Fisheries Bulletin of the Kentucky Department of Fish and Wildlife Resources

Muskellunge Streams Investigation at Kinniconick and Tygarts Creeks

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Bulletin No. 68 **June 1983**

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Abstract

Biological, chemical, and physical characteristics were determined at two native muskellunge (*Esox masquinongy*) streams, Kinniconick Creek and Tygarts Creek, in 1980-81. This study was carried out as part of Dingell-Johnson Project Number F-50 to determine the management potential of developing the muskellunge fisheries in muskellunge streams and evaluate the impact of stocking fingerling muskellunge in 1973, 1976, and 1979. The fish population structure was determined by sampling with a boat-type electrofishing unit. Water quality conditions were recorded and benthic macroinvertebrates were sampled seasonally. Thirty-five muskellunge were captured at Kinniconick Creek and 59 muskellunge were taken from Tygarts Creek during the two-year study. The mean catch rates for muskellunge at Kinniconick Creek were 0.5 fish per hour and 2.9 fish per mile. Muskellunge grew to a total length of 11.4 inches at age I, 17.6 inches at age II, 22.2 inches at age III, 26.3 inches at age IV, 30.1 inches at age V, and 33.1 inches at age VI in Kinniconick Creek. The total lengths for muskellunge from Tygarts Creek were 11.3, 17.9, 22.7, 27.0, 30.8, and 35.8 inches at ages I-VI, respectively. The mean annual exploitation rate on tagged muskellunge was 15% at Kinniconick Creek and 21% at Tygarts Creek. There were more muskellunge captured from year classes belonging to 2 of the 3 years of stocking at each stream than from unstocked years at both streams, except for the 1975 year class at Kinniconick Creek and the 1980 year class at Tygarts Creek. In order to maintain a more consistent recruitment from each year class of muskellunge in these two streams, an annual supplemental stocking of one 7-9 inch muskellunge per 2 acres of muskellunge pool habitat is recommended. Future muskellunge habitat in the form of fallen trees should be ensured by the protection of trees within the riparian zone near the shoreline of each stream.

Introduction

Kentucky is fortunate in having a large number of streams containing native muskellunge populations. Much debate has arisen regarding the form of muskellunge present in the Ohio River Drainage that includes the muskellunge streams in Kentucky. Esox ohioensis was designated for the barred form in this river system at one time; later, Esox masquinongy ohioensis was given as the scientific name of this form. The tendency in recent years has been to consider all forms part of a single species Esox masquinongy (Crossman 1978). However, Trautman (1981) still uses Esox masquinongy ohioensis for the form found in Ohio outside of the Great Lakes region. Branson et al. (1981a) used Esox masquinongy ohioensis as the form given conservation status in Kentucky. However, Clay (1975) and Burr (1980) refer to the form of muskellunge found within Kentucky as Esox masquinongy. No one has conducted a definitive study on the subspecies of muskellunge in recent years. Esox masquinongy will be the name used for the Ohio River system form in this report.

State fisheries agencies that have or had stream populations of the Ohio River form of muskellunge and conducted studies on this fish are Ohio (Clark 1964), Pennsylvania (Buss 1960), Tennessee (Parsons 1959, Riddle 1975, Garavelli 1977), and West Virginia (Miles 1978). The taxonomy and distribution of North American esocids was discussed by Crossman (1978). A literature review of large esocids was prepared by Hess and Heartwell (1980). Most other papers have dealt with the northern forms of the muskellunge.

Prior to 1967, little fish management work on muskellunge had been accomplished within Kentucky. In 1967, D-J Project F-31-R (Musky Studies) was initiated and carried out by Brewer (1980). Important life history information on Kentucky's native muskellunge populations was determined from this study. Another study on muskellunge (Axon 1978, 1981) was conducted at Cave Run Lake, an impoundment on the Licking River that is a native muskellunge stream (portions of Bath, Menifee, Morgan, and Rowan counties). Several prime muskellunge streams were influenced by the new reservoir - Beaver Creek, Blackwater Creek, North Fork, and a large portion of the Licking River.

Brewer recommended to supplementally stock large muskellunge fingerlings annually into pool habitat areas of selected native muskellunge streams. The goal of such stockings was to bring the number of young-of-year muskellunge to a level that would have naturally occurred without detrimental effects of certain environmental conditions (i.e., high discharge rates and low temperatures) that were found to occur during the spawning periods in most years. Stream stockings began in 1973 in response to Brewer's recommendations and were completed in 1979. Stockings at Kinniconick and Tygarts creeks are shown in Table 1. Another recommendation was that supplemental stockings should be evaluated to determine whether such stockings have resulted in stronger year classes and if future stockings are justified.

Table 1. Muskellunge stockings in Kinniconick and Tygarts creeks from 1973 - 1979.

	Kinniconick Creek		Tygarts Creek	
	Number	Length (in)	Number	Length (in)
1973	212	7 - 9	400	8
1976	390	5.5 - 6.5	833	4.5 - 5.5
1979	203	7.5	414	8.2

A muskellunge streams study was initiated in 1980 as part of D-J Project Number F-50 to determine (1) the fish population structure in muskellunge streams, (2) age and growth of muskellunge, (3) the exploitation rate and harvest of muskellunge, (4) the contribution of muskellunge stockings to the population, (5) the population of benthic macroinvertebrates, (6) water quality conditions, and (7) the management potential for developing the muskellunge fisheries in native muskellunge streams. The results of this study at Kinniconick Creek (Lewis County) and Tygarts Creek (Carter and Greenup counties) are discussed in this report.

Study Area

Figure 1 shows the Kinniconick and Tygarts creek drainages and their location in Kentucky. Kinniconick Creek rises in south central Lewis County and joins the Ohio River near Garrison, Kentucky. This stream is 50 mi long, drains roughly 200 mi^2, and has an average gradient of 12.2 ft/mi. The headwater elevation is about 1,100 ft msl; the elevation where it enters the Ohio River is about 490 ft msl. The mean gradient is 5.6 ft/mi within the portion of muskellunge range. Indian and Laurel creeks are the main tributaries. Better than 60% of Kinniconick Creek is bordered by wooded hillsides (800 - 1,000 ft msl); the remaining portion of the creek is bordered by crop fields (corn or tobacco) and pasture (hay or cattle). Most of these cleared areas are bordered by wooded hillsides. The upper reaches above Kinniconick, Kentucky are surrounded by mostly open land; the central and lower reaches are in a steep and narrow valley. The stream is well shaded and usually clears rapidly after becoming turbid. Brewer determined that there were 38 mi of muskellunge range within the stream; of this, 19 mi were determined to be muskellunge pool habitat. Kinniconick Creek lies within the Interior Low Plateau Province, Blue Gass Section, Knobstone Escarpment and Knobs, and Northeastern Blue Grass subsections. This region is made up of Devonian and Mississippian deposits. Upper Devonian is composed of extensive oil shale deposits that may pose a problem to the stream in the future as oil shale begins to be extracted as an alternate energy source.

Kinniconick Creek and Tygarts Creek Drainages

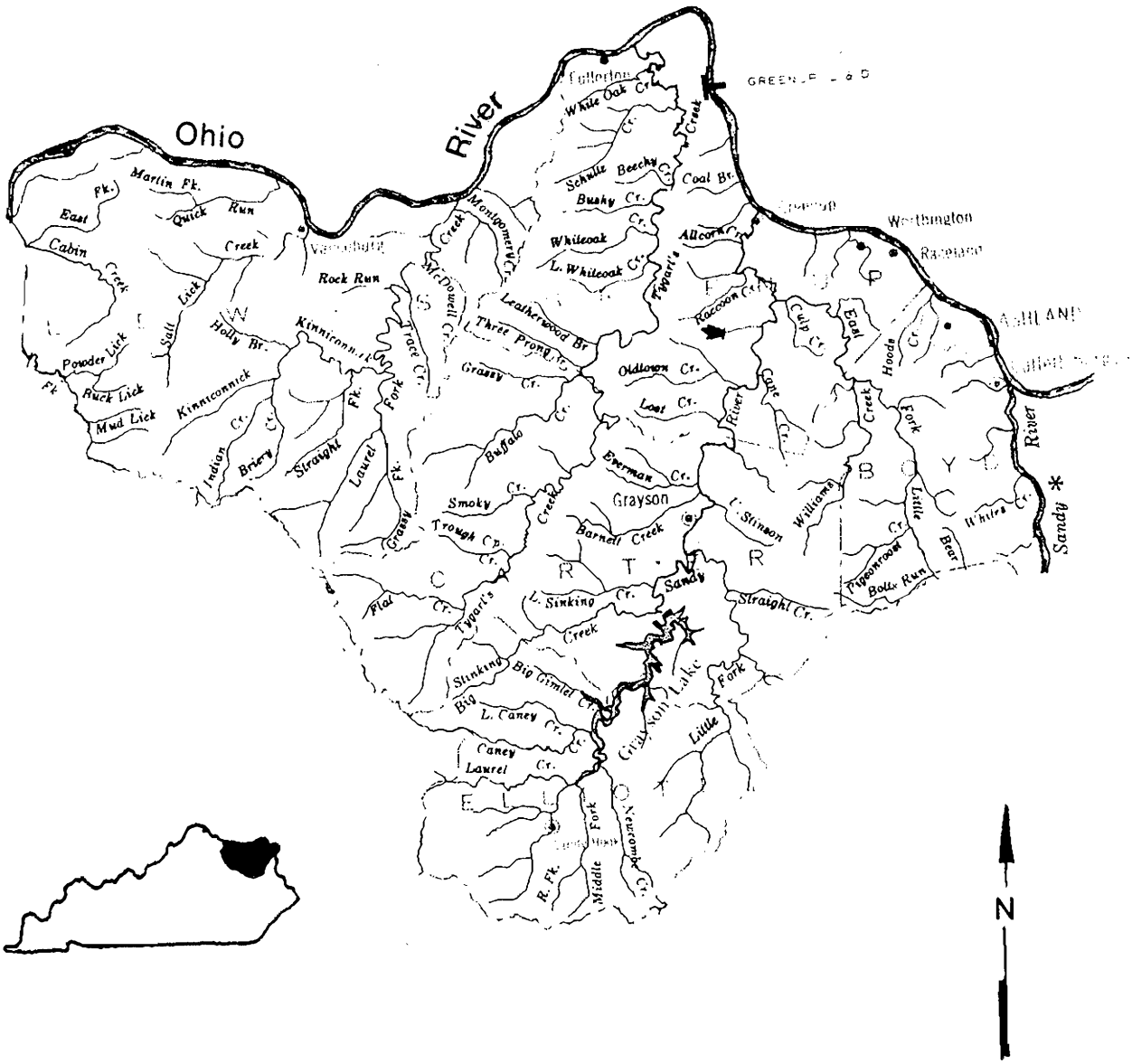

Figure 1. Stream map of Kinniconick and Tygarts Creek Drainages.

Tygarts Creek rises in southwestern Carter County and flows in a northeast direction through Greenup County where it joins the Ohio River near South Shore, Kentucky. Tygarts Creek is 85.5 mi long to its junction with Flat Fork and Upper Tygarts Branch. This stream has a mean gradient of 3.9 ft/mi and has a drainage area of ca 339 mi^2. The main tributary is Buffalo Creek that enters Tygarts Creek from the west at Kehoe, Kentucky. General muskellunge range was determined by Brewer to be 75 mi, of which 43 mi is muskellunge pool habitat. A portion of Tygarts Creek in Carter County flows through a narrow valley that forms a gorge. Some interesting caves are found in this vicinity and are protected within the boundaries of Carter Caves State Park. Above and below this gorge area, the valleys are wider and the slopes are less abrupt than at Kinniconick Creek. The banks are well lined with trees. Tygarts Creek has a slight color much of the year. The riparian habitat along Tygarts Creek is bordered by more fields than at Kinniconick Creek. The ratio of fields to wooded areas is almost reversed in comparison. Tygarts Creek lies within the Applachian Plateau Province, closely following the dividing line between this province and the Interior Low Plateau Province, and is in the Unglaciated Allegheny Plateau. The surrounding topography is made up of Pennsylvanian and Mississippian deposits.

METHODS

Study site locations (Table 2) were determined according access and location of pools that had adequate depth and area for muskellunge to inhabit. These sites included those sampled by Brewer. The fish populations in both streams were sampled for 2 consecutive years 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 60HZ per second, with adjustable output voltage from 0-720 volts in 120 volt steps. The aforementioned gear was mounted on a 16-ft aluminum Polar Kraft boat. The output while electrofishing was usually 5-9 amps at 360-480 volts at Kinniconick Creek and 6-8 amps at 240-480 volts at Tygarts Creek.

Table 2. Locations of fish population sample sites that were electrofished during 1980 and 1981 on Kinniconick and Tygarts creeks.

Kinniconick Creek (Lewis County)	
Station 1	From mouth (Ohio River mi 368) to just above 1st riffle area (mouth of Greenbrier Hollow); stream mi 0.0 - 2.3. 28 May 80, 4 June 80, 27 May 81, 29 June 81; vicinity of Garrison, Ky., Garrison Quad.

Station 2 From just below Tannery School to just above mouth of Trace Creek (vicinity of Tannery, Ky.), locally referred to as Tannery Hole; stream mi 10.0 - 10.8; 29 May 80; Garrison Quad.

Station 3 A section between Mill Branch and Leatherbelly Branch. Stream mi 11.8 - 12.8, locally referred to as Cooks Hole; 22 May 80, 28 May 80, 14 May 81; Garrison Quad.

Station 4 From mouth of McKinney Branch, upstream 1.2 mi; locally referred to as Goodwin Eddy; stream mi 16.1 - 17.3; 8 May 80, 23 May 80, 13 May 81; Garrison and Vanceburg Quad.

Station 5 From mouth of Puncheon Camp Creek to just downstream from Pipe Lick Creek; locally referred to as Puncheon Eddy; stream mi 17.8 - 19.4; 7 May 80, 8 May 81; Garrison, Head of Grassy, Vanceburg, and Wesleyville Quad.

Station 6 From mouth of Pipe Lick Creek, upstream 1.8 mi; locally referred to as Pipe Lick Eddy; stream mi 19.5 - 21.3; 6 May 80, 7 May 81; head of Grassy Quad.

Station 7 From mouth of Dogwood Branch off of St. Rt. 59/24, vicinity of Camp Dix, Ky., upstream 0.4 mi., locally referred to as Bakers Hole; stream mi 26.9 - 27.3; 9 May 80, 8 April 81; Head of Grassy Quad.

Station 8 From mouth of Pine Branch, upstream 1.4 mi, off of St. Rt. 59/24; locally referred to as Pine Eddy; stream mi 28.5 - 29.9; 2 May 80, 5 May 81; Head of Grassy Quad.

Station 9 From just above Grassy Branch upstream 0.55 mi off of St. Rt. 24, vicinity of Kinniconick, Ky.; locally referred to as Harrison Hole; stream mi 34.35 - 35.0; 9 May 80, 8 April 81; Vanceburg Quad.

Station 10 From mouth of Cassidy Hollow off of St. Rt. 24 upstream 1.2 mi: locally referred to as Beaver Hole; stream mi 36.9 - 38.1; 1 May 80, 7 April 81; Head of Grassy and Vanceburg Quad.

Tygarts Creek (Carter and Greenup counties)

Station 1 From mouth of Ohio River mi 353 to a point 2.5 mi upstream in vicinity of South Shore to Upper Kings Addition, Ky.; stream mi 0.0 - 2.5; 18 September 81; Greenup County; Portsmouth Quad.

Station 2 From mouth of Lower White Oak Creek in vicinity of Sunshine, Ky. off of St. Rt. 7 near Horseshoe Lake to just downstream from Bear Branch; stream mi 6.5 - 9.4; 23 July 81; Greenup County; Portsmouth Quad.

Station 3	From mouth of Lick Run in vicinity of Load, Ky. off of St. Rt. 7 at Tennessee gas upstream 0.8 mi; stream mi 28.5 - 29.3; 31 July 80; Greenup County; Load Quad.
Stations 4 5	Two pools located between Lost Creek and St. Rt. 2 bridge off of St. Rt. 7; stream mi 35.0 - 35.5 and 35.5 - 35.9; 8 August 80; Load Quad.
Station 6	From mouth of Slash Hollow, upstream 0.9 mi; locally referred to as Johnson Hole; stream mi 41.0 - 41.9; 6 August 80, 27 July 81; Tygarts Valley Quad.
Station 7	From mouth of Old She Hollow, upstream 0.5 mi off of St. Rt. 7/2; locally referred to as Old She Hole; stream mi 42.7 - 43.2; 30 July 80, 22 July 81; Greenup County; Tygarts Valley Quad.
Stations 8 9	Two pools within this section from mouth of Leatherwood Branch off of St. Rt. 7/2, Tygarts Valley, Ky.; stream mi 44.0 - 44.8 and 44.8 - 45.8; 26 June 80, 28 July 80, 20 July 81, 21 July 81; Greenup County; Tygarts Valley Quad.
Station 10	A small pool 0.2 mi in length; located 0.7 mi downstream from Ross Branch; stream mi 50.0 - 50.2; 25 June 80; Carter County; Tygarts Valley Quad.
Stations 11 12	Two pools above (0.9 mi) and below (0.3 mi) a site locally referred to as Huffmans Ford, east of Iron Hill, Ky. on St. Rt. 7 (0.8 mi), north on secondary road (1.3 mi) to Huffmans Ford. Stream mi 52.5 - 52.8 and 52.8 - 53.7; 23 June 80, 25 June 80, 17 July 81; Carter County; Tygarts Valley Quad.
Stations 13 14	Two pools from mouth of Clark Branch upstream to near Deevert, Ky. south of Iron Hill, Ky. and St. Rt. 7; stream mi 56.7 - 57.8 and 57.8 - 58.3; 20 June 80, 2 July 81; Carter County; Tygarts Valley Quad.
Stations 15 16	Two pools from mouth of Cave Branch just below St. Rt. 182 bridge over Tygarts Creek to an area in the vicinity of Devils Backbone within the boundaries of Carter Caves St. Pk.; stream mi 65.3 - 65.6 and 65.6 - 65.7; 19 June 80, 21 May 81; Carter County; Grahn Quad.
Station 17	Area south and east of Olive Hill, Ky. 0.7 mi. from city limits just below the mouth of Bens Run; stream mi 76.8 - 77.2; 11 June 80; Carter County; Olive Hill Quad.

Fish population sampling on Kinniconick Creek was conducted from 1 May - 4 June 1980 along 12.25 mi of stream that included 10 pool areas. Fish were again

sampled from 7 April - 29 June 1981 at nine pools that totaled 11.45 stream mi. Tygarts Creek was electrofished from 11 June - 8 August 1980 in 15 pools that totaled 8.8 stream mi. During 1981, the fish population was sampled from 21 May - 18 September; a total of 12 pools and 11.8 mi of stream were electrofished.

Both shorelines of each pool-sampling area were usually electrofished twice, once during initial tagging efforts and again during re-capture efforts. The exception was on pools that were narrow and one round of electrofishing effort was considered sufficient. Captured muskellunge and black bass were measured to the nearest 0.1 in and weighed to the nearest 0.01 lb. Scale samples were taken from each fish. Legal size muskellunge ($\geq$30 in) were 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. Sub-legal muskellunge and all black bass were marked by clipping one of their pelvic fins. Self-addressed scale envelopes were made available to fishermen at country stores and tackle shops within the area. Envelopes were also provided by local conservation officers and through the Kentucky Silver Musky Club. Fishermen were asked to fill out the questionnaire on the envelopes 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 returned, and a clutch-back pin was given for any subsequent returns.

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. This correction factor was obtained by extrapolation of the regression line represented by plotting the scale measurement against body length. The body-scale relationship determined by Brewer 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 has a correction factor of 4.5 in. This factor was somewhat high compared to Miles' (1978) determination of West Virginia muskellunge from a nomograph adjusted to a length of 2.5 in at the time of scale formation. It was also high when compared to Erickson's (1967) proposed correction factor of 2.6 in for Ohio River muskellunge. Brewer's (1980) 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 length-weight relationships were ascertained by employing the equation Log W = log a + n log L (Lagler 1956) where W is weight, a and n are constants, and L is the total length.

The total fish population was sampled during part of the first round of electrofishing. Captured fish 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. Seining was conducted in 1981 on riffles at water quality stations; these collections often included species not collected by electrofishing. Fish were identified using fish keys by Clay (1975) and Pfleiger (1975). Scientific and common names were assigned according to Robins et al. (1980). Some of the uncommon species have been deposited at one of the following localities. Eastern Kentucky University, Richmond; Nature Preserves Commission, Frankfort; and Minor Clark Fish Hatchery, Morehead.

Pool dimensions were measured by using topographic maps and a cartometer for length, a 100-ft plastic tape for width, and a Tom Mann, Bird Map, Hummingbird Super Sixty depth sounder for depth. 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 elevations from topographic maps.

Water quality parameters and benthic macroinvertebrates were taken seasonally during the spring, summer, and fall from lower, middle, and upper sections within Kinniconick and Tygarts creeks during 1981. Water quality and bottom fauna sampling were conducted at the following stations on Kinniconick Creek: lower - near Bevins Chapel, middle - a riffle between fish sampling stations 5 and 6, and upper - at fish sampling station 10. Stations on Tygarts Creek were located as follows: lower - at fish sampling station 2, middle - at fish sampling station 8, and upper - at fish sampling station 16. Water quality determinations consisted of temperature, dissolved oxygen, total alkalinity, turbidity, and pH. Temperature and dissolved oxygen were determined with a YSI Model 54 oxygen meter. Temperature was taken during each electrofishing trip with a standard mercury thermometer. Total alkalinity was measured using brom cresol green - methyl red as an indicator and titrating with 0.02N sulfuric acid. Turbidity (Formazin Turbidity Units) was determined using a Hach Turbidity Meter Scale and 4445 color filter. Hydrogen ion concentration was measured using either a Leeds and Nothrop or Analytical Measurements pH meter.

Benthic macroinvertebrates were collected by employing the "kick" method of dislodging benthic organisms from the substrate of a square meter area above a D-framed (34 mesh per inch) aquatic net. Two square meter samples were taken at each of three stations on each stream as mentioned above in the spring, summer, and fall and preserved in 80% ethanol for later sorting and identification in the laboratory. Specimens were identified to family by using keys from Brigham et al. (1982), Edmunds et al. (1976), Edmonson (1959(, Lehmkuhl (1979), Merritt and Cummins (1978), Pennak (1978), Usinger (1963), and others (e.g., EPA keys).

Benthic macroinvertebrates were collected as a means of determining levels of degradation (or lack of) rather than obtaining macroinvertebrate species composition. The Shannon-Weaver (1949) function, using the machine formula presented

by Lloyd, Bar, and Karr (1968), was utilized in calculating mean diversity ($\bar{d}$) where $\bar{d} = \frac{C}{N}(N \log_{10} N - \Sigma n_i \log_{10} n_i)$, C is a constant (3.321928), N = total number of individuals, and n_i = total number of individuals in the i^{th} species. Studies have shown that $\bar{d}$ lacks the sensitivity to demonstrate slight or moderate levels of degradation; thus Lloyd and Ghelardi (1964) devised a formula for determining equitability ($e = \frac{s}{s'}$) by comparing the number of species (s) in the sample with the number of species (s') based on $\bar{d}$.

Wilhm (1970) found that in unpolluted water, $\bar{d}$ was generally between 3 and 4 and, in polluted water, $\bar{d}$ was generally less than 1 (1 to 3 = moderately polluted). Equitability (e) generally ranged between 0.6 and 0.8 in most southeastern streams. Equitability generally ranges from 0 for polluted conditions and 1 for clean water, except for the case where there are relatively few species with several taxa (Weber 1973). Slight degradation generally results in e being 0 to 0.3.

Results and Discussions

Muskellunge Population Characteristics

Kinniconick Creek

Ten pools and 12.25 mi of stream were electrofished in Kinniconick Creek during 1980, and nine pools that totaled 11.45 mi of stream were electrofished in 1981. During 1980, 19 muskellunge were captured at a rate of 0.5 fish/hour and 1.6 fish/mi (Tables 3, 4). Of these fish, 0.65 legal-size muskellunge (≥30 in) and 0.90 sub-legal muskellunge were captured per mile. In 1981, 16 muskellunge were captured at a rate of 0.5 fish/hour and 1.4 fish/mi. A total of 0.44 legal size and 0.96 sub-legal muskellunge were captured per mile. The mean catch rate from both years of sampling was 0.5 muskellunge/hour and 1.5 muskellunge/mi. The numbers of fish captured in relation to sampling effort did not indicate any concentration in any section of Kinniconick Creek. Muskellunge are well distributed from mi. 0.0 to 38.1.

An attempt was made to estimate the population of muskellunge from each stream by using the Peterson formula, with modifications by Riker (1975), and expanding the numbers on a per mile basis. However, based on the number of recaptures of marked fish following completion of the studies, population estimates could not be made (Table 5). According to Robson and Regier (1964), population estimates were found to be highly inaccurate when fewer than four recaptures were made. There were only enough recaptures from Tygarts Creek in 1981 to estimate the population.

Not all muskellunge sighted were captured. This was due to several factors such as size of muskellunge, how well the fish were stunned, how able netters were at capturing sighted fish, how close the stunned fish were to the boat, and instream cover. Table 6 shows the number of muskellunge captured, additional fish sighted, and percent success of capture from Kinniconick Creek. There was

Table 3. Sampling effort and muskellunge captured at Kinniconick Creek in 1980 - 1981.

Section	Station(s)		Hours electrofished		Length of sampled areas (mi)		Number of muskellunge captured		Mean Width (ft)	Acres[a]
	1980	1981	1980	1981	1980	1981	1980	1981		
Lower (mi 0 - 15)	1 - 3	1, 3	11.1	7.4	4.1	3.3	2 (1 legal) (1 sub-legal)	4 (1 legal) (3 sub-legal)	70.1	10.2
Middle (mi 15 - 30)	4 - 8	4 - 8	19.1	18.7	6.4	6.4	13 (5 legal) (8 sub-legal)	8 (3 legal) (5 sub-legal)	93.5	73.7
Upper (mi 30 - 38.1)	9 - 10	9 - 10	7.5	4.3	1.75	1.75	4 (2 legal) (2 sub-legal)	4 (1 legal) (3 sub-legal)	121.2	49.5
Total			37.7	30.4	12.25	11.45	19	16		133.4
Mean									97.5	

[a]Based on mean width and length of each pool; does not include Stations 2 and 9.

Table 4. Rate of capture for muskellunge while electrofishing at Kinniconick Creek in 1980 - 1981.

	Fish/hour				Fish/mi			
	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total
1980								
Legal[a]	0.09	0.26	0.26	0.21	0.24	0.78	1.14	0.65
Sub-legal[b]	0.09	0.42	0.26	0.29	0.24	1.25	1.14	0.90
Combined	0.2	0.7	0.5	0.5	0.5	2.0	2.3	1.6
1981								
Legal	0.14	0.16	0.23	0.16	0.30	0.47	0.57	0.44
Sub-legal	0.41	0.27	0.70	0.36	0.91	0.78	1.71	0.96
Combined	0.5	0.4	0.9	0.5	1.2	1.2	2.3	1.4

[a] $\geq$ 30 inches long.

[b] $<$ 30 inches long.

Table 5. Muskellunge mark and recapture results at Kinniconick Creek in 1980 - 1981.

Year	Marking effort	Recapture effort	
	Number of fish	Number of unmarked fish	Number of marked fish
1980	16	3	1
1981	13	3	0

little difference between percent success in capturing legal and sub-legal size fish or between capture rates from either year. The largest muskellunge sighted, but not collected, was observed at Station 1.

Table 6. Muskellunge captured versus sighted and percent success of capture at Kinniconick Creek.

Year	Number captured			Number not captured			Capture rate (%)		
	Legal	Sub-legal	Total	Length	Sub-legal	Total	Legal	Sub-legal	Total
1980	8	11	19	4	7	11	67	61	63
1981	5	11	16	4	5	9	56	69	64
TOTAL	13	22	35	8	12	20	62	65	64

The mean length and weight for muskellunge captured during 1980 and 1981 was 23.2 in and 3.94 lb, respectively. Muskellunge collected in 1980 averaged 23.1 long (10.3 - 34.5 in), and 3.98 lb (0.20 - 9.34 lb). Fish captured in 1981 averaged 23.3 in (10.9 - 34.2 in) and 3.90 lb (0.28 - 10.02 lb).

Table 7 presents the length distribution of the 35 muskellunge collected during both years at Kinniconick Creek. One fish, captured in 1980, was suspected of being a tiger musky and is not included in further discussion of results. No fish between 15 and 20 in were collected.

Table 7. Length frequency of muskellunge captured by electrofishing a total of 68.1 hours on Kinniconick Creek during 1980 (37.7 hours) and 1981 (30.4 hours).

Year	Inch group																		Total	Fish/hr
	10	11	12	13	14	15	20	21	22	23	24	26	28	30	31	32	33	34		
1980	2		3	1	1	1				1	1	1		1	1	2	2	2	19	0.5
1981		1	2	1			1	1	2		1	1	1	2		1		2	16	0.5
TOTAL	2	1	5	2	1	1	1	1	2	1	2	2	1	3	1	3	2	4	35	0.5

The mean back-calculated lengths for the 34 muskellunge collected from Kinniconick Creek were 11.4, 17.6, 22.2, 26.3, 30.1, and 33.1 at ages I-VI, respectively (Table 8). This is similar to the results shown by Miles for

West Virginia muskellunge, except that 5-year old muskellunge from Kinniconick Creek are slightly longer. Two-year old fish from Middle Island Creek in West Virginia showed better growth than the same age fish from Kinniconick Creek. Growth rates from Cumberland Plateau streams (Parsons 1959) were similar for 4, 5, and 6-year old fish but showed slower growth rates during the first 3 years. The mean growth of muskellunge from nine Kentucky streams, calculated by Brewer, showed better growth at all ages than did those from Kinniconick Creek.

Table 8. Mean length (in) at each age for 34 muskellunge collected during 1980 and 1981 from Kinniconick Creek.

Year class	Year collected	Age	Number	Age I	II	III	IV	V	VI
1980	1981	I	4	10.6					
1979	1980	I	7	11.2					
	1981	II	1	11.3	17.8				
1978	1980		0						
	1981	III	4	12.4	18.3	21.8			
1977	1980	III	3	12.0	19.3	23.6			
	1981	IV	2	11.5	18.7	24.0	26.7		
1976	1980		0						
	1981	V	2	11.6	16.2	20.6	25.9	28.9	
1975	1980	V	4	12.0	17.7	22.9	27.0	30.5	
	1981	VI	3	10.5	16.2	21.6	25.7	30.6	33.2
1974	1980	VI	4	10.8	16.6	21.3	26.2	30.0	33.0
	1981		0						
Mean				11.4	17.6	22.2	26.3	30.1	33.1

The length-weight relationship of muskellunge collected at Kinniconick Creek is shown in Figure 2. This relationship is expressed by the equation Log W = -4.0417 + 3.2670 log L. The equation Log W = -4.11002 + 3.32788 log L was calculated by Brewer for muskellunge from nine Kentucky streams. Table 9 shows the calculated weights for the mean lengths of muskellunge as depicted in Table 8. Calculated weights were similar to the emipirical weights of the 34 muskellunge collected for Kinniconick Creek (Table A-1).

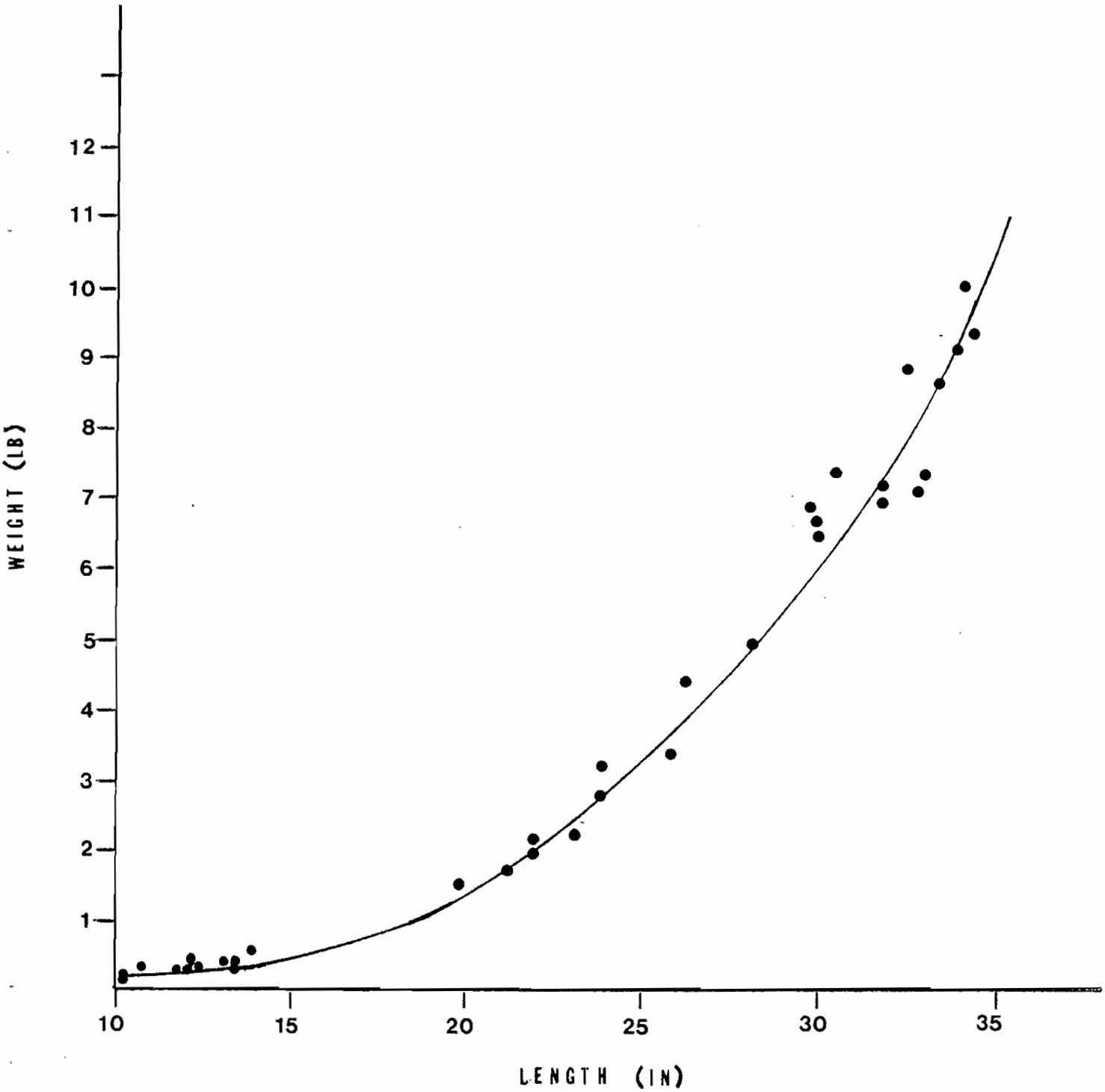

Figure 2. Length-weight relationship of muskellunge captured from Kinniconick Creek in 1980-1981. Dots represent actual lengths and weights at capture.

Table 9. Calculated weights for muskellunge at ages I-VI in Kinniconick Creek.

Age	Mean length (in)	Mean weight (lb)
I	11.4	0.26
II	17.6	1.06
III	22.2	2.27
IV	26.3	3.96
V	30.1	6.15
VI	33.1	8.39

The number of muskellunge collected per year class were 1980 (4), 1979 (8), 1978 (4), 1977 (5), 1976 (2), 1975 (7), and 1974 (4). The number of fish per year class, based on mail-in survey returns in 1975-1982 were: 1976 (3), 1975 (2), 1974 (4), 1973 (8), 1972 (4), 1971 (1), 1970 (1), and 1969 (1) (Table 10). The 1975 year class in Kinniconick Creek was one of the stronger year classes, yet 1975 was not a year of stocking. Another strong year class was 1973, based on mail-in survey returns, as it represents 33% of the returns. Muskellunge were stocked during that year and in 1976 and 1979. The 1977-1980 year-classes are not represented by the mail-in survey because they were not yet large enough (legal size) to enter the creel. The 1979 year class was the most abundant year class collected during the study in 1980 but few were collected during 1981. Sampling for at least 2 years on each stream is important in order to assure that a more representative sample of the age groups is taken. For example, seven muskellunge from the 1979 year class were collected in 1980, but only one was taken in 1981; no 1978 year class fish were collected during 1980, but four were collected in 1981; no 1976 year-class fish were collected in 1980, but two were collected in 1981; and four 1974 year-class muskellunge were collected in 1980, but none were collected in 1981.

There were few mail-in survey returns and electrofishing captures from the 1976 year class, although the greatest number of fish were stocked that year. The 1973 and 1979 stockings did evidently contribute to strong year classes from those years. One reason for poor survival of the 1976 stocking may be due to the smaller size of fish, 4.5 - 5.5 in long, compared to 7 - 9 in fish stocked in 1973 and 1979. However, the 1976 year class was well represented in Tygarts Creek. The 1975 year class was collected in small numbers. This was evidently a strong year class; however, as indicated by the number of mail-in survey returns (Table 10).

It was difficult to compare findings from this study with findings from Brewer (1980). Much of Brewer's data was combined due to the time involved in

Table 10. Year-class frequency of muskellunge captured at Kinniconick Creek by Brewer, from efforts of this study, and mail-in survey returns in 1975 - 1982.

	Year class																
	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1966	1965	1964	1963	1962
Captures by Brewer												1	1	3	4	4	2
Mail-in survey Returns					3	12	2	8	4	1	1	1					
Captures from the 1980-1981 study																	
1980		7		3		4	4										
1981	4	1	4	2	2	3											
TOTAL	4	8	4	5	5	19	6	8	4	1	1	2	1	3	4	4	2

studying many streams at one time. He also included fish sighted but not captured in some of his results; we did not. Brewer also used data from sodium cyanide studies and electrofishing results; whereas, we relied on findings based on electrofishing efforts.

A larger muskellunge population exists at the present time in Kinniconick Creek than when Brewer conducted his work if one compares results from Brewer's 4-year study at the same pools with results from this 2-year study. Brewer found legal muskellunge occurring at a rate of about one fish per 9 acres and sub-legal muskellunge occurring at a rate of about one fish per 11 acres. Results from this study at the same pools, conducting routine shoreline electrofishing, were one legal muskellunge per 3.43 acres and one sub-legal muskellunge per 2.45 acres. This increased catch rate cannot be entirely credited to stocking, based on the contribution of the 1975 year class. See Table 10 for comparison of year-class strength.

Thirteen legal-sized (≥30 inches long) muskellunge were tagged in Kinniconick Creek during the 2-year study period. To date, 3 of the 13 tags (23%) have been returned from tagged fish. These fish were caught 4.5 months, 10 months (caught about 4 mi downstream from release site), and 2 years (caught from same pool from which it was tagged) after being tagged. The mean exploitation rate on tagged fish during both study years was 15%, based on 2 of 13 tags returned of fish creeled within 1 year after being tagged. An additional fish, tagged prior to our studies in 1979, was caught 9 months after being tagged. We also collected a muskellunge that appeared to have lost a tag, based on scar tissue at the anterior base of the dorsal fin. Another muskellunge, from Station 1, was captured that had been tagged with a Floy anchor tag by Ohio River Sport Fishery Investigation personnel in that area a month earlier. This is a somewhat low return rate when compared to a 32% return of 14 legal size muskellunge (≥28 inches) within 1 year after being tagged in Middle Island Creek in West Virginia. Thirty-three percent of the 43 muskellunge (29 inches or longer) tagged by Brewer during 1967 - 1971 were creeled within a year after tagging. Based on the mail-in survey, numbers of fish harvested each month were as follows: 1980 - April (1), May (2), June (3), July (1), September (1), October (1), and November (1); 1981 - March (1); 1982 - May (2). Judging from the low returns over the last several years from Kinniconick and Tygarts creeks fishermen are either catching fewer fish, fishing less, or their interest in the tagging program is declining and they are no longer responding as well to the mail-in survey. I suspect the latter to be the primary reason for low returns.

Tygarts Creek

Twenty-four muskellunge were captured while electrofishing at 15 pools and 8.8 mi of Tygarts Creek in 1980. Thirty-five muskellunge were collected from 12 stations and 11.8 mi of pool habitat in 1981 (Table 11). Muskellunge were captured at a rate of 1.0 fish/hour and 2.8 (0.9 legal size, 1.8 sub-legal) fish/mi in 1980. In 1981, muskellunge were captured at a rate of 1.7 fish/hour and 3.0 (0.5 legal size, 2.5 sub-legal) fish/mi (Table 12). A total of 22 muskellunge were taken from stations 13 and 14, two pools that are only separated by a short riffle, at a rate of 13.75 fish/mi in 1981. This catch rate was by far the best in any section of Kinniconick or Tygarts creeks during the 2 years of study. The mean rate of capture from both years of electrofishing was 1.3 muskellunge/hour, about 2.6 times higher than at Kinniconick Creek, and 2.9 muskellunge/mi. Muskellunge were more concentrated in the middle section of Tygarts Creek (mi 30 - 60) below Carter Caves State Park in both years of sampling. Fifty-five of the 59 captured fish were from this section. The middle section begins immediately below the Carter Caves State Park where several spring fed streams enter Tygarts Creek. The concentration of muskellunge in this area may relate to preferred water temperatures that are provided by the supply of underground springs. Hoyt (1979) reported on muskellunge concentrating in a section of Barren River in Kentucky where springs were common.

Sufficient numbers of muskellunge were recaptured in 1981 at Tygarts Creek to estimate the population. The number of muskellunge captured within the 11.8 mi sample area was 53 fish or 4.5 fish/mi. An estimated population of 194 muskellunge were within the 43 mi of pool habitat available in Tygarts Creek. This includes 33 legal-size muskellunge (0.8 fish/mi of pool habitat) and 161 sub-legal fish (3.7 fish/mi of pool habitat). The population estimate from mark-recapture data in 1981 was based on 24 fish collected during the marking effort, 11 unmarked fish that were collected during recapture effort, and 9 marked fish that were recaptured during the recapture effort. Fourteen muskellunge were collected during the initial capture effort in 1980, 10 unmarked fish were collected during the recapture effort, and only 3 marked fish were recaptured.

The number of muskellunge captured versus sighted is shown in Table 13. Total rate of capture varies little from the rate of capture for legal and sub-legal fish, but is slightly higher than the rate experienced at Kinniconick Creek. This could be due to the fact that the pools at Tygarts Creek are generally shorter and the stream is less wide than Kinniconick Creek. The largest muskellunge observed at Tygarts Creek was not captured. This fish was observed at Station 6 and was the largest fish sighted in either stream.

The mean length and weight of muskellunge collected during both study years was 22.2 in and 3.29 lb. Muskellunge collected in 1980 averaged 24.8 in long (13.8 - 38.5 in), and 4.26 lb (0.52 - 18.75 lb). Fish captured in 1981 averaged 20.4 in long (12.4 - 32.7 in) and 2.62 lb (0.32 - 9.18 lb). Length distribution

Table 11. Sampling effort and muskellunge captured at Tygarts Creek in 1980 - 1981.

Section	Station(s) 1980	Station(s) 1981	Hours electrofished 1980	Hours electrofished 1981	Length of sampled area (mi) 1980	Length of sampled area (mi) 1981	Number of muskellunge captured 1980	Number of muskellunge captured 1981	Mean width (ft)	Acres
Lower (mi 0 - 30)	3	1 - 2	3.0	4.7	0.8	5.4	2 (1 legal) (1 sub-legal)	0	66.0[a]	43.1
Middle (mi 30 - 60)	4 - 14	6 - 9 11 - 14	19.1	14.2	7.1	6.0	21 (7 legal) (14 sub-legal)	34 (5 legal) (29 sub-legal)	73.3[b]	52.8[b]
Upper (mi 60 - 77.2)	15 - 17	15 - 16	2.7	1.8	0.8	0.4	1 (sub-legal)	1 (legal)	64.6[c]	3.2[c]
Total			24.8	20.7	8.7	11.8	24	35		1980) 56.0[d] 1981) 99.1
Mean									70.4	

[a] Station 3 not determined.

[b] Station 4, 5, 10 not determined.

[c] Station 17 not determined.

[d] Lower stations not determined in 1980.

Table 12. Rate of capture for muskellunge while electrofishing at Tygarts Creek in 1980 - 1981.

	Fish/hour				Fish/mi			
	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total
1980								
Legal[a]	0.33	0.36	0	0.32	1.25	0.99	0	0.92
Sub-legal[b]	0.33	0.73	0.37	0.65	1.25	1.97	1.25	1.84
Combined	0.7	1.1	0.4	1.0	2.5	3.0	1.2	2.8
1981								
Legal	0	0.35	0.56	0.29	0	0.83	2.5	0.51
Sub-legal	0	2.04	0	1.40	0	4.83	0	2.46
Combined	0	2.4	0.6	1.7	0	5.7	2.5	3.0

[a] $\geq$ 30 inches long.
[b] $<$ 30 inches long.

Table 13. Muskellunge captured versus sighted and percent success of capture at Tygarts Creek.

	Number captured			Muskellunge not captured			Capture rate (%)		
Year	Legal	Sub-legal	Total	Legal	Sub-legal	Total	Legal	Sub-legal	Total
1980	8	16	24	3	15	18	73	52	57
1981	6	29	35	3	5	8	67	85	81
TOTAL	14	45	59	6	20	26	70	69	69

of muskellunge collected from Tygarts Creek are represented in Table 14.

Table 14. Length frequency of muskellunge captured by electrofishing a total of 45.5 hours on Tygarts Creek during 1980 (24.8 hours) and 1981 (20.7 hours).

Year	Inch group																							Total	Fish/hour
	12	13	14	15	16	17	19	20	21	22	23	24	25	27	28	29	30	31	32	33	35	38			
1980			2	1	3		2	1				1	1	2	1	3	3		2		1	1		24	1.0
1981	1	4	3	6	3	1		1	1	4	1			1	3		2	2	1	1				35	1.7
Total	1	4	5	7	6	1	2	2	1	4	1	1	1	3	4	3	5	2	3	1	1	1		59	1.3

Age and growth of muskellunge in Tygarts Creek is expressed in Table 15. The age VI fish shown in this table probably represents the upper range in size for that age group and should not be considered as an average since only one fish was collected at that age. With that exception, the calculated growth of muskellunge is similar to growth in Kinniconick Creek. Mean calculated lengths were 11.3, 17.9, 22.7, 27.0, 30.8, and 35.8 inches at ages I-VI, respectively.

Table 15. Mean length(in) at each age for 59 muskellunge collected during 1980 and 1981 from Tygarts Creek.

Year class	Year collected	Age	Number	Age					
				I	II	III	IV	V	VI
1980	1981	I	18	10.9					
1979	1980	I	6	11.7					
	1981	II	7	10.7	18.6				
1978	1980	II	3	10.5	16.1				
	1981	III	1	10.7	16.9	23.6			
1977	1980	III	2	10.8	16.7	21.4			
	1981	IV	3	10.6	17.4	22.3	25.7		
1976	1980	IV	10	12.1	17.8	22.5	26.7		
	1981	V	6	11.8	18.9	23.7	27.5	30.2	
1975	1980	V	2	12.0	18.1	23.1	28.3	32.2	
	1981		0						
1974	1980	VI	1	11.5	17.2	22.2	27.5	32.4	35.8
Mean				11.3	17.9	22.7	27.0	30.8	35.8

The length weight relationship for muskellunge in Tygarts Creek is illustrated in Figure 3. This relationship fits closely with that for muskellunge in Kinniconick Creek. The age VI fish was not included in Figure 3, but was calculated in the length-weight equation. The length-weight relationship for muskellunge collected from Tygarts Creek is expressed by the equation Log W = -4.0777 + 3.2938. Calculated weights for each age group are shown in Table 16. Calculated weights compared fairly well with the empirical weights of the 59 muskellunge collected in Tygarts Creek (Table A-2).

Table 16. Calculated weights for muskellunge at Ages I-VI in Tygarts Creek.

Age	Mean length (in)	Mean weight (in)
I	11.3	0.25
II	17.9	1.12
III	22.7	2.45
IV	27.0	4.33
V	30.8	6.69
VI	35.8	10.98

Muskellunge were collected from the following year classes at Tygarts Creek in 1980 and 1981: 1980 (18), 1979 (13), 1978 (4), 1977 (5), 1976 (16), 1975 (2), and 1974 (1). Angler returns from the mail-in survey during 1975 - 1982 were for fish belonging to the 1977 (1), 1976 (12), 1975 (8), 1974 (3), 1973 (3), 1972 (4), 1971 (1), and 1970 (1) year classes (Table 17). The 1976 year class represented the greatest number of returns (36%); the 1975 year class was next, making up 24% of the total returns. Muskellunge were stocked in 1976, which was one of the strongest year classes collected during the study. Although fish stocked in 1976 were only 4.5 - 5.5 in, as were those stocked in Kinniconick Creek, these fish contributed more to the 1976 year class in Tygarts Creek and had better survival. This might be due to having more turbid water conditions than at Kinniconick Creek which is usually more clear. In addition, there were more than twice as many fish stocked in Tygarts Creek in 1976. The 1979 year class, also a year of stocking, was well represented in the electrofishing samples. Fish from this year class were not legal length of 30 in during the study; thus, they were not recorded from the mail-in survey returns. The 1980 spawn was successful in Tygarts Creek, as this year class was well represented in the collection of fish during 1981 electrofishing efforts. It is likely that the very strong 1976 year class contributed to the strength of the 1980 year class, as most of these fish were sexually mature by 1980. Based on numbers collected while electrofishing and from mail-in returns, the 1975 year class in Tygarts Creek was not as strong as in Kinniconick Creek, yet it was a strong year class. One factor that might contribute to the greater population density of muskellunge in Tygarts Creek versus Kinniconick Creek is total alkalinity, which generally is an indication of productivity. The alkalinity readings at Tygarts Creek were consistently higher, 3.3 times higher

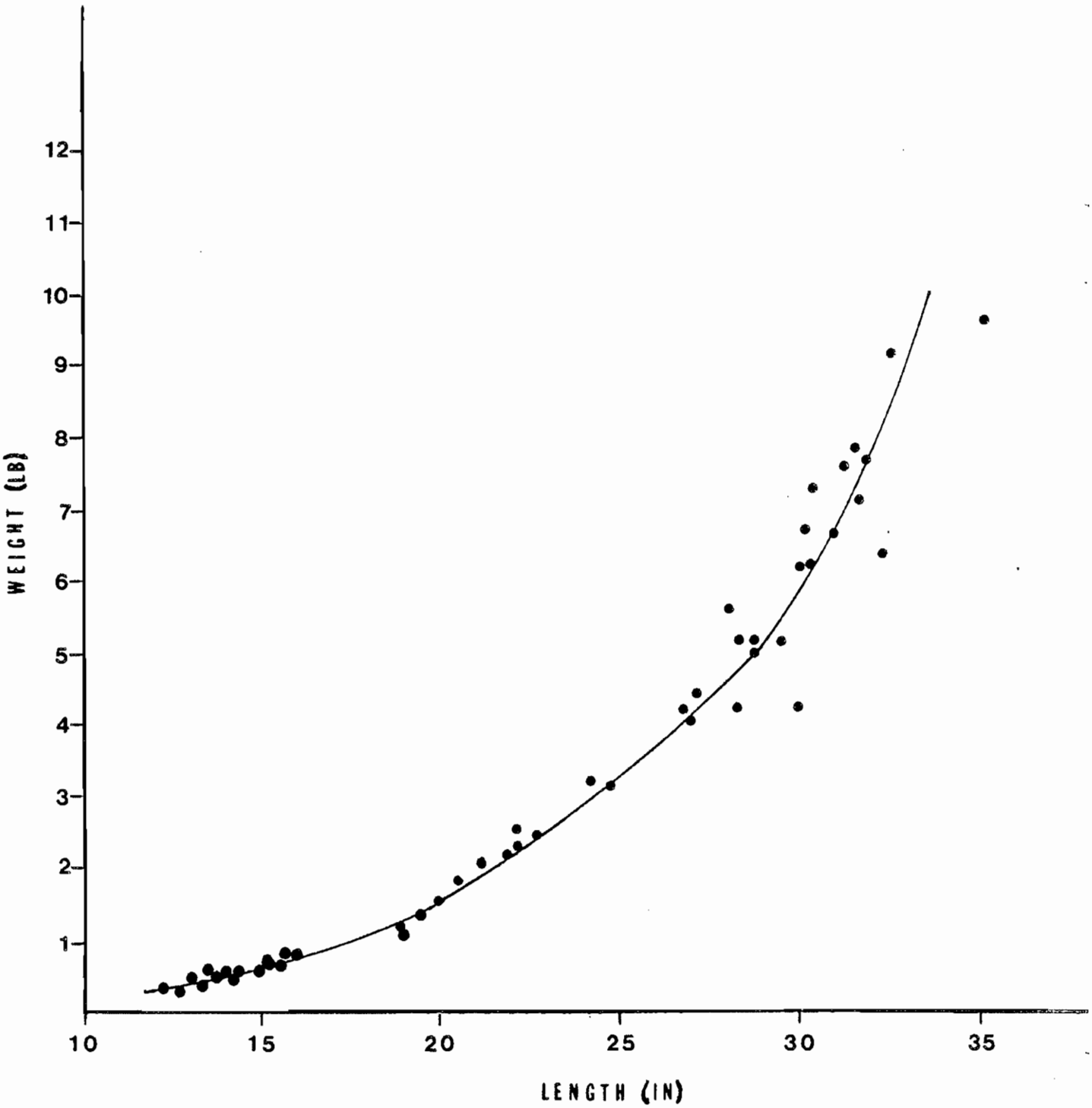

Figure 3. Length-weight relationship of muskellunge captured from Tygarts Creek in 1980 - 1981. Dots represent actual lengths and weights at capture.

Table 17. Year class frequency of muskellunge captured at Tygarts Creek by Brewer, from efforts of this study, and mail-in survey returns in 1975 - 1982.

	Year Class															
	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1966	1964	1963
Captures by Brewer											1	1	2	5	1	1
Mail-in survey returns				1	12	8	3	3	4	1	1					
Captures from the 1981 - 1982 study																
1980		6	3	2	10	2	1									
1981	18	7	1	3	6											
Total	18	13	4	6	28	10	4	3	4	1	2	1	2	5	1	1

on the average (Table 23). Another factor that may contribute to the better population of muskellunge in Tygarts Creek is the available forage. Gizzard shad and golden redhorse are abundant in Tygarts Creek, and may provide better forage than the striped shiner and golden redhorse that are the most abundant forage species found in Kinniconick Creek. Perhpas gizzard shad are better utilized by muskellunge at certain stages of their life. It is a well known fact that muskellunge prefer soft-rayed species in their diet. The abundant golden redhorse population in both streams is probably an important food item in both of these streams.

A total of 14 legal-size muskellunge were tagged in Tygarts Creek during 1980 - 1981; to date, a total of 5 tags have been returned. The duration from time of tagging to time of being creeled was 13 days (caught within the same pool from which it was tagged), 19 days, 21 days (caught from the same pool from which it was tagged), and 14 months. The mean annual exploitation rate for muskellunge creeled within 1 year after being tagged was 21%. Another tagged muskellunge was caught, but the tag was lost while the fish was on a stringer.

Supplemental Muskellunge Stocking Alternatives

The need for supplemental stockings of muskellunge in Kinniconick and Tygarts creeks has been demonstrated by the strength of two year classes in each stream that were from years of stocking. The density of the population in Kinniconick Creek was about 4 times greater after stocking, based on comparing catch rates from electrofishing effort by Brewer and efforts of this study. However, several complications exist in considering supplemental stockings of muskellunge in Kentucky streams. The most obvious is the availability of muskellunge fingerlings. Seventeen native muskellunge streams were listed by Brewer as having the potential for supplemental stockings. Several additional streams may be added to this list before the muskellunge stocking evaluation study is completed. The Minor Clark Fish Hatchery near Morehead, Kentucky cannot provide the number of fingerling muskellunge to stock all of these streams and the lakes now being stocked on an annual basis.

A difficult management decision is to know when to stock, if not annually. The greatest need for stocking would probably be when adverse environmental conditions (high discharge, very turbid water, and low water temperatures) occur within the streams during the spawning period in mid-April to early May. Brewer determined that adverse environmental conditions were most important in regard to survival of muskellunge egg and early sac fry stages. By the time a fishery biologist determines that environmental conditions have been adverse on muskellunge reproduction and survival in a particular stream it is too late for the hatchery to have time for rearing these fish. Therefore, two stocking strategies are available: (1) systematically design a stocking schedule for which the hatchery can plan production, and/or (2) have the district biologist or local

conservation officer monitor the stream conditions in the latter half of April and early May, and if the water conditions are adverse, recommend stocking with surplus muskellunge up to the maximum annual stocking rate recommended for that stream. Some of the needed fingerlings could be made available by reducing the number to be stocked in Cave Run Lake. If the second strategy was adopted, it would be most effective to have the hatchery rear surplus fingerlings every year for the purpose of stream stocking in response to adverse spawning conditions in a stream.

Brewer recommended an annual stocking rate of one large muskellunge fingerling per 2 acres of muskellunge pool habitat in most streams. Although subsequent stockings did not completely follow Brewer's recommendation at Kinniconick and Tygarts creeks, fingerlings were stocked at a rate of one fish per acre in 1973 and 1979 and two fish per acre in 1976. Muskellunge were stocked at rates higher than recommended in order to compensate for the years they were not available to be stocked.

If no fishing pressure existed, the native muskellunge populations in Kinniconick and Tygarts creeks would be expected to self-sustain themselves without the need for supplemental stockings. In fact, these populations would probably not be fished to extinction at the present rate of harvest. But, the need for supplemental stocking exists because of only an occasional strong year class that develops due in part to the few years when spring water conditions were favorable for a good spawn and survival of young-of-year fish. Also, in order to provide a population level close to carrying capacity of the stream and enhance the muskellunge fisheries, stocking is necessary. The integrity of the native population of muskellunge in these streams should be preserved, however, by not relying on supplementally stocking a ratio that would possibly threaten the status of the native populations.

Associated Fish Species in Kinniconick and Tygarts Creeks

A diverse assemblage of fish species is found within Kinniconick and Tygarts creeks (Table 18). Several fish collections have been conducted on both streams or their tributaries in the past. Brewer, Clark (1941), and Evenhuis (1972) have reported collections from Kinniconick Creek. Fish collections from Tygarts Creek have been reported by Branson et al. (1981b), Clark (1941), Evenhuis (1972), Harker et al. (1979), and Turner (1963).

Kinniconick Creek

Fish species collected during this study from Kinniconick Creek that were not taken in Tygarts Creek are silverjaw minnow *Ericymba buccata*, river chub *Nocomis micropogon*, popeye shiner *Notropis ariommus*, bigeye shiner *Notropis boops*, rosyface shiner *Notropis rubellus*, longhead darter *Percina macrocephala*, walleye *Stizostedion vitreum*, and mottled sculpin *Cottus bairdi*.

Table 18. Distribution of fishes, by station, collected while electrofishing Kinniconick and Tygarts creeks during 1980 and 1981.

Species	Kinniconick Creek stations										Tygarts Creek stations																
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Unidentified lamprey (fell off of a golden redhorse)			X																								
Longnose gar *(Lepisosteus osseus)*	X		X	X	X	X		X	X			X				X	X	X	X		X	X					
American eel *(Anguilla rostrata)*				X		X	X					X									X			X			
Skipjack herring *(Alosa chrysochloris)*												X															
Gizzard shad *(Dorosoma cepedianum)*	X				X						X	X				X	X	X	X		X	X	X	X		X	
Grass pickerel *(Esox americanus vermiculatus)*	X				X			X			X	X				X	X					X					
Muskellunge *(E. masquinongy)*	X		X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Central stoneroller *(Campostoma anamalum)*				X				X																X		X	
Common carp *(Cyprinus carpio)*	X			X	X	X		X	X	X	X	X				X	X	X	X			X	X	X	X	X	X
Silverjaw minnow *(Ericymba buccata)*										X																	
River chub *(Nocomis micropogon)*						X																					
Golden shiner *(Notemigonus crysoleucas)*																									X		
Rosefin shiner *(Notropis ardens)*						X	X		X	X																X	

Table 18 continued...

Species	Kinniconick Creek stations										Tygarts Creek stations																
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Popeye shiner *(N. ariommus)*					X	X			X																		
Emerald shiner *(N. atherinoides)*											X																
Bigeye shiner *(N. boops)*									X																		
Striped shiner *(N. chrysocephalus)*			X	X	X	X	X	X	X	X								X				X		X	X	X	X
Silver shiner *(N. photogenis)*			X	X		X	X	X	X	X		X				X		X	X		X	X	X	X	X	X	
Rosyface shiner *(N. rubellus)*	X		X	X	X	X																					
Mimic shiner *(N. volucellus)*																					X						
Bluntnose minnow *(Pimphales notatus)*			X	X		X	X	X	X	X	X					X	X	X	X		X	X	X	X	X	X	
Creek chub *(Semotilus atromaculatus)*					*			X	X									*									
River carpsucker *(Carpiodes carpio)*	X				X						X					X		X	X			X	X	X			
Quillback *(C. cyprinus)*											X						X						X			X	
Northern hog sucker *(Hypentelium nigricans)*			X	X	X	X		X	X	X						X	X	X	X			X	X	X		X	
Smallmouth buffalo *(Ictiobus bubalus)*	X										X					X	X	X	X								
Bigmouth buffalo *(I. cyprinellus)*	X												X			X											

Table 18 continued...

Species	Kinniconick Creek stations										Tygarts Creek stations																
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Spotted sucker *(Minytrema melanops)*	X				X	X	X	X	X	X	X							X				X	X		X	X	
Silver redhorse *(Moxostoma anisurum)*	X										X					X	X	X	X		X	X	X	X			
River redhorse *(M. carinatum)*											X	X	X				X										X
Black redhorse *(M. duguesnei)*	X											X				X	X		X		X	X	X	X	X	X	
Golden redhorse *(M. erythrurum)*	X		X	X	X	X	X	X	X	X	X	X				X	X	X	X		X	X	X	X	X	X	X
Shorthead redhorse *(M. macrolepidotum)*			X									X															
Yellow bullhead[a] *(Ictalurus natalis)*																											X
Channel catfish *(I. punctatus)*	X		X								X		X								X						
Brindled madtom *(Noturus miurus)*																					X						
Flathead catfish *(Pylodictus olivaris)*					X	X		X				X				X			X								
Trout-perch *(Percopsis omiscomaycus)*			X			X		X								X	X	X	X		X	X	X	X	X	X	
Brook silverside *(Labidesthes sicculus)*			X	X	X	X	X	X		X							X					X			X	X	X
Rock bass *(Ambloplites rupestris)*			X	X		X		X	X	X			X			X	X		X		X	X	X	X		X	
Green sunfish *(Lepomis cyanellus)*										X			X			X	X							X			

Table 18 continued....

Species	Kinniconick Creek stations										Tygarts Creek stations																
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Warmouth *(L. gulosus)*												X															
Bluegill *(L. macrochirus)*		X				X		X	X	X	X	X				X		X			X	X	X	X			
Longear sunfish *(L. megalotis)*	X		X	X	X	X	X	X	X	X	X	X				X	X	X	X		X	X	X	X	X	X	X
Smallmouth bass *(Micropterus dolomieui)*	X	X	X	X		X	X	X	X	X							X	X	X		X					X	X
Spotted bass *(M. puctulatus)*	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Largemouth bass *(M. salmoides)*	X	X			X	X	X	X	X	X	X					X	X				X	X	X		X	X	
White crappie *(Pomoxis annularis)*	X			X			X	X				X				X		X					X				
Greenside darter[a] *(Etheostoma blennioides)*					*	X			*							X		*	X		X	X		X		*	
Rainbow darter *(E. Caeruleum)*					*				*			*				X		*								*	
Fantail darter[a] *(E. flabellare)*										*		*				X											
Johnny darter *(E. nigrum)*							X																	X		X	
Variegate darter *(E. variatum)*																										X	*
Banded darter[a] *(E. Zonale)*					*		X			*						X		*								*	
Logperch *(Percina caprodes)*			X		X	X				X		*				X	X	X			X	X		X		*	
Longhead darter *(P. macrocephala)*			X			X		X																			

Table 18 concluded.

Species	Kinniconick Creek stations										Tygarts Creek stations																
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Blackside darter[a] *(P. maculata)*			X	X		X		X	X	X						X	X	X	X		X	X	X	X		X	
Slenderhead darter *(P. phoxocephala)*												X						X				X					
Dusky darter *(P. sciera)*												X										X					
Sauger *(Stizostedion canadense)*	X										X		X					X									
Walleye *(S. vitreum)*	X																										
Freshwater drum *(Aplodinotus grunniens)*	X		X		X	X					X	X				X	X	X	X			X		X	X		
Mottled sculpin *(Cottus bairdi)*										*																	

[a]Taken at water quality-benthos station near Bevins Channel by seine.

*Fishes takes by seine at water quality-benthos station.

Station 2 at Kinniconick Creek and stations 4, 5, and 10 at Tygarts Creek were sampled only in 1980; only muskellunge and black bass species were identified from these stations in 1980.

Brewer listed the species he collected from Kinniconick Creek, but not from Tygarts Creek. He listed fish from the entire stream, collections from particular sites were not reported, and many of the fishes were collected by use of sodium cyanide. He collected the following species from Kinniconick Creek that we did not collect: rainbow trout *Salmo gairdneri*, that is no longer stocked, bigeye chub *Hybopsis amblops*, river redhorse *Moxostoma carinatum*, stonecat *Noturus flavus*, brindled madtom *Noturus miurus*, warmouth *Lepomis gulosus*, variegate darter *Etheostoma variatum*, and dusky darter *Percina sciera*. Species that were collected in 1980 - 1981 and not by Brewer include: river carpsucker *Carpiodes carpio*, bigmouth buffalo *Ictiobus cyprinellus*, silver redhorse *Moxostoma anisurum*, black redhorse *Moxostoma duquesnei*, shorthead redhorse *Moxostoma macroplepidotum*, banded darter *Etheostoma zonale*, sauger *Stizostedion canadense*, and mottled sculpin *Cottus bairdi*.

A total of 52 species of fish were collected from Kinniconick Creek during this study; an additional 8 species were reported by Brewer. However, it is doubtful that the rainbow trout currently exists within the stream. The following number of species were collected per stream section: lower - 38 species from three stations; middle - 37 species from five stations; upper - 29 species from two stations.

Warren and Cicerello (personal communication 1982) are currently working on a manuscript dealing with new drainage records for 13 species of fish from Kentucky. Two of the records are based on findings from this study at Kinniconick Creek. One of the records concerns the popeye shiner. This species has not been recently reported from this drainage, although Brewer had reported it from his studies in the late 1960's. Clay (1975) reported this species from Cumberland, Green, and Kentucky drainages. Old records from the Salt and Big Sandy River drainages exist. The other fish, longhead darter, had not been reported from Kinniconick Creek in recent years, although it was collected by Brewer.

Tygarts Creek

Fishes collected from Tygarts Creek but not from Kinniconick Creek include: skipjack herring *Alosa chrysochloris*, golden shiner *Notemigonus crysoleucas*, emerald shiner *Notropis atherinoides*, mimic shiner *Notropis volucellus*, quillback *Carpiodes cyrpinus*, river redhorse *Moxostoma carinatum*, yellow bullhead *Ictalurus natalis*, brindled madtom, warmouth, variegate darter, slenderhead darter *Percina phoxocephala*, and dusky darter *Percina sciera*.

Several species of fish that we did not collect during our efforts on Tygarts Creek were collected from its tributaries by Harker et al. (1979). These species and their location were: Upper Tygarts Creek - white sucker *Cataostomus commersoni*, silverjaw minnow, and southern redbelly dace *Phoxinus erythrogaster;* Buffalo Creek - mottled sculpin and blacknose dace *Rhinichthys atratulus;* White Oak Creek - rosyside dace *Clinostomus funduloides*.

Turner also collected several species of fish from a fish population study conducted 2 mi above the proposed site of Kehoe Dam. Species of fish that were not collected during this study from Tygarts Creek include: least brook lamprey

Lampetra aepyptera, silverjaw minnow, river chub, rosyface shiner, spotfin shiner *Notropis spilopterus*, blacknose dace, white sucker, and stonecat.

Branson et al. collected an additional species of fish, Ohio lamprey *Ichthyomyzon bdellium*, not collected in previously mentioned studies.

The total number of species collected from Tygarts Creek during this study was 54; 6 additional specimens were reported by Harker et al. and another species by Branson et al. Species not reported by any of the above, but collected by Turner, are not included as they cannot be verified. The following number of species were collected by stream section during the study: lower - 37 species from 3 pools; middle - 46 species from 11 pools; upper - 30 species from 3 pools.

Specimens of slenderhead darter collected by Warren (1981) from Tygarts Creek represented the most upstream record for that specimen in the Ohio River valley in Kentucky. Several of these fish were collected from Station 2 (Tygarts Creek) on a riffle near the mouth of White Oak Creek. They were also collected from Stations 8 and 12.

There were several species of fish common to all muskellunge streams reported by Brewer. The streams were: Beaver Creek, North Fork Triplett Creek, North Fork Creek, Licking River, Red River, and Kinniconick Creek. The fish were longnose gar *Lepisosteus osseus*, gizzard shad *Dorosoma cepedianum*, muskellunge *Esox masquinongy*, central stoneroller *Campostoma anomalum*, common carp *cyprinus carpio*, striped shiner *Notropis chrysocephalus*, silver shiner *Notropis photogenis*, rosyface shiner, bluntnose minnow *Pimephales notatus*, northern hog sucker *Hypentelium nigricans*, spotted sucker *Minytrema melanops*, river redhorse, golden redhorse *Moxostoma erythrurum*, channel catfish *Ictalurus punctatus*, brindled madtom, rock bass *Ambloplites rupestris*, bluegill *Lepomis macrochirus*, longear sunfish *Lepomis megalotis*, smallmouth bass *Micropterus dolomieui*, spotted bass *Micropterus punctulatus*, largemouth bass *Micropterus salmoides*, white crappie *Pomoxis annularis*, greenside darter *Etheostoma blennioides*, rainbow darter *Etheostoma caeruleum*, fantail darter *Etheostoma flabellare*, Johnny darter *Etheostoma nigrum*, variegate darter, logperch, and blackside darter *Percina maculata*. All of these fishes were collected during this study with the following exceptions: rosyface shiner was taken only from Kinniconick Creek and the brindled madtom and variegate darter were only taken from Tygarts Creek. The composition of certain fish species was very similar in muskellunge streams according to Brewer's report. It will be important to learn how many species are commonly found and which species are most associated with muskellunge in all study streams once the Muskellunge Streams Investigation study is completed.

Several species of fish found in Kinniconick Creek, Tygarts Creek, and other streams were given conservation status by Branson et al. These species are:

Species	Status	Stream
Clinostomus funduloides[a]	Special concern	Tygarts Creek
Esox masquinongy ohioensis	Special concern	Kinniconick and Tygarts Creeks
Notrpois ariommus	Undetermined	Kinniconick Creek
Percina macrocephala	Threatened	Kinniconick Creek
P. Phoxocephala[b]	Special concern	Tygarts Creek
Percopsis omiscomaycus	Special concern, peripheral	Kinniconick and Tygarts Creeks

[a]Harker et al. (1979)

[b]According to Warren and Cicerello (unpublished manuscript; Drainage records and conservation evaluation for thirteen Kentucky fishes), *Percina phoxocephala* no longer warrents conservation status.

Both Kinniconick and Tygarts creeks have been recommended by the Kentucky Department of Fish and Wildlife Resources, with concurrence by the Kentucky Nature Preserves Commission, for inclusion in Kentucky's Outstanding Water Resource Classification.

Species Catch Per Effort Based On Electrofishing Results

In 1981, the total fish populations in Kinniconick and Tygarts Creeks were sampled during part of the first round of electrofishing. Numbers, length distribution, catch per unit effort (fish/hour) and percent of total catch for fish captured while electrofishing in 1981 are found in Table 19 for Kinniconick Creek and Table 20 for Tygarts Creek. The following species were frequently taken from Kinniconick Creek: longnose gar, *striped shiner*, spotted sucker, *golden redhorse*, rock bass, *longear sunfish*, and spotted bass. Fishes most frequently taken from Tygarts Creek were *gizzard shad*, bluntnose minnow, northern hog sucker, silver redhorse, black redhorse, *golden redhorse*, trout-perch, *longear sunfish*, spotted bass, and blackside darter. Fish in italics were the most abundant species captured.

Fishes collected during muskellunge studies presently being conducted in eastern Kentucky streams by Jones (Axon personnal communication 1982) reflect much the same composition as in Kinniconick and Tygarts creeks. The list of most abundant fish species captured in those stream studies by Jones in 1981 are (in order of abundance): South Fork Kentucky River - golden redhorse, longear sunfish, spotted bass, bluntnose minnow, and bigeye shiner; Sexton Creek - golden redhorse, emerald shiner, bluntnose minnow, striped shiner and spotted bass; Goose Creek - golden redhorse, striped shiner, longear sunfish, northern hog sucker, white sucker, spotted bass, and bluntnose minnow; Collins Fork - golden redhorse, brook silverside, striped shiner, and bluegill; Little Goose Creek - golden redhorse, hybrid sunfish, striped shiner, and spotted bass.

Table 19. Species and length distribution of fish obtained electrofishing during a total of eight hours on Kinniconick Creek in 1981.

Species	Inch group																																Total	No./hour	Percent
	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	32	33	34	36	42			
Longnose gar												1	2	1		1	1	5	1	1	2	2	1		1	1	2	1	1				2	1	27	3.4	2
Gizzard shad				1	2	2	1	4	1																										11	1.4	1
Grass pickerel									1																										1	0.1	t
Muskellunge[a]													1															1			2	1			5	0.6	t
Central stoneroller		2																																	2	0.2	t
Common carp																1		1		2	2	1													7	0.9	1
Silverjaw minnow		1																																	1	0.1	t
River chub		1																																	1	0.1	t
Rosefin shiner	11	12	2																																25	3.1	2
Popeye shiner		7																																	7	0.9	1
Bigeye shiner		1																																	1	0.1	t
Striped shiner	25	268	31	23	9	6	1	1																											364	45.5	33
Silver shiner		17	9	1																															27	3.4	2
Rosyface shiner	1	33	3																																37	4.6	3
Bluntnose minnow	4	42	8																																54	6.7	5
Creek chub		1				1																													2	0.2	t
River carpsucker															1																				1	0.1	t
Northern hog sucker		2	11	5	2	1	1	1			1		1																						25	3.1	2
Smallmouth buffalo															1							1		1											3[b]	0.4	t
Bigmouth buffalo																													1						1	0.1	t
Spotted sucker		6	17	13	1			5	2	3	1	4	2					1																	55	6.9	5
Silver redhorse											1	1																							2	0.2	t
Black redhorse			1	1				1		1	1	1		1																					7	0.9	1
Golden redhorse		23	17	3	2	3	8	5	11	13	17	13	8	1	2								1												127	15.9	11
Shorthead redhorse									1																										1	0.1	t
Channel catfish																		1																	1	0.1	t
Flathead catfish														1																					1	0.1	t
Trout-perch			5	4																															9	1.1	1
Brook silverside		4	23	3																															30	3.7	3

Table 19 concluded.

Species	Inch group																																Total	No./ hour	Percent
	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	32	33	34	36	42			
Rock bass	1			1	5	5	14	7	1																								34	4.2	3
Green sunfish		2	1																														3	0.4	t
Bluegill	3	2	2		1	6	2	1																									17	2.1	2
Longear sunfish		2	16	18	57	11																											104	13.0	9
Smallmouth bass							1	3	2	1			1																				8	1.0	1
Spotted bass			2	11	2	6	7	7	10	6	4	3	1	1	1																		61	7.6	5
Largemouth bass					1				4	2	1				1	1				1													11	1.4	1
White crappie								1				1																					2	0.2	t
Greenside darter		2																															2	0.2	t
Johnny darter		2																															2	0.2	t
Banded darter		1																															1	0.1	t
Logperch		3	3	3	1																												10	1.2	1
Longhead darter		4	2	1																													7	0.9	1
Blackside darter		10	6																														16	2.0	1
Walleye																		1															1	0.1	t
Freshwater drum									2		1				1		2																6	0.7	1

[a] See Table 7.

t < 0.5%

Table 20. Species and length distribution of fish obtained by electrofishing during a total of 6 hours on Tygarts Creek in 1981.

Species	Inch group																											Total	No./hour	Percent
	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	27	28	29	31			
Longnose gar																				1		1								2	0.3	t
American eel																											1			1	0.2	t
Gizzard shad			1	64	222	47	25	19	11	6	7	2																		404	67.3	31
Grass pickerel			1	2	1	2			1																					7	1.2	1
Muskellunge[a]														3	3	2					1	1	1				2		1	14	2.3	1
Central stoneroller		4	5																											9	1.5	1
Common carp														1		1	2		1	4	3	1		2	1	1		2		19	3.2	1
Golden shiner				1																										1	0.2	t
Rosefin shiner		1																												1	0.2	t
Emerald shiner[b]																																
Striped shiner		13	9	4	1																									27	4.5	2
Silver shiner		5	14	3																										22	3.7	2
Mimic shiner		2																												2	0.3	t
Bluntnose minnow	7	42	12	1																										62	10.3	5
River carpsucker															5	1	1	2												9	1.5	1
Quillback														1	1	1														3	0.5	t
Northern hog sucker		4	11	4	3	7	2	1																						32	5.3	2
Smallmouth buffalo														1			1		1			1								4	0.6	t
Spotted sucker			6	4	1				1					1																13	2.2	1
Silver redhorse			3	8	3	3	5	8	8	8	3	2	1	4	2			1	1											60	10.0	5
River redhorse				1	1										1															3	0.5	t
Black redhorse			3	4		1	7	5	2	7	9	3	1		2															44	7.3	3
Golden redhorse	1	10	30	11	2	10	13	15	30	40	25	20	11	3	2		1	2	4	1										231	38.5	18
Shorthead redhorse												1																		1	0.2	t
Flathead catfish																	1													1	0.2	t
Trout-perch		1	25	21																										47	7.8	4
Brook silverside			8	4																										12	2.0	1
Rock bass		1	1		6	1	2	3																						14	2.3	1
Green sunfish			1																											1	0.2	t

Table 20 concluded.

Species	Inch group																													Total	No./ hour	Per-cent
	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	27	28	29	31			
Bluegill	1	5	2		2	4																								14	2.3	1
Longear sunfish	1	24	16	35	25	1																								102	17.0	8
Smallmouth bass						2																								2	0.3	t
Spotted bass		2	3	4	3	5	1	1	2	2	3																			26	4.3	2
Largemouth bass			3	1			1																							5	0.8	t
White crappie										1																				1	0.2	t
Greenside darter		6	1																											7	1.2	1
Rainbow darter		2																												2	0.3	t
Fantail darter	1	2																												3	0.5	t
Logperch		1	8	6	1																									16	2.7	1
Blackside darter		33	24	2																										59	9.8	5
Sauger							3																							3	0.5	t
Freshwater drum			3	4							1	2																		10	1.7	1

[a]See Table 14.

[b]Too many to count; collected at the mouth of Tygarts Creek.

t < 0.5%

Several streams were sampled by Kornman under the Muskellunge Stream Investigation Study during 1982. By far the most commonly collected fish from those streams were: Red River - golden redhorse (41% of the fish collected), silver redhorse (16%), and longear sunfish (12%); Station Camp Creek - golden redhorse (31%) and longear sunfish (22%); Sturgeon Creek - golden redhorse (39%).

Golden redhorse is the most abundant species of fish in all muskellunge streams studied thus far. Collins Fork deviated somewhat from the other streams in that bluegill and largemouth bass were the most numerous centrarchids rather than longear sunfish and spotted bass. Largemouth bass was also more abundant than spotted bass in Station Camp Creek, sampled by Kornman in 1982. The following is a list of fish collected by electrofishing that are common to Kinniconick Creek, Tygarts Creek, the five streams studied by Jones in 1981, and the 3 streams studied by Kornman in 1982, unless otherwise noted. Muskellunge (not collected from Little Goose and Sturgeon creeks), carp (not collected from Sexton Creek, Collins Fork, and Little Goose Creek), striped shiner, bluntnose minnow, northern hog sucker, spotted sucker (not collected from South Fork Kentucky River and Sexton Creek), golden redhorse, brook silverside (not collected from the Red River), rock bass (not collected from Collins Fork or Little Goose Creek), bluegill (not collected from Sexton Creek), longear sunfish, smallmouth bass (not collected from Little Goose Creek), spotted bass, largemough bass, logperch (not collected from Sexton Creek), and blackside darter.

Riddle (1975) reported findings in muskellunge streams in Tennessee that showed some of the more abundant species, not including cyprinids and percids, closely resemble the same species found in the aforementioned Kentucky streams. Fish were collected from the Tennessee streams with the use of toxicants and nets. The most abundant species in these streams were: Big South Fork Cumberland River drainage - northern hog sucker, black redhorse (more numerous than the golden redhorse), rock bass, longear sunfish, and largemouth bass (more numerous than the spotted bass); Emory River drainage - northern hog sucker, golden redhorse, rock bass, bluegill, and smallmouth bass. There were several species common to both of the above drainages that were also common to the streams listed by Brewer and streams sampled in this study (pages 27-34 of this report). These fish are: muskellunge (Riddle collected few from the Cumberland River drainage), stoneroller, carp, northern hog sucker, golden redhorse, channel catfish, rock bass, bluegill, longear sunfish, smallmouth bass, spotted bass, largemouth bass, greenside darter, and logperch. Spotted bass was not the dominant black bass in these drainages in Tennessee as it is in most muskellunge streams in Kentucky.

There are three species of fish, golden redhorse, longear sunfish, and spotted bass, that are strongly associated with native muskellunge populations in Kentucky streams, based on results of the Muskellunge Stream Investigation Study thus far. These species are also abundant in streams that do not have muskellunge populations, but muskellunge may not occur in streams where these species are not found in abundance. The association is probably related to similar habitat requirements.

Black Bass Composition

A thorough study of the black bass populations found in Kinniconick and Tygarts creeks is being conducted by Surmont in partial fullfillment of a Master of Science degree at Morehead State University. Spotted bass was by far the most common of the three species of black bass captured in Kinniconick and Tygarts creeks, as it made up 73% and 82% of the bass numbers, respectively. Smallmouth bass and largemouth bass made up 15% and 12% of the black bass numbers collected at Kinniconick Creek, while largemouth bass made up 10% and smallmouth bass represented 8% of the bass captured at Tygarts Creek.

Smallmouth bass habitat (riffle and shoal areas) in both streams was not as thoroughly sampled in comparison to spotted bass and largemouth bass habitat (pool areas). Kinniconick Creek contains more smallmouth bass habitat than Tygarts Creek. The smallmouth bass habitat that does exist in Tygarts Creek is chiefly confined to the upper section. Smokey Valley Lake at Carter Caves State Park may contribute to the largemouth bass population in Tygarts Creek, as the dam overflows directly into Smokey Valley Creek several hundred yards upstream from its union with Tygarts Creek.

Based on the catch per unit effort for black bass, Kinniconick Creek has almost twice the population density of black bass than at Tygarts Creek. However, based on total alkalinity determinations, Tygarts Creek should be more productive. Therefore, some other limiting factor may be involved as to why there is a healthier black bass population in Kinniconick Creek than in Tygarts Creek. The larger population of muskellunge in Tygarts Creek may result in less survival of black bass than in Kinniconick Creek due to competition for food and habitat.

Physical - Chemical Determinations

There are several basic differences in the physical characteristics between Kinniconick and Tygarts creeks as follows (Tables 21, 22):

Length: Tygarts Creek is about a third longer than Kinniconick Creek, but the pools sampled on Kinniconick Creek are longer. However, unsampled pools that exist in the lower portion of Tygarts Creek are longer, narrow, and have slow flow.

Width: The mean widths of the pools are greater at Kinniconick Creek. A part of Tygarts Creek flows through a narrow gorge, but this stream has a wider flood plain.

Depth: Mean depths for pool areas sampled are about the same for both streams, with Kinniconick Creek being slightly deeper (4.1 versus 3.7 mean ft). Maximum depths are also greater at Kinniconick Creek.

Table 21. Physical characteristics from each pool electrofished for sampling the fish population on Kinniconick and Tygarts creeks.

Station	Length (mi)	Mean width (ft)	Mean depth (ft)		Maximum depth (ft)	Percent shade
Kinniconick Creek						
1	2.3	127.6	5.2[a]	10.0[b]	24.0	5-25 (Hwy 10 to mouth) 50-75 (Hwy 10 to 1st riffle)
2	0.8	N/D	N/D	N/D	N/D	N/D
3	1.0	114.7	2.9	6.0	10.0	5-25
4	1.2	110.8	3.7	5.7	13.5	25-50
5	1.6	101.6	5.2	9.0	16.0	25-50
6	1.8	93.0	3.6	5.0	12.0	25-50
7	0.4	81.0	4.5	4.0	18.0	25-50
8	1.4	81.0	3.3	6.0	15.0	50-75
9	0.6	N/D	N/D	N/D	N/D	N/D
10	1.2	70.1	4.1	7.0	16.0	25-50
Tygarts Creek						
1	2.5	66.8	4.8	7.0	13.0	25-50
2	2.9	65.2	4.0	7.5	14.0	25-50
3	0.8	N/D	N/D	N/D	N/D	N/D
4 & 5	0.9	N/D	N/D	N/D	N/D	N/D
6	0.9	85.6	3.6	7.0	11.0	25-50
7	0.5	76.0	3.8	7.0	10.0	50-75
8	0.8	76.5	4.0	8.0	13.0	25-50
9	1.0	60.7	3.5	5.0	11.0	50-75
10	0.2	N/D	N/D	N/D	N/D	N/D
11	0.3	74.0	3.3	4.0	15.0	25-50
12	0.9	69.5	3.2	5.0	9.0	25-50
13 & 14	1.6	71.0	4.1	6.0	9.0	25-50
15	0.3	67.5	3.1	5.0	9.0	50-75
16	0.1	61.7	2.9	6.0	11.0	50-75
17	0.4	N/D	N/D	N/D	N/D	N/D

[a]Depths taken from bank to bank at sites where widths were determined.

[b]Depths taken by using depth sounder throughout entire pool while making transits by boat back and forth across the stream; depth recordings did not include shallow areas near the shoreline.

N/D= not determined.

Table 22. Gradient, stream miles, and fish sampling stations within each stream section of Kinniconick and Tygarts Creeks.

Distance (stream mi) from headwaters to mouth	Gradient (ft/mi)	Stations
Kinniconick Creek	Upper section	
50.0 - 45.0	61.0	
45.0 - 40.0	16.0	
40.0 - 35.0	8.0	10
35.0 - 30.0	9.0	9
	Middle section	
30.0 - 25.0	8.0	7, 8
25.0 - 20.0	3.0	
20.0 - 15.0	2.0	4, 5, 6
	Lower section	
15.0 - 10.0	7.0	2, 3
10.0 - 5.0	4.0	
5.0 - 0.0	4.0	1
Tygarts Creek	Upper section	
85.5[a] - 80.0	8.0	
80.0 - 70.0	6.0	17
70.0 - 60.0	4.5	15, 16
	Middle section	
60.0 - 50.0	4.0	10, 11, 12, 13, 14
50.0 - 40.0	3.8	6, 7, 8, 9
40.0 - 30.0	2.7	4, 5
	Lower section	
30.0 - 20.0	2.0	3
20.0 - 10.0	2.5	
10.0 - 0.0	1.5	1, 2

[a]Mi 85.5 - where Flat Fork and Upper Tygarts Branch join to form Tygarts Creek. From head of Flat Fork to mi 85.5 the gradient is 68.6; from head of Tygarts Branch to mi 85.5 the gradient is 57.8.

Gradient: The gradients vary from section to section with the mean gradient being less on Tygarts Creek.

Annual flow: The annual flow within the streams is constant, with flow declining during the late summer and fall during most years. At this time, many riffles that normally have a foot or more of water flowing over them are reduced to a few inches or less. Kinniconick Creek generally clears more rapidly than Tygarts Creek after becoming turbid, and usually remains clear much of the year; Tygarts Creek is usually slightly to moderately turbid. Both streams were 1 to 2 ft below normal pool when determinations were made.

Fish shelter: Both streams have abundant fish shelter in the form of fallen trees, logs, log jams, brush, stumps, and undercut banks, etc. Both streams exhibit areas where rubble is the predominant substrate material (more so in Kinniconick Creek) and have occasional sections of small boulder habitat. Muskellunge were often captured where a fallen tree was located; a muskellunge was more likely to occur at a fallen tree if brush and debris had accumulated within the tree limbs. The presence of instream debris, particularly in the form of fallen trees, is very important for providing habitat for muskellunge.

Riparian zone: Kinniconick Creek has a wider riparian zone than Tygarts Creek. Few areas on either stream lack riparian vegetation.

Shade: Kinniconick Creek is generally wider than Tygarts Creek, which causes less overhead canopy in many areas of Kinniconick Creek.

Bottom type: The bottom in pool areas consisted chiefly of clay, silt, muck, and detritus. There were some areas of rubble to coarse gravel along hillside slips, and exposed shale along the bank occurred in a few areas on each stream. Few areas of exposed bedrock were observed as a substrate type. Riffle and raceway areas are composed chiefly of large rubble to coarse gravel intermixed with fine gravel and sand. Most riffles are swept clean of silt, muck, and detritus, but these materials are often accumulated immediately below the riffle.

Pool/riffle ratio: Greater than 90% of the area sampled by electrofishing at both streams during the study was pool habitat, better than 5% of the area sampled were raceways, and the remaining areas sampled consisted of deeper riffles. Longer riffle and raceway areas and numerous intermittent overflow channels (forming islands during high water) are found in Kinniconick Creek as compared to Tygarts Creek.

Aquatic Vegetation: Very little aquatic vegetation grows in Tygarts Creek; small patches of *Justicia sp.* grow on riffle or shallow areas along the shoreline. Kinniconick Creek has larger expanses of *Justicia sp.* growing along its course as well as many small patches of spatter-dock and, in a few areas, *Potomageton sp.*

The overall aesthetic value is greater at Kinniconick Creek than at Tygarts Creek, except the portion of Tygarts Creek that flows through a gorge. Kinniconick Creek lies in a different physiographic area than Tygarts Creek, although few air miles separate tributaries of each stream.

Water Quality

Water quality data is presented in Table 23. Some potential water quality problems from both streams are discussed below.

Table 23. Water quality determinations at three stations in Kinniconick and Tygarts creeks during 1981.

	Kinniconick Creek stations			Tygarts Creek stations		
	Lower	Middle	Upper	Lower	Middle	Upper
Temperature (^{o}C)						
April	11.5	11.0	11.0	13.5	13.5	13.0
July	26.0	25.0	24.3	25.3	24.8	24.3
October	14.0	10.0	13.8	13.3	14.0	11.5
Dissolved oxygen (mg/l)						
April	10.4	10.0	11.2	9.4	9.2	8.8
July	6.9	6.1	5.4	5.3	5.3	7.8
October	8.2	8.6	6.1	4.3	6.4	6.6
Total alkalinity (mg/l $CaCO_3$)						
April	20	20	20	55	75	75
July	25	32	20	70	100	115
October	45	40	50	90	130	200
Turbidity (FTU)						
April	1	1	0	10	9	5
July	30	30	30	49	20	20
October	20	10	45	20	20	20
pH						
April	7.2	7.2	6.7	7.3	7.5	7.0
July	7.1	6.9	6.9	7.1	7.0	7.5
October	7.2	7.1	6.8	7.1	7.3	7.6

Kinniconick Creek

Agricultural runoff (sediments, barnyard waste, pesticides, herbicides, etc.), wastes from small sawmill operations within the drainage, runoff from timber removal operations, creek gravel removal, and sewage from septic drains along its course, particularly the more populated area in the vicinity of Garrison, Kentucky, contribute to impacting the water quality in Kinniconick Creek. Also, as in many streams throughout the state, garbage is occasionally deposited into the creek or along its banks. Of special concern to the Kinniconick Creek drainage and the muskellunge fishery is the plan for extracting oil shale in the area. This stream flows through a belt of Devonian age oil shale deposits. The results of mining for oil shale will undoubtably have a detrimental impact on the fishery and all aquatic life in the stream.

Tygarts Creek

The Tygarts Creek basin is more populated than in the Kinniconick basin. Sources of pollution into Tygarts Creek are agricultural runoff, sewage from Olive Hill and South Shore, Kentucky, septic drains throughout the stream course, clay (mostly abandoned) and coal (small scale) mining activities, rock quarry operations, timber removal operations, and the removal of creek gravel. Garbage disposal by local residents is also a problem. Old tires are commonly observed in the stream from the Olive Hill area to the Carter/Greenup County line. Channelization work for flood control, authorized by the U.S. Corps of Engineers, has been completed on Tygarts Creek at Olive Hill, Kentucky.

A potential project that would definately alter a portion of Tygarts Creek is the authorized, but deferred, Kehoe Lake project (U.S. Corps of Engineers, Huntington District). The Kehoe Lake damsite would be located 48.5 mi above the mouth of Tygarts Creek and 1.7 mi above Kehoe, Kentucky at the Greenup/Carter County line. The minimum, recreation, and flood control pools would have corresponding pool areas of 666, 845, and 1,559 acres, respectively (USCE 1981).

The only significant difference between any water quality measurements on both streams was for total alkalinity. Alkalinity was about 3.3 times greater at Tygarts Creek. Alkalinity values increased from the lower station upstream to the upper station; part of the reason for a greater value in the upper section may be due to runoff from the rock quarry above the upper station.

Bottom Fauna

Kinniconick Creek

Little data is available on benthic macroinvertebrates in Kinniconick Creek. Warren (personal communication 1982) is currently writing a manuscript on the findings of a mussel survey that he conducted on Kinniconick Creek.

Seasonal benthic macroinvertebrate findings at 3 stations sampled in 1981 are shown in Table 24. Diversity ($\bar{d}$) and equitability (e) were fairly uniform throughout the stream in the spring. These values indicate near unpolluted water conditions. Diversity values from the summer samples at the lower and upper stations are similar to values in the spring and continue to indicate near unpolluted conditions. Diversity and equitability values at the middle station suggests somewhat degraded conditions. Based on fall samples, $\bar{d}$ and e values at the lower station indicate little degradation, while $\bar{d}$ and e values at the middle and upper stations indicate somewhat degraded conditions. More numbers of taxa were collected in the fall at the middle and upper stations that at the lower station. Numbers of taxa were similar at all three stations during all three seasons, except at the lower station in the summer where there were slightly more numbers. If those taxa with only one individual were excluded, e values would be higher throughout all samples at both Kinniconick and Tygarts creeks.

Low water levels during the summer and fall of 1981 did not appear to have an adverse impact on the benthic macroinvertebrate community, based on $\bar{d}$ and e values.

Tygarts Creek

Table 25 shows the results of seasonal benthic macroinvertebrate sampling at three stations in Tygarts Creek in 1981. Benthic invertebrate surveys had previously been conducted on Tygarts Creek by Harker et al. (1979) who presented a listing of the macroinvertebrate fauna collected from several tributary streams. Taylor (1980) also conducted a mussel survey within Tygarts Creek; Zeto (1979, 1980) reported a new mussel record from Tygarts Creek. The specimen, Lasmigona subviridis, had not previously been recorded from Kentucky. Specimens of Palaemonetes kadiakensis (glass shrimp) were taken while electrofishing from Station 2.

Results from this study showed that the lower section of Tygarts Creek, at fish sampling Station 2, had relatively unpolluted conditions in the spring, based on $\bar{d}$ and e values, and moderate degradation in the summer and fall. Slight degradation was indicated at the middle and upper stations in the spring and summer, but near unpolluted conditions existed at these locations in the fall. Diversity values in the summer were fairly uniform at all three stations. Diversity values in the fall were high, near or at 3, at the middle and upper stations; $\bar{d}$ was below 2 at the lower station. However, more taxa and total numbers of individuals were higher at the lower station in the fall than during any other time at any of the stations. Part of this occurrence is due to a greater number of taxa having only one individual in the fall sample.

The number of taxa was consistently higher at the lower and middle stations than at the upper station, except in the fall. During the summer, all three stations had lower numbers of families represented in the samples than in the spring and fall.

Table 24. Number of individuals per taxa, composition, density, diversity ($\bar{d}$), and equitability (e) values for benthic macroinvertebrates collected seasonally at three stations in Kinniconick Creek in 1981. The total sample from each station is from 2 square meter riffle areas.

	Stations								
	April 22			July 15			October 9		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Turbellaira:									
Planariidae									4
Nematoda								5	
Oligochaeta:									
Lumbriculidae	5	4	1		2		7		16
Tubificidae							4		
Cladocera:									
Daphnidae							3		2
Ostracoda				1					1
Isopoda:									
Asellidae				2			8		
Amphipoda:									
Gammaridae									1
Decapoda, Orconectes	2					4		1	2
Hydracarina							5	2	
Plecoptera:									
Nemouidae	3								
Perlidae	1		1	2	3				
Perlodidae	3	11	12		2			1	
Taeniopterygidae	1								
Ephemeroptera:									
Baetidae	41	21	20	3	1	5			
Ephemerellidae	30	9	33			2	5	4	13
Heptageniidae	14	37	26	131	301	104	10	9	4
Siphlonuridae	9	3	3	64	30	1	9	34	

Table 24 continued....

	Stations								
	April 22			July 15			October 9		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Odonata:									
Aeshnidae	1								
Coenagrionidae		1		1			17	14	9
Gomphidae				1	1	1			1
Libellulidae							3		
Megaloptera:									
Corydalidae				12	1			12	5
Sialidae			1			23			14
Trichoptera:									
Helicopsychidae			1						3
Hydropsychidae				24	10	10	5	570	5
Hydroptilidae				3					
Philoptamidae				2			66		
Polycentropodidae	29	25	16	2			1	1	
Coleoptera:									
Dryopidae	1		2	1		20		10	7
Elmidae				1	1				
Gyrinidae					1			1	
Psephenidae			1			1		2	3
Diptera:									
Chironomidae	9	3	45	37	36	53	74	17	218
Empididae								6	
Rhagionidae								2	
Simuliidae	2	2							
Tipulidae		1				3	1		1
Gastropoda:									
Planorbidae								2	
Pleuroceridae		2		1				2	
Pelecypoda:									
Sphaeriidae							59	12	

Table 24 concluded.

	Stations								
	April 22			July 15			October 9		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
TOTAL	151	119	162	288	389	227	211	773	309
Number of taxa	15	12	13	17	12	12	15	21	18
Diversity ($\bar{d}$)	2.98	2.70	2.80	2.38	1.27	2.32	2.92	1.69	1.93
Equitability (e)	0.73	0.75	0.77	0.44	0.23	0.57	0.73	0.20	0.28

Table 25. Number of individuals per taxa, composition, density, diversity ($\bar{d}$), and equitability (e) values for benthic macroinvertebrates collected seasonally at three stations in Tygarts Creek in 1981. The total sample from each station is from 2 square meter riffle areas.

	Stations								
	April 27			July 15			October 9		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Nematoda	2	3	1		2				5
Oligochaeta:									
Lumbriculidae		18	15				9	18	42
Tubificidae									17
Hirudinea:									
Glossiphoniidae								1	
Ostracoda							9		26
Isopoda:									
Asellidae	1					1			
Amphipoda:									
Gammaridae	2					1	3		
Decapoda, Orconectes			1	8		5	1		
Hydracarina							1		
Plecoptera:									
Nemouridae	1	2			1				
Perlidae		1			2				
Perlodidae	14	45							
Ephemeroptera:									
Baetidae	26	51	10	2	1			20	13
Baetiscidae		1	2						
Caenidae		2		1					
Ephemerellidae	26	11	28		1	21	9	47	122
Ephemeridae								2	19
Heptageniidae	62	377	24	324	228	54	17	4	7
Siphlonuridae	2	18	3	180	24	1	3		

Table 25 continued....

	Stations								
	April 27			July 15			October 9		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Odonata:									
Coenagrionidae									2
Gomphidae	1	1						18	
Hemiptera:									
Corixidae							1		
Megaloptera:									
Corydalidae					1				
Sialidae						1	1	7	4
Trichoptera:									
Hydropsychidae		7	11	64	48		646	8	4
Lepidostomatidae			1						
Limnephilidae	1						1	2	3
Philopotamidae		3			1		1		
Polycentropodidae		1					1		
Lepidoptera:									
Noctuidae					1				
Coleoptera:									
Dryopidae			1	6	3		3	4	
Elmidae	2	6	1	4	1	1		5	
Gyrinidae				3	8				
Hydrophilidae							2		4
Psephenidae								1	
Diptera:									
Ceratopogonidae	1	1							
Chironomidae	106	43	152	84	46	26	314	68	29
Empididae	5			1	1			1	
Ephydridae							1		
Rhagionidae	1								
Simuliidae				1			1	2	
Syrphidae		1							
Tabanidae							1		
Tipulidae	16		1				10	2	

Table 25 concluded.

	Stations								
	April 22			July 15			October 9		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Gastropoda:									
Planorbidae							3		
Pleuroceridae	5					2	5		
Pelecypoda:									
Sphaeriidae	2			1			208		
Total	276	592	251	679	369	113	1,251	210	297
Number of taxa	19	19	14	13	16	10	24	17	14
Diversity ($\bar{d}$)	2.76	2.06	2.06	2.00	1.89	2.05	1.93	3.00	2.84
Equitability (e)	0.50	0.29	0.39	0.41	0.30	0.55	0.21	0.71	0.71

Management Recommendations

Kinniconick and Tygarts creeks are among the best non-impounded, native muskellunge streams remaining in Kentucky. More emphasis on protecting and managing these streams should be carried out than has been conducted in the past.

The most important need in managing the muskellunge stream fisheries at Kinniconick Creek, Tygarts Creek, and all other native muskellunge streams is to assure the integrity of the stream habitat and water quality. Any drastic change in land use pattern within the two drainages should be closely monitored to prevent any detrimental impact on the fisheries. State and federal agencies involved in the responsibilities of water quality enforcement should see that any discharge into these streams does not exceed levels of established or future water quality criteria standards for these streams. Both Kinniconick and Tygarts creeks should be included as Outstanding Resource Waters and be given high priority in decision making processes that may affect either stream or its tributaries. Findings from this study and Brewer's study should be used for the protection of further encroachment on muskellunge habitat within these two streams and other native muskellunge streams upon completion of this study on those streams.

In order to increase the muskellunge population to near carrying capacity and provide more quality-size fish for anglers to catch and harvest, Kinniconick and Tygarts creeks should be stocked every year at a rate of no more than one fingerling muskellunge, 7-9 in long, per 2 acres of muskellunge pool habitat. At this rate, the annual stocking would be 100 fish at Kinniconick Creek and 200 fish at Tygarts Creek. This is also the rate recommended by Brewer that was never properly inacted. Year-class strength from 2 of 3 years of stocking in 1973, 1976, and 1979 at each stream did demonstrate the contribution that supplemental stockings can provide. By reducing the rates of stocking from those 3 years to the recommended rate and stocking each year instead of every 3 years, more year classes of muskellunge should benefit to assure a more consistent recruitment of fish on an annual basis. Annual stockings would be expected to also provide a more consistent and better quality fishery on an annual basis.

Muskellunge stocked into Kinniconick Creek should be released into the larger pools that have good access from stream mile 0 through mile 38. Those released into Tygarts Creek should be stocked into accessible pools from the mouth to mile 75, with greater numbers being stocked in the lower 30 miles during alternate years. A map will be prepared and submitted to fish transportation personnel that shows the location of preferred stocking sites.

The importance of debris in both streams for muskellunge habitat supports the need to preventing any major reduction of trees along the riparian zone. In fact, the muskellunge populations in both streams would probably benefit from expanding the population of trees along the stream bank.

A few pre-selected pools that have the best concentration of muskellunge should be sampled by electrofishing 4 years after beginning with annual stockings to determine the success of strengthening each year class by stocking. This effort

should be conducted on each musklellunge stream after being investigated and subsequently stocked for 4 years. Number, catch rate, and year-class strength of muskellunge should be compared with findings from this study in the same pools. Any changes in species composition should also be noted.

In the future, muskellunge fingerlings that are to be stocked should be tagged so they can be recognized for at least 4 years after stocking, if a marking technique is available that has that much longevity. This should be carried out in order to acquire more conclusive information on the impact and survival of muskellunge stocked into Kentucky streams.

Acknowledgements

I wish to express my gratitude to my able assistant, Albert F. Surmont, Jr., whose assistance and suggestions proved invaluable throughout all phases of the project. Credit is also due to summer aides Bill Adkisson and Anthony Gerard.

Thanks go to Jim Axon who initially set up the project, provided constructive suggestions throughout its course, always had new ideas to add to the workload, and edited this report. Dan Brewer also volunteered beneficial suggestions, and his report, A Study of Native Muskellunge Populations in Eastern Kentucky Streams, was most useful.

I also wish to express my appreciation to Dr. Gerald DeMoss of Morehead State University for his time and effort involved in identifying and confirming the identification of benthic samples that were picked and identified by Albert Surmont. I thank Mel Warren of the Nature Preserves Commission for confirming my identification of several of the more uncommon cyprinids and percids. Thanks also are extended to Karen Hukill for her fine job at typing this report.

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APPENDIX A

Table A-1. Lengths and corresponding empirical and calculated weights of muskellunge collected from Kinniconick Creek (duplicate lengths excluded).

Total length (in)	Empirical weight (lb)	Calculated weight (lb)
10.3	0.20	0.18
10.9	0.28	0.22
11.8	0.26	0.29
12.2	0.32	0.32
12.3	0.32, 0.38	0.33
13.2	0.36	0.42
13.5	0.39	0.45
13.8	0.52	0.48
19.9	1.56	1.59
21.1	1.74	1.93
21.9	2.15	2.17
22.0	1.98	2.21
23.0	2.22	2.55
23.8	3.17	2.85
23.9	2.72	2.89
25.8	3.42	3.72
26.3	4.42	3.96
28.1	4.98	4.91
29.8	6.84	5.95
30.0	6.45, 6.66	6.08
30.6	7.40	6.49
31.8	6.96, 7.20	7.36
32.5	8.90	7.90
32.8	7.15	8.14
33.0	7.32	8.30
33.4	8.68	8.64
34.0	9.15	9.15
34.2	10.02	9.33
34.5	9.34	9.60

Table A-2. Lengths and corresponding empirical and calculated weights of muskellunge collected from Tygarts Creek (duplicate lengths excluded).

Total length (in)	Empirical weight (lb)	Calculated weight (lb)
12.4	0.32	0.33
12.8	0.34	0.37
13.1	0.46	0.40
13.4	0.34	0.43
13.5	0.46	0.44
13.6	0.54	0.45
13.8	0.52, 0.54	0.47
14.0	0.50	0.50
14.3	0.48	0.53
14.6	0.58	0.57
15.0	0.56	0.62
15.1	0.68	0.64
15.2	0.66	0.65
15.3	0.65, 0.68	0.67
15.6	0.70	0.71
15.8	0.78	0.74
16.1	0.80, 0.81, 0.73	0.79
17.4	1.04	1.02
19.0	1.25	1.36
19.5	1.38	1.48
20.0	1.58	1.61
20.5	1.88	1.75
21.5	2.06	2.05
22.0	2.24	2.21
22.2	2.30	2.27
22.3	2.52	2.31
22.5	2.28	2.38
22.8	2.46	2.48
24.3	3.21	3.06
24.8	3.14	3.28
26.8	4.22	4.23
27.0	4.05	4.33
27.2	4.48	4.44
27.8	4.90	4.77
28.1	5.62	4.94
28.3	4.18	5.06
28.4	5.18	5.12
28.8	5.02, 5.20	5.36
29.5	5.12	5.80
30.0	4.21	6.13

Table A-2 concluded.

Total length (in)	Empirical weight (lb)	Calculated weight (lb)
30.2	6.22, 6.74	6.27
30.3	6.24	6.34
30.5	7.26	6.48
31.1	6.62	6.90
31.3	7.54	7.05
31.6	7.83	7.28
32.0	7.64	7.58
32.7	9.18	8.14
35.3	9.60	10.48
38.5	18.75	13.95