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NATURAL REPRODUCTION, GROWTH, AND POPULATION ANALYSIS OF THE FISHES IN BIG BEAR LAKE, OTSEGO COUNTY, MICHIGAN

by

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An investigation of the importance of the common sucker in Michigan waters was begun on East Twin Lake, Montmorency County, Michigan, in 1939. In 1940 the scene of the investigation was changed to Big Bear Lake in Otsego County. The main reason for this transfer was that an analysis of the fish population of East Twin Lake revealed that the walleye, and not the common sucker, as was supposed, was the dominant species. (Report No. 590). An analysis of the fish population of Big Bear Lake was made in 1940 (Report No. 653) and the sucker was found to be, by far, the dominant species, comprising 52.1 per cent of the estimated population compared to 47.9 per cent composed of 6 other species. The netting was repeated in 1941 and comparable results were obtained. Information relative to the game fish population will be given in this report and some preliminary remarks on the sucker will be made.

The 1941 investigation was begun on April 17. The early phase of the summer's work was largely observational. A gill net was placed in the lake immediately so that the ripening of the suckers could be followed and their time of spawning anticipated. On April 19, one male sucker was found to be nearly ripe. A female captured on the 20th was still green. On April 26, male and female suckers were captured in the

net but were not yet quite ripe. Water temperature had risen during the period from 44° to 47° Fahrenheit. By April 29 the 125-foot gill net was catching 6 to 8 suckers every 24 hours instead of one or none as before. The first suckers were observed in shallow water on the evening of May 1, although no splashing was seen or heard. The first actual spawning behavior was seen on the evening of May 2, 1941. The air at 6 P.M. was 63° and the water 52° Fahrenheit. Suckers continued to spawn through the evening of the 5th, with the peak of the activity on the evenings of the third and fourth. Ten unmarked and one marked sucker were removed on the evening of the 2nd; 311 on the night of the 3rd, and of these 30 were marked; and 275, of which 28 were marked, on the night of the 4th; 5 unmarked suckers on the night of the 5th, and none were removed on the night of the 6th. A total of 602 adult suckers were taken from the lake during the spawning run. Of these, 59, or 9.6 per cent, were marked. If we take the average percentage of recovery for the month of August, 1940, (after marking operations were discontinued) an average per cent of 9.6 is obtained. This is the same as the percentage of marked fish caught by fishermen in the spring of 1941. This is an indication that the marked fish do become evenly distributed throughout the lake, and lends further support to the population estimates. Fifteen different fishermen took part in the removal. These fishermen used light, large-meshed seines. With the fishermen moving up and down the shore rather constantly the fish were disturbed more or less continuously.

Up until the time of the actual spawning, no game fish of any kind had been observed in shallow water, although considerable time had been spent on the lake shore and in deep water at all times of the day. The only species observed before the suckers came in was the blunt-nosed minnow

which was found to be present along the shore in limited numbers. It is of interest to note that no species other than blunt-nosed minnows and suckers were captured while the seining was taking place. The only explanation here offered is that the game species present in the lake were still relatively inactive and occupied an entirely different habitat at this time of the year.

It was observed that the suckers came into shallow water at about dusk and stayed in the shallower water until nearly dawn. The fish were present in groups of 3 to 9 or 10 individuals, each female being accompanied by at least 2 males. The sexes are readily distinguishable because of the high coloration of the spawning males, a black stripe surmounted by a light one being present on the latter. The belly is white and the back black. The female is much duller in color. Spawning occurs in very shallow water and is confined to gravel areas. The spawning groups come up to within a few feet of the beach and the activity occurs in water so shallow that fins and parts of the fish's body may be exposed. While the suckers were inshore, blunt-nosed minnows were very numerous and were apparently feeding on the sucker eggs, as revealed by observation and by a few stomachs containing sucker eggs which were examined in the field. The spawning groups move slowly along shore, and when these groups occasionally stop the spawning act takes place. Hollows in the gravel were formed by the rapid vibration of the fishes' bodies during the spawning act, the movement in some instances being so violent as to displace gravel and bottom materials, exposing at some points the underlying clay and clouding the surrounding water for a few feet. The fish were readily frightened by people walking along the edge of the water, and because of this many of the fish were kept at a distance from shore.

Walking quietly in the water did not disturb them, and through the use of a light and a short handled dip net it was possible to capture specimens readily. Either because of the numbers of fishermen seining over a limited area, or because of predation by the blunt-nosed minnow, or because of poor collecting technique, few eggs and no fry were secured. The following results were obtained from information kindly furnished by W. F. Carbine: Sucker eggs were obtained by stripping individuals from White Lake, Oakland County. The eggs were obtained on May 2, 1937. These eggs were transported to the Drayton Plains Hatchery and there reared artificially. They hatched in 12 days at an average water temperature of 53°F. There were 1,000 eggs to the fluid ounce. The fry hatched from these eggs were very small with a long, slender yolk sac. They were not free swimming.

Sucker spawning occurred along the northeast shore of the lake in the areas marked No. 1 and No. 2 on the map. (Figure 1). No spawning activity could be found, nor were suckers observed in shallow water on other shores, although apparently suitable conditions are present at various localities around the lake. These areas which might have been expected to furnish spawning areas are marked on the map (Figure 1) A, B, C, D, E. The photographs, (Figures 2 and 3) will give an idea of the conditions present where spawning occurred. The gravel (from grapefruit size to marble size) extends lakeward to a depth of about 3 feet, followed by sand to a depth of 12 to 14 feet, and beyond that in the deeper water of the lake the bottom is soft pulpy peat. No activity was observed on the sand west of spawning area No. 1 and very few suckers and no actual spawning were seen on the sand between areas No. 1 and No. 2. No suckers were seen on the shoal south and east

Figure 1

Outline map of Big Bear Lake, Otsego County, Michigan, showing areas where sucker spawning occurred, No. 1 and No. 2 on map, and areas where spawning activity might have been expected but was not found, A, B, C, D, and E, on map.

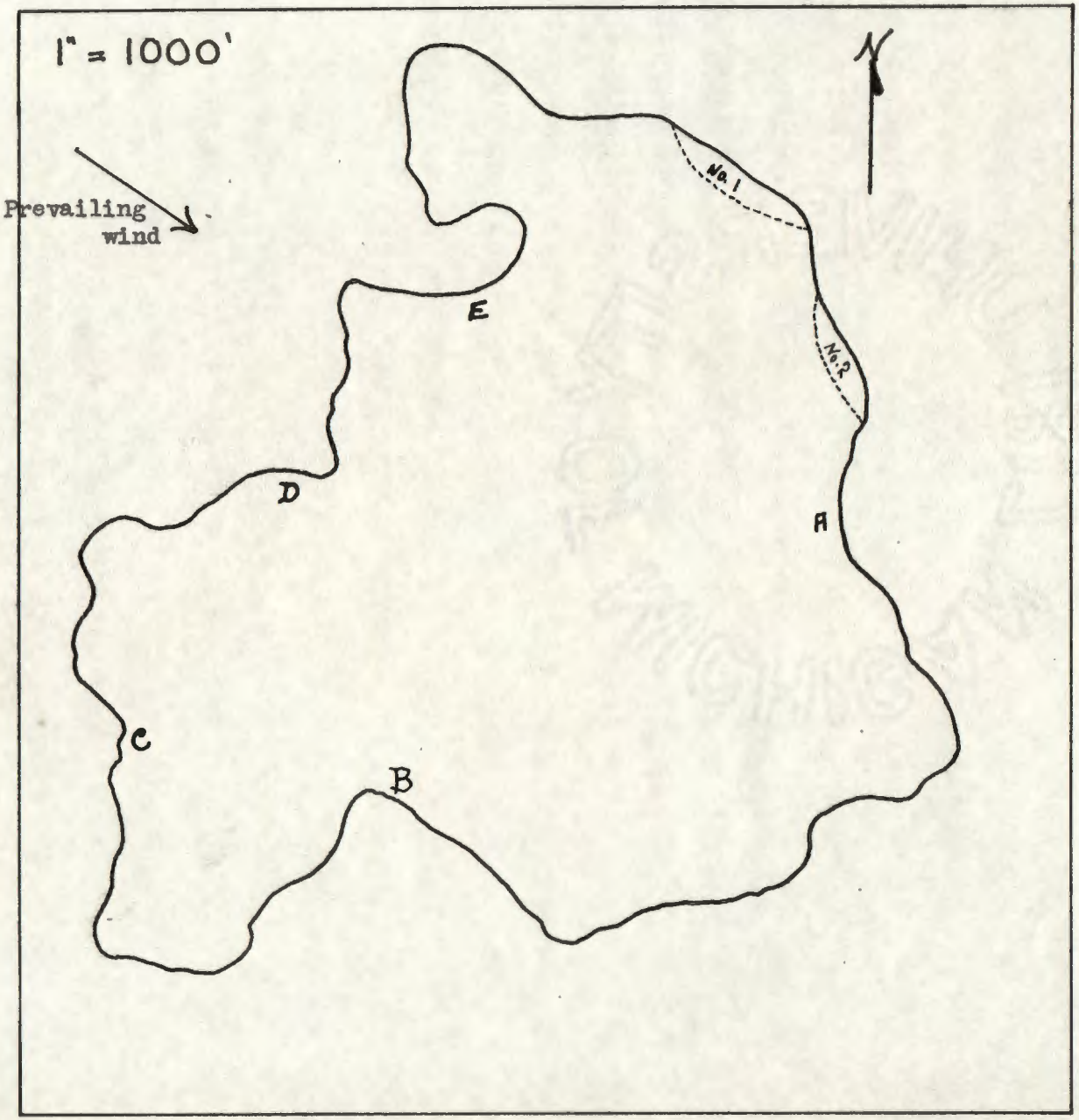

Figure 2

Photograph of sucker spawning area No. 1. Note sandy beach to the northwest. Also note the lines of vegetation showing former high water levels.

Figure 3

Photograph showing type of gravel used for spawning by suckers at Big Bear Lake, Otsego County, Michigan

(A on map) of area No. 2 although there is gravel present.

Two hundred spawning fish measured ranged in size from 330 mm. to 500 mm., the average size being 390 mm. This size range is about the same as that for fish captured later in the nets except that a few immature fish down to 265 mm. were captured in the nets.

Obviously more detailed observations must be made of the suckers' early life history in Big Bear Lake so that more information relative to the yearly production may result.

The second phase of the summer's investigation was learning something of the spawning of the game species in the lake. All game species except perch* were observed spawning, namely the smallmouth bass, the largemouth bass, the bluegill, the rock bass and the pumpkinseed. In all, 66 nests were positively identified (the guarding male identified) out of 83 which were carefully watched. The 66 nests identified consisted of 24 rock bass nests, of 13 belonging to bluegills, 13 to smallmouth, 9 to largemouth, and 7 to pumpkinseeds. Numerous other nests were known to be present but because many of them were in rather deep water and widely separated, only 83 found close to shore and in rather shallow water were watched. Centrarchid species were first observed in shallow water guarding territory on June 1. Bass and sunfish were found spawning actively from June 2 to June 25, and had not finished on that date. However, by June 25, all species but the bluegill were through spawning. Smallmouth spawned first, followed by rock bass, largemouth, pumpkinseeds and bluegills in that order. There was considerable overlap in the time of spawning of the various species, but the peaks of their activity were more or less separated. The order with the week of maximum activity

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* Young-of-the-year perch were found, and this species undoubtedly reproduces naturally. Its actual spawning has not, however, been observed.

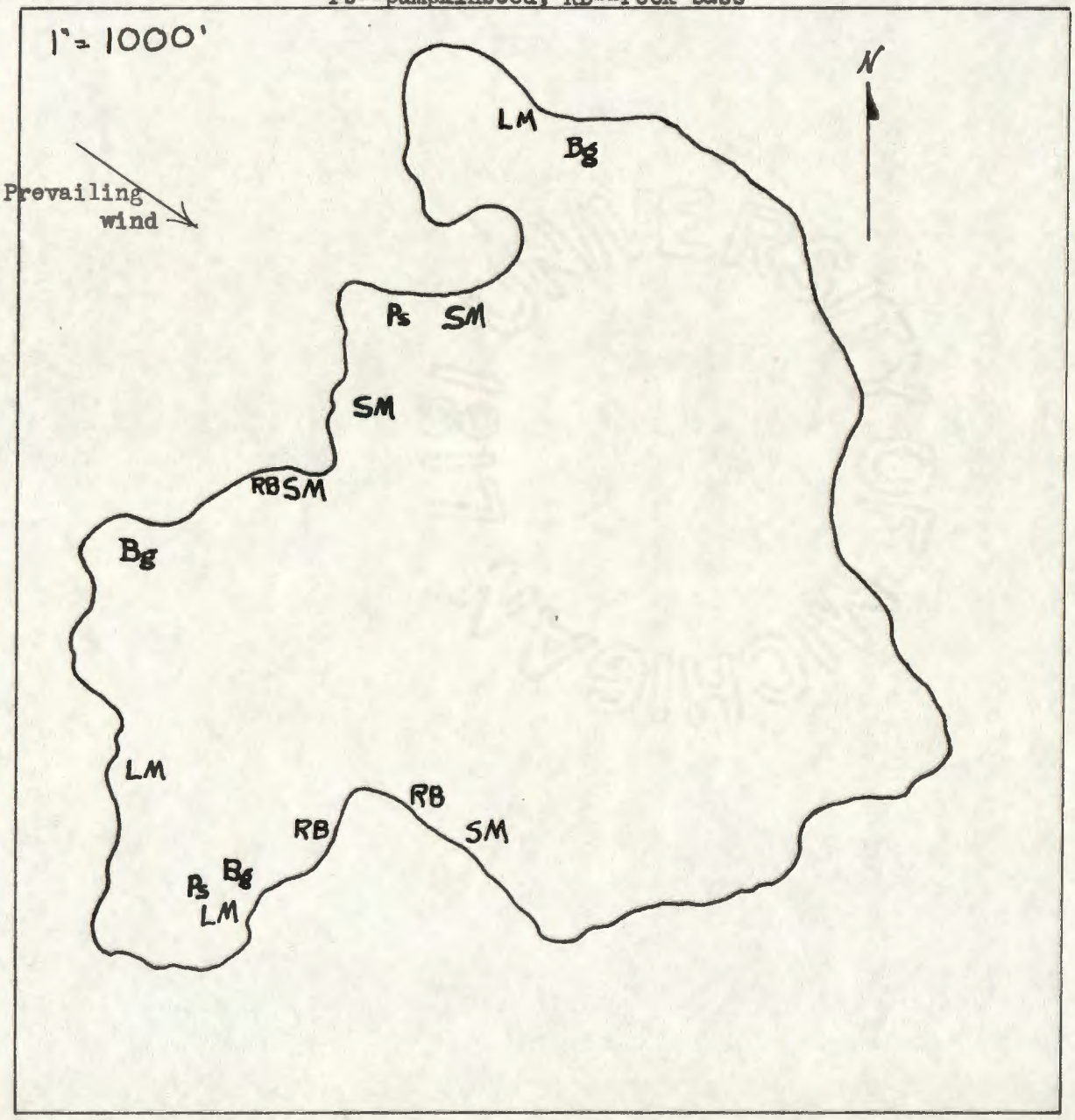
(underlined) was: smallmouth, first and second week in June; rock bass, first and second week of June; largemouth and pumpkinseeds, second and third weeks of June; and bluegills, third and fourth weeks of June. Even the above separates the spawning times of the various species more clearly than was actually the case. However, most of the nests identified in any one period would belong to one or two species rather than to any one of 5 species. Smallmouth nests with eggs present were first found on June 4. Fry were found on rock bass and smallmouth nests on June 10. Eggs and fry were found on largemouth and pumpkinseed nests from June 9 to June 20. Bluegill nests with eggs were first found on June 18 and nests with eggs and fry were still being found on June 25. By June 25 the only species still guarding territory was the bluegill. It was noted that the various species showed some preference for nest materials. Of 24 rock bass nests positively identified, 23 were on gravel, and one on clean sand under a small log. Of the 13 smallmouth nests, all were on gravel. Largemouth and pumpkinseeds showed much wider choice of nesting materials. Four largemouth nests were found on gravel, 2 on sand, and 3 in muck among water lily roots. Three pumpkinseed nests were found on sand, 2 on gravel, and 2 on muck among roots and vegetation. Three bluegill colonies were observed, two of them on clean sand with very little debris present, and one in muck among vegetation and roots. Of the thirteen nests positively identified in these colonies, 12 were on sand with small bits of debris present and one was in the muck. Smallmouth and rock bass were found to take advantage of cover, the nest being constructed under logs, or in the shelter of brush piles. Bluegill, largemouth, and sunfish nests were chiefly in the open. The only consistent difference between the species in the depths chosen for nesting

sites was that rock bass nests were in shallower water (6"-2', hence the larger number identified) than those of the other species. The nests of the others were placed in water varying in depth from 1½' to 4' or 5', and some nests belonging to unidentified fish were seen in even deeper water. Largemouth and smallmouth nests were generally in deeper water than those of bluegills and sunfish. There is little in the above data that does not correspond closely with information secured at Deep Lake, Oakland County, by Mr. Carbine. Possibly, the more extensive shoals and the greater amount of gravel present in Bear Lake has permitted more particular selection of spawning sites by the species present. Also the gradual slope of the shoal has given more opportunity for nesting at greater depths. The map (Figure 4) shows areas where bass and sunfish spawned in 1941. Most of the nests in a given region of the lake belonged to the species indicated by the letters. It will be noted that all of the nests identified are on the protected side of the lake; no nests were found on the south and southeast shores. Perhaps the reason lies in the fact that these shores are exposed to strong wave action, and are therefore not used for nesting sites by bass and sunfish although suitable gravel is present. Further checking will be necessary to verify this.

While the centrarchid species were spawning, every effort was made to detect predation of eggs by suckers. Nests were constantly watched, and no suckers were seen in the areas of the nests at any time while the game species were spawning or guarding. After the suckers spawned, none were observed in shallow water at any time. Sucker stomachs were secured at the time of the game species spawning and casual examination of these stomachs has not shown the presence of eggs of any sort. It seems very

Figure 4
Outline map of Big Bear Lake, Otsego County, Michigan, showing areas where various game species were found spawning during the spring of 1941.

LM--largemouth bass; SM--smallmouth bass; Bg--bluegill; Ps--pumpkinseed; RB--rock bass



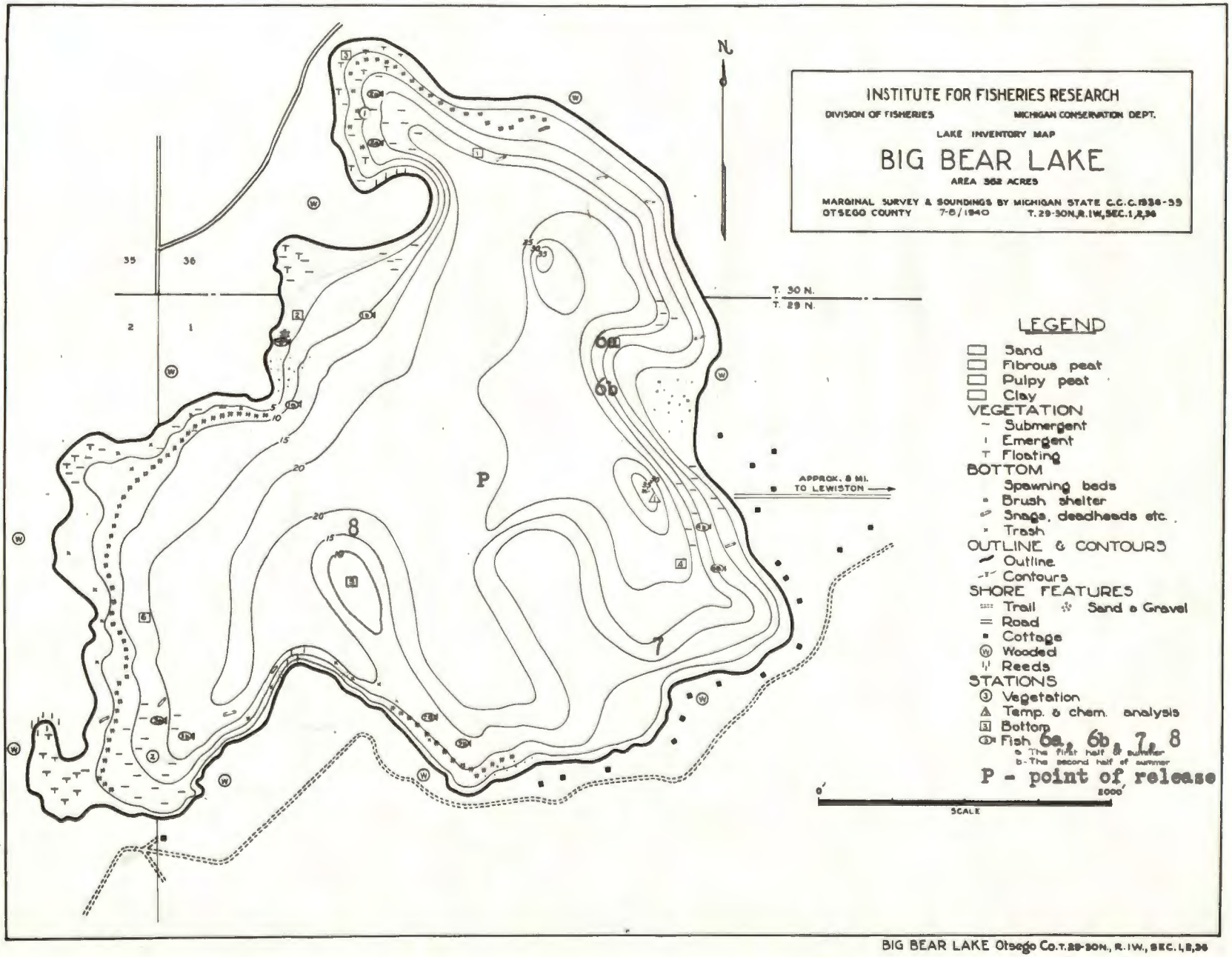
probable that if the sucker were of great importance as an egg stealer it would be found in the vicinity of the centrarchid nests when eggs are present.

The third phase of the 1941 investigation was a repetition of the population analysis. As pointed out in a former report (Report No. 653) a reasonably accurate knowledge of the lake's population is essential to an understanding of the effects of a part of that population on the other parts. Success of management practices can be much more accurately judged when we know the abundance of the various species.

Procedure in the determination of the population was about the same as in 1940, except for one innovation. In 1941 all species were marked in the same manner and released at one point in the lake. One net was lifted at a time, the catch placed in tubs, and transported to the middle of the lake before being marked and released. Also nets were set at three new stations, as indicated on the map. (Figure 5). Numbers 6, 7, and 8 were not used in 1940. The populations were estimated by three methods: (1) the method devised by Dr. David Thompson, (2) a method suggested by Dr. Hile, and (3) by direct proportion of marked to unmarked fish in the catch. Method 1, (Thompson) is explained in a former report (Report No. 590). In Method 3 (direct proportion) we assume that the number of marked fish caught is to the number of fish caught as the number of marked fish in the lake is to the total population. Method 2 (suggested by Dr. Hile) is as follows: The percentage of the number of marked fish present caught each day is tabulated and these percentages are averaged in order to obtain the average per cent of the marked population caught per 6-net day. For example, if the catch of smallmouth be tabulated for July 16 to 29 inclusive, the following would result:

Figure 5

Map of Big Bear Lake, Otsego County, Michigan, showing netting stations used in 1940 and 1941.



Date	No. marked SM in lake A	No. marked SM caught B	Per cent marked population caught B/A=C	No. SM caught D	Estimate D/av.C x 100
July 16	632	36	5.7	48	1,116
17	640	30	4.7	50	1,163
18	660	29	4.4	38	884
19	669	18	2.7	24	558
22	685	30	4.4	38	884
23	693	36	5.2	45	1,047
24	701	17	2.4	22	512
25	706	32	4.5	51	1,186
26	725	22	3.0	36	837
29	762	42	5.5	62	1,442
			av. 4.3		av. 963

The C column gives the per cent of the marked smallmouth caught every 24 hours. The average per cent is 4.3, thus for July 16 we have the following: 48/4.3 x 100 equals 1,116. The estimates for the different dates when averaged give 963. In order that the three methods might be treated in a uniform manner, the period of netting was divided into four periods of 10 days each, and each period was considered as a unit. That is, the estimates for any one period were made separately, and results combined at the end of the whole period. Only the results from 24 hour lifts were used, and on those days when fewer or more than 6 nets were lifted, figures were modified; for example, the catch of 5 nets would be divided by 5, then multiplied by 6 to give the expected catch for 6 nets. All nets fished so uniformly that this procedure should be sufficiently reliable. The estimated populations by all three methods are given in Table I. Results from methods 1 and 2 are combined and this figure is used in making other calculations concerning the population. The results obtained by the use of direct proportion are not used for they do not conform so closely as the other two, and the fluctuation is considerable from day to day, although the averages are not greatly different. The averages for the four periods by all three

Table I

Estimates of fish population in Big Bear Lake, Otsego County, Michigan, for four periods in summer of 1941. Populations estimated from formulae by three methods. Averages shown in red.

Date	2 Hile	1 Thompson	3 D. P.	2 Hile	1 Thompson	3 D. P.	2 Hile	1 Thompson	3 D. P.
		Total			Sucker			Pumpkinseed	
July 2	33,000	20,171	20,171	...	...	...	8,294	...	2,632
3	...	...	10,740	18,286	7,507	5,478	3,265	1,589	1,305
4	14,933	15,589	21,465	9,619	...	5,662	2,265	...	5,397
5	...	...	18,238	9,905	7,288	9,048	1,735	2,842	7,766
8	14,600	15,329	13,850	5,714	...	9,883	3,559	...	4,141
9	...	...	12,552	8,000	8,663	13,860	3,471	3,511	3,958
10	10,900	14,102	12,817	4,190	...	7,219	2,353	...	3,253
11	...	...	12,386	2,952	8,957	21,669	1,794	3,442	3,431
12	...	...	14,239	4,285	...	8,201	2,265	...	6,968
15	7,100	13,435	10,978	2,095	8,879	9,251	1,353	3,965	5,757
Av.	14,660	13,435	14,744	7,227	8,879	10,033	3,035	3,765	4,461
16	...	...	11,263	...	...	5,740	...	...	3,660
17	16,207	12,433	13,653	9,857	5,965	6,100	6,286	4,703	5,896
18	...	...	12,533	...	...	6,365	...	...	3,134
19	16,277	13,441	16,965	9,286	6,383	7,143	8,000	4,066	4,334
22	...	...	14,207	...	...	18,208	...	...	4,661
23	13,724	13,688	14,172	7,429	7,517	10,383	4,000	4,217	4,620
24	...	...	13,519	...	...	6,411	...	...	3,192
25	11,793	13,878	12,725	6,000	7,440	6,057	3,571	4,006	3,300
26	...	...	16,689	...	...	10,149	...	...	9,632
29	13,241	14,117	13,957	5,571	8,074	14,215	1,857	4,080	4,036
Av.	13,835	14,117	13,968	7,900	8,074	9,077	4,328	4,080	4,646
30	...	...	11,246	...	...	5,807	...	...	3,272
31	15,190	12,999	15,206	6,429	9,021	17,055	3,727	4,115	5,211
Aug. 1	...	...	12,372	...	...	8,675	...	...	2,604
2	12,476	13,117	14,387	8,857	10,198	14,074	2,182	3,551	4,536
5	...	...	18,832	...	...	9,299	...	...	5,494
6	19,286	14,779	17,061	15,714	9,745	9,501	7,455	4,454	5,783
7	...	...	18,615	...	...	11,897	...	...	4,858
8	17,190	15,536	17,250	16,429	10,721	14,517	4,545	4,472	4,187
9	...	...	17,230	...	...	16,410	...	...	4,243
12	19,524	16,204	21,171	22,286	12,186	18,285	4,909	4,519	5,169
Av.	16,324	16,204	16,337	12,357	12,186	12,552	4,591	4,519	4,536
13	30,182	...	18,980	...	...	10,537	8,222	3,305	3,305
14	16,545	19,246	19,752	12,800	12,718	21,005	...	...	3,814
15	...	...	14,461	...	...	11,897	3,444	3,338	2,967
16	13,818	18,192	19,636	10,800	16,620	35,399	...	...	2,429
19	...	...	18,227	...	...	18,551	2,555	3,074	2,680
20	15,818	18,024	18,182	20,400	14,973	10,507	...	...	2,233
21	...	...	22,401	...	...	16,548	1,555	2,969	2,948
22	19,909	18,405	18,672	10,800	14,744	11,229	...	...	2,680
23	19,091	...	24,241	28,800	...	22,327	3,333	2,924	2,144
24	...	18,883	27,315	...	15,423	21,177	...	...	...
Av.	18,545	18,883	20,188	16,600	15,423	17,818	3,098	2,924	2,802
		Bluegill			Largemouth bass			Smallmouth bass	

	Bluegill			Largemouth bass			Smallmouth bass		
July 2	3,615	...	...	8,888	...	...	1,788	...	2,026
3	1,577	1,040	648	6,278	14,370	10,050	2,455	2,325	1,717
4	885	...	...	6,000	...	18,720	1,712	...	2,196
5	962	2,453	...	5,444	9,094	5,346	939	1,759	1,360
8	2,462	...	3,355	4,000	...	3,938	1,152	...	889
9	1,231	2,554	1,829	2,389	4,099	1,710	803	1,220	816
10	2,115	...	2,695	2,556	...	2,480	1,318	...	1,259
11	1,346	2,558	2,401	3,278	3,487	3,083	1,030	1,203	1,101
12	2,731	...	4,414	2,833	...	2,292	1,015	...	1,031
15	1,346	2,856	2,460	2,722	3,075	2,512	773	1,101	774
Av.	1,827	2,856	2,543	4,439	3,075	5,570	1,299	1,101	1,317
16	3,273	...	3,744	2,571	...	2,628	1,162	...	843
17	2,364	2,540	1,787	1,929	2,558	2,472	1,163	944	1,067
18	5,273	...	2,995	2,214	...	1,740	884	...	865
19	5,364	2,921	3,299	1,500	2,324	3,003	558	916	892
22	3,455	...	1,984	1,643	...	2,084	884	...	868
23	3,182	2,607	2,399	2,143	2,395	3,063	1,047	897	867
24	1,636	...	1,750	1,643	...	1,965	512	...	907
25	636	2,550	5,516	2,929	2,360	2,437	1,186	930	1,125
26	1,455	...	3,176	3,786	...	2,463	837	...	1,186
29	1,455	2,693	6,664	4,000	2,429	2,659	1,442	977	1,125
Av.	2,809	2,693	3,331	2,436	2,429	2,451	963	977	975
30	2,708	...	2,115	2,300	...	1,989	1,623	...	1,103
31	3,083	2,676	3,143	2,450	1,959	1,933	1,623	1,227	1,377
Aug. 1	1,667	...	3,130	2,750	...	2,783	1,902	...	1,213
2	1,792	2,771	2,772	2,250	2,149	1,993	1,262	1,224	1,231
5	3,583	...	3,423	1,700	...	2,752	1,033	...	1,287
6	3,833	2,920	2,860	2,150	2,201	2,088	967	1,208	1,061
7	3,750	...	4,477	2,950	...	2,388	967	...	1,205
8	3,417	3,078	2,813	3,000	2,176	1,917	672	1,207	1,189
9	2,625	...	2,725	1,250	...	2,335	803	...	958
12	4,250	3,056	3,172	1,150	2,193	2,327	1,000	1,174	1,097
Av.	3,071	3,056	3,093	2,195	2,193	2,250	1,185	1,174	1,172
13	5,750	...	4,577	2,625	...	2,125	2,000	...	1,058
14	2,667	4,369	3,980	2,500	2,074	2,023	1,200	1,086	1,036
15	4,250	...	2,416	2,875	...	1,861	1,750	...	1,049
16	3,083	3,397	3,269	2,000	2,090	2,262	1,200	982	1,039
19	3,833	...	2,377	2,875	...	1,956	1,300	...	1,020
20	1,417	3,020	1,990	1,875	2,045	1,961	400	1,002	1,099
21	2,167	...	2,612	750	...	3,399	200	...	1,349
22	5,250	2,966	2,804	375	2,081	1,669	1,050	1,041	1,124
23	1,500	...	2,736	...	...	1,366	300	...	1,284
24	...	2,914	1,739	...	2,062	3,235	...	1,057	1,437
Av.	3,324	2,914	2,850	1,984	2,062	2,186	1,044	1,057	1,150

	Rock bass		
July 2	857	...	270
3	857	346	384
4	595	...	1,134
5	548	673	469
8	714	...	950
9	429	872	2,025
10	310	...	646
11	238	946	795
12	643	...	752
15	190	995	1,552
Av.	538	995	898

16	857	...	402		
17	1,357	529	656		
18	357	...	1,100		
19	643	591	672		
22	429	...	472		
23	500	698	1,673		
24	500	...	572		
25	357	651	415		
26	143	...	...		
29	429	654	512		
Av.	557	654	719		
30	470	...	518		
31	588	669	870		
Aug. 1	647	...	590		
2	1,118	642	651		
5	1,824	...	736		
6	882	701	855		
7	1,000	...	1,211		
8	588	731	570		
9	412	...	1,995		
12	706	814	3,420		
Av.	824	814	1,142		
13	833	...	713		
14	500	760	855		
15	...	...	...		
16	333	950	...		
19	167	...	...		
20	500	998	855		
21	...	...	285		
22	500	...	...		
23	333	950	...		
24	...	...	285		
Av.	452	950	599		

methods are given in the following table (Table II)

Table II

Average estimates of the populations of Big Bear Lake, Otsego County, for four ten-day periods, by three methods.

Species	Thompson 1	Hile 2	Direct proportion 3
Sucker	11,140	11,021	12,370
Ps	3,872	3,763	4,111
Bg	2,880	2,758	2,954
LM	2,440	2,763	3,114
SM	1,077	1,122	1,153
RB	853	593	839
Totals	22,262	22,020	24,541

Table III gives the figures for both 1940 and 1941. It will be noted that the sum of the specific totals has been used rather than the estimated total (estimated by formulae). The reason for this is that the various species behave differently, and it was felt that treating each species separately would give better results than treating them all as one species. For example, smallmouth bass, which were very readily caught in the nets, would have more effect on the total estimate than would the sucker which, though caught in large numbers, was taken much less frequently than the smallmouth, considering the relative numbers of each in the lake. The rates at which the various species were taken in the nets are given in Table IV. The 1940 figures are based on the use of but one method (Thompson). As can be seen from a comparison of the 1940 and 1941 figures (Table III) there has been an increase in the population, caused mainly by a greater abundance of pumpkinseeds and bluegills. The increase in the pumpkinseed and bluegill populations is here explained on the hypothesis that by 1941 a much greater number of the sunfish and bluegills present in the lake had reached a size large

Table III

Estimated populations of 6* species of fish in Big Bear Lake, Otsego County, Michigan. Percentage composition, and the size range of the fish captured in the nets is also given.

Species	1940 Estimate	1940 Per cent of total	1940 Size range inches	1941 Estimate	1941 Per cent of total	1941 Size range inches
Sucker	9,699	52.2	10.5 - 19.1	11,081	50.0	10.6 - 19.5
Ps	1,325	7.1	4.3 - 8.4	3,818	17.2	4.5 - 9.4
Bg	1,940	10.4	4.9 - 10.0	2,819	12.7	5.0 - 10.0
LM	2,987	16.1	6.9 - 17.1	2,602	11.8	6.9 - 17.1
SM	1,333	7.2	5.8 - 15.5	1,100	5.0	6.6 - 15.0
RB	1,307	7.0	5.0 - 7.6	723	3.3	5.1 - 8.4
Totals	18,591	100.0		22,143	100.0	

* Bullheads (two species) are not included, although estimates of 20 were obtained both years. All bullheads were caught several times, and we believe that an estimate of 20 would be rather close. Also estimated in 1941 were hybrid sunfish (bluegill x pumpkinseed) but so few were caught and recovered that estimates of their abundance would not be especially reliable, although we believe that 50 or so adults, as estimated by the use of the formulae, would not be far off. Two perch were also captured but since most of the perch present are too small to be taken by mesh of this size, no estimate was made.

Table IV

Tabulation of the rate at which various species were caught in trap nets at Big Bear Lake during the summers of 1940 and 1941.

Species	Catch for summer 1940	Catch for summer 1941	Estimated population 1940	Estimated population 1941	Per cent of estimated population caught 1940	Per cent of estimated population caught 1941
Sucker	2,665	4,141	9,699	11,081	27.5	37.4
Ps	1,502	2,436	1,325	3,818	113.4	63.8
Bg	687	2,368	1,940	2,819	35.4	84.0
LM	1,627	2,261	2,987	2,602	54.5	86.9
SM	1,566	2,903	1,333	1,100	117.5	378.9
RB	327	535	1,307	723	25.0	74.0

enough to be taken easily in the nets, that is over 1½ inches. The validity of this hypothesis is borne out, as will be shown, by a change in the average size of the pumpkinseeds and bluegills caught, and by scales which were examined. Data derived from the estimates, netting results, weights and measurements of large samples of the catch, and scales which were examined are presented. An analysis of the fishing at the different stations is given in Table V. It should be pointed out that Station 8 is not strictly comparable with the others, for a larger net was used, and this net was lifted only 9 times compared to the much more numerous lifts of the other nets. Nets set at either the "a" or "b" locations are considered as one station in the analysis.

Table V

Netting analysis of 8* stations where trap nets were set in Big Bear Lake, Otsego County, Michigan, during the summer of 1941. Figures in red denote catch per net day. Figures in parentheses under the station numbers give the number of lifts at that station.

Station	S	LM	SM	Ps	Bg	RB	BH	Bg x Ps	Perch	Total or average
1	689	307	663	310	419	173	8	6	...	2,575
(45)	(15.4)	(6.8)	(14.7)	(6.9)	(9.3)	(3.8)	(0.2)	(0.1)	...	(57.2)
2	412	360	434	532	544	80	6	5	...	2,373
(43)	(9.6)	(8.4)	(10.1)	(12.4)	(12.6)	(1.9)	(0.1)	(0.1)	...	(55.2)
3	337	266	344	507	167	73	6	8	1	1,709
(42)	(8.0)	(6.3)	(8.2)	(12.1)	(4.0)	(1.7)	(0.1)	(0.1)	(0.0)	(40.7)
4	252	147	217	116	91	9	3	3	1	839
(18)	(14.0)	(8.2)	(12.1)	(6.4)	(5.1)	(0.5)	(0.2)	(0.1)	(0.0)	(46.6)
5	973	663	326	478	511	57	8	2	...	3,018
(43)	(22.7)	(15.4)	(7.6)	(11.1)	(11.9)	(1.3)	(0.2)	(0.0)	...	(70.2)
6	420	297	471	309	367	108	31	3	...	2,006
(44)	(9.6)	(6.7)	(10.7)	(7.0)	(8.4)	(2.5)	(0.7)	(0.0)	...	(45.6)
7	483	107	316	136	186	31	4	...	...	1,263
(21)	(23.6)	(5.1)	(15.0)	(6.5)	(8.9)	(1.5)	(0.2)	...	...	(60.1)
8	575	114	132	48	83	4	1	...	...	957
(9)	(63.9)	(12.7)	(14.7)	(5.3)	(9.2)	(0.4)	(0.1)	...	...	(106.3)
All stations (264)	4,141	2,261	2,903	2,436	2,368	535	67	27	2	14,740
Average	(15.7)	(8.6)	(11.0)	(9.2)	(9.0)	(2.0)	(0.2)	(0.1)	(0.0)	(55.8)

*Excluding station 8 the total catch is 13,783, and the catch per net day, 54.1 fish.
S = Sucker, LM = Largemouth, SM = Smallmouth, Bg = Bluegill, RB = Rock Bass, BH = Bullhead, Bg x Ps = hybrid.

It should be noted that as in 1940 the best total catch, and also catch per net day, was made at Station 5 (exclusive of No. 8 which is not comparable).

The number of fish per net day for each of the stations for the two years are compared below.

Station number	Catch per net-day 1940	1941
1	30	57
2	47	55
3	37	41
4	26	47
5	55	70
6	...	46
7	...	60
8	...	106
Average	39	56

The number of fish and pounds per acre for the various species are given in the next table (Table VI). These data are based on large samples of the catch which were weighed and measured. The per cent of the total catch which was sampled is given in the table.

Table VI

Number and pounds of various species* to the acre
in Big Bear Lake, Otsego County, Michigan,
in 1940 and 1941.

	1940						1941						Per cent by wt. per acre	
Species	Per cent measured	Av. T.L. inches	Per cent weighed	Av. wt. ounces	Number per acre	Pounds per acre	Per cent measured	Av. T.L. inches	Per cent weighed	Av. wt. ounces	Number per acre	Pounds per acre	1940	1941
Sucker	43	14.9	43	18.5	26.8	30.9	47	15.5	9	18.3	31.7	36.3	78.83	77.73
Ps	30	6.2	30	3.5	3.7	0.8	37	5.9	11	3.0	10.9	2.0	2.04	4.28
Bg	27	6.7	27	4.2	5.4	1.4	40	6.6	9	3.6	8.6	1.9	3.57	4.07
LM	39	9.4	39	7.8	9.4	4.0	34	10.5	9	9.8	7.4	4.5	10.20	9.64
SM	32	9.0	32	6.3	3.7	1.5	28	10.0	9	8.3	3.1	1.6	3.83	3.43
RB	27	5.9	27	2.7	3.7	0.6	35	6.5	13	3.4	2.1	0.4	1.53	0.85
Total					51.5	39.2					63.8	46.7	100.00	100.00

* Bullheads, hybrid sunfish, and perch are not included. The figures include only adult and subadult fish, large enough to be taken in the trap nets used.

In 1941 each net caught, on an average, the fish from 0.85 acres as determined by dividing 54.1 (catch per net-day, Table V) by 63.8 (number of fish per acre, Table VI). In 1940 each net caught, on an average, the fish from 0.75 acres every twenty-four hours. Data from one other lake, East Twin Lake, Montmorency County, showed that the nets usually caught the fish from about the same surface area as in Bear Lake. If it is found that the nets usually catch the fish from about the same acreage of water, it will be possible to make rapid population estimates. (Thompson, 1941). Data from two other lakes of very different types from Big Bear Lake, and East Twin Lake will enable us to further check the uniformity of the results obtained through the use of the trap nets.

It will be seen from examination of Table VI that 78.8 per cent by weight of the pounds per acre was suckers in 1940, and 77.7 per cent in 1941. Further examination of the table (Table VI) shows that with the exception of 2 species, pumpkinseeds and rock bass, the per cent by weight of the population per acre has not changed greatly over a period of a year. It is of interest that the populations of other species have been so slightly affected by the change in the abundance of these species.[*] The increase in poundage is not large for any species except the pumpkinseed. The following table (Table VII) gives the total weekly catch and its percentage composition.

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[*] It is probable that the real change is in the pumpkinseed population, for the catch of rock bass was small both years, and, therefore, results from rock bass are not as reliable as those obtained for other species.

Table VII

Total weekly catch of 6* species of fish in
Big Bear Lake, Otsego County, Michigan.
Per cent of total catch is given in parentheses.

Date	Sucker	Ps	Bg	LM	SM	RB	Total
July 1-7	614 (24.1)	486 (19.1)	216 (8.5)	557 (21.9)	548 (21.5)	125 (4.9)	2,546
8-14	317 (15.8)	522 (26.1)	311 (15.6)	326 (16.3)	425 (21.3)	99 (4.9)	2,000
15-21	366 (23.7)	326 (21.1)	303 (19.6)	213 (13.8)	271 (17.6)	63 (4.1)	1,542
22-28	377 (29.0)	159 (12.2)	159 (12.2)	297 (22.8)	276 (21.2)	32 (2.5)	1,300
July 29-Aug. 4	340 (17.7)	226 (11.8)	349 (18.1)	333 (17.3)	594 (30.9)	81 (4.2)	1,923
5-11	701 (30.3)	385 (16.6)	527 (22.7)	263 (11.4)	348 (15.0)	93 (4.0)	2,317
12-18	915 (44.5)	261 (12.7)	357 (17.4)	179 (8.7)	312 (15.2)	32 (1.6)	2,056
19-24	511 (53.2)	71 (7.4)	146 (15.2)	93 (9.7)	129 (13.4)	10 (1.0)	960
Total	4,141	2,436	2,368	2,261	2,903	535	14,644
Average	(28.3)	(16.6)	(16.1)	(15.4)	(19.8)	(3.7)	

* Bullheads, hybrid sunfish, and perch are not included.

Examination of the above table (Table VII) shows that the abundance of the various species in the catch varied from week to week. The same was true of 1940. If the percentage composition of the catch for the first four weeks be averaged against that of the last four weeks, we find that suckers and bluegills formed a greater percentage of the catch in the last four weeks, while largemouth, smallmouth, pumpkinseeds and rock bass formed a smaller percentage of the catch. This is in agreement with 1940 data for bluegills, largemouth bass and smallmouth bass, but does not agree for other species.

Scale samples were taken from all species in 1940 and 1941. The results of the age determination for game species are given in the next table (Table VIII).

Table VIII

Age determinations as made from scale samples taken from game species in Big Bear Lake, Otsego County, Michigan in 1940 and 1941.

	1940					1941				
Species	No. spec.	Av. T.L. inches	Av. wt. oz.	Age	Year class	No. spec.	Av. T.L. inches	Av. wt. oz.	Age	Year class
LM	1	3.0	0.2	0	1940	...	...	...	...	...
	28	8.7	5.1	II	1938	4	9.1	5.7	II	1939
	3	11.8	12.7	III	1937	36	10.0	7.1	III	1938
	3	13.2	17.2	IV	1936	13	12.5	13.9	IV	1937
	3	13.5	17.8	V	1935	2	14.4	22.0	V	1936
	1	16.7	39.0	VI	1934	2	16.0	32.5	VI	1935
	1	17.3	51.0	VII	1933	...	...	...	...	...
SM	2	6.5	2.5	I	1939	...	...	...	...	...
	27	9.6	7.3	II	1938	20	8.1	4.3	II	1939
	2	12.0	14.0	III	1937	26	10.6	9.8	III	1938
	...	...	...	...	...	3	12.6	16.5	IV	1937
Bg	15	6.0	2.9	II	1938	...	...	...	...	...
	...	...	...	...	...	37	6.4	2.9	III	1938
	3	8.7	8.2	IV	1936	3	7.5	5.1	IV	1937
	...	...	...	...	...	3	9.0	8.2	VI	1935
	...	...	...	...	...	5	9.3	8.6	VII	1934
Ps	2	2.6	0.2	I	1939	...	...	...	...	...
	4	5.3	2.2	II	1938	...	...	...	...	...
	19	6.3	3.3	III	1937	25	5.9	2.4	III	1938
	4	7.2	5.4	IV	1936	7	7.1	4.9	IV	1937
	1	8.4	9.0	V	1935	4	7.5	5.3	V	1936
RB	5	5.5	2.4	II	1938	3	4.4	2.7	II	1939
	7	6.0	2.9	III	1937	25	6.3	2.9	III	1938
	3	7.5	5.0	IV	1936	16	6.4	3.1	IV	1937
	...	...	...	...	...	3	7.5	4.7	V	1936
	...	...	...	...	...	1	8.3	5.7	VI	1935
Perch	4	5.3	1.2	II	1938	2	5.9	0.9	II	1939
	3	7.0	2.4	III	1937	19	6.2	1.1	III	1938
	...	...	...	...	...	11	7.1	1.9	IV	1937
	...	...	...	...	...	1	9.1	3.6	V	1936
	...	...	...	...	...	1	12.5	13.1	IX	1932

The age determinations from the scales collected during the two summers are not combined because there is some indication that fish spawned in 1939 (in three species, smallmouth, bluegill and pumpkinseed) are not growing as rapidly as those spawned in 1938. It can be seen from the table (Table VIII) that two-year-old smallmouth from the 1938 year class, taken in 1940, averaged 9.6 inches in total length, while two-year-olds from the 1939 year class, taken in 1941, averaged only 8.1. Also, in 1940 two-year-old bluegills were readily captured and averaged 6.0 inches in total length. In 1941 no bluegills from the 1939 year class (two-year-olds) were captured, or at least no scale samples were secured. Admittedly the scale series might be larger, but since scale samples were taken from fish over the whole size range of those captured, it is not likely that many fish belonging to the 1939 year class were captured, for the smallest specimens captured were three-years-old. The same is true of the pumpkinseeds. If bluegills and pumpkinseeds from the 1939 year class were as large as those of the 1938 year class, they would have been captured in the nets and at least a few scale samples would have been secured. It therefore seems probable that the 1938 year class, which is the dominant year class in largemouth bass, smallmouth bass, bluegills, sunfish, and perhaps rock bass, is having a considerable effect on the growth of those fish which were spawned after 1938. For this reason it would be well to follow the growth of the fishes in Bear Lake for at least one more summer, so that the situation might be studied still further.

Length frequencies have been plotted for the samples of all species which were measured, and we have tried to correlate the scale data with these graphs. The graphs (Figures 6 to 10)* present this information.

* Not included in any but Institute file copy.

Figure 6 indicates that a large part of the adult and sub-adult largemouth population is composed of fish from the 1936, 1937, 1938, and 1939 year classes. In 1941 the two-year-olds (1939 year class) have come into the netted population, while the 6-year-olds (1935 year class) have become less numerous. From the data plotted on the graphs, it seems probable that the 1938 year class forms the major part of the populations of bluegills, largemouth- and smallmouth bass, and pumpkinseeds. The peaks of the frequencies have shifted to right in all cases (indicating an increase in the average size) except in the pumpkinseeds where the 1937 year class formed the dominant part of the catch in 1940 (hence the larger average size in 1940, Table VI). In 1941, however, the 1938 year class, many of which were apparently too small in 1940 to be captured, have come into the catch in very large numbers so that the greater part of the catch of pumpkinseeds in 1941 was composed of fish from the 1938 rather than the 1937 year class. The samples on which the graphs are based are large enough to be quite representative of the whole population. (Table VI).

If the estimates of the population are reliable, it is possible to determine the legal fish per acre, and also the number of legal fish available in the whole lake. The table below (Table IX) gives the figures for the legal fish.

Table IX

Estimated number of legal game fish in Big Bear Lake, Otsego County, Michigan, for 1940 and 1941. Estimates based on samples which were weighed and measured.

	1940				1941			
	No. legal	Per cent legal	Estimate		No. legal	Per cent legal	Estimate	
Species	in sample	in sample	In lake	Per acre	in sample	in sample	In lake	Per acre
LM	155	24.5	733	2.0	382	50.1	1,384	3.8
SM	63	12.4	164	0.4	484	58.6	645	1.8
Bg	86	46.0	892	2.5	774	80.8	2,277	6.3
Ps	277	62.6	829	2.3	151	21.0	801	2.2
RB	28	31.8	416	1.1	139	84.2	609	1.7
Totals			3,034	8.3			5,716	15.8

The percentage of legal fish has increased considerably in the period of a year except for the pumpkinseed, which has dropped sharply. The number of legal fish in the lake and per acre, except for the pumpkinseed, has increased 1.9 times and better fishing should have resulted.

As has been mentioned, a creel census has been conducted on the lake for two years. In 1940 the slips were given to fishermen who were asked to fill them out and return them. In 1941 all cottages were visited each day and records of the previous day's fishing were secured. The results indicate that the records for 1941 are better but since most of the fish were not examined by the clerk either year, many misidentifications may be present in the records. A brief analysis of the fishing for the two summers follows:

	1940	1941
Period covered by census	May 5 to Sept. 21	June 25 to Sept.9
Number of fishermen		
Men	403	909
Women	124	287
Resident	276	710
Non-resident	224	485
Residence unknown	27	1
Total	527	1,196
Number of hours fished	2,013	4,078
Av. hours per fisherman	3.8	3.4
Av. catch legal fish per hour	0.43	0.54
Per cent taking no legal fish	40.0	29.0
Number of fish caught		
Largemouth	318	476
Smallmouth	105	426
Bluegill	43	227
Pumpkinseed	65	150
Rock bass	166	377
Perch	166	536
Others	4	9
Total	867	2,201
Percentage composition of catch		
Largemouth	36.7	21.6
Smallmouth	12.1	19.4
Bluegill	5.0	10.3
Pumpkinseed	7.5	6.8
Rock bass	19.1	17.1
Perch	19.1	24.3
Others	0.5	0.4

Comparing the composition of the legal crop of game species available to the angler (as determined from the population analysis) with the composition of the angler's catch, we find that only the largemouth furnished close to the expected proportion of the catch (1941). That is, 24 per cent of the legal crop was composed of largemouth, while 22 per cent of the catch was composed of this species. The percentages of the others were as follows:

Species	Per cent of estimated legal population in 1941*	Per cent of angler's catch in 1941*
Largemouth	24	22
Smallmouth	11	19
Bluegill	40	10
Pumpkinseed	14	7
Rock bass	11	17

* Data from 1941 creel census.

The lack of correlation may be explained in two ways. Almost certainly the number of smallmouth recorded as caught by anglers is too high, because of misidentification, and as has been mentioned the clerk found it impossible in many cases to examine all the catches made. In connection with the population of smallmouth bass, it should be mentioned that the number of legal smallmouth increased 3.9 times from 1940 to 1941 while the number of legal largemouth increased only 1.9 times.** In 1940 the number of legal largemouth was 4.5 times as large as the number of legal smallmouth, while in 1941 it was only 2.1 times as large.** Consequently, it would be expected that the number of smallmouth caught would more nearly approximate the number of largemouth caught in 1941 than in 1940.

The second contributing cause for the apparent discrepancies is that the resort owners on the lake, and the fishermen themselves, consider the lake as primarily bass water, and therefore most of the time and effort is devoted to fishing for bass. It is true that there is some still fishing around the brush shelters, especially by women and children, and small numbers of pan fish are caught. As can be seen above, the correlation between the population and the catch is better for rock bass than it is for either bluegills or pumpkinseeds. This might be expected because of the ecology of the three species. The bluegill, being more pelagic than either of the other species, shows the poorest correlation, and the rock bass, hanging close to the brush piles as it does, is readily

** Table IX.

captured by such fishing. Quite possibly, if more fishermen fished for pan fish, the catch would more closely conform to the results which might be anticipated in view of the number of legal fish of each species actually available. Perch formed a significant part of the angler's take in both 1940 and 1941, but since the great majority of the perch in Big Bear Lake were too small to be captured in the nets used, no estimate of the population was made and we have no way of judging the size of the standing crop. Perch, being open water inhabitants, are captured by fishermen fishing for bass, and of the smaller game fish present, only the perch is taken readily on small minnows, used by a great many of the bass fishermen.

It is of especial interest to make some estimate of the effect of fishing pressures throughout the season. First, it should be pointed out that the following figures are based on estimates and should be considered in that light. However, since the estimates are the only available working basis, and since they are considered to be fairly reliable, this seems worthwhile.

At the end of the 1940 season, 733 legal largemouth were estimated to be present in the lake (Table IX). During the 1940 season 318 largemouth were removed by angling. Thus, 1,051 largemouth represent the total population of legal largemouth available to the angler during the season. A removal of 318 represents 30.3 per cent of the standing crop during the 1940 fishing season. The standing crop at the beginning of the 1941 season will be composed of what remained at the end of the 1940 season, plus those fish which have come in through growth, and minus those which have been lost through natural mortality. Disregarding the first few estimates (July 2 to 8, Table I) because the number of

marked fish was not large and estimates therefore not so reliable as later, about 1,400 legal largemouth were estimated to be present at the beginning of the 1941 season. Thus the removal during 1940 has been more than replaced by growth in 1941. An examination of the figures (Table I) reveals that there is a progressive reduction in the largemouth population from the beginning to the end of the season. If the legal-sized population were static, and not constantly being increased through growth and decreased by natural loss, we might expect it to be 924 (1,400 present at the beginning minus 476 removed by anglers during the season) at the end of the 1941 season instead of 1,384 as estimated (Table IX). Once more it is evident that growth compensates for removal and natural mortality. Throughout the 1941 season the total available (standing) crop would be 1,384 (present at the end of the season) plus 476 (removed during the season) or 1,860. During the summer of 1941, anglers removed 25.6 per cent of this standing crop of largemouth bass. The other game species may be treated in the same manner, and a tabulation follows:

Species	Per cent of standing crop removed by angling	
	1940	1941
LM	30.3	25.6
SM	39.0	35.0
Bg	4.6	9.1
Ps	7.3	15.8
RB	28.5	38.2
Total	22.2	27.8

Three thousand thirty-four legal fish (exclusive of perch) were estimated to be present in the fall of 1940. One thousand sixty-five legal fish, (exclusive of perch) were removed in 1941. Disregarding replacement by growth and over-winter mortality, this represents 55 per cent of the standing crop. The following tabulation gives the percentage of legal sized individuals of various species estimated to be present in the fall of 1940 which were removed by angling in the summer of 1941:

Largemouth	65 per cent
Smallmouth	213 per cent
Bluegill	25 per cent
Pumpkinseed	18 per cent
Rock bass	91 per cent

However, as shown earlier, such estimates are not accurate since they do not take into account the replacement of legal-sized fish from fall to the opening of the season and through the fishing season. The percentages of removal based on the catch and the population estimate during the fishing season in each year should be more reliable.

The angling pressure in the lake during the summer of 1940 seems to have had no very marked effect on the crop harvested in 1941. It is evident from comparing the population figures for the two years that the removal of legal fish in 1940 and natural mortality have more than been compensated for by growth in 1941. This is especially evident in the case of the smallmouth where the number removed by anglers in 1941 exceeded the number estimated to be present in the fall of 1940.

Records were secured from about twice as many fishermen in 1941 as in 1940, but the increase in the number of records was caused primarily by a more complete census. Fishing was better in 1941 and the fishing pressure was somewhat heavier, but certainly <u>not</u> more than twice as great as would be indicated by the census. Six fish per acre (38 per cent of the fish per acre) were removed during the summer of 1941. In 1940, according to the records, 2.4 fish per acre (29 per cent of the legal-sized fish per acre) were caught by anglers during the season. In 1940 a pressure of 1.5 fishermen per acre was recorded, and in 1941 the number of fishermen per acre was 3.3. The small but definite increase in the fish yield in 1941 can be attributed, first, to the larger available crop, and, secondly, to a lesser degree, to the increase in the fishing pressure. The increased catch per hour in 1941 in the face of heavier

fishing and greater yield indicate that angling might be even more intense than in 1941 without affecting adversely the yield or the quality of the fishing. The average size of the fish captured by angling is compared below with the average size of the legal fish measured while the netting operations were in progress:

Species	Average size of various species, as obtained from creel census records.	Average size of various species, as obtained from measurements made on net-captured specimens of legal size.
Largemouth	12.6 inches	11.6 inches
Smallmouth	11.6 "	10.8 "
Bluegill	6.8 "	6.8 "
Pumpkinseed	6.6 "	6.7 "
Rock bass	6.4 "	6.6 "

The figures agree rather well, except in the case of the largemouth and smallmouth bass. I think this can be explained by the average fisherman's very normal tendency to make 13 inchers out of 12 inchers. The average size as determined from net-caught specimens is, of course, more reliable because large samples were carefully measured to determine the averages. Many of the angler-caught fish were not actually measured but were estimated by the fisherman.

A planting of 224 legal smallmouth was made in the lake during the summer of 1941. These fish were tagged so that individuals could be followed. The crop of legal smallmouth present was composed of 74 per cent "wild" fish, and 26 per cent tagged fish. The catch of smallmouth, when analyzed, was composed of 82 per cent "wild" fish, and 18 per cent tagged fish. These figures indicate that the wild fish were more readily captured than were the tagged ones. Since the tagged fish were all smallmouth, the clerk could be certain of the identification of the tagged fish, but

undoubtedly many of the wild fish captured which were identified as smallmouth were actually largemouth. It is not likely that the wild fish were captured more readily.

Twenty-eight game fish stomachs containing food were examined. Nine, or about one third, were caught with rod and line, the others in nets. The twenty-eight stomachs were composed of 15 largemouth, 7 smallmouth, 5 rock bass, and one bluegill. Data from these stomachs are summarized in the following table (Table X).

Table X

Contents of 28 game fish stomachs collected at
Big Bear Lake during the summer of 1940.
Volume by water displacement
is given in per cent.

Food organism	Largemouth (15 stomachs)	Smallmouth (7 stomachs)	Rock bass (5 stomachs)	Bluegill (1 stomach)
Bluegill	63.3	...	...	...
Pumpkinseed	23.3	...	...	...
Perch	10.2	90.3	...	...
Minnow (2 sp.)	1.8	6.4	3.4	...
Diptera	1.2	...	...	...
Odonata	...	1.9	78.6	...
Hymenoptera	...	1.4	...	...
Neuroptera	...	...	13.9	...
Tricoptera	...	...	2.5	...
Coleoptera	...	...	...	33.0
Other insects	...	...	1.6	...
Mollusca	...	...	0.4	...
Plant remains	0.2	...	...	67.0
	100.0	100.0	100.0	100.0

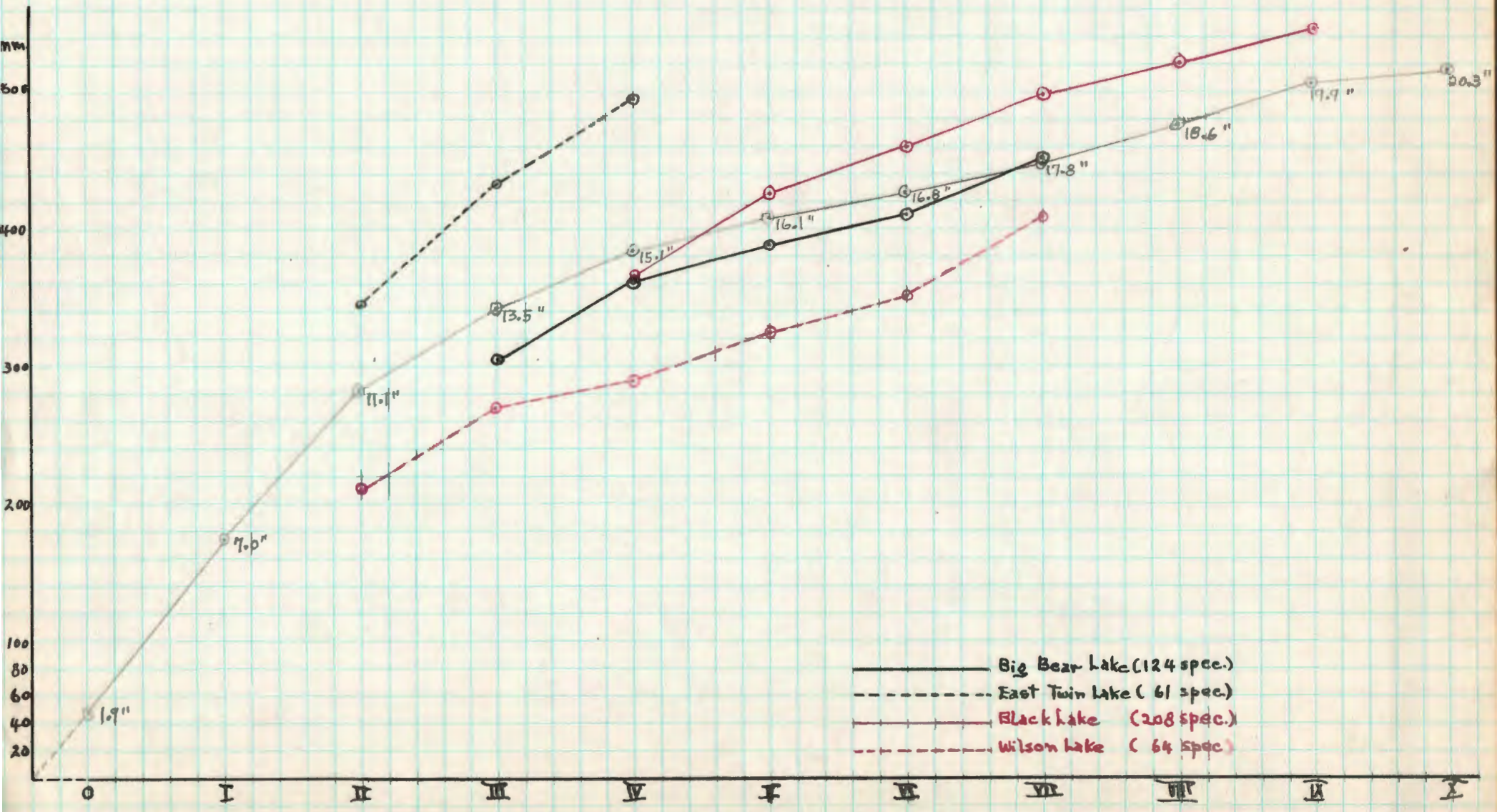
More stomachs were preserved but were found on examination to be empty. The empty stomachs consisted of 12 largemouth, 7 smallmouth, 6 bluegill, 1 pumpkinseed, and 9 rock bass. The emptiness is here explained by the fact that the fish were held in the nets and either could not feed, or the material present was digested before the stomachs were removed. An examination of Table X reveals that both largemouth and smallmouth ate 97 per cent fish, while the rock bass ate 97 per cent insects. Although the sample is not large, it probably does indicate the general situation, and therefore it is important to note that the sucker does not contribute materially, if at all, to the diet of the game species in the lake. No suckers have been found in game fish stomachs, either at Big Bear Lake or at East Twin Lake. It will be necessary to learn more of the suckers own food habits in order to clarify its position in the lake's economy, but from the evidence at hand it apparently does not contribute to the food of the game fishes.

Table XI* presents data derived from the examination of sucker scales from 36 different lakes in Michigan. The series available from some of the lakes are much larger than those from others but a tentative average has been drawn up in Figure 11. The suckers from Big Bear Lake and Wilson Lake fall below this average, while those from Black Lake and East Twin Lake are above. (Figure 11). As in the case of game fish at Big Bear Lake, size frequencies of the samples weighed and measured have been plotted for suckers (Figure 12). In 1940 the sucker population was composed of fish from the 1933 to the 1937 year classes inclusive. The 1938 year class was perhaps present in small numbers but no scale samples were secured from 2-year-old suckers in 1940. The graph indicates that if fish from the 1938 year class were captured at all, it was in very limited

* Because of their detailed nature, these are included only in the file copy at the Institute.

Figure 11

Average actual total lengths in inches and mm. of different age groups of suckers from 36 lakes (pencil line) in Michigan. Curve based on determinations made from 847 specimens. Comparisons made for 4 lakes.



numbers. In 1941 practically the whole sucker population was composed of fish from the 1934 to 1938 year classes. In 1941 the 1938 year class formed a significant part of the population, while the 1933 year class has virtually disappeared, judging both from the position of the 7-year-olds on the graph, and also the fact that no scales have been secured from 8-year-old suckers in Big Bear Lake.

The investigation on Big Bear Lake will be continued in 1942. More detailed observations on the spawning of the sucker will be made. By excluding fishermen from perhaps 200 to 300 feet of the gravel shoal the suckers would be enabled to spawn freely, and their behavior more closely followed. Ovaries from ripe females will be secured in order to determine their fecundity. In the protected area it should be possible to obtain eggs and fry. Stomachs from blunt-nosed minnows will be saved so as to learn whether or not their predation of sucker eggs is large. In following the spawning of the centrarchid species, more time will be devoted to learning something of the total natural reproduction in the lake. Secondly, careful observations will be made on the behavior of the smallmouth in particular. Ovaries and eggs of this species will be secured for counts. The intensive creel census will be continued. The netting operations will, if possible, be repeated, so that various matters, such as the dominance of the 1938 year class may be followed for one more year. More stomachs of game species and suckers will be secured. During the late fall or early winter of 1943 the sucker population will be materially reduced by netting and the effects of this reduction upon the whole population, and the yearly catch, will be followed closely for the next several years.

Conclusions

1. There is a spring spawning run of suckers in Big Bear Lake. In 1941 the run took place the first week of May. The fish did not come inshore till the water temperature had reached 52°F. The success of the suckers' spawning can, at present, be judged only from the adult population in the lake which is very large in comparison with populations of other species. Since suckers have not been stocked in the lake they must spawn successfully on the gravel shoals marked 1 and 2, shown on the map (Figure 1).

2. All game species in the lake reproduce naturally to an extent that makes the value of further stocking with young fish questionable.

3. The population estimates are thought to be fairly reliable and the change in the relative and total abundance of the various species is thought to be caused primarily by a relatively greater increase in the adult populations of pumpkinseeds and bluegills.

4. Growth of game species is at least average. The 1938 year class is the dominant group in smallmouth, bluegills, largemouth, and probably also in pumpkinseed and rock bass.

5. Growth of the sucker in Big Bear Lake is perhaps somewhat below average as judged from a limited amount of comparative material. Possibly the slower growth is correlated with the large sucker population present.

6. Results from the creel census indicate that in spite of a greater fishing pressure, the fishing was better in 1941 than it was in 1940. This improvement, and perhaps an even greater improvement, might have been expected in view of the greater crop of legal fish available to the angler. The crop of pan fish (bluegills, pumpkinseeds, and rock bass) is not fully utilized, most of the fishing effort being devoted

to the capture of bass. The fish removed in 1940 were readily replaced in 1941, and the indication is that angling pressure has had but little effect, if any, on the game fish population of the lake.

INSTITUTE FOR FISHERIES RESEARCH

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