Original: Fish Division
cc: Mr. Stanley Shust
Education-Game
Institute for Fisheries Research

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

November 5, 1943

REPORT NO. 899

AN ANALYSIS OF THE FISH POPULATION OF LINNBECK LAKE

by

John Greenbank

Introduction

As a part of the program of compiling and analyzing the data relative to the fish populations of the series of lakes which have been poisoned by the Institute, this report presents a study of the fish population of Linnbeck Lake. This particular population exhibited certain peculiarities probably not normally encountered in similar lakes (although what constitues a "normal" fish population is but poorly known or vaguely defined).

Linnbeck Lake is a very small lake (5.1 acres) in the Little Shakey River drainage in Menominee County. It was mapped by the Institute in the winter of 1939-40; and a fisheries survey was made August 22-23, 1940. This survey was reported by Moffett and Locke, Institute for Fisheries Research Report No. 674, in which details of the topographical, physical, chemical, and biological characteristics of the lake are contained.

The lake has a maximum depth of 25 feet, mostly peat and marl bottom, and an encroaching mat of border vegetation. The water is moderately hard, somewhat brownish, and relatively free from turbidity. It undergoes thermal

NOTE: The figures referred to in this report were not reproduced for lack of drafting help but are filed with the Institute file copy at Ann Arbor.

stratification in the summer; and the hypolimnion is cool enough and maintains a high enough oxygen content to support trout.

Prior to the poisoning of Linnbeck Lake a brush filter dam was constructed in the outlet stream to prevent migration of undesirable species of fish into the lake from the Little Shakey River system.

On the morning of September 11, 1940 the lake was poisoned with derris.* Using the usual technique, the poisoning party applied 125 pounds of the derris root powder (5 per cent rotenone content), making a calculated dosage of approximately 0.75 p.p.m. The surface temperature of the water at that time was 62°F. It was presumed that a complete, or virtually complete, kill of all fish in the lake was obtained.

On September 11-12, the dead fish were picked up as thoroughly as possible. Because of the mat of vegetation around the shore some difficulty in recovering dead fish was experienced. Also there no doubt was some failure to find all of the dead fish which sank to the bottom before drifting to shore, particularly in the case of the fish of relatively great specific gravity, such as the darters and small perch. Therefore, it is probable that, in spite of very diligent efforts, not over perhaps 90 to 95 per cent of the total fish population was recovered.

The fish were partially sorted in the field, certain length and weight measurements were made, and a series of scale samples of the game species was taken. In order to save time in the field, a large part of the dead fish, especially of the small-sized species, were preserved in 10 per cent formalin and taken to the laboratory for more complete study. Most of this work in the laboratory was performed during the following winter by the writer, W. R. Reavley, and Pat Galvin.

---

*The poisoning party consisted of John Greenbank, W. R. Reavley, David Anderson, and Pat Galvin.

In 1941 Linnbeck Lake was stocked with 1,000 yearling and 3,000 nine-months-old brook trout. However, following this planting a certain right of private property has been spitefully exercised and the only road which could yield public access to the lake was closed. Although the state owns frontage on this lake it is not accessible except over this private road. The present status of the fish population of the lake therefore is unknown and the future management policy is uncertain.

Yield

A total of 22,045 fish weighing 143.2 pounds was recovered. This is equal to 4323 fish, or 28.0 pounds, per acre. In comparison, other Michigan lakes which have been poisoned* have yielded from 10 (Witch Twin Lake, Marquette County) to 195 (Clear Lake, Alcona County) pounds per acre, and some lakes in more southern states have been found to contain an average of several hundred pounds of fish per acre (Bennett, 1943**; also other authors).

Table 1 gives a species breakdown of the Linnbeck Lake population. Following the practice now established in Institute papers, the species in this table have been divided into "game" fish, "coarse" fish, and "forage" fish. Of the game species, the yellow perch was the most abundant and furnished the greatest poundage. The pumpkinseed was present in fairly large numbers, but because of the small average size of individuals the total weight of this species was not very great. Largemouth bass, rock bass, and northern pike were present in relatively small numbers.

The yellow bullhead (Ameiurus n. natalis) was the only coarse fish taken. Eleven species of forage fish were present: blunt-nosed minnow (Hyborhynchus notatus), black-nosed shiner (Notropis h. heterolepis),

---

* An analytical study of the comparative yields of these lakes is to be the subject of a forthcoming report by the Institute.

** Bennett, George W. Management of small artificial lakes. Bulletin of the Illinois Nat. Hist. Survey, Vol. 23, Article 3; 1943.

Table 1. Fish Recovered, Linnbeck Lake

(Area equals 5.1 acres)

Species	Total Number	Number Per Acre	Total Weight, Pounds	Pounds Per Acre
GAME FISH:				
Largemouth bass	29	6	0.4	0.1
Rock bass	24	5	5.8	1.1
Pumpkinseed	1,142	224	13.4	2.6
Perch	2,524	495	31.2	6.1
Northern pike	16	3	15.3	3.0
Sub-totals	3,735	733	66.1	12.9
COARSE FISH:				
Bullhead	192	38	12.8	2.5
FORAGE FISH:				
Common shiner	19	4	1.1	0.2
Blunt-nosed minnow	2,735	536	9.5	1.9
Black-nosed shiner	3,330	653	10.1	2.0
Black-chinned shiner	1,173	230	4.0	0.8
Golden shiner	1,081	212	10.3	2.0
Northern dace	5	1	...	...
Madtom	1,845	362	9.8	1.9
Mud minnow	1,308	256	7.3	1.4
Iowa darter	33	6	0.1	...
Menona killifish	111	22	0.5	0.1
Brook stickleback	6,478	1,270	11.6	2.3
Sub-totals	18,118	3,552	64.3	12.6
Totals	22,045	4,323	143.2	28.0

black-chinned shiner (Notropis heterodon), golden shiner (Notemigonus crysoleucas auratus), tadpole madtom (Schilbeodes gyrinus), mud minnow (Umbra limi), brook stickleback (Eucalia inconstans), Menona killifish (Fundulus diaphanus menona), Iowa darter (Poecilichthys exilis), common shiner (Notropis cornutus frontalis), and northern dace (Margariscus margarita nachtriebi). The last four named were found only in small numbers. Dominating the population numerically was the brook stickleback. The blunt-nosed minnow and the black-nosed shiner also were abundant.

The game fish of legal size (10 inches for largemouth bass, 14 inches for northern pike, and 6 inches for perch, pumpkinseed, and rock bass) are listed in Table 2. Also shown are the bullheads of 7 inches or more (there is no legal size limit for this fish in Michigan). The totals for this table are 113 fish (weighing 39 pounds), or 23 fish (7.7 pounds) per acre. The total game fish in the lake would have made approximately 2 1/2 daily limit catches of perch, 2 limit catches of northern pike, and 1/2 of one limit catch of rock bass. Of the 1142 pumpkinseeds recovered, none was of legal size, and the 29 largemouth bass were all small (young of the year).

The sections below will consider some of the various individual species which made up the fish population of the lake.

Perch

As shown in Tables 1 and 2, the lake contained over 2500 perch, of which only 64 are known to have been of legal size. The largest perch which was measured was slightly less than 10 inches long and weighed 0.4 pounds.

A large proportion of all of the mature perch were individually sexed, weighed, and measured (total and standard lengths). Scale samples

Table 2. Legal-sized game fish

Species	Number	Number Per Acre	Weight, Pounds	Pounds Per Acre
Perch	64	13	9.1	1.8
Rock bass	13	3	4.9	1.0
Northern pike	10	2	13.7	2.7
Largemouth bass	None	...	...	...
Pumpkinseed	None	...	...	...
Bullhead*	26	5	11.0	2.2
Totals	113	23	38.7	7.7

* Since there is no legal size limit for bullheads in Michigan, a length of 7 inches was arbitrarily chosen as a minimum desirable size.

were taken from 347 adult* fish. Total lengths were measured on 150 young-of-the-year specimens (random sample); standard lengths also were measured on 50 of these.

The factors (reciprocal to each other) for conversion from total to standard length and vice versa were computed separately for the 50 young-of-the-year perch and for two arbitrary size ranges of the adults. These factors are given in Table 3. Each figure represents the average of the factors computed for the individual fish. These figures show slightly the trend observed by Hile and Jobes,** that the relative tail length tended to decrease with increased size of the fish (Table 3). Beckman*** also found the same trend in averages for inland waters of Michigan.

In the perch from Linnbeck Lake there was an apparent tendency for the females, of any one size group, to have shorter relative tail lengths than the males, but the figures are not divergent enough to be very significant. The same trend, however, was mentioned by Hile and Jobes (1941) for the perch of Saginaw Bay.

For some reason not apparent, the scales from the Linnbeck Lake perch were very difficult to read with assurance. Therefore no scale measurements were made. The number of annuli for each scale was determined as well as was possible. The age-growth relationships are given in Table 4. In this table the usual nomenclature is used; that is, age group I means one annulus on the scale (the fish being in its second summer of life), etc.

---

* "Adult" here means all fish older than one year.

** Hile, Ralph, and Frank Jobes. Age, growth, and production of the yellow perch, Perca flavescens (Mitchill), of Saginaw Bay. Trans. Amer. Fish. Soc., Vol. 70 (1940), pp. 102-122; 1941.
(Same). Age and growth of the yellow perch, Perca flavescens (Mitchill), in the Wisconsin waters of Green Bay and northern Lake Michigan. Papers Mich. Acad. Sci., Arts, Letters, Vol. XXVII, pp. 241-266; 1942.

*** Beckman, William C. Growth rate of some Michigan game fishes. Institute for Fisheries Research Report No. 741 (unpublished), 1942.

Table 3. Factors for Conversion of Standard and Total Lengths, Yellow Perch From Various Localities

Locality and Author	Size Range (St. length, mm.)	T. L. to S. L.	S. L. to T. L.
Linnbeck Lake	Under 70 (young of year)	0.840	1.19
	70 - 129	0.840	1.19
	Over 130	0.844	1.18
Michigan average (Beckman, unpublished)	Under 83	0.833	1.20
	84 - 169	0.847	1.18
	Over 170	0.852	1.17
Green Bay (Hile and Jobes, 1942)	Under 149	0.844	1.18
	150 - 209	0.853	1.17
	Over 210	0.858	1.17
Saginaw Bay (Hile and Jobes, 1941)	Under 175	0.849	1.18
	175 - 239	0.866	1.16
	Over 239	0.877	1.14

Table 4. Length-Frequency Distribution of Perch,

by Age and Sex

Standard Length, mm.	Age Group I ♂	I ♀	II ♂	II ♀	III ♂	III ♀	IV ♂	IV ♀	VI ♂	VI ♀	VII ♂	VII ♀
70-74	1	...	...	...	...	...	...	...	...	...	...	...
75-79	1	3	...	...	...	...	...	...	...	...	...	...
80-84	8	8	...	...	...	...	...	...	...	...	...	...
85-89	13	23	...	...	...	...	...	...	...	...	...	...
90-94	4	7	4	11	...	...	...	...	...	...	...	...
95-99	...	1	14	14	...	...	...	...	...	...	...	...
100-104	...	...	20	19	...	...	...	...	...	...	...	...
105-109	...	...	13	11	...	...	...	...	...	...	...	...
110-114	...	...	15	14	...	3	...	...	...	...	...	...
115-119	...	...	14	15	4	5	...	...	...	...	...	...
120-124	...	...	6	10	2	3	...	...	...	...	...	...
125-129	...	...	2	12	...	1	1	...	...	...	...	...
130-134	...	...	...	3	1	5	3	...	...	...	...	...
135-139	...	...	...	...	1	2	7	...	...	...	...	...
140-144	...	...	...	...	...	...	9	1	2	...	...	...
145-149	...	...	...	...	...	...	2	1	...	...	...	...
150-154	...	...	...	...	...	...	3	5	...	...	...	...
155-159	...	...	...	...	...	...	...	2	...	...	...	...
160-164	...	...	...	...	...	...	...	4	...	...	...	...
165-169	...	...	...	...	...	...	...	6	...	...	...	...
170-174	...	...	...	...	...	...	...	6	...	...	...	...
175-179	...	...	...	...	...	...	...	1	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...
210-214	...	...	...	...	...	...	...	...	...	...	...	1
Males:												
Average*	85.3		107.5		122.6		140.4		142.0		...	
Range	70 - 91		93 - 126		116 - 136		125 - 154		140 - 143		...	
Number	27		88		8		25		2		...	
Females:												
Average*	86.4		109.6		123.6		162.4		...		...	
Range	75 - 98		91 - 131		110 - 136		140 - 176		...		212	
Number	42		109		19		26		...		1	
Sexes Combined:												
Average*	86.0		108.7		123.3		151.6		...		...	
Number	69		197		27		51		2		1	

* Averages calculated from 5 mm. frequency classes, not from individual specimens.

Scales from young-of-the-year (0 annuli) perch were not read since these fish could quite obviously be distinguished from the older fish, there being no overlap between the 0 and I groups. The average total length of 150 young-of-the-year specimens was computed. The range of these total lengths was 60 to 78 mm., with a mean of 68 mm. These figures were multiplied by the conversion factor (0.840) which was derived from the 50-fish sample (see above), making the calculated range of standard lengths 50 to 66 mm., and the calculated mean standard length 57 mm.

Figure 1* gives the growth rate curves for the two sexes of perch (for the 0 group the sexes were not separated). It must be borne in mind, in interpreting this graph, that the fish were killed in September and thus had passed through almost a complete growing season after the formation of the last annulus. A difference in growth of the sexes is only slightly discernible in the younger groups, but in the IV group the females averaged definitely larger than the males. Whether this difference in size between the two sexes of this age group was peculiar to that particular year class and represented a differential growth throughout the life of that year class, or whether the perch of all year classes showed a difference in growth rate of the males and females which arose only after three or four years of life, is a question which obviously cannot be answered without scale measurements.

The growth rates of perch populations from several selected localities are given in Table 5. Each figure in this table represents an average of observed standard lengths for that particular group. Since the fish of the different populations were captured at different times during the summer, the figures are not strictly comparable. In most instances, however, the fish were taken fairly well along in the summer, and therefore were part or a whole growing season older than is indicated by the number of

*See footnote on page 1.

Table 5. Comparison of Growth Rates of Perch From Certain Localities. Average Standard Lengths, in mm., For Various Age Groups

Locality and Author	Age Group 0+	I+	II+	III+	IV+
Lake Jesse (Smith)	32	68	81	95	111
South Twin (Eschmeyer)	...	87	86	118	129
Linnbeck Lake	57	86	109	123	152
Michigan average (Beckman)	61	101	133	153	167
Lake Erie (Jobes)*	...	161	178	196	213

*Data for two summers (1927 and 1928) combined.

annuli. Therefore a + sign is appended to the numeral for each group.

One of the slowest growing perch populations reported in the literature was that of Lake Jesse, Nova Scotia.* This slow growth probably was caused, in part, by the cool temperatures and short summer seasons of that latitude. Perch which were IV+ years old averaged only 111 mm. in standard length (equivalent to about 5 inches total length). The perch of South Twin Lake** offer an example of some of the stunted perch populations which have been reported in Michigan. The Linnbeck Lake perch made a fairly good growth comparatively, but still were somewhat under the average for Michigan lakes.*** Finally, an example of an extremely fast growth is offered by the perch from Lake Erie,**** which were larger at I+ years than were those from Linnbeck Lake at IV+. All of these figures are shown graphically in Figure 2.

Although individual weights were recorded for the sample of 347 perch of I annulus and over, no calculation has been made of the factor "K", nor has any other weight-length relationship been derived.

---

* Smith, M. W. The fish population of Lake Jesse, Nova Scotia. Proc. Nova Scot. Inst. Sci., Vol. XIX, pp. 389-427. 1939.

** Eschmeyer, R. W. Some characteristics of a population of stunted perch. Papers Mich. Acad. Arts, Sci., Letters, Vol. XXII, pp. 613-628. 1937.

*** Beckman, unpublished. Cited above.

**** Jobes, Frank W. Preliminary report on the age and growth of the yellow perch (Perca flavescens Mitchill) from Lake Erie, as determined from a study of its scales. Papers Mich. Acad. Sci., Arts, Letters, Vol. XVII (1932), pp. 643-652. 1933.

Pumpkinseed

Over 1100 pumpkinseeds were recovered following the poisoning, and, as mentioned above, none was of legal size. In fact, the largest specimen which was measured was 112 mm. (4 1/2 inches) long and weighed approximately one ounce.

Scale samples were taken from some 225 random specimens, but unfortunately the scales were extremely difficult to read; so no precise age determinations were made. Casual inspection of the scales showed that the largest specimens had apparently either II or III annuli (were in either their third or fourth summer), with no older individuals present. There is no ready explanation for the presence in the lake of a large number of comparatively young pumpkinseeds and no old ones, a situation which no doubt is uncommon.

The length-frequencies of the pumpkinseed samples are given in Table 6. These figures are derived from two different samples. The first of these contained 225 specimens (105 females and 120 males) which were judged, in the field, to be fish one year or more old and hence were labelled "adults." The second sample consisted of 150 specimens taken at random from those fish judged to be young-of-the-year, and were called "young." However, as may be seen from Table 6, the size ranges of these two samples overlapped considerably, indicating that it was not possible to separate completely the young-of-the-year fish from the older ones without actual scale-readings, and probably that some of the fish which were incorrectly called one or the other. This situation is brought out graphically by Figure 3, which shows by histograms the frequency distribution of total lengths.

As was done for the perch, factors were computed for the pumpkinseed for conversion from standard to total length. These figures are: females over 70 mm. in standard length, 1.23; females under 70 mm. and all males, 1.24; and "young" specimens, 1.27. Thus again, as for the perch, there is

Table 6. Length-Frequency Distribution of Pumpkinseeds, Standard and Total Lengths

Length, mm.	"Young"	"Adults" ♀	"Adults" ♂
Standard length:			
35 - 39	11	...	...
40 - 44	51	...	...
45 - 49	51	...	...
50 - 54	32	1	...
55 - 59	4	8	14
60 - 64	1	30	14
65 - 69	...	39	15
70 - 74	...	16	20
75 - 79	...	4	35
80 - 84	...	3	13
85 - 89	...	3	8
90 - 94	...	1	1
Average*	46.0	67.0	72.2
Total length:			
45 - 49	4	...	...
50 - 54	30	...	...
55 - 59	54	...	...
60 - 64	40	...	...
65 - 69	19	5	4
70 - 74	2	5	13
75 - 79	1	27	12
80 - 84	...	39	9
85 - 89	...	15	14
90 - 94	...	6	28
95 - 99	...	2	22
100 - 104	...	2	13
105 - 109	...	3	4
110 - 114	...	1	1
Average*	58.7	82.5	88.8

*See footnote, Table 4.

evidence that the females have relatively shorter tails than the males, and that the relative tail length tends to decrease with increasing size of the fish. The figures here given agree fairly well with those given by Beckman (Institute for Fisheries Research Report No. 741, unpublished), which were: for fish over 95 mm. in standard length, 1.24; and for those under 95 mm., 1.26.

Although individual weights and lengths were measured on the 225 "adult" specimens, no length-weight relationship for these pumpkinseeds has been computed.

Largemouth Bass

Only 29 specimens of largemouth bass were taken, and all of these were obviously young-of-the-year, judging not only by their size but also by scale examination. The range of standard lengths was 53-85 mm., and of total lengths 64-100 mm.

It is hard to explain the presence of young-of-the-year bass when, apparently, older bass were entirely lacking in the lake. It is possible that, say one or two pairs of adults came into the lake from the stream, spawned, and then returned to the stream; or it may be that the young bass themselves migrated from the stream to the lake.

Rock Bass

Another "incomplete" population was that of the rock bass. Only 24 specimens in all were taken. Of these, 10 were from 80 to 93 mm. in standard length, and (as nearly as could be ascertained from their scales) were in age group either II or III or both. The other 14 specimens averaged 153 mm. in standard length (range 120 to 175), and apparently were all of one age group, probably VI. Thirteen of these were of legal size (over 6 inches, total length), and the largest was almost 9 inches long and weighed 1/2 pounds.

Again, the presence of only certain isolated age groups in a species is disturbing. And again, the most plausible explanation is migration from the outlet stream.

Northern Pike

The northern pike constituted still another "remnant" population. Sixteen specimens were killed. These ranged from 208 to 488 mm., standard length (10 to 22 inches, total length); ten of them were of legal size. The largest pike weighed 2 1/2 pounds.

Scale readings of these pike indicated that they were from 3 to about 6 or 7 years old. No very small or very young pike were taken. It seems likely that the pike spawned outside of the lake (i.e., in waters connected with the stream system), and that a limited number of the adult pike spent a part of the year in the lake. Even so, it is evident that these few pike made up the best potential fishing that the very meager legal-sized fish fauna of the lake afforded.

Bullhead

Of the 192 bullheads recovered, 157 were young-of-the-year, and 35 were older fish. The latter ranged from 121 to 325 mm. (5 to 13 inches) in total length, with 26 specimens being over 7 inches long. The young-of-the-year were from 27 to 60 mm. long, total length. In total weight the bullhead ranked fourth to the perch, pike, and pumpkinseed (Table 1).

Forage Fish

The most numerous fish in the lake was the brook stickleback, of which almost 6500 specimens were recovered. The tadpole madtom, the mud minnow, and four species of minnows (blunt-nosed minnow, black-nosed shiner, black-chinned shiner, and golden shiner) all were present in numbers of over 1000 each. The common shiner and the northern dace were represented by only a few individuals, which probably were either strays from the stream or escaped bait. The Menona killifish and the Iowa darter also were present

in rather small numbers, even assuming, as probably was the case, that part of the dead darters were not recovered because they sank to the bottom. Here again are more or less "incomplete" populations for which a wholly satisfactory explanation is not available (differential pick-up because of shoreline vegetation may have played some part in the numbers of some of the smaller fish recovered).

Length-Frequency Relationships

From each of the seven most abundant species of forage fish listed above, a random sample of 150 specimens was taken. These specimens were individually measured (total length). The length-frequency distributions are given in Table 7. Also in this table are the complete samples of the common shiner, the northern dace, the Iowa darter, and the Menona killifish, as well as the young-of-the-year bullheads and young-of-the-year largemouth bass, and random samples (150 specimens) of the young-of-the-year perch and the "young" pumpkinseeds (see above).

The length-frequencies of several of the small fish are shown by histograms in Figures 4 and 5. These diagrams tell disappointingly little, but do give a few hints as to the age and growth of these species.

Evidently most of these fish are rather short-lived and fast-growing, since only one or two, or at most a few, modes are to be discovered inany one diagram. In some of these species the small specimens (i. e., probable young-of-the-year) did not appear in the samples in nearly as great proportion as might be expected. Either the crop of young of that year actually was very small or more likely, many of these smaller fish either were missed in the picking-up process or failed to find their way into the "random" samples.

It is difficult to interpret these histograms in terms of age groups since there is overlap in lengths between age groups and since the average

Table 7. Frequency Distribution of Total Lengths of Fish Of Various Species. Mostly Random Samples (See Text).

Total length, mm.	Stickleback	Bullhead (young)	Iowa darter	Mud minnow	Madtom	Black-nosed shiner	Northern dace	Black-chinned shiner	Blunt-nosed minnow	Pumpkinseed (young)	Perch (young)	Golden shiner	Largemouth bass (young)	Pumpkinseed (adult)	Common shiner
15 - 19	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20 - 24	4	..	..	..	3	1	..	..	1	..	..	..	..	..	..
25 - 29	11	12	1	8	12	1	..	..	4	..	..	..	..	..	..
30 - 34	23	22	1	8	25	1	..	..	..	..	..	2	..	..	..
35 - 39	22	15	7	25	16	1	..	1	..	..	..	1	..	..	..
40 - 44	21	46	7	25	6	2	..	1	..	..	..	4	..	..	..
45 - 49	49	28	4	11	..	16	..	17	39	4	..	9	..	..	..
50 - 54	16	26	7	6	7	59	3	72	27	30	..	15	..	..	..
55 - 59	3	7	5	22	15	49	2	28	22	54	..	16	..	..	..
60 - 64	..	1	1	17	19	17	..	29	16	40	29	4	3	..	..
65 - 69	..	..	..	13	15	3	..	2	30	19	77	2	3	9	..
70 - 74	..	..	..	7	15	..	..	..	9	2	39	6	7	18	..
75 - 79	..	..	..	2	14	..	..	..	2	1	5	19	7	39	..
80 - 84	..	..	..	2	2	..	..	..	..	..	..	25	4	48	..
85 - 89	..	..	..	1	1	..	..	..	..	..	..	23	3	29	1
90 - 94	..	..	..	3	..	..	..	..	..	..	..	9	1	34	..
95 - 99	..	..	..	..	..	..	..	..	..	..	..	11	..	24	..
100 - 104	..	..	..	..	..	..	..	..	..	..	..	2	1	15	..
105 - 109	..	..	..	..	..	..	..	..	..	..	..	1	..	7	..
110 - 114	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..
115 - 119	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..
120 - 124	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
125 - 129	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
130 - 134	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
135 - 139	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
140 - 144	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5
No. in sample	150	157	33	150	150	150	5	150	150	150	150	150	29	225	19
Average length*	40.9	42.3	45.8	50.9	52.3	53.8	54.0	54.3	56.2	58.7	67.7	73.6	76.3	85.9	129.9

*See footnote, Table 4.

size at any one age may vary with the sex. The stickleback population appears to have been composed of at least two age groups, and the blunt-nosed minnows, golden shiners, madtoms, and mud minnows of three or more age groups each. Lacking actual age determinations, more definite deductions cannot be made.

A comparison of the lengths of the young of the perch, pumpkinseeds, and bullheads is shown in the histograms of Figure 6. Although the perch and the pumpkinseeds give diagrams approaching a normal curve, with one distinct mode, the bullheads show two apparent modes or size groups. This situation may plausibly be explained by the fact that the spawning season of the bullhead is prolonged and the two size groups probably represent two distinct broods.

Blunt-nosed Minnow

The length-frequency distribution of the blunt-nosed minnow (random sample of 150 specimens) is shown in Figure 7, which also gives by way of comparison diagrams for populations from three other localities.

The first of these is from Black Slough, Illinois (near Urbana), and is that described by Van Cleave and Markus.* It contained 369 specimens taken in one seine haul on April 27, 1928.

Another is a seine collection made by the Institute for Fisheries Research from Wintergreen Lake,** Kalamazoo County, Michigan. It was taken on May 5, 1935, and had 201 specimens.

The third collection came from Coleman Creek***, Bedford County, Tennessee.

---

* Van Cleave, H. J., and Henry C. Markus. Studies on the life history of the blunt-nosed minnow. American Naturalist, Vol. LXIII, pp. 530-539. 1929.

** I.F.R. Report No. 289. The fish fauna of Wintergreen Lake, etc., by Gerald P. Cooper. The collection of blunt-nosed minnows is now in the U. Mich. Museum of Zool., Catalog No. 108489.

*** Catalog No. 121030, U. Mich. Mus. Zool.

It was collected by seine, April 3, 1937, by L. F. Miller of the Tennessee Valley Authority and contained 146 specimens.

Measurements of the specimens of the two last-named collections were made by the writer on the preserved material in the University of Michigan Museum of Zoology.

The similarity of the four curves of Figure 7, especially in showing two modes each (exclusive of young specimens), is striking. As Van Cleave and Markus pointed out, this bimodal nature of the graph is largely due to a bisexual differentiation in rate of growth. In this species, as in certain other species of minnows, the male becomes larger and apparently lives longer than the female, which is quite the reverse of the situation in most teleost fishes. Thus these authors showed that the second mode in the curve for the Black Slough specimens represented almost entirely males (two and three years old), and the first mode represented mostly females (two years old). In that population only three-year males had breeding tubercles.

The fish of the other three collections were not aged; nor were they sexed, except that in the collections from Coleman Creek and Wintergreen Lake the males with tubercles were distinguished from the other fish (females and non-breeding males). However, in view of the similarity of the curves, it seems plausible that a situation existed in these populations similar to the one in the fish from Black Slough. Also it is significant that in the Wintergreen Lake collection all of the specimens over 68 mm. were males with nuptial tubercles, while no fish less than 63 mm. had tubercles. Likewise, in the collection from Coleman Creek all of the fish over 73 mm. had tubercles and no fish under 67 mm. did. Thus the second mode in the curve for each of these populations represents almost entirely breeding males. The Linnbeck Lake fish were taken late in the summer,

when the tubercles were scarcely in evidence, so no separation was made.

If it is granted that the similarity in the curves for the four populations is caused by a similarity of respective sex and age groups, then a comparison of the curves yields some information on the relative growth rates of the populations. The Coleman Creek fish showed a better growth rate (i.e., modes farther to the right in the figure) than the fish from Wintergreen Lake and Black Slough. This difference in growth probably is correlated with the difference in mean annual water temperature of the respective bodies of water. The fish of Linnbeck Lake showed an even slower growth rate.

Summary

1. Linnbeck Lake, a small lake in the Upper Peninsula, was poisoned as a part of the program of experimental management of certain Michigan lakes.

2. The yield, 28 pounds of fish per acre, was low in comparison with the average of the other Michigan lakes so far studied.

3. Seventeen species of fish were found, of which 5 were game fish, 1 coarse fish, and 11 forage fish.

4. The number of legal-sized game fish, or bullheads of desirable size, present was too low to make for very good fishing. The pumpkinseeds, although present in large numbers, were all of small size, as were most of the perch.

5. The perch, however, were not particularly stunted, but showed a growth rate only slightly below the average for other inland lakes of the state. The scarcity of large perch was thus mainly a scarcity of older perch.

6. Apparently older pumpkinseeds also were largely absent and of largemouth bass only young-of-the-year specimens were found.

7. Other "incomplete" populations were very much in evidence, especially those of rock bass, northern pike, common shiner, northern dace, and Iowa darter. The two minnows named probably represented escaped bait; the rock bass, pike, and darters perhaps were irregular immigrants from the connecting stream.

8. For most of the species in the lake histogram portrayals of length frequencies are only partially satisfactory in analyzing age and growth, and cannot be relied upon with nearly the confidence that is granted to actual age determinations. The histograms do, however, enable certain comparisons to be drawn, as for instance that between the apparent broods of young-of-the-year perch, pumpkinseeds, and bullheads.

9. The scales of the game species were extraordinarily difficult to read, and hence actual age determinations are presented here only for the perch, and no great accuracy is claimed for these.

10. The blunt-nosed minnow showed very good apparent correspondence, in the shape of the growth curve, with populations of this fish from three other selected localities.

INSTITUTE FOR FISHERIES RESEARCH

By John Greenbank

Report approved by: A. S. Hazzard

Report typed by: V. M. Andres