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VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN AND WATER TEMPERATURES IN LAKE HAMILTON WITH SPECIAL REFERENCE TO SUITABLE RAINBOW TROUT HABITAT

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ABSTRACT

Lake Hamilton is the middle of three lakes located in series on the Ouachita River in Southwestern Arkansas. Following the initial release of water through the penstocks from the upper newest lake, a subsurface current was detected in Lake Hamilton. During the summer of 1960, physical-chemical tests were made at nine stations along the channel to determine the extent of the current. Data collected showed the water remained oxygenated from the surface to the bottom. Cold water drawn from below the thermocline of the upper lake becomes oxygenated in the tailrace and slides under the warm upper stratum of water in the Lake Hamilton. Existing temperature ranges and sufficient dissolved oxygen levels, as were found in the channel, should sustain trout throughout the critical summer months.

INTRODUCTION

Lake Hamilton is the middle of three lakes located in series on the Ouachita River in southwestern Arkansas. This 7200 acre lake, lying a few miles southwest of Hot Springs, was created in 1931 by the construction of Carpenter Dam. It extends upstream from Carpenter Dam to Blakely Dam, a distance of nineteen miles. Immediately below Lake Hamilton is Lake Catherine, a 3000 acre lake impounded by Remmel Dam which was constructed in 1923. Above Lake Hamilton is Lake Ouachita, a 40,000 acre lake formed by the Blakely Dam. This dam was completed in 1952 and Lake Ouachita started filling during the winter of 1952 and early spring of 1953.

Dams forming Lakes Hamilton and Catherine were constructed by the Arkansas Power and Light Company to provide hydro-electric power. Blakely Dam was built by the U. S. Army, Corps of Engineers. Two generating units, with a generating capacity of 75,000 kilowatts were installed in Blakely Dam. Two sixteen-foot diameter penstocks and one nineteen-foot diameter flood control conduit permit release of water through the dam into Lake Hamilton.

Periodic water releases and various generator tests were made at Blakely Dam during the fall of 1955. Routine generation was established

TABLE 1.

PROFILE OF THE CHANNEL, ONE MILE ABOVE THE DAM, SHOWING pH, DISSOLVED OXYGEN CONTENT AND TEMPERATURES. TESTS MADE DURING JULY OVER A SIX-YEAR PERIOD.

Depth	pH						Dissolved Oxygen (ppm)						Temp. (Deg. F.)					
(Feet)	1955	1956	1957	1958	1959	1960	1955	1956	1957	1958	1959	1960	1955	1956	1957	1958	1959	1960
2	8.2	8.5	8.8	8.3	9.0	8.5	7.0	6.8	8.0	7.0	7.8	8.0	90.0	86.0	90.0	84.0	84.0	80.0
5													89.6	85.6	89.6	84.0	83.3	81.8
10	7.6	8.4	8.8	8.0	8.2	7.5	6.8	7.0	8.2	7.4	8.0	8.2	84.2	84.8	85.1	83.0	83.0	80.2
15													78.8	83.3	77.0	72.5	78.6	78.8
20	6.4	6.8	6.8	7.2	6.5	7.5	0.8	1.5	1.8	7.0	2.2	6.4	74.3	73.4	71.6	69.0	71.4	70.0
25													70.7	68.0	68.9	65.1	64.9	65.1
30	6.4	6.4	6.4	6.8	6.5	6.8	0.5	0.5	2.8	5.4	2.4	4.2	68.9	66.0	66.2	63.1	63.4	60.8
35													67.1	65.3	64.4	61.7	62.4	58.5
40	6.0	6.2	6.2	6.6	6.5	6.8	0.5	0.5	4.0	5.8	2.8	5.2	66.2	64.4	63.5	60.8	60.8	56.8
45													65.3	63.5	62.6	59.7	59.3	55.9
50	6.0	6.2	6.2	6.5	6.5	6.8	0.2	0.0	3.8	6.0	3.0	5.2	64.4	62.6	62.2	59.0	58.2	55.8
55													63.7	61.7	61.7	57.2	58.1	55.4
60	6.0	6.0	6.2	6.6	6.5	6.6	0.2	0.0	3.4	6.2	4.0	6.8	63.0	61.0	60.8	56.1	57.8	54.9
65															60.4	55.4	57.4	54.7
70			6.2	6.8	6.4	6.6			3.0	6.4	4.0	6.6			59.9	55.0	57.0	54.5

in the spring of 1956. Since 1956, the average annual flow through the dam into Lake Hamilton has been about 1500 cfs. These releases average about 2000 cfs during the summer and diminish during the winter and spring, except when flood control storage is being released. Discharge for power is intermittent and normally made about ten hours a day, Monday through Friday.

The three lakes, in series, are necessarily closely inter-related since water supply of the lower and smaller lakes is largely dependent upon release of water from the large upper lake. The headwaters of each lower lake extend to the dam of the lake above. Therefore, the headwater of Lake Catherine is the tailwater of Carpenter Dam and the headwater of Lake Hamilton becomes the tailwater of Blakely Dam.

A comparative fishery study of Lakes Catherine, Hamilton and Ouachita was begun in June 1955 and was continued, primarily during the summers, through 1960. Studies were conducted on the physical, chemical and biological properties of the lakes and fishery management recommendations made (Stevenson and Hulsey, 1958). All of these fishery management recommendations have since been carried to completion and incorporated into a routine fishery management program for the lakes. The data in this report were collected as part of the comparative fishery studies.[1]

PRELIMINARY LAKE STUDIES

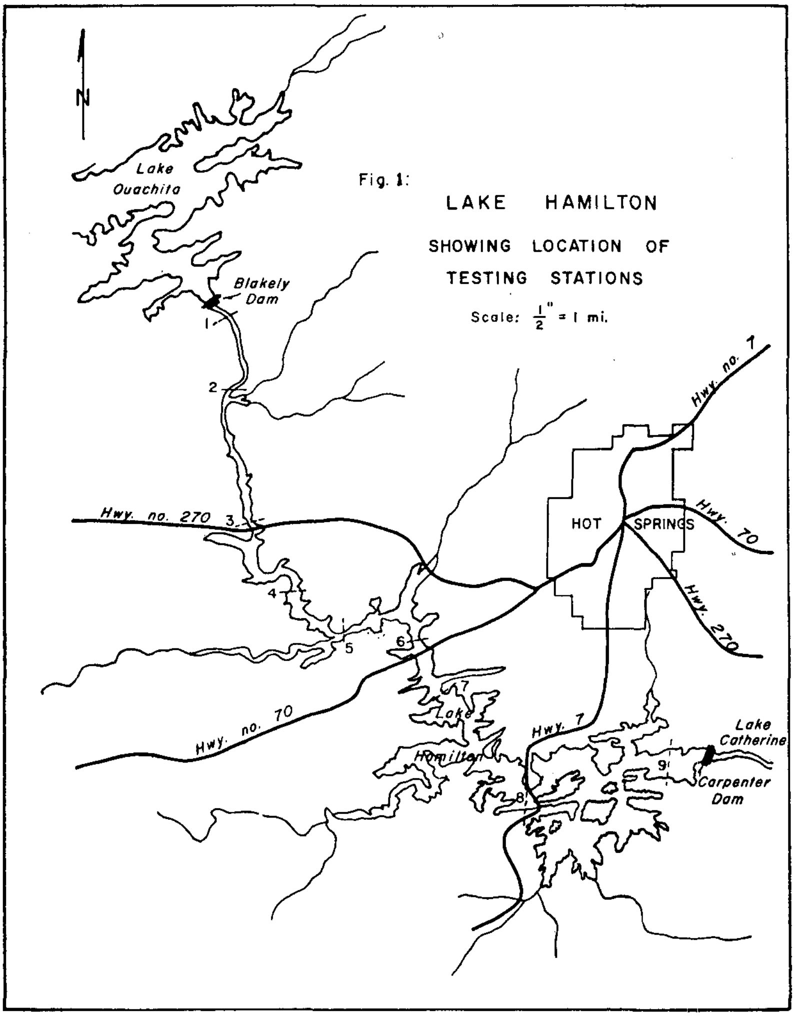
Physical-chemical tests were made at selected stations, once each month during the summers of 1955-60. One of these stations was located in the channel, approximately one mile above Carpenter Dam. Table 1 shows the pH, dissolved oxygen content, and temperature at various depths in the channel. Tests were conducted (surface to bottom) for pH, phenolphthalein and methyl orange alkalinity, free carbon dioxide, dissolved oxygen content and temperatures each month during June, July and August over a period of six years. The phenolphthalein and methyl orange alkalinity varied only slightly at different depths and are not included in the table. Since the lake appeared to have become stabilized during July, the pH, dissolved oxygen content and temperature values for the month of July only are shown. (Methyl orange alkalinity ranged between 22 and 26 ppm. Free carbon dioxide once reached a maximum of 14.0 ppm at a depth of 80 feet.)

There was a gradual increase in the acidity of the water from top to bottom. In 1959, the greatest range in pH values occurred with a reading of pH 9.0 at the surface and 6.4 at 70 feet. The maximum pH reading of 9.0 occurred at the surface in 1959 and the minimum of 6.0 occurred at 60 feet in 1955 and 1956.

The vertical distribution of dissolved oxygen during 1955 and 1956 followed the usual trend commonly found in lakes that are subject to thermal stratification. At 20 feet the dissolved oxygen content diminished abruptly to the point of depletion and remained at low levels or became exhausted at greater depths. In 1957 and continuing through 1960, the dissolved oxygen diminished in the region of the thermocline but increased at greater depths. In 1958, the minimum dissolved oxygen content was 5.4 ppm at 30 feet with an increase to 6.4 ppm at 70 feet. In 1959, a minimum of 2.2 ppm was reached at 20 feet but increased to 4.0 ppm at 60 feet. In 1960, the minimum reading of 4.2 ppm was found at 30 feet increasing to 6.8 ppm at 60 feet. Coinciding with the time of regular releases of water and generation of electricity at Blakely Dam in 1957, the water in Lake Hamilton presented definite zones with respect to dissolved oxygen. At the surface, the water was well aerated; in the region of the thermocline there was a reduction in the oxygen concentration; and below the thermocline, the dissolved oxygen content gradually increased.

During the period when Lake Ouachita was filling, the only water released was that necessary to maintain Lake Hamilton at the minimum power pool storage level. The atypical vertical distributions of dissolved oxygen which first occurred in 1957 suggest changes effected by the regular releases of cold water from Blakely Dam. Following regular generation of electricity, a fairly rapid water exchange occurred in

[1] These studies were financed by the Federal Aid in Fish Restoration Program and constituted Arkansas' Dingell-Johnson project F-5-R "A Comparative Fishery Study of Lake Catherine, Lake Hamilton and Lake Ouachita".



Lake Hamilton. The existence of density currents, as described by Wiebe (1941), became apparent in Lake Hamilton during the summer of 1957. A stratum of water low in dissolved oxygen, between two strata of relatively well aerated water, was found to continue through successive years.

PHYSICAL-CHEMICAL PROPERTIES OF THE CHANNEL

During the summer of 1960, the testing program was expanded to include nine stations located in the channel to trace the location of the subsurface current. These stations were spaced approximately two miles apart and extended from Blakely Dam to Carpenter Dam (Figure 1).

Vertical series of physical-chemical tests were made once a month in June, July and August at each station. Water samples were collected and analyses made of pH, dissolved oxygen and free carbon dioxide every ten feet and temperature readings were recorded at five foot depth intervals.

Table 2 gives the data collected at the nine testing stations. Attention was primarily focused on the dissolved oxygen content and temperature values since other properties remained well within limits of toleration for fish survival.

TABLE 2.

PROFILE OF CHANNEL IN LAKE HAMILTON AT SELECTED STATIONS OF APPROXIMATELY TWO MILE INTERVALS SHOWING pH, DISSOLVED OXYGEN, CARBON DIOXIDE AND TEMPERATURE READINGS.

Date	*Depth in feet*	*pH*	*O_2 ppm*	*CO_2 ppm*	*Temp. Deg. F.*
		STATION 1			
June 1960	2	7.5	8.2	4.5	48.4
	5				48.2
	10	7.5	8.2	6.0	48.3
	15				48.3
	20	6.5	8.2	9.0	48.2
July 1960	2	6.9	7.6	9.2	45.6
	5				45.5
	10	6.8	7.8	9.5	45.6
	15				45.6
	20	6.9	7.8	9.5	45.6
August 1960	2	6.8	6.8	9.3	53.7
	5				52.7
	10	6.7	6.4	9.5	52.7
	15				52.7
	20	6.9	6.4	9.5	52.7
		STATION 2			
June 1960	2	7.5	8.2	6.0	52.0
	5				51.8
	10	7.5	8.2	7.0	50.4
	15				50.4
	20	7.5	8.2	7.0	50.4
July 1960	2	6.9	7.6	8.4	59.0
	5				52.0
	10	6.8	7.4	7.2	51.8
	15				51.8
	20	6.7	7.4	8.6	51.4
August 1960	2	6.9	5.8	6.2	54.0
	5				52.7
	10	6.9	6.6	8.5	52.7
	15				52.7
	20	6.9	6.2	9.0	51.8
		STATION 3			
June 1960	2	7.8	7.6	2.0	81.0
	5				79.7
	10	6.8	7.8	6.0	54.5
	15				53.2
	20	7.5	8.0	3.2	51.8
	25				51.6
July 1960	2	7.8	7.8	2.0	82.0
	5				77.0
	10	7.3	7.2	4.6	57.0
	15				55.4
	20	6.9	7.6	8.6	54.5
	25				53.6
August 1960	2	7.5	7.0	4.2	74.0
	5				73.9
	10	7.0	7.0	5.7	54.5
	15				53.6
	20	7.0	7.2	6.2	53.6
	25				53.6
		STATION 4			
June 1960	2	7.9	7.0	2.0	82.0
	5				78.6
	10	7.8	7.2	3.0	63.7
	15				53.9
	20	7.5	7.8	5.0	52.7

STATION 4, Continued

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
July 1960	2	7.2	7.6	2.0	84.0
	5				83.3
	10	7.6	7.0	4.0	64.0
	15				59.9
	20	7.0	7.4	6.0	59.2
August 1960	2	8.0	7.2	1.5	86.0
	5				85.1
	10	7.2	6.9	5.4	64.0
	15				62.9
	20	6.9	7.0	8.2	60.5

STATION 5

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
June 1960	2	8.3	8.0	0.0	84.0
	5				83.3
	10	8.2	8.0	0.0	79.2
	15				70.7
	20	7.0	7.0	9.0	54.7
	25				53.9
	30	7.5	7.6	5.0	53.9
	35				53.6
	40	7.5	8.0	5.5	53.2
July 1960	2	7.8	8.2	2.0	86.0
	5				85.1
	10	7.8	7.2	1.8	83.3
	15				77.9
	20	7.0	6.2	7.4	58.1
	25				56.3
	30	7.0	6.6	8.2	55.4
	35				55.4
	40	7.0	6.6	8.6	55.4
August 1960	2	7.9	7.6	1.5	89.2
	5				88.7
	10	7.3	6.8	5.4	77.9
	15				72.7
	20	6.9	5.2	7.2	56.3
	25				55.9
	30	7.0	6.0	8.1	55.4
	35				55.4
	40	6.9	6.4	9.6	55.4

STATION 6

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
June 1960	2	7.8	7.8	2.0	85.0
	5				84.2
	10	7.8	7.8	3.0	77.2
	15				76.1
	20	7.5	6.6	6.0	75.2
	25				74.3
	30	6.6	7.8	11.0	56.3
	35				54.5
	40	7.4	7.6	6.0	54.5
	45				53.9
	50	7.0	7.8	8.0	53.6
July 1960	2	7.8	8.0	2.0	85.0
	5				84.9
	10	7.7	8.2	2.5	83.5
	15				80.9
	20	7.7	7.2	8.6	68.0
	25				66.7
	30	7.0	7.6	9.0	57.4
	35				55.9
	40	6.8	7.6	11.0	55.0
	45				54.1
	50	6.8	7.8	11.0	53.2

STATION 6, Continued

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
August 1960	2	7.5	7.8	3.5	89.0
	5				88.9
	10	7.3	7.2	4.2	86.9
	15				75.2
	20	7.0	6.6	6.4	68.0
	25				65.8
	30	6.9	6.2	8.6	65.3
	35				57.2
	40	7.2	6.4	9.9	56.3
	45				55.4
	50	6.8	6.4	10.2	55.4

STATION 7

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
1960	2	7.5	7.8	4.0	83.5
	5				82.4
	10	7.6	7.6	5.0	80.6
	15				74.3
	20	6.5	6.4	12.0	64.4
	25				62.9
	30	7.5	6.5	8.0	59.2
	35				59.0
	40	6.7	7.0	14.0	58.8
	45				58.1
	50	7.5	7.0	6.0	56.8
	55				56.1
	60	6.9	7.2	9.8	53.6
	65				53.2
July 1960	2	8.5	8.4	0.0	86.0
	5				85.1
	10	7.7	8.0	1.0	82.0
	15				73.4
	20	7.0	6.0	5.0	67.3
	25				62.2
	30	7.0	6.2	5.8	60.0
	35				58.6
	40	7.0	5.8	6.4	58.3
	45				57.5
	50	7.3	6.8	6.4	57.0
	55				55.9
	60	6.8	7.2	11.0	53.2
	65				52.2
August 1960	2	8.3	7.4	0.0	89.2
	5				88.7
	10	8.2	7.4	0.0	86.9
	15				76.1
	20	7.6	7.2	3.3	67.1
	25				63.5
	30	6.5	6.0	8.4	60.8
	35				59.9
	40	6.8	6.2	8.5	58.1
	45				58.1
	50	7.0	6.2	9.0	56.3
	55				56.3
	60	6.8	6.2	9.5	55.4
	65				55.4

STATION 8

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
June 1960	2	7.8	7.6	2.2	81.0
	5				80.6
	10	7.7	7.6	3.0	80.2
	15				77.0
	20	6.7	5.8	10.0	69.8
	25				62.2
	30	6.8	6.6	14.0	59.3

STATION 8, Continued

Date	*Depth in feet*	*pH*	*O_2 ppm*	*CO_2 ppm*	*Temp. Deg. F.*
	35				57.2
	40	6.5	7.0	15.0	56.3
	45				54.7
	50	7.4	7.2	10.0	54.5
	55				54.5
	60	7.5	6.8	8.0	52.7
	70	7.5	7.0	8.6	50.9
July 1960	2	8.7	8.4	0.0	85.0
	5				84.4
	10	8.8	8.6	0.0	80.9
	15				73.6
	20	7.0	4.6	12.0	66.9
	25				65.7
	30	6.9	5.0	14.0	60.1
	35				58.6
	40	7.0	6.2	16.0	55.7
	45				55.0
	50	7.2	6.4	14.0	54.8
	55				53.2
	60	7.2	6.6	14.0	52.7
	65				52.6
	70	7.2	6.4	16.0	51.4
August 1960	2	8.4	7.4	0.0	87.3
	5				86.9
	10	7.8	7.6	2.2	82.4
	15				71.6
	20	7.5	6.4	2.8	65.3
	25				61.7
	30	7.0	5.0	3.3	59.9
	35				58.1
	40	7.0	5.2	4.6	58.1
	45				58.1
	50	6.9	5.8	7.0	58.1
	55				57.2
	60	6.8	5.8	8.3	57.2
	65				56.3
	70	6.6	5.6	8.6	56.3

STATION 9

Date	*Depth in feet*	*pH*	*O_2 ppm*	*CO_2 ppm*	*Temp. Deg. F.*
June 1960	2	8.5	8.0	0.0	85.0
	5				84.0
	10	7.5	8.2	4.0	82.7
	15				78.8
	20	7.5	6.4	4.0	69.9
	25				65.1
	30	6.8	4.2	6.0	60.9
	35				58.5
	40	6.8	5.2	6.0	56.8
	45				56.1
	50	6.8	5.2	7.0	55.7
	55				55.4
	60	6.6	6.8	9.0	54.8
	70	6.6	6.6	10.0	54.5
July 1960	2	8.8	8.8	0.0	84.0
	5				83.5
	10	8.9	8.8	0.0	83.3
	15				78.1
	20	6.8	2.6	5.6	70.7
	25				66.2
	30	6.9	3.6	6.0	60.4
	35				59.2
	40	7.0	5.4	6.0	57.5
	45				57.2
	50	7.0	5.4	7.2	56.8

STATION 9, Continued

Date	Depth in feet	pH	O_2 ppm	CO_2 ppm	Temp. Deg. F.
	55				56.4
	60	7.0	5.6	6.8	56.1
	65				55.7
	70	7.0	5.6	6.8	55.4
August 1960	2	8.8	7.4	0.0	88.0
	5				87.8
	10	8.8	5.4	0.0	87.8
	15				77.9
	20	6.8	2.2	5.0	68.9
	25				67.1
	30	6.8	2.8	6.4	62.6
	35				61.7
	40	6.8	4.2	8.8	59.9
	45				59.0
	50	6.6	4.4	9.2	58.1
	55				58.1
	60	6.8	5.2	11.8	58.1
	65				57.2
	70	6.7	5.4	12.2	57.2

Tests made at Stations 1 and 2, located approximately one-half and two miles respectively below Blakely Dam, showed that the temperature of the water was consistently cold and that the temperature varied little from top to bottom. At Station 1, the maximum and minimum temperature readings were 53.7° F. and 45.5° F. respectively. The maximum temperature recorded at Station 2 was 59.0° F. occurring in July at the surface. The minimum temperature was 50.4° F. The water was found to be well aerated at both stations. Dissolved oxygen reached a minimum of 6.4 ppm at Station 1 and 5.8 ppm at Station 2.

A subsurface current of cold water was noted at Station 3, located about 4 miles below Blakely Dam. At this station, the water temperature dropped abruptly at ten feet and then remained uniform (51.6—57.0° F.) from there to the bottom. There was little change in the oxygen concentration with the content ranging between 7.0 and 8.0 ppm.

Readings made at Station 4 showed essentially the same profile as at Station 3 with the exception that water temperatures from 10 feet to the bottom (20 feet) were slightly higher (64.0° F. maximum). The water continued to be well aerated with a minimum D. O. of 6.9 ppm.

Evidence of unusual vertical distribution of dissolved oxygen was first noted at Station 5, located about 8 miles below Blakely Dam. Dissolved oxygen and temperature readings dropped at the 20-foot level, then the D. O. increased at greater depths.

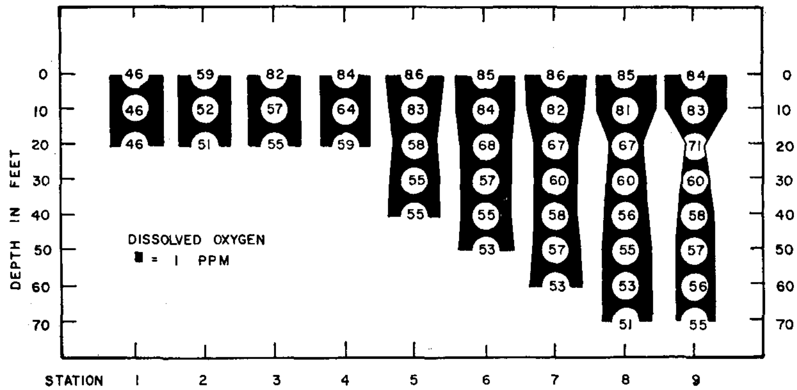
Data collected at Stations 6 and 7 showed essentially the same profile as that found at Station 5. Dissolved oxygen diminished in the 20 to 40-foot zone and increased at lower levels. A minimum of 5.8 ppm was recorded at 40 feet. The zone of diminished oxygen content covered a slightly greater vertical distance than at Station 5. The thermocline extended from the 10 foot level to 35 feet. The temperature at the lower limit of the thermocline ranged from 56.3° F. to 60.8° F. during the three months.

Station 8 was located two miles above Carpenter Dam. Dissolved oxygen reached a minimum content of 4.6 ppm at 20 feet and showed an increase at greater depths. At Station 9, located approximately three-fourths mile above Carpenter Dam, the minimum dissolved oxygen content was 2.2 ppm at 20 feet. This increased to 5.4 ppm at 70 feet. At both stations, thermal stratification occurred showing a thermocline between 15 and 30 feet.

A graphic presentation of the vertical distribution of dissolved oxygen and temperature readings is shown in Figure 2. Only one month is shown since little variation was found in dissolved oxygen values at any one station during the summer months.

At the first four stations covering a distance of approximately seven miles below Blakely Dam, little change in the dissolved oxygen content

Fig. 2. Profile of temperatures (deg. F.) and dissolved oxygen.



occurred between the surface and bottom. A minimum of 7.0 ppm and a maximum of 7.8 ppm were recorded.

At Station 5, the minimum dissolved oxygen content of 6.2 ppm was observed at the 20-foot level; this increased to 6.6 ppm at 40 feet. At Station 6, the fluctuation ranged from a concentration of 8.0 ppm at the surface to a minimum of 7.2 ppm at 20 feet to 7.8 ppm at 50 feet. Station 7 showed a similar trend with the exception that the zone of reduced oxygen content covered a greater vertical distance than at Station 6. An oxygen reduction from 8.0 ppm to 6.0 ppm occurred between 10 and 20 feet. At 50 feet, the dissolved oxygen increased to 6.8 ppm from a minimum of 5.8 at 40 feet.

The dissolved oxygen concentrations at Stations 8 and 9 showed a minimum level at 20 feet and gradually increased at deeper levels. A minimum of 4.6 ppm was recorded at Station 8 and 2.6 ppm at Station 9. A sharper diminution of dissolved oxygen between 10 and 20 feet occurred at these two stations as compared with upstream stations. Below 40 feet, the dissolved oxygen content remained practically unchanged.

Water temperatures at the first two stations were comparatively low and showed the effect of cold water from the penstocks. At Station 3, the cool water stratum extended from 10 feet to the bottom. The water above 10 feet was warm. From Stations 4 through 9 a typical thermal stratification existed.

Temperature variations at horizontal levels along the channel may be due to the effects of creek water entering the lake at certain points. It is also believed that agitation of the water by motor boats and water skiers may influence water properties to a depth of 20 feet.

DISCUSSION AND CONCLUSIONS

Temperatures and dissolved oxygen content found in the deeper levels along the channel in Lake Hamilton show tolerance values suitable for cold water fish, particularly for rainbow trout. Burdick et al. (1954) state that for hatchery reared rainbow trout, a minimum oxygen level of 2.47 ppm was found to be lethal at 71.7° F. A minimum level of 2.6 ppm was found at Station 9 where the water temperature was recorded as 70.7°F. The dissolved oxygen content in the channel reached minimal levels in the region of the thermocline and increased slightly at greater depths. At no level was the oxygen content in the channel found to be exhausted. The dissolved oxygen content and water temperatures in the channel of Lake Hamilton show that rainbow trout habitat exists in the channel from the upper to the lower end of the lake. The presence of a supply of dissolved oxygen throughout the vertical levels in the channel of Lake Hamilton appears to be due to the large volume of cold water released during routine hydro-electric generation at Blakely Dam. This cold water is drawn from below the thermocline in Lake Ouachita and becomes oxygenated in the tailrace of Blakely Dam before sliding under the warm upper stratum of water in Lake Hamilton.

Generation at Carpenter Dam tends to create a deep current of cold, oxygenated water moving through Lake Hamilton. Suitable temperature ranges and sufficient oxygen levels, as were found in the channel, should sustain trout throughout the critical summer months.

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THE RELATIVE RESISTANCE OF THIRTEEN SPECIES OF FISHES TO PETROLEUM REFINERY EFFLUENT[1,2]

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ABSTRACT

Twelve species of fishes native to Oklahoma were each tested four times in a series of twenty bioassays, and the guppy was included in each bioassay as a reference. The 24-hour median tolerance limits (TLm's) were determined. The relative sensitivity of each species was established. In a 5% multiple range test, the species were grouped into the following six statistical populations: (1); (2); (3-5); (4-10); (5-12); and (6-13). In the following ranked list, numbers in parentheses (also the rank numbers of the species) indicate the statistical populations to which the species could belong with no significant difference, while, species not included in numbers in parentheses are significantly different from the population included. Fishes rank from most resistant to least resistant as: 1. *Lebistes reticulatus* (1); 2. *Ictalurus melas* (2); 3. *Notemigonus crysoleucas* (3-5); 4. *Notropis lutrensis* (3-5), (4-10); 5. *Lepomis microlophus* (3-5), (4-10), (5-12); 6. *Pimephales notatus* (4-10), (5-12), (6-13); 7. *Notropis boops* (4-10), (5-12), (6-13); 8. *Lepomis cyanellus* (4-10), (5-12), (6-13); 9. *Lepomis megalotis* (4-10), (5-12), (6-13); 10. *Ambloplites repestris* (4-10), (5-12), (6-13); 11. *Chrosomus erythmrogaster* (5-12), (6-13); 12. *Ictalurus punctatus* (5-12), (6-13); 13. *Micropterus salmoides* (6-13).

The suitability of each species as a test animal is considered, based on information on the life histories and observations made during these tests.

INTRODUCTION

Bioassays are conducted to determine the effects of some agent or agents upon organisms. Currently, fishes are being used as test animals in the study of the effects of a number of groups of materials upon fish life. These materials include fish poisons, drugs and chemicals used in treating fish diseases, anesthetics used in handling and transporting fish, hormones used in spawn taking, respiratory gases in water, and pollutants that may affect aquatic life in natural waters.

The term 'pollution' as used in this paper will refer to the release of substances into natural waters in such quantities that they become detrimental to aquatic life. Major sources of pollution are mining wastes, agricultural poisons, domestic sewage, and industrial wastes. A nation-wide survey by the U. S. Public Health Service (1960) listed

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