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ACTIVITY PATTERNS AND DISTRIBUTION OF THE FISHES IN THE BUNCOMBE CREEK ARM OF LAKE TEXOMA

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ACTIVITY PATTERNS AND DISTRIBUTION OF THE FISHES

IN THE BUNCOMBE CREEK ARM OF LAKE TEXOMA

APPROVED BY

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DISSERTATION COMMITTEE

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CHAPTER I

INTRODUCTION

The Problem

The activity patterns and spatial distribution of fishes are little-known aspects of their behavior and ecology. It is the search for this basic knowledge with which this study is primarily concerned. More specifically, the purpose is to gather data on the activity patterns and distribution of the species of fish in the Buncombe Creek arm of Lake Texoma by investigating: (1) water temperatures at all depths as a possible influential factor; (2) the species present in the general fish population and, in so far as possible by the methods used, the relative abundance of each; (3) differences in seasonal and daily activity of the large species (those collected in gill nets); (4) movement patterns of the large species; (5) upstream-downstream distribution of all species (large and small), and shoreline-midchannel, in cove-out of cove, and depth distribution of the large species.

Since fish live in water direct observation of their activities is not ordinarily possible, and it is usually necessary to employ some type of fishing gear to obtain this information. Various types of diving gear, and in recent years echo-sounding equipment and underwater television, offer some promise in the study of fish behavior problems, but at present their use is limited. Gill nets have frequently been used for estimating the rate of activity of freshwater fishes. They were employed in this study along with several types of seines for collecting the small fishes.

The data were collected from June, 1953, to August, 1955. Although netting was done in all months of the year, the greatest effort was made during the spring and summer. The months of June, July and August, 1953, June and July, 1954, and February to August, 1955, were spent in residence at the lake. At other times I visited the lake at approximately 2-week intervals and set nets for a 24- to 36-hour period.

Description of the Study Area

Lake Texoma and vicinity

Lake Texoma, less commonly known as Denison Reservoir, is an impoundment of the Red and Washita Rivers in Grayson and Cooke counties, Texas, and Bryan, Johnston, Marshall and Love counties, Oklahoma (Figure 1). Its primary purpose is flood control, but it is also used for hydroelectric

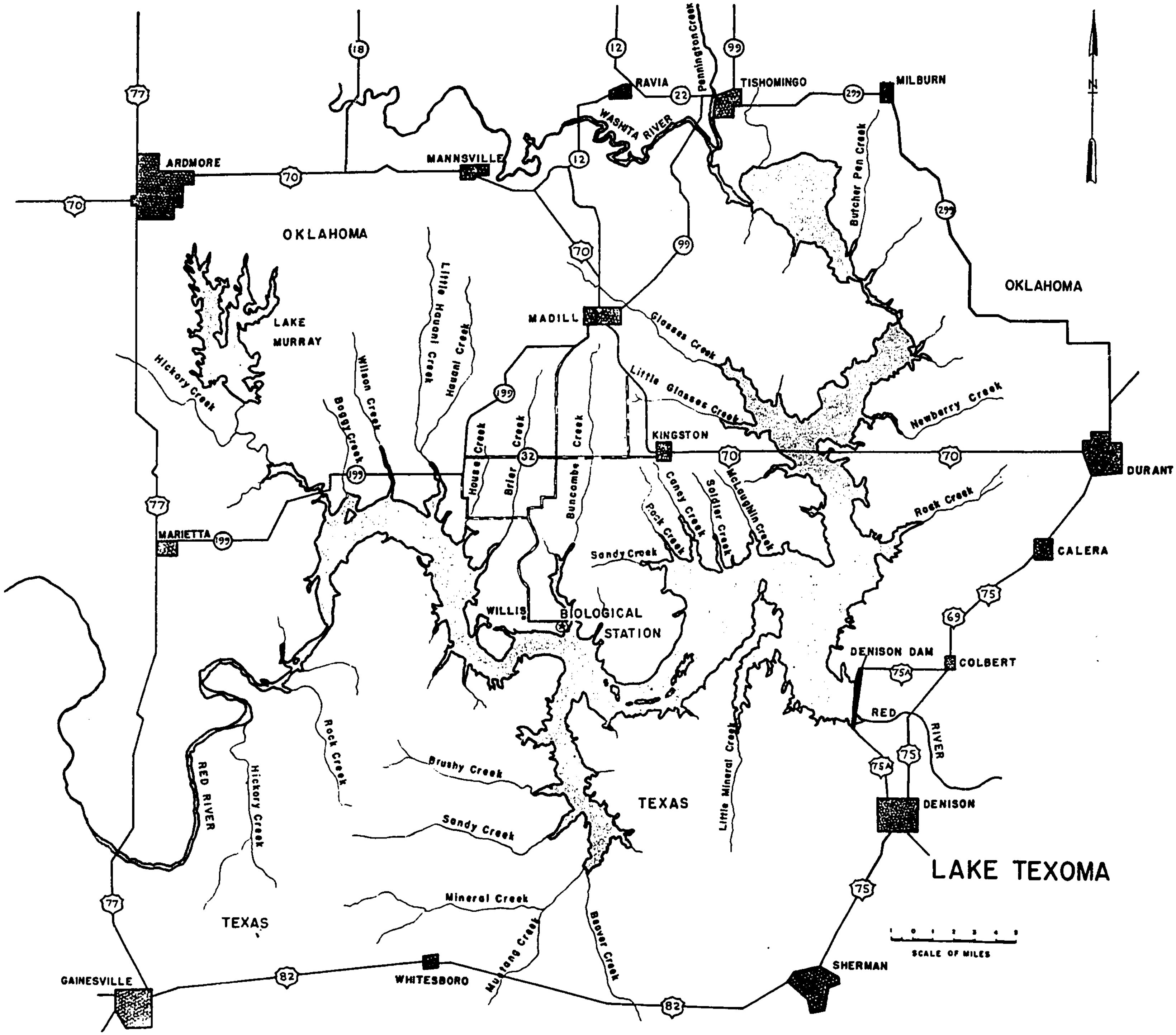

FIGURE 1. Lake Texoma and vicinity.

power production. The lake is impounded by the Denison Dam, a 15,200-foot earth-fill structure, on the Red River in Bryan County, Oklahoma, and Grayson County, Texas. The dam was essentially completed and in operation for flood control in 1944, but some impoundment had begun as early as 1942.

The lake is situated in the Gulf Coastal Plain physiographic province. Elevations in the vicinity range from about 500 feet above sea level at the base of the dam to about 850 feet in the central part of Marshall County, Oklahoma. At power pool elevation (617 feet above mean sea level) the lake has a surface area of 93,080 acres and a volume of 3,024,900 acre-feet. At this water level the length of the Red River arm of the lake is about 45 miles and that of the Washita River arm, 30 miles. The drainage area contains 38,291 square miles.

The bedrock strata of the reservoir area are chiefly of Comanchean age of the Cretaceous period. In addition, there are alluvial deposits found along the Red and Washita river valleys.

The normal rainfall for the drainage basin varies from 19.64 inches at Hereford, Texas, near the headwaters of the Red River, to 38.45 inches at Sulphur, Oklahoma, on the Washita River drainage (U.S. Army Corps of Engineers, 1950). Heaviest rainfall usually occurs in April and May. The average annual wind velocity is about 10 miles per hour, but strong winds frequently accompany storms. Since much of the lake is shallow and the morphometry is such that little protection is afforded, the wind action is usually sufficient to prevent stratification throughout most of the year.

Rapid fluctuation of the water level of Lake Texoma precludes well established beds of higher aquatic plants for more than one or two years at a time. Penfound (1953) indicated that this is generally true in flood control reservoirs, playas, and other bodies of water with considerable water level fluctuation.

The native terrestrial vegetation is characterized by post oak-winged elm on sandy soils, tall grass prairie on clay soils, and (under present conditions) a forest of mixed species along streams. Most of the typical bottom land forest of the river and creek valleys as described by Bullard (1926) was cleared prior to inundation. Tamarisk (*Tamarix gallica*), willow (*Salix nigra*), and cottonwood (*Populus sargentii*) are becoming common along the margin of many parts of the reservoir.

Considerable farming is done in the vicinity of the lake. Cotton is the staple crop though peanuts, corn, oats, Alfalfa, wheat, and sorghums are among others produced. Much of the lake's marginal land which was formerly tilled has been returned to grassland.

Except as acknowledged, the preceding data on Lake Texoma were obtained from the United States Army Corps of Engineers (1948), the United States Department of the Interior

(1943), and Bullard (1926). Additional information is available from these sources.

Buncombe Creek

Buncombe Creek is located on the north shore of the Red River arm of Lake Texoma in Marshall County, Oklahoma (Figure 1). It has a total length of approximately 11.5 air miles, and at power pool elevation (617 feet above mean sea level) the reservoir inundates the creek channel to Shay Ford (Figure 2), or about four and one-half miles upstream from the mouth. The area at this level is about 995 acres, and the creek is approximately one-half mile across at its mouth and continues at a width of one-quarter of a mile or more for three miles upstream. During much of this study, however, the reservoir portion terminated just above the small island along the west shore approximately two and one-half miles upstream from the mouth, and the width was somewhat less than described here. Under such conditions Station 13 (the portion of the narrow creek channel upstream from Station 12 which is subject to inumdation) was non-existent or represented by a few isolated pools. The location of Station 12 was subject to the greatest displacement of all the stations since it was decided to locate this station at midchannel near the upstream limits of the reservoir portion and to move it upstream or downstream with the fluctuation of the water level. The water at Station 12 would

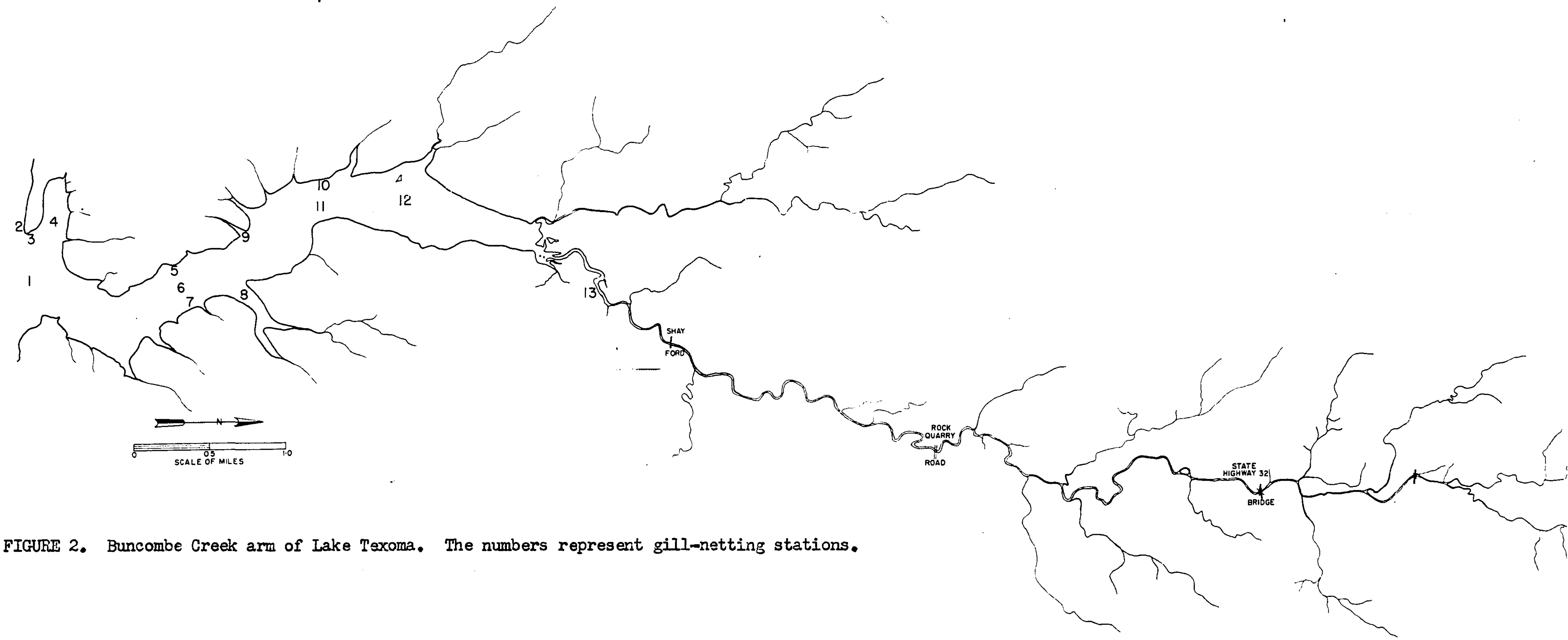

FIGURE 2. Buncombe Creek arm of Lake Texoma. The numbers represent gill-netting stations.

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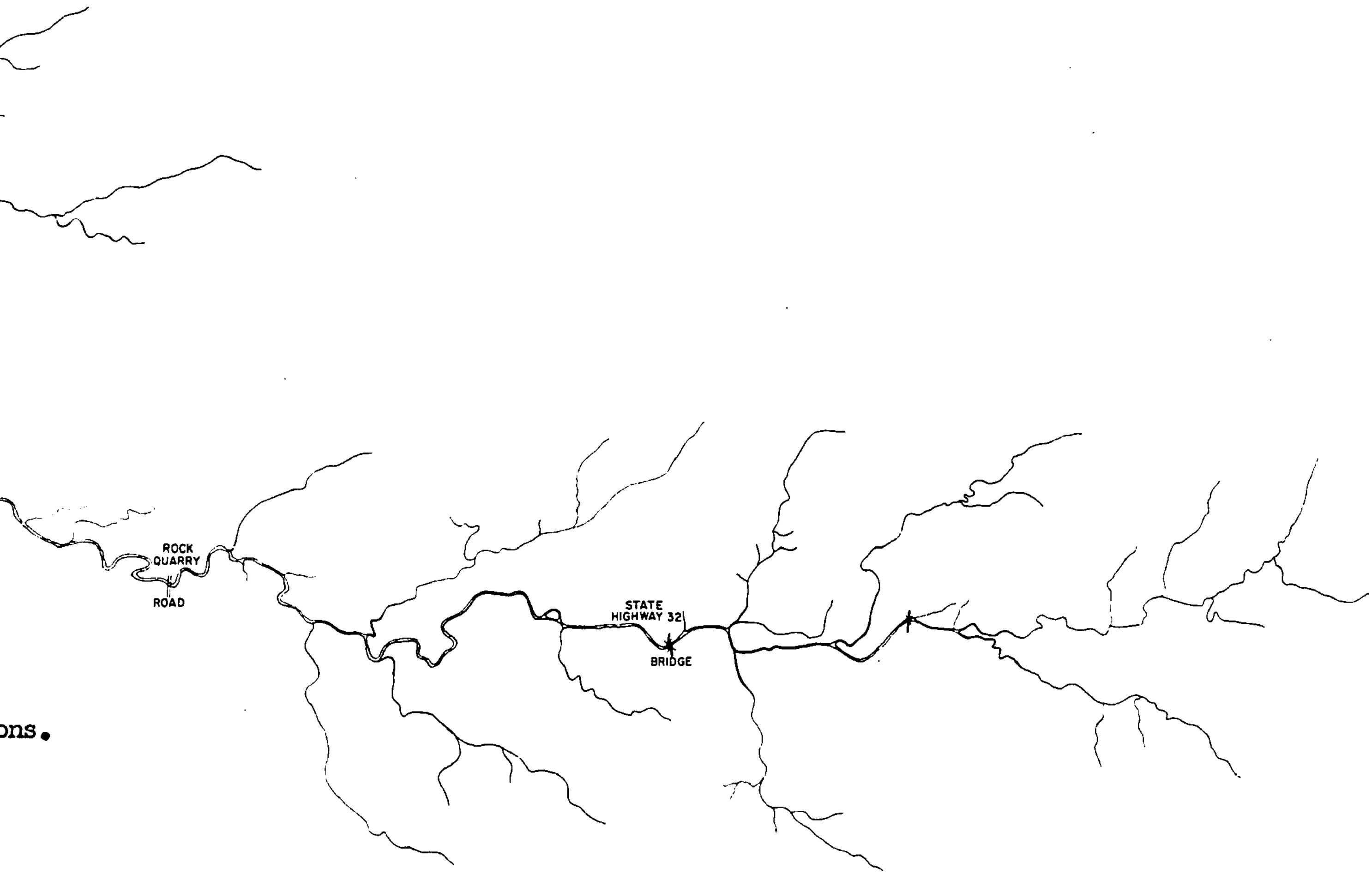


thus remain shallow (usually less than four feet) except at times of high water when Station 13 became activated. Above the region of inundation, the creek consists of a series of pools and riffles. During dry weather flow stops, leaving isolated pools, many of which dry up and leave only the deeper pools and some spring-fed pools in the upper region. The creek has no permanent pools above the State Highway 32 Bridge.

The locations, approximate depths, and bottom types, of the gill-netting stations are tabulated in Table 1. It is not possible to give accurate depths at each of the stations because the water-level fluctuated.

The bottom within the reservoir portion of the creek is characterized near the shore by sandy-loam soil with localized limestone and sandstone outcroppings; at midchannel it is predominantly silt-loam or clay (Table 1). This is in general agreement with Sublette (1955) who described the bottom along a transect just upstream from the mouth. The bottom at Station 13, located in the narrow and at times inundated portion of the old creek channel upstream from Station 12, consists of fine sand. This bottom type prevails up to Shay Ford (Figure 2). Between Shay Ford and the Rock Crusher Road there are occasional gravel bars along the otherwise sandy bottom. Above this region the sandy bottom soon gives way to gravel-rubble, and finally, in the region below the State Highway 32 Bridge, to

TABLE 1. Locations, depths, and bottom types of the gill-netting stations.

Station	Location	*Depth in feet	**Bottom type
1	Midchannel	55	Silt-loam
2	Shoreline	40	Sandy-loam
3	Shoreline	35	Sandy-loam
4	Cove	25	Fine sandy-loam
5	Shoreline	40	Fine sandy-loam; limestone outcroppings
6	Midchannel	42	Silt-loam
7	Shoreline	30	Loamy-sand; limestone outcroppings
8	Cove	25	Silt-loam; limestone outcroppings
9	Cove	22	Sandy-loam; sandstone outcroppings
10	Shoreline	12	Fine sand
11	Midchannel	22	Fine sandy-loam
12	Midchannel	15	Clay
13	Inundated creek above the bay	7	Fine sand

*The depths presented here are the approximate maximum depths encountered during the netting operations. It is not possible to give accurate depths because they varied with the lake level, and to some extent with the position of different sets made at the same station at the same lake level. The stations were represented by localities rather than by fixed positions since at any given station it was impossible to make all sets in the exact same place and position.

**Bottom type determinations were made by Dr. Elroy Rice of the University of Oklahoma Plant Science Department. The determinations were made from samples obtained with an Ekman dredge and categorized by cursory examination. They are presented here to give a general concept of the bottom types and are not intended as an accurate account.

gravel-rubble-boulder and some limestone bedrock. The region above the bridge continues with this type of bottom for a mile and a half or more before terminating farther upstream on the prairie in narrow tributaries of predominantly silt bottom. There is, of course, a certain amount of silt deposited as a thin layer throughout the course of the stream.

The vegetation and stratigraphy of Buncombe Creek are essentially as described for the general description of the lake.

Though turbidity readings were not made, it was observed that the water varied from a condition of very turbid, following heavy rains, to one of sufficient clearness that a white, one-quart can was visible to a maximum depth of four or five feet. Since the creek is located on the north shore of the lake, it is subjected to the strong prevailing south winds which blow during much of the year. Waves which I have conservatively estimated at six feet from trough to crest may occur at the mouth of the bay during such winds. The course of the creek is such that some protection is provided the upper part of the reservoir portion from southerly winds, and the narrow creek channel upstream is protected at all times.

CHAPTER II

PROCEDURE OF RESEARCH

Physical and Chemical Data

Water temperatures were obtained with a Foxboro electrical resistance thermometer. Readings were ordinarily recorded during the afternoon, the time varying with the daily work schedule and the season of the year. Since the water temperature was found to be relatively uniform from top to bottom on any given day, a few hours difference in recording the temperature only resulted in slight differences in the surface readings. The data were recorded at Stations 1 and 6, the two deep-water stations, except for three occasions when the temperatures were compared at all the stations. Air temperature and barometric pressure data were obtained from the U. S. Army Corps of Engineers at the Denison Dam. Chemical data were analyzed according to the methods described by Welch (1948).

Gill-netting Operations

Location of stations

Thirteen netting stations extending from the deep water at the mouth to the shallow water at the upper end of the bay were established to sample the fish population from shoreline, midchannel, and cove areas (Figure 2). Wide fluctuations of the water level made it necessary to represent the stations by localities rather than by fixed positions. These stations were chosen to represent the general habitat types within the bay.

Collecting procedure

The fishes were collected with gill nets, supplemented by seining for the small fishes. The limitations of gill nets for studying fish populations have been mentioned by Cady (1945), Moyle, et al., (1948), Moyle (1950), Patriarche (1953), Carlander (1953), and others. There seems to be general agreement that gill nets are selective of species and size, but valuable information can be obtained if enough samples are taken and it is realized that the data may not give a true indication of the abundance.

Most of the netting was done with experimental linen gill nets, 125 feet long and 6 feet deep, consisting of five 25-foot lengths of 3/4, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, and 2-inch bar mesh, and with 3-inch bar mesh nylon gill nets 200 feet long and $9\frac{1}{2}$ feet deep. Two other linen gill nets, 200 feet long and 8 feet deep, were used occasionally; one was of $1\frac{1}{2}$-inch and the other of 2-inch bar mesh. Evidence presented by Hewson (1951) and Peterson (1952) indicates that nylon nets are more efficient than either cotton or linen nets of comparable mesh size.

The 3-inch nylon net required the attachment of floats even when set in shallow water, for it included neither a cork line nor a lead line. The efficiency of this type of net (called a flag net by local commercial fishermen) is subject to controversy. It is certainly less efficient than a net with a float line and lead line if set near the surface in turbulent water, for it has a tendency to roll into a "rope", or the bottom of the net may drift with the waves. However, when not subjected to turbulence, there is reason to believe that it may be more efficient than ordinary nets. Since it has no lead line, fish hitting the net tend to be pulled upward in their forward drive. The result is that they usually loop over the main line along the top one to many times and become thoroughly entangled.

The combined total number of sets for all nets was 298 (Table 2). The most sets (44) were made at Station 12 and the least (7) at Station 13. An effort was made to keep the size of the daily collections small enough so that adequate data could be recorded from each collection. If too many fish were collected at one time, death and decomposition of the fish and lack of sufficient time prevented the complete collection of data. For this reason, not more than two nets were ordinarily fished simultaneously, and one of these was usually a 3-inch mesh nylon net. The catch of a 3-inch mesh net was always small. By setting it in

TABLE 2. Number of sets at each netting station with each type of gill net.

	Stations														
Type of net	1	2	3	4	5	6	7	8	9	10	11	12	13	Misc.	Total
3-inch nylon	6	5	7	9	9	13	15	9	6	4	17	15	1	7	123
2-inch linen	2	0	5	0	0	0	1	1	0	7	0	5	0	1	22
1½-inch linen	8	1	3	2	0	0	0	2	3	1	0	3	4	0	27
Experimental linen	12	12	10	5	9	11	9	13	5	7	4	21	2	6	126
Total	28	18	25	16	18	24	25	25	14	19	21	44	7	14	298

combination with a net of smaller mesh, a larger size distribution could be taken, and there was not as much risk of collecting more fish than could be processed. It was especially necessary to process the fish rapidly during warm weather before bloating occurred.

A total of 6,873.50 gill-net hours was fished with all nets (Table 3). (Here and hereafter a gill-net hour refers to one hour of fishing with a net regardless of type.) The most fishing was done in July and the least in September. The most hours were fished with 3-inch mesh nylon nets for the reason given above, and because they took more effort than nets of smaller mesh size to catch a sufficient number of large fish in order to learn something of their distribution. In computing the gill-net hours for each month, hours fished during the night on the last day of one month and the first day of the following month were credited to the first day of the later month since the lift was made on the morning of this day. The time involved in setting, lifting, or removing a net was not considered as fishing time.

The duration of each set was usually 24 to 36 hours, although sets of shorter and longer duration were frequently made. Lifts were made twice daily, usually soon after sunrise and just prior to sunset. Longer intervals between lifts would have resulted in a greater mortality of fish in the nets, particularly during the summer months. Van Oosten (1936) and Kennedy (1951) have shown that the size of the

TABLE 3. Numbers of hours of fishing each month with each type of gill net at each netting station.

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
2-inch nylon net													
1			68.25		18.25		78.75						165.25
2			46.00			46.50	22.75						115.25
3		46.50		46.75				58.50			43.00		194.75
4	37.75			60.25		49.00	70.25				16.75	23.75	257.75
5		47.00	72.25	69.75		46.25							235.25
6		120.25					164.25		23.00		75.50		383.00
7	39.00		79.25		46.75	46.50	60.25	45.50		41.75			359.00
8		23.75		23.00	35.50	23.00		36.75			37.75		179.75
9	23.50		61.50		23.50	46.50							155.00
10			22.50	46.25	46.50					36.75			152.00
11		37.00		58.00		47.00		135.50	25.50	21.50			324.50
12	40.25	51.75	13.25			22.75	100.25				38.00		266.25
13							22.00						22.00
Misc.						45.75				22.00	73.00	75.00	215.75
Total	140.50	326.25	363.00	304.00	170.50	373.25	518.50	276.25	48.50	122.00	284.00	98.75	3025.50
2-inch linen net													
Station													Total
1			38.25										38.25
2													
3	39.00	22.50		56.75			23.00						141.25
4													
5													
6													
7											39.25		39.25
8	22.75	23.75											46.50
9													
10		14.25	37.75	35.25					26.50	71.50		38.50	223.75
11													
12	22.00			35.00							74.50		131.50
13													
Misc.						27.50							27.50
Total	83.75	60.50	76.00	127.00		27.50	23.00		26.50	71.50	113.75	38.50	648.00
...en net													
Station													Total
1					18.25	51.50	81.00	22.50					173.25
2					12.75								12.75
3						44.25	22.50						66.75
4						23.50	23.00						46.50
5													
6													

1½-inch linen net	Station													Total
	1					18.25	51.50	81.00	22.50					173.25
	2					12.75								12.75
	3						44.25	22.50						66.75
	4						23.50	23.00						46.50
	5													
	6													
	7													
	8					23.75		11.00						34.75
	9					35.00			46.75					81.75
	10						22.25							22.25
	11													
	12						23.00	45.25						68.25
	13					56.75	23.00							79.75
	Misc.													
	Total					146.50	187.50	182.75	69.25					586.00
Experimental net	Station													Total
	1		69.75	70.75		93.00		69.75						303.25
	2		37.00	44.25	91.75		46.00	45.50						264.50
	3		24.00		46.00	45.00	45.50	45.75		21.75				228.00
	4			22.75	46.75			46.25						115.75
	5			94.50				69.00					47.50	211.00
	6			69.75	71.00			67.75				44.75		253.25
	7		45.75		92.00		45.75					22.50		206.00
	8			69.25			46.75	24.00				23.50		163.50
	9		24.00	22.25			22.75	23.00			23.00			115.00
	10		44.50		14.00	47.00	46.25				22.50			174.25
	11		46.75		23.50						22.50			92.75
	12	21.75	46.00	8.50	81.75	21.75	47.75	51.25			43.75			322.50
	13					28.25		23.50						51.75
	Misc.					67.25			45.25					112.50
	Total	21.75	337.75	402.00	466.75	302.25	300.75	465.75	45.25	21.75	111.75	90.75	47.50	2614.00
Total, all nets		246.00 *(4)	724.50 (11)	841.00 (12)	897.75 (13)	619.25 (9)	889.00 (13)	1190.00 (17)	390.75 (6)	96.75 (1)	305.25 (4)	488.50 (7)	184.75 (3)	6873.50
Per cent														
	3-inch	57	45	43	34	27	42	44	70	50	40	58	53	44
	2-inch	34	8	9	14		3	2		27	23	23	21	9
	1½-inch					24	21	15	18					9
	Exper.	9	47	48	52	49	34	39	12	23	37	19	26	38

*Indicates figure above expressed in per cent of the total hours fished with all nets during all months (6873.50 hours).

catch does not increase in direct proportion to the length of time between lifts.

All sets were perpendicular to the shoreline. When shoreline sets were made with experimental gill nets, the 3/4-inch mesh was placed nearest the shore.

In depth distribution studies it has been common practice to employ bottom sets. This method was used almost exclusively by Dendy (1945, 1946), Cady (1945), Haslbauer (1945), Bryan and Howell (1946), Hile and Juday (1941), Odell (1932), and Borges (1950). In effect, these studies measured the fish population within six or eight feet immediately above the bottom. Using this method, fish which occur near the surface or more than eight feet above the bottom where the water exceeds this depth are not sampled and therefore not considered. In this study the nets were set at various depths, including bottom sets, by suspending them at the depth desired (Figure 3). Quart oil cans were used as additional floats. For experimental gill nets, six floats were added--one at each end of the net and four at the junctions of the various mesh sizes. For the other nets used, nine floats were added and spaced equidistantly along the length of the net. A heavy anchor was fastened to each end of all nets with sufficient cord attached to permit the net to be lifted to the surface for removal of the catch (Figure 3). By suspending the nets, as in this study, an attempt is made to show the depth distribution of fish at

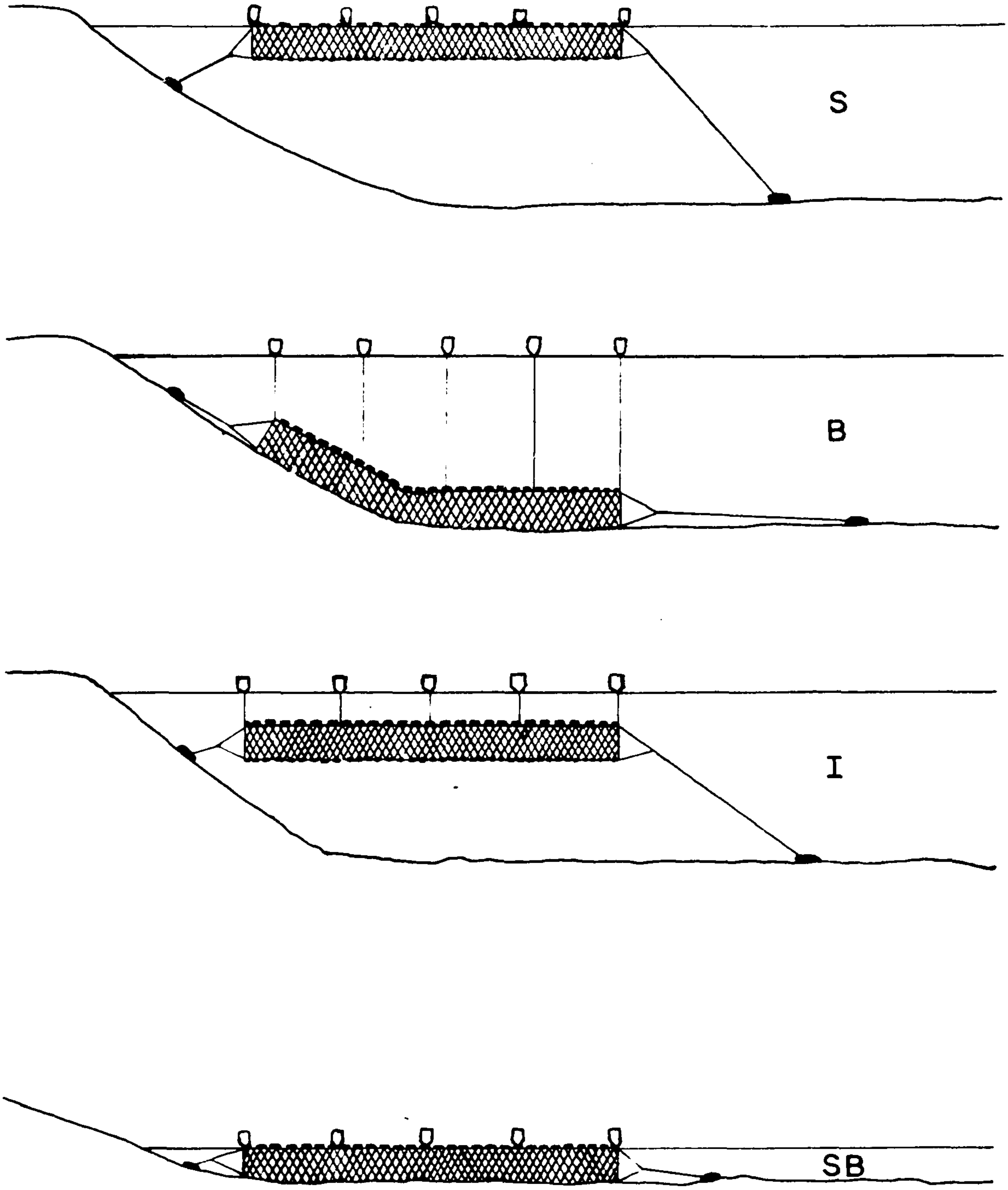


FIGURE 3. Types of gill-net sets. S = surface; B = bottom; I = intermediate; SB = surface to bottom.

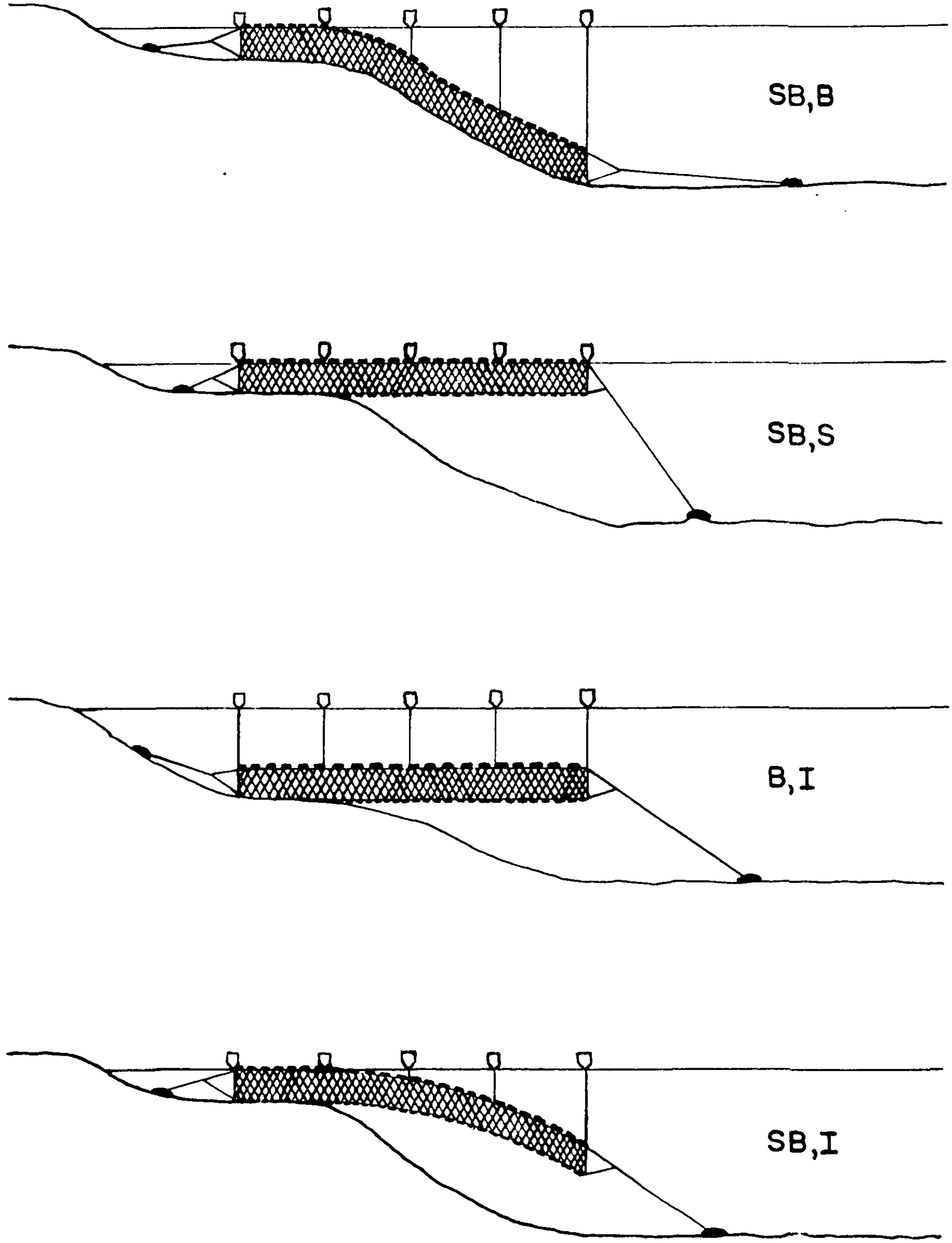


FIGURE 3 - continued. SB,B = surface to bottom-bottom; SB,S = surface to bottom-surface; B,I = bottom-intermediate; SB,I = surface to bottom-intermediate.

all depths between the surface and the bottom in water of different depths. However, because this requires additional sets at deep-water stations, it is not possible to duplicate a particular set as frequently as is possible when nets are set at only one depth.

Because the nets were alternated among the stations, and the depths at the stations varied with the fluctuation of the water level or a slight difference in the location of the set, it was necessary to take depth readings each time a net was set. For experimental nets, depths were recorded at each end and at the junctions of the various mesh sizes for a total of six readings. Other nets were divided into four equal sections and five readings taken--one at each end and three at equidistant points along the net. The number of gill-net sets at different depth intervals are tabulated in Table 4.

A code was developed, using 2-inch colored corsage pins inserted at key positions on the fish, which provided a field record for each fish (Figure 4). Depth in the net (recorded as top, middle, or bottom one-third), direction of travel, and the section of the net or mesh size in which the fish was captured were indicated by the color and position of the pins. When more than one net was lifted the catch of each net was kept in a separate tub. These data were permanently recorded later in the laboratory.

After being set for not more than 72 hours, the

TABLE 4. *Number of gill-net sets at different depth intervals, January, 1954 to Au

Total depth in feet	Depth intervals in feet	Jan 3	Jan 2	Jan Ex**	Feb 3	Feb 2	Feb Ex	Mar 3	Mar 2	Mar Ex	Apr 3	Apr 2	Apr Ex	May 3	May 1½	May Ex
0-10																
	0-5	3	3	1	4	4	14	5	1	6	4	7	15	3	8	5
	6-10	2	2		1	3	5	5	1	3	4	4	10	3	5	2
11-20																
	0-10	4	1		2	2	7	7	1	6	6	2	13	3	1	4
	11-20				2	1	2	4		2	4	1	6	2	1	1
21-30																
	0-10		1		2			2		4	2		3	1		1
	11-20				2	1	2	3		4	5		3	2	1	2
	21-30				2	1	1	2		4	1		3		1	
31-40																
	0-10				1		1		1	1						1
	11-20						1	1		1						
	21-30				1		1	2	1	1						1
	31-40						1	1	1	1						1
Over 40																
	0-10									1				1	1	1
	11-20							1		1						
	21-30							1								1
	31-40							1		1						1

*Though some sets occurred entirely within one depth interval, they often extended t should be interpreted as the number of times which at least some of a net occurred w occur within an interval if the interval contained one-third or more of the net's de all other type nets. Since the fish were recorded as caught in the top, middle, or these thirds would be recorded for any depth interval credited with a set.

**Ex indicates an experimental net, 3 indicates a net with 3-inch mesh, etc.

to August, 1955.

y		June				July				Aug		Sept	Oct		Nov		Dec	
½	Ex	3	2	1½	Ex	3	2	1½	Ex	3	1½	Ex	3	Ex	3	Ex	3	Ex
	5	1		7		2	1	3	8				2	5	2	2	1	2
	2	1		4		1	1	2	4				2		2	2	1	
	4	10		3	8	6	1	3	4	2	2	1	2	3	2	2	1	2
	1	10		3	4	4	1	3	3	2	1		1	1	2	2		1
	1	6	1	1	5	3			1	1		1			1	1		1
	2	10		1	4	3		1	3	2					2	1		1
		5			4	2		1	2	1					1			1
	1	3	1			3			2									
		3				3			2									
	1	3				2												
	1	1				2			2									
	1	1				3		2	2		1							
		1				3		2	1									
	1	1		1		2												
	1			1		3			1									

ıded through two or more. Therefore, the number of sets designated for each depth interval
rred within the interval rather than as sets of an entire net. A net was considered to
t's depth for one-fifth of the length of experimental nets and one-fourth the length of
e, or bottom one-third of a net, this would assure that the catch from at least one of

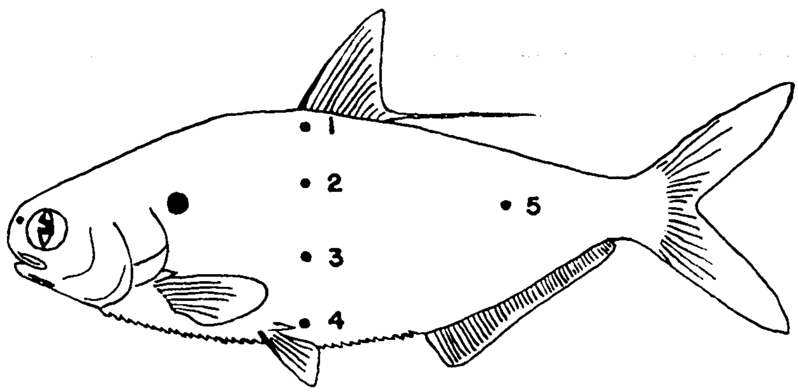


FIGURE 4. Field method of recording the gill-netting data pertaining to each fish. Key positions, shown by numbers on the above sketch, were used to designate the section of the net in which captured. When using experimental nets, which consisted of five sections of different mesh size, the smallest mesh (3/4-inch) was always designated section one, 1-inch mesh section two, etc. Thus, the same positions used for designating the sections were used to record mesh size. A two-inch colored pin was inserted at one of the key positions. Fish collected in the top, middle, and bottom one-thirds of the net were pinned with white, green, and red pins, respectively. If the fish were traveling upstream, the pin was inserted on the right side and if downstream on the left side. For example, a green pin inserted on the left side at position 3 would be used to designate a fish caught in the middle one-third of the net, traveling downstream, in the third section of the net (or, if experimental net, in the $1\frac{1}{4}$-inch mesh). (Redrawn from a drawing of Carl D. Riggs.)

nets were brought in, placed on a reel, rinsed, and dried. Necessary repairs were made before resetting. The gill-netting data on which this study is based were derived from nets which were in good to excellent condition at all times.

Laboratory procedure

The following information from each fish was recorded in the laboratory whenever possible: total— and standard-length, weight, sex, station where captured, depth in net, direction of travel, and section of net in which it was caught. A scale sample, or a spine from the dorsal fin on catfish, was removed from each fish except some of the more abundant species late in the study, and saved in a standard scale envelope. Beginning with February, 1955, and continuing through the spawning season, notes were taken on the gonad condition for each species. Occasional notes were taken on deformities and parasitism. Much of these data are not included in this study.

The depth distribution of each species was computed in the following manner. Assume a fish is caught in the bottom one-third of a net six feet in depth fishing five feet below the surface. The depths at the ends of the section of the net in which the fish is caught are 20 and 24 feet. Since the fish is caught in the bottom two feet of the net, an assumption that it was in the middle would place it at one foot above the bottom of the net, five feet below the top of the net and 10 feet below the surface of the water. In this case, a depth of 22 feet is obtained as an average total depth of the water. This fish would then be assigned the fraction 10/22, meaning that it was caught 10 feet below the surface in water that was 22 feet deep. By assigning such fractions to each fish of a given species, the depth distribution of that species could be determined.

Using this method, no fish would normally be assigned a fraction indicating a depth less than one foot above the bottom since an average depth within the net is assumed for all fish caught in the bottom one-third of the net. However, fish were sometimes credited to the maximum depth of the water for reasons which follow. When a net was set in shallow water the bottom part often lay on the bottom. This was necessary either because the water's depth was less than that of the net, or because it was necessary to set the net approximately three feet below the surface in order to allow clearance for outboard motors. Fish were frequently caught in the extreme bottom part of such sets. Apparently those caught in this way were either rooting around on the bottom and became entangled, or, as has been observed, wave action caused the net to bow out in the middle and permitted the entire depth of the net to fish.

Small-fish Collections

Collecting procedure

The small-fish collections were made almost entirely with seines. An electric shocker, which was not functioning properly, was used on one occasion with poor results. A few collections, consisting chiefly of young gars, were made using a small fry seine in dip-net fashion. In addition, a very small flathead catfish and channel catfish were collected from a can that had been suspended beneath the boathouse.

The seines included a linen bag seine (25 feet long and 6 feet deep with an 8-foot bag and ¼-inch bar mesh), common sense minnow seines (1/8-inch bar mesh), and small fry seines made of plastic screen wire having 16 meshes per inch. The bag seine was used only along the open shoreline of the lake. The fry seines were particularly useful for collecting in the isolated pools and riffles upstream. Many of the upstream collections were made entirely with these seines. The common sense seines were used in both the upstream and downstream areas.

The fish were preserved at the time of collection in a solution of ten per cent formalin. The first few seine hauls of each collection were preserved in their entirety. Thereafter, an effort was made to preserve samples of each species from each seine haul in proportion to its relative abundance and to save all of any newly represented or doubtful species.

Collecting areas

The collections were made from numerous sites extending from the mouth to the extreme upper end of the creek. For the purpose of discussing the small-fish collections, the creek has been divided into five areas as follows: Area 1--the lake region of Buncombe Creek extending up to the narrow creek channel approximately three and three-fourths miles from the mouth; Area 2--from the termination of Area 1 to Shay Ford; Area 3--from Shay Ford to approximately one mile above the Rock Quarry Road; Area 4--from the termination of Area 3 to the State Highway 32 Bridge; Area 5--the region above State Highway 32 Bridge. At the time this study was conducted the foundation of the State Highway 32 Bridge was several feet higher than the pool immediately downstream and thus formed a barrier to upstream movement into Area 5 except at times of high water.

Frequency of collections

At least one collection was made in all months except December (Table 5). Areas 1 and 2 were worked most thoroughly; collections were made from both in nine different months. Fewer months were represented by the collections from Areas 3 and 4, but these collections represented the different seasons of the year. Area 5 was dry during much

TABLE 5. Months in which small-fish collections were made from each area. Each "X" represents one or more collections.

Months	Area 1	Area 2	Area 3	Area 4	Area 5
January		X			
February	X			X	
March	X	X	X		
April	X	X		X	
May	X	X	X	X	X
June	X	X	X	X	X
July	X	X	X	X	X
August	X	X			X
September		X			
October	X	X	X	X	
November	X				

of the year. Spring rains usually filled the pools of this region and restored the flow of the creek. This afforded the fish an opportunity to move into Area 5 from downstream or from the overflow of farm ponds in the vicinity.

CHAPTER III

PHYSICAL AND CHEMICAL DATA

Air Temperatures and Barometric Pressures

In general, there was an inverse relationship between air temperatures and barometric pressures during the period when the study was conducted (Figure 5).

The lowest average weekly air temperature was in January for both 1954 (40.8°F) and 1955 (45.7°F). The highest was in June in 1953 (104.6°F), in July in 1954 (105.2°F), and in July in 1955 (99.8°F). The summer of 1954 was exceptionally hot. The air temperature exceeded 90.0°F on all but seven days during June and July, and there were 20 consecutive days in July in excess of 100.0°F. There was very little wind during this period which probably provided the best conditions for thermal stratification to which the lake has been subjected.

The lowest average weekly barometric pressure occurred the last week in April, 1955, and the highest the second week of November, 1953. Though the barometric pressures were subject to wide fluctuations, they were usually highest in winter and lowest in summer.

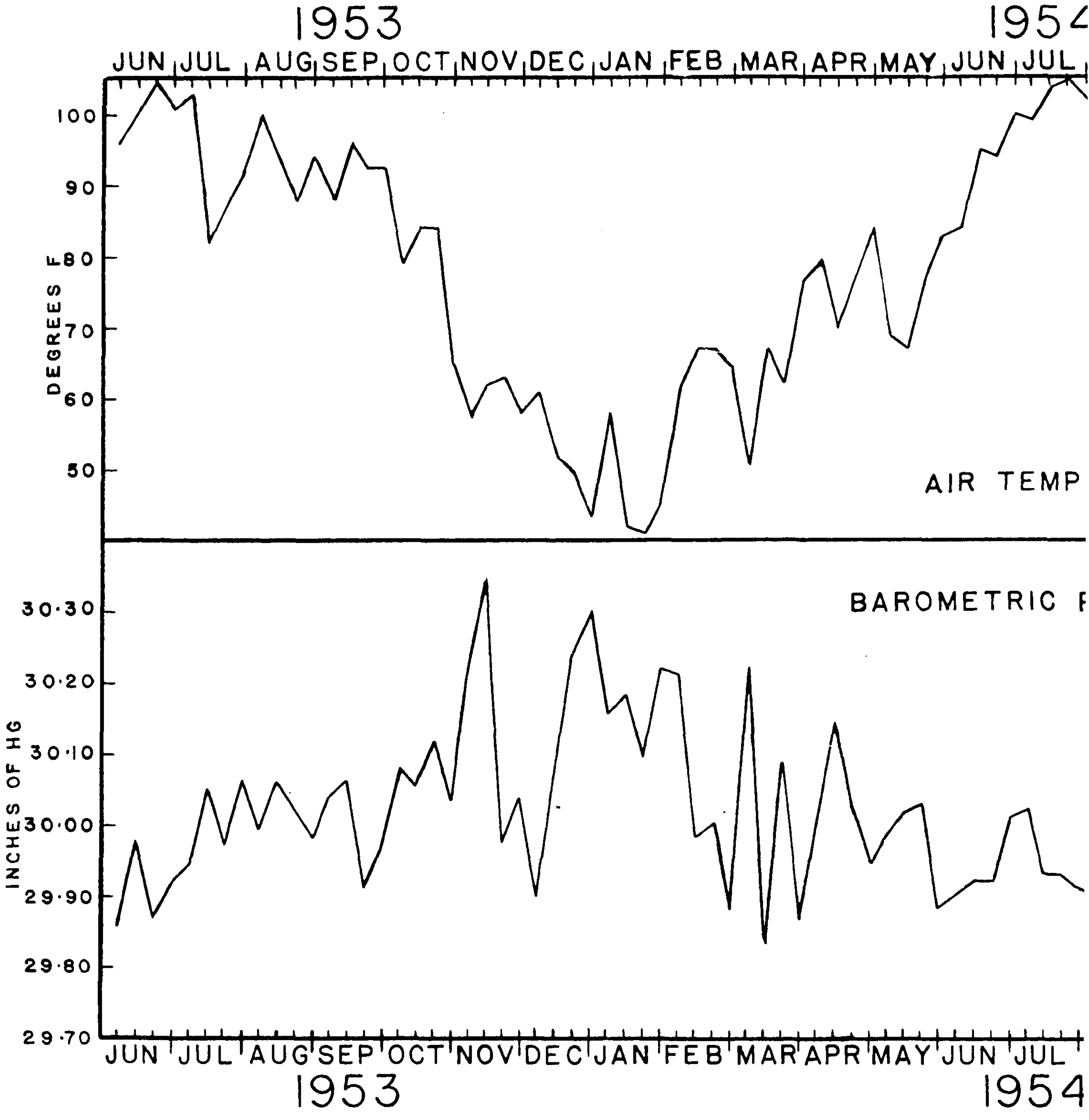
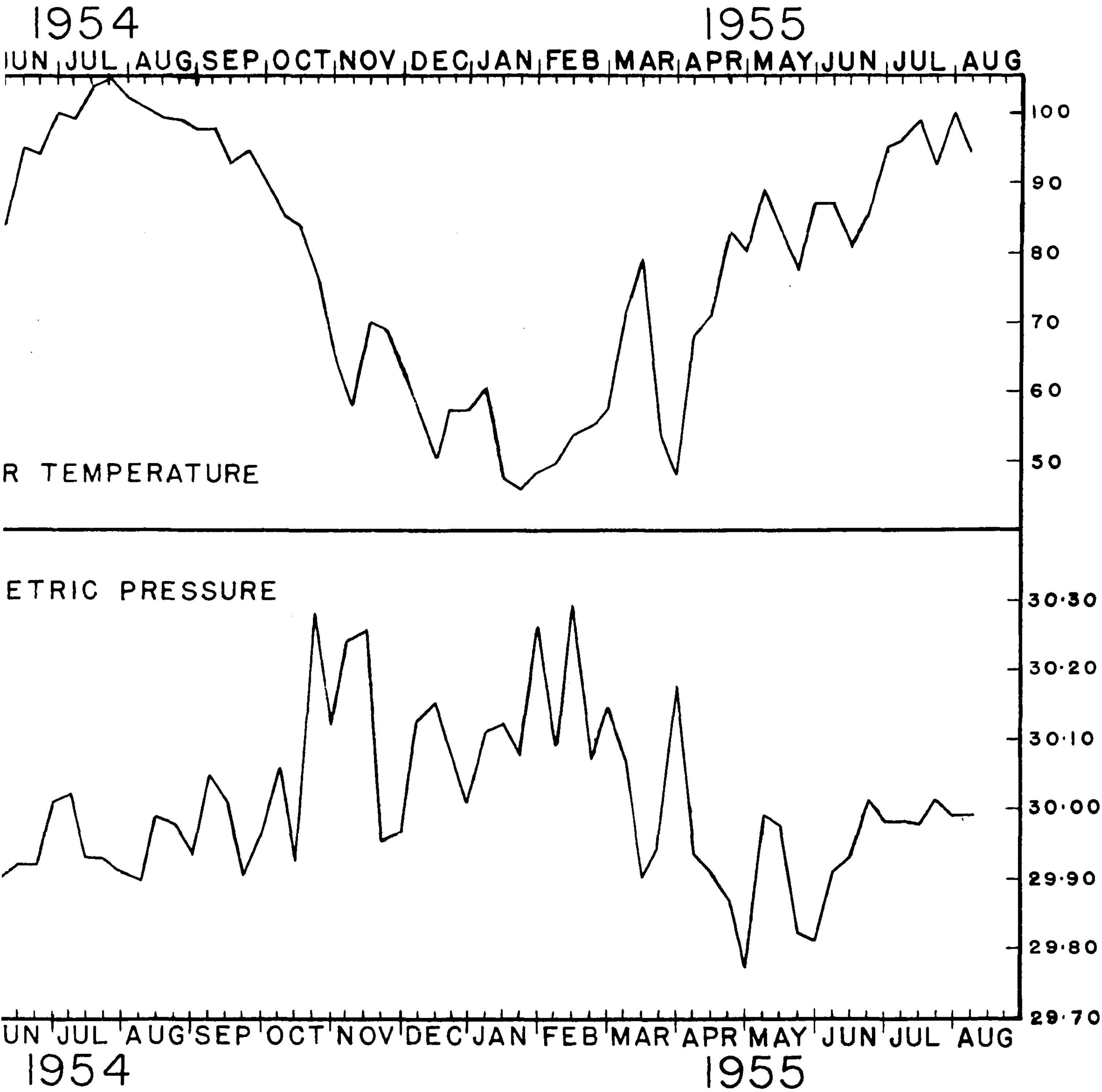


FIGURE 5. Average weekly air temperatures and barometric pressures. Data were prov
at the Denison Dam.



a were provided by the U. S. Army Corps of Engineers and were recorded daily at 4:00 P.M.

The effects of meteorological conditions (particularly barometric pressure) on the activity of fish have long been a controversial issue and still remain unsolved. Many fishermen associate rising barometric pressures with good fishing and falling barometric pressures with poor fishing which therefore could presumably be associated with periods of greater and lesser activity. Although many fishermen are convinced of this adage, it has not been conclusively demonstrated.

The average weekly air temperatures and barometric pressures during the course of the study are presented in Figure 5. When their averages were considered on a monthly basis and compared with the catch per gill-net hour in experimental gill nets for corresponding months, no consistent correlations were revealed. It is acknowledged that such long-range data are not well suited for this type of study and could only reveal broad trends. However, Sieh and Parsons (1950) conducted a study in which the nets were usually lifted at 2-hour intervals and reported no correlation could be detected between the periods of activity of the fish and barometric changes, wind, sky cover, or solunar periods.

Water Level Fluctuations

The water level of Lake Texoma was low during most of the period in which data for this study were gathered

(Figure 6). During 15 of the 26 months the water level was less than 610 feet (all elevations given in feet above mean sea level). Power pool elevation (617 feet) was reached only in May and June, 1954, and May, June, and July, 1955. Elevations varied from a low of 602.23 on October 25, 1953, to a high of 618.79 on May 16, 1954, a fluctuation of 16.56 feet.

The effects of wide fluctuations of the water level on fish populations are not well understood. Certainly the effects are not the same at different times of the year. A rapid fall in water level during the spawning season could result in a poor year-class for a species. Bennett (1954) believes that the practice of drawdown merits further study as a management tool. He found that a drawdown in the fall resulted in a good spawn of largemouth bass the following spring, and in the year following the drawdown more black bass were taken than during any previous year. It was found to have little effect on the survival of young-of-year bass or on bass in general but reduced the number of bluegills.

No attempt has been made to control the water level of Lake Texoma for fishery management purposes. However, the lake is usually at its peak in late spring and early summer, and there is generally a downward trend until the next spring. Numerous plants are inundated with the rise each spring and provide excellent spawning conditions for many species, if the rise comes early enough.

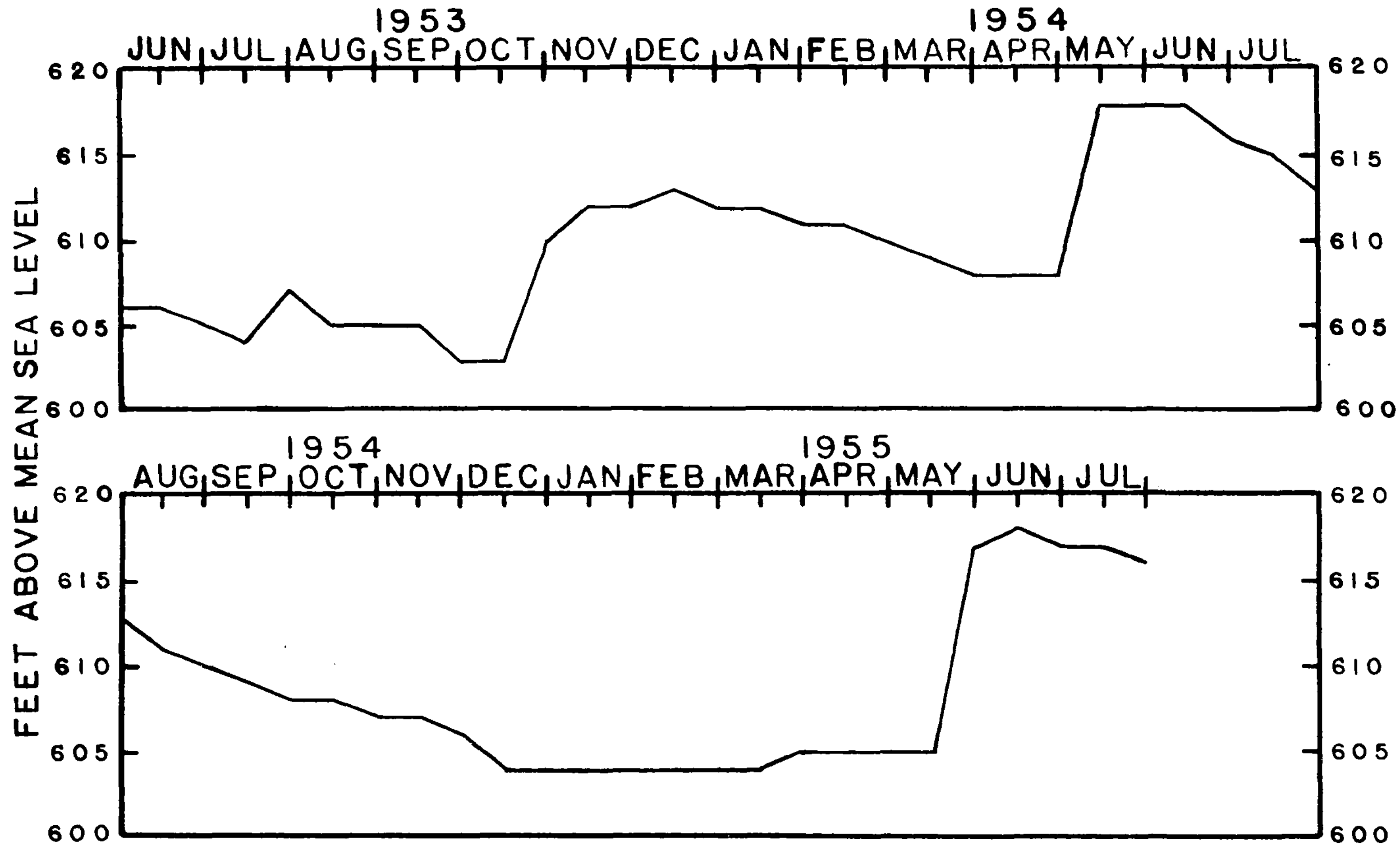


FIGURE 6. Water levels of Lake Texoma (feet above mean sea level) from June 1, 1953, to August 1, 1955. Data were provided by the U. S. Army Corps of Engineers at the Denison Dam and were recorded at 4:00 P.M. on the first and fifteenth of each month.

Monthly Water Temperatures

Monthly water temperature data at all depths, recorded at stations 1 and 6 from September, 1953, through July, 1955, are presented in Figure 7. The temperature profiles of January, February, October, November, and December show that during these months the temperature was virtually the same from top to bottom. At times in March and April the temperature was quite uniform from top to bottom while at other times, when there was less turbulence, there was a temporary thermocline at the surface as the result of rapid heating of the surface water. Thermoclines were usually present during the months of May, June, and July. Whether they were able to persist was dependent upon the extent of wave action. Thus, a thermocline occurred in May, 1955, but was not present on June 7, and June 19.

The effect of a windstorm on a thermocline in Buncombe Creek is well exemplified by data taken prior to and following a severe windstorm on the evening of July 31, 1954. The summer of 1954 was very hot (Figure 5), and the lake's surface was smooth much of the time. A thermocline had persisted from the middle of May through June and on July 23, was located at depths extending from 27 to 33 feet. On this date the surface temperature was 88.5°F and the bottom temperature at 33 feet was 80.5°F. On the morning of August 1, 1954, following the windstorm, the temperature was 84.0°F at the surface and 84.5°F at the bottom. No other thermoclines

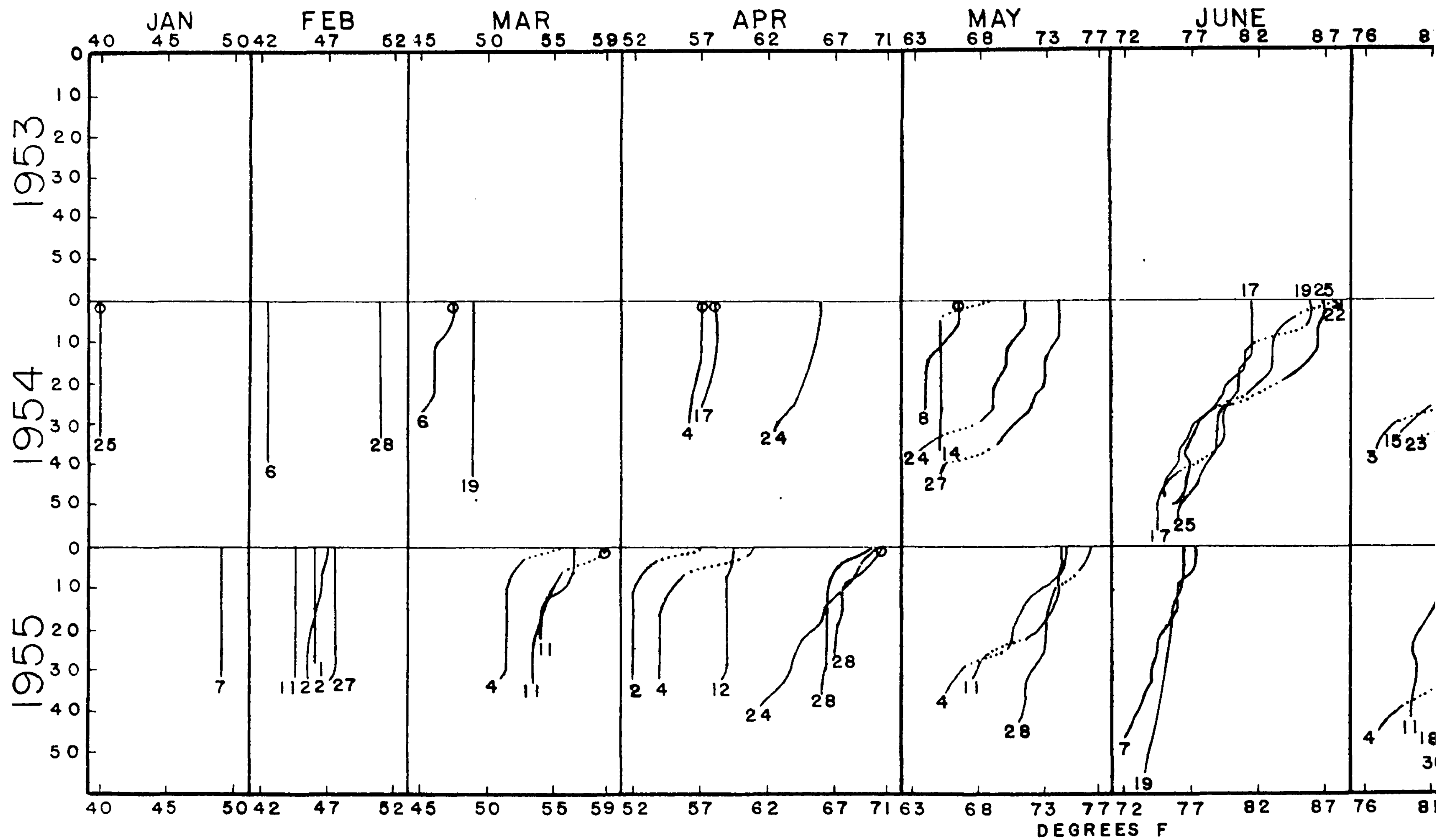
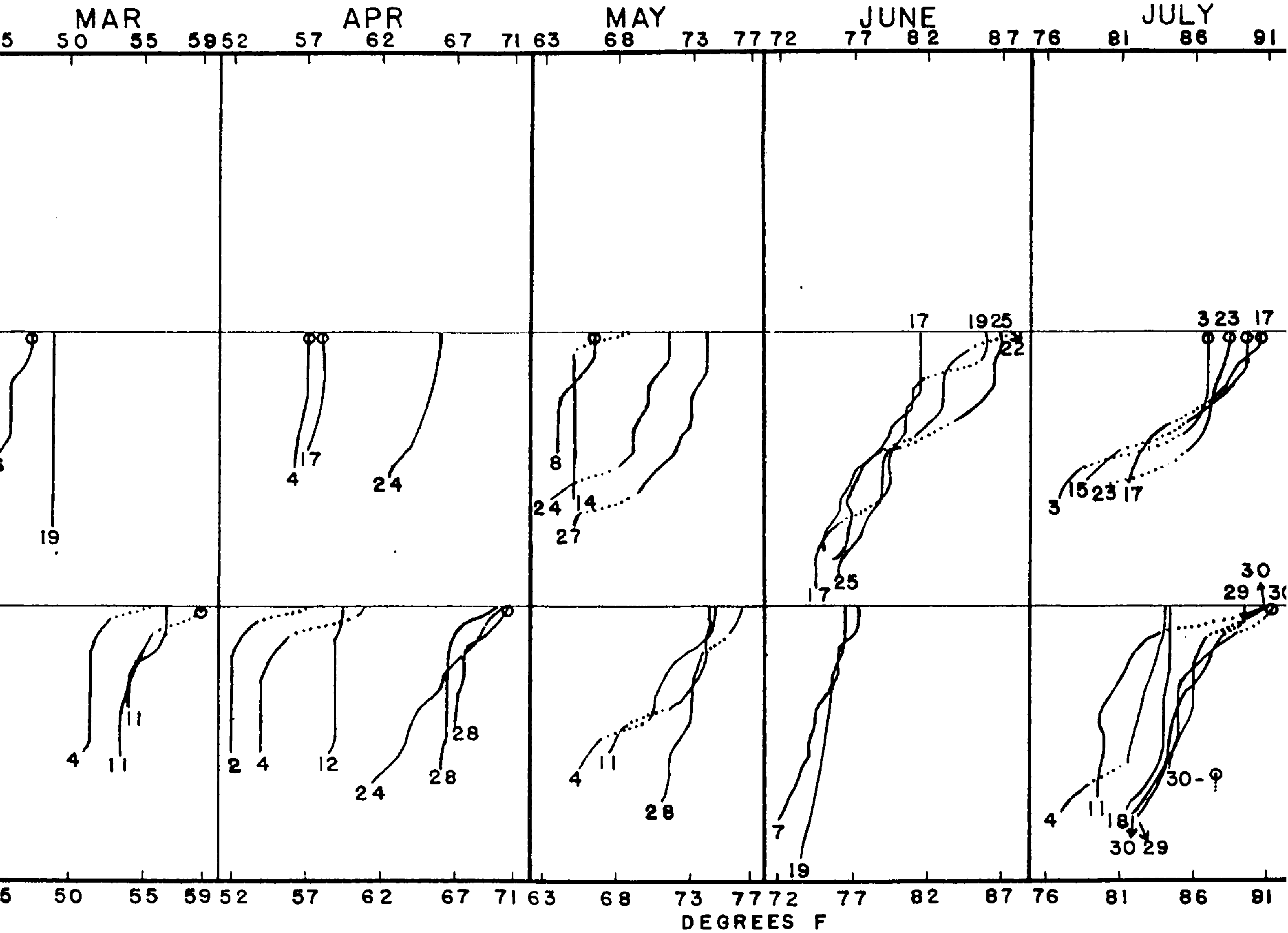
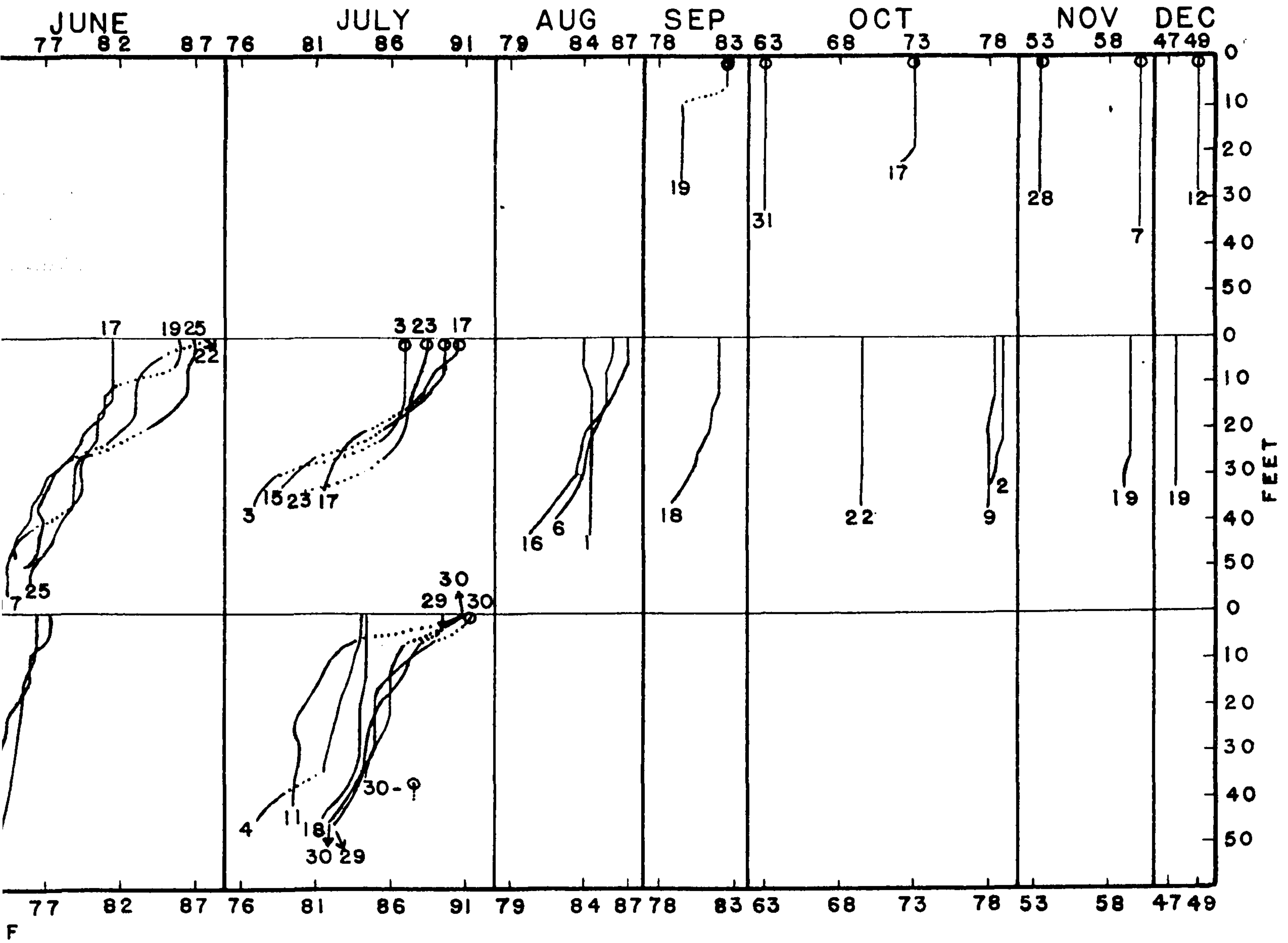


FIGURE 7. Monthly water temperatures at all depths at two deep-water stations (1 and 6). Profiles with small circles at
Numbers at either end of the profiles are days of the months. Dotted portions indicate a thermocline.



eratures at all depths at two deep-water stations (1 and 6). Profiles with small circles at the top are
profiles are days of the months. Dotted portions indicate a thermocline.



iles with small circles at the top are those of Station 6, the shallower of the two stations.
ocline.

were detected throughout the remainder of the year. It should be noted that the data in July prior to the storm were taken at Station 6 whereas the data on August 1 were taken at Station 1, a deeper station. However, data collected at these two stations in July, 1955, indicate that their respective temperatures were very similar at corresponding depths (Figure 7). This is also shown by the data of Figure 8 discussed in the following section.

The lowest water temperature recorded was 40.0°F on January 25, 1954. This reading was obtained at all depths in water 33 feet deep. The highest temperature recorded for Stations 1 and 6 was 91.5°F on July 30, 1955. The maximum surface to bottom temperature deviation recorded on any date for the same station occurred at Station 1 on June 22, 1954, when a reading of 87.5°F was obtained at the surface and 75.5°F at the bottom in water 49 feet deep. Though this is a difference of 12.0°F, surface to bottom temperatures usually varied less than 10.0°F.

The general concept presented by the data in Figure 7 is that during the late fall and winter months the temperature of the water in Buncombe Creek bay is essentially uniform from top to bottom, but thermoclines may develop during the spring, summer, and early fall months if there is an extended period of high temperatures and little wind. These thermoclines may be readily destroyed by wave action.

Comparison of Water Temperatures at All Stations

In order to obtain an understanding of the variation of water temperatures at the different netting stations, a series of readings was taken at all depths at the stations within a two-hour interval on three occasions (Figure 8). Variations in depth of a station on the three dates were due either to a difference in water level or to a slight difference in the location at which the readings were taken. The maximum temperature difference recorded for the stations on a given date was 14.5°F. This was the difference which existed between the bottom of Station 1 (82.0°F), the deepest station, and the surface of Station 13 (96.5°F), the shallowest station, on July 30, 1955. The temperature differences were not so great for stations exceeding five feet in depth. Thermoclines occurred at all stations in July, but it should be noted that they occurred immediately beneath or near the surface. They were thus only temporary and could easily be disrupted by slight wave action.

In general, the data indicate that the temperatures at the different stations were very similar for corresponding depths on each of the three dates. However, the shallower stations had slightly warmer surface and near-surface temperatures than deeper ones. The data presented later on the distribution of the fishes appear to indicate that water temperature was an influential factor in the distribution of certain species.

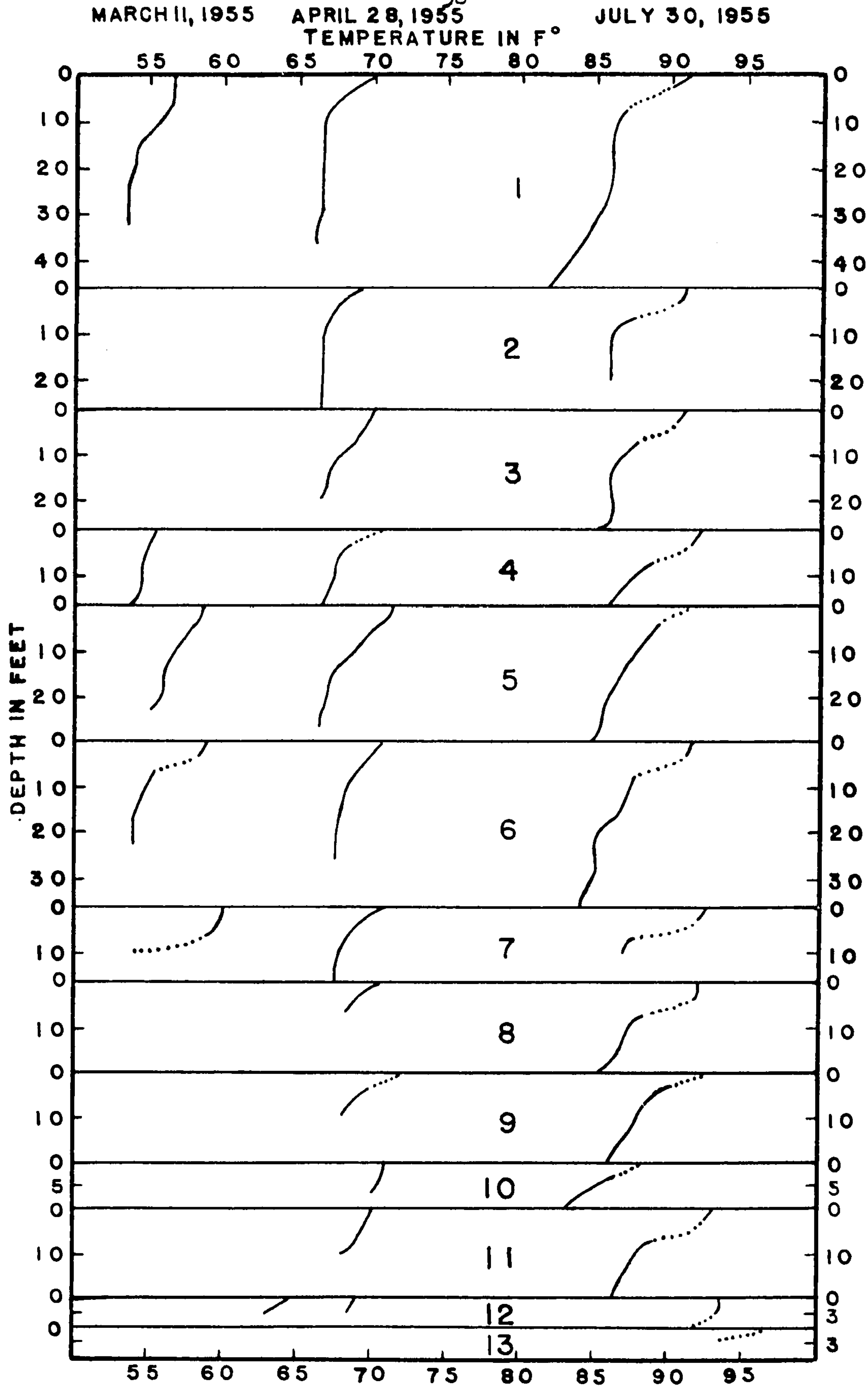


FIGURE 8. Water temperatures at all depths on March 11, April 28, and July 30, 1955, at the gill-netting stations.

Limnological Conditions

In a study of this type it would be desirable to have a complete record of the limnological conditions with which fish distribution could be correlated. Unfortunately, time was not available for collecting these data. Only one series of limnological tests was made (Table 6). These data are presented not because they contribute much to the overall understanding of the limnological conditions, but because they were taken in July, 1954, a time when stratification and the deviation of surface to bottom temperatures were near the maximum encountered during the course of the study. Under these conditions oxygen should have been distributed more poorly than at almost any other time during the study. Thus, the data should represent atypical conditions for oxygen distribution and consequently conditions when fish distribution would most likely be influenced by low oxygen concentrations.

The thermocline which occurred between 16 and 20 feet had considerable influence on the limnological data. A pH of 8.4 was obtained at the surface, 10 feet, and 20 feet, but there was a decrease to 8.2 at 30 feet and to 8.0 at 33 feet (bottom). Carbon dioxide was absent from the top 20 feet, but readings of 10 and 11 ppm. were obtained at 30 feet and 33 feet, respectively. Phenolphthalein alkalinity was absent at all depths. Methyl orange alkalinity varied from 20 ppm. at the surface to 30 ppm. at the bottom.

TABLE 6. Limnological data recorded at Station 6 at 2:00 P.M., July 17, 1954. A thermocline was present from 16 to 20 feet (Figure 7).

Depth in feet	pH	CO_2 ppm.	Phth. alk. ppm.	M.O. Alk. ppm.	O_2 ppm.	H_2O temp. F°
Surface	8.4	0	0	20	6.4	90.5
10	8.4	0	0	24	5.8	88.5
20	8.4	0	0	25	5.0	84.5
30	8.2	10	0	28	1.0	82.0
*33	8.0	11	0	30	0.2	81.5

*Bottom

A surface sample contained 6.4 ppm. of oxygen, and a sample at 20 feet contained 5.0 ppm., indicating that there was plenty of oxygen to support fish life at depths extending through the thermocline. However, a sample taken at 30 feet contained only 1.0 ppm. and at 33 feet the oxygen content was reduced to 0.2 ppm. Since these data were taken on July 17, 1954, and there was little turbulence subsequent to this date until the windstorm on July 31, it is possible that there was a complete depletion of oxygen at the bottom just prior to the storm. I should like to re-emphasize, however, that the month of July, 1954, must have represented atypical conditions with respect to oxygen distribution.

Thompson (1925) and Moore (1942) have studied the oxygen requirements of freshwater fishes under winter conditions, and their data are in close agreement. Thompson suggests that dissolved oxygen concentrations between 0.0 and 2.0 ppm. will kill all kinds of fishes. Moore concludes that at winter temperatures the oxygen thresholds of many species of freshwater fishes lie between 1.0 and 2.0 ppm., but some of the less tolerant species may require up to 3.0 ppm., possibly higher. Jenkins (1949), in a fishery survey of the Great Salt Plains Reservoir, Oklahoma, found that concentrations of 1.4 to 3.0 ppm. of dissolved oxygen were typical of bottom waters over the entire lake, but had no apparent effect on the movements of catfish, carp, or carpsuckers. Concerning fish distribution in Norris Reservoir, Tennessee, Dendy (1945) obtained no evidence to indicate that fish distribution was influenced by the amount of dissolved oxygen where it exceeded 3 ppm., but found that some species seemed to remain in areas where the oxygen content was only 1.6 to 3.0 ppm. In view of these data, it seems reasonable to assume that the month of July, and possibly June, 1954, was the only time during this study when dissolved oxygen was a limiting factor at any depth to the distribution of fish in the reservoir portion of Buncombe Creek.

Some additional limnological data on Lake Texoma proper are presented by the Oklahoma Planning and Resources Board (1951, 1952) and Sublette (1955).

CHAPTER IV

GENERAL DISCUSSION OF SPECIES

General Facts

A total of 50 species and one hybrid, representing 30 genera and 14 families, was collected (Table 7). Both common and scientific names presented in this table are according to Moore (1952) except those of the bullheads for which the genus Ictalurus is used following Taylor (1954). As would be expected, the minnow family, Cyprinidae, contained the largest number of species (15 and the hybrid). More than half of these were of the genus Notropis. The families Centrarchidae and Catostomidae were next in number of species with eight and seven, respectively. Six of the 14 families contained only one species each. One of these (Clupeidae) was represented by the gizzard shad, probably the most abundant species in the lake.

Of the species collected, 19 were taken with both gill nets and seines. Four species--the blue sucker, black buffalo, golden redhorse, and blue catfish--were taken only with gill nets and 28 species (including the hybrid minnow) only with seines. Therefore, a total of 23 species was collected using gill nets and 47 species using seines.

TABLE 7. Species list of the fishes collected from the Buncombe Creek arm of Lake Texoma.

Common name	Scientific name	*Method
Shortnose gar	Lepisosteus platostomus Rafinesque	G,S
Spotted gar	L. productus Cope	G,S
Longnose gar	L. osseus (Linnaeus)	G,S
Gizzard shad	Dorosoma cepedianum (LeSueur)	G,S
Goldeye	Hiodon alosoides (Rafinesque)	G,S
Mexican banded tetra	Astyanax fasciatus (Filippi)	S
Blue sucker	Cycleptus elongatus (LeSueur)	G
Bigmouth buffalo	Ictiobus cyprinellus (Valenciennes)	G,S
Black buffalo	I. niger (Rafinesque)	G
Smallmouth buffalo	I. bubalus (Rafinesque)	G,S
River carpsucker	Carpiodes carpio (Rafinesque)	G,S
Golden redhorse	Moxostoma erythrurum (Rafinesque)	G
Spotted sucker	Minytrema melanops (Rafinesque)	S
Carp	Cyprinus carpio Linnaeus	G,S
Golden shiner	Notemigonus crysoleucas (Mitchill)	S
Silver chub	Hybopsis storeriana (Kirtland)	S
Plains shiner	Notropis percobromus (Cope)	S
River shiner	N. blennius (Girard)	S
Chub shiner	N. potteri Hubbs and Bonham	S
Blacktail shiner	N. venustus (Girard)	S
Red shiner	N. lutrensis (Baird and Girard)	S
Hybrid	N. venustus X N. lutrensis	S
Red River shiner	N. bairdi Hubbs and Ortenburger	S
Sand shiner	N. deliciosus (Girard)	S
Ghost shiner	N. buchanani Meek	S
Plains minnow	Hybognathus placita Girard	S
Fathead minnow	Pimephales promelas Rafinesque	S
Parrot minnow	P. vigilax (Baird and Girard)	S
Stoneroller	Campostoma anomalum Rafinesque	S
Blue catfish	Ictalurus furcatus (LeSueur)	G
Channel catfish	I. punctatus (Rafinesque)	G,S
Black bullhead	I. melas (Rafinesque)	S
Yellow bullhead	I. natalis (Le Sueur)	S
Flathead catfish	Pilodictis olivaris (Rafinesque)	G,S
Blackstripe topminnow	Fundulus notatus (Rafinesque)	S
Plains killifish	F. kansae Garman	S
Gambusia	Gambusia affinis (Baird and Girard)	S
Brook silversides	Labidesthes sicculus (Cope)	S
Mississippi silversides	Menidia audens Hay	S
White bass	Morone chrysops (Rafinesque)	G,S
Spotted bass	Micropterus punctulatus (Rafinesque)	G,S

Species of Special Interest

My collections of several of the 47 species are among the few records for these species from the lake. These include the Mexican banded tetra, Mississippi silversides, golden redhorse, spotted sucker, Red River shiner, and the yellow bullhead. Riggs (1954) reported the first Mexican banded tetra from Lake Texoma in 1952. Since then, at least 48 additional specimens have been taken, 39 from the Buncombe Creek arm in connection with this study. The initial occurrence of this species in Lake Texoma was attributed to bait bucket introduction, but specimens as small as 19 mm. collected in the spring of 1955 indicate that the species is probably reproducing in the lake (Dowell and Riggs, in press). The first specimens of the Mississippi silversides were taken early in 1954. Its sudden appearance has been discussed by Riggs and Dowell (in press). By the summer of 1955 it had become one of the most abundant species in the lake. The golden redhorse, spotted sucker, and Red River shiner are still uncommon. Less than six specimens of each have been recorded from the lake exclusive of this study which added one golden redhorse, two spotted suckers, and three Red River shiners. Seven additional catostomids from 16 to 20 mm. in total-length were taken, however, and there is good reason to believe that these are spotted suckers. Though the yellow bullhead had not been reported from Lake Texoma, it is apparently not uncommon, for a total of 37 young-of-year were collected from six collections.

Evaluation of the Species

Because of the selectiveness of gill nets and seines, it is difficult to evaluate the relative abundance of the different species and their over-all role in the fishery. However, certain generalizations seem justified. White bass, white crappie, and largemouth bass comprise the bulk of the sport fishery, but considerable fishing effort is directed toward the channel, blue, and flathead catfishes, particularly by trotline fishermen. The bigmouth buffalo and flathead catfish are the principal species sought by commercial fishermen though carp and smallmouth buffalo are frequently utilized. Several species are of importance as forage fish. The gizzard shad assumes the principal role, but the two species of silversides and the many species of minnows, especially the red shiner, share in this role.

Reproduction

Minimum and maximum total-lengths were taken from all species. The data on minimum lengths indicate that young-of-year were probably collected for all species except the golden redhorse, black buffalo, blue sucker, and blue catfish of the larger species and possibly the golden shiner, silver chub, and Red River shiner of the smaller species. The smallest specimen and its date of collection for the last three names(in order of their listing) is: 39mm., June 14, 1954; 53 mm., July 19, 1954; and 40 mm., July 9, 1953. It is not surprising that young-of-year of golden redhorse, black buffalo, and blue sucker were not collected since these species seem to be uncommon in the lake. However, the fact that no young-of-year blue catfish were taken leads me to suspect that little or no spawning of this species occurs in the Buncombe Creek arm and that perhaps most of the spawning is done in the rivers. Since no gravid females were collected by netting there is additional support for this hypothesis, though it must be acknowledged that not many mature females were taken. Young about an inch in total-length have been collected from the Washita River near the mouth of Honey Creek in the vicinity of Turner Falls, Carter County, Oklahoma. The smallest specimen taken from the Buncombe Creek arm was five inches in total-length. It was found dead in the boathouse cove of the University of Oklahoma Biological Station on April 2, 1955. This problem merits further investigation.

CHAPTER V

ACTIVITY PATTERNS

Seasonal and Daily Activity

Total catch from gill nets

A summarization of the catch of all species from all gill nets (Table 8) seems in order before discussing their seasonal and daily activity. Though these data show the monthly catch of each species, they give no indication of seasonal variations of activity, since the data for the different months are not based on equal effort and methods. The totals of the species do not necessarily denote relative abundance.

The combined total of all species collected with all gill nets was 7218 fish. Of these, 27 per cent (1965) were gizzard shad. This is probably the most abundant species since the goldeye was next high with 17 per cent (1262) of the total catch. Other species ranking high in the total catch were: white bass, 14 per cent (1006); white crappie, 10 per cent (737); and river carpsucker, 8 per cent (567). Though the goldeye is certainly one of the more abundant species, it probably ranks after the white bass,

TABLE 8. Monthly catches of all species from all gill nets.

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	*Per cent of total of all species
Shortnose gar				19	45	12	5			2	2		85	1
Spotted gar	1		3	16	7	5	3		1		1		37	1
Longnose gar	2	4	8	33	71	30	30	1	4	35	2		220	3
Gizzard shad	41	268	254	437	303	164	175	11	106	141	60	5	1965	27
Goldeye	37	243	105	84	164	200	210	111	6	29	57	16	1262	17
Blue sucker	5	1	4			1							11	-
Bigmouth buffalo	5	2	4		3	16	2				9		41	1
Black buffalo		2			2	2	4			3			13	-
Smallmouth buffalo	10	12	14	37	9	28	11	7	5	15	28	9	185	3
River carpsucker	46	22	5	97	76	104	102	4	1	61	38	11	567	8
Golden redhorse				1									1	-
Carp	22	21	10	41	33	30	19	17	8	20	73	7	301	4
Blue catfish		2	9	22	15	11	14	6		2	3		84	1
Channel catfish		14	13	19	20	26	29	12	4	3	17	2	159	2
Flathead catfish		2	4	5	5	5	7	1	1	2	5		37	1
White bass	12	167	102	158	125	39	106	7	9	48	209	24	1006	14
Spotted bass		1	2		2					1	1	1	8	-
Largemouth bass	8	26	19	6	5	5	3	1		8	10	2	93	1
Warmouth				1									1	-
Longear sunfish			1	5	8		6						20	-
Bluegill		1	4	12	39	7	29						92	1
White crappie		20	31	155	72	165	176	48	3	26	24	17	737	10
Freshwater drum		3	2	13	8	55	194	11		6	1		293	4
Monthly totals of all species combined	189	811	594	1161	1012	905	1125	237	148	402	540	94	7218	
Per cent of total of all species for all months	3	11	8	16	14	13	16	3	2	6	7	1	100	

*Figures are given to nearest one per cent. A dash (-) indicates less than one-half of one per cent.

and possibly the white crappie, in abundance. Its teeth make it easily caught in gill nets and increases its percentage of catch in proportion to most other species. This is exemplified by the fact that 78 were taken in 3-inch mesh nets, a mesh size far too big to catch this species in the normal way. The freshwater drum probably does not comprise four per cent of the population as the data indicate. The greatest number of this species was collected in July from a few large catches.

Judging from the catch of sport fishermen and from personal observations, the percentage of the total gill-net catch comprised by certain species of the family Centrarchidae is low. Species of this family have been reported to avoid gill nets (Carlander, 1953). The largemouth bass constitutes one of the important game species, but only 93 were collected. Of these, 73 were collected in 3-inch mesh nets, which were all "flag nets", and seem more efficient than leaded nets for collection this species. A total of 133 bluegill was collected in May, 1955, in two lifts of a wire trap set for 34 hours, but only 92 were collected by all gill-net sets. An experiemental net set in the same vicinity, but at a slightly greater distance from the rock-ledge shoreline, caught only one bluegill in three lifts during the same period. The additional distance of the net from the shoreline would be expected to make a difference in the catch of this species, but would not seem to justify such a vast difference. The number of young-of-year longear sunfish collected with seines leaves little doubt that it is more common than the gill-net collections indicate. White crappie are taken in great abundance by sport fishermen and may constitute a larger percentage of the total population than is shown in Table 8.

Seasonal variations

The size of gill-net catches generally depends upon the amount of movement of the fish, and therefore the catch per hour is a function of the activity of the fish in the vicinity of the nets as well as their abundance (Carlander, 1953). Year-around data should thus reveal the months of the year when fish are most active if comparable time and methods are applied during each month or if the differences of these are taken into consideration. Since it was not possible to devote equal time and methods to the various months in this study, the catch of each month has been computed for each species and for each type of net by gill-net hours (Tables 9-12) so that the data for all months can be compared. No attempt is made to take into consideration differences in the locations and depths of sets since, due to seasonal changes in water temperature, oxygen content, wave action, etc., fish would not be expected to react in a consistent manner to these factors in different seasons of the year. Thus, it is assumed that variations in seasonal

TABLE 9. Catch in number of fish per gill-net hour in the 3-inch bar mesh nylon gill nets. T
Figures in the left of the two columns under each month represent the number of fish collecte
to the nearest 0.001).

Species	Jan 140.50		Feb 326.25		Mar 363.00		Apr 304.00		May 170.50		June 373.25		July 518.	
Shortnose gar														
Spotted gar	1	0.007					1	0.003						
Longnose gar					1	0.003	7	0.023	2	0.012	1	0.003	5	[illegible]
Goldeye	2	0.014	11	0.034	13	0.036	1	0.003	2	0.012	11	0.029	6	[illegible]
Blue sucker	4	0.028			2	0.006								
Bigmouth buffalo	5	0.036	2	0.006	4	0.011			3	0.018	16	0.043	2	[illegible]
Black buffalo									1	0.006	2	0.005	2	[illegible]
Smallmouth buffalo	2	0.014	8	0.025	8	0.022	8	0.026	5	0.029	11	0.029	6	[illegible]
River carpsucker	1	0.007												
Carp	6	0.043	10	0.031	6	0.017	8	0.026	4	0.023	10	0.027	8	[illegible]
Blue catfish			1	0.003	2	0.006					3	0.008	2	[illegible]
Channel catfish			2	0.006									1	[illegible]
Flathead catfish			2	0.006	4	0.011	4	0.013	5	0.029	5	0.013	7	[illegible]
White bass					2	0.006	1	0.003	1	0.006			1	[illegible]
Largemouth bass	7	0.050	24	0.074	18	0.050	6	0.020	5	0.029	2	0.005	1	[illegible]
White crappie			5	0.015	8	0.022	2	0.007						
Freshwater drum			1	0.003							3	0.008	1	[illegible]
Total	28	0.199	66	0.202	68	0.187	38	0.125	28	0.164	64	0.171	42	[illegible]

gill nets. The total hours of fishing for each month is given immediately below the month.
ish collected; figures in the right column, the number collected per gill-net hour (computed

e .25	July 518.50		Aug 276.25		Sept 48.50		Oct 122.00		Nov 284.00		Dec 98.75		Total, all months 3025.50	
									1	0.004			1	-
													2	0.001
0.003	5	0.010	1	0.004			1	0.008					18	0.006
0.029	6	0.012	21	0.076	2	0.041	2	0.016	4	0.014	3	0.030	78	0.026
													6	0.002
0.043	2	0.004							9	0.032			41	0.014
0.005	2	0.004					3	0.025					8	0.003
0.029	6	0.012	7	0.025			2	0.016	13	0.046	4	0.041	74	0.024
									1	0.004			2	0.001
0.027	8	0.015	17	0.062	3	0.062	4	0.033	16	0.056	1	0.010	93	0.031
0.008	2	0.004	2	0.007					2	0.007			12	0.004
	1	0.002							1	0.004			4	0.001
0.013	7	0.014	1	0.004			2	0.016	4	0.014			34	0.011
	1	0.002											5	0.002
0.005	1	0.002	1	0.004					9	0.032			73	0.024
									4	0.014	1	0.010	20	0.007
0.008	1	0.002	1	0.004									6	0.002
0.171	42	0.081	51	0.185	5	0.103	14	0.115	64	0.225	9	0.091	477	0.158

TABLE 10. Catch in number of fish per gill-net hour in the 2-inch bar mesh linen gill nets Figures in the left of the two columns under each month represent the number of fish colle to the nearest 0.001).

Species	Jan 83.75		Feb 60.50		Mar 76.00		Apr 127.00		May		June 27.50		2
Shortnose gar							12	0.094					
Spotted gar							6	0.047					1
Longnose gar	2	0.024					5	0.039					
Gizzard shad	5	0.060	9	0.149			6	0.047					
Goldeye	8	0.096	23	0.380	9	0.118	4	0.031					
Blue sucker	1	0.012			2	0.026							
Smallmouth buffalo	8	0.096	4	0.066	2	0.026	27	0.213					
River carpsucker	45	0.537	9	0.149	3	0.039	52	0.409			1	0.036	22
Golden redhorse							1	0.008					
Carp	16	0.191	11	0.182	2	0.026	29	0.228			6	0.218	2
Blue catfish			1	0.017			6	0.047					
Channel catfish			2	0.033	2	0.026	3	0.024			1	0.036	1
Flathead catfish							1	0.008					
White bass	7	0.084	47	0.777	17	0.224	57	0.449			3	0.109	6
Spotted bass			1	0.017									
Largemouth bass	1	0.012											
White crappie			7	0.116	4	0.053	14	0.110					1
Freshwater drum													1
Total	93	1.110	114	1.884	41	0.539	223	1.756			11	0.400	34

en gill nets. The total hours of fishing for each month is given immediately below the month. fish collected; figures in the right column, the number collected per gill-net hour (computed

ne ,50	July 23.00		Aug	Sept 26.50		Oct 71.50		Nov 113.75		Dec 38.50		Total, all months 648.00	
								1	0.009			13	0.020
	1	0.043		1	0.038			1	0.009			9	0.014
				1	0.038			2	0.018			10	0.015
						4	0.056	6	0.053	1	0.026	31	0.048
				1	0.038	12	0.168	14	0.123	7	0.182	78	0.120
												3	0.005
				5	0.189	11	0.154	15	0.132	5	0.130	77	0.119
0.036	22	0.957		1	0.038	35	0.490	32	0.281	10	0.260	210	0.324
												1	0.002
0.218	2	0.087		5	0.189	12	0.168	57	0.501	6	0.156	146	0.225
												7	0.011
0.036	1	0.043		1	0.038			12	0.105	1	0.026	23	0.035
				1	0.038							2	0.003
0.109	6	0.261		2	0.075	19	0.266	144	1.266	18	0.468	320	0.494
										1	0.026	2	0.003
												1	0.011
	1	0.043				1	0.014	13	0.114	3	0.078	43	0.066
	1	0.043										1	0.011
0.400	34	1.478		18	0.679	94	1.315	297	2.611	52	1.351	977	1.508

TABLE 11. Catch in number of fish per gill-net hour in the $1\frac{1}{2}$-inch bar mesh linen gill nets. The total hours of fishing for each month is given immediately below the month. Figures in the left of the two columns under each month represent the number of fish collected; figures in the right column, the number collected per gill-net hour (computed to the nearest 0.001).

Species	May 146.50		June 187.50		July 182.75		Aug 69.25		Total, all months 586.00	
Shortnose gar	43	0.294	8	0.043	3	0.016			54	0.092
Spotted gar	4	0.027	5	0.027					9	0.015
Longnose gar	29	0.198	5	0.027	5	0.027			39	0.067
Gizzard shad	54	0.369	27	0.144	4	0.023	3	0.043	88	0.150
Goldeye	34	0.232	123	0.656	87	0.476	62	0.895	306	0.522
Blue sucker			1	0.005					1	0.002
Black buffalo	1	0.007							1	0.002
Smallmouth buffalo	4	0.027	14	0.075					18	0.031
River carpsucker	45	0.307	89	0.475	31	0.170	3	0.043	168	0.287
Carp	17	0.116	11	0.059	1	0.005			29	0.049
Blue catfish	6	0.041	5	0.027	7	0.038	2	0.029	20	0.034
Channel catfish	9	0.061	13	0.069	8	0.044	1	0.014	31	0.053
White bass	85	0.580	13	0.069	39	0.213	6	0.087	143	0.244
Largemouth bass			2	0.011	1	0.005			3	0.005
Longear sunfish	2	0.014							2	0.003
Bluegill	24	0.164	6	0.032					30	0.051
White crappie	15	0.102	26	0.139	52	0.285	36	0.520	129	0.220
Freshwater drum	4	0.027	7	0.037	26	0.142	1	0.014	38	0.065
Total	376	2.567	355	1.893	264	1.444	114	1.646	1109	1.892

TABLE 12. Catch in number of fish per gill-net hour in the experimental linen gill nets
Figures in the left of the two columns under each month represent the number of fish col
to the nearest 0.001).

Species	Jan		Feb		Mar		Apr		May		June		
	21.75		337.75		402.00		466.75		302.25		300.75		
Shortnose gar							7	0.015	2	0.007	4	0.013	
Spotted gar					3	0.007	9	0.019	3	0.010			
Longnose gar			4	0.012	7	0.017	21	0.045	40	0.132	24	0.080	2
Gizzard shad	36	1.655	259	0.767	254	0.632	431	0.923	249	0.824	137	0.456	17
Goldeye	27	1.241	209	0.619	83	0.206	79	0.169	128	0.423	66	0.219	11
Blue sucker			1	0.003									
Black buffalo			2	0.006									
Smallmouth buffalo					4	0.010	2	0.004			3	0.010	
River carpsucker			13	0.038	2	0.005	45	0.096	31	0.103	14	0.047	4
Carp					2	0.005	4	0.009	12	0.040	3	0.010	
Blue catfish					7	0.017	16	0.034	9	0.030	3	0.010	
Channel catfish			10	0.030	11	0.027	16	0.034	11	0.036	12	0.040	1
Flathead catfish													
White bass	5	0.230	120	0.355	83	0.206	100	0.214	39	0.129	23	0.076	6
Spotted bass					2	0.005			2	0.007			
Largemouth bass			2	0.006	1	0.002					1	0.003	
Warmouth							1	0.002					
Longear sunfish					1	0.002	5	0.011	6	0.020			
Bluegill			1	0.003	4	0.010	12	0.026	15	0.050	1	0.003	2
White crappie			8	0.024	19	0.047	139	0.298	57	0.189	139	0.462	12
Freshwater drum			2	0.006	2	0.005	13	0.028	4	0.013	45	0.150	16
Total	68	3.126	631	1.868	485	1.206	900	1.928	608	2.012	475	1.579	78

. linen gill nets. The total hours of fishing for each month is given immediately below the month.
umber of fish collected; figures in the right column, the number collected per gill-net hour (computed

	June 300.75		July 465.75		Aug 45.25		Sept 21.75		Oct 111.75		Nov 90.75		Dec 47.50		Total, all months 2614.00	
7	4	0.013	2	0.004					2	0.018					17	0.007
.0			2	0.004											17	0.007
2	24	0.080	20	0.043			3	0.138	34	0.304					153	0.059
4	137	0.456	171	0.367	8	0.177	106	4.874	137	1.226	54	0.595	4	0.084	1846	0.706
3	66	0.219	117	0.251	28	0.619	3	0.138	15	0.134	39	0.430	6	0.126	800	0.306
															1	-
			2	0.004											4	0.002
	3	0.010	5	0.011					2	0.018					16	0.006
3	14	0.047	49	0.105	1	0.022			26	0.233	5	0.055	1	0.021	187	0.072
.0	3	0.010	8	0.017					4	0.036					33	0.013
0	3	0.010	5	0.011	2	0.044			2	0.018	1	0.011			45	0.017
6	12	0.040	19	0.041	11	0.243	3	0.138	3	0.027	4	0.044	1	0.021	101	0.039
											1	0.011			1	-
9	23	0.076	60	0.129	1	0.022	7	0.322	29	0.260	65	0.716	6	0.126	538	0.206
7									1	0.009	1	0.011			6	0.002
	1	0.003	1	0.002					8	0.072	1	0.011	2	0.042	16	0.006
															1	-
0			6	0.013											18	0.007
0	1	0.003	29	0.062											62	0.024
9	139	0.462	123	0.264	12	0.265	3	0.138	25	0.224	7	0.077	13	0.274	545	0.208
3	45	0.150	166	0.356	9	0.199			6	0.054	1	0.011			248	0.095
2	475	1.579	785	1.685	72	1.591	125	5.747	294	2.630	179	1.972	33	0.695	4655	1.781

activity can probably be measured just as accurately, if not more accurately, from sets made at numerous localities and depths as from sets made only in one locality and at a constant depth.

Year-around data were obtained only for 3-inch mesh and experimental nets since most of the netting was done with these nets. It is therefore necessary to discuss seasonal activity on the basis of the catch of these nets and supplement these data with the catch of 2-inch and $1\frac{1}{2}$-inch mesh nets. A listing of the species is presented below with a brief discussion of the seasonal activity of each. The number in parentheses immediately following the name of the species represents the total number gill-netted. Following this, data are presented which show the month in which the greatest catch per gill-net hour occurred (based on 3-inch mesh and experimental nets only), the number of fish caught per gill-net hour in that month, and the type of net which produced the catch. Finally, a broader interpretation of the seasonal activity of the species, based on the data from all nets, is presented.

Shortnose gar (85). October; 0.018; experimental. The rate of catch shown here for October is based on only two fish. It seems probable that the period of greatest activity is actually in April and May as indicated by the catch in May from $1\frac{1}{2}$-inch nets, in April and May from 2-inch mesh nets, and by spawning activity observed in May. During the summer shortnose gars were sometimes observed at the surface of the water gulping air. None was taken in the months of December through March, nor was there any evidence of activity as during the warmer months.

Spotted gar (37). April; 0.019; experimental. April also had the highest rate of catch for 2-inch mesh nets. No 1½-inch mesh nets were set in April, but of the four months in which they were fished their rate of catch of this species was greatest in May and June. Spawning activity was at its peak around the middle of May. Only one fish was taken in the months of December through February.

Longnose gar (220). October; 0.304; experimental. Many of the longnose gars taken in October were young-of-year which were taken in 3/4-inch mesh. The next highest rate of catch for the experimental net was 0.045 fish per gill-net hour in April. Both the 3-inch and 2-inch mesh nets attained their highest rate of catch in April while the rate of catch of 1½-inch mesh nets was greatest in May (no 1½-inch mesh nets were fished in April). It appears that this species is most active in April and May. Some spawning activity was observed in May. Frequently during the summer large numbers were seen at the surface of the water gulping air. Activity was very low during the winter months which seems to correspond with the two species of gars previously discussed.

Gizzard shad (1965). September; 4.874; experimental. The rate of catch for September was considerably higher than for any other month. It is probably too high in proportion to the other months since it was based on only a few hours of fishing. However, the rate of catch for October was also among the highest. During these months the young-of-year were taken in large numbers by the smaller mesh sizes of the experimental nets and certainly contributed to this increased rate of catch. The months with the maximum rate of catch for the other nets were: 2-inch mesh nets, February; and 1½-inch mesh nets, May. None was caught in 3-inch mesh nets. If the increased catch of September and October is attributed largely to recruitment of young-of-year rather than to an actual increase in the activity of the individuals, then seasonal activity appears to be greatest in the early spring.

Goldeye (1262). January; 1.241; experimental. The seasonal activity of this species is peculiar in that some of the lowest rates of catch were obtained during April and May, a time which should be associated with its spawning. This may indicate that the main concentration moves out of the Buncombe Creek arm or possibly out of the lake to spawn. Although the highest rate of catch occurred in January with experimental nets, the over-all data from all nets show that this species was most active during August.

Blue sucker (11). January; 0.028; 3-inch mesh net.

Of the 11 collected, five were taken in January, one in February, four in March, and one in June which suggests that it was most active when the water was cold. This is confirmed by gill-netting in Lake Texoma by C. D. Riggs and others in which the greatest catches were also in the winter or early spring.

Bigmouth buffalo (41). June; 0.043; 3-inch mesh net. All fish of this species were taken with 3-inch mesh nets. None was collected in April, August, September, October, and December even though 304 hours were fished with 3-inch mesh nets in April and 276 hours in August. In comparison, 373 hours fished in June with 3-inch mesh nets caught 16 fish. It is peculiar that no fish of this species were collected which weighed less than approximately three pounds.

Black buffalo (13). These 13 fish were collected at various times throughout the year.

Smallmouth buffalo (185). November; 0.046; 3-inch mesh net. The data from 3-inch mesh nets indicate that this species is most active in November and December with a secondary high in the spring. The highest rate of catch for those taken in 2-inch mesh nets was in April. The 2-inch and 3-inch mesh nets accounted for nearly all the catch.

River carpsucker (567). October; 0.233; experimental. A large number of this species was collected in 2-inch and 1½-inch mesh nets. The highest rate of catch for these nets was in July and June, respectively, but may not be reliable because of the paucity of netting with these nets.

Golden redhorse (1). The only fish that was collected was taken in April with a 2-inch mesh net.

Carp (301). August and September; 0.062; 3-inch mesh net. The rate of catch was greatest in May for experimental and 1½-inch mesh nets and in November for 2-inch mesh nets. This gives little indication of the season of greatest activity for this species.

Blue catfish (84). August; 0.044; experimental. The rate of catch for experimental nets was almost as high in April and May as in August, and was based on more fish and more hours of fishing than in August. Since it was highest in April for 2-inch mesh nets and in May for 1½-inch mesh nets, the blue catfish was probably most active during these two months.

Channel catfish (159). August; 0.243; experimental. The data of the different nets are not in agreement on the time of greatest activity but indicate that it is sometime during the period of June through November.

Flathead catfish (37). May; 0.029; 3-inch mesh net. Only three fish were taken in nets other than 3-inch mesh. These data indicate that May was the most active period for this species.

White bass (1006). November; 0.716; experimental.

Most of this species were taken in experimental and 2-inch mesh nets. The catch from both of these nets indicated that the peak of activity was in November with a secondary peak in February.

Spotted bass (8). No trends of activity were indicated.

Largemouth bass (93). February; 0.074; 3-inch mesh net. The data indicate that February was definitely the month of maximum activity for the larger members of this species. Only 20 fish were taken in nets other than 3-inch mesh. The highest rate of catch for these smaller fish was in October.

Warmouth (1). The only fish of this species collected was caught in April in an experimental net.

Longear sunfish (20). These fish were collected in the period, March through July.

Bluegill (92). July; 0.062; experimental. This species was collected entirely with experimental and 1½-inch mesh nets. The highest rate of catch of the 1½-inch mesh net occurred in May which was the secondary high for experimental nets.

White crappie (737). June; 0.462; experimental. The activity of this species increased sharply from March to April and reached a peak in activity in June as indicated by the catch of these months. Activity was low during the winter months.

Freshwater drum (293). July; 0.356; experimental. The catch indicates that this species was definitely most active in July. Of the 248 fish taken in all months with experimental gill nets, 166 were taken in July.

The month with the highest rate of catch per gill-net hour for all species combined was September (5.747) for experimental nets and November (0.225) for 3-inch mesh nets. At least some netting was done with 2-inch mesh nets in all months except August, and their highest rate of catch was in November (2.611). The high catch per gill-net hour in September with experimental nets was due chiefly to a large catch of gizzard shad made in one set of only a few hours. It is probably an exaggeration of the true conditions. However, since the greatest catch per unit of effort for both the 3-inch and 2-inch mesh nets was made in November and the catch of experimental nets was also high (2.630 per gill-net hour) in October, the data suggest that all species of fish combined were most active in the fall months. The rates of catch for February, April, and May were also quite high in proportion to those of other months and were generally based on more hours of fishing. It is therefore possible that the rate of activity was greatest in one of these months. The tendency for catches to be lower during the summer months may indicate that the general population tends to migrate out of the bay to deeper water during that time.

The species with the largest catch per gill-net hour on a year-around basis were gizzard shad (0.706), goldeye (0.306), white crappie (0.208), and white bass (0.206). All catches were obtained with experimental nets. The total catch of all species per gill-net hour for all months fished was 1.781 with experimental nets, 1.892 with $1\frac{1}{2}$-inch mesh nets, 1.508 with 2-inch mesh nets, and 0.158 with 3-inch mesh nets. It is apparent from these data that $1\frac{1}{2}$-inch mesh and experimental nets are the most efficient for collecting large numbers of fish from Lake Texoma, and that the rate of catch decreases markedly from 2-inch to 3-inch mesh nets. Carlander (1953) reported that a net of 3-inch bar mesh caught so few fish that its use was discontinued.

The catch of the various species seems unusually small when expressed as fish per gill-net hour. It was especially low for 3-inch mesh nets because the catch in these was limited primarily to the larger fish which, of course, represent the older, less-abundant age-groups. The total catch of 3-inch mesh nets for all months combined averaged less than one fish in 10 gill-net hours for each of the species. However, the data for experimental nets compare favorably with that obtained by Carlander (1953) in a study of Clear Lake, Iowa. His data show the numbers of fish caught per 125-foot experimental linen gill net for each hour of the day based on catches taken over a period of several summers. According to his data the maximum hourly catch (equivalent to catch per gill-net hour used here) of the following species was: bluegill, 0.1; crappie, 0.06 (both Pomoxis annularis and P. nigromaculatus); white bass, 0.07; and carp, 0.06. In comparison, the data obtained with 125-foot experimental linen gill nets from Lake Texoma in this study show the following catch per gill-net hour for these species (based on year-around data): bluegill, 0.024; white crappie, 0.208; white bass, 0.206; and carp, 0.013. Moyle, et al., (1948) found that experimental gill nets had a low efficiency for black bass, crappie, sunfish, carp, and other large rough fish. The data of this study support this statement with the possible exception of the crappie which ranked third among 21 species in catch per gill-net hour with experimental gill nets as determined from year-around data. It has previously been suggested, however, that the catch of crappie was probably low.

Day vs. night catches

The percentage of fish caught during the night greatly exceeded that during the day for most species (Table 13), indicating a much higher rate of activity during the night. There is no reason to doubt the general trend of the data given for each species. However, the difference in activity between day and night is probably not as great as indicated since the night sets usually included at least an hour of daylight following daybreak and frequently as much prior to nightfall. Furthermore, gill nets are not so

TABLE 13. *Monthly catch of day and night gill-net sets for each species.

Species	Jan		Feb		Mar		Apr		May		June		July		Aug	
	**D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Shortnose gar							4	15	7	38		12	1	4		
Spotted gar		1			3		4	12	2	5	1	4		3		
Longnose gar		2	1	3	4	4	11	22	13	58	4	26	6	24	1	
Gizzard shad	14	27	4	264	11	243	23	414	11	292	22	142	13	162	2	9
Goldeye		37	4	239	3	102	12	72	29	135	9	191	7	203	13	98
Blue sucker		5		1	1	3					1					
Bigmouth buffalo		5		2		4				3	4	12	1	1		
Black buffalo				2					1	1		2		4		
Smallmouth buffalo		10	2	10	2	12	1	36	2	7	3	25	2	9		7
River carpsucker	9	37	7	15	1	4	26	71	25	51	40	64	46	56	2	2
Golden redhorse							1									
Carp	1	21	1	20	3	7	14	27	3	30	5	25	3	16	6	11
Blue catfish				2	3	6		22		15	1	10	1	13		6
Channel catfish			1	13	3	10		19	1	19	2	24	7	22	2	10
Flathead catfish				2		4		5	1	4		5		7		1
White bass	1	11	4	163	5	97	25	133	46	79	17	22	68	38	2	5
Spotted bass				1	1	1			1	1						
Largemouth bass	2	6	5	21	8	11	2	4	3	2	4	1	2	1		1
Warmouth								1								
Longear sunfish					1		2	3	5	3			3	3		
Bluegill			1		3	1	6	6	25	14	6	1	15	14		
White crappie				20		31	24	131	12	60	49	116	37	139	7	41
Freshwater drum				3		2		13	1	7		55	12	182	3	8
Total (all species)	27	162	30	781	52	542	155	1006	188	824	168	737	224	901	38	199
Total of all species in per cent	14	86	4	96	9	91	13	87	19	81	19	81	20	80	16	84

*Refer to Chapter II for definition of day and night sets.
**"D" represents day catch; "N" represents night catch.

July		Aug		Sept		Oct		Nov		Dec		Total (all months)		Total (all months) in per cent	
D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
1	4						2		2			12	73	14	86
	3			1					1			11	26	30	70
6	24	1			4	14	21		2			54	166	25	75
13	162	2	9	1	105	5	136	15	45	1	4	122	1843	6	94
7	203	13	98		6		29	1	56		16	78	1184	6	94
												2	9	18	82
1	1								9			5	36	12	88
	4					1	2					2	11	15	85
2	9		7	2	3	1	14	2	26	3	6	20	165	11	89
46	56	2	2	1		31	30	7	31	4	7	199	368	35	65
												1		100	
3	16	6	11	5	3	8	12	9	64		7	58	243	19	81
1	13		6				2		3			5	79	6	94
7	22	2	10	1	3		3	3	14		2	20	139	13	87
	7		1		1		2		5			1	36	3	97
68	38	2	5		9	7	41	31	178	2	22	208	798	21	79
						1		1			1	4	4	50	50
2	1		1			7	1	2	8		2	35	58	38	62
													1		100
3	3											11	9	55	45
15	14											56	36	61	39
37	139	7	41		3	1	25	2	22		17	132	605	18	82
12	182	3	8				6		1			16	277	5	95
224	901	38	199	11	137	76	326	73	467	10	84	1052	6166		
20	80	16	84	7	93	19	81	14	86	11	89	15	85		

effective when the fish can see the nets (Rounsefell and Everhart, 1953) which could contribute to lower daylight catches.

The percentage of the total catch of all species caught at night was usually higher during the winter than during the summer (Table 13). The night catch varied from a low of 80 per cent of the catch in July to a high of 96 per cent in February. This may be the result of longer nights and consequently more hours of fishing during the night in winter. If this were true, however, the night catch of December and January should be greater than that of February. The unusually high percentage of fish caught by night in February is more likely due to the fact that gizzard shad and goldeye composed a large part of the total catch. The combined totals of all months indicate that a very high percentage of both of these species is caught at night.

The higher rate of catch by night during the winter was particularly true for the white bass and white crappie. It seems probable that the increased catch of these species during the day in the summer may be correlated with factors other than an increase in the number of hours fished during the day. No white crappie were collected from day sets during December, January, February, and March while 68 were collected from night sets during this period. In contrast, 49 (30 per cent) of 165 white crappie collected in June were collected from day sets. The additional fishing time devoted to day sets during the summer as compared to winter does not seem to be the explanation for such an increased day catch.

The numbers in night sets constituted the following percentages of the total catch of each species:

90-100	Gizzard shad, goldeye, blue catfish, flathead catfish, and freshwater drum.
80-89	Shortnose gar, blue sucker, bigmouth buffalo, black buffalo, smallmouth buffalo, carp, channel catfish, and white crappie.
70-79	Spotted gar, longnose gar, and white bass.
60-69	River carpsucker and largemouth bass.
50-59	Spotted bass.
40-49	Longear sunfish.
30-39	Bluegill.

The only specimen of the golden redhorse was collected from a day set; that of the warmouth from a night set. Although, in general, the centrarchids were more active during the day than the other species, only the longear sunfish and bluegill were taken in greater abundance from day sets than from night sets. The flathead catfish was the most nocturnal of all species. Only one of the 37 flathead catfish was taken in a day set. Carlander (1953) obtained larger catches of white bass during the night than during the day, but there was little difference in the day and night catches of carp and crappie (both *Pomoxis annularis* and *P. nigromaculatus*). Spencer (1929) studied the activity of carp in a laboratory by means of a device for graphically recording their swimming movements and reported that there was a period of intense activity during the night.

Catches by 2-hour intervals

In order to obtain an accurate concept of the time of day when fish are most active, it is necessary to make frequent checks of the collecting gear. Time did not permit frequent checking regularly during this study, but checks were made at 2-hour intervals throughout two 24-hour periods in midwinter (Table 14) and throughout an 18-hour period of a 24-hour set in April (Table 15). The data from these are not extensive, but they seem worthwhile to present since they appear rather typical of many of the catches.

Although the data presented in these tables are limited and do not justify any conclusions, they do suggest several interesting points. Thus, it is apparent that most of the fish were caught during the hours of darkness which is in agreement with the data presented in Table 13. Furthermore, the distribution of the catch of 127 gizzard shad throughout the two 24-hour periods in midwinter suggests that this species becomes increasingly more active after darkness until a peak in activity is reached around 1:00 A.M. Thereafter, there is a general decline in activity until daybreak when a pronounced decline occurs. Apparently there is less activity during the daylight hours than during the night. Of the 26 white bass caught during the same two periods, some were taken on all lifts which included the

TABLE 14. Catch at 2-hour intervals of two 24-hour sets made on January 31-February 1, 1955, and February 2-3, 1955. These were surface to bottom-bottom sets with an experimental gill net. One was set at Station 3, the other at Station 9.

Species	A.M.						P.M.						Total
	1	3	5	7	9	11	1	3	5	7	9	11	
Gizzard shad	29	24	20	21	1					5	10	17	127
Goldeye	1		1							3		3	8
Black buffalo												1	1
White bass	3	5	7	5						3	1	2	26
Freshwater drum											1		1
Total	33	29	28	26	1					11	12	23	163

TABLE 15. Catch at 2-hour intervals (except from 1:00 A.M. to 7:00 A.M.) of a 24-hour set made April 7-8, 1955. This was a bottom set with an experimental gill net at Station 3.

Species	A.M.				P.M.						Total
	1	7	9	11	1	3	5	7	9	11	
Gizzard shad		11					1		2	2	16
Goldeye	1										1
Smallmouth buffalo	1										1
River carpsucker	1							1			2
Blue catfish									1	1	2
White bass					1	1					2
White crappie		3		1	1	1			2		8
Total	3	14		1	2	2	1	1	5	3	32

hours of darkness, but their numbers were somewhat more abundant in the morning hours just before daybreak. None was taken during the day. In contrast, only two white bass were collected during the 24-hour period in April, but both were collected during the day.

Movements

Upstream-downstream movements

Beginning in January, 1954, the direction of movement (upstream-downstream and in cove-out of cove) was recorded for each fish whenever it could be determined. Often fish became so thoroughly entangled, particularly in the 3-inch mesh "flag nets", that it was not possible to determine their direction of travel. When this phase of the study was initiated it was expected that the data obtained might reveal a definite pattern of movement for the different species, such as movement upstream by night and a counteracting downstream movement by day. The results indicate that none of the species, with the possible exception of the smallmouth buffalo, carp, and largemouth bass, shows such a pattern of movement (Table 16). In fact, the direction of travel showing the greatest catch by day also commonly showed the greatest catch by night. There was some indication that the three species mentioned above tend to move upstream at night and downstream by day.

TABLE 16. Upstream-downstream movement of fishes by day and night. The data exclude sets made in coves (Stations 4, 8, and 9), sets at Station 2, all species collected prior to 1954 except gars, and any fish whose direction of travel was questionable.

Species	Day				Night			
	Number of fish		Per cent		Number of fish		Per cent	
	Up	Down	Up	Down	Up	Down	Up	Down
Shortnose gar	5	7	42	58	31	32	49	51
Spotted gar	7	4	64	36	10	9	53	47
Longnose gar	22	23	49	51	64	73	47	53
Gizzard shad	38	60	39	61	559	707	44	56
Goldeye	15	15	50	50	279	468	37	63
Blue sucker	1		100		1	2	33	67
Bigmouth buffalo	1	2	33	67	5	6	45	55
Black buffalo	1		100		6	1	86	14
Smallmouth buffalo	1	4	20	80	37	25	60	40
River carpsucker	51	76	40	60	111	137	45	55
Carp	6	9	40	60	31	24	56	44
Blue catfish	2	1	67	33	21	24	47	53
Channel catfish	7	2	78	22	34	32	52	48
Flathead catfish					2	11	15	85
White bass	43	42	51	49	204	193	51	49
Spotted bass	2	1	67	33	2		100	
Largemouth bass	8	9	47	53	12	8	60	40
Longear sunfish	4	5	44	56	3	3	50	50
Bluegill	25	15	63	37	15	7	68	32
White crappie	42	36	54	46	179	219	45	55
Freshwater drum	5	7	42	58	80	131	38	62
Total	286	318	47	53	1686	2112	44	56

In cove-out of cove movements

The data on movement of fish in and out of coves by day and night are limited but are presented in Table 17. There is some evidence that gizzard shad, river carpsucker, and white bass may tend to move in by night and out by day. The total of all species gave some indication that the general fish population tends to move in by day and out by night. Because the data are limited, their validity remains questionable.

Indications of schooling at night

Certain individual lifts frequently produced a catch which indicated that movement was predominantly in one direction. This was especially noticeable for such species as gizzard shad and goldeye which were sometimes taken in large numbers and would thus better illustrate this point. For example, a set from 6:30 P.M. to 7:30 A.M. April 20-21, 1955, contained 70 gizzard shad moving downstream to 21 moving upstream. Additional evidence is provided by the following data collected on gizzard shad at 2-hour intervals on February 2-3, 1955; 11:00 P.M. to 1:00 A.M., 3 upstream and 24 downstream; 1:00 A.M. to 3:00 A.M., 2 upstream and 21 downstream; 3:00 A.M. to 5:00 A.M., none upstream and 20 downstream. The evidence provided here suggests that the fish were moving about in schools during the night. If so, this does not substantiate the work of Breder and Nigrelli (1935)

TABLE 17. Movement in and out of coves by day and night. Data consist of sets made at Stations 4, 8, and 9 and exclude all species collected prior to 1954 except gars, and any fish whose direction of travel was questionable.

Species	Day				Night			
	Number of fish		Per cent		Number of fish		Per cent	
	In	Out	In	Out	In	Out	In	Out
Shortnose gar						2		100
Spotted gar					1	1	50	50
Longnose gar					1	7	12	88
Gizzard shad	5	4	56	44	79	95	45	55
Goldeye		1		100	27	26	51	49
Blue sucker						1		100
Bigmouth buffalo	2		100		4	3	57	43
Smallmouth buffalo	1		100		6	16	27	73
River carpsucker	18	6	75	25	3	14	18	82
Carp		2		100	11	9	55	45
Blue catfish					1		100	
Channel catfish	5		100		6	4	60	40
Flathead catfish					2	3	40	60
White bass	20	23	47	53	40	25	62	38
Spotted bass		1		100	1		100	
Largemouth bass	7	4	64	36	8	2	80	20
Longear sunfish					1		100	
Bluegill	3	3	50	50	2	4	33	67
White crappie	13	10	57	43	30	36	45	55
Freshwater drum						1		100
Total	74	54	58	42	223	249	47	53

who stated that most, if not all, schooling fishes disperse at night, leading to the belief that schools are largely dependent on vision. They released a fish temporarily blinded with vaseline and lampblack in an aquarium containing a large well-condensed aggregation, and it moved at random for several hours. When the blindfold was removed the fish immediately sought a place in the aggregate and became part of it. Morrow (1948) presents an excellent review of the literature pertaining to the schooling behavior of fishes. He cites several references which maintain that vision is the prime physical factor in the formation of schools. The factors which are responsible for maintaining schools are beyond the scope of this study, but from the data collected it seems that the gizzard shad and goldeye do, at least on some occasions, travel in schools at night.

CHAPTER VI

DISTRIBUTION

Distribution of Species Gill-netted

In establishing the gill-netting stations (Figure 2) the goal in mind was not only to sample various habitats but also to obtain an idea of both vertical and horizontal (upstream-downstream, littoral-limnetic, and in cove-out of cove) fish distribution within the bay. Data for checking differences in horizontal distribution are presented in Table 18. When interpreting the data of this table, the reader should bear in mind that the netting effort was not equal at all stations (Table 3). The total hours of fishing with all nets was distributed as follows among the gill-netting stations: Station 12, 788.50; Station 1, 680.00; Station 6, 636.25; Station 3, 630.75; Station 7, 604.25; Station 10, 572.25; Station 5, 446.25; Station 8, 424.50; Station 4, 420.00; Station 11, 417.25; Station 2, 392.50; Miscellaneous stations, 355.75; Station 9, 351.75; and Station 13, 153.50.

Upstream-downstream distribution

The catch at each station is briefly summarized in

TABLE 18. Numbers of each species collected at each station and the percentage taken at each station of the total of each species collected at all stations combined.

Species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	Misc.	Total
Shortnose gar	4 *(5)	4 (5)	12 (14)	1 (1)	1 (1)			1 (1)		8 (9)		17 (20)	36 (42)	1 (1)	85
Spotted gar		1 (3)	4 (11)	2 (5)						5 (14)		17 (46)	7 (19)	1 (3)	37
Longnose gar	5 (2)	8 (4)	12 (5)	1 –	10 (5)		2 (1)		7 (3)	42 (19)	15 (7)	88 (40)	21 (10)	9 (4)	220
Gizzard shad	171 (9)	275 (14)	410 (21)	73 (4)	59 (3)	161 (8)	208 (11)	59 (3)	59 (3)	92 (5)	134 (7)	157 (8)	55 (3)	52 (3)	1965
Goldeye	222 (18)	116 (9)	210 (17)	24 (2)	45 (4)	125 (10)	75 (6)	29 (2)	12 (1)	108 (9)	61 (5)	126 (10)	2 –	107 (8)	1262
Blue sucker			2 (18)	2 (18)	1 (9)		2 (18)		1 (9)	2 (18)		1 (9)			11
Bigmouth buffalo		2 (5)	1 (2)	8 (20)	3 (7)		3 (7)	5 (12)	3 (7)			13 (32)		3 (7)	41
Black buffalo		1 (8)	1 (8)			1 (8)	4 (31)			1 (8)		4 (31)	1 (8)		13
Smallmouth buffalo	3 (2)	6 (3)	34 (18)	22 (12)	3 (2)	6 (3)	3 (2)	13 (7)	3 (2)	43 (23)	4 (2)	38 (21)	4 (2)	3 (2)	185
River carpsucker	3 (1)	24 (4)	61 (11)	21 (4)	2 (1)		11 (2)	10 (2)	13 (2)	79 (14)		252 (44)	81 (14)	10 (2)	567
Golden redhorse			1 (100)												1
Carp	3 (1)	17 (6)	31 (10)	19 (6)	2 (1)	8 (3)	4 (1)	19 (6)	5 (2)	51 (17)	22 (7)	93 (31)	7 (2)	20 (7)	301
Blue catfish	21 (25)	10 (12)	13 (15)	2 (2)		11 (13)	6 (7)			1 (1)	2 (2)	9 (11)	1 (1)	8 (10)	84
Channel catfish	4 (3)	13 (8)	8 (5)	3 (2)	7 (4)	5 (3)	15 (9)	10 (6)	7 (4)	23 (14)	2 (1)	30 (19)	14 (9)	18 (11)	159
Flathead catfish	1 (3)	2 (5)	3 (8)	3 (8)	1 (3)	1 (3)	7 (19)	6 (16)	1 (3)	6 (16)	3 (8)	1 (3)	1 (3)	1 (3)	37
Whitebass	24 (2)	149 (15)	145 (14)	38 (4)	27 (3)	9 (1)	169 (17)	47 (5)	27 (3)	161 (16)	17 (2)	131 (13)	40 (4)	22 (2)	1006
Spotted bass			1 (13)					2 (25)		2 (25)		1 (13)	2 (25)		8
Largemouth bass		6 (6)	3 (3)	4 (4)	6 (6)	1 (1)	9 (10)	18 (19)	11 (12)	8 (9)	1 (1)	25 (27)		1 (1)	93
Warmouth												1 (100)			1
Longear sunfish				1 (5)								8 (40)	11 (55)		20
Bluegill	1 (1)	3 (3)	1 (1)	12 (13)				2 (2)	1 (1)	3 (3)	1 (1)	31 (34)	34 (37)	3 (3)	92
White crappie	59 (8)	66 (9)	80 (11)	33 (4)	50 (7)	24 (3)	100 (14)	30 (4)	32 (4)	75 (10)	8 (1)	114 (15)	28 (4)	38 (5)	737
Freshwater drum	12 (4)	5 (2)	25 (9)		56 (19)	103 (35)	12 (4)	3 (1)	1 –	22 (8)	3 (1)	36 (12)	5 (2)	10 (3)	293
Total	533 (7)	708 (10)	1058 (15)	269 (4)	273 (4)	455 (6)	630 (9)	254 (4)	183 (3)	732 (10)	273 (4)	1193 (17)	350 (5)	307 (4)	7218

*Percentage (to the nearest one per cent) of the total collected at all stations combined.
A dash (–) indicates less than one-half of one per cent.

the following paragraphs by presenting the principal species (those collected in greatest numbers) in order of their abundance, the percentage which each represents of its total collected at all stations (in parentheses), and usually comments on other less common species for which a high percentage of their total number was collected at that station.

Station 1. Goldeye (18), gizzard shad (9), and white crappie (8). The blue catfish was not taken abundantly at any of the stations, but this station produced 25 per cent of its total catch.

Station 2. Gizzard shad (14), goldeye (9), white bass (15), and white crappie (9).

Station 3. Gizzard shad (21), goldeye (17), white bass (14), and white crappie (11). This station also accounted for a rather high percentage of the total catch of smallmouth buffalo (18), blue catfish (15), and shortnose gar (14). Two of the 11 blue suckers and the only golden redhorse collected were taken at this station.

Station 4. Gizzard shad (4), white bass (4), and white crappie (4). The catch at this station was low but can probably be attributed to the low netting effort and the high percentage of 3-inch mesh nets used. However, this station ranked high in the catch of bigmouth buffalo (20), smallmouth buffalo (12), and bluegill (13). Two of the blue suckers were also taken here.

Station 5. Gizzard shad (3), freshwater drum (19), white crappie (7), and goldeye (4).

<u>Station 6</u>. Gizzard shad (8), goldeye (10), fresh-water drum (35), and blue catfish (13). For all other species, the catch at this station constituted only a small percentage or none of the total catch of the species. There were no gars collected, and the only centrarchids were 24 white crappie and one largemouth bass.

<u>Station 7</u>. Gizzard shad (11), white bass (17), and white crappie (14). A large percentage of the black buffalo (31), flathead catfish (19), and largemouth bass (10) were taken at this station though the percentages are based on only a few fish.

<u>Station 8</u>. Gizzard shad (3), white bass (5), and white crappie (4). Although these species were taken in greater abundance than others, the catch of each was low and consequently represents only a small percentage of their total from all stations. However, the catch at this station accounted for a high percentage of the total catch of large-mouth bass (19), flathead catfish (16), and bigmouth buffalo (12).

<u>Station 9</u>. Gizzard shad (3), white crappie (4), and white bass (3). The catch at this station was very similar to that of Station 8. A rather high percentage of the large-mouth bass (12) was taken, considering that fewer hours were fished here than at any other station except Station 13.

<u>Station 10</u>. White bass (16), goldeye (9), gizzard

shad (5), river carpsucker (14), and white crappie (10). In addition to these species which were more commonly collected, this station accounted for a high percentage of the following species: smallmouth buffalo (23), longnose gar (19), carp (17), flathead catfish (16), channel catfish (14), and spotted gar (14). Two of the 11 blue suckers and two of the eight spotted bass were taken here.

Station 11. Gizzard shad (7), goldeye (5), and carp (7). The catch was very low for all species, but this can be attributed to the very high proportion of 3-inch mesh nets that were used.

Station 12. River carpsucker (44), gizzard shad (8), white bass (13), goldeye (10), and white crappie (15). A high percentage of the total catch was obtained for most of the species at this station. The highest percentage of all stations was obtained for nine species. However, over 100 more gill-net hours were fished here than at any other station, and only approximately one-third of the total hours fished was with 3-inch mesh nets which consistently caught fewer fish. Other species taken at this station and the percentage of their total catch were: spotted gar (46), longnose gar (40), longear sunfish (40), bluegill (34), bigmouth buffalo (32), black buffalo (31), carp (31), largemouth bass (27), smallmouth buffalo (21), shortnose gar (20), and channel catfish (19). The one warmouth collected was taken here. Turbidity was ordinarily higher at this station than at other stations because it was shallow and subject to considerable wave action. This may be partially accountable for the higher catch at this station, particularly the centrarchids which are reputed to avoid nets.

Station 13. River carpsucker (14), gizzard shad (3), white bass (4), shortnose gar (42). Additional species whose catch at this station ranked high in the percentage of the total catch of each are: longear sunfish (55), bluegill (37), spotted gar (19), and longnose gar (10). Two of the eight spotted bass were collected here. Fewer hours of netting were done here than at any other station, but only 22 of the 153.50 hours fished were with 3-inch mesh nets.

Miscellaneous stations. Goldeye (8), gizzard shad (3), and white crappie (5).

Since the different types of nets were not fished equally at all stations, it is difficult to be certain how the stations rank in regard to productiveness. It has been shown in Tables 9-12 that there is little variation in the over-all catch of fish per gill-net hour in the different nets except for the 3-inch mesh nets (3-inch mesh, 0.158; 2-inch mesh, 1.508; 1½-inch mesh, 1.892; experimental net, 1.781). The data of Table 19 provide a comparison for each station of the percentage of the total catch of all species combined (catch percentage) with the percentage of the total gill-net hours with all nets (netting percentage). If the percentage of netting with 3-inch mesh nets at each station

TABLE 19. Per cent of the total catch (all species), per cent of the total gill-net hours (all nets), and per cent of netting with 3-inch mesh nets for each of the stations. All figures are expressed to the nearest one per cent.

	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	Misc.
Per cent of total catch	7	10	15	4	4	6	9	4	3	10	4	17	5	4
Per cent of total gill-net hours	10	6	9	6	6	9	9	6	5	8	6	11	2	5
Per cent of netting with 3-inch mesh nets	24	29	31	61	53	60	59	42	44	27	78	34	14	61

(Table 19) is considered when the data are interpreted, it is possible to deduce which stations are probably the most and least productive. Thus, the catch percentage exceeded the netting percentage for the following stations (amount exceeded given in parentheses): 2, (4); 3, (6); 10, (2); 12, (6); and 13, (3). According to this method of analysis, stations 12 and 3 appear to be the most productive. The catch percentage and netting percentage were equal for Station 7. This would indicate that the productiveness of this station, compared to the others, was also quite high since 59 per cent of the netting was with 3-inch mesh nets. The percentage of netting with 3-inch mesh nets was high for all stations where the netting percentage exceeded the catch percentage, with the exception of Station 1. Therefore, it seems probable that there is little difference in the productivity of these stations and those whose catch percentage only slightly exceeded the netting percentage but involved less netting with 3-inch mesh nets. Station 1 was quite definitely the least productive of the stations. Its catch percentage was three per cent less than the netting percentage though only 24 per cent of the netting was with 3-inch mesh nets. This was the deepest of the stations, and, except when surface or near-surface sets were made which frequently took good catches of goldeye, the catch was usually low.

The general upstream-downstream distribution of each species is summarized below. In this discussion, reference made to the downstream area refers to Stations 1, 2, 3, and 4 and reference to the upstream area refers to the upper part of the inundated region or Stations 10, 11, 12, and 13. It does not include the creek channel upstream from Station 13.

Shortnose gar. This species was most common in the upstream area. More than half of the specimens (62 per cent) were collected at Stations 12 and 13 although a large number of those taken at Station 13 were collected while on a spawning run. Several were taken near the mouth, but only two were taken from the region of Stations 5-9. The high percentage of 3-inch mesh nets used at these stations is at least partially accountable for this low catch.

Spotted gar. Of all the gars, this species was the most closely associated with the upper part of the inundated region. Stations 12 and 13 accounted for 65 per cent of the total catch.

Longnose gar. Like the other gars, this species was most common in the upstream area where it was taken most abundantly at Stations 12, 10, and 13, in the order listed. Most of the catch at Station 13 was the result of a spawning run. The catch at Station 10 (19 per cent) and that of the downstream stations suggest that this species is not quite as closely associated with the upstream area as the other two species of gars.

Gizzard shad. This species ranked high in the catch of all stations, but, in general, was taken most abundantly at the downstream stations. The catch at Station 3 produced 21 per cent of the total catch of the species while Station 12 produced only eight per cent even though more than 150 more gill-net hours were fished at Station 12 than at Station 3. The difference in usage of 3-inch mesh nets was only slightly greater at Station 12 than at Station 3.

Goldeye. Although this species was collected at all stations, it was most abundant in the downstream area. Stations 1 and 3 accounted for 35 per cent of the total catch.

Blue sucker. The few fish of this species were collected from various stations extending from Station 3 near the mouth of the creek to Station 12 upstream.

Bigmouth buffalo. The catch was scattered among the stations, but the largest number was taken at Station 12.

Black buffalo. Only eight were collected. They were distributed from Station 2 of the downstream area to Station 13 at the extreme upper part of the inundated region.

Smallmouth buffalo. No definite trends of upstream-downstream distribution are indicated. It was taken at all stations in approximately equal numbers except that the catch was greatest at those stations where the netting effort was particularly heavy.

River carpsucker. This species was definitely most abundant in the upstream area in the shallow mud-flat region of Station 12. This station accounted for 44 per cent of the total catch. Borges (1950) found that recently inundated fields were productive for carpsuckers, and Bass (1954) found that they were most often collected in water not exceeding 10 feet in depth over bottoms of silt or sand and silt. The evidence presented here support their data.

Golden redhorse. The only specimen collected was taken at station 3 at the mouth of the creek. It is interesting to note that the other two specimens of this species previously taken from Buncombe Creek were also collected near the mouth.

Carp. Though this species was collected at all stations, almost half (48 per cent) were collected from Stations 10 and 12 which suggests a preference for the shallow water over the mud flats upstream in the bay.

Blue catfish. A definite preference was shown for the downstream area where the water was deeper than upstream.

Channel catfish. The catches at Stations 10 and 12 suggest a somewhat greater abundance in the upstream area. However, it was taken at all stations and apparently has a very general distribution.

Flathead catfish. The distribution of this species appears quite general also, for it was collected at all stations even though the total catch was small. It was taken chiefly by 3-inch mesh nets. Station 10 was probably the most productive since its catch was among the highest and its use of 3-inch mesh nets among the lowest of all stations.

White bass. This species was collected at all stations and was well represented in both the upstream and downstream areas. It was taken most abundantly at Station 7 even though a high percentage of the netting at this station was with 3-inch mesh nets.

Spotted bass. Both the upstream and downstream areas were represented by the few fish taken.

Largemouth bass. The largest catches were taken at Stations 12 and 8, but the species appears to have a rather general upstream-downstream distribution.

Warmouth. The only specimen collected was taken at Station 12.

Longear sunfish. Only 20 fish of this species were collected, but 19 of these were taken from Stations 12 and 13 which suggests a preference for the upstream area.

Bluegill. Stations 12 and 13 accounted for 71 per cent of the total catch. A few were taken in the downstream area, but direct observations along the shore indicated that they were considerably more common in this area than is revealed by the data.

White crappie. This species was represented in the catch of all stations and indicated no definite trends in preference of upstream or downstream areas of the bay.

Freshwater drum. Fifty-four per cent of the collection of this species was taken from Stations 5 and 6. However, the catch at these stations consisted of a few large catches made in July; therefore, the data may not indicate the typical distribution. It was quite generally distributed among the other stations.

Shoreline-midchannel distribution

By comparing the catch of Stations 1, 6, and 11 (midchannel stations) with Stations 2, 3, 5, 7, and 10 (shoreline stations), differences in preference of the species for littoral or limnetic habitats are revealed. Data of the other stations are not considered in this discussion since the sets in cove stations (Stations 4, 8, and 9) and at Stations 12 and 13 had characteristics of both littoral and limnetic sets. With the exception of Station 5, where the gradient was steep, the shoreline stations represented rather shallow regions with a gradual increase in depth from 0 to rarely more than 40 feet (usually less than 30 feet) whereas the midchannel stations were deeper than corresponding shoreline stations at the same water level and provided a large expanse of open water.

The catch of shoreline stations was considerably greater than midchannel stations for most species (Table 18). Blue catfish, goldeye, gizzard shad, freshwater drum, and, at times, white crappie were commonly taken at midchannel. Blue catfish, goldeye, and possibly the freshwater drum appear to be the only species which can be taken more abundantly at midchannel than along the shoreline. The high percentage of blue catfish caught at Stations 1 and 6 suggests a preference for deep water. Large catches of goldeye were frequently taken from sets near the shore, but surface sets over deep water were usually more productive. Martin (1952) also found surface sets and sets in open water (more than 25 feet from the shore) most effective in netting this species. The data show that the largest catch of freshwater drum was definitely at midchannel (Station 6), but these data were taken primarily from a few sets in July and may not represent typical conditions.

Certain species were not taken or rarely taken at midchannel at deep-water stations. With the exception of the white crappie, this was true of all other centrarchids collected (spotted bass, largemouth bass, warmouth, longear sunfish, and bluegill) although the catch of these species was small and would not justify any conclusions. No spotted gar, blue sucker, bigmouth buffalo, golden redhorse, and only one river carpsucker were collected from midchannel stations. Again, it must be emphasized that, except for the river carpsucker, all of these species were taken in small numbers. A few very large bigmouth buffalo were taken at Station 1 in a ragged 5-inch mesh net, but the data are not included here.

In cove-out of cove distribution

Stations 4, 8, and 9 show the catch of each species from three coves (Table 18). A comparison of their data with other stations indicates that bigmouth buffalo and largemouth bass are attracted to certain coves. The catch of goldeye, blue catfish, and freshwater drum was very low in coves while other species collected regularly appeared to present no definite trends if differences in amount of netting and net types are considered.

Depth distribution

Much of the work on depth distribution of fish in freshwater lakes has been conducted on the T.V.A. reservoirs. Some of the more important studies of this type are those of Dendy (1945, 1946), Cady (1945), and Haslbauer (1945) on Norris Reservoir, Tennessee; Dendy (1948) on Norris, Douglas, and Cherokee Reservoirs, Tennessee; Bryan and Howell (1946) on Wheeler Reservoir, Alabama; Hile and Juday (1941) on some lakes of the Northeastern Highlands of Wisconsin; Odell (1932) on some New York lakes; and Borges (1950) on the Niangua arm of the Lake of the Ozarks, Missouri. All of these studies were helpful in various ways, but the conditions of Wheeler Reservoir, Alabama, seemed most nearly comparable to those of the Buncombe Creek arm of Lake Texoma. Since these studies were based on data obtained almost exclusively from bottom sets, it seems reasonable that sets made at various depths from the surface to the bottom in water of different depths, as in this study, should give a more detailed and accurate concept of depth distribution. However, the data obtained by setting nets at various depths cannot be as intensive at a particular location as data from bottom sets alone unless considerably more effort is applied than one person can give. This is because the additional sets that must be made at various depths from the surface to the bottom preclude duplicating each type of set as frequently as would be possible if only bottom sets were made. Since most of the netting was done without assistance, the frequency with which a particular type of set could be duplicated was definitely limited.

Setting nets at various depths below the surface may result in confusion when discussing the depths at which fish are caught, for the depth given might be interpreted as the total depth of the water or as the depth below the surface at which the fish were caught. In the discussion which follows, a statement such as, "---in water 40 feet deep", has reference to fish distributed somewhere between the surface and the bottom where the total depth of the water was 40 feet, and not necessarily that the fish were at a depth of 40 feet below the surface. All references to depths are therefore to total depths unless specifically stated as a depth below the surface or above the bottom.

Figures 9-16 diagrammatically present the data on depth distribution for 20 of the 23 species gill-netted from January, 1954, to August, 1955. When the distribution is presented by months, it represents the combined catch during both years for those months applicable. The data include both day and night sets. Because the different species varied in abundance, it was advantageous to treat their data differently. The depth distribution of each of those species most abundant in the collections (gizzard shad, goldeye, white bass, and white crappie) is shown for each of 10 months. For those species which were next most abundant in the collections, the data of several months have been combined in an effort to show their depth distribution during certain seasons of the year. Finally, the data of all months were combined for those species which were least abundant in the collections.

Each diagram represents a generalized cross section of the lake from shore to midchannel, but cannot be interpreted as such literally since the data of all stations are combined. Thus, the data of Station 12 were always placed in the shallow end of the diagram though the distance from the shore was sometimes more than 100 yards whereas most of the data of Station 5 (a shoreline station with a steep gradient) was placed in the deeper end. The number of fish collected, and usually the period of time covered by the data, are shown with the diagrams for each species. If the period covered by the data is not given, the data represent the combined catch of all months. Because it was not possible to keep nets set at all depths during all times of the year, the data presented within each diagram must be interpreted in conjunction with the netting effort at different depths as shown in Table 4. The netting effort has been considered in the discussion of each species which will follow. It is almost certain that the paucity of fish in the upper three feet as indicated in some of the diagrams was not actual since it was often necessary to set the nets three feet below the surface to avoid boats, particularly in the spring and summer months. The practice of assuming an average depth of catch in the nets frequently gives the appearance of bunching at 2-foot intervals if the netting effort was light.

In the following discussion of each species, figures placed in parentheses after the month(s) being discussed represent the number of fish collected during that period. For those species for which the data of all months are combined, the number of fish collected is placed in parentheses following the name of the species.

Gizzard shad (Figure 9).

January (39). The fish seemed most closely associated with the bottom. Collecting was limited mainly to water less than 10 feet deep.

February (265). The fish were concentrated in the bottom six feet in water not exceeding 20 feet in depth.

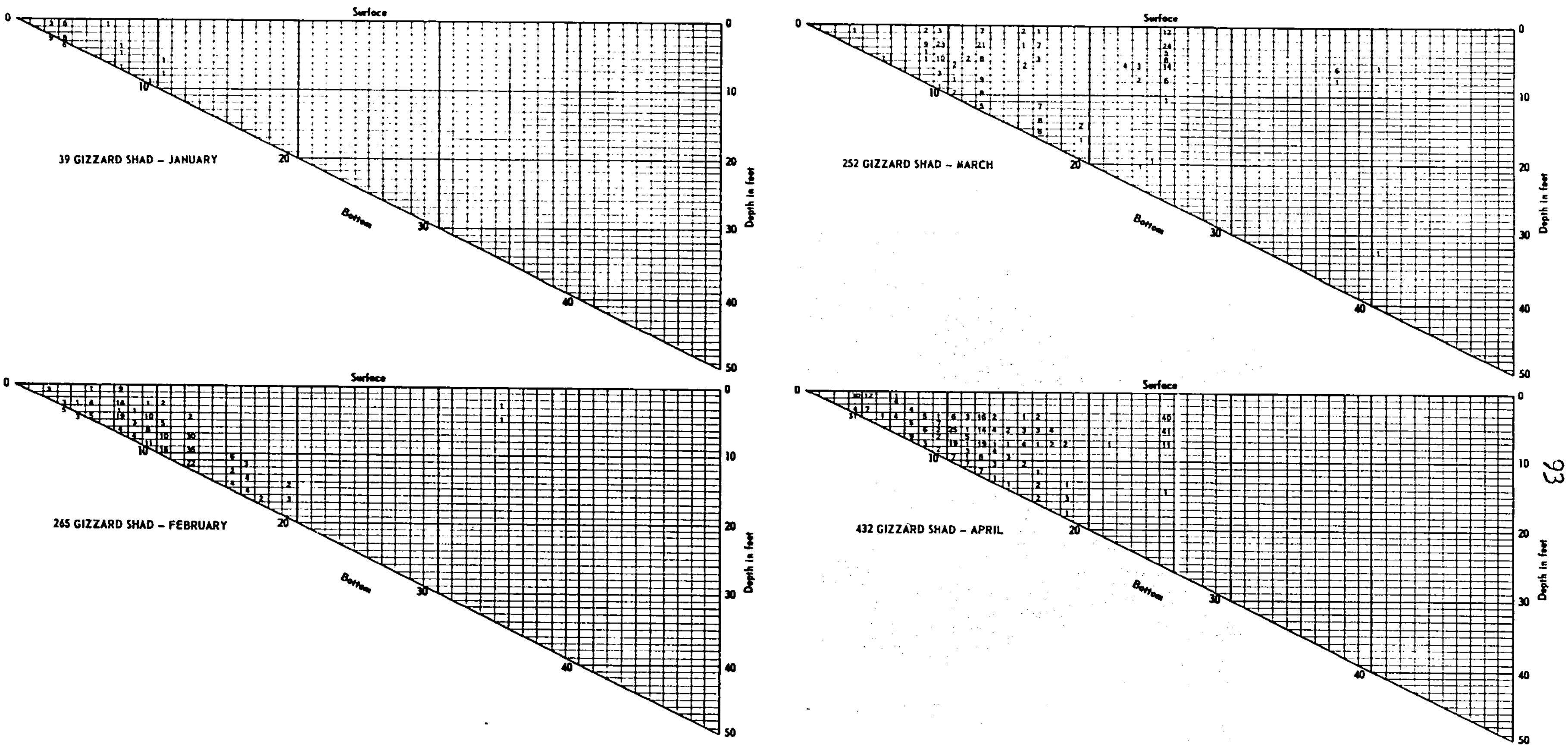


FIGURE 9. Depth distribution of the gizzard shad. Numbers in the diagrams represent the numbers of fish collected at the depth indicated by their position.

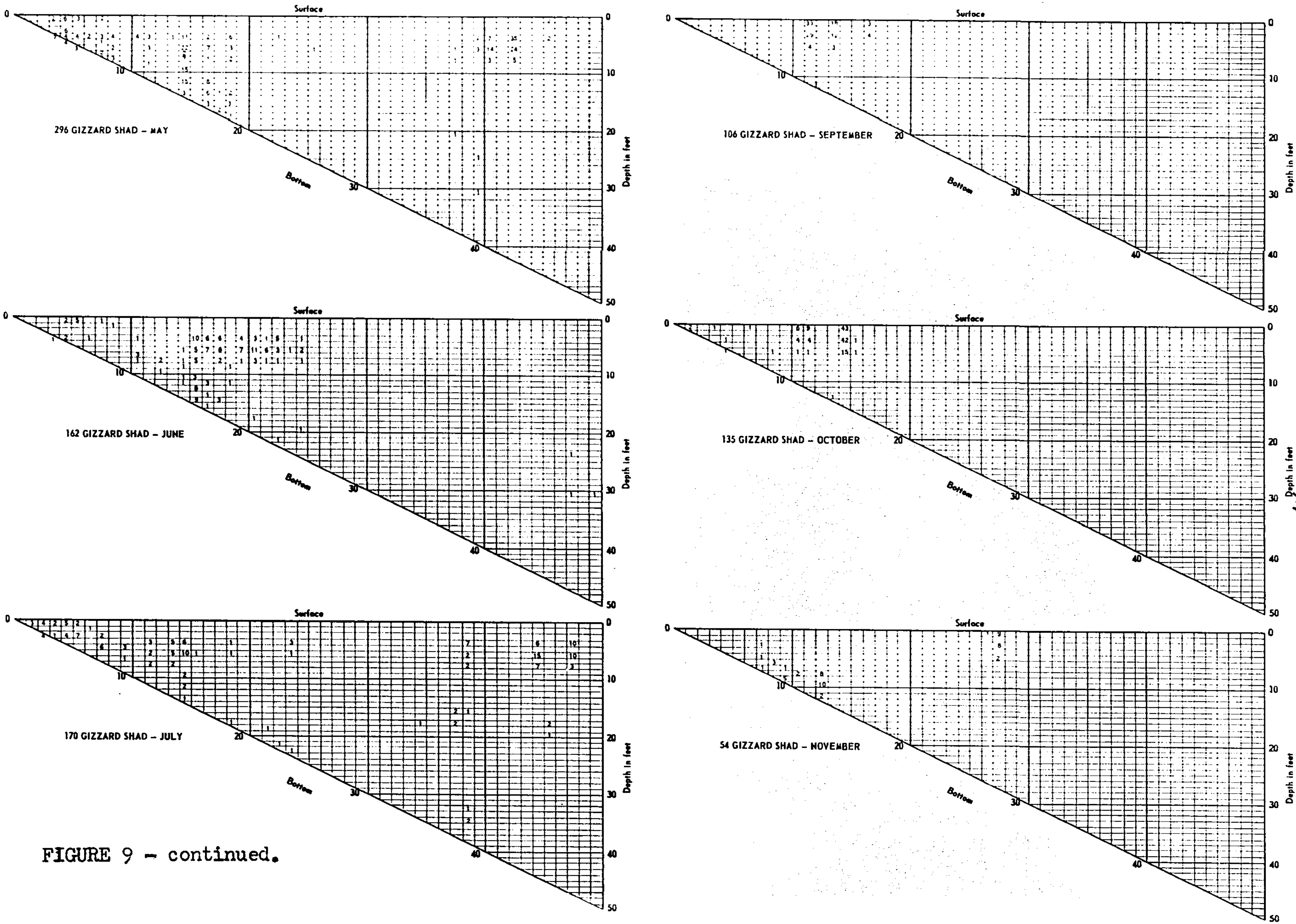


FIGURE 9 – continued.

Only two fish were taken in water more than 20 feet deep though several sets were made at various depths in deeper water.

March (252). Distribution was more scattered than in February, but the largest numbers were collected in the upper 10 feet in water less than 30 feet deep.

April (432). Distribution was very similar to that of March with the greatest concentration occurring in the upper 10 feet. Most of the netting was in this depth range, but sets were made below the upper 10 feet in water varying from 21-30 feet and only one fish was collected.

May (296). The netting effort was similar to that of March, but larger numbers were taken in water exceeding 40 feet in depth. The greatest concentration remained in the upper 10 feet.

June (162). No netting was done in water exceeding 35 feet in depth. The data obtained indicated that the greatest concentration remained in the upper 10 feet.

July (170). Although the largest numbers were still taken from the upper 10 feet, the distribution was quite scattered. Fish were taken at virtually all depths from surface to bottom in water varying from 0-40 feet in depth and in the upper 20 feet in water where the depth was 40-50 feet.

September (106). The data presented here came from one surface set. However, since the catch was larger than usual, it very probably represented a region of high concentration. The largest numbers were taken within one foot of the surface. All of these fish were small (5.3 to 9.2 inches in total-length).

October (135). All collections were made in water not exceeding 20 feet in depth and the data suggest a repetition of conditions in September. The largest numbers occurred within three feet of the surface.

November (54). These data suggest a continued scattered type of distribution with the greatest concentration in the upper 10 feet.

According to these data, the gizzard shad occurred in greatest abundance in the upper 10 feet of water throughout most of the year. It occurred near the bottom in January and February and was most abundant in water not more than 20 feet in depth. In March it had a general distribution from top to bottom with the greatest concentration in the upper 10 feet, and had moved towards deeper water. This more scattered type of distribution appeared to continue until the return of cold weather. Haslbauer (1945) obtained about equal numbers of shad in the upper, middle, and lower one-thirds of nets set on the bottom.

Goldeye (Figure 10).

January (32). No fish were taken in water exceeding 12 feet in depth though some netting was done in the

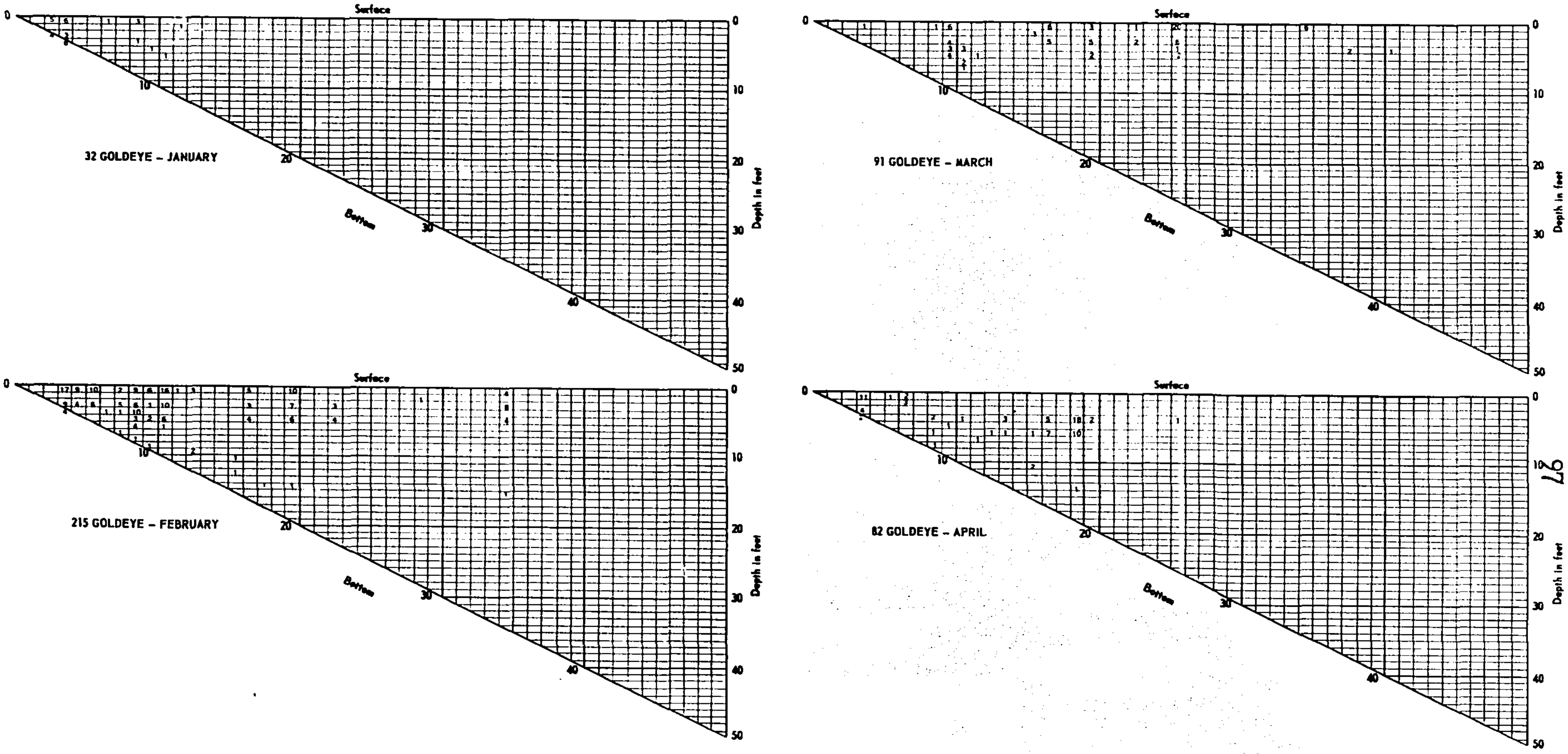


FIGURE 10. Depth distribution of the goldeye. (See legend of Figure 9.)

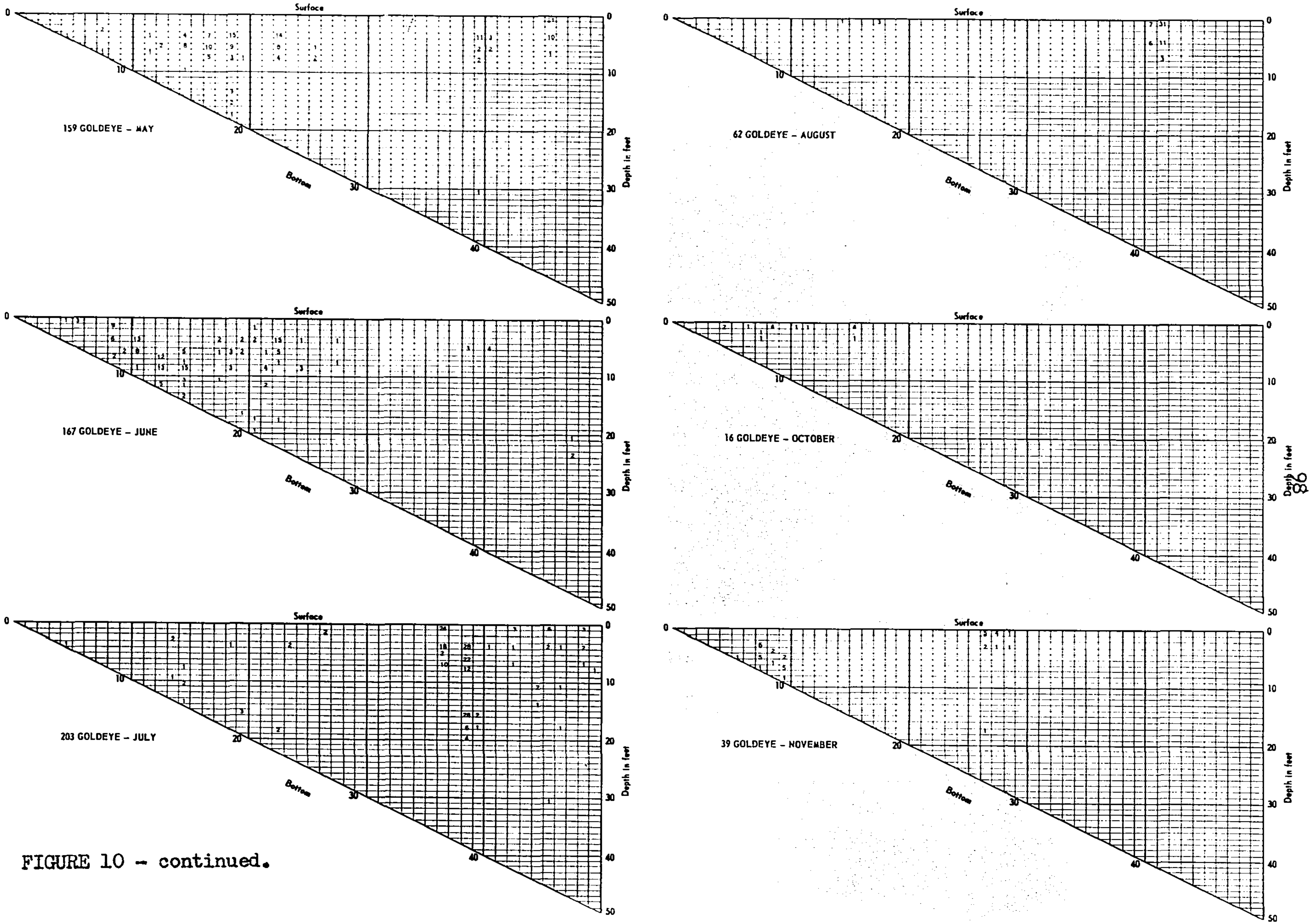


FIGURE 10 - continued.

upper 10 feet of water 21-30 feet deep. All fish were taken within six feet of the surface.

February (215). Of the 215 fish for which data are presented, 200 were collected within five feet of the surface. This distribution cannot be attributed to insufficient netting effort at greater depths, for nets were set at all depths in water which varied from 0-40 feet. A few fish were taken in the deeper water, but most (190) were collected in water not exceeding 20 feet in depth.

March (91). No fish were taken more than seven feet below the surface. There was a definite trend to move out to deeper water. The largest number was collected in the upper one foot in water 27 feet deep. It seems significant to point out that strictly bottom sets would not have detected this movement and would have taken fish only in the very shallow water, thus giving an erroneous impression of both abundance and distribution.

April (82), May (159), June (167), and July (203). During these months the fish were more widely distributed in depth than in previous months, but the greatest concentration remained in the upper 10 feet. In both May and July a fish was taken 31 feet below the surface. The scarcity of fish at all depths in deep water in the collections of April and June can probably be attributed to low netting effort. The combined data of May and July show that only five fish were taken in water 10 feet or less in depth, but large numbers occurred in water exceeding 35 feet in depth. The small number collected in shallow water was not due to lack of effort there. However, greater numbers than are shown for these months were present in shallow water in both April and June. It should be noted that considerable numbers were taken from 16-20 feet below the surface in water 39 feet deep in July.

August (62). The netting effort was very limited, but those fish collected suggest a continuation of the distribution pattern of July.

October (16) and November (39). The data are limited but suggest that the fish were apparently still concentrated in the upper 10 feet.

From these data, it seems that the goldeye occurs in greatest abundance in the upper 10 feet (largest catches are frequently at the surface) throughout the year, and that any netting for this species at a depth greater than 20 feet below the surface is wasted effort. Although considerable netting was done at depths greater than 20 feet, such sets accounted for only five of the 1066 fish for which data are presented. The fish were concentrated near the shore during midwinter but in March showed evidence of movement to deeper water where some of the larger catches were taken near the surface in the spring and summer months.

White bass (Figure 11).

January (12). The scattered distribution of the

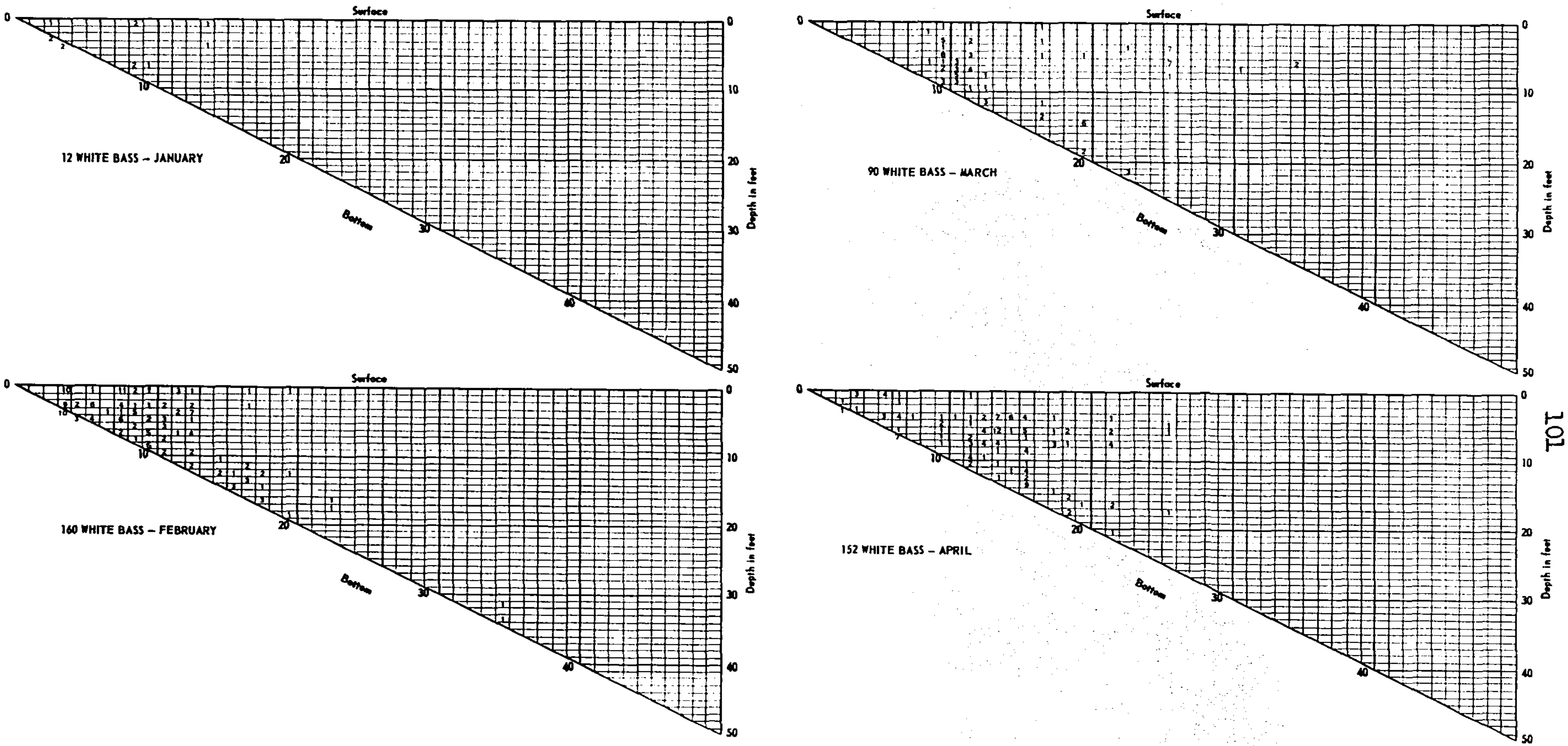


FIGURE 11. Depth distribution of the white bass. (See legend of Figure 9.)

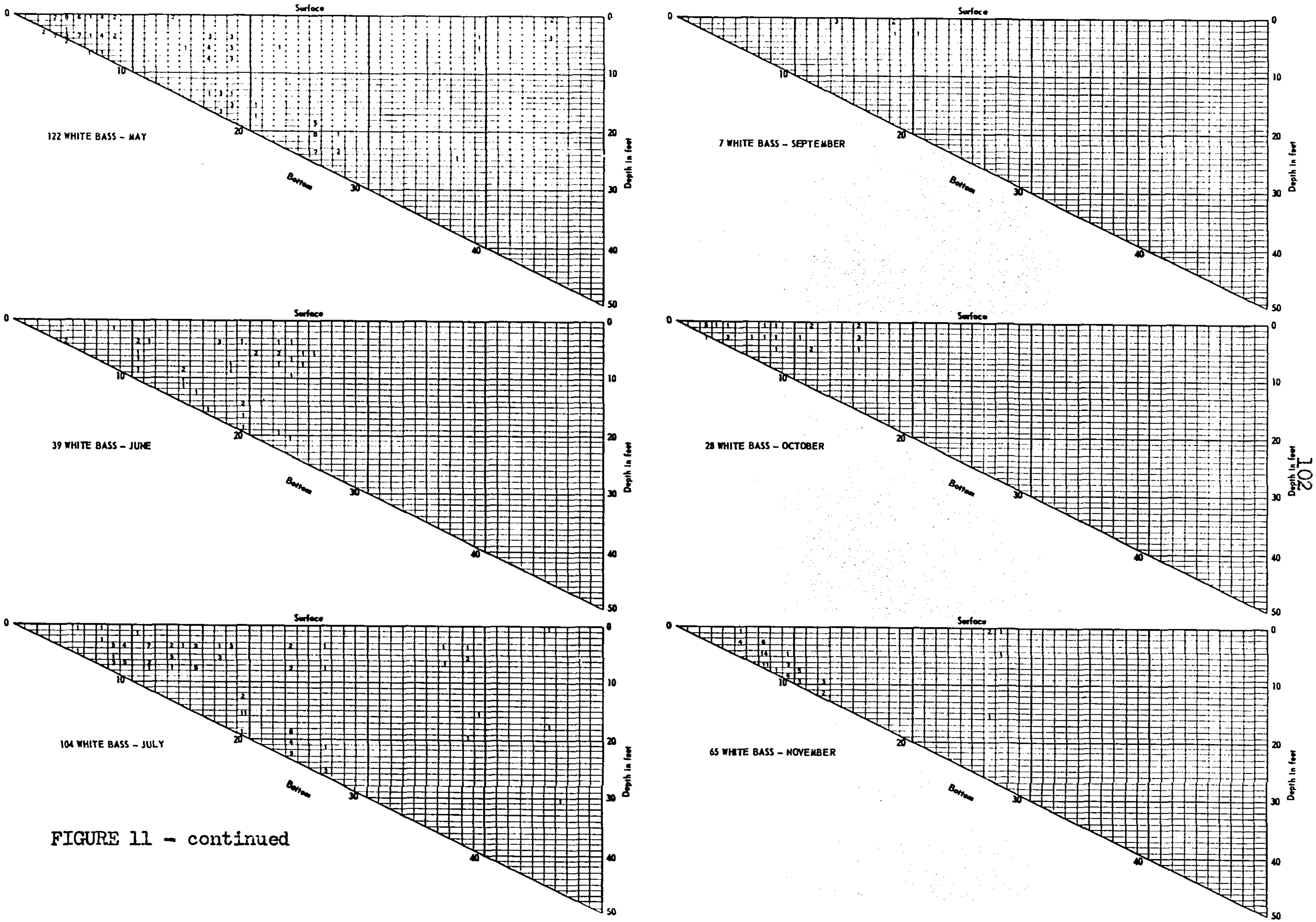


FIGURE 11 - continued

12 fish collected appears to correspond with that of February.

February (160). Although netting was done at all depths in water varying from 0-40 feet, only four of the 160 fish collected were taken in water more than 20 feet in depth. These were taken near the bottom. Those fish collected in water not exceeding 20 feet in depth were approximately equally distributed from the surface to the bottom.

March (90) and April (152). Most of the fish were collected in water not more than 23 feet deep. These appeared to be about equally distributed from the surface to the bottom. Some of the fish moved out to deeper water in March where they were collected more commonly in the upper 10 feet.

May (122), June (39), and July (104). Most of the fish continued to be widely scattered from the surface to the bottom in water not more than 27 feet deep. Several fish were taken in water more than 40 feet deep where they occurred from the surface to a depth of 31 feet.

September (7) and October (28). The netting effort was limited almost entirely to the upper 10 feet in shallow water which accounts for the restricted distribution.

November (65). The data here are not sufficient to warrant any conclusions but suggest a closer association of the fish with the bottom than in previous months.

Although this species was frequently taken in deep water after February, the greatest numbers were collected in water not exceeding 20 feet in depth throughout all months for which data are presented. In areas of this depth, it was well distributed from the surface to the bottom for all months except September (when the netting effort was very low and sampling was probably inadequate) and November when there seemed to be a closer association with the bottom.

White crappie (Figure 12).

February (18). Only 18 of this species were collected although the netting effort was quite thorough at all depths in water varying from 0-40 feet deep. The distribution indicated a rather close association with the bottom in shallow water (not more than 20 feet deep) or with intermediate depths in deeper water. Two fish were collected in the upper 10 feet, 12 at depths 11-20 feet below the surface, and four at depths greater than 20 feet below the surface. Only one fish was taken in water less than 15 feet deep.

March (27). The catch was low but those fish collected exhibited a very scattered type of distribution occurring at virtually all depths in the regions netted. This included practically all depths of water to 40 feet below the surface in water varying in depth from 0 to approximately 50 feet. There was definitely a tendency for the fish to occur nearer the surface than in February. Of the 27 fish collected, 19 were taken in the upper 10 feet of water.

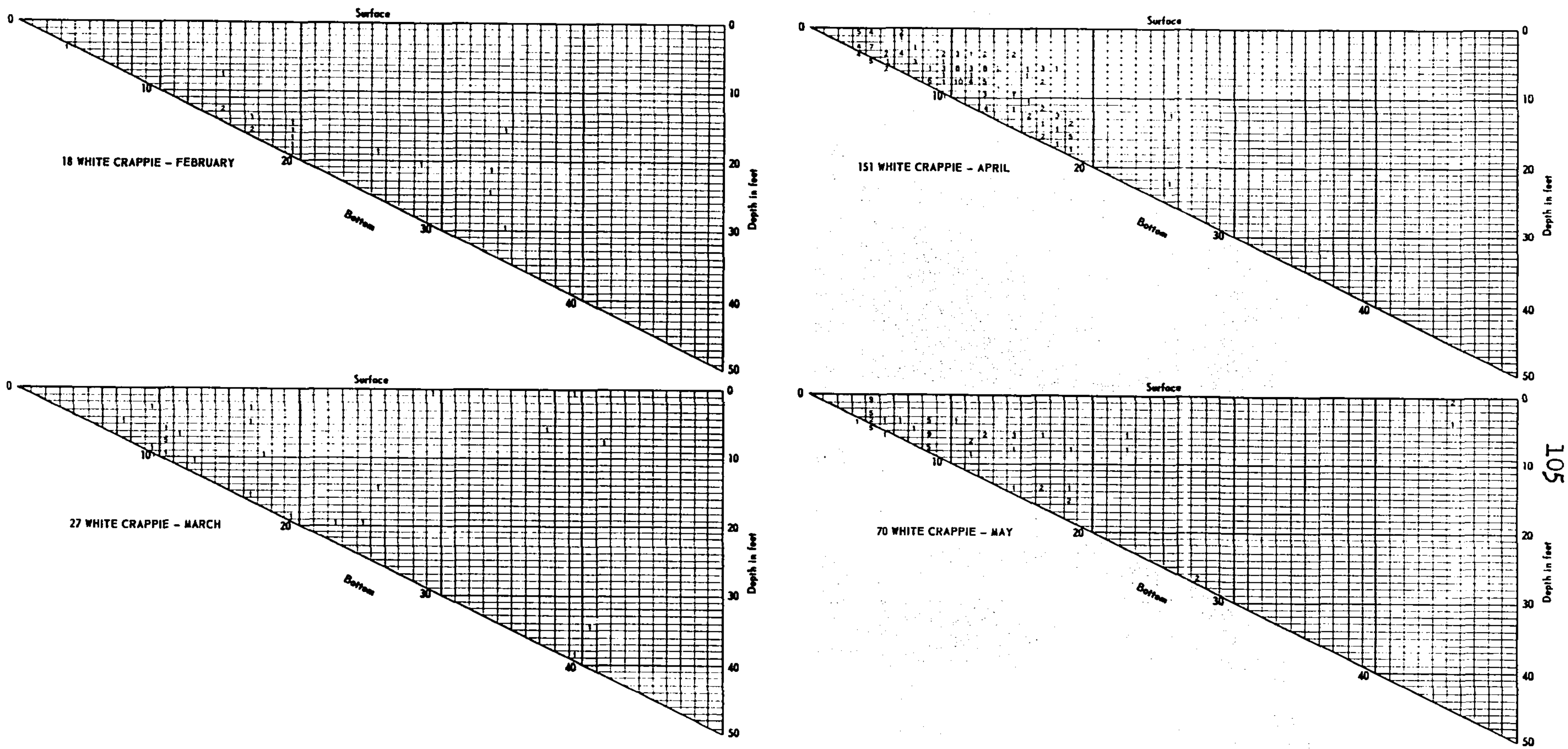


FIGURE 12. Depth distribution of the white crappie. (See legend of Figure 9.)

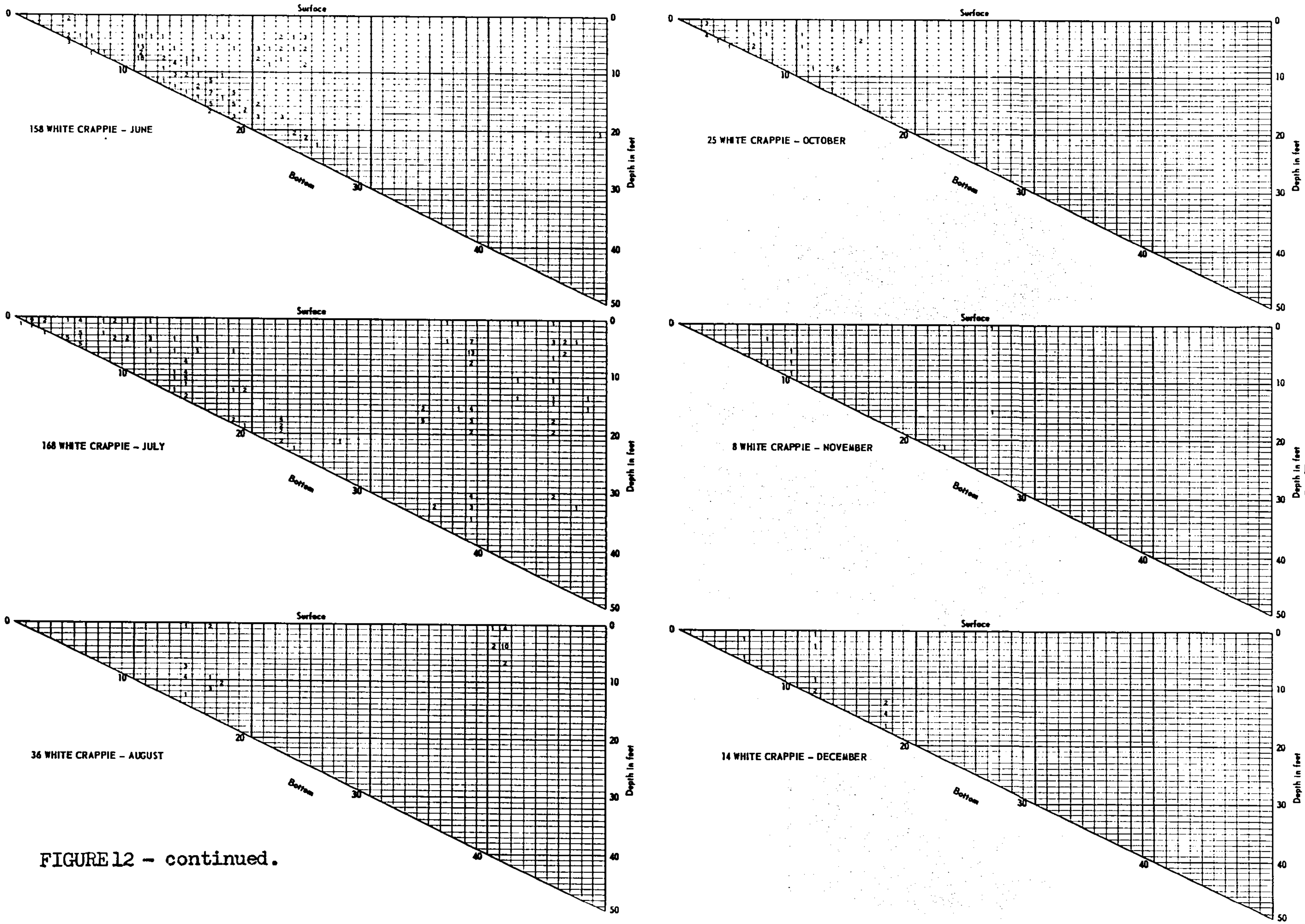


FIGURE 12 - continued.

April (151) and May (70). The data for these months show that white crappie were most abundant in shallow water where the depth was not more than 20 feet. Here, they were distributed at essentially all depths with the greatest concentration in the upper 10 feet. The combined data of these months show that only nine of the 221 fish collected were taken in water where the depth exceeded 20 feet.

June (158). The greatest numbers were collected in water not more than 20 feet deep (chiefly in water 10-20 feet deep), but 36 of the 158 fish collected were taken where the depths exceeded 20 feet. This indicates the beginning of the return to deep water as evidenced by the data of July.

July (168). An extremely scattered distribution was exhibited for this month. Fish were taken at practically all depths in water varying from 1-49 feet deep. The distribution of fish by depth intervals below the surface was as follows: 0-10 feet, 98; 11-20 feet, 53; 21-30 feet, 4; 31-40 feet, 13. No netting was done below a depth of 40 feet which explains the absence of fish caught below this depth. More than half (89 of 168) were collected in water more than 20 feet deep.

August (36). The distribution of those fish collected suggest the same pattern of distribution as in July.

October (25), November (8), and December (14). The limited data presented in these months do not warrant any conclusions.

The data show that the chief concentration of this species is as follows: winter--mostly near the bottom in shallow water or at intermediate depths in deep water; spring--shallow water (usually not more than 20 feet deep) with fairly even distribution from the surface to the bottom; and summer--deep water with distribution from the surface to a depth of at least 35 feet below the surface.

Shortnose gar (81; Figure 13).

This species was taken in greatest abundance from the upper one foot in water less than 10 feet deep. Only 20 of thd 81 specimens were collected in water where the depth exceeded 10 feet and only five in water where the depth exceeded 20 feet.

Longnose gar (Figure 13).

January, February, March, and October (48). All were collected from water less than 17 feet deep. The largest catch occurred in the upper one foot in water three feet deep.

April, May, June, July, and September (155). The catch was as follows: 91 in water 0-10 feet deep, 44 in water 11-20 feet deep, and 20 in water exceeding 20 feet deep. Only 11 of the 155 collected were taken at depths greater than 10 feet below the surface.

Spotted gar (34; Figure 13).

All but five of the 34 fish were collected in water

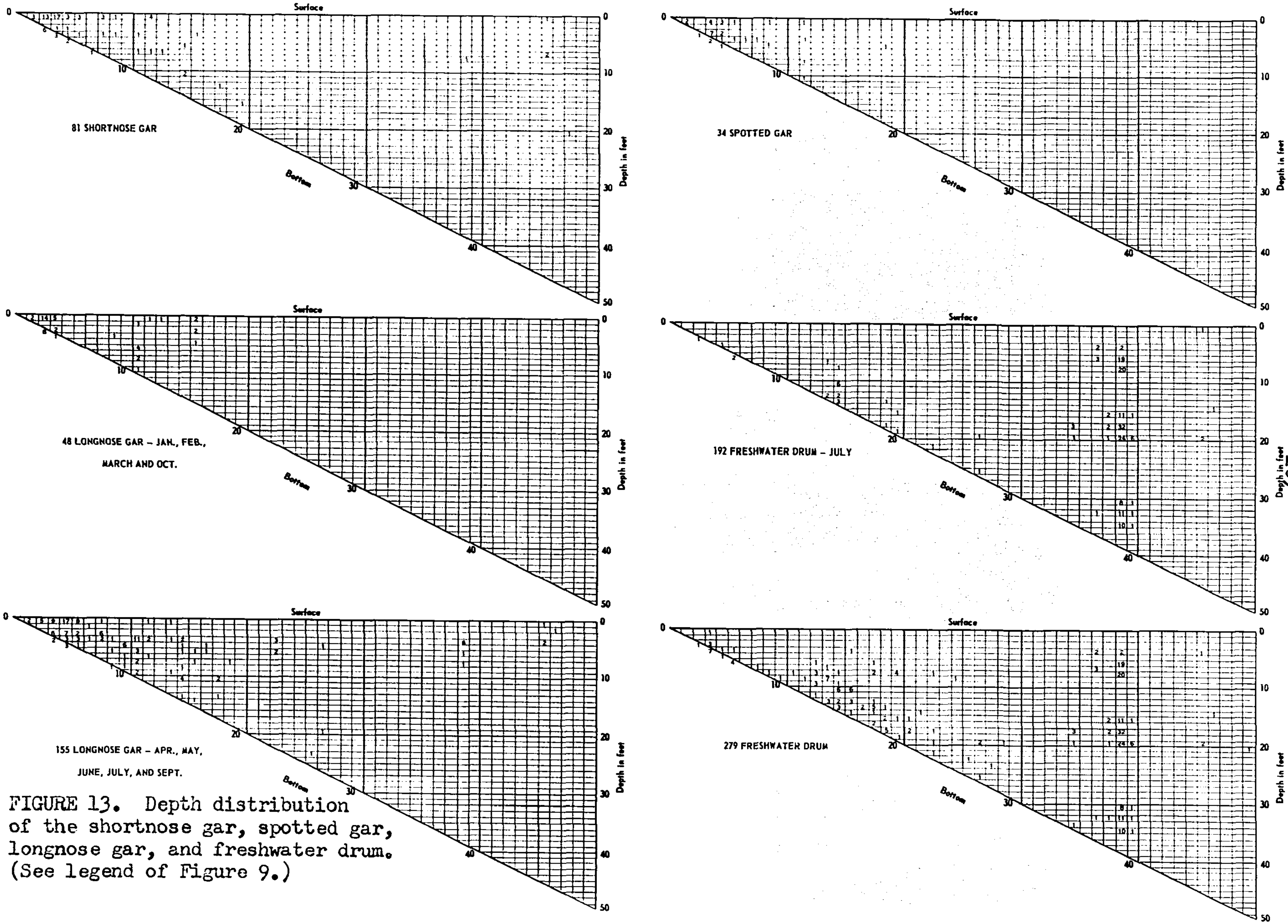


FIGURE 13. Depth distribution of the shortnose gar, spotted gar, longnose gar, and freshwater drum. (See legend of Figure 9.)

less than 10 feet deep.

Freshwater drum (Figure 13).

July (192) and all months combined (279). Since the catch during July comprised such a large proportion of the total catch (69 per cent), it is presented separately in order to provide a comparison with the total catch of all months (including July). This species was concentrated in deep water during July and was distributed in considerable abundance at all depths from the surface to near the bottom in water 40 feet deep. If the data of July were excluded, the data of the other months would indicate that most of the fish were distributed within six feet of the bottom in water less than 30 feet deep. Cady (1945) reported this species was taken in moderately deep water, and Haslbauer (1945) collected it most frequently in the lower one-third of nets set on the bottom.

Smallmouth buffalo (Figure 14).

January, February, March, October, November, and December (39). During these fall and winter months, 26 of the 39 collected were taken within three feet of the bottom in water varying from 3-41 feet in depth.

April, May, June, July, and August (69). During these spring and summer months, 42 of 69 were collected within three feet of the bottom in water varying from 2-30 feet in depth.

This typical bottom-feeding species was associated

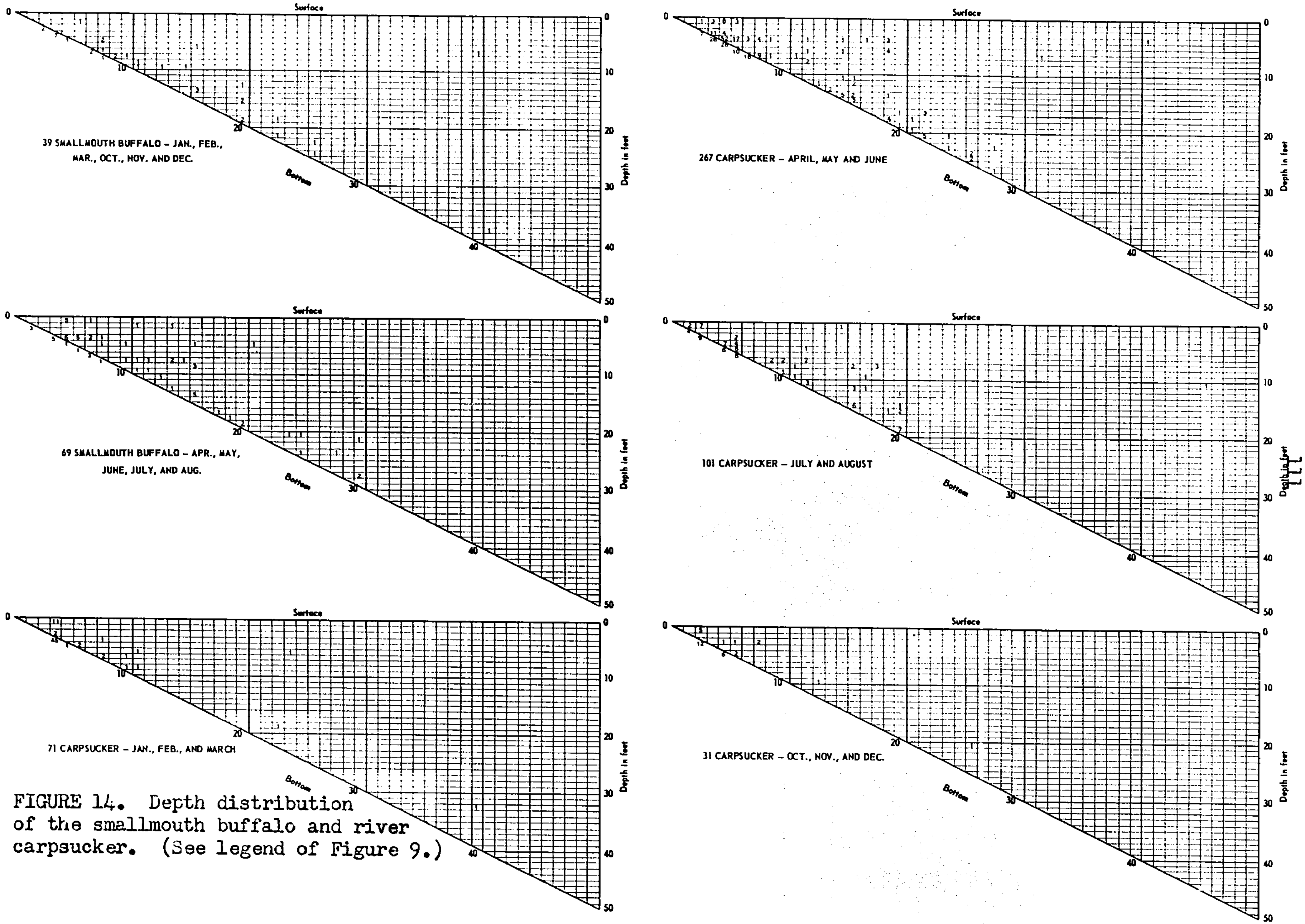


FIGURE 14. Depth distribution of the smallmouth buffalo and river carpsucker. (See legend of Figure 9.)

with the bottom at all times of the year although perhaps not as closely as might be expected. The combined total collected within three feet of the bottom for the catch of all months was 68 of 108.

River carpsucker (Figure 14).

January, February, and March (71); April, May, and June (267); July and August (101); and October, November, and December (31). Data of winter, spring, summer, and fall months are combined in the manner shown here, but they show basically the same pattern of distribution at all seasons. The greatest part of the catch for all seasons was collected in water not exceeding 10 feet in depth and is as follows for each: winter, 66 of 71; spring, 206 of 267; summer, 62 of 101; and fall, 29 of 31. This is in accord with the data of Bryan and Howell (1946) who found this species most abundant in water less than eight feet deep. Considerable numbers were collected to a depth of 30 feet during the spring and 20 feet during the summer. Only four of 470 fish, which represent the combined data of all months, were collected in water more than 30 feet deep. Most of the fish occurred near the bottom, but there were a few scattered at various depths between the surface and the bottom during all seasons, particularly in the very shallow water. The number collected within three feet of the bottom for each of the seasons is as follows: winter, 54 of 71; spring, 216 of 267; summer, 76 of 101; and fall, 26 of 31.

Blue sucker (11; Figure 15).

None was collected in water more than 16 feet deep. The few fish collected were well distributed between the surface and the bottom and were not definitely associated with either. Additional data are needed to show any reliable trends.

Bigmouth buffalo (30; Figure 15).

None of the 30 fish was taken from water more than 27 feet deep. Only five were taken in water exceeding 16 feet deep. In general, this species had a scattered distribution from the surface to the bottom and could not be definitely associated with the bottom as would be expected of this bottom feeder. Only 12 of the 30 were taken within three feet of the bottom.

Black buffalo (9; Figure 15).

The nine fish collected suggest that this species is very closely associated with the bottom. Only one was taken at a distance more than two feet above the bottom. All were taken in shallow water not more than 18 feet deep.

Largemouth bass (83; Figure 15).

This species was commonly taken in water less than 20 feet deep, but most of the catch (54 of 83) were collected in water not more than 10 feet deep. Only five were taken from water exceeding 20 feet in depth. The fish were well distributed from the surface to the bottom.

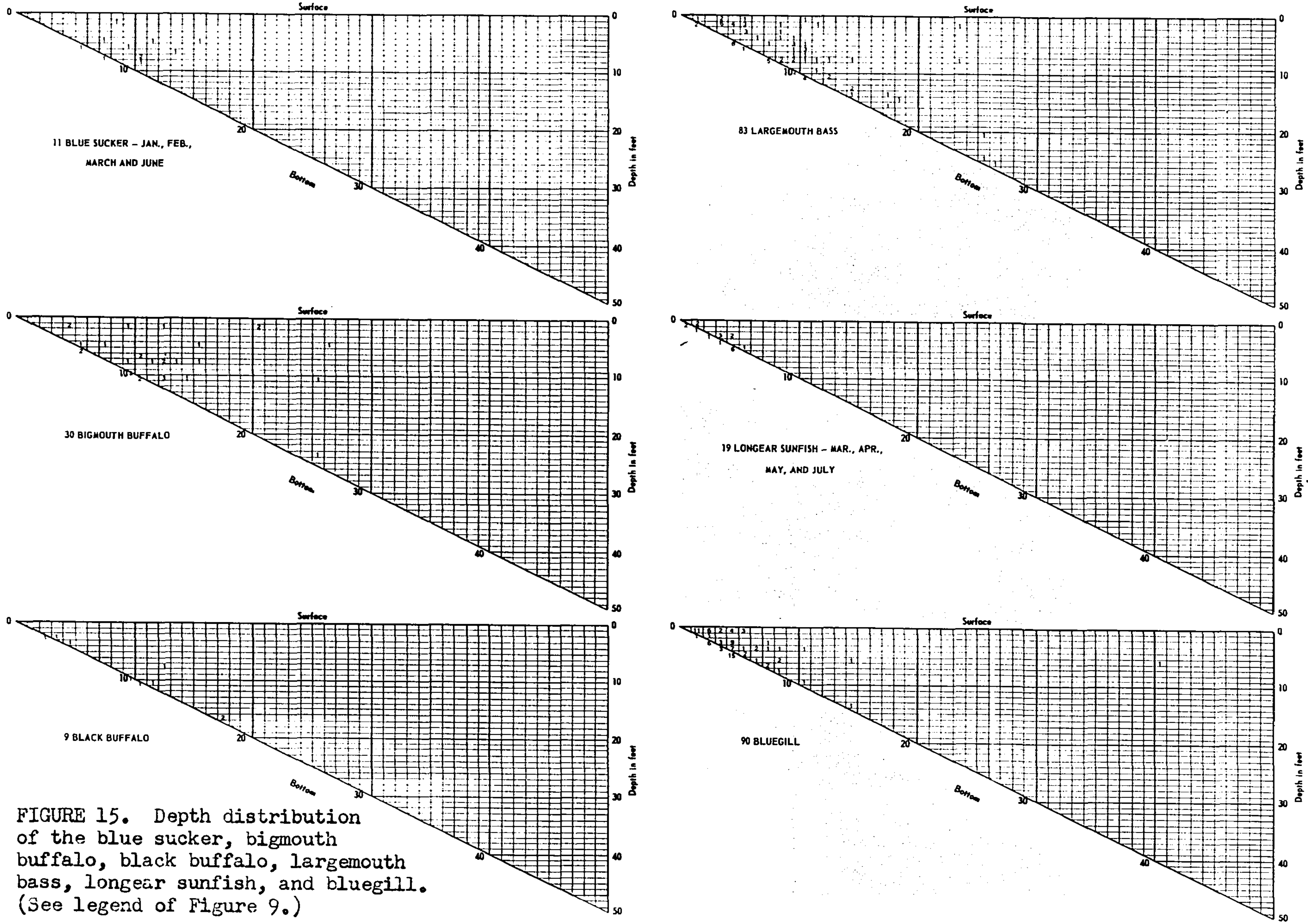


FIGURE 15. Depth distribution of the blue sucker, bigmouth buffalo, black buffalo, largemouth bass, longear sunfish, and bluegill. (See legend of Figure 9.)

Longear sunfish (19; Figure 15).

The 19 fish were collected from water less than seven feet deep.

Bluegill (90; Figure 15).

All but five of the 90 collected were taken from water less than 10 feet deep and were distributed from the surface to the bottom. Byrd (1951) studied the depth distribution of bluegill in farm ponds and found that during summer thermal stratification the greatest numbers were in shallow water.

Carp (Figure 16).

January, February, March, and October (49). During these winter and fall months the fish were collected in greatest abundance near the bottom, chiefly in water not more than 10 feet deep. Of the 49 fish for which data are presented, 34 were collected within three feet of the bottom and only five were collected at depths greater than 10 feet.

April, May, June, and July (103). During these spring and summer months, the species was not as closely associated with the shallow water as in the winter and fall months. The catch of 103 fish was distributed as follows for the different depths: 0-10 feet, 58; 11-20 feet, 25; 21-30 feet, 14; 31-40 feet, 4; and 41-50 feet, 2. In general, the fish were distributed from the surface to the bottom, but 59 were collected within three feet of the bottom.

Bryan and Howell (1946) collected the carp most

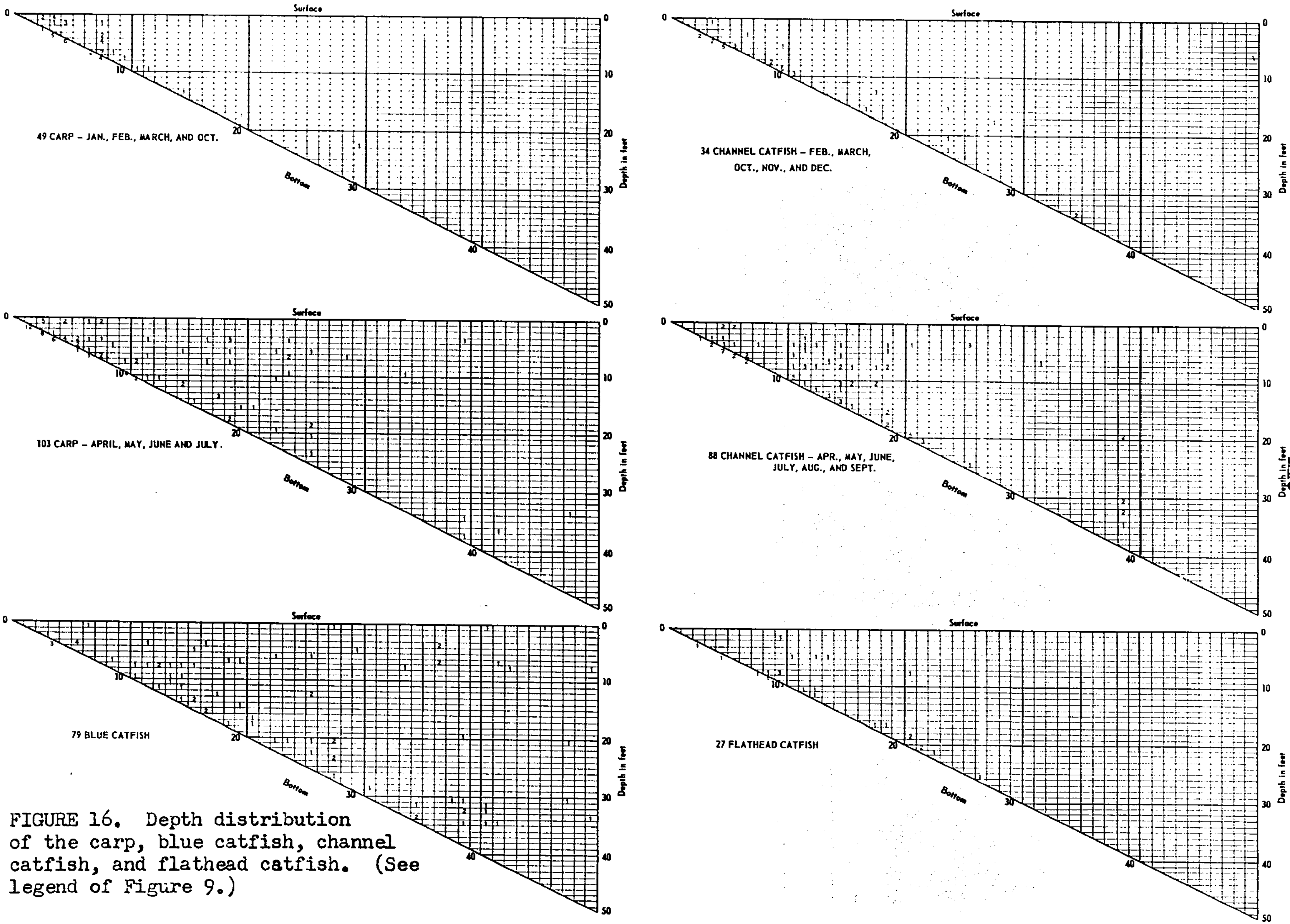


FIGURE 16. Depth distribution of the carp, blue catfish, channel catfish, and flathead catfish. (See legend of Figure 9.)

frequently in the upper 10 feet. Since their data were based on bottom sets, this would indicate a greater abundance in shallow water which is in agreement with the data presented here. Haslbauer (1945) obtained his largest catches in the lower one-third of nets set on the bottom.

Blue catfish (79; Figure 16).

Catfish are reputed to be bottom-dwelling species. It is, therefore, surprising to find that this species had a wide distribution from surface to bottom in water ranging from 4-40 feet deep. (No netting was done at depths more than 40 feet below the surface, though nets were set in water approximately 50 feet deep.) That this species is a frequent inhabitant of the near-surface regions is shown by the following numbers of fish collected by depth intervals below the surface: 0-10 feet, 38; 11-20 feet, 16; 21-30 feet, 11; 31-40 feet, 14. The catch was largest in the upper 10 feet which seems amazing in view of the fact that most of the fish were taken in deeper water than is true of most species. Only nine fish were taken where the depth of the water was 10 feet or less. However, the data should not necessarily be interpreted as indicating that the blue catfish can be taken in greater abundance at the surface than at the bottom, for the netting effort was greatest in the 0-10 feet depth interval and least in the 31-40 feet depth interval. Again, it seems important to point out that strictly bottom sets could not have detected the frequent occurrence of this species near the surface in deep water.

Channel catfish (Figure 16).

February, March, October, November, and December (34). During these winter and fall months the channel catfish was closely associated with the bottom at all depths. Of the 34 fish collected, 27 were taken within two feet of the bottom in water varying from 3-35 feet in depth.

April, May, June, July, August, and September (88). In these spring and summer months the channel catfish was collected in water varying from 3-47 feet in depth although 68 of the 88 were taken in water less than 20 feet deep. They were much more widely distributed between the surface and the bottom than during the winter and fall months, but 35 were taken within two feet of the bottom.

Haslbauer (1945) indicates that the channel catfish is not as closely associated with the bottom as is popularly believed. The data presented here tend to support this opinion. However, it seems to be more closely associated with the bottom than the blue catfish.

Flathead catfish (27; Figure 16).

These data show that this species is definitely a bottom dweller. Haslbauer (1945) concurs. Of the 27 fish for which data are presented, 22 were taken within three feet of the bottom in water varying from 3-27 feet in depth.

The data of Table 20 provide a comparison of the catch in different depths of water and at different depths

TABLE 20. Summation of the catch and the approximate netting effort in different depths of water and at different depths below the surface. The catch represents the combined total of the 20 species for which depth distribution data are presented. Figures in parentheses indicate the per cent of the total.

Depth of water in feet	Catch of fish	Gill-net sets
0-10	2222 (35.7)	189 (33.1)
11-20	2448 (39.3)	175 (30.7)
21-30	667 (10.7)	123 (21.6)
31-40	518 (8.3)	47 (8.2)
41-50	373 (6.0)	36 (6.3)
Depth in feet below surface		
0-10	5088 (81.6)	365 (64.0)
11-20	927 (14.9)	137 (24.0)
21-30	124 (2.0)	50 (8.8)
31-40	89 (1.4)	18 (3.2)

below the surface for the combined totals of the 20 species for which depth distribution data are presented. The approximate netting effort is also shown. Since the entire net was not always fished within one depth interval (see footnote of Table 4), it is emphasized that the data on netting effort are only approximate. Furthermore, no effort was made to distinguish between the different types of nets. According to these data, the greatest catch per number of net sets (compare percentages of "catch of fish" and "gill-net sets" columns) occurred in water from 11-20 feet deep, but the catch percentage exceeded the netting percentage in water from 0-20 feet deep. In water of greater depths, the catch and netting percentages were approximately equal or, as at depths of 21-30 feet, the netting percentage considerably exceeded the catch percentage. Odell (1932), in a study of some New York lakes, obtained 76 per cent of his total catch from water less than 15 feet deep though only 60 per cent of the nets were set at this depth. However, none of the fish for which he presents data occurs in Lake Texoma.

It is interesting to note that 81.6 per cent of all fish were taken in the upper 10 feet of water though only approximately 64.0 per cent of all sets were made in this region. The netting percentage exceeded the catch percentage at all depths below 10 feet. Several factors probably contributed to the high rate of catch near the surface. It was certainly influenced by the fact that gizzard shad and goldeye were the two species collected in greatest abundance, and they were taken primarily from the upper 10 feet throughout most of the year. It is also true that water less than 10 feet deep produced good catches. Because the bottom is assumed to be sloping, all of the depth intervals designated below the surface (Table 4) include a certain amount of bottom sets, but none consists entirely of bottom sets. It can be stated, however, that the catches of bottom sets in deep water with small mesh nets (2-inch bar mesh or less) were not ordinarily as large as were those of surface sets. Bryan and Howell (1946) collected the greatest number of their combined catch of all species in the upper one-third of nets set on the bottom while Haslbauer (1945) collected the greatest number from the lower one-third of bottom sets.

Upstream-downstream Distribution of the Small Fishes

Fishes have definite habitat preferences which cause them to be definitely arranged in streams which have a graded series of conditions from mouth to source (Shelford, 1911). Thompson (1933) attributed this variation in distribution of species within a stream to a difference in their preference of size of stream. He indicated that during times of high water fish tend to move upstream until they find their optimum stream size or conversely to drift downstream during drought periods. Trautman (1943) emphasizes the importance of stream gradients in determining the presence, or size, of the populations of various species of fish. Burton and Odum (1945) found that the longitudinal succession of fish in streams was more pronounced the greater the altitude but that distinct differences occurred with little change in altitude.

In addition to gill-netting, collections of small fishes were made periodically with seines in an effort to determine their upstream-downstream preference within the creek and also to investigate whether the larger species were reproducing in the lake or its immediate tributaries (Table 21). A brief discussion of the distribution of each of the 47 species collected (including a hybrid) is presented below. They are discussed in relation to upstream-downstream areas as described in the section on Procedure of Research.

Lepisosteus platostomus (shortnose gar), *L. productus* (spotted gar), *L. osseus* (longnose gar), and *L.* sp. Only a few of the young gars collected in seines were of sufficient size to permit positive identification. Some were less than an inch in total-length. Those which could not be positively identified are listed as *L.* sp. A total of 157 of these unidentified gars was collected. There is no reason to doubt that all of the three species named above are included in these. With the exception of one specimen, they were all collected from Areas 1 and 2, but mostly from Area 2, where all three species were observed spawning in

TABLE 21. Numbers of each species of fish collected (chiefly by seining) from five areas extending from the mouth to the source of Buncombe Creek. The number of collections made from each area is in parentheses.

Scientific name	1 (33)	2 (19)	3 (5)	4 (7)	5 (5)	Total, all areas (69)	Number of collections represented
Lepisosteus platostomus		1				1	1
L. productus		2				2	2
L. osseus	2					2	2
*L. sp.**	40	116		1		157	18
Dorosoma cepedianum	348	160				508	27
Hiodon alosoides	7					7	2
Asytanax fasciatus	3	33	2		1	39	10
Ictiobus cyprinellus		4				4	3
I. bubalus	3	12				15	4
Carpiodes carpio	7					7	3
Minytrema melanops				2		2	2
Cyprinus carpio	196	97	1			294	29
Notemigonus crysoleucas	1	1		2		4	4
Hybopsis storeriana	11	2				13	4
Notropis percobromus	91	29				120	23
N. blennius		2				2	1
N. potteri	12					12	5
N. venustus	68	22	2	1		93	23
N. lutrensis	1580	694	278	419	663	3634	60
N. venustus X *N. lutrensis*	18		2			20	6
N. bairdi	3					3	1
N. deliciosus	18	121	197	29	6	371	29
N. buchanani	50	105				155	15
Hybognathus placita	169	1	1	1		172	9
Pimephales promelas		11	2	8	50	71	11
P. vigilax	211	188	6	25		430	45
Campostoma anomalum	4	24	148	102	27	305	22
Ictalurus punctatus	17	13				30	6
I. melas				32	101	133	7
I. natalis		14	19	4		37	6
Pilodictis olivaris	2					2	2

Ictiobus cyprinellus		4				4	3
I. bubalus	3	12				15	4
Carpiodes carpio	7					7	3
Minytrema melanops				2		2	2
Cyprinus carpio	196	97	1			294	29
Notemigonus crysoleucas	1	1		2		4	4
Hybopsis storeriana	11	2				13	4
Notropis percobromus	91	29				120	23
N. blennius		2				2	1
N. potteri	12					12	5
N. venustus	68	22	2	1		93	23
N. lutrensis	1580	694	278	419	663	3634	60
N. venustus X N. lutrensis	18		2			20	6
N. bairdi	3					3	1
N. deliciosus	18	121	197	29	6	371	29
N. buchanani	50	105				155	15
Hybognathus placita	169	1	1	1		172	9
Pimephales promelas		11	2	8	50	71	11
P. vigilax	211	188	6	25		430	45
Campostoma anomalum	4	24	148	102	27	305	22
Ictalurus punctatus	17	13				30	6
I. melas				32	101	133	7
I. natalis		14	19	4		37	6
Pilodictis olivaris	2					2	2
Fundulus notatus	38	51	46	155		290	36
F. kansae	1	5		3		9	5
Gambusia affinis	142	428	103	13		686	46
Labidesthes sicculus	253	50		38		341	32
Menidia audens	2370	348				2718	35
Morone chrysops	89	19				108	15
Micropterus punctulatus	12	1	18			31	7
M. salmoides	142	55		5		202	32
Chaenobryttus coronarius	10	58				68	12
Lepomis cyanellus	7	20	32	192	178	429	27
L. megalotis	114	272	39	54	6	485	50
L. humilis	3	12		46		61	17
L. macrochirus	275	237	5	40		557	41
Pomoxis annularis	31	76	1			108	21
Percina caprodes	29	33	3	2		67	26
Etheostoma spectabile		5	182	141		328	12
Aplodinotus grunniens	41	15				56	10
Totals, all species	6418	3337	1087	1315	1032	13189	

*Most of the very small young-of-year gars could not be conclusively identified to species.

May, 1954. Indications are that most of those collected from Area 1 were longnose gars while shortnose and spotted gars were most common in Area 2. The longnose gar appeared common in Area 2 also. Most of the young-of-year gars collected appeared to be longnose gars which concurs with the gill-netting data. Although it is not possible to be certain, there is no reason to believe that any young of the alligator gar, L. spatula, were collected.

Dorosoma cepedianum (gizzard shad). All fish were collected from Areas 1 and 2. This species is undoubtedly more abundant than the data indicate, but it was frequently absent from the collections probably because it was capable of evading the seines or because it inhabited deeper water within a few months after hatching.

Hiodon alosoides (goldeye). Only seven fish of this species were taken in spite of its over-all abundance in the lake. These were collected from Area 1 near the mouth of the creek. Little is known of its spawning habits, but the fact that these fish were only 31-70 mm. in total-length suggests that at least some spawning probably occurs within the lake.

Astyanax fasciatus (Mexican banded tetra). This recently introduced species (Riggs, 1954) was represented in 10 different collections. The largest number (33) was collected from Area 2, but it was collected from all areas except Area 4. It has presumably extended its distribution to the entire length of the creek through migration.

Ictiobus cyprinellus (bigmouth buffalo). Only four fish were collected and all were taken from Area 2. Their total-lengths ranged from 34-104 mm. This suggests at least limited reproduction in the lake proper or the lower portions of Buncombe Creek. However, it is peculiar that during all of the gill-netting no fish of this species was taken in nets smaller than 3-inch bar mesh, and none weighed less than approximately three pounds.

Ictiobus bubalus (smallmouth buffalo). The 15 fish collected were taken from Areas 1 and 2.

Carpiodes carpio (river carpsucker). All seven specimens collected were taken from Area 1.

Minytrema melanops (spotted sucker). Two fish were collected from spring-fed pools in Area 4. Seven additional catostomids less than an inch in total-length were collected from one of these same pools and are probably spotted suckers. They are apparently absent or very rare in the lake.

Cyprinus carpio (carp). Young-of-year carp were often taken in considerable numbers from inundated weedy areas along the shoreline of Areas 1 and 2. No young-of-year were taken farther upstream. One specimen, approximately 10 inches in total-length, was collected from Area 3 and others of similar size were observed in Area 4.

Notemigonus crysoleucas (golden shiner). The golden shiner is uncommon in Buncombe Creek. The four collected were taken from Areas 1, 2, and 4 and were taken on four different occasions.

Hybopsis storeriana (silver chub). This species was taken occasionally in the downstream region of Areas 1 and 2. None was taken farther upstream.

Notropis percobromus (plains shiner). It is interesting to note that this species, which is common in the lake, was collected no farther upstream than Area 2.

Notropis blennius (river shiner). The only two fish collected were taken from Area 2. It is uncommon in the Buncombe Creek arm of the lake at the present time.

Notropis potteri (chub shiner). Twelve specimens were taken in five different collections. All were collected from Area 1.

Notropis venustus (blacktail shiner). It was locally common in Area 1 but was less common with progression upstream. Only one was collected from Area 4 and none from Area 5.

Notropis lutrensis (red shiner). This is probably the most abundant of the small fishes, for it was taken abundantly from all areas and was represented in more collections than any other species (60 of the 69 collections).

Notropis venustus X N. lutrensis. Twenty of these hybrids were collected, 18 of which were collected from Area 1 and the other two from Area 3. (Identifications were made by Dr. Clark Hubbs, University of Texas.)

Notropis bairdi (Red River shiner). Only three were collected. All were taken in the same collection from Area 1. It is apparently uncommon in the creek.

Notropis deliciosus (sand shiner). It was taken from all areas, but was most abundant in Area 3 where the bottom was predominantly sand.

Notropis buchanani (ghost shiner). All specimens were collected from Areas 1 and 2, the most from Area 2.

Hybognathus placita (plains minnow). Although distributed as far upstream as Area 4, 169 of 172 collected were taken from Area 1. One specimen was collected from each of Areas 2, 3, and 4.

Pimephales promelas (fathead minnow). A definite preference is indicated for the stream type of habitat. It was collected from all areas except Area 1, the lake proper region. It was represented in 11 different collections, but ordinarily only a few specimens were taken in each collection. An exception to this occurred when 49 were taken at one time from a pool which was drying up in Area 5.

Pimephales vigilax (parrot minnow). Unlike the fathead minnow, this minnow was very common in the downstream region in Areas 1 and 2. It was taken upstream as far as Area 4.

Campostoma anomalum (stoneroller). Although this species was collected from all areas, it was most common in the gravel riffles of Area 3 and in the gravel-rubble regions of Area 4. It was definitely least common in Area 1.

Ictalurus punctatus (channel catfish). Distribution was restricted to Areas 1 and 2 in the downstream region. A total of 30 fish were taken in six collections.

Ictalurus melas (black bullhead). This species was common in Areas 4 and 5, particularly in Area 5, but none was taken from the other areas. Since none was taken in the gill nets, there is reason to believe that it is virtually absent from the lake. Many are destroyed when the shallow pools of Area 5 dry up, but apparently they are restocked from pools below or from farm ponds in the vicinity when the pools are again refilled.

Ictalurus natalis (yellow bullhead). Although this species had not been previously reported from Lake Texoma, it seems to be fairly common in the midsection of Buncombe Creek where 37 were taken in six collections. None was collected from Area 1 or Area 5.

Pilodictis olivaris (flathead catfish). Only two were collected and both were taken from Area 1. One was removed from a tin can and was only 19 mm. (total-length).

Fundulus notatus (blackstripe topminnow). Since this species is often seen swimming at the surface, a special attempt was usually made to collect at least a few with each collection. The data presented are therefore probably exaggerated in comparison with other species. It was represented in 36 of the collections and was common in all areas except Area 5 where it was not collected. It was most common in Area 4.

Fundulus kansae (plains killifish). This species was rather uncommon, but a total of nine were taken from Areas 1, 2, and 4.

Gambusia affinis (gambusia). It was most abundant in Area 2, but large numbers occurred in the three most downstream areas. It was considerably less common upstream in Area 4 and was not taken from Area 5.

Labidesthes sicculus (brook silversides). The greatest numbers were collected from Areas 1 and 2, but it was frequently taken upstream in Area 4. The fate of this species in the lake region is presently uncertain, for the 1955 collections indicated that it was rapidly becoming uncommon there (Dowell and Riggs, in press).

Menidia audens (Mississippi silversides). With the decrease in numbers of the brook silversides there has been a corresponding increase in numbers of this species (Dowell and Riggs, in press). It has only recently gained entrance into Lake Texoma (Riggs and Dowell, in press), but in 1955 it was probably the most abundant of the small fish present in the lake proper region, although the red shiner appeared to be the most abundant throughout the over-all course of the creek. It was taken in great abundance from Area 1, less abundantly in Area 2, and none was collected above this region.

Morone chrysops (white bass). This species was collected in seines only from Areas 1 and 2.

Micropterus punctulatus (spotted bass). It is fairly common in the three downstream areas, but none was taken from Areas 4 and 5. However, since the most were taken from Area 3, it probably occurs in Area 4 also.

Micropterus salmoides (largemouth bass). The young-of-year were very common in protected places along the margin of the lake, and some were collected as far upstream as Area 4.

Chaenobryttus coronarius (warmouth). This species was fairly common in Areas 1 and 2, particularly Area 2, but was not collected farther upstream.

Lepomis cyanellus (green sunfish). Although collected from all stations, it showed a definite preference for the stream habitat where it occurred in greatest abundance in Areas 4 and 5.

Lepomis megalotis (longear sunfish). This is a very common species as indicated by the fact that it was represented in 50 of the collections and was collected from all areas. It was least common in Area 5.

Lepomis humilis (orangespotted sunfish). Most of those collected were taken from Area 4 where it was common. A few were collected from Areas 1 and 2, but none was collected from Areas 3 and 5.

Lepomis macrochirus (bluegill). None was collected from Area 5, but it was common throughout the stream below this region. It was particularly abundant in Areas 1 and 2.

Pomoxis annularis (white crappie). One was collected from Area 3 and another was observed there; otherwise, all were taken from Areas 1 and 2.

Percina caprodes (logperch). The logperch was definitely most abundant downstream in Areas 1 and 2, but was collected as far upstream as Area 4. Although usually not taken in large numbers, it is apparently fairly common, for it was represented in 26 of the collections.

Etheostoma spectabile (orangethroat darter). Distribution was practically restricted to the gravel and rubble riffles of Areas 3 and 4 where they could be collected seasonally in great abundance. A few were collected from Area 2, but none was collected from Areas 1 and 5.

Aplodinotus grunniens (freshwater drum). Most were collected from Area 1, and none was collected above Area 2.

The number of species collected for each area was: Area 1, 38; Area 2, 38; Area 3, 20; Area 4, 23; and Area 5, 8. The hybrid minnow is considered as a species in this compilation, but those listed as Lepisosteus sp. are excluded in order to avoid duplication of other Lepisosteus included. Starrett (1950) found that the number of species increased with increase in stream width and watershed. This is not demonstrated well by the data presented here, but the conditions are probably modified by the lake's presence at the downstream end of the creek. Thus, the lake portion of the creek (Area 1) is certainly wider than the narrow inundated creek channel immediately above (Area 2), but approximately the same number of species was collected from each even though 14 less collections were made from the inundated creek channel. The inundated creek channel has the advantage of being located between typical creek conditions upstream and typical lake conditions downstream, thus benefiting from the species of both regions. It is true, however, that fewer species were collected in the upstream areas and that the least number was collected from Area 5 which was farthest upstream. It is possible that the barrier formed by the foundation of the State Highway 32 Bridge may have prevented some species from reaching Area 5. The decrease in number of species in the upstream areas may appear to be the result of fewer collections, and this is probably partially true, but the sampling was sufficient that it does not seem likely that many additional species would have been taken with more collecting. It is, of course, very probable that more thorough collecting, particularly with such methods as the use of rotenone or an electric seine, would reveal species which were not collected in this study. Nevertheless, it seems quite certain that the number of species in the upstream region would never attain that of the downstream region.

CHAPTER VII

SUMMARY

1. A study was made of the activity patterns and distribution of the fishes in the Buncombe Creek arm of Lake Texoma from June, 1953, to August, 1955. Gill nets were used to collect the large fishes, and various types of seines were the primary means used to collect the small fishes.

2. In general, there was an inverse relationship between air temperatures and barometric pressures. There was no correlation between monthly averages of air temperature or barometric pressure and the activity of fishes based on catch per gill-net hour.

3. Water levels were generally low. Power pool elevation of Lake Texoma is 617 feet above mean sea level, but the water level was less than 610 feet for 15 of the 26 months included in this study.

4. During the late fall and winter months the water temperature of Buncombe Creek is essentially uniform from top to bottom, but thermoclines may develop during the spring, summer, and early fall if there is an extended period of high temperatures and little wind. These readily disappear

with increased wave action.

5. A total of 50 species and one hybrid representing 30 genera and 14 families of fishes was collected.

6. White bass, white crappie and largemouth bass comprise the bulk of the sport fishery, though there is considerable fishing for channel, blue, and flathead catfishes.

7. Young-of-year are believed to have been collected of all species except the golden redhorse, black buffalo, blue sucker, and blue catfish of the larger species and possibly the golden shiner, silver chub, and Red River shiner of the smaller species.

8. A total of 7218 fish was collected in gill nets. The principal species collected and the percentage of the total catch which each comprised were: gizzard shad, 27; goldeye, 17; white bass, 14; white crappie, 10; river carpsucker, 8; and others, 24.

9. The number of fish of each species collected per gill-net hour was computed on a monthly basis for each type of gill net used.

10. Night sets accounted for 85 per cent of the total catch of all species combined.

11. With the possible exception of the smallmouth buffalo, carp, and largemouth bass, none of the species showed a definite pattern of upstream-downstream movement.

12. The data on in cove-out of cove movement were too limited to justify any conclusions, but there was a slight

indication that the general fish population tends to move in by day and out by night.

13. There was evidence that, at least on some occasions, gizzard shad and goldeye travel in schools at night. There are statements in the literature that fish do not school at night.

14. The gill-netting data indicate that the shortnose gar, spotted gar, longnose gar, carpsucker, carp, longear sunfish, and bluegill were more abundant in the shallow water in the upstream part of the bay whereas gizzard shad, goldeye, and blue catfish were more abundant in the downstream region. The other species which were gill-netted were more generally distributed.

15. The catch of shoreline stations was considerably greater than midchannel stations for most species. Blue catfish, goldeye, gizzard shad, freshwater drum, and, at times, white crappie were commonly taken at midchannel. Blue catfish, goldeye, and possibly the freshwater drum appear to be the only species which can be taken more abundantly at midchannel than along the shoreline.

16. Bigmouth buffalo and largemouth bass appear to be attracted to certain coves while the catch of goldeye, blue catfish, and freshwater drum in coves was low. No definite trends were indicated for other species.

17. Depth-distribution data are presented and discussed for 20 of the 23 species gill-netted. A comparison is made

of the catch in different depths of water as well as at different depths below the surface for the combined totals of these 20 species.

18. The greatest catch per unit of effort occurred in water from 11-20 feet deep.

19. The upper 10 feet of water produced 81.6 per cent of all fish collected though only 64.0 per cent of all sets were made in this region.

20. A total of 47 species (including one hybrid) was collected in 69 small-fish collections. Their upstream-downstream distribution, based on the relative abundance of each species collected from various places from the mouth to the source of the creek, was determined.

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