AN ANALYSIS OF THE FISH POPULATION AND ITS DEPTH DISTRIBUTION AS INFLUENCED BY VERTICAL TEMPERATURES IN LAKE CARL BLACKWELL PAYNE COUNTY, OKLAHOMA

By

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INTRODUCTION

The investigation with which this paper is concerned was made in an attempt to correlate depth distribution of fish with vertical water temperatures in an artificial impoundment of central Oklahoma. The objectives of the investigation were threefold: (1) to analyze the fish population, (2) to learn if and how temperature effects vertical distribution of fish, (3) to discover principles which will help the average fisherman to catch more fish.

The number of anglers and man-hours of fishing has increased many times in Oklahoma within the last two decades. There probably are few sections of the country where the populace is more interested in angling. This interest is due in part to the numerous reservoirs that have been recently constructed by the U. S. Corps of Engineers, the U. S. Bureau of Reclamation, municipalities and others. The investigation was inaugurated in an attempt to help the fishermen increase the fish harvest from Lake Carl Blackwell. A greater harvest could be accomplished and a service rendered the fishermen if they could know in advance where in the lake the best fishing could be found. Such information should increase the fishing success and encourage more fishing. An increased harvest might aid in the alleviation of competition for food caused by overpopulation.

It was reported for certain T.V.A. reservoirs (Dendy, 1945) that where an adequate supply of oxygen existed, the depth distribution of fish was influenced by thermal stratification. The depths and temperatures at which largemouth bass, walleye (pike perch), and sauger were most abundant were located throughout the seasons. Later the locations of these fish were predicted on a weekly or biweekly basis from temperature readings and the information released through

newspapers. Biologists at T.V.A. reported that the information helped the fisherman to increase his catch by informing him of the proper area and depth at which to fish.

Field work was begun in September 1947 by Mr. Donald D. Poole, a graduate student at Oklahoma Agricultural and Mechanical College. The study was planned on a five-year basis with Mr. Poole in charge until August 1948. At that time Mr. Charles Harris, also an A & M student, continued the investigation until February 1949. The writer terminated the investigation in March 1950 when it became evident that no new information was forthcoming from continued field studies. Mr. Poole and Mr. Harris have not published their findings, therefore, this paper is based entirely on the data collected by the writer.

The study was made possible by support from several sources to which the writer is indebted. The Andy Anderson Fellowship provided a monthly stipend for 13 months and the Oklahoma Cooperative Wildlife Research Unit a monthly stipend for five months. The Game and Fish Department provided a boat and a motor. The Research Foundation of Oklahoma Agricultural and Mechanical College paid help and transportation costs, besides providing an outboard motor, nets, seines, traps, and cost of repairs. The Zoology Department furnished laboratory equipment, gasolene, oil, and aid by consultations.

SITUATION INVESTIGATED MAR 49 – MAR 50

Lake Carl Blackwell, located 9 miles west of Stillwater, Oklahoma, a reservoir of 3,300 surface acres at spillway level, was selected for study. The dam forming the impoundment was constructed by the Resettlement Administration during 1935-1937.

The main axis of the lake lies east and west with several broad shallow arms extending north and south from an old creek bed. The lake has a maximum

depth of 40 feet with a maximum depth of 25 feet in the arms. Relatively deep water begins just above the dam and extends westward along the old creek bed. However, most of the lake basin is shallow and the bottom is largely clay soil. Many trees were left standing in the basin when the reservoir was completed. The trees, now dead, furnish shelter for fish, obstruct boating, and hinder netting.

Twenty-one netting stations for sampling were located on five prominent arms of the lake. The sampling stations were chosen to include several ecological niches, in shallow and deep water, in and near emergent vegetation, in open, wind swept stretches, in well protected coves, among the trees, and on rocky and muddy bottoms.

METHODS

Three types of gear for capturing fish were used throughout the period of study and were set at what seemed to be the most advantageous positions with reference to the existing water temperatures.

Three gill nets were used. Two of them were 125 feet long by 6 feet deep, and one was 300 feet long by 8 feet deep. All had a mesh of 1½ inches, bar measure. The gill nets were set on the bottom and at right angles to the shoreline. The depth of set often varied from one end of the net to the other, depending upon the contour of the lake bottom. Some sets were made near the shore and others in deeper water off shore. As only one mesh-size was used, the nets were set singly rather than in groups since the entire size variation of fishes could not be sampled with the available equipment. The hoopnets were of the commercial type with one-inch mesh and six hoops. The front hoop was 3½ feet in diameter with each successive hoop smaller in size. The nets

were anchored in position on the lake bottom in depths from 1½ to 20 feet and so situated that the lead was pointed toward the shore. In most sets not more than two nets were used.

Five wire traps were used. Each trap consisted of reinforcing steel welded to form a cylindrical frame 2½ feet in diameter, by 6 feet long. The frame was covered with one-inch mesh woven wire with a wire cone attached at each end. The cones extended inward and terminated with a 4-inch opening through which the fish could enter the trap.

The traps were set on the bottom at depths varying from 2½ to 20 feet. All three types of gear were used most of the year, but traps only were set during cold weather because of the ease of operation.

Temperature of the water was recorded throughout the investigation. An H-B deep-sea reversing thermometer was used to record air, surface, and bottom temperatures. When a difference between surface and bottom water temperatures was sufficient to indicate a possible thermocline, readings were taken at each three-foot interval of depth. All temperature measurements were taken in close proximity to the nets and trap sets just prior to the time the nets and traps were raised.

Turbidity, hydrogen-ion concentration, dissolved CO_2, and dissolved O_2 determinations were made of Lake Carl Blackwell water by E. M. Leonard of the Department of Zoology, Oklahoma Agricultural and Mechanical College at bi-monthly intervals during the period of this investigation. It was agreed at the initiation of the study that his records for the above mentioned factors would be used to eliminate duplication of effort. His records are to be published soon.

CREEL INFORMATION

The men in charge of concessions and lake supervision have maintained a checking station to which the fishermen may bring their catches for weighing. Checking was not compulsary but was furnished as a convenience for the anglers. Weekly records were kept for the purpose of lake publicity, and were made available to the writer by the local newspaper reporter. The catches reported for the year, 1949, were tabulated and are included merely as an indication of the angling success during the period covered by the investigation.

Attention is invited to the fact that the anglers who used the weighing station were a select group. Anglers who rented boats were compelled to return to the concession where the weighing station was maintained, and they would be more likely to report than an angler who used his own boat and docked in another part of the lake. Also, anglers tend to report only their good catches, and the information mentioned herein does not include reports of fishermen who met poor or no success.

Despite the selectivity of the anglers who reported their catches, the information is included because the creel is the only measure by which the fisherman determines his success and because it is evidence that fish were being taken from the lake.

Bass, crappie, and channel catfish were the only fish reported at the checking station, where 2,289 fish weighing a total of 4,515 pounds were recorded. Of this number 230 were bass weighing a total of 830 pounds. The records show that the catches were fairly evenly distributed throughout the year. Channel catfish were taken each month of the investigation. Of these, 1,351 fish weighing 2,895 pounds were reported for the year. One-half were caught during June and August with good catches taken each month from May to October. During the year the fishermen reported 1,311 crappie weighing 1,200

pounds. Recorded catches would suggest that May, August, September, and October were the best months for crappie fishing (Table 1).

It may be observed from the above data that channel catfish were most abundant from the anglers point of view in both pounds and total numbers of fish reported.

TAGGING

Eight hundred and forty fish taken in hoop nets were tagged using standard procedures, and were released at the place of capture. No tagged fish were recovered either by fishermen or in the nets and traps. An explanation for the lack of recovery must include the possibility that a small harvest was accomplished from a large population. We know neither the size of the population nor the extent of the harvest.

SPECIES OF FISH COLLECTED

The fishes that were taken by the investigator are listed below. Minnows were abundant in the lake and have been recorded by previous workers. (Poole, unpub.)

1.	White crappie	Pomoxis annularis Rafinesque
2.	Channel catfish	Ictalurus lacustris (Walbaum)
3.	Largemouth bass	Micropterus salmoides (Lacepede)
4.	Gizzard shad	Dorosoma cepedianum (LeSueur)
5.	Carp sucker	Carpiodes carpio (Rafinesque)
6.	Carp	Cyprinus carpio Linnaeus
7.	Drum	Aplodinotus grunniens Rafinesque
8.	Bluegill	Lepomis macrochirus Rafinesque

TABLE 1

Anglers Catch per Month of 1949 as

Reported at the Weighing Station

	January	February	March	April	May	June	July	August	September	October	November	December
Ave. temp.		37	57	77	83	81	81	70	68	64	63	
Bass		2	31	33	14	27	38	11	28	11		
Channel cat		25	28	25	133	354	162	295	172	149	33	
White crappie		44	63	91	139	77	30	135	194	209	23	

9.	Longear sunfish	Lepomis megalotis Cope
10.	Green sunfish	Lepomis cyanellus Rafinesque
11.	Black crappie	Pomoxis nigro-maculatus (LeSueur)
12.	Yellow bullhead	Ameiurus natalis (LeSueur)

LIMNOLOGICAL DATA

The limnological factors observed varied only slightly throughout the year. Temperature, pH, and dissolved gases changed during the summer, but the changes were small even at the maximum depths netted. Density currents and dissolved oxygen profiles as described by Weibe (1939, 1940) were not found.

Dissolved Oxygen

Dissolved oxygen varied from a maximum of 11.6 ppm. in the surface water on March 3, 1949, to a minimum of 0.0 ppm. at 41 feet on July 8, 1949. Table 2 shows the records made. It is worthy of note that the low concentrations of O_2 existed only at 20 feet or greater depths, and only between June 25 and August 16, 1949. These depths occur only in the main body of the lake and not in the arms or other areas netted.

Hydrogen-ion Concentration

The pH values ranged from 7.6 to 8.4.

Free Carbon Dioxide

Free CO_2 was absent from the water at all levels for most of the year (Table 3). During the period from June 25 to August 16, 1949, some free CO_2 was present at most lower levels, varied considerably below 16 feet, but was discovered only once in surface water.

TABLE 2

Dissolved Oxygen Content of Lake Carl Blackwell

Expressed in P.P.M. 1949-50

Station 1

Date	Feet								
	0	16	20	23	26	30	33	36	39
Mar. 3	11.6	11.2						11.0	
28	11.1	11.1						10.8	
Apr. 8	10.4	8.9						8.8	
22	9.0	8.5						8.3	
May 20	10.0	7.7						7.7	
June 10	8.1	6.1							5.8
25	6.2	5.9	3.3	2.2	1.9	0.7	0.7	0.5	
July 8	6.0	5.1	1.4	0.5	0.3	0.1	0.1	0.1	
21	7.4	4.9	3.8	1.9	1.9	1.1	0.6	0.5	
Aug. 2	6.5	5.2			3.2	1.4	1.2	0.2	
16	5.8	4.9			1.7	0.6			
Sept. 3	5.9	5.8						5.8	
20	6.2	6.0						5.9	
Oct. 10	6.8	6.5						6.1	
26	7.6	7.5						6.5	
Nov. 14	8.8	8.5						8.3	
28	8.2	8.1							
Dec. 5	9.3	9.1						9.0	
30	10.5	10.3							
Jan. 17	11.2	11.0						10.6	
30	10.6	10.4							
Feb. 16	9.8	9.5						9.4	
25	9.9	9.4						9.2	

TABLE 3

Free Carbon Dioxide Content of Lake Carl Blackwell

Expressed in P.P.M. 1949-50

Station 1

Date		Feet								
		0	16	20	23	26	30	33	36	39
Mar.	3	0.0	0.0						0.0	
	28	0.0	0.0						0.0	
Apr.	8	0.0	0.0						0.0	
	22	0.0	0.0						0.0	
May	20	0.0	0.0						0.0	
June	10	0.0	0.0							0.0
	25	0.0	0.0	3.0	6.0	6.0	6.0	8.0	9.0	
July	8	0.0	14.0	12.0	9.0	8.0	6.0	1.0	11.0	
	21	0.0	8.0	8.0	8.0	9.0	9.0	9.0	9.0	
Aug.	2	0.0	5.0	5.0	-	-	6.0	6.0	6.0	
	16	1.6	5.0	-	-	7.0	7.0	-		
Sept.	3	0.0	0.0						0.0	
	20	0.0	0.0						0.0	
Oct.	10	0.0	0.0						0.0	
	26	0.0	0.0						0.0	
Nov.	14	0.0	0.0						0.0	
	28	0.0	0.0							
Dec.	5	0.0	0.0						0.0	
	30	0.0	0.0							
Jan.	17	0.0	0.0						0.0	
	30	0.0	0.0							
Feb.	16	0.0	0.0						0.0	
	25	0.0	0.0						0.0	

Turbidity

Lake Carl Blackwell is a turbid lake. Apparent brown color in the water is due to a suspension of colloidal clay. The turbidity increased with each runoff and decreased between rains. The 1949-1950 turbidity readings were practically uniform at all levels for the same date, but varied from time to time depending on the runoff, viz, bottom water was 40 ppm. in March 1949, 94 ppm. in May, then decreased to less than 25 ppm. in December where it remained during the rest of the study. The water maintained a dingy appearance at all times when turbidity readings were less than 25 ppm.

WATER TEMPERATURE AND DISTRIBUTION OF FISH

The temperature of the water varied during the course of the investigation from a low of 37 degrees to a high of 87 degrees Fahrenheit. However, the water was so thoroughly mixed that little or no change occurred in temperature from the surface to the maximum depth at which the nets were set (25 feet).

Certain species of fish moved into extremely shallow water in the spring before spawning occurred and subsequently withdrew into deeper water. The migrations to shallow water occurred at a time when the water temperature reached about 54 degrees Fahrenheit, and the fish retreated to deeper water or at least disappeared from the shallow water when the temperature had reached 63 degrees Fahrenheit. There are data showing a correlation between temperature and spawning dates (Poole, unpub.), but information acquired here does not indicate a correlation of fish location and temperature. A thermocline was absent at all netting stations where the fish numbers were approximately equal at all depths (Table 4). The spawning movements to and from shallow water may have been caused by ecological factors other than water temperature.

TABLE 4

Numbers of Each Species Collected, Showing the Depth in Feet and the Temperature in Degrees Fahrenheit at Which the Specimens were Captured.

Depth in Feet	Temperature in Degrees Farhenheit									
	37-42	43-47	48-52	53-57	58-62	63-67	68-72	73-77	78-82	83-87
White Crappie										
0-3		10		4				4		
3-6	30	47	23	32			22		2	1
6-9	31	61	69	25	10	23	168		96	72
9-12	39	7	63		20		24		94	46
12-15	97	88	42			5	223		213	
15-18		4					2			
18-21	85	13					35			
21-24		10								
Bluegill										
0-3										
3-6		1		3			12			
6-9		8		6	7	5	18		7	
9-12			4				17			
12-15	4	2	1		1					
15-18	2	1								
18-21	4									
Carp										
0-3								4	6	2
3-6								2	20	6
6-9			10				1		23	
9-12									17	
12-15									2	
Carp Sucker										
0-3							2	6	3	1
3-6	1							1	6	6
Black Crappie										
0-3										
3-6		1	1	1						
6-9		21	4						2	
9-12	3		1							
12-15	3	2	2						2	
15-18		9								
18-21	5									

TABLE 4 (CONTINUED)

Depth in Feet	Temperature in Degrees Farhenheit									
	37-42	43-47	48-52	53-57	58-62	63-67	68-72	73-77	78-82	83-87
					Channel Catfish					
0-3							3	1	1	1
3-6	1	10		1			1	2	2	1
6-9		1					1		2	
9-12							1		1	1
12-15				1					2	2

NETTING RETURNS

A total of 197 samples of fish were taken from the lake. A sample was the fish taken in a net or trap during one day. When possible the nets were left at one station for five days and each was lifted once a day. Then the nets were dried for two days and reset at a different station. Usually four stations were sampled per trip to the lake and the stations were visited in numerical order.

As indicated by the netting results (Table 5), white crappie were the most abundant fish in the lake, with other species ranking as follows: bluegill, carp, black crappie, channel catfish, carp sucker, largemouth black bass, green sunfish, longear sunfish, gizzard shad, drum, and yellow bullhead.

The white crappie and bluegill were well distributed throughout the lake and at all depths and temperatures. Carp and carp suckers seemed to be most active during the warmer months and were fairly abundant in water 3 to 12 feet deep. Black crappie were taken frequently in the fall and winter when the water was cool. Channel catfish were caught in comparatively equal numbers at all depths, but more particularly during spring and summer when the water was warming or warm. The rest of the species were not collected in sufficient numbers to show a time of greater movement (Table 4).

GEAR SELECTIVITY

It seems well established that each type of gear employed in the analysis of a fish population is selective (Hile, 1941). Hart (1932) stated that large fish can be taken in small-meshed gill nets, but smaller fish are seldom taken in nets of coarse mesh. Also Miller (1945) reported that hoop nets are highly selective for different species of fish. In the present study, six species

TABLE 5

The Number of Fish of Each Species Collected

White crappie	1,927
Bluegill	102
Carp	74
Black crappie	58
Channel catfish	36
Carp sucker	26
Largemouth black bass	16
Green sunfish	10
Longear sunfish	10
Gizzard shad	6
Drum	4
Yellow bullhead	3
Total	2,272

were caught in gill nets. The hoop nets captured 12 species and a wider range of fish sizes was noted. The traps were also selective. They took all sizes except the smaller specimens and captured some of 8 species. Whole year classes and certain species were not captured by any of the gear.

A comparison of the fish taken in hoop nets, gill nets, and wire traps (Table 6) shows that the hoop nets were most effective and captured 17.53 fish per set. The wire traps took 9.28 fish per set, while the gill nets caught 3.22 fish per set. The hoop nets and traps were most effective for taking white crappie and other centrarchids, while the gill nets were most effective for carp and carp suckers.

SOME ECOLOGICAL CHANGES CAUSED BY WATER FLUCTUATION

The waters of southwestern reservoirs, as evidenced by fishing success, are highly productive of fish and fish food for a short period following impoundment. Eutrophic conditions prevail from the time water fills the basin, and periods of good fish productivity usually last for 3 to 5 years, then the fish crops gradually decrease. Some lakes continue to decline until fishing returns are practically nil (Irwin, 1945).

There have been two explanations for the succession. First, lakes tend to deposit their silt loads following rains during the early part of their existence (Irwin, 1948). The clearing process is due to dissolved organic material in the water (Irwin and Stevenson, 1951). As the organic material is exhausted, the water requires longer periods to clear after each successive rain until it fails to clear and becomes permanently muddy. Second, the fish reproduce at such a rapid rate that soon the food supply is inadequate and all but a few individuals become stunted and undesirable for angling (Irwin, 1948).

TABLE 6

The Average Number of Fish Captured in Each Type of Gear, Showing the Number of Sets and Numbers of Species Captured in Each Type

Type of gear	Gill nets	Hoop nets	Wire traps
Number of sets	44	86	67
Number of species	6	12	8
Total number caught, all species	142	1508	622
Average number of fish caught per set	3.22	17.53	9.28

A similar succession has been in progress in Lake Carl Blackwell. When fishing was first permitted in the spring of 1941, 1½ tons of fish were removed the first day. Bullheads, green sunfish, bluegill, and largemouth black bass were caught in large numbers for at least two years. By 1945 there was a marked change in the species composition as reported by anglers. The catch of bullheads, sunfish, and bass had markedly decreased and the catch of crappie had increased. Changes are still taking place. Large numbers of crappie and numerous channel catfish are caught each year.

Certain changes in water level have modified or retarded the rapid decline in fish production. When first inundated the basin was covered with an excellent growth of plants. The plants, when submerged, soon decayed and the organic matter, dissolved into the water, added to the productivity of the lake. Each time the water level rose covering land for the first time, water spread over additional vegetation sometimes totalling many hundreds of acres. Several major water level changes have occurred (Table 7). The first important major rise occurred between April 9 and May 21, 1941, when the water level rose 10.5 feet. The second was a rise of 7 feet, between January 28 and April 25, 1942, which completed a total rise since April 9, 1941, of 21.9 feet, from the 918.9 to 941.7 foot level. The water at the 941.7 foot level covered at least three times as many acres of land as were covered at the 918.9 foot level.

During the summer and fall of 1942 the water level was lowered (12.9 feet) to the 928.8 foot level by December 1942. The spring rains of 1943 raised the water to the 937 foot level. It should be noted that this rise did not add vegetation to the lake because a growing period did not exist during the drawdown.

TABLE 7

The Major Water Level Fluctuations of Lake Carl Blackwell

Expressed as Feet of Elevation Above Sea Level

November 7, 1940	916.5
April 9, 1941	918.9
May 21, 1941	930.3
January 28, 1942	934.7
April 25, 1942	941.7
November 11, 1942	932.2
December 16, 1942	928.8
May 31, 1943	937.0
June 26, 1944	943.9
December 8, 1944	942.0
September 20, 1945	940.3
September 29, 1945	946.1
September 30, 1945	947.7
October 2, 1945	946.1
February 2, 1946	939.1
December 11, 1946	937.0
April 21, 1947	941.8
July 22, 1947	939.8
November 19, 1947	935.0
January 1, 1948	935.0
November 22, 1948	934.8
May 24, 1949	939.8
July 15, 1950	942.9
December 15, 1950	941.0

A third important rise occurred between May 31 and June 26, 1944, when the water rose to a level of 943.9 feet (6.9 feet). Little fluctuation occurred the next year, with the level standing at 943.3 feet on September 20, 1945. The fourth major rise occurred when heavy rains filled the lake to overflowing on September 30, 1945. On September 30, 1945, the water level stood at 947.7 feet, which was 1.6 feet above spillway level (946.1 feet). By February 2, 1946, the water level had been reduced to 939.1 feet. The drawdown was slow, allowing the water to completely remove the vegetation from the inundated area. During 1946 the water level remained almost constant, the reading being 939.1 feet on February 2, and 937.0 feet on December 11, 1946. By April 1947 the water level stood at 941.8 feet. Water was again withdrawn and from November 19, 1947, to November 22, 1948, the level stood at approximately 935.0 feet or an average of 11 feet below spillway level, during which time a new spillway was added to the dam. The water level began to rise slowly and was recorded at 939.8 feet on May 24, 1949, and 942.9 feet in July 1950 which was the highest elevation recorded since the overflow of September 30, 1945.

It seems likely that the repeated fluctuation of water level added sufficient organic matter to the lake to materially effect its fertility and turbidity. The periodic addition of fertility would produce additional fish food and tend to perpetuate fish productivity. Evidence of increased fish production is shown by the fact that during the early part of 1950 white crappie were caught in large numbers near the bridge on Oklahoma State Highway 86 which spans the lake near its western end. The lake bottom near the bridge, when exposed during the summer of 1949, had been covered with a thick growth of sunflowers and duck millet. After the winter rains raised the water level, the area not only developed into an excellent fishing spot but the water became quite clear.

Lake Carl Blackwell has continued to provide good fishing for a longer period of time than is provided by most lakes which lie in the Permian red bed soil. There were several times when increased water level added large quantities of organic matter in the form of vegetation to the water. The writer believes that this organic matter may have been a factor in prolonging the succession of good fishing.

DISCUSSION

Results obtained from this investigation to determine the distribution of fish in relation to water temperature in Lake Carl Blackwell show failure of accomplishment of objectives.

One cannot conclude that the lake was more difficult to study than other southwestern impoundments. It is actually rather typical of the area. It differs from some T.V.A. lakes in that most of the basin is shallow and that the strong prevailing winds prevent thermal stratification to any great extent. The lake is accessible and contains a large population of fish, at least the fisherman reports would lead one to so conclude. Fair fishing has been provided for a longer period than in many other Oklahoma reservoirs. The lake still provides some good strings of crappie, bass and channel catfish, although bass fishing is not as good as was reported for the first three years that fishing was permitted. With the exception of periodic crops of gizzard shad, rough fish do not seem to be abundant. The lake management personnel has given good cooperation, and the nets and traps were only infrequently molested.

The gear used to capture fish was of fairly standard type. If gill nets of a variety of sizes, both larger and smaller than 1½-inch mesh, had been used, a more diverse sample would undoubtedly have been obtained. Yet, such

an addition would probably not have increased the number of species taken or justified the additional cost. The hoop nets were of standard size as compared to those used at T.V.A. and for population studies elsewhere. The traps were effective for certain species, although less so than the hoop nets. Wire traps were an addition to the gear used by most investigators. A larger crew and more equipment would have added to total returns, but the cost would have been prohibitive in this case at least.

A consistent and conscientious effort was made to keep the equipment operating continuously and efficiently. At times severe winds or boat or motor trouble prevented operation during the time available. The lake was visited 62 separate times and 197 samples of fish were taken yielding a total of 2,272 fish. The help was paid at student wages of 65 cents per hour. Exclusive of equipment cost, a total of $2,020.00 was spent on labor and transportation which was about 89 cents per fish collected. The gill nets were the least efficient, for in 44 sets, six species and 142 fish were captured which was 3.22 fish per set. Hoop nets in 86 sets caught 12 species and 1,508 fish, or 17.53 fish per set. The traps in 67 sets caught 8 species and 622 fish, or 9.28 fish per set.

The analysis of information obtained does not permit conclusions or offer suggestions concerning a pattern of distribution of fish in Lake Carl Blackwell in association with water temperature or any other observed ecological factor. Previously black bass and crappie had been observed to enter the shallow waters at the beginning of spawning season but net and trap sets failed to show an increased catch when placed to take advantage of this known movement. Too few locations could be sampled at a time to present adequate evidence of the presence or absence of concentrations of fish in any particular part of the lake. Repeated sets in any one location failed to show an abundance or a scarcity of

fish for that location. The only information of a concentrated population in the lake was provided by fisherman reports. It is common knowledge that the area containing submerged brush and trees has a concentration of crappie. The area could not be sampled with nets and traps because of the debris. There was no consistency of catch per set of either net or trap. The gill net-take varied from 0 to 10, the hoop net-take varied from 0 to 113, and the traps from 0 to 35. The variation fitted no pattern for time of year, location in the lake, temperature or depth of water. At one lifting of the nets the catch might be excellent, and the next lifting from the same depth and location might be extremely poor, or the situation might be reversed.

An analysis of the entire investigation, including the approach to the problem, the conditions involved and the methods used, seems to point to a need for a better method of sampling a fish population. It has been shown: that Lake Carl Blackwell presents no difficulties for study that are peculiar to it alone; that the gear used was sufficiently similar to that used by other workers to warrant acceptance; and that a consistent and fairly efficient effort was expended over a year's time. However, the returns show 2,272 fish taken from about 2,600 surface acres, or less than one fish per surface acre. Actually the total area netted was not more than 170 surface acres allowing 100 yards lakeward from the set farthest from shore. From the 170 surface acres a sample of 13.36 fish per acre was captured. Since 2,364 man-hours were expended to capture 2,272 fish with nets and traps, it seems that the man-/ hours expended by anglers on Lake Carl Blackwell has been nearly as productive.

We do not know what percentage of the population we did capture either for the entire lake or for the immediate area of the net. We have no specific information regarding the relative abundance of any one species with regard to another or the entire population. We know little of the size ratio of the

members of a species. We do not know whether the fish captured were permanent residents of the area netted or if they had recently moved into the area. We do not know the fate of the 840 fish tagged since none were recaptured. Since we were unable to secure a significant sample for a definite area, it seems improbable that we would have recognized population movements (if existent) to or from areas of small temperature differences.

One must conclude that one or more of the methods used was faulty. Since (1) there is no evidence that the lake presents an impossible handicap, (2) more time and energy could not have been expended without increased finance, (3) there is evidence from creel catches that a sizable population of fish existed, the failure must have been due to the gear used to sample the fish and their movements. At present the only known method of determining a population seems to be to drain the water from the basin, screening the fish as the lake is drained. The draining method would give the population and the composition but not the movements of the fish, and would destroy the fish crop and their habitat.

It is apparent that a more efficient sampling method must be devised. The present gear captures fish of certain habits, of limited kinds and sizes, and then only when the select individuals make the error of allowing themselves to become entrapped. The initiative for fish capture must be changed from the fish to the collector. An efficient sampling method should remove all the fish at one time from a given area. Until we can collect the entire population from an area of known size unhampered by many specimens escaping or entering the sample we cannot determine the size, composition, or movement of fish populations.

SUMMARY

1. The results of an investigation to correlate depth distribution of fishes with vertical water temperatures, and to analyze the fish population, are presented.
2. Selected records of fishing success are presented as an indication that fishes were present in sizable numbers.
3. Thermal stratification was absent from all but the main body of the lake, and did not occur at any time in the area netted.
4. Netting results showed the fish to be fairly evenly distributed in depth throughout the lake.
5. Fish distribution in the lake did not seem to be restricted or increased by the slight water temperature differences found at different depths.
6. Water level fluctuation and subsequent inundation of vegetation showed evidence of having lengthened the period of fish productivity.
7. A prime factor which prevented the procurement of adequate fish samples for population analysis is attributed to the inefficiency and selectivity of the gear used.
8. An analysis of the sampling methods used is presented.
9. The need for further study in the development of adequate methods of sampling populations of fish is suggested.

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THESIS TITLE: An Analysis of the Fish Population and Its Depth Distribution as Influenced by Vertical Temperatures in Lake Carl Blackwell, Payne County, Oklahoma

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