SECTION G, CONSERVATION

Effects of a Flood on Fish Distribution in Keystone Reservoir[1]

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Flood waters entered the Cimarron arm of Keystone Reservoir, Oklahoma, in September, 1965. The Cimarron River discharge increased from 452 cfs on 20 September to 41,529 cfs on 22 September (U.S. Army Corps Eng., 1965). Currents carried silt and organic debris through the reservoir. An oil slick covered most of the water surface.

Vertical distribution of fishes and physico-chemical parameters were determined before and after flood waters had reached a point 9.6 nautical miles upstream from the confluence of the Arkansas and Cimarron arms of the reservoir.

A vertical latin-square net was set from the reservoir surface to the bottom (0-11 m) for two 24-hr periods. The net consisted of four rectangular designs employing ¾-, 1-, 1½-, 2-, 2½-, and 3-inch (square measure) mesh (Houser and Ghent, 1964). These designs were randomly combined in stack-like fashion.

Temperature, turbidity, conductivity and dissolved oxygen were determined at each meter of depth. Water temperature was recorded in degrees Celsius using a Yellow Springs telethermometer. Micromhos of specific conductance were measured in situ using an Industrial Instruments Solu-bridge. Water samples were

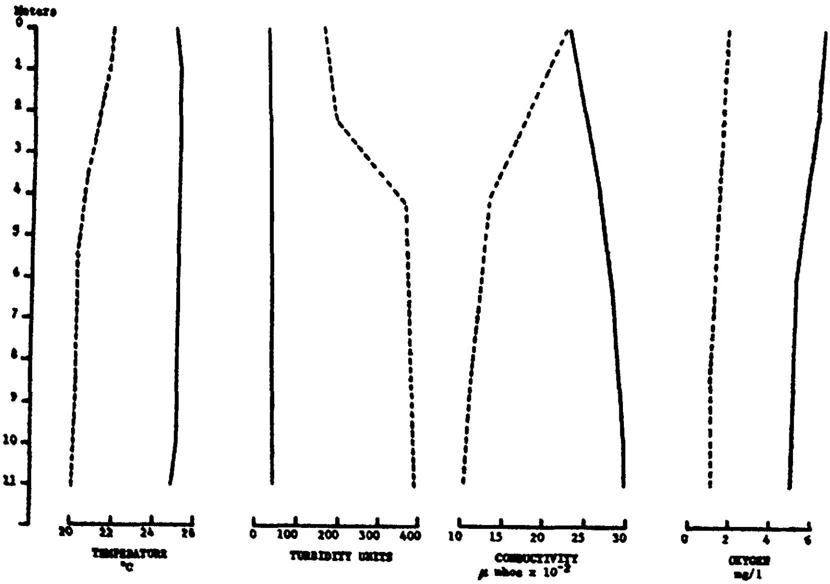

Figure 1. Physico-chemical conditions in the Cimarron Arm of Keystone Reservoir before and during the flood of September, 1965. September 21 = (—), September 23 = (- -).

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taken with a Kemmerer water bottle. Turbidity, as measured with a Bausch and Lomb Spectronic-20 Colorimeter calibrated against a Jackson Turbidimeter, is expressed as "Turbidity Units," roughly equivalent to mg/liter. Dissolved oxygen was determined by the Alsterberg (Azide) modification of the Winkler method (A.P.H.A., 1960).

Approximately uniform physico-chemical conditions prevailed at the sampling site on 21 September (Fig. 1). Temperature remained constant, turbidity and conductivity increased slightly and oxygen showed a small decrease with depth.

Flood water which entered the reservoir was cooler and less conductive because of dilution of runoff. This water also carried a heavy load of suspended solids and organic matter and sank below the lighter reservoir water. As these waters mixed, dilution first occurred in the bottom layers and progressed toward the surface. By 23 September, complete mixing had occurred up to a point 4 m below the surface as shown by temperature, turbidity and conductivity measurements (Fig. 1). Four changes in mean values of the water mass occurred during the 48-hr period. Temperature decreased from 25.2 to 20.8 C, turbidity increased from 40 to 320 turbidity units, specific conductance decreased from 2750 to 1450 micromhos, and dissolved oxygen decreased from 5.6 to 1.4 mg/liter. The severe decrease in dissolved oxygen was attributed to the high oxygen demand of dissolved organic substances.

Fishes responded to these physico-chemical changes by moving closer to the surface, with mean depth of capture of all species changing from 5.70 to 3.28 m (Fig. 2). A t-test applied to the differences between paired numbers of fishes caught at meter intervals gave a $t = 2.45$ with 112 degrees of freedom, which indicated significant differences between the two depth averages ($p > 0.05$). In addition to changes in depth, distressed fishes were observed swimming on the surface of the water.

Oxygen and turbidity were probably the critical factors causing a decrease in the mean depth where fishes were taken. Whitmore et al. (1960) found that centrarchids have almost instantaneous responses to changes in oxygen concentrations. Other authors have also noted fishes reacting negatively to a deficiency of oxygen by moving away with quickly developing respiratory distress (Shelford and Allee, 1913; Jones, 1962). Wallen (1951) observed that the first symptom due to turbidity is appearance of fishes at the surface of the water swimming rapidly, gulping air and surface water.

Drum reacted to physico-chemical changes more than any other fish by decreasing their mean depth 3.49 m. White bass showed a distinct reaction to these changes by decreasing their mean depth 2.90 m. All other species decreased their mean depths, except carp which increased 2.11 m (Table I). Carp were unaffected by the increase in turbidity below 4 m, where 320 ppm was recorded for the highest reading. This observation is in agreement with Wallen (1951), who found that carp showed distress symptoms only when turbidity reached 20,000 ppm.

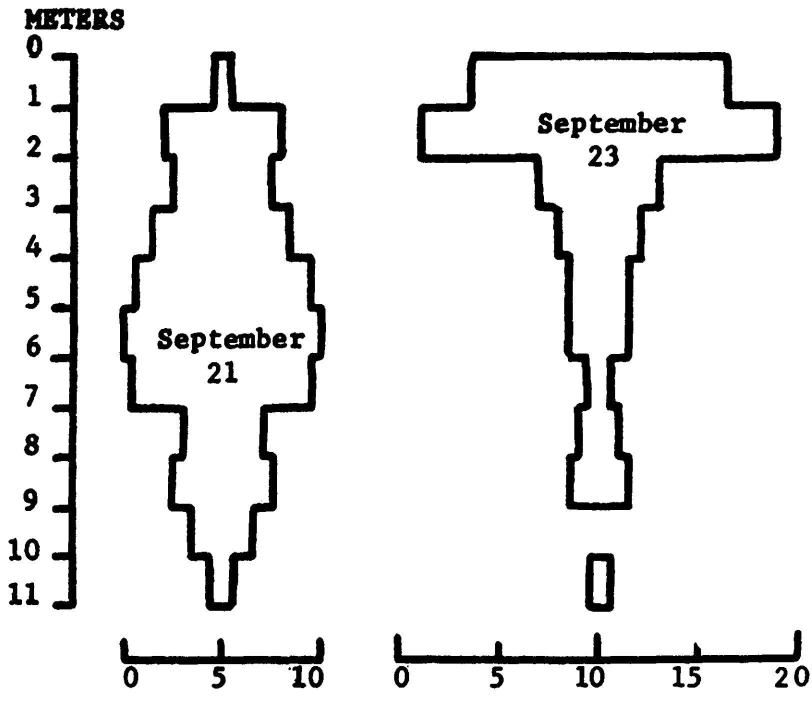

Figure 2. Distribution of fishes before and during the flood of September, 1965.

TABLE I. AVERAGE DEPTH OF CAPTURE OF FISHES

Species	21 September Nos.	21 September $\bar{x}$ Depth	23 September Nos.	23 September $\bar{x}$ Depth
Drum	22	5.73	34	2.24
Carp	11	4.09	5	6.20
Gizzard shad	8	7.88	5	7.00
Black bullhead	7	6.29	3	6.00
White bass	5	4.40	4	1.50
Channel catfish	4	5.73	1	4.00
Walleye	2	6.50	1	6.00
White crappie	1	5.00	1	1.00

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