Original: Fish Division
cc: Fish Division
Education-Game
Institute for Fisheries Research
C. T. Yoder
H. L. Thompson
J. E. Williams
F. E. Simonis

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

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ANN ARBOR, MICHIGAN

August 8, 1952

Report No. 1347

OBSERVATIONS ON PIKE SPAWNING AT THE NORTH END OF OTSEGO LAKE, OTSEGO COUNTY, DURING THE SPRING OF 1952

by

John E. Williams and Floyd E. Simonis

Abstract

Owners of the marsh at the north end of Otsego Lake, Otsego County, began filling and dredging operations, during 1950, to convert this land to resort property. Since this marsh is the last important pike spawning area in this famed pike-fishing lake, the Conservation Department in the fall of 1950, secured a consent decree against the owners, preventing them from filling below 1274.5 feet m.s.l. Also the owners were required to install culverts under the two north-south roads which prevented pike from reaching much of the marsh. Observations conducted during the spring of 1951 indicated that pike spawning was slight due to low water level and non-installation of culverts. Observations were to be made again this year (1952) to see what spawning activity took place.

In the spring of 1952, spawning occurred in all three sections of the marsh, being heaviest in Section A or the westernmost section, from April 14 to 21. A total of at least 106 pike-days in the marsh were observed with at least 50 pike being involved. The pike freely used the culverts

which were installed in 1951. Pike fry were not found in the marsh, for one or more of the following reasons: either (a) most eggs did not hatch, (b) most fry migrated to the lake soon after hatching or (c) most fry were devoured by the thousands of mudminnows (Umbra limi) present. The last reason is suspected as the most important, as mudminnows are known to be carnivorous and they are plentiful everywhere that spawning occurred. Some pike are known to have survived, however.

Water level conditions were optimum in Otsego Lake and the marsh this spring, with the lake level reaching 1274.10 feet m.s.l. (0.4 foot under the high reading of 1922 used as a high-water contour in the consent decree). The water level of the marsh dropped only 2 1/2 inches by six weeks after spawning and this should have favored the hatching of the eggs and migration of the fry to the lake.

Various methods of increasing pike-spawning habitat at Otsego Lake have been considered. Dredging a channel to Fowler Lake would be of little use, as during low-water years the flow would be too slight and during high-water years spawning area is plentiful in the marsh at the north end. Digging canals into the marsh at right angles to the lagoon at the north end of the lake would serve to increase the marshy border in which pike could spawn during low-water years. Connecting the pond at the south end of Otsego Lake with the lake might serve to furnish additional pike-spawning area, provided it did not lower the water level of Otsego Lake during low-water years and flood low-lying developed areas around the pond in high-water years.

Observations will be made on pike spawning at Otsego Lake every spring for the duration (several years) of the creel census operations there, in order that variables affecting both the spawning of pike and the mortality

of the young may be determined. Tagging of pike in Otsego Lake previous to their spawning run would be of assistance in determining both the size of the run and whether or not pike from the entire lake spawn in the north end. It should certainly be determined next spring (1953) whether the presence of a large population of mudminnows can cause a low survival of pike fry.

It is recommended most emphatically that the culverts be maintained (and checked each spring before spawning time to see that they are open) and that there be no further filling below 1274.5 feet m.s.l. over <u>any part</u> of the <u>entire</u> marsh.

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Introduction

Owners of property at the north end of Otsego Lake, Otsego County, Michigan had, during the summer of 1950, begun dredging and filling operations in order to convert this marshy area to worthwhile resort property. Since it was reported in Institute for Fisheries Research Report No. 1255 (Taube, 1950) that this marsh was the most important pike-spawning area left on Otsego Lake, it was feared that its destruction would have a serious effect on the sport fishery for pike in Otsego Lake. Therefore, a restraining order was secured from the Otsego County Circuit Court by the Department of Conservation against the property owners, halting all operations until the October term of court. At the hearing in open court it was agreed that the owners could continue to develop this property (known as Government Lot 1, Bagley Township) as long as they agreed to two conditions: (1) there was to be no further filling below 1274.5 feet mean sea level (the high water level during the past thirty years) and (2) there would be provided and maintained culverts, with an invert

elevation of 1272.5 m.s.l. at both ends, at the two locations where filled roads across the marsh blocked access of pike to the remainder of the marsh. The defendants agreed to this and it was then simply a matter of the Department laying out the contour line 1274.5, the defendants then submitting their plat map based on this information, the decree being signed by the court and recorded by the registrar of deeds. The final hearing on the decree has been postponed to the October, 1952, term of court, due to difficulties among the defendants.

Since the Department of Conservation was interested in knowing whether pike would use the culverts to reach all parts of the marsh, and desired to be able to furnish proof as to just how extensive pike spawning was in this marsh, observations were carried on during the spring seasons of 1951 and 1952. Observations made during 1951 have already been reported in Institute for Fisheries Research Report No. 1286 (Williams, 1951). Briefly summarized, pike in 1951 were barred access to areas B and C (Fig. 1) by the two road fills. Contrary to decree specifications, culverts had not been installed before the spawning season. This, combined with below average water levels, restricted pike to area A. It was agreed by observers that only a light spawning effort was made by the pike. Since the Department had still not had a chance to see the effect the culverts would have on the pike, especially during a year of higher water, observations were continued during the spring of 1952.

Spawning Observations

Since the junior author (F. E. Simonis) began creel census operations on Otsego Lake during the spring of 1952, and would be on hand at the spawning time, it was decided that he should make the majority of the

observations. The resulting data were outlined by the senior author and supplemented by him when in the vicinity. It was hoped that observations could be made showing the approximate number of pike in the spawning run, the use by pike for spawning of various portions of the marsh, and of the success of the egg hatch and fry migration to the lake.

Observations were begun on the area on April 1, 1952 by Mr. Simonis, all following data are from observations by Mr. Simonis, except where stated as done by the senior author. Both the lake and the marsh were still ice-bound on April 1, except for a small area of open water at the outlet of Culvert No. 2. Seven water-level gages (meter sticks) were placed at various locations in all three sections of the marsh by spudding through the ice and driving the sticks into the bottom. These gages were installed to indicate changes in water level between sections of the marsh and to indicate the loss of water in the marsh from spawning to post-hatching time of the eggs. Location of these gages is indicated on Figure 1 and readings are given in Appendix I. (Appendix I, on file with the Institute copy of the report) Gages were read one or two times daily on most days until May 1 after which they were read several times a week until June 12. Water temperatures were taken at times of gage reading and these data are also given in Appendix I. Air temperatures, lake water temperatures, U.S.G.S. gage readings, percentage of cloudiness, wind direction and velocity, and precipitation were also recorded from April 1 to May 1 and the data are given in Appendix II. (Appendix II, on file with the Institute copy of the report)

On April 8, both authors were present and, although some melting had occurred, conditions were not advanced enough to bring on pike spawning. Conditions which prevailed are shown in the photographs of Figures 3 and 4. Additional pictures taken, but not included in this report, are in the senior author's files.

Figure 1. Marsh at north end of Otsego Lake. From a map prepared by the Department of Conservation, Division of General Operations, as revised July 2, 1952, with field notes added from the present study.

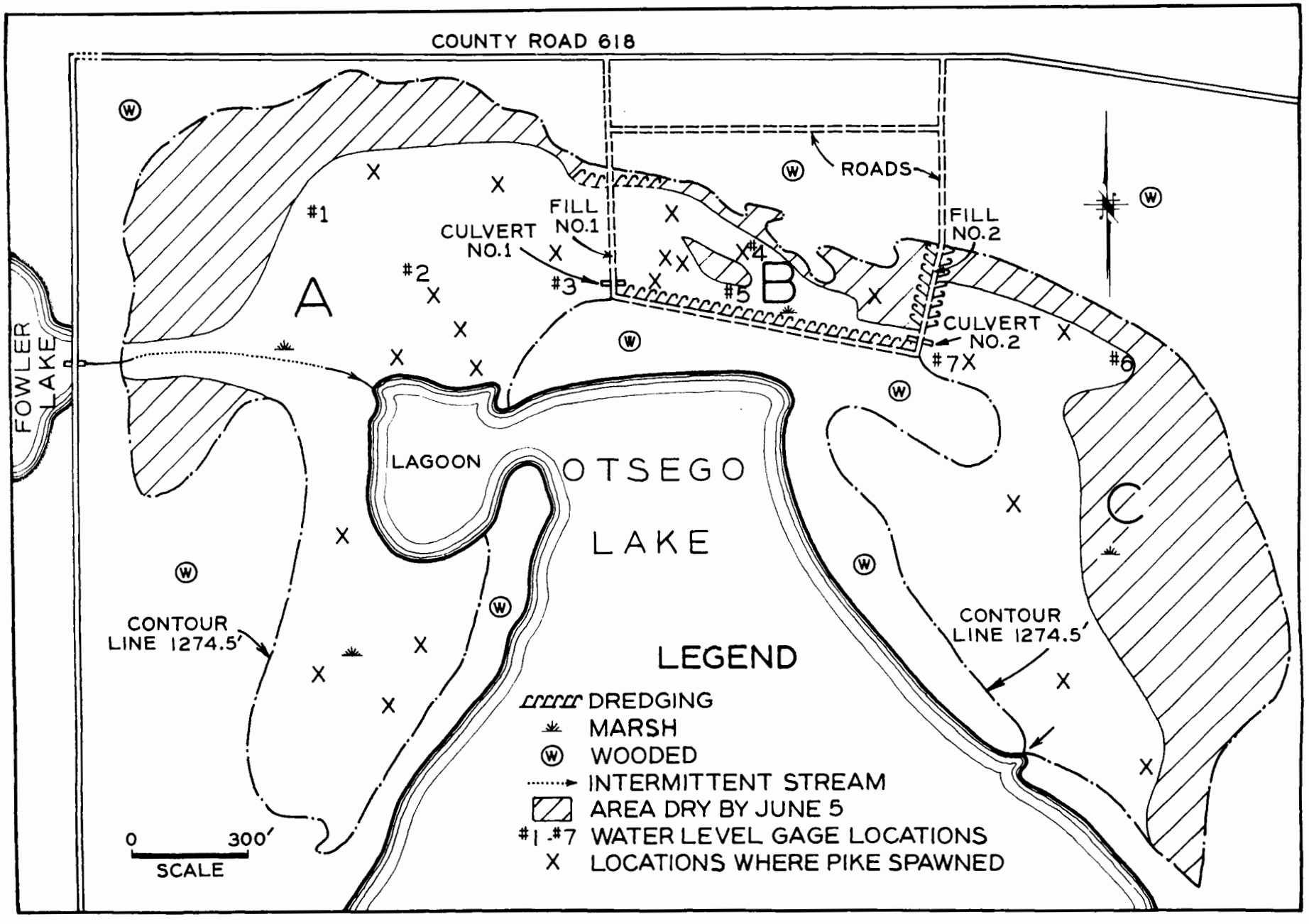
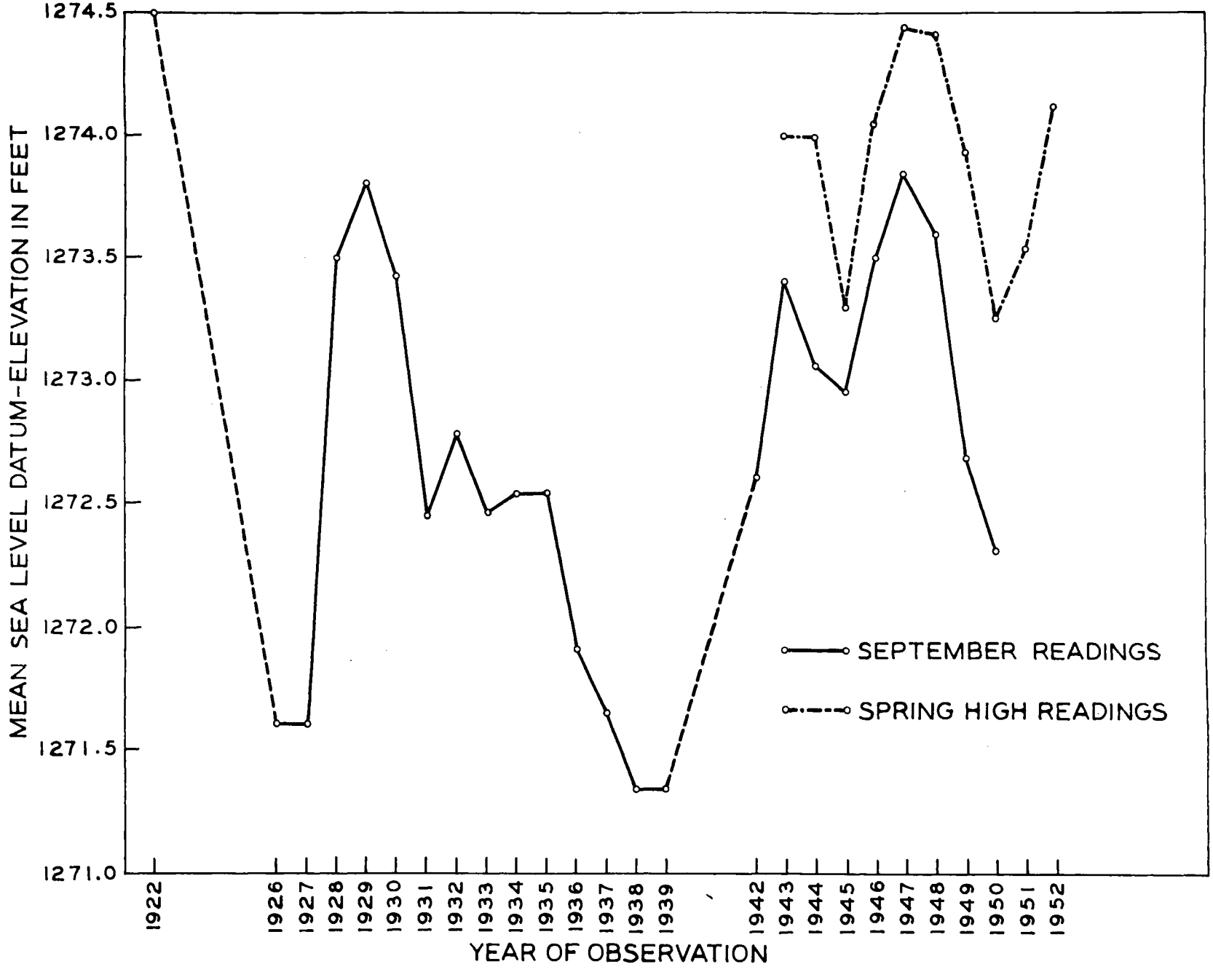

COUNTY ROAD 618
ROADS
FILL NO.1
CULVERT NO.1
FILL NO.2
CULVERT NO.2
#1
#2
#3
#4
#5
#6
#7
A
B
C
FOWLER LAKE
LAGOON
OTSEGO LAKE
CONTOUR LINE 1274.5'
CONTOUR LINE 1274.5'
LEGEND
DREDGING
MARSH
WOODED
INTERMITTENT STREAM
AREA DRY BY JUNE 5
#1 -#7 WATER LEVEL GAGE LOCATIONS
X LOCATIONS WHERE PIKE SPAWNED
0 300'
SCALE

Figure 2. Hydrograph for Otsego Lake (From U. S. G. S. Gage Readings)


MEAN SEA LEVEL DATUM-ELEVATION IN FEET
1274.5
1274.0
1273.5
1273.0
1272.5
1272.0
1271.5
1271.0
1922
1926
1927
1928
1929
1930
1931
1932
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1934
1935
1936
1937
1938
1939
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEAR OF OBSERVATION
SEPTEMBER READINGS
SPRING HIGH READINGS

Figure 3. Photograph taken April 8, 1952 looking eastward at Section C from the south end of fill No. 2. Upstream end of Culvert No. 2 and water level gage No. 7 in foreground. U. S. G. S. gage reading 1.90 feet (1273.90 feet m.s.l.).

Figure 4. Photograph taken April 8, 1952 looking WE stward at Section B from the south end of fill No. 2. Downstream end of Culvert No. 2 in foreground. U. S. G. S. gage reading 1.90 feet (1273.90 feet m.s.l.).

By April 11, 3/4 of Section A, 1/2 of Section B and 1/4 of Section C were free of ice except for a film of ice present in the morning. At this time there was about 1 foot of open water along the north shore of Otsego Lake. By mid-afternoon, shallow water in parts of the marsh had warmed to 62°. On April 12, which was cooler, fish activity was noticed around the edge of the lagoon. These fish were principally perch and common suckers although, from some of the wakes seen, it was suspected that pike were present. April 13 was cold and rainy and no activity was noticed.

The first spawning activity of pike was observed at 4:30 p.m. on April 14 in Section B. The water temperature at this time in Section B was 41°, air temperature was 38°, the sky was completely cloudy and a light wet snow had fallen earlier in the afternoon. Three pike were seen at this time, and from 7:00 to 7:30 p.m. seven pike were seen in Section B, at least 2 pair of which were spawning. In the evening, water in Section B was 40° F., air temperature was 37°, the sun was just showing through a 100 percent overcast and there was a light west wind. Otsego Lake water temperature was 33° at the margin. All activity appeared to stop at sundown, at which time the air temperature was 36°.

On April 15, there was heavy spawning action from 10 a.m. to 7 p.m. in both Sections A and B. The senior author was present from 2 to 4 p.m. and saw at least 6 pike in each section. Later in the afternoon there was light action in Section C also. It was estimated that at least 25 to 30 pair of pike were present during the day, plus numerous singles. Figures 5 to 7 were taken on this date and show prevailing water and ice conditions. Other pictures taken, but not included in this report, are in the senior author's files. Ice was still present along the east edge of Section B and much of Section C. Open water was present at the north

Figure 5. Photograph taken April 15, 1952 looking westward at Section B from the south end of fill No. 2. (same location as Figure 4, but one week later). Downstream end of Culvert No. 2 in foreground. Nail in left side of stake in left foreground indicates the stipulated height of the top of the culvert, or 1274.5 feet m.s.l. U. S. G. S. gage reading 2.07 feet (1274.07 feet m.s.l.). Heavy spawning action was going on at this time in the open water in the background, beyond the ice.

Figure 6. Photograph taken 3:00 p.m. April 15, 1952 looking northeastward at Section B from the south end of fill No. 1. Upstream end of culvert No. 1 in left foreground. U. S. G. S. gage reading 2.07 feet (1274.07 feet m.s.l.). Heavy spawning action was going on in the section at this time. The circled area indicates the location of the two pike shown in Figure 8.

Figure 7. Photograph taken April 15, 1952 looking westward at Section A from the south end of fill No. 1. Downstream end of Culvert No. 1. in the right foreground with water level gage No. 3 just beyond its mouth. U. S. G. S. gage level 2.07 feet (1274.07 feet m.s.l.). Heavy spawning action was going on in this section at the time.

end of Otsego Lake in a strip 3 to 4 feet wide along the shore. Figure 8 shows two pike that had been spawning vigorously in Section B for some time and which were lying at rest. They were located just behind the bush in the left central region of Figure 6. Figure 9 shows a single pike about 24 inches long which was observed in Section A. The photograph, taken toward the north, shows trees along the north shore of the marsh in Section A. Two pike, one 18 to 20 inches and the other 32 to 36 inches, were observed from 10:15 to 11:00 a.m. in Section A. They spawned often and vigorously from 10:15 to 10:30 a.m. after which the action became less often and less vigorous until by 11:00 a.m. the action had ceased and the pike separated. Water temperature, when spawning began, was 40°. Some of the earlier spawning action was violent enough to break a layer of ice 1/8 inch thick which had formed on the marsh during the night. Four more pike, all 18 to 20 inches long, were observed spawning about 50 feet away at the same time. This action only lasted for twenty minutes, after which the pike separated. Water temperature here was 46°. One pike was observed at 11:15 a.m. passing through Culvert No. 1 (Figure 1) from Section B into Section A, and possibly was one of the pike observed in Section B the day before. This pike may or may not have finished spawning but at any rate it was showing a tendency to move downstream toward the lake. April 15 was clear, with light northerly gusts of wind. The air temperature rose to 50° by 3 p.m. and the marsh water to 60°. Heavy spawning or at least splashing took place between dark and midnight in Sections A and B, according to Conservation Officer Leo Marlatt who was patrolling the area. On the afternoon of April 15, the senior author checked a marsh on the west side of Otsego Lake. This marsh, of 1 to 2 acres, is located about 1/4 mile north of Otsego County Park and lies just south of and adjoining

the southernmost of the two canals dredged back from the lake toward Irma Road. Two pike were seen cruising together at the margin of the canal and the marsh, but examination of the marsh failed to reveal additional pike. Mr. Simonis also saw two pike here on April 16, but evidently not many pike used this marsh for spawning.

Spawning action on April 16 was estimated at 12 to 15 spawning pike per hour in Section A, 1 to 3 per hour in Section B and 1 to 2 per hour in Section C. In two hours observation (mostly in Section A), approximately 30 pike were seen, in pairs (spawning or quiet) or singly. Water temperatures in Section A ranged up to 64 to 70° at 4:30 p.m. Spawning at this time mostly took place in cooler water. Three pike spawning in Section C were doing so in water at 58° Splashing during the night of April 16 to 17 continued all night, and spawning was probably taking place as water temperatures did not drop below 40°. April 16 was clear with a light west wind, and the air temperature reached 62° by 4 p.m.

Spawning action on April 17 was light, averaging from 2 to 5 pairs per hour for the entire marsh. Marsh water temperatures at 4 p.m. ranged from 50 to 70° in Section A, 61 to 67° in Section B and from 54 to 68° in Section C. In all cases the shallowest water was the warmest, water below 6 inches in depth being around 70°, while 18 to 20 inch water was about 50°. No spawning action was found in water over 65° in temperature. This may be the reason why spawning was never noticed in shallow water (under 6 inches in depth). It had been noticed by the senior author that spawning didn't seem to occur in very shallow water and it was his belief that the pike were wary of this shallowness, perhaps instinctively knowing that this shallow water may be soon dry land. To this now must be added the possibility that the high temperatures of the very shallow water may be the factor discouraging the pike from spawning here. If temperature

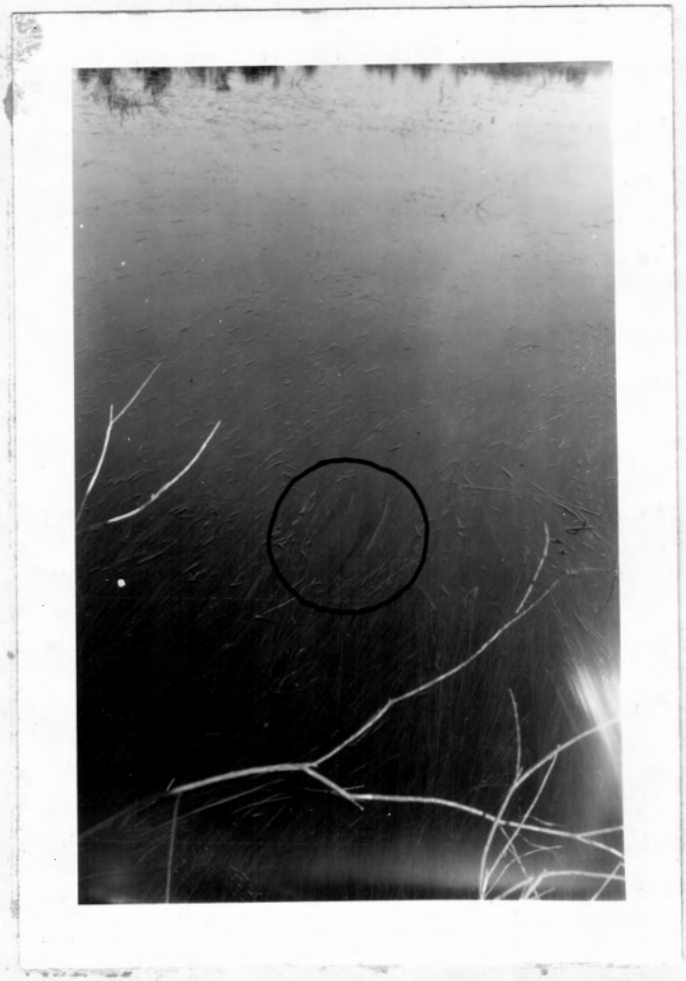

Figure 8. Photograph taken at 3:00 p.m. April 15, 1952, showing two pike (circled) in Section B (exact location shown in Figure 6). These pike had been spawning vigorously but at the time of the picture were lying at rest on the grass. The ideal pike-spawning habitat of flooded marsh grass is shown in this photograph. The larger female (on the left) can be distinguished by her distended midsection.

Figure 9. Photograph taken at 2:30 p.m., April 15, 1952, showing a single pike (underlined), about 24 inches in length, in Section A. The photograph, looking northwest, shows the northern edge of the marsh in Section A. The flooded marsh-grass habitat can again be seen clearly. By July this grass had grown to two feet above the water.

is the discouraging factor, however, it would be expected that pike would be seen spawning in shallow water on days or parts of days when the water was cooler. They have not been seen to do this, but perhaps the number of observations have been too few. In one observation pike were seen spawning in 18 inches of water at 50°, when water at 74° was present only 70 feet away. Spawning action was still going on in Section C from 8 to 8:15 p.m. but, according to Field Administration men present, action was very light during the night. On April 17 it was noticed that some water was draining through a ditch between Section C and the marsh. This was dammed up with the thought that it would create more flow westward through the culverts.

Spawning action on April 18 was very light, with only 2 to 3 pairs per hour noted in Section A, one pair per hour in Section B and 1 to 3 pairs per hour in Section C. Water temperature in Section C reached 77° by 4:00 p.m. The day was mostly clear with light west wind and a maximum air temperature of 66°. Action was very light again through the night.

On April 19, the only observations made were by the senior author from 1 to 4 p.m. Marsh water temperatures ranged up to 69° F. No pike were seen in Sections B and C, and Section A also seemed empty except for one pike seen near the lagoon. Many people were passing through the marsh, as they had all week, in hopes of seeing the pike spawning. Evidently they came out of interest or curiosity, as there was no evidence of any attempted violations. The ice went out of Otsego Lake completely on this date.

Action was very light during the nights of April 19, 20 and 21, according to Field Administration men. No observations were made on April 20. On April 21, one pike was seen in Section B and one in Section A. On April 22, no pike were seen, nor were any seen after that date by Department personnel.

It is possible to make a fair estimate of the numbers of pike present in a marsh at any one time if one is careful to observe where disturbed pike go and if one covers the entire marsh thoroughly. In a large marsh the numbers counted would be a bare minimum unless considerable time was spent covering the entire marsh. It is impossible, however, to make any close estimate of the numbers of pike present over a period of days, as it is not known how many of the same pike are being recounted each day and how many enter or leave the area each day. About the only estimate that may be made would be in pike-days--6 pike present one day and 15 the next would give a total of 21 pike-days, even though there may have been a total of only 15 pike involved. Thus, in this years spawning at Otsego Lake, 7 pike were seen on April 14, 50 plus on April 15, 30 on April 16, 10 on April 17, 6 on April 18, 1 on April 19 and 2 on April 21. These are the maximum number seen at one time each day and are certainly not all the pike that were present in the marsh. However, we can say that a total of at least 106 pike-days were spent in the marsh by at least 50 pike (the most counted at one time). It is the senior author's belief that these 50 pike actually seen represented less than 50 percent of the pike that were actually present. It should be possible to make a definite check of the numbers of pike present here (possibly next spring) and the approximate time spent in the marsh by each, either by temporary marking of fish with colored darts, or by using a small weir in No. 1 Culvert to at least determine the numbers in Sections B and C. It may then be possible, with known numbers of pike present, to observe the number of spawning fish splashes on optimum spawning days, or to make random counts of fish seen in short walks through the marsh. These two methods might give an index which could be used on other marshes to give an idea of the numbers of pike present. The pike in this marsh spent less time in the marsh than

is the case where pike run up an inlet stream to spawn. In the ditches at Houghton Lake in 1939 and 1940, it was discovered that the length of time pike remained upstream ranged from 4 to 90 days following their upstream migration (Carbine, 1942a). However, at Whitmore Lake, Washtenaw County, where the spawning marsh is directly connected to the lake (as it is in Otsego Lake), pike were observed in the marsh this spring (1952) for a period of only 10 days (Williams, 1952). On cold cloudy days no pike were present at all and the pike seemed to return to the lake each night.

It was reported to Conservation Officer Marlatt that, about May 10 or 11, 8 to 10 adult pike were trapped behind the dam in the ditch connecting the east end of Section C and Otsego Lake. The dam (it was reported) was opened up with shovels. While the men were gone to get the shovels, one pike reputedly jumped out on dry land and died. If this report was true, these pike had either entered Section C through this ditch before it was dammed on April 17, or through the culverts. If they entered through the culverts, they either were unable to find the culvert again or preferred to go out the ditch. If they entered through the ditch, they were obviously trying to get back out the same way. It seems reasonable that this ditch should remain open so that pike entering Section C would have an additional way of getting out.

Attempts to collect fry and fingerlings

About May 10 to 15, the junior author on several occasions spent time in the marsh looking for pike fry. These were only visual attempts, and no fry were seen. This would be expected if the fry were still in the sac stage. Young fry will attach themselves to vegetation and remain so for a week or longer after hatching, or until they have absorbed their yolk sac and are strong enough to swim and capture macroscopic crustacea.

On May 30, both authors, using a 10-foot common sense minnow seine, seined many areas of open water in the marsh and dredgings but caught no small pike. It was thought that possibly those pike fry which still remained might be in the heavy marsh grass; therefore, a reinforced cheesecloth scap net was used here, but only a few mudminnow fry were taken. On June 19, the authors seined small areas of open water with a 2-foot cheesecloth seine, but again no pike were taken. The dredgings were seined again on June 20 by the junior author and Mr. Harold Thompson, District Fisheries Supervisor, with a 25-foot seine, but only a few mudminnows and 2 golden shiners (Notemigonus crysoleucas) were taken. It was realized before this that either the majority of the fry must have migrated to the lake soon after reaching migrating size, or the eggs must not have hatched, or the fry must have died. The advanced season during the latter half of April and the first half of May might have caused fry to grow rapidly enough to have mostly migrated to the lake by May 10. It was hoped, however, that, as usually happens when there is plenty of food in the marsh, some of the faster-growing, more cannibalistic pike fingerlings would remain behind, showing little tendency to move to the lake until either the water level became too low or the food supply dwindled. In the case of the Otsego marsh, many mudminnows and their fry would furnish this food. Therefore, in discussing the matter with Dr. Edwin L. Cooper, in charge of the Pigeon River Trout Research Area, and his staff, it was suggested that possibly the Direct Current Electric Shocker, because of its known tendency to attract fish, might show the presence of pike fingerlings in the heavy marsh vegetation where it was so difficult to do any collecting. Consequently, on July 11, the D. C. shocker was used by Dr. Cooper and the senior author. Areas which were shocked included the marsh and dredgings

in Section B, the north shore of Otsego Lake, the east and north shoreline of the lagoon, and a large area in Section A from the inlet from Fowler Lake to the No. 1 Culvert. No pike fingerlings were taken, although several fish above minnow size escaped capture in the heavy vegetation. Many mudminnows were taken throughout the marsh; indeed, it was practically impossible to lay the electrode down without attracting a mudminnow. This may offer a clue to the reason for the scarcity of pike fry in the marsh. In the pike-fry trap operated at the Houghton Lake ditches in 1942 (Carbine, 1942b), 4 mudminnows were taken along with 21 small pike in one lifting of the trap; these mudminnows each had 4 small pike in their stomachs. Since it is known that mudminnows will eat pike and they were so numerous in the marsh this spring, there is a strong possibility that the mudminnows decimated the pike fry as fast as they hatched. Unfortunately, it was not realized that mudminnows were so numerous, in time to collect samples to determine whether or not they were feeding heavily on the pike. The fish taken from Otsego Lake (North Shore and Lagoon) with the D. C. shocker were as follows:

Species	Number	Size range millimeters
Largemouth bass, Micropterus salmoides	6	29-42
Smallmouth bass, Micropterus dolomieui	1	45
Yellow perch, Perca flavescens	2	40
Banded killifish, Fundulus diaphanus	1	62
Bluntnose minnow, Pimephales notatus	2	42

Fish collected from the marsh were:		inches
Largemouth bass, Micropterus salmoides	1	8 1/2
Pumpkinseed sunfish, Lepomis gibbosus	1	5
Yellow bullhead, Ameiurus natalis	1	6 1/2

Black bullhead, Ameiurus melas (Several hundred of a school taken but most were returned to the water)	6	1
Mudminnow, Umbra limi	75	1 3/16 to 3 3/16
Yellow perch, Perca flavescens	1	3 7/16

A small screen trap was installed at the downstream end of Culvert No. 1 on July 11 to see if any small pike were still moving downstream. By July 16, when it was removed, no pike had been taken. However on July 12, the senior author spent several hours looking into the various dredgings of Section B on the chance that a pike might be seen. A pike between 4 and 5 inches in length was finally seen in the dredging running east and west along the south side of Section B. This pike was undoubtedly one hatched this spring. An attempt was made to capture the fingerling but it escaped. It had, however, been called to the attention of two men picking blueberries in the vicinity and after observing it they agreed that it was a small pike. The names and addresses of the men were secured.

Water Levels in Otsego Lake and the Marsh

Water level in the marsh was high this year (1952), and Officer Marlatt was of the opinion that it was "very" high. On checking the U. S. G. S. gage located on the west side of the lake on April 2, it was found that the level of Otsego Lake was 1.82 (1273.82 above mean sea level). On April 7, the gage reading was 1.90, compared to 1.37 on April 8, 1951. The reading on April 16 was 2.07 (1274.07 m.s.l.) as compared to the 1.39 reading of April 15, 1951. Last year the gage level stood at 1.53 on April 26 when spawning was in progress; thus this year the water in Otsego Lake was at least 6 inches higher than last year. The high level of the lake this year, according to our records (Appendix II, on file with the

Institute copy of the report), occurred about April 23 when it was at 2.10 (1274.10 m.s.l.). From this stage the level gradually dropped, reaching 1.95 on May 7 and finally reaching 1.78 on June 4 when gage reading was discontinued.

Water depths in the marsh varied from dry land (at the margin) to 3 or 4 feet in some of the dredgings and pot-holes. On the average, however, most of the marsh proper contained from 4 to 18 inches of water. Gages indicated that the water level in the marsh dropped very gradually. Readings of the seven gages indicated that, by two weeks after the spawning period, the water level had dropped an average of 0.4 inch. Approximately one month after spawning, the water level had dropped an average of 1.4 inches, while 6 weeks after spawning the loss amounted to about 2 1/2 inches. Thus all regions where spawning was observed still had at least a few, and in most places 4 to 10, inches of water left. This loss of 2 1/2 inches in 6 weeks in the marsh checks closely with the known reduction of 3 inches in the lake for the same period (2.07 feet to 1.82 feet = 0.25 feet or 3 inches). Evidently the level of the water in the marsh is determined closely by the level of Otsego Lake. Yet by July 16, water was still flowing through both culverts toward the lake. However, Culvert No. 2 had become half filled with sand.

Water level records for the staff gage operated by the U. S. G. S. on the McCloud property are available from 1922 to the present time, with the exception of the years 1923 to 1925 and 1940 to 1941. These readings, roughly shown in Figure 2, indicate that the record water level during the past 30 years occurred in 1922 when the water level was at 1274.5 feet above mean sea level (or 2.5 feet on the gage). It is not known during what month this high stage occurred but, since subsequent readings through 1939

were taken in September, it possibly was a fall reading. Readings since 1942 have usually been taken monthly, and the high spring reading occurred in May, 1947 when the level was at 1274.45 feet (2.45 feet on the gage). The level for May, 1948 was nearly as high, reading 1274.43 feet. Therefore, this year's high reading of 1274.10 was within 0.35 feet of the high stage of the past 10 years. Low, spring levels during the past 10 years occurred during 1945 (1273.3 feet) and 1950 (1273.25 feet). Even lower water levels probably occurred during the springs of 1926 and 1927 (levels of 1271.7 feet at the September readings). The lowest water recorded is for October, 1939, when the level stood at 1271.2 feet. The spring water level during that year is probably the spring low water record since 1922, as the level stood at only 1271.8 feet in May, or about 2.3 feet below the 1952 spring's reading. It is evident therefore that Otsego Lake has fluctuated nearly 40 inches during the past 30 years (1271.2 feet to 1274.5 feet). Since pike production is undoubtedly determined by the marsh land available for spawning, production during low water years was probably very low. This poor production would undoubtedly show up 2 to 3 years later as poor pike fishing. When the catch per hour of pike is high, these pike are usually small, averaging 21 inches or less in length, and are usually mostly 2 to 3 years old. Two or three years after high water (and its resultant high production) the catch per hour of these 2- and 3-year-old pike can be expected to be high. In 1949, when the Institute for Fisheries Research made a survey of Otsego Lake (Taube, op cit.), 121 pike were collected by gill nets, and pike were listed as abundant in the lake. Fifty percent of these pike were two years old and had been hatched during the spring of 1947 when the water level reached 1274.45 feet, or the highest level since 1922. The poor pike fishing

present today in Otsego Lake is probably the result of the low water levels in 1950 which would mean the absence of the 2-year-old fish which should be contributing heavily to the catch. Although no adequate statistics are available at present, the junior author has checked 4 pike on Otsego Lake so far this year. All four were over 20 inches in length. Fishermen had reported during the past winter that there seemed to be a great decline in the number of small pike seen from their shanties, which further substantiates this reasoning. It is certainly to be expected that, as water levels were high this year and will possibly remain so for some years, the numbers of pike will increase and the fishing will improve; provided that with the rise in water level, marshland is still present to be flooded.

Possible Methods of Furnishing Additional Spawning Habitat

Several possibilities have been suggested as to various methods which might give the pike in Otsego Lake access to additional spawning grounds. The main solution suggested has been to dredge out, or at least clean out, the old channel between Otsego Lake and Fowler Lake; the latter is located 1/4 mile west of the north end of Otsego Lake. Fowler Lake has an extensive marshy border which would be fine pike spawning ground. The level of Fowler Lake, which is 3.11 feet higher than Otsego Lake, is determined by the elevation of the culvert under County Road 618. During most of the year there is little flow through this culvert, and even at periods of high water, such as this spring, the channel runs only intermittently to Otsego Lake. Water from Fowler Lake, upon reaching the marsh at the north end of Otsego Lake, sinks into the marsh and reappears further down near the lagoon. There is no assurance that, if a channel were cut through the marsh here, the flow of water in the channel would be sufficient to entice

pike. The only years in which it would possibly attract pike would be years of high water level in the spring. During these years there is plenty of available marsh at the north end of Otsego Lake. When the water level in Otsego Lake is low, the flow from Fowler Lake would also be low. Lowering the culvert level from Fowler Lake would of course increase the flow from Fowler Lake but the decrease of water in Fowler Lake itself then would undoubtedly expose much of its spawning area and defeat the purpose. Therefore, the authors do not recommend any work done on this channel as the probability exists that no advantages would be forthcoming. If local sportsmen wish to clear or dig out this channel, probably no harm would be done. However, it should be born in mind that if, during years of high water, pike should be attracted up this channel to Fowler Lake there is no assurance that they would all return to Otsego Lake. It has been noted in several places by the senior author that pike migrating from one lake into another to spawn often do not return to the original lake, at least not by midsummer of that same year.

A further suggestion has been to dig or dynamite channels into Section C in order that pike would be able to migrate farther into the marsh during periods of low water level. Since some pike undoubtedly spawn along the fringes of marshland during years of low water level, this should serve to give the pike more of this fringe to spawn in. No harm can be seen in this proposal, and it would seem to increase the spawning area during periods of low water. Probably many short channels at right angles to the edge of the lagoon would be more useful than one or two long channels extending far into the marsh.

The third proposal suggested was to connect Otsego Lake to the marsh and pond at the south end of the lake. This pond, which has extensive

marsh, was a part of the lake many years ago. The prevailing northwest winds, however, finally built a high sand bar completely across the south end, from west to east, cutting off this pond or beach-pool. This sand bar, erroneously called the "beaver dam," is now occupied by cottages except for the western half. About 1936, the owner of the western section of the "beaver dam" cut a channel through it in order to connect the pond with Otsego Lake. Local inhabitants secured an injunction against the land-owner to cease this operation as it was feared that it would lower the level of Otsego Lake. Otsego Lake is usually about 18 inches higher than this pond, according to cottage owners in the vicinity. Raising this pond 18 inches would probably not reduce Otsego Lake by more than an inch or two but even this might serve to reduce the water in the marsh areas at the north end, perhaps critically in some years when water levels were already low. At the same time, raising this pond to 1274.5 feet m.s.l., or higher, in years of high water level might flood out cottages and roads built on lower levels. Although appearances of the general area seem to indicate that raising the pond several feet might possibly form an outlet to the south, this must not be true, as years ago, when the lake level was at a much higher stage, the outlet was on the east side of the lake, near Ken-Mar Lodge, and was connected to the North Branch of the Au Sable River (Scott, 1921). If it could be demonstrated that connecting this pond with Otsego Lake would not appreciably affect the level of Otsego Lake, and if higher water level in the pond would not adversely affect the nearby property owners, then connecting the lake and marsh would be justified, for it would undoubtedly offer pike additional spawning area. All of the pike in Otsego Lake, and especially those resident in the south end, probably do not spawn at the north end. There is a possibility that those

in the south end are not able to spawn at all because of the absence of suitable habitat. Furnishing spawning habitat at the south end of the lake might be very advantageous to the pike population, but those considerations outlined above must be fully investigated first.

Conclusion

The following conclusions have been drawn concerning the spawning of pike at Otsego Lake this spring:

(1) Spawning began on April 14 and continued until about April 21, with the majority of the action occurring on April 15 and 16.

(2) At least 106 pike-days were spent in the marsh by at least 50 pike. It is probable that over 100 pike participated in the spawning, although difficulty was encountered in estimating the numbers of pike present over a weeks time.

(3) Spawning took place in all three sections of the marsh with most spawning occurring in Section A and the least in Section C. The pike freely used the culverts that had been installed.

(4) At least some pike hatched and grew to fingerling size as a result of spawning in the marsh this spring (1952).

(5) Large numbers of pike fry were not encountered, for one of the following reasons: either (A) most eggs did not hatch, or (B) most fry migrated to the lake soon after hatching, or (C) most fry were devoured by the numerous mudminnows present in the marsh. While it is not known which of the above reasons, or combinations of reasons, is the explanation for the absence of pike fry, it is strongly suspected that (C) is the most applicable.

(6) Water level conditions in the marsh and in Otsego Lake this spring were optimum and considerably better than average. Otsego Lake, at spawning

time, was within 4 inches of the record high of 1922, 6 inches above the level in 1951, and one foot above the 1950 spring level. Six weeks after spawning, the water level of Otsego Lake had decreased 3 inches, while the marsh water level had dropped about 2 1/2 inches.

(7) Dredging a channel to Fowler Lake would be of little help for pike spawning as during low water years the flow would be too small to attract pike and during high water years plenty of spawning area would be present at the north end of Otsego Lake.

(8) Digging canals at right angles to the lagoon at the north end of Otsego Lake would probably result in there being more marshy border for pike to spawn in during low water years.

(9) Connecting the pond at the south end of Otsego Lake with the lake might serve to furnish additional pike spawning area provided it did not lower the water level of Otsego Lake during low water years and flood low lying developed areas around the pond during high water years.

Recommendations

It is recommended that the junior author, with whatever assistance is available, make further observations during the spring of 1953 and, preferably, as long as he is creel census clerk on Otsego Lake. Long-term observations here could be of considerable assistance in determining the variables affecting both the actual spawning of pike and the success of such spawning. In particular, it is hoped that observations next year can answer questions largely unanswered this year, such as the total number of pike spawning in this area and the amount and cause of possible heavy mortality to the pike fry. It is important to determine whether or not the large mudminnow population in the marsh is having a serious effect on the survival of the pike fry. It is further recommended that,

if at all possible, netting and tagging of considerable numbers of pike in all parts of Otsego Lake should be done, so that by the operation of a small weir, or by direct observation, it may be determined whether pike come from all parts of Otsego Lake to spawn here next spring. This netting and tagging would of course have to be done prior to next spring.

It is recommended most emphatically that the culverts be maintained (and checked each year before the spawning season to see that they are open) and that there be no further filling below 1274.5 feet m.s.l. over any part of the entire marsh.

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