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The Effect Of Environmental Factors Upon The Growth Rates Of Minnesota Fishes

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Fishes, such as our game fishes, trout, pike, and bass, all feed on about the same kind of food and are, therefore, competitors of each other. It should be kept in mind that a lake provides support for only a limited amount of fish and when a competitive fish is introduced, it is only reasonable to assume that the maintenance of the native species will be reduced. The introduction of a new species into any lake should be studied carefully. It is sometimes much harder to remove it than it was to introduce it. It is seldom that bass lakes can be found in which trout will live, but thousands of dollars worth of fry of various species of trout have been wasted in attempts to establish these fish in all kinds of lakes. This type of planting is not good management and is not based on careful surveys. Lakes should be managed for lake trout only in rocky lakes where surveys show sufficient oxygen in the cold water below thermocline during the hot summer months.

All introductions have not been mistakes. There are many cases of small lakes without fish or with only perch which have been successfully stocked with bass and in some cases with rainbow trout. Many large lakes in the northeastern part of the state, until fifteen years ago, contained only pickerel or great northern pike and a few rough fish. The conditions of these lakes were considered carefully by Mr. Thaddeus Surber of the Division of Game and Fish and wall-eyed pike were introduced. The result of these introductions has been one of the most valuable and successful phases of management of Minnesota fishes before it was called management.

It is essential that all fish management must be based on common sense. Fish management is the method by which the reputation of Minnesota fishing will be maintained. No business could be run the way our fish resources have been managed for the past seventy-five years. No information was available of the extent of the fisheries resources or the rate at which they are renewed. Fish management based on lake surveys and population studies will improve the environment and will maintain the proper fish balance.

THE EFFECT OF ENVIRONMENTAL FACTORS UPON THE GROWTH RATES OF MINNESOTA FISHES *[1]

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The effects of certain environmental conditions upon the rate of growth have been investigated for a few species of fishes, but little has been done toward a general solution of the problem. Under natural conditions the growth rate is not always modified by a single factor, but by a number of interacting factors, some of which may be favoring growth while others are inhibiting it. During the growth rate studies being carried out by the University of Minnesota and the Minnesota Department of Conservation with the aid of the NYA and the WPA, an attempt has been made to solve this problem. To date, growth rates have been studied for almost 20,000 fishes from about 300 Minnesota lakes and rivers on many of which biological and chemical surveys have been made. These data form the basis for a comprehensive study of this problem.

Sufficient data to permit an analysis of the differences in the growth rates are available for fourteen species of fish: lake trout (*Cristivomer namaycush*), tullibee (*Leucichthys artedi tullibee*), whitefish (*Coregonus clupeiformis*), sucker (*Catostomus commersonii*), redhorse (*Moxostoma aureolum*), European carp (*Cyprinus carpio*), pickerel (*Esox lucius*), perch (*Perca flavescens*), wall-eyed pike (*Stizostedion vitreum*), large-mouthed black bass (*Huro floridana*), pumpkinseed sunfish (*Eupomotis gibbosus*), bluegill (*Helioperca incisor*), rock bass (*Ambloplites rupestris*), and crappie (*Pomoxis sparoides*).

The factors controlling the growth rates of fishes may be divided into two groups: hereditary and environmental. Except for differences between species and between races, it is likely that under natural conditions, environment is more important in modifying the growth rates. Heredity is responsible for the differences between the growth rates of two species of fishes, but environment plays an important part in determining the variations in the growth rates of a single species of fish in different lakes.

The present study deals entirely with environmental factors, only a few of which have been investigated as yet. These factors fall into three groups: lake fertility, length of growing season, and the density of fish population. The fertility of a lake may be indicated in a number of ways. In the present studies, the fertility has been measured both by the determination of various dissolved substances and by the abundance of food organisms. The dissolved materials in the water form the basic fertility of the lake and may be measured by the total dissolved solids content of the water.

An attempt was made to correlate the growth rates of the 14 species with the total dissolved solid contents of the lakes from which they came. In five species a correlation was noted. In four of these, whitefish, sucker, bluegill, and pickerel, the growth rates were more rapid where the lakes were more productive. The growth rate of the crappie, however, showed a reverse condition. The growth was more rapid in lakes where the fertility was low. This was probably due to population densities which will be discussed later.

*[1] Prepared with the assistance of Works Progress Administration, Official Project No. 665–71–3–69. Sub-project (69) No. 218, sponsored by University of Minnesota (1936–1940).

Another important measure of the fertility is the abundance of carbonates, which are important basic materials in the food chain of the fishes. An attempt was made to correlate the growth rates of 12 species of fishes with the total carbonate content of the lakes. In four species, the sucker, rock bass, bluegill and pickerel, the growth was more rapid where the total carbonates were most abundant. It is interesting that the rock bass showed this correlation with the total carbonate content when it did not show such a correlation with the total dissolved solids. It would thus seem that the carbonate content is more important to the growth of the rock bass than is the fertility as measured by the total dissolved solids.

The range of hydrogen-ion concentration or pH in the lakes is not enough to cause differences in growth rates, but the pH may be an indicator of other factors. Five of the fourteen species, investigated, viz., the tullibee, the whitefish, sucker, redhorse, and rock bass, showed a correlation between the growth rate and the hydrogen-ion concentration. In all cases, the growth was more rapid where the hydrogen-ion concentration was lower. It is interesting that the species affected included both of the members of the whitefish family and both of the suckers included in this study.

The food supply is frequently cited as an explanation for growth rate differences. Where food is abundant, it is reasonable to expect rapid growth, but this is not always the case. In the present study, two sources of food were quantitatively measured: the plankton and the bottom fauna. Eaten extensively by young fishes and by the adults of only a few species such as the coregonids, plankton forms are an important element in the food chain of all fishes. Four species, the lake trout, sucker, bluegill, and the wall-eyed pike, showed more rapid growth where the plankton production was most abundant.

The organisms on the lake bottom form a substantial part of the food of many species of fish. Three species, the sucker, lake trout, and sunfish, showed more rapid growth where the bottom fauna were more abundant. The sucker is largely a bottom feeder, but the other two species feed only partially on the bottom.

Most fish are inactive and show very little growth during the winter. It might be expected, therefore, that the length of the growing season would affect the growth rate. All except three of the species showed more rapid growth where the season was longer. The growth of the bluegill showed no correlation with the length of the growing season. Perch and crappie growth was more rapid where the growing season was shorter, probably due to other factors. All three species tend to show stunted populations where fishing is heavy. This question will be discussed later, but it should be pointed out here as a possible explanation of the more rapid growth where the growing season was shorter, since most of the stunted populations were found in the southern part of the state.

This leads to a discussion of the population density. Swingle and Smith *[2] showed that a given fish pond would yield a definite number of pounds of fish. If the population density were high, the growth rate was slow; if the population density were low, the growth rate was rapid. Kawajiri *[3] secured similar results with rainbow trout. The total food is evidently the limiting factor and when the population increases, the competition for food becomes so great that growth decreases.

The determination of the effects of population density upon the growth rates of fishes under natural conditions is difficult. Several attempts made to determine the population densities in various Minnesota lakes have met with little success. Because of this, the effect of population densities upon growth rates must be largely determined from scattered examples, but these examples are so striking as to indicate that the population densities are the most important factors in causing differences in growth rates in the various lakes.

In 1938, studies were made of the fish populations of a series of lakes in Ramsey County. These lakes were all of the same general type, comparatively hard water eutrophic lakes in glacial drift basins, ranging in total dissolved solids from 140 to 270 p.p.m. The population densities were determined by seining large areas and counting the number of fish per acre. Data were secured on the bluegill populations in six lakes. Three lakes showed low populations (25.34 to 48.63 fish per acre) and rapid growth (taking 2.82 to 3.48 years to reach a length of 5 inches.) The other three showed high populations (320.52 to 501.43 fish per acre) and slow growth (taking 4.03 to 5.02 years to reach the same length.) The separation into these two groups is very clear and indicates a correlation between high populations and slow growth.

Data were also secured on the crappie populations of five of these lakes. Two of the lakes showed low populations (.14 to 2.65 fish per acre) and rapid growth (taking 2.4 to 3.76 years to reach a length of seven inches); three showed high population densities (80 to 450 fish per acre) and slow growth (taking 4.29 to 4.76 years to reach the same length).

It has often been noted that in some lakes, fishermen can catch large numbers of small fish, while in nearby lakes they catch comparatively few fish, but those that they do catch are large.

The bass population is so dense in Long or Lost Lake in Clearwater County that a fisherman may get his limit of large-mouth black bass within an hour, but they are small, ranging from 7 to 9 inches in length. In this lake the growth is so slow that it is com-

*[2] Swingle, H. S. and E. V. Smith, 1940. Increasing fish production in ponds. Penn. Angler 9 (1): 18–29.

*[3] Kawajiri, Minoru, 1928. On the studies of the population-density of cultured fishes. I. On the influence of population-density of fishes upon the survival-rate and the rate of growth. Jour. Imp. Fish. Inst. (Tokyo) 24 (1): 8–11.

puted the bass fail to reach 12 inches in length until they are five and a half years old. In nearby Lake Itasca, only a few bass are caught each year, but they are 12 inches long when three and a half years old. A similar situation is found among the bluegills in these two lakes. The bluegills in Itasca grow one and a half times as fast as those in Long Lake.

In North Lindstrom Lake, Chisago County, the crappies are so abundant that an angler may easily catch his limit in a short time. These crappies are small, however, most of them being about six inches long. Furthermore, they are thin and underweight. They weigh only about 73% as much as crappies of the same length in other lakes. The growth rate for the crappies in this lake is lower than that of most of the other lakes in the state. Also, the bluegills are small, weighing only 67% as much as bluegills of the same length in other lakes and showing very slow growth. Apparently the population density in this lake has become so great that growth is extremely slow.

Crappies, sunfishes, and perch often show large populations of stunted fish. In all such cases examined by the authors, these fishes show very slow growth rates. Such conditions have also been noted among bass, pickerel, and other species.

Although the evidence is, as yet, not entirely conclusive, it seems that these large populations of undersized fish are associated with heavy fishing. The fisherman is selective and tends to remove the larger fish. Under normal conditions, most fishes produce many more fry than the lake can support. These larger game fish are the natural checks upon the small fish, even of their own kind. When the large fish are removed, the small fish are allowed to survive in large numbers, becoming crowded and stunted.

There is one further piece of evidence that the population density is an important factor in controlling the growth rates of fishes. It has often been noted that when a species is successfully introduced into a new habitat, the growth is unusually good. This is largely because of the small number of individuals present and the lack of competition within the species. As reported in a previous paper, *[4] wall-eyed pike apparently grow more rapidly in the northeastern part of the state where they have been recently introduced than they do elsewhere in the state. This is undoubtedly due to the lack of competition among the pike in these lakes.

In summarizing the results of these studies, it seems that the population density is the factor of greatest importance in modifying the growth rates of fishes. The productivity of the lakes seems to determine the total number of pounds of fish, but the population density seems to control their growth rate. Two possibilities seem to be open as methods of improving fishing conditions. The total

*[4] Eddy, Samuel, and Kenneth Carlander, 1939. Growth rate of wall-eyed pike in various lakes in Minnesota. Proc. Minn. Acad. of Science 7:44–48.

yield may be increased by fertilizing the lake, or the population density may be controlled so that the growth rate is more rapid. If the fish populations can be maintained at a proper balance, both in reference to population density and to age class distribution, the outlook for future fishing will be very bright.

EXPERIMENTAL SIMULATION OF WINTER ANAEROBIOSIS

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ABSTRACT

Typical lake bottom ooze was studied under anaerobic winter conditions at 0°, 5° and 10° C. for 120 days, with respect to survival of the constituent organisms and CO_2 production. More CO_2 was produced at 0° than at 5°, suggesting the presence of "cold-loving" anaerobic bacteria. Three dipterous larvae (*Chironomus plumosus, Chironomus decorus, Palpomyia sp.*) and an oligochaete (*Tubifex*) were able to endure 120 days of anaerobiosis in mixed populations. Temperature had a marked effect on survival. The data seemed to indicate that none of the organisms studied would be able to survive anaerobiosis indefinitely, with the possible exception of certain cryptomonad flagellates.

REGIONAL PLANKTON STUDIES IN MINNESOTA

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The magnitude of plankton produced in Minnesota and the great variety of conditions under which this plankton develops suggest many intriguing limnological problems. This present study is concerned with the distribution of planktonic species in several limnological regions of Minnesota. It has considered three distinct lake regions which may be termed the Superior region, the Chippewa region and the Prairie region.

All lakes selected for study from the Superior region are located in Cook County. They tend to be deep cold lakes ranging in depth from fifty to two hundred feet and may be considered as oligotrophic. Since the prevailing surface formations of the area are the Superior red drift and the exposed graywackes and gabbros, the basins of all except one are in bed rock. The lakes studied in the Chippewa region range in depth from thirty to ninety feet and are