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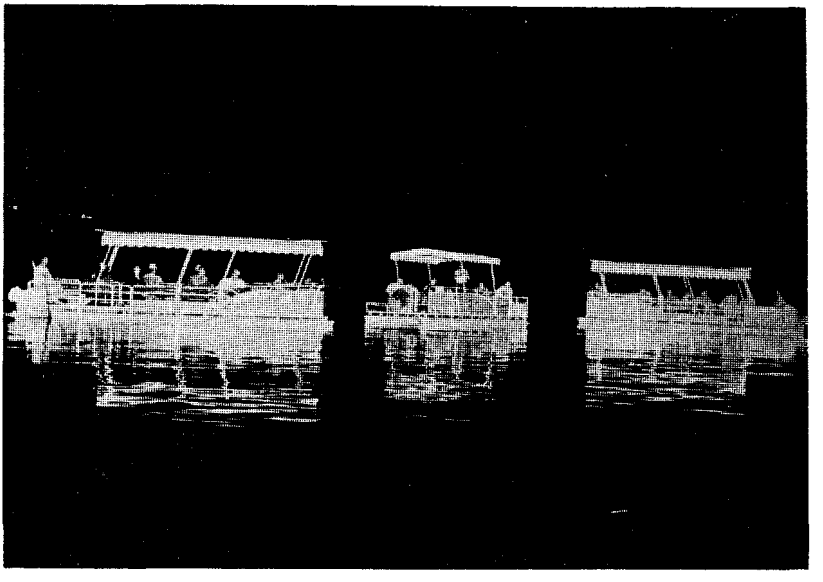

A SURVEY OF BULL SHOALS LAKE, ARKANSAS, FOR THE POSSIBILITY* OF AN EXISTING TWO-STORY LAKE SITUATION

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1967

ABSTRACT

The position of Bull Shoals Lake as the lower lake in a chain of four large reservoirs located on the main stem of the White River in Arkansas and Missouri is described. During the three years of 1961, 1962, and 1963, physical-chemical determinations were made at three sampling stations situated along the channel of the lake.

Trout requirements with respect to temperature and dissolved oxygen as reported by other authors in the Southeastern United States are reviewed. Data collected showed that trout could survive year 'round

*A paper prepared for presentation at the Twenty-First Annual Conference, Southeastern Association of Game and Fish Commissioners, New Orleans.

in the vicinity of all stations. Concurrent experimental stocking of tagged rainbow trout, *Salmo gairdneir*** (Richardson), and tag returns during this study are discussed.

DESCRIPTION OF STUDY AREA

Bull Shoals Dam is the lower in a series of four large dams on the upper White River in the Ozark Mountain region of northern Arkansas and southern Missouri. Three of the dams, Beaver, Table Rock and Bull Shoals, were constructed by the U. S. Corps of Engineers as multi-purpose dams, for the generation of hydro-electric power and flood control. Powersite Dam, forming Lake Taneycomo, is owned and operated by the Empire District Electric Company of Joplin, Missouri, for the production of hydro-electric power only.

The 28,220-acre Beaver Lake is the upstream lake on the White River system of large lakes. The lake was not impounded during the early phase of this study, but was beginning to fill as the study ended. It probably exerted no influence on Bull Shoals Lake during the study period. At the present time, it is full and power generation is underway.

The tailwater of Beaver Lake runs immediately into the headwaters of Table Rock Lake, consisting of 43,100 acres at the top of the power pool.

The tailwater of Table Rock Dam in turn becomes the headwaters of Lake Taneycomo, a narrow, channel lake 23.3 miles in length and with a surface area of 2,500 acres. With the normal water releases at Table Rock Dam, the cold water drawn from below the thermocline of the lake and aerated in the tailrace is changed little in temperature as it passes through Lake Taneycomo and into the headwaters of Bull Shoals Lake. Therefore, the possibility that a density current existed in Bull Shoals Lake, similar to that found in Lake Hamilton (Stevenson and Hulsey — 1961), was considered. Density currents are fairly well known in large impoundments in the Southeastern United States (Wiebe —1941).

Bull Shoals Lake, created by the construction of Bull Shoals Dam on the White River, lies in Baxter and Marion Counties in Arkansas, and Taney County, Missouri. Impounded in 1952, the extremely clear lake has a surface area of 45,400 acres, and a rough, rocky shoreline of 740 miles. The top of the power pool* is at 654 feet, mean sea level, the maximum depth of 204 feet is found near the dam (Baker—1960).

It was believed that the density current would exist after generation commenced at Table Rock Dam. This current of cold, oxygenated water should slide underneath the upper stratum of warm surface water in the headwaters of Bull Shoals Lake and thence proceed unbroken to the Bull Shoals Dam as a sub-surface current. It was reasoned that if such a current existed, it could be located, documented and utilized for the establishment of a trout fishery. Such a trout fishery in an otherwise warm water impoundment is known to fishery biologists as a "two-story" trout fishery.

REQUIREMENTS FOR TROUT

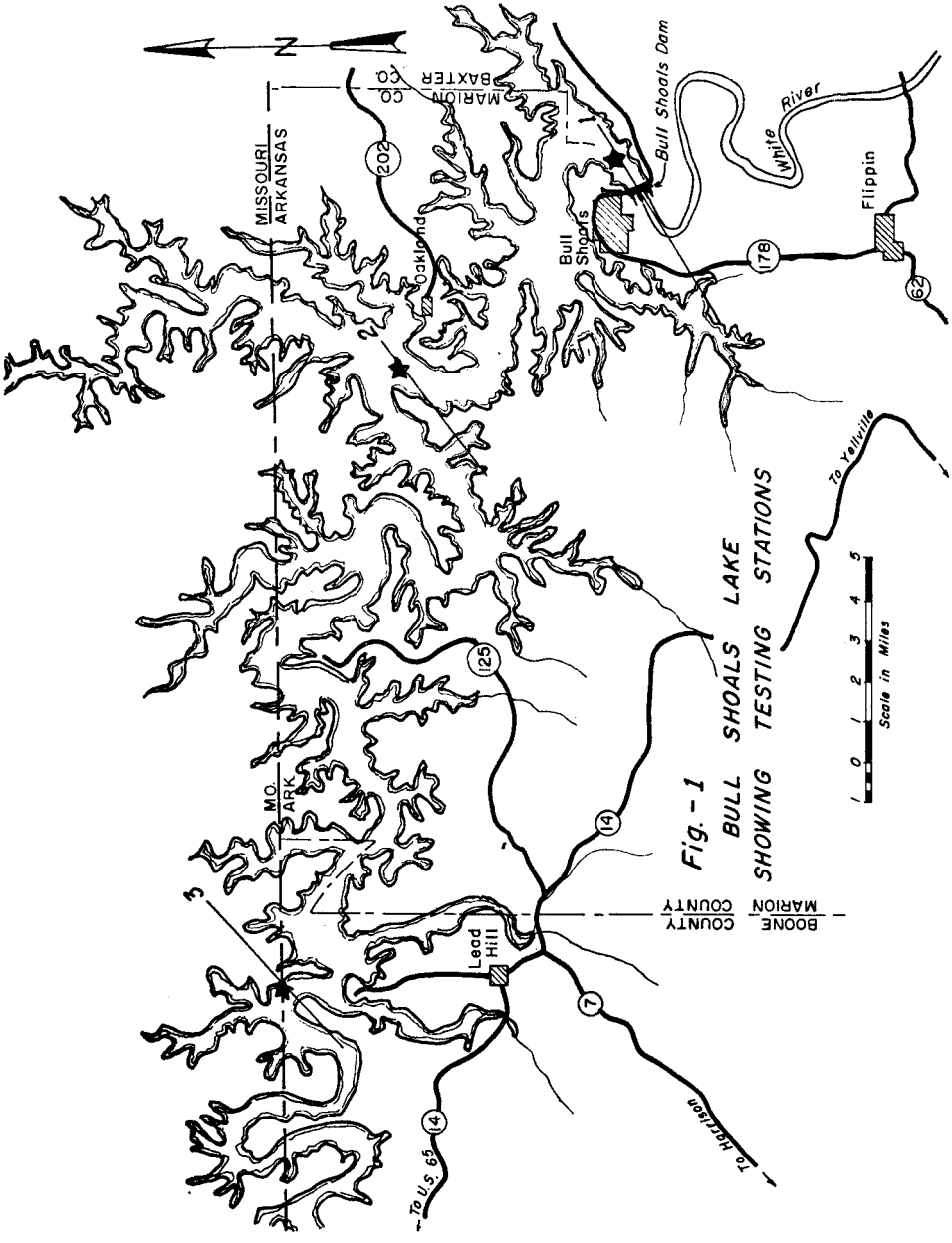
Most trout authorities agree that flourishing populations of trout are not found in bodies of water where water temperatures occur in excess of 70°F. for an extended period (Mullan—1960). There have been differences among authors from different sections of the nation concerning dissolved oxygen requirements of trout. Burdick (1954) stated that lethal concentrations of dissolved oxygen for hatchery reared rainbow trout was 2.7 ppm. Some of the variance in dissolved oxygen criteria may be explained by differences in water quality. For purposes of this study, it was determined that a temperature requirement of 70°F. and dissolved oxygen content of 3 ppm, as accepted by authors in the Southeastern United States, would be sufficient (Nichols—1962; Kirkland and Bowling—1966; Frey and Pierce—1966; Louder and Baker —1966).

**Nomenclature recommended by American Fisheries Society, Special Publication No. 2.
*In Arkansas, we consider the top of the power pool to be the "normal" size of a reservoir.

LIMNOLOGY OF BULL SHOALS LAKE

Limnological profiles at three stations on Bull Shoals Lake (Fig. 1) were determined monthly throughout the years 1961, 1962 and 1963, with the primary concern being given to temperature and dissolved oxygen.

Three permanent, mid-channel sampling stations were established. Station number one was located one-fourth of a mile above Bull Shoals Dam where the maximum depth is 204 feet. Station number two was



located near Oakland, fourteen miles above the dam where the maximum depth is 155 feet. Station number three was located forty-five miles above the dam at Lead Hill where the maximum depth is 100 feet. At all three stations attention was centered on the dissolved oxygen and temperature values since the other properties were thought to be within the tolerance limits for trout survival.

The limnological information gathered at Station one over the three-year period was studied. There were no important changes in the position of the winter-storage water at this station. In 1961, the bulk of the winter-storage water was somewhat smaller than the other two years. Considering the minimum requirements established above, the quality of the water for trout survival in this area was excellent.

The information gained from Station two over the three-year study was analyzed. Again conditions were favorable for trout in the vicinity of this station. At times during the year, less than three ppm dissolved oxygen was found near the top of the thermocline. This occurred after the death of a pulse of plankton, and showed clearly the location of the so-called "fall-out" zone. This small area of low dissolved oxygen did not materially reduce the volume of water suitable for trout.

The information garnered at Station three shows that the conditions here were not so good as at the other two stations. However, only in September and October of 1961 were conditions completely unfavorable to trout.

The carbon dioxide content at Station one ranged from one to five ppm at the surface and from five to 14 ppm at 150 feet. This same range was noted at the other stations. The pH ranged from 8.0 to 8.3 at all stations. Methyl-orange alkalinity ranged from 108 to 144 ppm, typical of this limestone area.

Thermal stratification occurs at approximately the same time and the same depth each year. This stratification is responsible for the plankton fall-out zone mentioned above. This zone is not apparent during the entire summer, but seems to occur periodically, possibly after "die-offs" of plankton blooms.

Just as in Georgia (Kirkland and Bowling — 1966), it was found that the upper reaches of the lake gradually became unsuitable for trout as the summer progressed, due to low oxygen levels. The total amount of trout water diminishes steadily in size until the area around Station Three is unsuitable for survival around September-October some years. At this time, the area suitable for trout extends from the dam to approximately 35 miles upstream.

TROUT STOCKING

Trout stocking on an experimental basis was started concurrently with the beginning of this project in February 1961.[1] Rainbow trout were used exclusively. The factor of predation by species of warm water fish was reduced by stocking fish larger than eight inches in length. The stocking was done in the winter when the surface temperatures were cold enough to support trout. This cold temperature made the entire lake into trout habitat. The hatchery trout had time enough to become acclimated, and were then able to seek new areas which were more favorable as the warm temperatures caused their habitat to shrink. Another factor entering into this stocking was the winter kill of threadfin shad, *Dorosoma petenense* (Guenther), which occurs every year in this lake. As the temperature nears 40°F. the shad swim around drunkenly, as in a stupor. In this condition, they are swept through the turbines and come out in the tailrace where they also form a major item in the diet of the trout in the tailwater. It is thought that this period of time when the shad are near death, is the best time to stock trout in the reservoirs. The larger sized trout (above eight inches in total length) which have been stocked are able to utilize these shad immediately upon stocking.

[1] Trout for this project were obtained from the Norfork National Trout Hatchery, Norfork, Arkansas.

The first fish were stocked approximately eight miles above the dam. The one thousand trout released (Table I) were tagged in order

TABLE I — TROUT STOCKING RECORD.

Lot No.	Date	Species	Number	Size	No.	Tagged	Returns
1.	2-1961	Rainbow	1,000	10″	500	Dart	1.7
					500	Mandible	4.7
2.	2-1962	Rainbow	1,000	10″	1,000	Mandible	13.9
3.	1961-1962	Rainbow	35,653	10″	—		—
4.	3-1963	Rainbow	1,000	10″	500[1]	Mandible	22.6
					500[2]	Mandible	13.8
5.	1963	Rainbow	10,157	10″	—		—
6.	3-1964	Rainbow	500	10″	500	Mandible	8.0
7.	1963-1964	Rainbow	109,212	10″	—		—
8.	1964-1965	Rainbow	147,322	10″	—		—
9.	1965-1966	Rainbow	171,680	10″	—		—

[1] Trout released 5 miles above dam.
[2] Trout released 35 miles above dam.

to gain what information we could. One lot of five hundred were tagged with a dart type tag, while another lot of five hundred were tagged with a Monel metal strap tag attached around the mandible. The returns from the dart type tag were so meager that dart tags were discontinued after this initial trial. These fish were stocked in 1961 and tag returns were received throughout 1962, leaving no doubt that trout could survive throughout the year. Of the three years included in this study, 1961 was the least desirable, and yet trout survived "over summer." Not only did these trout survive this poor year, but they grew at the rate of 0.83 inches per month.

In February 1962, one thousand (1,000) trout were tagged with the metal strap tag and released about five miles above the dam. A very encouraging 13.9% of the tags were returned, reflecting an increase in fishing pressure as our fishermen found out about the trout and devised methods of capture. These tags continued to be returned throughout 1963 and 1964. The rate of growth ranged from 0.53 inches to 0.96 inches per month, some individuals caught during 1964 weighing as much as four pounds.

Also during 1962, additional trout (35,653) were obtained and stocked in Bull Shoals Lake on an experimental basis. A fair trout fishery developed that year from these stocks.

In March 1963, one thousand (1,000) tagged trout were released at two widely-spread points on the lake. Five hundred (500) were released about five miles above the dam. The tag returns from this area (22.6%) are further indications, not only of trout survival, but of a developing fishery. The growth rate for these fish was 0.83 inches per month. The other five hundred (500) fish were released at the junction of State Highway 125 with the lake some 35 miles from the dam. Tag returns from these fish of 13.8% were very encouraging. The growth rate of these fish was 0.74 inches per month.

The pattern woven by the tag returns showed that fish released at the Highway 125 area (35 miles above the dam) were moving toward the dam as the summer progressed (Fig. 2). Two theories were advanced to explain this movement. The most obvious reason is that the dissolved oxygen decreases in the hypolimnion in the upper end of the lake as summer progresses, reaching its lowest point in the September-October period. Another theory is that the trout retreated toward the dam as their food (threadfin shad) moved toward the dam. Only eleven tags were returned from the vicinity of Highway 125 where they were released, while the remainder of the tags from the fish released at Highway 125 were returned from within fifteen miles of the dam.

Also in 1963, another batch of trout (10,157), no smaller than eight inches in length, were stocked. Again, stocking was accomplished in the winter.

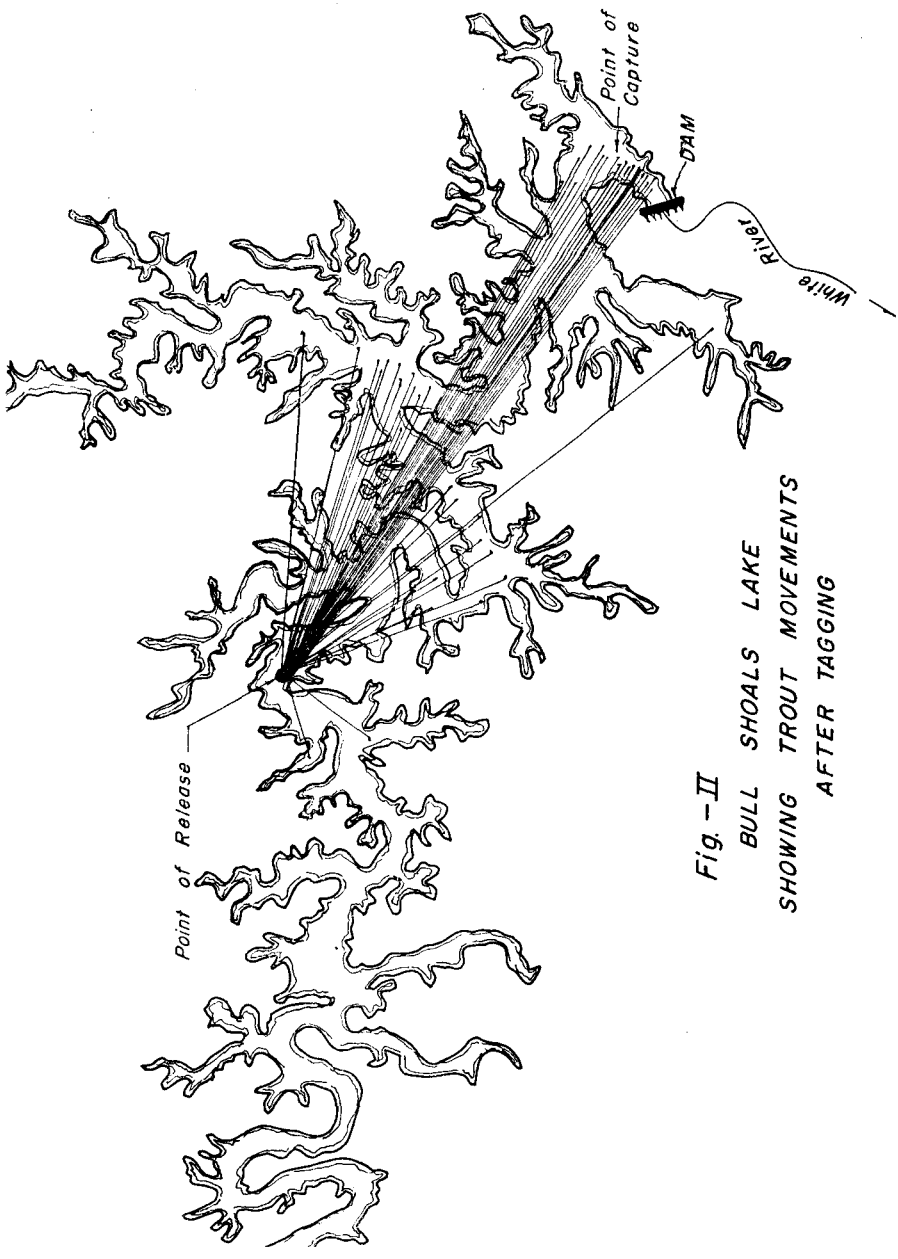


Fig. -II
BULL SHOALS LAKE
SHOWING TROUT MOVEMENTS
AFTER TAGGING

In March 1964, five hundred (500) tagged trout were released at the Highway 125 point to check on the movement noticed in 1963. As expected, the migration toward the dam occurred just as it did before. No tags were returned from above this point. While the tag returns of 8.0% were disappointing, the information is considered valid. The growth rate from those returned averaged 0.72 inches per month.

As a result of this study, numbers of trout for stocking have been increased. In 1964, one hundred nine thousand two hundred twelve

(109,212) rainbow trout were stocked and in the winter of 1965-66 we obtained three hundred nineteen thousand (319,000) rainbow trout for Bull Shoals Lake (Table I).

As a result of this study, we consider that the trout fishery on Bull Shoals Lake has evolved out of the experimental stage. A good trout fishery has developed and is increasing in popularity as more of the carry-over trout are caught. Fish in the four to six pound class are quite common and six to eight pounders are frequently caught.

The most productive method devised for catching these trout is fishing by night with lights. This is the same method used for catching crappie and white bass at night. Worms, minnows, corn and cheese are used as bait. Artificial baits are used in the winter and early spring when the trout are at the surface.

The trout fishery has added another dimension to the fishery of Bull Shoals Lake, and has contributed to the economy of the area and the State as a whole.

FOOD HABITS

The success of threadfin shad in Lake Hamilton, Garland County, Arkansas, led to the introduction of threadfin shad into all our large impoundments. The threadfin shad have reproduced in Bull Shoals, adequate stocks have survived the winter, and they form the major item in the diet of the trout in Bull Shoals Lake.[1]

Each winter when the temperatures are low, a part of the threadfin shad population will winter-kill, and it is then, when they are in a weakened condition and cannot escape, that the newly stocked trout learn to forage on them. Threadfin shad make up the major portion of the diet, but other small fish are also found in the stomachs along with crayfish, aquatic insect larvae and terrestrial insects at certain times of the year (Fig. 3).

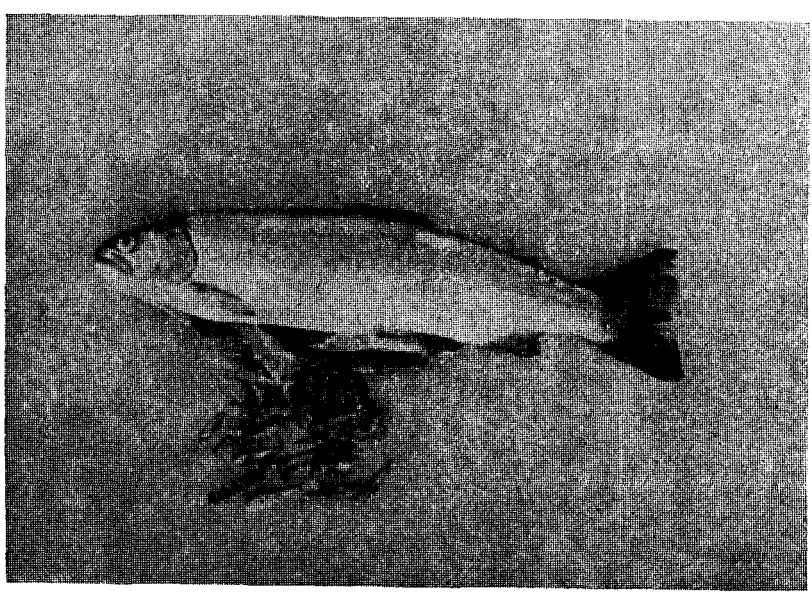


Figure 3. Stomach contents of Rainbow Trout caught in Bull Shoals Lake (Note threadfin shad).

[1] South Central Reservoir Investigations group, Fayetteville, Arkansas. Personal Communication.

CONCLUSIONS

At no time during the three-year study was there evidence of a sub-surface current of oxygenated water in the 35,540-acre portion of Bull Shoals Lake that lies in Arkansas.

Data collected at the three testing stations over the three years indicated that there was a sufficient volume of cold, oxygenated water in and below the thermocline throughout the summer to support trout in the main channel for about thirty miles above Bull Shoals Dam (Fig. 4).

Fig. IV

Trout stocked in this "warm-water" reservoir, with an established and successful warm water fish population, survived from one season to the next by utilizing the winter stored water located below the epilimnion in the lower region of the lake near the dam.

Growth of these trout was exceptional and a "quality" fishery was created.

Tagged trout released at several points, up to 35 miles from the dam, showed a pronounced movement toward the dam as the summer progressed.

Stomach examination revealed that threadfin shad were the major item in the diet of the trout.

Since the first year of the study, Bull Shoals Lake has been stocked with increasing numbers of rainbow trout and a good fishery has developed, which has added much to the economy of the area and to the State as a whole.

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