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POPULATION ANALYSIS OF EAST TWIN LAKE

by

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East Twin Lake lies in the extreme southwest corner of Montmorency County (T. 29 N., R. 1 E., Secs. 27, 28, 33, and 34), at the town of Lewiston. It was mapped and sounded in the winter of 1935-36 by a crew from the CCC Camp Au Sable. The physical and chemical characteristics are tabulated and discussed in a former report (Institute Report No. 589). The lake has sufficient area to allow for considerable wind sweep, causing a certain amount of wave action. The bottom for the most part is soft (pulpy peat), but sand and gravel are found close to shore, usually to a depth of 3 or 4 feet. The greater part of the lake's area is shoal. Inlets and outlets are lacking. The water is usually quite clear and colorless (Secchi disk, 14' 6"). The shores are bold and wooded, except for the northeast side of the lake which is cleared pasture. The water is alkaline, and probably has sufficient dissolved oxygen from top to bottom the year around. Common bottom food organisms such as blood worms, mayfly nymphs, etc. are not abundant. Plankton (microscopic plants and animals, such as water bloom and water fleas) is also negligible. However, other food (forage fish, crayfish) is present in good quantity.

East Twin Lake was selected for this investigation for several reasons. Its fishing reputation was poor, and it presumably had a large population of suckers. This last was of prime importance as a starting point for a detailed study of the common sucker in Michigan waters. At the request of local sportsmen, suckers had been removed during the winter of 1936-37. This work was done by commercial fishermen and the suckers' sale was permitted in payment for the work. A total of 2,041 suckers was removed, having an approximate weight of 4,338 pounds, or something over 2 pounds apiece. These weights are only approximate, for they were not actually weighed, but their weight was estimated by the commercial fishermen. However, it is probably safe to assume that the fish averaged close to 2 pounds. Fishermen around the lake claim that fishing was improved by the removal of suckers, but that the fishing fell off as the population became re-established. It was hoped that the investigation would throw some light on this problem. In recent years the significance of populations in fisheries management has become increasingly important, and it was decided that population estimates would be made for the lake. Total, specific and relative populations would be determined. Age determinations would be made for all game species, and the growth of the sucker would be carefully studied. Methods used in making population estimates were adapted from those methods used by other workers, chiefly Dr. David Thompson of Illinois. Stomach analyses of game species would be made in the hope of determining the importance of suckers, either as fry or sub-adults in the game species' diet. Sucker feeding habits were to be investigated also to determine whether or not they consume spawn of game fish, and to what extent they compete with game fish for food. Through tagging it was hoped that some information on the migrations of the mature fish about the lake might be discovered. Plantings of legal and sub-legal small-mouth bass were to be made. These would be tagged and measured and thus some data

on their movements, growth, and acclimatization might be gathered.

Work was started on June 21. A commercial fisherman, Mr. Ralph Curl of Black River, Michigan, was employed on contract and his gear was used throughout the investigation. Ten trap nets (called "small subs") were operated from a large rowboat (15½ feet). The nets were constructed with a double pot, a single 600 foot lead, and two 20-foot wings or hearts. The pots measured 4 feet deep, by 4 feet wide by about 10 feet long. The mesh in the lead was 4 inches stretched and that in the pots about 2½ inches stretched. The nets were easily operated and took adult game fish and suckers quite readily. A total of 7,242 fish was taken in 8 weeks, or an average of 905 fish per week, or 125 fish per day. This catch, compared with experimental gill net fishing in our inland lakes, seems good. Nets could be left in one place for about two weeks at a time and then had to be moved because of the algae and debris which had collected on the twine. This debris is destructive to the twine and impairs the efficiency of the nets. The back of the pot could be lifted to the side of the boat, some of the fish removed through a lace hole, and the rest allowed to remain in the water at the side of the boat. The accompanying photographs (Figs. 1 and 2) give a fair idea of this operation.

Procedure in population determinations was as follows. Nets were lifted every day. About a dozen fish were transferred to a wash tub in the bottom of the boat. These fish were marked by the amputation of a pectoral fin, and were then released on the far side of the boat from the net. Counts were kept of all fish taken, and of marked fish recaught. The percentage of recoveries was carefully recorded, and when the percentage was found to be consistent (that is when it was found to remain relatively constant from day to day), no more fish were marked. Marking was discontinued after July 25 except for a few fish which were tagged. More briefly, the

the percentage of recoveries had grown consistent at the end of 5 weeks. It should be noted here that the percentage of recoveries was approximately the same regardless of size of catch or position of nets. About 5 to 7 nets were operated at one time, and 18 different stations were established. The lake was thoroughly netted except for one corner, the northwest, near camp. Throughout, this part of the lake is too shallow to permit the proper use of the nets.

It was soon noticed that some fish were retaken more readily than others. For instance, bullheads and sunfish were recaught as soon as a very few had been marked. However, recoveries soon began to show in nets near which no fish had yet been released, and we felt that all errors inherent in the work tended to balance one another. Populations were estimated by the use of the formula $P = \frac{\Sigma AB}{\Sigma C}$ in which P is the estimated population on any particular date, A is the number of fish caught on that certain date, and B is the total number of marked fish already in the lake on the same date. AB is the product of A times B, and ΣAB is the sum of the products calculated up to that date, C is the number of returns (i.e. marked fish recaptured) on a certain date, and ΣC is the sum of all returns on that date. In other words ΣAB and ΣC increase from day to day and the other numbers are of course quite variable. The Greek letter sigma (Σ) is a statistical symbol used to denote a summation or the sum of the totals. It does not enter algebraically into the calculations. Population estimates are tabulated in Tables I to VIII inclusive. The relative population based on the estimates derived from the use of the formula is given in Table IX. It will be noted that there is some disparity between the estimated total population and the figure obtained through the addition of the estimated specific populations. However, since the use of one figure gives 11.5 adult fish to the acre, and the other gives 12.8 fish to the acre, the discrepancy

does not seem very significant. We think that these estimates give an accurate picture of the lake's adult fish population, with the exception of perch, which are unquestionably rather abundant. Unfortunately, legal sized perch could swim through the nets, so the perch population, which because of the small average size of the fish is not an important population to the fishermen, must be disregarded in the estimate this year. The study has shown quite clearly that the wall-eye is the dominant fish in the lake at present. The sucker, though certainly an important part of the population, is not the most abundant fish in the lake at this time. We would like to point out that the average size of the suckers is at present smaller than formerly. Mr. Curl, who was one of the commercial fishermen engaged in the removal of suckers in the winter of 1936-37, noticed immediately that the suckers we took during the summer of 1939 ran smaller than those they had taken before. Those we caught this summer (1939) had an average weight of something over a pound (19 oz.); those taken in the winter of 1936-37 had an average weight of probably very close to two pounds. From this, it seems likely that the 2,041 suckers having an approximate weight of 4,338 pounds, removed from East Twin Lake in 1936-37, constituted a large part of the adult population present at that time. This assumption is borne out by the fact that the weekly catch for that period (1936-37) shows a steady decline. If the above conclusion is correct, it means that a great part of the suckers taken this summer (1939) have grown to a weight of a little over a pound since the spring of 1937. In other words, most of the commercially legal crop was harvested in the winter of 1936-37, and the adult sucker population was drastically reduced by the operation of the fishermen that winter. Examination of the scales taken from suckers in East Twin Lake this past summer should serve as a check on whether or not the above assumption is correct.

The relative populations in per cent (Table IX) were calculated from the specific populations estimated from the formula. Although the estimated specific populations may differ to some extent from the actual populations, the relative populations are probably essentially correct, because the errors in the estimates are probably uniform.

Along with the population studies made on the lake, some data for the determination of age and growth were taken. Besides the counting of the fish each day, some were measured, usually those from one net, and in this way average lengths of all game species and suckers were obtained. Also a good representative sample of all species was weighed before being released. A series of scale samples was taken from all species, though the samples from perch and rock bass are admittedly inadequate. This gap will be filled during the coming summer (1940). The scales were used to determine age, and this added to the other data should help furnish a tentative picture of the general growth conditions in the lake. Results of these scale exminations are tabulated and compared with the growth rate determined for the same species during surveys of Black Lake (Cheboygan and Presque Isle counties) and Long Lake (Alpena and Presque Isle counties) made during the summer of 1939 (Table X).

It can be seen from an examination of the above table that the game species from East Twin Lake for which we have adequate scale samples show at least an average growth when compared with the same species from two other lakes in the same general region. The wall-eye reaches legal size sometime in the third summer of life, pumpkinseed sunfish sometime in the fourth summer, small-mouth in the third summer, rock bass in the third or fourth summer, and perch in the third. So far as we now know, this is about average. The fish from Black Lake show, on the whole, a little better growth, and those from Long Lake grow a little more slowly. As pointed out before, the samples of rock bass and perch are inadequate at present.

A total of 437 fish was tagged, and 125 more fin-clipped (clipped differently from those used in the population study). There were then 562 specifically marked fish in the lake. Of these, 200 were fish either native to the water or well established from former plantings. The rest (362) were legal and sub-legal small-mouthed black bass introduced from Lake Huron in three different plantings on August 28, 29, and September 1. The plantings were made after the nets had been removed from the lake. The tagging of the native fish was done shortly before the nets were removed during the first two weeks of August. Up to the present there have been 20 recoveries of marked fish, exclusive of 8 tagged fish which were picked up dead.

Of the 20 recoveries to date, 9 were native fish; 8 were recovered in our nets before they were removed from the lake, and one was turned in by a fisherman.

Eleven recoveries of the introduced small-mouth have been turned in by fishermen up to the present.

The record of the recoveries has been kept on a map (map not included in this report because the number of recoveries does not yet seem sufficient to warrant any clear cut conclusions as to dispersal, etc.). From these recoveries it seems clear that the introduced small-mouth have spread out considerably from their point of release. Turning to the native fish recoveries, it is evident that many of the fish are concentrated near the island, the favorite fishing ground of the sport fishermen on the lake.

Eight of the tagged fish were picked up dead. Of these, 7 were native fish and 1 an introduced small-mouth. This is here attributed to the fact that the tagging of the native fish was done at the height of the summer when the water was very warm (80°F.). A considerable mortality is probably inevitable when fish are handled under such conditions. It seems likely

that these conditions (very warm water and hot weather) rather than the tag or the clipped fin caused the deaths, which though few are to be avoided if possible.

Concerning the mortality of the fish caused through the handling or some more natural cause, something might be added here in the way of supplementary data. An attempt was made to examine a portion of the shore each day, and to bury any dead fish found. In this manner the whole shore was examined several times. Also records of the fish killed by being gilled in the nets were kept. A total of 174 unmarked fish was found dead. One hundred and sixty marked fish were picked up dead. The decomposition of a few (probably 30-40) had progressed too far to enable one to tell whether or not they had been marked. The latter are not included in the population estimates. The figure of 160 does not include the 8 tagged fish which were found dead since these are treated separately in the preceding paragraph. However, these figures indicate that the mortality of the marked fish was not significantly greater than that of the unmarked fish. Unquestionably, the handling of game species in warm water, at the height of the summer, led to some deaths but the number was not as great as might have been anticipated.

An attempt was made to find some correlation between weather conditions and fish catch by the nets. Little was learned. One thing which seems fairly clear upon examination of our field records is that more fish were taken on rough, cool days than on calm, quiet ones. This, however, would be difficult to prove for nets were constantly being changed, and while some would be dirty and inefficient, others clean and freshly set would be making good catches. Our records show that the best catches were made on rough, cool days, especially when there was also a high wind. We assume that the cooler water and the high wind caused more movement, and hence more fish were taken.

We plan to continue work on the lake during the summer of 1940, and brief plans for this continuation are given here. It is possible that the population counts will be repeated in order to check the results of last summer and the methods used. Also, we hope if possible to determine whether or not any great change has taken place in the population. Additional stomachs will be obtained in order that more complete food studies can be made. An attempt was made this past winter (1940) to get some stomachs, but only 5 wall-eye stomachs were obtained through three weeks' continuous "ice-fishing." Scale sampling will be continued. By omitting plantings this spring we hope to be able to determine definitely if the wall-eye spawns in the lake. In a former report (Institute Report 589) management recommendations are made. Besides this work, we plan to conduct a creel census in order that a complete record of the actual fishing results may be obtained. The work at East Twin will be correlated with some work that has been done this past winter (1939-40). Two commercial fishermen were permitted to remove suckers from two inland lakes of the state, Black Lake in Cheboygan and Presque Isle counties, and Carp Lake in Emmet County. The fishermen were permitted to sell the coarse fish taken. We hope that we shall be able to learn something of the effect of this reduction of the sucker population. A creel census is to be conducted on Black Lake if a CCC project is approved. During the summer of 1940 we shall start work on another lake where we hope to get a complete picture from the beginning of operations. This is Big Bear Lake, 8 miles from Lewiston. Local fishermen have asked that suckers be removed and this may be done if conditions warrant, but it will be absolutely necessary to get as complete a creel census and fish population estimate as possible prior to the removal of any suckers.

Many questions concerning the relation of suckers to game fish have arisen. Do they compete for food? Is the sucker a spawn eater? Do they furnish a significant portion of the game species diet? Will they crowd out game fish unless their numbers are periodically decreased? We hope through a careful study of the lakes mentioned to throw some light on these problems.

INSTITUTE FOR FISHERIES RESEARCH

TABLE I

Estimated total adult game fish and sucker population, exclusive of perch, East Twin Lake, Montmorency County, Michigan. Estimates based on use of formula $P = \frac{\Sigma AB}{\Sigma C}$*

Date	No. of fish taken A	No. clipped already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	43	...	...	...	...	...	...
22	268	43	11,524	11,524	...	...	...
23	323	311	100,453	111,977	4	4	29,943
24	102	630	64,260	176,237	2	6	29,373
25	1	730	730	176,967	1	7	25,281
26	98	730	71,540	248,507	6	13	19,116
27	70	822	57,540	306,047	5	18	17,003
28	87	887	77,169	383,216	2	20	19,161
29	136	972	132,192	515,408	6	26	19,823
30	140	1,102	154,280	669,688	13	39	17,171
July 1	202	1,229	248,258	917,946	37	76	12,078
2	38	1,394	52,972	970,918	10	86	11,290
3	105	1,422	149,310	1,120,228	6	92	12,176
4	54	1,521	82,134	1,202,362	8	100	12,024
5	36	1,567	56,412	1,258,774	5	105	11,988
6	27	1,598	43,146	1,301,920	6	111	11,729
7	79	1,619	127,901	1,429,821	9	120	11,915
8	262	1,689	442,518	1,872,339	49	169	11,079
9	297	1,902	564,894	2,437,233	66	235	10,371
10	220	2,133	469,260	2,906,493	50	285	10,198
11	97	2,303	223,391	3,129,884	18	303	10,330
12	171	2,382	407,332	3,537,206	34	337	10,496
13	154	2,519	387,926	3,925,132	31	368	10,666
14	224	2,642	591,808	4,516,940	49	417	10,832
15	0	2,817	0	4,516,940	0	417	10,832
16	556	2,817	1,566,252	6,083,192	107	524	11,609
17	100	3,266	326,600	6,409,792	23	547	11,718
18	183	3,343	611,769	7,021,561	54	601	11,683
19	146	3,472	506,912	6,534,863	44	645	10,132
20	162	3,574	578,988	7,113,851	53	698	10,192
21	133	3,683	489,839	7,603,690	35	733	10,373
22	313	3,781	1,183,453	8,787,143	92	825	10,651
23	0	4,002	0	8,787,143	0	825	10,651
24	280	4,002	1,120,568	9,907,703	103	928	10,676
25	148	4,179	618,492	10,526,195	54	982	10,719
26	116	4,373	507,268	11,033,463	40	1,022	10,796
27	124	4,373	542,252	11,575,715	44	1,066	10,859
28	108	4,373	472,284	12,047,999	35	1,101	10,943
29	214	4,385	938,390	12,986,389	83	1,184	10,968
30	133	4,385	583,205	13,569,594	55	1,239	10,952
31	151	4,385	662,135	14,231,729	54	1,293	11,007
Aug. 1	123	4,385	539,355	14,771,084	46	1,339	11,031
2	81	4,398	356,238	15,127,322	30	1,369	11,050
3	109	4,423	482,107	15,609,429	40	1,409	11,078
4	130	4,442	577,460	16,186,889	52	1,461	11,079
5	119	4,448	529,312	16,716,201	38	1,499	11,152
6	82	4,448	364,736	17,080,937	20	1,519	11,245
7	85	4,448	378,080	17,459,017	39	1,558	11,206

Table I (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 8	35	4,453	155,855	17,614,872	12	1,570	11,220
9	80	4,455	356,400	17,971,272	25	1,595	11,267
10	76	4,465	339,340	18,310,612	33	1,628	11,246
11	75	4,472	335,400	18,646,012	26	1,654	11,273
12	52	4,503	234,156	18,880,168	29	1,683	11,218
13	45	4,517	203,265	19,083,433	5	1,688	11,305
14	30	4,529	135,870	19,219,303	11	1,699	11,312
15	39	4,547	177,333	19,397,136	15	1,714	11,317
						Ave. for Aug.	11,200

* P = estimated population

A = no. of fish caught on any date

B = no. of marked fish already in lake on some date

C = returns on any date

AB = product of A x B

ΣAB = sum of all products to date

ΣC = sum of all returns to date

TABLE II

Estimated adult wall-eyed pike population, East Twin Lake, Montmorency County, Michigan. Estimate based on use of formula $P = \frac{\Sigma AB}{\Sigma C}$

Date	No. of fish taken A	No. marked fish already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	33	...	...	...	...	...	...
22	160	33	5,280	5,280	...	...	...
23	173	193	33,389	38,669	...	...	...
24	39	366	14,274	52,943	...	...	...
25	1	405	405	53,348	1	1	53,348
26	31	405	12,555	65,903	...	1	65,903
27	11	436	4,796	70,699	...	1	70,699
28	16	447	7,152	77,851	...	1	77,851
29	41	463	18,983	96,834	2	3	32,275
30	30	502	20,080	116,914	5	8	14,614
July 1	94	527	49,538	166,452	16	24	6,936
2	11	605	6,655	173,107	1	25	6,924
3	33	615	20,295	193,402	4	29	6,669
4	12	644	7,728	201,130	5	34	5,916
5	16	651	10,416	211,546	5	39	5,424
6	10	662	6,620	218,166	2	41	5,321
7	37	670	24,790	242,956	4	45	5,399
8	153	703	107,559	350,515	25	70	5,007
9	78	831	64,818	415,333	21	91	4,564
10	72	888	63,936	479,269	16	107	4,479
11	31	944	29,264	508,533	5	112	4,540
12	44	970	42,680	551,213	17	129	4,273
13	44	997	43,868	595,081	8	137	4,344
14	86	1,033	88,838	683,919	20	157	4,356
15	0	1,099	0	683,919	...	157	4,356
16	268	1,309	350,812	1,042,731	58	215	4,850
17	27	1,331	35,937	1,078,668	5	220	4,903
18	66	1,379	91,014	1,169,682	18	238	4,915
19	49	1,411	69,139	1,238,821	17	255	4,858
20	69	1,454	100,326	1,339,147	26	281	4,766
21	44	1,482	65,208	1,404,355	16	297	4,728
22	117	1,563	182,871	1,586,526	36	333	4,764
23	0	1,563	0	1,586,526	...	333	4,764
24	64	1,627	104,128	1,690,654	33	366	4,619
25	36	1,663	59,868	1,750,522	15	381	4,594
26	24	1,663	39,912	1,830,346	8	389	4,705
27	35	1,663	58,205	1,888,551	20	409	4,617
28	25	1,672	41,800	1,930,351	14	423	4,563
29	76	1,672	127,072	2,057,423	42	465	4,425
30	41	1,672	68,552	2,125,975	23	488	4,357
31	47	1,672	78,584	2,204,559	22	510	4,323
Aug. 1	21	1,675	35,175	2,239,734	10	520	4,307
2	27	1,683	45,441	2,285,175	16	536	4,263
3	43	1,694	72,842	2,358,017	20	556	4,241
4	76	1,700	129,200	2,487,217	34	590	4,216
5	35	1,700	59,500	2,546,717	15	605	4,209
6	35	1,700	59,500	2,606,217	14	619	4,210
7	34	1,705	57,970	2,664,187	17	636	4,189
8	15	1,705	25,575	2,689,762	9	645	4,170
9	34	1,709	58,106	2,747,868	14	659	4,170

Table II (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 10	47	1,721	80,887	2,828,755	25	684	4,136
11	46	1,741	80,086	2,908,841	19	703	4,138
12	20	1,745	34,900	2,943,741	15	718	4,100
13	6	1,750	10,500	2,954,241	1	719	4,109
14	15	1,760	26,400	2,980,641	5	724	4,117
15	19	1,764	33,516	3,014,157	9	733	4,112
						Ave. for Aug.	4,179

* Formula symbols explained in footnote under Table I.

TABLE III

Estimated adult pumpkinseed sunfish population, East Twin Lake, Montmorency County, Michigan. Estimates based on use of formula $P = \frac{\Sigma AB^*}{\Sigma C}$

Date	No. of fish taken A	No. marked fish already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	6	...	...	...	...	...	...
22	45	6	270	270	...	...	...
23	56	51	2,856	3,126	3	3	...
24	20	104	2,080	5,206	...	3	...
25	1	124	124	5,330	1	4	...
26	28	124	3,472	8,802	2	6	...
27	21	150	3,150	11,952	1	7	...
28	23	170	3,910	15,862	2	9	...
29	26	191	4,966	20,828	1	10	...
30	21	216	4,536	25,364	2	12	...
July 1	35	235	8,225	33,589	5	17	...
2	8	265	2,120	35,709	1	18	...
3	26	272	7,072	42,781	1	19	...
4	14	297	4,158	46,939	2	21	...
5	12	309	3,708	50,647	1	22	...
6	4	320	1,280	51,927	1	23	...
7	7	323	2,261	54,188	...	23	...
8	58	330	19,140	73,328	9	32	...
9	83	379	31,457	104,785	15	47	...
10	37	447	16,539	121,324	13	60	...
11	13	471	6,123	127,447	3	63	...
12	51	481	24,531	159,978	7	70	...
13	42	525	22,050	174,028	9	79	...
14	39	558	21,762	195,790	11	90	...
15	...	586	...	195,790	...	90	...
16	97	586	56,842	252,632	19	109	...
17	32	664	21,248	273,880	9	118	...
18	41	687	28,167	302,047	7	125	...
19	37	721	26,677	328,724	10	135	...
20	24	748	17,952	346,676	8	143	...
21	27	764	20,628	367,304	21	164	...
22	57	785	44,745	412,049	11	175	...
23	1	831	831	412,880	1	176	...
24	84	831	69,804	482,684	28	204	...
25	40	887	35,480	518,164	17	221	...
26	31	910	28,210	546,374	12	233	...
27	23	910	20,930	567,304	7	240	...
28	40	910	36,400	607,704	10	250	...
29	54	912	49,248	652,952	14	264	...
30	38	912	34,656	687,608	13	277	...
31	30	912	27,360	714,968	9	286	...
Aug. 1	39	912	35,568	750,536	13	299	2,510
2	16	917	14,672	765,208	4	303	2,525
3	34	925	31,450	796,658	9	312	2,553
4	20	930	18,600	815,258	7	319	2,556
5	36	930	33,480	848,738	10	329	2,580
6	26	930	24,180	872,918	3	332	2,629
7	16	930	14,880	887,798	6	338	2,627
8	7	932	6,524	894,322	1	339	2,638
9	23	933	21,459	915,781	7	346	2,647

Table III (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 10	13	935	12,155	927,936	3	349	2,659
11	16	939	15,024	942,960	2	351	2,686
12	17	946	16,082	959,042	7	357	2,686
13	10	951	9,510	968,552	1	358	2,705
14	7	956	6,692	975,244	2	360	2,709
15	8	962	7,696	982,940	3	363	2,709
						Ave. for Aug.	2,628

* Symbols in formula explained in footnote after Table I.

TABLE IV

Estimated adult sucker population, East Twin Lake, Montmorency County, Michigan. Estimate based on the use of the formula $P = \frac{\Sigma AB^*}{\Sigma C}$

Date	No. of fish taken A	No. marked fish already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	1	...	...	...	...	...	...
22	17	1	17	17	...	...	...
23	59	18	1,062	1,079	...	...	...
24	5	77	385	1,464	...	...	...
25	...	82	...	1,464	...	...	...
26	12	94	1,128	2,592	...	...	...
27	12	104	1,248	3,840	2	2	1,920
28	7	111	777	4,617	...	2	2,309
29	12	123	1,476	6,093	...	2	3,047
30	6	129	774	6,867	...	2	...
July 1	12	140	1,680	8,547	1	3	...
2	4	143	572	9,119	1	4	...
3	8	151	1,208	10,327	...	4	...
4	21	172	3,612	13,939	...	4	...
5	1	173	173	14,112	...	4	...
6	1	174	174	14,286	...	4	...
7	23	196	4,508	18,794	1	5	...
8	1	197	197	18,991	1	6	...
9	56	203	11,368	30,359	6	12	...
10	77	253	19,481	49,840	16	28	...
11	40	314	12,560	62,400	6	34	1,835
12	40	348	13,920	76,320	3	37	...
13	22	385	8,470	84,790	3	40	...
14	68	404	27,472	112,262	10	50	...
15	...	462	...	112,262	...	50	...
16	128	462	59,136	171,398	21	71	2,414
17	17	569	9,673	181,071	5	76	...
18	33	581	19,173	200,244	13	89	...
19	15	601	9,015	209,259	4	93	...
20	39	612	23,868	233,127	11	104	2,242
21	30	640	19,200	252,327	5	109	...
22	94	665	62,510	314,837	26	135	...
23	...	733	...	314,837	...	135	...
24	68	733	49,844	364,681	28	163	...
25	34	773	24,922	389,603	8	171	...
26	17	799	13,583	403,186	4	175	...
27	40	799	31,960	435,146	8	183	...
28	11	799	8,789	443,935	3	186	2,387
29	23	799	18,377	462,312	10	196	2,359
30	27	799	21,573	483,885	9	205	2,360
31	38	799	30,362	514,247	13	218	2,359
Aug. 1	22	799	17,578	531,825	6	224	2,374
2	24	801	19,224	551,049	6	230	2,396
3	13	803	10,439	561,488	3	233	2,410
4	20	803	16,060	577,548	6	239	2,417
5	18	803	14,454	592,002	4	243	2,436
6	14	803	11,242	603,244	2	245	2,462
7	14	803	11,242	614,486	5	250	2,458
8	4	803	3,212	617,698	...	250	2,471
9	10	803	8,030	625,728	2	252	2,483

Table IV (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 10	5	804	4,020	629,748	1	253	2,489
11	4	804	3,216	632,964	3	256	2,473
12	5	805	4,025	636,989	2	258	2,469
13	1	805	805	637,794	...	258	2,472
14	3	805	2,415	640,209	2	260	2,462
15	1	805	805	641,014	...	260	2,465
						Ave. for Aug.	2,449

* Symbols of formula explained in footnote after Table I.

TABLE V

Estimated Adult small-mouthed bass population, East Twin Lake, Montmorency County, Michigan. Estimates based on use of formula $P = \frac{\Sigma AB^*}{\Sigma C}$

Date	No. of fish taken A	No. marked fish already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	2	0	0	0	...	...	...
22	33	2	66	66	...	...	...
23	18	35	630	696	...	...	...
24	20	53	1,060	1,756	...	...	...
25	0	73	0	1,756	...	...	...
26	8	81	648	2,404	...	...	...
27	16	97	1,552	3,956	2	2	1,978
28	22	119	2,618	6,574	...	2	...
29	26	145	3,770	10,344	...	2	...
30	40	185	7,400	17,744	3	5	3,549
July 1	29	214	6,206	23,950	4	9	...
2	4	218	872	24,822	2	11	...
3	30	248	7,440	32,262	...	11	...
4	8	256	2,048	34,310	1	12	...
5	3	259	777	35,087	1	13	2,699
6	5	264	1,320	36,407	1	14	...
7	5	269	1,345	37,752	...	14	...
8	42	311	13,062	50,814	9	23	...
9	56	367	20,552	71,366	10	33	...
10	28	395	11,060	82,426	8	41	...
11	11	406	4,466	86,892	3	44	...
12	31	437	13,547	100,439	5	49	2,050
13	34	471	16,014	116,453	10	59	...
14	22	493	10,846	127,299	6	65	...
15	...	493	...	127,299	...	65	...
16	33	526	17,358	144,657	6	71	...
17	13	539	7,007	151,664	1	72	...
18	24	563	13,512	165,176	9	81	...
19	19	582	11,058	176,234	7	88	...
20	15	597	8,955	185,189	3	91	...
21	9	606	5,454	190,643	3	94	...
22	25	631	15,775	206,418	10	104	1,985
23	...	631	...	206,418	...	104	1,985
24	34	665	22,610	229,028	9	113	2,027
25	18	683	12,294	241,322	8	121	1,994
26	29	683	19,807	261,129	11	132	1,978
27	14	683	9,562	270,691	8	140	1,934
28	24	684	16,416	287,107	6	146	1,966
29	54	684	36,936	324,043	15	161	2,013
30	9	684	6,156	330,199	5	166	1,989
31	25	684	17,100	347,299	9	175	1,985
Aug. 1	21	685	14,385	361,684	8	183	1,976
2	3	685	2,055	363,739	1	184	1,977
3	10	685	6,850	370,589	3	187	1,982
4	11	685	7,535	378,124	4	191	1,980
5	18	685	12,330	390,454	7	198	1,972
6	3	685	2,055	392,509	...	198	1,982
7	11	687	7,557	400,066	5	203	1,971
8	5	688	3,440	403,506	1	204	1,979
9	2	688	2,064	405,570	2	206	1,969

Table V (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 10	5	689	3,445	409,015	...	206	1,986
11	3	692	2,076	411,091	...	206	1,995
12	4	692	2,768	413,859	2	208	1,990
13	...	692	...	413,859	...	208	1,990
14	2	693	1,386	415,245	1	209	1,987
15	3	693	2,079	417,324	...	209	1,997
						Ave. for Aug.	1,982

* Symbols in formula explained in footnote after Table I.

TABLE VI

Estimated adult rock bass population, East Twin Lake, Montmorency County, Michigan. Estimates based on use of formula $P = \frac{\Sigma AB^*}{\Sigma C}$

Date	No. of fish taken A	No. clipped already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	1	...	...	...	...	...	...
22	12	1	12	12	...	...	...
23	16	13	208	220	1	1	...
24	16	29	841	1,061	2	3	...
25	...	45	...	1,061	...	3	...
26	14	45	630	1,691	...	3	...
27	9	59	531	2,222	...	3	...
28	16	68	1,088	3,310	...	3	...
29	35	84	2,940	6,250	4	7	...
30	43	119	5,117	11,367	3	10	...
July 1	31	162	5,022	16,389	11	21	...
2	11	193	2,123	18,512	5	26	...
3	8	204	1,632	20,144	1	27	...
4	4	212	848	20,992	2	29	...
5	2	216	432	21,424	...	29	...
6	5	218	1,090	22,514	2	31	...
7	6	223	1,338	23,852	3	34	...
8	6	229	1,374	25,226	3	37	...
9	16	235	3,760	28,986	7	44	...
10	9	251	2,259	31,245	2	46	...
11	3	260	780	32,025	1	47	...
12	4	263	1,052	33,077	2	49	...
13	8	267	2,136	35,213	1	50	...
14	6	275	1,650	36,863	2	52	...
15	...	281	...	36,863	...	52	...
16	28	281	7,868	44,731	3	55	...
17	9	309	2,781	47,512	2	57	...
18	16	318	5,088	52,600	5	62	...
19	20	334	6,680	59,280	5	67	...
20	14	354	4,956	64,236	4	71	...
21	17	368	6,256	70,492	4	75	...
22	18	385	6,930	77,422	8	83	...
23	...	403	...	77,422	...	83	933
24	30	403	12,090	79,512	7	90	...
25	13	433	5,629	91,602	3	93	...
26	12	446	5,352	97,231	4	97	1,002
27	11	446	4,906	102,137	1	98	1,042
28	6	446	2,676	104,813	2	100	...
29	6	447	2,682	107,495	2	102	...
30	12	447	5,364	112,859	3	105	...
31	9	447	4,023	116,882	1	106	1,103
Aug. 1	13	447	5,811	122,693	6	112	1,095
2	8	451	3,608	126,301	1	113	1,118
3	8	455	3,640	129,941	5	118	1,101
4	2	456	912	130,853	1	119	1,100
5	5	456	2,280	133,133	1	120	1,109
6	2	456	912	134,045	...	120	1,117
7	9	456	4,104	138,149	5	125	1,105
8	2	457	914	139,063	1	126	1,104
9	10	457	4,570	143,633	...	126	1,140

Table VI (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 10	5	461	2,305	145,938	3	129	1,131
11	4	461	1,844	147,782	1	130	1,137
12	2	461	922	148,704	1	131	1,135
13	4	462	1,848	150,552	2	133	1,132
14	1	462	462	151,014	...	133	1,135
15	4	465	1,860	152,874	2	135	1,132
						Ave. for Aug.	1,119

* Symbols of formula explained in footnote under Table I

TABLE VII

Estimated adult large-mouthed bass population, East Twin Lake, Montmorency County, Michigan. Estimate based on use of formula $P = \frac{\Sigma AB}{\Sigma C}$ *

Date	No. of fish taken A	No. clipped already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	...	...	...	...	...	...	...
22	1	...	...	...	...	...	...
23	1	1	1	1	...	...	...
24	1	2	2	3	...	...	...
25	...	3	...	3	...	...	...
26	...	3	...	3	...	...	...
27	...	3	...	3	...	...	...
28	1	3	3	6	...	...	...
29	2	4	8	14	...	...	...
30	...	6	...	14	...	...	...
July 1	...	6	...	14	...	...	...
2	...	6	...	14	...	...	...
3	...	6	...	14	...	...	...
4	...	6	...	14	...	...	...
5	...	6	...	14	...	...	...
6	2	6	12	26	2	2	...
7	...	8	...	26	...	2	...
8	1	8	8	34	1	3	...
9	...	9	...	34	...	3	...
10	1	9	9	43	...	3	...
11	...	10	...	43	...	3	...
12	1	10	10	53	...	3	...
13	2	11	22	75	...	3	...
14	1	13	13	88	...	3	...
15	...	14	...	88	...	3	...
16	...	14	...	88	...	3	...
17	...	14	...	88	...	3	...
18	1	14	14	102	...	3	...
19	4	15	60	162	...	3	...
20	...	19	...	162	...	3	...
21	4	19	76	238	...	3	...
22	2	23	46	284	1	4	...
23	...	25	...	284	...	4	...
24	2	25	50	334	1	5	...
25	3	27	81	415	1	6	...
26	2	27	54	469	1	7	...
27	...	27	...	469	...	7	...
28	1	27	27	496	...	7	...
29	1	27	27	523	...	7	...
30	5	27	135	658	1	8	...
31	2	27	54	712	...	8	...
Aug. 1	3	27	81	793	...	8	99
2	2	28	56	849	1	9	94
3	...	28	...	849	...	9	94
4	1	28	28	877	...	9	97
5	4	28	112	989	1	10	99
6	1	28	28	1,017	1	11	93
7	...	28	...	1,017	...	11	93
8	2	28	56	1,073	...	11	98
9	1	28	28	1,101	...	11	100

Table VII (Continued)

Date	A	B	AB	ΣAB	C	ΣC	Estimated population
Aug. 10	...	28	...	1,101	...	11	100
11	...	28	...	1,101	...	11	100
12	1	29	29	1,130	...	11	103
13	...	30	...	1,130	...	11	103
14	...	30	...	1,130	...	11	103
15	3	30	90	1,220	...	11	111
						Ave. for Aug.	99

* Symbols of formula explained in footnote following Table I

TABLE VIII

Estimated adult bullhead population, East Twin Lake, Montmorency County, Michigan. Population estimated from formula $P = \frac{\Sigma AB}{\Sigma C}$ *

Date	No. of fish taken A	No. marked fish already in lake B	Product AB	Sum of all products to date ΣAB	Returns C	Sum of all returns ΣC	Estimated population
June 21	...	...	...	...	...	...	...
22	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...
24	1	...	...	...	...	...	...
25	...	1	...	...	...	...	...
26	1	1	1	1	...	...	...
27	1	2	2	3	...	...	...
28	2	3	6	9	...	...	...
29	...	5	...	9	...	...	...
30	...	5	...	9	...	...	...
July 1	1	5	5	14	...	...	...
2	...	6	...	14	...	...	...
3	...	6	...	14	...	...	...
4	...	6	...	14	...	...	...
5	2	6	12	26	...	...	...
6	...	8	...	26	...	...	...
7	1	8	8	34	1	1	...
8	1	9	9	43	1	2	...
9	...	10	...	43	...	2	...
10	1	10	10	53	...	2	...
11	...	11	...	53	...	2	...
12	...	11	...	53	...	2	...
13	1	11	11	64	...	2	...
14	2	12	24	88	...	2	...
15	...	14	...	88	...	2	...
16	2	14	28	116	...	2	...
17	...	16	...	116	...	2	...
18	2	16	32	148	2	4	...
19	2	18	36	184	1	5	...
20	1	20	20	204	1	6	...
21	1	21	21	225	1	7	...
22	...	22	...	225	...	7	...
23	...	22	...	225	...	7	...
24	1	22	22	247	...	7	...
25	3	23	69	316	2	9	...
26	1	26	26	342	...	9	38
27	1	26	26	368	...	9	41
28	...	26	...	368	...	9	41
29	...	26	...	368	...	9	41
30	1	26	26	394	1	10	39
31	...	26	...	394	...	10	39
Aug. 1	...	26	...	394	...	10	39
2	1	26	26	420	1	11	38
3	...	26	...	420	...	11	38
4	...	26	...	420	...	11	38
5	1	26	26	446	...	11	41
6	1	26	26	472	...	11	43
7	...	26	...	472	...	11	43
8	...	26	...	472	...	11	43
9	...	26	...	472	...	11	43

Table VIII (Continued)

Date	A	B	AB	Σ AB	C	Σ C	Estimated population
Aug. 10	1	26	26	498	1	12	42
11	2	26	52	550	1	13	42
12	2	26	52	602	1	14	43
13	3	26	78	680	1	15	45
14	2	26	52	732	1	16	46
15	1	26	26	758	1	17	45
						Ave. for Aug.	42

* Symbols of formula explained in footnote following Table I

TABLE IX

Estimates of the adult game fish and sucker population. Percentages calculated from the population figure derived from the addition of estimated specific populations. Number per acre and pounds per acre determined from estimated specific populations.

Specific population as estimated		Total population as estimated	No. per acre	Pounds per acre	Per cent of total population
		11,200	11.5		
Wall-eye	4,179		4.3	5.6	33.4
Pumpkinseed	2,628		2.7	1.5	21.0
Sucker	2,449		2.5	3.0	19.6
Small-mouth	1,982		2.0	1.5	15.9
Rock bass	1,119		1.1	0.3	9.0
Large-mouth	99		0.1		0.008
Bullhead	42		0.04		0.003
Total	12,498 (12.8 per acre)		12.7	11 lbs., 14 oz.	98.9

TABLE X

Average standard and total lengths in millimeters (total lengths in inches) for age groups represented by game species in three** lakes. Numbers in parentheses represent number of specimens from which averages were computed.*

Species	0 S	0 T	I S	I T	II S	II T	III S	III T	IV S	IV T	V S	V T	VI S	VI T	Lake
Wall-eye	153 - 183		200 - 237		313 - 373		350 - 419		392 - 464		426 - 507				
	7.3		9.3		14.7		16.5		18.3		20.0				E. Twin
	(1)		(1)		(45)		(29)		(17)		(3)				
			202 - 240				392 - 464		415 - 491		440 - 520				
			9.5				18.3		19.4		20.5				Black
			(2)				(1)		(4)		(3)				
					177 - 217		310 - 364		380 - 445		400 - 466				
					8.5		14.4		17.6		18.4				Long
					(2)		(1)		(1)		(1)				
Sunfish			57 - 71		100 - 127		143 - 177		164 - 204		174 - 216				
			3.0		5.0		7.0		8.1		8.5				E. Twin
			(2)		(1)		(15)		(19)		(6)				
															Black
															Long
Small-mouth	68 - 83		87 - 105		215 - 257		245 - 302		267 - 331		345 - 430		335 - 415		
	3.1		4.1		10.1		12.0		13.0		17.0		16.5		E. Twin
	(1)		(1)		(4)		(11)		(3)		(1)		(1)		
					214 - 255		213 - 260								
					10.0		10.3								Black
					(1)		(1)								
					136 - 164		228 - 278		298 - 358		342 - 412		444		
					6.5		11.0		14.1		16.5		17.5		Long
					(2)		(1)		(1)		(1)		(1)		
Rock bass			64 - 79						168 - 208		175				
			3.1						8.3						E. Twin
			(1)						(3)		(1)				
					76 - 96		100 - 125		156 - 193		150 - 187				
					3.8		5.0		7.6		7.4				Black
					(1)		(1)		(1)		(1)				
					72 - 90		92 - 115		125 - 153						
					3.3		4.5		6.1						Long
					(1)		(1)		(1)						
Perch					155 - 183		163 - 194		216 - 252						
					7.3		7.8		10.0						E. Twin
					(2)		(1)		(1)						
					129 - 151		130 - 150		178 - 210						
					6.0		6.0		8.4						Black
					(4)		(1)		(1)						
					116 - 136		146 - 173		230 - 271						
					5.4		7.0		10.8						Long
					(10)		(1)		(1)						

*/ Comparative data furnished by Mr. W. C. Beckman

**/ East Twin Lake, Montmorency County.
Black Lake, Cheboygan and Presque Isle counties
Long Lake, Alpena County.

Fig. 1
Picture showing fish being removed from trap net. Note dip net. The remaining fish are able to stay in water at side of boat.

Fig. 2
Removing fish from trap net. Note how net lies across gunwales of boat.

Fig. 3
Tagging lake fish. Note long nosed pliers, measuring board, and tub for holding fish.