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SAWMILL RIVER ROAD, ROUTE 100C

TARRYTOWN, NEW YORK 10591

Copies to all members of the Three Lakes Council Inc.

AQUATIC
ENVIRONMENTAL
SCIENCES
(914) 345-3974

March 15, 1973

Mr. Wayne Van Tassell
President, Three Lakes Council, Inc.
Cove Road
RFD # 1
South Salem, New York 10590

Dear Mr. Van Tassell:

As you are, of course, aware the AQUATIC ENVIRONMENTAL SCIENCES Department of Union Carbide has been carrying out an in-depth study of Lakes Waccabuc, Oscaleta and Rippowam since July 1972. This study, which is still going on, is being made with the kind consent and cooperation of the Three Lakes Council and the members of the community surrounding the lakes. We are grateful indeed for this cooperation, and are now ready to present the results of our study to date and a specific recommendation for future action. This recommendation, along with a summary of our findings, is presented in the attached "Proposal for the Restoration of Lake Waccabuc".

In brief, we find the lakes to be moderately eutrophic (over nourished) and believe that they will eutrophy at an accelerated rate if no steps are taken to alleviate the situation. While such obvious measures as reducing the inflow of nutrients into the lake will assist in slowing down the rate of eutrophication somewhat, it is probable that the sediments have absorbed sufficient quantities of nutrients from previous inputs to sustain dense algal growths.

Our recommendation is that the hypolimnion (deep water) of the lakes be oxygenated to prevent nutrient regeneration from the sediments, thus reducing the amount available for plant growth. We propose that such a process be undertaken on Lake Waccabuc this summer and the Lake Oscaleta be used as a "control" to permit a definitive comparison of the effects of the oxygenation treatment. We propose to conduct this work at our own expense because we feel it will assist us to further our own knowledge of lake restoration problems and thus allow us to apply the technique to the many thousands of lakes in this country now undergoing the same eutrophication process as your three lakes.

We respectfully submit the attached proposal for your consideration.

Sincerely,

AQUATIC ENVIRONMENTAL SCIENCES

(Original signed by C. W. Cowley)
C. W. Cowley
Manager

CWC/ldd

A PROPOSAL FOR THE RESTORATION OF LAKE WACCABUC

by

Union Carbide Corporation
Aquatic Environmental Sciences
Tarrytown Technical Center
Tarrytown, New York 10591

March 15, 1973

Introduction

Henry David Thoreau (Walden, 1834) observed that, “Nothing so fair, so pure, and at the same time so large, as a lake, perchance, lies on the surface of the earth. Sky water.” Thoreau, of course, was not familiar with the perils that face many of our lakes today. These perils are related to population density and the products of our advanced technology (e.g. lawn fertilizer, detergents, mercury, etc.). The consequences of these perils are often manifested by the process of accelerated eutrophication. Eutrophic means, “well nourished”, and the eutrophication process is a natural aging process whereby lakes accumulate nutrients (such as phosphorus and nitrogen), become more productive, fill with sediments and eventually become marsh and dry land. The eutrophication process is greatly accelerated by increased loads of nutrients from septic tank drainage, lawn or agricultural fertilizer run-off, and other aspects of civilization.

Eutrophic lakes are characterized by dense growth of algae (both microscopic floating plants, and rooted plants) turbid water, green floating scums that accumulate in windrows on the lee shore, fish kills, very dense swarms of flying insects, noxious odors and other undesirable conditions. As unproductive, clean water lakes become eutrophic, they generally pass through different stages. To understand these changes, we will first describe the anatomy of a lake.

During the summer, a lake is divided into three depth zones based on water temperature, and therefore water density (Fig. 1). The shallow, warm epilimnion typically extends from the surface to 15 feet depth. This zone is well mixed by the wind and oxygen concentrations are near saturation. Most of the algae and warm water fishes (e.g. bass, bluegill, pike) are found in this zone. The thermocline is the intermediate zone, and is characterized by a sharp temperature decrease. The thermocline may extend from 15 to 30 feet (as shown in Fig.l), and is not circulated by the wind as is the shallow epilimnion. The third zone, the deep, cold hypolimnion is likewise completely out of contact with the lake surface, and water currents are minimal. The hypolimnion temperature is typically between 40°F and 50°F. In unproductive lakes, oxygen concentrations in the hypolimnion are usually greater than 5 parts per million (ppm), and these lakes will support cold water fishes, such as trout or salmon. Hypolimnetic oxygen concentrations in productive, eutrophic lakes, on the other hand, are zero. Associated with this oxygen depletion are high concentrations of noxious gases such as hydrogen sulfide (rotten egg odor), ammonia and carbon dioxide; and the absence of fish and other higher aquatic life.

Also associated with hypolimnetic oxygen depletion, is the resolution of nutrients (such as phosphorus) from the bottom sediments. These sediments contain very high concentrations of nutrients, and under oxygenated conditions the nutrients are insoluble and unavailable for plant growth. Consequently, as a lake becomes more eutrophic: (1) oxygen is depleted from the hypolimnion, (2) cold water fish are eliminated, (3) nutrients formerly trapped in the sediments are solubilized and released into the water, (4) these nutrients promote even denser growths of plants, and the rate of eutrophication is accelerated, and (5) eventually the lake’s value (and surrounding property values) Is greatly reduced.

Solutions to the Eutrophication Problem

Several procedures have been used to alleviate eutrophication. Despite much effort and money, these procedures have given only partial relief. In some cases they have worked well, but in other cases, not at all. In short, there is no panacea. Methods that have been used, and are now being developed include:

(1) Reducing the inflow of nutrients into the lake. This can be partly achieved by advanced sewage treatment methods. Conventional sewage treatment may partly reduce the nutrients, or divert them from the lake, which is to say relocate the problem. Other means of reducing nutrient input include reduced use of fertilizers on lawns and agricultural lands, better erosion control, and green belts around the water courses. It is very desirable to reduce nutrient inputs even if other methods of eutrophication control are used. Conversely, reduced nutrient input is sometimes not enough, by itself, to significantly reduce eutrophication. If the lake sediments have absorbed sufficient quantities of nutrients from previous inputs, then these may be sufficient to sustain dense algal growths, etc. even though further nutrient inputs have been reduced.

(2) Dredging and removal of the sediments has been used successfully in conjunction with (1), but this procedure is very expensive and doesn't always work. If the accumulation of nutrient rich sediments is very deep then dredging will only expose additional nutrient rich deposits. Removal of all the nutrient rich deposits under these conditions may be impossible or extremely expensive.

(3) Chemical treatment can be used to poison the algae and/or other biota and improve the symptoms, but not the cause of eutrophication. Copper sulfate, chlorinated hydrocarbons and certain synthetic compounds are sometimes used, but because of the persistence and extreme toxicities of many of these compounds they may create another, more serious set of problems.

(4) Weed removal is sometimes used in shallow weed-choked lakes. However, this procedure can only be used on 'rooted" algae and not on microscopic algae. It also requires continuous harvesting during the summer with the necessary investment in personnel and special equipment.

(5) Artificial oxygenation of a lake with compressed air or liquid oxygen is widely used to alleviate eutrophication problems. It prevents nutrient regeneration from the sediments, thus reducing the amount available for plant growth, eliminates hydrogen sulfide and other gases, improves the fishery habitat and fish growth rates and improves drinking water quality.

There are many types of aeration systems (Fig.2). There are systems for ponds, streams and lakes. The lake aeration systems are divided into two categories: <u>Destratification</u> and <u>Hypolimnion</u> aeration. Destratification with compressed air typically involves a compressor on the shore and one or more air lines leading to the deepest point in the lake (Fig .3). Air is released from these lines and causes the hypolimnetic waters to be upwelled, mixed with shallower water, and oxygenated in the process. Destratification leads to the complete mixing of the lake and the elimination of the three depth zones. All the water is of equal temperature and about as warm as the surface waters before destratification began. Therefore, the cold waters required by trout and salmon are eliminated. While destratification is very beneficial in most cases (especially for drinking water quality), it does not always reduce algal densities and in some cases may increase algal growth, for reasons not fully understood.

Hypolimnion aeration operates much differently than destratification. Here the object is to maintain thermal stratification (i.e. the three depth zones), but to increase the oxygen concentration in the hypolimnion. The Limnox aerator is an example of this method of aeration (Fig .4). A shore based compressor pumps air into the Limnox aerator where it is released from a diffusor near the base of the unit. This air rises within the aerator drawing in hypolimnetic water which is aerated. The air and water separate within the aerator, and the water flows back into the hypolimnion saturated with oxygen. The air is then vented to the atmosphere through a small diameter pipe. Thus, hypolimnetic water is oxygenated and circulated, but not heated nor mixed with surface waters.

Hypolimnion aeration is a very recent development. It was developed in Europe, and is still more widely used there. We know of only one application in the United States to date. While the full effects of hypolimnion aeration are still not evaluated, preliminary results in Europe and the U.S.A. indicate that it is much more preferable to artificial destratification. It may more effectively and consistently reduce algal growth. Furthermore, since hypolimnion aeration oxygenates without eliminating the cold water, it will allow the establishment of trout or salmon populations where none could exist previously.

Our Assessment of Lakes Waccabuc, Oscaleta and Rippowam

Coincident with our needs for further field testing of our lake aeration systems, we learned of the three lake communities' concern about the condition of their lakes. This led to a meeting during July 1972 with Mr. Wayne Van Tassell (President of the Three Lakes Council, Inc.) to discuss our mutual interests. We concluded that a thorough assessment should be made of the three lakes by our Aquatic Environmental Sciences Program personnel. The results of this work were later presented to the Three Lakes Committee, and still later (during September 1972), we made a presentation at the annual meeting of the Three Lakes Council, Inc.

Briefly, we began assessment during August 1972. Three sampling stations were selected in each lake (Fig.5), where we measure oxygen, temperature, pH, alkalinity, turbidity, conductivity, and chlorophyll concentrations. The oxygen and temperature profiles for each lake are similar, allowing for depth differences between the lakes (Figures 6, 7 and 8). These profiles for all three lakes are characteristic of moderate levels of eutrophication. This is typified by zero hypolimnetic oxygen in all three lakes, their low transparency, and green color. In our opinion, the lakes will eutrophy at accelerated rates if no steps are taken to alleviate the situation. This may lead to the very objectionable conditions cited earlier. Although we cannot accurately predict the time required to reach the worst state of eutrophication, our best guess is from 5 to 15 years. At that point drastic action (such as dredging, in combination with some other remedial actions) could be necessary to restore the lakes even to their present conditions.

It is also our opinion that artificial hypolimnion aeration will greatly benefit the lakes at this time, and halt or reverse the eutrophication process. Hypolimnion aeration will create suitable year around conditions for trout (none can survive year around now) and may reduce concentrations of microscopic algae (which will result in greater water clarity). Although we cannot guarantee these results, we believe they will occur, based on experiments conducted elsewhere, and on theoretical considerations.

Our Proposed Lake Restoration Program

We propose to conduct a lake restoration project on the three lakes during the summer of 1973, using the Limnox aeration system. This project will be conducted as part of our research and development program for lake restoration. As such, we propose to conduct this work at our expense.

As discussed, we are very much interested in the Limnox aeration system and wish to learn more about it before we promote its use nation-wide. As already discussed with the Three Lakes Council, our tentative plans are as follows: We have ordered two Limnox aerators and an electric air compressor from Sweden. These should arrive and be installed during May, such that we can begin aeration during June 1973. The aerators will probably be installed by helicopter near the deepest points in Lake Waccabuc. We have selected Lake Waccabuc to receive the aerators since it is the deepest of the three lakes, it is furthest downstream, and since we need the other two lakes as “controls” with which to evaluate the aeration effects. The air compressor will be located in a sound proofed shore enclosure which will be unobtrusively set back from the shore. The air line from the compressor to the aerators will be submerged and therefore not a hindrance to pleasure craft. We will buoy off an area around the aerator vent pipes, as well as other, small selected locations in both Lake Waccabuc and Oscaleta. These buoys will locate important sampling locations, and while they are not in use by our personnel, lake residents may tie up to them at their pleasure. We are now negotiating research contracts with Adelphi University (Dr. Martin Garrell) and Ithaca College (Dr. John Confer) to assist us with certain specialized aspects of the evaluation. Researchers at the Universities of New Hampshire and Georgia have also expressed interests in the work. Although some of the samples will be analyzed at our Tarrytown Laboratories, we will analyze most of the samples in our mobile, trailer laboratory which we will station near the lake. We are now negotiating for a location where we may station the trailer. We plan to stock several thousand trout in Lake Waccabuc, probably during July. We will monitor the movements of these fish using electronic depth recorders, vertical gill nets and special sonic tags. The tags will be placed on only a few fish, and are essentially miniature radio transmitters that emit coded signals which we will detect using hydrophones. The lake residents are encouraged to fish for the trout. We would prefer to stock rainbow trout, but are also considering brook trout, brown trout and lake trout. The species selected, fish sizes and numbers stocked will depend on the availability of the fish. The New York State Department of Environmental Conservation has granted us a stocking permit for these species.

We will probably begin aeration during June 1973 and continue aeration through October 1973. Our plans for 1974 are indefinite at this time, and are largely dependent on the results of this summer’s work. Depending on these results, and the considerations of the Three Lakes Council, we may either continue our evaluation through 1974 at our expense, negotiate with the Three Lakes Council for ownership of the aeration system, or remove the system from the lake. All removal will be conducted at our expense.

The beneficial effects of our aeration may not be fully realized until 1974, since there Is a one year time lag between the time when nutrients are regenerated in the hypolimnion (or not regenerated) and when they may become available to the algae during the season of maximum algal growth.

In other words, nutrients regenerated in the hypolimnion during 1972 will be “most available” for algal growth during the summer of 1973. Likewise, the cessation of hypolimnetic nutrient regeneration may not be fully realized until the summer of 1974. Therefore, two years of aeration may be necessary to fully evaluate Its effects.

We believe that both the lake residents, and our Environmental Sciences Program will benefit greatly from this program. We are gratified by the cooperation we have received, and are looking forward to the restoration evaluation.

Figure 1

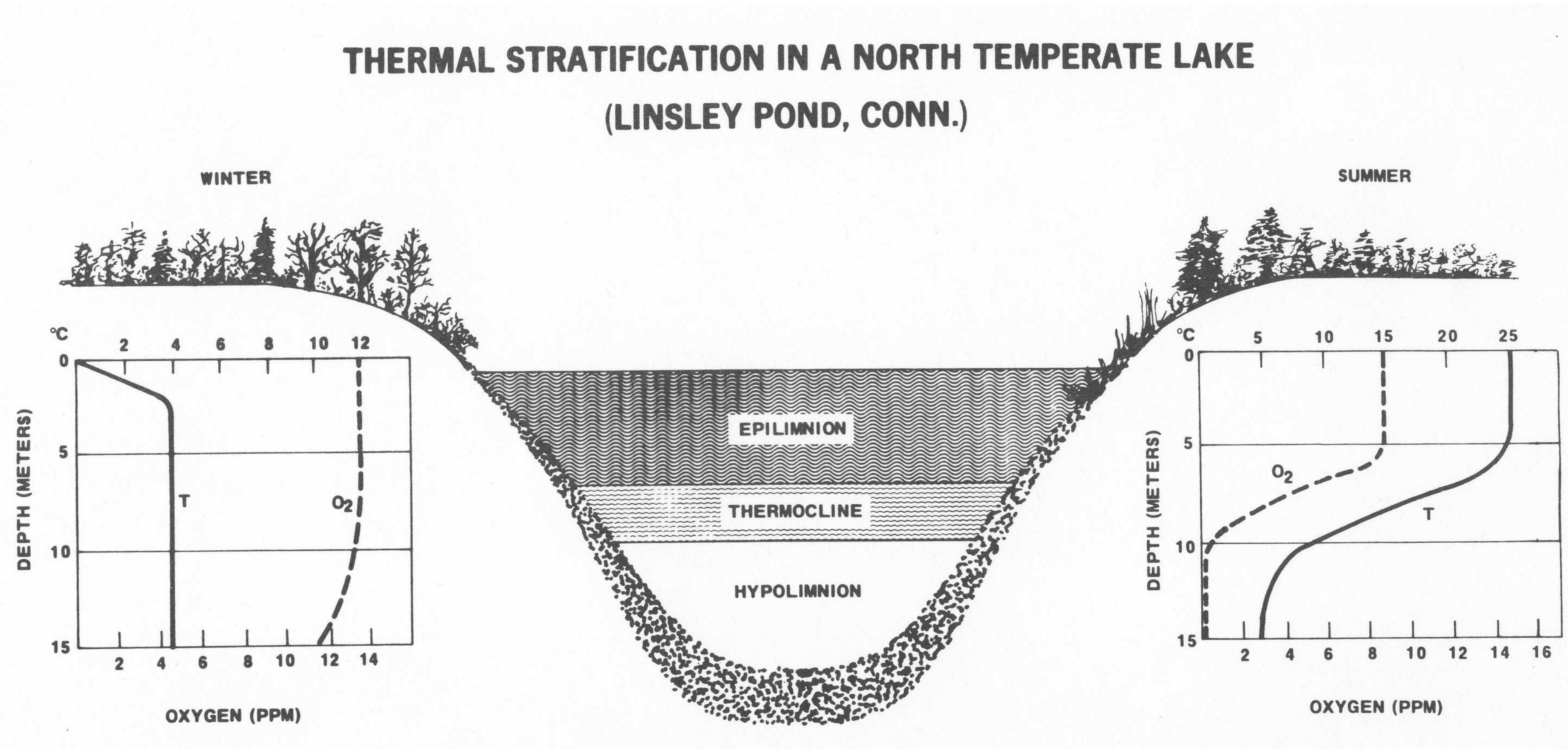

Fig. 1. Three depth zones of a typical lake during summer stratification. Typical oxygen and temperature profiles (with depth) are shown for summer and winter conditions.

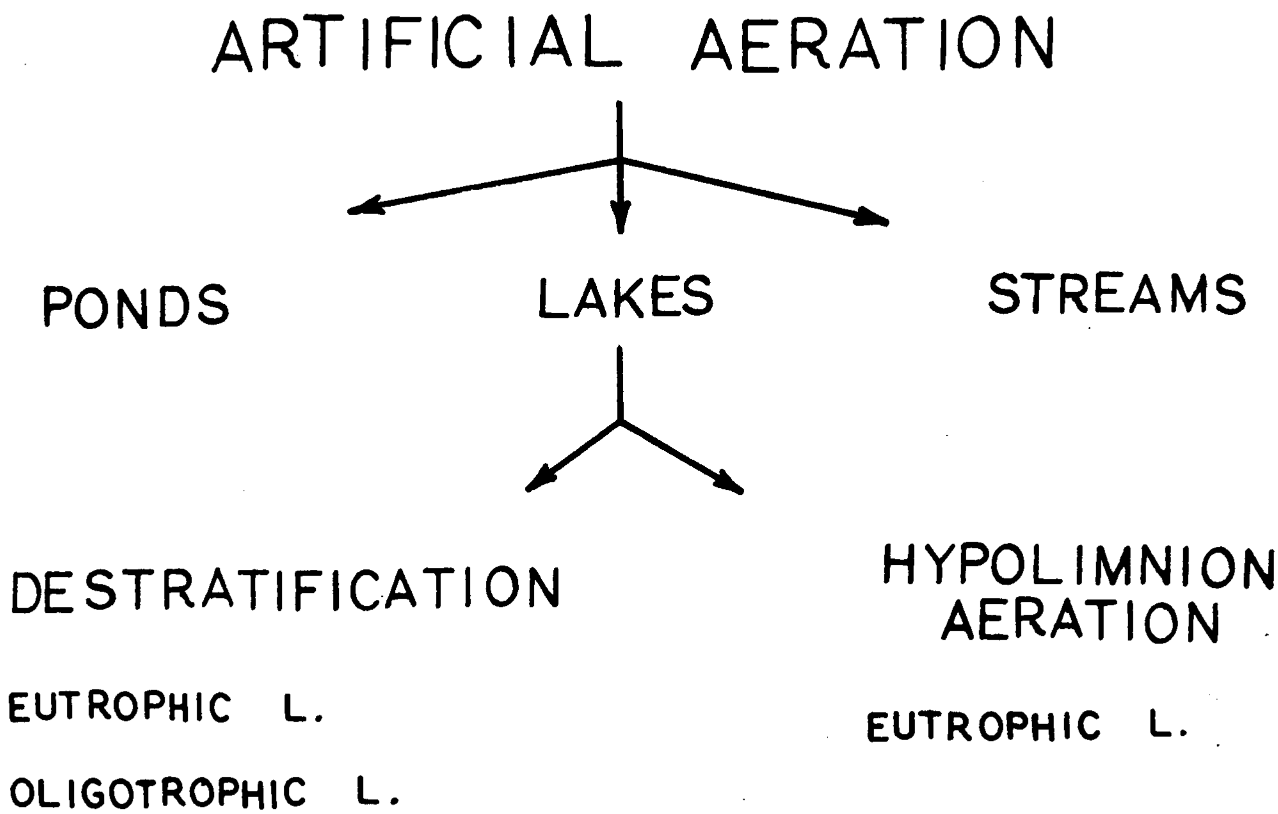

Fig. 2. Artificial aeration systems have been developed for ponds, lakes and streams. There are two categories of lake aeration systems: destratification and hypolimnion aeration, as described in the text.

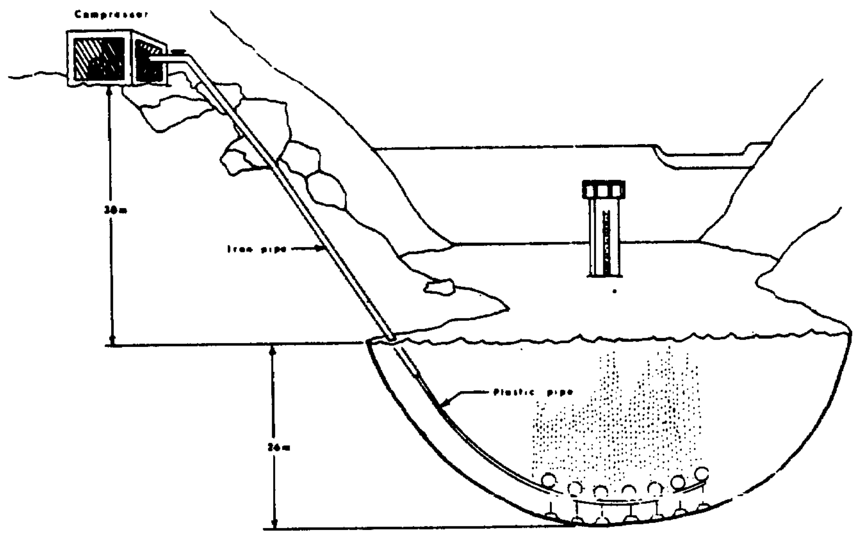

Fig. 3. A simple destratification system consists of an air compressor on the shore and a simple air line along the bottom of the lake. Air is released through holes in the air line.

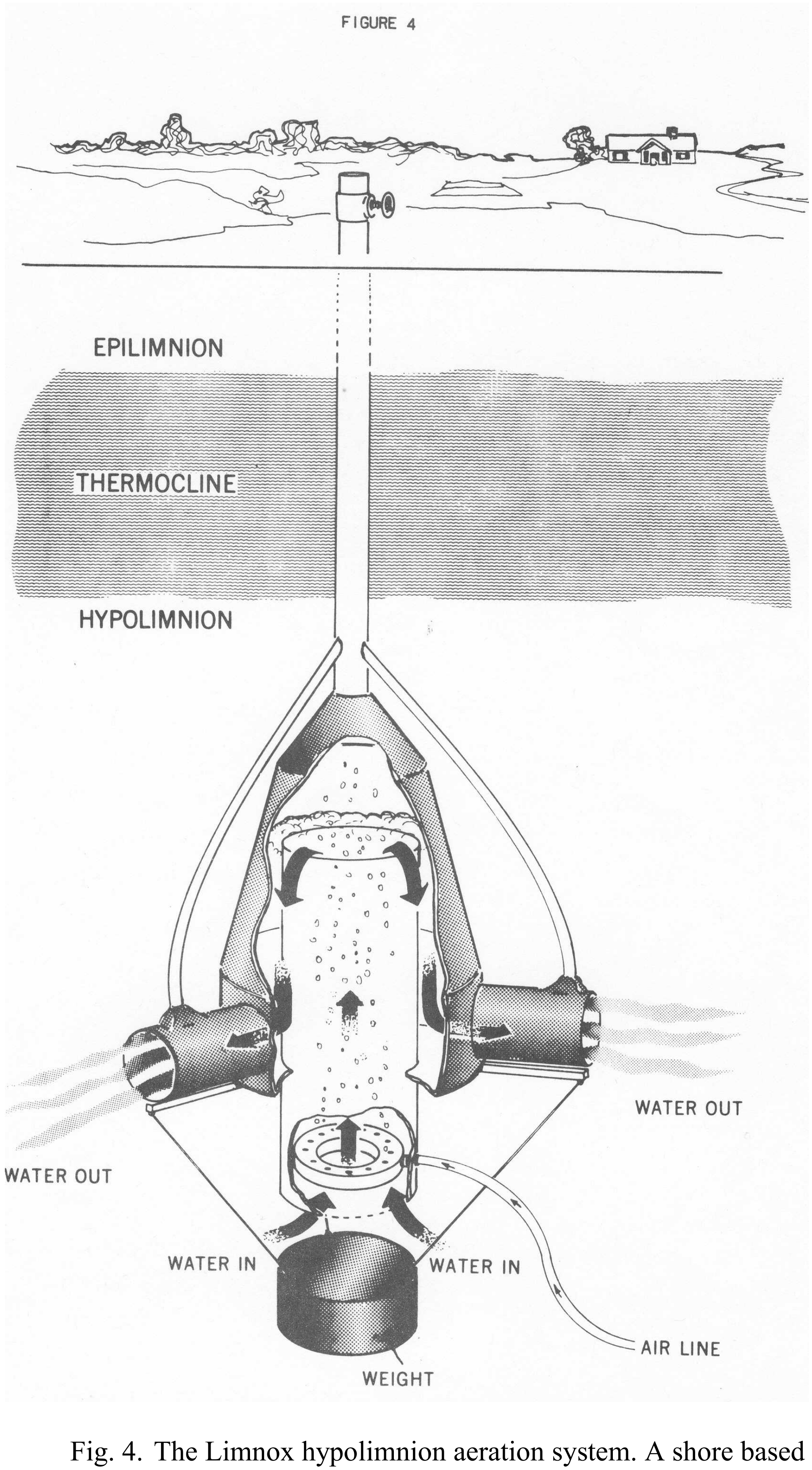

Fig. 4. The Limnox hypolimnion aeration system. A shore based compressor delivers air to the aerator, which is submerged at the deepest point of the lake.

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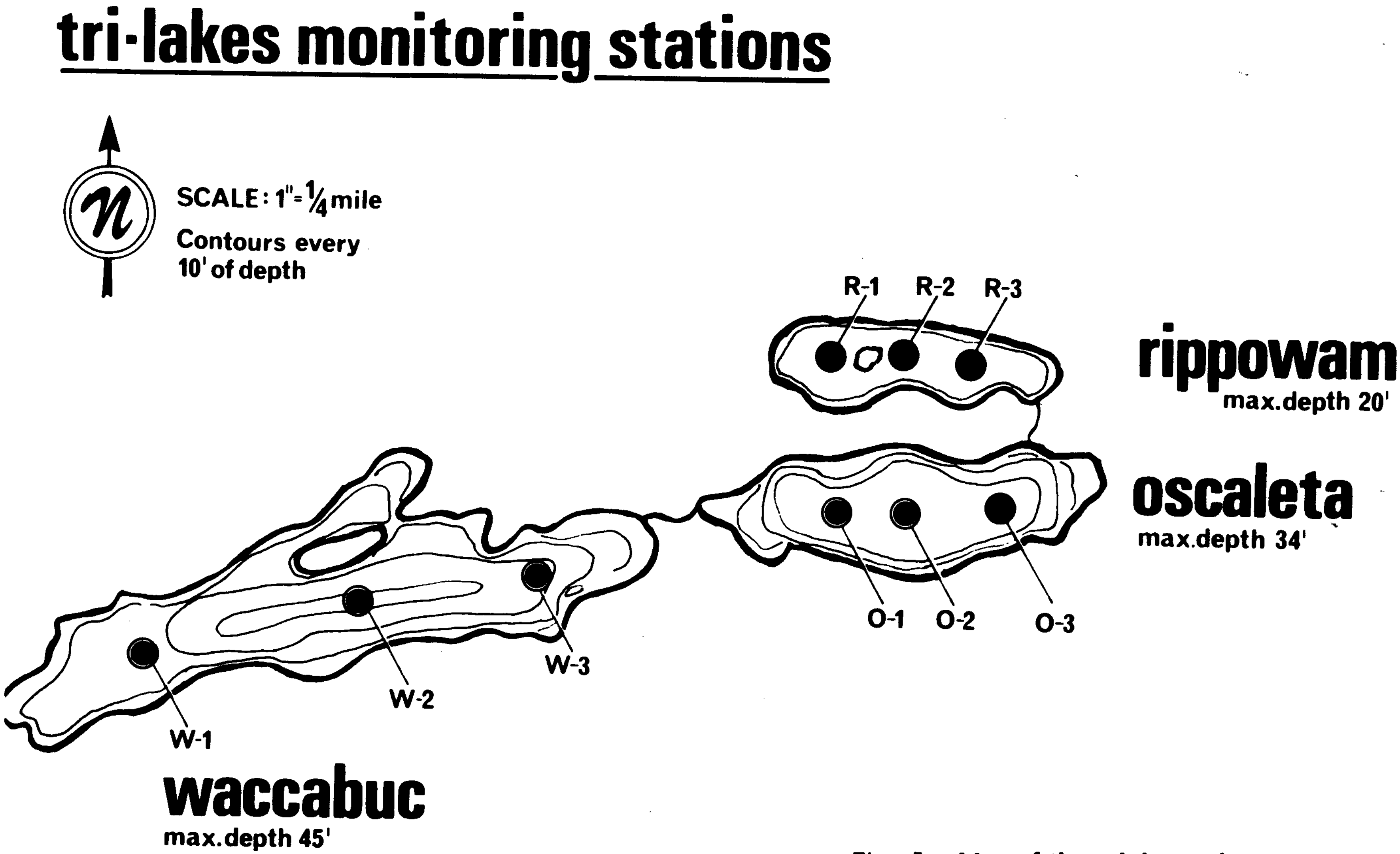

Fig. 5. Map of three lakes, showing monitoring stations in each lake.

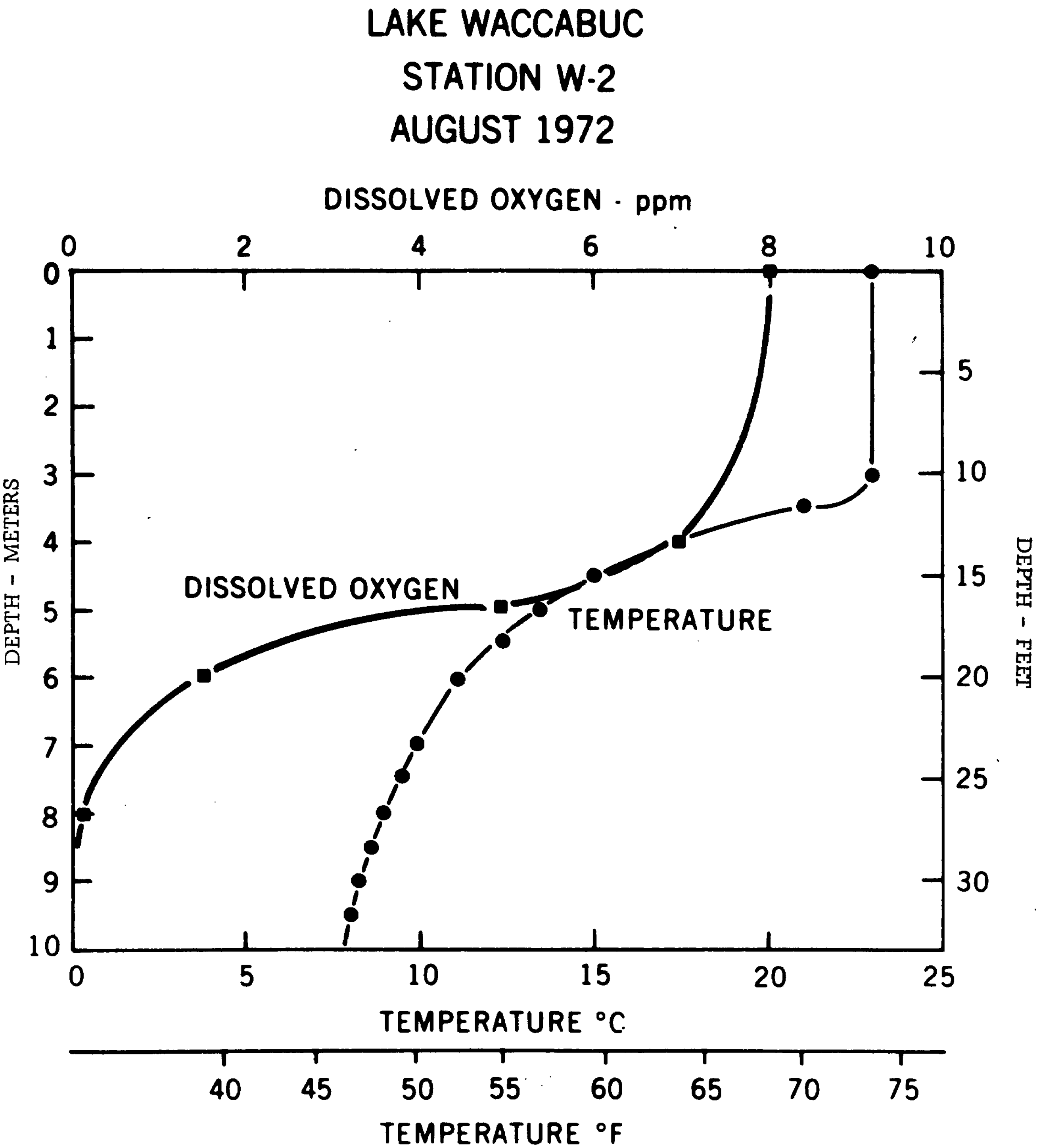

Fig. 6. Oxygen and temperature profiles for Lake Waccabuc taken at Station W-2.

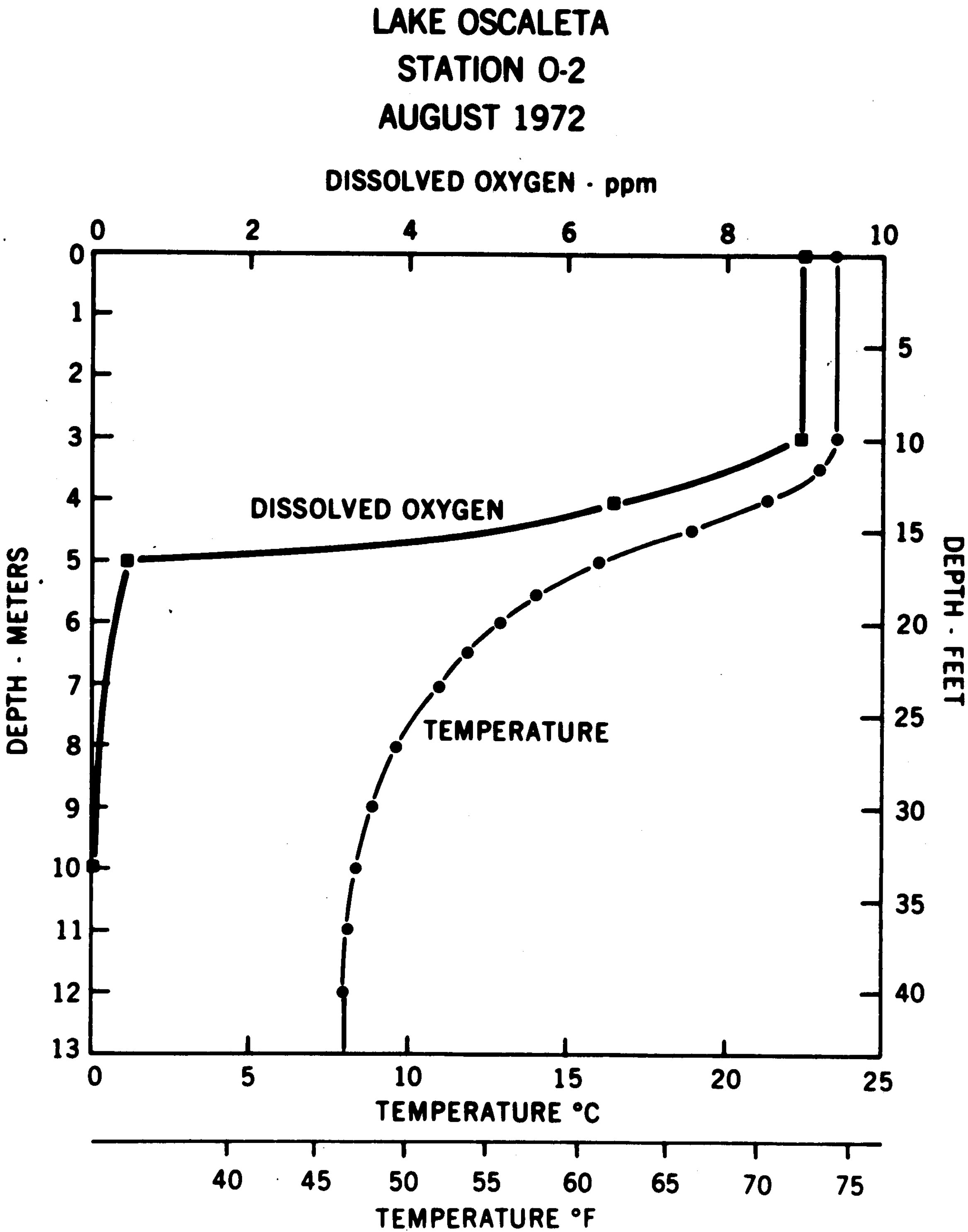

Fig. 7. Oxygen and temperature profiles for Lake Oscaleta taken at Station O-2.

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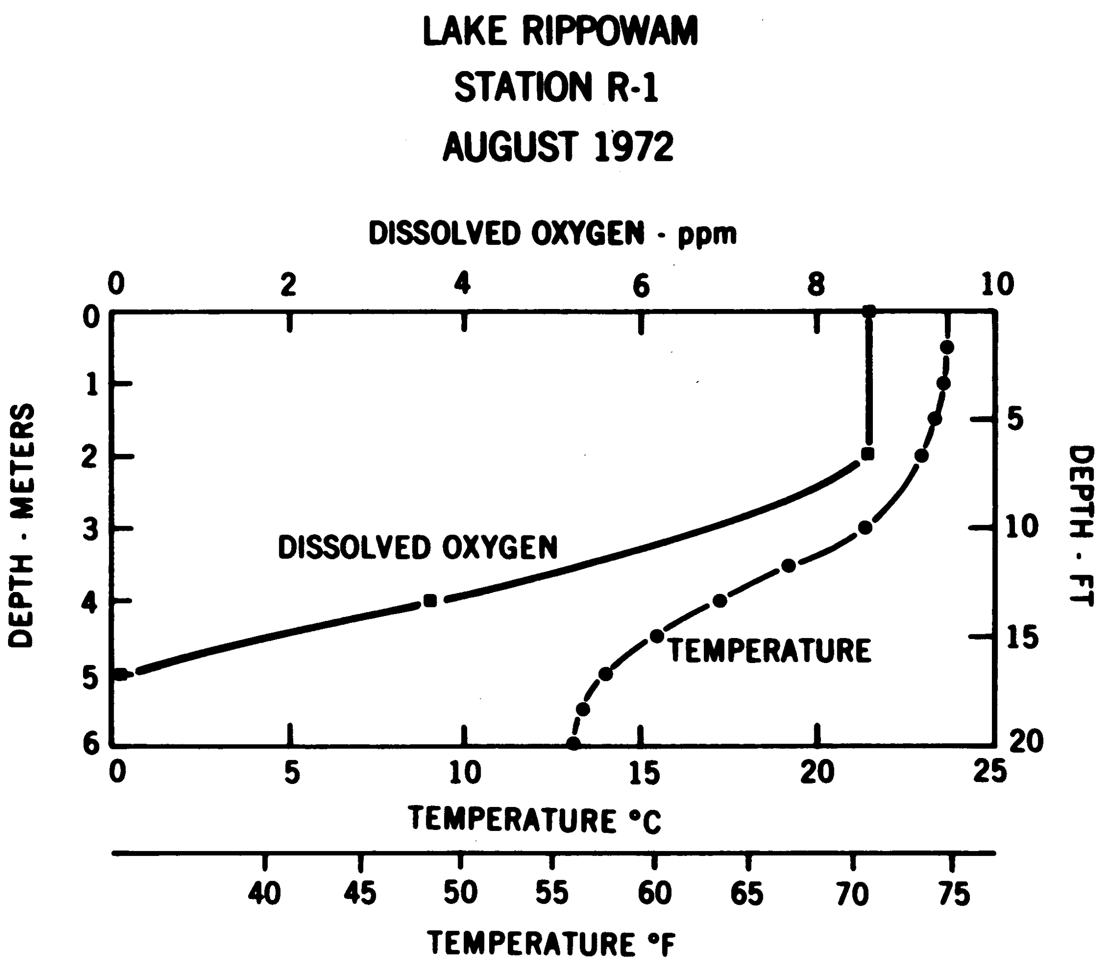

Fig. 8. Oxygen and temperature profiles for Lake Rippowam taken at Station R-1.