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THE BREEDING HABITS OF LAKE TROUT, CRISTIVOMER NAMAYCUSH NAMAYCUSH (WALBAUM), IN NEW YORK

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CRISTIVOMER NAMAYCUSH NAMAYCUSH (WALBAUM)

THE BREEDING HABITS OF LAKE TROUT IN NEW YORK ~~STATE~~

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ABSTRACT

Lake trout were observed during spawning season in 1939, 1940, and 1941 in several lakes in New York State, and actual spawning was seen in Otsego Lake, New York. Extensive data on spawn-taking operations were ~~furnished by~~ obtained from the New York State Conservation Department and existing literature on the subject was reviewed.

The findings were that Except for a striking color change in the males while on the spawning area, lake trout ~~were found to lake~~ lacked sexual dimorphism. They matured ~~usually~~, in about their sixth year at lengths varying from 15 to 30 inches in different lakes.

Spawning occurred once each year during the autumn. The date varied from late September to early December depending on the race of trout, the amount of sunlight, the ~~change~~ autumnal drop in temperature, and the depth of the lake.

In the deep water of Seneca Lake, one race spawned early. In all other lakes studied, the lake trout spawned in shallow water, and usually later. Increased cloudiness in July, August, and September, and low temperatures in September, advanced the date of spawning in Racquette Lake. Shoaler lakes had earlier spawning dates. At the time of spawning, water temperature varied from 58°F. to 37°F., but in Racquette and Otsego Lakes it was observed that spawning time approximated the turnover time of the lake. Generally, the spawning period was about 20 days, but varied from 10 to 40 days and was fairly consistent from year to year in any one lake.

Spawning, whether in shallow or deep water, took place on gravel ~~and~~ or rubble bottom ~~which possessed~~ that had crevices into which the eggs could roll. No nest or redd was built. No evidence of spring water was observed near any spawning area.

~~from 2 to about 10 lake trout participated in the spawning act~~

In the spawning act, which usually occurred during the evening, from 2 to ~~about~~ 10 lake trout participated. Each attempt at spawning lasted only a few seconds and was repeated many times.

~~The eggs were recovered from the crevices in the rocks of Otsego Lake and were found to be 79 percent alive~~

About one month after spawning, ~~the eggs were~~ a sample of eggs ~~were~~ recovered from the crevices in the rocks of Otsego Lake ~~and were~~ was found to be 79 percent alive. No measurement was possible on the effects of predation on eggs, but it was estimated that only eggs which failed to roll into crevices ~~of~~ between the stones ~~were affected~~ could be eaten.

In Otsego Lake the eggs hatched about April 15, ~~1941~~ 1940, and the fry left the spawning area about May 22. In the deep water of Seneca Lake, where the lake trout had spawned in early October, a single advanced fry was taken on ~~in early~~ April 2, 1940. Its development indicated that hatching occurred in late January.

Extensive operation of a small beam trawl, set lines, and minnow traps in Otsego, Keuka, and Seneca Lakes failed to produce any lake trout between advanced fry stage and a length of about ~~6~~ six inches. Twelve specimens between 6 and 10 inches long that ~~which were~~ captured in gill nets in Keuka Lake were found to be one- and two-year-olds and to be feeding mostly on *Mysis relicta*.

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INTRODUCTION

The several races of lake trout (Cristivomer namaycush) are widely sought in all of the more accessible parts of their range. In the Great Lakes, where it is one of the most valued food species, it is the subject of a major fishery. In smaller lakes of the northeastern United States and southern Canada, where commercial fishing usually is prohibited, it is highly prized as a game fish.

This popularity has been accompanied by severe declines in the populations of lake trout in some lakes, notably ~~Lake Huron~~ in the Great Lakes. Detailed knowledge of the habits and preferances of the species - particularly of the eggs, larvae, and juveniles below the sizes commonly caught - is required in order to devise corrective measures to prevent such declines as well as to successfully introduce this desirable species in additional lakes.

Almost nothing is known of the habits of young lake trout, probably because of their deep-water habitat. In fact, Very few wild lake trout less than 8 inches in length have even been seen; their reproductive habits have been imperfectly known, and very little has been published on their size and age at maturity. Accordingly, ~~it was for this reason that~~ this study of the breeding habits and life history of the young lake trout was undertaken, ~~by myself as a part of the requirements for a degree of Doctor of Philopophy at Cornell University from 1938 to 1941.~~

SEXUAL DIMORPHISM

The lake trout, unique among the salmon family, lacks almost completely the malformed jaws or kype common to the mature males

of other genera. Examination of several hundred lake trout from ~~many~~ various lakes in New York State reveals that it is ~~nearly~~ almost impossible to distinguish the sex of mature lake trout by examination of the head alone. Critical comparison of many individuals, ~~however,~~ shows that males have only a slight tendency toward a more pointed snout.

It is pertinent to compare ~~the~~ this ~~characteristic of the~~ lack of malformed jaws lake trout with those of the Pacific salmon where the kype attains its maximum development. These ~~fish~~ salmon migrate enormous distances to the spawning ground and live entirely on stored food for almost a year prior to spawning. Mottley [a] (1936) suggests that the development of the kype in the males may occur because their demand on the material mobilized for the development of the gonads differs from that of the female. He postulates that the ovaries would have a general requirement for stored materials, while the testes would require little albuminoids or fat. These materials might be utilized in the growth of the kype instead of being excreted.

insert ~~Reference to Literature cited~~

~~The lake trout would appear to be a dimetric opposite. It has no kype, migrates only the sh~~

[a] Publications referred to parenthetically by date are listed in the Literature Cited, P. ? = single-space

The lake trout would appear to be a diametric opposite. It has no kype, migrates only the short distance from the deep to the shoal waters of a lake, and feeds up to and through the spawning period 4. Since the lake trout does not acquire a

4 Rayner (1940) found the stomachs of ripe lake trout taken on the spawning area ~~to~~ contained fish, lake trout eggs, and miscellaneous invertebrates.

kype and since the maturation of the gonads parallels that of the salmon, Mottley's suggestion leaves some things to be explained. Possibly, since the lake trout feed right up to and through the spawning season, the gonads can develop from ingested food instead of mobilizing stored material from the body.

Like the external structural, ~~differences~~ the color ~~diff~~ of male and female lake trout, ~~as usually seen~~ when removed from the water, is very similar. (Hamerstrom in New York State). The normal coloration of both sexes varies widely from lake to lake. The lake trout of the large, clear Finger Lakes are light olivaceous, almost silvery on the back

and sides, with a little yellow or orange in the fins. There are all gradations between the colors of these trout and the very dark trout of the brown-water Adirondack lakes. The latter have stronger colors, and the sexual differences are a little more pronounced. Here the males tend to have more brilliant yellow, orange, and black in the paired fins than the females. But, even with these lake trout it is not always possible to distinguish the sexes on the basis of external differences.

This normal coloration is considerably changed when the male lake trout are greatly excited on the spawning area. While courting the females, the chromatophores on the back contract, making the back appear decidedly light colored, while the sides--flooded with pigment--become very lustrous and almost black (Fig.1).

Figure 1.--Male lake trout on the spawning grounds in Otsego Lake, New York

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Merriman (1935) observed this condition in the lake trout of Squam Lake, and it was seen by the writer in Otsego Lake in 1940 and 1941. At this time selected fish were speared and the brilliant coloration was found to be restricted to the males.

Striking as was this coloration during the courting or spawning, the colors were most ephemeral. After the fish were netted or speared, the color differences could not be detected.

The Spawning Habits of the Lake Trout

Age and Size at Maturity

The age analysis (by means of scales) of the lake trout caught by gill nets on the spawning area off Peach Orchard Point in Seneca Lake, New York showed that 13 had 5 annuli and the remaining 20 had 6 annuli. Comparison of the lengths of the lake trout in this sample with the length frequency of 424 lake trout taken during the spawning season in 1941 showed that these age groups comprised the bulk of the catch, but probably an appreciable quantity of older fish were taken.

Additional data collected during 1940 on the lake trout of Lake Simcoe, Ontario, showed that 13 out of 20 five-year-old and 16 out of 17 six-year-old lake trout were mature. Samples from Keuka Lake, New York in the same year showed similar results: 15 out of 18 five-year-old and 5 out of 6 six-year-old trout were mature. There was a slight tendency in these two lakes, as well as in Seneca Lake, for the greater proportion of the young males to be mature.

Fry and Kennedy (1937) estimated, by means of the modes of a length frequency distribution, that the lake trout of Lake Opeongo, Algonquin Park, Canada, reached the minimum age at maturity in their fifth year of life (corresponding, presumably, to 4 annuli). Inasmuch as they had only 5 lake trout less than 13 inches long, and since my observations indicate very small growth of lake trout in their first year, I believe that they assigned an age to each mode ~~of one~~ 1 year less than it should have been.

These data are substantiated by data on the growth of hatchery-reared trout. Surber (1933) secured eggs from female lake trout aged 4 years and 6 months ~~at~~ whose lengths ~~varying~~ varied from 18 to 26 inches. But, at this time, only 10 females out of somewhat less than 3,000 males and females spawned, producing only an average of 962 eggs per female. No data on subsequent spawning was presented, but certainly the majority of his fish did not spawn before their sixth year. Surber felt that this age at maturity was comparable to that attained by wild fish. He gives the length of the trout at the end of their first, second, third, and fourth years of life as 10, 14, 16 to 18, and 18 to 26 inches respectively. This rate of growth in the first and second years of life is markedly greater than that existing in Keuka Lake. With this start it is possible that the hatchery fish spawned earlier than they would have in the wild, ~~as~~ which is known to be true with some other species of hatchery-reared trout, especially brook trout.

The rapidly growing lake trout of Seneca Lake, New York, whatever their age, do not mature until they are 26 to 30 inches total length. The lake trout of Keuka Lake, New York, mature at a total length of 18 to 24 inches. In Skaneateles Lake, New York, however, Rayner (op. cit.) captured many mature lake trout of 15 and 16 inches total length. Fry (1939) reported that the minimum size at maturity in some lakes of Algonquin Park, Canada, varied from 14 to 18 inches according to the lake.

Obviously with this variation in size at maturity a uniform minimum legal size limit of 15 inches, such as exists in New York State, may permit the taking of many immature, rapidly growing fish in some lakes while providing entirely too much protection in other lakes. It would appear necessary to consider the growth rate and fishing pressure in each lake in setting a minimum size limit.

Slowly growing lake trout may be subject to senility at a small size. Fry and Kennedy (1937) reported that none of the lake trout of Lake Opeongo, Algonquin Park, Ontario, of more than 22 inches fork length were capable of spawning. Such widespread impotency was not observed in any of the New York lake trout. The Conservation Department employees engaged in spawn-taking operations on the Adirondack and Finger Lakes reported that only occasionally would an impotent fish be found. The more limited observations I made also failed to show any impotency, and it is quite likely that after the lake trout in New York State lakes are mature they may spawn several times before succumbing to the infirmities of age.

The Time of Spawning

The available information shows that lake trout and most other trout spawn once a year in the fall when the temperature is dropping and the days are becoming shorter. Among different races of lake trout, small variations in the spawning date are found. This is also true among the same race of lake trout in different lakes, and among different years in the same race in the same lake. It appears probable that fluctuations in the light and temperature, in the physical characteristics of different lakes, and in the varying response of different races are the determining factors.

Many of these factors have been proven to be important in influencing the spawning time of other species. Hoover and Hubbard (1937) have shown that brook trout which normally spawned in December could be induced to spawn in late August and early September by increasing the amount of light in early spring and decreasing it in late summer. Bissonette and Burger (1940) state

> ". . . there is no uniform control of the sexual cycle applicable to all fish. In some fish, temperature seems to be the major factor; in others, light and temperature play cooperative roles; while in still others, light appears to be the most important factor."

Merriman and Schedl (1941) on the basis of laboratory experiments on the four-spined stickleback, Apeltea quadracus (Mitchell), concluded that light influenced oogenesis but not spermatogenesis, while temperature somewhat unequally affected the maturation of the gonads of both sexes. McCay, et al. (1930) concluded on the basis of feeding experiments that the spawning time of brook trout could be influenced by the food supply. They found that the age at maturity

could be advanced or postponed by increasing or decreasing the amount of food fed to the hatchery trout, but the question of changing the date of spawning of mature trout was not clarified.

After several years of ~~spawn~~ netting lake trout in Racquette Lake for spawn-taking, the hatchery men of the New York State Conservation Department ~~noticed~~ observed that the lake trout ran earlier after a cold snap. The Extensive data on their operations were made available to me. (Table 1) In addition, Weather data were obtained from the United States Weather Bureau.

The average air temperature for ~~the month of~~ September as reported by the Indian Lake weather station was used because it was the nearest station with complete records for the eight years of the spawning data. The average number of cloudy days for the entire northern plateau region of New York was selected because many of the smaller stations had no automatic sunshine recorders and their estimates of cloudiness varied considerably. The number of cloudy days in July, August, and September ~~was also used~~ were used because the work of Hoover and Hubbard (op. cit.) ~~(1937)~~ indicated that changes in the light required a considerable time to influence the development of the eggs, and these ~~are~~ were the three months ones ~~of~~ which had decreasing amounts of daylight immediately preceding the spawning season.

The analysis of these data by multiple regression (Table 2) indicated

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TABLES 16 and 17 GO HERE****

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that the date of spawning ~~of~~ was advanced by lower temperatures or more cloudy days and retarded by warmer or less cloudy weather. However, neither the partial regression of the spawning date on air temperature alone, nor on cloudiness alone, was statistically significant ~~(table 2)~~. When both factors were considered in a multiple regression coefficient then the result was ~~statt~~ significant (R = .8643 when R of .836 or greater is to be expected 5 percent of the time with 5 degrees of freedom).

Analysis of similar ~~data~~ on ~~the~~ data of the peak of egg-take of lake trout from Upper Saranac Lake (tables 3 and 4) was less conclusive. ~~Here~~ in 1941 the date of peak of egg-take was about a month later than usual. But If we omit this aberrant observation the date of the peak of egg-take seems to bear the same relationship to air temperature and cloudiness as it did in Racquette Lake. However, ~~nonexofxthe~~ neither the partial nor multiple regression coefficients are significant (R = .699 when R of .930 or greater is to be expected 5 percent of the time with 3 degrees of freedom).

Other things ~~arexto~~ must be considered in evaluating these analyses. The data were few, only 6 years in one instance and 8

TABLES 3 and 4 TAKEN OUT HERE***

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DEPARTMENT OF COMMERCE

BUREAU OF FISHERIES

NOTICE OF TAGGED FISH

The Bureau of Fisheries has tagged and released several thousands of food fishes along the Atlantic coast during recent years in order to get accurate knowledge on their movements, their rate of growth and their spawning habits.

Persons catching tagged fish are requested to send the tags to the Bureau of Fisheries, Washington, D. C., together with as much of the following information as possible:

1. When was fish caught?

2. Where was fish caught? (Be as accurate as possible.)

3. What is the number on the tag?

4. What kind of gear was fish caught with?

5. At what depth was fish caught?

6. When was tag noticed?(on deck,cleaning,in fish house,etc.)

7. How long was fish?
   (Give accurate measurement, from tip of snout to end of tail fin. Don't guess! If a ruler is not handy, lay the fish along the deck or on a board, mark the length and measure the distance later.)

8. Was there any soreness on the fish at the place of attachment of the tag?

One dollar ($1) will be paid for each tag returned with accurate information as to the date and place of catching the tagged fish. If the tag is sent without such information, 50¢ will be paid.

Please send tags in promptly. Do not save them until you have forgotten the information that goes with them.

Tags will be returned on request to those who wish them for souvenirs.

HENRY O'MALLEY

Washington, D. C.

Commissioner

in the other, and the weather bureau data on air temperaure and cloudiness can not be a precise measurement of the temperature and the light actually affecting the fish. Furthermore, the period during which the light and the temperature changes are influential can only be surmised, and other factors may be important. For example, in Racouette Lake in 1938 the notably high water level was suspected of being the cause of why almost no lake trout were caught. However, it was not certain whether this affected the migrations or prevented the nets from operating effectively.

Considering that a significant relationship was established in one instance, and while other data were inconclusive but showed a similar tendency, it is probable that both light and temperature do influence the spawning time of lake trout.

The lake trout in Racquette Lake (Oliver R. Kingsbury in a report to the New York State Conservation Department, November 1935) spawn at about the same time ~~that~~ of the lake turns over. In the middle of the 1935 spawning season, temperatures taken at the surface and at depths ~~up~~ down to 56 feet revealed no more than 3° ~~Fahrenheit~~ F. difference between top and bottom. This seems to be ~~much~~ far more important than the actual surface temperature. In 1933 the surface temperature on the date the first eggs were taken was 58° ~~Fahrenheit;~~ F.; in ~~1935,~~ 1934, 52° F.; and in 1935, 50° F. Merriman (1935) reports ~~observing~~ the lake trout spawning in ~~Squano~~ Squam Lake, New Hampshire, when the surface temperature was 42° F. In Otsego Lake, New York, in 1940, the lake trout were observed spawning December 6, when the surface temperature was 37° F. No facilities were available for taking deep-water temperatures at that time. But in 1941 the fish were observed late in their spawning season on December 3, when the water temperatures ~~were~~ were uniformly 43° F. from the surface down to 60 feet. These wide variations in surface temperature indicate its slight value as a criterion of the spawning period.

Such differences in the progress of cooling in different lakes are probably associated with the depth of the lake, and it appears that the depth of the lake is associated with the time of lake trout spawning. Table 5 presents data from the files of the State of New York Conservation Department on the time and duration of lake trout spawn-taking operations in some New York lakes. Figure 2, which incorporates information from Table 5, from Raynor (1941) for Skaneateles Lake, and from my observations on Otsego Lake, shows this relationship graphically.

Figure 2. ~~The relationship of the date of lake trout spawning to the depth of some New York lakes.~~

It appears that the lake trout spawn early in the shoal lakes and later in the deep lakes. If, as indicated previously, they spawn at about the turnover time of the lake, this would be expected, since the deeper lakes cool off more slowly.

insert fig. 2 title (see illustrations page for title)

TABLE 5 TAKEN OUT HERE

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~~that in New York State the time of lake trout spawning may vary from late September to early December~~.

Like many good rules, ~~the~~ a rule that the deeper the lake the later the lake trout spawn has an outstanding exception. In Seneca Lake, the deepest lake in New York State (625 feet maximum), the lake trout spawn the earliest. They start in late September and continue through the month of October. Here they spawn in water from 100 to 200 feet deep at a time well in advance of the turnover period of the lake. Temperature data taken from September 29 to October 17, 1941 showed that the surface temperature ranged from 57°F. to 62°F.

This large difference in the time of spawning may be attributed to racial difference in the lake trout. Milner (1874) gives the spawning time of the Siscowet (Cristovomer namaycush siscowet) as late August and early September in the deep waters of Lake Superior. In the same lake the common lake trout (Cristovomer n. namaycush) spawns in from 7 feet to 15 fathoms of water during the month of October and in early November (Milner, op. cit., and Van Oosten, 1935). Hubbs (1930) has described the Rush Lake trout (Cristivomer namaycush huronicus) and states that it spawns in deep water in late summer rather than in fall, as does the ordinary lake trout in the same lake.

Dymond (1926) gives the time of spawning of the common lake trout as the month of October in Lake Nipigon. But, in addition, he points out ~~in addition~~ that there is a black race of trout in the same lake which ascend some of the tributary streams and start spawning about September 20, and a third race which is said to spawn in deep water from October 20 to November 10.

In New York State the data on the spawning indicate that two races[13]

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[13] Other evidence of racial difference is available. New York State fish hatchery foremen agreed that eggs from Seneca Lake trout average about 240 per ounce, while eggs of lake trout of comparable size from Adirondack lakes average about 200 to 210 per ounce. No measurements of the actual diameters of the eggs were available, but the counts of the hatchery foremen appeared to be fairly consistent. D. C. Haskell (unpublished material gathered in 1941) also reports that the Seneca Lake trout grow significantly faster under hatchery conditions than the young lake trout from Racquette and Upper Saranac Lakes.

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of lake trout exist. One, the Seneca Lake trout, ~~which~~ that spawns early in deep water, and the other, ~~which is~~ widespread in the Finger Lakes and Adirondack Lakes, ~~which~~ that spawns in shallow water at about the time of the turnover of the lake.

With these differences in reactions and spawning habits, it would be desirable to determine if the Seneca Lake trout can adapt themselves to → see following pp

the conditions existing in Adirondack Lakes and vice versa before extensive stocking is attempted. Until such knowledge can be secured it would be wise to stock lake trout in lakes similar to the lake from which the eggs were obtained.

The Duration of the Spawning Period

Table 5 summarizes the data on the receipt of lake trout eggs at some of the New York State hatcheries. The date of receipt of eggs closely corresponds to the date of taking the eggs, except for the first one or two days of the spawning season. Ordinarily, only a few ripe fish are found at first, and if only a few thousand eggs were obtained, they were often held for a day or two until more eggs were available to make the trip to the hatchery worth while. The date when the first eggs were taken probably averages about one day earlier than the date of the receipt at the hatchery. At the peak of the spawning season the eggs were usually rushed to the hatchery immediately, so the date of the peak receipt of eggs corresponds to the date of the peak egg-take.

The data of Table 5 do not indicate the complete spawning season but rather the season during which it was feasible to catch and strip the trout. High water sometimes so affected the fishing of the nets that it was not economically practical to continue fishing, and bad weather sometimes cut short the stripping operations. Hence, a short period of egg-take is not necessarily indicative of a short spawning season. It seems likely, however, that the longer periods of spawn-taking closely approximate the spawning season.

It appears that the lake trout spawning season lasts from ten to twenty days in the smaller New York State lakes, the duration is fairly uniform in the same lake from year to year. The lake trout of Lake George consistently completed their spawning in about a week to ten days at the most. Piseco Lake produced ripe fish for a period of about twenty days.

The length of spawning season increases in the larger lakes. Van Oosten (1935) gives the duration of the spawning season in Lake Michigan as October 10 to November 21; Lake Huron, October 10 to November 15; and in Lake Superior, October 1 to November 6. Seneca Lake is similar to the Great Lakes in both date and duration of the spawning season. The earliest and latest dates on which the New York State Conservation Department obtained eggs in Seneca Lake are September 23 and November 3. These dates are for different years, but the earliest and latest dates were very similar from year to year.

D. The Place of Spawning

Conforming with the habits of other trout and with the shelter and food requirements of the eggs and young, the lake trout lay their eggs in gravel or rubble. Since they make no effort to bury the eggs the bottom must have crevices into which the eggs may roll and receive protection through the many months of the incubation and larval periods. The observations of Merriman (1935), Royce (1936), and the author indicate that lake trout spawning areas are restricted to bottom meeting this requirment, that is clean gravel or rubble which is free of sand or mud.

The location of these suitable areas of bottom in the lake is primarily determined by currents or wave action which keep ~~that~~ the bottom swept clean. The lake trout will roll the smaller stones around and fan off the silt, but they cannot remove sand or mud from the crevices. Any bottom which is not swept by currents or waves ~~must~~ eventually be covered with mud, although in the usual oligotrophic lake-trout lake this process would take a very long time. ~~Currents in lakes must be caused primarily by wind action. The currents thus caused are most violent in the upper few feet of water and~~ the width of the area of clean rocks or sand in the littoral zone is directly dependent on the size of the lake and its exposure to the wind. In the smaller New York State lakes the lake trout may generally be found spawning on a windy point near the deep water (Royce, op. cit. ~~1936~~) on ~~the~~ a bottom which is kept clean by wave action. A typical example of such shallow water spawning is to be found in Otsego Lake, New York, O.K.

In larger lakes the lake trout may go to ~~utilize~~ deeper water for their spawning ~~activities~~. Milner (op. cit. ~~1874~~) reports that the lake trout in Lake Superior spawn in from 7 feet to 15 fathoms of water. Evidence of spawning in the deep water was provided by the capture of ripe fish at that depth and by ~~the~~ raising in the nets ~~of~~ fragments of honeycombed rocks containing eggs. In Seneca Lake, New York, the lake trout are captured for stripping in from 100 to 200 feet of water at a time when no lake trout are found in shallow water. The fact ~~Proof~~ that these ripe lake trout are captured over bottom which is suitable for spawning is strong evidence that the trout are actually spawning in these depths. Further proof was provided by the capture on the spawning bed in Seneca Lake in April 1940 of a lake trout fry 25 millimeters total length in water 130 feet deep.

There is much evidence that these deeper spawning areas are swept by strong currents. In Seneca Lake the hatchery fishermen reported that their nets were often rolled over and over by the currents. In this same lake off Peach Orchard Point the 40°F. isotherm rose from a depth of 260 feet on September 29, 1941, to 100 feet on October 1 after a strong south wind. On October 7 it was back down to a depth of 230 feet. Such a change must be accompanied by the movement of a huge quantity of water.

These currents in Seneca Lake and the other Finger Lakes have left evidence of a prevailing direction of flow. All of these lakes are very long and narrow and lie with their long axis in very nearly a north-south direction. Seneca Lake is the largest lake: about 40 miles long and 3 miles wide at its widest point. The prevailing winds come from the northwest or the southeast. Thus the winds blow obliquely to the south on the east shore and obliquely to the north on the west shore of the lakes. The general result of this tendency has been to form the tips of deltas to the south of the stream mouths on the east shore of the lakes and to the north of the stream mouths on the west shore of the lakes.

In addition to the characteristic orientations of the deltas, there is a definite gradient in the size of the material deposited in the parts of the delta. Off the tip of Peach Orchard Point in Seneca Lake down to a depth of at least 300 feet, only clean gravel and rubble could be found with a clamshell dredge and noted in bottom photographs (fig. 3). The lighter materials, such as mud, were deposited in the coves adjacent to Peach Orchard Point.

insert fig. 3 title

(see illustrations page 29)

Evidently other deltas in this lake have similar deposits since the lake trout are captured in large number during the spawning season near the tips of the points.

The ~~author~~ writer has found no evidence to indicate that lake trout select a lake bottom supplied with spring water for the deposition of eggs. The spawning area in Otsego Lake was on a fill about 100 feet out from the original shore line which was bedrock and showed no evidence of any spring seepage. Numerous water temperatures taken on the spawning area and in the nearby lake at all seasons of the year showed no difference in temperature. Additional evidence was noted in the presence of an equally thick ice cover over the spawning area on March 31, just before the spring break-up, when any springs should have caused some erosion of the ice. No mention of the presence of spring water on lake trout spawning areas has been found in literature which the ~~author~~ writer has perused. It is concluded that (unlike some other species of trout) spring water is a negligible factor in a lake trout's selection of a spawning area.

C. Spawning

All of ~~the author's~~ my observations on the ~~actual~~ spawning act of lake trout were made at a spawning area on Otsego Lake, New York. Otsego Lake is about ~~eight~~ 8 miles long and averages about three fourths of a mile in width. Its maximum depth is 168 feet and about 90 percent of it is more than 60 feet deep (Odell and Senning, 1936). Chemical conditions are ideal for lake trout and the lake has produced fairly good lake trout fishing for many years. The spawning area which ~~was~~ I kept under observation was the only one well known to the local residents and the only one which ~~the author could find~~ could be found. This area was situated along the middle of the west shore opposite the deepest part of the lake.

Observations were made ~~on the lake trout spawning~~ in this area on November 16, 30, December 1, and 5, 1940 and on December 1, 2, and 3, 1941. The trout were observed from 7 a.m. to 11 p.m. on some of the above days, but mostly the area was visited in the evening.

Some trout were ~~active~~ on the spawning area at all times of day during the spawning season, but most of the activity was restricted to the evening hours. During periods of bright sunlight only a few males could be seen and these kept to fairly deep water so that observation was difficult. The direct rays of the sun were cut off by a mountain at about 4 p.m. and about this time many trout would appear on the spawning area. Both males and females would arrive and the males would start courtship and attempt the spawning act. The peak of the activity observed was to occur from 5 p.m. to 9 p.m. Later in the evening the trout again

The males began their courtship upon the appearance of the females on the area. ~~The usual procedure was for the male to~~ Usually the male nudged the female in the side with his snout and then ~~to~~ attempted the spawning act. ~~It was not unusual for~~ Frequently two or more males ~~to~~ courted and attempted to spawn with ~~the~~ one female at the same time. During the courtship the males displayed the characteristic coloration and commonly held the dorsal fin erect. These displays were apparently identical to those noted by Merriman (op. cit.) ~~(1935)~~.

Insert Figure 4 title

The spawning act or attempts at it ~~usually~~ normally consisted of one or two ~~xxxxxx~~ males approaching a female, pressing against the female's sides with their vents in close proximity and then quivering all over. Usually the mouths of both sexes were open and the dorsal fin of the males held erect. This act was seen clearly at close range several times when no eggs or milt were expressed. On two occasions a cloudiness was noted in the vicinity of the vents which was probably ~~likely~~ caused by emission of sperm. No eggs were seen but ~~probably~~ this could ~~not~~ have been ~~seen~~ because of the distance from the fish and the turbidity of the water. No other act or behavior was seen which could be construed to accompany oviposition. ~~It seems most likely that an~~ Probably the attempt at the spawning act is a part of courtship and is repeated over and over again until the fulfillment.

Insert Figure 5 title

The spawning act was not attempted solely by two or three trout but often by several. As many as seven males and three females were seen at one time all pressing together in one large group and quivering in unison. No spawning act was seen to last for more than a few seconds and it seems that a female must accomplish many unions to empty

see illustrations page

completely her ovaries. It was impossible to follow any pair of fish in the milling group, but ~~it is improbable that anything~~ nothing like monogamy exists. The females ~~apparently~~ evidently mated with any male that came along.

No tendency toward oviposition in any definite place on the spawning area was observed. The trout mated at random all over the area which had been cleaned off. Nor was any attempt made by either sex to bury the eggs. This seeming carelessness ~~about~~ in regard to the fate of their young was justified upon attempting to find the eggs. A casual examination of the bottom revealed practically no eggs, but upon ~~carefully~~ carefully turning over the stones, the eggs could be picked up by the hundreds. Eggs were recovered in water from three inches ~~of water down~~ to fourteen feet in depth. Those ~~taken~~ collected in more than two feet of water had to be taken in a Peterson dredge and no estimate of the abundance could be obtained. ~~But~~ Along the shore in less than ~~two~~ 2 feet of water, however, where only an occasional trout was seen spawning, from 20 to 50 eggs could be recovered per-square-foot of bottom. The eggs were difficult to pick up, and the slightest motion of the water sent them rolling further ~~into~~ into crevices ~~of~~ between the rocks. In their selection of the bottom on which to spawn the lake trout had ~~uniquely~~ arranged an ideal for ~~the~~ shelter ~~of~~ their eggs and young.

~~F. Summary of Spawning Habits~~

The lake trout spawn in the autumn when temperatures are falling. They utilize a coarse gravel or rubble bottom usually on the shoals of a lake but sometimes in deep water. The migrational distance from the deep water summer habitat is very short. No period of fasting is observed; the trout feed right up to and through the spawning season.

disappeared until only a few were left at 11 p.m. when observations were discontinued.

No nest or redd was built. The males spent their time cruising along close to the bottom occasionally giving the stones a little fillip with their tail. Several male trout showed considerable abrasion on the lower jaw and under side of the tail from this fanning and digging. The result of this activity was to ~~thoroughly~~ clean several hundred square feet of bottom so thoroughly ~~the bottom was so clean~~ that it was easy to distinguish the area on which the trout were working even when the trout were not present.

It has been the experience of the New York State Conservation Department in netting lake trout for spawn that the males appear in the nets on the spawning area earlier in the season, and usually more males are caught. From this experience, and from the fact that the males predominated on the area in Otsego Lake, it is probable that the males are almost entirely responsible for any cleaning of the spawning area prior to spawning.

Belying their appearance the males are not pugnacious. Occasionally one would make threatening motions at another male, but no vigorous fighting was observed. Several whitefish (Coregonus clupeaformis) and a large eel (Anguilla fastonierrsis) were seen among the milling lake trout and were unmolested. It was noted, however, that the males were nearly of the same size. Perhaps they had already disposed of any venturesome small males!

Merriman (~~1935~~ op. cit.) and others have noted the spawning lake trout splashing at the surface. In Otsego Lake this was noted only ~~occasionally~~ infrequently, ~~perhaps~~ possibly because the spawning was on a steep slope in from 2 to 15 feet of water and in deeper water than that in which Merriman had ~~observed the trout~~ made his observations.

ENVIRONMENT AND DEVELOPMENT OF EGGS AND ~~YOUNG~~ LARVAE

Efficiency of Fertilization

It has been a long-cherished belief of fish-culturists that the natural spawning of trout is a highly inefficient, hit or miss process. All critical investigations have shown that ~~such is seldom the case~~ this belief to be untrue. White (1930) was able to hatch 79 per cent of a lot of naturally fertilized eggs brook trout which were removed from their redd and placed in a hatchery, and 66 per cent of another lot placed in a screen basket and buried back in the redd. Hobbs (1937), after intensive investigation taking the redds of brown trout, rainbow trout, and quinnat salmon, ~~redds~~ found that an average of more than 99 per cent of the eggs were fertilized. He also found that subsequent heavy loss in the pre-eyed, eyed, and alevin stages was a result of adverse environmental conditions. Under favorable conditions the natural reproduction was a highly efficient process.

A test of the efficiency of the natural spawning of the lake trout in Otsego Lake provided further reassuring evidence that natural reproduction is efficient. On December 28, 1941, about 25 days after the trout were observed on the spawning area, a sample of 309 eggs was collected from under the rocks along shore with a small rubber bulb and tube. Of these 309 eggs, 18, or 5.8 percent, were not fertilized, and 47, or 15.2 per cent, had died from some other cause. ~~79.0~~ Seventy-nine per cent of the eggs were alive and apparently entirely normal after having been on the lake bottom nearly a month. This percentage probably represents a near minimum figure for the survival (exclusive of those eaten by predators; see page 58) since the eggs were of necessity collected in only a few inches

of water where they were subject to heavy wave action. The vast majority of the eggs were seen to be laid in deeper water out of reach of available collecting apparatus and where they should have been more adequately protected.

Temperature Requirements

Lake trout eggs appear to both require and to withstand slightly lower temperatures than the eggs of other trout. Embody (1934) found that brook and rainbow trout eggs suffered excessive mortality and developed at a different rate when the water temperature was below 37.4°F. He found also, that lake trout and brown trout eggs followed

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Rainbow trout eggs suffered high mortality at temperatures below 43°F. but Embody thought that this was due in some cases to inferior eggs.

---

followed the same rate of development down to 35.2°F. and he judged that development proceeded normally. Brook trout usually spawn in spring water so that their eggs are not subjected to near freezing temperatures during the winter (Greeley, 1932; Hazzard, 1932; and White, op. cit.). Rainbow trout normally spawn in the spring when the water is warming (Rayner, op. cit.). Cook (1929) reports that lake trout eggs develop satisfactorily at the Duluth hatchery where the water temperatures remain at about 32.5°F. throughout the winter. The 140-day incubation period of the lake trout eggs in Otsego Lake indicates an average temperature of between 36°F. and 37°F. in the egg development tables of Embody (op. cit.). At the New York State hatchery at Rome, high mortality occurred in lake trout eggs developing at water temperatures of over 50°F. when other trout eggs developed normally. In other hatcheries, at lower temperatures lake trout eggs from the same source developed normally.

These facts would indicate that lake trout eggs can develop successfully in a lake in the winter as long as they do not freeze, and that they do not require spring water.

No data are available on the temperature requirements of the alevins. In the spring of 1941, however, In Otsego Lake they left the spawning area when the water temperature was about 55° F. It seems likely that they would avoid temperatures of over 60° F.

Effects of Predation

~~None of the percentages given under Efficiency of Fertilization indicates a true value for~~ The data on the survival of eggs in Otsego Lake (page 35) do not indicate the true value because they do not consider the removal of eggs by predators. Predators are an ever present danger to lake trout from the egg stage almost until the time they mature and cause a loss which is exceedingly difficult to evaluate. No precise measurements have ever been made on the effect of predation at any stage in the growth of wild trout.

Many are the potential predators of eggs and alevins. Table 6 lists the animals captured within 100 yards of the lake trout spawning area in Otsego Lake during April and May 1941. Many of these would destory eggs if they were available to them. Atkinson (1931), and Greene, Hunter, and Senning (1932) found that numbers of lake trout eggs were eaten by suckers, (*Catostomus commersonii*) and bullheads, (*Amieurus nebulosus*). Both of these species occur in Otsego Lake although they were not captured in the immediate vicinity of the lake trout spawning area. Greeley (1936) states that a fisherman reported finding lake trout eggs in the stomachs of the Otsego Lake whitefish. Rayner (op. cit.) found many lake trout eggs in the stomachs of the adult lake trout. A female

brown trout and quinnat salmon was very small. The spawning trout themselves are important predators and they could scarcely be accused of eating all their own spawn. It seems most likely that predation would have no more effect on lake trout eggs. If the lake trout can spawn on the bottom, which they seem to prefer, the eggs and alevins are certainly well protected until they emerge from the rubble. It was necessary to dig well into the rubble to capture either the eggs or alevins in the Otsego Lake spawning area. Additional evidence is provided by the lack of any lake trout alevins in the stomachs of the following fish captured in the immediate vicinity of the lake trout spawning area between April 27, and June 2, 1941: 6 whitefish (Coregonus clupeaformis;

1 adult lake trout (Cristivomer n. namaycush); 11 shiners (Notropis hudsonius); 1 blunt-nosed minnow (Hyborhynchus notatus); 1 chain pickerel (Esox niger); 17 yellow perch (Perca flavescens); 22 johnny darters (Boleosoma nigrum olmstedi); 1 smallmouth bass (Micropterus d. dolomieu); 4 common sunfish (Lepomis gibbosus); 13 rock bass (Ambloplites rupestris); and 11 slimy muddlers (Cottus cognatus). These fish were all captured during the time the alevins were absorbing the yolk sac and leaving the spawning bed. Such negative evidence is inconclusive but reassuring. It is important to note that most trout egg predators have been indicted for their activities during the time the eggs were being laid and not after the eggs were hidden in the gravel.

It is ~~not~~ concluded that the lake trout eggs and alevins suffer little from predation after the spawning season, and that during the spawning the eggs which are eaten are only those left exposed on the bottom.

Development of Eggs and Alevins

Greeley (op. cit.) collected eyed eggs and newly hatched alevins on the Otsego Lake spawning area on April 12, and more advanced alevins on May 9. I took newly eyed eggs on February 17, 1941, and later-eyed stages on March 31, 1941, by chopping holes through the ice. (The lake trout had been observed spawning December 1, 2, and 3, 1940). Later, on April 27, with the surface water temperature 44° F., newly hatched sac fry were taken, and on May 17, 1941 many more advanced fry were taken (temperature data in Fig. 6). All of the stages were taken

Insert Fig. 6 title

Figure 6.--Insert title.

&&&&&

from the rubble on the spawning area. (Several hauls of the trawl in the vicinity of the spawning area on April 27 and May 17 produced no fry.) Both eggs and fry were well buried in the stones. The eggs were taken with a Peterson dredge, and only after the surface stones were removed could the eggs be found.

TABLE 6 TAKEN OUT HERE

TO BE TYPED SEPARATELY---FAD

4/9/50

~~and only after the surface stones were removed could the eggs be found.~~ The fry were all taken with a trawl fitted with a heavy weight out in front ~~to dig up~~ which turned over the stones. On June 2, 1941, 18 tows of the trawl over the spawning area and in the vicinity down to depths of 60 feet failed to produce any young lake trout. They had definitely moved from the spawning area and the habitat of the earliest feeding stages was still unknown.

Comparison of the development of the wild fry which were captured and those grown in a hatchery indicates that ~~the time of~~ hatching in Otsego Lake in 1941 was about April 15 and the time at which the fry ~~leave~~ left the shelter of the spawning area was ~~about~~ through May 20 ~~&~~ 25.

In Seneca Lake, where the lake trout spawn during late September and the month of October (temperature data in ~~Figure 9~~ Fig. 6), a single advanced fry was captured in about 130 feet of water off Peach Orchard Point on April 2, 1940. This fry was considerably more advanced than a hatchery fry two months old. ~~In addition, the fry from the lake probably had to endure colder temperatures.~~ This would place the time of hatching in late January and indicate an incubation period of ~~about~~ approximate four months.

Consideration of the type of bottom ~~type~~ and the kinds of invertebrate inhabitants (~~fauna~~) of the lake trout spawning area in Otsego Lake ~~brings home~~ emphasizes the striking resemblance of this area to a typical trout-stream environment. Clean gravel and rubble bottom inhabited by stonefly and mayfly nymphs and caddis larvae ~~certainly~~ ordinarily would ~~ordinarily~~ be associated with a stream instead of a lake. ~~Perhaps this is a factor responsible for the successful life cycle of a lake trout.~~ Certainly

it seems that lake trout fry and fingerlings would fare best under conditions similar to those selected by the young of other trout.

This trout-stream-like environment in Otsego Lake gave ~~the author~~ me high hopes ~~of being able~~ that I would be able to capture the early fingerling stages in the vicinity. But all efforts were ~~of no avail~~. ~~Minnow~~ including minnow traps and trawl ~~were~~ unsuccessful. The trout may have moved out of the vicinity or have been wary and ~~well~~ sheltered enough to avoid the nets. The only reference to the capture of young lake trout which was found was that of Kendall and Goldsborough (1908). They captured several young lake trout 1.87 to 2.37 inches in length in small spring tributaries of the First Connecticut Lake on July 16, 18, and August 10. This definitely can ~~certainly~~ not be considered a normal habitat since the State of New York ~~State~~ Biological Survey captured no small lake trout in its extensive seining of the shores of Adirondack lakes and streams, many of which were adjacent to lake trout waters. Doubtless small lake trout are ordinarily inhabitants of the deeper waters of lakes and probably they seek rocky bottom.

Notes on the Capture of Juvenile Lake Trout in Keuka Lake

Intermittently from April 18 to September 16, 1940, an effort was made to capture the fingerling and juvenile sizes of lake trout in Keuka Lake. Their capture was attempted with gill nets, trawls, set lines, and minnow traps ~~(see section on Descriptions of Apparatus)~~. A number of 100-foot ~~One hundred feet~~ sections of gill nets of from 5/8-inch bar to 1-1/2-inch bar were set for an aggregate of 67 nights at depths of from 10 to 130 feet. Fifty-nine tows of a trawl were made over a similar range of depths.

TABLE 7 TAKEN OUT HERE

TO BE TYPED SEPARATELY----FAD

4/9.50

A set-line equipped with 80 No. 7 hooks was set for 4 days covering depths from 15 to 40 feet. Minnow traps were set for 8/~~11~~ days at depths of from 40 to 80 feet.

The net result of this fishing as far as lake trout were concerned was the capture of 41 lake trout (all in gill nets) of which 13 were more than 15 inches total length--the minimum legal-size limit in New York State. The stomach content of the 13 legal-size lake trout and of 11 other legal-size trout gathered from anglers was 100 percent sawbellies (Pomolobus pseudoharengus) or unidentifiable fish which were probably of the same species. (Anglers report finding practically nothing but sawbellies in the lake trout stomachs.)

The lengths and stomach contents of the sub-legal specimens are listed in table 7. Of the 16 specimens between 10 and 15 inches in length, only one had eaten arthropods, while the principal food of those between 6 and 10 inches was arthropods (mostly Mysis relicta).

In most cases the capture of the lake trout was very erratic. The 10 small specimens taken May 11 were all taken in the same place at very nearly the same depth of 100 feet. Nets set in the same place on following nights caught nothing. The other small specimens taken during May and June and all the larger lake trout were caught one or two at a time in different places but almost entirely at depths of from 80 to 120 feet.

Some consistency, however, was found in the capture of the young lake trout caught September 11 to 16, 1940. These were taken two- or three-per-night in 5/8- to 3/4-inch bar-gill nets set in one

restricted location between depths of 40 and 70 feet. This place was off the southern tip of Bluff Point, on a very rocky steep underwater slope. Nets of the same mesh set in the same depths in the vicinity on mixed mud and rubble bottom failed to catch any trout. Large lake trout were taken in larger-mesh nets in the same area, so it seems that the juveniles must have been relying on the shelter of the rocks for protection from their voracious elders.

- Scale examination indicated that these 6-1/2- to 10-inch trout were yearling and two-year-olds. Since the lake trout of Keuka Lake spawn in late November and probably hatch in late April, (see pages 62 and 63) a rate of growth comparable to hatchery growth would allow them to reach only two or three inches by the first September. Possibly these fingerling fish could be found in some such location as the yearlings. Lack of time and equipment prevented any further effort in this direction but it is a good ~~place~~ stage to ~~pick up~~ resume the search in the future.

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TABLE 6

~~Table 7~~. A list of the animals found on and near the lake trout spawning area in Otsego Lake, between April 27 and June 2, 1941.

1 Coelenterata

Hydra sp.

2 Platyhelminthes

Planaria sp.

3 Arthropoda

Amphipoda

Hyalella sp. Amphipod

do Neuroptera

Sialis sp. (Larvae) Alderfly = c/y

do Ephemerida (May-flies)

do Blasturus sp. (Nymphs) Mayfly

Ephemerella sp. " do "

Stenonema sp. " do "

Hexagenia sp. " do "

Ephemera sp. " do "

do Odonata

do Gomphus sp. (Nymphs) Dragonfly

Didymops transversa " do Dragonfly

Epicordulia princeps " do Dragonfly

Helocordulia uhleri " do Dragonfly

Neurocordulia obsoleta " do Dragonfly

Argia moesta " do Damselfly

Enallagma sp. " do Damselfly

do Plecoptera

Neoperla sp. (Nymphs) Stone Fly

? do Coleoptera

Dineutus sp. Whirligig Beetle

See previous tables for set-up

TABLE 6 = Parent title

~~Table~~ 7. (cont.)

Arthropoda (cont.)

do Trichoptera ~~(Caddice flies)~~

Stenophylax scalaripennis	(Larvae)	Caddice Fly
Molanna sp.	"	
Phrynganea sp.	"	
Glossosomatinae, two or more species.[1]	"	

do Diptera

Chironomus sp.	(Larvae)	(Midge Fly)
Tanytarsus sp.	"	

Mollusca

Gastropoda ~~(Snails)~~

Limnea sp.	Pond Snail
Planorbis sp.	Wheel-Snail

Pelecypoda ~~(Clams)~~

One unidentifiable. Clam

Chordata

do Pisces

do

Coregonus clupeaformis	Whitefish
Cristivomer n. namaycush	Lake trout
Notropis h. hudsonius	Spot-tail shiner
Hyborhynchus notatus	Blunt-nosed minnow
Esox niger	Chain pickerel
Anguilla bostoniensis	American Eel
Perca flavescens	Yellow Perch
Stizostedion v. vitreum	Yellow Pike-perch
Boleosoma nigrum olmstedi	Johnny darter
Micropterus d. dolomieu	Small-mouth bass
Lepomis gibbosus	Pumpkinseed
Ambloplites rupestris	Rock bass
Cottus cognatus	Slimy muddler

do Amphibia

Triturus viridescens	Newt

1/ two or more species.

This is a sample

TABLE 6.--A list of the animals found on and near the lake trout spawning area in Otsego Lake between April 27 and June 2, 1941

Wanter

Phylum	Order	Species	Common Names	Stages
Coelenterata	------	Hydra sp.	-------	------
Platyhelminthes	------	Planaria sp.	-------	--------
Arthropoda	Amphipoda	Hyalella sp.	Amphipod	-------
Do.	Neuroptera	Sialis sp.	Alderfly	Larvae
Do.	Ephemerida	Blasturus sp.	Mayfly	Nymphs
Do.	-----do---	Ephemerella sp.	----do---	Do.
Do.	-----do---	Stenonema sp.	----do---	Do.
Do.	-----do---	Hexagonia sp.	----do---	Do.
Do.	-----do---	Ephemera sp.	----do---	Do.
Do.	Odonata	Gomphus sp.	Dragonfly	Do.
Do.	-----do---	Didymops transversa	do---	Do.
Do.	-----do---		----do---	Do.
Do.	-----do---		----do---	Do.
Do.	-----do---		----do---	Do.
Do.	-----do---		----do---	Do.
Do.	-----do---	Enallagma sp.	----do---	Do.
Do.	Plecoptera	Neoperla sp.	Stonefly	Do.
Do.	Coleoptera	Dineutus sp.	Whiligig beetle	-----
Do.	Trichoptera	Steno. Sc. etc.	Caddice Fly	Larvae
Do.	-----do---	Molanna sp.	----do---	--Do.-
Do.	-----do---	Phry sp	----do---	--Do.
Do.	-----do---	Glosso. etc.	-----do---	Do.
Do.	Diptera	Chiro etc.	Midge Fly	Do.
Do.	-----do---	Tanytarsus sp.	-----do---	Do.
Mollusca	Gastropoda	Limnea sp.	Pond Snail	-------
Do.	-----do---	Planorbis sp.	Wheel Snail	-------
Do.	Pelecypoda	One unidentifiable	Clam	-------
Chordata	Pisces	Coregonus clup	Whitefish	-------
Do.	-----do---	Christivomer etc	Lake trout--z	-------
Do.	-----do---	Notr etc.	Spot-tail shiner	-------
Do.	-----do---	Hybor etc.	Blunt-nosed minnow	----
Do.	-----do---	Esox et	Chain pickerel	-----
Do.	-----do---	Anguilla etc.	American eel	------
Do.	-----do---	Perca etc.	Yellow perch	-----
Do.	-----do---	Stizo etc.	Yellow Pike-perch	------
Do.	-----do---	Boleo etc.	Johnny darter	-----
Do.	-----do---	Micro etc.	Small-mouth bass	-----
Do.	-----do---	Lepomis etc.	Pumpkinseed	----
Do.	-----do---	Amblo B etc.	Rock bass	-------
Do.	-----do---	Cottus cognatus	Slimy muddler	-----
Do.	Amphibia	Triturus viridescens	Newt	-------

15+2 = 17 (+5) 11+2 13 (5) 25+2 27 1 20 10

(28) 1 two or more species 85

ILLUSTRATIONS

FIGURE Page

1. Male lake trout on the spawning grounds in Otsego Lake, New York----------

2. The relationship of the average date of the peak of lake trout spawning activity and the maximum depth of some New York STATE lakes----------

3. The bottom of Seneca Lake west-south-west off the tip of Peach Orchard Point where the lake trout congregate during the spawning season. The picture covers an area on the bottom about 18 by 27 inches at a depth of 120 feet. Part of the camera equipment is at right----------

4. The courtship act. The male at left is nudging the female in the side----------

5. Just after completion of the spawning act. Two males have just spawned with the female in the center----

6. The temperature stratification of Otsego Lake associated with different stages of larval development of lake trout----------

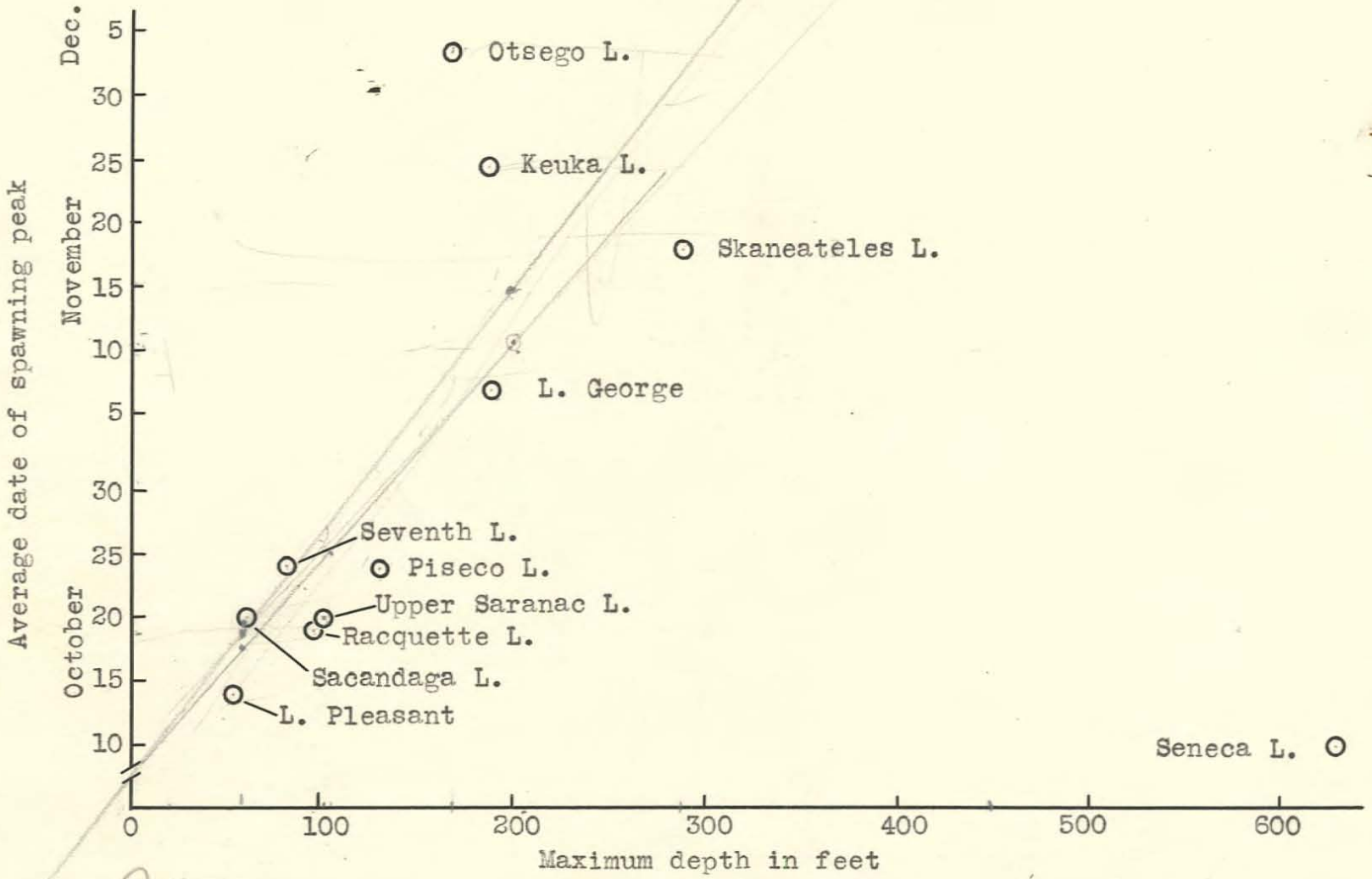


Figure 10. The relationship of the average date of the peak of lake trout spawning activity and the maximum depth of some New York State lakes.

6|126 . 2|77

The relationship of the average date of the peak of lake trout spawning activity and the maximum depth of some New York lakes.

Lake	Date	Days from Oct 1 X	Max depth Y
Racquette	Oct 19	1.9	96
George	Nov 7	38	187
Pleasant	Oct 14	14	53
Sacandaga	Oct 20	20	60
Piseco	Oct 24	24	129
7th	Oct 24	24	85
~~Seneca~~			
Keuka	Nov 25	56	187
Otsego	Dec 3	66	168
Skaneateles	Nov 18	49	287
Upper Saranac	Oct 21	21	100

ΣX	331
$\bar{x}$	33.1
Σx^2	13887
$(\Sigma x)^2/n$	10956
Σx^2	2931
ΣY	1352
$\bar{y}$	135.2
Σy^2	230022
$(\Sigma Y)^2/n$	182790
Σy^2	14723.2
ΣXY	53731
$(\Sigma X)(\Sigma Y)/n$	44751
Σxy	8980

Seneca Oct 10 625

$\hat{Y} = \bar{y} + \frac{\Sigma xy}{\Sigma x^2}(X - \bar{x})$

$\hat{Y} = 135.2 + 3.0638X - 101.4118$

$\hat{Y} = 33.8 + 3.06X$

$\hat{X} = \bar{x} + \frac{\Sigma xy}{\Sigma y^2}(Y - \bar{y})$

$\hat{X} = 33.1 + .1901Y - 25.7$

$\hat{X} = 7.4 + .19Y$

~~Let~~ $X = 20$ $\hat{Y} =$

60

~~Let~~ $Y = 60$ $X = 18.8$

200 $X = 45.4$

Lake	Date	X Days from Oct 1	Y Max. Depth
Raquette	Oct 19	19	96
George	Nov. 7	38	187
Pleasant	Oct 14	14	53
Saranac	Oct 20	20	60
Placid	Oct 24	24	129
7th	Oct 24	24	85
Keuka	Nov. 25	56	187
Skaneateles	Nov. 18	49	287
Upper Saranac	Oct 25	25	103

ΣX	269
$\bar{x}$	29.9
ΣX^2	9715
$(\Sigma X)^2/n$	8040
Σx^2	1775
ΣY	1157
$\bar{y}$	131.9
Σy^2	202407
$(\Sigma Y)^2/n$	156552
Σy^2	45855
ΣXY	43118
$(\Sigma X)(\Sigma Y)/n$	35478
Σxy	7640

$$\hat{X} = \bar{x} + \frac{\Sigma xy}{\Sigma y^2}(Y - \bar{y})$$

$$\hat{X} = 29.9 + .167Y - 22.0$$

$$\hat{X} = 7.9 + .167Y$$

Let $Y = 60$ $X = 17.9$
$= 200$ $X = 41.3$

The relationship of the average date of the peak of lake trout spawning activity and the max. depth of some N. Y. lakes.
(linear regression by squares)

Lake	Date	X Days from Oct 1	Y Max Depth
Raquette	Oct 19	19	96
George	Nov. 7	38	187
Pleasant	Oct 14	14	53
Racandaga	Oct. 20	20	60
Piseco	Oct 24	24	129
7th	Oct 24	24	85
Keuka	Nov 25	56	187
Otsego	Dec. 8	64	168
Ahwaneta	Nov. 18	49	287
Upper Saranac	Oct 21	21	103

ΣX	329	Total of X
$\bar{x}$	32.9	" " " / no.
ΣX^2	13627	Sum of X^2
$(\Sigma X)^2/n$	10824	^{2} of total / no.
Σx^2	2803	
ΣY	1355	
$\bar{y}$	135.5	
ΣY^2	230631	
$(\Sigma Y)^2/n$	183603	
Σy^2	47028	
ΣXY	53458	Sum of X times Y
$(\Sigma X)(\Sigma Y)/n$	44580	Total X times Y / no.
Σxy	8878	Diff.

$$\hat{X} = \bar{x} + \frac{\Sigma xy}{\Sigma y^2}(Y - \bar{y})$$

$$\hat{X} = 32.9 + .189Y - 25.6$$

$$\hat{X} = 7.3 + .189Y$$

Let $Y = 60$ $X = 18.6$
200 $X = 45.1$

$\bar{X}$ = mean of X plus

Lake	Date	X Days from Oct 1	Y Max Depth
Marquette	Oct 19	19	96
George	Nov. 7	38	187
Pleasant	Oct 14	14	53
Lacandaga	Oct 20	20	60
Piseco	Oct 24	24	129
7th	Oct 24	24	85
Kenka	Nov. 25	56	187
Otsego	Dec. 3	64	168
Ahmeasteles	Nov. 18	49	287
Upper Saranac	Oct 25	25	103

ΣX	333
$\bar{x}$	33.3
ΣX^2	13811
$(\Sigma X)^2/n$	11089
Σx^2	2722
ΣY	1355
$\bar{y}$	135.5
ΣY^2	230631
$(\Sigma Y)^2/n$	183603
Σy^2	47028
ΣXY	558 70
$(\Sigma X)(\Sigma Y)/n$	45122
Σxy	8748

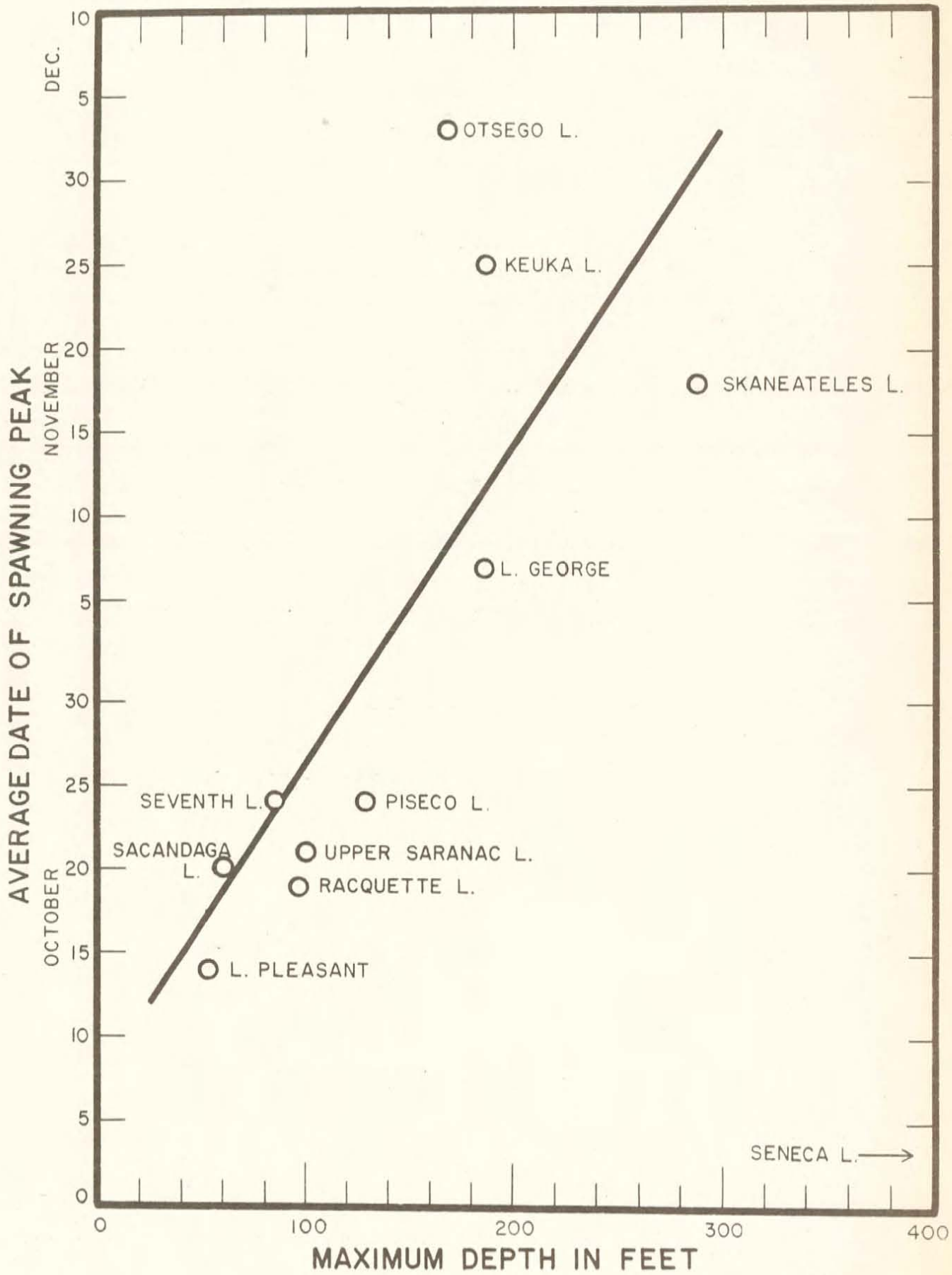
$$\hat{X} = \bar{x} + \frac{\Sigma xy}{\Sigma y^2}(Y - \bar{y})$$

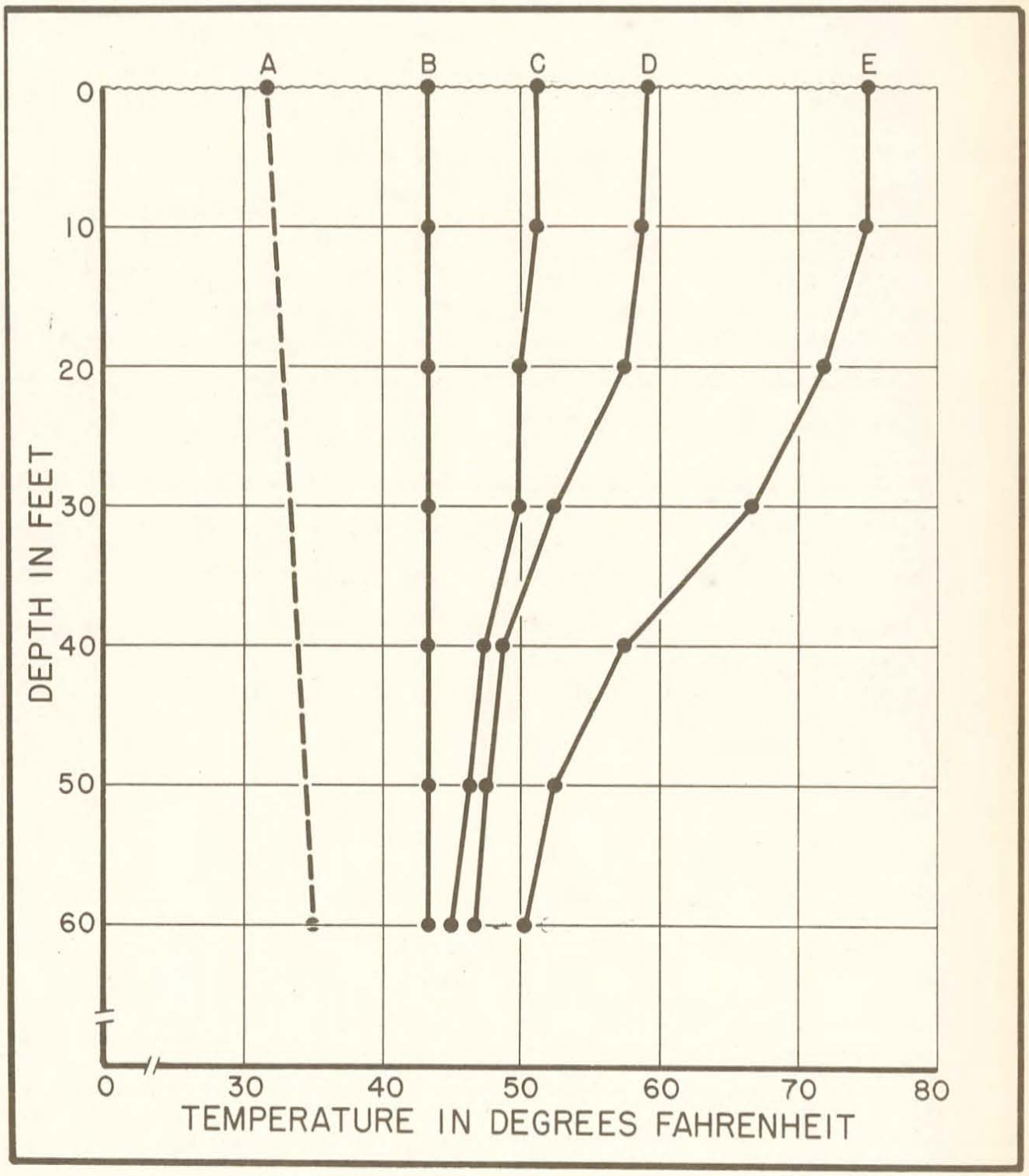
$$\hat{X} = 33.3 + .186Y - 25.2$$

$$\hat{X} = 8.1 + .186Y$$

Let $Y = 60 \quad X = 19.3$

$\quad\quad = 200 \quad X = 45.3$


AVERAGE DATE OF SPAWNING PEAK
DEC.
NOVEMBER
OCTOBER
10
5
30
25
20
15
10
5
30
25
20
15
10
5
0
OTSEGO L.
KEUKA L.
SKANEATELES L.
L. GEORGE
SEVENTH L.
PISECO L.
SACANDAGA L.
UPPER SARANAC L.
RACQUETTE L.
L. PLEASANT
SENECA L.
0
100
200
300
400
MAXIMUM DEPTH IN FEET


A
B
C
D
E
0
10
20
30
40
50
60
DEPTH IN FEET
0
30
40
50
60
70
80
TEMPERATURE IN DEGREES FAHRENHEIT

Edited for A.F.S. 480 requirements

caps & small - centered

The Breeding Habits of Lake Trout in New York State

caps - center

William F. Royce

United States Department of the Interior,
Fish and Wildlife Service
Woods Hole, Mass.

caps & small center

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The Breeding Habits of Lake Trout in New York State

Wm. F. Royce
Rte.

Abstract

Lake trout were observed during the spawning season in ~~many~~ several lakes in New York State. Actual spawning was seen in Ostego Lake, New York. The New York State Conservation Department furnished extensive data on spawn-taking operations and existing literature on the subject was reviewed.

Except for a striking color change in the males while on the spawning area, Lake trout were found to lack sexual dimorphism. They matured, usually, in their sixth year at lengths varying from 15 to 30 inches in different lakes.

Spawning occurred once each year during the autumn. The date varied from late September to early December depending on the race of trout, amount of sunlight, the change in temperature, and the depth of the lake.

In the deep water of Seneca Lake one race spawned early. ~~All~~ In other lakes studied showed the lake trout spawned ~~in shallow water and usually later~~. Increased cloudiness in July, August, and September, and low temperatures in September, advanced the date of spawning. Shoaler lakes had earlier spawning dates. At the time of spawning, water temperature varied from 58° Fahrenheit to 37° Fahrenheit, but in Racquette and Osego Lakes it was observed that spawning time approximated the turnover time of the lake. Generally, the spawning period was about 20 days, but varied from 10 to 40 days and was fairly consistent from year to year in any one lake.

The Eggs were recovered from the crevices in the rocks of Otsego Lake. They were found to be 79 percent alive about one month after spawning. No measurement was possible on the effects of predation on eggs, but it was estimated to affect only eggs which failed to roll into the crevices of the stones during spawning

The eggs hatched in Otsego Lake about April 15, 1940 and the fry left the spawning area about May 22. A single advanced fry was taken in Seneca Lake on April 2, 1940 where the lake trout had spawned early in October in deep water. Its development indicated that hatching occured in late January.

Extensive operation of a small beam trawl, set lines, and minnow traps in Otsego, Keuka, and Seneca Lakes failed to produce any lake trout between the advanced fry stage and a length of about 6 inches. Twelve specimens between 6 and 10 inches long were captured in gill nets in Keuka Lake. These were found to be one and two years old and to be feeding mostly on <u>Mysis relicta</u>

THE BREEDING HABITS OF THE LAKE TROUT IN NEW YORK STATE

Introduction

~~Important as~~ The several races of both a food and game species, the lake trout, (Cristivomer n. namaycush), ~~is~~ are widely sought in all of the more accessible parts of ~~its~~ their range. It is one of the most ~~sought~~ valued food species in the Great Lakes where it is the subject of a major fishery. In smaller lakes of the northeastern United States and southern Canada where commercial fishing usually is prohibited it is highly prized as a game fish.

This popularity has ~~led to~~ been accompanied by severe declines in the populations of lake trout in some lakes, notably Lake Huron. ~~This~~ Devising corrective measures ~~for~~ to prevent such declines as well as ~~the urge~~ to successfully introduce this desirable species in additional lakes ~~requires~~ is required detailed knowledge of the habits and preferences of the species, particularly of the eggs, larvae, and juveniles below the sizes commonly caught.

Probably because of ~~the~~ their habitat ~~in~~ deep-water, almost nothing is known of the habits of young lake trout. Very few wild lake trout less than 8 inches in length have even been seen; their

cap + small center

SEXUAL DIMORPHISM

The lake trout ~~is~~ unique among the salmon family ~~in the~~ lacks almost completely ~~in~~ the malformed jaws or kype common to the mature ~~mature~~ males of other species. It is nearly impossible to distinguish the sex of mature lake trout by examination of the head alone. The males have a slight tendency toward a more pointed snout ~~but it is apparent only by~~ critical comparison of many individuals. The kype attains its maximum development ~~in~~ the Pacific salmons ~~which~~ migrate enormous distances to the spawning ground and ~~which~~ may live entirely on stored food for almost a year prior to spawning.

on the material mobilized for the development of the gonads differs from that of the female. The ovaries would have a general requirement for stored materials while the testes would require little albuminoids or fat. These materials ~~may~~ be utilized in the growth of the kype instead of being excreted.

and sides with a little yellow or orange in the fins. There are all graduations between these trout and the very dark trout of the brown-water Adirondack lakes which have stronger colors, and in which the sexual differences are a little more pronounced. Here the males tend to have more brilliant yellow, orange, and black in the paired fins than the females. But, even with these lake trout it is not always possible to distinguish the sexes on the basis of external differences.

This normal coloration is greatly changed male lake trout when they are sexually excited on the spawning area. While courting the females the chromatophores on the back contract so making the back appear very light colored, while the sides, flooded with pigment, become lustrous almost black (Fig. 1).

INSERT FIGURE 1 HERE

Merriman (1935) observed this condition in the lake trout of Squam Lake and it was seen by the author in Otsego Lake in 1940 and 1941. At this time selected fish were speared and the brilliant coloration was found to be restricted to the males.

Striking as was this coloration during courting or spawning the colors were most ephemeral. After the fish were netted or speared, the color difference could not be detected

Fry and Kennedy (1937) estimated the minimum age at maturi

of the lake trout of Lake Opeongo, Algonquin Park, Canada, as t

fifth year of life (presumably ~~with~~ corresponding to 4 annuli), by means of the

modes of a length frequency distribution, ~~Surber~~ Inasmuch as they had only

five lake trout less than 13 inches long, and since my observatio

indicate very small growth of lake trout in their first year, I

believe that they assigned an age to each mode of one year less

than it should have been.

These data are substantiated by data on the growth of lake trout. ~~Surber (1933) raised lake trout to maturity in a fish hatchery.~~ Surber (1933) ~~He~~ secured his first eggs from ~~the~~ female lake trout ~~at the~~ age ~~of four~~ years and ~~six~~ 10 months ~~and a~~ at length varying from 18 to 26 inches. But at this time, only ~~ten~~ 10 females out of somewhat less than 3,000 males and females spawned, ~~and~~ produced only an average of 962 eggs per female. No data on subsequent spawning was presented, but certainly the majority of his fish did not spawn before their ~~sixth~~ fifth year. Surber felt that this age at maturity was comparable ~~with~~ to that obtained ~~in~~ by wild fish. He gives the length of the trout at the end of their first, second, third, and fourth years of life as 10, 14, 16 to 18, and 18 to 26 inches.

respectively. This rate of growth in the first and second years of life is markedly greater than that existing in Keuka Lake. With this start it is possible that the hatchery fish spawned earlier than they would have in the wild, ~~and each~~ as ~~this condition~~ is known to be ~~the case~~ true with some other species of hatchery reared trout, especially brook trout.

Whatever their age, the rapidly growing lake trout of Seneca Lake, New York, do not mature until they are 26 to 30 inches total length. The lake trout of Keuka Lake, New York, mature at a total length of 18 to 24 inches, but in Skaneateles Lake, New York, however, Rayner (1941) captured many mature lake trout of 14 and 15 inches fork length (Total length would be about 1-3/8 inches greater). Fry (1939) reports that the minimum size at maturity in some lakes of Algonquin Park, Canada, ~~lakes~~ varies from 14 to 18 inches according to the lake. Obviously in lakes with rapidly growing populations of lake trout a uniform minimum legal size limit of 15 inches such as exists in New York State permits the taking of many immature fish which would still grow rapidly for several year. If signs of overfishing appear in these lakes it might be highly desirable from the standpoint of fisheries management to raise the minimum legal size limit to 18 inches or more.

Fry and Kennedy (1937) report that none of the lake trout of Lake Opeongo, Algonquin Park, Ontario, of more than 22 inches fork length were capable of spawning. This seems to be a characteristic peculiar to the population on that lake. No one has observed this condition in any New York lakes. The Conservation Department employees engaged in spawn taking operations on the Adirondack and Finger Lakes reported ~~that they had never observed any widespread impotency in large lakes~~

~~trout. They said~~ that only occasionally would an impotent fish be found. ~~Neither was~~ failed to show any impotency ~~found in any~~ either. of the author's more limited observations. It is likely that after the lake trout are mature ~~that ordinarily~~ they may spawn several times before succumbing to the infirmities of age ~~make them impotent.~~

B. The Time of Spawning

The lake trout, ~~as do~~ and most other trout, spawn once ~~in~~ a year in the fall when the temperature is dropping and the days are becoming shorter. Small variations in ~~this yearly cycle~~ the data are found among different ~~species~~ races of lake trout, among the same ~~species~~ race of lake trout in different lakes, and among different years in the same ~~species~~ race in the same lake. ~~Weather changes from year to year cause small variation in the time of the culmination of the reproductive cycle, but the larger variations occur because of the differential response of different species and races to the fluctuations in light and temperature. In addition, the physical characteristics of each lake impose their own modification on the interval between the change in weather and the response of the fish.~~

This is also true

It appears probable that fluctuations in light and temperature, physical characteristics of different lakes, and the varying response of different races are the determining factors.

Hoover and Hubbard (1937) have shown that brook trout which normally spawned in December could be induced to spawn in late August and early September by increasing the amount of light in early spring and decreasing it in late summer. Bissonette and Burger (1940) state "--there is no uniform control of the sexual cycle applicable to all fish. In some fish, temperature seems to be the major factor; in others, light and temperature play cooperative roles; while in still others, light appears to be the most important factor." Merriman and

Study of these factors have also proved useful in controlling the spawning time of other species.

Schedl (1941) on the basis of laboratory experiments on the four-spined stickleback (*Apeltea quadracus* (Mitchell), concluded that light influenced oogenesis but not spermatogenesis, while temperature somewhat unequally affected the maturation of the gonads of both sexes. McCay et. al. (1930) concluded on the basis of feeding experiments that the spawning time of brook trout could be influenced by the food supply. Examination of his data indicates that the age at maturity could be advanced or postponed by increasing or decreasing the amount of food fed to the hatchery trout, but the question of changing the date of spawning of mature trout was not clarified.

in the other, and the weather bureau data on air temperature and cloudiness can not be a precise measurement of the temperature and light actually affecting the fish. The period during which the light and temperature changes are important can only be surmised. Also important may be other factors. In 1938 in Racquette Lake the water level was very high and was suspected of being the cause of catching almost no lake trout but it was not certain whether the migrations of the fish or the fishing of the nets was affected.

Considering that a significant relationship was established in one instance, and that while other data were inconclusive they still supported the theory, it is concluded that both light and temperature influence the spawning time of lake trout.

that in New York State the time of lake trout spawning may vary from late September to early December.

Life most good rules, the rule that the deeper the lake the later the lake trout spawn has an outstanding exception. In Seneca Lake, the deepest lake in New York State (625 ft. maximum), the lake trout spawn the earliest. They start in late September and continue through the month of October. Here they spawn in water from 100 to 200 feet deep at a time well in advance of the turnover period of the lake. Temperature data ~~taken~~ from ~~Figure 9 illustrates the temperature stratification accompanying the spawn taking operations in 1941. The~~ ~~October 1947~~ September 29 & October 17, 1948 showed that the surface temperature ranged from 57° F. to 62° F. ~~physical characteristics of Seneca Lake and the time of lake trout spawning are very similar to those in Lake Superior and, to a lesser degree, in Lake Michigan and Lake Huron.~~

In general it may be said that when the lake trout spawn inshallow water the time of spawning approximates the turnover period of the lake. This turnover period is influenced by the latitude, altitude, and physical characteristics of the lake. In New York State the reaction of the lake to the seasonal changes in light and temperature is closely associated with the maximum depth of the lake.

~~Other~~ This large differences in the time of spawning may be attributed to racial differences in the lake trout. Milner (1874) gives the spawning time of the Siscowet, (Cristivomer namaycush siscowet), as late August and early September in the deep waters of Lake Superior. In the same lake the common lake trout, (Cristivomer n. namaycush), spawns in from ~~seven~~ 7 feet to ~~fifteen~~ 15 fathoms of water during the month of October and in early November (Milner, 1874, and Van Oosten, 1935). Hubbs (1930) has described the Rush Lake Trout, Cristivomer namaycush huronicus, and

attributed to it the habit of spawning in deep water in late summer rather than in the fall, as does the ordinary lake trout in the same lake.

Dymond (1926) gives the time of spawning of the common lake trout as the month of October in Lake Nipigon. But he points out in addition that there is a black race of trout in the same lake which ascend some of the tributary streams and start spawning about September 20, and a third race which issaid to spawn in deep water from October 20 to November10.

In New York State the data on the spawning indicate that two races of lake trout exist. One, the Seneca Lake trout, which spawns early in deep water, and the other which is widespread in the Finger Lakes and Adirondack Lakes and which spawns in shallow water at about the time of the turnover of the lake. The size of the eggs provides further evidence of racial differences. New York State fish hatchery foremen agreed that eggs from Seneca Lake lake trout averaged about 240 per ounce while eggs of lake trout of comparable size from Adirondack lakes average about 200 to 210 per ounce. No measurements of the actual diameters of the eggs were available but the counts of the hatchery foremen appeared to be fairly consistent. (It is a problem worthy of inquiry in any further racial studies). D. C. Haskell (Unpublished material gathered in 1941) also reports that the Seneca Lake trout grow significantly faster under hatchery conditions than the young lake trout from Racquette and Upper Saranac Lakes.

With these differences in reactions and spawning habits it would be desirable to determine if the Seneca Lake trout can adapt themselves to

Further proof was provided by the capture of a lake trout fry 25 millimeters total length in Seneca Lake in April, 1940, in water 130 feet deep.

There is much evidence that these deeper ~~xxxxxxx~~ spawning areas are swept by strong currents. In Seneca Lake the hatchery fishermen reported that their nets were often folled over and over by the currents. In this same lake off Peach Orchard Point the 40° F. isotherm rose from a depth of 260 feet on September 29, 1941 to 100 feet on October 1 after a strong south wind. On October 7 it was back down to a depth of 230 feet. Such a ~~xxxxx~~ change must be accompanied by the movement of a huge quantity of water.

See underneath.

largest lake: ~~and is~~ about 40 miles long and three miles wide at its widest point. The prevailing winds come from the northwest or the southeast. Thus the winds blow obliquely to the south on the east shore and obliquely to the north on the west shore of the lakes. The general result of this tendency has been to form the tips of deltas to the south of the stream mouths on the east shore to the lakes and to the north of the stream mouths on the west shore of the lakes.

The effect of these currents and seiches has been to allow virtually only gravel and rubble to be deposited off the tip of Peach

[illegible]
Lower Jaw [illegible]
only clean gravel and [illegible] [illegible]

The lighter materials such as mud were deposited Orchard Point in Seneca Lake down to depths of at least 300 feet. (obscure!)

~~The lighter materials have been swept to the less exposed parts of the lake bottom. Large amounts of mud may be found in the coves adjacent to Peach Orchard Point. Probably other places in Seneca Lake are swept clean in the same manner since the lake trout are cpatured in large numbers during the spawning season off the tips of several other points.~~ Doubtless these points possess similar bottom conditions although lack of time prevented mapping them as was done for Peach Orchard Point.

Evidently other deep lake bottoms have similar deposits since the lake trout are captured in large numbers during the spawning season near the tips of the points

The author has found no evidence to indicate that lake trout select a lake bottom supplied with spring water for the deposition of eggs. The spawning area in Otsego Lake was on a fill about 100 feet out from the original shore line which was bedrock and showed no evidence of any spring seepage. Furthermore, numerous water temperatures taken on the spawning area and in the nearby lake at all seasons of the year showed no difference in temperature. But, of course, it was impossible to take the temperature in amongst the rocks where White (1930) found spring water temperatures in brook trout spawning areas. Additional evidence was noted in the presence of an equally thick ice cover over the spawning area on March 31, just before the spring break-up, when any springs should have caused some erosion of the ice. No mention of the presence of spring water on lake trout spawning areas has been found in the literature which the author has perused. It is concluded that spring water is a negligible factor in a lake trout's selection of a spawning area.

disappeared until only a few were left although observations were not continued after 11 p.m.

It has been the experience of the New York State Conservation Department in netting lake trout for spawn that the males migrate toward the spawning area earlier in the season and usually more males are caught. From this experience and from the fact that the males appear to be predominated on the area ~~present on the area the greater proportion of the time~~ it is probable ~~seems likely~~ that the males are almost entirely responsible for any cleaning of the spawning area prior to spawning. No nest or redd was ~~is~~ built. ~~On the Otsego Lake spawning area~~ The males spent their time cruising along close to the bottom occasionally giving the stones a little fillip with their tail. Several male trout showed considerable abrasion on the lower jaw and under side of the tail from this fanning and digging. The result of this activity was the thorough cleaning of several hundred square feet of bottom. The bottom was so clean that it was easy to distinguish the area on which the trout were working even though the trout were not present.

Belying their appearance the males were not pugnacious. Occasionally one would make threatening motions at another male but no vigorous fighting was observed. Several whitefish (Coregonus clupeaformis) and a large eel (Anguilla bostoniensis) were seen among the milling lake trout and were unmolested. It was noted however that the males were nearly of the same size. Perhaps they had already disposed of ~~on~~ any venturesome small males!

Merriman (1935) and others have noted the spawning lake trout splashing at the surface. In Otsego Lake this was noted only occasionally, perhaps because the spawning was on a steep slope in from two to 15 ~~fifteen~~ feet of water; deeper than that in which Merriman observed the trout.

They build no nest or redd and make no attempt to cover the eggs but rely on the interstices of the bottom to provide the necessary protection. The courtship and spawning acts are much the same as observed in other species of trout. Table 6 compiled from Embody (1934), Greeley (1932), Hazzard (1932), Hobbs (1937), Kendall and Dence (1929), Merriman (1935), Milner (1874), Neeham and Taft (1934), Schultz (1938) Smith (1941), and White (1930) lists the principal points of similarity and difference of the spawning habits of New York State trouts.

of water where they were subject to heavy wave action. The vast majority of the eggs were seen to be laid in deeper water out of the reach of available collecting apparatus and where they should have been more adequately protected. ?

B. Temperature Requirements.

Lake trout eggs appear to both require and withstand slightly lower temperatures than the eggs of other trout. Embody (1934) found ~~that brook trout eggs required an abnormally long time to hatch below 3° C. and~~ that brook and ~~other~~ rainbow trout eggs suffered excessive mortality ~~when~~ and developed ~~below about 5° C.~~ He found that lake trout and brown trout eggs followed the same rate of development down to ~~1.8° C.~~ 35.2° F. and ~~from two~~ trout eggs. Brook trout eggs normally spawn in spring water so the eggs are not subjected to near freezing temperatures during the winter (Greeley, 1932, Hazzard, 1932, and White, 1930). Rainbow trout usually spawn in the spring when the water is warming (Rayner, 1941). Cook (1929) reports that lake trout eggs develop satisfactorily at the Duluth hatchery where the water temperatures remain at about 32.5° F. throughout the winter. The incubation period of the lake trout eggs in Otsego Lake of 140 days indicates an average temperature of between ~~2°~~ 36° and ~~3° C.~~ 37° F. in the egg development tables of Embody (1934). At the New York State hatchery at Rome high mortality occurred in lake trout eggs developing at water temperatures of over 50°, when other trout eggs developed normally. Lake trout eggs from the same source developed normally in other hatcheries at lower temperatures. These facts would indicate that lake trout eggs can develop successfully

Rainbow trout eggs suffered high mortality at temperatures over 43° F. but Embody thought that this was not the case in some cases. inferior eggs.

1 adult lake trout; Cristivomer n. namaycush; 11 Notropis hudsonius; 1 blunt-nosed minnow, Hyborhynchus notatus; 1 chain pickerel, Esox niger; 17 yellow perch, Perca flavescens; 22 johnny darters, Boleosoma nigrum olmstedi; 1 smallmouth bass, Micropterus d. dolomieu; 4 common sunfish, Lepomis gibbosus; 13 rock bass, Ambloplites rupestris; and 11 slimy muddlers, Cottus cognatus. These fish were all captured during the time the alevins were absorbing the yolk sac and leaving the spawning bed. Such negative evidence is inconclusive but reassuring. It is not ~~likely~~ that the lake trout eggs and alevins suffer ~~much~~ little from predation after the spawning season. Insert A on back It is important to note that most trout egg predators have been indicted for their activities during the time the eggs were being laid and not after the eggs were hidden in the gravel.

D. Development of Eggs and Alevins

Greeley (1936) collected eyed eggs and newly hatched alevins on the Otsego Lake spawning area on April 12, and more advanced alevins on May 9. The author took newly eyed eggs on February 17, 1941, and later eyed stages of March 31, 1941, both by chopping holes through the ice. (The lake trout had been observed spawning December 1, 2, and 3, 1940). Later on April 27, with the surface water temperature 44° F. newly hatched sac fry were taken and on May 17, 1941 many more advanced fry were taken (temperature data in Figure ~~16~~ 5). All of the stages were taken from the rubble on the spawning area. Insert Figs 5 + 16 Several hauls of the trawl in the vicinity of the spawning area on April 27 and May 17 produced no fry. Apparently no migration had yet taken place. Both eggs and fry were well buried in the stones. The eggs were taken with a Peterson dredge

and that during spawing the eggs which are
ten are only those left ~~on the~~ exposed on
a bottom

A set line equipped with 80 No. 7 hooks was set for ~~four~~ 4 days covering depths from 15 to 40 feet. Minnow traps were set for ~~eight~~ 8 days at depths of from 40 to 80 feet.

The net result of this fishing as far as lake trout were concerned was the capture of 41 lake trout (all in gill nets) of which ~~28~~ 13 were less than ~~fifteen~~ 15 inches total length, the minimum legal size limit in New York State. ~~The lengths and stomach contents of these sub-legal specimens are listed in Table 8.~~ The stomach contents of the 13 legal-size trout and of 11 other legal-size trout gathered from anglers were 100 per cent sawbellies, (Pomolobus pseudoharengus), or unidentifiable fish which were probably of the same species. (Anglers report finding practically nothing but sawbellies in the lake trout stomachs). It is interesting and perhaps significant that the smaller lake trout depended more and more on Arthopods, principally Mysis relicta, for food. The trawl collections showed the Mysis to be abundant throughout the depths of the lake.

In most cases the capture of the lake trout was very erratic. The small specimens taken May 11 were all taken in the same place at very nearly the same depth of 100 feet. Nets set in the same place on following nights caught nothing. The other small specimens taken during May and June and all the larger lake trout were caught one or two at a time in different places but almost entirely at depths of from 80 to 120 feet.

Some consistency, however, was found in the capture of the young lake trout caught September 11 to 16, ~~1939~~ 1940. These were taken two or three per night in 5/8-and 3/4-inch bar gill nets set in one

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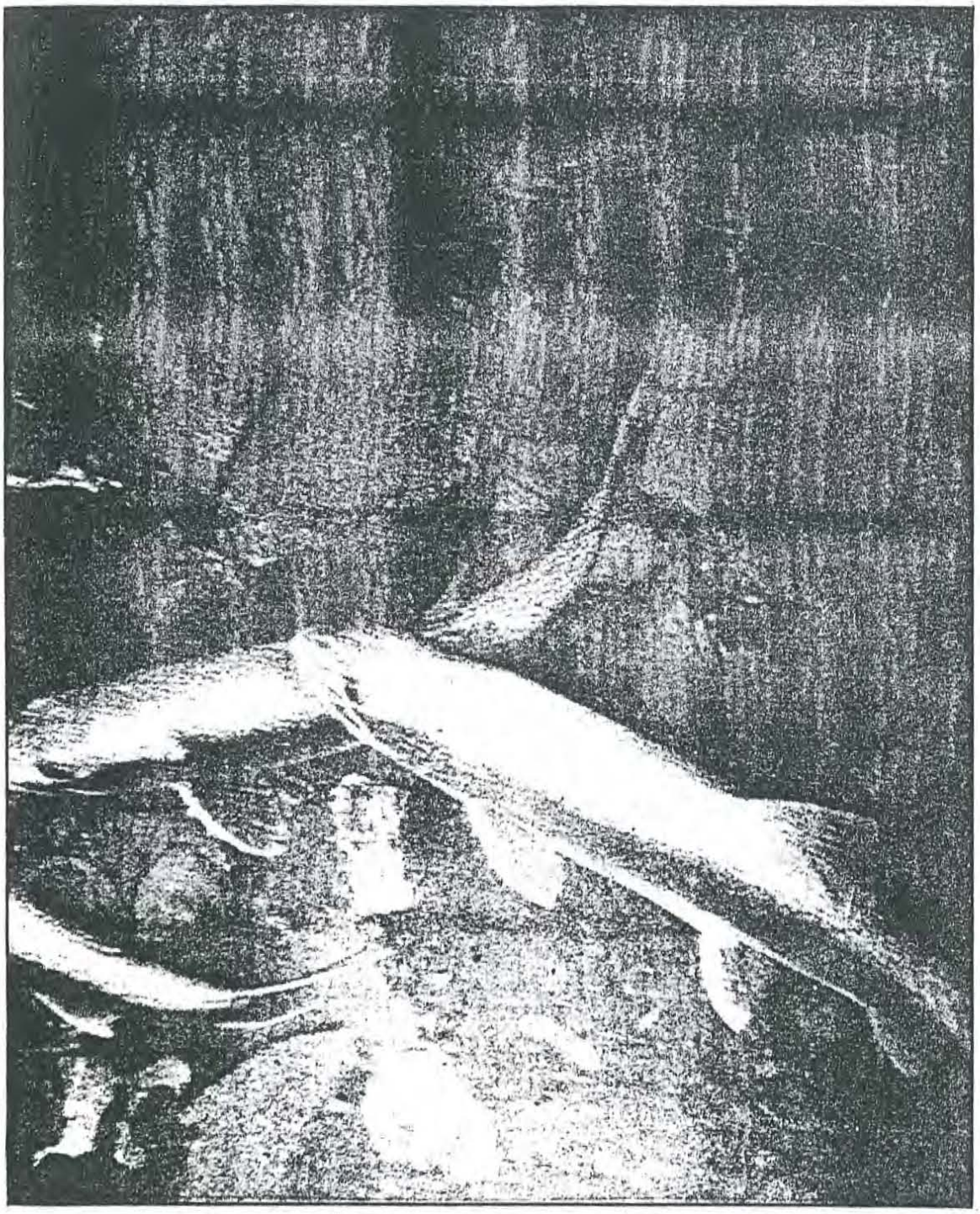
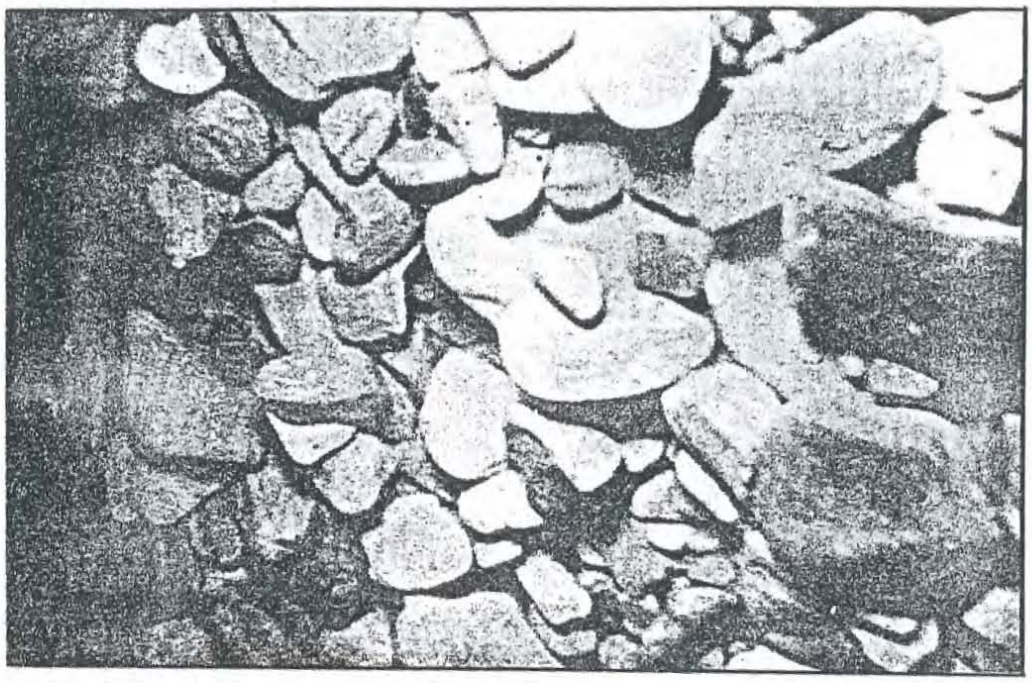
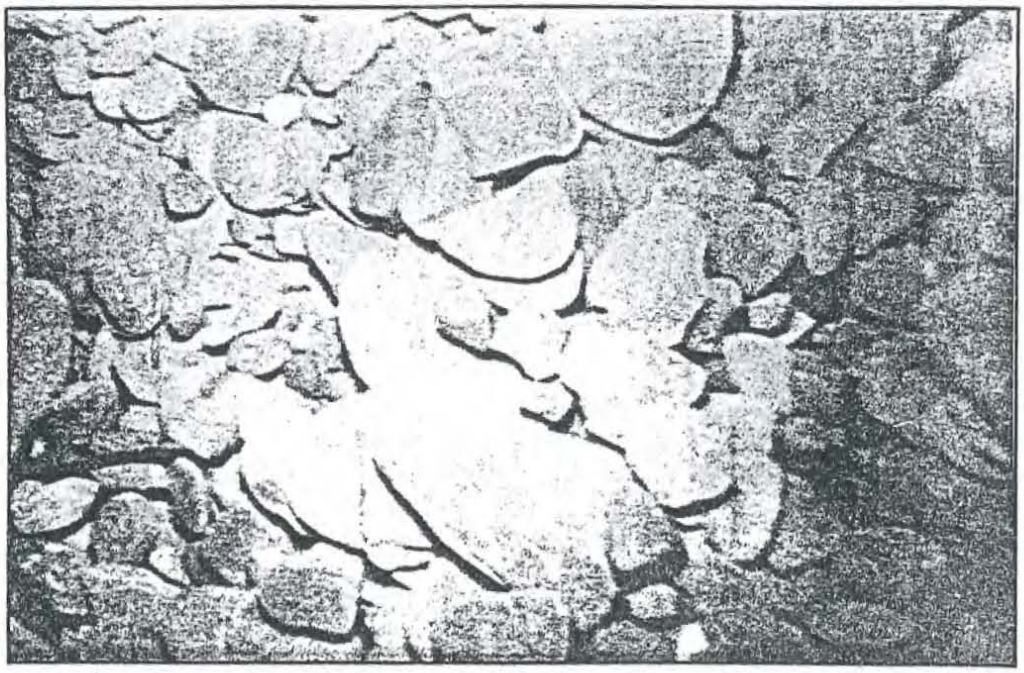


Fig. 1. Male lake trout on the spawning grounds in Otsego Lake, N. Y.



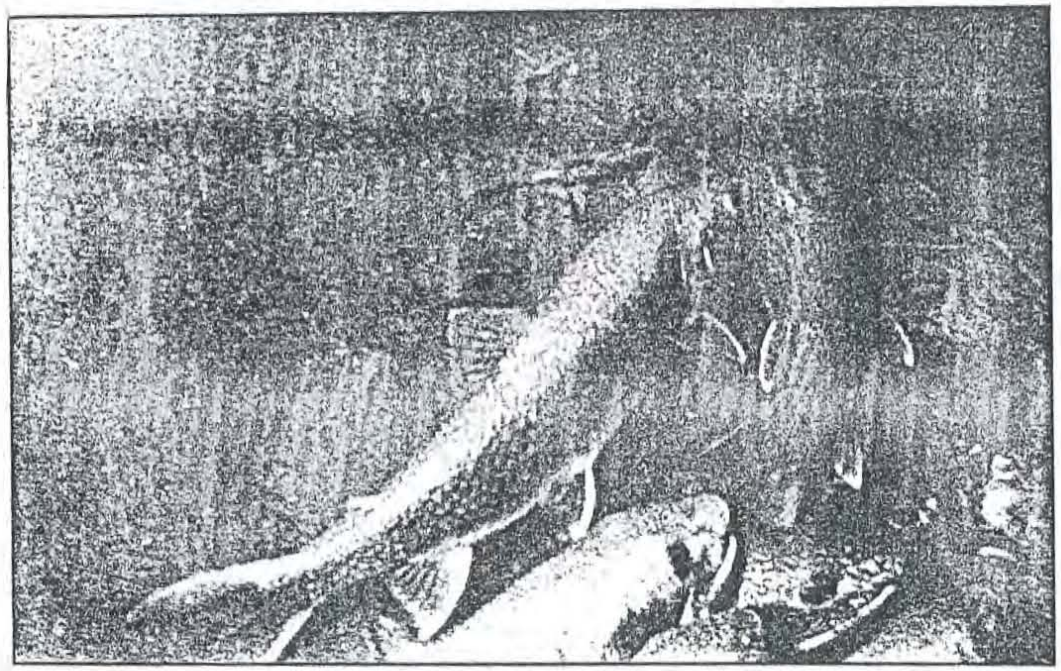
A



B

Use A only

Figure ~~II~~ 3. The bottom of Seneca Lake west south west off the tip of Peach Orchard Point where the lake trout congregate during the spawning season. A, 78 foot depth; and B, 120 foot depth. Both pictures enclose an area on the bottom about 18 inches by 27 inches.



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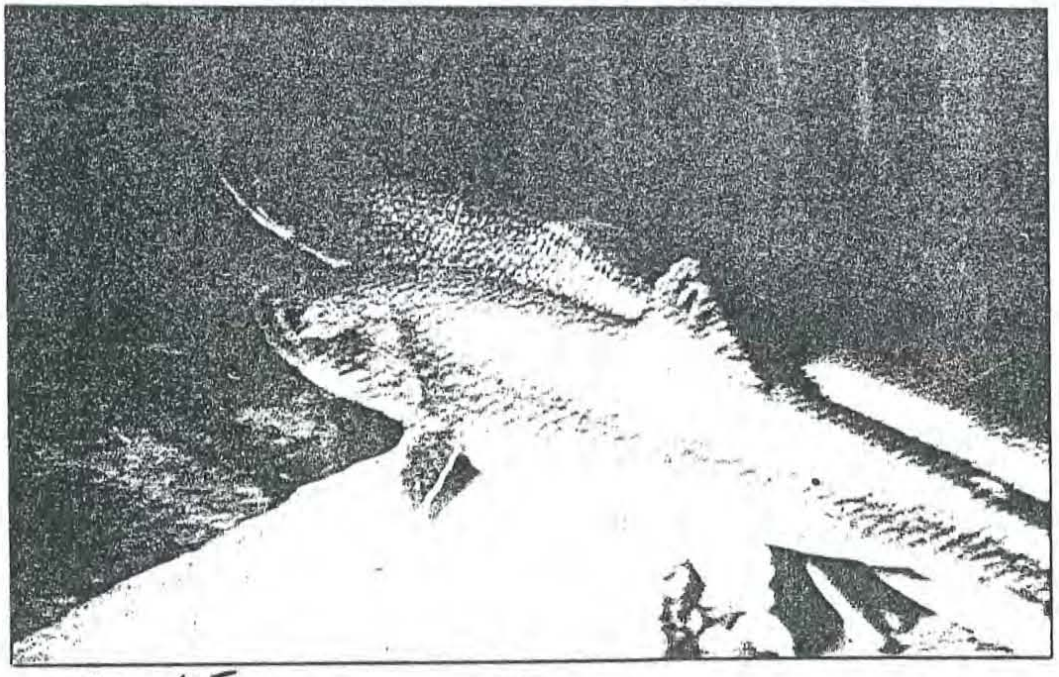

B

Figure ~~13~~ 4 and 5. A, The characteristic courtship act of spawning lake trout. B, Just after the completion of the spawning act.

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