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FISHERIES DIVISION

TECHNICAL REPORT

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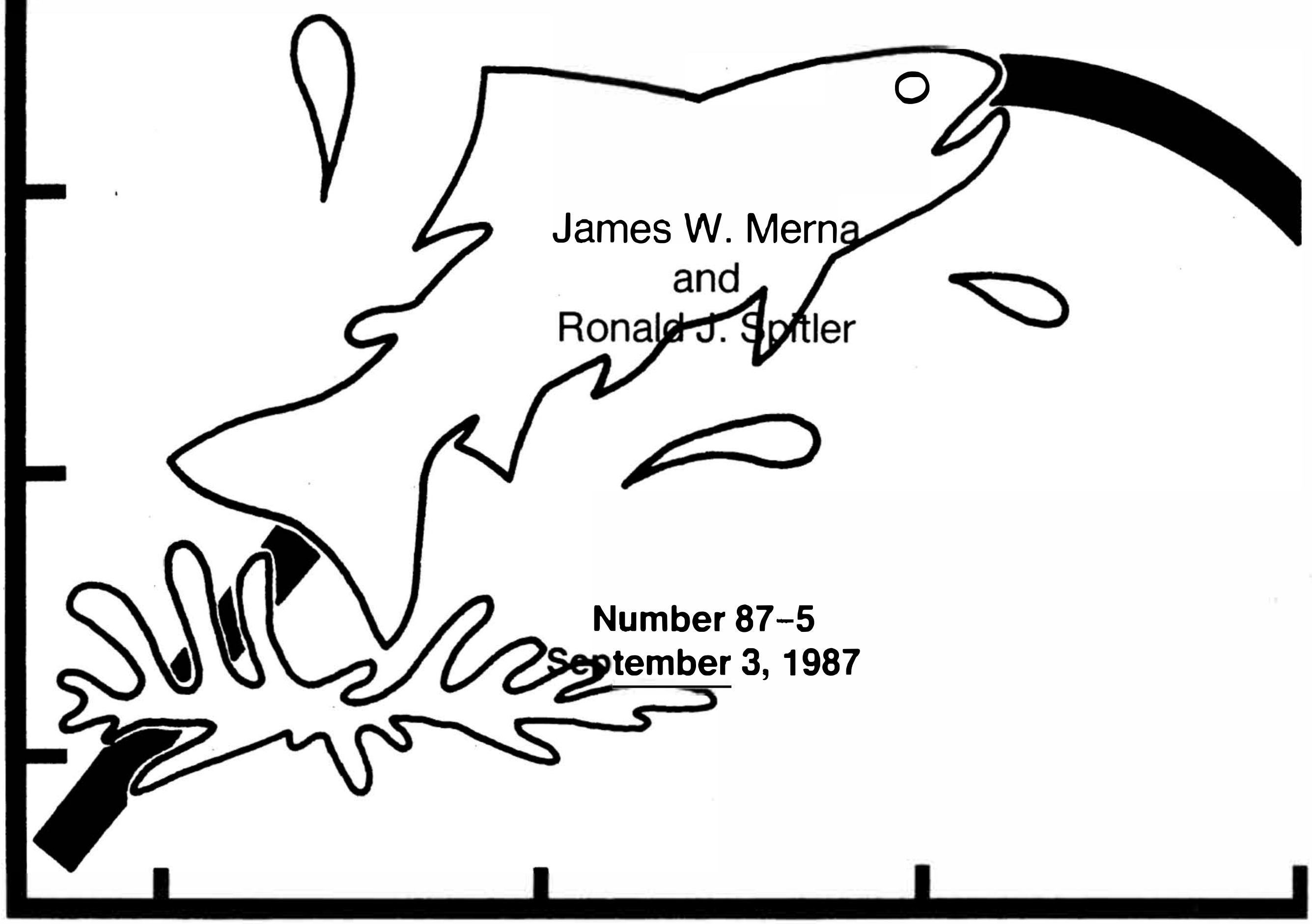

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CIRCULATION OF A LAKE BY OPERATING OUTBOARD MOTORS THROUGH THE ICE[1]

James W. Merna

and

Ronald J. Spitler

[1]Contribution from Dingell-Johnson Project F-35-R, Michigan.

ABSTRACT

On March 5, 1987, five outboard motors were operated through holes in the ice for 5 hours on Dickinson Lake, Oakland County, Michigan. The vertical oxygen stratification, before and after the motors were run, was used to evaluate the extent of circulation. Disruption of the oxygen profile indicated that the lake was thoroughly mixed to a depth of 40 feet and partially mixed to the bottom (68 feet). A current was visibly evident in the lake while the motors were running, and the oxygen data indicated circulation continued for some time after the motors were stopped. In addition to mixing the lake, the motors also added an appreciable quantity of oxygen to the entire water mass.

INTRODUCTION

Elimination of undesirable fish populations from lakes by the use of various toxicants is an accepted and widely used fisheries management procedure. Fish removal projects are usually done during open-water seasons when wind action will mix the toxicant throughout the lake. Considerable effort is almost always required to pick up and remove dead fish from the lake.

Spitler (1986) reported several advantages of lake treatments in the winter. He applied rotenone to a lake the first day of ice cover by plowing through the thin ice with metal boats powered by outboard motors. The chemical was metered into the propeller wash. The lake refroze immediately before dead fish could be washed onto shore by wave action. The dead fish were mostly decayed and settled into the deeper areas of the lake by spring, thus eliminating the need for dead fish removal. The chemical remained toxic all winter under the ice and a total kill of fish was achieved.

One disadvantage of Spitler's method is the difficulty of predicting the exact day a lake will freeze over. Unexpected warm weather following toxicant application could delay ice cover for an extended period of time and fish removal would be required. An additional disadvantage is the fact that there may be only 1 day during which ice conditions are satisfactory for toxicant application. This would limit the number of lakes that could be treated or possibly even the ability to complete treatment of one large lake.

Due to the advantages of winter treatment, the ideal application would probably be injection of the toxicant through the ice in midwinter. Ice 10–12 inches thick would allow the use of vehicles to haul barrels of toxicant onto the lake, and injection through the ice would be a simple procedure. The obvious disadvantage of this method is lack of circulation of lakes under ice cover. The objective of this study was to evaluate the feasibility of circulating a lake under ice cover by running outboard motors through holes in the ice.

Merna (1965) operated outboard motors in a lake in an attempt to alleviate winterkill. He observed a strong current under the ice for a considerable distance behind the motors even though he had the motors tilted up to throw water onto the surface of the ice. In the present study the motors were operated vertically in order to create a current without throwing water up on the surface of the ice.

METHODS

Five outboard motors (10 and 15 horsepower) were operated for 5 hours in Dickinson Lake (T5N, R7E, Secs 29, 30, Oakland County, Michigan) on March 5, 1987. Dickinson Lake is 44 acres in area and has a maximum depth of 68 feet. The main basin has a steep drop-off from shore to the 50-foot contour. Sixty-three percent of the lake is deeper than 15 feet. The motors were operated through holes in the ice just large enough to admit the propeller and shaft. All motors were over approximately the 40-foot contour and were directed to create a clockwise circulation in the lake. Boards (2"x10"x10') were nailed together in the configuration of a letter H and set on the ice over the holes. The motors were mounted to the cross board of the "H" with the shaft through the hole in the ice. While the motors were running, back-pressure of the shaft against the ice prevented the boards and motors from moving. The ice was about 10 inches thick. The motors were run in forward gear at approximately one-half throttle. The motors exert tremendous pressure on the ice and boards, and considerable care must be taken in construction of the wooden braces. Nails pulled out of several of the boards requiring modifications on the lake. Care must also be taken to assure that the motor shafts are not tilted up toward the surface of the ice. In this position a large hole is soon created in the ice and the efficiency of creating a current under the ice is reduced. The ideal position of the motors would be tilted downward slightly to direct the force of the propeller down and away from the surface of the ice. Several of the motors were not tilted down enough, and large holes were melted through the ice. Most of the holes were immediately behind the motors, but one hole melted through the ice approximately 200 feet behind the motor. To avoid creating a hazardous condition for anglers on the lake the motors were stopped 1 hour sooner than planned.

The oxygen stratification of the lake was used as a "tracer" to evaluate mixing. It was reasoned that disruption of stratification would indicate circulation and mixing. Since stratification was gradually more severe from 20 feet to the bottom, it was also possible to determine the depth to which the lake was mixed.

RESULTS AND DISCUSSION

The oxygen concentrations at the three stations monitored indicate the oxygen was affected from surface to bottom throughout the main basin of the lake (Table 1). Almost the entire water column was apparently mixed at Stations 2 and 3 and only slightly less mixed at Station 1. Oxygen was not measured at Station 3 prior to running the motors. This was a station where an additional motor was operated for only 15-20 minutes. The motor then stopped and could not be restarted. Since the water was 40 feet deep at this station, it almost certainly was stratified similar to the other stations.

All motors were directed to create a clockwise current parallel to shore. After 3 to 4 hours of operation, a strong current was detectable within the path of the motors throughout the periphery of the lake. A fishing line dropped through a hole in the ice was deflected by the current and particles could be seen moving past a hole. Some of the holes where current was detectable were 200 yards from the nearest motor. Oxygen Stations 1 and 2 were located toward the center of the lake away from the path of the motors. These stations were located in areas that were probably least affected by the mixing. The oxygen concentrations at these stations indicate that the lake was thoroughly mixed to a depth of 40 feet with partial mixing to the bottom. The oxygen values recorded on March 6, the day after the motors were operated, indicate that significant mixing continued after the motors were stopped. It is also significant that the greatest increase in oxygen on March 6 was at the bottom of the lake.

In addition to mixing the lake and creating a more uniform oxygen profile, the motor operation also introduced appreciable quantities of oxygen to the entire lake. This was unexpected and difficult to explain. The motors were always operated through rather small holes in the ice. There was a tendency for the motors to enlarge the hole in which they were running, however, when this happened the motors were stopped and restarted in a new hole. While the motors were running, air being drawn through the holes could not be detected. When the motors were stopped though, it was obvious that this was happening. Large air bubbles could be seen under the ice, mostly moving back toward the hole to escape. It now seems that the operation of outboard motors in this manner warrants additional experimentation as a method of alleviating winterkill. Merna (1965) used outboard motors to prevent winterkill, but the objective of that study was to move water over the surface of the ice. It seems that motors operated through small holes in the ice create enough force to suck air through the hole and circulate the bubbles throughout the lake.

SUMMARY

Five outboard motors operated through holes in the ice mixed almost the entire main basin of a 44-acre lake with a maximum depth of 68 feet. No attempt was made to create mixing in a shallow marsh area or in channels behind an island. It seems obvious that this could be accomplished and is only a matter of using additional motors and learning to direct the current created. Additional work will be required to learn the number of motors and running time needed and the most efficient method of directing the mixing. Conceivably any size lake could be mixed with sufficient motors.

This method of mixing a lake should have practical application in the management procedure of eliminating undesirable fish populations with toxicants. The method also seems to be ideally suited for citizen participation projects. Management biologists might in the future inject toxicant through several holes in the ice of a lake to be treated while the lake association or sportsmen club members mix the lake with their outboard motors.

Though not tested, it is quite likely that a lake could not be circulated in this manner during open-water periods. Without an ice cover, the energy put into the lake by the propellers would rather quickly be lost to wave action. Additionally, circulation created would be opposed by the natural wind-induced circulation in the lake and also by existing temperature stratification. It is easier to mix water in a "closed container" free of opposing outside forces.

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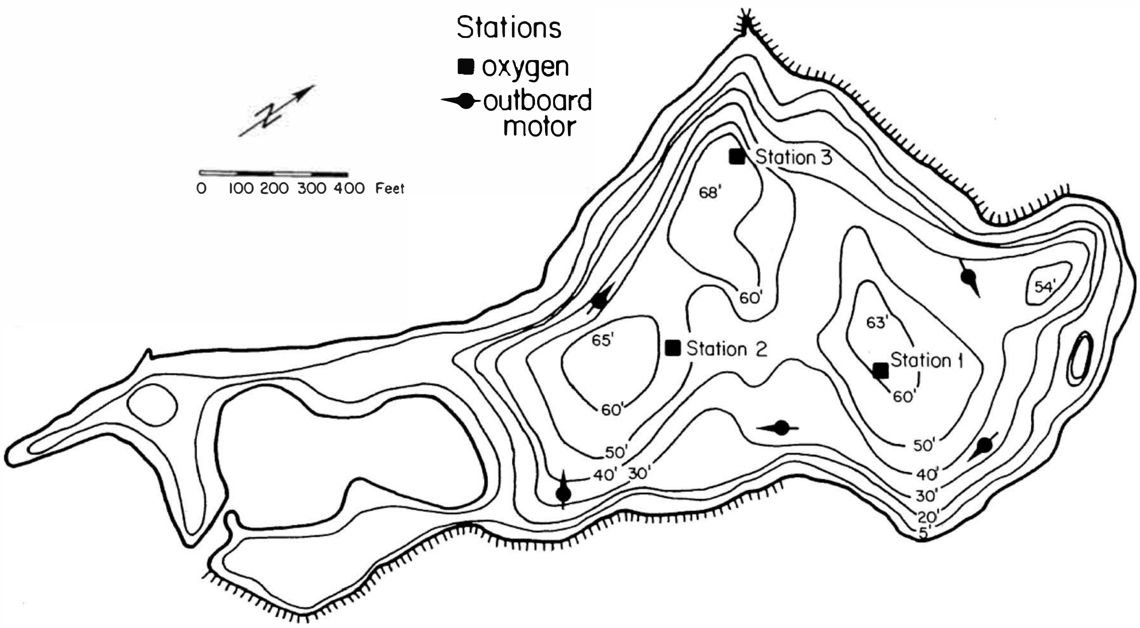

Figure 1. Dickinson Lake showing stations where outboard motors were run and dissolved oxygen measured.

Table 1. Oxygen concentration (mg/l) in Dickinson Lake before and after operating outboard motors through the ice (B = bottom).

	Station 1			Station 2			Station 3
Depth (feet)	11:00AM 3/5/87	2:00PM 3/5/87	2:30PM 3/6/87	11:30AM 3/5/87	2:30PM 3/5/87	3:00PM 3/6/87	4:00PM 3/5/87
0	9.0	9.7	—	7.5	10.0	—	9.0
4	9.0	9.6	10.0	7.4	9.6	10.0	9.4
8	9.0	9.6	—	7.4	9.6	—	9.3
12	8.8	9.6	9.5	7.3	9.6	9.7	9.2
16	8.8	9.6	—	7.0	9.5	—	9.2
20	8.2	9.6	9.7	6.8	9.2	9.7	9.2
24	8.0	9.1	—	6.8	8.9	—	9.1
28	7.8	8.6	—	6.8	8.8	—	9.0
32	7.6	8.5	9.2	6.6	8.8	9.5	9.0
36	7.4	8.2	—	6.6	8.7	—	8.9
40	7.0	8.2	9.3	6.5	8.8	9.4	8.9
44	5.9	6.0	—	6.3	8.8	—	B
48	5.0	5.4	8.4	5.1	8.4	8.6	—
52	3.6	4.0	—	4.7	6.0	—	—
56	2.0	3.1	5.5	4.2	5.1	8.0	—
60	1.2	2.5	4.9	B	—	—	—
64	B	—	—	—	—	—	—

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