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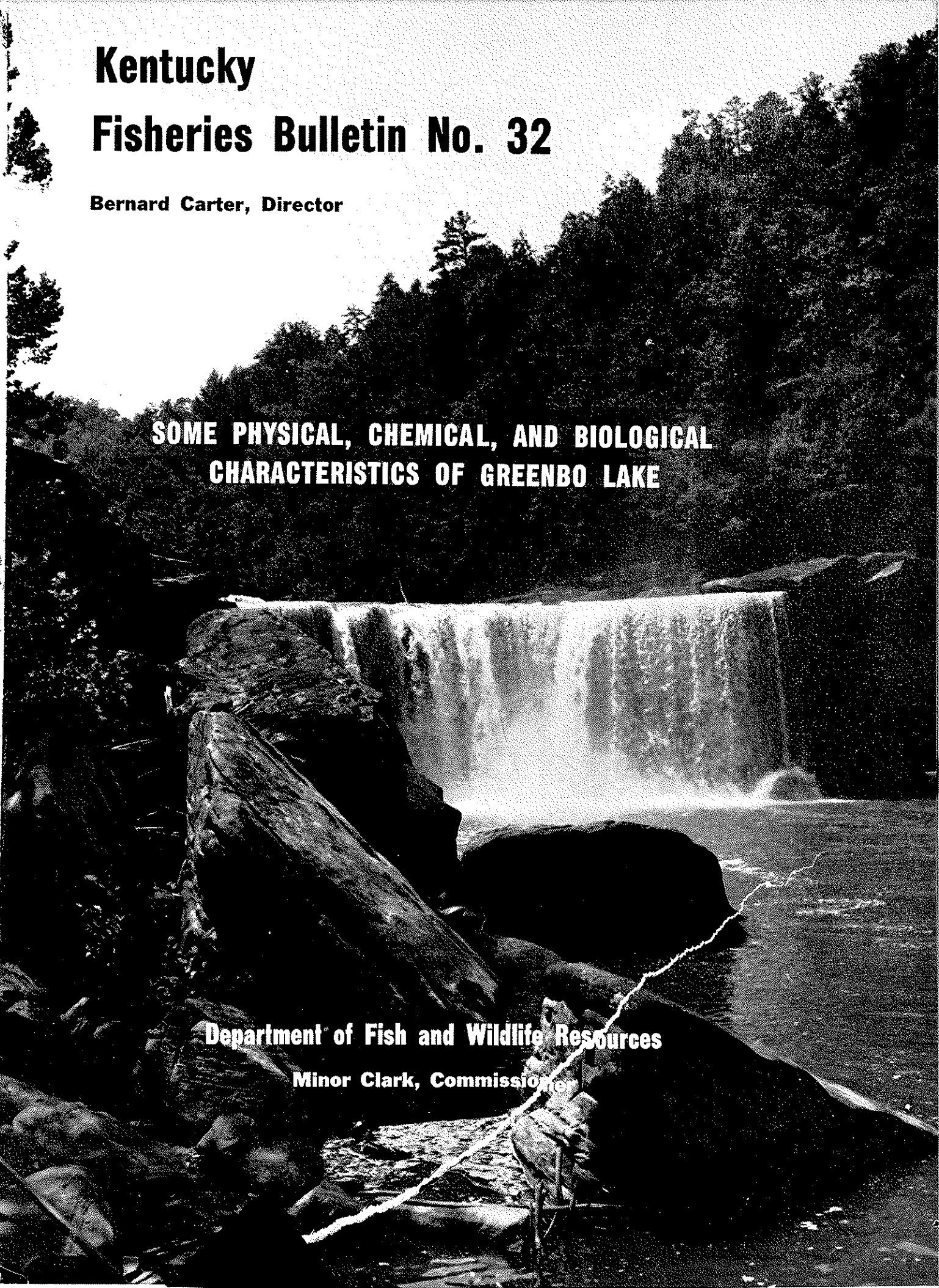
Bernard Carter, Director



SOME PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF GREENBO LAKE

Department of Fish and Wildlife Resources

Minor Clark, Commissioner

SOME PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF GREENBO LAKE

By

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ABSTRACT

Physical, chemical, and biological studies were conducted at Greenbo Lake from 1958 through 1966.

A bathymetric map of the lake is presented. Other physical data are given which include surface area, shoreline mileage, volume, and mean and maximum depth. Mean monthly temperature profiles are presented. Stratification was usually evident by early May when the thermocline extended from 9 to 17 feet. Fall overturn was complete by late October.

Mean monthly dissolved oxygen profiles show this characteristic to be present in amounts adequate for fish survival (3 ppm) to a depth of 20 feet during all sampling periods. It became void in the lower depths from July through November. Annual maximum, mean, and minimum values are given for total alkalinity, total phosphates, pH, and free carbon dioxide.

Population studies indicated an improving fish population from 1958 to 1965. The average standing crop increased from 70 pounds per acre in 1958 to 188 pounds per acre in 1965. There were approximately 55 pounds per acre more fish of a size desirable to the angler in 1965 than there were in 1958.

Creel survey studies showed an increasing harvest from 1958 to 1962, and a decreasing harvest from 1962 to 1965. However, there was a steady improvement in the average quality of each fish taken from 1958 to 1965.

The fertilization studies indicated a good increase in the quality and quantity of the fishery during the years when an inorganic fertilizer (20-20-5) was applied at the rate of 40 pounds per acre per application.

Introduction

Greenbo Lake is a 192-acre impoundment located in Greenup County in the Eastern Coalfield Physiographic Region of the state. It was built in 1965 and opened to public fishing in January of 1958. This report includes studies conducted on the lake from 1958 to 1966. The physical and chemical studies were conducted from 1958 through 1963, fish population studies from 1958 through 1965, creel survey studies from 1958 through 1966, fertilization studies from 1961 through 1965, and aquatic vegetation studies in 1964. The stocking record was as follows:

DATE	SPECIES	SIZE	NUMBER
4/6/56	Bluegill	Adult	13,500
4/13/56	Redear sunfish		132
5/28/56	Largemouth bass	Fingerling	25,000
5/29/56	Redear sunfish		400
6/4/57	Pike	2"	1,500
8/20/57	Bluegill	4 - 5"	2,400
12/16/60	Channel catfish	Fingerling	3,000
11/22/61	Channel catfish	4 - 6"	3,000
10/15/62	Channel catfish	3 - 5"	10,000
11/4/63	Channel catfish	4 - 5"	8,400
6/22/64	Largemouth bass	2 - 3"	62,000
9/3/64	Channel catfish	3"	5,625
4/13/65	Rainbow trout	10 - 12"	500
8/2/65	Channel catfish	5 - 8"	6,000
4/11/66	Rainbow trout	8 - 10"	300
11/66	Channel catfish	2 - 6"	11,000

METHODS

Physical

The basic outline of the bathymetric map, presented in Figure 1, was made from an aerial photograph. The depths and contour intervals were determined using a Raytheon Echo Sounder.

Temperature profiles were recorded monthly with a Whitney thermometer, near the dam, at the point of greatest depth. Temperatures were taken in one-foot decrements and recorded at every 0.5° F. change.

Chemical

Dissolved oxygen profiles were determined monthly using the modified Winkler method. Samples for this characteristic were collected every 5 feet to a depth of 20 feet and then every 10 feet to the bottom.

Total alkalinity, pH, free carbon dioxide, and total phosphate determinations were made from monthly samples collected as described above. All sampling was done near the dam at the point of greatest depth. The amount of free CO_2 present was determined by nomograph using known quantities of pH and alkalinity. The values presented in this report are an average of

the results obtained from samples collected at the surface, middle and near-bottom.

Soil samples were taken from the watershed with a soil auger, which sampled to a depth of six inches. These samples were taken in proportion to the amount of specific types of soils present in the watershed. Analyses of these samples were made by the University of Kentucky Soils Laboratory.

Biological

Population studies were conducted each year in pre-selected cove areas. These areas were measured to the nearest tenth of an acre by the plane table method. At approximately 7:00 a.m., a block net measuring 300' x 20' x 1" (bar measure) was placed across the mouth of the cove to be sampled. Emulsifiable rotenone (Chem-Fish Regular) was applied with a venturi-type bailer at the rate of 1 ppm (0.05 ppm actual rotenone). All fish that surfaced in the sample area within 60 hours were picked up, sorted to species, counted, measured to the nearest inch, and weighed.

A two-hour stratified creel survey was conducted from 1958 through 1966. This survey had two variations - from 1958 through 1961 the survey had 58 sampling periods while from 1962 to 1966 it had 49 sampling periods. The survey was taken during pre-selected two-hour periods between 7:00 a.m. and 7:00 p.m. Each week, one weekday and one weekend day were sampled. The days and time periods sampled were rotated each week until the total time surveyed amounted to 58 days and included 2-hour periods for 6 Mondays, 6 Tuesdays, 6 Wednesdays, 6 Thursdays, 6 Fridays, 14 Saturdays, and 14 Sundays, or 49 days and 7 of each. A conservation officer conducted the survey. At the beginning of each survey period the officer boated completely around the lake and made a total count of all fishermen. After making the count he began interviewing fishing parties (a fishing party consists of one or more fishermen), trying first to contact two parties who had completed their trips for the day. After making

or failing to make these contacts, the officer moved around the lake interviewing fishing parties until he had boated completely around the lake, making sure that he stayed within the two-hour period. The survey was then complete for that day.

To insure that interviews were taken in all areas of the lake, the officer, after making the total count began interviewing at the dam, moving one day to the left and the next to the right. The third and fourth days after making the count, he began interviewing at the farthermost point from the dam moving one day to the left and the next to the right. The fifth and sixth days he returned to the dam and repeated the procedure.

The data from the parties who were interviewed were projected to determine fishing pressure, catch, fishing methods, sex ratio, and numbers of resident and non-resident fishermen.

Greenbo was fertilized each year from 1961 through 1965 with an inorganic fertilizer (20-20-5) at the rate of 40 pounds per acre per month. Eight applications were made in the lake each year beginning in April and continuing through September. Double applications were made in April and May. The fertilizer was placed in the lake at eight different sites (in water one to three feet deep). Water temperatures and secchi disc readings were taken once a week by the conservation officer conducting the creel survey.

Aquatic vegetation studies were conducted in 1964 to identify and preserve aquatic plants from the lake and its watershed.

Physical Characteristics

A bathymetric map of Greenbo Lake is presented in Figure 1. The lake has a maximum depth of 60.0 feet, a mean depth of 13.5 feet, 7.2 miles of shoreline, and a total volume of 2,600 acre feet. Table 1 gives the volume in gallons and cubic feet, and the percent volume for each five-foot contour.

FIGURE 1.

GREENBO LAKE
GREENUP, KY.

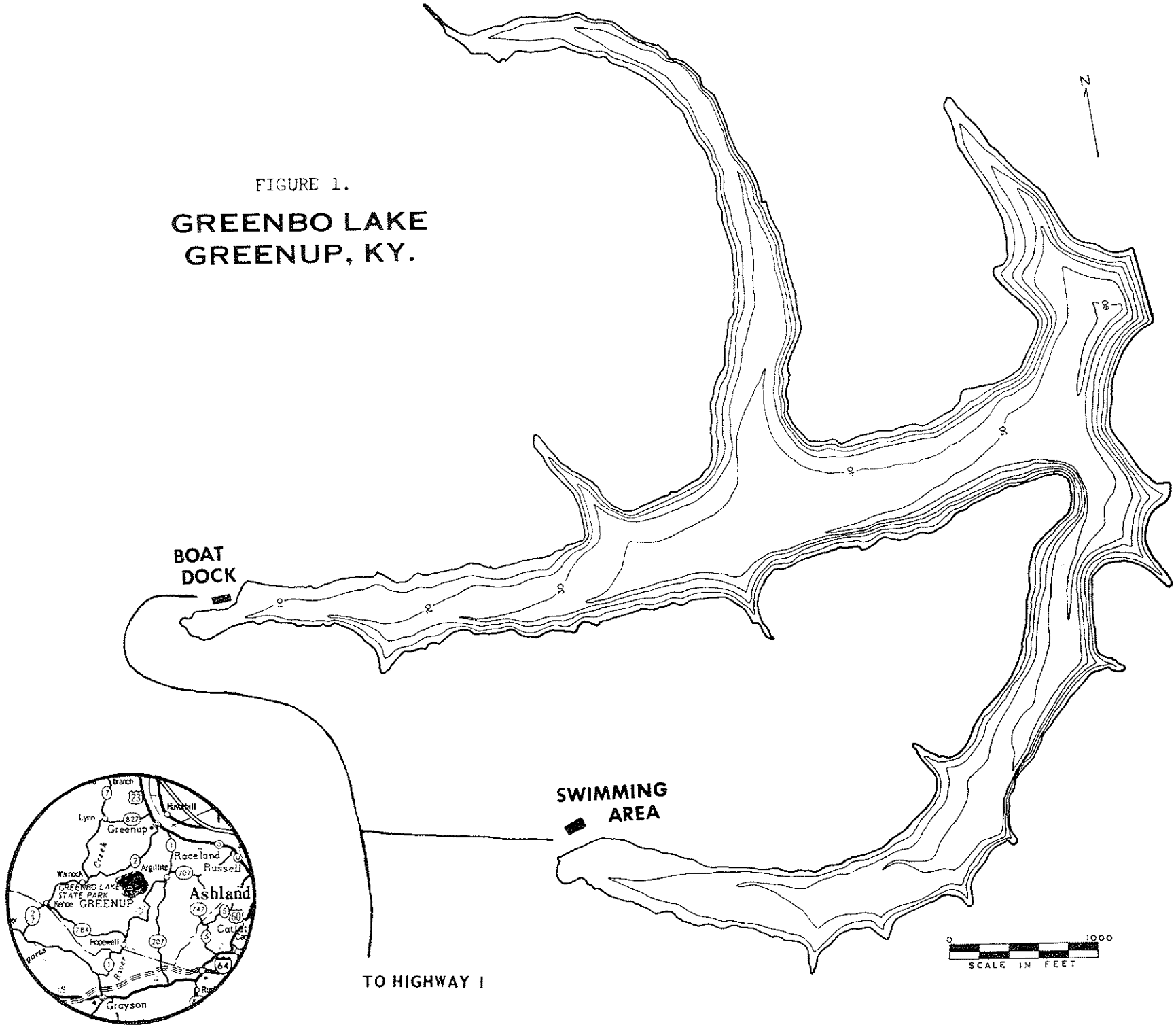

Table 1. Percent volume of Greenbo Lake for each five-foot contour in gallons and cubic feet.

Depth	Volume		Percent volume
	Gallons	Cubic feet	
0 - 5'	175,151,680	23,416,000	20.7
5' - 10'	126,157,680	16,866,000	14.9
10' - 15'	113,247,720	15,140,000	13.4
15' - 20'	99,902,880	13,356,000	11.8
20' - 25'	86,932,560	11,622,000	10.3
25' - 30'	74,515,760	9,962,000	8.8
30' - 35'	61,006,880	8,156,000	7.2
35' - 40'	48,320,800	6,460,000	5.7
40' - 45'	33,136,400	4,430,000	3.9
45' - 50'	18,909,440	2,528,000	2.2
50' - 55'	9,290,160	1,242,000	1.1
55' - 60'	478,720	64,000	0.6
60' +	74,800	10,000	0.1

Temperature

The values given in Table 2 are a monthly average of temperatures taken once a month for six years (1958-1963). Stratification usually became evident during early May when the thermocline extended from 9 to 17 feet. From this position, it gradually moved downward, as the epilimnetic layer of water warmed, until late October when it became very weak and was broken up by fall overturn. Just prior to this phase it was located between 20 and 28 feet. Inverse stratification was recorded in January. A homothermic condition was recorded in February.

Chemical Characteristics

The watershed of Greenbo Lake is comprised of pasture and woodland. An analysis of the soil from the watershed showed it to be moderately acidic (pH - 5.6), with a medium amount of available phosporous (155 pounds per acre), and available potassium (42 pounds per acre).

Oxygen

The mean monthly dissolved oxygen profiles are presented in Table 2 with the mean monthly temperature profiles. Dissolved oxygen was present in adequate

Table 2. Mean temperatures and dissolved oxygen concentrations (ppm) for Greenbo Lake.

Depth in Feet	Jan. D.O.-°F	Feb. D.O.-°F	Mar. D.O.-°F	Apr. D.O.-°F	May D.O.-°F	June D.O.-°F	July D.O.-°F	Aug. D.O.-°F	Sept. D.O.-°F	Oct. D.O.-°F	Nov. D.O.-°F	Dec. D.O.-°F
0-	11.2-36°	11.6-38°	10.9-43°	10.8-54°	9.9-69°	8.6-78°	7.5-82°	8.2-81°	8.0-75°	6.8-68°	8.4-55°	8.1-47°
5-	11.4-36°	11.6-38°	11.2-43°	10.4-54°	10.3-69°	8.7-76°	7.7-81°	7.6-80°	8.0-75°	7.0-65°	8.0-55°	8.3-47°
10-	10.8-36°	12.0-38°	11.1-43°	10.7-53°	10.6-63°	8.1-73°	6.4-77°	8.5-78°	7.8-74°	7.0-65°	7.5-55°	8.3-57°
15-	11.5-35°	10.9-38°	11.0-43°	10.7-53°	10.3-56°	7.4-60°	5.5-65°	7.2-68°	7.1-72°	6.5-64°	7.6-54°	8.2-46°
20-	10.3-36°	11.3-38°	11.1-43°	10.1-50°	9.6-50°	7.5-53°	4.7-56°	3.9-57°	4.1-64°	5.0-62°	7.7-54°	8.3-46°
25-	- -36°	- -38°	- -42°	- -47°	- -48°	- -50°	- -52°	- -51°	- -54°	- -57°	- -53°	- -46°
30-	10.4-36°	11.5-38°	10.8-42°	9.9-46°	8.1-46°	5.2-47°	2.4-49°	1.3-4[illegible]°	0.4-50°	1.0-52°	7.2-53°	8.4-46°
35-	- -37°	- -38°	- -42°	- -45°	- -45°	- -47°	- -48°	- -47°	- -48°	- -49°	- -51°	- -46°
40-	10.3-37°	12.3-38°	10.6-41°	9.2-45°	6.9-45°	3.2-46°	0.9-47°	0.5-46°	0.1-47°	0.1-48°	0.3-49°	8.2-47°
45-	- -37°	- -38°	- -42°	- -45°	- -44°	- -46°	- -46°	- -46°	- -47°	- -47°	- -48°	- -47°
50-	10.3-37°	12.3-38°	10.7-43°	8.5-45°	6.4-44°	1.6-45°	0.1-46°	0.0-46°	0.0-47°	0.0-47°	0.0-48°	7.5-47°
55-	- -37°	- -38°	- -43°	- -46°	- -44°	- -45°	- -45°	- -46°	- -47°	- -47°	- -47°	- -47°

Thermocline ---------- Oxygen Depletion Zone ————————

amounts for fish survival (above 3 ppm) to a depth of 20 feet during all sampling periods. From July through October it became inadequate below 20 feet, and limited the survival of fishes below that depth. From December through May dissolved oxygen was present in adequate amounts all the way to the bottom. Mean surface concentrations fluctuated from a high of 11.6 ppm in February to a low of 6.8 ppm in October.

Alkalinity

Total alkalinity expressed as ppm $CaCO_3$ showed very little fluctuation, Table 3. The mean annual value for the six years of study (1958-1963) ranged from 19 to 22 ppm.

Total Phosphates

Mean total phosphate concentrations showed widely fluctuating values, ranging from 0.01 ppm in 1959 to 0.35 in 1961, Table 3. After three years of fertilization (1961-1963) values increased 75% over the three years previous to 1961.

pH

Mean pH values ranged from 6.7 to 7.2, Table 3. Analysis of the watershed soil samples indicated a pH of 5.6.

Free Carbon Dioxide

Monthly free CO_2 concentrations ranged from a low of 0.8 ppm in 1961 to a high of 25.9 ppm in 1958. Mean lake concentrations decreased steadily from 1958 to 1961, Table 3.

Biological Characteristics

Aquatic Vegetation Studies

In 1964, three aquatic plant species were collected, identified and preserved from Greenbo Lake - the rush *Juncus balticus* Michx., the spike rush

Table 3. The annual maximum, mean, and minimum values (unless otherwise noted) for alkalinity, total phosphates, pH, and free CO_2 in Greenbo Lake from 1958 through 1963. Values for alkalinity, total phosphates, and free CO_2 expressed as ppm.

	1958	1959	1960*	1961	1962	1963
Alkalinity	27	21	20	24	27	30
	22	19	20	19	19	22
	17	16	20	14	12	12
Total phosphates	0.15	0.03	0.53	0.93	0.51	0.61
	0.08	0.01	0.19	0.35	0.14	0.28
	0.07	0.00	0.00	0.01	0.00	0.01
pH	7.0	7.0	7.1	7.8	-	-
	-	-	-	-	-	-
	6.4	6.3	6.8	6.7	-	-
Free CO_2	25.9	19.8	6.1	16.2	-	-
	14.9	9.3	4.4	4.9	-	-
	6.3	3.3	3.2	0.8	-	-

* Values presented for 1960 were taken from samples collected in August. No other months were sampled during that year.

Eleocharis obtusa (Willd.) Schult., and the narrow-leaved cattail *Typha angustifolia* L.

Fish Population Studies

In 1958, the cove population studies conducted in Greenbo Lake showed it to be in poor condition. An average standing crop of 70 pounds per acre was recovered. This weight was composed of 27% game fish, and 73% panfishes, Table 4. The population exhibited an F/C ratio of 3.4 and a low A_t value of 18. Ample reproduction of both largemouth bass and bluegill was found.

The studies conducted in 1959 showed an increase in the standing crop of approximately 35 pounds per acre over 1958. A standing crop of 105 pounds per acre was recovered, Table 5. This weight was composed of 15% game fishes, 6% food fish, and 79% panfishes. The F/C ratio increased to 6 in 1959 while the A_t value remained unchanged. The increased F/C ratio resulted from a

good carryover of the 1958 fingerling size group into the intermediate size group of 1959. The latter was increased by 50 pounds per acre over 1958. Reproduction of both the largemouth bass and the bluegill was very light.

In 1960, a standing crop of 88 pounds per acre was recorded, Table 6. This represents a 16 pound per acre drop from 1959. The F/C ratio also dropped (from 6 in 1959 to 2.4 in 1960) and indicated an increased bass population and a reduced intermediate bluegill population. A much improved A_t value of 64 showed good recruitment into the harvestable size group. Ample reproduction of both the largemouth bass and the bluegill was indicated.

The studies conducted in 1961 showed a substantial increase in the standing crop of 54 pounds per acre over that recorded in 1960, Table 7 (1961 was the first year Greenbo was fertilized with an inorganic fertilizer, analysis 20-20-5). There was a further decrease in the F/C ratio. This resulted from a two-fold increase in standing crop of largemouth bass. There was an increase from 15 to 45 pounds per acre of harvestable bluegill, and an increase from 5 to 29 pounds per acre of intermediate-size largemouth bass. This resulted in a decrease in the A_t value from 64 to 40. Reproduction of the largemouth bass was high while the bluegill reproduction was very low.

In 1962, there was a further increase in the standing crop of 20 pounds per acre. This was accounted for by a good carryover of the fingerling and intermediate groups of largemouth bass of 1961 into the intermediate and harvestable group of 1962, and the appearance of 12 pounds per acre of harvestable channel catfish, Table 8. The F/C ratio remained the same as recorded in 1961 (1.4). An increase in the A_t value of 8% was largely due to the appearance of the harvestable-size channel catfish.

A decreased standing crop of 113 pounds per acre was recovered in 1963, Table 9. The loss was accounted for by a decrease in the weight and number of the intermediate- and harvestable-size groups of largemouth bass and bluegill.

Table 4. Average weight and number of fish per acre taken from Greenbo Lake during 1958 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Largemouth bass	0-4	895	7.07	5-9	27	4.58	10	5	7.49	927	19.14	12.76	27.35
Spotted bass	0-4	5	0.01	5-9	-	-	10	-	-	5	0.01	0.07	0.01
TOTAL		900	7.08		27	4.58		5	7.49	932	19.15	12.83	27.36
PANFISHES													
Rock bass	0-2	-	-	3-5	-	-	6	1	0.15	1	0.15	0.01	0.21
Bluegill	0-2	4611	20.66	3-5	1662	24.13	6	16	3.52	6289	48.31	86.56	69.04
Green sunfish	0-2	-	-	3-5	3	0.09	6	-	-	3	0.09	0.04	0.13
Longear sunfish	0-2	1	0.01	3-5	13	0.69	6	1	0.19	15	0.89	0.21	1.27
Redear sunfish	0-2	1	0.01	3-5	17	0.66	6	1	0.62	19	1.29	0.26	1.84
TOTAL		4613	20.68		1695	25.57		19	4.48	6327	50.73	87.08	72.49
FORAGE FISH													
Lampreys	0-3	1	0.02	4-7	-	-	8	-	-	1	0.02	0.02	0.05
Madtoms	0-3	3	0.03	4-7	2	0.05	8	-	-	5	0.08	0.07	0.10
TOTAL		4	0.05		2	0.05		-	-	6	0.10	0.09	0.15
GRAND TOTAL		5517	27.81		1724	30.22		24	11.98	7265	69.98	100.00	100.00
% OF TOTAL		75.96	29.73		23.73	43.17		0.31	17.10	100.00	100.00		

Table 5. Average weight and number of fish per acre taken from Greenbo Lake during 1959 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Grass pickerel	0-4	-	-	5-9	1	0.07	10	-	-	1	0.07	0.01	0.06
Largemouth bass	0-4	32	0.79	5-9	106	6.69	10	5	8.27	143	15.75	4.79	15.04
TOTAL		32	0.79		107	6.76		5	8.27	144	15.82	4.80	15.10
FOOD FISH													
Channel catfish	0-4	-	-	5-9	12	2.24	10	12	4.43	24	6.67	0.81	6.37
TOTAL		-	-		12	2.24		12	4.43	24	6.67	0.81	6.37
PANFISHES													
Bluegill	0-2	44	0.19	3-5	2701	73.42	6	27	4.36	2772	77.97	93.08	74.43
Green sunfish	0-2	1	0.02	3-5	6	0.26	6	-	-	7	0.28	0.21	0.27
Redear sunfish	0-2	-	-	3-5	12	0.39	6	20	3.58	32	3.97	1.06	3.79
TOTAL		45	0.21		2719	74.07		47	7.94	2811	82.22	94.35	78.49
FORAGE FISH													
Misc. cyprinids	0-3	1	0.01	4-7	1	0.03	8	-	-	2	0.04	0.04	0.04
TOTAL		1	0.01		1	0.03		-	-	2	0.04	0.04	0.04
GRAND TOTAL		77	1.01		2839	83.10		64	20.64	2980	104.75	100.00	100.00
% OF TOTAL		2.56	0.97		95.32	79.33		2.12	19.70	100.00	100.00		

Table 6. Average weight and number of fish per acre taken from Greenbo Lake during 1960 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Largemouth bass	0-4	568	3.23	5-9	31	5.79	10	6	15.24	605	24.26	15.69	27.50
Black crappie	0-4	6	0.03	5-7	1	0.12	8	-	-	7	0.15	0.18	0.17
TOTAL		574	3.26		32	5.91		6	15.24	612	24.41	15.87	27.67
FOOD FISH													
Channel catfish	0-4	-	-	5-9	-	-	10	4	4.02	4	4.02	0.10	4.56
TOTAL		-	-		-	-		4	4.02	4	4.02	0.10	4.56
PANFISHES													
Bluegill	0-2	2194	7.30	3-5	636	33.44	6	92	12.28	2922	53.02	75.78	60.09
Green sunfish	0-2	31	0.22	3-5	84	2.14	6	-	-	115	2.36	2.98	2.67
Longear sunfish	0-2	-	-	3-5	9	0.27	6	-	-	9	0.27	0.23	0.32
Redear sunfish	0-2	-	-	3-5	1	0.04	6	11	3.38	12	3.42	0.31	3.88
TOTAL		2225	7.52		730	35.89		103	15.66	3058	59.07	79.30	66.96
FORAGE FISH													
Misc. minnows	0-3	182	0.73	4-7	-	-	8	-	-	182	0.73	4.73	0.83
TOTAL		182	0.73		-	-		-	-	182	0.73	4.73	0.83
GRAND TOTAL		2981	11.51		762	41.80		113	34.92	3856	88.23	100.00	100.00
% OF TOTAL		77.31	13.05		19.76	47.38		2.93	39.57	100.00	100.00		

Table 7. Average weight and number of fish per acre taken from Greenbo Lake during 1961 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Largemouth bass	0-4	538	13.06	5-9	311	29.74	10	14	14.61	863	57.41	37.18	39.93
Black crappie	0-4	26	0.32	5-7	1	0.06	8	-	-	27	0.38	1.16	0.26
White crappie	0-4	5	0.15	5-7	-	-	8	1	0.42	6	0.57	0.26	0.40
TOTAL		569	13.53		312	29.80		15	15.03	896	58.36	38.60	40.59
FOOD FISH													
Channel catfish	0-4	1	0.01	5-9	1	0.08	10	-	-	2	0.09	0.09	0.05
TOTAL		1	0.01		1	0.08		-	-	2	0.09	0.09	0.05
PANFISHES													
Bluegill	0-2	276	1.28	3-5	953	36.26	6	132	34.63	1316	72.17	58.64	50.19
Green sunfish	0-2	-	-	3-5	17	0.76	6	1	0.24	18	1.00	0.78	0.70
Longear sunfish	0-2	1	0.01	3-5	19	1.08	6	3	0.24	23	1.33	0.99	0.92
Redear sunfish	0-2	-	-	3-5	1	0.03	6	8	6.26	9	6.29	0.38	4.38
TOTAL		277	1.29		990	38.13		144	41.37	1411	80.79	60.79	56.19
COMMERCIAL FISH													
White sucker	0-4	-	-	5-11	3	0.90	12	2	2.98	5	3.88	0.22	2.70
Spotted sucker	0-4	-	-	5-11	1	0.40	12	-	-	1	0.40	0.04	0.28
TOTAL		-	-		4	1.30		2	2.98	6	4.28	0.26	2.98
							ABOVE FORAGE SIZE						
FORAGE FISH													
Misc. cyprinids	0-3	3	0.13	3-7	3	0.14	8	-	-	6	0.27	0.26	0.19
TOTAL		3	0.13		3	0.14		-	-	6	0.27	0.26	0.19
GRAND TOTAL		850	14.96		1310	69.45		161	59.38	2321	143.79	100.00	100.00
% OF TOTAL		36.62	10.40		56.44	48.30		6.94	41.30	100.00	100.00		

Table 8. Average weight and number of fish per acre taken from Greenbo Lake during 1962 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Largemouth bass	0-4	392	3.67	5-9	248	31.49	10	22	25.28	662	60.44	4.16	37.19
Grass pickerel	0-4	-	-	5-9	1	0.09	10	-	-	1	0.09	0.01	0.05
White crappie	0-4	13	0.17	5-7	24	3.21	8	2	0.55	39	3.93	0.24	2.42
TOTAL		405	3.84		273	34.79		24	25.83	702	64.46	4.41	39.66
FOOD FISH													
Channel catfish	0-4	-	-	5-9	-	-	10	10	12.43	10	12.43	0.06	7.65
TOTAL		-	-		-	-		10	12.43	10	12.43	0.06	7.65
PANFISHES													
Warmouth	0-2	1	0.01	3-5	1	0.17	6	-	-	2	0.18	0.01	0.11
Bluegill	0-2	13,253	19.36	3-5	620	22.07	6	133	36.41	14,006	77.84	87.94	47.89
Green sunfish	0-2	128	0.60	3-5	48	1.65	6	4	0.54	180	2.79	1.13	1.72
Longear sunfish	0-2	-	-	3-5	-	-	6	1	0.10	1	0.10	0.01	0.06
Redear sunfish	0-2	-	-	3-5	-	-	6	1	0.06	1	0.06	0.01	0.04
TOTAL		13,382	19.97		669	23.89		139	37.11	14,190	80.97	89.10	49.82
COMMERCIAL FISH													
Buffalofishes	0-4	-	-	5-11	-	-	12	1	1.43	1	1.43	0.01	0.88
White sucker	0-4	-	-	5-11	-	-	12	1	0.48	1	0.48	0.01	0.30
Bullhead	0-4	1,014	1.26	5-8	-	-	9	1	1.43	1,015	2.69	6.37	1.65
TOTAL		1,014	1.26		-	-		3	3.34	1,017	4.60	6.39	2.83
							ABOVE FORAGE SIZE						
FORAGE FISH													
Misc. cyprinids	0-3	6	0.05	4-7	1	0.01	8	-	-	7	0.06	0.04	0.04
TOTAL		6	0.05		1	0.01		-	-	7	0.06	0.04	0.04
GRAND TOTAL		14,807	25.11		943	58.69		176	78.71	15,926	162.52	100.00	100.00
% OF TOTAL		92.97	15.46		5.92	36.11		1.11	48.43	100.00	100.00		

Table 9. Average weight and number of fish per acre taken from Greenbo Lake during 1963 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Grass pickerel	0-4	-	-	5-9	1	0.05	10	1	0.08	2	0.13	0.01	0.11
Largemouth bass	0-4	95	2.24	5-9	108	19.96	10	31	21.50	234	43.70	1.55	38.57
TOTAL		95	2.24		109	20.01		32	21.58	236	43.83	1.56	38.68
FOOD FISH													
Channel catfish	0-4	-	-	5-9	1	0.13	10	2	10.98	3	11.11	0.02	9.80
TOTAL		-	-		1	0.13		2	10.98	3	11.11	0.02	9.80
PANFISHES													
Warmouth	0-2	-	-	3-5	-	-	6	1	0.07	1	0.07	0.01	0.06
Bluegill	0-2	14,434	18.07	3-5	293	13.40	6	100	19.78	14,827	51.25	98.25	45.23
Green sunfish	0-2	1	0.02	3-5	10	0.56	6	1	0.20	12	0.78	0.08	0.69
Longear sunfish	0-2	-	-	3-5	-	-	6	1	0.11	1	0.11	0.01	0.10
Redear sunfish	0-2	-	-	3-5	1	0.03	6	1	0.11	2	0.14	0.01	0.12
TOTAL		14,435	18.09		304	13.99		104	20.27	14,843	52.35	98.36	46.20
COMMERCIAL FISH													
White sucker	0-4	-	-	5-11	-	-	12	2	2.33	2	2.33	0.01	2.06
Carp	0-4	-	-	5-11	-	-	12	1	2.30	1	2.30	0.01	2.03
Bullhead	0-4	1	0.01	5-8	1	0.14	9	2	1.23	4	1.38	0.03	1.22
TOTAL		1	0.01		1	0.14		5	5.86	7	6.01	0.05	5.31
							ABOVE FORAGE SIZE						
FORAGE FISH													
Misc. cyprinids	0-3	1	0.01	4-7	-	-	8	-	-	1	0.01	0.01	0.01
TOTAL		1	0.01		-	-		-	-	1	0.01	0.01	0.01
GRAND TOTAL		14,532	20.35		415	34.27		143	58.69	15,091	113.31	100.00	100.00
% OF TOTAL		96.30	17.96		2.75	30.24		0.95	51.80	100.00	100.00		

Table 10. Average weight and number of fish per acre taken from Greenbo Lake during 1964 (6 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Largemouth bass	0-4	205	1.65	5-9	112	16.10	10	21	16.74	338	34.49	0.92	21.66
Black crappie	0-4	19	tr.	5-7	-	-	8	-	-	19	tr.	0.05	tr.
White crappie	0-4	617	2.04	5-7	-	-	8	-	-	617	2.04	1.67	1.28
Grass pickerel	0-4	-	-	5-9	tr.	tr.	10	-	-	tr.	tr.	tr.	tr.
TOTAL		841	3.69		112	16.10		21	16.74	974	36.53	2.64	22.94
FOOD FISH													
Channel catfish	0-4	3	tr.	5-9	2	tr.	10	1	13.02	6	13.02	0.02	8.18
TOTAL		3	tr.		2	tr.		1	13.02	6	13.02	0.02	8.18
PANFISHES													
Bluegill	0-2	34,424	85.01	3-5	1,441	21.00	6	14	2.39	35,879	108.40	97.15	68.09
Green sunfish	0-2	5	tr.	3-5	55	1.26	6	1	tr.	61	1.26	0.17	0.79
Longear sunfish	0-2	-	-	3-5	tr.	tr.	6	-	-	tr.	tr.	tr.	tr.
Redear sunfish	0-2	-	-	3-5	2	tr.	6	tr.	tr.	2	tr.	tr.	tr.
TOTAL		34,429	85.01		1,498	22.26		15	2.39	35,942	109.66	97.32	68.88
COMMERCIAL FISH													
Spotted sucker	0-4	-	-	5-11	tr.	tr.	12	tr.	tr.	tr.	tr.	tr.	tr.
Bullhead	0-4	-	-	5-8	tr.	tr.	9	-	-	tr.	tr.	tr.	tr.
TOTAL		-	-		tr.	tr.		tr.	tr.	tr.	tr.	tr.	tr.
FORAGE FISH							ABOVE FORAGE SIZE						
Misc. cyprinids	0-3	2	tr.	4-7	8	tr.	8	tr.	tr.	10	tr.	0.03	tr.
Madtoms	0-3	tr.	tr.	4-7	-	-	8	-	-	tr.	tr.	tr.	tr.
TOTAL		2	tr.		8	tr.		tr.	tr.	10	tr.	0.03	tr.
GRAND TOTAL		35,275	88.70		1,620	38.36		37	32.15	36,932	159.21	100.00	100.00
% OF TOTAL		95.51	55.71		4.39	24.09		0.10	20.10	100.00	100.00		

Table 11. Average weight and number of fish per acre taken from Greenbo Lake during 1965 (2 studies).

SPECIES	FINGERLING SIZE			INTERMEDIATE SIZE			HARVESTABLE SIZE			TOTAL		% OF TOTAL	
	Range	No.	Wt.	Range	No.	Wt.	Min. in.	No.	Wt.	No.	Wt.	No.	Wt.
GAME FISH													
Largemouth bass	0-4	30	0.14	5-9	97	16.48	10	23	23.38	150	40.00	1.42	21.28
Black crappie	0-4	3	0.03	5-7	13	1.72	8	4	1.18	20	2.93	0.19	1.56
White crappie	0-4	-	-	5-7	3	0.44	8	-	-	3	0.44	0.03	0.23
TOTAL		33	0.17		113	18.64		27	24.56	173	43.37	1.64	23.07
FOOD FISH													
Channel catfish	0-4	1	0.02	5-9	1	0.03	10	6	16.72	8	16.77	0.07	8.92
TOTAL		1	0.02		1	0.03		6	16.72	8	16.77	0.07	8.92
PANFISHES													
Bluegill	0-2	8179	8.96	3-5	1931	90.46	6	181	24.23	10,375	126.73	89.20	67.42
Green sunfish	0-2	25	0.16	3-5	53	1.85	6	1	0.21	79	2.22	0.74	1.18
Longear sunfish	0-2	-	-	3-5	-	-	6	4	0.74	4	0.74	0.03	0.39
Redear sunfish	0-2	-	-	3-5	1	0.12	6	-	-	1	0.12	0.01	0.07
TOTAL		8204	9.12		1985	92.43		186	25.18	10,375	126.73	98.20	67.42
COMMERCIAL FISH													
Bullhead	0-4	1	0.01	5-8	4	0.60	9	1	0.48	6	1.09	0.06	0.53
TOTAL		1	0.01		4	0.60		1	0.48	6	1.09	0.06	0.53
							ABOVE FORAGE SIZE						
FORAGE FISH													
Misc. cyprinids	0-3	3	0.01	4-7	-	-	8	-	-	3	0.01	0.03	0.01
TOTAL		3	0.01		-	-		-	-	3	0.01	0.03	0.01
GRAND TOTAL		8242	9.33		2103	111.70		220	66.94	10.565	187.97	100.00	100.00
% OF TOTAL		78.02	4.96		19.89	59.42		2.09	35.62	100.00	100.00		

This was a proportional loss between the piscivorous and non-piscivorous species as indicated by an almost unchanged F/C ratio of 1.1. The loss between the intermediate group and the harvestable group was also proportional as indicated by an almost unchanged A_t value of 51. Largemouth bass reproduction fell from 392 (1962) to 97 (1963) fish per acre while the bluegill reproduction remained high as recorded in 1962.

The studies conducted in 1964 indicated an increase in the standing crop of 46 pounds per acre over 1963. This increase was accounted for by an extremely heavy spawn of bluegill which comprised 53% of the total weight, Table 10. Largemouth bass were also successful in spawning and doubled their numbers over 1963. Due to the lack of substantial numbers of intermediate bluegill during 1963, the crop of harvestable bluegill produced in 1964 amounted to only 2.39 pounds per acre and considerably lowered the A_t value (21). The F/C ratio was calculated at 2.4.

In 1965 (final year of work on Greenbo), the cove population studies produced a further increased standing crop of 188 pounds per acre, or 29 pounds per acre higher than recovered in 1964, Table 11. The largemouth bass population, which had had no size limit (12 inch) imposed on it since 1963, showed no appreciable change in its structure. The bluegill population had moved its 1964 spawn to the 3 to 5 inch groups and was accounting for 73% of the total bluegill weight. The 6, 7, and 8 inch groups, which were almost completely lacking in 1964, had increased but still left much to be desired. There were more fish of a desirable size available to the angler in 1965 as indicated by a 42% increase in the A_t value.

Creel Survey Studies

During the first year of study (1958) a harvest of 19.6 pounds per acre (109 fish) was cropped from Greenbo Lake, Table 13. Fishermen were successful in harvesting fish at the rate of 0.5 per hour or 1.4 per trip, Table 12.

Largemouth bass and bluegill were the only two species harvested in 1958, Table 13.

There was a total of 17,670 fisherman trips to the lake, Table 14. Of that number 87% were still fishermen, while 13% used the casting method. Ninety-two percent were residents, and 79% males.

The 7-month survey in 1959 indicated an almost unchanged harvest of 21.2 pounds per acre (226 fish), Table 13. However, fishermen caught twice as many fish per hour as were caught in 1958. This resulted from a decrease in fishing pressure (Table 14) and a decrease in the quality of each fish taken, Table 13.

There was a total of 14,007 fisherman trips made to the lake in 1959, Table 14. This represents a decrease of 21% from 1958. The fishing methods, sex ratio, and residency status remained in approximately the same proportions as recorded in 1958.

During the 1960 survey period anglers harvested a total of 28.5 pounds of fish per acre, Table 13. This was an increase of approximately 7 pounds per acre over 1959, and was accounted for by an increased catch of bluegill. The largemouth bass harvested in 1960 were of a better quality than those taken in 1959, Table 13. Fishermen were successful in catching fish at the rate of 1.1 fish per hour or 3.2 fish per trip, Table 12.

There were 13,598 fisherman trips made to the lake in 1960. This was approximately the same pressure recorded in 1959. The other categories remained unchanged, Table 14.

In 1961 a harvest of 51.1 pounds per acre was creeled from the lake, Table 13. This was a significant increase of 22.6 pounds per acre, or 79% over the 1960 harvest. The bluegill, crappie and channel catfish harvest all showed an increase in the quality of the catch. However, there was a significant reduction in the quality of the largemouth bass taken, Table 13. Fisherman success was the same as recorded in 1960, Table 12.

There was a decrease in the fishing pressure in 1961 of approximately 1,000 trips per acre. Small increases were recorded in the percent of still fishermen, residents and males, Table 14.

A further increase in the harvest occurred in 1962. A total harvest of 63.6 (12.5 more than in 1961) pounds of fish per acre was cropped from the lake. A 12 inch minimum size limit was imposed on the largemouth bass in 1962, and as a result the harvest of that species dropped to 1.2 pounds per acre (1 fish) as compared to 19.3 pounds per acre (75 fish) in 1961, Table 13. Consequently, the increase in harvest was accounted for by more than a 100% increase in the catch of bluegill.

The fishing pressure increased greatly in 1962. There were approximately 18,000 more fisherman trips made to the lake, Table 14. Increases were also recorded in the percent of casters, non-residents, and females, Table 14.

A decreased catch of 48.1 pounds per acre was harvested in 1963. This was due to a 15 pound reduction in the catch of bluegill, Table 13. Fisherman success was rated at 0.3 fish per hour or 1.5 fish per trip, resulting from an increased fishing pressure and an increased trip length. It should be pointed out that the average trip varied from 3 to 5 hours.

The fishing pressure (hours per acre - Table 12) increased in 1963, however the total fisherman trips decreased, resulting from an increased average trip of from 4 to 5 hours. The percent of male and still fishermen returned to the values recorded in 1961, Table 14.

In 1964 a harvest of 46.1 pounds per acre was cropped. This was almost identical to the harvest of 1963, Table 13. There was, however, a definite change within the composition of the creel. The harvest of largemouth bass jumped from 1 (1.3 pounds) per acre in 1963 to 84 (36 pounds) per acre in 1964, Table 13. This resulted from the removal of the 12 inch minimum size

limit. Concurrently there was a large decrease in the weight of the bluegill taken (from 45 pounds per acre in 1963 to 8.2 pounds per acre). These offsetting shifts resulted in an unchanged total harvest.

Fisherman success did not change, Table 12, even though there was a decrease in the fishing pressure of 12,000 trips per acre (Table 14). The weight of each fish taken, however, was double that recorded in 1963, Table 12.

During the survey period in 1965 there were approximately 34.6 pounds of fish per acre cropped from the lake (Table 13). The decrease from 1964 was accounted for by a decreased catch of largemouth bass. This loss was partly offset, however, by an increased harvest of crappie, Table 13. Fisherman success was approximately the same as recorded last year.

In April of 1965, 500 rainbow trout, ranging from 10 to 12 inches in length, were stocked in the lake. Approximately 125 or 25% of these fish were creeled during the 7-month survey.

There was no significant change in the fishing pressure of the other categories recorded in Table 14.

The final year of creel survey study was conducted on Greenbo Lake in 1966. During the 7-month survey period there was a total of 48.4 pounds of fish per acre harvested, or 14.0 pounds per acre more than in 1965, Table 13. This increase was accounted for by a good catch of bluegill. Fisherman success and the quality of the fish taken increased slightly in 1966, Table 12.

Rainbow trout were stocked again in 1966. Approximately 300 fish, 8 to 10 inches in length, were placed in the lake in the early part of April. None of these fish were taken during the 7-month survey.

The fishing pressure and the other categories recorded in Table 14, with the exception of the methods used, showed no change. Trolling entered the fishing methods category for the first time.

Table 12. Catch statistics from Greenbo Lake for 1958-1966.

Year surveyed	Acres	Avg. no. fisherman hrs./acre	Avg. no. fisherman trips/acre	Avg. no. fish/hour	Avg. wt. fish/hour	Avg. no. fish/trip	Avg. wt. fish/trip
1958	192	312	78	0.5	-	1.4	-
1959	192	284	71	1.0	-	2.9	-
1960	192	276	69	1.1	0.14	3.2	0.41
1961	192	248	62	1.0	0.20	4.0	0.80
1962	192	642	161	0.4	0.08	1.6	0.32
1963	192	669	149	0.3	0.07	1.5	0.32
1964	192	431	86	0.3	0.11	1.6	0.60
1965	192	307	77	0.5	0.10	1.9	0.45
1966	192	330	83	0.6	0.15	2.2	0.59

Table 13. Average catch per surface acre at Greenbo Lake 1958-1966.

Year surveyed	Acres	Largemouth bass		Sunfish		Crappie		Channel catfish		Totals	
		No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
1958	192	39	12.0	70	7.6	0	0.0	0	0.0	109	19.6
1959	192	81	8.9	126	7.5	0	0.0	10	4.8	226	21.2
1960	192	17	7.8	198	17.8	0	0.0	3	2.9	218	28.5
1961	192	75	19.3	171	25.6	7	2.8	1	3.4	254	51.1
1962	192	1	1.2	257	56.0	17	5.4	tr.	1.0	276	63.6
1963	192	1	1.3	215	45.2	2	1.0	2	0.6	220	48.1
1964	192	84	35.8	49	8.2	3	2.0	2	0.2	136	46.1
1965*	192	27	13.2	61	8.8	54	10.8	2	1.9	144	34.6
1966	192	14	6.8	156	34.0	5	2.0	7	5.6	182	48.4

* Rainbow trout - No. 0.66; Wt. 0.40.

Table 14. Creel survey statistics, Greenbo Lake, 1958-1966.

Year surveyed	Total no. fisherman trips	No. still fishing	% of total	No. casting	% of total	No. trolling	% of total	No. residents	% of total	No. non-residents	% of total	No. males	% of total	No. females	% of total
1958	17,670	15,338	87	2,332	13	0	0	16,310	92	1,360	8	13,917	79	3,753	21
1959	14,007	12,438	89	1,569	11	0	0	13,355	95	652	5	11,689	83	2,318	17
1960	13,598	11,739	86	1,839	14	0	0	12,731	94	847	6	11,424	84	2,154	16
1961	12,451	11,502	92	949	8	0	0	11,929	96	522	4	10,742	86	1,709	14
1962	30,837	26,568	83	4,269	17	0	0	27,427	86	3,410	14	25,601	80	5,236	20
1963	28,560	26,255	92	2,248	8	0	0	24,676	86	3,884	14	24,417	85	4,143	15
1964	16,556	13,835	84	2,721	16	0	0	13,621	82	2,935	18	13,045	79	3,511	21
1965	14,807	12,669	86	1,989	13	0	0	11,822	81	2,985	19	12,864	87	1,943	13
1966	15,859	13,672	86	2,041	13	146	1	13,095	83	2,764	17	12,788	81	3,071	19

Fertilization Studies

Figure 2 shows a comparison of the standing crop, weight of harvestable fish (A_t), and the fish harvest from 1958 through 1965. During the three years previous to fertilization (1958-1960) the standing crop averaged 88 pounds per acre, the A_t averaged 28 pounds per acre, and the harvest averaged 23 pounds per acre. After three years of fertilization the average standing crop increased to 136 pounds per acre, the average A_t to 68 pounds per acre, and the average harvest to 54 pounds per acre. After five years of fertilization these values increased to a standing crop of 150 pounds per acre, an A_t of 81 pounds per acre and a harvest (slight decrease) of 49 pounds per acre. This represents a good increase in the quality and quantity of the fishery at Greenbo Lake during the years when an inorganic fertilizer was applied at the rate of 40 pounds per acre per application (8 applications).

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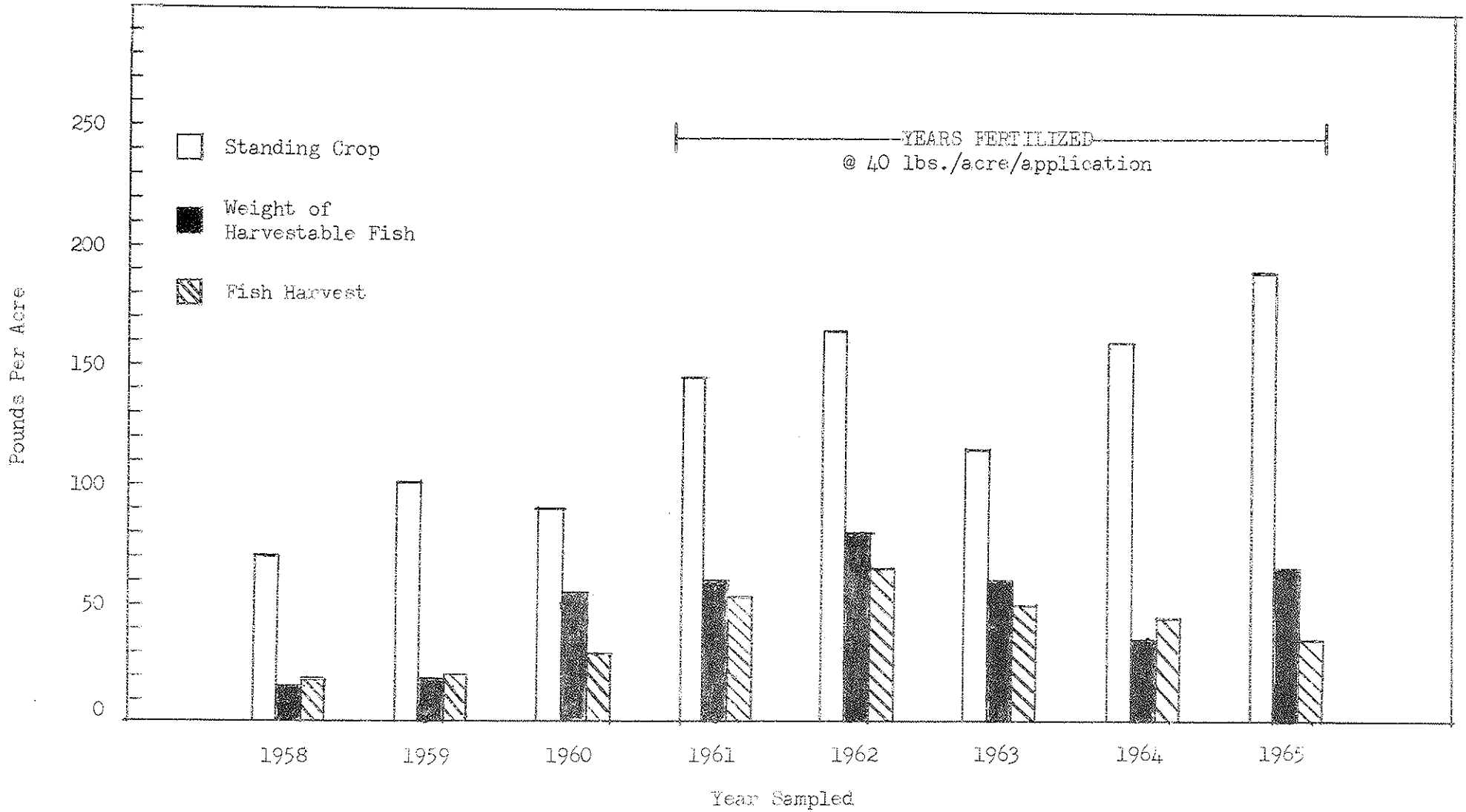
Figure 2. Standing Crop, Weight of Harvestable Fish, and Fish Harvest in Greenbo Lake From 1958-1965.



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