POWER PLANT HEATED DISCHARGE WATER AND BENTHOS IN BOOMER LAKE, PAYNE COUNTY, OKLAHOMA[1]

RICHARD E. CRAVEN[2] AND BRADFORD E. BROWN[3]

ABSTRACT

Heated water entering Boomer Lake, Payne County, Oklahoma, resulted in stream conditions being simulated in the power plant discharge riffle. Trichoptera (*Cheumatopsyche* and *Hydropsyche*) and Diptera (*Simulium vittatum* Zetterstedt) were abundant in the riffle and may have supplemented the food supply of fishes in the lake.

Populations of Ephemeroptera (*Hexagenia*), Diptera (Chironomidae), Megaloptera (*Sialis*), and Oligochaeta (*Branchiura sowerbyi* Beddard) from two areas on the lake were compared. Both areas were coves, but one had heated water entering it. Since monthly mean numbers of organisms and biomass per individual *Hexagenia* from the two areas were similar, the heated water apparently had little, if any, effect on the benthos.

The building of power plants on many large streams and lakes requires that the possible effects of such installations on aquatic life be studied. The significance of power plant heated water cannot be underestimated: in the 1980's some 200 billion gallons of water per day will be needed for cooling (6%) and boiler make-up (94%) in steam-electric plants (Trembley, 1965).

Mihursky and Kennedy (1967) have discussed the ecological significance of heated discharge water on organisms in several habitats. This study compares the benthos of two similar areas on Boomer Lake, Payne County, Oklahoma, one of which received heated water from a power plant.

DESCRIPTION OF LAKE

Boomer Lake, completed in 1925, has the following morphology: surface area, 251 acres; watershed area, 8,954 acres; shoreline length, 8.6 miles; shoreline development, 4.17; mean depth, 9.7 feet.

A 21,750 kilowatt-rated power plant was located on the southwest corner of the lake. Water is pumped into the plant, used for cooling the natural gas turbines, and then dumped into a concrete canal (Fig. 1) that transports the heated water back to the lake. The end of the canal is a 25 by 100 ft riffle with wooden pilings set in concrete bases packed closely together (Fig. 2). Water in the riffle varies from 2 to 8 inches deep with a surface velocity of about 2 ft/sec (Upham, 1964).

[1] Accepted for publication May 13, 1969. This study was supported by funds from the U. S. Bureau of Sport Fisheries and Wildlife.

[2] Biology Dept., Kansas State College, Pittsburg.

[3] Oklahoma Coop. Fish. Unit, Oklahoma State University, Stillwater.

JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY 43:122–128. April, 1970.

FIG. 1. Canal for transporting heated water to the lake.

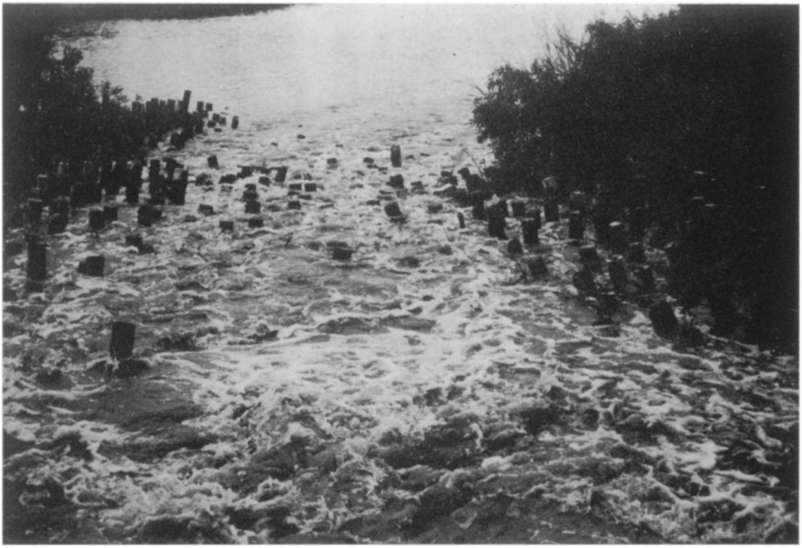

FIG. 2. Riffle area in heated water discharge canal.

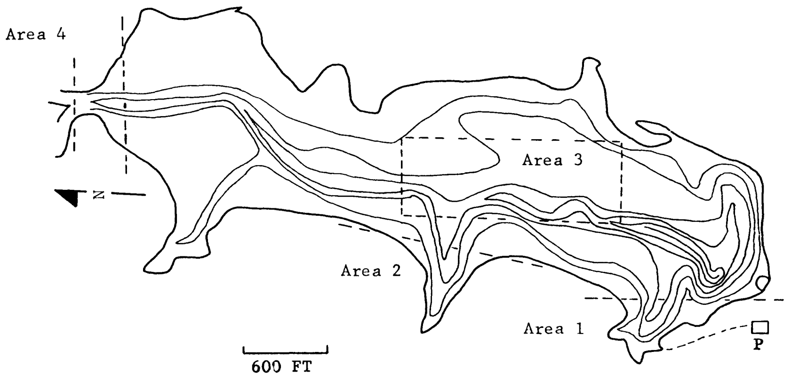

FIG. 3. Boomer Lake. Sampling areas bounded by dashed lines. Contour intervals approximately 5 feet. P = power plant and canal.

METHODS

The lake had been divided into four areas for intensive sampling of benthos (Fig. 3); areas 1 and 2 are of concern in this presentation. Area 1 was a 5-acre cove that received coolant water from the power plant; area 2 was a 6-acre cove not exposed to the coolant water.

Each area was subdivided into units that one could locate by landmarks while in a boat. Samples were collected weekly from March to September, 1966, biweekly during September and October, and monthly from November, 1966 through February, 1967. For each sampling period, five sample sites within each area were selected using a table of random numbers. One Ekman dredge sample, and surface and near bottom temperatures (less than 6 inches from the bottom) were taken at each site. Water temperature was measured with a thermistor on a galvanic cell oxygen analyzer.

Samples were washed in the field in a sieve of 0.42 mm mesh; the remaining benthos and debris were preserved in 10% formalin. After additional washing and sorting in the laboratory, all organisms were preserved in 70% isopropanol.

The power plant canal was not systematically sampled. However, collections were made and the relative numbers of organisms present were observed.

Coolant water inflow was calculated from records at the power plant office.

All *Hexagenia* from each sample were dried at 212°F for 24 hours and then weighed on an analytical balance.

RESULTS

Highest and lowest daily mean water flow leaving the power plant were recorded in July and April, respectively (Fig. 4). The variation

FIG. 4. Daily mean flow of coolant water leaving Boomer Lake power plant.

in outflow volume resulted from varying demand for electricity. Power plant intake water volume was increased to keep the turbines cooled and to keep the temperature of the outflow water no more than about 10°F above that of plant intake water.

Temperature differences between surface and bottom were greater in area 1 than in area 2 (Table 1). The only apparent cause for the greater temperature difference in area 1 is that the inflowing water heated the surface but had little effect on the bottom water. Since

TABLE 1. Monthly mean surface and bottom temperatures (°F), areas 1 and 2, Boomer Lake, Oklahoma, 1966–1967.

	Area 1[a]			Area 2[a]		
Month	Surface	Bottom	Difference	Surface	Bottom	Difference
March	——	——	——	——	——	——
April	60.66	57.92	+2.74	57.69	56.91	+0.78
May	71.00	67.77	+3.23	70.75	67.33	+3.42
June	79.38	76.57	+2.81	78.03	76.77	+1.26
July	87.04	83.98	+3.06	85.44	84.07	+1.37
August	83.05	80.78	+2.27	82.20	81.10	+1.10
September	78.35	75.52	+2.83	75.61	74.77	+0.84
October	64.83	62.92	+1.91	63.54	62.87	+0.67
November	57.38	54.86	+2.52	58.10	57.56	+0.54
December	36.77	36.95	−0.18	35.60	35.60	0
January	45.50	44.06	+1.44	44.06	43.16	+0.90
February	46.49	42.71	+3.78	41.00	41.00	0

[a] Number of samples per area is listed in Table 3.

TABLE 2. Monthly mean MG per *Hexagenia* and 95% confidence intervals, samples taken at Boomer Lake, Oklahoma, 1966–1967.

Month	Area 1	Area 2
March	0.69 ± 0.05	0.74 ± 0.05
April	1.09 ± 0.03	0.91 ± 0.03
May	1.58 ± 0.07	1.85 ± 0.14
June	1.90 ± 0.14	2.41 ± 0.29
July	3.14 ± 0.44	2.13 ± 0.23
August	2.91 ± 0.75	2.18 ± 0.94
September	0.72 ± 0.14	0.82 ± 0.50
October	0.56 ± 0.20	0.77 ± 0.17
November	0.24 ± 0.09	0.38 ± 0.08
December	0.59 ± 0.10	0.50 ± 0.06
January	0.58 ± 0.11	0.47 ± 0.03
February	0.64 ± 0.10	0.59 ± 0.06

the sample sites were selected randomly, they were, at times, quite a distance from the immediate outflow.

The temperature of water immediately exiting from the plant and at the point of entrance into the lake, measured on several sampling trips, was always approximately the same. Thus, as water flowed down the canal very little heat was dissipated.

Near the outlet, the force of the water entering the lake produced complete mixing, indicated by homeothermic conditions from surface to bottom. Probable effects of this current were (1) scouring of the area immediately in the path of the canal outlet and (2) turbulence and suspension of bottom materials. These effects would limit the type of invertebrate able to inhabit this area.

The discharge canal riffle functioned as a habitat for lotic organisms. The riffle was not sampled regularly, and the following description is based on occasional observations of the more obvious fauna.

Two genera of Trichoptera (Hydropsychidae: *Cheumatopsyche* and *Hydropsyche*) and one species of Diptera (Simuliidae: *Simulium vittatum* Zetterstedt) were abundant in the riffle. Both trichopterans were found in close proximity on the same rocks in the riffle. *Simulium vittatum* seemed to be second in abundance to the trichopterous larvae. Such debris as paper, boards, and vegetation lodged in the pilings as well as the large rocks of the riffle served as points of attachment for all three taxa. However, only two specimens of *Cheumatopsyche* and none of *Hydropsyche* were collected from the lake during the study. Dipterous and trichopterous larvae may have supplemented the diet of fishes, since they probably were swept into the lake in periods of emergence.

Invertebrates in the riffle may be adversely affected by the warm water during summer months (Upham, 1964), while during other periods of the year the warm water may result in increased growth rate. Adverse effects of heated water on the benthos of area 1 were

TABLE 3. Monthly mean number[a] of *Branchiura sowerbyi* and *Sialis* in areas 1 and 2, Boomer Lake, Oklahoma, 1966–1967.

Month	Area 1		Area 2		No. samples per area
	Branchiura	*Sialis*	*Branchiura*	*Sialis*	
March	9	17	13	13	10
April	24	12	19	21	25
May	17	17	17	15	20
June	17	17	22	15	20
July	26	53	40	38	25
August	200	41	84	26	20
September	47	60	129	4	10
October	77	39	116	0	10
November	34	26	129	34	5
December	43	34	69	9	5
January	43	0	34	26	5
February	69	0	60	9	5

[a] Number per square meter.

doubtful; the growth of *Hexagenia* (Ephemeroptera) apparently was not affected (Table 2).

Chironomidae contributed from 20.4 to 36.1% and *Hexagenia* from 18.5 to 56.3% of the total number of macroinvertebrates collected from the lake during the study. Since these taxa compared to others were relatively abundant in all samples, Duncan's new multiple range test (Steel and Torrie, 1960) was applied, at the 0.05 level of significance, to each taxon represented in areas 1 through 4.

Monthly mean number of *Hexagenia* in areas 1 and 2 did not differ significantly, and mean biomass per individual *Hexagenia* was also similar in areas 1 and 2 (Table 2). Monthly mean number of Chironomidae in areas 1 and 2 differed significantly only in December and February. These small differences indicate that the heated water entering area 1 apparently did not adversely affect abundance of *Hexagenia* and Chironomidae.

Sialis (Megaloptera) was more abundant in area 1 than in area 2 (Table 3), perhaps in response to the current from the inflow water. However, abundance was not great enough for further analysis.

Branchiura sowerbyi Beddard (Oligochaeta) has been reported in association with heated water from power stations (Brinkhurst, 1965; Mann, 1958). In Boomer Lake, this association was not evident. Comparison of the standing crops from areas 1 and 2 indicates that trends and abundance relationships are comparable (Table 3).

DISCUSSION

In Boomer Lake, effects of heated water during the study were minimal owing to the relatively low volume and velocity of the water and the relatively constant and low temperature difference of the lake and the water being discharged.

Increasing water volume probably would result in a more pronounced erosional effect on the lake substrate and thus further decreased habitat for lentic taxa. The power plant, which is to be enlarged, will produce a larger volume of heated water.

The addition of typically lotic taxa probably can be considered beneficial since many of the insects would be carried into the lake by the flow of water and consumed by fish.

ACKNOWLEDGMENTS

The authors appreciate the cooperation of Messrs. A. Faust, G. Keeler, M. King, J. May, and Drs. R. Summerfelt and F. Wade.

LITERATURE CITED

Brinkhurst, R. O. 1965. The biology of the Tubificidae with reference to pollution. *In*: Biological Problems in Water Pollution. Third Seminar, 1962. Public Health Ser. Publ. No. 999-WP-25, p. 57–66.

Mann, K. H. 1958. Occurrence of an exotic oligochaete, *Branchiura sowerbyi* Beddard, 1892, in the River Thames. Nature (London) 182:732.

Mihursky, J. A., and V. S. Kennedy. 1967. Water temperature criteria to protect aquatic life. *In*: A symposium on water quality criteria to protect aquatic life. Amer. Fish. Soc., Trans., Suppl., 96(1):20–32.

Steel, G. D. Robert, and J. H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., New York. 481 p.

Trembley, F. J. 1965. Effects of cooling water from steam-electric power plants on stream biota. *In*: Biological Problems in Water Pollution. Third Seminar, 1962. Public Health Ser. Publ. No. 999-WP-25, p. 334–345.

Upham, R. W., Jr. 1964. A study of the larval populations and comparison of lengths of pupal filaments of simuliids in north-central Oklahoma. M.S. Thesis, Okla. St. Univ., Stillwater. 38 p.