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Thermal and chemical stratification is a common phenomenon in lakes and ponds during the summer months. Most lakes, 20 or more feet deep, have a warm epilimnion separated from the colder deep water stratum, the hypolimnion, by a thermocline or zone in which the water rapidly becomes colder with increased depth.

During a fisheries investigation of McFarland's Pond, a relatively rich artificial pond located 5 miles northeast of Ames in Story County, Iowa, it was found that only a thin layer of water near the surface was not stagnated in the spring and summer months. This elongate and comparatively deep pond, with a surface area of approximately 7 acres, was formed in 1946 by the construction of an earthen dam across the narrow valley of a semi-permanent creek. Roughly 75 percent of the water is deeper than 5 feet and a maximum depth of 23 feet has been recorded. Temperature and chemical conditions in the pond were observed at least weekly during the period of the investigation. The banks rise rather abruptly from the pond and are wooded so that wind effect is considerably reduced and this, plus the rather steep gradient and irregular nature of the basin, aids in the development of thermal stratification early in the spring. A thermocline formed as early as April 29 in 1949 and April 14 in 1950 and persisted until mid or late September. In general, both the epilimnion and hypolimnion were considerably restricted in size. Lewis (1949) found a somewhat similar situation in Red Haw Lake near Chariton, Iowa, where the epilimnion included only the upper eight feet of the lake in July and August of 1948. This body of water, like McFarland's Pond, is in a sheltered valley where wind action is limited.

Concentrations of dissolved oxygen were found to be rather closely associated with the thermal stratification of the pond. As the thermal stratification became more pronounced in 1949 the dissolved oxygen in subsurface strata decreased until by mid-July only the upper 5 feet of water contained more than 3.5 p.p.m. of oxygen (Table 1). During the last two weeks of August all water in depths greater than 3 feet contained less than 1.5 p.p.m. of oxygen. Cold

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Table I

Dissolved oxygen (in p.p.m.) and temperature (in degrees F.) at various depths in McFarland's Pond in the summer of 1949 and the spring of 1950.

Depth in feet	1949 June 20 T	O	July 18 T	O	Aug. 22 T	O	Sept. 17 T	O	1950 April 21 T	O	May 24 T	O	June 21 T	O
0.3	82	10.9	86	9.0	76	1.8	64	9.2	48	11.6	72	8.4	70	4.7
3.3	78	10.3	80	6.9	73	1.3	64	7.6	48	11.6	69	8.1	62	2.3
6.5	69	2.6	76	1.1	72	0.2	62	4.1	47	11.6	61	8.0	58	2.4
9.8	60	2.5	60	1.0	62	0.0	62	2.6	46	10.6	53	5.6	58	2.3
13.1	54	2.2	56	0.0	55	0.0	56	0.8	42	6.8	51	1.0	57	2.1
16.4	50	1.2	52	0.0	52	0.0	54	0.0	42	6.2	50	0.9	56	....

weather delayed the development of extreme stratification in the spring of 1950. Extreme turbidity from heavy rains and erosion in late May resulted in a temporary and partial depletion of oxygen but concentrations similar to those in the 1949 summer oxygen pattern returned in the upper levels as turbidity cleared.

Vertical distribution of bluegills, *Lepomis macrochirus*, was studied by the use of wire box traps at different levels in the pond. During the spring and fall overturn periods, the members of all size groups tended to inhabit the deeper levels. As thermal stratification developed in the spring and the deeper water became deficient in oxygen the normal activities of fish were curbed to the extent of "squeezing" the population into those shallower strata where more oxygen was available (Table 1). This undoubtedly decreased the area in which bottom feeding was uninhibited and forced the fish to inhabit the warmer levels for greater periods of time in the summer.

Confinement of the population's normal activities to a small portion of the lake volume during the spring and summer growth periods probably has a serious effect on fish production, especially in bodies of water where the banks and bottom have a steep gradient. Annual conditions of this nature are believed to have contributed to the development of stunted growth in McFarland's Pond bluegills.

Although most of the bluegills were restricted to the warmer oxygenated waters, there was evidence that many bluegills left the oxygenated levels and penetrated into lower strata where oxygen was much reduced. The length of time that the fish could remain under these anaerobic conditions was limited, however. Ellis (1937) stated that few fish would be found in water where the oxygen concentration became less than 4 p.p.m. in the summer. More recently Moore (1942), after studying the oxygen thresholds of seven common fresh-water species, reported that an oxygen content of at least 3.5 p.p.m. is essential for the maintenance of fish life at summer temperatures of 15-26°C. (59-79°F.).

In the present investigation a trap set at a depth of 10 feet in water containing no detectable dissolved oxygen (temperature, 61°F.) on August 1, 1949, yielded 11 dead bluegills. Similarly, traps set at a depth of 15 feet in water (temperature 54°F.) having 0.3 p.p.m. of oxygen in mid-September of the same year contained only dead fish when examined one day later. Two other traps, which were lifted after having been in water containing 1.3 p.p.m. of oxygen for nearly 48 hours in early August, 1949, produced a total of 17 dead and 19 living bluegills. Three or more specimens were collected on each of several other occasions when traps were set in or below the thermocline. Apparently the bluegills went into the deeper waters for short periods of time but suffocated if they were trapped and detained under those conditions. Pearse and Achtenberg (1920) and Hile and Juday (1941) have reported similar movements of yellow perch, *Perca flavescens*, into oxygen deficient regions for short periods of time.

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