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Part I

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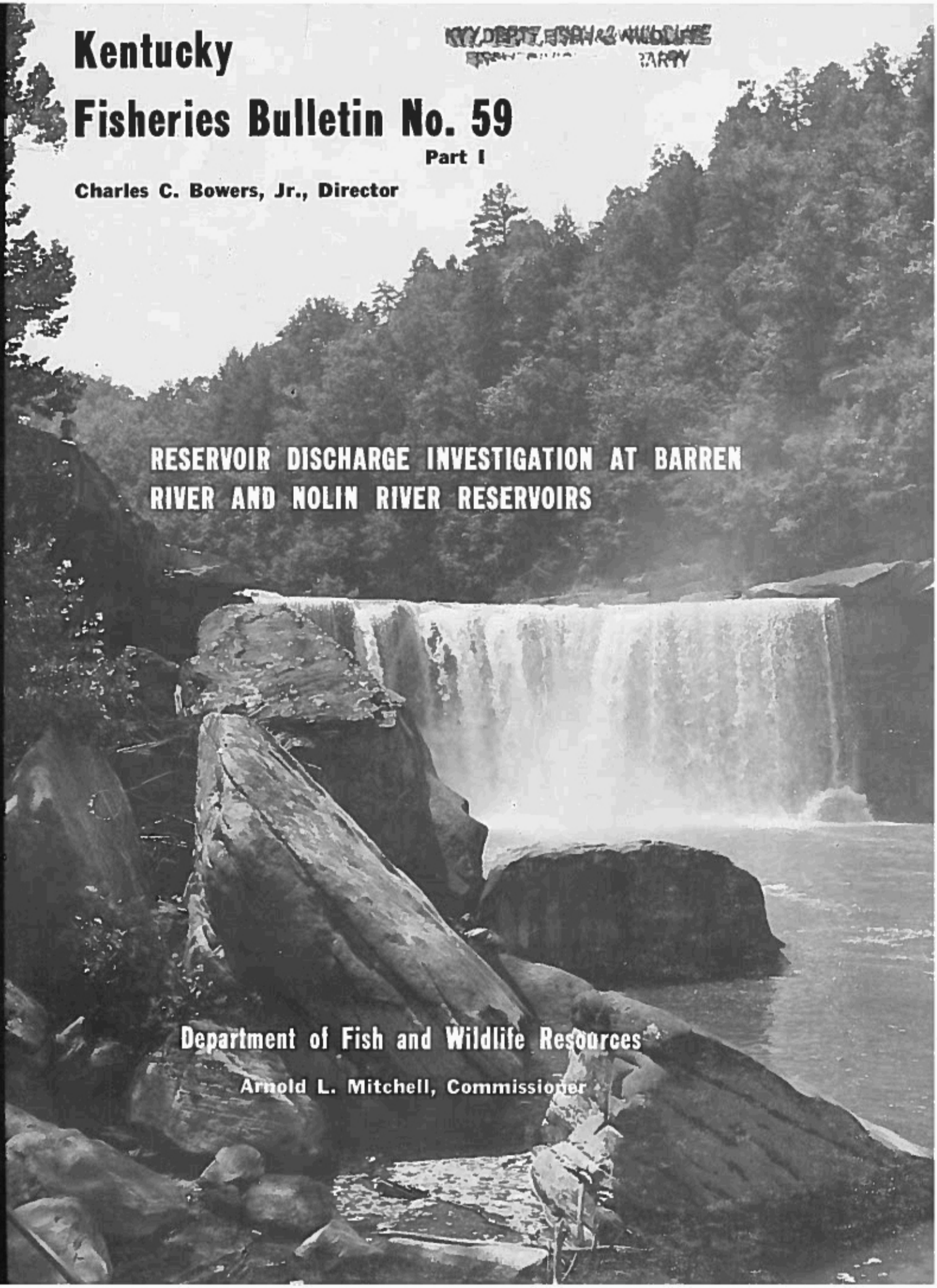

RESERVOIR DISCHARGE INVESTIGATION AT BARREN RIVER AND NOLIN RIVER RESERVOIRS

Department of Fish and Wildlife Resources

Arnold L. Mitchell, Commissioner

RESERVOIR DISCHARGE INVESTIGATION

AT BARREN RIVER AND NOLIN RIVER RESERVOIRS

[PART I of 3 PARTS]

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C O N T E N T S [P A R T I]

A B S T R A C T

The effects of epilimnial versus hypolimnial discharge regimens on water quality, benthos, fish populations, and sport fisheries of 2 south-central Kentucky flood control reservoirs, and their respective tailwaters, were compared over a 4-year period (1968-1971). Water was discharged from the epilimnion at Nolin River Reservoir (5,800 acres) during 1968 and 1969, while 25 air miles to the south, at Barren River Reservoir (10,000 acres), water was withdrawn from the hypolimnion. Discharge regimens were reversed during 1970 and 1971 at both of these Corps of Engineers' impoundments.

The precise relationships between discharge outlet location and dissolved oxygen distribution at both BRR and NRR were obscured by hydrological events and inadequate epilimnial discharge facilities at each reservoir. Substantial supplemental discharge was required from the flood gates (hypolimnion) to maintain seasonal pool elevations during 1 year of the 2-year cycle scheduled for epilimnial discharge at both reservoirs. Hydrological factors, such as rainfall amounts and patterns of inflow, appeared to influence dissolved oxygen content and distribution more than did discharge location. High inflows early in the year (high-oxygen-demand water) resulted in reduced dissolved oxygen content later in the summer when stratification became more pronounced, regardless of discharge regimen. High summer inflows during hypolimnial discharge years resulted in improved dissolved oxygen distribution to greater depths in the reservoirs since the resultant evacuation was of oxygen-deficient hypolimnetic waters. Dissolved oxygen distribution was more restricted during those years with low summer reservoir inflow. Conversely, during epilimnial discharge regimens, dissolved oxygen was found deeper during years of low summer inflow (more oxygen-rich surface waters retained) than in years with high summer inflow. Taken collectively, these findings tend to indicate that hypolimnial discharge regimens augment the vertical distribution of dissolved oxygen in reservoirs that are subject to frequent and extensive summer precipitation.

Dipterans and Oligochaeta were the most abundant macroinvertebrates in BRR. Benthic organisms generally were most abundant at the 15-foot depths and least abundant at the 40-foot depths. They were more abundant during the third period (late summer) than during the first period (early summer). The upper- and mid-reservoir stations were more productive than the lower main pool. Benthos findings at NRR paralleled those at BRR as regards abundance, species composition, and distribution. Reservoir discharge regimen had no discernible effect on the abundance or distribution of benthos in either BRR or NRR.

No differences in either fish population composition or fish biomass attributable to discharge regimen were found at either BRR or NRR. In fact, both the highest and lowest total fish biomass values, obtained by cove sampling with rotenone, were recorded during the hypolimnial discharge years at BRR. At NRR, regardless of discharge regimen, the annual standing fish crop value consistently declined throughout the 4-year sampling period.

Expansion of data resulting from weekly non-uniform probability creel surveys (March 1-October 31) revealed no relationship between empirical creel

survey statistics and discharge regimen at either BRR or NRR. Both the greatest total harvest (11.3 pounds per acre in 1971) and the least total harvest (7.5 pounds per acre in 1970) were recorded during years of hypolimnial discharge at NRR; intermediate values of 10.5 and 8.7 pounds per acre were harvested during 1968 and 1969 (epilimnial discharge). Total harvest at BRR ranged from a maximum of 12.0 pounds per acre in 1968, to a minimum of 7.3 in 1969, both epilimnial discharge years; the 1970 and 1971 harvests were 9.7 and 7.7 pounds per acre. Neither total harvest nor angler catch rate was directly related to the availability of harvestable-size fish in the population (determined by cove rotenone sampling); neither was appreciably affected by discharge regimen at either reservoir. Rainbow trout were stocked in the tailwaters of both BRR and NRR during hypolimnial-discharge years; this bonus species was avidly utilized, particularly in the NRR tailwater where it comprised 58% and 38% of the total catch in 1970 and 1971.

It was recommended that: 1) since no adverse effects were found, choice of discharge regimen at any particular reservoir in Kentucky is an administrative decision, with each case being decided on its individual merits (downstream water quality needs, two-story stocking plans, local angler preferences, etc.); 2) future reservoir discharge facilities be of sufficient capacity and of adequate design to provide maximum water quality control flexibility; 3) any future field investigations pertaining to reservoir discharge regimens be designed for a minimum of 5 years under each discharge regimen at each reservoir in order to preclude domination of the study design by prevailing weather conditions.

I N T R O D U C T I O N

By 1968, the U. S. Army Corps of Engineers had constructed and was operating 10 large reservoirs in Kentucky; additional reservoirs were under construction or in the planning stage. Five of those reservoirs have dams with multiple-level bypass outlets which permit selective temperature regulation of discharge water. The outlets were incorporated into the dam control tower structure at the request of the Kentucky Department of Fish and Wildlife Resources and the U. S. Bureau of Sport Fisheries and Wildlife. The ostensible purpose of the multi-level outlets was to restore water temperatures in the tailwaters below the dams to their original pre-impoundment levels; however, with this kind of flexibility designed into the control structure, the Department could request from the Corps water discharge regimens that would meet critical environmental requirements of either warmwater or coldwater fish species. Despite this flexibility, there remained basic, unanswered questions regarding the effects of high-level (epilimnial) reservoir discharge versus low-level (hypolimnial) discharge upon the water quality and the biotic communities of not only the manipulated reservoir, but of its tailwater as well. Underscoring this lack of knowledge was the emergence among fisheries scientists of 2 sharply-divided schools of thought concerning preferred discharge regimens. Consequently, when the Sport Fishing Institute approached the Department with a request to participate in a project designed to investigate the overall effects of high-level versus low-level discharge on reservoir ecosystems, its request was accepted. The Department's role in the overall project, which dovetailed nicely with research plans then being formulated, was to compare the effects of epilimnial and hypolimnial discharges at Barren River Reservoir and Nolin River Reservoir, and their respective

tailwaters, on (1) water quality, (2) benthos production, (3) fish populations, and (4) sport fish harvest.

This publication reports the findings of our 5-year investigation which began February 1, 1968 and terminated March 31, 1973. The study was approved and funded as a Dingell-Johnson Federal Aid to Fisheries project, F-34 (1-5), entitled *Reservoir Discharge Investigation*. Interim progress reports were published in 1969 (Charles, 1969) and 1972 (Charles, 1972), and are cited throughout the text. This bulletin is being published in 3 parts: Part I, Part II, and Part III. Part I (Text) encompasses the entire life of the project and deals with all 4 years' field data. Part II (Appendices) contains 1970 tabular data only, with no supporting text. Part III (Appendices) contains 1971 tabular data only, with no supporting text. Part I is being sent to all persons and organizations on our current mailing list; Parts II and III will be sent to persons and organizations considered appropriate, but not to all. Parts II and III are available upon specific request to:

Kentucky Department of Fish and Wildlife Resources
Capital Plaza Tower
Frankfort, Kentucky 40601

A C K N O W L E D G M E N T S

Many individuals from diverse organizations contributed to the progress of this investigation. Special acknowledgment is made to Richard H. Stroud, Executive Vice President, Sport Fishing Institute, who conceived the overall project of which this present investigation was part, and whose wise counsel was invaluable. Robert G. Martin, Assistant Executive Vice President of the SFI, served as coordinator and liasion supervisor; the insights provided by his incisive mind, the assistance lent when needed, and the overall excellence of his performance whenever called upon were absolutely essential

to project success and were sincerely appreciated. Bernard T. Carter, former Director, Division of Fisheries, Kentucky Department of Fish and Wildlife Resources, played a primary role in the conception and implementation of this investigation; his interest and constant encouragement were deeply appreciated. He and Minor E. Clark, former Commissioner of KDFWR, made this project possible. Their respective roles were later assumed by Arnold L. Mitchell, present Commissioner, and Charles C. Bowers, Jr., present Director, Fisheries Division. Practically every member of the Fisheries Division, at one time or another during the life of this project, made some contribution. To those employees we offer our thanks for their cooperation. Special thanks go to those conservation officers who conducted the weekly creel surveys in fair weather and in foul: at Barren River Reservoir we had the services of George Kidwell, Rex Brown, Wendell Stephens, and Jarvis Rippy; at Nolin River Reservoir there were James Stewart, Kenneth Merideth, Dane "Pappy" Warner, and Ernest Duggins. We certainly want to single out Summer Aides James Oliver, Larry Allison, William Harding, Charles Wilkins, and John Snider for their competent help during the busy summer months of those years they assisted us. As senior author and project leader, I want to personally thank those men who served as assistant project leaders: Michael McBrayer, who worked only a few months before going into military service; James R. Axon, who worked for 1 year before being promoted to lead his own project; William N. McLemore, junior author, who completed the investigation with me.

The following staff members (alphabetically) of the Louisville District Office, U. S. Army Corps of Engineers, were particularly helpful; we have long since come to expect cordial and courteous cooperation from this Corps office: Leon Carver, William Christman, Neil Connell (present BRR Manager),

Frank U. Druml, Carl Ed Flener, Robert H. Gregory (former Area Reservoir Manager), L. K. "Pappy" Neat, Harry Rankin, Thomas H. Reich, Kenneth Skaggs (former BRR Manager and present Area Reservoir Manager), James Smith, John Stephens (NRR Manager) and Gordon Whitten.

The benthos phase was contracted to personnel at Western Kentucky University. Special thanks go to Assistant Professor John D. Parker who supervised the initial benthos work during 1968; his contribution to the investigation, before leaving Kentucky, was not limited to benthos. Dr. Parker contributed in many ways and in practically all aspects of the project, in addition to which he was a valued friend. He was succeeded by Associate Professor Rudolph Prins for the remainder of the investigation. Others at WKU who were involved are (alphabetically): STAFF: E. O. Beal, William Courtney, Gary Dillard, Elmer Gray, Rodney McCurry, Curtis Wilkins; GRADUATE STUDENTS: David Abel, Barbara Betts, Roger Byrd, Michael Cannon, Stephen B. Crider, Charles Dapra, Donald Gollob, David Hill, Michael Molley, Frank Myers, Arthur Searcy, William Settles, Edward Van Meter, Robert Williams, John Wright; UNDERGRADUATE STUDENTS: William Black, Steven Carder, Rory Flynn, William Kaufman, Larry Lay, Barbara Powell; SECRETARIES: Wanda Day, Phyllis Sower, Karen Kennedy Travis.

Special acknowledgment is made to personnel of the National Reservoir Research Program (NRRP), Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior, for their contributions to the project. Robert M. Jenkins, Director of the NRRP gave advice, encouragement, and provided men and equipment for mutually-helpful endeavors. We looked forward every year to the arrival of Alfred Houser, South Central Reservoir Investigations of the NRRP, and his competent co-workers, Bill Culley and Milt Myers. Our nocturnal midwater trawl sampling provided annual standing crop estimates

of young-of-the-year gizzard shad at both Barren River and Nolin River reservoirs.

Dr. Don W. Hayne of the Southeastern Cooperative Fish and Game Statistics Project, Institute of Statistics, North Carolina State University, served as consultant on matters pertaining to creel survey design and data expansion. Although we did not call upon him directly, we profitted substantially, both directly and indirectly, from contributions made by Dr. James E. Dunn, Head, Mathematics Department, University of Arkansas. His astute observations were very helpful.

The secretarial help we have received from Mrs. Patsy Peavler and Mrs. Betty Gardner is sincerely and gratefully acknowledged.

Finally, we would be remiss were we not to acknowledge the hospitality and good will proffered us each year in Athens, Georgia at our annual coordination meeting by the late Eugene W. Whitney. Gene, a former KDFWR staff biologist whose untimely death saddened all who knew him, truly made unique contributions to the progress of this investigation.

METHODS AND EQUIPMENT

Water Quality Determinations

Water quality determinations during the 4-year period (1968-1971) were conducted at both Barren and Nolin River Reservoirs by the Kentucky Department of Fish and Wildlife Resources (hereinafter KDFWR) and the U. S. Army Corps of Engineers (hereinafter COE), Louisville District. During 1968, project personnel determined temperature, dissolved oxygen, total alkalinity, pH, and specific conductance values at 7 stations on Barren River Reservoir (hereinafter BRR) and at 5 stations on Nolin River Reservoir (hereinafter NRR) and at a single station in each tailwater. The COE monitored the abovementioned

parameters (except total alkalinity) at the same stations but on alternate weeks. KDFWR sampling stations were relocated on both reservoirs in 1969 to include tributary arms and inflowing streams, thus allowing more complete coverage of both reservoirs. KDFWR water quality determinations were made at 5- or 10-foot intervals; dissolved oxygen content and temperature were measured in 5-foot decrements; pH, specific conductance, and total alkalinity samples were taken at each 10-foot level.

Barren River Reservoir Sampling Stations

	Kentucky Department of Fish & Wildlife Resources	U. S. Army Corps of Engineers
Station A:	Dam (at log boom)	1. Dam (at log boom)
B:	Beaver Creek arm (Ky. 232 bridge)	2. Baileys Point boat ramp
C:	Skaggs Creek arm (U.S. 31E bridge)	3. Parksite boat ramp
D:	Peter Creek arm (U.S. 31E bridge)	4. Walnut Creek boat ramp
E:	U.S. 31E bridge	5. Browns Ford bridge
F:	Mile 100 (power line crossing)	6. Ky. 100 bridge
T:	Tailwater	7. Skaggs Creek arm
		T. Tailwater

Nolin River Reservoir Sampling Stations

	Kentucky Department of Fish & Wildlife Resources	U. S. Army Corps of Engineers
Station A:	Dam (at log boom)	1. Dam (at log boom)
B:	Davis Creek arm (mouth)	2. Mouth of Brier Creek
C:	Conoloway Creek arm	3. Mouth of Conoloway Creek
D:	Dog Creek arm (Long Fall Rd.bridge)	4. Wax bridge (Ky 88)
E:	Rock Creek arm (Ky 88 bridge)	5. Broad Ford bridge (Ky 1214)
F:	Mouth of Cane Run	T. Tailwater
T:	Tailwater	

Water temperatures were measured in degrees Centigrade but were later converted to degrees Fahrenheit, the latter being used exclusively throughout this report; dissolved oxygen concentrations were measured in parts per million using a Yellow Springs Instrument Company Model 54 dissolved oxygen meter. Water samples for pH, specific conductance, and total alkalinity determinations were taken with a Kemmerer water sampler. pH values were measured using an Analytical Measurements Model 707B meter. Specific conductance values (micromhos per centimeter) were determined with a Beckman Model RA-2A meter the first 3 years of the project, and replaced with a much-improved Beckman Model RB3 Solu Bridge meter the final year of the project. Total alkalinity values (parts per million) were determined by titrating with 0.02N sulfuric acid, using a combined (brom cresol green and methyl red) indicator solution.

Semiannual (before thermal stratification and during thermal stratification) water samples were collected by project personnel during 1968 and 1969 from both reservoirs and major inflowing streams and submitted to the then-named Federal Water Quality Administration (Federal Water Pollution Control Administration in 1968) laboratory in Evansville, Indiana, for detailed chemical analysis. During 1970-1971, supplemental water quality samples were collected and analyzed by Dr. Curtis Wilkins, of the Western Kentucky University Chemistry Department. His findings are included in Dr. Rudolph Prins' progress reports (Prins, 1970; Prins, 1971).

Benthos Studies

The benthos production phase of this investigation was implemented by staff members and graduate students of Western Kentucky University's Biology Department. Dr. John D. Parker directed the benthic studies during 1968; Dr. Rudolph Prins was in charge the next 3 years. Their contract specified that 6 sampling stations would be established in each reservoir and 1 station

would be located in each tailwater. On both sides of each reservoir at each station a benthos collecting device was established on the substrate at the level of the epilimnion (15 feet), the metalimnion (25 feet), and the hypolimnion (40 feet). These 36 benthos samplers were cylindrical wire-mesh baskets (actually, Barbeque baskets) filled with crushed limestone about 2 inches in diameter (Mason, et al., 1967). Three benthos baskets were also placed in each tailwater. The benthos samplers were left in place for a period of 2 months before being retrieved and cleaned of the accumulated benthic organisms; they were then returned to their former locations. The sampling schedule called for 3 two-month sampling periods each summer (April-May, June-July, August-September) but was not met some years for various reasons, including vandalism, flooding, wash-out and loss. Tailwater sampling was attempted the first 3 years (1968-70) but was finally abandoned because the sampler recovery rate from each tailwater was practically nil because of wash-out.

The samplers were cleaned at the time they were removed from their substrate positions. Organisms were preserved in the field for later processing in the laboratory. After identifying and counting, the macroinvertebrates were composited and dried for 24 hours at 60°C, then weighed (milligrams per sampler).

Fish Population Studies

Fish population studies were conducted monthly (May through September) in cove areas at both reservoirs. The cove study areas were nominally 2 acres in surface area; the September studies, planned to be 5 acres each at both reservoirs, actually encompassed 7.16 acres at BRR and 5.18 acres at NRR. An annotated description of the standard methods used in sampling these coves with rotenone/cube', as developed by the KDFWR fisheries staff, follows:

1. Coves selected for fish population sampling will be at least 1 acre in size; 2-acre areas are preferable. [Smaller areas are less likely to contain representative fish populations.]

2. Coves will be measured by accepted surveying methods, not by visual estimation. Soundings will be made to determine the average depths.

3. A net that effectively blocks the cove mouth from shore to shore and from surface to bottom will be used. [We used either of 2 nets (both 300 feet long): one was 40 feet deep with 1/2-inch bar-measure mesh; the second was 20 feet deep with 3/4-inch mesh.]

4. All population studies will begin between the hours of 7 and 9 p.m. prevailing local time, the earlier hour being preferable. [The block net was positioned before other activities relevant to the study were begun.]

5. Population studies will not be conducted in water having a surface temperature less than 75°F.

6. Liquid fish toxicants will be mixed with water at 1:10 ratio and applied through the propeller wash via a venturi-type boat bailer attached to the anti-cavitation plate of the outboard motor. In deep coves, the mud-ball method (powdered cube') will be used additionally for better penetration of the metalimnion. [Noxfish, a specially-formulated emusifiable toxicant containing the equivalent of 5% rotenone, was used at a concentration of 1.0 ppm, or 0.05 ppm actual rotenone.]

7. Fish within the study area will be picked up for 3 days (50 to 60 hours). Freshly-killed fish (from under or through the block net) will not be counted the second or third days. [Sanitary and esthetical considerations require disposal of floating extraterritorial fish before leaving the lake.]

8. Fish will be sorted according to species, measured by inch-groups (0 to 1.4" = 1 inch, 1.5" to 2.4" = 2 inch, etc.), and weighed to the nearest 0.01 pound. [Small species, as well as questionable larger specimens, were preserved in formalin for later identification.]

9. Appropriate field notes will be kept and resulting data will be reported according to recommendations of the Southern Division's Reservoir Committee. [Standardized field forms, designed to complement the Kentucky-version of the standard method of reporting fish population data, were used in recording measurable data.]

10. Fish nomenclature, both scientific and common, will comply with recommendations of the American Fisheries Society.

Barren River Reservoir Cove Sampling Stations

Location	Size (acres)	Hypolimnial discharge 1968	1969	Epilimnial discharge 1970	1971
Mile 101 area	1.75	-	-	AUG	MAY
Walnut Creek area	1.50	JUN	MAY	MAY	JUL
Peter Creek arm	2.00	JUL	JUN	JUN	JUN
Island (Baileys Point)	2.00	AUG	AUG	JUL	AUG
Skaggs Creek arm	7.16	SEP	SEP	SEP	SEP
Total	14.41	12.66	12.66	14.41	14.41

Nolin River Reservoir Cove Sampling Stations

Location	Size (acres)	Epilimnial discharge 1968	1969	Hypolimnial discharge 1970	1971
Buck Branch (above Wax)	2.00	JUN	MAY	MAY	MAY
Island-in-Mouth (below Wax)	2.00	JUL	JUL	JUL	JUL
Opposite mouth of Dog Creek	2.00	AUG	JUN	JUN	JUN
Conoloway Creek arm	5.18	OCT	SEP	SEP	SEP
Negro Creek (dam area)	2.00	-	AUG	AUG	AUG
Total	13.18	11.18	13.18	13.18	13.18

Estimation of the total abundance of certain pelagic species in both reservoirs, particularly gizzard shad, was made each summer by nocturnal midwater trawl sampling. A total of 45 timed hauls at various depths were made each year at each reservoir. The Bureau of Sport Fisheries and Wildlife's South Central Reservoir Investigation team (led by Alfred Houser) from Fayetteville, Arkansas, provided the necessary trawling equipment and calculated the resultant data. We provided supplemental gear and assistance. The methods used to derive population estimates from midwater trawl samples have been described by Houser and Dunn (1967) and a description of the gear was presented by Houser and Bryant (1967).

Spatial distribution, and corresponding relative abundance, of littoral and pelagic fishes were determined with fair success in both reservoirs each year during August and again in September, periods of pronounced stratification. At 2 locations in each reservoir, individual 300' by 8' sinking gill nets of 1", 1 1/2", 2", and 2 1/2" bar-measure mesh were fished 2 consecutive nights. The nets were stretched perpendicularly from the shoreline; a depth sounder and dissolved oxygen meter were employed to document temperatures and D.O. content at all depths fished by each net.

No attempt was made after the first year of the investigation to evaluate with electrofishing apparatus the numerical abundance or species composition of either tailwater fishery. The fish shocker either did not perform satisfactorily (below NRR) or high and/or turbid discharges precluded using electrofishing gear effectively; consequently, the annual March-October creel survey provided essential information about the fish population of each tailwater.

Creel Surveys

Non-uniform (unequal) probability creel surveys were conducted annually (1968-71) at both reservoirs and at their tailwaters between March 1 and

October 31. Prior creel survey data were utilized in assigning the probability values used. Local departmental conservation officers, all of whom had had previous experience in creel survey work, served as creel clerks.

The creel surveys used were designed, and the resultant data expanded, according to recommendations of Dr. Don W. Hayne of the Southeastern Cooperative Fish and Game Statistics Project (North Carolina State University, Institute of Statistics). Pfeiffer, who employed the same type of creel survey on a small state-owned lake in 1965, has published (1966) a report that details the methodology used in designing a survey of this type. The only difference in our methods was that of the basic time periods used: he divided the 12-hour fishing day (7 a.m. to 7 p.m.) into 2-hour time periods because his lake was small, and which we were able to employ at the tailwaters of BRR and NRR; however, we used 6-hour time periods at both BRR and NRR because more time was required for the creel clerks to make fisherman counts and conduct interviews on these large reservoirs. Actually, because of their size and the distances involved, each reservoir was divided into approximate halves for creel survey purposes, and a creel clerk assigned to each half. The non-uniform probability creel survey permitted creel data to be tabulated, and expanded, on a weekly basis. These weekly data have been combined and the resultant values are presented by month, rather than by week.

DESCRIPTION OF STUDY AREAS

Barren River Reservoir

This impoundment, created in late 1964 by the U. S. Army Corps of Engineers, is named after the river that was dammed nearly 80 miles upstream from its confluence with the Green River. Barren River Reservoir (BRR) is located in Allen, Barren, and Monroe Counties in south-central Kentucky. When held at

seasonal pool level (elevation 552) from April 1 through September 30, it impounds 10,000 acres and extends upstream about 33 miles. At minimum pool level (elevation 525) the surface area is reduced to 4,320 acres. BRR was constructed primarily for flood control (it was designed to contain more than 15 inches of run-off from the 940 square miles that drain to the dam); the cities of Glasgow and Scottsville obtain their municipal water supplies from it. BRR is well-served by highways, boat ramps, and recreational facilities. The Commonwealth of Kentucky, known nationally for its excellent state park system, has established a state park, complete with ultra-modern lodge, cottages, camping area, stables, picnic area, and boat dock on the shores and on land adjacent to BRR.

The tailwater below Barren River Dam resembles a golf course: the valley through which it flows is flat, the grass is kept well-clipped, and picnic tables with cookout grills are provided. Consequently, the fishing pressure recorded there was tremendous; some 4.30 acres of the tailwater were included in the weekly creel survey.

Nolin River Reservoir

This impoundment, also created by the U. S. Army Corps of Engineers, was essentially completed early in 1963. It, too, is named after the river that was dammed about 8 miles upstream from its confluence with the Green River in Mammoth Cave National Park. Nolin River Reservoir (NRR) is located in Edmonson, Grayson, and Hart Counties in south-central Kentucky. At seasonal pool (elevation 515), April 1 through September 30, NRR impounds 5,800 surface acres and extends some 39 miles upstream. When drawn down to minimum pool (elevation 490) the surface area is reduced to 2,890 acres. NRR is primarily a flood-control reservoir; it was designed to accomodate up to 15 inches of

rain on its 703-square-mile drainage basin. NRR is more remote than BRR and is not as well-served by highways and recreational facilities; boat launching ramps are adequate, however. Non-local people encountered on NRR are usually from Louisville; the numerous summer residences are invariably owned by Louisvillians.

The tailwater below Nolin River Dam during the course of this investigation (it has since been immensely improved) was utilized only by those anglers who truly wanted to fish there. Access was particularly difficult and entailed walking over the steep and rocky downstream face of the dam. There is a sheer cliff along much of the left bank and both banks were heavily vegetated. Not too surprisingly, the weekly total fisherman count there was quite often zero. Only 2.78 acres were considered accessible enough to be included in the creel survey area.

WATER QUALITY CHARACTERISTICS

Barren River Reservoir, 1968-1969

During the first 2 years of the project (1968-1969) water was released from the hypolimnial region of the reservoir between April 1 and September 30 through a pair of inlets on the control tower structure.

Water quality determinations during 1968 began in April and were concluded in November. Sampling began in January the following year and was terminated in December (Charles, 1968; Charles, 1972).

The first year of the project (1968) was normal in that seasonal (summer) pool (552' msl) was attained during the first week of April and remained at or near that elevation until fall drawdown began on September 15. On June 23, 1969, a torrential rain covered the watershed, increasing the lake elevation 19 feet above summer pool and the surface area of BRR to 14,550 acres (summer pool is 10,000 acres). To prevent possible agricultural crop damage below

the dam, water was discharged at a restricted rate and BRR returned to seasonal pool on August 15.

Pronounced thermal stratification had developed at BRR as water quality determinations were conducted on June 4-6, 1968. Thermal stratification was well-defined during 1969 when water quality determinations began on May 6. The maximum surface temperatures recorded during the first 2 years of the project were 88°F. and 90°F. during the months of August and July, respectively (Charles, 1969; Charles, 1972). A well-defined metalimnion as described by Axon (Charles, 1969) existed throughout the reservoir during the summer months of 1968 until late September. During the June "flood" of 1969, the upper shallow tributary stations (B, C, and D) were adversely affected, although 2 of the stations did restratify before fall overturn. Winter drawdown usually began on or about September 15, decreasing the water level 2 feet by October 15, and attaining winter pool (520') by November 30.

During 1968, isothermal conditions were evident at Station 3 by September 25; the entire reservoir was essentially isothermal from fall turnover by October 29. BRR had started fall turnover on October 8-9, 1969, and was similar to the previous year in that the reservoir was essentially isothermal by the end of October.

Dissolved oxygen content of the surface samples recorded during 1968-1969 were minimum (5.2 and 3.5 ppm) during the October sampling periods of both years. Maximum surface D.O. content values (11.5 and 13.0 ppm) recorded during the 2 years were recorded during April and November, respectively. Dissolved oxygen content of less than 4.0 ppm was recorded from near-bottom samples at most stations between the first and third weeks of June. Depletion of D.O. during 1968, was greatest during late August and September. During 1969, D.O. depletion was greatest during the July 8-9 sampling period; 72% of those 68 samples contained less than 4.0 ppm. Equal distribution of oxygen at all depths was recorded at most stations by late October of both years.

Total alkalinity concentrations were measured by project personnel only. Axon, during 1968, reported surface alkalinity values that ranged from 61 ppm in June to 110 ppm in November, and a gradual increase in concentration of alkalinity with depth at all stations (Charles, 1969). During 1969, surface alkalinity values ranged from 56 ppm in July to 152 ppm in November. Most of the stations sampled during 1969 also exhibited a general increase in value with depth. Total alkalinity concentrations recorded during the 2 years of hypolimnial discharge were highest during the months of November and October, respectively. Modal values derived from data collected during 1969 were greater in value than modes from 1968 data. The difference is possibly due to the relocation of the sampling stations after 1968 to monitor more closely the inflowing streams into BRR (Table 1).

pH values recorded during the 2 years of hypolimnial discharge generally decreased with depth at most stations. pH values recorded during 1968 were between 6.0 and 9.0; the 1969 sampling period had values that ranged between 5.1 and 9.1. The modes derived from data collected by both agencies during the first 2 years were generally in the 7^{+} class (Table 2 and 3).

Specific conductance values recorded from July through October (1968-1969) at Stations 1 through 7 generally increased in value with depth from surface to bottom. A substantial increase in the 35- to 40-foot level, ranging from 607 to 900 umhos/cm, was recorded at Station 4, (Walnut Creek boat ramp) from August through October of 1969. Modal values derived from data collected during 1968 were between 125 and 245 umhos/cm, followed by modes between 145 and 275 umhos/cm in 1969 (Tables 4 and 5).

Barren River Reservoir, 1970-1971

During the final 2 years of the project (1970-1971) water was released from the epilimnial region of the reservoir through 2 upper ports on the

tower structure (April 1 through September 30).

Water quality determinations during 1970-1971 began in May and January and were concluded in December. Comprehensive water quality tabular data are appended in Parts II (1970) and III (1971).

Barren River Reservoir reached seasonal pool (552') on April 23, 1970, but continued to rise until May 5, returning to seasonal pool on May 20; BRR remained at or near that elevation until winter drawdown started on October 1. During 1971, BRR did not reach summer pool as expected during the months of April or May; summer pool was attained on July 14, but the reservoir continued to rise and crested at a maximum elevation of 558.7' on August 6. BRR returned to summer pool on August 20.

Thermal stratification was well-defined at all stations when water quality determinations were conducted on May 26, 1970. Surface temperatures recorded at that time ranged from 75°F. to 81°F. Pronounced thermal stratification during 1971 was evident at 5 of the 6 deep-water stations during the April 21-23 sampling period. Surface temperatures during this sampling period ranged from 64°F. to 67°F. (Table 1, Parts II and III). A well-defined metalimnion existed throughout the reservoir during both years, lasting through the month of September. Fall overturn during 1970-1971 was evident at all stations by the second or third week of October. Isothermal conditions existed throughout the reservoir during the first week of November. Winter pool (525') was attained on November 30 of both years.

Dissolved oxygen content of the surface samples recorded during 1970-1971 were minimum (5.8 and 5.6 ppm) during the September (1970) and October (1971) sampling periods. Maximum D.O. content values recorded during the 2 years (13.3 and 16.1 ppm) were recorded during May and January, respectively.

During the May 26, 1970 sampling period, personnel recorded the D.O. content from near-bottom samples, of less than 4.0 ppm at 5 of the 6 stations. On June 10, 1971, all stations exhibited similar oxygen difficiencies at maximum depths. Dissolved oxygen depletion in BRR during 1970 was greatest during the September 21-23 sampling period; 57% of the 47 samples recorded contained less than 4.0 ppm. During 1971, 60% of the 64 samples recorded during the August 23-26 sampling period contained less than 4.0 ppm D.O. Equal distribution of D.O. at all depths was recorded at most stations by the first week of November of both years.

Total alkalinity concentrations were measured by KDFWR personnel only. During 1970 and 1971, 91% and 80% of samples recorded from surface to bottom exhibited a general increase in values with depth. Surface samples recorded during 1970 ranged from 66 ppm in September to 115 ppm in October. During 1971, alkalinity values recorded from surface samples ranged from 45 ppm in August to 128 ppm in May. Alkalinity data collected during the 2 years of epilimnial discharge exhibited similar modal values. All modes, with the exception of a bimodal value (127 ppm) at Station C, were between 82 and 87 ppm (Table 1).

pH values collected during the 2 years of epilimnial discharge were similar to the previous 2 years as values generally decreased with depth at most stations. Modal values derived from data from the 1970 sampling periods were between 6.8 and 8.7; generally, pH modes of 8^+ were from the deep, mid-water stations, whereas, pH modal values of 6^+ and 7^+ were representative of the inflowing stream stations. During 1971, the extremes of modal values were between 6.9 and 7.5 (Tables 2 and 3).

Specific conductance values recorded during 1970-1971 generally increased in value with depth. Extremely high conductance values (ranging up to 810

umhos/cm) were recorded from August through October during 1970 and 1971 at the deeper depths of Station 4; values up to 900 umhos/cm were recorded at the same station during 1969. Modal values derived from conductance values recorded at Stations 1 through 7 during 1970 and 1971 were very similar; these modes were between 185 and 255 umhos/cm (Table 4). Conductance modes derived from data collected at the tributary arm stations during 1970 were substantially higher (265-325 umhos/cm) than modal values of 1971 data (205-245 umhos/cm) (Table 5).

Barren River Reservoir Tailwater, 1968-1969

Water was released from the hypolimnion of the reservoir during the first 2 years (1968-1969) of the project (between April 1 and September 30) through a pair of inlets located on the control tower at an invert elevation of 513' msl.

Water temperatures recorded during these 2 years were essentially the same as temperatures recorded near the bottom of the reservoir at Station A (Charles, 1969; Charles, 1972). The monthly averages of temperatures recorded by both agencies (KDFWR and COE) from July through October during the first 2 years of the project were: 64°F., 65°F., 64°F., and 66°F. (1968); and 67°F., 69°F., 70°F., and 67°F. (1969). The higher temperatures of 1969 were due to the great volume of warm water that was discharged from the reservoir following the "flood" of 1969.

This dissolved oxygen content recorded at BRR-T during the first 2 years always exceeded the D.O. content in the area of withdrawal at Station A; that increase was undoubtedly due to aeration as the water passed through the control tower. The minimum D.O. content recorded during the 2-year period was 5.4 ppm in August of 1969. The monthly averages of D.O. content recorded by both agencies from July through October during the first 2 years were: 7.6 ppm, 7.5 ppm, 6.8 ppm, and 8.6 ppm, (1968); 8.3 ppm, 6.7 ppm, 6.5 ppm, and 8.8 ppm, (1969).

Table 1. Minimum, maximum, and modal concentrations of total alkalinity values, recorded from 1968 through 1971 at KDFWR water quality stations, Barren River Reservoir.

Station	1968		Station	1969		1970		1971	
	Mode	Range		Mode	Range	Mode	Range	Mode	Range
1	77	55 - 95	A	82	30 - 215	82	65 - 105	82	70 - 115
2	78	60 - 100	B	113	80 - 175	83	70 - 155	83	70 - 145
3	77	60 - 110	C	112	45 - 155	82	65 - 130	87 127*	60 - 135
4	88	65 - 115	D	98	75 - 115	88	70 - 120	83	80 - 120
5	77	75 - 105	E	92	30 - 130	82	65 - 125	82	55 - 115
6	58	75 - 105	F	83	55 - 145	83	70 - 115	83	45 - 110
7	87	60 - 110							

*Bimodal

Table 2. Minimum, maximum, and modal pH values recorded from 1968 through 1971 at COE water quality sampling stations, Barren River Reservoir.

Station	1968		1969		1970		1971	
	Mode	Range	Mode	Range	Mode	Range	Mode	Range
1	7.4	7.2 - 7.4	7.5	5.1 - 9.0	7.5	6.2 - 8.6	7.2	6.5 - 8.8
2	7.7	7.7 - 7.7	8.3	6.0 - 8.4	8.3	5.6 - 8.7	7.1	6.6 - 8.8
3	7.6	7.6 - 7.7	7.6	6.2 - 8.9	7.7 8.1*	6.5 - 8.7	7.2	6.6 - 8.8
4	7.6	7.5 - 7.7	7.4	6.3 - 9.1	8.0	6.4 - 8.7	6.9	6.6 - 8.8
5	7.6	7.6 - 7.6	6.5	6.4 - 8.6	8.0 8.7*	6.8 - 8.9	7.4	6.9 - 8.5
6	7.6	7.6 - 7.6	7.5	6.9 - 8.5	7.8	6.7 - 8.5	7.4	7.2 - 8.0
7	7.6	7.6 - 7.7	6.9	5.9 - 8.6			7.3	6.6 - 8.8

Table 3. Minimum, maximum, and modal pH values recorded from 1968 through 1971 at KDFWR water quality sampling stations, Barren River Reservoir.

Station	1968		Station	1969		1970		1971	
	Mode	Range		Mode	Range	Mode	Range	Mode	Range
1	7.0	6.6 - 8.6	A	7.7	6.2 - 8.5	6.8	6.5 - 7.8	7.1	6.8 - 8.6
2	6.8	6.0 - 8.2	B	7.3 7.6*	6.8 - 8.5	7.0	6.8 - 8.2	7.2	6.9 - 8.7
3	7.2	6.0 - 7.6	C	7.4 7.8*	6.9 - 8.3	7.6	6.9 - 8.0	7.4 7.5*	7.0 - 8.6
4	7.0	6.6 - 9.0	D	7.1	6.9 - 8.1	7.5	6.7 - 8.0	7.2	7.0 - 8.6
5	7.2 7.8*	6.8 - 8.2	E	7.1	6.3 - 7.9	7.3	6.4 - 8.1	7.1	6.7 - 8.6
6	7.6	6.8 - 7.9	F	6.9	6.3 - 8.3	6.8	6.0 - 8.3	7.1	6.8 - 8.7
7	6.8 8.1*	6.8 - 8.7							

*Bimodal

Table 4. Minimum, maximum, and modal values of specific conductance (umhos/cm) recorded from 1968 through 1971 at COE water quality sampling stations, Barren River Reservoir.

Station	1968		1969		1970		1971	
	Mode	Range	Mode	Range	Mode	Range	Mode	Range
1	155	110 - 210	185	60 - 350	205	140 - 280	225	180 - 300
2	145	100 - 210	225	50 - 280	205	150 - 300	205	150 - 300
3	125 135*	100 - 230	195	60 - 300	185	110 - 380	195 205*	150 - 270
4	145 155*	100 - 280	145	70 - 900	185 195*	160 - 820	195	120 - 820
5	155	100 - 200	225	110 - 250	215	120 - 240	215 235*	140 - 260
6	155	120 - 190	235	90 - 270	225 235*	80 - 240	245	200 - 250
7	155	80 - 230	205	110 - 350			255	190 - 340

Table 5. Minimum, maximum, and modal values of specific conductance (umhos/cm) recorded from 1968 through 1971 at KDFWR water quality stations, Barren River Reservoir.

Station	1968		Station	1969		1970		1971	
	Mode	Range		Mode	Range	Mode	Range	Mode	Range
1	195	110 - 250	A	225	100 - 350	265	240 - 300	205	180 - 310
2	215	110 - 270	B	275	210 - 400	295 315*	280 - 370	235 245*	200 - 330
3	205	100 - 380	C	275	210 - 410	315 325*	300 - 400	225	210 - 380
4	195	120 - 450	D	195	120 - 250	275	260 - 300	225	180 - 240
5	205	150 - 250	E	195	110 - 310	285	240 - 300	215	180 - 410
6	245	150 - 250	F	195 215*	150 - 530	275	230 - 340	235	180 - 320
7	225	110 - 300							

*Bimodal

Total alkalinity values recorded during the 1968-1969 sampling periods were generally lowest in the spring, gradually increasing until the fall overturn occurred. The minimum-maximum alkalinity values of both years were recorded during 1969: 49 ppm in July and 127 ppm in September. Alkalinity values recorded the first 2 years of the project exhibited a modal value between 85 and 90 ppm.

pH values recorded during 1968 ranged from 6.0 to 7.6, followed by extremes of 6.1 to 8.6 during the 1969 sampling period.

Specific conductance values recorded during 1968 were between 135 and 250 umhos/cm, followed by extremes of 108 and 278 umhos/cm in 1969. By combining all conductance values recorded by both agencies during 1968 and 1969, BRR-T exhibited average conductance values of 169 and 200 umhos/cm, respectively.

Barren River Reservoir Tailwater, 1970-1971

The discharge regimen was reversed the final 2 years (1970-1971) as water was released from the epilimnion of BRR between April 1 and September 30. Comprehensive water quality Tables are appended in Parts II (1970) and III (1971). Water temperatures recorded those final 2 years of the project were similar to the temperatures recorded near the surface at Station A. The monthly average temperatures from July through October were: 78°F., 80°F., 74°F., and 65°F. (1970); and 81°F., 72°F., 80°F. and 68°F. (1971).

The dissolved oxygen content in BRR-T during the final 2 years of sampling was generally equal to or greater than the D.O. content in the area of withdrawal. The D. O. content recorded during 1970 ranged from 6.6 ppm in June to 14.0 ppm in March, followed by extremes of 7.0 and 16.8 ppm during 1971. The monthly averages of D.O. content recorded by both agencies from July through October during the final 2 years were: 8.1 ppm, 8.1 ppm, 8.0 ppm, and 9.1 ppm (1970); and 8.0 ppm, 8.1 ppm, 7.8 ppm, and 7.4 ppm (1971).

Total alkalinity values recorded during the 1970-1971 sampling period were similar to the samples of 1968-1969 in that alkalinity values were generally lowest in the spring, gradually increasing until fall turnover occurred. During 1970, total alkalinity values ranged from 66 to 104 ppm, followed by extremes of 75 and 115 ppm during the 1971 sampling period. Alkalinity values recorded the final 2 years of the project exhibited modal values of 77 and 83 ppm, respectively.

pH values recorded at BRR-T during 1970 ranged from 6.5 to 8.5 and revealed a modal value of 7.7. Values recorded during 1971 were between 7.0 and 8.7 and had a modal value of 7.4.

Specific conductance values recorded during 1970 were between 145 and 300 umhos/cm, followed by extremes of 182 and 260 umhos/cm recorded during the 1971 sampling period. By combining all conductance values recorded by both agencies during 1970 and 1971, BRR-T revealed average conductance values of 222 and 211 umhos/cm, respectively.

Nolin River Reservoir, 1968-1969

During the first 2 years of the project (1968-1969) water was released from the epilimnial region of the reservoir between April 1 and September 30.

Water quality determinations began in April and May and were terminated in November and December. Nolin River Reservoir (NRR) attained seasonal (summer) pool (515' msl) on April 28, 1968 and April 25, 1969, remaining at or near that elevation until winter drawdown began the middle of September.

Pronounced thermal stratification had developed at NRR as water quality determinations were conducted on May 5, 1968, and on May 7, 1969. The maximum surface temperatures recorded during the first 2 years of the project were: 89°F. and 88°F. during the months of August and July, respectively (Charles, 1969; Charles, 1972). A well-defined metalimnion existed throughout the

reservoir both years until late September. Winter drawdown began on September 15, decreasing the water level 2 feet by October 15, and attaining winter pool (490') by November 30. Isothermal conditions were evident at 5 of the 6 deep-water stations during October 28-29, 1968. All stations were isothermal when water quality determinations were conducted during the last week of October of 1969.

Dissolved oxygen content of the surface samples recorded during 1968-1969 were minimum (5.9 and 6.1) during the October and September sampling periods. Maximum surface D.O. content values (12.2 and 16.2 ppm) recorded during the 2 years were recorded during October and May, respectively. Dissolved oxygen content of less than 4.0 ppm were recorded from near-bottom samples at most stations between the first and third weeks of June. Depletion of D.O. during the 2 years was greatest during the July 18-19, 1968 and August 25-27, 1969 sampling periods; approximately two-thirds of the samples taken from surface to bottom contained less than 4.0 ppm. At Station 1 on June 23, 1969, COE personnel recorded an unusual D.O. content profile. Adequate (4^+ ppm) dissolved oxygen content was recorded from the surface to the 20-foot level, and was again found between the 40- to 95-foot levels. The 40- to 95-foot vertical column of 4^+ ppm D.O. decreased in volume weekly and was recorded for the last time at a depth of 55 feet on August 26. Fall turnover occurred between the second and fourth weeks of October, resulting in nearly uniform D.O. concentration from surface to bottom at all stations.

Total alkalinity determinations were made by project personnel only. During 1968, surface alkalinity values ranged from 50 ppm in May to 186 ppm in October. All alkalinity values generally increased in value with depth, increasing in value throughout the summer with maximum values recorded in November (Charles, 1969). Alkalinity values recorded from surface samples at NRR during 1969 ranged from 69 ppm in July, to 236 ppm in November. Most

of the stations sampled exhibited a general increase in value with depth. Total alkalinity concentrations recorded during the second year of epilimnial discharge were highest when last recorded in November. Modal values derived from data collected during 1969 at Stations A, B, and C were higher than values collected at the 3 deep-water stations the previous year (Table 6).

pH values recorded during the 2 years of epilimnial discharge generally decreased with depth at most stations. pH values recorded during 1968 were between 6.4 and 8.6; values recorded during the 1969 sampling period were between 5.5 and 9.0. The modes derived from data collected by both agencies during the first 2 years were generally in the 7^{+} class (Tables 7 and 8).

Specific conductance values recorded during 1968 were greatest when determinations were conducted at the end of January. Conductance values in 1969 were maximum during the September 8-9 sampling period. Values recorded at most stations during July through October of 1968 generally increased in value with depth; however, no definite pattern as to an increase or decrease in values with depth was evident in the 1969 data. Modal values derived from data collected during 1968 were between 165 and 355 umhos/cm. Data collected during 1969 revealed modal values between 165 and 325 umhos/cm (Tables 9 and 10).

Nolin River Reservoir, 1970-1971

During the final 2 years of the project (1970-1971) water was released from the hypolimnial region of the reservoir from April 1 through September 30.

Water quality determinations during the final 2 years of the project began in May and January and were concluded in December. Comprehensive water quality tables are appended in Parts II (1970) and III (1971).

Nolin River Reservoir attained seasonal (summer) pool (515' msl) on April 16, 1970, but continued to rise and crested at 530' (8,170 surface acres)

on May 3. This 15-foot rise above seasonal pool was of short duration as water was discharged at a very high rate (approximately 8,000 cfs) resulting in NRR returning to summer pool on May 13. During 1971, NRR attained summer pool on May 8 and remained at or near that elevation until September 18 when winter drawdown began. Minimum (winter) pool was attained both years by the end of November.

Thermal stratification was evident at all stations as project personnel began sampling on May 19, 1970. Surface temperatures during that sampling period ranged from 78°F. to 84°F. Pronounced thermal stratification was evident at all 4 deep-water stations when COE personnel conducted water quality determinations on April 20, 1971. Surface temperatures during this sampling period ranged from 66°F. to 72°F. (Table 6, Parts II and III). Fall overturn was evident at most stations during the last 2 weeks of October 21, 1970 and October 27, 1971 sampling periods at Stations A through F. Winter pool was attained on November 30.

Dissolved oxygen content of the surface samples recorded during 1970-1971 at NRR were minimum (4.5 and 5.8 ppm) during the October (1970) and September-October (1971) sampling periods. Maximum D.O. content values (16.0 and 15.2 ppm) recorded during the final 2 years were recorded during May and January, respectively. During the May 26-27, 1970 sampling period, project personnel recorded the D.O. content from near-bottom samples, of less than 4.0 ppm at 5 of the 6 stations. On June 8, 1971, all stations exhibited similar oxygen deficiencies at maximum depths. Dissolved oxygen depletion in NRR during 1970 was greatest during the COE July 6-7 sampling period; more than three-fourths of the samples (66) taken from surface to bottom contained less than 4.0 ppm. D.O. depletion during 1971 was greatest during 2 separate sampling periods: August 26-27 and September 7-8. During these

periods, approximately three-fourths of the 65 samples contained less than an adequate amount of dissolved oxygen. Fall turnover was evident at all stations during the last 2 weeks of October of both years, resulting in nearly uniform D.O. concentrations from surface to bottom.

Total alkalinity determinations were made by project personnel only. During 1970, surface alkalinity values ranged from 55 ppm in July to 162 ppm in October. Alkalinity values recorded from surface samples during 1971 ranged from 65 ppm in July to 172 ppm in April. Total alkalinity values recorded during the last 2 years generally increased in value with depth at most stations. However, values recorded at Station D (Dog Creek arm) usually revealed lower values near the bottom than at the surface. Modal values derived from data collected during the 1970 sampling period were between 68 and 108 ppm; followed in 1971 by modal extremes of 78 and 108 ppm (Table 6).

pH values recorded during the 2 years of hypolimnial discharge generally decreased with depth at most stations. Modal values derived from data collected in 1970 were between 6.9 and 8.5; modal values from data recorded during 1971 were all in the 7^{+} class, and ranged between 7.0 and 7.6 (Tables 7 and 8).

Specific conductance values recorded during the 1970-1971 sampling periods generally increased in value with depth at most stations. Conductance values recorded during 1970 were between 100 and 490 umhos/cm, followed in 1971 by extremes of 148 and 423 umhos/cm. Modal values derived from data collected in 1970 were between 195 and 345 umhos/cm, followed by modal values from 1971 data that were between 205 and 285 umhos/cm. Conductance modes derived from data recorded the last 2 years at Stations A through F were very similar (Tables 9 and 10).

Table 6. Minimum, maximum, and modal concentrations of total alkalinity values recorded from 1968 through 1971 at KDFWR water quality stations, Nolin River Reservoir.

Station	1968		Station	1969		1970		1971	
	Mode	Range		Mode	Range	Mode	Range	Mode	Range
1	112	50 - 120	A	142	85 - 160	82	65 - 115	102	70 - 135
2	108	70 - 130	B	133	90 - 165	108	75 - 135	108	75 - 125
3	112	85 - 145	C	127	85 - 175	77	75 - 135	112	70 - 125
4	118	85 - 135	D	108 112*	45 - 150	78	65 - 90	88	30 - 105
5	127	80 - 155	E	123	65 - 205	77	65 - 125	87	40 - 120
6	173	160 - 190	F	72	65 - 240	68	55 - 170	78* 87	65 - 190

Table 7. Minimum, maximum, and modal pH values recorded from 1968 through 1971, at COE water quality sampling stations, Nolin River Reservoir.

Station	1968		1969		1970		1971	
	Mode	Range	Mode	Range	Mode	Range	Mode	Range
1	8.3	6.4 - 8.3	7.4	6.2 - 8.9	7.2	6.2 - 9.2	7.0	6.6 - 8.5
2	6.9	6.9 - 8.3	7.6	5.6 - 8.7	6.9	6.1 - 8.9	7.0	6.7 - 8.8
3	7.8	7.2 - 8.0	7.3	5.5 - 8.6	6.9 7.4*	6.5 - 9.0	7.0	6.7 - 8.7
4	7.6	7.6 - 8.3	7.4	6.7 - 9.0	7.3	6.3 - 9.0	7.2	6.8 - 8.5
5	8.0	7.5 - 8.6	7.8	7.3 - 8.8	7.5	7.1 - 8.2	7.6	7.1 - 8.3

*Bimodal

Table 8. Minimum, maximum, and modal pH values recorded from 1968 through 1971, at KDFWR water quality stations, Nolin River Reservoir.

Station	1968		Station	1969		1970		1971	
	Mode	Range		Mode	Range	Mode	Range	Mode	Range
1	7.4	6.4 - 8.5	A	7.2	6.3 - 8.2	7.3	6.6 - 8.9	7.3	6.7 - 8.4
2	7.2	7.0 - 8.4	B	7.2	6.6 - 8.1	6.9	6.5 - 8.5	7.1	6.7 - 8.2
3	7.1 7.2*	7.0 - 7.6	C	7.7	6.8 - 8.3	7.1	6.5 - 8.4	7.1	6.8 - 8.2
4	7.2	6.9 - 7.6	D	7.3	6.2 - 8.2	6.9	6.4 - 8.2	7.2	6.7 - 8.2
5	7.4	6.8 - 8.5	E	7.5	6.6 - 8.3	7.1	6.0 - 8.1	7.1 7.3*	6.7 - 8.5
6	7.4	7.0 - 8.2	F	7.5	7.2 - 8.7	7.8 8.5*	7.1 - 8.8	7.2	6.8 - 8.6

Table 9. Minimum, maximum, and modal values of specific conductance (umhos/cm) recorded from 1968 through 1971 at COE water quality sampling stations, Nolin River Reservoir.

Station	1968		1969		1970		1971	
	Mode	Range	Mode	Range	Mode	Range	Mode	Range
1	185	130 - 340	225	160 - 400	195	100 - 350	245	160 - 370
2	185	150 - 330	245	170 - 350	235	100 - 360	245	210 - 340
3	165	140 - 350	185	160 - 340	285	100 - 360	255	180 - 340
4	185	130 - 290	245	160 - 410	345	130 - 490	205	140 - 390
5	305	150 - 310	325	190 - 410	315	210 - 410	285	230 - 420
6	355	350 - 360						

Table 10. Minimum, maximum, and modal values of specific conductance (umhos/cm) recorded from 1968 through 1971 at KDFWR water quality stations, Nolin River Reservoir.

Station	1968		Station	1969		1970		1971	
	Mode	Range		Mode	Range	Mode	Range	Mode	Range
1	185 205*	180 - 320	A	225	160 - 310	265	240 - 310	255	200 - 320
2	235	170 - 300	B	265	170 - 290	275	240 - 360	255	220 - 290
3	245 265*	190 - 310	C	245 255*	200 - 300	285	250 - 380	245	220 - 290
4	265	170 - 300	D	215	120 - 280	275	230 - 340	205	200 - 240
5	185	180 - 340	E	295	200 - 300	245	230 - 260	215	200 - 270
6	265	260 - 270	F	165	160 - 420	245	240 - 420	245	180 - 430

*Bimodal

Nolin River Reservoir Tailwater, 1968-1969

During the first 2 years of the project (1968-1969) water was released from the epilimnial region of the reservoir from April 1 through September 30. Water quality determinations during the 2 years began in April and May and were concluded in November and December (Charles, 1969; Charles, 1972).

Water temperatures recorded in the tailwater during the first 2 years were generally higher than temperatures recorded near the epilimnial inlets. The monthly averages of temperatures recorded by both agencies (KDFWR and COE) from July through October during 1968-1969 were: 81°F., 81°F., 75°F., and 61°F., (1968); and 84°F., 79°F., 76°F., and 51°F. (1969).

The dissolved oxygen content recorded at NRR-T was generally equal to or exceeded by D.O. content in the area of withdrawal at Station A; the dissolved oxygen content from all 42 samples recorded during both years exceeded 4.0 ppm. The minimum-maximum contents recorded during those 2 years were: 6.0 - 11.0 ppm and 5.4 - 13.4 ppm. The monthly averages of D.O. contents recorded by both agencies from July through October during 1968-1969 were: 7.6 ppm, 7.4 ppm, 8.2 ppm, and 8.1 ppm (1968); and 7.5 ppm, 8.1 ppm, 8.3 ppm, and 10.2 ppm (1969).

Total alkalinity values recorded at NRR-T were generally lowest in the spring, increasing in value until late summer. Alkalinity values during 1968 ranged from 104 to 119 ppm and averaged 112 ppm for the year; following in 1969 with extremes between 86 and 159 ppm that averaged 112 ppm (Charles, 1969; Charles 1972).

pH values recorded during the 1968 sampling period ranged from 7.6 to 9.4; the latter value was recorded during the March 5-7 sampling period. pH values recorded during the second year of epilimnial discharge were between 6.9 and 9.1. The pH modal value derived from data collected during the first 2 years was 7.6 for each year.

Specific conductance values recorded during the first 2 years ranged from 104 to 250 umhos/cm in 1968, followed in 1969 by extremes of 184 and 318 umhos/cm. By combining all conductance values recorded by both agencies during 1968-1969, NRR-T exhibited modal values of 185, and 265 umhos/cm (Charles, 1969; Charles, 1972).

Nolin River Reservoir Tailwater, 1970-1971

The water discharge regimen was reversed the final 2 years (1970-1971) to a hypolimnial withdrawal from April 1 through September 30. Comprehensive water quality tables are appended in Parts II (1970) and III (1971).

Water temperatures in this tailwater were essentially the same as temperatures recorded near the bottom of the reservoir at Station A. The monthly averages of all temperatures recorded by both agencies from July through October were: 60°F., 62°F., 63°F., and 66°F. (1970); and 61°F., 64°F., and 69°F. (1971).

The dissolved oxygen content of 24 samples recorded from February through December of 1970 ranged from 7.5 to 15.0 ppm. During 1971, the D.O. content from 30 water quality samples ranged from 7.9 to 16.5 ppm. The monthly averages of D.O. content recorded by both agencies at NRR-T from July through October of the final 2 years were: 8.8 ppm, 8.7 ppm, 7.9 ppm, and 9.2 ppm, (1970); and 9.3 ppm, 8.5 ppm, 8.5 ppm, and 8.6 ppm (1971).

Total alkalinity values recorded at the tailwater during 1970 ranged from 87 to 116 ppm and averaged 104 ppm. Alkalinity values the following year were between 88 and 136 ppm and averaged 111 ppm.

pH values recorded during the 2 years of hypolimnial discharge ranged from 6.4 to 8.0 in 1970, followed by extremes of 6.8 and 8.0 during the 1971 sampling period. By combining all pH values recorded by both agencies, NRR-T had modal values fo 7.5 (1970) and 7.2 (1971).

Specific conductance values recorded during 1970 were between 210 and 300 umhos/cm, followed in 1971 with extremes of 230 to 300 umhos/cm. By combining all conductance values recorded by both agencies, NRR-T revealed modal values of 265 and 255 umhos/cm in 1970 and 1971.

B E N T H O S S T U D I E S

Barren River Reservoir

The 36 substrate samplers (2" crushed limestone in wire baskets) were placed in 3 areas: Station A (lower main pool); Station B (mid-lake area); and Station C (upper lake). At each station 4 samplers were deployed at depths of 15, 25, and 40 feet from the surface; these depths generally corresponded to regions adjacent to the epilimnion, metalimnion, and hypolimnion during summer stratification. A delay in installation during the first summer, coupled with high losses of samplers, suggested that the available data from the 2 collecting periods be combined. It was found that regardless of the distance of the samplers from the dam or the depth at which any sampler had been located, the dipteran genera, *Tendipes* and *Tanypus*, were the most frequently encountered in 1968. These forms exhibited a distinct preference for epi- and metalimnetic conditions over that of the hypolimnion. The trichopterans and ephemeropterans, perhaps due to their relatively high oxygen requirements, showed an even stronger tendency to occur only in the upper 2 strata. These forms were almost totally absent from the hypolimnion. Average numbers and weights of benthos in BRR are shown in Figure 1; more detailed information may be found in the first annual progress report (Charles, 1969).

Complications brought about by a 19-foot rise above normal seasonal pool in late June of 1969 caused the loss of all substrate basket samplers in this reservoir. Continued high water prevented their reinstallation until September.

Ekman dredge samples were used during the high-water period to assess benthos production in the epi- , meta-, and hypolimnetic areas; great discrepancies in the numbers of organisms and sample weights were found between the limestone samples and the Ekman samples, rendering these data generally incomparable. Most interpretations were based upon average numbers of dominant organisms and particularly upon species diversity. Excepting phantom midge larvae, the limestone baskets accumulated greater numbers and kinds of benthos, some forms occurring on them only. The average number of organisms increased from 6 per sample at both Stations A and B (dam and mid-lake areas) to 19 at Station C (upper lake). There was a general decrease in numbers of individuals and taxa from the 15- to 40-foot depths. There was a general increase in numbers of individuals from Period 1 (May-June) to Period 3 (September-October). Average numbers and weights of benthos in BRR are shown in Figure 1; benthos production is more fully explored in the second progress report (Charles, 1972).

During 1970, the first year of the epilimnetic discharge regimen at BRR, there was a general, but inconsistent, tendency for individual taxa to increase in numbers from one period to the next. Oligochaetes were frequently responsible for major shifts in numbers. Decreases in weights from 15 to 40 feet were consistent. Species diversity was slightly greater in shallower areas. Numbers and weights (with many exceptions) generally decreased from Station A to Station C in Period 1, and conversely in the subsequent 2 periods. Average numbers and weights of benthos recorded at BRR in 1970 are shown in Figure 1; additional data may be found in Part II (Appendices) of this bulletin.

Overall, benthos in 1971 at BRR tended to be most abundant at the 15-foot depth, and at Stations A and B; however, except at Station B at 25 feet, the differences were small. Taxa primarily responsible for major increases in numbers from Periods 1 to 3 were dipterans *(Chironomus* and *Glyptotendipes)*

and Oligochaetes. Average weights decreased from Periods 1 and 2, increasing dramatically during Period 3. Benthos weight values generally parallelled numerical values. Average numbers and weights found in BRR during 1971 are depicted in Figure 1; additional data may be found in Part III (Appendices) of this bulletin.

To summarize, dipterans and Oligochaeta were the most abundant macroinvertebrates in BRR. Benthic organisms generally were most abundant at the 15-foot depths and least abundant at the 40-foot depths. They were more abundant during the third period (late summer) than during the first period (early summer). The upper- and mid-reservoir stations were more productive than the lower main pool. Reservoir discharge regimen had no discernable effect on the abundance or distribution of benthos in either BRR or NRR.

Nolin River Reservoir

For the same reasons (delayed installation and high sampler losses) benthos data from the summer of 1968 were combined. Here, too, as at BRR, the dipterans, *Tendipes* and *Tanypus*, were the most-often found organisms. There was indication that neither the average number nor the average dry weight of the organisms per sampler was influenced by distance of the collecting station from the dam. However, there was a distinct indication that vertical distribution was being influenced by some factor such as thermal stratification. Average numbers and weights of benthos in NRR are shown in Figure 1; more detailed information may be found in the first annual progress report (Charles, 1969).

Forty-four benthos samples (limestone baskets), or about 15 from each depth zone, were analyzed in 1969. Generally, there were increases in numbers of individuals from Stations A (dam) to C (uplake); the same was true from Period 1 to Period 3 (May through October). The overall trend was a decrease

in both numbers and weights of benthic forms from the epilimnetic to the hypolimnetic areas; these shifts were not as striking as would have been expected if more traditional sampling methods (e.g., Ekman dredge) had been employed. Average numbers and weights found at the 3 depths during 1969 are shown in Figure 1; benthos production is more fully explored in the second progress report (Charles, 1972).

The discharge regimen at NRR was changed in 1970 to hypolimnetic. Overall, average numbers of organisms were greater at Station C than at Station A, with regard to both taxa and dominant forms. The general trend was for numbers of organisms to increase from Period 1 to Period 3. Increases of Oligochaeta were especially pronounced. The trend of benthos weights from Stations A to C was highly variable, but on the basis of averages from all periods, increases in weights from Stations A to C were consistent. Species diversity decreased at 40 feet. Average numbers and weights of benthos recorded at NRR in 1970 are shown in Figure 1; additional data may be found in Part II (Appendices) of this bulletin.

During 1971, there was a tendency for benthos density to increase from Period 1 to Period 2, then decrease during Period 3. Average numbers were similar between all stations at 15 feet; they were similar between Stations A and B at 25 feet. Benthos numbers were consistently lowest at the 40-foot level. Taxa primarily responsible for fluctuations in numbers from period to period were *Glyptotendipes* (Diptera), *Stenonema* (Ephemeroptera), and Cnidaria. The taxa diversity did not vary appreciably throughout the summer; however, there tended to be fewer at 40 feet. Average numbers and weights found in NRR during 1971 are depicted in Figure 1; additional data may be found in Part III (Appendices) of this bulletin.

In summary, benthos findings at NRR paralleled those at BRR as regards abundance, species composition, and distribution. Here too, reservoir discharge regimen apparently did not detectably influence benthos production.

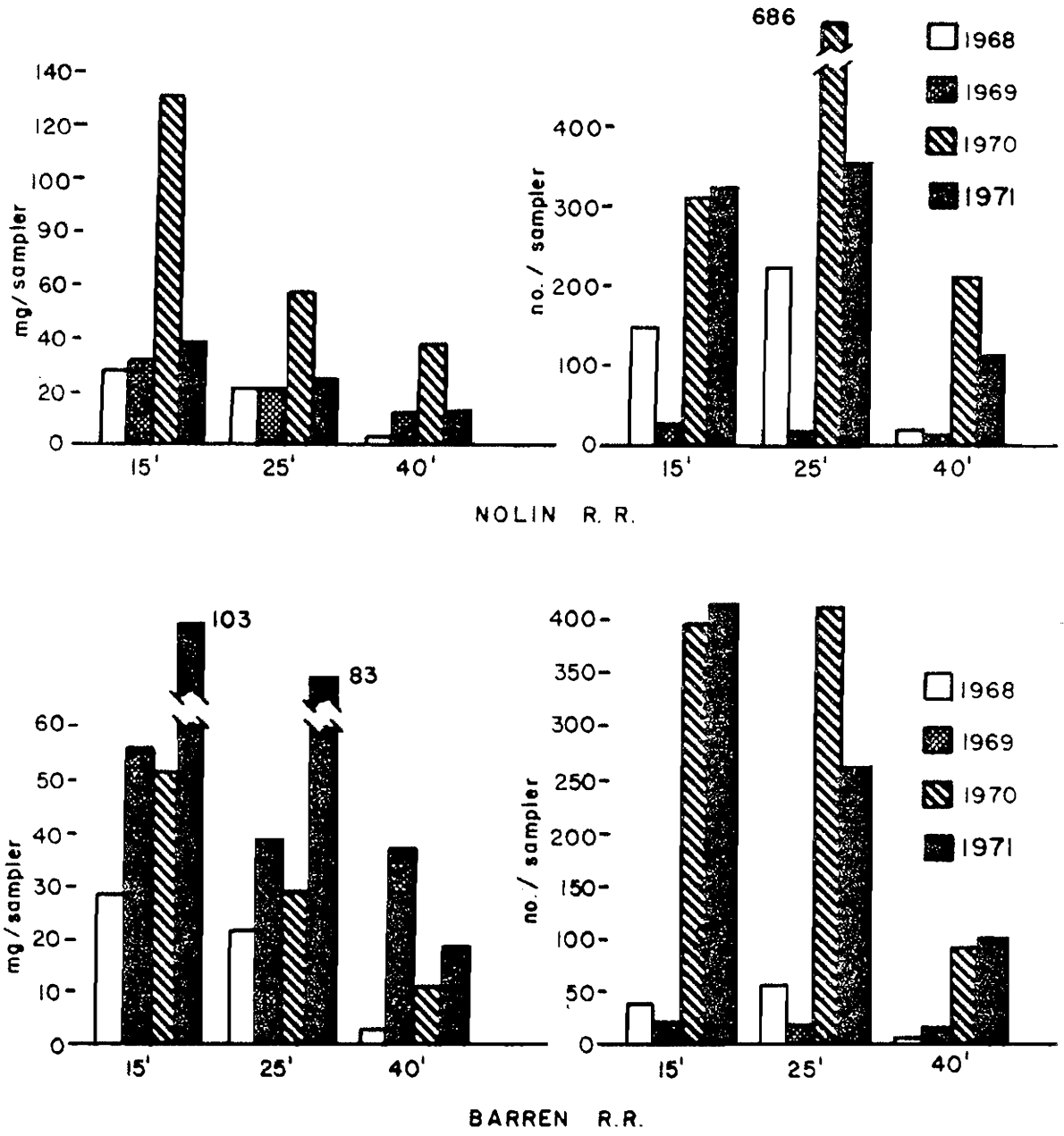

Fig. 1. Average weights and numbers of benthos in Barren and Nolin Reservoirs, 1968-1971, inclusive

F I S H P O P U L A T I O N S T U D I E S

The following list (Table 11) of fishes encountered during the course of this investigation at both Barren River Reservoir and Nolin River Reservoir conforms to the nomenclature, both scientific and common, prescribed by the American Fisheries Society in its Special Publication No. 6 (1970), entitled *A List of Common and Scientific Names of Fishes from the United States and Canada* (Third Edition). Common names are used throughout this report.

In accordance with recommendations of the Reservoir Committee, Southern Division, American Fisheries Society, as reported by Surber (1959), fish population study data are presented in this report in a modified version of the proposed standard method. The Kentucky-version of the standard method for reporting population study data divides all species into 2 major categories: piscivorous or non-piscivorous, based primarily upon their adult food habits. Each major category is sub-divided into 3 arbitrary groups: The piscivorous category is composed of game fishes, food fishes, and predatory fishes; the non-piscivorous breakdown is panfishes, commercial fishes, and forage fishes. The individual species are further separated according to total length, into fingerling, intermediate, and harvestable sizes. Harvestable size was determined either by regulation (there are legal size limits on a few species in Kentucky) or considered judgement (the smallest size the average angler would probably keep). The following list (Figure 2) covers all species.

Barren River Reservoir

The fish population of this 10,000-acre flood control reservoir in south-central Kentucky was sampled monthly (June through September) at different locations during 1968, the fifth year of its impoundment. The combined acreage of the 4 study coves was 12.66 acres (the May study was not attempted because of high water levels and low water temperatures). The average or mean standing

Table 11. List of fishes taken from Barren River Reservoir and from Nolin River Reservoir cove population studies conducted annually, 1968-1971. Single-starred species occurred only in NRR; twin-starred species occurred only in BRR.

LEPISOSTEIDAE	
Lepisosteus osseus (Linnaeus)	Longnose gar
CLUPEIDAE	
Dorosoma cepedianum (Lesueur)	Gizzard shad
Dorosoma petenense (Günther)	Threadfin shad
ESOCIDAE	
**Esox americanus vermiculatus* Lesueur	Grass pickerel
CYPRINIDAE	
Campostoma anomalum (Rafinesque)	Stoneroller
Carassius auratus (Linnaeus)	Goldfish
Cyprinus carpio Linnaeus	Carp
Notemigonus crysoleucas (Mitchill)	Golden shiner
**Notropis atherinoides* Rafinesque	Emerald shiner
Notropis cornutus (Mitchill)	Common shiner
Pimephales notatus (Rafinesque)	Bluntnose minnow
CATOSTOMIDAE	
**Carpiodes carpio* (Rafinesque)	River carpsucker
Minytrema melanops (Rafinesque)	Spotted sucker
**Moxostoma anisurum* (Rafinesque)	Silver redhorse
Moxostoma breviceps (Cope)	Shorthead redhorse
Moxostoma carinatum (Cope)	River redhorse
Moxostoma duquesnei (Lesueur)	Black redhorse
Moxostoma erythrurum (Rafinesque)	Golden redhorse
ICTALURIDAE	
Ictalurus melas (Rafinesque)	Black bullhead
Ictalurus natalis (Lesueur)	Yellow bullhead
Ictalurus punctatus (Rafinesque)	Channel catfish
Noturus miurus Jordan	Brindled madtom
Pylodictis olivaris (Rafinesque)	Flathead catfish
CYPRINODONTIDAE	
***Fundulus catenatus* (Storer)	Northern studfish
***Fundulus notatus* (Rafinesque)	Blackstripe topminnow
PERCICHTHYIDAE	
Morone chrysops (Rafinesque)	White bass
CENTRARCHIDAE	
**Ambloplites rupestris* (Rafinesque)	Rock bass
Chaenobryttus gulosus (Cuvier)	Warmouth

Table 11. continued

CENTRARCHIDAE (cont.)	
Lepomis cyanellus Rafinesque	Green sunfish
**Lepomis humilis* (Girard)	Orangespotted sunfish
Lepomis macrochirus Rafinesque	Bluegill
Lepomis megalotis (Rafinesque)	Longear sunfish
Lepomis microlophus (Günther)	Redear sunfish
Micropterus dolomieui Lacépède	Smallmouth bass
Micropterus punctulatus (Rafinesque)	Spotted bass
Micropterus salmoides (Lacépède)	Largemouth bass
Pomoxis annularis Rafinesque	White crappie
Pomoxis nigromaculatus (Lesueur)	Black crappie
PERCIDAE	
Etheostoma blennioides Rafinesque	Greenside darter
**Etheostoma caeruleum* Storer	Rainbow darter
Etheostoma nigrum Rafinesque	Johnny darter
**Etheostoma zonale* (Cope)	Banded darter
Percina caprodes (Rafinesque)	Logperch
Percina maculata (Girard)	Blackside darter
Stizostedion vitreum vitreum (Mitchill)	Walleye
COTTIDAE	
**Cottus carolinae* (Gill)	Banded sculpin
ATHERINIDAE	
Labidesthes sicculus (Cope)	Brook silverside

Figure 2. Kentucky's standard form for reporting fish population study data. A_{T1} ("legal total availability") applies only to those species that have a legal size limit.

	FINGERLING SIZE	INTERMEDIATE SIZE	HARVESTABLE SIZE
	Range (inch group)	Range (inch group)	Range (inch group)
GAME FISHES			
Rainbow trout	0-4	4-7	8
Ohio muskellunge	0-4	5-29	30 (A_{T1})
Chain pickerel	0-4	5-11	12
Grass pickerel	0-4	5-9	10
White bass	0-4	5-8	9
Striped bass	0-4	5-14	15 (A_{T1})
Sauger	0-4	5-11	12
Walleye	0-4	5-14	15 (A_{T1})
Largemouth bass	0-4	5-9	10 (A_{T1})
Smallmouth bass	0-4	5-9	10 (A_{T1})
Spotted bass	0-4	5-9	10 (A_{T1})
Black crappie	0-4	5-7	8
White crappie	0-4	5-7	8
FOOD FISHES			
Blue catfish	0-4	5-9	10
Channel catfish	0-4	5-9	10
Flathead catfish	0-4	5-9	10
PREDATORY FISHES			
Skipjack herring	0-4	5-9	10
Goldeye	0-4	5-9	10
Mooneye	0-4	5-9	10
Longnose gar	0-4	5-23	24
Shortnose gar	0-4	5-23	24
Spotted gar	0-4	5-23	24
Bowfin	0-4	5-13	14
American eel	-	8-15	16
PANFISHES			
Rock bass	0-2	3-5	6
Bluegill	0-2	3-5	6
Green sunfish	0-2	3-5	6
Hybrid sunfish	0-2	3-5	6
Longear sunfish	0-2	3-5	6
Redear sunfish	0-2	3-5	6
Warmouth	0-2	3-5	6

Figure 2. continued

	FINGERLING SIZE	INTERMEDIATE SIZE	HARVESTABLE SIZE
	Range (inch group)	Range (inch group)	Range (inch group)
COMMERCIAL FISHES			
Sturgeons	0-7	8-23	24
Paddlefish	0-7	8-23	24
Buffalo fishes	0-4	5-11	12
Carpsuckers	0-4	5-11	12
Hogsucker	0-4	5-11	12
Redhorses	0-4	5-11	12
White sucker	0-4	5-11	12
Spotted sucker	0-4	5-11	12
Carp	0-4	5-11	12
Bullheads	0-4	5-8	9
Drum	0-4	5-9	10
FORAGE FISHES			
Lampreys	0-3	4-7	8
Gizzard shad	0-3	4-7	8
Threadfin shad	0-3	4-7	8
Shiners	0-3	4-7	8
Misc. cyprinids	0-3	4-7	8
Madtoms	0-3	4-7	8
Topminnows	0-3	4-7	8
Darters	0-3	4-7	8
Orangespotted sunfish	0-3	4-7	8
Brook silverside	0-3	4-7	8
Sculpins	0-3	4-7	8
PISCIVOROUS TOTAL (Game-Food-Predatory)			
NON-PISCIVOROUS TOTAL (Pan-Commercial-Forage)			
GRAND TOTAL			

fish crop of the aggregate cove samples was 2,085 fish and 220 pounds, respectively, per acre. The A_{T1} value (previously-described "legal A_T"), or percent of the weight comprised by harvestable-size fishes, was 70. The fish population composition and standing crop values of the 1968 combined samples are shown in Table 12. The game fish group (6 species; primarily largemouth and spotted basses) comprised 9% of the sampled population and 6% of its biomass. The food fish group, made up of channel and flathead catfishes, occupied a minor position in the cove populations. Less than 1% of the recovered fishes belonged to this group; its biomass was exactly 1% of the total. No species belonging to the predatory fish group (hiodontids, gars, bowfin, etc.) was among the 26,395 fish taken in the 1968 BRR studies. The panfish group (5 species; primarily bluegill, longear sunfish, and warmouth) accounted for 27% of the sampled population and 8% of the biomass. The commercial fish group (8 species, primarily carp) contributed only 4% to the population and 23% to the biomass. The forage fish group (shads, shiners, darters, brook silverside, etc.) outnumbered and outweighed all the other groups combined. Gizzard shad "above forage size" (7.5 inches total length and larger) contributed more than any other species and/or size-class to making this the dominant group: 30% of the entire population and 51% of the total biomass were shad of this size. The forage fishes combined made up 59% of all fish recovered and 63% of the biomass.

Houser (1968) has summarized the results of nocturnal midwater trawling done at BRR and NRR in 1968. There was better agreement between the estimates for the BRR population than for the NRR population (trawling vs. cove sampling). It must be remembered that one method sampled pelagic areas while the other measured cove populations; the true average standing crop values lie somewhere between the extremes.

Gill netting results (2 consecutive nights at 2 locations in September,1968) are shown in Table 13; individual net catches are shown in the first annual progress report (Charles, 1969). These data are not clear-cut, as regards vertical

distribution in relation to dissolved oxygen content since there was confusion regarding netting objectives the first year of the project. During succeeding years the gill netting results clearly depict distribution in relation to D.O. content.

The fish population in BRR during 1969 was sampled monthly, May through September, except in July when high water from the 19-foot rise above seasonal pool in late June still prevailed. The same 4 coves (12.66 acres) used in 1968 were again sampled in 1969. The standing fish crop during BRR's sixth year of impoundment averaged 7,483 fish and 387 pounds, respectively, per acre. The A_{TI} value was 45. The game fishes (7 species; primarily largemouth, spotted, and white basses) comprised 2% of the sampled population and 4% of the biomass. The food fishes (channel and flathead catfishes) occupied a minor position in the cove samples. Less than 1% of the recovered fishes belonged to this group; its biomass was not quite 1% of the total. Only 2 specimens of longnose gar, the sole species representing the predatory fish group, were taken from the 1969 studies. Measured against the 95,000 fish recovered from the combined samples, the gar had only trace values. The panfish group (bluegill, longear sunfish, warmouth, and redear sunfish) accounted for 53% of the population and 11% of the biomass. The commercial fish group (carp, spotted sucker, redhorses, and yellow bullhead) contributed only 1% to the population and 13% to the biomass. The forage fish group (gizzard shad, darters, brook silverside, etc.) did not outnumber the other groups combined, but it did outweigh them. Intermediate-size (3.5" to 6.5") gizzard shad contributed more than any other species (except bluegill) and/or size-class: 33% of the population and 37% of the biomass were shad of this size. The forage fishes combined made up 43% of all fish recovered and 71% of the biomass.

Standing crop values and population estimates of certain pelagic species were derived from nocturnal midwater trawling in July-August, 1969. The trawling operation, performed jointly by Houser and ourselves, sampled pelagic

areas, as opposed to the relatively shallow cove areas sampled with rotenone. Houser's 1969 estimates were published that same year (Houser, 1969).

Gill netting results are summarized in Table 13, which shows that no fish were caught in the August sets deeper than 20 feet from the surface (D.O. content at 20 feet was 5.1 ppm). Very few fish (32), were caught in the September sets below 25 feet (3.8 ppm D.O.), compared to those caught above 25 feet (233).

The standing fish crop during 1970, the seventh year of impoundment, averaged 4,709 fish and 339 pounds, respectively, per acre (Table 12). The percentage of the biomass comprised by harvestable-size fish was 31. The game fish group (7 species, primarily white crappie and largemouth bass) comprised 6% of the sampled population and 5% of the biomass. The food fish group, made up of channel and flathead catfishes, occupied a minor position in the 5 cove samples (14.41 acres). Less than 1% of the recovered fishes belonged to this group; its biomass was less than 4% of the total. A single longnose gar was the only representative taken belonging to the predatory fish group. The panfish group (4 species; primarily bluegill and longear sunfish, some warmouth, and a few redear sunfish) accounted for 20% of the population and 7% of the biomass. The commercial fish group (6 species, primarily carp) contributed only 2% to the population and 17% to the biomass. The forage fish group (shads, shiners, misc. cyprinids, darters, etc.) outnumbered and outweighed all the other groups combined. Intermediate-size gizzard shad (inch groups 4 to 7) contributed more than any other species and/or size-class to make this the dominant group: 62% of the population and 53% of the biomass were shad of this size. The forage fishes combined made up 72% of all fish recovered and 68% of the biomass. Individual cove study statistics may be found in Part II (Appendices). Houser (1970) has summarized the 1970 midwater trawling results.

Gill net catches at BRR during 1970 were much reduced, compared to 1968 or 1969, but an inspection of the data in Table 13 clearly shows no fish taken

below 20 feet, either in the August or September sets. D.O. content at the first-mentioned site was 7.3 ppm at 20 feet; at the other site it was 0.1 ppm.

The standing fish crop in BRR during 1971, the eighth year of impoundment, averaged 6,934 fish and 329 pounds, respectively, per acre (Table 12). The percentage of the biomass comprised by harvestable-size fishes was 45 . The game fish group (7 species) comprised 3% of the sampled population and 4% of the biomass. The food fishes, channel and flathead catfish, were barely represented in the cove samples; their biomass was not quite 2% of the total. Longnose gar, the only species representing the predatory fish group, were so few in number that when computed against the 99,917 fish recovered, they registered only trace values. The panfishes (5 species) accounted for nearly 13% of the population and 9% of the biomass. The commercial fish group (6 species) contributed less than 2% numerically, but 23% to the population biomass. The forage fish group (shad, cyprinids, darters, etc.) greatly outnumbered all the other groups combined by accounting for 82% of the population; its biomass, at 61%, also exceeded all the other groups combined. Intermediate-size gizzard shad contributed more than any other single species and/or size-class: 71% of the population and 42% of the biomass were shad of this size. Individual cove study data are given in Part III (Appendices). Houser (1971) has published the results of our 1971 midwater trawl samples and has made the annual pelagic fish estimates, as well as summarizing all 4 years' data compiled at BRR and NRR.

Gill net catches at BRR during the final year were improved over 1970. During the August 1971 sets, fish were caught to a depth of 20 feet (a straggler was gilled between 26 and 30 feet); D.O. content at 20 feet was 0.8 ppm. Fish were caught to a depth of 25 feet (0.4 ppm D.O.) in the September sets; two stragglers were gilled between 31 and 35 feet, where the D.O. was about 0.3 ppm.

Table 12. Composite standing fish crop values (species composition, number and pounds per acre) derived from cove rotenone samples taken annually at Barren River Reservoir, May through September, 1968-1971.

GROUP/species	Hypolimnial discharge				Epilimnial discharge			
	1968		1969		1970		1971	
	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
GAME FISHES								
White bass	23	2.5	21	2.6	46	3.4	20	2.4
Walleye	2	0.2	t	0.4	t	t	t	0.1
Largemouth bass	98	7.7	110	8.5	80	7.7	148	7.7
Smallmouth bass	-	-	t	t	t	t	t	t
Spotted bass	45	0.4	28	1.2	35	1.1	33	1.3
Black crappie	5	0.5	3	0.4	1	0.1	3	0.5
White crappie	18	1.1	7	0.8	123	5.0	21	2.4
Total	192	12.6	169	13.8	286	17.3	225	14.3
% of total population	9.2	5.7	2.3	3.6	6.1	5.1	3.2	4.3
FOOD FISHES								
Channel catfish	5	1.8	3	1.1	26	5.7	9	4.9
Flathead catfish	1	0.3	2	2.4	4	5.7	2	1.2
Total	6	2.1	4	3.5	29	11.4	12	6.1
% of total population	0.3	1.0	0.1	0.9	0.6	3.3	0.2	1.9
PREDATORY FISHES								
Longnose gar	-	-	t	0.1	t	t	t	t
Total	-	-	t	0.1	t	t	t	t
% of total population	-	-	t	t	t	t	t	t
PISCIVOROUS TOTAL	198	14.7	173	17.4	315	28.7	237	20.4

Table 2 (continued)

GROUP/species	Hypolimnial discharge 1968 Number	Hypolimnial discharge 1968 Pounds	Hypolimnial discharge 1969 Number	Hypolimnial discharge 1969 Pounds	Epilimnial discharge 1970 Number	Epilimnial discharge 1970 Pounds	Epilimnial discharge 1971 Number	Epilimnial discharge 1971 Pounds
PANFISHES								
Bluegill	459	10.7	3,547	35.7	652	17.9	554	22.5
Green sunfish	t	t	–	–	–	–	t	t
Longear sunfish	69	4.2	337	5.2	211	4.9	280	6.4
Redear sunfish	t	t	t	t	t	t	t	t
Warmouth	43	1.9	68	1.5	66	1.6	42	1.5
Total	571	16.8	3,952	42.4	930	24.5	876	30.4
% of total population	27.4	7.7	52.8	11.0	19.7	7.2	12.6	9.3
COMMERCIAL FISHES								
Redhorses	9	7.8	7	5.1	5	4.2	7	4.3
Spotted sucker	19	8.9	8	3.7	12	5.3	6	3.3
Carp	51	32.6	67	42.8	68	47.0	79	67.8
Bullheads	5	0.7	8	0.4	5	0.5	13	0.6
Total	83	50.0	89	52.0	90	57.0	105	76.0
% of total population	4.0	22.8	1.2	13.4	1.9	16.8	1.5	23.1
FORAGE FISHES								
Gizzard shad	1,076	135.5	3,227	274.0	3,243	226.6	5,620	200.0
Shiners	t	t	t	t	1	t	1	t
Misc. cyprinids	3	1.2	3	0.7	3	1.3	t	0.1
Brindled madtom	2	t	2	t	1	t	3	t
Topminnows	1	t	t	t	t	t	t	t
Darters	52	0.8	23	0.5	61	0.8	83	1.9
Orangespotted sunfish	t	t	t	t	1	t	t	t
Brook silverside	99	0.6	12	0.1	64	0.4	9	t
Banded sculpin	t	t	–	–	–	–	–	–
Total	1,233	138.2	3,269	275.3	3,374	229.1	5,717	202.1
% of total population	59.1	62.9	43.7	71.1	71.7	67.5	82.4	61.4

Table 12 (continued)

GROUP/species	Hypolimnial discharge				Epilimnial discharge			
	1968		1969		1970		1971	
	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
NON-PISCIVOROUS TOTAL	1,887	205.0	7,310	369.8	4,394	310.6	6,698	308.5
GRAND TOTAL	2,085	219.7	7,483	387.2	4,709	339.3	6,934	328.9

Table 13. Vertical distribution, in relation to depth and oxygen content, of fishes caught in 4 gill nets (each 300' by 8') fished for 2 consecutive nights at 2 differing locations in Barren River Reservoir, 1968-1971. Dashed lines indicate maximum depths.

Depth (feet)	1968				1970			
	SEP 4-6		SEP 17-19		AUG 10-12		AUG 31-SEP 2	
	D.O. content (ppm)	No. of fish	D.O. content (ppm)	No. of fish	D.O. content (ppm)	No. of fish	D.O. content (ppm)	No. of fish
0- 5	7.1-7.0	238	7.8-7.6	53	7.9-7.9	41	8.2-8.3	68
5-10	7.0-6.9		7.6-7.6		7.9-8.0	46	8.3-8.2	45
10-15	6.9-6.9		7.6-7.2		8.0-7.7	36	8.2-5.7	63
15-20	6.9-6.9		7.2-6.9		7.7-7.3	20	5.7-0.1	13
20-25	6.9-6.9	172	6.9-5.5	37	7.3-0.4	0	0.1-0.1	0
25-30	6.9-1.5	118	5.5-3.2	7	0.4-0.1	0	0.1-0.1	0
30-35	1.5-0.0		3.2-0.7				0.1-0.1	0
35-40			0.7-0.1				0.1-0.2	0
40-45			0.1-0.0					
Total fish caught		528		97		143		189

Depth (feet)	1969				1971			
	AUG 11-13		SEP 11-13		AUG 25-27		SEP 9-11	
0- 5	6.2-6.4	289	7.3-6.3	72	9.1-9.1	133	9.0-9.2	45
5-10	6.4-5.9	127	6.3-5.4	43	9.1-9.1	138	9.2-7.4	86
10-15	5.9-5.5	77	5.4-5.5	56	9.1-8.6	107	7.4-3.5	43
15-20	5.5-5.1	19	5.5-4.9	42	8.6-0.8	12	3.5-2.5	15
20-25	5.1-4.4	0	4.9-3.8	20	0.8-0.3	0	2.5-0.4	10
25-30			3.8-3.1	10	0.3-0.3	1	0.4-0.3	0
30-35			3.1-2.6	6	0.3-0.4	0	0.3-0.4	2
35-40			2.6-0.3	16	0.4-0.4	0	0.4-0.5	0
Total fish catch		512		265		391		201

Nolin River Reservoir

The standing fish crop in this 5,800-acre flood control reservoir in south-central Kentucky during 1968, the sixth year of impoundment, averaged 6,955 fish and 532 pounds, respectively, per acre (Table 14). The A_{TI} value was 18. The game fishes (white, largemouth, and spotted basses; white crappie) comprised 14% of the sampled population and 6% of the biomass. The food fishes (channel and flathead catfishes) were a minor component of the population. Less than 1% of the recovered fishes belonged to this group; its biomass made up 3% of the total. Only one species belonging to the predatory fish group, longnose gar, was recovered from the cove samples. Since nearly 78,000 fish were taken from the 4 coves sampled in 1968 (11.18 surface acres), the 3 gar had only a trace value. The panfishes (5 species; primarily bluegill, longear sunfish, and warmouth) accounted for 16% of the population and 7% of the biomass. The commercial fishes (8 species, primarily carp) contributed only 3% to the population and 16% to the biomass. The forage fish group, as well as the entire population, was dominated both in numbers and in weight by a single species: gizzard shad. The group as a whole made up 67% of the population and 68% of the biomass. Shad alone accounted for 65% of all fish and 66% of the total weight. The great majority were gizzard shad between 3.5 and 7.5 inches total length (intermediate size).

As mentioned previously, Houser (1968) has summarized the midwater trawling data and has made population estimates of pelagic species at NRR (and BRR).

The results of gill netting in NRR during 1968 are summarized in Table 15. Most (83) of the 97 fish netted during the first September sets were found in the upper 20 feet of water, where the D.O. content was high. The remainder (14) were caught where the D.O. content was 0.3 ppm, or less. The later September sets showed a similar pattern: 134 fish were caught in the upper

25 feet, where D.O. content was high; only 17 were caught below 25 feet (0.1 ppm D.O.).

The standing fish crop in NRR during 1969, determined by sampling 5 coves that encompassed 13.18 acres, averaged 4,831 fish and 392 pounds, respectively, per acre (Table 14). The A_{Tl} value was 20. The game fishes (7 species; primarily spotted, largemouth, and white basses; white crappie) comprised 6% of the sampled population and 5% of the biomass. The food fishes (channel and flathead catfishes) were a minor component of the population. Less than 1% of the recovered fishes belonged to this group; its biomass made up 2% of the total. Only one species belonging to the predatory fish group, longnose gar, was recovered from the cove samples. Since more than 63,000 fish were taken from the study coves, the 9 gar had only trace values. The panfishes (5 species; primarily bluegill, longear sunfish, and warmouth) accounted for 16% of the population and 6% of the biomass. The commercial fishes (7 species, primarily carp) contributed only 2% to the population and 14% to the biomass. The forage fish group, as well as the entire population, was dominated both in numbers and in weight by a single species: gizzard shad. The group as a whole made up 75% of the population and 72% of the biomass. Shad alone accounted for 74% of all fish and 70% of the total weight. The great majority were gizzard shad between 3.5 and 7.5 inches total length (intermediate size).

Standing crop values and population estimates for certain pelagic species were derived by nocturnal midwater trawling; these data have been published by Houser (1969).

Gill netting results at NRR during 1969 are shown in Table 15. All but 7 of the 158 fish caught during the August sets were in the upper 25 feet, where D.O. content was 3.4 ppm or greater. The September sets also showed all but 16 of the 137 fish caught were in the upper 20 feet, where D.O. content was high; below 20 feet the D.O. content dropped very sharply from 1.1 to 0.1 ppm.

The standing fish crop in NRR during 1970, determined by sampling the same 5 coves (13.18 acres) used the previous year, averaged 8,461 fish and 369 pounds, respectively, per acre. The A_{T1} value was 25. The game fishes (6 species; primarily white crappie; largemouth, white, and spotted basses) comprised 42% of the sampled population and 9% of the biomass (some 42,000 white crappie young-of-the-year recovered from one cove study caused these disproportionate and unusual game fish values). The food fishes (channel and flathead catfishes) were a minor component of the population. Less than 1% of the recovered fishes belonged to this group; its biomass made up 2% of the total. Only one species belonging to the predatory fish group, longnose gar, was recovered from the cove samples. Since more than 111,500 fish were taken in the NRR studies, the 4 gar actually recovered had only trace values. The panfishes (6 species; primarily bluegill, longear sunfish, and warmouth) accounted for 11% of the population and 9% of the biomass. The commercial fishes (7 species, primarily carp) contributed less than 1% to the population and 11% to the biomass. The forage fish group barely dominated the other groups numerically by accounting for 46% of the population; it accounted for 70% of the biomass. The forage fishes would have overwhelmed all the other groups had not the abnormally large number of y-o-y white crappie been recovered. Gizzard shad alone accounted for 43% and 68% of the population and biomass. The great majority were gizzard shad between 3.5 and 7.5 inches total length (intermediate size).

Houser (1970) has summarized the 1970 midwater trawling results at NRR; his estimates of the standing crop of certain pelagic species are contained therein.

Gill netting results from the August and September (1970) sets in NRR are shown in Table 15. The earlier-date catch was scattered from top to bottom; most (81) of the 93 fish caught were found gilled in the upper 25 feet, where D.O. content was high. The remaining 12 were caught below 25 feet, where D.O.

content was 0.2 ppm or less. The great majority (170) of the September fish were entangled in the upper 25 feet (minimum D.O. content of 3.1 ppm); the 5 fish caught below 25 feet had only 0.1 to 0.2 ppm D.O. available to them.

The standing fish crop in NRR during 1971, determined by sampling the same 5 coves (13.18 acres) used the previous 2 years, averaged 6,998 fish and 340 pounds, respectively, per acre. The A_{T1} value was 30. The game fishes (6 species; primarily white crappie; largemouth, white, and spotted basses) comprised 25% of the sampled population and nearly 11% of the biomass (somewhat distorted by the occurrence of 1,173 y.o.y. white crappie per acre in the combined studies). The food fishes (channel and flathead catfishes) were better represented than in any previous year; exactly 0.5% of all fish recovered belonged in this group; its biomass was exactly 3% of the total. Longnose gar, as usual, the only representative of the predatory group, was a very minor component of the population; since more than 92,000 fish were taken during the 1971 studies, the gar actually recovered had only trace values. The panfishes (5 species; primarily bluegill, longear sunfish, and warmouth) accounted for 13% of the population and 8% of the biomass. The commercial fishes (7 species, primarily carp) contributed slightly more than 1% to the total population and 19% to the biomass. The forage fishes completely dominated the entire population; 60% of all fish recovered belonged to this group, as did 60% of the biomass. Gizzard shad was the primary species responsible for that dominance (53% of the population, 58% of the biomass); however, brook silverside and the darters made a greater-than-usual contribution in 1971 (6% and 1.4%).

Houser (1971) has published the results of our 1971 midwater trawl samples and has made the annual pelagic fish standing crop estimates, as well as summarizing all 4 years' data compiled at NRR (and BRR).

More fish were caught during the final year's gill netting than during previous years' netting. Nearly all of the 200 fish caught during the August sets were found in the upper 20 feet, where D.O. content was at least 4.3 ppm; 4 fish were caught deeper than 20 feet. The catch in September totaled 222 fish; all but 7 were caught in the upper 25 feet of the reservoir, where the D.O. content was relatively high; below 25 feet the D.O. content measured between 0.3 and 0.4 ppm.

Table 14. Composite standing fish crop values (species composition, number and pounds per acre) derived from cove rotenone samples taken annually at Nolin River Reservoir, May through September, 1968-1971.

GROUP/species	Epilimnial discharge				Hypolimnial discharge			
	1968		1969		1970		1971	
	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
GAME FISHES								
Grass pickerel	-	-	t	t	t	t	-	-
White bass	8	0.8	6	1.2	75	3.7	161	5.5
Largemouth bass	95	13.7	122	11.5	163	12.3	247	16.5
Smallmouth bass	-	-	t	t	-	-	t	t
Spotted bass	41	3.7	128	2.2	71	3.0	132	4.9
Black crappie	1	0.1	1	0.1	t	0.1	40	1.2
White crappie	827	11.8	47	5.6	3,269	13.4	1,173	7.9
Total	972	30.1	303	20.8	3,578	32.5	1,753	35.9
% of total population	14.0	5.7	6.3	5.3	42.3	8.8	25.1	10.6
FOOD FISHES								
Channel catfish	17	7.6	8	6.4	11	5.4	26	6.6
Flathead catfish	9	9.6	4	2.1	6	3.1	10	3.7
Total	26	17.2	12	8.5	16	8.5	36	10.3
% of total population	0.4	3.2	0.2	2.2	0.2	2.3	0.5	3.0
PREDATORY FISHES								
Longnose gar	t	0.2	1	0.1	t	0.2	1	0.1
Total	t	0.2	1	0.1	t	0.2	1	0.1
% of total population	t	t	t	t	t	0.1	t	t
PISCIVOROUS TOTAL	998	47.5	315	29.3	3,595	41.2	1,790	46.3

Table 4 (continued)

GROUP/species	Epilimnial discharge 1968 Number	Epilimnial discharge 1968 Pounds	Epilimnial discharge 1969 Number	Epilimnial discharge 1969 Pounds	Hypolimnial discharge 1970 Number	Hypolimnial discharge 1970 Pounds	Hypolimnial discharge 1971 Number	Hypolimnial discharge 1971 Pounds
PANFISHES								
Rock bass	t	t	t	t	t	t	t	t
Bluegill	902	26.1	403	15.2	517	18.7	490	13.7
Green sunfish	1	0.1	1	t	t	t	1	t
Longear sunfish	181	8.6	314	8.2	346	10.1	328	9.7
Redear sunfish	-	-	-	-	t	t	-	-
Warmouth	40	3.2	52	1.7	71	2.4	97	2.8
Total	1,124	38.0	770	25.2	935	31.3	915	26.1
% of total population	16.2	7.2	15.9	6.4	11.1	8.5	13.1	7.7
COMMERCIAL FISHES								
River carpsucker	t	t	-	-	-	-	-	-
Redhorses	4	3.5	3	2.0	1	1.7	1	1.2
Spotted sucker	2	1.1	2	0.8	3	0.4	4	1.0
Carp	169	80.0	108	53.1	54	37.0	85	62.1
Bullheads	2	0.3	t	t	2	0.2	2	0.4
Total	176	84.9	113	56.0	60	39.3	93	64.6
% of total population	2.5	16.0	2.3	14.3	0.7	10.7	1.3	19.0
FORAGE FISHES								
Gizzard shad	4,513	352.1	3,561	275.6	3,659	251.3	3,679	195.6
Threadfin shad	16	0.2	-	-	-	-	-	-
Shiners	1	t	1	t	1	t	1	t
Misc. cyprinids	12	7.1	10	5.6	8	4.7	7	4.4
Brindled madtom	-	-	t	t	2	t	7	t
Darters	25	0.8	11	0.2	76	0.9	96	1.2
Brook silverside	90	0.8	51	0.5	125	0.3	410	1.8
Total	4,657	361.0	3,633	281.9	3,871	257.2	4,201	203.1
% of total population	67.0	67.9	75.2	71.8	45.8	69.7	60.0	59.7

Table 14 (continued)

GROUP/species	Epilimnial discharge				Hypolimnial discharge			
	1968		1969		1970		1971	
	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
NON-PISCIVOROUS TOTAL	5,957	483.9	4,516	363.1	4,866	327.8	5,208	293.8
GRAND TOTAL	6,955	531.5	4,831	392.4	8,461	369.0	6,998	340.1

Table 15. Vertical distribution, in relation to depth and oxygen content of fishes caught in 4 gill nets (each 300' by 8') fished for 2 consecutive nights at 2 differing locations in Nolin River Reservoir, 1968-1971. Dashed lines indicate maximum depths.

	1968				1970			
	SEP 9-11		SEP 11-13		AUG 12-14		SEP 2-4	
Depth (feet)	D.O. content (ppm)	No. of fish	D.O. content (ppm)	No. of fish	D.O. content (ppm)	No. of fish	D.O. content (ppm)	No. of fish
0- 5	7.7-7.6	83	7.1-7.1	71	8.9-9.2	18	7.7-7.6	59
5-10	7.6-7.6		7.1-7.0		9.2-9.3	13	7.6-7.6	40
10-15	7.6-6.7		7.0-7.0		9.3-8.9	33	7.6-7.6	37
15-20	6.7-0.3		7.0-5.1	63	8.9-5.6	9	7.6-7.5	21
20-25	0.3-0.1	9	5.1-0.1		5.6-0.2	8	3.1-0.1	13
25-30	0.1	5	0.1	17	0.2-0.1	7	0.1-0.2	5
30-35	0.1		0.1		0.1-0.1	2	0.2-0.1	0
35-40	0.1		0.1		0.1-0.2	2		
40-45	0.1		0.1		0.2-0.2	1		
Total fish caught		97		151		93		175

	1969				1971			
	AUG 13-15		SEP 8-10		AUG 23-25		SEP 7-9	
0- 5	7.7- 7.8	58	8.4-8.4	56	7.7-7.8	93	7.4-7.6	45
5-10	7.8- 7.8	36	8.4-8.4	28	7.8-7.9	74	7.6-7.4	44
10-15	7.8- 7.8	30	8.4-6.5	27	7.9-7.9	14	7.4-6.7	60
15-20	7.8-16.6	17	6.5-1.1	10	7.9-4.3	15	6.7-5.0	57
20-25	16.6- 3.4	10	1.1-0.1	6	4.3-1.0	4	5.0-0.3	9
25-30	3.4- 0.1	7	0.1	6	1.0-0.4	0	0.3-0.3	4
30-35	0.1- 0.2	0	0.1	3	0.4-0.4	0	0.3-0.4	3
35-40			0.1	1			0.4-0.4	0
40-45			0.1	0				
Total fish caught		158		137		200		222

Barren River Reservoir

Sport fishing quality was judged to have been excellent during the March-through-October creel survey period in 1968. The annual average catch rate was 1.6 fish per hour (Table 16). The highest catch rate was posted in August when interviewed anglers caught 2.5 fish per hour; the poorest month was October when only 0.8 fish per hour was creeled. Overall fisherman success was very high: nearly 7 out of every 10 anglers caught something. Survey data indicated that 347,286 fish, or 35 per acre, and 120,410 pounds or 12.0 per acre, were removed from this 10,000-acre reservoir. About half the harvest both in fish and pounds, was composed of black and white crappies (Table 17). After crappies, other species entering the creel were: sunfishes, 22%; white bass, 9%; black basses and carp, 7% each; and bullheads, 3%. Total fishing pressure amounted to 221,544 man-hours, or 22 hours per surface acre. The most fishing occurred during April (86,347 m-h); the least fishing was done during August (10,824 m-h). The typical angler at BRR in 1968 was a male Kentucky resident who still fished from a boat for crappies, and who was successful during about 7 trips out of 10 in catching primarily crappies and sunfishes (Table 18).

Sport fishing quality was again judged to have been excellent during the March-through-October creel survey period in 1969, the second consecutive year of the hypolimnial discharge regimen. The annual average catch rate was 1.5 fish per hour (Table 16). The highest catch was posted in September when interviewed anglers caught 1.7 fish per hour; the poorest month was August when only 1.3 fish per hour were creeled. Overall fisherman success was again very high: 7 out of 10 anglers caught something. Survey data indicated that 149,194 fish, or 15 per acre, and 72,862 pounds, or 7.3 per acre, were taken

Table 16. Composite summary of expanded creel survey statistics obtained at Barren River Reservoir each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Hypolimnial discharge		Epilimnial discharge	
	1968	1969	1970	1971
Anglers				
No. interviewed	1,743	1,359	1,947	2,066
% successful	68	70	62	60
Fishing pressure				
Total man-hours	221,544	100,939	160,832	143,138
M-h/acre	22	10	16	14
Harvest [yield]				
Fish	347,286	149,194	206,065	176,919
No./acre	35	15	21	18
Pounds	120,410	72,862	96,661	77,095
Lb./acre	12.0	7.3	9.7	7.7
Catch rate				
Fish/hr.	1.6	1.5	1.3	1.2
Lbs./hr.	0.54	0.45	0.60	0.54

in 1969. About a third of the harvest was sunfishes; black basses and crappies each accounted for a quarter of the catch (Table 17). Total fishing pressure dropped drastically to only 100,939 man-hours, or 10 hours per surface acre. This severe reduction, to less than half that of the previous year, was caused by the 19-foot rise above seasonal pool on June 23, 1969; it was the middle of August before the COE was able to bring BRR down to seasonal pool. Fishermen deserted the reservoir during this high-water period; fishing success was also poorest during July. Most fishing took place in April (21,032 m-h); least fishing was done during June (6,179 m-h). The typical angler at BRR in 1969 was a male Kentucky resident who still fished from a boat for black basses and who was equally successful in catching sunfishes, black basses, and crappies during 7 trips out of 10 (Table 18).

Sport fishing quality was rated only good during the 1970 creel survey year. The annual average catch rate was 1.3 fish per hour (Table 16). The highest catch rate was posted in April when interviewed anglers caught 2.1 fish per hour; the poorest month was June when only 0.8 fish per hour was creeled. Overall fisherman success during the first year of the switch to epilimnial discharge was fairly high: nearly 62 out of every 100 anglers caught something. Survey data indicated that 206,065 fish, or 21 per acre, and 96,661 pounds, or 9.7 per acre, were removed from BRR in 1970. About two-thirds of the harvest was composed equally of sunfishes and crappies (both black and white). Total fishing pressure amounted to 160,832 man-hours, or 16 hours per surface acre. The most fishing occurred during May (47,007 m-h); the least fishing was done during March (8,547 m-h). Other species entering the creel were: black basses, 20%; white bass, 8%; carp and bullheads, 2% each (Table 17). The typical angler at BRR during 1970 was again a male Kentucky resident who still fished from a boat with a stated preference for either black basses or "anything," caught mostly crappies and sunfishes, and who was successful during 6 trips out of 10 (Table 18).

Sport fishing quality, though rated good when compared to the typical warmwater reservoir, was poorest during 1971 in terms of annual average catch rate; each year registered a slight decline, from 1.6 fish per hour in 1968, to 1.2 fish per hour the final year of the project (Table 16). The best fishing came in July when interviewed anglers caught 1.8 fish per hour; the worst month was May when only 0.8 fish per hour was creeled. Overall fisherman success was also poorest of the 4-year period; only 60 out of every 100 anglers were successful during 1971. The expanded data indicate that 176,919 fish, or 18 per acre, and 77,095 pounds or 7.7 per acre, were harvested during the 8-month period surveyed. Nearly half (48%) of the fish creeled were black and white crappies; the sunfishes accounted for nearly a third of the catch; black basses

Table 17. Sport fishing harvest at Barren River Reservoir each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

Yield	Hypolimnial discharge 1968	1969	Epilimnial discharge 1970	1971
White bass				
Number	30,229	24,361	15,610	1,018
% of total catch	8.7	16.3	7.6	0.6
Pounds	10,019	10,914	11,687	538
% of total weight	8.3	15.0	12.1	0.7
Black basses				
Number	24,672	37,671	40,256	28,596
% of total catch	7.1	25.2	19.5	16.2
Pounds	29,854	42,776	50,600	43,066
% of total weight	24.8	58.9	52.3	55.9
Crappies				
Number	183,244	35,976	69,576	85,199
% of total catch	52.6	24.1	33.8	48.2
Pounds	56,370	11,373	22,003	23,694
% of total weight	46.8	15.6	22.8	30.7
Channel catfish				
Number	-	173	247	37
% of total catch	-	0.1	0.1	t
Pounds	-	66	166	22
% of total weight	-	0.1	0.2	t
Flathead catfish				
Number	27	-	-	8
% of total catch	t	-	-	t
Pounds	183	-	-	5
% of total weight	0.2	-	-	t
Sunfishes				
Number	75,033	45,052	73,201	57,917
% of total catch	21.5	30.2	35.5	32.7
Pounds	8,312	4,790	8,717	7,249
% of total weight	6.9	6.6	9.0	9.4
Suckers				
Number	120	-	114	-
% of total catch	t	-	0.1	-
Pounds	67	-	42	-
% of total weight	t	-	t	-

Table 17 (continued)

Yield	Hypolimnial discharge 1968	1969	Epilimnial discharge 1970	1971
Carp				
Number	23,505	3,220	3,320	4,049
% of total catch	6.7	2.2	1.6	2.3
Pounds	12,442	2,126	2,218	2,476
% of total weight	10.3	2.9	2.3	3.2
Bullheads				
Number	10,456	2,741	3,741	95
% of total catch	3.0	1.8	1.8	0.1
Pounds	3,162	814	1,228	45
% of total weight	2.6	1.1	1.3	0.1

made up 16% of the creel; some 2.3% of the catch was carp (Table 17). Total fishing pressure was estimated at 143,138 man-hours, or 14 hours per acre. More fishing was done during April (43,573 m-h); the least effort was expended in May (9,281 m-h). The typical angler at BRR during 1971 was again a male Kentucky resident who fished from a boat, professed to be after black basses or crappies, caught mostly crappies and black basses, and was successful during 6 trips out of 10 (Table 18).

Table 18. Miscellaneous creel survey statistics at Barren River Reservoir 1968-1971.

Characteristic	Percent			
	1968	1969	1970	1971
Sex				
Male	87.3	81.3	80.4	79.8
Female	12.7	18.7	19.6	20.2
Residency				
Resident	93.6	91.2	91.8	91.2
Non-resident	6.4	8.8	8.2	8.8
Method used				
Still fishing	66.6	47.8	56.9	55.3
Casting	22.8	30.0	31.0	31.8
Fly fishing	1.1	1.5	0.4	1.6
Spinning	-	3.1	0.2	0.4
Jigging	3.1	4.8	2.9	3.8
Trolling	6.3	12.8	8.7	7.0
Mode				
Boat	81.2	79.6	83.1	87.0
Bank	18.8	20.4	16.9	13.0
Success				
Successful	67.8	70.3	61.7	59.9
Unsuccessful	32.2	29.7	38.3	40.1

Barren River Reservoir Tailwater

Sport fishing quality in the 4.30-acre section below Barren River Reservoir that was creel-surveyed annually (March through October, 1968-1971) varied from very poor in August and September of 1968, when only 0.3 fish per hour was caught, to excellent in April, when 2.1 fish per hour were creeled. The overall annual average catch rate that first year under the influence of a hypolimnial discharge regimen was 1.0 fish per hour. Fisherman success was considerably lower in this tailwater than in the reservoir above; slightly less than half all anglers caught fish. Fishing success during 1968 was apparently correlated with downstream discharge; fishing was best during months of greatest discharge volume and poorest during months of low discharge. The total harvest was 43,129 fish, or 10,030 per acre, and 11,415 pounds, or 2,655 per acre (Table 19). Black and yellow bullheads were the species most often caught; together, they made up nearly 34% of the total catch (Table 20). Total fishing pressure was extremely high: 43,957 man-hours, or 10,223 hours per surface acre. More fishing was done in August, 11,140 m-h, than in any other month; the least fishing occurred during September, when only 1,565 m-h were logged. In addition to bullheads, the other species entering the creel were sunfishes, 20% of the harvest; white bass, 14%; crappies, 13%; rainbow trout, 9%; carp, 4%; and black basses, 1%. The typical angler at BRR-T during 1968 was a male Kentucky resident who still fished from the bank for no particular species, and who was successful in catching bullheads and sunfishes every other trip (Table 21).

Sport fishing quality during 1969 below BRR varied from excellent in April and August, when 4.8 and 2.0 fish per hour were caught, to mediocre in September when only 0.7 fish per hour was creeled. The overall annual (8-month) average catch was 2.0 fish per hour (Table 19). Fisherman success was a little lower in the tailwater than in the reservoir above; slightly less than 65% of all anglers caught fish from BRR-T.

Table 19. Composite summary of expanded creel survey statistics obtained at Barren River Reservoir Tailwater each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Hypolimnial discharge		Epilimnial discharge	
	1968	1969*	1970	1971
Anglers				
No. interviewed	849	322	448	444
% successful	50	65	53	41
Fishing pressure				
Total man-hours	43,957	23,826	19,974	35,070
M-h/acre	10,223	5,541	4,645	8,156
Harvest [yield]				
Fish	43,129	47,474	31,335	41,997
No./acre	10,030	11,040	7,287	9,767
Pounds	11,415	19,033	13,671	17,117
Lbs./acre	2,655	4,426	3,179	3,981
Catch rate				
Fish/hr.	1.0	2.0	1.6	1.2
Lbs./hr.	0.26	0.80	0.68	0.49

*Four weeks' data missing from total (35-week survey) because creel clerk surveyed on incorrect dates.

Fishing success was not correlated with downstream discharge volume as it was during 1968. The total harvest was 47,474 fish, or 11,040 per acre, and 19,033 pounds, or 4,426 per acre. White bass was the species most often caught (46% of the harvest), followed by carp and rainbow trout (13% each), and crappies (12%) (Table 20). The typical angler at BRR-T during 1969 was again a male Kentucky resident who still fished from the bank for no particular species, and who was successful about two-thirds of the time in catching white bass (Table 21).

During the first year (1970) of the reversed discharge regimen (hypolimnial to epilimnial) sport fishing quality at BRR-T varied from very poor in August and September, when only 0.3 fish per hour was caught, to excellent in April and May when 2.3 and 2.4 fish per hour were creeled. The overall annual (8-month) catch rate was 1.6 fish per hour (Table 19). Fisherman success was lower here than in the reservoir above; only 53% of all tailwater anglers caught fish. Total harvest was 31,335 fish, or 7,287 per acre, and 13,671 pounds, or 3,179 per acre. Black and white crappies were the most frequently caught species, together they comprised 41% of the total catch (Table 20). Total fishing pressure was very high: 19,974 man-hours, or 4,645 hours per surface acre. More fishing was done in April (5,465 m-h) than in any other month. The least fishing occurred during March, when only 830 m-h were logged. Other species that entered the catch were white bass, 21% of the harvest; carp, 20%; sunfishes, 11%; suckers, 3%; bullheads, 2%; channel catfish and black basses, 1% each. The typical angler at BRR-T during 1970 was the usual male Kentucky resident who still fished from the bank for no particular species and who was successful every other trip in catching crappies (Table 21).

Sport fishing quality at BRR-T during 1971, the last year of the project, slumped to an overall annual catch rate of 1.2 fish per hour, the second-lowest (1.0 in 1968) figure posted during the 4-year period (Table 19). The extremes were 2.9 fish per hour in March, and 0.29 fish per hour in July. Fisherman success was definitely the poorest; only 41 out of every 100 anglers who visited this tailwater caught fish during 1971. Total harvest was calculated to have been 41,997 fish, or 9,767 per acre, and 17,117 pounds, or 3,981 per acre. The two crappie species, blacks and whites, were most often caught, accounting for 44% of the total catch (Table 20). Next came white bass, comprising 30% of the catch, followed by carp (12%), sunfishes (11%), channel catfish (2%) and

Table 20. Sport fishing harvest at Barren River Reservoir Tailwater each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Hypolimnial discharge		Epilimnial discharge	
Yield	1968	1969	1970	1971
Rainbow trout				
Number	3,823	6,039	53	-
% of total catch	8.9	12.7	0.2	-
Pounds	1,718	1,410	13	-
% of total weight	15.0	7.4	0.1	-
White bass				
Number	6,033	21,643	6,626	12,552
% of total catch	14.0	45.6	21.1	29.9
Pounds	1,901	9,239	3,513	8,363
% of total weight	16.7	48.5	25.7	48.9
Walleye				
Number	350	268	84	48
% of total catch	0.8	0.6	0.3	0.1
Pounds	172	340	147	238
% of total weight	1.5	1.8	1.1	1.4
Black basses				
Number	505	165	174	478
% of total catch	1.2	0.3	0.6	1.1
Pounds	334	125	291	534
% of total weight	2.9	0.7	2.1	3.1
Crappies				
Number	5,771	5,505	12,857	18,494
% of total catch	13.4	11.6	41.0	44.0
Pounds	1,221	1,187	2,907	2,290
% of total weight	10.7	6.2	21.3	13.4
Channel catfish				
Number	426	20	358	769
% of total catch	1.0	t	1.1	1.8
Pounds	221	37	292	139
% of total weight	1.9	0.2	2.1	0.8
Flathead catfish				
Number	-	-	8	-
% of total catch	-	-	t	-
Pounds	-	-	6	-
% of total weight	-	-	t	-

Table 20 (continued)

Yield	Hypolimnial discharge 1968	1969	Epilimnial discharge 1970	1971
Sunfishes				
Number	8,801	3,533	3,303	4,449
% of total catch	20.4	7.4	10.5	10.6
Pounds	1,044	424	500	783
% of total weight	9.1	2.2	3.7	4.6
Suckers				
Number	935	46	779	43
% of total catch	2.1	0.1	2.5	0.1
Pounds	475	36	553	39
% of total weight	4.2	0.2	4.0	0.2
Carp				
Number	1,902	6,113	6,254	5,035
% of total catch	4.4	12.9	20.0	12.0
Pounds	1,252	5,147	4,743	4,630
% of total weight	11.0	27.0	34.7	27.1
Bullheads				
Number	14,583	4,142	725	115
% of total catch	33.8	8.7	2.3	0.3
Pounds	3,076	1,088	318	77
% of total weight	26.9	5.7	2.3	0.4
Drum				
Number	-	-	114	14
% of total catch	-	-	0.4	t
Pounds	-	-	388	25
% of total weight	-	-	2.8	0.1

black basses (1%). Total fishing pressure rose to 35,070 man-hours, or 8,156 per surface acre--the second highest during the life of the project. More fishing was done in June (8,920 m-h) than any other month; the least fishing occurred in October, when only 1,048 m-h were recorded. The typical angler at BRR-T during 1971 was the usual male Kentucky resident who still fished from the bank for no particular species and who was successful in catching crappies and white bass about 4 trips out of 10 (Table 21).

Table 21. Miscellaneous creel survey statistics at Barren River Reservoir Tailwater, 1968-1971.

Characteristic	Percent			
	1968	1969	1970	1971
Sex				
Male	77.1	84.2	84.8	83.8
Female	22.9	15.8	15.2	16.2
Residency				
Resident	96.7	94.1	96.9	97.1
Non-resident	3.3	5.9	3.1	2.9
Method				
Still fishing	86.3	61.8	61.2	77.9
Casting	7.8	3.1	3.8	5.2
Fly fishing	0.5	2.8	0.9	-
Spinning	1.5	32.0	31.7	16.7
Jigging	3.9	0.3	2.5	0.2
Trolling	-	-	-	-
Mode				
Boat	-	-	-	2.3
Bank	100.0	100.0	100.0	97.7
Success				
Successful	49.7	64.6	52.5	40.8
Unsuccessful	50.3	35.4	47.5	59.2

Nolin River Reservoir

Sport fishing quality in this 5,800-acre flood control reservoir was decidedly poor during the 8-month survey period (March-October) in 1968, the first year of the epilimnial discharge regimen. The overall average catch rate was 0.56 fish per hour, exhibiting a range between 0.79 fish per hour in April, to 0.38 fish per hour in March. Fisherman success was also poor: only 39 anglers of every 100 caught at least one fish (Table 22). Even during the best month, April, only 52% of the anglers were successful. During the worst month, September, only 26% of the interviewed fishermen had caught fish. The survey data show that 159,706 fish weighing 61,091 pounds were removed from NRR during 1968. This was a harvest of 28 fish per acre and 10.5 pounds per acre. The various sunfishes collectively comprised 56% of the total catch (Table 23). In addition to sunfishes, the other species caught were crappies (27% of the harvest); black basses, 11%; and carp, 6%; relatively unimportant species were white bass, channel and flathead catfishes, black and yellow bullheads, suckers, and goldfish. Total fishing pressure was found to have been 286,262 man-hours, or 49 hours per surface acre--more than double that expended at BRR on a per-acre basis. More fishing was done in April (68,401 m-h) and the least occurred in August (16,643 m-h) and March (17,544 m-h). The typical NRR angler in 1968 was a male Kentucky resident who still fished from a boat for black basses or crappies, and who was successful 4 trips out of 10 in catching sunfishes and crappies (Table 24).

Sport fishing quality was again decidedly poor at NRR during 1969. The overall average catch rate was only 0.57 fish per hour, ranging from a high of 0.79 fish per hour in March, to a low of 0.26 fish per hour in October (Table 22). Fisherman success was also poor: only 39 anglers of every 100 caught at least one fish. Success was highest in April, and then only 49%

Table 22. Composite summary of expanded creel survey statistics obtained at Nolin River Reservoir each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Epilimnial discharge		Hypolimnial discharge	
	1968	1969	1970	1971
Anglers				
No. interviewed	3,069	2,504	2,184	2,347
% successful	39	39	40	40
Fishing pressure				
Total man-hours	286,262	248,145	193,477	242,654
M-h/acre	49	43	33	42
Harvest [yield]				
Fish	159,706	141,185	95,651	149,913
No./acre	28	24	17	26
Pounds	61,091	50,331	43,309	65,340
Lbs./acre	10.5	8.7	7.5	11.3
Catch rate				
Fish/hr.	0.56	0.57	0.49	0.62
Lbs./hr.	0.21	0.20	0.22	0.27

of the interviewees caught fish. The poorest month for success was March, when a mere 23% of all fishermen caught fish. The survey data show that 141,185 fish weighing 50,331 pounds were removed from NRR during 1969. This was a harvest of 24 fish per acre and 8.7 pounds per acre. The various sunfishes collectively accounted for 60% of all fish caught. After sunfishes, crappies were most often caught, accounting for 21% of the harvest. Then came the black basses (13%), carp (4%), and the minor species that measured less than 1% each: white bass, black and yellow bullheads, channel catfish, and suckers (Table 23). Total fishing pressure expended was found to be 248,145 man-hours, or 43 m-h per surface acre--more than 4 times that expended on a per-acre basis at BRR. May experienced the greatest pressure by far when 56,800 m-h were recorded. The least fishing was done in March (7,105 m-h) and September (18,904 m-h). The typical NRR angler in 1969 was a male Kentucky resident who still

fished from a boat for black basses, and who was successful 4 trips out of 10 in catching sunfishes and crappies (Table 24).

Sport fishing quality at NRR was very poor during the 1970 survey period, the first year of the hypolimnial discharge regimen. The overall average catch rate was 0.49 fish per hour, exhibiting a range between 0.66 fish per hour in June, to 0.23 fish per hour in March. Fisherman success was also poor: only 40 anglers out of every 100 caught at least one fish. Even during the best month (October), only 48% of the anglers were successful. During the worst month (March) only 27% of the interviewed anglers were successful. The survey data show that 95,651 fish weighing 43,309 pounds were removed from NRR during 1970 (Table 22). This was a harvest of 17 fish per acre and 7.5 pounds per acre. The various sunfishes collectively comprised 49% of the total catch. In addition to sunfishes, the other species caught were black basses (25% of the harvest); crappies, 16%; white bass 6%; and carp, 4%. Channel catfish, bullheads, flathead catfish, and goldfish each contributed less than one percent to the creel (Table 23). Total fishing pressure was found to have been 193,477 man-hours, or 33 hours per surface acre--more than double that expended at BRR on a per-acre basis. More fishing was done in May (49,417 m-h) and the least occurred in March (9,468 m-h). The typical NRR angler was a male Kentucky resident who still fished from a boat for black basses, and who was successful 4 trips out of 10 in catching sunfishes (Table 24).

Sport fishing quality continued poor during the final year of the project, compared to a typical warmwater reservoir; however, the overall catch rate of 0.62 fish per hour posted in 1971 was the highest recorded during the 4-year period (Table 22). It fluctuated between 0.86 fish per hour in April, to 0.34 fish per hour in August. Fisherman success remained poor with only 40 of every 100 anglers catching at least one fish. The best month was April,

Table 23. Sport fishing harvest at Nolin River Reservoir each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Epilimnial discharge		Hypolimnial discharge	
Yield	1968	1969	1970	1971
White bass				
Number	244	1,069	6,078	13,463
% of total catch	0.2	0.8	6.4	9.0
Pounds	163	626	4,220	8,051
% of total weight	0.3	1.2	9.7	12.3
Black basses				
Number	16,895	18,969	23,847	22,515
% of total catch	10.6	13.4	24.9	15.0
Pounds	21,558	17,674	20,633	21,611
% of total weight	35.3	35.1	47.6	33.1
Crappies				
Number	42,574	29,994	15,250	51,543
% of total catch	26.7	21.2	15.9	34.4
Pounds	18,382	12,650	6,312	22,875
% of total weight	30.1	25.1	14.6	35.0
Channel catfish				
Number	191	229	360	452
% of total catch	0.1	0.2	0.4	0.3
Pounds	133	266	221	316
% of total weight	0.2	0.5	0.5	0.5
Flathead catfish				
Number	35	116	52	34
% of total catch	t	0.1	0.1	t
Pounds	50	77	43	39
% of total weight	0.1	0.2	0.1	0.1
Sunfishes				
Number	89,265	84,013	46,442	58,053
% of total catch	55.9	59.5	48.6	38.7
Pounds	13,954	15,007	8,741	9,487
% of total weight	22.8	29.8	20.2	14.5
Suckers				
Number	47	57	-	-
% of total catch	t	t	-	-
Pounds	57	31	-	-
% of total weight	0.1	0.1	-	-

Table 23.(continued)

Yield	Epilimnial discharge 1968	Epilimnial discharge 1969	Hypolimnial discharge 1970	Hypolimnial discharge 1971
Carp				
Number	10,030	5,953	3,412	3,544
% of total catch	6.3	4.2	3.6	2.4
Pounds	6,709	3,874	3,080	2,810
% of total weight	11.0	7.7	7.1	4.3
Bullheads				
Number	390	785	180	280
% of total catch	0.2	0.6	0.2	0.2
Pounds	68	124	44	128
% of total weight	0.1	0.2	0.1	0.2
Goldfish				
Number	35	-	30	29
% of total catch	t	-	t	t
Pounds	16	-	15	22
% of total weight	t	-	t	t

when 50% were successful; the worst month was August, when only 29% caught fish. Total harvest the last year of the project was 149,913 fish weighing 65,340 pounds. These values are equivalent to 26 fish and 11.3 pounds, per acre. Most often caught were the sunfishes (39% of the total harvest), followed by the crappies (34%), the black basses (15%), white bass (9%), and carp (2%). Very minor in the creel were channel catfish, bullheads, goldfish, and flathead catfish (Table 23). Total fishing pressure expended at NRR during 1971 was 242,654 man-hours, or 42 m-h per surface acre--exactly triple that expended at BRR on a per-acre basis. More fishing was done in April (62,863 m-h) and the least fishing occurred in March (13,269 m-h). The typical NRR angler during 1971 was a male Kentucky resident who still fished from a boat for black basses, and who was successful 4 trips out of 10 in catching sunfishes and crappies (Table 24).

Table 24. Miscellaneous creel survey statistics at Nolin River Reservoir, 1968-1971.

Characteristic	Percent			
	1968	1969	1970	1971
Sex				
Male	83.2	82.2	82.7	81.9
Female	16.8	17.8	17.3	18.1
Residency				
Resident	93.8	94.7	92.4	92.2
Non-resident	6.2	5.3	7.6	7.8
Method				
Still fishing	66.9	65.9	59.0	57.8
Casting	26.8	27.4	31.2	30.7
Fly fishing	0.7	0.7	0.5	0.4
Spinning	-	0.1	tr	-
Jigging	0.6	0.5	1.7	1.6
Trolling	5.0	5.4	7.1	9.5
Mode				
Boat	88.3	91.5	90.3	88.0
Bank	11.7	8.5	9.7	12.0
Success				
Successful	38.5	38.6	39.7	39.5
Unsuccessful	61.5	61.4	60.3	60.5

Nolin River Reservoir Tailwater

Sport fishing quality in the 2.78-acre section below NRR ranged from extremely good to extremely poor during the 8-month survey in 1968. A catch rate of nearly 10 fish per hour in September was contrasted by a rate of 0.20 fish per hour in August. The overall average was 1.23 fish per hour during the first year of an epilimnial discharge regimen (Table 25). Fisherman success varied from 0% (March) to 100% (September), averaging 43% for the entire survey period. It was estimated that 9,044 fish weighing 2,559 pounds were caught during 1968. The harvest was equivalent to 3,253 fish and 921 pounds, respectively, per acre. The sunfishes provided the bulk of the harvest, about 79% of all fish caught. Besides the sunfishes, carp was next most often caught, about 6% of the catch being that species. Crappies and bullheads each comprised about 5% of the harvest, and the black basses contributed almost 2%. The other species caught were of minor significance: white bass, blue and channel catfishes, suckers, and drum (Table 26). Fishing pressure was calculated to be 7,365 man-hours, or 2,649 hours per surface acre. The typical NRR-T angler in 1968 was a male Kentucky resident who still fished from the bank for "anything," and who was successful in catching sunfishes about 4 trips out of 10 (Table 27).

Sport fishing quality during 1969 ranged from very good to extremely poor. A catch rate of 4.1 fish per hour in April was contrasted with a rate of 0.19 fish per hour in September. The overall average for the 8-month survey period was 0.70 fish per hour (Table 25). Fisherman success varied from 0% in March, when there was no fishing activity, to 42% in both April and June. About 38% of all anglers were successful in 1969. It was estimated that 2,111 fish weighing 814 pounds were caught. The harvest was equivalent to 759 fish and 293 pounds, respectively, per acre. The various sunfishes and carp provided the bulk of the harvest; the former accounted for 53% of

Table 25. Composite summary of expanded creel survey statistics obtained at Nolin River Reservoir Tailwater each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Epilimnial discharge		Hypolimnial discharge	
	1968	1969	1970	1971
Anglers				
No. interviewed	171	63	280	253
% successful	57	62	60	37
Fishing pressure				
Total man-hours	7,365	3,001	8,025	14,330
M-h/acre	2,649	1,079	2,887	5,155
Harvest [yield]				
Fish	9,044	2,111	4,925	9,825
No./acre	3,253	759	1,772	3,534
Pounds	2,559	814	2,179	4,724
Lbs./acre	921	293	784	1,699
Catch rate				
Fish/hr.	1.23	0.70	0.61	0.69
Lbs./hr.	0.35	0.27	0.27	0.33

the catch, while the latter contributed 18% (Table 26). Besides sunfishes and carp, crappies were the next most-often caught species, accounting for about 9% of the catch. White bass and channel catfish each contributed about 7% to the creel, while blue catfish made up nearly 4%. The other species were of minor importance to the harvest (drum, black basses, and flathead catfish). Fishing pressure totaled 3,001 man-hours at NRR-T during 1969, or 1,079 hours per surface acre. September was by far the month during which most fishing occurred. The 1,033 m-h expended that month left only 1,968 m-h to be apportioned among the other 7 months of the survey. The typical NRR-T angler in 1969 was a male Kentucky resident who sat on the bank still fishing for anything that would bite, and who was unsuccessful in catching fish more often than he was successful (Table 27).

Sport fishing quality during 1970, the first year of the hypolimnial discharge regimen, ranged from fair to poor. A catch rate of 0.78 fish per hour in May was contrasted by a rate of 0.13 fish per hour in September. The overall average was 0.61 fish per hour. Fisherman success varied from 0% (March) to 55% (June), averaging 40% for the entire survey period. It was estimated that 4,925 fish weighing 2,179 pounds were caught from the 2.78 acres under survey (Table 25). The harvest was equivalent to 1,772 fish and 784 pounds, respectively, per acre. Rainbow trout was the species most often caught, accounting for nearly 58% of the total catch. Besides rainbow trout, the various sunfishes collectively made up 15% of the harvest, followed by carp (10%), white bass (7%), crappies (5%), black basses (3%), and channel catfish (2%). A few suckers (less than 1%) were creeled (Table 26). Fishing pressure totaled 8,025 man-hours, or 2,887 hours per surface acre. May was the month when most fishing occurred (2,421 m-h); very little fishing was done during October; no fishing was logged during March. The typical NRR-T angler was a male Kentucky resident who sat on the bank still fishing for trout, and who was successful in catching trout only 4 trips out of 10 (Table 27).

Sport fishing quality in 1971, the final year of the project, was considered to be mediocre, with an overall catch rate of 0.69 fish per hour (Table 25). The extremes were 1.2 fish per hour in October and 0.09 fish per hour in September. Fisherman success was by far the poorest recorded during the 4-year study: only 37% of those who fished NRR-T caught something. This low rate ranged from 52% success in August to 17% success in September. Total harvest was estimated to have been 9,825 fish and 4,724 pounds, or 3,534 fish and 1,699 pounds, per acre. These values were the highest recorded during the 4 years, despite the low individual catch rate and percentage of successful anglers in 1971. Rainbow trout was again the most-often creeled species, accounting for 38% of the total harvest. Other species comprising the last year's

Table 26. Sport fishing harvest at Nolin River Reservoir Tailwater each year between March 1 and October 31, 1968-1971. Values were derived from expansion of data resulting from fisherman counts and from angler interviews.

	Epilimnial discharge		Hypolimnial discharge	
Yield	1968	1969	1970	1971
Rainbow trout				
Number	-	-	2,834	3,736
% of total catch	-	-	57.5	38.0
Pounds	-	-	966	1,607
% of total weight	-	-	44.3	34.0
White bass				
Number	22	156	348	2,471
% of total catch	0.2	7.4	7.1	25.2
Pounds	8	91	243	888
% of total weight	0.3	11.2	11.1	18.8
Black basses				
Number	164	10	127	13
% of total catch	1.8	0.5	2.6	0.1
Pounds	173	9	94	8
% of total weight	6.7	1.0	4.3	0.2
Crappies				
Number	480	179	268	1,554
% of total catch	5.3	8.5	5.4	15.8
Pounds	137	88	150	551
% of total weight	5.4	10.9	6.9	11.7
Blue catfish				
Number	69	77	-	39
% of total catch	0.8	3.6	-	0.4
Pounds	36	54	-	23
% of total weight	1.4	6.7	-	0.5
Channel catfish				
Number	64	159	90	69
% of total catch	0.7	7.5	1.8	0.7
Pounds	44	82	36	49
% of total weight	1.7	10.1	1.7	1.0
Flathead catfish				
Number	-	9	-	-
% of total catch	-	0.4	-	-
Pounds	-	4	-	-
% of total weight	-	0.5	-	-

Table 26 (continued)

Yield	Epilimnial discharge 1968	Epilimnial discharge 1969	Hypolimnial discharge 1970	Hypolimnial discharge 1971
Sunfishes				
Number	7,179	1,112	742	1,051
% of total catch	79.4	52.7	15.1	10.7
Pounds	1,141	198	128	163
% of total weight	44.6	24.3	5.9	3.4
Suckers				
Number	10	-	24	-
% of total catch	0.1	-	0.5	-
Pounds	6	-	24	-
% of total weight	0.2	-	1.1	-
Carp				
Number	580	369	492	870
% of total catch	6.4	17.5	10.0	8.9
Pounds	858	258	538	1,434
% of total weight	33.5	31.7	24.7	30.4
Bullheads				
Number	424	-	-	35
% of total catch	4.7	-	-	0.4
Pounds	101	-	-	9
% of total weight	3.9	-	-	0.2
Drum				
Number	52	40	-	-
% of total catch	0.6	1.9	-	-
Pounds	56	30	-	-
% of total weight	2.2	3.6	-	-

catch were white bass (25%), crappies (16%), sunfishes (11%), and carp (9%). Minor species included channel and blue catfishes, bullheads, and black basses (Table 26). Fishing pressure was decidedly higher the final year of the project: 14,330 man-hours, or 5,155 hours per surface acre, were expended at NRR-T during 1971. The typical angler at NRR-T in 1971 was again a male Kentucky resident who was fishing for either trout or "anything," and who was most often successful in catching trout about 37% of the time (Table 27).

Table 27. Miscellaneous creel survey statistics at Nolin River Reservoir Tailwater, 1968-1971.

Characteristic	Percent			
	1968	1969	1970	1971
Sex				
Male	86.0	93.7	83.9	88.5
Female	14.0	6.3	16.1	11.5
Residency				
Resident	98.2	95.2	98.6	98.0
Non-resident	1.8	4.8	1.4	2.0
Method				
Still fishing	93.6	82.5	91.1	81.8
Casting	5.8	17.5	8.9	17.8
Fly fishing	0.6	-	-	0.4
Spinning	-	-	-	-
Jigging	-	-	-	-
Trolling	-	-	-	-
Mode				
Boat	-	-	-	4.7
Bank	100.0	100.0	100.0	95.3
Success				
Successful	43.3	38.1	39.6	36.8
Unsuccessful	56.7	61.9	60.4	63.2

S U M M A R Y

At both Barren River and Nolin River reservoirs, regardless of discharge regimen, temperatures in the upper 15 feet were similar. Stratification became more severe in late summer and early fall; the upper limits of the metalimnion tended to be nearer the surface and temperatures at greater depths tended to be lower, under epilimnial discharge regimens than under hypolimnial discharge regimens. These differences would have undoubtedly been even more pronounced had the integrity of the specified epilimnial discharge regimen been maintained throughout the project. Because of inadequate capacity to bypass greater-than-average inflows through the epilimnial discharge outlets, supplemental discharge of the cooler hypolimnial reservoir waters was made via the flood control gates during years scheduled for epilimnial discharge; this tended to increase lower-strata water temperatures. During the June-through-September period, about 61% of the total reservoir discharge from BRR in 1971, and 52% of the total discharge from NRR in 1968, was released from the hypolimnial flood gates, thereby disrupting the integrity of the specified epilimnial discharge regimens for those years.

Hydrological factors, such as rainfall amounts and patterns of inflow, appeared to influence dissolved oxygen content and its distribution more than did discharge outlet location. Between June 1 and September 20, in both 1968 and 1969, approximately 67% and 68%, respectively, of the total volume of BRR contained at least 4 ppm dissolved oxygen (hypolimnial discharge); the following 2 years, with epilimnial discharge, the percentages were 63% and 68%. Corresponding percentages at NRR were 44% and 58% (1968-1969; epilimnial); the following 2 years (hypolimnial) those values were 46% and 57%.

High inflows early in the year (high-oxygen-demand water) resulted in reduced dissolved oxygen content later in the summer when stratification became

more pronounced, regardless of discharge regimen. High summer inflows during hypolimnial discharge years resulted in improved dissolved oxygen distribution to greater depths in the reservoirs since the resultant evacuation was of oxygen-deficient hypolimnetic waters. Dissolved oxygen distribution was more restricted during those years with low summer reservoir inflow. Conversely, during epilimnial discharge regimens, dissolved oxygen was found at greater depths during years of low summer inflow (more oxygen-rich surface waters retained) than in years with high summer inflow. Taken collectively, these findings tend to indicate that hypolimnial discharge regimens augment the vertical distribution of dissolved oxygen in reservoirs that are subject to frequent and extensive summer precipitation.

Dipterans and Oligochaeta were the most abundant macroinvertebrates in BRR. Benthic organisms generally were most abundant at the 15-foot depths and least abundant at the 40-foot depths. They were more abundant during the third period (late summer) than during the first period (early summer). The upper- and mid-reservoir stations were more productive than the lower main pool. Benthos findings at NRR paralleled those at BRR as regards abundance, species composition, and distribution. Reservoir discharge regimen had no discernible effect on the abundance or distribution of benthos in either BRR or NRR.

No differences in either fish population composition or fish biomass attributable to discharge regimen were found at either BRR or NRR. In fact, both the highest and lowest total fish biomass values, obtained by cove sampling with rotenone, were recorded during the hypolimnial years at BRR. Cove rotenone sampling has long been employed in Kentucky as a standard fish population evaluation technique (Carter, 1957). Mean standing fish crop values (pounds per acre) at BRR in 1968 and 1969 (hypolimnial discharge) were 220 and 387; the following 2 years (epilimnial discharge) those values were 339 and 329. At NRR,

regardless of discharge regimen, the mean annual standing crop value consistently declined throughout the 4-year period: 1968-1969 (epilimnial discharge) 532 and 392; 1970-1971 (hypolimnial discharge) 369 and 340.

Limited fish depth distribution studies (gill nets) at both BRR and NRR showed little difference in depth distribution attributable to discharge regimen during the 4-year investigation.

Gizzard shad, the primary forage species in both reservoirs, dominated the fish populations throughout the investigation. Annual standing crop estimates of young-of-the-year gizzard shad obtained by a midwater trawl sampling program exhibited random variation, apparently independent of specific epilimnial or hypolimnial discharge regimens. At BRR, standing crops of 6.8 and 13.5 pounds per acre were estimated in 1968 and 1969, during hypolimnial discharge; corresponding estimates were 0.9 and 3.1 pounds per acre in 1970 and 1971, during epilimnial discharge. Corresponding estimates at NRR were 6.9 and 1.9 pounds per acre in 1968 and 1969 (epilimnial discharge); these values were 0.9 and 4.8 pounds per acre in 1970 and 1971 (hypolimnial discharge). Estimates of y-o-y gizzard shad abundance obtained from midwater trawl sampling were generally comparable to estimates obtained from concurrently-collected cove rotenone samples with respect to trends in population levels, if not in absolute values.

Expansion of data resulting from weekly non-uniform probability creel surveys (March 1-October 31) revealed no relationship between empirical creel survey statistics and discharge regimen at either BRR and NRR. Both the greatest total harvest of 11.3 pounds per acre in 1971 and the least total harvest of 7.5 pounds per acre in 1970 were recorded during years of hypolimnial discharge at NRR; intermediate values of 10.5 and 8.7 pounds per acre were harvested during 1968 and 1969 (epilimnial discharge). Total harvest at BRR ranged from a maximum of 12.0 pounds per acre in 1968, to a minimum of 7.3 in 1969, both epilimnial

discharge years; the 1970 and 1971 harvests were 9.7 and 7.7 pounds per acre. Neither total harvest nor angler catch rate was directly related to the availability of harvestable-size fish in the population (determined by cove sampling); neither was appreciably affected by discharge regimen at either reservoir. Rainbow trout, stocked in the tailwaters of both BRR and NRR during hypolimnial-discharg years, were avidly utilized, particularly in the NRR tailwater where this bonus species comprised 58% and 38% of the total catch in 1970 and 1971.

C O N C L U S I O N S

The precise relationships between discharge outlet location and dissolved oxygen distribution at both BRR and NRR were obscured by hydrological events and inadequate epilimnial discharge facilities at each reservoir. Substantial supplemental discharge was required from the flood gates (hypolimnion) to maintain seasonal pool elevations during one year of the 2-year cycle scheduled for epilimnial discharge at both reservoirs. Hydrological factors, such as rainfall amounts and patterns of inflow, appeared to influence dissolved oxygen content and distribution more than did discharge location. There were no differences in oxygen or temperature values within the epilimnion which could be attributed to reservoir discharge regimen. Taken collectively, our findings tend to indicate that hypolimnial discharge regimens augment the vertical distribution of dissolved oxygen in reservoirs that are subject to frequent and extensive summer precipitation.

Reservoir discharge regimen had no discernable effect on the abundance or distribution of benthos in either BRR or NRR. Benthos production at BRR paralleled that at NRR as regards abundance, species composition, and distribution. No differences in either fish population composition or fish biomass attributable to discharge regimen were found at either BRR or NRR. In fact, both the highest and lowest total fish biomass values, obtained by cove sampling with rotenone, were recorded during the hypolimnial discharge years at BRR. At NRR, regardless of discharge regimen, the annual standing fish crop value consistently declined throughout the 4-year sampling period.

It was concluded, after evaluation of all available field data, that significant differences did not occur in any of the reservoir productivity indices studied (standing fish crop, benthos, sport fish harvest) that could be specifically attributable to either epilimnial or hypolimnial discharge regimens.

R E C O M M E N D A T I O N S

1. Since no adverse effects were found, choice of discharge regimen at any particular reservoir in Kentucky appears to be an administrative decision, with each case being decided on its individual merits, such as downstream water quality needs, two-story stocking plans, local angler preferences, etc.

2. It is strongly recommended that future reservoir discharge facilities be of sufficient capacity and of adequate design to provide maximum water quality control flexibility.

3. Any future field investigations in Kentucky pertaining to reservoir discharge regimens should be designed for a minimum of 5 years under each discharge regimen at each reservoir in order to preclude domination of the study design by prevailing weather conditions.

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