

Original: Fish Division
cc: Institute for Fisheries Research
Education-Game

Mr. Leland R. Anderson
INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN
Mr. Ralph Marks
Mr. Harold Hughes
Mr. R. Fortney

ALBERT S. HAZZARD, PH.D.
DIRECTOR

July 9, 1948

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

Report No. 1185

STUDIES OF WINTERKILL IN LAKES OF SOUTHERN MICHIGAN, 1948

by

L. R. Andersen

This report is a compilation of data taken in the field relative to the study of oxygen depletion and subsequent mortalities (winterkills) on some southern Michigan lakes during the winter and spring of 1948.

Winterkill develops on certain lakes when these lakes are covered for an extended period by a thick layer of snow or a combination of snow and cloudy ice. This layer of snow over the ice shuts out sunlight and thereby reduces the photosynthetic production of oxygen by aquatic plants. The normal processes of oxygen consumption in the water reduces the dissolved oxygen to a very low^{or} vanishing point.

Some early observations of winterkill on Michigan Lakes are summarized in Institute reports 146 and 151; more detailed accounts are found in reports 853 and 853a by Greenbank, and Report 1014 by Cooper and Washburn.

The lakes on which water analysis were made, their geographic locations, and the location of the water analyses stations on each are shown in Table 1.

Table 1.--Lakes in southern Michigan where winter water analyses were made in 1948.

Name of lake	County	Town	Range	Sections	Location where samples were taken
First Sister	Washtenaw	2S	5E	25	Center of lake
Green	Washtenaw	1S	3E	21,22,27,28	Near center of lake
Sugarloaf	Washtenaw	1S	3E	31,32	Near center of lake
West	Washtenaw	1S	4E	30	N.E. center of lake
Batteese	Jackson	1S	1E	9	Near center of lake
Merkle	Jackson	1S	2E	14,15	Near center of lake
Pleasant	Jackson	1S	1E	7,8,16,17	East center of lake
Goose	Jackson	2S	1,2E	24,25,19,30	Various points
Grass	Jackson	2S	2E	29,32	Near center of lake
Haven Hill	Oakland	3N	8E	19	Near center at outlet
Lower Straits	Oakland	2N	8E	11,12,13,14	Near center of lake
Long	Oakland	2,3N	8E	1,2,3,5,36	Near center of lake
Huntoon	Oakland	3N	9E	8,9	Near center of lake
Mud	Oakland	1N	8E	3,10	North central part of lake
Robinson	Oakland	3N	8E	2	East central part of lake
Richmond	Oakland	3N	9E	16	Near center of lake
Nepessing	Lapeer	7N	9E	14	South central part of lake

on
At first analyses were made only a few representative lakes in Washtenaw and Jackson counties, but as the season progressed reports were received that other lakes were suspected of low oxygen content, or that fish were showing signs of distress, and in some cases mortality had already occurred, so analyses were carried out on some of them also.

During the period from January 15 to February 18, 1948, some of the lakes were visited four times, others only once, depending on their suspected rate of oxygen decrease. On each occasion observations were made regarding winterkill, thickness of ice, snow cover, weather conditions, and amount of winter fishing carried on. Water samples were taken at various depths (usually at a point of maximum depth).

The dissolved oxygen was determined by the unmodified Winkler method. The water samples were collected with a covered-can type sampler and fixed in the field; titrations were made later in the laboratory.

Most of the lakes are uniformly shallow, and it is assumed that one collection station at a point of maximum depth would be representative for each.

Ice cover on all of the lakes tested was about the same. Freeze-up occurred near the middle of December. Snow and sleet on New Years day produced a cloudy layer from two to three inches deep over the ice surface. The ice cover varied from eight to twelve inches on January 15 to eighteen to twenty inches on February 18. The snow cover over this period varied from one-half inch to two or three inches. On or about February 18 a general thaw occurred, at which time most of the snow disappeared and large amounts of snow-water seeped through the ice. Though snow again covered the ice for about two weeks, no further water analyses were made.

1. First Sister Lake

At 10:00 a.m. on January 15, 1948, water samples were taken at the approximate center of the lake in depths ranging up to fifteen feet. The air temperature was 10° F., weather cloudy with snow flurries and a strong south wind. The maximum depth of the lake was eighteen feet with a pulpy peat bottom. At noon on January 30 another series of water samples was taken at the same location in depths ranging from one to eleven feet. The air temperature was 12° F., the weather moderately cloudy. Oxygen content had dropped to a dangerous low of 1.4 p.p.m. at a depth of one foot. At 4:00 p.m. on February 6, a third series of water samples was taken ranging in depth from two to twelve feet. The air temperature was 25° F., and the weather clear. Oxygen content had dropped to 0.3 p.p.m. at twenty inches (immediately under ice surface). The water had a faint odor of decayed vegetation. About two dozen minnows which showed signs of distress were observed to rise into the hole; a dozen of these were easily scooped out onto the ice with cupped hands. They included mudminnows, golden shiners and western lake chub suckers. A hole out in the ice about fifteen feet from the west shore over a depth of five feet emitted a strong odor of decayed vegetable matter.

No further oxygen analyses were made and on March 22 when Institute personnel visited this lake they found it partly free of ice, but there was no evidence of a fish mortality. One dead "shiner" was the only fish observed. Further observations were made on March 24, at which time most of the ice had disappeared. There was no sign of a "winterkill." It is possible that had a mortality occurred on the minnow population prior to the breakup that the fish had sunk to the bottom and decayed

beyond a state of bouyancy. The patented windmill that supplied air to this lake in previous years was not working this season. Previous winterkills are believed to have largely eliminated most of the game fish from this private lake.

2. Green (Stofer's) Lake

At 11:30 a.m. on January 15, water samples were taken at the approximate center of the lake in depths ranging from one to six feet. The air temperature was 16° F; the weather, cloudy with snow flurries and a strong south wind. The maximum depth at this point was twelve feet. The water immediately under the ice approached near saturation of dissolved oxygen. At 4:30 p.m. on January 30 another series of water samples was taken at approximately the same location only over a maximum depth of seven feet. The air temperature was 20° F. and the weather moderately cloudy. At 10:30 a.m. on February 6, a third series of water samples was taken at the same location ranging in depth from twenty inches to seven feet. In the second and third instances there was still ample oxygen, but it had diminished rapidly. At 11:00 a.m. on February 18, a fourth and final series of water samples was taken over a maximum depth of ten feet. A sample taken at twenty inches contained 1.9 p.p.m. of oxygen, whereas at seven feet there was not a trace. The air temperature was 40° F; the weather moderately cloudy and cool. A thaw occurred at this time so the ice was covered with slush, and aerated snow water was flowing through the fractures in the ice. Observations were made through two holes in the ice at the inlet and no distressed or dead fish were observed. There was very little winter fishing done on this lake.

Dr. Otto K. Engelke phoned the Institute on March 29 to report that he had visited Green Lake within the past week, and had observed only a few dozen dead fish after examining much of the shoreline. Species observed were bluegills, yellow perch, mud pickerel and chub suckers, but no bass. It is quite obvious from this report that the winterkill in this lake was very light and of no practical importance.

3. West Lake

At 10:45 a.m. on January 15, 1948, a series of water samples was taken near the northeast center of the lake over a maximum depth of five feet. The air temperature was 14° F; the weather, snow flurries and a strong south wind. The oxygen content of the water was high. At 9:30 a.m. on February 6, a water sample was taken at the same approximate location. The air temperature was 17° F. and the weather clear. Oxygen content had depreciated considerably, but had not reached a danger point. At 4:00 p.m. on February 17, the last water sample was taken. The air temperature registered 40° F; the weather was moderately cloudy. Due to thawing weather conditions, the ice was covered with water and slush. Aerated snow water was flowing rapidly through the ice and thus eliminating any lack of dissolved oxygen.

Winter fishing was not heavy on this lake, but the fishermen who speared northern pike here were having fair success. They had observed no occurrence of fish distress or mortality. It is doubtful whether any winterkill occurred here at all. None is reported as of this date. Bad road conditions made it impossible to carry out further investigations.

4. Batteese Lake

At 2:00 p.m. on January 15, a series of water samples was taken near the center of the lake where the maximum depth is fifteen feet. Samples

were taken from one to eleven feet. The oxygen content ranged from 7.1 to 3.0 p.p.m. The air temperature was 19° F; the weather cloudy with a strong wind from the south. At 2:30 p.m. on January 30, a similar series was taken in depths ranging from one and a half to eleven and a half feet. The oxygen content had fallen off considerably. The air temperature was 20° F., and the weather cloudy. A third series of water samples was taken at 12:30 a.m. on February 6, 1948. Examination showed that the dissolved oxygen content was reaching a dangerous low, ranging from 0.9 to 0.0 p.p.m. in two to twelve feet of water. The last series was taken at 12:30 a.m. on February 18 at the same location. Due to thawing conditions the oxygen content under the ice had come up to 3.2 p.p.m. The air temperature was 49° F; the weather was moderately cloudy.

Winter fishing was moderate. There were about 30 spearing shanties present. Fishing was reported fair. No fish mortality was reported. On March 22, Institute personnel made observations on Batteese, at which time most of the ice was gone, yet no fish mortality was observed. Residents reported good fishing during the 1947 season.

5. Merkle Lake

At 1:00 p.m. on January 15, a series of water samples was taken near the center of the lake in depths ranging from one to six feet at a maximum depth of seven to nine feet. The air temperature was 17° F; the weather, snow flurries and a strong north wind. At 3:00 p.m. on January 30, a second series of water samples was taken at the same location. Oxygen content had fallen from 5.2 to 2.3 immediately beneath the ice. The air temperature was 19° F; the weather was cloudy. The third series was taken at 11:15 a.m. on February 6. The air

temperature was 22° F. and the weather was clear. Very little fishing is done here during the winter and that had fallen off to nothing at this date. A local resident claimed that the perch had quit biting. The surface water oxygen contained 1.3 p.p.m. of dissolved oxygen. The last series was taken at 11:00 a.m. on February 18, and though the weather was warm, there was no evidence of excess water on the ice as found on the other lakes at this date. Water analysis showed a range of 0.8 to 0.1 p.p.m. of dissolved oxygen in depths ranging from twenty inches to seven feet.

Institute personnel making observations on March 22, found that about half the ice had disappeared and there was no trace of dead fish; no winterkill had been reported as of this date.

6. Goose Lake

At 3:00 p.m. on January 15, a sample of the water was taken from the north central part of this shallow lake (about 80 percent of the lake has a depth less than five feet). The air temperature was 23° F; the weather, snow flurries with a strong south wind. Dissolved oxygen in water was 10.5 p.p.m. A second water sample was taken at 2:00 p.m. on January 30 in the northwest end of the lake at a depth of two feet. The amount of dissolved oxygen had dropped about 5 p.p.m. The air temperature was 17° F; the weather was cloudy. At 2:45 p.m. on February 6 a third sample was taken at a location over four feet of water just off the most prominent southern point. The oxygen content was still comparatively high at 4.7 p.p.m. The air temperature was 25° F. and the weather, clear. The last sample was taken at 1:15 p.m. on February 18 at the northwest end of the lake. The amount of dissolved oxygen at two feet had raised to 5.5 p.p.m. The air temperature was

46° F; the weather moderately cloudy with a south wind. Large amounts of snow water were flowing through the ice at this time.

Winter fishing was light. Some perch and bluegills were caught up until the time the last analysis was taken. Fish had showed no signs of distress at any time during the winter. This lake was checked by Institute personnel on March 22, at which time only the north shore line was free of ice; no dead fish were observed or reported. It is believed that a winterkill did not occur here this year.

7. Grass Lake

On February 6, 1948, it was reported that fish in Grass Lake were showing signs of distress (coming to the top for air when holes were opened in the ice). So at 3:30 p.m. of that date a sample of the water near the center of this large shallow lake was taken. The maximum depth at this point was four feet. The air temperature was 25° F. and the weather clear. Water analyses showed that the amount of dissolved oxygen was only 0.7 p.p.m. This lake had been fished extensively during January and good catches of yellow perch and bluegills were made. A few fishermen contacted on February 6 were still catching fish, but they reported that fishing had fallen off considerably, but no signs of distress were observed among the fish.

A second water sample was taken at the same location at 2:00 p.m. on February 18. Due to thawing weather, large amounts of aerated snow water were flowing through cracks in the ice or down the bulrush stalks. The oxygen content at this time was 4.7 p.p.m. immediately below the ice and at the bottom (4 feet), 0.6 p.p.m. The few fishermen on the lake were taking no fish. Numerous small bullheads and some small bluegills were

observed on the ice around fishing holes where fishermen had undoubtedly placed them. The air temperature was 46° F; the weather was cloudy.

An investigation of the small outlet at the southeast end of the lake was made on February 18. Numerous dead fish were found stranded in the bulrushes and reeds; they included numerous large bowfin, some bluegills, yellow perch, bullheads, rock bass and mud pickerel. Live fish also to be observed in this area but showing signs of distress were: bowfin, yellow perch, bullheads, mud pickerel and black nosed shiners. (These were easily picked up with a scap net). A local minnow dealer who had fished this lake on February 10 reported that his large shiner decoy had died within an hour and a half, and that numerous ^{small} bullheads which appeared in the spearing hole showed signs of distress.

Institute personnel checking Grass Lake on March 22 and 23 reported the lake to be almost free of ice. A moderately heavy kill was evident. Numerous sea gulls and blue bill ducks were present. The gulls were evidently feeding heavily on dead fish.

A survey of the winterkill was made by Institute personnel on March 24. A general idea as to the intensity of the kill was gathered by measuring the length of shore line on which the fish were concentrated, and counting the number of each species in representative 50-foot samples. The following formula was used in determining the number of fish washed up on shore:

$$TN = \frac{L}{50} \times N$$

where: TN is the total number, L is the total length of shore line where fish were found; 50 is the length of the representative sample and N is the number of fish of a given species.

Other factors that enter into the estimate of winterkill intensity are: (1) the number of days the lake has been free of ice prior to the fish count; (2) the number of fish that may be caught in submergent and off shore emergent weeds; (3) fish that have decayed beyond the stage of bouyancy and may be laying on the bottem; and (4) the number of gulls that may have been feeding on dead fish before the count was made.

The fish counted on Grass Lake are listed by species in Table 3. About 200 sea gulls and 3,000 ducks were observed on the lake between the time that the ice went out and the fish counts were made. Live fish (bass, bluegills, bowfin and mud pikeperch) were observed at the time the count was made. Some of these were in a very weak condition. It is believed that the kill was rather extensive but only partial. A collection of scale samples was made from a representative sample of the dead fish found along the shores. These will be used for studies of fish growth and compared with similar samples taken in the past or after future winterkills, should they occur again. This lake is certainly in the category of those subject to frequent winterkills.

8. Haven Hill Lake

On February 16, 1948, a fish mortality was reported by Mr. C. Harris of the Michigan Parks Division to have occurred on this lake. At 10:00 a.m. on February 17 the author made an analysis of the water at two stations (near the middle and at the outlet dam). The air temperature was 39° F; the weather was clear and warm. The first sample of water was taken from a two-foot square hole which had been cut in the ice the previous day. The water at twenty inches (immediately below the ice) contained 11.1 p.p.m. of dissolved oxygen. This concentration of oxygen was probably due to sunlight and thawing conditions on the previous day. There were only

Table 3.--Lakes checked on which winterkill occurred and the estimated numbers of dead

fish of each species found.

Lake and county	Bluegill	Pumpkin-seed	Large-mouth bass	Small-mouth bass	Yellow perch	Black crappie	Long-eared sunfish	Warmouth bass	Rock bass	Bull-heads	White sucker	Lake chub-sucker	Northern pike	Grass pickerel	Golden shiner	Bowfin and carp	Total
Grass Lake Jackson Co.	6,551	108	772	...	413	39	...	259	332	245	...	408	...	187	11	105	9,430
Leeke Lake Jackson Co.	common	...	...	...	scarce	...	...	scarce	...	abundant	...	common	...	scarce	...	scarce	heavy
Concord Mill Pond Jackson Co.	1,330	1	90	...	...	...	...	10	...	50	...	...	...	...	1	1	1,483
Green Lake Washtenaw Co.	scarce	...	...	...	scarce	...	...	...	...	...	...	scarce	...	scarce	...	...	light
First Sister L. Washtenaw Co.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	scarce	...	light
Legget's Lake Oakland Co.	scarce	scarce	scarce	...	scarce	...	...	...	...	...	...	...	...	scarce	...	...	light
Haven Hill Lake Oakland Co.	scarce	scarce	...	...	scarce	...	...	...	...	scarce	...	scarce	...	scarce	...	...	light
Little Muskrat L. Kent Co.	scarce	...	...	...	...	...	...	...	scarce	...	...	...	scarce	...	...	...	light
Pickerel Lake Kent Co.	scarce	scarce	...	...	common	...	...	...	...	common	...	abundant	...	scarce	abundant	...	medium heavy
Duck Lake Montcalm Co.	6,300	700	480	...	530	10	...	10	...	250	10	80	30	20	10	20	7,850
Tamarack Lake Montcalm Co.	250,525	50,325	2,039	...	13,870	15	...	...	...	6,985	...	10	...	15	...	...	323,794
Mud Lake Washtenaw Co.	scarce	...	...	...	...	...	...	scarce	scarce	...	...	...	...	...	...	...	light
Belas Lake [↓] Cass Co.	common(?)	...	common(?)	...	abundant	scarce(?)	...	...	...	...	...	...	...	scarce(?)	...	...	heavy
Moon Lake [↓] Shiawassee Co.	common	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	heavy
North Twin Cheboygan Co.	336	250	...	2,600	13,000	...	...	...	...	1,200	...	...	...	...	...	...	heavy
Crooked Lake Missaukee Co.	abundant	common	...	...	common	...	...	...	few-	few	rare	...	rare	...	...	...	heavy
Bertha Shiawassee Co.	2,293	...	337	...	1,778	...	173	...	...	71	1	...	...	...	...	...	heavy

[↓] Observations made while ice was still on lake

0.2 p.p.m. of oxygen at seven feet, and none at 12 feet. A sample taken under the ice a hundred yards away contained only 0.6 p.p.m. of oxygen. The samples near the outlet were similar in intensity -- 0.7 p.p.m. under the ice and none at the bottom. Observations at the lake's inlet showed only a small flow of water, mainly from a few small springs. No dead or distressed fish were found here. There was a light flow of water over the dam and the odor of hydrogen sulphide was evident. There were no signs of dead fish in the small area of open water above the dam, but a few dead fish were found entangled in the grass and brush below the dam; these undoubtedly had washed over it. Species found dead were bluegills, yellow perch, bullheads, mud pike, minnows and frogs. Northern pike are reported to be plentiful in this lake, yet none were observed dead.

Further observations were made here by Institute personnel on March 26. The winterkill was considered light as there were only a few hundred dead bluegills and a couple dozen dead pumpkinseed sunfish and bullheads swept up on a quarter mile of the windward shore. The ice went out of this lake on March 24 and 25, 1948. This amount of mortality is considered of little importance on the effect of the present fish population.

The following lakes in Oakland County have been subjected to winterkill in previous years, therefore the water was analyzed for amount of oxygen in this critical period of heavy ice and snow cover.

1. Huntoon Lake

At 11:00 a.m. on February 11, 1948, samples of water were taken from the approximate center of this lake where the maximum depth was eleven feet. The air temperature was 23° F., and the weather cloudy. The dissolved oxygen content was low, but distributed to the bottom. It is believed that it was not yet insufficient to maintain fish life. There were no signs of winter fishing.

On March 25, Mr. H. Hughes, District Fisheries Supervisor, conducted observations on this lake, but saw no signs of a fish mortality.

2. Long Lake

At 11:45 a.m. on February 11, samples of water were taken near the center of this shallow lake where the maximum depth was seven feet. The air temperature was 23° F. and the weather cloudy. Dissolved oxygen was plentiful all the way to the bottom. There were numerous spearing shanties scattered around the lake above the five-foot contour.

On March 26, Institute personnel conducted observations on this lake and found no indications of winterkill. The ice had gone out two days prior to the examination.

3. Lower Straits Lake

1958
At 12:30 a.m. on February 11, samples of water were taken near the center of this lake where the maximum depth was eight feet. The air temperature was 22° F. and the weather cloudy. Dissolved oxygen was plentiful from the top to the bottom. There were numerous spearing shanties present and there was evidence of considerable winter fishing. No winterkill has been observed or reported.

4. Mud Lake (Walled Lake drainage)

At 2:00 p.m. on February 11, water samples were taken from the north central part of this shallow, weedy lake where the maximum depth was eight feet. The air temperature was 27° F. and the weather cloudy. Analysis showed that there was only 0.4 p.p.m. of dissolved oxygen under the ice and none at seven feet. If this amount of dissolved oxygen prevailed over the entire lake the conditions would be very unsatisfactory for the maintenance of fish life. No winterkill has been observed or

reported as of this date. It is possible that the fish may have moved out into Walled Lake through the outlet channel.

5. Robinsons Lake

At 3:10 p.m. on February 11, a water sample was taken at the east central part of the lake where the maximum depth is five feet. Analysis showed no oxygen present in the water beneath eighteen inches of ice. The air temperature was 26° F. and the weather cloudy. This very shallow lake has been subject to severe winterkill in the past. Bullheads are the only fish reported to be present. It is doubtful whether anyone ever attempts to fish this body of water. No reports have been received of a fish mortality this season.

6. Richmond Lake

At 6:00 p.m. on February 11, a water sample was taken near the center of this small lake. The air temperature was 22° F. and the weather cloudy. The amount of dissolved oxygen present immediately under the ice was considered insufficient for most game species of fish. Very little is known of the present fish population. No winterkill has been reported as of this date.

7. Nepessing Lake, Lapeer County

A series of water samples for analysis were taken from this lake at the request of the District Fisheries Supervisor. An extensive summer mortality occurred in this large lake in June 1947.

At 4:45 p.m. on February 11, 1948, water samples were taken in the south central part of the lake where the maximum depth was twelve feet. The air temperature was 26° F. and the weather cloudy. Analysis showed dissolved oxygen ranging from 9.4 to 7.3 p.p.m. in depths of one and a half to eleven and a half feet. There was evidence of extensive winter

fishing on this lake. No winterkill or distressed fish were observed and no reports of any have been received. Summer fishing was reported to be good in 1947.

Some of the other lakes in lower Michigan and their location, which were reported to have, or are subject to, winterkill are listed below, and these are briefly discussed in the following pages.

1. Belas Lake, T6S, R14W, S. 13 and 24, Cass County
2. Munro Lake, T37N, R3W, Sec. 4, 9, and 16, Cheboygan County
3. North Twin Lake, T35N, R2W, Sec. 21, Cheboygan County
4. Cotton Lake, T3S, R7W, Sec. 18, Calhoun County
5. Mud Lake, T1S, R6W, Sec. 14, Calhoun County
6. Rose Lake, T5S, R1W, Sec. 26, Clinton County
7. Little Pine Lake, T2N, R9W, Sec. 13, 24, Barry County
8. Gillette Lake, T2E, R2S, Sec. 27, 28, 33, 34, Jackson County
9. Leeke Lake, T1S, R2E, Sec. 13, Jackson County
10. Pond Lily Lake, T2S, R2E, Sec. 12, Jackson County
11. Concord Mill Pond, T3S, R3W, Sec. 26, 27, Jackson County
12. Pickerel Lake, T8N, R10W, Sec. 14, Kent County
13. Little Muskrat Lake, T8N, R9W, Sec. 4, 8, 9, Kent County
14. Tamarack Lake, T12N, R8W, Sec. 8 and 10, Montcalm County
15. Duck Lake, T10N, R5W, Sec. 10, 11 and 15, Montcalm County
16. Big Mud Lake, T10N, R5W, Sec. 8 and 9, Montcalm County
17. Hisington Lake, T10N, R6W, Sec. 30, Montcalm County
18. McBride's Lake, T9N, R7W, Sec. 3, Montcalm County
19. Crooked Lake, T22N, R8W, Sec. 4, Missaukee County
20. Jac Jungle Bayou, T7N, R15W, Sec. 1 (Bayou off Grand River), Ottawa County

21. O'Brien Lake, T7N, R13W, Sec. 25, Ottawa County
22. Sullivan Lake, T7N, R13W, Sec. 25, Ottawa County
23. Leggett's Lake (part of Oakland Lake) T3N, R9E, Sec. 2, Oakland County
24. Moon Lake, T5N, R1E, Sec. 21 and 22, Shiawassee County
25. Bertha Lake, T18N, R5W, Sec. 22, Clare County
26. Mud Lake, T1S, R3E, Sec. 31, Washtenaw County
27. Long Lake, T22N, R9W, Sec. 2, Wexford County

Certain of these lakes were put under special fishing regulations during part of the past winter, allowing fishing through the ice for any species of fish with hook and line, hand nets, or spear, namely: Cotton and Mud Lakes in Calhoun County; Belas Lake in Cass County; Leeke Lake in Jackson County; Crooked Lake in Missaukee County, Duck, Big Mud and Hisington lakes in Montcalm County; Moon Lake in Shiawassee County and Long Lake in Wexford County. The object of this regulation was to crop distressed fish before a winterkill occurred.

1. Belas Lake

On February 3, 1948, Mr. Troy Yoder, District Fisheries Biologist at Wolf Lake, examined this lake for possible winterkill. A small spring inlet about a half mile long was littered with thousands of dead perch from its mouth to the source. There were also a few dead small bass, bluegills, mud pike and minnows. Local residents reported that in years past the shores were littered with bass and bluegills after the ice went out. There was no evidence of fish mortality in the lake proper (dark water made observation impossible beyond one foot).

On February 12, an analysis of the water was made at a six-foot depth and found it to contain 0.2 p.p.m. of dissolved oxygen. Numerous

perch were found dead, and bluegills showed signs of distress by rising in holes out in the ice. These facts were presented to Mr. A. B. Cook, Assistant Chief of the Fish Division, and the lake was added to the list of lakes put on special winter fishing regulations.

On February 15, 16, and 17 large crappies were being taken and small crappies were seen dying.

On February 18, further water analyses showed 2 p.p.m. of dissolved oxygen (this was after a thaw for several days at which time all the snow had melted). The remaining living fish were again active and feeding.

2. Munro Lake

On March 13, 1948, Walter R. Crowe, District Fisheries Biologist, accompanied by Conservation Officer Norman Auldrieh visited this lake which had been reported by fishermen to have numerous dead fish laying on the bottom. The lake was checked at several points for dissolved oxygen and found that it was practically gone. It ranged from 0.45 p.p.m. at the surface to 0.2 p.p.m. at the bottom (9 feet). Crowe reports that a complete winterkill very probably occurred on this lake. Winter fishing is very light.

3. North Twin Lake

An evaluation of the extent of winterkill was made by Mr. Walter Crowe and Mr. J. Skinner on April 12. Estimates of the numbers of dead fish present are shown in Table 3. Gulls were reported consuming fish in considerable numbers at the time the observations were made, and the estimate given should be considered as an absolute minimum. A small trap net set overnight (April 21-22) took no fish, and no live fish were seen. The kill is thought to have been virtually complete.

4 and 5. Cotton and Mud lakes, Calheun County

These lakes were among the first waters to be opened to removal of fish with dip nets or spear in mid-February, by which time the imminence of a winterkill became apparent. Results of this emergency harvest are not known, and the extent of the winterkill which actually occurred was not determined, insofar as can be determined by an examination of the Institute files.

6. Rose Lake

A winterkill was reported at this lake on February 12, arising from the comment of a fisherman that fish appeared to be in distress. An inspection by Mr. Russell Patterson, assistant in charge at the Rose Lake Wildlife Station, and Conservation Officer Goff at St. Johns, revealed no dead fish. A three-day thaw at this time was thought to have eliminated the danger of a winterkill this year.

7. Little Pine Lake

A kill of bullheads and minnows was observed in this lake on February 20, 1948, and investigated by Mr. Lyle Newton and Mr. Clifford Fuller. The extent of the kill is not known. The lake is not believed to contain a worthwhile population of game species.

8. Gillette Lake

On March 22, Institute personnel made observations on this lake, which was only half free of ice. No evidence of winterkill could be found on the shores or in the area of open water. No further reports have been received.

9. Leeke Lake

On February 4, 1948, a reported winterkill was investigated by R. G. Fortney, District Fisheries Supervisor at Hastings. This is a small lake in the eastern part of Jackson County. Mr. Fortney reported

the "kill" as light and consisting primarily of chub suckers, mud pike, pumpkinseed sunfish and bowfin. This lake was opened under special regulations to harvest as many fish as possible before an extensive winterkill occurred. This lake gets a medium amount of fishing both during the summer and winter.

On March 29, Conservation Officer Don Richards and Institute personnel carried out further investigations. Observations were limited to two hundred feet of shore area because of high water. It was concluded that the winterkill was heavy. A summary of the intensity of the kill is found in Table 3 of this report.

10. Pond Lily Lake

On March 22, Institute personnel making observations on a number of lakes suspected of winterkill found no dead fish on this lake. It was only partially free of ice. No further reports have been received.

11. Concord Mill Pond

Upon a report of a fish mortality by Mr. Gerald Beisel of Concord, Institute personnel checked on this pond which lies in the drainage of the North Branch of the Kalamazoo River. A concentration of dead fish was found near the outlet and others were scattered lightly along the shore above the railroad bridge. A summary of species found is given in Table 3. The northern pike population is reported as low, none having been caught or observed during the entire winter. A few were reported caught in the summer of 1947. A considerable number of dead fish were reported to have washed over the outlet dam. It is considered that the winterkill in this instance was serious but not complete.

12. Pickereel Lake

This is a small private lake of about fifteen acres which has been subjected to winterkill in past years. Observations were made by Institute personnel on March 31, 1948. Many dead fish in an advanced stage of decay were found along 1,000 feet of the southern shore; the greatest concentration being near the outlet. A small earthen dam at the outlet raises the water about two feet above normal. High water and extreme decay made counts impossible, but the intensity of kill was estimated and summarized in Table 3. The winterkill in this lake is considered medium to heavy. Live fish were observed in the outlet stream and in the flooded marshy areas.

13. Little Muskrat Lake (designated as Muskrat Lake on the county map).

Winterkill has occurred on this lake in previous years. On March 31 observations were made by Institute personnel along 1,500 feet of the western shore. Though the water was extremely high, hindering observation, very few fish were found. The numbers are summarized in Table 3. The mortality is considered light and of little consequence. Live fish (probably northern pike) were observed in the flooded marsh area.

14. Tamarack Lake (near Lake View)

Mr. Claude Lydell, District Fisheries Supervisor, recommended that observations be made on this lake for presence of a winterkill. Winterkill has occurred here in previous years. On April 1, 1948, Institute personnel accompanied by Mr. Lydell made observations along one and a half miles of the east and south shoreline. This lake had been practically free of ice one week prior to the survey. The wind had been predominantly from the north, and sea gulls and ducks were observed and reported numerous since the ice went out. There was a light concentration

of dead fish along 2,500 feet of the southwest shore and a heavy concentration along 2,300 feet of the south shore. The heavy concentration of fish was mixed in a wash-up of crushed ice, thus making accurate counts rather difficult. An estimate of the number of dead fish along the south and westerly shores was made by the same method used on Grass Lake, Jackson County, only fewer counts were made as the time was a limiting factor. A summary of the total number of each species counted along the shores is given in Table 3. Though the winterkill on this lake is considered very heavy, it was not complete. No northern pike were observed along the shore, but it was reported that violators had been caught spearing pike in the lakes a few days previous to the survey. Scale samples were taken from a representative sample of the species found along the shore.

15. Duck Lake

Mr. Claude Lydell, in a letter to Regional Fisheries Supervisor R. S. Marks of Jackson, on February 5, 1948, relates that after reports of a fish mortality on Duck Lake he made some observations on February 2, and found no dead fish; but on talking with fishermen, found that fish had concentrated at the west side of the lake (near outlet), and with ice and snow conditions such as they were a winterkill was imminent. (Decoy minnows used in spearing shanties lived only a few minutes after being put into the water).

This lake was then added to the list of lakes opened to special regulations to harvest stricken fish before a winterkill occurred. Winterkill occurred here in 1945 and ^{the lake} was replanted in 1946 with bass and bluegills.

On April 1, 1948, Institute personnel accompanied by Mr. Lydell made a survey of a reported winterkill on this lake. Observations were made along about two and a half miles of shore line, and some open water was covered with a boat. The largest concentration of dead fish was found along the southwest shore line near the outlet and along the west shore of the island opposite the outlet. The total area of concentration was about 1,000 feet. Very few fish were observed in the submerged weeds or on the open bottom. The lake became free of ice on March 30, but had some open water for about one week previously. Estimates as to the number of fish found along the shore were calculated similarly to those found on Grass and Tamarack lakes. A summary of the total number of species counted is found in Table 3. The total of about 8,000 fish is considered to be about the full extent of the kill. Residents on the lake report that the kill of northern pike is comparatively light, and that common suckers and golden shiners have been caught since the spring break-up occurred; therefore we conclude that the winterkill is, though significant, only partial.

16. Mud Lake (Montcalm County)

In the same letter to Mr. Marks, Lydell stated to have observed worse conditions on Mud Lake than he found at Duck Lake. Though no dead fish were observed on February 2, large numbers of small distressed fish were observed rising in spearing holes near the inlet. This lake also winterkilled in 1945 and was restocked in 1946. Mud Lake was also put on the list of lakes open to special fishing regulations this winter. No report has yet been received as to the amount of fish that were harvested under these regulations, or has there been any reports of a winterkill. Roads in the vicinity were impassable at the time (April 1) a survey was made on Duck Lake.

We were able to check on Little Mud Lake which is in the same drainage as Mud Lake and tied into same by a small creek. Some ice was still present and the water was too high to make suitable observations. No dead fish were observed along the west shore of this lake.

17. Hisington Lake

This small lake has been subject to severe winterkill in past seasons and was thus added to the list of lakes put under special winter fishing regulations. No report was received as to the outcome of this experiment and no reports have been received of a winterkill this season. This lake was not checked in the April 1 survey due to bad road conditions.

18. McBride's Lake

Mr. C. Glen McBride of Rockford reported a severe winterkill by letter to the Conservation Department, on April 13. It was investigated by Conservation Officer Earl Bigelow on April 14. He reported a "bad kill," but did not mention the species affected other than to indicate that "even.....a large number of bullheads" were found along the shore. Mr. McBride states that there have been no such kills for nearly thirty-five years in this particular lake.

19. Crooked Lake

A reported winterkill was investigated by Mr. E. Basford, Mr. S. Lievense and Conservation Officer R. Price on March 15. A very considerable number of dead fish of several species were seen. Dissolved oxygen values at three widely separated points in the lake varied from 0.1 to 0.7 p.p.m. Mr. Lievense returned to the lake on April 11, and made an estimate of the relative abundance of dead fish of the several species seen. These are listed in Table 3. The loss was thought to be moderately heavy, but not complete.

20. Jac Jungle Bayou

Bluegills, crappies and bass were observed suffering or dead on January 28, by Mr. Wm. Zolund. The extent of the damage was not determined. A foul odor was reported from several holes which were cut through the ice at various points in the bayou.

21. O'Brien Lake

Mr. John Kroll, Conservation Officer for Kent County, reported a winterkill on February 9. The species affected were mud pickerel, bullheads, perch, "sunfish," and chub suckers, all of small size. An estimate of total numbers killed was not made, but the kill was thought to be heavy. A previous loss had occurred during the winter of 1945-46.

22. Sullivan Lake

An unspecified number of small fish of undesignated species (presumably bullheads, mud pickerel and sunfish) were reported suffering or dead by Mr. John Kroll on February 9. This is a small private lake. A winterkill was reported previously in 1945.

23. Leggett's Lake (part of Oakland Lake)

This is a shallow, weedy lake and has been suspected of winterkill. On March 26, 1948, Institute personnel in making observations here found an obvious but light winterkill, which should have no serious effect on fishing conditions. Approximately 200 dead fish were counted where they were concentrated along 100 yards of shore line. A summary of intensity of species counted is found in Table 3.

24. Moon Lake

Mr. Harold Hughes, District Fisheries Supervisor, relates in a letter to Mr. R. S. Marks on February 17, 1948, that he investigated a report of probable winterkill on the day prior. From observations made

in the company of Mr. Melrose who owns most of the property on this lake, he concluded: "A few dead bluegills were observed on the lake bottom below fish shanties from which observations were made. The water supply is from springs and on the west side of the lake there was quite a large opening in the ice resulting from a small spring stream coming in, and here the concentration of live fish of all sizes was very heavy, and they seemed to be in a stupor and practically helpless, as they could be removed by hand or by dip net and unless the water condition improves the kill will no doubt be heavy."

This lake was subsequently put under the special winter fishing regulations. No report has been received as to the effect of those regulations or whether a heavy mortality occurred.

25. Bertha Lake

A winterkill was reported to Mr. J. T. Wilkinson on April 2, and investigated by Mr. Stanley Lievense on April 9. A heavy kill was observed. Estimated numbers of the various species present are shown in Table 3. Further observations were made on April 21, when shore line seining and observation yielded only two (living) Iowa darters. The kill is thought to have been very nearly complete.

26. Mud Lake, Washtenaw County

It is the opinion of residents at Sugarloaf Lake, which is connected to Mud Lake to the west by a small stream, that large numbers of fish hatch in Sugarloaf and migrate into Mud each spring or summer and die of winterkill the following winter.

On March 24, 1948, Institute personnel made observations along a half mile of the west and south shores (toward which prevailing winds had been blowing) of Mud Lake and found only a light occurrence of winterkill.

An actual count along this stretch of shore line showed about 50 dead centrarchids. This is not considered important enough to effect the fish population of this lake, or Sugarloaf from which drainage occurs.

27. Long Lake

Upon receipt of reports of past winterkills by local residents, and the Regional Fisheries Supervisor, Stanley Lievense, District Fisheries Biologist, and two local persons made an analysis of water at two different stations on this large, shallow lake. The amount of dissolved oxygen varied from 0.4 and 0.6 p.p.m. at a two foot depth to 0.4 p.p.m. at a four foot depth, where the maximum depth was five and six feet, respectively.

Realizing that such small amounts of dissolved oxygen are conducive to severe winterkill, an immediate report was made and this lake was put on the list of lakes open to special winter fishing regulations. No reports have been received to date as to the results of these regulations or whether a winterkill occurred.

Summary

Of the forty-three lakes in southern Michigan listed in this report, observations were made on thirty-two of them at intervals between January 15 and April 1, 1948.

Ice and snow conditions prevailing over an extended period (December 15 to April 1) were found conducive to winterkill. Of the twenty lakes on which oxygen analyses were made, the following showed a very low amount of dissolved oxygen: First Sister, Green, Sugarloaf lakes in Washtenaw County; Batteese, Merkle, Grass lakes in Jackson County; Haven Hill, Mud, Robinsons, and Richmond lakes in Oakland County; Belas Lake in Cass County; Munro Lake in Cheboygan County; Keeler Lake in Van Buren County; and Long Lake in Wexford County.

The amount of severe winterkill was probably held to a minimum by a thaw which occurred during the week of February 13-19. This eliminated the snow blanket from most of the lakes in the southern half of lower Michigan and large amounts of aerated snow water drained through the fractured ice.

Of the thirty-two lakes examined no complete winterkills are believed to have occurred. Relatively heavy kills were encountered on Grass and Leeke lakes and Concord Mill Pond in Jackson County; Pickerel Lake in Kent County; Duck and Tamarack lakes in Montcalm County; Moon Lake in Shiawassee County; and Belas Lake in Cass County. There are undoubtedly others that come under this category that have not been reported or on which observations were not made. Lakes on which light kills were observed are First Sister, Green and Mud lakes in Washtenaw County; Haven Hill and Legget's lakes in Oakland County; and Little Muskrat Lake in Kent County. There are undoubtedly numerous others in lower Michigan that would come into this category on which no observations were made or reports received.

Many lakes were suspected of winterkill on which observations were not made when the ice went out because of impassable roads.

Conclusions and Recommendations

Despite the severe winter of 1947-1948 it can be concluded that the winterkill on southern Michigan lakes as a whole was comparatively light.

Whether the kill was light or heavy, evidence of winterkill as observed and reported over a period of the last twenty years by Michigan residents, sportsmen and Conservation Department field personnel shows that certain and numerous weedy and shallow southern Michigan lakes have a tendency to become low in dissolved oxygen and follow up by a "spring

mortality" periodically, when the snow and ice conditions prevail over an extended period during mid-winter.

The results of field observations after the spring breakup are available for only two of these lakes (Leeke in Jackson County and Duck in Montcalm County).

Ten lakes were opened to special winter fishing regulations under authority of Act 165, P.A. 1929 as amended. Observations showed that despite the opportunity of fishermen to take all species of fish present by hook and line, spear or hand nets, thousands of fish still died and were washed up on the shores. It is not certain that had these lakes been opened up ^{under} these special regulations earlier in the season, a mortality would not have occurred, but at least more fish would have been utilized by the public. In the light of an all-over picture of the winterkill situation, it is believed that special regulations should be set up for all lakes that are subject to winterkill. This does not necessarily mean that lakes should be opened to spearing and netting of any or all species present. Rather, regulations permitting hook and line fishing in their respective open seasons with no limit on size or catch per day might result in less waste.

It might be argued that it is illogical to restock those species that are most subject to winterkill in these lakes year after year. That is, on some lakes bass and bluegills kill out year after year, while perch and pike, which can tolerate lower amounts of oxygen concentration, survive in relatively greater numbers. It might be presumed that many of these lakes would support more perch, pike and other tolerant species if the bass and bluegills were not introduced. Also it might seem rather ill-advised to restock bass and bluegills in those lakes which

kill out every 3 or 4 years. However, this should not be applied to all lakes. Some productive lakes which kill out only every 10 years or so should probably be restocked to produce maximum fishing facilities for the eight or nine years following restocking.

Acknowledgements

This outline of observations on winterkill relative to amount of dissolved oxygen and other pertinent biological and physical conditions present in some southern Michigan lakes is a follow up of studies suggested by Dr. A. S. Hazzard, Director of the Institute for Fisheries Research. Several members of the Institute, Fish, Game and Field Administration staffs and of the interested public assisted in taking water oxygen samples, supervised and assisted in counting dead fish, ^{taking} data relative heretofore and reporting instances of winterkill or probable fish mortalities. Their cooperation is appreciated.

Literature cited

Hazzard, A. S.

1941. Effect of Snow and Ice on Fish Life. Institute for Fisheries Research Report No. 709.

Greenbank, John

1945. Limnological conditions on ice covered lakes, especially as related to winterkill of fish. Ecol. Monographs, Vol. 15.

Cooper, G. P. and G. N. Washburn

1945. Winterkill Investigations (1944-45) on Michigan Lakes. Institute for Fisheries Research Report No. 1014.

INSTITUTE FOR FISHERIES RESEARCH

Leland R. Anderson
Fisheries Biologist I

Approved by: A. S. Hazzard

Typed by: S. E. Putman