trout and Land-locked Salmon were taken (not including the fish which were caught and released). This catch consisted of 8,460 trout and 2,165 salmon; thus trout outnumbered salmon about 4 to 1. The greatest number of trout (3,750) was taken from Rangeley Lake; Kennebago Lake ranked second with 2,500; and Mooselookmeguntic was third with 1,460. These figures on number of trout caught represent only those fish which were taken from the lakes. The wardens reported that Kennebago Lake fishermen released about half of the trout which they caught; therefore, the actual catch of trout from Kennebago was about 5,000. It was reported that fishermen on the other lakes kept most of their fish; therefore, the above records are presumably complete for those lakes. Mooselookmeguntic headed the list of lakes in catch of salmon, with 1,350; and Rangeley Lake was second with 610. The reported catches of trout and salmon in the Richardsons and Aziscoos lakes were low as compared to the other three lakes. (See Table XXXIII.) The number of trout taken from the Richardson lakes was probably considerably more than the 300 fish indicated by the census.

Figures on the number of fish caught per fisherman-day, as calculated from the census records (Table XXXIV), indicate that the average fishermen for the entire season on all lakes caught 1.23 trout and salmon per day. The best average was made by fishermen on Kennebago Lake (about 2.7 fish), although these fishermen kept less (1.38) than did fishermen on Rangeley Lake (1.48 fish per day).

May and June fishing was decidedly better for the lakes as a whole than July and August fishing. The catch per fisherman-day was 1.4 trout and salmon in May and June; and 0.98 in July and August. This seasonal difference was considerable in all except Rangeley Lake with 1.52 per day in May and June and 1.43 in July and August; thus, the fishing in Rangeley Lake held up better during the summer than it did in the other lakes, and trout fishing remained practically the same (1.28 and 1.27). The seasonal drop in the catch from Kennebago from 1.78 to 0.94 was obviously due to the special law permitting only fly-fishing on this lake; in July and August, most of the trout were in deep water and below the reach of the fly-fisherman. In the lakes as a whole, trout fishing held up better during the summer than did salmon fishing, as indicated by the ratios of 3.33 trout to 1 salmon in May and June and 5.95 to 1 in July and August.

Out-of-state fishermen. The records revealed that nearly one-half (43 per cent) of the 1939 fishing in these six Rangeley lakes was done by fishermen from outside of the State of Maine. To this should be added a reportedly large (but unknown) part of the remaining 57 per cent for non-resident fishermen who came to the Rangeley region from other parts of Maine. The great majority of the fishing, therefore, was done by people who came to the region as temporary guests.

More fishing was done during May and June than during the remainder of the season (see Table XXXIV); on Mooselookmeguntic Lake 66 per cent of the fisherman-days was for May and June, 34 per cent for July and August; on Rangeley Lake the figures were 63 per cent and 37 per cent; on Kennebago, 53 and 47; on all lakes, 61 and 39. This 61 per cent of the fishing which was done in May and June took 5,620, or 66.4 per cent, of the 8,460 trout taken during the entire season; it took 1,688, or 78.0 per cent, of the 2,165 salmon; or it took 7,308, or 68.8 per cent, of the 10,625 trout and salmon. The out-of-state people did most of their fishing in the Rangeley region during the last half of the season; they did 53 per cent of the fishing in July and August as against 36 per cent in May and June. The out-of-state guests, therefore, did most of their fishing in the part of the season when the least amount of fishing was being done, and when the fishing was not at its best.

Smelt dipping. The following information on the number of fishermen who "dipped smelts" from stream spawning runs, and on the amount of smelts so taken, are based on the warden census. Spawning smelts from Mooselookmeguntic Lake were dipped from the Kennebago River; Rangeley Lake smelts were dipped from Haley and Hatchery brooks; and Upper Richardson Lake smelts from Mill Brook. Out-of-state people did only about one per cent of the smelt dipping.

The census was made on Haley and Hatchery Brooks and Kennebago River during the 1938 run from April 18 to 30. Three hundred fishermen were contacted by the wardens and the total fishing intensity for the season was calculated to be approximately 1,500 fisherman-days (nights), of which 1,000 were on the Kennebago River, and 500 on Haley and Hatchery brooks. Their catch was calculated to be 3,300 and 1,700 quarts of smelts, respectively, or a total of 5,000 quarts or approximately 250,000 individual smelts.

The 1939 census (smelt runs from April 28 to May 17) on smelt dipping yielded the following figures:

	Haley and Hatchery brooks	Kennebago River	Mill Brook	Total
Fishermen checked by wardens	95	597	235	927
Number fisherman-days (calculated)	500	1,410	500	2,410
Average catch (in quarts)	2	2¼	4	2¾
Total catch (in quarts)	1,000	3,200	2,000	6,200
Total catch, number of smelts (estimated)	45,000	168,000	100,000	313,000

Of considerable interest at this point is the opinion expressed, after the 1939 smelt run was completed, by Chief Warden Roy Gray and other local wardens that the 1939 runs were much smaller than they had been in the recent past. There may also be some significance in the fact that the average fisherman on the tributaries of Rangeley and Mooselookmeguntic lakes obtained only about half of his legal limit of four quarts of smelts.

RECENT PLANTINGS OF TROUT AND SALMON

With exception of the early and successful stocking of the Smelt, the only fish which have been stocked extensively in these six Rangeley lakes are trout and salmon. The complete records of stocking trout and salmon in these lakes and their tributaries for the six fiscal years from 1933-34 to 1938-39, inclusive, by the Maine Department of Inland Fisheries and Game, are summarized by lakes and their tributaries, by year (year-class of the fish), and by size of fish, in Table XXXV. The stocking records are those reported by the hatchery superintendents and are on file in the office of the Fish and Game Department. Since our studies on age of trout and salmon obtained from the Rangeley lakes during the 1939 survey revealed that most of the fish present at that time were six years or less in age, it was concluded that the 1939 fish populations of the lakes corresponded in origin, by year-class, to this period of stocking.

The stocking records are given (in Table XXXV) for the two Richardson lakes and their tributaries together, because some records were not specific in stating which of the two had been stocked. The tributaries of the other lakes, which were stocked, were as follows: Rangeley Stream, Kennebago River, Cupsuptic River, Bemis Stream, and Otter, Beaver, and Toothaker brooks of Mooselookmeguntic and Cupsuptic lakes; Long Pond Stream, Greenvale Stream, Dodge Pond Stream, and South Bog Stream of Rangeley Lake; and the Magalloway rivers of Aziscoos Lake. Round, Dodge, Gull, Haley, and Long ponds are located on tributaries of, and are close to, Rangeley Lake. It might be expected that the trout populations of these

TABLE XXXV. The numbers and lengths of trout and salmon planted in the Rangeley lakes and their immediate tributaries for the six fiscal years from July 1, 1933 to June 30, 1939, arranged according to the year in which the fish were hatched. (Condensed from reports submitted by fish-hatchery personnel of the Maine Department of Inland Fisheries and Game)

Lake, and tributaries	Fish planted (in thousands, add ,000)							
	Brook Trout				Land-locked Salmon			
Year of hatch	Fry	2″ to 4″*	4″ to 6″	"Mature": over 6″	Fry	2″ to 4″*	4″ to 6″	"Mature": over 6″
Both Richardson lakes:								
1933	..	33	44	..	..	..	..	..
1934	..	..	58	1	..	..	..	..
1935	..	..	98	..	..	..	..	..
1936	..	..	21	7	..	47	..	..
1937	..	..	74	..	..	19	..	..
1938	..	..	51	22	15	..	..	..
Mooselookmeguntic and Cupsuptic lakes:								
Lakes: 1933	97	2	46	..	20	11	..	..
1934	..	5	22	40	..	..	..	..
1935	63	15	64	..	..	23	..	..
1936	..	..	5	10	..	10	..	..
1937	29	..	22	..	..	..	18	..
1938	..	..	6	76	16	12	19	..
Tributaries: 1933	..	8	3	3	..	12	..	10
1934	20	..	4	20	75	38	..	5
1935	12	43	19	..	140	..	..	..
1936	..	..	25	3	230	18	..	..
1937	35	11	15	..	..	28	10	..
1938	13	6	10	6	66	19	..	..
Rangeley Lake:								
Lake: 1933	..	..	50	..	..	5	..	..
1934	132	4	23	57	94	15	..	..
1935	..	..	63	..	147	..	..	..
1936	..	..	14	1	..	35	..	..
1937	48	..	29	..	..	28	35	..
1938	..	..	7	50	11	10	12	..
Tributaries: 1933	..	20	..	..	..	5	1	5
1934	..	..	..	..	..	23	..	9
1935	..	..	8	..	98	..	..	..
1936	..	..	6	5	100	..	..	..
1937	..	..	16	..	..	..	..	..
1938	..	..	7	..	10	10	..	..
Round, Dodge, Gull, Haley, and Long ponds:								
1933	..	23	31	..	5	16	..	3
1934	240	5	1	5	..	15	..	1
1935	87	71	52	..	76	..	..	..
1936	..	13	22	..	..	12	..	..
1937	53	20	15	..	..	20	..	..
1938	20	18	11	..	..	14	..	..
Kennebago Lake:								
1933	..	..	..	13	..	..	..	..
1934	..	..	..	4	..	..	..	..
1935	..	15	..	..	..	..	..	..
1936	..	..	4	..	..	..	..	..
1937	..	..	7	..	..	..	..	..
1938	..	..	6	..	..	..	..	..
Aziscoos Lake:								
Lake: 1933	..	..	10	..	..	..	..	..
1934	..	..	14	7	..	..	..	..
1936	..	..	9	..	..	..	..	..
1937	..	..	30	..	..	..	..	..
1938	..	..	20	11	..	..	..	..
Tributaries: 1934	100	..	2	2	..	..	..	..
1936	..	..	3	..	..	..	..	..
1937	..	..	..	..	..	5	..	..

* About half of the trout and salmon listed above were 2″ to 4″ fish; the other half were 2″ to 3″ fish.

five ponds have access to the larger lake, at least during certain seasons of high water; therefore, the stocking records for these ponds have been considered in connection with the stocking of Rangeley Lake. Most 4- to 6-inch and larger fish were planted during late fall, and most fry and 2- to 4-inch fish were planted during the summer months. Most fish were planted in the same year in which they were hatched.

The total numbers in thousands of trout and salmon of all lengths planted in the lakes and their tributaries were as follows (condensed from Table XXXV):

Fish hatched in year	Both Richardsons	Mooselookmeguntic	Rangeley and ponds*	Kennebago	Aziscoos	All lakes
Brook Trout						
1933	77	159	124	13	10	383
1934	59	111	467	4	125	766
1935	98	216	281	15	..	610
1936	28	43	61	4	12	148
1937	74	112	181	7	30	404
1938	73	117	113	6	31	340
Total	**409**	**758**	**1,227****	**49**	**208**	**2,651**
Land-locked Salmon						
1933	..	53	40	..	..	93
1934	..	118	157	..	..	275
1935	..	163	321	..	..	484
1936	47	258	147	..	..	452
1937	19	56	83	..	5	163
1938	15	132	67	..	..	214
Total	**81**	**780**	**815****	..	**5**	**1,681**

*Includes fish planted in Round, Dodge, Gull, Haley, and Long ponds.

**The totals for Rangeley Lake for the six years, and not including the five outlying ponds, were 540 thousand trout and 653 thousand salmon.

The above figures are not directly comparable as to potential stocking value, because of differences in size of the fish planted. Some fish were planted as fry, others as 2- to 4-inch fingerlings, others as 4- to 6-inch fish, and others as "mature" fish or over 6 inches. Fish are planted at different sizes as a result of the fact that the hatcheries can hatch and rear more small fish than they have facilities for rearing fish up to 6 inches or more in length.

The rate of mortality of young fishes in natural waters is usually very great, but it decreases rapidly with increase in size of the fish. A 6-inch trout or salmon might be expected to have a much greater chance of survival when planted in natural waters than would a 2-inch fish. Conversion factors for allowances for size differences in stream stocking tables for trout have been given by Embody[22], and by Davis,[23] as follows:

[22] Embody, G. C.: 1927. Stocking policy for the Genesee River system. *In* A Biological survey of the Genesee River system. Suppl. to 16th Ann. Rept., N. Y. S. Conserv. Dept. See p. 26.

[23] Davis, H. S.: 1938. Instructions for conducting stream and lake surveys U. S. Bur. Fish., Fishery Circular No. 26, see Table 2 on p. 21.

For fish of lengths:	1″	2″	3″	4″	5″	6″	
Multiply by:	x12	x1.7	x1	x0.75	x0.63	x0.6	(Embody)
Multiply by:	x10	x2.5	x1	x0.7	x0.62	x0.55	(Davis)

These factors are roughly in proportion to the expected rate of mortality at different lengths which may be expressed, also, by the following approximate figures:

Of 1-inch fry, 5 per cent will live to be 6 inches long
Of 3-inch " 50 " " " " " " " "
Of 5-inch " 90 " " " " " " " "

The figures (in Table XXXV) on the numbers of trout and salmon of various lengths which were stocked in the Rangeley waters have been converted into equivalents of 6-inch fish on the basis of 5, 50, and 90 per cent survival of fry, 2- to 4-inch fish, and 4- to 6-inch fish, respectively. The "mature" fish (average length about 7 inches) were figured to be worth 7.5 per cent more than 6-inch fish. It is recognized that the rate of survival of trout and salmon in the Rangeley region may be somewhat different from that involved in these conversion factors. The figures obtained by the conversion, on the other hand, are undoubtedly more reliable in evaluating the different plantings, than are the figures on the actual number of fish planted. The figures (in thousands) on plantings, converted to the equivalents of 6-inch fish, were as follows:

Fish hatched in year	Both Richard-sons	Mooselook-meguntic	Rangeley and ponds*	Kenne-bago	Azis-coos	All lakes
Brook Trout						
1933	56	57	94	14	9	230
1934	53	92	111	4	29	289
1935	89	108	151	7	..	355
1936	27	41	50	4	11	133
1937	67	41	70	6	27	211
1938	70	106	87	5	30	298
Total	**362**	**445**	**563****	**40**	**106**	**1,516**
Land-locked Salmon						
1933	..	23	23	..	..	46
1934	..	28	42	..	..	70
1935	..	18	17	..	..	35
1936	23	26	28	..	..	77
1937	9	39	56	..	2	106
1938	1	36	29	..	..	66
Total	**33**	**170**	**195****	..	**2**	**400**

*Includes fish planted in Round, Dodge, Gull, Haley, and Long ponds.
**The totals for Rangeley Lake for the six years, and not including the five outlying ponds, were 344 thousand trout and 148 thousand salmon.

The 2,651 thousands (or over 2½ millions) of trout planted in the Rangeleys during the six years in question were thus equivalent to 1,516 thousands of 6-inch fish; the 1,681 thousands of salmon planted during this period were equivalent to 400 thousand 6-inch fish. The greater drop in the number of salmon was due to the smaller size of the salmon which were planted. The above figures for 6-inch fish revealed that stocking of trout in each individual lake, and stocking of salmon in Mooselookmeguntic and Rangeley lakes, were carried out with a fair degree of uniformity from year to year. The most notable exceptions were the somewhat larger plantings of trout

during 1935, the smaller plantings of trout during 1936, and the larger plantings of salmon during 1937. The plantings in years of low and high totals were distributed among the various lakes in about the same proportion as in other years.

A partial evaluation of the recent trout and salmon plantings may be made by comparing them with the catch of fish in 1939 as revealed by the warden census, and by a comparison with the gill net collections made by the survey during 1939. The following comparison is based on the 1939 catch by fishermen of 10,625 trout and salmon as estimated from the warden census; since this estimate of total catch was apparently much too low (see page 156), the following figures on returns to the angler are correspondingly too low. Furthermore, if the total catch of fish in 1939 was considerably below that of the years 1936 to 1938, then the per cent returns from this six-year period of stocking was somewhat greater than is indicated in the following figures. The 1939 catch of trout and salmon, the average numbers per year in thousands of fish stocked in equivalents of 6-inch fish, and the per cent returns, are as follows:

	Both Richard-sons	Mooselook-meguntic	Rangeley	Kenne-bago	Azis-coos	All lakes
Trout						
Planted ...	60	76	94(57)	7	18	255
Caught.....	300(?)	1,460	3,750	2,500	450	8,460
Per cent ...	0.5+(?)	1.9	4.0(6.6)	36	2.5	3.3
Salmon						
Planted ...	6	28	33(25)	0	0.3	67
Caught.....	25(?)	1,350	610	120	60	2,165
Per cent....	0.4+(?)	4.8	1.8(2.4)	..	20(?)	3.2

The returns for trout and salmon from the Richardsons are questionable because the census was inadequate; the figures on salmon in Aziscoos do not represent a fair check on returns from stocking because few were planted and few were caught. The per cent of fish caught to fish planted for the lakes as a whole was 3.3 for trout and 3.2 for salmon, but this almost identical return for the two species did not hold true for the individual lakes. The three lakes of the group which were fished most heavily (Mooselookmeguntic, Rangeley, and Kennebago) gave quite different returns. If Mooselookmeguntic and Rangeley are compared, Mooselookmeguntic gave the best returns (4.8) on salmon, and Rangeley Lake gave the best returns (6.6 — not figuring the stocking of outlying ponds) on trout. Rangeley Lake, furthermore, gave somewhat better returns on the two species combined; and this fact is especially significant in view of the fact that Mooselookmeguntic Lake has much better tributaries for natural reproduction.

It should not be inferred that all of the fish caught were the results of plantings; quite the opposite is indicated for Kennebago Lake which has maintained a large population of trout with relatively little aid from artificial propagation. The 3.3 per cent and 3.2 per cent returns of trout and salmon in the entire region is presumably partially attributable to natural reproduction.

A comparison of the planting records with the fish taken by the 1939 survey was not particularly helpful in evaluating the stocking program, because of many complicating factors. The numbers of trout and salmon of various year classes which were taken by fairly random samples during the survey, and the numbers (in thousands of 6-inch fish, or their equivalent) in each year class in the plantings, were summarized for the entire group of lakes as follows:

Fish young of:	1938	1937	1936	1935	1934	1933
Trout						
Number planted	298	211	133	355	289	230
Taken by survey......	9	75	109	36	11	
Salmon						
Number planted	66	106	77	35	70	46
Taken by survey......	..	5	8	17	11	3

The 1938 and the 1937 (in part) year-classes contained fish which were either mostly too small to be taken by the nets, or were not present in the open water of the lakes. The drop in numbers of fish in the 1934 and 1933 year-classes might have been attributed to age-mortality and fishing intensity. The figures definitely revealed that direct returns from any one year's stocking in these lakes were small after an elapse of about six years. The lack of correlation between the numbers of trout and salmon of the 1936 and 1935 year-classes in the plantings and in the survey collections may have been partially due to such factors as fishing intensity, age mortality, and the role of natural reproduction.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions. Five of the six Rangeley lakes (or all except Aziscoos) considered in this report are natural lakes with their levels raised more or less by artificial dams. All of these five lakes have maximum depths of over 100 feet, and all may be classified as very good trout and salmon lakes on the basis of temperature and supply of oxygen in the deep water during the summer. Temperatures of the upper warm-water layer during the hottest part of the summer were mostly in the low seventies, or somewhat below the temperature limits usually set for trout and salmon waters. This upper section of each of the Rangeley lakes during the summer (extending to depths of 30 to 35 feet) may therefore be classed as marginal trout and salmon water. Even though the water in all of these five lakes was very good for trout and salmon, some differences were detected. If a comparison is made on the basis of total quantity of good water, then Mooselookmeguntic Lake ranks first, followed by Rangeley,

Kennebago, Lower Richardson, and Upper Richardson. If, however, the comparison is made on a percentage basis, the order is quite different with Kennebago Lake first, followed by Rangeley, Lower Richardson, Upper Richardson, and Mooselookmeguntic, respectively. Aziscoos Lake is in a category by itself, with a maximum depth of only 60 feet and a limited amount of deep cold water which is depleted of its oxygen by early summer due to organic decomposition. The upper warm-water zone of Aziscoos reached the low seventies during the summer and is therefore classed as marginal or "not good" trout and salmon water. The only good trout and salmon water in this lake during the summer is to be found near stream mouths, and, judging from our survey collections, this is where the fish were congregated at this season.

The basic food supply in the form of plankton and bottom organisms did not vary greatly among the different lakes. Bottom organisms were mostly quite rare and were low in total quantity per unit area, and there was very little aquatic vegetation in any of the Rangeley lakes to support insect life. This meagre bottom fauna was correlated with the scarcity of bottom organisms in the summer food of the trout and salmon. Kennebago Lake had the best supply of bottom food, but even in this lake it was quite scarce and was utilized very little as food by the trout. The supply of plankton, or minute animals and plants floating in the water, was found to be quite low per unit volume of water; but if the enormous volumes of water in the lakes are taken into consideration, the plankton in the Rangeley lakes has a great productive capacity. Circumstantial evidence indicated that the plankton was abundant to the extent that it was not being fully utilized by fishes, or utilized to its full extent in the complete food chain in the production of trout and salmon. The predominant links in this food chain in the Rangeley lakes are from the plankton crustaceans, to the smelts, to the trout or salmon. The lakes with the greatest densities of trout and salmon, namely Kennebago and Rangeley, had the lowest populations of plankton. It is concluded, therefore, that the basic plankton food supply is not the limiting factor in the production of game fishes in the lakes as a whole.

The game fish populations varied considerably among the different lakes with respect to the total populations of trout and salmon, density of the populations, ratio of trout to salmon, and the returns to the angler. These variations, as indicated by the results of the field survey and the results of the warden census, can be seen in the following brief resumes of conditions for each lake.

Kennebago Lake had a dense population of Brook Trout, but had comparatively few salmon. Our netting records indicated it had nearly as large a trout and salmon population combined as did the larger Rangeley and Mooselookmeguntic lakes; and in spite of the denser population, the trout were growing just as rapidly in Kennebago. This lake was affording the best trout fishing to the individual angler; and about two-thirds as many fish were being killed by all anglers as in Rangeley Lake which is three times as large. This production in Kennebago Lake was being maintained in spite of very limited stocking.

The two lakes most nearly comparable in a combination of factors as size, amount of trout and salmon water, extent of stocking, and intensity of fishing, are Rangeley and Mooselookmeguntic. These two together support the great bulk of the trout and salmon of the Rangeley chain, afford a major part of the fishing, and receive a major part of the fish planted by hatcheries. Our survey net records seemed to indicate that Rangeley Lake had denser populations of both trout and salmon, but that Mooselookmeguntic Lake had a slightly greater number of trout and salmon which were scattered over a greater lake area. Records of the fishermen's catches, which involved many times the number of fish that were in the net catches, indicated quite a different situation in the relative numbers of trout and salmon in the two lakes. In the catch records from Rangeley Lake, trout outnumbered salmon about 6 to 1; while in Mooselookmeguntic Lake the ratio was about 1 to 1; the former lake produced about two and one-half times as many trout, while the latter produced twice as many salmon. If the angler's catch of 1939 is converted in terms of per cent returns from the fish which were stocked, Rangeley Lake gave about three times as good returns on trout, and Mooselookmeguntic gave about twice as good returns on salmon. It appears, on the basis of net catches, census records, and per cent returns from stocking, that Rangeley Lake is a much better trout lake than a salmon lake, and that it is a better trout lake than is Mooselookmeguntic; on the other hand, Mooselookmeguntic is a better salmon lake than trout lake, and is a much better salmon lake than is Rangeley Lake.

Our survey records and the warden census together indicated that, in the two Richardson lakes, trout outnumbered salmon about 10 to 1. Recent plantings of the two species were in about the same proportion of nearly 10 to 1. The two lakes are fished more lightly than are Mooselookmeguntic, Rangeley and Kennebago.

Our net records seemed to indicate that the total trout and salmon populations of Aziscoos Lake were quite small compared to the other Rangeley lakes, and that the fish were concentrated near stream mouths during the summer. The lake is fished lightly for its size, having about one-tenth the fishing intensity of Rangeley Lake.

If the 1939 fishing season is taken as an average, then fishermen catch at least 3.3 trout and 3.2 salmon (probably more; see page 163) for every 100 six-inch trout and 100 six-inch salmon (or their

equivalents in smaller fish) which are planted in the Rangeley lakes and their tributaries. Since a considerable proportion of the catch must be attributed to natural reproduction, with the possible exception of Rangeley Lake, the rate of return of stocked fish to the angler must be little, if any, more than the 3.3 and 3.2 per cent. Even if the 1939 fishing season was considerably poorer than that of the previous ten years, as is suggested by Mr. Turner's data for Mooselookmeguntic Lake (see page 152), the returns from stocked fish over this period would still be quite low.

One of the most promising methods of greatly increasing the trout and salmon populations of the Rangeley region, in the writer's opinion, would be to greatly increase the chances of survival of the approximately 600,000 fish which are planted in the Rangeley lakes and their tributaries each year. The rate of survival of these small fish is largely dependent upon two factors: a suitable place to live, and an adequate food supply. The survey obtained no evidence that loss by predation was a serious factor in the region. During the survey it was found that the lakes themselves were generally quite barren of bottom insect food and the only large food supply available to trout and salmon was the smelts. Furthermore, trout and salmon usually spawn in streams whenever possible, and the young are primarily adapted to living in streams. Our growth studies on the scales of Rangeley salmon revealed that practically all of the salmon in this region spend at least their first two years in very slow growth. This slow growth for the first two years is presumably made in streams, for we commonly found young and yearling salmon in the tributaries, but rarely in the lake shallows, and not at all in the stomachs of large trout and salmon from the lakes. The same facts apply to the young trout. The success of the production of young trout and salmon by natural reproduction, and the degree of survival of the fry and 2- to 4-inch (probably also the 4- to 6-inch) trout and salmon which are planted, must be in proportion to the carrying capacity of the tributaries of each lake. Rangeley Lake and the two Richardsons do not have, in the writer's opinion, sufficient tributary waters to support the numbers of trout and salmon fry which have been planted in these lakes. Mooselookmeguntic has the greatest amount of potential fry-producing waters in the Kennebago and Cupsuptic river systems. It is doubtful if the tributaries of Kennebago Lake are adequate to maintain the present excellent fishing in this lake for many years if the fishing intensity greatly increases, without considerable aid from artificial reproduction. In brief, it may be stated that the Rangeley lakes vary considerably in the capacity of their tributaries to support young trout and salmon. Any big differences which might exist in the productive capacity of the different waters for small fish do not extend through to the production of large fish, judging from the data on conditions in 1939. Mooselookmeguntic Lake with its greater fry-producing capacity had no more adult fish, did not produce as many to the angler, and gave no better returns on the basis of planted fish, than did Rangeley Lake with its more limited fry-producing waters. It appears from this comparison that the limiting factors in the production of numbers of large trout and salmon in Mooselookmeguntic Lake involve the trout and salmon populations in the lake itself. Our survey gill net records, seining records, and growth studies on scales, together indicated that trout and salmon entered the open waters of the lakes at about seven inches in length. In the lakes they fed almost exclusively on the Smelt and other fishes. Any change from an insect diet in streams to a fish diet in lakes was fairly abrupt, for the 7- to 9-inch trout and salmon in the lakes were feeding as exclusively on smelts and other fishes as were the larger trout and salmon.

The Smelt is the main link in the fish production of the Rangeley waters. That fact has been emphasized in practically every article written on the fishing in the Rangeley region since the Smelt was introduced. It was the unqualified conclusion by Kendall in his report on these lakes. The importance of the Smelt is recognized by practically all guides and fishermen in the region. The point on which there is, and has been, considerable difference of opinion concerns the abundance of this fish. Less than five years after the Smelt was introduced in 1895 into the Rangeleys, fishermen began to complain that the poor fishing was due to an over-abundance of smelts. The reason was given that the trout and salmon had so many smelts to eat that they could not be caught by the fishermen. Among the ten local guides who responded to the 1939 questionnaire, half were of the same opinion, while the other half stated that smelts were not over-abundant. The pertinent point in this problem is not so much a question of any one individual fish having so many smelts in his stomach at a given time that it refuses to bite on a hook; it is the question as to whether or not the Smelt has been so abundant over a period of years that fishermen could not catch a reasonable proportion of the trout and salmon which were present.

All available evidence obtained by the present survey, and most of the evidence in the fragmentary records of the history of the fishing, point to the conclusion that the Smelt, at present, is not so abundant that it is ruining the trout and salmon fishing. There is little reason to believe that this situation ever did exist. It is the present writer's opinion that just the opposite situation did exist, namely, that any general decline in the production of game fishes in the Rangeley region over the past 30 years has been generally associated with and mostly the result of a decline in the smelt populations. It is also maintained by the present writer that these Rangeley lakes could and would support much greater total trout and salmon populations

than they supported in the early days, if the smelt populations were allowed to increase to their maximum. The data supporting these opinions are from a variety of sources, and may be summarized as follows: The first point is that the continual complaint by fishermen over the period of the last 50 years that the Smelt was ruining the trout and salmon fishing, is, in itself, hardly logical. If the fish were being so well fed and had such an unlimited food supply that they could not be taken by fishermen, then the total population of trout and salmon should have increased. Such an increase in the trout and salmon populations might be expected to continue only until they had caught up with the food supply. Judging from the records compiled by Kendall (see Fig. 12), such an increase probably occurred after the introduction of the Smelt just before 1900. During that period when the Smelt was spreading and greatly increasing in numbers throughout the Rangeley region, the catch of trout and salmon was increasing. This increase in the reported catch from about 1895 (when the Smelt was introduced) to 1914 may have been partly the result of greater fishing intensity, but fishing intensity has also increased since 1914. The obvious conclusion is that if there has been a general decrease in numbers of fish caught since 1914, it could hardly be ascribed to over-abundance of smelts.

The second point is in connection with the smelt populations and concerns the abundance of smelts in the spawning runs and in the stomachs of trout and salmon. According to the 1939 census the local fishermen took over 6,000 quarts of smelts from the runs from Rangeley, Mooselookmeguntic, and Upper Richardson lakes. This quantity, in itself, does not seem to be very great; and, directly, it would feed probably less than 1,000 adult trout or salmon for one year. The approximately 300 thousand individual smelts in these 6,000 quarts would, however, produce many millions of Smelt fry for the lakes. The taking of these smelts from the spawning grounds would have an important effect on the total food supply of the lakes if that total supply of smelts was relatively low. The local Fish and Game Wardens expressed the opinion that the smelt runs are smaller than they were years ago. So did half of the local guides whose opinions were solicited; the remaining guides stated that there are too many smelts at present, but none volunteered the opinion that there are more smelts now than in the past. The average 1939 catch on the spawning runs of Rangeley and Mooselookmeguntic lakes was only about half the legal limit of four quarts of smelts. The present smelt fishing, therefore, hardly seems to conform to a 1910 statement that the supply was unlimited and to a 1907 report that "one man dipped four bushels." Among the numerous past complaints that the smelts were making it impossible to catch fish, were references to trout and salmon containing large numbers of smelts. The survey findings were quite the opposite. The stomachs of 221 trout and 43 salmon from the Rangeley region were examined; the trout contained an average of 0.4 smelt, and the salmon an average of 1.1 smelts. The above information on spawning runs and stomach contents of the game fishes certainly does not indicate an over-abundance of smelts.

A third approach to the Smelt problem in the Rangeley region is by a consideration of the maximum size and the rate of growth of the trout and salmon. It is a well known fact that fish must have plenty to eat if they are to grow to a large size; and it is generally believed that most of the larger game fishes attain their maximum size only in large bodies of water. A third factor which would also affect the numbers of fish reaching a large size is fishing intensity, for very heavy fishing might continually remove most of the fish as they reach a legal size. It would take extremely heavy fishing, however, to prevent every fish from reaching that maximum size which would be limited by natural causes. Thus the trend of change in maximum size of trout and salmon in the Rangeley region was probably related to food supply. The maximum size of Brook Trout has decreased somewhat over the past 70 years. The majority of the larger trout were reported prior to the extinction of the Blueback Trout about 1900, and early reports attributed this large size of the Brook Trout to their feeding on the bluebacks. The maximum size of salmon in the Rangeleys (16.5 to 18.5 pounds) was reported in 1903 and 1905, about 30 years after the salmon was introduced, but only about five years after the introduced Smelt had become abundant. The maximum size of 549 salmon reported in 1915 was 8½ pounds. The largest salmon taken during the 1939 survey was of 6 pounds; the oldest salmon were three IX-year fish, but these weighed only 4 to 4¾ pounds each; the largest trout taken by the survey was one of 4½ pounds; a 7½ pound trout, taken by an angler, was six years old; and most VI- to VII-year trout were 2 to 4 pounds in weight. The maximum age of Brook Trout is rarely over seven years, and that of Land-locked Salmon is rarely over nine years; and there is no reason to believe that the 12-pound trout and 18-pound salmon reported from the Rangeleys in the past were much, if any, older. The conclusion is that they were larger because they had more to eat and grew more rapidly; likewise, it seems to be the most logical conclusion that at present the trout and salmon are not growing to their maximum size because of an inadequate food supply. There appears to be evidence of a greater scarcity of food in Mooselookmeguntic Lake than in Rangeley Lake, judging from the much slower growth of salmon in the former.

Still further evidence supporting the present writer's belief that the smelt populations of the Rangeley lakes are low and are the limiting factor in the production of trout and salmon, is concerned with the potential productivity of the lakes at present as compared to

the past. These lakes produced reportedly good trout fishing before either the salmon or Smelt were introduced. The early reports indicated that the larger trout fed mostly on native minnows and on the bluebacks. After the Smelt was introduced, the trout shifted its diet mostly to this forage fish, judging from past reports and the 1939 survey findings. The introduced salmon is also feeding mostly on smelts. Therefore, the pressure of predation on the minnow populations must have been considerably reduced by the introduction of the Smelt; and there should be, at present, a larger total minnow population, or at least as large a one, as there was in the early days of trout fishing. Minnows are not at all abundant in the lakes at the present time; and, if the preceding argument is sound, they never were very abundant. The addition of smelt populations to the populations of minnows in the lakes certainly greatly increased their potential productivity. The early records of trout fishing are not out of harmony with this conclusion. The early trout fishing was best known for the large size of the fish, and not for unusually large numbers. During Allerton's 1869 fishing trip, for example (see page 143), he caught a total of 247 trout over a period of three weeks during the best part of the fishing season. This catch was not at all remarkable in terms of numbers of fish, but was unusual in that it contained 13 trout weighing from 5 to 8½ pounds each. The 247 trout caught by Allerton in 1869 had an average weight of 15.2 ounces. In comparison with this, the average weight of trout and salmon taken by nets from the lakes during our 1939 survey might be cited. The 148 trout from Rangeley, Mooselookmeguntic, and the Richardson lakes had an average weight of 14.5 ounces; the 94 trout from Kennebago and Aziscoos lakes had an average weight of 11.5 ounces; the 51 salmon from all six lakes had an average weight of 37.3 ounces; and the 191 trout and salmon together from Rangeley, Mooselookmeguntic, and the Richardson lakes had an average weight of 20.5 ounces. After making allowances for the smaller fish taken by our nets and for the thirteen 5- to 8-pound trout taken by Allerton, it appears that the average weight of the great majority of trout in Rangeley and Mooselookmeguntic lakes was larger in 1939 than the average weight of trout in these lakes in 1869. If the salmon is included in the comparison, then it is obvious that the average fish available to the angler in the Rangeley region at present is larger than was the average trout taken by Allerton in 1869. This is not inconsistent with the writer's conclusions that the lakes produced more fishing after the Smelt was introduced than they did before, and that, if there has been a considerable decrease in fishing over the past ten years, it has probably been due to a decrease in the numbers of smelts.

A hasty perusal of the preceding discussion on the Smelt might give the impression of an important inconsistency in connection with the maximum and average sizes of trout and salmon and their relation to the food supply. The decrease in maximum size of trout over the past 70 years and of salmon over the past 35 years is explainable, even though the average size of trout and salmon in the lakes at present is apparently greater than that of Allerton's catch of 247 trout in 1869. Since early reports before 1900 attributed the large size of the Brook Trout to the bluebacks, the extinction of the latter about 1900 might account for the decrease in size of the Brook Trout. The maximum size of the salmon was attained about 1905 and after the Smelt had become abundant; thus a decrease in the supply of smelts over the past 30 years would account for a decrease in the size of salmon. Thus, with the present food supply of both smelts and minnows, there could still be more food and larger average fish now than in 1869; and this would not be inconsistent with the greater maximum size of the Brook Trout in these early days, if that maximum size was correctly attributed by the early reports to the Blueback.

The decrease and present inadequacy (which, in the present writer's opinion, does exist) of the smelt populations of the Rangeley lakes (particularly Rangeley and Mooselookmeguntic) could hardly be attributed to anything but over-fishing on the smelt runs, or possibly to the smelts being reduced by trout and salmon predation. Regardless of which of the two causes may have been most effective, the present smelt dipping is presumably reducing the production of trout and salmon for the angler; and the two pounds of trout and salmon caught per day by the angler is worth more to the local people of the Rangeley region than is a four-quart pail of smelts taken from the spawning run.

Present fishing intensity and the catch of fish are great, as compared to the supply of fish available, judging from the following conditions in Mooselookmeguntic Lake in 1939. The total number of adult salmon in the spawning runs in Kennebago River and, Rangeley Stream was estimated by Mr. Henry W. Davenport, Superintendent of the State fish hatchery at Oquossoc, at 1,600 fish; this estimate was based on the actual capture of 1,077 salmon for stripping. Our survey findings revealed that most of the legal-sized salmon (over 14 inches) in Mooselookmeguntic during the summer were maturing for fall spawning. If the assumption is correct that most of the salmon spawn in Kennebago and Rangeley streams (as reported), the conclusion seems justified that there were less than 2,000 legal sized salmon left in the lake after the 1939 fishing season had removed considerably more than 1,350. The 1939 catch represents more than the apparent 40 per cent, for the average age of the legal-sized fish in the lake was more than four years. Judging from the above comparison, our net records, and the warden census, the present drain by fishing on the supply of both salmon and trout in both Mooselookmeguntic and Rangeley lakes is great.

Recommendations. The following recommendations are based on the data obtained by the 1939 survey and from other sources, and presented in the preceding sections of this report. The recommendations are made with the sole purpose in mind of affording more trout and salmon and better fishing in the Rangeley lakes. The recommendations are as follows:

Give the Smelt much more protection in the Rangeley region, and close the season entirely on taking smelts from the spawning runs in the tributaries of Rangeley (Oquossoc) and Mooselookmeguntic lakes.

In the fish planting program, stock Rangeley Lake mostly, if not entirely, with Brook Trout; and stock Mooselookmeguntic Lake mostly, if not entirely, with salmon. (This recommendation is based on the facts that Rangeley Lake in 1939 gave the best returns on trout, and Mooselookmeguntic Lake gave the best returns on salmon, both in proportion to the plantings of hatchery fish over the preceding six years.) Stock only Brook Trout in Kennebago, Aziscoos, and the Richardson lakes.

Plant fry and 2- to 4-inch trout and salmon only in the tributary streams; and stock these streams in proportion to the numbers recommended in the following section of this report.

Expand rearing pool facilities and raise as many of the trout and salmon as possible for two years and up to a length of seven inches, or more, before they are planted in the lakes. (The lakes are generally lacking in food for small fish.) Stock the lakes as recommended in the following section of this report.

It is recommended that those tributary streams of the two Richardson lakes, Mooselookmeguntic and Cupsuptic lakes, Rangeley Lake, and Kennebago Lake which are now closed to fishing be kept closed. It is also the writer's opinion that the September fly fishing for trout and salmon in the spawning runs in Cupsuptic and Kennebago rivers should be discontinued, in view of the present intensity of fishing on Mooselookmeguntic Lake and the necessity of protecting the spawning runs.

The limited capacity of the tributaries of Rangeley, Kennebago, and the Richardson lakes makes the drastic control of beaver on these streams very desirable.

Reduction of the populations of minnows and suckers in South Bog Stream, tributary to Rangeley Lake, by seining under Game Warden supervision, is recommended. (This trout breeding stream was found to be over-run with these fishes.)

Do not introduce any species of game fishes in the Rangeley lakes or any of their tributary waters except Brook Trout and Land-locked Salmon. It is the writer's opinion that the introduction of the togue or Lake Trout and the further introduction of Brown Trout and Rainbow Trout would not help the fishing. The introduction of any of the warm-water game fishes such as the White Perch, Yellow Perch, bass, or pickerel is extremely undesirable.

It is recommended to the anglers and bait dealers that no live bait be brought into the Rangeley region from other areas, because of the potential danger of bringing in the young of undesirable species.

STOCKING POLICY FOR THE RANGELEY LAKES AND THEIR TRIBUTARIES

The following recommended program of yearly plantings of trout and salmon for the Rangeley lakes and their tributaries has been based on the results obtained by the 1939 survey and presented in this report. The recommendations have been made somewhat flexible with respect to the size of fish to be planted, in order to allow for differences in size of the fish available. In the writer's opinion, it is very desirable that fish-rearing facilities be greatly expanded so that trout and salmon can be reared for two years and to a length of seven inches or more before they are planted in the open waters of the lakes; fish less than six inches long should be planted only in tributary streams, and only to the extent of the carrying capacity of each stream.

The proposed stocking policy for the lakes has been based on four factors, namely: area, available food, spawning grounds, and fishing intensity. A fifth factor which has been considered in trout and salmon stocking recommendations for lakes of southern Maine is competition by warm-water game fishes (Survey Report No. 2[1]); but this factor is not involved in the Rangeley lakes. The area computed as a basis for stocking each lake is not the total area, but is an average between the total area and the area of lake bottom available to trout and salmon during the summer months. These average areas of lake bottom available to the trout and salmon in the different lakes during the summer were approximately in proportion to the average volumes of water available to the fish (see Figures 2 to 6). The available food supply of the various lakes was evaluated on the basis of several factors, namely: the general abundance of plankton and bottom food organisms; the general abundance of smelt and minnow fry in the shallow waters of the lakes; the abundance of smelts in the spawning runs and the success of fishermen in obtaining their legal limits of smelts; the relative abundance of smelts in the lakes as indicated by their capture in gill nets and by their abundance in trout and salmon stomachs; the density of trout and salmon populations which the lakes were maintaining in 1939, in relation to fishing intensity, past stocking, and spawning facilities;

[1] See footnote p. 10.

and, finally, the rate of growth of the trout and salmon. By taking all of these factors into consideration, each of the six lakes was accredited with a food grade (of I, II, or III) with reference to the species for which stocking is recommended. The general classification of the tributaries of the different lakes was based on the extent of available spawning grounds and the capacity of the streams to rear fish to a size suitable for natural stocking of the lakes. The factor of fishing intensity was evaluated on the basis of the 1939 census by the Fish and Game Wardens. The computations of the numbers of fish to be stocked per acre in each lake have been based on a "planting table for trout lakes" proposed by Dr. H. S. Davis[24]; the figures proposed by Davis have been modified to apply to 6-inch fish (Table XXXVI).

TABLE XXXVI. Stocking table for trout and salmon lakes; number of 6-inch fish per acre*

Modified from Davis, 1938: Planting table for trout lakes

Fishing intensity	Grade I — Food abundant		Grade II — Food average		Grade III — Food poor	
	Good spawning	Poor spawning	Good spawning	Poor spawning	Good spawning	Poor spawning
Heavy	100	130	50	65	25	35
Medium	50	100	25	50	15	25
Light	15	65	10	35	10	15

* Not based on total area of the lake, but on the average between the total area and the area of lake bottom available to trout and salmon during late summer.

The stocking recommendations for the tributary streams have been based on the following factors: maximum water temperature, amount of stream flow; average width of the stream; the extent of pools and cover, expressed as a Pool Grade; the abundance of bottom food organisms, expressed as a Food Grade; and the length of stream suitable for stocking. The maximum water temperature and the minimum amount of stream flow were considered as factors determining whether or not a given stream was suitable for stocking. For those streams which had suitable temperature and adequate water supply, stocking has been recommended on the basis of pools, food, and stream width and length. A brief description of the streams has been given earlier in this report (see page 137). The numbers of fish to be planted in the streams have been computed on the

[24] Davis, H. S.: 1938. Instructions for conducting stream and lake surveys U. S. Bur. Fish., Fishery Circular No. 26.

basis of a "stocking table for trout streams" proposed by Dr. G. C. Embody[22] for the Genesee River System in New York (Table XXXVII).

TABLE XXXVII. Stocking table for trout streams

As proposed by G. C. Embody (1927) for streams of the Genesee River System in New York State, and used as the basis for the present stocking recommendations for tributaries of the Rangeley lakes.

Stream width, in feet	Number of 3-inch* fingerlings per mile								
	Pools A Food 1	Pools A Food 2	Pools A Food 3	Pools B Food 1	Pools B Food 2	Pools B Food 3	Pools C Food 1	Pools C Food 2	Pools C Food 3
1	144	117	90	117	90	63	90	63	36
2	288	234	180	234	180	126	180	126	72
3	432	351	270	351	270	189	270	189	108
4	576	468	360	468	360	252	360	252	142
5	720	585	450	585	450	315	450	315	180
6	864	702	540	702	540	378	540	378	216
7	1,008	819	630	819	630	441	630	441	252
8	1,152	936	720	936	720	504	720	504	284
9	1,296	1,053	810	1,053	810	567	810	567	324
10	1,440	1,170	900	1,170	900	630	900	630	360

* In the above table the values refer to 3-inch fingerlings only. In order to apply them to fish of various sizes, multiply the values in the table by the following:

For fish of:	1"	2"	3"	4"	5"	6"
	x12	x1.7	x1	x0.75	x0.63	x0.6

If the figures given in these two stocking tables were applied to the Rangeley waters in proportion to the evaluations of these waters as made by the present survey, and applied to their full extent, the yearly stocking would amount to the equivalent of over one and one-half million 6-inch fish (992,000 trout and 600,000 salmon). This would be about five times the average rate at which these waters were stocked during the six years from 1933 to 1939; the 4,332,000 fish planted in the Rangeley region during this period were equivalent in terms of expected survival to about 317,000 six-inch fish (250,000 trout and 67,000 salmon) per year. A 500 per cent increase in the plantings in Rangeley waters would require a great expansion of the present hatchery and rearing station facilities, or

[22] See footnote on p. 161.

a transfer of fish usually allotted to other waters in the state. The latter does not seem justifiable since the Rangeley region is already receiving its share, at least, of the hatchery trout and salmon. Furthermore, in the writer's opinion, it is a much more urgent necessity to increase the size of the fish which are being planted in the lakes, than to greatly increase the number. The numbers of trout and salmon which are here recommended for yearly stocking in these lakes, therefore, represent a reduction to one-fifth of the theoretical rate at which the lakes might be stocked.

The numbers of trout or salmon recommended for yearly stocking in each of the lakes and their tributaries, and a summary of the various factors upon which the stocking recommendations for the lakes have been made, are given in Table XXXVIII. The fish recommended for the streams have been considered as a part of the calculated stocking requirements of the lakes. The relatively small stocking of Aziscoos Lake was recommended because of extreme oxygen depletion in the deep water during the summer making it necessary for the fish to congregate around stream mouths. The justification for stocking only salmon in Mooselookmeguntic Lake and only trout in Rangeley Lake has been discussed previously in this report. Stocking the lakes during either spring or fall is recommended as preferable to stocking in July and August when the surface water is the warmest. The fish planted in streams should be scattered with some degree of uniformity along each stream, regardless of the considerable amount of effort which might be involved.

TABLE XXXVIII. Yearly stocking recommendations for the Rangeley lakes and their tributaries and a summary of the factors upon which the recommendations for lake stocking have been based

Lake	Area*: acres	Food grade	Tributary spawning grounds	Fishing intensity	Recommended yearly stocking** of Brook Trout and Land-locked Salmon for the lakes.	Recommended yearly stocking*** for tributary streams
Lower Richardson Lake	2,200	II	Fair	Medium ?	17,000 six-inch trout, or 15,000 seven-inch trout	Bailey Brook?
Upper Richardson Lake	3,250	II	Fair	Light	11,000 six-inch trout, or 10,000 seven-inch trout	Metallock Bk.: 3,200 three-inch trout Mosquito Bk.: 4,500 three-inch trout
Mooselookmeguntic and Cupsuptic lakes (together)	11,450	II	Good	Heavy	100,000 six-inch salmon, or 92,000 seven-inch salmon	Kennebago River: 28,300 three-inch salmon Rangeley Stream: 2,000 three-inch salmon
Rangeley Lake	4,850	I	Poor	Heavy	123,000 six-inch trout, or 113,000 seven-inch trout	South Bog Stream: 4,700 three-inch trout Long Pond Stream (lower half only): 1,100 three-inch trout
Kennebago Lake	1,450	I	Fair	Heavy	28,000 six-inch trout, or 26,000 seven-inch trout	Wilbur Bk.: 500 three-inch trout Big Sag Bk.: 6,500 three-inch trout Little Kennebago River: 7,200 three-inch trout
Aziscoos Lake	0*	III	Good	Light	5,000 six-inch trout, or 4,500 seven-inch trout	Big Magalloway River: 9,000 three-inch trout Little Magalloway River: 1,100 three-inch trout

*Not total area; see text.
**If 4- to 6-inch fish are planted in the lakes, multiply the figures given for 6-inch fish by 1.1; if 2-inch to 4-inch fish must be planted, multiply the number given for 6-inch fish by 2.
***If 1-inch fry are planted in the tributary streams, multiply the figures given for 3-inch fish by 12.

APPENDIX A

Observations on Horseshoe Pond in West Bowdoin College Grant

A preliminary survey of Horseshoe Pond in West Bowdoin College Grant, Piscataquis County, was made[25] on June 2 to 4, 1939. The area of the pond was estimated at approximately 175 acres. Extensive soundings revealed a maximum depth of 41 feet. Thus the lake was sufficiently deep, in proportion to its size and protected location, to maintain marked thermal stratification during the summer. Thermal stratification was not extreme or typical of midsummer conditions at the time of analyses on June 3 (see Table XXXIX), for the apparent reason that the ice had "gone out" of

TABLE XXXIX. Vertical distribution of temperature, oxygen, and pH in Horseshoe Pond, West Bowdoin College Grant, on June 3, 1939, 3 to 5 P.M. Station: in middle of western half of the pond. Depth of water: 36 feet

Depth in feet	Temperature: °F.	Oxygen: p.p.m.	pH
Surface	60.3	10.7	6.8
10	57.2	....	...
13	56.5	....	...
15	54.7	10.8	6.8
19	48.0	....	...
20	46.9	....	...
25	45.9	10.8	6.5
30	45.7	10.5	6.3
36	45.5	10.4	6.3

the pond less than a month previously. The vertical distribution of oxygen was found to be practically uniform on June 3, but this had little significance in indicating late summer conditions.

No other species of fish besides the Brook Trout were seen in the

[25] The writer was assisted by Dr. E. C. Nelson, C. M. Aldous, and Chief Warden Charles Green.

pond, taken by gill net or hook and line, or found in the trout stomachs. This apparent absence of any other species but trout was confirmed by local report. Also according to a local report, no fish had ever been stocked in the pond, and the pond had been fished very lightly. Our observations indicated that trout were exceptionally abundant. Studies on samples which were collected revealed that the fish were growing very slowly to a maximum length of about nine to eleven inches in four to five years (Table XXXI and Figure 11), and on a summer diet mostly of aquatic insects supplemented by terrestrial insects and plankton water-fleas (see Tables XVIII and XIX and Figure 9).

A study of the bottom food organisms available to trout was based on 23 nine-inch by nine-inch samples collected with an Ekman Dredge, and screened through No. 40 brass sieves, on June 3 and 4. The kinds, volumes, and numbers of organisms in these samples are given in Table XL. Aquatic insects made up a major part of the bottom fauna; and the fresh-water shrimp was also relatively abundant. On the basis of these 23 samples, the average bottom fauna for the lake was calculated to be 31.8 individual organisms of 0.229 cubic centimeters in volume per square foot of lake bottom (see Table XLI). In quantity of bottom food, Horseshoe compared very favorably with other lakes and ponds in Maine which have been studied thus far (Table XIII).

The available evidence from the brief survey on Horseshoe seems to indicate that abundance of the bottom fauna was the factor limiting growth and increase in abundance of trout in the pond. Trout were very abundant. They were feeding, with some degree of uniformity, on all types of the bottom organisms in proportion to the abundance of these organisms (Figure 9). They were feeding quite extensively on planktonic, or possibly benthic, water-fleas, which, in the writer's opinion, is an index of relative scarcity of food. And, finally, the trout were growing very slowly.

The introduction of a species of minnow such as the Red-bellied Dace (*Chrosomus eos*) or the Golden Shiner (*Notemigonus crysoleucas*), or the introduction of the Smelt, would probably result in an increase in the size of trout in Horseshoe Pond. It could not be safely predicted, however, that such introductions would result in any great increase in either the number or total weight of trout in the pond, for the introduced species woudl become food competitors with the trout to some extent and the larger trout might become cannibalistic.

TABLE XL. Volumes and numbers of each type of organism in 23 bottom samples taken from Horseshoe Pond West Bowdoin College Grant, arranged according to depth of water and type of bottom

Depth range in feet	Type of bottom	Number of samples	Volume in cubic centimeters and number (in parentheses) of organisms in samples													
			Aquatic earthworms (Oligochaeta)	Fresh-water shrimp (Amphipoda)	Alder-fly larvae (*Sialis*)	Mayfly nymphs (Ephemerida)	Dragonfly nymphs (Anisoptera)	Damselfly nymphs (Zygoptera)	Beetle larvae (Coleoptera)	Caddisfly larvae (Trichoptera)	Midge larvae (Chironomidae)	Mosquito larvae (*Corethra*)	Pill clams (Sphaeridae)	Snails (Amnicolidae)	Other snails (Gastropoda)	All organisms
3–10	Gravel, sand	2	0.01 (1)	0.03 (9)	....	0.07 (4)	....	......	......	......	......	......	......	.....	.....	0.11 (14)
	Sand	6	0.02 (2)	0.17 (63)	....	0.07 (5)	0.43 (2)	......	0.01 (4)	0.06 (1)	0.035 (6)	0.005 (1)	0.05 (10)	0.01 (2)	0.02 (2)	0.88 (98)
	Gravel, mud	2	......	0.14 (15)	....	0.04 (3)	....	......	......	......	0.01 (2)	......	......	.....	.....	0.19 (20)
	Mud	2	......	0.085 (24)	0.01 (2)	0.04 (2)	....	0.04 (1)	......	......	0.02 (8)	......	0.025 (6)	.....	.....	0.22 (43)
11–20	Gravel, sand	1	......	0.02 (6)	....	0.13 (9)	....	......	......	......	0.01 (3)	......	......	.....	.....	0.16 (18)
	Sand	2	......	0.13 (15)	....	0.05 (2)	....	0.05 (1)	......	0.02 (1)	0.722 (7)	......	0.018 (7)	0.01 (3)	.....	0.03 (36)
	Mud	5	0.02 (1)	0.232 (29)	0.02 (5)	0.15 (9)	....	......	......	0.04 (2)	0.115 (37)	0.08 (19)	0.013 (3)	.....	.....	0.67 (105)
21–30	Mud	2	0.015 (1)	0.05 (9)	....	....	....	......	......	0.02 (1)	0.015 (8)	0.10 (20)	0.01 (3)	.....	.....	0.21 (42)
31–40	Mud	1	0.005 (1)	......	....	....	....	......	......	0.02 (1)	0.01 (2)	0.19 (31)	0.005 (1)	.....	.....	0.23 (36)
3–40	....	23	0.07 (6)	0.857 (170)	0.03 (7)	0.55 (34)	0.43 (2)	0.09 (2)	0.01 (4)	0.16 (6)	0.237 (37)	0.375 (71)	0.121 (30)	0.02 (5)	0.02 (2)	2.97 (412)

TABLE XLI. Volumes and numbers of all organisms in 23 bottom samples, and calculated volumes and numbers of bottom organisms per square foot in Horseshoe Pond, West Bowdoin College Grant, according to depth of water. Based on data given in Table XL

Depth of water in feet	Number of samples	Total organisms in samples		Organisms per square foot (calculated)	
		Vol. in c.c.	Number	Vol. in c.c.	Number
3–10	12	1.40	175	0.207	25.9
11–20	8	1.13	159	0.251	35.3
21–30	2	0.21	42	0.187	37.3
31–40	1	0.23	36	0.409	64.0
3–40	23	2.97	412	0.229	31.8

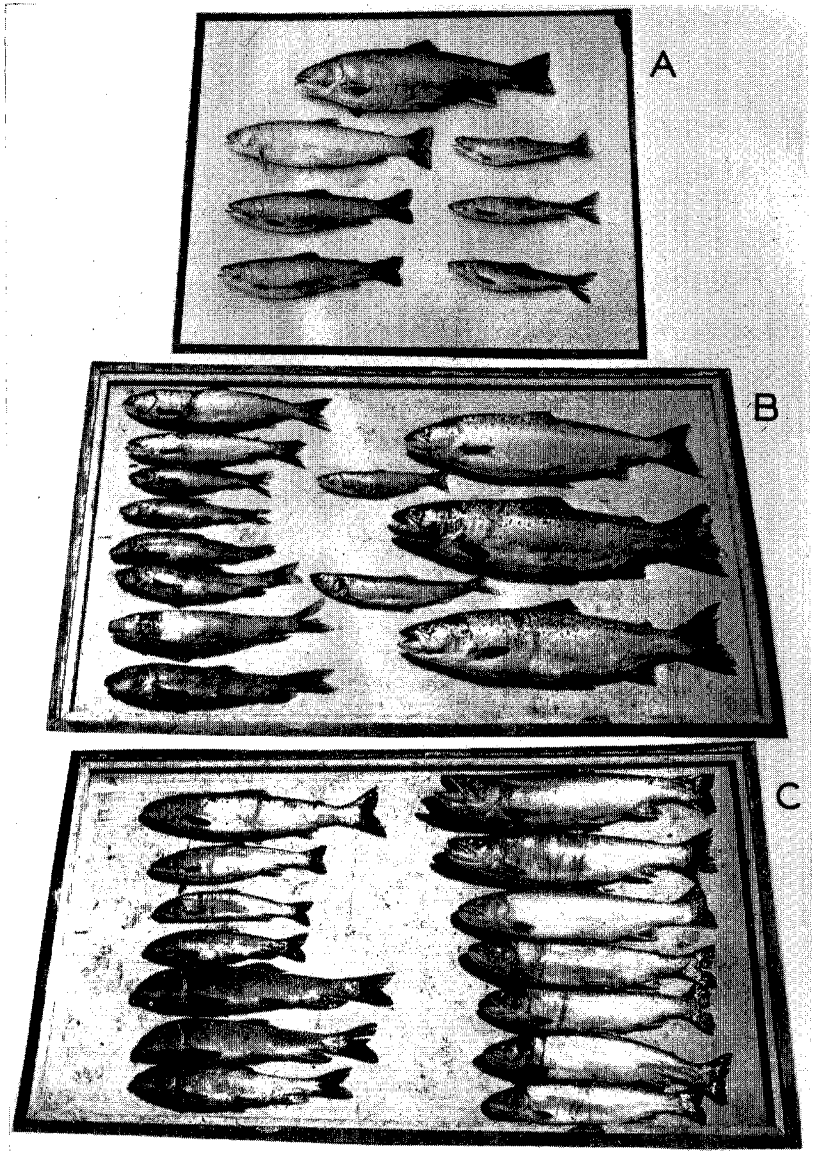

PLATE I

Gill net catches from the Rangeley lakes by the 1939 survey.

A — Upper Richardson Lake. August 8. Brook Trout (5) and Fine-scaled Suckers (2). Largest trout, 17 1/8 inches.

B — Mooselookmeguntic Lake. July 25. Brook Trout (1), Land-locked Salmon (5), Smelt (1), Common Suckers (2), and Fine-scaled Suckers (4). Largest salmon, 20 7/8 inches.

C — Mooselookmeguntic Lake. July 20. Brook Trout (9), salmon (1), Common Suckers (3), and Fine-scaled Sucker (1), Largest trout, 16 3/4 inches.

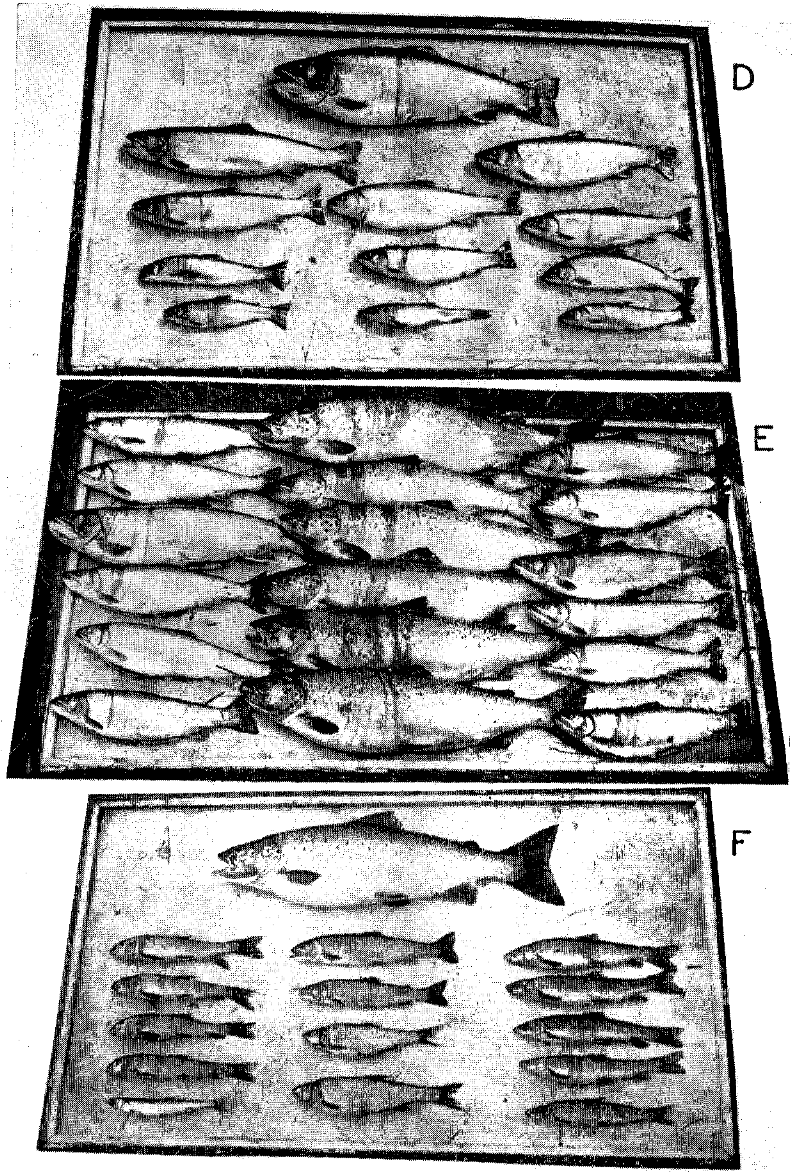

PLATE II

Gill net catches from the Rangeley lakes by the 1939 survey.

D — Rangeley Lake. July 10. Brook Trout (11) and Fine-scaled Sucker (1). Largest trout, 19 1/2 inches.

E — Rangeley Lake. July 11. Brook Trout (11) and salmon (7). Largest salmon, 22 3/8 inches, 5 lbs. 1 oz.

F — Rangeley Lake. September 8. Brook Trout (2), salmon (1), Smelt (1), Common Suckers (4), Fine-scaled Suckers (5) and Fallfish (2). Largest fish (salmon), 22 1/2 inches, 5 lbs. 3 ozs.

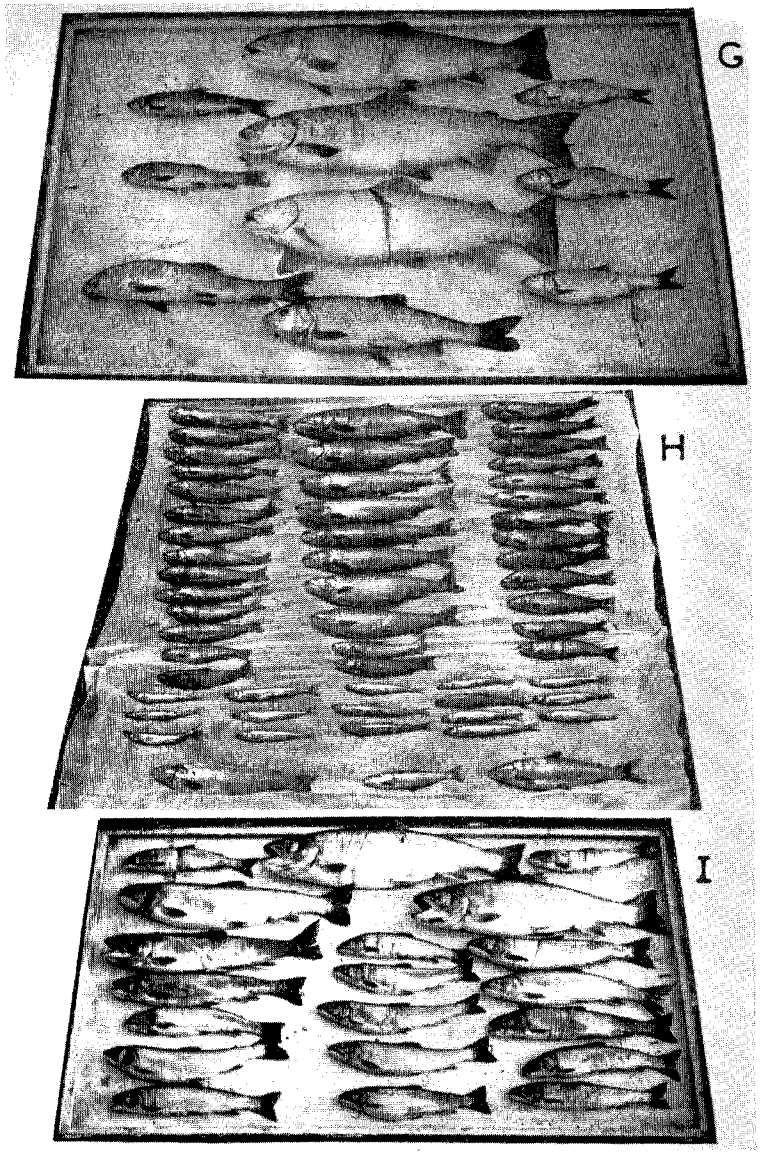

PLATE III

Gill net catches from the Rangeley lakes by the 1939 survey.

G — Rangeley Lake. September 10. Brook Trout (1), salmon (1), Brown Trout (1), Common Suckers (2), Fine-scaled Sucker (1), and Fallfish (4). Largest fish (salmon), 20 3/4 inches, 3 lbs. 13 ozs. The 20 3/4-inch salmon had completed its sixth growing season, the 20 1/4-inch Brook Trout had completed its fifth season, and the 18 15/16-inch Brown Trout had completed its fourth.

H — Kennebago Lake. August 22. Brook Trout (37), salmon (2), Brown Trout (1), and Smelt (16). Largest trout, 17 1/2 inches.

I — Kennebago Lake. August 21. Brook Trout (20). Largest trout, 18 7/8 inches.

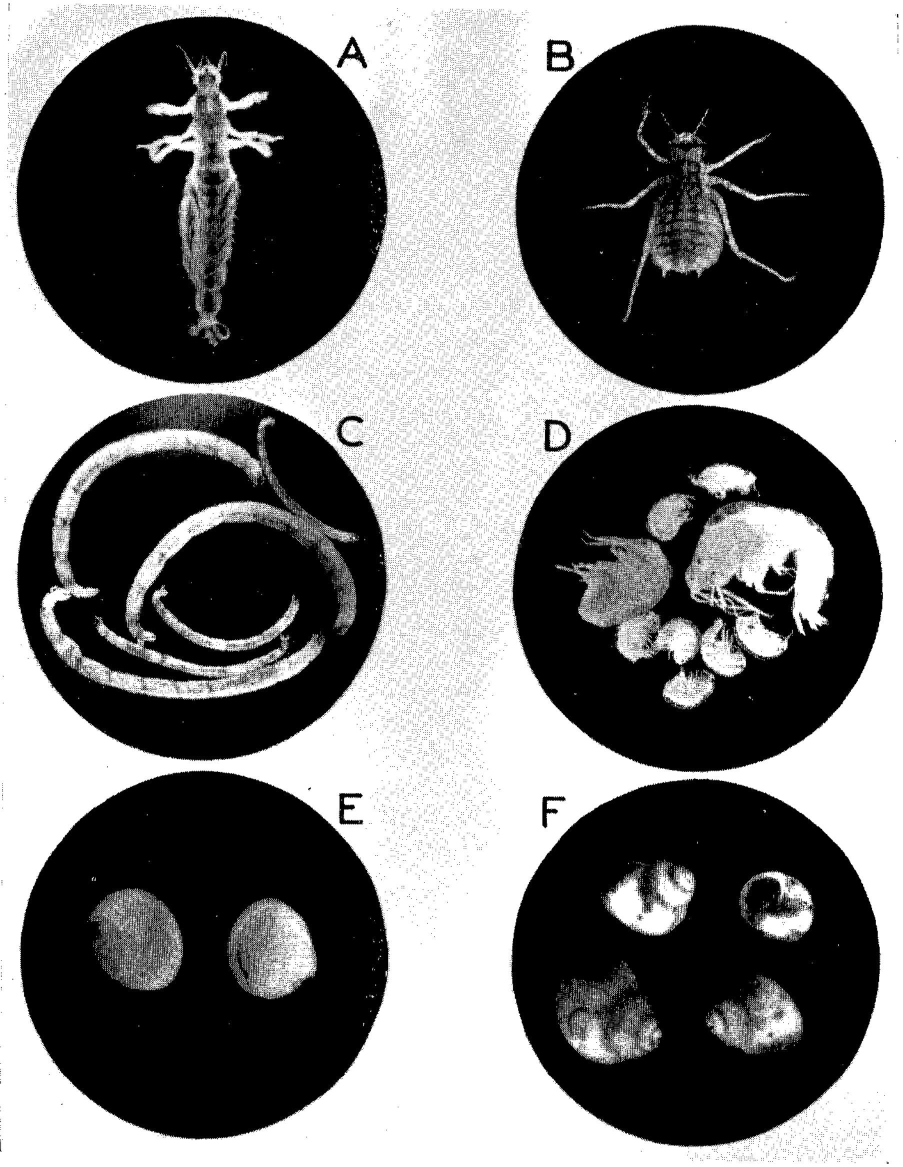

PLATE IV
Some common types of bottom food organisms, from trout stomachs and from bottom samples.
A — Burrowing Mayfly nymph; **B** — Dragonfly nymph; **C** — Midge larvae; **D** — Fresh-water shrimp; **E** — Pill clams; and **F** — Snails (Amnicolidae).

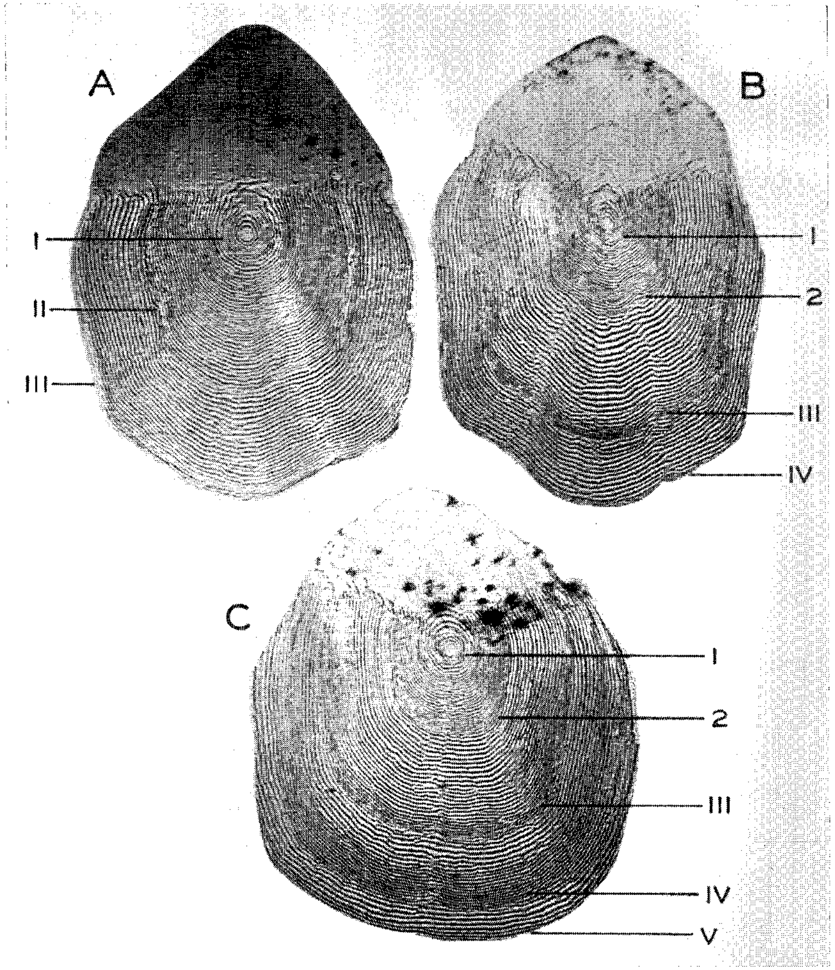

PLATE V
Scales of Land-locked Salmon (*Salmo sebago*).
A — From spawning run in Cold Stream Pond at Enfield, Maine. November 11, 1936. Adult female, 15 3/4 inches long. Three years old. Growth history: 1-II.
B — From spawning run in Cold Stream Pond. November 11, 1936. Adult female, 18 3/4 inches long. Four years old. Growth history: 2-II.
C — From spawning run in Cross Lake Thoroughfare at Guerette, Maine. October 30, 1936. Adult female, 22 inches long. Five years old. Growth history: 2-III.

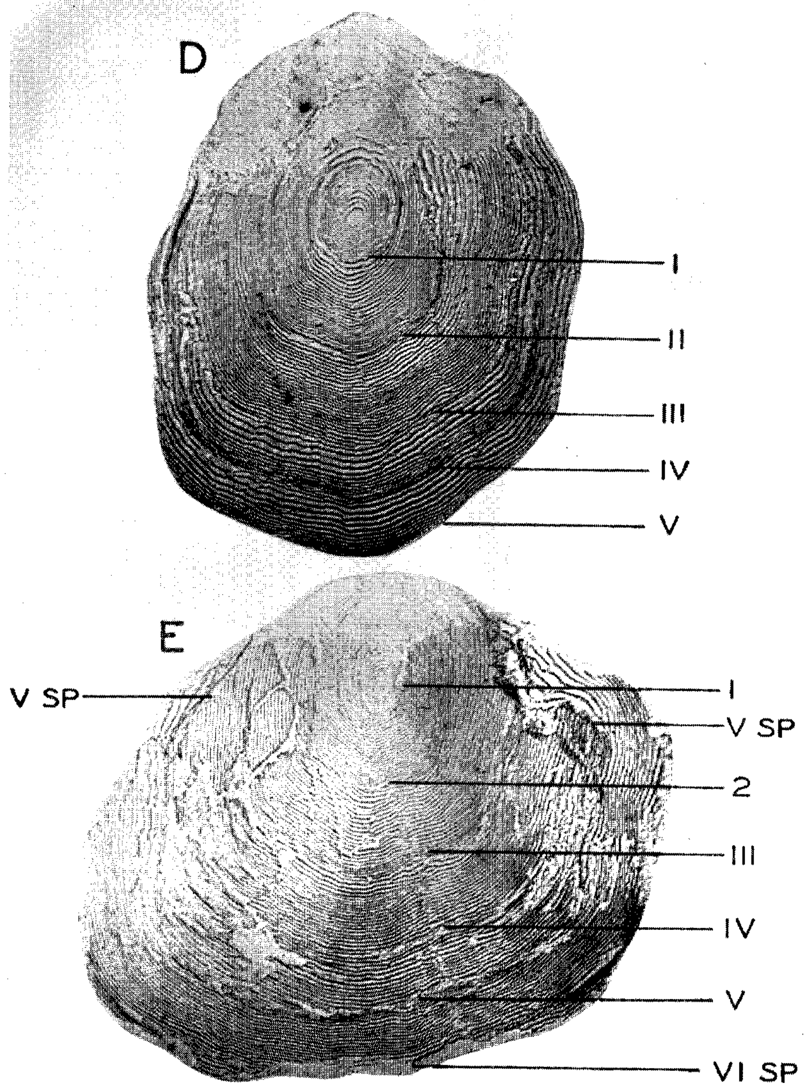

PLATE VI

Scales of Land-locked Salmon (*Salmo sebago*).

D — From spawning run in Cross Lake Thoroughfare at Guerette, Maine. October 30, 1939. Adult female, 20 1/4 inches long. Five years old. Growth history: 1-IV.

E — From spawning run in Cross Lake Thoroughfare. November 13, 1938. Adult male, 10 lbs. 4 ozs., 32 1/3 inches long. Six years old. Growth history: 2-IIIS-IS.