Illinois State Water Survey
CHEMISTRY DIVISION

SWS **Contract Report 506**

MONITORING OF EUREKA SPORTSMEN'S CLUB LAKE FOR 1990

by
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Prepared for the Eureka Sportsmen's Club,
Eureka, Illinois

February 1991

Illinois Department of Energy end Natural Resources

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February 1991

ACKNOWLEDGMENTS

The authors wish to thank the following persons for their contribution to this study: Leanne Nieukirk and Richard George for sample collection and chemical analysis, and Davis Beuscher for algal and bacterial analyses. Also, Linda Johnson for sample collection and typing, Gail Taylor for editing, and John Brother and Dave Cox for figure preparation. Most of all, the authors thank Mickey Simenc, Merle Wuethrich, Tim Wuethrich, and Keith Cable, who were willing to drop anything they were doing at the time to join us at the lake for sample collection and monitoring. The solid support of the club membership is very much appreciated.

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INTRODUCTION

The Eureka Sportsmen's Club owns approximately 27 acres of wooded land in Olio Township between Goodfield and Eureka in Woodford County, Illinois (T26N, R1W, Sec 33). Located on this property is a man-made lake approximately 4 to 5 acres in size that club members use for swimming, fishing, and rowboating. The lake, which was created in 1963 by the damming of a ravine on the property, primarily receives surface runoff from the watershed immediately surrounding it. Overflow from the lake flows into the Mackinaw River.

During the last ten years the lake experienced severe fish kills twice, in 1981 and 1987, and has had recurring algal problems. In an effort to improve the water quality of their lake and thus prevent future fish kills, the club members decided to install a mechanical destratifier in the lake at a location where the water is the deepest.

The destratifier, built by Zimmerman Welding of Eureka, features a 220 volt, 3/4 horsepower electric motor and transmission. A six-vane underwater propeller blade 4 feet in diameter is attached through a vertical metal shaft 4 feet long and 1 inch in diameter. This motor-transmission assembly was mounted atop two 4-foot-long aluminum pontoons.

The destratifier was designed to push surface water downward during warm-weather months and also to be reversed to pull warmer bottom waters up during cold-weather months. Its purpose during summer months was to create vertical water currents that would send oxygen-bearing water down to the bottom, which would then spread out in all directions, circulating and mixing with the water in the main body of the lake. This action would eliminate any stratified layers of water that were devoid of oxygen, thus preventing any fish kills due to lack of oxygen or to the presence of chemicals that could be toxic to fish.

On June 23, 1990, the club members installed the mechanical destratifier in a location approximately midway between the island and the earthen dam, where the water depth was 16 feet. The Illinois State Water Survey monitored the lake biweekly from May 15 through October 26, 1990. Readings for temperature and dissolved oxygen were made at 2-foot intervals (from the surface to the bottom) in the deepest part of the lake near the destratifier by using a YSI Model 58 dissolved oxygen meter and 40-foot probe. Samples for chemical analyses were collected at the surface and 1 foot above the bottom. Surface water samples were collected for algal identification and enumeration.

METHODS AND MATERIALS

Samples taken for analysis were rushed to the laboratory, where they were immediately analyzed for pH, alkalinity, and conductivity. Soon thereafter, analyses were performed for all other parameters. Table 1 lists the water quality parameters analyzed and the analytical methods used in the laboratory.

Algal samples were identified by microscopy and counted as to individuals up to species level in four main groups: blue-greens, greens, diatoms, and flagellates.

Table 1. Analytical Procedures

pH	Combination pH electrode, Metrohm-Herisau (E588)
Alkalinity	Potentiometric titration
Specific conductance	Conductivity cell, Metrohm-Herisau (E587)
Turbidity	Ratio Turbidimeter, HF DRT 100D
Total suspended solids	Dry weight of total suspended solids retained on glass fiber filter, dried at 103-105°C
Total phosphorus	Acid digestion, ascorbic acid reduction
Dissolved ammonia	0.45 uM filtration, modified phenate method
Dissolved nitrate	0.45 uM filtration, chromotropic acid
Dissolved solids	0.45 uM filtration, residue of evaporation, dried at 103-105°C

RESULTS AND DISCUSSION

Where the depth of an impoundment or lake is significant, thermal stratification acts as an effective barrier to wind-induced mixing. The oxygen transfer to the deep waters is essentially confined to the molecular diffusion mechanism. As a result, when bottom sediments exert a high demand for oxygen, the oxygen resources of the hypolimnion (bottom layer of water) are quickly exhausted. Anoxic conditions will then prevail in the bottom waters during the warm summer months.[1]

Isothermal plots and isopleths of dissolved oxygen for the Eureka Sportsmen's Club lake are shown in figures 1 and 2, respectively. The tendency for the lake to stratify is clearly noticeable during May and June. The stratification would have reached a peak, probably at depths below 6 to 8 feet from the surface, between mid-July and mid-August. However, with the installation of the destratifier on June 23, water temperatures became more or less uniform through the water column. The maximum observed surface water temperature was about 30°F.

1. Kothandaraman, V., and R. L. Evans. 1982. *Aeration-Destratification of Lake Eureka Using a Low Energy Destratifier*. Illinois State Water Survey Circular 155, 32 p.

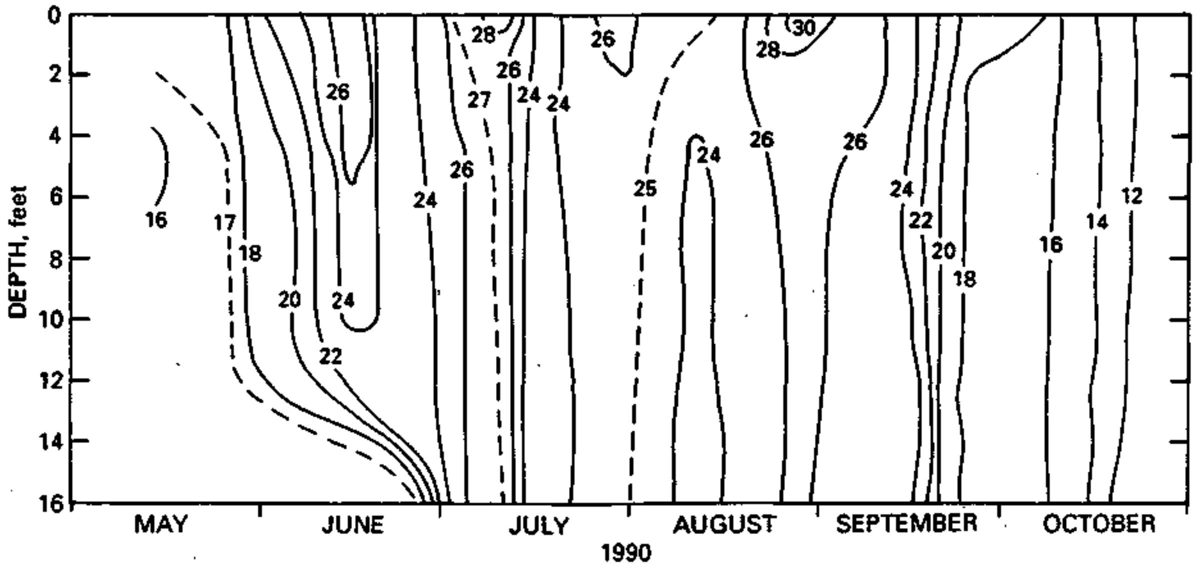

Figure 1. Isothermal plots for the deep station

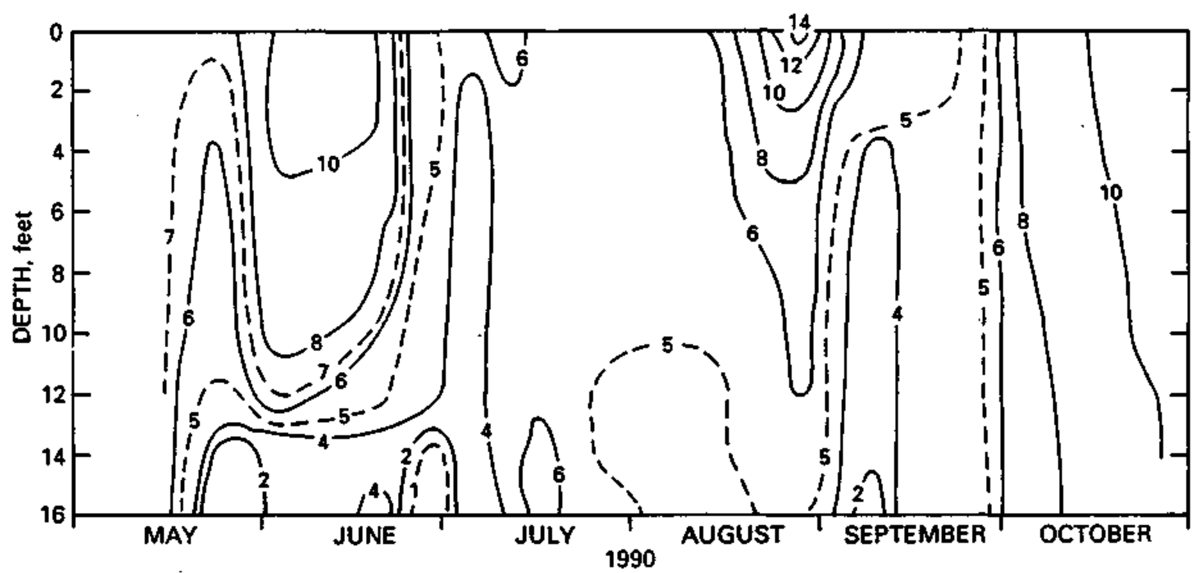

Figure 2. Isopleths of dissolved oxygen for the deep station

The isopleths of dissolved oxygen (figure 2) indicate that dissolved oxygen concentrations in the bottom waters during the critical months of July and August were well above 5 milligrams per liter (mg/L). Without the destratifier, the lake would have been devoid of oxygen at depths below 6 to 8 feet from the water surface during this period. Dissolved oxygen supersaturated conditions were observed during late August, primarily as a result of algal photosynthesis. The dissolved oxygen and temperature data for the lake indicate that the destratifier has performed well.

Another significant result of using the destratifier was the control of hydrogen sulfide odor from the bottom sediments and near-bottom water. The bottom water and sediments contained the distinct odor of hydrogen sulfide on all sampling dates before the destratifier was used. However, after the destratifier had been run for 24 hours, aerobic conditions prevailed in the bottom of the lake and the noxious smell was eliminated.

Figure 3 shows the temperature and dissolved oxygen profiles for nine different sampling dates. Thermal stratification existed in the lake on May 24 through June 23, as is evidenced by significantly lower temperatures and lower or no dissolved oxygen at or near the bottom. On June 24, after the destratifier had been run for 24 hours, we can see how uniform the dissolved oxygen and temperature values were throughout the vertical water column. True stratification did not occur throughout the remainder of the year as temperature and dissolved oxygen values remained nearly the same from top to bottom.

Figure 4 shows the temporal variations in dissolved oxygen at the surface and 1 foot above the bottom from May 15 through October 26. Dissolved oxygen levels in the surface water were above 6 mg/L during most of the study, while levels of dissolved oxygen near the bottom fell almost to zero twice and then were slightly lower than 5 mg/L but more than 4 mg/L after installation of the destratifier.

Stratification is shown to exist until June 24, just 24 hours after the destratifier was turned on. Stratification did not exist thereafter. Dissolved oxygen values in the bottom waters generally remained below 5 mg/L from June 25 through September 25, indicating the demand of the bottom sediments for oxygen. The high level of dissolved oxygen observed in the surface water on August 28 is thought to be due to the occurrence of excess photosynthesis.

Table 2 lists the means and ranges of chemical constituents tested in the lake during the study. It shows that the mean dissolved oxygen level at the surface was 7.62 mg/L, and the mean dissolved oxygen level in the bottom foot of water was 4.14 mg/L.

Another significant phenomenon observed during stratification between May 24 and June 18 was a buildup of ammonia in the bottom waters on June 18 (figure 4). High ammonia levels in these waters, which were already devoid of oxygen, created conditions in which fish could not have survived. After the destratifier started running on June 23, surface aeration and lake circulation patterns created by the destratifier had developed to such a point by June 25 that the high levels of ammonia-nitrogen in the bottom waters had been oxidized and changed to the nitrate form, resulting in a drop in ammonia levels. Nitrate values then increased rapidly in both the top and bottom areas of the water column. As the destratifier continued to aerate

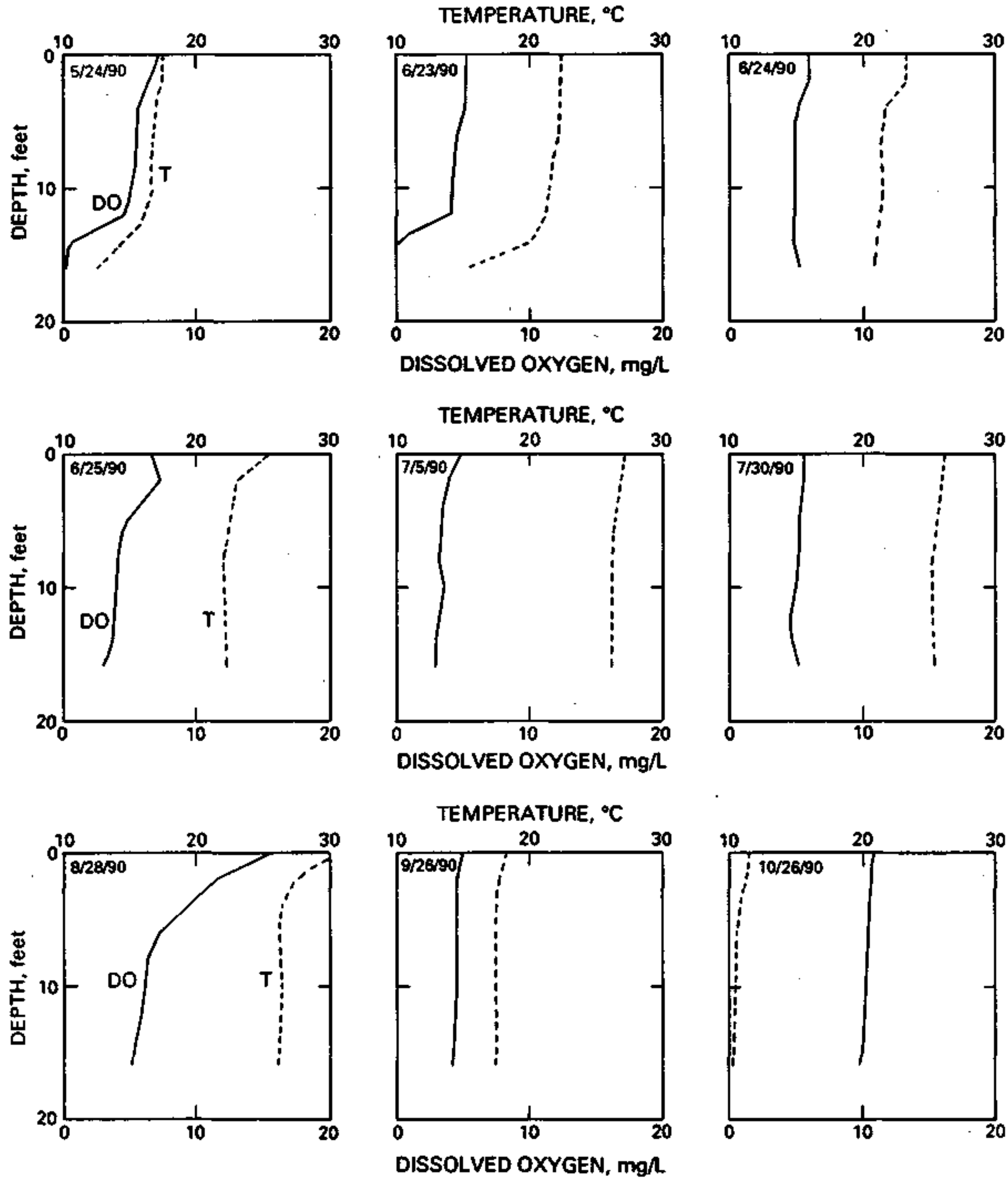

Figure 3. Temperature and dissolved oxygen profiles for the deep station on selected dates

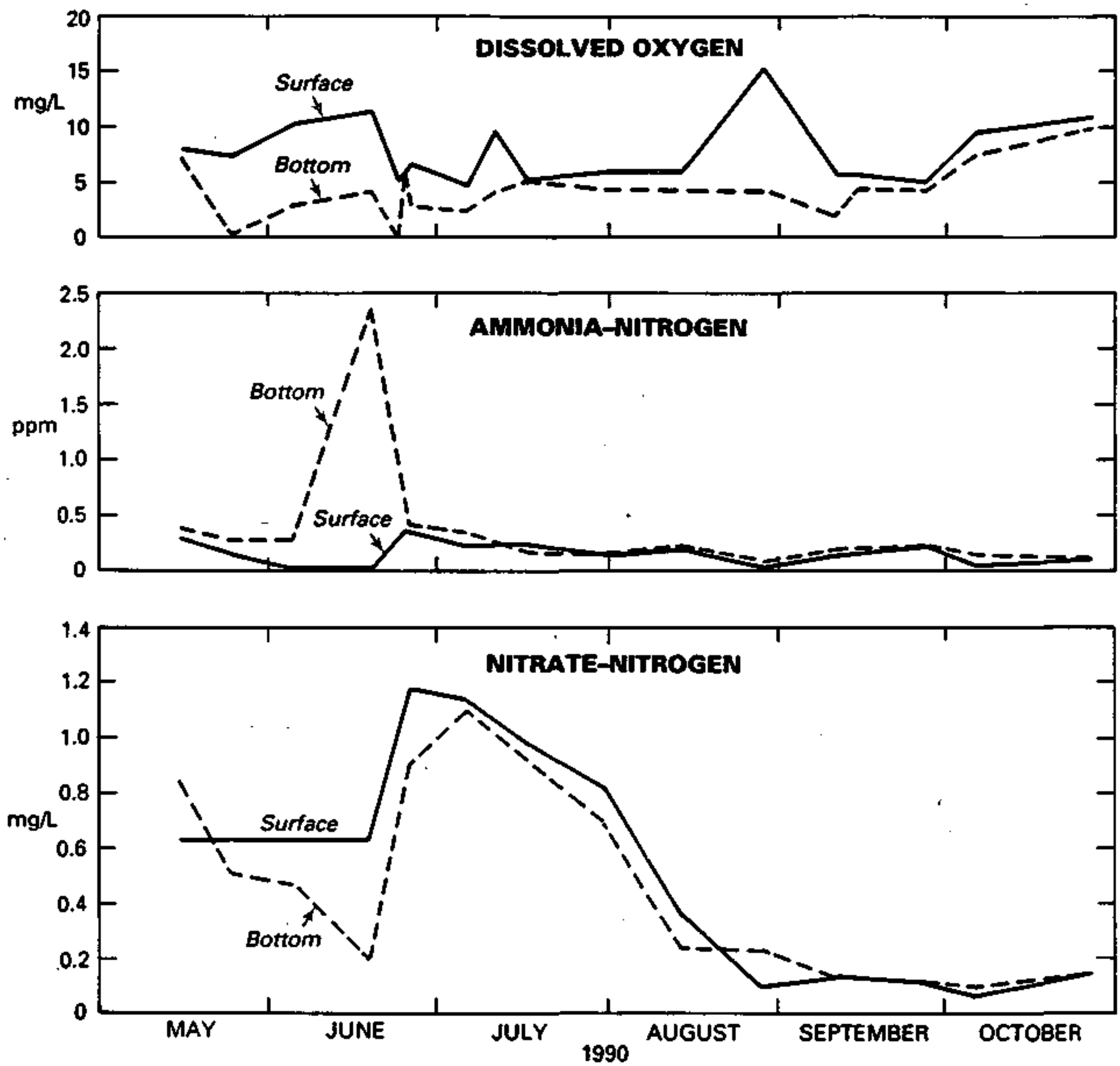

Figure 4. Temporal variations in dissolved oxygen, ammonia-nitrogen, and nitrate-nitrogen at the deep station

Table 2. Means and Ranges of Chemical Constituents, May 15 to October 26, 1990

	Surface		*1 foot above bottom*	
	Mean	*Range*	*Mean*	*Range*
Temperature (°C)	23.2	11.4-30.7	20.2	10.1-26.9
Dissolved oxygen (ppm O_2)	7.62	4.85-15.2	4.14*	0.0-9.9*
Specific conductance (µmho/cm at 25°C)	425	324-466	473	406-465
Suspended solids (ppm)	8	3-14	26	10-106
Turbidity (NTU)	14	9-35	27	14-82
pH(pH units)	8.35	7.90-8.91	8.17	7.82-8.52
Alkalinity (ppm as $CaC0_3$)	175	157-188	179	161-222
Total phosphorus (ppm P)	0.16	0.08-0.26	0.23	0.10-0.58
Diss. ammonia-nitrogen (ppm N)	0.15	0.0-0.37	0.38	0.10-2.35
Diss. nitrate-nitrogen (ppm N)	0.54	0.07-1.18	0.47	0.10-1.09
Dissolved solids (ppm)	276	252-312	273	228-310

**Dissolved oxygen values for the bottom foot of water.*

the water, permitting natural degradation to occur, the levels of nitrate gradually decreased until September, when they were lower than they had been even at the beginning of the study.

Mean values of ammonia-nitrogen were 0.15 mg/L in the surface water and 0.38 mg/L in the bottom water (table 2). Although nitrate values fluctuated temporally, they tended to be similar in the top and bottom of the water column. Most other parameters were similar in the surface and deep water layers because of lake mixing.

The algal types and densities in the area near the destratifier are shown in table 3. Of the blue-green algae, *Aphanizomenon flos-aquae* was present on 12 of 15 sampling dates, although not in dangerous bloom proportions. The green alga *Pediastrum duplex* was found on 12 sampling dates; the diatom *Melosira granulata* was present 13 times; and the flagellate *Trachelomonas creba* was also present on 13 of the 15 sampling trips.

Algal densities in the lake were not as high as those found in other recreational lakes such as Johnson Sauk Trail Lake or Lake Le-Aqua-Na. However, profuse growths of duckweed were noted during most of the monitoring period. At times the lake surface was completely covered with duckweed mat. This problem was particularly severe along the shoreline, the beach area, and the sheltered shallow cove areas.

Although it is feasible to control this problem by appropriate chemical treatments, it is desirable to remove the duckweed mats by seining, using mosquito net fabric or similar straining devices. A few years of destratifier operation may be needed before the algae and duckweed problems are gradually brought under control. However, it is heartening to note that the use of copper sulfate as practiced in the past was completely avoided in 1990.

Table 3. Algal Types and Densities at the Deep Station

	Algal species	***5/15***	***5/24***	***6/4***	***6/18***	***7/5***	***7/10***	***7/16***	***7/31***	***8/13***	***8/28***	***9/10***	9/74	***9/26***	***10/5***	***10/26***	***Number of times found***
BG:	***Anabaena spiroides***					106								8			2
	Anacystis thermalis					223		221	65		143						4
	Aphanizomenon flos-aquae				82	859	1859	2489	124	132	837	502	529	137	69	48	12
	Oscillatoria sp.						284	116				19	9			27	5
G:	***Chlorosorcina consociata***										159					6	2
	Coelastrum microporum				11	11				8	42				11		5
	Crucigenia rectangularis														46	59	2
	Errerella bornhemiensis									2							1
	Oocystis borgei			5	2	42					106		11	6		9	7
	Pediastrum duplex				6	21	137	63	132	23	201	4	6	40	13	6	12
	P. simplex							11									1
	Sphaerocystis schroeteri					392	609	189	113								4
	Scenedesmus dimorphus			32													1
	Ulotrix variabilis						116										1
D:	***Cyclotella atomus***	1256	44	1606													3
	Melosira ambigua									11						8	2
	M. granulata	42		196	23		210	242	67	78	106	15	8	17	101	44	13
	Synedra acus											13					1
F:	***Carteria multifilis***	270	166	122													3
	Ceratium hirundinella			5				11	134				6			2	5
	Euglena acus									6			2				2
	E. gracilis					42											1
	E. oxyuris							21									1
	E. viridis		6											6			2
	Glenadium sp.										27						1
	Phacus sp.												2		145		2
	Trachelomonas creba	11	6			37	42	74	6	44	138	32	11	17	65	11	13
Total		1579	222	1966	124	1733	3257	8437	641	304	1759	585	584	231	450	219	
Number of species		4	4	7	6	9	7	10	7	8	9	6	9	7	7	10	

Note: Density in counts per millimeter; BG - Blue-greens; G - Greens; D - Diatoms; and F - Flagellates.

CONCLUSIONS AND RECOMMENDATIONS

Because the lake on the Eureka Sportsmen's Club property is nearly completely surrounded by trees, leaves tend to accumulate on the bottom of the lake. The leaves then become an integral part of the bottom sediment, and as they decompose they exert a huge demand for oxygen on the water above the bottom. As decomposition progresses, the oxygen in the bottom waters is reduced to near zero when the lake becomes stratified, as happened from May 24 through June 23, 1990. The ammonia-nitrogen level in the bottom waters increased to 2.35 mg/L.

Had the mechanical destratifier not been started on June 23, the oxygen-devoid layer of water could have risen toward the top, thus forcing all fish life to stay in the surface water layer. Had algae and duckweed been allowed to thrive in the surface layer and to consume oxygen there, another fish kill quite possibly could have occurred. It is easy to see that after the destratifier had run for 24 hours the lake became more evenly mixed as well as aerated, thus eliminating conditions favorable for a fish kill.

Our recommendations for 1991 are as follows:

1) Continue using the destratifier.

2) Postpone the use of bubblers in the three bay areas unless they are absolutely necessary.

3) Install mechanical mixers in the three bay areas to keep water in constant motion. This should be tried first in the bay nearest the swimming area.

4) Remove as many leaves as possible from the lake.

5) Remove as much duckweed as possible from the lake whenever it is present.

6) Install a plastic snow fence around the lake in the fall before the leaves fall, to prevent leaves from entering the lake.

7) Monitor dissolved oxygen and temperature profiles in the lake twice monthly. Continue useful chemical tests and algal enumeration.

8) Characterize bottom sediments during spring and late fall.

In addition, if horizontal-flow mechanical mixing devices can be added in the three bay areas (at least in the bay closest to the swimming beach), the shallow water in those areas can be kept in constant motion. This should reduce the amount of algae and duckweed that accumulate and grow in the bay.

Through the removal of as many leaves and as much duckweed from the lake as possible, considerable amounts of nitrogen, phosphorus, and carbon (all growth nutrients) can be eliminated from the lake. This may help discourage further growth of algae and duckweed.