Evaluation of Two Methods of Aeration to Prevent Winterkill

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EVALUATION OF TWO METHODS OF AERATION TO PREVENT WINTERKILL

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AERATION OF WINTERKILL LAKES to eliminate loss of fish has been studied by many investigators. Results have not been uniformly successful, but Hemphill [*3*], Rasmussen [*5*], and Halsey [*2*] were reasonably successful in preventing winterkill. Conversely, Patriarche [*4*], Woods [*9*], and Seaburg [*7*] found their attempts with aeration unsuccessful.

Two kinds of lake situations exist which may be amenable to aeration. The first, a marginal winterkill lake, is one which usually maintains an acceptable dissolved oxygen level throughout the winter, but may winterkill under severe weather conditions. The second lake situation, one in which dissolved oxygen always drops to low levels, presents a different problem to the fisheries scientist. Lakes such as the second, with proper aeration, might be economically managed to support a valuable fishery in regions of very high demand.

This paper presents a comparison of two aeration approaches to maintain or replenish dissolved oxygen. The first technique involves continuous aeration throughout the winter while the second involves initiating aeration when dissolved oxygen has been reduced.

STUDY AREA

Parvin Lake, a Colorado Division of Game, Fish, and Parks research station, was selected for experimental aeration. This lake has the advantages of considerable limnological background data, electrical power, and laboratory facilities. Located at 2500 meters elevation, the lake covers 19 hectares and has a maximum depth of 10 meters (fig. 1). Ice cover usually lasts from November to April and reaches 40 to 60 centimeters thickness.

Parvin Lake does not normally winterkill, but a decline in dissolved oxygen occurs in deep water every winter. With the large amount of background data, we can accurately evaluate the effects of aeration.

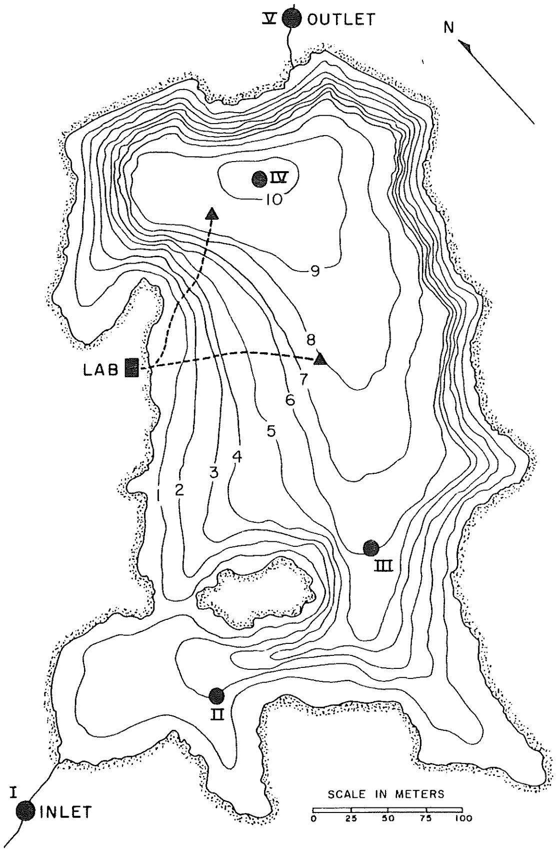

Figure 1.—Map of Parvin Lake, Colorado. Depth contours in meters; triangles show location of aerators; dashed line shows location of plastic pipe.

AERATION SYSTEM

The aerators selected for this study consisted of a one-piece 46-centimeter-diameter polyethylene tube containing a continuous polyethylene coil, which divides the tube into two separate longitudinal sections (fig. 2). Air is released at the bottom through several small holes. The coiled design lengthens the air-water interface compared to a simple perforated pipe. Water upwelling is created by bottom water drawn up the tube. Two aerators were used in Parvin Lake.

Compressed air was provided by a single stage air-cooled compressor mounted in the laboratory (fig. 1). Maximum displacement of this compressor was rated at 2.1 cubic meters per minute and maximum pressure at 4.2 kilograms per square centimeter. The system was run continuously by a single compressor, although a second was connected into the system as an alternate.

Heavy duty (7 kg/cm) capacity polyethylene pipe (3.8 cm diameter) connected the aerator and compressor. Concrete blocks, 20 cubic centimeters (15 kg), were attached at 3-meter intervals along the pipe to serve as anchors. The system operated at about 1 to 1.4 kilograms per square centimeter.

SAMPLING

A standard sampling program was carried out at Parvin Lake during a control winter (December 1968—April 1969), treatment winter I (December 1969—April 1970), and treatment winter II (December 1970—April 1971). During treatment I, the aeration system was in continuous operation. In treatment II, aeration was begun on March 15 when the dissolved oxygen reached a low level.

Five sampling stations were selected and permanently marked (fig. 1). Station I was located in the inlet creek approximately 50 meters above the confluence with the lake. Station II was in water 2 meters deep and outside the main body of the lake. Station III was in water 6 meters deep. Station IV was placed in the deepest part of the lake (10 meters). The outlet stream station (V) was about 50 meters downstream. Water samples and temperature were normally taken weekly but daily when oxygen decline was noted.

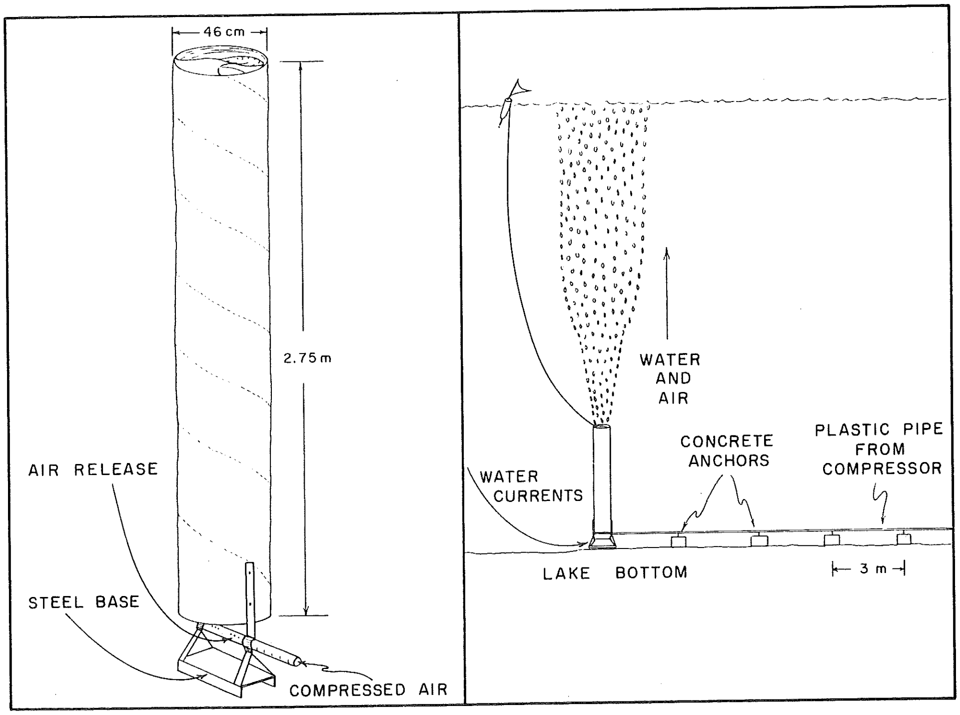

Figure 2.—Aerators used at Parvin Lake showing general design and placement in lake.

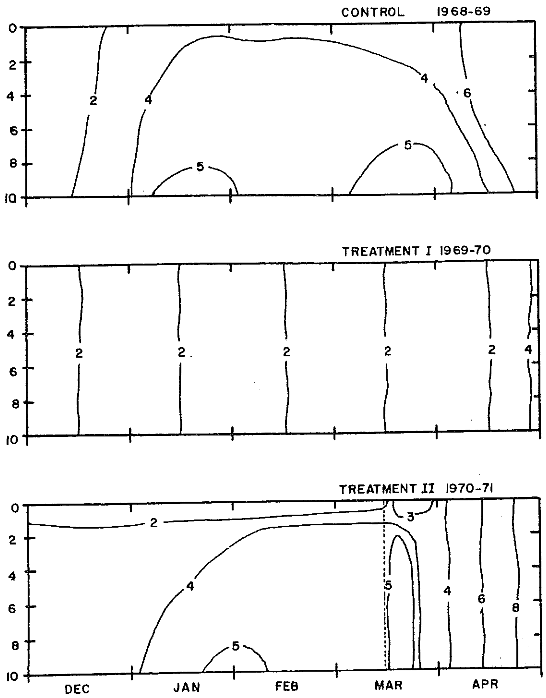

Figure 3.—Water temperature (° C.) in Parvin Lake during control and treatment winters. Depth (meters) given on left; shaded area indicates aeration system in operation.

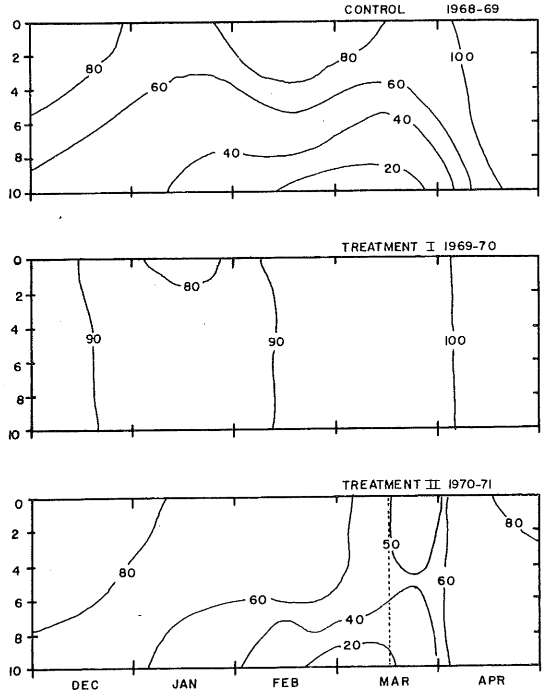

Figure 4.—Dissolved oxygen (percent saturation) in Parvin Lake during control and treatment winters. Depth (meters) given on left; shaded area indicates aeration system in operation.

RESULTS AND DISCUSSION

Water Temperature

During the control winter, the difference between the surface and bottom temperatures of the lake ranged from 1° to 3° C. (fig. 3). The stratification was completely eliminated in treatment I (fig. 3). Water temperatures during this treatment were lower than normal, which could have some effect on the growth rate of the fish. Lowering of water temperatures during winter aeration is typical [*4, 6, 8*]. It is undoubtedly caused by continued cooling at the air-water interface and elimination of the ice cover insulation. During treatment II, aeration was initiated in March when thermal gradients were present in the lake. These gradients were eliminated very rapidly.

Dissolved Oxygen

Parvin Lake is a dimictic lake in which low dissolved oxygen concentrations develop in deeper water in winter (fig. 4). Dissolved oxygen during treatment I increased compared to control and no loss developed in deeper water during this treatment winter (fig. 4). During treatment I, when aeration was conducted continuously, a minimum of 80 percent saturation was observed. In the control winter, however, minimum saturation values dropped to 20 percent in deeper water.

During treatment II, aeration was not begun until mid-March. The immediate reaction to aeration was a decrease in weighted dissolved oxygen concentration (March 15th, 5.7 mg/1; March 16th, 4.4 mg/1) (fig. 4). Similar results were found by Halsey [*2*]. Flick [*1*], however, found that if turbulence at the pumping stations was kept to a minimum, no decreases occurred in dissolved oxygen. Any turbulence at the aeration holes caused the newly aerated water to mix with the oxygen deficient water in the lower reaches. This oxygen, when transported to the bottom of the lake, was consumed by decomposition of organic material. The overall effect was to lower the oxygen levels throughout the lake.

When aeration is initiated during periods of low oxygen, resultant mixing may cause additional problems. Due to the uniform temperature gradient which will immediately develop, mixing of top and bottom waters would require less turbulence. This could cause an immediate lowering of oxygen values.

Iron

Iron normally follows a definite seasonal cycle in Parvin Lake. Increases occur in deeper water in winter due in part to lower dissolved oxygen levels and the presence of a reducing agent. In this case, decomposing organic matter acts as the reducing agent. During treatment I, iron content decreased and a uniform reading was present from top to bottom (fig. 5). When aeration was initiated in treatment II, an initial increase in iron occurred (fig. 5). This may be correlated with the dissolved oxygen decline that occurred with commencement of aeration. This was further enhanced by the increase in decomposition of the organic matter. After the initial iron increase, the dissolved oxygen content slowly increased and stabilized. The iron then decreased and became more uniform throughout the lake.

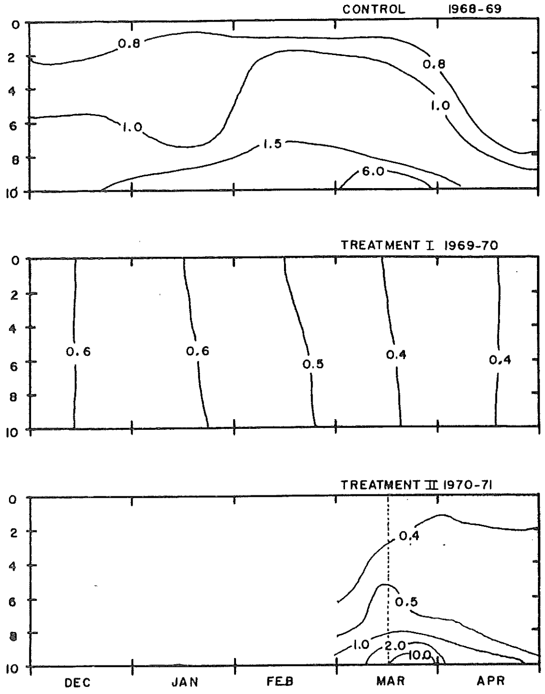

Figure 5.—Iron (mg/l) in Parvin Lake during control and treatment winters. Depth (meters) given on left; shaded area indicates system in operation.

CONCLUSIONS

1. Winter aeration results in loss of thermal gradients and a lowering of the average water temperatures. This may slow growth rates of fish and have other biological implications.

2. Continuous aeration in winterkill lakes can be successful in combating low dissolved oxygen concentrations, but care should be taken in beginning aeration with low dissolved oxygen levels.

3. Prevention of turbulence caused by aeration would probably allow aeration at any time of the winter without causing oxygen decreases and iron increases.

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