

## Some Observations on Limnology and Fish Distribution In The Illinois River Below Tenkiller Reservoir<sup>1,2</sup>

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The possibility of a limited trout fishery in the cold waters of the Illinois River below Tenkiller Reservoir has prompted investigations by state and federal agencies during the past two years to determine habitat suitability. Finnell (4) concluded that insufficient dissolved oxygen, and not high temperature or reduced stream flow, would limit trout survival.

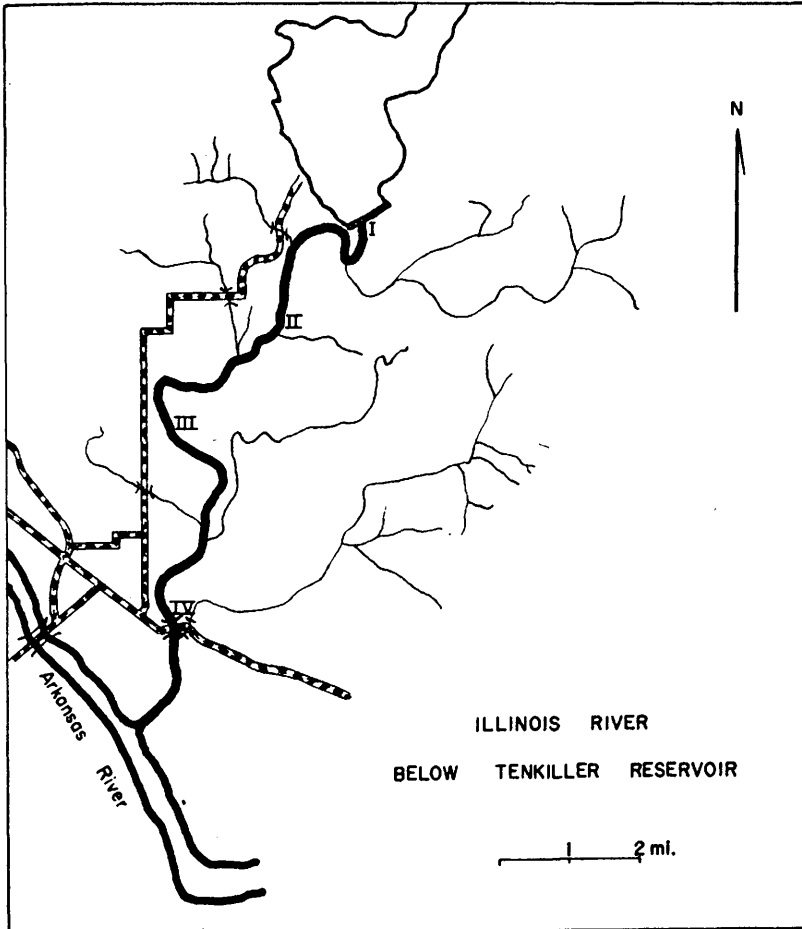


FIGURE 1. Map of Illinois River below Tenkiller Reservoir, with sampling stations indicated by Roman numerals.

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The present study was undertaken in August, 1954, after eight months of hydro-electric plant water release operations, in an effort to establish the limnological conditions and fish population composition in the 8.5 mile section of the river below the dam (Figure 1).

#### DESCRIPTION

The Illinois River and Tenkiller Reservoir have been described by Finnell (4). His study revealed that the reservoir exhibits a definite and stable thermocline, with a hypolimnion of low dissolved oxygen content (0.0 - 1.5 ppm.) during the summer months. This condition produces a profound reduction in temperature and dissolved oxygen concentration in the river below the dam when large amounts of water are released through the penstock tunnel.

Water releases during the period of study (August 3-14) began at 0700 and ceased at 2100 on week days, with the rate of discharge through the penstock tunnel varying from 2020 to 4040 cfs. (average - 3365 cfs.), subject to variation depending upon power production demands. Under normal operation, power production is discontinued over the weekend, beginning Saturday evening, and remaining off until 0700 Monday morning.

#### MATERIALS AND METHODS

Four sampling stations were selected along the upper 8.5 mile section of the river below the dam (Figure 1.) The station locations are as follows:

Station I—Samples were collected at the opening of the penstock tunnel directly below the power plant.

Station II—A long, deep pool, approximately two miles below the dam at the Corps of Engineers gaging station.

Station III—Above a riffle at the Oak Grove Recreation Area, 3 miles downstream from Station II.

Station IV—Beneath the U. S. Highway 64 bridge near Gore.

Surface temperatures and dissolved oxygen concentrations were measured daily at each station before discharge began at 0700, and after discharge when the river was at its peak of flow. The sampling days were August 3 through August 14, 1954, inclusive. Dissolved oxygen values were determined by the azide modification of the Winkler method (1), and temperatures were measured with a standard centigrade laboratory thermometer. Water samples taken for oxygen determinations were secured with a 1 liter Kemmerer sampler. Circular, double-throated, 3 by 6-foot wire traps of one inch mesh, were used in collecting fish in the river current. Fish were removed from the traps in the morning and in the afternoon after being subjected to 7-8 hours of peak discharge flow. Oxygen concentrations were determined at trap depth each time fish were removed.

#### RESULTS

Temperatures, dissolved oxygen concentrations, and time and date of sampling for each of the four stations are presented in Table I. These data were arranged in three groups: 1) pre-discharge period; 2) during discharge; 3) day of no discharge; and averages for each period are presented in Figure 2.

Average dissolved oxygen (D. O.) values in the pre-discharge period were higher at each station than those during discharge, but significantly lower than those found during the day of no discharge. Stream dissolved oxygen concentrations during discharge averaged below 1.5 ppm. for at least 2 miles below the dam, and below 2.0 ppm. at 5 miles. Laboratory experiments by Burdick, *et al.*, (2), demonstrated a median lethal oxygen concentration of 1.34 ppm. for rainbow trout after a period of 48 hours at 60° F. On August 10, during water release of 4000 cfs., the dissolved oxygen content dropped to 1.3 ppm. at Station III, 5 miles below the dam, and this condition might be expected at intervals throughout the summer months.

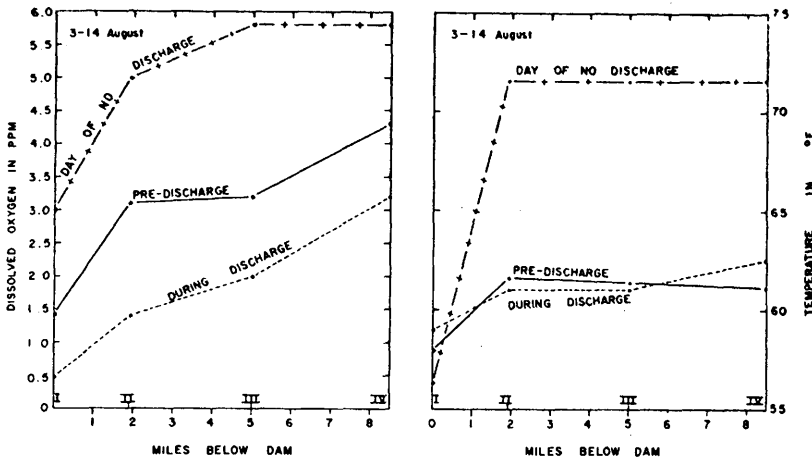


FIGURE 2. Average dissolved oxygen concentrations and temperatures recorded at sampling stations in the Illinois River below Tenkiller dam during the period 3-14 August 1954. Discharge and pre-discharge averages are based on ten observations at each station, and the day of no discharge on two observations.

During such periods, D. O. deficient waters might bar trout from the upper 5 miles of the stream.

Average temperatures during discharge compared to pre-discharge were very similar, but a significant increase was recorded on the day of no discharge (Figure 2.) The temperatures recorded at each station lie well within the range required for trout during normal operation of the hydroelectric plant. However, the temperature recorded on the day of no discharge suggests that the lethal limit (85° F.) may be reached if periods of no water release last for more than 48 hours during the summer months.

A back-water slough near Station III, one-half mile in length, showed a D.O. value of 2.4 ppm. at the mouth, which increased to 3.2 ppm. at the head. An increase in temperature from 62.4 to 67.1° F. was also noted. This slough, and a number of others along the course of the river, may serve as havens for fish during periods of high flow when the D. O. is extremely low in the main channel.

## DISCUSSION

Many writers have discussed the distribution and movement of fishes, and their physiological tolerances, with respect to minimum dissolved oxygen and maximum temperature limits, both in the laboratory and in natural situations. Sprugel (6) found that one-half of the bluegills trapped in a pond were dead after being held 48 hours in water containing 1.3 ppm. D. O. at a temperature of 73° F. In another test, all the bluegills were found dead after a 24 hour period in water containing 0.3 ppm. D. O. at 54° F. Burdick, *et al.* (2), found that the median lethal oxygen concentration for smallmouth bass was 0.87 ppm. at 60° F. Moore (5) determined winter oxygen thresholds under ice cover for a 48-hour period as follows: largemouth bass and northern pike, 2.3 ppm.; yellow perch, 1.5 ppm.; black crappie, 1.4 ppm.; pumpkinseed sunfish, 0.9 ppm.; bluegill, 0.8 ppm.; black bullhead, 0.3 ppm.; and golden shiner, 0.0 ppm. Winter oxygen thresholds determined by Cooper and Washburn (3) during a study on several Michigan

lakes were slightly lower than Moore's figures for the same species, and markedly lower for largemouth bass and black crapple.

The limited observations of this study on oxygen tolerances agree with the findings of the authors cited above. Nineteen species were taken from the Illinois River in water containing less than 3.0 ppm. D. O., 15 of these in less than 2.0 ppm., and 13 in less than 1.5 ppm. (Table II). Black bullhead, bluegill, green sunfish, longear sunfish, rock bass, longnose gar, and smallmouth bass apparently are able to survive in D. O. concentrations between 0.5 and 0.9 ppm., in a swift current at temperatures of 54 to 64° F. Only bullheads were found alive in waters containing less than 0.5 ppm.

The presence of these fishes does not imply that the habitat is suitable for large populations of desirable species. A total of only 373 individuals were captured in 50 trap lifts, and few of these were of catchable size. Mid-morning observations in a backwater area, 100 yards below the penstock tunnel outlet, revealed several species of fishes in distress. Large numbers of shad and bluegill and a few bass were grouped just beneath the surface, and carp and buffalo were gasping at the surface, indicating a lack of D. O. The surfacing of gar was noticed throughout the study approximately 0.4 mile downstream from the dam. Fishermen's catches were very limited along the Illinois River during periods of high flow, but a few fish were caught in the brief period before turbine operation began in the mornings. The information collected and observations made during the

study suggest that good summer fishing below Tenkiller Dam is unlikely during high water releases.

No rainbow trout were trapped, and there were no reports of angler's catches during August. The low D. O.'s recorded render the possibility of adequate growth and well-being of this species highly unlikely during the summer months throughout the greater portion of the river.

#### LITERATURE CITED

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TABLE I.

Temperatures, dissolved oxygen concentrations, date, and time of sampling at each station in the Illinois River below Tenkiller Reservoir, 3-14 August, 1954.

STATIONS		I			II		
Date (August 1954)	D.O. (ppm)	Temp. (°F)	Time of Sampling	D.O. (ppm)	Temp. (°F)	Time of Sampling	
3	0.4	59.0	1300	1.4	61.0	1400	
4	1.6	58.1	0440	2.8	61.2	0530	
4	0.4	59.0	1630	1.4	59.4	1700	
5	1.4	57.6	0530	2.8	62.6	0600	
6	2.0	57.7	0640	3.6	60.3	0700	
7	3.0	61.2	0640	3.6	60.8	0700	
7	0.4	57.7	1110	2.0	61.3	1255	
*8	0.8	59.0	0640	3.6	64.4	0710	
*8	3.0	56.3	1515	5.0	71.6	1655	
9	0.8	54.5	0655	2.8	59.9	0630	
9	0.5	59.0	1200	1.2	60.8	1705	
10	1.2	56.3	0645	3.2	60.8	0630	
10	0.1	57.6	1700	1.0	60.8	1630	
11	1.0	58.1	0630	1.4	60.8	0645	
11	0.4	59.9	1730	1.2	60.8	1800	
12	1.0	59.0	0645	3.8	62.6	0630	
12	0.6	59.9	1815	1.4	61.7	1900	
13	1.2	57.2	0655	2.8	61.3	0640	
13	0.8	59.5	1430	1.6	61.2	1515	
14	1.8	59.0	0700	3.8	63.0	0630	
14	0.5	59.9	1800	1.4	61.7	1715	

\* No water released on August 8

III			IV		
D.O. (ppm)	Temp. (°F)	Time of Sampling	D.O. (ppm)	Temp. (°F)	Time of Sampling
2.0	62.0	1500	3.2	63.0	1600
2.4	60.4	0420	4.2	59.9	0400
2.0	59.7	1745	3.4	61.2	1810
2.0	60.6	0515	3.4	61.2	0445
3.4	60.8	0615	4.8	61.2	0600
3.6	60.8	0620	4.6	59.9	0600
2.4	60.6	1820	3.8	61.7	1845
3.4	62.6	0740	4.8	63.0	0800
5.8	71.6	1730	5.8	71.6	1820
4.2	61.2	0615	4.6	61.7	0600
2.4	60.8	1815	3.6	62.1	1900
3.8	60.8	0615	4.6	60.8	0600
1.3	59.2	1715	1.8	62.6	1800
2.0	62.6	0700	2.6	62.2	0730
1.6	60.8	1830	2.8	61.7	1900
3.6	61.7	0600	5.0	61.2	0530
2.0	62.6	1730	3.6	63.5	1700
2.8	61.2	0620	3.8	61.2	0600
2.2	62.2	1600	3.0	63.5	1730
3.6	62.2	0600	4.8	61.2	0530
2.0	62.4	1630	3.4	64.2	1600

TABLE II.

Numbers of various species trapped in the Illinois River below Tenkiller Dam under various dissolved oxygen concentrations. Temperatures ranged from 54.5 to 64.2° F.

Species	Dissolved Oxygen (ppm.)								Length range (inches)
	0.0-0.4	0.5-0.9	1.0-1.4	1.5-1.9	2.0-2.4	2.5-2.9	3.0-3.9		
Black bullhead	6	8							6.0-9.4
Bluegill	13*	88(4*)	43	12	25	51	2		3.8-7.8
Greensunfish	8*	16	2	1	1		1		4.5-7.5
Longear sunfish		5	8	11	5	5	2		4.3-5.7
Rock bass		2				1			4.5-6.2
Longnose gar		1							23.0
Smallmouth bass		1							9.5
White crappie	1*		6	3	2	5			5.7-7.9
River carpsucker	3*		2	8					6.8-13.6
Golden redbreast		1*	2	2	1				10.8-13.6
Warmouth			1	2		2			4.8-8.0
Spotted bass			1	2		1	4		7.4-13.1
Gizzard shad			1						9.1
Channel catfish	1*	1*		1	1	1			8.2-10.9
Black buffalo				1					11.3
Redear sunfish					1				5.1
Eastern sauger					1				17.0
Largemouth bass						1			9.1
Spotted sucker						1			13.1

\* Dead when removed from trap.