PRELIMINARY OBSERVATIONS ON THE ESTABLISHMENT OF A RESERVOIR TROUT FISHERY

LEON KIRKLAND AND MICHAEL BOWLING
Georgia Game and Fish Commission
Atlanta, Georgia

"Federal Aid to Fish Restoration Funds under Dingell-Johnson Project F-17-R-1"

ABSTRACT

A sport fishery for rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo trutta*) was created in the lower one-third of a 38,000-acre Oligotrophic reservoir. Maximum temperatures of 70° F. and a minimum of 3 p.p.m. oxygen were evaluated as criteria for establishing this "two-story" fishery. Stockings of 8 - 10-inch trout were made in the winter months and weight gains were up to threefold in a six-month period. Food utilized by the trout was primarily the threadfin shad (*Dorosoma petenense*). Movement of the trout did not exceed ten miles from the stocking locations, and a majority was caught within five miles.

INTRODUCTION

In recent years considerable emphasis has been placed on the establishment of "two-story" trout fisheries in warmwater impoundments in the Southeast. (Sharpe, 1961.) The term "two-story" denotes the vertical position in the lake inhabited by trout, below that normally occupied by warmwater species. This term is not completely accurate since trout move into warmwater zones during periods when temperatures are suitable. They also move ino these zones for short periods to feed even during the summer months. The concept which gave rise to the development of this type fishery was based on the premise that the lower reservoir level was not being utilized fully and that food conditions in many impoundments were such that they could support an additional species without serious harm to existing fisheries.

The criteria to determine which impoundments are suitable for "two-story" fisheries have not yet been firmly established. This presentation shows temperature and oxygen conditions where a successful "two-story" fishery does exist and verifies a criteria that is currently in use.

The most desirable species, size range, and stocking time to produce optimum growth and harvest are considered.

Life history information including food habits, growth, and movement of trout in the reservoir is also presented.

DESCRIPTION OF AREA

Lake Lanier, where this experiment was conducted, is a 38,000-acre Corps of Engineers impoundment that was filled to full pool elevation in July, 1958. It is located forty miles northeast of Atlanta, Georgia, at Latitude 34° 19′ to 34° 30′ and Longitude 83° 40′ to 84° 19′. The lake is formed by the Chattahoochee and Chestatee Rivers. At full pool elevation of the lake, it is 1,070 feet above mean sea level. Additional Morphometric data is given in appendix A.

Lake Lanier is a fairly typical oligotrophic Southeastern impoundment. It has a warmwater fish population consisting of largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), catfishes (*Italurus* sp.), green sunfish (*Lepomis cyanellus*), carp (*Cyprinus carpio*), white bass (*Roccus chrysops*), and other related warmwater species. It also has the forage species, threadfin shad (*Dorisoma petenense*).

METHODS AND MATERIALS

Determination of temperature profiles was made with a thermomarine recorder. Dissolved oxygen was determined by the modified Winkler method.

Fish population studies were conducted on two-acre cove samples with a 3/8" mesh block-off net and treating the area with one p.p.m. 5% liquid rotenone. Fish were recovered for three days.

The regular creel census was a stratified sampling type with a randomly selected starting time and point. Creel census was carried out from the latter part of February to the first of December. During the period when trout were being caught, a special day census doubling the sampling intensity was initiated. A night census was also employed from May twenty-second to September one.

The creel clerks took weights and lengths of each trout. The data was recorded separately from regular creel data and any marked fish were noted. Stomachs were also taken and preserved in ten percent formaldehyde solution to be examined later.

All creel data and stomach samples were taken from trout caught by hook and line except eight large trout (2.0-5.75 lbs.) which were taken in two-inch mesh gill nets in netting studies.

STRATIFICATION

Thermal and chemical stratification occurs in Lake Lanier. Thermal stratification begins during April with shallow and weak thermoclines being formed. These are sometimes broken up by heavy wave action and circulation. By mid-May a stable thermocline has formed (Table I).

TABLE I Typical Mid-Month Stratification Pattern of Lake Lanier

Stations	MAY 1[1]		2[2]		3[3]		JULY 1		2		3	
Depth	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.
0	84	8.9	82	10.1	78	8.7	83	7.1	84	7.0	84	7.0
10	78	8.6	79	9.3	77	8.6	82	7.0	84	7.0	84	7.0
20	66.5	8.4	66	8.6	66	8.6	74	4.6	83	6.9	84	7.0
30	59	8.0	61	7.9	60	8.4	59	3.3	73	4.1	69	5.5
40	55	7.8	57	6.5	56	8.7	56	3.0	62	3.0	62	4.4
50	51	7.7	53	6.8	53	8.6	52	2.6	58	3.4	57	4.7
60	50	7.5	50	9.0	50	8.4	50	1.9	55	4.2	55	5.6
70			49	9.2	48	8.4			51	3.7	51	5.5
80			49	7.8	48	8.3			49	4.0	50	5.4
90			48	6.6	47	8.1			48	3.0	49	5.0
100					46	7.9			48	2.4	48	4.8
120					46	7.6			48	2.1	48	5.4
130					45	7.7			48	2.0	48	4.0
140					44	7.5					48	3.8
150					44	6.9					48	3.0

Stations	SEPTEMBER 1		2		3		OCTOBER 1		2		3	
Depth	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.	Temp	D.O.
0	80.5	8.3	80	8.1	81.5	8.0	71	8.7	73	7.6	72	7.6
10	80	8.0	79	8.1	81	8.0	71	8.6	73	7.5	72	7.6
20	79	6.3	79	8.0	80	8.25	70	8.5	72	7.5	72	7.8
30	74	2.2	74.5	1.2	79	8.3	69	8.2	72	7.3	72	7.7
40	63.5	.26	64	.7	71	3.0	68	7.8	72	7.2	72	7.9
50	59	2.5	58	1.7	63	2.9	67	7.4	64	.8	72	7.9
60	54	0	53	2.8	53.5	5.2	59	1.5	60	1.7	60	2.7
70	52	0	51	2.3	52.5	5.4	55	0	57	1.3	58	2.9
80			49.5	.5	51	5.0	53	.1	55	.3	56	3.2
90			48	.1	50	3.5			53	.3	54	3.2
100			47.5	0	48	2.0			51	0	52	2.7
110			47	0	46	1.7			51	0	50	.7
120					46	1.5			51	0	49	1.3
130					46	0			50	0	49	0
140											49	0
150											49	0

1. Station #1 - 21 miles above dam
2. Station #2 - 11 miles above dam
3. Station #3 - at dam

Overturn begins generally in October and is completed by mid-December.

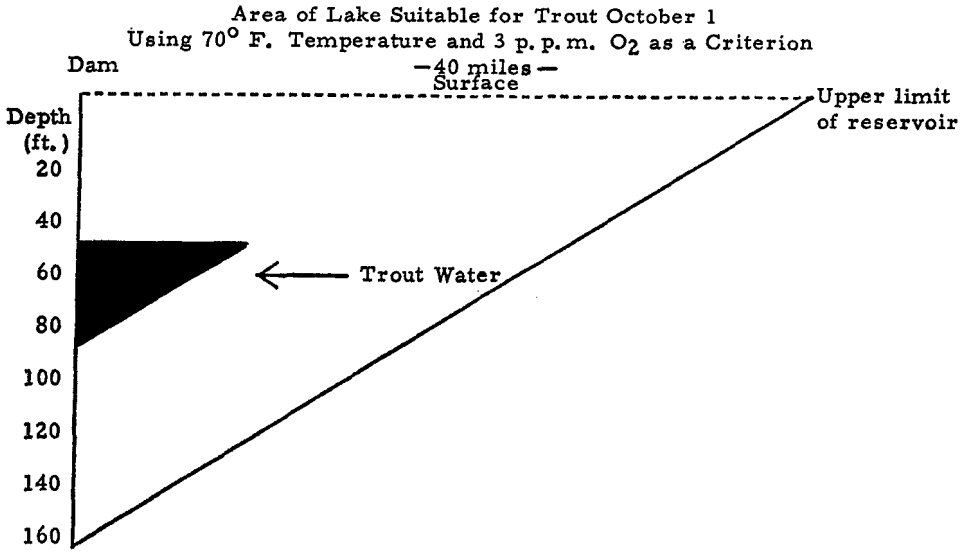
The temperature remains sufficiently cool for trout to inhabit any area of the lake below the thermocline throughout the season. Dissolved oxygen is the critical factor that determines what areas within and below the thermocline that trout can survive. CO_2 concentrations are never sufficiently high to prevent trout from using this area.

Reduction in oxygen in the hypolimnion begins immediately following establishment of a stable thermocline and continues until fall overturn begins.

An arbitrary criterion of 70° F. temperature and 3 p.p.m. O_2 has been suggested and is being used by some of the Southeastern states for determining whether lakes are suitable for trout. Using this criteria, all areas of the main channel of the lake remain suitable for trout survival through July. After July, low oxygen made the upper reaches of the reservoir unsuitable for trout. As the season progresses, the area suitable for trout gradually diminishes. By mid-September Station No. 2, eleven miles above the dam, is at the critical point for trout survival. The area continues to diminish until the middle of October when surface waters cool sufficiently to permit trout to return to the surface waters.

The first part of October is the critical time for trout in the impoundment according to the proposed criteria. At this time the layer of suitable water has been reduced to a zone immediately above the dam for a distance of six to eight miles. (Figure I.)

Figure I



TROUT STOCKING

The initial stocking of trout in Lake Lanier was made in the winter of 1964 and the program expanded in 1965. All trout stocked in Lanier were released in the lower area of the lake at several release points, all of which were within seven miles of the dam.

Immediate mortality from transportation was negligible in all releases made. In all cases the trout could be observed grouped near the release point for one to two days before scattering into the deeper areas of the lake.

The trout stocked in Lake Lanier are divided into lots according to stocking dates, species, and marking. (Table II.)

TABLE II. TROUT STOCKINGS IN LAKE LANIER 1964 - 1966.

Lot No.	Date	Species	Avg. Length*	Range	Number	Total Wt. lbs.	Avg. Wt. lbs.	Clip**
1	12/16/64	Rainbow	8.7	6.0 - 11.0	11,025	2,205	0.2	None
2	12/20/65	Rainbow	10.0	7.7 - 12.7	13,684	6,439	0.47	R.P.
3	12/20/65	Brown	9.0	— —	3,400	1,200	0.35	R.P.
4	2/ 3/66	Rainbow	8.0	7.4 - 8.9	13,200	2,360	0.18	Adp.

* Length is measured by inches.
** Clips used were R. P. (Right Pelvic), and adp. (Adipose).

CRITERIA FOR STOCKING

There were four major factors considered in formulation of stocking plans. These factors were 1) species of trout to be used; 2) the best time to stock; 3) size of fish to be used; and 4) the location to stock.

Rainbow trout and brown trout were selected as the species most suitable because of their greater tolerance for warm temperatures.

The major factors in determining the stocking time were to stock when there was a readily available food source and the trout would be subject to less predation by other fish in the impoundment and fishermen. On the basis of these factors, a winter stocking when the surface temperature reached approximately 55° was selected. This is just prior to the shad "winterkill," which normally occurs at approximately 45°. It is also when largemouth bass, which would probably be the principal predator, are becoming relatively inactive and fishing pressure is very low.

The size trout to use was based on previous work by the authors in the tailwater of Lake Lanier. In the tailwater, trout were dependent on the threadfin shad that came through the turbines from the lake during the winter months. It was assumed that the lake-stocked fish would utilize this same food source. This assumption proved to be correct (See Food Habits). In the tailwater observations indicated that an 8 - 10-inch fish was necessary to utilize the threadfin shad produced in the lake. (Kirkland, 1962.)

The stocking location selected was in the lower one-third of the lake near the dam. This is the only area that is suitable for trout all year according to the criteria used. It is also away from the major tributaries, which would minimize the likelihood of a high percentage of the stocked fish entering these tributaries. This had been a problem with trout stockings in other reservoirs in the past.

NOTES ON LIFE HISTORY OF RAINBOW AND BROWN TROUT IN LAKE LANIER

Age and Growth Studies

The growth rate of trout released in Lanier was comparable to growth reported for other reservoirs. (Table III.) (McCaig, et al. 1960.)

Lot number one showed largest gain for a comparable time period, and this rate did not slow following additional stockings. Lot number two also exhibited good growth. More samples were taken from this group than any other, because of increased creel census and increased fishing pressure for trout. Lot number three, the only brown trout stocking, showed a greater increment than lot number two. This may be exaggerated somewhat because fewer samples were taken. Lot number four exhibited the least growth increment.

TABLE III LENGTH AND WEIGHT INCREMENT OF TROUT IN LAKE LANIER AT VARIOUS SAMPLING INTERVALS

FROM HOOK & LINE SAMPLES (CREEL CENSUS)

Lot #	Number in Sample	Mean Length and Weight at Stocking		Mean Length and Weight when Sampled		Mean Time Lapse (Days)	Mean Increment	
		Length (inches)	Weight (lbs.)	Length (inches)	Weight (lbs.)		(inches)	(lbs.)
1	11	8.7	0.2	16.6	2.1	240	7.9	1.9
1	8*			19.5	3.95	360	10.8	3.75
1	8			19.9	3.7	515	11.2	3.5
2	46	10.0	0.47	17.3	1.5	150	7.3	1.03
2	39			15.5	1.64	180	5.5	1.17
2	14			15.8	1.81	210	5.8	1.34
3**	6	9.0	0.35	14.8	1.8	195	5.8	1.45
4	19	8.0	0.18	12.0	0.8	195	4.0	0.62

* Gill Net Samples

** Brown Trout

A total of 128 stomach samples were taken by hook and line (creel), and gill nets. Complete analysis and results are shown in Table IV.

TABLE IV FOOD HABITS OF RAINBOW AND BROWN TROUT IN LAKE LANIER

Showing Items Found and Frequency of Occurence by Month, Species, and Size Group

Month Species	Size Range (inches)	Aquatic Insects # %	Terrestial Insects # %	One Shad # %	2-5 Shad # %	6-10 Shad # %	Over 20 Shad # %	Empty # %	Bait** # %	Total #
December Rainbow	17-21	0	0	0	0	2-25.0	5-62.5	1-12.5	0	8
May Rainbow	10-14	1-16.6	2-33.3	1-16.6	0	0	0	2-16.6	0	6
	14.5-16.5	0	2-4.5	8-25.8	17-54.8	0	0	3-9.7	1-2.3	31
	17 ±	0	0	3-60.0	1-20.0	0	0	0	1-20.0	5
May Brown	14.0-16.5	0	0	2-66.6	1-33.3	0	0	0	0	3
June Rainbow	10-14	0	0	1-6.6	6-40.0	0	0	4-26.6	4-26.6	15
	14.5-16.5	0	2-7.1	7-25.0	8-28.6	0	0	10-35.7	1-3.5	28
	17 ±	0	1-20.0	1-20	0	0	0	2-40.0	1-20.0	5
June Brown	14.0-16.5	0	0	0	0	0	0	0	0	0
July Rainbow	10-14	0	0	2-33.3	2-33.3	0	0	1-16.7	1-16.7	6
	14.5-16.5	0	0	2-16.7	5-41.6	0	0	2-16.7	3-25.0	12
	17 ±	0	0	1-33.3	0	1-33.3	0	1-33.3	0	3
July Brown	14.0-16.5	0	0	2-100	0	0	0	0	0	2
August Rainbow	10-14	0	0	1-100	0	0	0	0	0	1
	14.5-16.5	0	0	1-33.3	2-66.6	0	0	0	0	3
	17 ±	0	0	0	0	0	0	0	0	0
August Brown	14.0-16.5	0	0	0	0	0	0	0	0	0
TOTALS		1-0.8	7-5.5	32-25.0	42-32.8	3 - 2.3	5-3.9	26-20.3	12-9.4	128

** "Bait" includes pink worms, marshmellows, apple, corn,and hooks.

Seven classes of forage items were found and the frequency of occurrence and percentages of occurrence were recorded. Empty stomachs were also recorded.

In all size classes, species, and months, the threadfin shad was the most frequently occurring forage item with the exception of the 10"-14" rainbow in May which showed a preference for aquatic and terrestial insects. This may be because the optimum size threadfin for this size fish was not available at this time of year. It is especially interesting to note that the threadfin was utilized exclusively as trout forage in the spring when they were at their lowest density and other forage was available.

Aquatic insect larvae apparently make up a very small percentage of the trout diet. Only one stomach contained aquatic insect larvae. This was not unexpected since aquatic insect larvae are almost non-existent in the lower end of this lake. Cooperative studies with the Federal Water Pollution Control Administration on Lake Lanier during autumn of 1965, showed the benthic population to be very sparse. The only forms in this area were oligochaets, tendipedid larvae, and the phantom midge (*Chaoborus*).

Terrestial insects made up a small percentage of the diet, but they were taken by all size classes of rainbow trout. No brown trout stomachs taken contained terrestial insects. Trout in Lanier did come to the surface to feed upon threadfin shad, and this probably accounts for the terrestial insects found.

MOVEMENT OF TROUT IN THE RESERVOIR

All trout stockings were made within seven miles of the dam, and the greatest distance from that point that a trout has been caught is ten miles. Ninety-eight percent of the fish checked have been within eleven miles of the dam. Therefore, it appears that with a readily available food supply the trout will not be expected to move in excess of ten miles from the stocking point near the dam, and that the majority will be caught within five miles of the stocking location.

There has been no evidence that trout are attracted to the main tributaries that feed the lake. In this case, main feeder streams are approximately forty miles from the dam or 33 miles from the nearest stocking location.

There is a definite tendency for the trout to move up small tributary streams adjacent to the stocking locations primarily during the winter months.

RETURN OF STOCKED FISH

The effort to determine return of stocked fish has been difficult due to the erratic nature of the fishery.

During the 1965 season following the initial stocking of rainbow (Lot No. 1) there was not a substantial day fishery for trout. Some good catches of fish were made at night, and considerable effort was expended in a night fishery. A night census was not in effect at that time and data was not obtained on the pressure or the catch.

During the months of January and February the trout began running up the small tributaries adjacent to the area near the dam, evidently in an effort to spawn, and a notable fishery developed. These fish were not included in the catch.

Although there was very little fishing activity following the stockings in 1964, by 1965 the program had been well publicized and a considerable number of trout were caught by fishermen immediately after stocking. This was particularly noticeable in one instance where a stocking was made near the upper end of one of the small arms of the lake. The trout were attracted to the small stream entering the arm, and many were reported caught. Small trout were also reported caught in other tributary streams. Specific information was not collected on any of these catches.

During the 1966 season a night census was designed to run from 8:00 p.m. until 12:00 midnight. Initially most of the fishing occurred during this time. During the middle of the season much of this pressure shifted over to fishing from about 2:00 a.m. until daybreak. This pressure and catch was not censused.

The total catch and pressure as calculated from creel census is

therefore a very minimal figure and probably does not reflect the magnitude of the fishery.

The fishing pressure for the day fishery for trout (Table V) ranks fifth in importance compared with other species in the reservoir. Com-

TABLE V CREEL CENSUS - LAKE LANIER 1966
By Species Fished for
Actual Creel Census Figures

DAY FISHERY

Month	No. Fhmn.	BASS Hrs.	BASS Fish	CRAPPIE Hrs.	CRAPPIE Fish	SUNFISH Hrs.	SUNFISH Fish	W.BASS Hrs.	W.BASS Fish	CATFISH Hrs.	CATFISH Fish	PERCH Hrs.	PERCH Fish	CARP Hr.	CARP Fish	TROUT Hr.	TROUT Fish	OTHERS Hr.	OTHERS Fish
February	71	117	4	18	0	0	0	0	0	3	0	0	0	0	0	41	1	0	0
March	631	734	74	576	300	58	16	0	0	101	15	1	1	1	0	5	1	0	0
April	1205	1718	353	780	654	136	49	1	6	142	17	22	5	41	16	0	0	0	0
May	1125	1860	257	316	221	249	199	36	6	120	31	6	7	31	2	315	53	18	2
June	748	1133	168	54	53	270	226	13	5	33	9	6	2	8	2	106	3	15	1
July	391	349	33	148	42	204	192	8	1	34	3	0	0	8	1	2	0	12	1
August	408	257	24	101	37	409	111	0	0	84	31	8	10	36	6	46	2	0	0
Total	4579	6168	913	1993	1307	1326	793	58	18	517	106	43	25	125	27	515	60	45	4

NIGHT FISHERY

Month	No. Fshmen.	BASS Hrs.	BASS Fish	CRAPPIE Hrs.	CRAPPIE Fish	SUNFISH Hrs.	SUNFISH Fish	PERCH Hrs.	PERCH Fish	TROUT Hrs.	TROUT Fish
May	10	0	0	0	0	0	0	0	0	14	1
June	241	1	0	8	0	0	0	0	0	286	35
July	112	4	1	0	0	6	0	0	0	99	10
August	78	0	0	0	0	0	0	0	1	67	4
September	25	0	0	0	0	0	0	0	0	49	0
Total	466	5	1	8	0	6	0	0	1	515	50

TABLE VI
CATCH PER HOUR - LAKE LANIER 1966

By Species Fished For

DAY FISHERY

MONTH	BASS	CRAPPIE	SUNFISH	CATFISH	WHITE BASS	YELLOW PERCH	CARP	TROUT	OTHER
February	.034	0	0	0	0	0	0	.024	
March	.100	.520	.275	.148	0	1.000	0	.200	
April	.205	.838	.360	.119	6.000	.227	.390	0	
May	.138	.649	.799	.258	.166	1.166	0.64	.168	
June	.148	.981	.837	.272	.384	.333	.250	.028	
July	.194	.283	.941	.088	.125	0	.125	0	
August	.093	.366	.271	.369	0	.800	.166	.043	
Average	.148	.655	.598	.205	.310	.581	.216	.116	

NIGHT FISHERY

MONTH	BASS	CRAPPIE	SUNFISH	CATFISH	WHITE BASS	YELLOW PERCH	CARP	TROUT	OTHER
May	0	0	0	0	0	0	0	.071	
June	0	0	0	0	0	0	0	.122	
July	.250	0	0	0	0	0	0	.101	
August	0	0	0	0	0	0	0	.054	
Average	.200	0	0	0	0	0	0	.097	

bined with the night pressure, trout would probably rank higher. Only the lower end of the reservoir was censused at night, therefore a valid comparison cannot be made. The night fishery in this lower area was predominately for trout. The highest catch rate was in March and May for day fishing (Table VI), and in June for night fishing.

The return of Lot No. 1 fish amounted to approximately three per cent (Table VII) by number and forty-three per cent by weight. It is

TABLE VII. STATISTICS OF LANIER TROUT FISHERY, 1966.

Day Fishery	February 26 - August 31			
Night Fishery	May 22 - August 31			
Total Trout Pressure		Day	10,616	Hours
		Night	5,740	Hours
Total Trout Caught:				
Lot #1: Rainbow	1965	Day Fishery	178	Fish
	1966	Day Fishery	116	Fish
	1966	Night Fishery	37	Fish
	Return by No. 3%		Return by Wgt. 43%	
Lot #2: Rainbow		Day Fishery	1,242	Fish
		Night Fishery	402	Fish
	Return by No. 12%		Return by Wgt. 41%	
Lot #3: Brown		Day Fishery	92	Fish
		Night Fishery	0	Fish
	Return by No. 3%		Return by Wgt. 14%	
Lot #4: Rainbow		Day Fishery	222	Fish
		Night Fishery	72	Fish
	Return by No. 2.2%		Return by Wgt. 10%	

interesting to note that a comparison of the day fishery shows that of the total caught thirty-nine per cent were caught the second year.

Return of Lot No. 2, rainbow stocked in December, 1965, amounted to twelve per cent by number and forty-one per cent by weight for the partial first-year return.

Brown trout stocked in December, 1965 (Lot No. 3), did not show as high a return as the rainbow with only three per cent return by number and fourteen per cent by weight. It is also interesting to note that in the night fishery, there were no brown trout taken.

February and March stocked rainbows (Lot No. 4), showed the poorest return this season with only 2.2 per cent return by number and ten per cent return by weight.

CONCLUSIONS

1. Trout survived in a warmwater reservoir with a zone that had maximum temperatures of 70° and minimum oxygen concentrations of approximately 3 p.p.m.
2. Growth of these trout was exceptional and a "quality" fishery was created.
3. Stocking time influenced returns of stocked fish for the short period involved.
4. Movement of trout from the stocking location did not exceed ten miles, and a majority were caught within five miles. There was a tendency for large trout to enter adjacent tributary streams in the winter months and for small trout to enter these streams following winter stockings, particularly if they were stocked adjacent to these streams.
5. Threadfin shad were the principal food items of the stocked trout. Although other fish forage was present, it was not taken by trout.
6. December stocked rainbow trout showed higher return rates the first season than either brown trout stocked at the same time or rainbow trout stocked in February and March.

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ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Mr. Dan Holder, student of Cooperative Fisheries Unit, University of Georgia, for assistance in collection of limnological data and to Dr. Louis Corrick, Federal Water Pollution Control Administration, Atlanta, for use of the information on benthic organisms.

APPENDIX A

LAKE LANIER

Morphometric Data

Elevation of Dam 1,106'
Length of Dam 1,630'
Date reservoir filled with water July, 1958
Size of drainage area 1,000+ sq. mi.
Normal water level elevation 1,070'
Flood level elevation 1,085'
Normal surface area 38,000 acres
Flood surface area 47,000 acres
Volume normal level 1,917,000 Acre Ft.
Volume flood level 2,554,000 Acre Ft.
Length of shoreline, normal level 540 Mi.
Length of shoreline, flood level 670 Mi.
Length of reservoir along major axis 54 Mi.
Maximum depth 1,515' Normal pool
Normal volume flow discharge 450 week end, 4,500 week days
Flood volume flow discharge 5,354 cfs.
Annual average volume flow of discharge 1,918 cfs.
Trees were cleared from elevation 1,025' to elevation 1,071'
Remarks*
Power Units (Kilowatts)

Main (2)	40,000
Service (1)	6,000
Depth of intake	
Bottom of Penstock	978 Ft. Above MSL
Top of Penstock	919 Ft. Above MSL

Total Hardness 5-10 p. p. m.