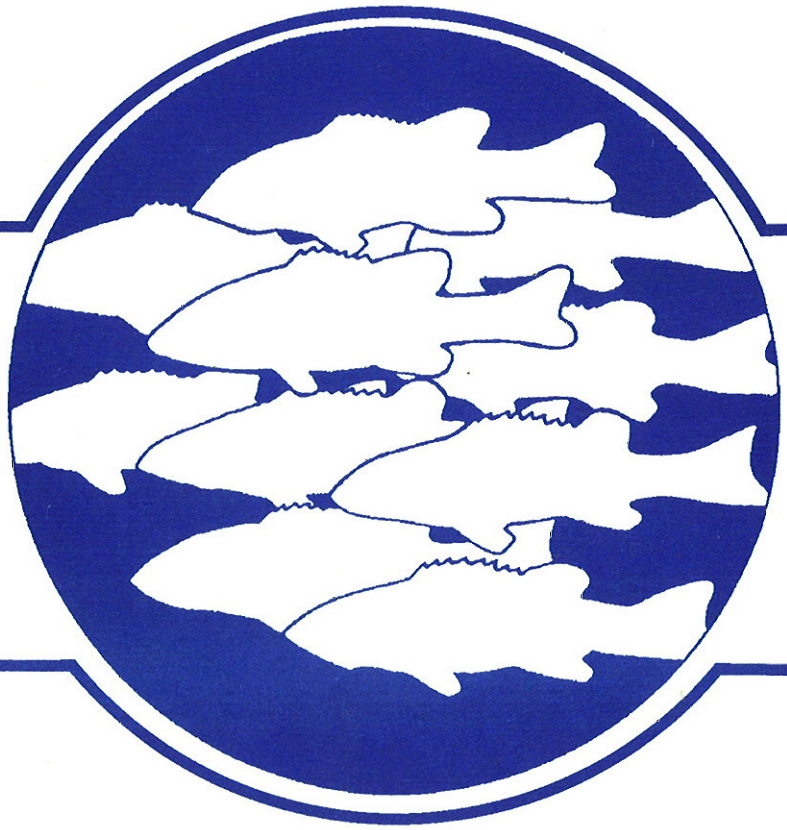

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Muskellunge Fishery Investigation in the Licking River

by

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CONTENTS

ABSTRACT

The main stem of the Licking River below Cave Run Lake was part of a muskellunge streams investigation study from 1983-1986. In 1983, a fish population survey was conducted at two stations in the Licking River tailwater below Cave Run Reservoir. In 1984-1986, the Licking River downstream of the tailwater station was investigated, primarily to determine the range and population status of the muskellunge, the success of past muskellunge stockings, and management needs for the muskellunge fishery. Data was gathered from selected species and attempts were made to document all fish species present within the study sites. Bottom fauna and selected chemical characteristics were gathered seasonally, and pertinent physical features and relative observations were recorded at each study pool. Thiry-nine miles of the Licking River were electrofished at least once during this study (18 pool-electrofishing stations and 16 riffle-seine sites). In all, 62.6 hours were spent electrofishing 66.8 miles of the river. During this time, only 12 muskellunge were captured and 9 were observed that escaped capture; a hybrid muskellunge was also collected. The catch rate was 0.2 muskellunge per hour. However, when only the upper section was sampled in 1985, the catch rate was 0.7 muskellunge per hour. Hatchery broodstock acquisition from the Cave Run Reservoir tailwater area of Licking River during the spring of 1983-1988 resulted in an average of 191.53 lb of muskellunge removed (and subsequently an equivalent number was restocked) annually. Muskellunge primarily range from Licking River mile 110.0-173.4, although a muskellunge was reportedly harvested at river mile 40. Scale analysis of angler harvested muskellunge from mail-in survey returns in 1983-1987 identified muskellunge from the following year classes: 1976 (3), 1977 (1), 1978 (2), 1979 (7), 1980 (5), 1981 (7), 1982 (2), 1983 (1). Back calculated lengths (in) from these same fish at each age were: 1 - 12.0, 2 - 17.7, 3 - 22.7, 4 - 27.4, 5 - 30.8, 6 - 34.1, 7 - 37.2, 8 - 40.6, and 9 - 41.8. Two stations, the immediate tailwater and a station 4 miles downstream, were studied in the spring, summer, and fall of 1983. Thirty-nine species of fish were sampled in the immediate tailwater and 45 species from the downstream station. However, fish were more abundant within the tailwater station during all seasons sampled. Gizzard shad was the most abundant species taken from both stations during all seasons except during the fall at the downstream station. Eighty-eight species of fish (and 3 hybrids) were collected from the main stem of Licking River during this study. An additional 13 fish species have been collected from tributary streams to the Licking River by project personnel in recent years. Stations 13-16 had the greatest fish diversity. The five most abundant species collected by electrofishing from a timed subsample period within each pool in 1984 were (Stations 1-11 and 13-16): longear sunfish, gizzard shad, golden redhorse, emerald shiner, and steelcolor shiner; during 1985 (Stations 10-16) and 1986 (Stations 1, 2, 5, 7-9): gizzard shad, longear sunfish, emerald shiner, golden redhorse, and freshwater drum. Black bass composition based on total numbers collected for all years and stations combined (minus the 2 tailwater study sites), was spotted bass - 62.3%, smallmouth bass - 32.8%, and largemouth bass - 4.9%. Of these black bass, 29.4% of the largemouth bass,

4.4% of the smallmouth bass, and 2.8% of the spotted bass were ≥ 12.0 inches long. At the two tailwater sites (all black bass and seasons combined), black bass were represented by the following: immediate tailwater - largemouth bass (56.5%), spotted bass (42.0%), and smallmouth bass (1.5%). At the station 4 miles downstream, black bass composition was as follows: spotted bass - 78.3% and largemouth bass - 21.7%. Chemical parameters and benthic macroinvertebrate samples indicated characteristics of good water quality in the Licking River to support a diverse, viable community of warmwater fishes and aquatic macroinvertebrates. A total of 16 orders and 117 species of macroinvertebrates were identified from the 3 seasonal sample sites during 1985. The Licking River harbors a rich and abundant community of fishes, aquatic insects, and unionid mussels (29 genera and 48 species). Every effort should be taken to protect the Licking River below Cave Run Reservoir from any man-made or natural intrusions which may impact these communities. Several threats exist, which if realized, could drastically impact this system. They are the proposed Falmouth Lake Dam and the potential for the development of the oil shale industry within this region. Sedimentation, as in most streams within Kentucky, remains a concern; better land use practices are needed. Riparian habitats should be protected in order to assure bank stabilization, canopy, and a future supply of fallen tree habitat to create instream cover. Annual supplemental muskellunge stockings should continue within the Licking River.

INTRODUCTION

Muskellunge, *Esox masquinongy*, currently ranges throughout 700 miles of 18 streams in Kentucky. The majority of these streams are found in eastern Kentucky. Prior to 1967, virtually nothing was known regarding the habits of the native muskellunge within Kentucky streams. Beginning in 1967, a D-J Project (Muskie Studies) was begun under the direction of Brewer (1980) who completed his sampling in 1971. This work provided the foundation for all future muskellunge studies and management in Kentucky and remains the only study dealing with the life history of the muskellunge in Kentucky. One of Brewer's (1980) recommendations was the supplemental stocking of one large fingerling muskellunge per two acres of pool habitat in 17 streams. The reasoning behind this was to replace recruitment losses from adverse environmental conditions (ie, high discharge rates and low water temperatures) often found to occur during the spawning period of the stream muskellunge. Table 1 presents stockings that have taken place in the Licking River below Cave Run Lake from 1973-1986, the area studied within this report.

Based on the results and recommendations of Brewer's studies, a muskellunge stream investigation study was undertaken in 1980 (D-J Project F-50). Current project goals were established to determine: (1) the size and structure of the muskellunge population and the fish population in selected streams, (2) the relative success of muskellunge stockings, (3) certain physical and chemical characteristics of each study stream (and/or pool), (4) information relating to the macroinvertebrate population, and (5) the management potential for sustaining and improving the muskellunge fisheries in these streams.

Expected results and benefits are as follows: Muskellunge stockings should have increased fishing opportunities and contributed to the standing crop in those streams, particularly from stockings during years of poor spawning success. Investigation of the fish populations in these streams are made in order to determine if these and more recent introductions have improved the total fish population and fishery in stocked streams. Results will determine future supplemental stocking plans. Information on the physical and chemical features of muskellunge streams and biological data from fish and bottom fauna samples will be instrumental in characterizing the habitat required and most beneficial for muskellunge. Habitat for muskellunge can possibly be improved, once the primary habitat requirements are known. Muskellunge streams that are deficient for one of these requirements can thus be managed to improve habitat and the muskellunge fisheries.

Studies which have been completed under the Muskellunge Streams Investigation include Kornman (1983 - Kinniconick and Tygarts creeks), Jones and Stephens (1984 - South Fork Kentucky River drainage), Kornman (1985 - Red River, Station Camp, and Sturgeon creeks), Prather (1985 - Middle Fork and North Fork Kentucky River drainage and upper Licking River). Results of these studies were summarized by Axon and Kornman (1986). Bonny Laflin (personal communications) has been investigating the Green and Barren River drainage

since 1984 and has collected information regarding muskellunge (Kentucky Department of Fish and Wildlife Resources, Annual Performance Reports, Subsection II Stream Research and Management, 1984, 1985, 1986, 1987, and 1988).

This study reveals findings from the Licking River (portions of Bath, Rowan, Fleming, Nicholas, Harrison, Robertson, Pendleton, Campbell, and Kenton counties) below Cave Run Reservoir, an 8,270 acre Corps of Engineers flood control impoundment on the Licking River that was completed in 1974. Brewer was concerned with the potential impacts of proposed flood contol projects and reported that muskellunge were thought to range from mile 131 - mile 240 within the Licking River. Cave Run dam was constructed at Licking River mile 173.6, flooding 58 miles of stream where muskellunge previously ranged. Brewer (1980) studied Beaver Creek, North Fork Creek, and the Licking River during 1967 - 1971, which are now tributary arms of Cave Run Lake. North Fork Creek was determined to be the best native muskellunge stream in Kentucky of the 11 that Brewer (personal communication) studied at that time. Cave Run Reservoir now impounds the first 9 miles of North Fork Creek at normal pool and an additional 4 miles during flood stage. Brewer (1980) determined that muskellunge range from mile 0 - mile 10 of this stream (prior to impoundment). Six-and one-half miles of Beaver Creek is impounded during normal pool with another 3.5 miles flooded by "normally" high waters. General muskellunge range was from mile 0 - mile 7 within this stream prior to impoundment (Brewer 1980). Although the native stock of muskellunge and other fishes were "lost" due to this impoundment, an excellent muskellunge fishery has since developed in the lake from annual fingerling stockings. Axon (1978, 1981) reported the development of the muskellunge fishery with this lake.

Brewer (1980) investigated one site on the Licking River that now lies below Cave Run dam. Prather (1985) studied the Licking River above Cave Run Reservoir; he sampled 8 pools that represented 5.44 stream miles. He reported that the main limiting factor to good muskellunge habitat in that section was siltation. No other studies have dealt specifically with muskellunge populations, but several investigators have done survey work pertaining to the fishes within the Licking River drainage. Their findings will be discussed later in this paper. Field sampling for this study was initiated in 1983 and completed in 1986.

STUDY AREA

Figure 1 illustrates the Licking River drainage as well as sampling site locations. From its headwaters in Magoffin County, the Licking River flows in a northwesterly direction for 320 miles and drains roughly 3,660 square miles (Bettandorff and Sholar 1985); approximately 10% of Kentucky. Along its course the Licking River flows through, or forms the border of, the following counties (headwaters to mouth): Magoffin, Morgan, Menifee, Rowan, Bath, Fleming, Nicholas, Harrison, Robertson, Pendleton, Campbell, and Kenton counties, before flowing into the Ohio River at Ohio River mile 470.2 (mile 0 being at the confluence of the Allegheny and Monongahela rivers, Pittsburg, Pennsylvania) at Covington/Newport, Kentucky.

Tributary streams to the Licking River are relatively short and have steep gradients, thus influencing the high runoff rates and low flows during dry

periods (Bettandorff and Sholar 1985). Principal tributaries of the Licking River are North Fork and South Fork of the Licking River. Other important tributaries of the Licking River are Elk Fork (Morgan County), North Fork Creek (Morgan and Rowan counties), Triplett and North Fork Triplett creeks (Rowan County), Slate Creek (Bath and Montgomery counties), Fox and Fleming creeks (Fleming County), and Grassy Creek (Grant and Pendleton counties).

As discussed in the introduction, the Licking River is dammed at mile 173.6, the tailwater area being mile 173.4, forming Cave Run Lake. Prather (1985) studied that portion of the Licking River above Cave Run Lake. This report deals with findings from the main stem of Licking River below Cave Run Lake. By the time the Licking River reaches the tailwater of Cave Run Lake, it has coursed from the (Unglaciated) Appalachian Plateaus Province (Cumberland Plateau), an area underlain with Pennsylvanian and Mississippian deposits. From the tailwater to its confluence with the Ohio River, the Licking River winds through the Blue-Grass Section (Knobstone Escarpment and Knobs Subsection, Outer Blue-Grass Subsection), having Devonian and Silurian deposits, and into the Eden Shale Belt Subsection having Ordovician deposits. According to Omerniks' (1987, map 1986) ecoregion classification of the United States, the Licking River arises in the Central Appalachians ecoregion and flows through the Western Allegheny Plateau and Interior Plateau ecoregions. Most of the Licking River studied for this report lies within the Interior Plateau ecoregion. Kentucky was classified into major ichthyofaunal habitats by Burr and Warren (1986); the Licking River fits into their classification of Riverine Systems (III), Upland Stream and River Subsystem (D), Appalachian Plateaus (1), and Blue Grass Section (2).

What is now called the Licking River was once under the influence of the ancient Teays River drainage during the Pliocene and Pleistocene. The Licking River at that time flowed along its present course and northeastward through the valley now occupied by the Miami River to join the Teays River in what is now east-central Ohio (Hocutt 1979). Several investigators have dealt with fish dispersal and zoo-geography of the region which includes the Licking River (and/or the Ohio River basin): Hocutt (1979), Branson (1985), Burr and Page (1986), Burr and Warren (1986), Jenkins, et al. (1971). Clark (1941) described the physical, chemical, and biological condition within the Licking River drainage and offers some interesting historical information.

Elevation of the Licking River below Cave Run Lake (tailwater - River mile 173.4) is 655 feet mean sea level and 455 feet mean sea level at the mouth (mile 0) for an average gradient of 1.15 feet/mile; this is a drop of 200 feet from the tailwater to the Licking River confluence with the Ohio River.

Above Cave Run dam, silviculture constitutes the major land usage, with much of the lands within the Cave Run Lake watershed falling within the confines of the Daniel Boone National Forest. Land usage in the upper Licking River drainage have been affected by both deep and strip mining, oil and gas extraction, as well as timerbering and agriculture. The steep terrain of the area promotes erosion, and stream siltation is a problem. Agriculture is the chief land usage within the watershed below Cave Run Lake, much of the land is in pasture but row crops contribute to siltation. Most of the silt and sediments entering the Licking River drainage settle out in the long sluggish pools with the riffle areas generally being swept clean of these deposits.

METHODS

Table 2 reveals locations of stations that were sampled in the Licking River. Study sites were chosen based on accessibility. Some sites were so difficult to get into that they were only sampled one year. Riffle-seine samples were generally those that formed the upper and/or lower limit of the pools which were electrofished. Other riffle-seine sites were sampled based upon accessibility and were randomly chosen throughout the river. Fishes collected by seine were recorded by species with no attempt being made to record numbers collected. This method (seining) was chosen to sample habitats not accessible by electrofishing boat and to document species present.

Electrofishing was conducted at two sites in the Licking River tailwater - one in the immediate tailwater and the other approximately 4 miles downstream; they were sampled 12 April, 7 July, and 3 November 1983. Stations 1-11 and 13-16 were sampled in 1984, Stations 10-16 in 1985, and Stations 1, 2, 5, 7, 8, and 9 were sampled in 1986. In all, 18 pools were electrofished; stations 3, 4, 6, and 12 were only sampled once, stations 17 and 18 were sampled 3 times (in the same year), and all other stations were sampled twice. Sixteen riffle sites were seined at least once. Time constraints and river conditions (muddy, too high, etc) were chiefly responsible for the disparity in sampling.

Fish sampling in pools was conducted with the use of a boat-type electrofishing unit. This unit consisted of a Homelite 5,000 watt, 60 cycle, single phase, 120/240 volt generator as a power source. The AC output was controlled by a Smith-Root Type VI Electrofisher at 60 Hz per second, with adjustable output voltage from 0-720 volts in 120 volt steps. The output while electrofishing was 240 volts and 8 amps at the lower two stations and 360 volts and 5-6 amps in the upper 2 stations. Output was 360 volts and varied from 6-8 amps at all other stations.

Due to the lengths of most sample pools, each shoreline was only sampled once, from one riffle boundary (upstream or downstream) to the other riffle boundary and back to the point of origin. Captured muskellunge and other selected fish collected during a prescribed timed subsample within each pool were measured to the nearest 0.1 inch and weighed to the nearest 0.01 lb, all other fishes were measured only. In order to determine age and growth characteristics, scale samples were taken from each muskellunge captured and a representative sample from other selected species (ie. gizzard shad, white bass, rock bass, bluegill, longear sunfish, largemouth bass, spotted bass, smallmouth bass, white crappie, black crappie, sauger, and walleye). Age and growth findings of the aforementioned species are beyond the scope of this report and will not be included herein. Legal size muskellunge ($\geq$30 inches long) were to be tagged on the anterior basal edge of the dorsal fin with a numbered, monel self-piercing, jaw tag identified as belonging to the Kentucky Department of Fish and Wildlife Resources. No legal size muskellunge were captured during this study. Sub-legal ($\leq$30 inches long) muskellunge were marked by clipping one of their pelvic fins. Self-addressed scale envelopes were made available to anglers at country stores and tackle shops within the area. Envelopes were also provided by local conservation officers and through the Kentucky Silver Muskie Club. Anglers were asked to fill out the questionnaire on the envelope upon catching a legal-size muskellunge, insert a

few scales and any tags recovered, and return the envelope by mail. A certificate and clutch-back pin, depicting a muskellunge, were given by the Department for information on the first fish from which information was returned, and a clutch-back pin was given for any subsequent returns. This program was discontinued in 1988.

Age and growth determinations were made by reading scales that were dampened and mounted between glass slides and projected by a Bausch and Lomb Tri-Simplex Microprojector. Back-calculations of growth were determined by utilizing a modification of the Lee method (Lagler 1956, Everhart and Youngs 1981), using a correction factor determined by Brewer (1980). This correction factor was obtained by extraplotation of the regression line represented by plotting the scale measurement against body length. The body-scale relationship determined by Brewer (1980) was based on 152 muskellunge collected from nine streams in eastern Kentucky. The relationship between body length and scale length, as determined by Brewer, was expressed in the equation $L = 4.5 + 3.6S$, which reveals a correction factor of 4.5 inches. Brewer's correction factor was substituted into the formula:

$$L' = C + \frac{s'}{s} (L-C)$$

where:

L' = length of fish at annulus
C = correction factor
s' = length of scale radius at annulus
s = length of total scale radius
L = total length of fish at capture

The total fish population structure was obtained by electrofishing the upper and/or lower sections of each study pool for 30 minutes (subsample time). These time samples covered the entire shoreline of the pool when the length of the pool could be covered in approximately 30 minutes. During this timed subsample period, attempts were made to collect all fishes observed. After the subsample period, the remaining area of the pool was electrofished, collecting only muskellunge, certain game fishes, and any fish deemed "unusual" or thought not to have been previously collected. Fish captured during the subsample were sorted to species, counted, measured to the nearest inch group, and released. Any fish not readily identified in the field was preserved in 10% formalin and later identified in the laboratory. Fish were identified using fish keys by Clay (1975), Pfleiger (1975), and Trautman (1981). Scientific and common names were assigned according to Robins et al. (1980) with additional changes recognized since Robins, such as Smith and Stearley (1989). Appendix A lists the scientific names of species not listed elsewhere within this report. Specimens have been deposited at one or more of the following institutions: Eastern Kentucky University, Richmond; Morehead State University, Morehead; Northeastern Fishery District reference collection, Morehead; and/or Southern Illinois University, Carbondale, Illinois.

Pool dimensions were measured using topographic maps and a cartometer to determine lengths, a 100-foot plastic tape to measure widths, and a Tom Mann, Bird Trap, Hummingbird Super Sixty depth sounder to establish depths unless too shallow; here a metal meter stick was used. General physical

characteristics were recorded on stream survey forms for each pool sampled (i.e. fish shelter, bottom type, pool-riffle ratio, vegetation, pollution, land usage, etc.). Gradient was determined by measuring mileage and reading elevation from topographic maps.

In 1983, water quality was taken at Stations 17 and 18 during April, July, and November. Water quality was taken during spring, summer, and fall in 1984 and 1985 at four different stations. Water quality determinations consisted of temperature, dissolved oxygen, total alkalinity, turbidity, pH, salinity, and specific conductivity. Temperature and dissolved oxygen were determined using a YSI Model 54 oxygen meter. Total alkalinity (high range-methyl orange) was determined using a HACH Model AL-AP Alkalinity test kit using Brom Cresol Green-Methyl Red as an indicator. Total alkalinity in grains per gallon as CaC03 is equal to the total drops of Sulphuric Acid Standard Solution; grains/gal was converted to mg/l by multiplying by 17.1. Turbidity (NTU) was measured using an H.F. Instruments DRT-15, Series "A" portable battery operated turbidimeter. A HACH digital pH meter (Model 19000) was used to determine pH. Salinity (ppt) and conductivity (umhos) were measured by using a YSI Model 33 S-C-T meter.

Benthic macroinvertebrates were collected by employing the "kick" method of dislodging benthic organisms from the substrate of a square meter area above a hand held D-framed (34 mesh per inch) aquatic net. Two square meter samples were taken at each of the stations during spring, summer, and fall of 1985 and preserved in 80% ethanol for later sorting and identification in the laboratory. Some of the data presented is represented as the average for the two square meter samples. Macroinvertebrates were identified and values (i.e. Taxa Richness, Species Diversity, Equitability, and Ephemeroptera/Plecoptera/ Trichoptera Index) were provided by S. Call (Kentucky Department for Environmental Protection, Division of Water). Specimens were identified to species if possible using appropriate taxonomic keys.

For this study, benthic macroinvertebrates were collected as a means of determining levels of degradation (or lack of) rather than obtaining macroinvertebrate species composition, although the listing provided is useful in providing data for those particular sites. Numerical data follows that adopted by the Kentucky Division of Water (1987). The following definitions are used: Taxa Richness (TR) is the total number of taxa present at a site and classified: TR $\geq$ 50 as high, TR 30-50 as moderate, TR $<$ 30 as low. Species diversity ($\bar{d}$) and equitability (e) were calculated using the methods outlined by Weber (1973). The Division of Water (1987) has added the formula ($\frac{K-1}{2n}$) to the Shannon-Weaver formula (Weber 1973) to correct for small sample size. The letter n is equal to the total numbers of taxa per sample. Species diversity was interpreted as follows: $\bar{d} \geq 3.000$ as high, $\bar{d}$ between 2.000 and 3.000 as moderate, and $\bar{d} \leq 2.000$ as low. Equitability was interpreted as follows: $e > 0.7000$ as high, e between 0.5000 and 0.7000 as moderate, and $e < 0.5000$ as low. Species diversity and equitability have traditionally been used to assess the effects of impacts on the macroinvertebrate community. The Division of Water (1987) cautions that care should be taken when evaluating $\bar{d}$ and e values. They further state that "adequate estimates of $\bar{d}$ cannot be obtained from one sample, and $\bar{d}$ and e are subject to seasonal fluctuations caused by natural variations in populations of aquatic insects. Furthermore, $\bar{d}$ and e are of limited usefulness because they do not consider the taxonomic

composition of the entire community. Therefore, the macroinvertebrate $\bar{d}$ and e values are considered to be of limited value and will be evaluated only in conjunction with other invertebrate data". The Ephemeroptera/Plecoptera/ Trichoptera Index (EPT) was also analyzed. This index was calculated by summing the number of Ephemeroptera, Plecoptera, and Trichoptera species collected at each site. The following criteria was used to estimate water quality: > 20 as good, 12-20 as fair, and < 12 as poor.

RESULTS AND DISCUSSION

Muskellunge Population Characteristics

Thirty-nine miles of the Licking River were electrofished during 1983-1986. Table 3 reveals the sampling effort expended for stations 1-16 (1984-1986) and Table 4 shows the effort undertaken during a special tailwater study below Cave Run Lake conducted during 1983 (Stations 17 and 18). Table 5 summarizes efforts and findings by study year. All studies combined resulted in 62.6 hours of electrofishing on 66.8 miles of stream; this represents electrofishing some of the same pools more than once. In all, 13 muskellunge were collected for a rate of 0.2 muskellunge per hour. An additional 7 muskellunge were observed but not collected. The catch rate for muskellunge collected and observed combined was 0.3 per hour. This was well below the average of 0.6 muskellunge per hour reported by Axon and Kornman (1986) from 12 Kentucky muskellunge streams. In looking at Table 5, one can see much more variability in catch rates, with 1985 catch rates (0.7 muskellunge per hour) comparing more favorably to the 0.6 fish per hour reported by Axon and Kornman. The paucity of muskellunge sampled within the Licking River is no doubt related to the size of the stream. The pools are longer and the stream widths wider on the average than from those streams previously studied (Kornman - 1983 and 1985), resulting in difficult sampling conditions. Also, there appears to be progressively less preferable muskellunge habitat downstream.

Lengths and weights of muskellunge collected per study pools, along with sampling dates, can be found in Table 6. Nearly all muskellunge collected were sampled during 1985. All of these fish were from the 1984 year class and probably represent fish stocked by this agency during 1984. In July 1984, 604 muskellunge ranging from 6.5 to 9.5 inches long ($\bar{x}$ 7.9) and 95 muskellunge averaging 13.2 inches long were stocked into this portion of the Licking River. Most of these muskellunge were stocked from Licking River mile 143 upstream to the tailwater area below Cave Run Lake (mile 173.4). The muskellunge collected during 1985 sampling were found from Licking River mile 129.8 to mile 161.1, the farthest upstream sampled at that time. Brewer (1980) indicated that Licking River mile 131 through mile 240 was the general muskellunge range within this river; Cave Run Lake is now located at mile 173.6. No muskellunge were collected or observed downstream of Station 11 (river mile 110), and nearly all muskellunge collected were sampled during 1985. Two muskellunge were collected from Station 18 during 1983 and no muskellunge were observed during 1986 sampling. Sampling during 1986 was confined to downstream stations, areas probably too far downstream of where muskellunge generally range. However, on 28 October 1986, Conservation Officer Barth Johnson confirmed an angler caught a muskellunge (32 inches

long) 5 miles upstream from Butler, Kentucky (Pendleton County). This is approximately Licking river mile 40, near our sampling Station 4.

Brewer (1980) determined that the total muskellunge range within the Licking River from Cave Run Lake dam downstream was 42 miles. This range would encompass Station 12-18. Muskellunge were captured or observed from Stations 11-18 during this study. Only one of Brewer's Licking river sampling sites correspond to any of the sampling sites from this study. This site was at Station 16, which was Station 25 from Brewer's study. Brewer's (1980) other Licking River sampling sites are now impounded by Cave Run Lake. Brewer (personal communication) observed one legal sized muskellunge each year (1967 and 1968) he sampled at Station 16. One muskellunge was the largest he observed from any stream during his entire study. During this study (1984 and 1985), we captured 2 muskellunge and observed 3 additional muskellunge from this site. The three observed were estimated to be 32, 36, and 38 inches long. The two collected were 15.8 and 16.7 inches long.

Muskellunge stocking (1973 to present), the impounding of the Licking River forming Cave Run Lake, and the influence of the lake's discharge are major changes that have taken place since Brewer (1980) completed his studies. These changes have probably resulted in an increased range of muskellunge within the Licking River and several of its tributaries (i.e. Triplett and Fox creeks). Muskellunge primarily range within 60 miles of Cave Run Reservoir tailwater, with the better habitat somewhat less than that. Occasional strays may show up anywhere in the system as indicated by the muskellunge recently caught in Pendleton County.

The dam impounding what is now Cave Run Lake was being constructed during Brewer's (1980) studies. Brewer (1980) determined that below this dam site, there were about 32 miles or 433 acres of muskellunge pool habitat. Brewer's field sampling was carried out from 1967 to 1971. During 1973, soon after the Minor Clark Fish Hatchery was completed, hatchery personnel removed 28 adult muskellunge from the tailwater immediately below Cave Run Lake. These fish were taken in order to boost the muskellunge broodstock at the hatchery. Brewer calculated the weight of the muskellunge to be 316 pounds. Expanding this to include the range of muskellunge habitat within the Licking River (433 acres of muskellunge habitat), Brewer (1980) determined that, at least in the spring of 1983, 0.7 pounds of muskellunge per acre of pool habitat occurred within the Licking River below Cave Run Reservoir. Brewer (1980) also ascertained that anglers creeled about 20 legal muskellunge from the tailwater during this period. Brewer (1980) figured that uncollected and/or creeled legal size muskellunge plus sub-legal muskellunge within the tailwater during early 1973 occurred at a poundage rate similar to that determined from smaller study streams when expanding these tailwater findings to the 433 acres discussed above.

Due to a die-off of hatchery reared muskellunge broodstock in 1983, mature replacement broodstock was sought by hatchery personnel from the Licking River in the immediate tailwater of Cave Run Lake. This activity has continued to date. For informational and comparative purposes in order to provide an example of the numbers and poundage of muskellunge that exist within the immediate tailwater during the spring of each year, the results of broodstock acquisition activities is presented in Table 7. As can be seen by this table, a substantial number of muskellunge were collected within the immediate

tailwater below Cave Run Lake. These numbers are considered to be very conservative because it does not include those muskellunge that were collected but not retained and those observed but not collected, especially sub-adult muskellunge that were not needed for spawning. Also, in many instances the hatchery personnel were seeking certain sizes and sexes of muskellunge, retaining those needed and releasing those not needed. In 1987 and 1988, hatchery personnel were searching primarily for adult males because it was determined that lesser numbers could be retained in brood ponds and it might be possible to collect needed fish every year. It should be noted that this information is only from sampling periodically during March and April, the period when the most number of muskellunge were suspected of being present within the tailwater. Total calculated weights of all muskellunge collected from the Licking River and retained for spawning purposes at the hatchery were as follows: 1983 (81.97 lb), 1984 (83.57 lb), 1985 (171.30 lb), 1986 (204.34 lb), 1987 (354.54 lb), and 1988 (253.47 lb). These weights are also considered to be very conservative for the same reason as discussed for numbers. In addition, muskellunge captured during this time of year should be at or near their best condition, especially females ripe with eggs. Weights were calculated based on lengths as reported by Brewer (1980), since hatchery personnel measured the fish to the nearest 0.5 inch, taking no weight measurement. The above weights can be compared to that found by Brewer during 1973 sampling within the Licking River immediately below Cave Run Lake (316 lb).

Even though Cave Run Lake impounded many miles of muskellunge pool habitat and Prather (1985) determined that siltation had elimited the muskellunge habitat in that portion of the Licking River system upstream of the influence of the Cave Run impoundment, a good muskellunge fishery still exists within the Licking River below Cave Run Lake.

To date muskellunge continue to be taken from the tailwater below Cave Run Lake and angling for this species is generally good but sporadic. The presence of muskellunge in the immediate tailwater is highest in the spring (primarily March and April), followed by early summer, winter, and fall. Apparently, muskellunge migrate from farther downstream up into the immediate tailwater area, especially during the early spring months, probably associated with spawning movements. The majority of the muskellunge then recede downstream. When flow in the Licking River is excessively high, the muskellunge within the tailwater area move into small tributary streams that normally do not have enough water to support muskellunge or into backwater areas created by the rip-rap placement within the tailwater area. Muskellunge lay behind the calmer water created by natural shoreline indentions or in the calmer water behind trees (normally not in the water) growing along the bank.

Mail-in survey returns from the Licking River (1983-1987) revealed that all fish reportedly harvested within the Licking River were caught within the tailwater below Cave Run Lake. Catches occurred as follows: 1983 - JAN (1), APR (1), JUN (2); 1984 - JUN (1), AUG (1); 1985 - MAR (1), APR (2), MAY (1), JUN (1), JUL (1), SEPT (1); 1986 - APR (1), MAY (2), JUN (1), JUL (1), DEC (1); 1987 - MAR (1), MAY (2), JUN (4), JUL (1), OCT (1), NOV (1).

Back-calculated age and growth analysis from scales revealed that 28 of the muskellunge were from the following year classes:

1976	1977	1978	1979	1980	1981	1982	1983
3	1	2	7	5	7	2	1

Back-calculated mean lengths of the 28 returns that could be aged showed the following lengths in inches per age group: 1 - 12.0, 2 - 17.7, 3 - 22.7, 4 - 27.4, 5 - 30.8, 6 - 34.1, 7 - 37.2, 8 - 40.6, 9 - 41.8. Back-calculated lengths are close to that determined from previous muskellunge stream investigations (Kornman 1983, 1985, Prather 1985).

To provide an example of muskellunge growth and survival, the following is provided. In 1984, 7 muskellunge from the hatchery broodstock were spawned and subsequently tagged in order to determine survival of fish injected with chorionic gonadotropin. In 1985, these fish were once again captured, injected, spawned, and returned to hatchery holding ponds. In 1986, these fish were again spawned and released into the tailwater below Cave Run Lake. Two of these tagged fish have been caught by anglers. One, which was 38 inches long in April 1984, was caught 29 July 1986 and reported to be 45 inches long (this fish was 40 inches long when spawned in April 1985 and 43 inches long when released in April 1986). The other fish was 39 inches long when tagged in April 1984 (41 inches long when spawned in 1985). It was reported to be 42.5 inches long when caught by an angler fishing the tailwater on 6 May 1986.

The weight of muskellunge caught by anglers from the tailwater, based on mail-in returns, is probably not accurate. Keeping this in mind, the following information based on these returns is provided. The total poundage caught by anglers per year was: 1983 (41.61 lb - 4 fish), 1984 (30.0 lb - 2 fish), 1985 (69 lb - 7 fish), 1986 (86.5 lb - 6 fish), and 1987 (130.7 lb - 10 fish). Based on mail-in returns for muskellunge, the tailwater below Cave Run Lake no doubt offers the most consistent angling opportunities for muskellunge within the Licking River.

Muskellunge stream investigations conducted during 1986 and 1987 in Triplett Creek, North Fork Triplett Creek (Rowan County) and Fox Creek (Fleming County) resulted in muskellunge being captured within these streams, which are tributaries to the Licking River. Results of these findings will be reported in the future. An occasional angler-caught muskellunge has been reported from lower Slate Creek (personal communication Bath County Conservation Officer H. Vinson); however, movements are restricted due to an old mill dam located 5.5 miles upstream of the confluence with the Licking River. The section of Slate Creek below this dam only offers limited muskellunge habitat. It is not known whether muskellunge utilize Fleming Creek. North Fork and South Fork Licking river are many miles downstream of the general muskellunge range withing the Licking River. Muskellunge would be unable to migrate into the South Fork Licking River as it is dammed 1.1 mile above its confluence with the Licking River. The remaining tributary streams to the Licking River are too small to support a muskellunge fishery, although the lower reaches of some of the tributary streams may occasionally be used by muskellunge during high flows or by young muskellunge.

FISH POPULATION CHARACTERISTICS AND FINDINGS

Cave Run Lake Tailwater

During 1983, two stations were electrofished on 12 April, 7 July, and 3 November. Station 18 was located within the immediate tailwater and Station 17 was located 4.1 miles below the dam.

A total of 39 species of fish were taken from Station 18 and 45 species from Station 17. Based on catch per unit effort (CPUE - fish/hour), fish were more abundant at Station 18 during all seasons sampled than at Station 17. Swink and Jacobs (1983) found fish densities to be greater from the tailwater station they sampled closest to the dam below Green River Lake. Jacobs and Swink (1983) found the same to be true in the Barren River Lake tailwater. Table 8 reveals total abundance and CPUE at each station, seasonally.

The majority of fish, based on numbers and species, were collected during the spring and fall sampling from Station 18 and spring sampling at Station 17. Species found at Station 18 which were not collected at Station 17 include muskellunge, hybrid muskellunge, emerald shiner, flathead catfish, redbreast sunfish, warmouth, redear sunfish, and smallmouth bass. Those fish species collected from Station 17 but not sampled at Station 18 were: least brook lamprey, longnose gar, striped shiner, silver shiner, golden redhorse, channel catfish, brindled madtom, white bass, and banded darter. Channel catfish and white bass are caught by anglers in the immediate tailwater. Paddlefish have been taken in the tailwater and a specimen was observed while testing a DC electrofishing unit in the tailwater on 29 July 1983. Prior to Burr and Warren (1986), this species had not been reported from the Licking River since 1951 (Burr 1980).

Fish species that were found at both stations during all three sample dates were gizzard shad, carp, bigmouth buffalo, spotted sucker, bluegill, longear sunfish, spotted bass, largemouth bass, and white crappie. Fishes collected from Station 18, not including the above, on all three sample dates, included smallmouth buffalo, green sunfish, warmouth, redear sunfish, black crappie, and drum. Those fish species taken during all three periods from Station 17 (not including those found at both stations) were steelcolor shiner, golden redhorse, and logperch.

Tables 9-11 show relative abundance, length distribution, CPUE, and percent occurrence of the fishes collected while electrofishing seasonally at the two stations within the Licking River below Cave Run Lake. Table 12 represents the five most frequently taken species from each station by sample date. Gizzard shad was the most abundant species sampled from both stations during all seasons except at Station 17 in November where it was third in abundance.

Fishes Collected and a Review of Licking River Drainage Fish Investigations

Several investigators have provided accounts of fishes found within the Licking River drainage. A few of these investigators summarized fishes known to occur within the system, while others reported the fishes actually

collected during the course of their investigations of the Licking River drainage. Table 13 provides a listing of investigations that discussed or provided accounts which included the fish fauna of the Licking River or its tributaries. This table serves as a historic record of these investigations. Table 14 gives an account of those species of fish that were collected by or reported by the investigators listed in Table 13. In reviewing Table 14, one can see when individual species were first reported from the Licking River drainage, thereby gaining some historical perspective regarding early documentation. In doing so, comparisons of past investigations to more recent findings can be made. Several fish species on this list are unsubstantiated, and thereby, looking under No. 16 (Burr and Warren 1986) one can find whether or not that record has been verified. All problematical fishes listed as collected by the NEFD personnel (No. 14) have been verified by Burr (Southern Illinois University). Several old records were based on misidentification or are unsubstantiated.

In recent years, several new records for native fishes have been reported (or assumptions verified) from the Licking River drainage such as : American brook lamprey (Prather 1985, assumed by Stauffer et al. 1982), paddlefish (verified in this study), redside dace (Clark 1941a, rediscovered Meade, et al. 1986), streamline chub (Prather 1985, assumed by Tompkins and Peters 1952), golden shiner (Burr and Warren 1986), mountain madtom (Stauffer et al. 1982; Burr and Warren 1986; and this study), northern madtom (Stauffer et al. 1982; Hannan et al. 1984 and this study), white bass (this study), and bluebreast darter (Warren and Cicerello 1983 and this study). Burr and Warren (1986) do not acknowledge the rosefin shiner within the Licking River drainage; they instead report its sister species, the redfin shiner, as occurring in the Licking River drainage and all previous Licking River records for rosefin shiner are assumed to be that of the redfin shiner.

Several species of fish considered to be introductions have also recently been collected from the Licking River drainage. These species include: threadfin shad (introduced into Cave Run Lake by KDFWR), northern studfish (Burr and Warren 1986 from Morehead State University collections and Kentucky Division of Water 1986), brook stickleback (Burr and Warren 1986), striped bass, redbreast sunfish, and pumpkinseed (this study and Burr and Warren 1986), and rainbow and brown trout from KDFWR stodkings in the Cave Run Lake tailwater.

Burr (1980) and Burr and Warren (1986) divided Kentucky into 11 ichthyofaunal regions as they related to major drainage or fish distributional patterns. The Licking River was placed into region K with 102 native fish species found within this region; 98 native fish species were reported to occur within the Licking River drainage (Burr and Warren 1986). This represents 43% of the 226 native fishes known to occur in the waters of Kentucky. Of the 217 fishes known to occur in the lower Ohio-Upper Mississippi basin (Burr and Page 1986), 45% of the total occur in the Licking River drainage.

In addition to the native species, 11 species of fish found in the Licking River drainage are considered introductions (Burr and Warren 1986). These are: threadfin shad, brown bullhead, northern pike (to date not actually collected from any streams within the drainage), rainbow trout, northern studfish, mosquitofish, brook stickleback, striped bass, redbreast sunfish,

pumpkinseed, and redear sunfish. Two species are regarded as native, but are probably introduced - burbot and warmouth. Three species are considered exotic: goldfish, grass carp, and carp. The recently introduced brown trout adds another species to this listing. One native species is considered extirpated - shovelnose sturgeon. With the 98 native species, plus those introduced and exotics, at least 114 species of fish occur or have been known to occur within the Licking River drainage.

The Licking River fish fauna would be classified within the Ohio Basin Upland Group according to Burr and Page (1986). Burr and Page (1986) presented a list of fishes characteristic of this group. Burr and Warren (1986) present a somewhat different list of fishes charactistic of the Ohio Basin Upland Group, which includes streamline chub, river chub, popeye shiner, silver shiner, rosyface shiner, stonecat, tippecanoe darter, variegate darter, and longhead darter. The popeye shiner has not been collected from the Licking River drainage. Only unsubstantiated records exist for the longhead darter. The streamline chub was only recently collected by Prather (1985). The tippecanoe and gilt darters are uncommon. The continued existence of rarer forms may be explained by the intolerance of this group of continuous turbidity and siltation. These species require streams with permanent flow, high gradients, and coarse gravel or rock bottom (Burr and Page 1986).

Cluster analysis of Kentucky's fish fauna (Burr and Warren 1986) shows three basic faunal groupings: 1) a big river/lowland fauna, 2) an upland fauna, and 3) Terrapin Creek. Burr and Warren (1986) further interpreted the analysis of phenetic relationships of drainage and physiographic units supporting the recognition of at least seven ichthyofaunal divisions in Kentucky. Based on this; the Licking River is characteristic of the Eastern Upland faunal unit (one of the seven divisions recognized). This division includes the Eastern Highland Rim, Cumberland Enclave, entire Blue Grass, and Cumberland Unglaciated Allegheny plateaus. Fishes characteristic of the Eastern Upland faunal unit are nothern brook lamprey, river chub, mottled sculpin, bluebreast darter, variegate darter, and sharpnose darter. The northern brook lamprey has not been reported from the Licking River, and the record listed by Mills (1988) has been identified as Ohio lamprey (Brooks M. Burr, personal communication). The bluebreast darter has only been recently discovered as well (Warren and Cicerello 1983), and was collected at a few more localities during this study. Burr and Warren (1986) also showed the lower Licking River drainage to be represented by a minor cluster; Knobstone Escarpment and Knobs - Outer Blue Grass. Burr and Page (1986) showed that high fish faunal resemblances occur between the Kentucky and Licking River drainages.

Table 15 presents a listing of fishes known to occur in the Licking River drainage and their status as threatened or of special concern according to Warren et al. (1986).

Table 16 provides a listing of fishes collected, including relative numbers from subsample periods, from the main stem Licking River during muskellunge investigations for this study. Fishes collected included 80 species considered native, 8 species considered to be exotic or introduced, and 3 hybrids (Table 14 and 16). In addition, 13 other fish species have been collected by the author and his staff from tributary streams to the Licking River (see Table 14). Stations 13-14, and 15-16 had the greatest number of

species (55 each). Our sampling was primarily for muskellunge, but attempts were made to record other species present within study sites. Sampling was not carried out in an attempt to determine the fishes of the Licking River, but only to assess their distribution, relative abundance, species diversity, and composition of those fish collected by electrofishing, keeping in mind the known bias of electrofishing. Thus, certain species were probably poorly collected. Small fish such as shiners, minnows, and darters are obviously underestimated. Seining was carried out to sample habitats that could not be sampled with boat mounted electrofishing gear. In these samples, fish abundance was not documented; only fish species present at that site were recorded. Fishes represented in Table 16, that were collected by seine but not sampled by electrofishing, include silverjaw minnows, river chub, sand shiner, suckermouth minnow, northern madtom, pumpkinseed, tippecanoe darter, and gilt darter.

Fish species collected from the main stem Licking River (Table 16) that occurred in three or fewer electrofishing and/or seine sample sites and the number of collection sites are as follows: lamprey ammocoetes (1), Ohio lamprey (1), least brook lamprey (1), muskellunge hybrid (1), goldfish (2), silver chub (2), river chub (1), sand shiner (2), suckermouth minnow (1), fathead minnow (2), creek chub (2), highfin carpsucker (3), black redhorse (3), yellow bullhead (1), mountain madtom (2), northern madtom (2), mosquitofish (1), striped bass (1), white bass x striped bass hybrid (1), redbreast sunfish (1), pumpkinseed (1), redear sunfish (2), bluebreast darter (3), orangethroat darter (1), tippecanoe darter (2), gilt darter (2), and river darter (3).

Fishes reported in the literature or collected during this study, from the main stem Licking River below Cave Run Lake, but have not been reported from the main stem Licking River above Cave Run Lake are: Ohio lamprey, shovelnose sturgeon, paddlefish, longnose gar (found in Cave Run Reservoir), bowfin (no recent record), Americal eel, skipjack herring, mooneye, goldfish, speckled chub, bigeye chub, golden shiner, river shiner, suckermouth minnow, fathead minnow, bullhead minnow, river carpsucker, blue sucker, blue catfish (Clark 1941a considered it common in the Licking River), black bullhead, yellow bullhead (found in Cave Run Lake), brown bullhead, mountain madtom, burbot (no recent records), mosquitofish, white bass (found in Cave Run Reservoir), striped bass (only reported from extreme lower Licking River near the confluence with the Ohio River), redbreast sunfish (only one record), pumpkinseed, warmouth (found in Cave Run Lake), redear sunfish, black crappie (found in Cave Run Lake), bluebreast darter, orangethroat darter, tippiecanoe darter, river darter, sauger, and walleye (one old upstream record). Those species reported from Cave Run Lake should likely be found within the upper Licking River.

Those species of fish reported from the main stem Licking River upstream of Cave Run Lake, but not reported from the main stem Licking River downstream of Cave Run Lake are: American brook lamprey and streamline chub, both records recently discovered by Prather (1985).

Several species of fish have been reported from tributaries of the Licking River, but not the main stem; these species are: redside dace (tributaries to Cave Run Lake), bigeye shiner (tributaries to Cave Run Lake and tributaries downstream of the lake), southern redbelly dace (tributaries downstream, to

the lake, and above the lake), blacknose dace (same as southern redbelly dace), trout-perch (2 records from a tributary downstream of the lake), blackstripe topminnow (tributaries downstream of the lake), brook stickleback (one record from a tributary downstream of the lake), spotted darter (one old record from South Fork Licking River), and mottled sculpin (most records from tributaries to and upstream of the lake, and one tributary downstream of the Lake). Several species discussed previously are more apt to be found in tributary streams to the Licking River rather than the main stem.

Two species of fish not collected during this study from the main stem Licking River, but considered common within the drainage, were white sucker and johnny darter. Both have been collected from the main stem Licking River below Cave Run Lake. Prather (1985) found the white sucker to be the second most abundant fish collected from the main stem Licking River above Cave Run Lake.

Fishes that are likely to occur within the Licking River, but have not been reported to date are: northern brook lamprey, silver lamprey, and goldeye. Two species of fish, common within nearby drainages but avoiding the Licking River, are rosefin shiner and dusky darter. The stripetail darter was reported from the Licking River (Bauer and Branson 1979), but the record is believed to be erroneous (Burr and Warren 1986). There are other old records, shown in Table 14, of fishes that were reported from the Licking River that cannot be accounted for by one reason or another (i.e. misidentification, taxonomic changes, no valid records or voucher specimens, etc).

Catch Per Unit Effort (CPUE) - Relative Abundance of Fishes Collected While Electrofishing

Timed electrofishing subsample periods were carried out at least once during the study period (1984-1986) at each study pool. During this period an attempt was made to pick up all fish observed. For the remaining sample time within each pool, only muskellunge, black bass, and species of fish not assumed to be collected already from that pool were sampled; these species and time periods are treated and discussed separately. Electrofishing sampling was confined to areas that could be sampled with the electrofishing rig; shallow riffle areas, bars, and bedrock habitats could not be smapled in this manner.

Timed subsample findings are broken down into two tables. Table 17 represents Stations 1-11 and 13-16 sampled during 1984. Table 18 represents Stations 1, 2, 5, and 7-9 sampled in 1986 and Stations 10-14 and 16 sampled during 1985. Station 15 was sampled, but no CPUE was recorded due to high and swift water at the time. These tables reveal species composition, catch rate (CPUE=fish/hr), and % total species composition of the fish collected during these timed samples.

Based on percent occurrence, the five most frequently sampled species within the Licking River below Cave Run Reservoir, taken by electrofishing, were:

Species 1984 (Sta. 1-11 and 13-16)	Total No. collected	Fish/hour	% of Total
Longear sunfish	1,086	73.9	18.8
Gizzard shad	1,067	72.6	18.4
Golden redhorse	478	32.5	8.3
Emerald shiner	361	24.6	6.2
Steelcolor shiner	311	21.2	5.4

Species 1986 (Sta. 1,2,5,7-9) 1985 (Sta. 10-16)	Total No. collected	Fish/hour	% of Total
Gizzard shad	703	57.6	24.0
Longear sunfish	537	44.0	18.4
Emerald shiner	241	19.8	8.2
Golden redhorse	232	19.0	7.9
Freshwater drum	139	11.4	4.7

Prather (1985) in sampling the Licking River above Cave Run Lake, found gizzard shad (73.1 fish/hour), carp (41.1 fish/hour), and golden redhorse (24.7 fish/hour) to be the most abundant species collected during 1982 sampling. In 1983 he found gizzard shad (42.7 fish/hour), white sucker (30.0 fish/hour), and golden redhorse (13.3 fish/hour) to be the most abundant species sampled while electrofishing this area.

Black Bass Composition

Attempts were made to pick up all black bass observed within the study pools. Table 19 represents black bass composition while comparing all pools sampled during 1984 with the same stations (or similar stations) sampled during 1985 and 1986. Stations 17 and 18, sampled in 1983, are treated separately. For all years combined, based on total numbers of black bass collected (698 total), spotted bass comprised the greatest percentage (62.3%), followed by smallmouth bass (32.8%) and largemouth bass (4.9%).

Of the black bass sampled, 29.4% of the largemouth bass, 4.4% of the smallmouth bass, and 2.8% of the spotted bass sampled were $\geq$ 12.0 in group. Of the black bass sampled in the immediate tailwater (Station 18), largemouth bass (56.5%) were most abundant, followed by spotted bass (42.0%) and smallmouth bass (1.5%). At Station 17, a station downstream from the tailwater used for comparison purposes, spotted bass (78.3%) were more abundant, followed by largemouth bass (21.7%). No smallmouth bass were sampled from this station.

Spotted bass were the most abundant black bass sampled and were found throughout the Licking River below Cave Run Lake. Spotted bass was the dominant black bass species taken in 9 of the 12 muskellunge streams reported by Axon and Kornman (1986). Largemouth bass were most abundant at Stations 1 and 2 and again at Stations 17 and 18 (especially Station 18). Elsewhere,

largemouth bass were infrequently sampled, but ranged throughout the Licking River. Smallmouth bass were most abundant at Stations 3-10.

Prather (1985) reported the following black bass composition from the Licking River above Cave Run Lake: spotted bass (95%), largemouth bass (5%), and no smallmouth bass.

PHYSICAL CHARACTERISTICS

Selected physical characteristics for the Licking River below Cave Run Lake are shown in Tables 20 and 21. A brief discussion of each characteristic follows:

Length: Licking River, as measured from topographic maps from the confluence with the Ohio River (mile 0) upstream to Cave Run Lake spillway basin, is 173.4 miles long. The average length of the study pools sampled was 2.1 miles (0.5 - 3.4 miles).

Width: The average width of study pools was 134.5 ft (82.4 - 240.0 ft). Pools from Stations 1-6 were >150 ft wide; pools above this point were < 150 ft in width, and pools averaged ca 100 ft wide from Stations 11-18.

Depth: Average depth was 3.2 ft (2.1 - 4.3 ft) for Stations 3-18. Station 1 had an average depth of 14.8 ft and Station 2 averaged 11.3 ft deep. The maximum depth averaged 10.3 ft (6.0 - 21.0) for Stations 3-18. Maximum depth was 38 ft deep at Station 1 and 27.0 ft at Station 2. Stations 3-7 were generally shallower than other Licking River sampling sites.

Gradient: The average gradient from mile 173.4 (elevation 655 ft msl) to mile 0 (elevation 455 ft msl), an elevation change of 200 ft, is 1.2 ft/mi. Several sections exceed this average gradient. The average gradient for the lower section (mi 60 - mi 0) was 1.2 ft/mi. The average gradient for both the middle section (mi 120 - mi 60) and the upper section (mi 173.4 - mi 120) was 1.1 ft/mi. The average gradient for the 82.0 mi of the Licking River above Cave Run Reservoir was 3.3 ft/mi (Prather 1985).

Annual flow: That portion of the Licking River below Cave Run Reservoir flows constantly and greatly depends upon the discharge rates from Cave Run Lake. Generally, water stored by Cave Run Lake during flood periods reduce peak flows, and gradual release of storage results in abnormally extended periods of high flow; extremely low flows are eliminated by augmentation (Jordan 1980).

Streamflow characteristics at Licking River USGS Catawba gaging station (ca river mi 48.5) from 1914-1983 are shown below (Bettandorff and Sholar 1985).

7-day, 10 year low flow	Minimum discharge	Average discharge	Maximum discharge	100-year flood
13 ft^3/s[a]	2.5 ft^3/s or 1.6 M gal/d[b]	4,143 ft^3/s	95,000 ft^3/s or 61,300 M gal/d	84,900 ft^3/s

[a]Cubic feet per second.
[b]Million gallons per day.

Fish shelter (pool habitat): The mouth (Station 1) of the Licking River is dredged for barge traffic and thus is relatively deep. Here visible fish shelter was confined to the shoreline areas and included riprap, construction debris, pilings, brush, logs, etc. At Station 2, fish shelter was mainly logs, stumps, brush, and overhanging limbs; this area was also relatively deep, but not as deep at Station 1. From Station 2 upstream to Falmouth, the majority of the fish shelter was composed of undercut banks, rock ledges, medium size boulders, and brush, but relatively few logs or fallen trees. From Falmouth upstream to Station 14, the amount of instream fish habitat was considered medium. Within this area, rubble, small to medium boulders, and rock ledges have been created where moderate to steep hillsides have been cut through by the river. Small intermittent streams running off these slopes create shallow, rocky deposits that fan out into the river, generally providing a current break and additional fish habitat. Instream logs, fallen trees, and brush become more abundant here. Farther upstream, fallen trees, logs, and brush are more abundant; instream rock is less abundant, except within riffle areas. Muskellunge appear to be positively associated with fallen trees or logs that accumulate debris and drift. This type of habitat offers shade, cover, and current breaks that stream muskellunge prefer. The lower Licking River (except for the deeper areas such as Stations 1 and 2) offered much less of this type habitat. Fallen trees and logs appear to be readily washed away throughout this area. The middle portion of the Licking River provides moderate amounts of this type habitat; within the upper Licking River (to Cave Run dam) this type of habitat is more abundant. Kornman (1983 and 1985) and Axon and Kornman (1986) eluded to the importance of fallen trees to stream muskellunge (see aquatic vegetation comments).

Riparian zone: (Percentages used below is that observed from the river) Kenton/Campbell counties - Station 1 was primarily

bordered by Covington/Newport industrial sites accompanied by barge loading facilities. A 10-20 m riparian zone existed where there was vegetation. Station 2 was surrounded by rolling hills (elevation 500-800 ft msl) and was largely wooded with some bottomland being formed for row crops. From Station 2 to the Pendleton County line, 50% of the surrounding hills were wooded. The riparian zone from Station 2 to the county line was 20-30 m or greater.

Pendleton County - that portion upstream to Falmouth is surrounded by rolling hills rising to 800 ft msl, primarily in pasture, approximately 60% is void of trees. The riparian zone ranged from 10-30 m or greater. From Falmouth to the Harrison/Bracken county line, the Licking River valley is surrounded by rolling hills, approximately 50% wooded, with the riparian zone generally 30 m or greater. Often the river cuts through hillside leaving steep, rubble strewn banks.

Harrison/Bracken counties - The Licking River here is surrounded by rolling hills, approximately 50% wooded/50% pasture land, with the lower section intermixed with some bottomland row croping and becoming 60% wooded within the upstream section. The riparian zone is 10-20 m where planted fields are present, becoming >30 m adjacent to the steeper wooded hillsides.

Nicholas/Robertson counties - Generally surrounded by 60% pastured (or fallow fields) rolling hills; approximately 40% wooded. Hillsides are generally steep along the Licking River. The riparian zone is 10-20 m where fields are planted within the floodplain and > 30 m where hillsides are adjacent to the river.

Fleming/Nicholas counties - In Nicholas County where the Licking River borders the Clay Wildlife Management Area (WMA), the surrounding hills are approximately 75% wooded. Across the river in Fleming County, a greater percent of the hillsides are in pasture; hills rise 600-800 ft msl. Upstream from the Clay WMA, the Licking River is bordered by 75% pastured hillsides, with many drainages and hollows being wooded as well as the riparian zone. The Licking River in many places flows through steep wooded hillsides within this section.

Bath/Fleming counties - Hillsides are often steep and wooded adjacent to the river, but surrounding hilltops are 80% fallow or planted fields or pastureland. Bottomland comprises much of the lower Slate Creek valley and is tilled for row crops. That portion of the Licking River upstream from Slate Creek flows through wooded bluffs with hills ranging from 650-970 ft msl.

Bath/Rowan counties - Riparian zones along the Licking river generally range from 10-20 m or less. Much of the river here is bordered by bottomland planted in row crops and the river has the widest floodplain of any area along the Licking River below Cave Run Lake; these wide floodplains exist from ca river mile 155 upstream to the Cave Run Lake dam. Only 10% of this bottomland can be considered wooded, with the riparian zone 10-20 m or less. Several oxbow lakes exist within the floodplain. The hillsides adjacent to the floodplain in Rowan County are approximately 75% wooded, while most of the bottomland is farmed. Cave Run Lake impounds the Licking River and the near lake area is surrounded by Daniel Boone National Forest lands. Hills here are approximately 1,000 ft msl. Trees commonly associated with the riparian zone include: sycamore, box elder, silver maple, and to a lesser extent alder, river birch, willows, and ash. Understory vegetation is typical of the mesic species growing in floodplain areas throughout the bluegrass region of Kentucky. Slopes within this region are primarily oak-hickory with many areas in various stages of succession.

Shade: Percent shade depends upon stream width and riparian zone vegetation. At Stations 1 and 4, the percent shade was considered to be 0-5%. Stations 2, 3, and 5-10 were considered to be 5-25% shaded. At Stations 11-16 and 18, shade was considered 25-50% and at Station 17 - 50-75%.

Bottom type: Because pool areas were chiefly sampled, bottom type will be confined to this type of habitat. Riffles were generally swept clean and were comprised of small boulder, rubble (large and small - most common), and coarse and fine gravel intermixed with sand. Bottom type was classified very generally. Stations 1 and 2 were generally comprised of silt, muck, and clay bottom. Stations 3-7 were rocky with bedrock comprising 5-50% of the pool areas sampled; these pools were intermixed with small boulder and rubble; in some areas gravel and sand was present. Clay banks existed except where rocky hillsides were exposed. Sand, silt (being more prominant), and muck generally accumulated in slow flow areas and "dead water". Very little detritus was observed except in eddy areas above or below riffles. Very little bedrock was exposed within stations sampled above this point. Within Stations 8-17, the bottom, shorelines, and banks consisted of 35-95% sand, clay, silt, muck, and/or detritus, with clay and silt being more abundant. Rock, chiefly in the form of rubble, was more prevalent at Stations 8-14 and virtually absent at Stations 15-17. Station 18 had rip-rap banks in the immediate tailwater and along a portion of the Minor Clark Fish Hatchery. Banks are composed of clay-sand-silt sediments which were deposited over long periods of time; often sections slough off into the river, particularly along the portions of river from

Stations 15-18 where large expanses of floodplain planted in crops exist. These areas also have narrow riparian zones due to being cleared for cropland. Where the Licking River has cut through hillsides, generally below Station 15, limestone in the form of rubble and limestone shelves comprise the shoreline area (below bank).

Pool/riffle ratio: Pool habitat was the primary habitat sampled in the Licking River. The first major riffle above the mouth that occurs within the Licking River is at mile 20. Several shallows (deep riffles), that could not be considered riffles, occurred between river mile 15 and 20. Below is a list of pool/riffle ratio found to occur within the study sites:

Station	Pool/riffle ratio(%)
1	100/0
2	100/0
3	70/30
4	80/20
5	85/15
6	85/15
7	80/20
8	90/10
9	95/5
10	95/5
11	98/2
12	85/15
13	95/5
14	85/15
15	97/3
16	100/0
17	100/0
18	100/0

Aquatic vegetation: Instream aquatic vegetation is virtually non-existent within the Licking River, thus the importance of fallen trees or large woody debris for muskellunge (as well as other fish) cover is great. Cover for fish is also provided by logs, log-jams, brush, overhanging (and partially sumberged) limbs, rock and rubble, undercut banks, and root wads. Large boulders are rare within the Licking River below Cave Run Lake. *Justicia americana* did occur on riffle margins, but rarely to the extent that occurs in smaller tributary streams within the region. Some of the larger riffles did have small trees such as willow and sycamore, as well as other small shrubs and herbaceous plants, growing on them. *Potamogeton crispis* was found growing in the shallows at the lower end of Station 13 and S" ; and may occur elsewhere.

Aesthetic value: The aesthetic value was considered good to excellent throughout the Licking River, except at Station 1. Those areas where the Licking River is bordered by steep wooded hillsides have a much higher aesthetic appeal than the wider, relatively shallow lower reaches and upper reaches bordered by large bottomland in agricultural production. Within the floodplain from mile 155 to Cave Run dam are several oxbow lakes created long ago due to river channel changes. Also in this area are several wetlands. Both of these natural features are being lost due to draining for cropland. These unique habitats should be protected. Elsewhere, although pastureland and/or cultivated fields exist on suitable lands along the Licking River floodplain, many steep wooded hillsides and ravines have been left relatively undisturbed.

Along the Licking River can be found the remains of fish dams and log dams. At mile 84 (Harrison County), the remains of a sunken barge can be found. This wooden barge sank while hauling stone from a quarry in Rowan County. The stone (and outline of the barge) can be seen in the shallows. Located at mile 92 is Blue Licks Battlefield State Park (Robertson County). Bordering the Licking River from ca mile 107-116 is the Clay Wildlife Management Area (Nicholas County), managed by the Kentucky Department of Fish and Wildlife Resources; at mile 125 the supports for the Sherburne covered bridge can be found. Only in recent years was this bridge burned. The Minor Clark Fish Hatchery (Rowan County), owned and operated by this agency, is located adjacent to the Licking River at mi 171-173.

Access: Except for Falmouth, Butler, and the Covington/Newport area, no towns can be seen from the river below Cave Run Lake. With the exception of the Covington/Newport area, no major industry exists along the Licking River. Two interstates (I-275 and I-64), 14 highway bridges, and three railroads cross the Licking River below Cave Run Lake. Six of these bridges are found within the first 20 miles. Boat access, other than what can be "car topped", is very limited. Five boat ramps can be found between the mouth and Cave Run Lake dam; two of them have been constructed by this agency. Boat ramps are located at mile 3.2 (vicinity of Wilder, Campbell County), mile 10.0 (vicinity Ryland Heights, Kenton County), mile 79.5 (vicinity Claysville, Harrison County), mile 109.7 (Clay WMA, Nicholas County), and mile 173 (Cave Run tailwater, Bath County).

Recently (1988 Memorandum from Sherri A. Evans, Wild Rivers Program, Kentucky Division of Water) the Kentucky Protection Planning Committee listed candidate rivers for potential inclusion on a state Rivers Registry. The registry will be a list of the state's most significant free-flowing rivers in terms of

their outstanding natural, cultural and recreational values. Candidate rivers are ranked into three priority classes (priotiry 1, 2, and 3) based on the number of outstanding resource values and a "threat value" identified for each segment. Higher priority rivers will be studied first. Licking River, river mile 52-159 (confluence of South Fork Licking River, to a point ca 3 miles below I-64 crossing), was assigned Priority 1. Outstanding Resource values assigned to the Licking River segment listed included natural values such as scenic value, fish and wildlife value, and water quality. Recreational Values included sport fishing and recreational boating. Also listed for the Licking River was a cultural and threat value. Not included within this preliminary listing was wildlife/recreation management. This value should also be included as this segment of the Licking River traverses portions of Blue Licks State Park (Robertson County) and the Clay Wildlife Management Area (Nicholas County).

WATER QUALITY

Water quality sample site locations are shown in Table 22 while Table 23 shows water quality criteria deemed preferred and harmful for warmwater fish and aquatic habitat. Table 24 reveals water quality determinations taken during the tailwater survey carried out during April, July, and November 1983. Figure 2 reveals the optimum monthly temperature profile established by the Army Corps of Engineers for the Cave Run Lake release (Licking River tailwater). Results of water quality determinations for data collected in July and October 1984 and April, July, and October 1985 are shown in Table 25. Tables 26 (at Covington), 27 (at Butler), and 28 (at Sherburne) show water quality determinations for a variety of parameters showing maximum, minimum, and mean findings from 1984, 1985, and 1986, the primary sampling years during this study. This data is presented for comparison and to show additional water quality parameters. Results will not be discussed in this report. This data was provided by Lewis G. Miller, Kentucky Division of Water.

Findings from the tailwater survey indicate water quality criteria set forth for warmwater fish habitat was met for all parameters, but alkalinity was below preferred levels. Rainbow trout are stocked into the tailwater to provide a put-and-take fishery for this species. They are stocked in April, May, June, and October; a put-grow-and-take fishery for brown trout was established in 1988. July and August water temperatures, according to that depicted in Figure 2, may reach harmful levels for coldwater fish habitat, but not for warmwater fish habitat, if followed. Seasonal problems may exist concerning levels of iron and manganese in the tailwater due to hypolimnetic release.

According to the Kentucky Division of Water (1988), Cave Run Lake is threatened by brine pollution from oil well operations within its watershed. The mean chloride concentration at the dam was 4 mg/l for 1974-1976; 10 mg/l in 1981, 13 mg/l in 1983, and 22 mg/l by 1986. Within the Licking River flowing into Cave Run Lake the average chloride levels were 9 mg/l (1972-1976), 23 mg/l (1981), 57 mg/l (1983), 200 mg/l (1985), and 158 mg/l (1986). These concentrations are currently below that set forth for the protection of aquatic life.

Water quality determined in 1984 and 1985 during this study revealed no parameters that would be considered at levels harmful to warmwater fish habitat; however, in several instances water quality parameters were found to be above or below those levels in the preferred ranges. Alkalinity is considered preferred for warmwater fish habitat at levels $\geq$ 100 mg/l. This level was met only at Stations 1 (during all sampling periods), 2 (in April 1984 and July 1985), and 3 (July 1985). Thus, the Licking River has limited buffering capacities to sudden changes in pH. If oil shale development within the Licking River watershed is realized, potential impacts to the water quality, thus associated aquatic communities, could become a reality. This resource (oil shale) should be carefully and conscienciously studied if development is ever seriously considered. A great deal of water is also needed in retorting oil shale and this may become a problem if the industry is developed with the Licking River watershed. Hannan et al. (1984) discussed some of the aquatic resource impacts associated with oil shale development.

The pH range considered preferred for warmwater fish habitat is 6.5-8.2; readings taken from Station 4 in July 1984, Stations 1-4 in July 1985, and Stations 1-3 in October 1985 were below the 6.5 desirable range.

Turbidity levels were generally within the suitable $\leq$ 200 NTU range except for short durations following heavy rains or abnormal increased discharge from Cave Run Reservoir.

All other water quality parameters for warmwater fish habitat were determined to be suitable at the time they were taken.

Little development (other than agriculture) occurs on the main stem Licking River. Water quality impacts are chiefly associated with runoff from land use patterns (non-point source), and whatever impacts are associated with waters entering the Licking River from tributary streams. A major urban and industrial center exists in the Kenton/Campbell county area, accompanied by rail and barge traffic. Outside this area, no major urban or industrial sites exist along the main stem Licking River. Other than Butler and Falmouth in Pendleton County, no other towns of consequence are located on the main stem Licking River below Cave Run Lake dam. Other than some agricultural practices, a few bridges, barns, and habitations, a person utilizing the river for recreation seldom sees any sign of man, other than litter. Besides the Kenton/Campbell County area, potential sources of sewage pollution within the Licking River below Cave Run Lake dam occur at Butler, Falmouth, from the South Fork Licking River drainage (ie. Cynthiana, Paris, Millersburg, and Carlisle), and Morehead.

One potential impact that would alter a substantial section of the Licking River below Cave Run Lake would be the construction of the Falmouth dam. This project is authorized but currently inactive. This dam would be located slightly downstream from McKinneysburg in Pendleton County (River mile 60.6). The reservoir, if constructed, would impound portions of the Licking River in Pendleton, Harrison, Bracken, Robertson, Fleming, Nicholas and Bath counties. It would have a minimum pool of 9,500 acres at elevation 610, and a summer pool of 12,300 acres at elevation 620. During major flood, the storage capacity to spillway crest at elevation 650 would be 25,700 acres (Army Corps of Engineers 1981). If constructed, this reservoir would inundate the entire segment that is proposed for protection under the River Registry program, and

lost forever would be the unique characteristics and aqautic faunas discussed in this report, as well as one of the few unaltered river segments left within the Commonwealth.

BOTTOM FAUNA

Two replicate aquatic macroinvertebrate samples were collected with a D-framed aquatic net sampler during 1985 in the spring (April 15), summer (July 15), and fall (October 15) at three locations in the Licking River (Tables 29 and 30). The lower most site was located at Falmouth, Kentucky (Pendleton County) at a wide, shallow riffle just above the confluence with South Fork Licking River. Because of activities of the Falmouth water plant, located in a pool just above this site, this area was subject to fluctuating water levels. The middle station was located in a narrow, fairly deep riffle on the Nicholas and Robertson county line, approximately 1 mile south of Piqua, Kentucky just above the confluence with Painter Creek. The uppermost station was located in a narrow, very swift riffle at Johnson Ford on the Bath and Fleming county line approximately 4 miles upstream from the junction with Slate Creek and 2 miles southwest of Stringtown, Kentucky. The depth and swiftness of the current at the latter two locations decreased the efficiency of the triangular kick-net sampler, resulting in a lower number of taxa and individuals (Table 30).

There is no published macroinvertebrate data on the portion of the Licking River from Falmouth to Johnson Ford. However, Hannan et al. (1984) and the Kentucky Division of Water (1986) provided aquatic invertebrate data on a few tributary streams that discharge to this section of the Licking River.

Prather (1985) reported 48 species of invertebrates from the Licking River above Cave Run Lake. From the three benthos stations below Cave Run Lake, 16 orders and 117 species were identified. Dipterans were most numerous with 54 species, followed by ephemeropterans with 16 species, trichopterans with 11 species, and plecopterans with 9 species. The macroinvertebrate data indicates that the water quality in the portion of the Licking River between Falmouth and Johnson Ford (approximately 100 miles) is sufficient to support diverse, viable communities of aquatic invertebrates. The spring sample, at all locations, typically had a greater number of taxa, higher species diversity index value and a higher Ephemeroptera/Plecoptera/Trichoptera index than the summer and fall samples (Table 30). This is a common, naturally occurring phenomenon in streams, resulting from emergence patterns of aquatic insects.

The Licking River at Falmouth supported the most diverse fauna of the three sampling sites. Annelids, mollusks, crustaceans, and all major groups of aquatic insects were represented. The dipterans and ephemeropterans were the most numerous. The specie being most abundant during spring and fall was the ephemeropteran *Stenonema terminatum*, and during summer the trichopteran *Cheumatopsyche* sp. All numerical data were generally good for all seasons, particularly the EPT index. These are excellent indications of the present good water quality at this location.

The middle station, the Licking River at Painter Creek, also exhibited a diverse macroinvertebrate fauna. As stated earlier, the apparent reduction in

fauna from that observed at Falmouth is probably due, in large part, to the inefficiency of the kick-net in deep, fast riffle areas. Representatives of the annelids, mollusks, crustaceans, and all major groups of aquatic insects were present. Again, the numerical data were generally good for all seasons. The most abundant species by season were the dipteran *Simulium* sp. 2 (spring) and the ephemeropteran *stenonema terminatum* (summer and fall).

The upper station, Licking River at Johnson Ford, was similar to the middle station with respect to fauna and numerical data, though somewhat reduced. Again, this reduction can be attributed in large part to the inefficiency of the sampling technique used in deep, swift riffles. The annelids, mollusks, crustaceans, and all major groups of aquatic insects were represented. Most abundant in the spring and summer samples were the heterodontan *Corbicula fluminea*. Of the aquatic insects, the ephemeropteran *Isonychia* sp. was collected with the greatest frequency during the spring; during the summer and fall, the trichopteran *cheumatopsyche* sp. was most abundant. The numerical data for the spring and fall were comparable or sometimes superior to the other two sites; however, the summer numerical data were generally the lowest observed at any of the three sampling locations.

Jordan (1980) investigated the effects of Cave Run Lake discharges on macroinvertebrate tailwater communities. Jordan (1980) compared samples taken upstream and downstream of Cave Run Lake and compared this data with pre-impoundment surveys. Jordan's (1980) results "showed significant changes in macroinvertebrate communities several kilometers downstream from the dam. Diversity and equitability were reduced, and increasing numbers of attached, filter-feeding organisms dominated the benthic community. Organisms intolerant of environmental stress were a smaller proportion of the samples in the affected zone. Recovery, indicated by increased diversity and community structure similar to upstream stations, was apparent downstream from the mouth of Triplett Creek" (approximately 5 miles downstream of the tailwater).

In addition to a diverse fish and aquatic insect community, the Licking River also harbors a diverse mussel fauna. Schuster (1987) listed 29 genera and 48 species of unionid mussels known to occur within the Licking River drainage (Table 31); an additional 5 species of mussels are recognized by Kentucky Nature Preserves Commission (personal communication Ronald R. Cicerello). No complete unionid survey of this draingage has ever been published. Schuster (1987) states "it is clear that this river (Licking River) contains one of the most diverse unionid fauna of any river in Kentucky". Thirty-one species of unionid mussels have been recorded from one riffle area alone (personal communication Ronald R. Cicerello, Kentucky Nature Preserves Commission, indicated by * in Table 31). Of those mussels listed in Table 31, 15 species are considered by Warren et al. (1986) as either endangered, threatened, or of special concern. Two of the species shown in Table 31 are also listed by the United States Fish and Wildlife Service (1987) as endangered; 7 other species are listed under status review.

Branson and Batch (1981) reported distributional records for gastropods and sphaeriid clams in Kentucky, which included Licking River drainage records. Branson et al. (1987) provided additional distribution records for aquatic snails and fingernail clams which included Licking River drainage records, and Branson (1988) revealed information on sphaeriacean clams of Kentucky which included several Licking River drainage references.

As mentioned previously, little information is availabe regarding the macroinvertebrate fauna within the Licking River. Efforts should be made to more thoroughly investigate the existing aquatic invertebrate fauna of this system. Additional efforts should also be undertaken to assure the protection of the diverse mussel fauna within the Licking River and its tributaries.

RECOMMENDATIONS

A major portion of the large river systems within Kentucky have been altered from their free flowing state of pools, riffles, and runs into a series of sluggish pools due to the construction of navigation dams (ie. Ohio, Green, Kentucky, lower Cumberland and lower Tennessee rivers). Flood control impoundments have been built on many other rivers within Kentucky (ie. Barren, Cumberland, Green, Licking, Little Sandy, Nolin, Rough, and Salt rivers). However, segments of several rivers below these impoundments remain relatively unimpacted (ie. Green and Licking rivers). There are a few rivers (and several streams) that have not been significantly altered either by impoundments, channelization, or strip mining (ie. Little South Fork and South Fork Cumberland River, South Fork Kentucky River, Red River, Rockcastle River, Rolling Fork, and Russell Fork). Since there are so few relatively undisturbed river habitats and associated faunal communities remaining within the Commonwealth, it is of considerable importance that they be protected, along with other important unimpounded or undisturbed stream systems not mentioned above. Thus, the importance of identifying, documenting, and protecting their integrity, such as that proposed by the Rivers Registry designation, Outstanding Resource Waters designation, Wild Rivers Program, etc.

It is nearly impossible to put a value on our free-flowing waters and their adjoining floodplains (riparian zone, wetlands, etc.). Man has altered or degraded thousands of miles of streams in Kentucky. The U.S. Army Corps of Engineers estimated that mitigation for the 4.5 miles Tug Fork "Big Bend Cutoff" would be at least $8 million, half for Kentucky half for West Virginia. That equates to nearly $1.8 million per mile of river.

In many cases, stream alteration projects are likely not as beneficial as retaining the stream in its natural state. It becomes obvious that billions of dollars worth of natural stream, river, and wetland ecosystems have been lost. The economic loss is minor compared to the loss of the resource, a resource that we depend upon for our well-being as well as for life as we know it. If we continue to alter, pollute, degrade, and destroy the aquatic resources, are we slowly destroying the life-giving substance needed to sustain life?

Great strides have been made in recent years. Many problems have been well documented and, increasingly, citizen concern has been aroused. We should not and cannot tolerate the continual destruction and pollution of our aquatic resources. Many regulations have been adopted and increased regulatory functions mandated; monitoring has also increased. The biggest problems are compliance and enforcement. In too many instances, violators and violations are ignored, both at the local and statewide level. Increased enforcement positions are obviously needed for adequate enforcement of

environmental laws in the state. There should be room for progress and development, but it sould be compatable with the environment. The Commonwealth of Kentucky and the Federal Government have the laws, regulations, statutory function, and highly qualified field personnel from regulatory agencies. There should be adequate committment to provide enough enforcement personnel to assure that the laws and regulations are properly adhered to and properly enforced. The Licking River drainage is no exception.

Due to many unique features, some of which were discussed previously in this report, a large segment of the Licking River below Cave Run dam is in need of protection to assure that these unique qualities remain for future generations. There are several major potential threats that would drastically impact what is remaining of the excellent aquatic communities within the Licking River. The major obvious impacts include the Falmouth dam, the mining of oil shale, and the industry created by the extraction of oil from these shales. Sedimentation and brines associated with oil drilling operations have already impacted the Licking River drainage above Cave Run Lake. The Licking River should be given high priority in decision making processes that may adversely affect this system. The author concurs with the Priority 1 assignment proposed for the Licking River (River miles 52-159) based on the Kentucky Division of Water Rivers Registry. However, based on populations of certain fishes downstream of this point (ie. blue sucker, mountain madtom, northern madtom, tippecanoe darter, and others); although most have also been found upstream of River mile 52, the proposed segment should be expanded downstream to ca River mile 20.

Brewer (1980) determined that there were 433 acres of muskellunge pool habitat within the Licking River, from Cave Run dam downstream 34 miles. Based on muskellunge observed during this study, muskellunge were found to occupy an area somewhat farther downstream than 34 miles (as far as 60 miles), but were taken more frequently upstream. Being a larger system than most of the streams supporting muskellunge populations (Axon and Kornman 1986), the Licking River can support a greater population of these fish. Brewer (1980) reported that most Kentucky native muskellunge streams supported about one muskellunge for every 2 acres of muskellunge pool habitat. For the past several years (Table 1), 7-9 inch long muskellunge have been stocked annually at a rate of one muskellunge per acre of suitable habitat. This rate may have been higher than necessary to support a muskellunge fishery within the river segment that muskellunge primarily range. One of the purposes of stocking at a higher rate is to assure a source of broodstock within the tailwater of the Licking River if needed. If stocked annually, stockings should continue at a rate of no less than 300 fingerling muskellunge. Unless it can be determined that their frequency of occurrence increases downstream below rive mile ca 110.

As fallen trees and large woody debris is important habitat for muskellunge in streams (as well as for other species), riparian zones and instream cover should be protected in order to provide shade, bank stabilization, and future supplies of fallen tree habitat. Programs for better land management practices should be initiated within the drainage to protect against increased sedimentation.

Illegal netting activities have been documented within the Licking River and within the mouths of major tributary streams. Attempts should be made to

eliminate or discourage these activities. Impacts to game fish populations in streams from the use of unregulated, unmaned "fishing gear" (jug fishing, bank poles, limb lines, etc.) were discussed by Kornman (1985).

One species of game fish that has always occurred in the Licking River, but never in large numbers, is the walleye. Attempts have been made in recent years to establish a better fishery for this species through stocking. Approximately 20,000 walleye fingerlings have been stocked annually since 1984, within the same river segment that the muskellunge range. These stockings should be carried out for at least 5 years in order to establish a fishery, or at least a spring walleye run to the tailwater below Cave Run dam, that would attract anglers fishing for that species. In the near future, these walleye stockings should be evaluated to determine its success. Illegal netting and gigging may also impact the walleye fishery.

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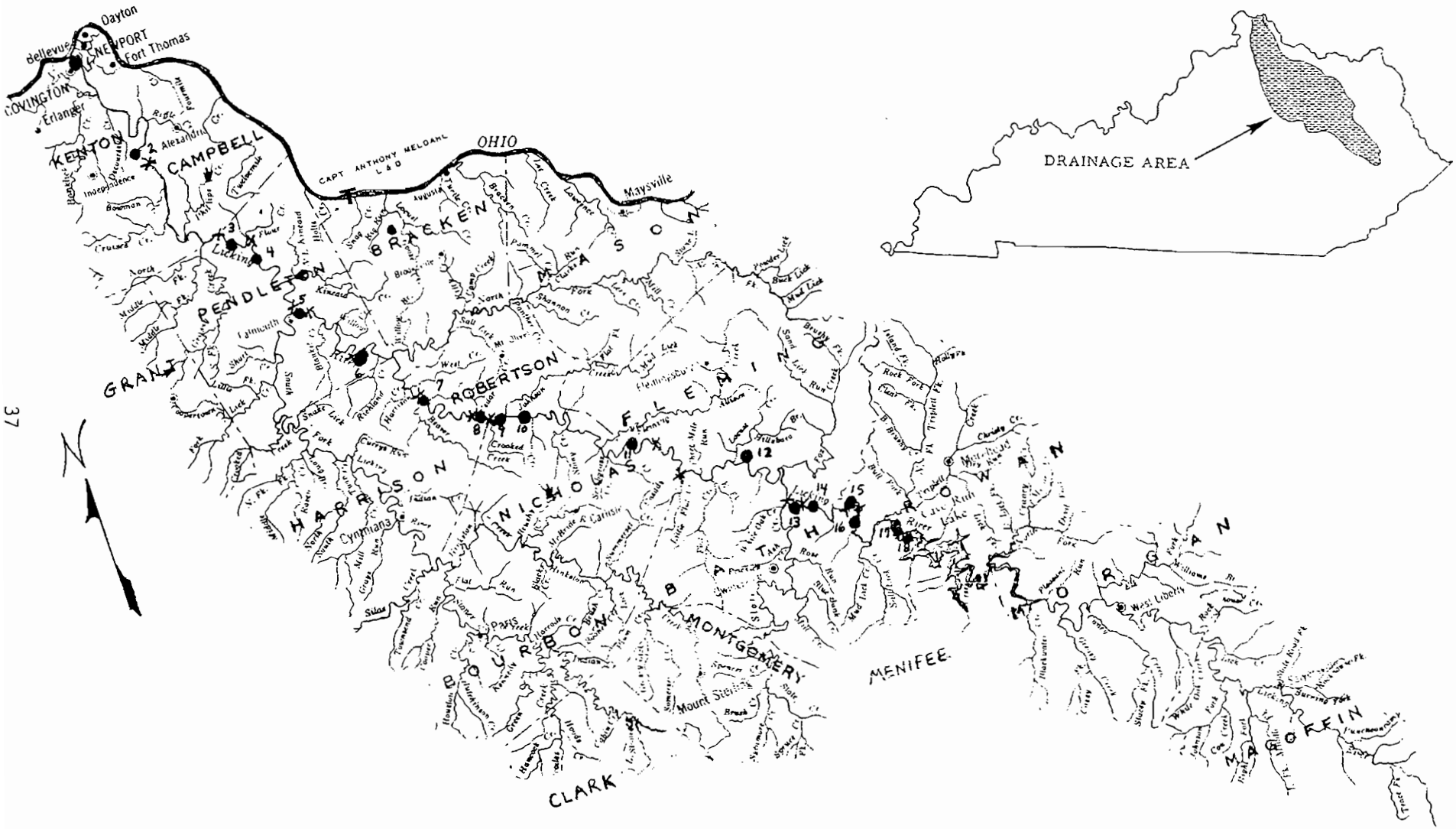

Figure 1. Licking River drainage, Kentucky (●-electrofishing stations, x-seine sites).

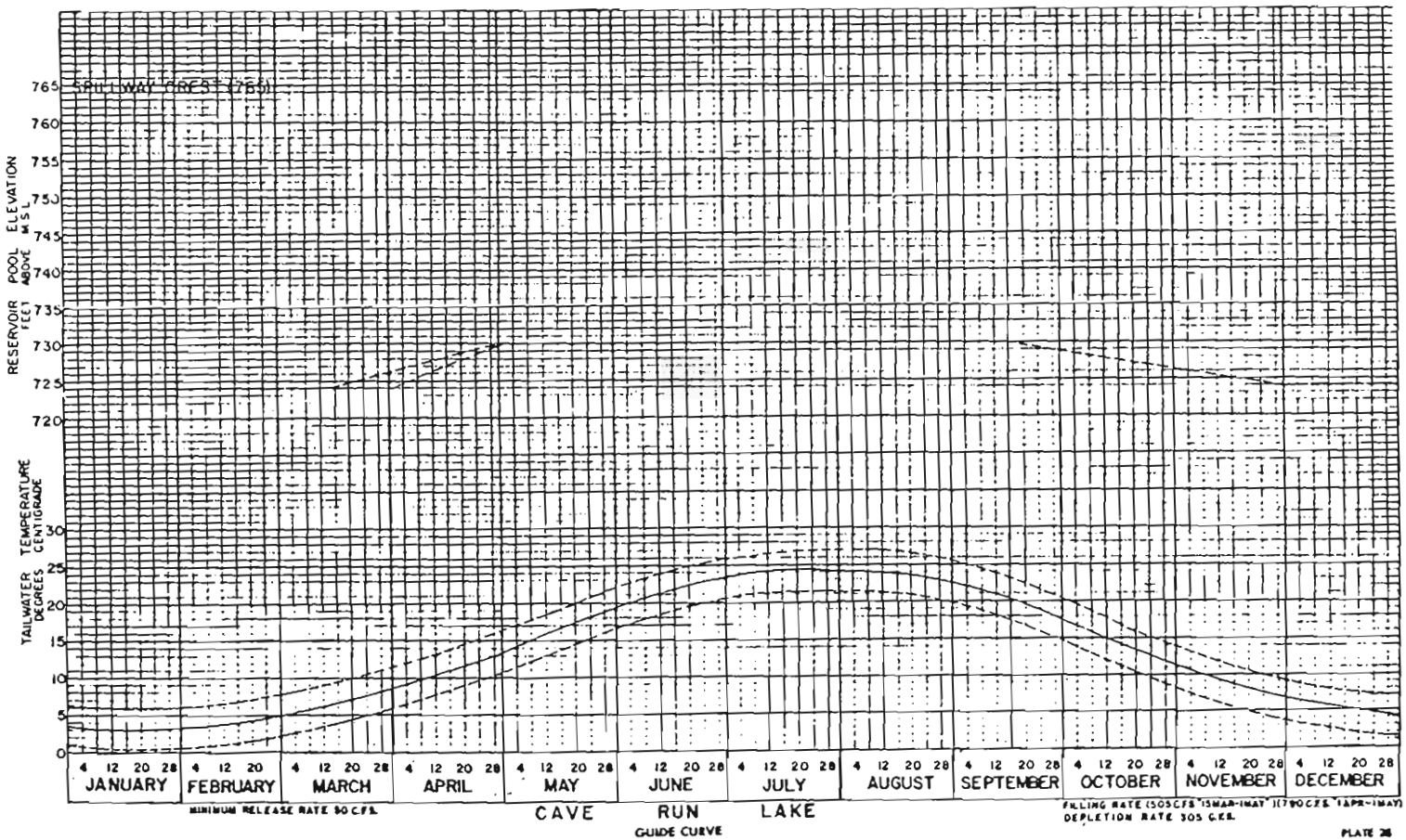

Figure 2. Desired tailwater temperature curve for Cave Run Lake tailwater, based on natural stream temperatures.

Table 1. Muskellunge stockings in Licking River below Cave Run Lake in 1973 - 1988.

Year	Number	Average size (inches)
1973	1,756	8.0
1975	2,000	1.0
	177	4.5
	15	12.0
1976	200	1.0
	35	31.0-46.0
1979	433	7.8
1980	13	8.6
1981	90,000	0.5
1984	604	7.9
	95	13.2
1985	30,000	0.5
	600	8.1
1986	450	9.8
1987	508	8.4
1988	140,977	0.5
	513	8.8

Table 2. Location of Licking River fish sampling stations below Cave Run Lake (1983-1986). Electrofishing sites are indicated by numbers, seine sampling sites are indicated by S.

Station	Location
1	Campbell/Kenton counties. From mouth (confluence Ohio River) upstream to mouth of Threemile Creek (Wilder, Campbell Co., KY boat ramp). River mi 0-3.2, 18 Sept 84 and 30 July 86. Covington and Newport, KY - OH Quads.
2	Campbell/Kenton counties. From boat ramp (1.0 air mi N of Ryland Heights, KY, Kenton County) on St. Rt. 1930, upstream 2.3 mi. River mi 10.0-12.3, 15 Aug 84 and 29 July 86. Alexandria, KY Quad.
S[a]	Campbell/Kenton counties. Confluence with unnamed tributary flowing along Visalia Road (off of St. Rt. 1936, Campbell Co.), 0.6 air mi SE of Visalia, KY. River mi 20.3, 29 July 86. Alexandria, KY Quad.
3 S[b]	Pendleton County. From confluence with Sandy Branch (seined here) upstream 2.4 mi to just above confluence with Willow Creek (vic. Butler, KY). River mi 33.2-35.6, 17 Aug 84. Demossville and Butler, KY Quads.
S[c]	Pendleton County. Confluence with Flour Creek, 1.2 air mi E of Butler, KY, off of St. Rt. 177. River mi 37.6, 29 July 86.
4	Pendleton County. From just downstream of confluence with Harris Creek, 2.5 air mi SE of Butler, KY, off of St. Rt. 609, upstream 1.8 mi to confluence with Steer Creek. River mi 40.5-42.3, 13 Aug 84. Butler and Falmouth, KY Quads.
5 S[d], S[e]	Pendleton County. From confluence with South Fork Licking River (S[d] 28 July 86) Falmouth, KY, upstream 3.0 mi (S[e], 14 Aug 84). River mi 52.0-55.0, 14 Aug 84 and 28 July 84. Falmouth, KY Quad.
6 S[f]	Pendleton County. From confluence with unnamed tributary (just downstream from bridge at McKinneysburg) upstream 1.5 mi (seined here 16 Aug 84). River mi 65.1-66.6, 16 Aug 84. Seined at McKinneysburg bridge 29 July 86. Kelat, KY Quad.
7 S[g]	Harrison/Robertson counties. From confluence with Beaver Creek, vicinity Claysville, KY (seined here 31 July 86), upstream 1.4 mi to large riffle area (02 Aug 84 and 31 July 86) then upstream 1.6 mi further (02 aug 84). River mi 79.9-81.3 and 81.7-83.3. Claysville and Shady Nook, KY Quads.
8 S[h]	Harrison/Robertson counties. From confluence with Cedar Creek (seined here 31 July 86), 1.2 air mi S of Kentontown, Robertson,Co., KY, upstream 1.9 mi to just downstream of

Table 2 (continued).

Station	Location
	confluence with Crooked Creek (Nicholas County). River mi 84.1-86.0, 01 Aug 84 and 31 July 86. Piqua, KY Quad.
9 S[i]	Nicholas/Robertson counties. From confluence with Crooked Creek, Nicholas Co (seined here 01 Aug 86), upstream 1.5 mi to just below confluence with Johnson Creek (Robertson Co.). River mi 86.0-87.5, 31 July 84 and 01 aug 86. Piqua, KY Quad.
10	Nicholas/Robertson counties. From confluence with Painter Creek (Nicholas Co., 1.0 air mi S of Piqua, KY, Robertson Co) upstream 1.7 mi to confluence with Sugar Creek (Nicholas Co). River mi 88.7-90.4, 30 July 84 and 24 June 85. Piqua, KY Quad.
11	Fleming/Nicholas counties. From confluence with unnamed tributary (2.0 air mi NE of Myers, Nicholas Co., KY) upstream 2.8 mi to confluence with Fishtrap Creek (Nicholas Co.). River mi 108.4-111.2, 20 July 84. From access boat ramp at Clay WMA, Nicholas Co. upstream 1.5 mi to confluence with Fishtrap Creek. River mi 109.7-111.2, 01 July 85. Moorefield, KY Quad.
S[j]	Fleming/Nicholas counties. Old ford at Upper Blue Licks (Fleming Co.) River mi 116.1, 18 July 85. Sherburne, KY Quad.
S[k]	Bath/Fleming/Nicholas counties. Off of Milltown-Little Flat-Ledford Hwy. River mi 121, 18 July 85. Sherburne, KY Quad.
12	Bath/Fleming counties. From confluence with Forge Creek (Bath Co) upstream 2.5 mi to a ford at end of St. Rt. 1336 (4.0 air mi W of Hillsboro Fleming Co., KY). River mi 129.8-132.3, 20 June 85. Hillsboro, Ky Quad.
S[l]	Bath/Fleming counties. Confluence with Slate Creek. River mi 143.5, 18 July 85. Colfax, KY Quad.
13	Bath/Fleming counties. From riffle (0.9 mi upstream from confluence with Claver Br; 1.0 air mi S Wyoming, Bath Co. KY) upstream 2.0 mi to just below Johnson Ford (at confluence with unnamed tributary, Fleming Co). River mi 145.5-147.5, 20 July 84 and 19 June 85. Colfax, KY Quad.
S[m]	Bath/Fleming counties. Riffle between Sta 13 and 14, Johnson Ford. River mi 147.5, 27 July 84 and 18 July 85. Colfax, KY Quad.
14	Bath/Fleming counties. From Johnson Ford (2.0 air mi SW Stringtown, Fleming Co, KY) upstream 1.7 mi. River mi 147.5-149.2, 18 July 84 and 19 June 85. Colfax, KY Quad.

Table 2 (continued).

Station	Location
S[n]	Bath/Rowan counties. Old St. Rt. 211 ford, 0.5 mi N of Moores Ferry, Bath Co., KY. River mi 154, 18 July 85. Farmers, KY Quad.
15	Bath/Rowan counties. From riffle (1.0 air mi NE Moores Ferry, Bath Co., KY; Ingrams Bend) upstream 3.4 mi to riffle 0.2 mi downstream of confluence with Bluebank Branch (Rowan Co). River mi 155.0-158.4, 17 July 84 and 17 June 85. Farmers, KY Quad.
S[o]	Bath/Rowan counties. Riffle between Sta 15 and 16, just below confluence with Bluebank Branch. River mi 158.5, 18 July 85. Farmers, KY Quad.
16	Bath/Rowan counties. From confluence with Bluebank Branch (Rowan Co) upstream 2.5 mi to I-64 bridge crossing. River mi 158.6-161.1, 16 July 84 and 04 June 85. Farmers, KY Quad.
17	Bath/Rowan counties. From US 60 crossing (0.5 air mi E Farmers, Rowan Co, KY) upstream 0.5 mi. River mi 169.5-170.0; 12 Apr, 07 July, and 03 Nov 83. Farmers, KY Quad.
S[p]	Bath/Rowan counties. Old man-made structure in river Ca 0.6 mi below Bayou Creek (Bath Co). River mi 171.9, 18 July 85. Salt Lick, KY Quad.
18	Bath/Rowan counties. From a point 0.5 mi downstream of spillway basin below Cave Run Reservoir dam, upstream into the spillway basin. River mi 172.9-173.4; 12 Apr, 07 July, 03 Nov 83. Salt Lick, KY Quad.

Table 3. Sampling effort and muskellunge captured by electrofishing in the Licking River in 1984 - 1986.

Station	Date sampled	Total hours electrofished	Subsample time (hr)	Length of sample pool (mi)	Number of muskellunge actually captured	Number of additional muskellunge observed
1	18 Sept 84	1.0	1.0 (same)	3.2	0	0
	30 Jul 86	2.5	2.5 (same)	3.2	0	0
2	15 Aug 84	1.8	1.8 (same)	2.3	0	0
	29 Jul 86	2.0	1.5	2.3	0	0
3	17 Aug 84	1.7	1.0	2.4	0	0
4	13 Aug 84	1.8	0.8	1.8	0	0
5	14 Aug 84	2.0	0.8	3.0	0	0
	28 Jul 86	2.1	1.0	3.0	0	0
6	16 Aug 84	1.7	0.8	1.5	0	0
7	02 Aug 84	3.3	0.8	3.0	0	0
	31 Jul 86	1.6	1.0	1.4	0	0
8	01 Aug 84	2.0	0.9	1.9	0	0
	31 Jul 86	1.9	0.7	1.9	0	0
9	31 Jul 84	1.7	1.0	1.5	0	0
	01 Aug 86	1.6	1.0	1.5	0	0
10	30 Jul 84	1.6	0.8	1.7	0	0
	24 Jun 85	1.5	0.5	1.7	0	0
11	20 Jul 84	2.9	1.0	2.8	0	1
	01 Jul 85	1.8	1.0	1.5	0	1
12	20 Jun 85	2.5	1.0	2.5	1	0
13	19 Jul 84	2.1	0.9	2.0	0	0
	19 Jun 85	1.9	0.5	2.0	4	0
14	18 Jul 84	1.6	0.8	1.7	0	0
	19 Jun 85	1.7	0.5	1.7	3	1
15	17 Jul 84	3.0	1.0	3.4	0	0
	17 Jun 85	3.1	N/A	3.4	1	1
16	16 Jul 84	2.9	1.3	2.5	0	2
	04 Jun 85	2.8	1.0	2.5	2	1

Table 4. Sampling effort and muskellunge captured from Licking River (Stations 17 and 18); a seasonal comparison from two Cave Run Lake tailwater stations (1983).

Station	Date sampled	Total hours electrofished	Length of sample pool (mi)	Number of muskellunge captured	Number of additional muskellunge observed
17	12 Apr 83	0.8	0.5	0	0
	07 Jul 83	0.8	0.5	0	0
	03 Nov 83	0.9	0.5	0	0
18	12 Apr 83	1.0	0.9	1[a]	0
	07 Jul 83	0.4	0.5	1	0
	03 Nov 83	0.6	0.5	0	0

[a]Hybrid muskellunge also collected (17 inches long).

Table 5. Totals for Licking River sampling derived from Tables 3 and 4.

Year	Stations	Total hours electrofished[b]	Total hours subsample time	Total miles electrofished	Number of muskellunge captured (per mile; per hour)	Number of muskellunge observed (per mile; per hour)
1983	17 - 18[a] (2 station)	4.5	same	3.4	2 (0.6; 0.4)	0
1984	1-11, 13-16 (15 stations)	31.0	14.7	34.7	-	3 (0.09; 0.1)
1985	10 - 16 (7 stations)	15.3	4.5	15.3	11 (0.7; 0.7)	4 (0.3; 0.3)[c]
1986	1,2,5,7-9 (6 stations)	11.8	7.7	13.4	-	-
Combined		62.6	31.4	66.8	13 (0.2; 0.2)	7 (0.1; 0.1)

[a]Represents 3 seasonal samples at each station.

[b]Represents duplicate pools.

[c]Catch rates of muskellunge collected and observed, combined. reveal 1.0 muskie per hour and per mile.

Table 6. Muskellunge captured or observed (but not captured) in the Licking River below Cave Run Lake.

Station	Date	Pool length (mi)	Hours electrofished	Length (in)	Weight (lb)	Additional muskellunge observed (no.)	Additional muskellunge observed (length in inches)
11	20 Jul 84	2.8	2.9	-	-	1	35
	01 Jul 85	1.5	1.8	-	-	1	30
12	20 Jun 85	2.5	2.5	15.1	0.71		
13	19 Jun 85	2.0	1.9	15.8	0.76		
				17.6	1.00		
				18.0	1.20		
				19.4	1.60		
14	19 Jun 85	1.7	1.7	16.1	0.96	1	16
				16.2	0.78		
				17.9	1.18		
15	17 Jun 85	3.4	3.1	15.7	0.70	1	16
16	16 Jul 84	2.5	2.9	-	-	2	32,36
	04 Jun 85	2.5	2.8	15.8	0.85	1	38
				16.7	0.98		
18	12 Apr 83	0.9	1.0	36.0	10.86		
	07 Jul 83	0.5	0.4	15.1	-		

Table 7. Results of muskellunge broodstock acquisition[a] (by electrofishing) within the Licking River in the immediate tailwater below Cave Run Reservoir[b].

Date Collected	Sex[c]	Length (inches) of muskellunge retained for broodstock[d]	Weight (lb)[e]
1983			81.97
MAR (15)	F	34, 39	
	M	30, 36, 39	
APR (21,28)	F	37[f]	
	M	35	
1984			83.57
MAR (22,30)	F	32, 33.5, 35	
	M	28, 31.5	
APR (4,10,17)	F	29.5, 43.5	
	M	30.5, 32.5	
1985			171.30
MAR (7,26)	F	38	
	M	35, 39	
APR (no dates available)	F	37, 43	
	M	11 fish: 31.5 - 34.5	
After spawning, 2 F - 43 in and 1 M - 42 in released in tailwater.			
1986			204.34
MAR (10,24)	F	36, 38, 40(2), 42.5	
	M	30, 33, 34 (2), 35, 37	
APR (1)	F	36, 39 (2)	
	M	30.5, 31.5, 34.5	
After spawning, 13 F $\bar{x}$ 40 in and 19 M (26-38 in) released into tailwater.			
1987			354.54
MAR (9,13,16, 19,23,26)	F	28, 31, 32.5, 33.5, 37, 38(2), 41.5, 42	
	M	29.5, 30(2), 31, 33.5(2), 34.5(2), 35, 35.5, 36, 36.5(2), 38.5(2)	
APR (2,3,6,9)	F	30.5, 32, 33, 41, 42	
	M	33, 33.5, 38	
After spawning, 47 M (29-38 in) released into tailwater.			
1988			253.47
MAR (2,10,16, 25,30)	F	31(3), 33, 35(2), 36, 42, 43.5	
	M	32, 35, 35.5, 36(2), 37(2), 38, 39	
APR (4,7)	F	30.5, 31	
	M	36.5, 37.5	
22 adults later released into tailwater.			

[a]By Minor Clark Fish Hatchery personnel.
[b]Information derived from Division of Fisheries monthly reports and personal communication with D. Brewer (hatchery manager).
[c]Muskellunge 28-31 inches long determined to be female could possibly be males.
[d]Does not include muskellunge captured, measured, and released or additional muskellunge sighted but not captured; these numbers were substantial at times.
[e]Calculated weights from Brewer (1980); muskellunge collected by hatchery personnel were measured to the nearest 0.5 in; none were weighed.
[f]The 37 inch long muskellunge collected 21 March had flowing eggs and was accompanied by another adult (assumed to be a male); apparently these fish were in the act of spawning.

Table 8. Some characteristics of the fish population based on electrofishing surveys in the Cave Run Lake tailwater in Licking River.

	Station 18			Station 17		
	Apr	Jul	Nov	Apr	Jul	Nov
Total number of species collected	28	20	28	29	26	26
Total number of fish collected	352	182	356	261	210	190
Fish/hour	370	433	593	348	253	211

Table 9. Electrofishing results from Station 18 (0.95 hour) and Station 17 (0.75 hour) in Cave Run Lake tailwater, Licking River, during 12 April 1983. " designates data from Station 17.

Species	Inch group																					Number of fish	Fish/hour	Percent
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	23	36			
Least brook lamprey"						1																	1	1.3	t
Gizzard shad					13	58	3	2	1		1		1										79	83.2	22
Gizzard shad"				1	37	72	11	3															124	165.3	47
Muskellunge																						1	1	1.1	t
Hybrid muskellunge																	1						1	1.1	t
Carp									1	1	7	19	6	3	2	1	2		2				44	46.3	13
Carp"										1	3	6	1	6	8	5	4	1	2		1		38	50.7	15
Striped shiner"							1																1	1.3	t
Silver shiner"			1																				1	1.3	t
Rosyface shiner"		1																					1	1.3	t
Spotfin shiner"			1																				1	1.3	t
Steelcolor shiner"		12	21	1																			34	45.3	13
Creek chub"		1																					1	1.3	t
Fathead minnow			2																				2	2.1	1
Fathead minnow"		3																					3	4.0	t
Bluntnose minnow			1																				1	1.1	t
River carpsucker																	2						2	2.1	1
Quillback														1									1	1.1	t
Quillback"													1										1	1.3	t
Northern hog sucker							1	1	3														5	5.3	1
Smallmouth buffalo																1							1	1.1	t
Bigmouth buffalo											1	4	16	20	10	8	1		1	1			62	65.3	18
Bigmouth buffalo"												2		2									4	5.3	2
Spotted sucker					1			2	2	4	1	1											11	11.6	3
Spotted sucker"								1		1	1												3	4.0	1
Black redhorse"									2		1												3	4.0	1
Golden redhorse"												4								1			5	6.7	2
Shorthead redhorse															1								1	1.1	t
Shorthead redhorse"															1								1	1.3	t

Table 9 (continued).

Species	Inch group																						Number of Fish	Fish/hour	Percent
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	23	36			
Brindled madtom*		1																					1	1.3	t
Brook silverside*		2	3																				5	6.7	2
Rock bass								1	1														2	2.1	1
Rock bass*				1																			1	1.3	t
Green sunfish			1	2	1	1		1															6	6.3	2
Warmouth		1			1																		2	2.1	1
Bluegill			2	16	17	5	1																41	43.2	12
Bluegill*	1	1																					2	2.7	1
Longear sunfish			2		1																		3	3.2	1
Longear sunfish*					4	2																	6	8.0	2
Redear sunfish					1																		1	1.1	t
Hybrid sunfish*		1	2	3	2																		8	10.7	3
Spotted bass				1				1	1	4	2	1	1	1									12	12.6	3
Spotted bass*						1	1	1			1		2										6	8.0	2
Largemouth bass							2	2	10	9	7	6	1	1									38	40.0	11
Largemouth bass*												1											1	1.3	t
White crappie			1	1	4	11	3	1		1													22	23.2	6
White crappie*				2				1		1													4	5.3	2
Black crappie					1			1															2	2.1	1
Black crappie*									1														1	1.3	t
Greenside darter		1																					1	1.1	t
Banded darter*		1																					1	1.3	t
Logperch*				2																			2	2.7	1
Channel darter*		1																					1	1.3	t
Blackside darter			3																				3	3.2	1
Sauger																			1				1	1.3	t
Walleye														1			1						2	2.1	1
Freshwater drum					1	2			1												1		5	5.3	1

Table 10. Electrofishing results from Station 18 (0.4 hour) and Station 17 (0.8 hour) in Cave Run tailwater, Licking River, during 7 July 1983. " designates data from Station 17.

Species	Inch group																							Number of fish	Fish/hour	Percent
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	27			
Gizzard shad							13	21	7	6	5														52	123.8	29
Gizzard shad"							14	29	5	2	1														51	61.4	24
Muskellunge														1											1	2.4	1
Grass pickerel"					4	2																			6	7.2	3
Carp											2	1	1	1					1	1	1				8	19.0	4
Carp"									1	2	6	11	9	1	3	2	2	1			1	4	2		45	54.2	21
Steelcolor shiner		3																							3	7.1	2
Steelcolor shiner"		4	1																						5	6.0	2
Bluntnose minnow	1																								1	2.4	1
Quillback												1													1	2.4	1
Quillback"											2	2													4	4.8	2
Northern hog sucker"											1														1	1.2	t
Smallmouth buffalo														1	2				1						4	9.5	2
Smallmouth buffalo"													2	2	1	2	2								9	10.8	4
Bigmouth buffalo												2		1		2		2							7	16.7	4
Bigmouth buffalo"												1	2	1					1						5	6.0	2
Spotted sucker						1			1		1														3	7.1	2
Spotted sucker"								1	2		1														4	4.8	2
Silver redhorse"												2													2	2.4	1
River redhorse"																				1			1		2	2.4	1
Black redhorse"														2											2	2.4	1
Golden redhorse"											2	1													3	3.6	1
Shorthead redhorse"										1				1											2	2.4	1
Channel catfish"										1															1	1.2	t
Flathead catfish																			1					1	2	4.8	1
Brook silverside"	1																								1	1.2	t
Rock bass"	1			4		1																			6	7.2	3
Green sunfish				1																					1	2.4	1
Warmouth					2																				2	4.8	1
Bluegill			9	12	1																				22	52.4	12
Bluegill"		1	1	1	1																				4	4.8	2
Longear sunfish		3	5	19	6																				33	78.6	18
Longear sunfish"	1	8	14	17	6																				46	55.4	22
Redear sunfish				1																					1	2.4	1

Table 10 (continued).

Species	Inch group																							Number of fish	Fish/hour	Percent
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	27			
Spotted bass		1				6	5		2	1	2		1												18	42.9	10
Spotted bass[a]		2				1																			3	3.6	1
Largemouth bass			1		1				1		1	2													6	14.3	3
Largemouth bass[a]		1																							1	1.2	t
White crappie				3	8																				11	26.2	6
White crappie[a]					1	1																			2	2.4	1
Black crappie						1																			1	2.4	1
Greenside darter[a]	1																								1	1.2	t
Logperch[a]			1	1																					2	2.4	1
Sauger[a]													1												1	1.2	t
Freshwater drum							1								1		1	1				1			5	11.9	3
Freshwater drum[a]																		1							1	1.2	t

[a] Paddlefish were not collected but one individual was observed in the spillway basin.

Table 11. Electrofishing results from Station 18 (0.55 hour) and Station 17 (0.9 hour) in Cave Run Lake tailwater, Licking River, during 3 November 1983. [a] designates data from Station 17.

Species	Inch group																						Number of Fish	Fish/hour	Percent
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	25			
Longnose gar[a]													1										1	1.1	1
Gizzard shad								18	34	10	3												65	118.2	18
Gizzard shad[a]								5	13	11	2												31	33.7	16
Grass pickerel									1														1	1.8	t
Grass pickerel[a]								1															1	1.1	1
Carp											1		2	2			1		1	1	1		9	16.4	3
Carp[a]												3	8	13	4	5	3	4					40	43.5	21
Emerald shiner			1																				1	1.8	t
Rosyface shiner		1																					1	1.8	t
Spotfin shiner		1																					1	1.8	t
Spotfin shiner[a]				1																			1	1.1	1
Steelcolor shiner		2	6	1																			9	16.4	3
Steelcolor shiner[a]			4	1																			5	5.4	3
River carpsucker[a]													1										1	1.1	1
Northern hog sucker											1												1	1.8	t
Smallmouth buffalo																		1					1	1.8	t
Bigmouth buffalo												2	6	7	4	1	1			1			22	40.0	6
Bigmouth buffalo[a]													1										1	1.1	1
Spotted sucker								2	3	7	2												14	25.5	4
Spotted sucker[a]									4	2													6	6.5	3
Silver redhorse[a]												1											1	1.1	1
Golden redhorse[a]														1	1								2	1.8	1
Yellow bullhead[a]										1													1	1.1	1
Channel catfish[a]																					1		1	1.1	1
Brook silverside		2	20																				22	40.0	6
White bass[a]									1														1	1.1	1
Rock bass							3																3	5.5	1
Redbreast sunfish[b]					2	2																	4	7.3	1
Green sunfish		1	3	4	1																		9	16.4	3
Green sunfish[a]			1	3																			4	4.3	2
Warmouth						1																	1	1.8	t
Bluegill	1	12	6	9	21	8																	57	103.6	16
Bluegill[a]		3	1	5	2	1																	12	13.0	6
Longear sunfish	2	1		7	6																		16	29.1	4

Table 11 (continued)

Species	Inch group																					Number of Fish	Fish/hour	Percent
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	25			
Longear sunfish[a]	2	2	15	16	12	3																	50	54.3	26
Redear sunfish					1																		1	1.8	t
Hybrid sunfish			5	6	3																		14	25.5	4
Hybrid sunfish[a]			1	1	1																		3	3.3	2
Smallmouth bass			1	1																			2	3.6	1
Spotted bass		2	2		2		2	9	4	2	5												28	50.9	8
Spotted bass[a]			1	2				1	2	1	2												9	9.8	5
Largemouth bass		15	6		1				1	3		2	2	1	2					1			34	61.8	10
Largemouth bass[a]			1							1		1											3	3.3	2
White crappie						15	12																27	49.1	8
White crappie[a]						5																	5	5.4	3
Black crappie						2	2	2															6	10.9	2
Logperch					2																		2	3.6	1
Logperch[a]			1	1																			2	2.2	1
Channel darter[a]		1																					1	1.1	1
Blackside darter[a]			2																				2	2.2	1
Walleye																				1		1	2	3.6	1
Walleye[a]													1										1	1.1	1
Freshwater drum												2					1						3	5.5	1
Freshwater drum[a]													1					3	1				5	5.4	3

[a]Probably escaped from hatchery.

Table 12. The five most abundant species (based on percent of total) collected seasonally at Stations 17 and 18 from Cave Run Lake tailwater in the Licking River during 1983.

Station 18				Station 17			
Species	No.	Fish/hour	%	Species	No.	Fish/hour	%
				APRIL			
Gizzard shad	79	83.2	22	Gizzard shad	124	165.3	47
Bigmouth buffalo	62	65.3	18	Carp	38	50.7	15
Carp	44	46.3	13	Steelcolor shiner	34	45.3	13
Bluegill	41	43.2	12	Hybrid sunfish	8	10.7	3
Largemouth bass	38	40.0	11	Longear sunfish	6	8.0	2
				Spotted bass	6	8.0	2
				JULY			
Gizzard shad	52	123.8	29	Gizzard shad	51	61.4	24
Longear sunfish	33	78.6	18	Longear sunfish	46	55.4	22
Bluegill	22	52.4	12	Carp	45	54.2	21
Spotted bass	18	43.0	10	Smallmouth buffalo	9	10.8	4
White crappie	11	26.2	6	Grass pickerel	6	7.2	3
				Rock bass	6	7.2	3
				NOVEMBER			
Gizzard shad	65	118.2	18	Longear sunfish	50	54.3	26
Bluegill	57	103.6	16	Carp	40	43.5	21
Largemouth bass	34	61.8	10	Gizzard shad	31	33.7	16
Spotted bass	28	50.9	8	Bluegill	12	13.7	6
White crappie	27	49.1	8	Spotted bass	9	9.8	5

Table 13. List of Investigations that Included the Licking River Drainage.

Corresponding numbers for use with Table 14	Investigation
1	Rafinesque, C.S. (1820, 1832, as in B.W. Everman, 1918) - first records of fishes collected from the Licking River draingage.
2	Woolman, A.J. (1892) - reported on fishes obtained from rivers in Kentucky, including the Licking River and Triplett Creek.
3	Everman, B.W. (1918) - distributional catalogue of fishes known to occur in Kentucky and Tennessee, primarily a literature review including Rafinesque's and Woolman's findings (see above).
4	Welter, W.A. (1938) - report of the fishes of the Licking River drainage.
5	Clark, M.E. (1941a) - a list of fishes in northeastern Kentucky including the Licking River drainage; (1941b) - biological survey of the Little Sandy and upper Licking River drainage.
6	Tompkins, W.A. and M.M. Peters (1952) - evaluation of the fisheries of the Licking River drainage, primarily summarizes Clark (1941b) and Carter (1951 - biological survey of slate Creek, Bath and Montgomery counties, unpublished). They did not differentiate Licking River proper.
7	Carter, B.T. (1956) - feasibility study of a controlled commercial fishery in the Licking River (unpublished).
8	Jones, A.R. (1970) - extensive sampling, inventory and classification of streams in the Licking River drainage.
9	Harker, D.F., Jr., et al (1979) - aquatic biota and water quality survey of Appalachian Province, eastern Kentucky, included: Licking River - Magoffin Co., Beaver Creek - Menifee Co., Caney Creek - Morgan Co., and North Fork Triplett Creek - Rowan Co.
10	Brewer, D.L. (1980) - muskellunge study in eastern Kentucky streams, including: Licking River (Bath, Rowan, Menifee counties), North Fork Creek (Morgan//Rowan County line), and North Fork Triplett Creek (Rowan County).

Table 13 (continued).

Corresponding numbers for use with Table 14	Investigation
11	Stauffer, J.R., Jr., et al (1982) - checklist of the fishes of the central and northern Appalachian Mountains, including Licking River drainage.
12	Hannan, R.R., et al (1984) - aquatic biota and water quality and quantity survey of the Kentucky oil shale region, included the following Licking River drainage sites: Licking River (mouth of Slate Creek) Bath County, Fox and Sandlick creeks (Fleming County), and Slate Creek (Montgomery County).
13	Prather, K.W. (1985) - muskellunge streams investigation, including the upper Licking River (above Cave Run Lake impoundment).
14	Fishes collected from the mainstem Licking River below Cave Run Lake 1983-1986 (this study indicated by x in Table 14). Fishes collected by NEFD staff from Licking river tributaries (not directly a part of this study) included: North Fork Licking River (Bracken, Robertson, Mason, Lewis and Fleming counties), South Fork Licking River (Pendleton and Harrison counties), Stoner Creek (Bourbon County), Stroder Creek (Bourbon and Clark counties), Hinkston Creek (Bourbon and Nicholas counties), Fox Creek (Fleming County), Slate Creek (Bath and Montgomery counties), Triplett and North Fork Triplett creeks (Rowan County), Brushy Creek (Menifee County), Craney and Mirror creeks (Morgan and Rowan counties). Fishes collected from these tributaries, but not from the Licking River are indicated by a / in Table 14.
15	Fishes collected by NEFD staff from Cave Run Lake.
16	Burr, B.M. and M.L. Warren, Jr. (1986) - distribution atlas of Kentucky fishes, includes Licking River drainage (should be considered the current official listing of fishes known to occur within the Licking River drainage).
17	Mills, M.R. (1988) - catalogue of fish collections of the Kentucky Division of Water, includes Licking River proper (mouth of Slate Creek, Ky Hwy 32 and 11, and US Hwy 62 - Bath, Fleming and Nicholas counties). Also, several tributary streams including: North Fork

Table 13 continued.

	Licking River (Mason County), South Fork Licking River (Harrison County), Brushy Creek drainage (Nicholas County), Fleming Creek (Fleming County), Slate Creek, Flat Creek and Salt Lick Creek (Bath County), Brushy Fork and Rockhouse creeks (Magoffin County). See also: Kentucky Division of Water 1984, 1986[a] and 1986[b].

Table 14. A review of fishes collected from or reported from the Licking River drainage (see Table 13). "x" indicates fish species reported from the Licking River proper (some surveys did not differentiate between main stem and tributaries). "/ " indicates fish species reported from Licking River tributaries (or general checklist). If reported from the Licking River proper, no distinction was made if the species was found in tributaries as well.

	Investigations																
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Ohio lamprey				x	/	/	x				/			x		x	x
Northern brook lamprey											P						x[c]
Silver lamprey						/					P						
Least brook lamprey				x[a]	/	/		/		x[a]	/			x		x	
American brook lamprey											P		x			x	
Shovelnose sturgeon				[b]	[b]						/					EP	
Paddlefish						/					/			x		x	
Longnose gar	x		x	x	x	/		x		x[a]	/			x	x	x	x
Bowfin											/					x	
American eel	x		x	[b]	[b]	/				x	/			x		x	
Skipjack herring								[b]		x	/			x		x	
Gizzard shad				x	x	/	x	x[cd]	/	x[a]	/	x	x	x	x	x	/
Threadfin shad															x	I	
Goldeye											P						
Mooneye				x	[b]	/		/		x	/			x		x	
Rainbow trout								[b]		[a]	I			x		I	
Brown trout														x			
Grass pickerel		/	x	x	/	/		[d]	/	x[a]	/	/		x		x	
Northern pike																I	
Muskellunge				/	/	/	[x]	[b]		x[a]	/		x	x	x	x	
Central stoneroller	x	/	x	x[a]	x	/		x[cd]	[d]	x[a]	/	/	x	x	x	x	x
Goldfish								/			I			x	x	Ex	
Redside dace					/	/					/			/		x	
Grass carp																Ex	
Carp						/	x	x		x[a]	I		x	x	x	Ex	x
Silverjaw minnow		x	x	/[a]	x	/		x	[d]	/	/	/		x		x	x
Speckled chub		x	x	x	x	/					/	x		x		x	x
Bigeye chub		/	x	/[a]	/	/		[b]	/	x	/			/		x	
Streamline chub						/							x			x	
Silver chub					x	/		[b]		x	/		x	x	x	x	
Hornyhead chub							[a]	[a]									
River chub		x	x	[b]	x	/		x		x[a]	/		x	x		x	
Golden shiner														/		x	/
Rosefin shiner[f]					x	/		/		/	/						x[e]
Emerald shiner		x	x	i	x[c]	/		x		x	/		x	x		x	/
River shiner			x		x	/		[b]		/	/						x
Bigeye shiner				/[a]	/	/		/	/	/	/			/		x	
Ghost shiner				[g]	[g]	[g]					/					x	/
Striped shiner		x	x	x	x	/		[cd]	[d]	x[a]	/	/	x	x	x	x	/
Silver shiner				x	x	/		/	[d]	x[a]	/	x	x	x		x	/
Rosyface shiner		/	/	/[ai]	[b]	/		[c]	/	x[a]	/			x		x	x
Spotfin shiner				[i]	x	/		[b]	/	/	/	x	x	x	x	x	/
Sand shiner		/		/	/	/		[b]	/		/	/		x		x	x
Redfin shiner				/	/	/		/	/	x[a]	/	/	x	/		x	x
Mimic shiner				g	x	/		/		x[a]	/	x		x		x	x
Steelcolor shiner		x	x	[i]	x	/		x		x	/	x		x		x	x

Table 14 continued.

Species	Investigations																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Suckermouth minnow				/	x	/		/			/			x		x	
Southern redbelly dace				/	/	/		/	/		/			/		x	
Bluntnose minnow		x	x	x[a]	x	/		x[c,d]	d	x[a]	/	/	x	x	x	x	x
Fathead minnow				x	/	/		[b]		/	/			x	x	x	/
Bullhead minnow					x	/		[b]		x	/			x		x	x
Blacknose dace					/	/		/	/		/			/		x	
Creek chub				/[a]	/	/		x[c,d]	d	x[a]	/	/		x	x	x	x
River carpsucker				x	x	/		/		x	/			x		x	
Quillback				x	[b]	/	x	x		x	/		x	x		x	
Highfin carpsucker					x	/		[b]		x	/		x	x		x	
White sucker				x	x	/	x	[c]	d	x[a]	/	/	x	/		x	/
Blue sucker					x	/	x	x			/			x		x	
Creek chubsucker[h]				[b]	[b]	/											
Northern hog sucker		/	x	x[a]	x	/	x	x[c]	d	x[a]	/	x	x	x	x	x	x
Smallmouth buffalo						/	x	/		x	/		x	x	x	x	x
Bigmouth buffalo				x	x	/		[b]		x	/		x	x	x	x	
Black buffalo											P						
Spotted sucker				x[a]	d	/	x	d		x[a]	/	/	x	x	x	x	/
Silver redhorse				/	/	/	x	[b]		x[a]	/		x	x	x	x	
River redhorse							x	x		x[a]	/		x	x		x	x
Black redhorse		[b]			/	/		x[c]	d		/			x		x	x
Golden redhorse			x	x[a,i]	x	/	x	x[c,d]	d	x[a]	/	/	x	x	x	x	x
Shorthead redhorse					/	/		x[c]		x[a]	/	x	x	x	x	x	x
Blue catfish				x	x	/	x				/					x	
Black bullhead				/	/	/		/		/	/			/		x	/
Yellow bullhead				x	x	/		/		x	/	/		x	x	x	/
Brown bullhead				x	/	/		/			/					I	
Channel catfish		/	x	x	x	/	x	x[c]	/	x[a]	/	x	x	x	x	x	x
Mountain madtom											/			x		x	
Slender madtom								[c]									
Stonecat		/	x	x	x	/		x[c]	/	x[a]	/	x		x		x	x
Carolina madtom								[c]									
Brindled madtom				x	x	/		/	d	x[a]	/	/		x	x	x	
Northern madtom											/	x		x		x	
Flathead catfish					[b]	/	x	/		x[a]	/		x	x	x	x	x
Trout perch				/	/	/					/					x	
Burbot											P,I					I	
Northern studfish																I	/[d]
Blackstripe topminnow				/	/	/					/	/		/		x	
Mosquitofish								/			I			x		I	
Brook stickleback																I	
Brook silverside		/	x	x[a]	x	/		d	/	x[a]	/	/	x	x	x	x	/
White bass											P			x	x	x	
Striped bass														x		I	
Rock bass			x	x	/	/		x[c,d]	d	x[a]	/	x	x	x	x	x	/
Redbreast sunfish														x		I	
Green sunfish	x	/	x	x[a]	/	/		/	d	x[a]	/	/	x	x	x	x	/
Pumpkinseed											I			x		I	
Warmouth					/	/		/		x[a]	/			x	x	I	
Orangespotted sunfish					/	/		/			/						

Table 14 continued.

Species	Investigations																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bluegill	x	/	x	x	x	/	x	x[d]	/	x[a]	/	/	x	x	x	x	/
Longear sunfish	x	/	x	x[a]	/	/	x	x[cd]	d	x[a]	/	/	x	x	x	x	x
Redear sunfish					/	/		/			I			x		I	
Hybrid sunfish								/	/	[a]				x	x		
Smallmouth bass	x	/	x	x[a]	[b]	/	x	/	d	x[a]	/	/		x	x	x	/
Spotted bass				x	[b]	/		x[cd]	d	x[a]	/	/	x	x	x	x	x
Largemouth bass		/	x	x[a]	x	/	x	/		x[a]	/	/	x	x	x	x	/
White crappie				x	/	/	x	/	/	x[a]	/	/	x	x	x	x	x
Black crappie						/	x	/		x[a]	/			x	x	x	
Eastern sand darter				x[i,a]	x	/		[b]		x[a]	/			x		x	x
Greenside darter		[j]	x	x	x	/		[cd]	d	x[a]	/	x		x	x	x	x
Rainbow darter		/	x	/[a]	x	/		x	/	x[a]	/	/		x	x	x	x
Bluebreast darter												x		x		x	
Fantail darter		x	x	/[a]	x	/		x[cd]	d	x[a]	/	x		x	x	x	x
Spotted darter				[k]	[b]						/					EP	
Johnny darter		x	x	x[i]	/	/		x[d]	d	x[a]	/	x		/	x	x	/
Orangethroat darter					x	/		/			/	x		x		x	/
Speckled darter								[b]		x[e]							
Tippecanoe darter					x	/					/			x		x	
Variegate darter		/	x	[b]	x	/		/		x[a]	/	x		x		x	x
Banded darter		x	x	x	x	/		x[cd]	d	x[a]	/	x		x		x	x
Logperch	x		x	/[a]	x	/		x[c]	d	x[a]	/	x	x	x	x	x	x
Channel darter				[l]	x	/		[c]	/	x[a]	/	x		x		x	x
Gilt darter					x	/		/		x	/	x		x		x	x
Longhead darter								[b]		x[l]	P						
Blackside darter		[j]	x	/[a]	/	/		x[cd]	d	x[a]	/	/	x	x		x	/
Sharpnose darter[m]					x	/		[c]		x	/	x	x	x		x	x
Dusky darter											P						
River darter					x	/		[b]		x	/			x		x	x
Sauger								[b]		x	P			x		x	x
Walleye	x		x	[b]	[l]	/					/			x		x	
Freshwater drum				x[i]	x	/	x	x		x[a]	/		x	x	x	x	
Mottled sculpin				/	/	/		/	/	[a]	/			/		x	

P - Probably present, I - Introduced (or probably so), EP - Extirpated, EX - Exotic

[a]Now impounded portions of Licking River tributaries (by Cave Run Lake). Where "a" is shown under 10, represents North Fork Creek; 2 stations now impounded, one is not.

[b]Reported or described species, but not necessarily collected.

[c]Portions of Licking River now impounded by Cave Run Lake.

[d]Upper Licking River, above Cave Run Lake, or upper drainage.

[e]Misidentified.

[f]Not assumed to be in Licking River; these fish are probably redfin shiner.

[g]Two forms generally discussed by early investigators: Notropis volucellus buchanani and N. v. volucellus.

[h]Taken in Licking River at Farmers (Welter, 1938); erroneous (Burr and Warren, 1986).

[i]Licking River at West Liberty, Morgan County.

[j]Collected by Gilbert and Henshall (1888); Woolman (1892).

Table 14 continued.

[K]Collected by Henshall from S. Fork Licking River at Cynthiana (Welter, 1938); only record from Licking River drainage.

[1]Record cannot be substantiated.

[M]Early investigators reported the slenderhead darter; now the Licking River form is known to be the sharpnose darter.

Table 15. Endangered, threatened, and rare fishes known to occur in the Licking River drainage[a].

Species	Status KAS-KNPC	Status Federal
American brook lamprey	T	
Redside dace	S	
Blue sucker	-	C2
Northern madtom	S	
Trout perch[b]	S	
Burbot[c]	S	
Eastern sand darter	S	
Spotted darter[d]	T	
Tippecanoe darter	S	
Gilt darter	S	
Longhead darter[e]	T	C2

[a]Warren et al (1986).
[b]Has not been collected since Welter (1938) and Clark (1941a) despite extensive collecting since then.
[c]No recent collections, record from Clay (1975).
[d]Thought to be extirpated, record from S. Fork Licking River (Burr and Warren, 1986).
[e]Record cannot be substantiated (Burr and Warren, 1986).
T - Threatened.
S - Special concern.
C2 - ...conclusive data on biological vulnerability and threat are not available to support proposed rules...USFWS (1985).

Table 16. Fishes collected in the main stem Licking River from the mouth (Station 1) to Cave Run Lake tailwater (Station 18). Numbers represent actual number of fish collected during a timed subsample period within each pool, x represents species taken from that pool but not during the timed subsample period and S represents fishes taken by seine[1].

Species	Stations																															
	1	2	s[a]	s[b]	3	s[c]	4	s[d]	5	s[e]	s[f]	6	s[g]	7	s[h]	8	s[i]	9	10	11	s[j]	s[k]	12	s[l]	13	s[m]	14	s[n]	15	s[o]	16	17[2]	s[p]	18[2]
Lamprey ammocoetes[3]																									1									
Ohio lamprey[4]																																		
(Ichthyomyzon bdellium)																							1											
Least brook lamprey																															x			
(Lampetra aepyptera)																																		
Paddlefish[4]																																		x
(Polyodon spathula)	x																																	
Longnose gar*	1	3			7		3		1			2		1		x		1	x	4					x		1		x		x	x		x
(Lepisosteus osseus)	1	3	x						1				x						x	x			1		x		1		x		1			
American eel									x									x	x										x					
(Anquilla rostrata)																x																		
Skipjack herring	9															1		1	1															
(Alosa chrysochloris)	x																																	
Gizzard shad*	360	36			56		87		32			170		87		27		30	49	37					25		33		15		23	x		x
(Dorosoma cepidianum)	72	136	x						66					23		41		65	17	45	x		30	x	97		49		x	x	62			
Mooneye					3													x		2														
(Hiodon tergisus)											x			1															x					
Grass pickerel																															x	x		x
(Esox americanus vermiculatus)																									x				x					
Muskellunge																				x											x			x
(E. masquinongy)																				x			x		x		1		x		1			
Muskellunge hybrid "tiger muskie"[5]																																		x
Central stoneroller*				x												1		1	3	1														
(Campostoma anomalum)			x			x		x	1		x		x	3	x	2	x			5				x		x		x		x				
Goldfish[5,6]																																		x
(Carassius auratus)									x																									
Carp*	3	4			16		4		3			4		4		7		5	7	7					15		6		18		20	x		x
(Cyprinus carpio)	2	7							8					10		3		2	2	1			18		15		5		x		14			
Silverjaw minnow (Ericymba buccata)													x								x			x		x								
Speckled chub (Hybopsis aestivalus)											x				x				1		x		x	x				x		x	x		x	

Table 16 continued.

Species	Stations																																	
	1	2	s[a]	s[b]	3	s[c]	4	s[d]	5	s[e]	s[f]	6	s[g]	7	s[h]	8	s[i]	9	10	11	s[j]	s[k]	12	s[l]	13	s[m]	14	s[n]	15	s[o]	16	17[2]	s[p]	18[2]
Silver chub	5				3																													
(H. storeriana)	1																																	
River chub																																		
(Nocomis micropogon)																												x						
Emerald shiner*	3	124			31		18		15	x	x	15		5		15		15	7	5					47		11		19		31			x
(Notropis atherinoides)	2	52	x			x		x	22		x		x			11	x	27	21	17			55	x	18	x	10	x	x		6			
Striped shiner																2		2	1	1												x		
(N. chrysocephalus)			x			x							x		x	6	x		1			x				x				x				
Silver shiner									1																						1	x		
(N. photogenis)													x		x			3						x										
Rosyface shiner																									2							x		x
(N. rubellus)																	x												x	x				
Spotfin shiner*					1				4		x	25		1		11		13	20	18					17	x	29		5		13	x		x
(N. spilopterus)			x			x			4		x			2	x	3			5	7	x	x	28	x	9	x	4		x	x	8			
Sand shiner																																		
(N. stramineus)																												x		x				
Mimic shiner*										x	x	1				3			3	1					3	x	2				2			
(N. volucellus)								x			x		x		x	1	x	1		2	x	x	16	x	1	x	4		x	x				
Steelcolor shiner*				x	10		16		10	x	x	25		10		13		22	76	24					35	x	44		16		10	x		x
(N. whipplei)			x			x		x	5		x		x	3	x	6		2	20	7	x	x	36	x	9	x	16	x	x	x	6			
Suckermouth minnow																																		
(Phenacobius mirabilis)				x																														
Bluntnose minnow*				x	1		6		3	x	x	2		5		13		7	11	6					5		12		x		2			x
(Pimephales notatus)			x			x			1		x		x		x	2	x	3	4	6	x		28		9	x	11			x	x			
Fathead minnow[4]													x																					x
(P. promelas)																																		
Bullhead minnow*					2		17		4		x	18		2		2		2	2	3					1		3				1			
(P. vigilax)		1				x			4				x	2	x								1				3		x					
Creek chub[6]																				x														
(Semotilus atromaculatus)																																x		
River carpsucker*	x				4		7		16			11		4		x		2	2	1							1		2		1	x		x
(Carpiodes carpio)	4	1							7					4		1		1	4				1		1				x		2			
Quillback	1				1		3							5		6		2		2					6		x		1		5	x		x
(C. cyprinus)																2									1		1				2			

Table 16 continued.

Species	Stations																															
	1	2	s[a]	s[b]	3	s[c]	4	s[d]	5	s[e]	s[f]	6	s[g]	7	s[h]	8	s[i]	9	10	11	s[j]	s[k]	12	s[l]	13	s[m]	14	s[n]	15	s[o]	16	17[z]	s[p]	18[z]
Highfin carpsucker[6] (C. velifer)		1					1		1																									
Blue sucker (Cycleptus elongatus)		1	x		17		11		1			3		x		1		1	1														
Northern hog sucker* (Hypentelium nigricans)					7		1	x	2				x	1	x	6		7	15	x					9		5		x		x	x		x
Smallmouth buffalo* (Ictiobus bubalus)	11	1			9		1		x			x		4		23		9	6	19					6		3		16		13	x		x
Bigmouth buffalo (I. cyprinellus)		3							2					7		8		5	x	3			4		7		2		x		18			
Spotted sucker (Minytrema melanops)									2							1		x		x							1		x			x		x
Silver redhorse* (Moxostoma anisurum)									1					1		1															3			
River redhorse* (M. carinaturm)					10		6		12			3		2		3		1	3	1			1		11		6		6		4	x		
Black redhorse (M. duquesnei)		1							4					2		3		2	1	1			1		6		2		x		8			
Golden redhorse* (M. erythrurum)					22		17		3			6		11		13		11	3	5					5		1		3		1	x		
Shorthead redhorse* (M. macrolepidotum)		1							1					4		1		7	1	2			6		4		3							
Yellow bullhead (Ictalurus natalis)																									1		3					x		
Channel catfish* (I. punctatus)																									1		1							
Mountain madtom (N. eleutherus)	x	8			68		14		65			23		33		34		43	71	22					48		16		19		12	x		
Stonecat (Noturus flavus)		3							32					24		12		33	38	5			49		7		14		x		15			
Brindled madtom (N. miurus)		2			17		22		8			12		11		17		15	19	4					3		3		2		3	x		x
Northern madtom (N. stigmosus)									2					1		22		7	3	2			1		1		x		x		1			
	x				12		11		2			3		9		2		5	1	1					5		3		1		x	x		x
	x	x							2		x		x	2	x	4		8	x	1			5		x		4		x					
				x			1																											
				x							x	1													x	x	1							
																	x					x					x		x					
																									1	x	1	x				x		
				x				x																				x						

Table 16 continued.

Species	Stations																																	
	1	2	s[a]	s[b]	3	s[c]	4	s[d]	5	s[n]	s[r]	6	s[g]	7	s[h]	8	s[i]	9	10	11	s[j]	s[k]	12	s[l]	13	s[m]	14	s[n]	15	s[o]	16	17[2]	s[p]	18[2]
Flathead catfish*	2				9		13		5			33		15		2		5	x	2					1		2		1		x			x
(Pylodictis olivaris)	8	2							8					3		2		7	x	1			x		1		1				x			
Mosquitofish[3]																															x			
(Gambusia affinis)																																		
Brook silverside*							1													1					2						1	x		x
(Labidesthes sicculus)			x			x		x					x		x		x		1				2	x				x		2			
White bass*	17						x		1										x						x							x		x
(Morone chrysops)	2	1	x						2					1				1	x	1			x											
Striped bass[6]	4																																	
(M. saxatilis)																																		
White bass x striped bass hybrid	14																																	
Rock bass*					5		4		2			11		6		3		8	x						3		5		4		1	x		x
(Ambloplites rupestris)														x		1		5	x	2			12		7		3				x			
Redbreast sunfish[5]																																		x
(Lepomis auritus)																																		
Green sunfish									1			2				3			1						2		1					x		x
(L. cyanellus)																2			1	3			8						x		1			
Pumpkinseed[4]																																		
(L. gibbosus)						x																												
Warmouth							1																		1				1					x
(L. gulosus)																													x					
Bluegill*	10	21			5		18		3			2		x		1		1	x	1					6		10		5		14	x		x
(L. macrochirus)	10	9				x			4					2		3		1					4		x		1		x		2			
Longear sunfish*	6	29			145		65		68			75		19		28		41	33	59					120		225		88		85	x		x
(L. megalotis)	3	10	x						46				x	12		31		35	44	40			131		61		102		x		22			
Redear sunfish[6]																													1					x
(L. microlophus)																																		
Sunfish hybrid[6]					2		2		4																				2			x		x
Smallmouth bass*	2	7			23		22		10			37		13		12		33	10	4					1				1					x
(Micropterus dolomieui)	2	5						x	12							1		10	2	3			4	x	2		x							
Spotted bass*	5	35			47		19		33			53		13		5		10	9	13					7		16		10		10	x		x
(M. punctulatus)	1	5	x						12				x	3	x	5		1	11	12			22		8		11		x		6			

Table 16 continued.

Species	Stations																																
	1	2	s[a]	s[b]	3	s[c]	4	s[d]	5	s[e]	s[f]	6	s[g]	7	s[h]	8	s[i]	9	10	11	s[j]	s[k]	12	s[l]	13	s[m]	14	s[n]	15	s[o]	16	17[2]	s[p]	18[2]
Largemouth bass*	5	3			1													1							x		2					x		x
(M. salmoides)	8	5	x						1							1		1	1				1											
White crappie*	1				1				1			1				1				x					x		1		x		x	x		x
(Pomoxis annularis)	x																								3		x		x					
Black crappie					2																				1							x		x
(P. nigromaculatus)																									x				x					
Eastern sand darter																									3	x					1			
(Ammocrypta pellucida)																								x		x							x	
Greenside darter*				x	x						x	2		1		2		1	4	1					4	x	4		1			x		x
(Etheostoma blennioides)								x	4		x		x		x	1	x	2						x	2		2	x		x				
Rainbow darter										x		1							1	x														
(E. caeruleum)						x											x	1						x										
Bluebreast darter																										x								
(E. camurum)																							x	x										
Fantail darter									1		x	2		x		2		2	2	1					1		x							
(E. flabellare)									6					x			x			1			6		2		1	x			x		x	
Orangethroat darter[3]																											1							
(E. spectabile)																																		
Tippecanoe darter[6]				x		x																												
(E. tippecanoe)																																		
Variegate darter																1											x							
(E. variatum)								x							x		x										1							
Banded darter*				x	1		x			x	x														x	x			x		x	x		
(E. zonale)						x		x			x		x				x			1	x		1	x		x		x		x	x		x	
Logperch*					6		3		7		x	14		7		4		2	8	6					9		9		7		1	x		x
(Percina caprodes)		3				x			7				x	1		3	x	2	3	2	x		x	x	x		2	x						
Channel darter*							2					1				2			1						14	x	15		2		3	x		
(P. copelandi)								x	3		x		x				x				x		6	x	12	x	12	x		x			x	
Gilt darter[3]																												x		x				
(P. evides)																																		
Blackside darter							1									2			1						2		3		5		2	x		x
(P. maculata)																							2		1		2							
Sharpnose darter*					4		3		4	x	x	14		2		4		4	3	5					5	x	8		4		1			
(P. oxyrhyncha)									1		x		x			1	x	3	4		x		6		3		1							
River darter																									2		1							
(P. schumardi)																												x						

Table 16 continued.

Species	Stations																																	
	1	2	s[a]	s[b]	3	s[c]	4	s[d]	5	s[e]	s[c]	6	s[g]	7	s[h]	8	s[i]	9	10	11	s[j]	s[k]	12	s[l]	13	s[m]	14	s[n]	15	s[o]	16	17[2]	s[p]	18[2]
Sauger*	5								3			1		2		x		1	2	x												x		x
(Stizostedion canadense)	3								1					2		1		x	x	4			x		x		x		x					
Walleye																1											x				1	x		x
(S. vitreum)																			x															
Freshwater drum*	18	36			46		42		36			42		17		16		5	8	11					2		2		1		x	x		x
(Aplodinotus grunniens)	13	36	x						39					11		13		7	10	1			3		3		2		x		1			
Number of species sampled per station[7]	23	22	15	9	34	14	33	12	42	7	17	35	21	35	15	44	16	41	45	42	12	5	39	19	49	18	44	16	45	16	42	44	5	42
Timed subsample period (minutes) 1984	60	105			60		50		45			50		45		55		60	45	60					55		50		60		80			
1985																			30	60			60		30		30		N/A		60			
1986	150	90							60					60		42		60																

[1]Stations 1-11, 13-16, and S (b, e, f, m) sampled during 1984 (first row of figures).
Stations 10-16 and S (j-p) sampled during 1985 (second row of figures).
Stations 1,2,5,7-9 and S (a,c,d,f-i) sampled during 1986 (second row of figures).

[2]Stations 17 and 18 were only sampled during 1983, see Tables 9, 10, and 11.

[3]1985

[4]1986

[5]Probably an escapee from Minor Clark Fish Hatchery.

[6]1984

[7]Does not include hybrids. Those stations that are lumped represent pools electrofished and riffles seined at the head and/or tail-end of that respective pool. For stations 13-14 and 15-16, those pools were sampled as well as the riffle separating the two pools.

*Species generally found throughout the Licking River below Cave Run Lake.

Table 17. Fish species, length distribution, and relative abundance from electrofishing the Licking River (Stations 1-11 and 13-16) during a timed subsample period (all pools combined - 14.71 hours) during 1984.

	Inch group																																	Fish/	% of
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	35	Total	hour	total
Longnose gar					2	1	1	2	2		1	1	1		1			1			1	1	3		3			1		1	1	24	1.6	0.4
Skipjack herring				2	4	3				1					2																	12	0.8	0.2
Gizzard shad		46	207	226	25	4	121	242	131	59	5	1																				1,067	72.6	18.4
Mooneye									4	1																						5	0.3	0.1
Central stoneroller		3	2	1																												6	0.4	0.1
Carp				1					1					2	9	7	10	12	11	11	12	16	10	10	2	2	3	3	1			123	8.4	2.1
Speckled chub		1																														1	0.1	t
Silver chub				6	2																											8	0.5	0.1
Emerald shiner	39	163	137	22																												361	24.6	6.2
Striped shiner		4		2																												6	0.4	0.1
Silver shiner			2																													2	0.1	t
Rosyface shiner			2																													2	0.1	t
Spotfin shiner		78	77	2																												157	10.7	2.7
Mimic shiner	1	14																														15	1.0	0.3
Steelcolor shiner	6	113	147	43	2																											311	21.2	5.4
Bluntnose minnow	6	53	14																													73	5.0	1.3
Bullhead minnow	10	39	8																													57	3.9	1.0
River carpsucker											1	1	6	3	8	7	19	4	1		1											51	3.5	0.9
Quillback			1	6	1	2					2	4	6	6		3	1															32	2.2	0.6
Highfin carpsucker							1								1	1																3	0.2	t
Blue sucker													1	1	2	1	7	1	2	2	6	1	6	1	3	1						35	2.4	0.6
Northern hog sucker		4	7	2	9	8	3	3	4	2	3	2	6	6																		59	4.0	1.0
Smallmouth buffalo								1					2	14	17	16	20	16	12	7	5											110	7.5	1.9
Bigmouth buffalo																	2		1	1												4	0.3	0.1
Spotted sucker					1					1		1																				3	0.2	t
Silver redhorse			1	1	1			3	1	6	15	4	5	10	9	6	2	1	1		1	1										68	4.6	1.2
River redhorse					10	7		1		2		3	1	5	8	5	7	14	10	13	5	4	2	1	1		2					101	6.9	1.7
Black redhorse											1	2	1																			4	0.3	0.1
Golden redhorse			1	13	40	12	3	9	13	14	82	108	73	51	35	12	4	2	1	1	2	2										478	32.5	8.3
Shorthead redhorse		1	2		1	1	2	4	3	7	14	20	30	34	16	1	2															138	9.4	2.4
Channel catfish		2		1		1			1	3	7	10	10	3	6	3	2	3		3												55	3.7	1.0
Stonecat			2																													2	0.1	t
Northern madtom			1																													1	0.1	t
Flathead catfish					2	10	6	9	9	16	13	7	4	6	2	3	1		1													90	6.1	1.6

Table 17 continued.

Species	Inch group																														Total	Fish/ hour	% of total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	35			
Brook silverside		1	4																													5	0.3	0.1
White bass				1	8	6	2								1																	18	1.2	0.3
Striped bass				3		1																										4	0.3	0.1
W.B. x S.B. hybrid				5	6	1						1			1																	14	1.0	0.2
Rock bass		2	6	24	8	6	2	3	1																							52	3.5	0.9
Green sunfish			2	3	3	2																										10	0.7	0.2
Warmouth				1	2																											3	0.2	t
Bluegill	7	11	9	17	21	23	8	1																								97	6.6	1.7
Longear sunfish	58	314	328	268	93	25																										1,086	73.9	18.8
Redear sunfish					1																											1	0.1	t
Sunfish hybrid			5	1	2	2																										10	0.7	0.2
Smallmouth bass		24	42	16	22	37	15	5	1	2	3	3	3	1			1															175	11.9	3.0
Spotted bass	4	30	104	25	33	24	21	19	12	6	2	4		1																		285	19.4	4.9
Largemouth bass					1			2		2	2	5																				12	0.8	0.2
White crappie			1			1		1	1	2																						6	0.4	0.1
Black crappie						1		2																								3	0.2	t
Eastern sand darter		4																														4	0.3	0.1
Greenside darter		13	7																													20	1.4	3.5
Rainbow darter		1	1																													2	0.1	t
Fantail darter		8	3																													11	0.7	0.2
Variegate darter				1																												1	0.1	t
Banded darter		1																														1	0.1	t
Logperch		7	31	26	12	7																										83	5.6	1.4
Channel darter	4	36																														40	2.7	0.7
Blackside darter		1	15																													16	1.1	0.3
Sharpnose darter		11	42	8																												61	4.1	1.1
River darter		1	2																													3	0.2	t
Sauger					1	2	1		2	1		1	1	3	1		1															14	1.0	0.2
Walleye											1								1													2	0.1	t
Freshwater drum		3	12	4	2	13	41	44	23	19	35	18	16	13	9	12	8	5	2	1	2											282	19.2	4.9

t < 0.05

Table 18. Fish species, length distribution, and relative abundance from electrofishing the Licking River (Stations 10-16, CPUE not det. for Station 15, during 1985 - 4.5 hours; and Stations 1,2,5, 7-9 during 1986 - 7.7 hours) during a timed subsample period, all pools combined (total hours = 12.2).

	Inch group																														
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total	Fish/hour	Total
Lamprey ammocoetes						1																								1	0.1	t
Ohio lamprey									1																					1	0.1	t
Longnose gar				2		1												1					1	2					1	8	0.7	0.3
Gizzard shad		29	68	1	5	137	254	106	70	26	5	1	1																	703	57.6	24.0
Mooneye			1																											1	0.1	t
Muskellunge																2														2	0.2	0.1
Central stoneroller		9		2																										11	0.9	0.4
Carp														1	1	3	7	7	11	8	10	11	14	7	1	3	1	2		87	7.1	3.0
Silver chub			1																											1	0.1	t
Emerald shiner	5	66	140	30																										241	19.8	8.2
Striped shiner		6	1																											7	0.6	0.2
Silver shiner		3																												3	0.2	0.1
Spotfin shiner		16	45	9																										70	5.7	2.4
Mimic shiner		25																												25	2.0	0.9
Steelcolor shiner		29	46	31	4																									110	9.0	3.8
Bluntnose minnow		41	23																											64	5.2	2.2
Bullhead minnow		10	1																											11	0.9	0.4
River carpsucker										1			1	4	10	1	5	3	1											26	2.1	0.9
Quillback									1				2	2	1															6	0.5	0.2
Blue sucker																							2		1					3	0.2	0.1
Northern hog sucker		2		2	3		2			1	4	2	2	1	1															20	1.6	0.7
Smallmouth buffalo											2	7	5	4	7	9	10	7	6	2	8		1	2						70	5.7	2.4
Bigmouth buffalo																	2			1										3	0.2	0.1
Spotted sucker				1	1					1	2	1																		6	0.5	0.2
Silver redhorse								1	1	1	2	3	5	6	3	5	2	1												30	2.5	1.0
River redhorse							1		1	1	1	1	2		3	4		4	3	5	2	1		1						30	2.5	1.0
Black redhorse											1	1																		2	0.2	0.1
Golden redhorse				5	3	2	21	25	14	14	15	26	46	42	12	4	1			1		1								232	19.0	7.9
Shorthead redhorse						1		1	1	2		5	13	14	3															40	3.3	1.4
Channel catfish										4	3	5	3	3	3	3	1	1												26	2.1	0.9
Brindled madtom		1	1																											2	0.2	0.1
Flathead catfish		1				1		2	2	3	8	6	4	3	1		1	1												33	2.7	1.1
Brook silverside			5																											5	0.4	0.2
White bass			1	1			1		1		2		2																	8	0.7	0.3

Table 18 continued.

Species	Inch group																												Total	Fish/hour	Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29			
Rock bass		2	2	11	5	4	5	1																						30	2.5	1.0
Green sunfish		3	8	1	2	1																								15	1.2	0.5
Bluegill	1	1		3	6	22	3																							36	3.0	1.2
Longear sunfish	2	51	186	139	123	36																								537	44.0	18.4
Smallmouth bass	1	1	7	2	4	2	5	4	7	6	1		1																	41	3.4	1.4
Spotted bass	1	6	28	9	6	11	14	9	7	5			1																	97	8.0	3.3
Largemouth bass		2	7		1		1	1			2	1	1	1		1														18	1.5	0.6
White crappie					1		1	1																						3	0.2	0.1
Greenside darter		6	5																											11	0.9	0.4
Rainbow darter	1																													1	0.1	t
Fantail darter		16																												16	1.3	0.5
Orangethroat darter		1																												1	0.1	t
Banded darter		2																												2	0.2	0.1
Logperch		4	9	8	2																									23	1.9	0.8
Channel darter		33																												33	2.7	1.1
Blackside darter			4	1																										5	0.4	0.2
Sharpnose darter		2	16	1																										19	1.6	0.6
Sauger				1					1	4	3	2																		11	0.9	0.4
Freshwater drum		2	3	2		6	17	21	18	15	17	9	7	3	7	1	1	7	1	2										139	11.4	4.7

t < 0.05

Table 19. Black bass composition from the Licking River below Cave Run Lake (% = black bass only).

Species	1984[a] %	1985-1986[b] %	% black bass all years combined[c]
Smallmouth bass	34.6	27.0	32.8
Spotted bass	62.0	63.2	62.3
Largemouth bass	3.4	9.8	4.9

% Black bass > 12.0 in, for that species (all years combined[c])	
Smallmouth bass	4.4
Spotted bass	2.8
Largemouth bass	29.4

% Black bass Cave Run tailwater[d]	Sta 17	Sta 18
Smallmouth bass	0	1.5
Spotted bass	78.3	42.0
Largemouth bass	21.7	56.5

% Black bass > 12.0 in, for that species, (Cave Run tailwater)	Sta 17	Sta 18
Smallmouth bass	0	0
Spotted bass	11.1	10.3
Largemouth bass	40.0	24.4

[a]Stations 1-11, 13-16.
[b]Stations 10-14 and 16 (1985); 1, 2, 5-9 (1986).
[c]Does not include stations 17 and 18.
[d]All sample seasons combined (Apr, Jul, Nov 1983).

Table 20. Selected physical characteristics from each pool sampled during 1983 - 1986 in the Licking River below Cave Run Lake.

Station.	No. of muskellunge[a]	Stream Mile	Pool length (mile)	Average width (ft)	Acreage	Average depth (ft)	Maximum depth (ft)	Percent Shade
1	(0)	0b-3.2	3.2	240.0	93.1	14.8	38.0	0-5
2	(0)	10.0-12.3	2.3	184.0	51.3	11.3	27.0	5-25
3	(0)	33.2-35.6	2.4	184.4	53.6	2.4	7.0	5-25
4	(0)	40.5-42.3	1.8	177.1	38.6	2.6	8.0	0-5
5	(0)	52.5-55.0	3.0	166.6	60.6	2.9	7.0	5-25
6	(0)	65.1-66.6	1.5	156.0	28.4	2.5	6.0	5-25
7	(0)	79.9-81.3 81.7-83.3	3.0	122.0	44.4	2.5	8.0	5-25
8	(0)	84.1-86.0	1.9	136.2	31.4	4.3	11.0	5-25
9	(0)	86.0-87.5	1.5	128.2	23.3	4.0	10.0	5-25
10	(0)	88.7-90.4	1.7	119.9	24.7	3.1	8.0	5-25
11	(2)	108.4-111.2	2.8	113.7	38.6	5.4	21.0	25-50
12	(1)	129.8-132.3	2.5	105.8	32.1	3.4	12.0	25-50
13	(4)	145.5-147.5	2.0	104.2	25.3	2.5	13.0	25-50
14	(4)	147.5-149.2	1.7	102.3	21.1	2.1	12.0	25-50
15	(2)	155.0-158.4	3.4	82.4	34.0	3.0	11.0	25-50
16	(5)	158.6-161.1	2.5	92.2	27.9	3.1	11.0	25-50
17	(0)	169.5-170.0	0.5	106.6	6.5	3.6	11.0	50-75
18	(2)	172.9-173.4	0.5	98.8	6.0	3.7	9.0	25-50
Total			38.02		640.9			
Mean			2.1	134.5	35.6	3.2c	10.3c	

[a]Number collected and observed all years combined.
[b]0 is river mouth.
[c]Does not include Stations 1 and 2.

Table 21. Stream miles, gradient, corresponding sampling stations, and number of muskellunge (captured and observed, all years combined) for the Licking River below Cave Run Lake.

Stream mile	Miles	Elevation msl (ft)	Drop (ft)	Gradient[a] (ft/mi)	Sample stations with this range	Number of muskellunge
			Lower section (mi 0-60)			
0[b] - 18.0	18.0	455 - 460	5	0.3	1, 2	0
18.0 - 35.0	17.0	460 - 480	20	1.2	-	-
35.0 - 43.0	8.0	480 - 500	20	2.5	3	0
43.0 - 53.5	10.5	500 - 520	20	1.9	4	0
53.5 - 72.0	18.5	520 - 540	20	1.1	5, 6	0
			Middle section (mi 60-120)			
72.0 - 83.8	11.8	540 - 560	20	1.7	7-11	2[c]
83.8 - 105.5	22.0	560 - 580	20	0.9	12	1
105.5 - 125.5	20.0	580 - 600	20	1.0	-	-
			Upper section (mi 120-173.4)			
125.5 - 145.0	19.5	600 - 620	20	1.0	13, 14	8
145.0 - 166.0	21.0	620 - 640	20	1.0	15, 16	7
166.0 - 173.4[d]	7.4	640 - 655	15	2.0	17, 18	2

[a]Average gradient from mile 0 (elevation 455 ft msl) to mile 173.4 (elevation 655 ft msl), a drop of 200 ft, is 1.2 ft/mi.

[b]Mile 0 represents river mouth.

[c]Both muskellunge from Station 11.

[d]Cave Run Lake dam.

Table 22. Water quality station locations in the Licking River. Benthos was taken at Stations 2 - 4.

Station	Location
1	Boat ramp located on Licking River at mouth of Threemile Creek, Wilder, Campbell County, Kentucky; river mi 3.0.
2	Just above the confluence with South Fork Licking River, Falmouth, Pendleton County, Kentucky; river mi 52.0.
3	Just above the confluence with Painter Creek, Nicholas County, Kentucky; river mi 88.7.
4	At Johnson Ford, 2.0 air mi SW Stringtown, Fleming County, Kentucky; river mi 147.5.

Table 23. Water quality criteria for warmwater fish habitat.

Parameter	Preferred	Harmful
Temperature (°F/°C, summer)	>68/20 and <89/31.7	>95/35
Dissolved oxygen (mg/l)	≥5	<3
Total alkalinity (mg/l)	≥100	
Turbidity (NTU)	≤200	≥20,000
pH	6.5 - 8.2	<4.7 and >9.0
Salinity (mg/l)	≤400 (0.4 ppt)	≥2,000 (2ppt)
Conductivity (umohs/cm)	≤1,000	≥4,000

Additional warmwater aquatic habitat criteria[a]. Parameters to be referred to Tables 26, 27, and 28.

Arsenic[b]	50 ug/l	
Beryllium	11 ug/l	soft water[c]
	1100 ug/l	hard water[c]
Cadmium	4.0 ug/l	soft water
	12.0 ug/l	hard water
Chlordane	0.0043 ug/l	
Chloride	600 mg/l	
Chlorine (total residual)	10 ug/l	
Chromium	100 ug/l	
Cyanide (free)	5 ug/l	
Hydrogen sulfide (undissociated)	2 ug/l	
Iron[d]	1.0 mg/l	
Mercury	0.2 ug/l	
Phthalate esters	3 ug/l	
Polychlorinated biphenyls	0.0014 ug/l	
Zinc	47 ug/l	

[a]From 401 KAR 5:031, January 1986 (Kentucky Division of Water 1987).
[b]Metals are total recoverable metals to be measured in an unfiltered sample.
[c]Soft water has an equivalent concentration of $CaCO_3$ of 0-75 mg/l.
Hard water has an equivalent concentration of $CACO_3$ ≥75 mg/l.
[d]The daily average total recoverable concentration shall not exceed 3.5 mg/l when it is established that there will be no damage to aquatic life.

Table 24. Water quality determinations from Cave Run Lake tailwater during 1983. Stations 1 was near the Cave Run Lake dam and Station 2 was 4.1 mi below the dam.

	1	2
Temperature (°F/°C)		
12 Apr	48/8.9	47/8.3
07 Jul	75/23.9	73.5/23.0
03 Nov	60/15.6	61/16.1
Dissolved oxygen (mg/l)		
12 Apr	12.1	7.8
07 Jul	8.4	7.8
03 Nov	9.5	8.8
Total alkalinity (mg/l)		
12 Apr	20.0	30.0
07 Jul	85.5	68.4
03 Nov	85.5	68.4
Turbidity (NTU)		
12 Apr	5.1	5.2
07 Jul	2.5	16.0
03 Nov	4.5	3.0
pH		
12 Apr	8.2	8.6
07 Jul	7.7	6.7
03 Nov	8.3	7.9
Salinity (ppt)		
12 Apr	0	0
07 Jul	0	0
03 Nov	0	0
Conductivity (umohs)		
12 Apr	135	135
07 Jul	148	148
03 Nov	120	130

Tailwater discharge: 12 Apr - 348 cfs, 07 Jul - 52 cfs, 03 Nov - 175 cfs.

Table 25. Water quality determinations from the Licking River below Cave Run Lake.

	1984[a] Stations				1985[b] Stations			
	1	2	3	4	1	2	3	4
Temperature (°F/C)								
Apr	-	-	-	-	65/18.5	62/16.5	61/16.0	62/16.5
Jul	79/26.1	75/23.9	75/23.9	74/23.3	79/26.0	80/26.5	77/25.0	78/25.5
Oct	67/19.4	65/18.3	65/18.3	66/18.9	66/19.0	67/19.5	68/19.8	69/20.5
Dissolved oxygen (mg/l)								
Apr	-	-	-	-	11.8	11.6	10.8	11.4
Jul	5.1	6.9	7.2	7.4	5.6	6.9	6.1	7.4
Oct	8.1	8.4	7.5	7.9	7.9	6.0	6.3	6.6
Total alkalinity (mg/l)								
Apr	-	-	-	-	153.9	119.7	85.5	51.3
Jul	171.0	136.8	102.6	51.3	111.2	85.5	102.6	76.9
Oct	102.6	85.5	68.4	68.4	136.8	76.8	68.4	68.4
Turbidity (NTU)								
Apr	-	-	-	-	>200	14.0	15.0	6.3
Jul	74.0	36.0	39.0	12.0	172.0	>200	128.0	55.0
Oct	19.0	8.4	7.3	6.1	28.0	25.0	23.5	9.0
pH								
Apr	-	-	-	-	6.8	7.0	6.9	6.8
Jul	6.8	6.9	6.7	6.3	5.9	6.3	6.1	6.0
Oct	7.2	6.9	6.8	6.5	6.3	6.0	6.3	6.6
Salinity (ppt)								
Apr	-	-	-	-	0	0	0	0
Jul	0	0	0	0	0.25	0	0	0
Oct	0	0	0	0	0	0	0	0
Conductivity (umohs/cm)								
Apr	-	-	-	-	315	235	180	140
Jul	320	260	230	120	260	218	198	229
Oct	190	150	138	125	295	232	220	217

[a] 1984 - 27 Jul, 17 Oct

[b] 1985 - 16 Apr, 15 Jul, 15 Oct

Table 26. Selected water quality determinations from the Licking River at Covington[a] (River mile 4.5) during 1984-1986[b].

		(n)[c]	Water temp. (°C)	Conductivity at 25C (umhos/cm)	Dissolved oxygen (mg/l)	pH (su)	Total alkalinity ($CaCO_3$ mg/l)	Residue TOT NFLT (mg/l)	NH3+NH4-N TOT (mg/l)	TOT KJEL N (mg/l)	NO2 & NO3 N-Total (mg/l)	PHOS-TOT (mg/l P)	Cyanide CN-TOT (mg/l)	TOT HARD $CaCO_3$ (mg/l)
1984	PCTL (50)		12.0	347.0	9.2	7.6	ND	42.0	0.12	0.74	0.85	0.14	0.001	140.0
	Maximum		25.0	450.0	12.2	8.1		425.0	0.23	2.00	2.50	0.78	0.002	280.0
	Minimum		0.1	211.0	5.0	7.2		10.0	0.04	0.26	0.01	0.04	0.001	112.0
	Mean	(12)	13.3	340.0	8.7	7.5		84.9	0.13	0.76 (11)	1.02 (11)	0.20	0.001	159.7
1985	PCTL (50)		12.2	345.0	8.3	7.5	ND	38.0	0.09	0.44	0.66	0.13	0.001	120.0
	Maximum		25.0	600.0	14.6	8.2		174.0	0.15	0.70	1.84	0.14	0.004	170.0
	Minimum		0.5	260.0	5.5	7.2		10.0	0.05	0.19	0.23	0.07	0.001	54.0
	Mean	(12)	14.7	367.8	9.0	7.6		51.4 (10)	0.09	0.44	0.86	0.12	0.001	120.8
1986	PCTL (50)		14.0	320.0	8.3	7.5	ND	24.0	0.08	0.52	0.44	0.17	0.001	124.0
	Maximum		26.0	550.0	13.5	8.1		532.0	0.24	1.60	1.50	0.91	0.011	198.0
	Minimum		3.8	225.0	4.4	6.4		8.0	0.05	0.10	0.20	0.03	0.001	68.0
	Mean	(12)	16.0	362.5 (11)	8.8	7.5		85.7 (10)	0.09 (11)	0.56 (11)	0.66 (10)	0.27 (10)	0.002 (17)	132.2 (11)

		(n)[c]	Chloride Total (mg/l)	Sulfate SO^{-4}-TOT (mg/l)	Arsenic As TOT (ug/l)	Barium Ba,TOT (ug/l)	Cadmium Cd, TOT (ug/l)	Chromium Cr, TOT (ug/l)	Copper Cu, TOT (ug/l)	Iron Fe, TOT (ug/l)
1984	PCTL (50)		ND	35.0	1.0	50.0	1.0	10.0	5.0	1,600.0
	Maximum			63.0	5.0	100.0	1.0	16.0	1,340.0	16,000.0
	Minimum			16.0	1.0	44.0	1.0	10.0	2.0	480.0
	Mean	(12)		37.4 (11)	2.3 (4)	63.5 (4)	1.0	11.5 (4)	117.9	3,230.8
1985	PCTL (50)		15.0	26.0	1.5	60.0	1.0	10.0	3.0	1,720.0
	Maximum		22.0	42.0	2.0	80.0	2.0	10.0	22.0	5,500.0
	Minimum		15.0	12.0	1.0	30.0	1.0	10.0	2.0	1,160.0
	Mean	(12)	18.5 (2)	27.0 (10)	1.6 (4)	62.5 (4)	1.1	10.0 (4)	4.8	2,187.5
1986	PCTL (50)		20.0	29.0	1.3	40.0	1.0	10.0	6.0	1,400.0
	Maximum		49.0	103.0	1.6	40.0	1.0	10.0	280.0	22,000.0
	Minimum		6.0	15.0	0.5	40.0	1.0	10.0	2.0	120.0
	Mean		21.4 (7)	45.8 (10)	1.1 (3)	40.0 (3)	1.0 (18)	10.0 (5)	35.5 (12)	3,369.1 (12)

Table 26 (continued)

[a]Determined by Ohio River Valley Water Sanitation Commission.
[b]Information provided by Lewis G. Miller, Kentucky Division of Water.
[c](n) equals number of samples; if otherwise, indicated by () beside parameter.

Table 27. Selected water quality determinations from the Licking River at Butler[a] during 1984 - 1986[b].

Year		Water Temp (°C)	Turbidity (FTU)	Conductivity at 25c (umhos/cm)	Dissolved oxygen (mg/l)	pH (su)	T alkalinity CaCo3 (mg/l)	NH3 + NH4 - N total (mg/l)	TOT KJEL N (mg/l)	Phosphorous Total (mg/l P)	Total Hardness CaCo3 (mg/l)	Chloride Total (mg/l)	Sulfate SO4-TOT (mg/l)
1984	PCTL (50)	8.0	9.0	205.0	10.0	7.4	66.0	ND	0.8	0.06	ND	9.0	29.0
	Number	4	4	4	4	4	1		4	4		4	4
	Maximum	24.5	35.0	360.0	13.4	8.0	66.0		1.7	0.13		17.0	35.0
	Minimum	4.5	1.0	155.0	7.2	7.4	66.0		0.6	0.04		9.0	25.0
	Mean	13.0	16.0	245.0	10.5	7.6	66.0		1.03	0.08		11.5	30.0
1985	PCTL (50)	12.0	25.0	280.0	6.4	8.0	114.0	0.39	0.7	0.16	170.0	12.0	33.0
	Number	4	4	4	4	4	4	1	4	4	1	4	4
	Maximum	23.5	45.0	410.0	12.7	8.0	172.0	0.39	1.7	0.30	170.0	23.0	38.0
	Minimum	2.5	2.7	240.0	4.7	7.6	106.0	0.39	0.7	0.03	170.0	11.0	28.0
	Mean	14.8	28.4	313.8	8.1	7.9	127.0	0.39	1.0	0.17	170.0	14.5	33.0
1986	PCTL (50)	5.0	5.6	270.0	8.0	6.9	60.0	0.01		0.04	130.0	23.0	35.0
	Number	2	2	2	2	2	1	2		2	1	2	2
	Maximum	12.5	12.0	330.0	13.0	8.6	60.0	0.04		0.05	130.0	23.0	44.0
	Minimum	5.0	5.6	270.0	8.0	6.9	60.0	0.01		0.04	130.0	23.0	35.0
	Mean	8.8	8.8	300.0	10.5	7.8	60.0	0.025		0.045	130.0	23.0	39.5

[a]Determined by United States Geological Service.

[b] Information provided by Lewis G. Miller, Kentucky Division of Water.

Table 28. Selected water quality determinations from the Licking River at Sherburne during 1984-1986".

Year		Water temp. (°C)	Conductivity (umhos/cm)	Dissolved oxygen (mg/l)	pH (SU)	Turbidity (NTU)	Total alkalinity CaCO3 (mg/l)	Chloride total (mg/l)	Sulfates SO_4-Diss (mg/l)	Residue TOT NFLT (mg/l)	Aluminum Al, total (ug/l)	Arsenic AS, total (ug/l)	Barium BA,total (ug/l)	Cadmium Cd,Total (ug/l)	Chromium Cr,total (ug/l)
1984	PCTL (50)	18.4	165.0	8.1	7.7	19.0	44.0	9.6	24.8	16.0	179.0	1.0	34.0	1.0	3.0
	Number	9	9	9	9	8	9	9	9	9	9	9	9	8	9
	Maximum	27.0	263.0	12.0	8.0	63.0	68.6	18.6	33.8	32.0	421.0	3.0	59.0	1.0	6.0
	Minimum	5.6	140.0	6.3	6.5	2.2	25.1	6.9	20.0	9.0	50.0	1.0	21.0	1.0	1.0
	Mean	17.0	182.7	8.8	7.4	24.6	41.6	10.2	25.9	17.4	198.4	1.2	35.1	1.0	2.8
1985	PCTL (50)	15.0	229.0	8.5	7.4	25.0	49.4	10.6	28.7	19.0	257.0	1.0	37.0	1.0	2.0
	Number	12	12	12	12	12	11	12	12	11	11	10	10	11	11
	Maximum	26.0	277.0	13.8	9.6	388.0	86.3	32.7	32.1	284.0	4,780.0	1.0	91.0	1.0	6.0
	Minimum	2.4	169.0	6.2	6.5	13.0	34.5	5.7	19.2	12.0	122.0	1.0	8.0	1.0	1.0
	Mean	14.4	226.3	9.6	7.5	64.1	53.2	15.6	27.5	54.45	724.5	1.0	39.5	1.0	2.3
1986	PCTL (50)	12.1	206.0	8.5	7.1	42.0	50.2	9.4	25.7	23.0	340.0	2.0	33.0	1.0	4.0
	Number	12	12	12	12	11	11	10	10	11	12	12	12	12	12
	Maximum	26.9	270.0	14.2	7.8	396.0	79.3	27.3	34.5	644.0	4,910.0	5.0	80.0	1.0	9.0
	Minimum	0.7	147.0	5.9	6.9	8.0	29.4	2.2	12.9	1.0	34.0	1.0	1.0	1.0	1.0
	Mean	14.7	211.1	9.6	7.3	83.5	47.5	14.6	26.0	85.9	909.4	2.1	33.9	1.0	4.2

Year		Copper Cu, Total (ug/l)	Iron Fe, Total (ug/l)	Lead Pb, Total (ug/l)	Manganese Mn (ug/l)	Mercury Hg, Total (ug/l)	Zinc Zn, Total (ug/l)	Total Hardness CaCo3 (mg/l)	NH3+NH4- N Total (mg/l)	NO2&NO3 N-Total (mg/l)	Total KJEL N (mg/l)	Phosphorus Total (mg/l P)	Fecal Coliform MFM-FCBR /100 ml
1984	PCTL (50)	2.0	300.0	2.0	90.0	0.1	6.0	72.8	0.05	0.47	0.33	0.03	60.0
	Number	9	8	9	8	9	8	9	9	9	9	9	9
	Maximum	5.0	800.0	3.0	120.0	0.3	14.0	108.0	0.07	1.65	0.48	0.10	280.0
	Minimum	1.0	200.0	1.0	50.0	0.1	1.0	51.0	0.05	0.12	0.20	0.02	20.0
	Mean	2.2	380.0	1.9	87.5	0.1	7.0	75.1	0.05	0.65	0.34	0.03	97.6
1985	PCTL (50)	1.0	590.0	3.0	110.0	0.1	17.0	83.0	0.05	0.42	0.22	0.03	52.0
	Number	10	10	11	10	12	10	12	12	12	12	12	12
	Maximum	4.0	7,090.0	15.0	410.0	16.6	35.0	214.0	0.07	0.94	1.45	0.77	4,000.0
	Minimum	1.0	310.0	1.0	80.0	0.1	3.0	67.5	0.05	0.12	0.08	0.02	8.0
	Mean	2.0	1,409.0	4.4	114.0	2.4	17.4	100.0	0.05	0.55	0.35	0.10	523.2

Table 28 (continued).

Year		Copper Cu, Total (ug/l)	Iron Fe, Total (ug/l)	Lead Pb, Total (ug/l)	Manganese Mn (ug/l)	Mercury Hg, Total (ug/l)	Zinc Zn, Total (ug/l)	Total Hardness CaCo3 (mg/l)	NH3+NH4- N Total (mg/l)	NO2&NO3 N-Total (mg/l)	Total KJEL N (mg/l)	Phosphorus Total (mg/l P)	Fecal Coliform MFM-FCBR /100 ml
1986	PCTL (50)	3.0	680.0	3.0	120.0	0.1	20.0	83.6	0.05	0.51	0.32	0.04	130.0
	Number	12	12	12	12	12	12	12	12	12	12	12	12
	Maximum	15.0	2,910.0	10.0	580.0	0.2	81.0	110.0	0.13	1.35	1.46	0.19	5,000.0
	Minimum	1.0	330.0	1.0	70.0	0.1	12.0	43.7	0.05	0.20	0.14	0.02	2.0
	Mean	4.9	975.0	3.8	167.5	0.2	35.0	83.0	0.06	0.62	0.45	0.06	693.8

*Determined by Kentucky Division of Water, information supplied by Lewis G. Miller, KDOW.

Table 29. Synoptic list of the macroinvertebrates collected seasonally from the Licking River below Cave Run Lake during 1985.

		Falmouth			Painter Creek			Johnson Ford		
		Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Haplotaxida	Limnodrilus/Tubifes gp.	9	2	-	5	-	-	13	1	-
Hirudinea	Helobdella stagnalis	-	1	3	-	-	-	-	-	-
	H. sp.	1	-	-	-	-	-	-	-	-
Mesogastropoda	Elimia sp.	24	175	15	2	7	-	12	1	1
	Pleurocera canaliculatum	-	10	-	-	6	-	-	5	5
Limnophila	Ferrissia rivularis	1	-	-	-	-	-	1	-	6
Heterodonta	Corbicula fluminea	28	19	3	8	26	-	185	94	30
	Sphaerium simile	-	-	-	1	51	9	-	-	-
	Pisidium sp.	-	1	-	-	6	-	-	-	-
Amphipoda	Hyalella azteca	16	-	-	-	-	-	-	-	-
Isopoda	Asellus sp.	-	-	1	-	-	-	-	-	-
	Lirceus fontinalis	26	2	-	-	-	-	-	1	-
Decapoda	Orconectes rusticus	1	2	-	-	7	1	-	-	-
Ephemeroptera	Baetisca obesa	1	-	-	-	-	-	-	-	-
	Baetis sp.	3	24	15	16	3	6	18	1	19
	Pseudocloeon sp.	-	-	-	9	-	-	4	-	-
	Caenis sp.	69	1	8	-	-	-	-	-	-
	Hexagenia sp.	-	-	-	1	-	-	-	-	-
	Heptagenia maculipennis	-	5	6	-	4	-	-	-	-
	Stenacron interpunctatum	58	5	8	1	63	66	-	-	-
	Stenonema femoratum	5	-	-	-	-	-	-	-	-
	S. mediopunctatum	-	-	-	-	-	-	14	6	22
	S. modestum	-	12	1	-	-	-	-	-	-
	S. terminatum	150	291	222	30	104	162	49	9	20
	Rhithrogenia sp.	-	-	-	1	-	-	-	-	-
	Paraleptophlebia sp.	28	3	18	2	1	-	-	-	-
	Isonychia sp.	37	109	88	9	21	26	62	16	8
	Ephoron leukon	-	3	-	-	4	-	-	-	-
	Tricorythodes sp.	-	-	17	-	-	3	-	-	29
Plecoptera	Acroneuria abnormis	1	-	-	-	-	-	-	-	-
	A. evoluta	-	-	-	-	-	2	-	-	-
	A. internata	-	14	7	-	10	6	-	-	-
	Beloneuria sp.	-	-	-	1	-	-	-	-	-
	Neoperla clymene	-	1	-	-	-	-	-	-	-
	Perlista placida	12	-	-	19	-	-	4	-	-

Table 29 continued.

		Falmouth			Painter Creek			Johnson Ford		
		Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
	Phasganophora capitata	1	-	7	1	-	-	-	-	-
	Isoperla sp.	10	-	-	26	-	-	26	-	-
	Strophopteryx fasciata	-	-	-	2	-	-	3	-	-
Odonata	Argia sp.	-	-	-	-	-	6	-	-	-
	Enallagma sp.	3	-	-	-	-	-	-	-	-
	Dromogomphus sp.	-	-	-	-	-	-	1	-	1
	Stylogomphus albistylus	-	-	-	-	-	-	-	-	1
Coleoptera	Helichus lithophilus	-	-	-	-	-	-	1	-	-
	Macronychus glabratus	-	-	-	-	2	-	-	-	-
	Stenelmis crenata	2	6	-	-	-	-	1	3	-
	S. sexlineata	4	24	11	5	-	-	-	-	-
	S. sp. (Larvae)	36	109	13	-	2	-	4	-	1
	Ectopria nervosa	-	-	-	-	-	-	-	-	1
	Psephenus herricki	-	-	1	-	-	-	-	-	1
Megaloptera	Corydalus cornutus	-	15	8	-	1	5	4	-	2
	Sialis sp.	-	-	-	-	2	1	-	-	-
Trichoptera	Glossasoma sp.	1	113	-	-	-	-	-	-	-
	Ceratopsyche sparna	-	1	1	3	1	2	1	1	3
	Cheumatopsyche sp.	29	526	170	33	34	2	8	28	75
	Hydroptila sp.	-	-	1	-	-	-	-	-	-
	Ochrotrichia sp.	1	-	1	2	-	-	-	-	-
	Nectopsyche sp.	1	-	-	-	-	-	-	-	-
	Oecetis sp.	-	-	-	-	-	-	-	-	1
	Hydophylax sp.	-	-	-	-	-	-	-	1	-
	Chimarra sp.	1	-	-	5	-	-	2	-	-
	Cyrnellus sp.	-	-	-	-	-	-	1	-	-
	Rhyacophila ledra	4	-	-	9	-	-	-	-	-
Lepicloptera	Petrophila sp.	2	4	3	-	-	-	-	-	-
Diptera	Bezzia/Johannsenomyia/ Palpomyia sp.	3	-	-	-	-	-	-	-	-
	Hemerodromia sp.	2	6	2	2	-	3	8	-	2
	Simulium sp. 1	1	-	-	5	-	1	15	-	-
	S. sp. 2	5	7	1	40	-	-	37	-	-
	Hexatoma sp.	2	-	-	-	-	-	-	-	-
	Tipula sp.	-	-	1	-	-	-	-	-	-
	Trichocera sp.	-	-	-	-	-	-	1	-	-
	Ablabesmyia parajanta	-	1	-	2	-	-	-	-	-
	Cardiocladius obscurus	-	7	7	-	-	-	5	-	-

Table 29 continued.

	Falmouth			Painter Creek			Johnson Ford		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Coelotanypus concinnus	-	-	-	-	-	1	-	-	-
Conchapelopia flavifrons	3	-	-	-	-	-	-	-	-
C. sp.	-	-	-	-	-	1	-	-	-
Cricotopus annulator	-	-	-	2	-	-	6	-	-
C. bicinctus	2	-	3	-	-	-	1	-	-
C. curtus	-	-	-	-	-	-	1	-	-
C. tremulus gp.	2	-	-	8	-	-	11	-	-
C. triannulatus	-	-	-	2	-	-	13	-	-
C. sp.	-	-	-	-	-	-	1	-	-
Cricotopus/Orthocladius sp.A	2	-	-	-	-	-	-	-	-
Cricotopus/Orthocladius sp.B	2	-	-	-	-	-	-	-	-
Cryptochironamus fulvus	1	-	2	-	-	-	1	-	-
Dicrotendipes modestus	-	-	-	1	-	-	-	-	-
D. neomodestus	-	-	-	1	-	-	-	-	-
Eukiefferiella brevicalcar gp.	1	-	6	3	-	-	2	-	-
E. devonica gp.	-	4	-	-	-	-	-	-	-
E. pseudomontana gp.	-	-	-	3	-	-	2	-	-
Glyptotendipes paripes	3	-	-	-	-	-	-	-	-
G. sp.	-	-	-	-	-	-	1	-	-
Microtendipes caelum	2	-	1	-	2	-	-	-	-
Nanocladius rectinervis	-	2	-	-	-	-	-	-	-
N. spinniplenus	-	-	-	2	-	1	-	-	-
Natarsia baltimoreus	11	-	-	-	-	-	-	-	-
N. sp. A	1	-	-	-	-	-	-	-	-
Orthocladius carlatus	1	-	-	-	-	-	-	-	-
O. obumbratus	1	-	2	10	-	-	7	-	-
O. sp.	-	-	-	5	-	-	-	-	-
Pentaneura sp.	1	-	-	-	-	-	-	-	-
Phaenopsectra dyari	1	-	-	-	-	-	-	-	-
P. jucundus	2	-	-	-	-	-	-	-	1
Polypedilum aviceps	-	-	-	-	-	-	-	-	1
P. convictum	16	2	47	36	1	-	4	-	-
P. illinoense	1	-	-	-	1	-	1	-	-
P. sp.	-	-	-	-	-	-	-	-	1
P. sublettei	2	-	-	-	-	-	-	-	-
Pseudochironomus fulviventris	-	-	-	-	-	-	1	-	-

Table 29 continued.

	Falmouth			Painter Creek			Johnson Ford		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Rheotanytarsus exiquus gp.	-	4	-	5	17	-	-	-	-
R. distinctissimus	-	-	-	-	-	-	-	-	15
R. sp.	-	-	-	-	-	5	-	-	-
Tanytarsus glabrascens	-	-	-	1	-	-	-	-	-
T. querlus gp.	3	-	1	5	-	-	3	-	-
T. sp.	1	-	-	-	-	-	-	-	-
Thienemannimyia norena	-	-	-	-	-	-	-	-	1
T. sp.	3	-	1	-	-	-	-	-	1

Table 30. Numerical data collected seasonally from the Licking River below Cave Run Lake at three locations in 1985.

	Falmouth			Painter Creek			Johnson Ford		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Total Number of Taxa	61	34	37	40	23	20	41	12	25
*Number of Individual Per Square Meter	323	754	356	335	185	155	268	83	124
*Species Diversity Index	3.9755	3.0340	2.7580	4.5120	3.1415	2.2625	3.6605	1.8110	3.2100
*Equitability	0.5945	0.4375	0.3980	0.8430	0.7205	0.4525	0.6110	0.5860	0.7600
Ephemeroptera/Plecoptera/Trichoptera	19	14	15	18	10	9	12	5	9

*Average values.

Table 31. Unionid mussels known to occur in the Licking River drainage[a].

Species[b]	Common name[b]	Status[c]	
		KAS-KNPC	Federal
*Actinonaias ligamentina**	Mucket		
*Alasmidonta marginata**	Elktoe	T	
A. viridis	Slippershell mussel		
*Amblema p. plicata**	Three-ridge		
*Anodonta grandis**	Giant floater		
A. imbecillis[a]	Paper pondshell		
Anodontoides ferussacianus	Cylindrical papershell		
*Cyclonaias tuberculata**	Purple wartyback		
Cyprogenia stegaria	Fanshell	T	C2
*Ellipsaria lineolata**	Butterfly		
Elliptio crassidens	Elephant-ear		
*E. dilatata**	Spike		
Epioblasma torulosa rangiana[a]*	Northern rifflesheIl	E	
E.t. torulosa	Tubercled blossum	E	E
*E. triquetra**	Snuffbox	S	
Fusconaia ebena[a]	Ebonyshell		
*F. flava**	Wabash pigtoe		
*F. subrotunda**	Long-solid	T	
*Lampsilis cardium**	Plain pocketbook		
*L. fasciola**	Wavy-rayed lampmussel		
*L. siliquoidea**	Fatmucket		
*L. teres**	Yellow sandshell		
*Lasmigona c. complanata**	White heelsplitter		
*L. costata**	Fluted-shell		
*Leptodea fragilis**	Fragile papershell		
Ligumia recta	Black sandshell		
*Megalonaias nervosa**	Washboard		
*Obliquaria reflexa**	Threehorn wartyback		
*Obovaria subrotunda**	Round hickorynut		
*Plethobasus cyphyus**	Sheepnose	S	
Pleurobema clava	Clubshell	E	C2
*P. coccineum**	Round pigtoe		
P. cordatum[d]	Ohio pigtoe		
P. plenum	Rough pigtoe	E	E
P. pyramidatum	Pyramid pigtoe	E	C2
*Potamilus alatus**	Pink heelsplitter		
P. ohiensis	Pink papershell		
*Ptychobranchus fasciolaris**	Kidneyshell		
Quadrula c. cylindrica	Rabbitsfoot	E	C2
Q. fragosa[a]	Winged mapleleaf	E	C2
*Q. metanevra**	Monkeyface		
Q. nodulata	Wartyback		
*Q. p. pustulosa**	Pimpleback		
*Q. quadrula**	Mapleleaf		
Simpsonaias ambigua	Salamander mussel	T	C2
*Strophitus undulatus**	Squawfoot		
Toxolasma parvus	Lilliput		
*Tritogonia verrucosa**	Pistolgrip		

Table 31 continued.

Species[b]	Common name[b]	Status[c] KAS-KNPC	Federal
Truncilla donaciformis	Fawnsfoot		
*T. truncata**	Deertoe		
Villosa fabalis	Rayed bean	E	C2
V. iris	Rainbow		
*V. lienosa**	Little spectaclecase	S	

[a]Primarily from Schuster (1987).
[b]Species and common names from Turgeon et al. 1988.
[c]Warren et al (1986). E - Endangered, T - Threatened, S - Special Concern, C2 - Status review (USFWS 1985).
[d]Additional species from Licking River recognized by Kentucky Nature Preserves Commission.
[e]Problematical.

*List of mussels from a riffle near Moores Ferry (Bath and Rowan counties) provided by Ronald R. Cicerello, Kentucky Nature Preserves Commission.

APPENDIX A

Appendix A-1. List of common and scientific names of fishes used in this report, not listed in Table 16.

Family/*scientific name*	Common name
PETROMYZONTIDAE	
Ichthyomyzon fossor	Northern brook lamprey
I. unicuspis	Silver lamprey
L. appendix	American brook lamprey
ACIPENSERIDAE	
Scaphirhynchus platorynchus	Shovelnose sturgeon
AMIIDAE	
Amia calva	Bowfin
CLUPEIDAE	
Dorosoma cepedianum	Threadfin shad
HIODONTIDAE	
Hiodon alosoides	Goldeye
SALMONIDAE	
Oncorhynchus mykiss	Rainbow trout
Salmo trutta	Brown trout
ESOCIDAE	
Esox lucius	Northern pike
CYPRINIDAE	
Clinostomus elongatus	Redside dace
Ctenopharynyodon idella	Grass carp
Hybopsis amblops	Bigeye chub
H. dissimilis	Streamline chub
Nocomis biguttatus	Hornyhead chub
Notemigonus crysoleucas	Golden shiner
Notropis ardens	Rosefin shiner
N. ariomus	Popeye shiner
N. blennius	River shiner
N. boops	Bigeye shiner
N. buchanani	Ghost shiner
N. umbratilis	Redfin shiner
Phoxinus erythrogaster	Southern redbelly dace
Rhinichthys atratulus	Blacknose dace
CATOSTOMIDAE	
Catostomus commersoni	White sucker
Erimyzon oblongus	Creek chubsucker
Ictiobus niger	Black buffalo
ICTALURIDAE	
Ictalurus furcatus	Blue catfish

APPENDIX A-1 (continued).

Family/*scientific name*	Common name
I. melas	Black bullhead
I. nebulosus	Brown bullhead
Noturus exilis	Slender madtom
N. furiosus	Carolina madtom
PERCOPSIDAE	
Percopsis omiscomaycus	Trout - perch
GADIDAE	
Lota lota	Burbot
FUNDULIDAE	
Fundulus catenatus	Northern studfish
F. notatus	Blackstripe topminnow
GASTEROSTEIDAE	
Culea inconstans	Brook stickleback
CENTRARCHIDAE	
Lepomis humilis	Orangespotted sunfish
PERCIDAE	
Etheostoma kennicotti	Stripetail darter
E. maculatum	Spotted darter
E. nigrum	Johnny darter
E. stigmaeum	Speckled darter
Percina macrocephala	Longhead darter
P. phoxocephala	Slenderhead darter
P. sciera	Dusky darter
COTTIDAE	
Cottus bairdi	Mottled sculpin