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Population Distribution and Demographics of Smallmouth Bass (Micropterus dolomieu) in Silver Creek, Madison County, Kentucky

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Population Distribution and Demographics of Smallmouth Bass

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By

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DEDICATION

This thesis is dedicated to my parents Greg and Lisa Basham, my brother Jake Basham, my grandparents Glen and Barbara Johnson, and all my aunts and uncles for their constant support and love given to me throughout my life and in pursuit of my dreams and for teaching me to go after what you want, but not to be afraid to pay the price involved and to never forget where you came from.

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Abstract

The objective of this study was to determine the population distribution and demographics of smallmouth bass *Micropterus dolomieu* in Silver Creek, Madison Co, KY. The stream was electro-shocked at 19 locations during the Fall of 2011 and Spring of 2012. At each stream site width (m), depth (m), flow (m/s), and percentage of substrate type pool, riffle, run was recorded across transects as the microhabitat. Kentucky Division of Water's rapid habitat assessment was used to assess the habitat within the stream and the riparian vegetation surrounding the stream. The majority of smallmouth bass collected in Silver Creek were collected in runs and heads of riffles. In addition a large number were collected from under large rocks with deep ledges. Stepwise regression analysis indicated the presence of gravel and vegetation accounted for 43.4% ($p<0.05$) and 12.6% ($p<0.05$) of the variation in catch per unit effort (CPUE) of smallmouth bass among all sites. A total of 251 smallmouth bass were collected and 54.4% were age 0. Weights of smallmouth bass caught from Silver Creek followed the relative weight curve for smallmouth bass of specific lengths caught from other streams in the region. Silver Creek was among the top streams of its size in smallmouth bass abundance in Kentucky according to data from this study and information collected by the Kentucky Department of Fish and Wildlife Resources (KDFWR).

Keywords: *Micropterus dolomieu* (smallmouth bass), relative weights, population distribution, demographics, abundance, predominant substrate.

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CHAPTER 1

Introduction

Smallmouth Bass

Smallmouth Bass (*Micropterus dolomieu)* are freshwater game fish of the Order Perciformes and Family Centrarchidae native to the temperate regions of the United States (Etnier and Starnes 1993). However, they have been introduced throughout the western and northeast United States as a way to improve fisheries for recreational angling purposes (Sharma *et al.* 2009).. Optimal smallmouth bass habitat is characterized by cool, clear, mid-order streams >10.5 m wide; these streams have an abundance of shade and cover and contain deep pools, moderate current and rocky substrate (Edwards *et al.*1983) Smallmouth bass prefer underwater structures such as logs, treetops, and rock outcroppings much like the other black basses(Carey *et al* 2011). Altena (2003) found that smallmouth bass in the upper Mississippi River predominately used eddies created by rock or woody debris; these areas also had a substrate composition of sand in areas >1.2 m^2, with sand/silt in areas <1.2 m^2. In Arkansas, adult smallmouth bass were primarily collected within runs containing rocky substrate and submerged woody debris; with juvenile smallmouth bass being collected in riffles at the head of runs (Johnson *et al.* 2009).

Smallmouth bass are a light brown color with dark green vertical stripes that act as camouflage against predators when they are juveniles and to conceal them from prey as adults (Fiss and Churchill 2003). Fry feed on microcrustaceans, while juvenile smallmouth feed on crayfish, larger insects and smaller fish (Edwards *et al.* 1983). Adults generally feed on larger fish and crayfish depending on prey abundance (Fiss and Churchill 2003). Like many of the other black basses, smallmouth bass spawn in April and May, when water temperatures reach 15°-17° C (Altena 2003).

In streams, smallmouth bass can reach up to 530mm in length and be 15 years old; on average they reach 350mm by age 6 in streams and by age 4 in reservoirs (Fiss and Churchill 2003). Orth *et al.* (1983) found that smallmouth bass in Glover Creek in southeast Oklahoma had a maximum age of 6 years; however 79% of their sample was found to be < 3 years of age. Glover Creek also supported a population of smallmouth bass that ranged in mean weight from 4-146 grams (g) and mean length of 60-242 millimeters (mm) in fishes between the ages of 0-3 years (Orth *et al.*1983). The Glover Creek study also found lower growth rates when compared to smallmouth bass in larger rivers and reservoirs. This is expected since there is more readily available food in larger rivers and reservoirs (Orth *et al.*1983). Dauwalter *et al.* (2007) found that third order streams yielded higher abundances of smallmouth bass than did smaller order streams; most likely due to the higher percentage of spawning habitat in the streams. Jansen *et al.* (2008) sampled six Iowa rivers and found the relative weight of smallmouth bass generally decreased with an increase in the length of the rivers sampled. However, smallmouth sampled from the Tennessee River in Alabama indicated the opposite; i.e., mean relative weight averaged over 100g for smallmouth bass > 300mm in length (Jansen *et al*. 2008).

Water temperature has been shown to affect the variability in relative weight of smallmouth bass (McClendon *and* Rabeni 1987). Edwards *et al.* (1983) found that growth in *M. dolomieu* does not begin until water temperatures reach 10-14°C, with adults preferring temperatures ranging between 21-27°C (Edwards *et al.* 1983). Once temperatures drop between 15-20°C smallmouth bass migrate to dark areas in deep pools; as the temperature falls to 6-7°C smallmouth bass seek shelter under rocks (Edwards *et al.* 1983). The protection of riparian vegetation and maintenance of good water quality are very important to having optimal smallmouth bass habitat (Fiss *and* Churchill 2003).

Fiss *et al* (2001) found that by increasing the minimum length of fish kept by anglers in a system where most of the population mortality is from angling, agencies could potentially increase the number of quality size (350mm) fish in the system. Therefore, when smaller fish are protected from angling mortality; the number of quality fish in the system should increase. The drawback to this is to not set the minimum length limit too high since many streams are not able to support a large population of trophy size fish (Fiss *and* Churchill 2003). Streams that support a low smallmouth bass population should be managed carefully in order to increase the population size. Simple stocking is not always the answer; as with any other stocking projects precautions should be taken. Silver Creek in Madison Co., KY, is not known for trophy size smallmouth bass; instead most fish caught from Silver Creek are of medium size (200-300mm) and within the legal limit (KDFWR, 2012). The Kentucky Department of Fish and Wildlife Resources (KDFWR) does not typically manage wadeable streams; thus, there are no data on the smallmouth bass population in Silver Creek.

The purpose of this study was to determine the population distribution and demographics (i.e. abundance, age, size, and condition) of smallmouth bass in Silver Creek, Madison County, Kentucky. In addition, smallmouth bass abundance in Silver Creek was compared to abundance in other streams in Kentucky to determine if abundance was similar. I determined the relationship between habitat parameters (i.e., physical instream variables such as stream depth, flow, and substrate composition, riparian attributes, such as vegetative protection and riparian width) and smallmouth bass in Silver Creek, and determined if these relationships changed with landuse (forested, partially forested, nonforested).

CHAPTER 2

Study Area

The study was conducted in central Kentucky on Silver Creek in Madison County. Silver Creek's headwaters (37° 33' 48.3012" N, 84° 15' 31.7586"W) are located near Berea, Kentucky, and the stream empties into the Kentucky River (37° 47' 48.285" N, 84° 28' 27.771" W) northwest of Richmond, Kentucky. Silver Creek is located in the Outer Bluegrass Ecoregion of Kentucky (USGS 2012). The headwaters are at the edge of the Knobs region, while the mouth of the stream is located at the edge of the Inner Bluegrass region. Silver Creek is a medium sized creek that varies in depth from < 0.5m to 2.5m at normal flow, and meanders north from Berea for approximately 64 km to its mouth at the Kentucky River (USGS 2012). The area contains fragmented plots of deciduous hardwood trees, row crops, beef and dairy cattle operations, and subdivisions. Silver Creek shows little evidence of channelization and supports varying amounts of riparian vegetation and adjacent deciduous hardwood forest.

CHAPTER 3

Methods

A total of 19 randomly chosen sites were sampled for smallmouth bass during Fall 2011 and Spring 2012 (Table 1)[1]. Site 1 was located nearest the mouth of Silver Creek; sites were numerically designated in ascending order until reaching the stream's headwaters near Berea, Kentucky (Figure 1). Sites were sampled for smallmouth bass using a LR-24 backpack electro-fisher (Smith-Root, Vancouver, WA) for at least 600 shocking seconds, and no more than 2000 shocking seconds, in a 200m reach within Silver Creek; with each reach containing at least 2 pools, 2 riffles, and 2 runs (KDOW 2008). A block net was used in an effort to keep larger fish from escaping upstream (as larger fish are sometimes more difficult to collect using a backpack electro-fisher). Every smallmouth bass captured was weighed using a portable digital scale (g), and measured for total length (TL; mm) (Johnson *et al.* 2009). Scales were taken from each smallmouth bass for determination of age and growth (Murphy and Willis 1996). Scale samples were collected from above the lateral line below the anterior base of the dorsal fin (Murphy and Willis 1996). Five scales were taken from each fish to account for any scales that were potentially regenerated due to prior injuries. Scales were placed in separate labeled vials and taken back to the laboratory to be aged. All smallmouth bass were released unharmed.

Water temperature (°C), dissolved oxygen (mg/l), pH, and conductivity (µmhos) were measured with a YSI multi-probe handheld portable meter (Yellow Spring

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[1] Tables are present in Appendix A. Figures are located in Appendix B.

Instruments Inc., Yellow Springs, OH) placed midstream at the downstream end of each sample site. At each site, a transect spanning the width of the stream was placed within each of the two riffles, two runs, and two pools. The width of each transect was determined using a TruPulse 200 range finder (Laser Technology Inc., Centennial, CO). Each transect was divided into 5 equally spaced sampling points. At each point, I determined stream depth (m), flow velocity (m/s), and visually assessed the substrate composition, which consisted of percent cover of bedrock/boulder, gravel, cobble,sand/silt, and detritus. Stream depth was determined using a calibrated wading rod; and flow was measured using a March-McBirney flow meter (Marsh-McBirney Inc., Frederick, MD) with the sensor attached to the wading rod. The wading rod was placed on the stream bed with the sensor placed at approximately 60% of the water depth.

Using the Kentucky Division of Water Rapid Bioassessment Protocol (RBP, KDOW 2008), I assessed habitat conditions at each site within the stream as well as the riparian vegetation and land directly surrounding the stream. Within the stream channel, the KDOW protocol addresses epifaunal substrate/available cover, embeddedness, velocity/depth regime, sediment deposition, channel flow, channel alteration, and frequency of riffles or bends. Each of these parameters received a score of 0-20. In the riparian zone the protocol addresses bank stability, vegetative protection on the bank, and riparian vegetative zone width (KDOW 2008). The three parameters for assessing the riparian area were scored on a scale of 0-10 for each bank while looking downstream. The KDOW (2008) protocol for rapid bioassessment is on a scale from 0-

200. For this study, a score of 0-50 represented poor habitat, 51-100 marginal, 101-150 suboptimal, and 151-200 optimal conditions.

I recorded the types of land use practices around the sites sampled in this study to determine if any relationship existed between the habitat parameters and abundance of smallmouth bass. Three categories were determined based on forestation surrounding each stream site; “nonforested” indicated no riparian vegetation on left and right banks, “forested” indicated riparian vegetation on both banks, and “partially forested” indicated riparian vegetation on one bank.

To determine smallmouth bass abundance in Silver Creek, catch per unit effort (CPUE) was calculated for each site electro-shocked (Johnson *et al.* 2009) and expressed as number of smallmouth bass collected per hour. The CPUE data were compared among sites within Silver Creek as well as with other streams in Kentucky sampled by the KDFWR. These included streams in eastern Kentucky as well as one in western Kentucky; i.e., Left Fork of Beaver Creek, Knox Creek, Middle Fork of Kentucky River, Poor Fork, Tug Fork, Line Fork, Quicksand Creek, Troublesome Creek, Russell Fork (Eastern Kentucky Fisheries District), Barren River (Western KentuckyFisheries District), upper Cumberland River, South Fork of the Kentucky River, and Little South Fork of Kentucky River (Southeastern Kentucky Fisheries District). Data collected from Silver Creek was compared with the data from the afore mentioned streams to provide an idea of how the smallmouth bass population in Silver Creek was doing relative to other streams in the region.

Relative weights were calculated for all smallmouth bass >149mm collected in Silver Creek to assess fish health (Murphy and Willis 1996). Relative weight is a ratio of the actual weight of a collected fish to what a rapidly growing healthy fish of the same length should weigh (Murphy and Willis 1996). To calculate the relative weights for each smallmouth bass caught, I divided the actual weight (in grams) of each fish caught by the standard weight of a fish of the same length (Murphy and Willis 1996). Thus, relative weight is given by the following equation: W = $\frac{W}{W_s}\ X\ 100$, (Murphy and Willis 1996) where *W* is the weight of an individual and W_s is a length specific standard weight. The standard weight functions are obtained from $W_s = a'L^{b'}$. A mean W_r of 100 across a broad range of size groups is indicative of ecological and physiological optimality (Murphy and Willis 1996). For W_r values well below 100, there are problems with food availability.

In the laboratory, smallmouth bass scales were placed on a drop of glycerin (which aids in clearing the scales and providing a better view of annuli) between two microscope slides and the slides taped together at the ends to hold scales in place for viewing. Slides were labeled with the individual fish's locality, length, and weight. A stereoscope with a mounted video camera and widescreen television was used to view each scale. Aging was determined by myself and two others during separate events. To determine the age of each fish the annuli were counted on each scale, with each annulus representing one full year of growth. The number of annuli on each scale was totaled to determine an age for that particular fish. Age determinations were compared for each fish and any discrepancies were discussed and a consensus of each fish's age was reached.

Smallmouth bass growth was determined from back-calculated lengths, which were based on distances measured between the focus and annular marks (Murphy and Willis 1996). The distance between the focus and each subsequent annulus was measured and recorded. The final distance was measured between the focus and the edge of the scale. Using the distance measured from the focus to the edge of the scale, and the actual length of the fish, a proportion was calculated. By multiplying the above proportion to the actual length of the smallmouth bass, it was possible to estimate the length of each smallmouth bass in every year of its life. These differences represent the amount of growth that took place each year of the smallmouth bass's life (Murphy and Willis 1996). Mean growth rates were determined for each age class.

CHAPTER 4

Data Analysis

A step-wise regression was used to discern the relationship among riparian variables (i.e. sediment deposition, bank stability, vegetative protection, and riparian width), predominant substrate, flow velocity, stream depth, and stream width with CPUE of smallmouth bass across all sites. A second stepwise regression was used to discern the same relationships by landuse type to determine if the relationships differed among the three landuses. Flow velocity, stream depth, and width were $\log_{10}$ transformed and substrate relative abundances arcsin square root transformed to normalize the data (Zar 1999).

CHAPTER 5

Results

A total of 251 smallmouth bass were collected, of which 54% were “age 0” (i.e. they were in their first year of growth, Figure 2). Sample sites closer to the mouth of Silver Creek typically yielded greater abundance (Figure 3) and larger smallmouth bass (Figure 4) than other sites upstream.

Silver Creek ranked near the middle for average smallmouth bass CPUE in comparison with CPUE data provided by the KDFWR (Figure 5). There were only 8 streams that yielded higher CPUE’s of smallmouth bass than did Silver Creek and three of those eight are larger order streams (Figure 5). Silver Creek exhibited a higher abundance of smallmouth bass ranging in size from 0-300mm than the upper Cumberland River and South Fork of the Kentucky River (Figure 5). Smallmouth bass in Silver Creek ranged in year classes from 0-4 (Table 2).

Mean (+/- SE) relative weights for smallmouth bass >149mm was 108.63 +/- 31.74g, indicating that individuals in Silver Creek are healthy. Growth rates indicated that smallmouth bass collected from Silver Creek averaged 91.95mm +/-2.63mm of growth in year class 0-1, and 62.78mm +/- 3.46 of growth in year class 3-4 (Figure 6).

A step-wise regression showed only gravel and stream flow to be significantly related to CPUE across all sites. Gravel was negatively associated with smallmouth bass abundance and accounted for 43.4% of the variation ($p<0.05$) while stream flow was positively associated, accounting for 12.6% ($p<0.05$). Vegetative protection accounted for 73% of the variation ($p<0.05$) in CPUE across non-forested sites. Other landuses (i.e., partially forested and forested) showed no significance with any of the parameters and CPUE.

CHAPTER 6

Discussion

Smallmouth bass ages in Silver Creek ranged from 0-4 years. In Iowa, Jansen *et al.* (2008) reported collecting smallmouth bass 0-8 years of age. Jansen *et al.* (2008) also reported collecting smallmouth bass of lengths greater than 450mm; the largest smallmouth bass collected in Silver Creek was 355mm. Silver Creek also had a lower abundance of preferred size (KDFWR 2012) smallmouth bass (>350 mm). Orth *et al.* (1983) reported smallmouth bass collected from Glover Creek in eastern Oklahoma to be between 0-6 years old, with a maximum length of 346 mm. Silver Creek and Glover Creek show the same type of trend in number of fish per age class, i.e. there was a greater amount of smallmouth bass ages 0-2 than smallmouth older than 3 years of age.

Smallmouth bass collected in Silver Creek reached 300mm in length between the ages of 3 and 4. Johnson *et al.* (2009) found that smallmouth bass collected in the Lower Eleven Point River in Arkansas reached lengths of 305mm between 3 and 4 years of age. Silver Creek and Arkansas's Lower Eleven Point River exhibited rapid growth rates, however Jansen *et al.* (2008) used otoliths to age fish while I used scales. It has been reported that the use of scales greatly underestimates the actual age of fish (Beamish and McFarlane 1987).

Jansen *et al.* (2008) reported three of the Iowa streams that were sampled to have a CPUE similar to Silver Creek. However, the other three streams sampled by Jansen *et al.* (2008) reported a much higher CPUE (> 50) than was found at Silver Creek (24.81). The majority of smallmouth bass in Silver Creek were collected in runs, similar to what was reported for smallmouth bass in Iowa Rivers (Jansen *et al*. 2008). Johnson *et al.* (2009) reported that smallmouth bass abundance was lower downstream in the Lower Eleven Point River in Arkansas, most likely due to the reduced amount of riffles and runs present. As the riffle/run habitat in Silver Creek increased, abundance of smallmouth bass generally increased. However, I also found that increased gravel at sites sampled had a negative correlation with CPUE of smallmouth bass in Silver Creek. Therefore, since most runs in Silver Creek were characterized by bedrock with slab rock and cobble, and most riffles were found to have an abundance of gravel; the sites with the highest CPUE's were those which exhibit good runs with little or no gravel.

Johnson *et al.* (2009) reported relative weight was consistent among length groups for smallmouth bass in Arkansas's Eleven Point River.Relative weight of *M. dolomieu* in Iowa generally decreased with increasing group length. Smallmouth bass in the Tennessee River showed an average relative weight >100 g for smallmouth bass >300mm in length (Weathers and Bain 1992). Smallmouth bass in the New River in Virginia were reported as having an average relative weight of 73-83 g (Austen and Orth 1988). Smallmouth bass in streams in lower latitudes have a higher relative weight average than do those in more northern states; these differences may be linked to water temperature as reported by (McClendon and Rabeni 1987). As water temperatures warmed in Silver Creek, smallmouth bass overall abundance at each site increased.

Fiss and Churchill (2003) indicate that spawning habitat and adequate water supply are two major factors in sustaining smallmouth bass fisheries. Johnson *et al.*

(2009) reported adult smallmouth bass were collected in runs associated with rocky substrate while the majority of juvenile smallmouth bass were collected in riffles or at the heads of runs. Optimum smallmouth bass habitat in rivers and streams is characterized by cool, clear water with abundant shade and cover , moderate flow, and a gravel and cobble substrate (Edwards *et al.* 1983). Altena (2003) found that smallmouth bass primarily used eddies characterized by sand and gravel. The majority of juvenile smallmouth bass were collected in riffles and along the banks of the stream; where large cobble and boulders were present. Adult smallmouth bass in this study were generally collected in areas with large cobble and boulders as well as in bedrock runs with submerged isolated areas of cobble and boulder.

Riparian habitat is important to sustaining a healthy population of smallmouth bass in any stream. Increased riparian zone width allows for more shade over the stream as well as less human disturbance to the habitat around the stream. I found that sampling locations with larger riparian zone widths tended to support a greater abundance of smallmouth bass; as well as a greater number of smallmouth bass of preferred size (>300mm in length). I also found that “non forested” sites had a larger CPUE when there was an increased amount of vegetation along the banks. This intuitively makes sense because increased vegetation on the banks along the stream help to prevent erosion of the stream bank. This in turn helps to keep the amount of silt in the stream bed to a minimum and thus allows for a higher flow rate that smallmouth bass prefer. If further studies on smallmouth bass in Silver Creek take place, I recommend that an equal number of forested, non-forested, and partially forested sites be sampled to get a more accurate representation of whether or not landuse is an important factor in determining smallmouth bass abundance in the stream.

Based on the data obtained in this study, Silver Creek appears to support a healthy population of smallmouth bass relative to the region in which it is located. However, there are places along Silver Creek that support a greater abundance of smallmouth bass than other areas. Data from this study suggest the smallmouth bass abundance throughout Silver Creek is predominantly influenced by the type and amount of available habitat within the stream (i.e., the amount of gravel and cobble present in the stream). However, prey abundance (specifically crayfish) may also be a factor in the abundance of smallmouth bass at sampling locations. Throughout the length of the stream there is an abundance of aquatic insects for smallmouth bass of ages 0 to 1 to prey upon. Probst *et al.*(1984) states that crayfish contain the most calories of all smallmouth bass prey (i.e., crayfish, fish, aquatic insects). I recommend that future smallmouth bass research in Silver Creek investigate the influence of crayfish abundance, sunfish abundance, and aquatic insects on smallmouth bass numbers. I hypothesize areas with a high abundance of aquatic insects and low abundance of crayfish and sunfish will support a higher abundance of smaller smallmouth bass than areas with a greater abundance of crayfish and sunfish species.

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APPENDIX A:

TABLES

Table 1

Smallmouth bass sampling sites along Silver Creek, Madison Co., KY, 2011-2012.

te #	Site Locality	Latitude(N)/ Longitude(W)	Sample Date
1	Maple Grove (downstream)	37.77516/084.46778	12 Apr 2012
2	Maple Grove (upstream)	37.76823/084.45741	12 Apr 2012
3	Jigwater (downstream)	37.75463/084.45424	28 Feb 2012
4	Jigwater (upstream)	37.74792/084.45060	28 Feb 2012
5	Bogey Mill (@ crossing)	37.73545/084.43735	11 Nov 2011
6	Bogey Mill (Lynn's Farm)	37.72305/84.415331	7 Nov 2011
7	Barnes Mill Rd (Falls 1)	37.71159/084.39404	27 Mar 2012
8	Barnes Mill Rd (Falls 2)	37.70844/084.41920	27 Mar 2012
9	Minerich Farm 1	37.71706/084.37817	4 Oct 2011
10	Minerich Farm 2	37.71464/084.37450	4 Oct 2011
11	Julia Adams Farm	37.69144 /84.31544	19 Apr 2012
12	Hagans Mill (downstream)	37.69492/084.36206	6 Oct 2011
13	Hagans Mill (upstream)	37.69170/084.36129	6 Oct 2011
14	Barnes Farm 1	37.65456/084.36606	18 Oct 2011
15	Barnes Farm 2 (Moran Summit Rd)	37.64547/084.35027	18 Oct 2011
16	25 Bridge (downstream)	37.60058/084.25850	7 Feb 2012
17	25 Bridge (upstream)	37.60208/084.28046	7 Feb 2012
18	1016 & Shortline Pike	37.58754/084.26866	1 Feb 2012
19	Silver Creek Baptist Church(headwater)	37.56363/084.25887	6 Feb 2012

Table. 2**.**

Smallmouth bass ages per collection site in Silver Creek, Madison Co., KY, 2011-2012.

Collection Site	Year 0-1	Year 1-2	Year 2-3	Year 3-4	Total
1	9	1	4	0	16
2	8	5	4	1	18
3	21	1	0	0	22
4	14	4	31	11	60
5	5	0	0	0	5
6	6	1	0	0	7
7	18	0	3	0	21
8	19	10	6	1	36
9	11	2	0	0	13
10	3	4	0	0	7
11	4	4	11	1	20
12	0	2	2	1	5
13	8	1	1	0	10
14	4	0	0	0	4
15	4	0	0	0	4
16	1	0	0	0	1
17	0	0	0	0	0
18	2	0	0	0	2
19	0	0	0	0	0
Total # of individuals	136	35	62	15	251

APPENDIX B:

FIGURES

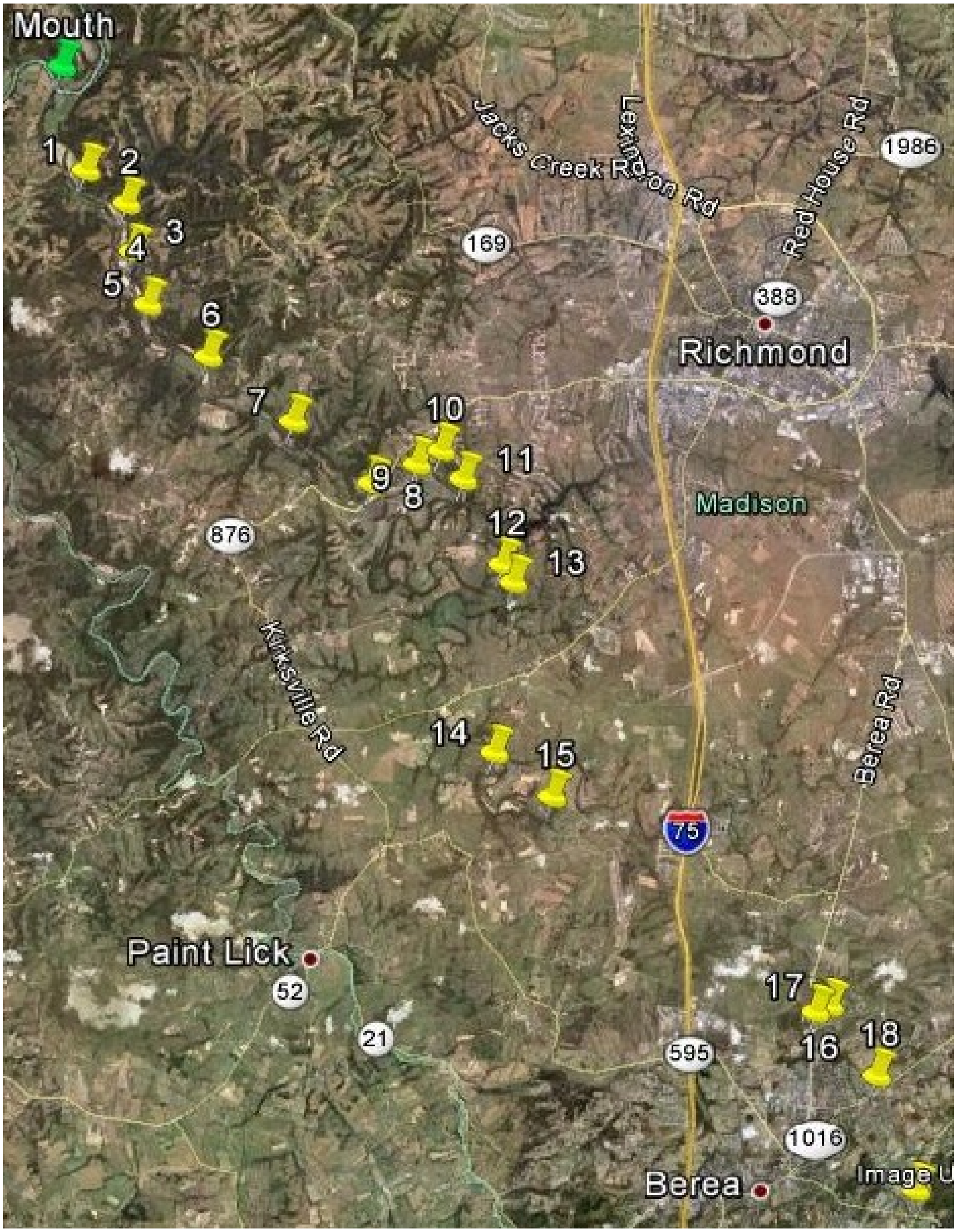


Figure 1**.** Smallmouth bass sampling locations in Silver Creek, Madison Co., KY, 2011-2012

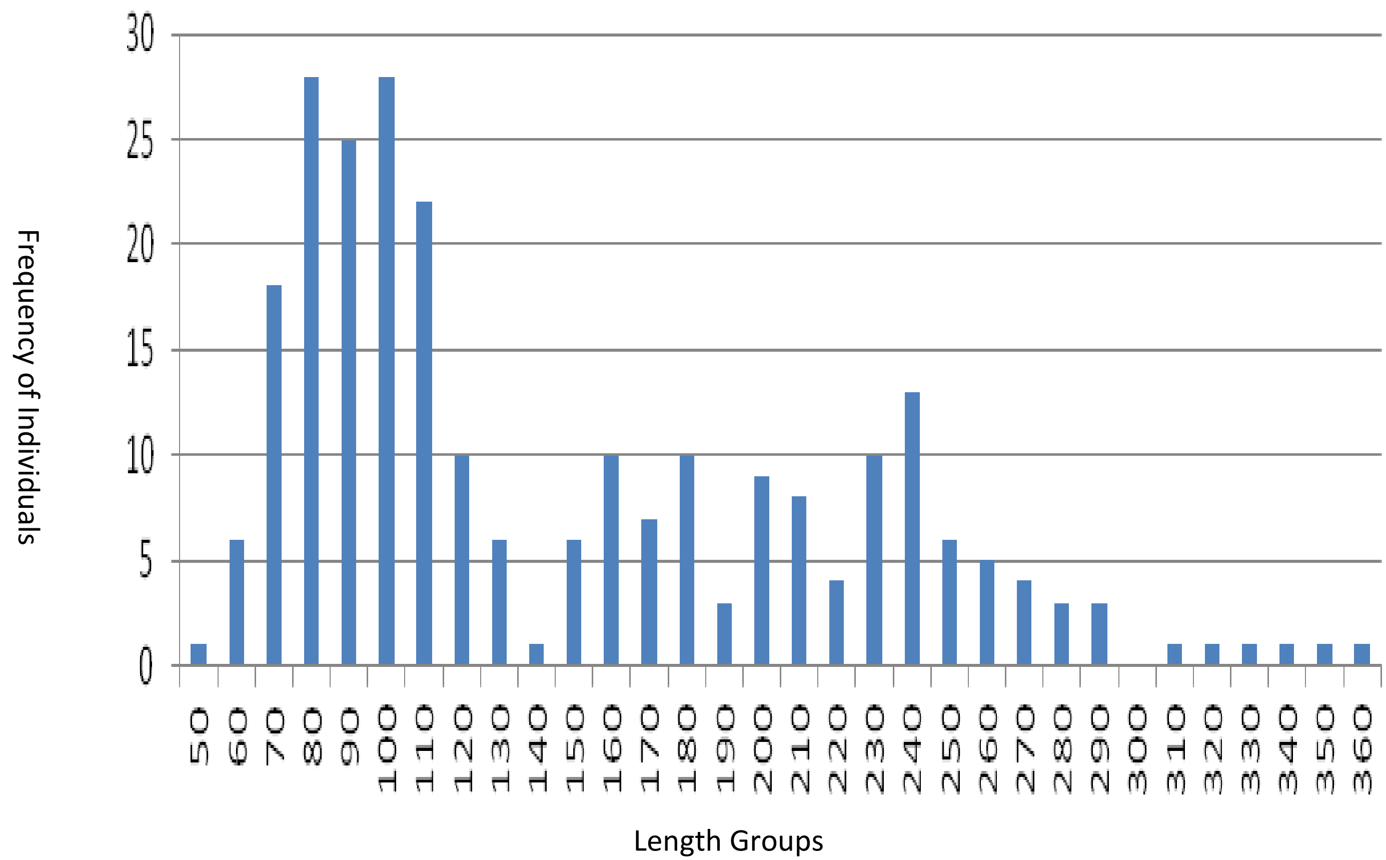


Figure 2. Length frequency groups of smallmouth bass collected in Silver Creek, Madison Co., KY, 2011-2012.

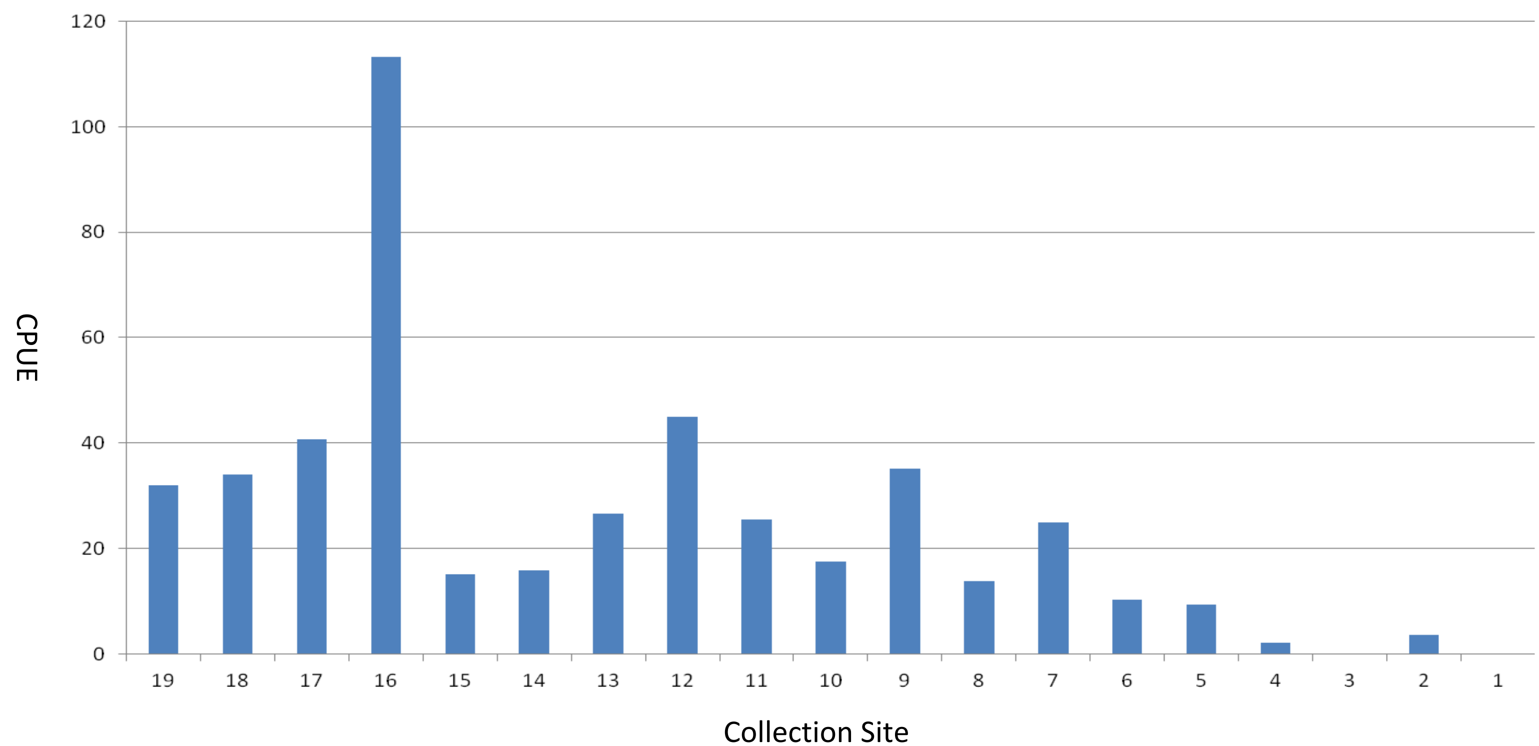
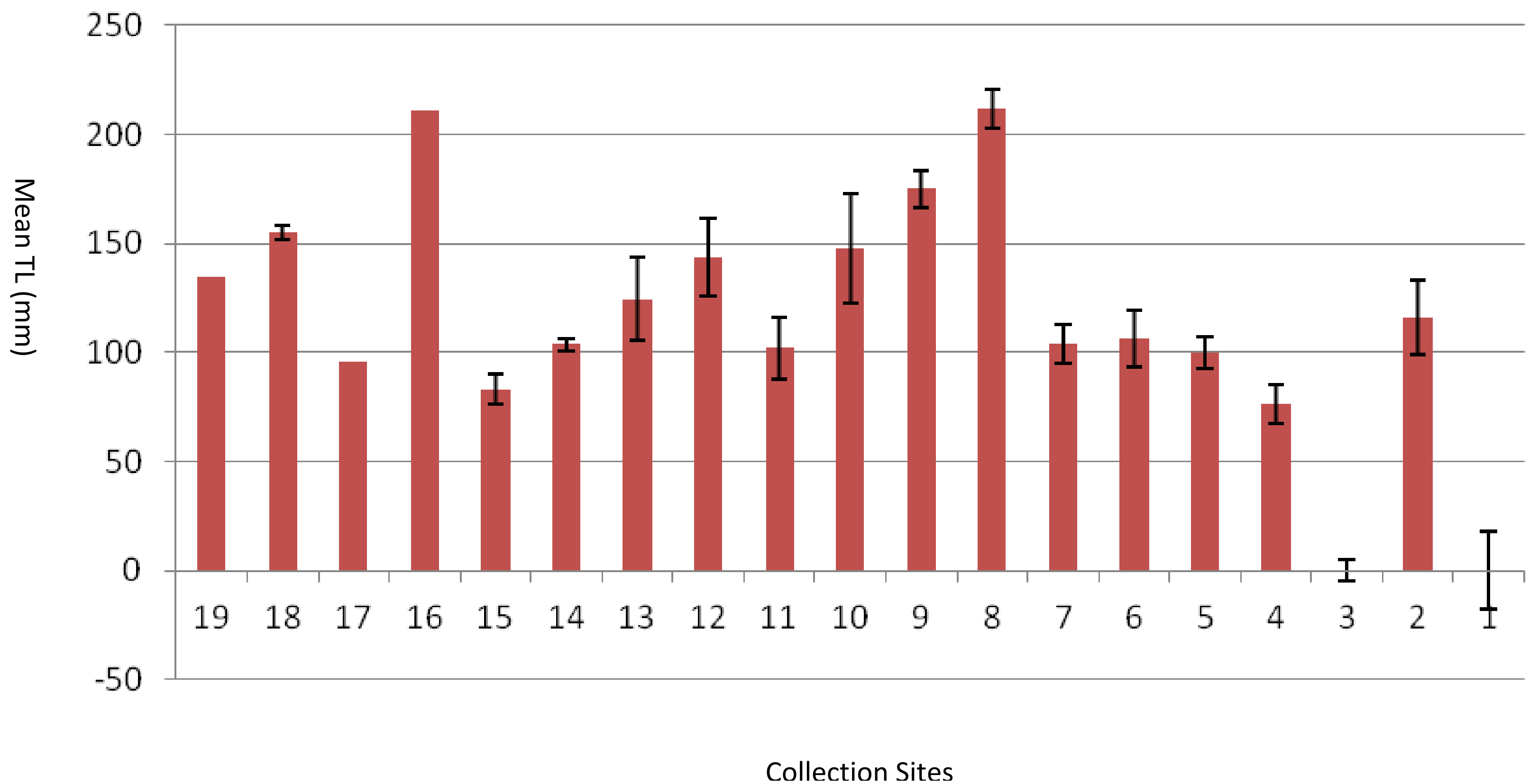


Figure 3: Smallmouth bass catch per unit effort (CPUE) for all sampling sites in Silver Creek, Madison Co., KY, 2011-2012.



Mean total length (TL) of smallmouth bass for all sampling sites in Silver Creek, Madison Co., KY, 2011-2012

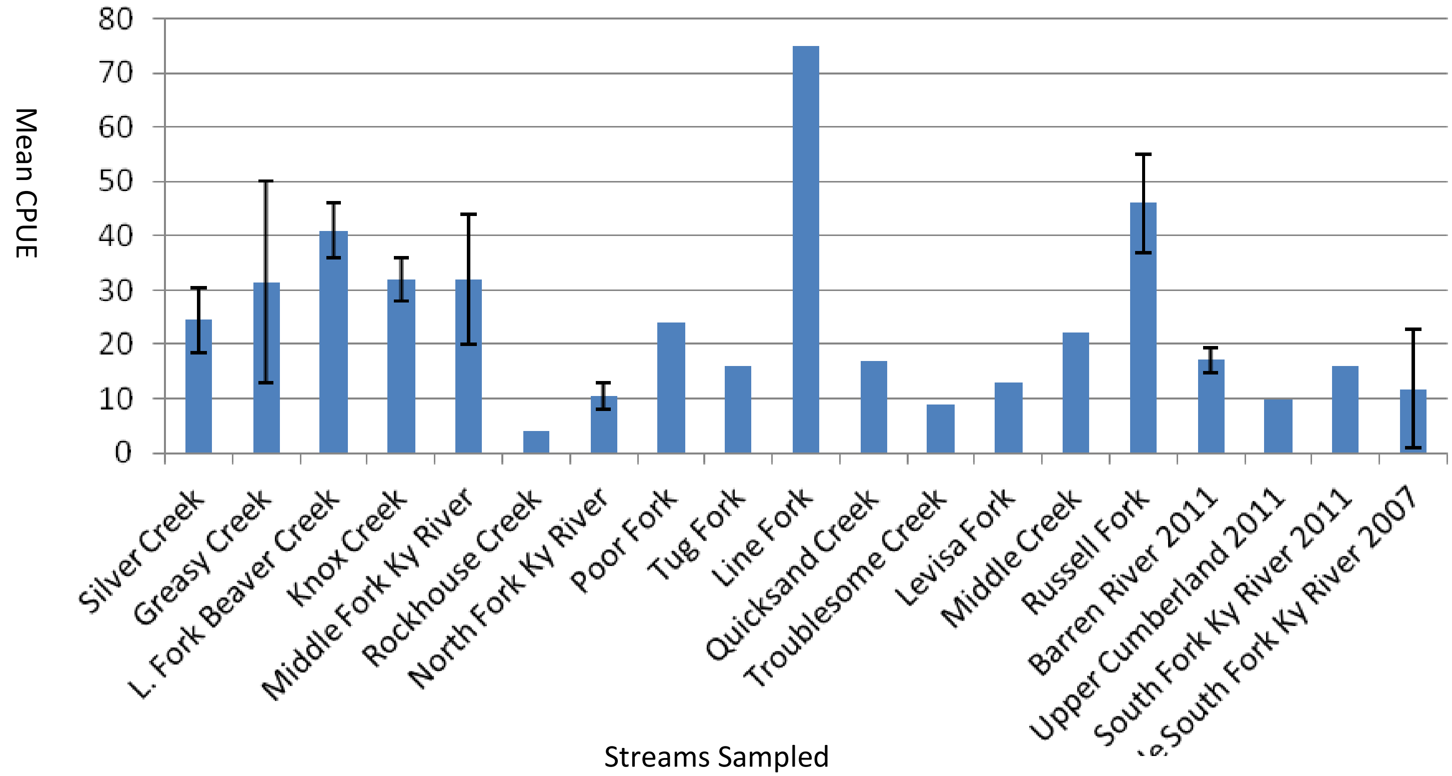


Figure 5. Catch per unit effort for Silver Creek (this study) and other Kentucky streams sampled by the Kentucky Department of Fish and Wildlife Resources.

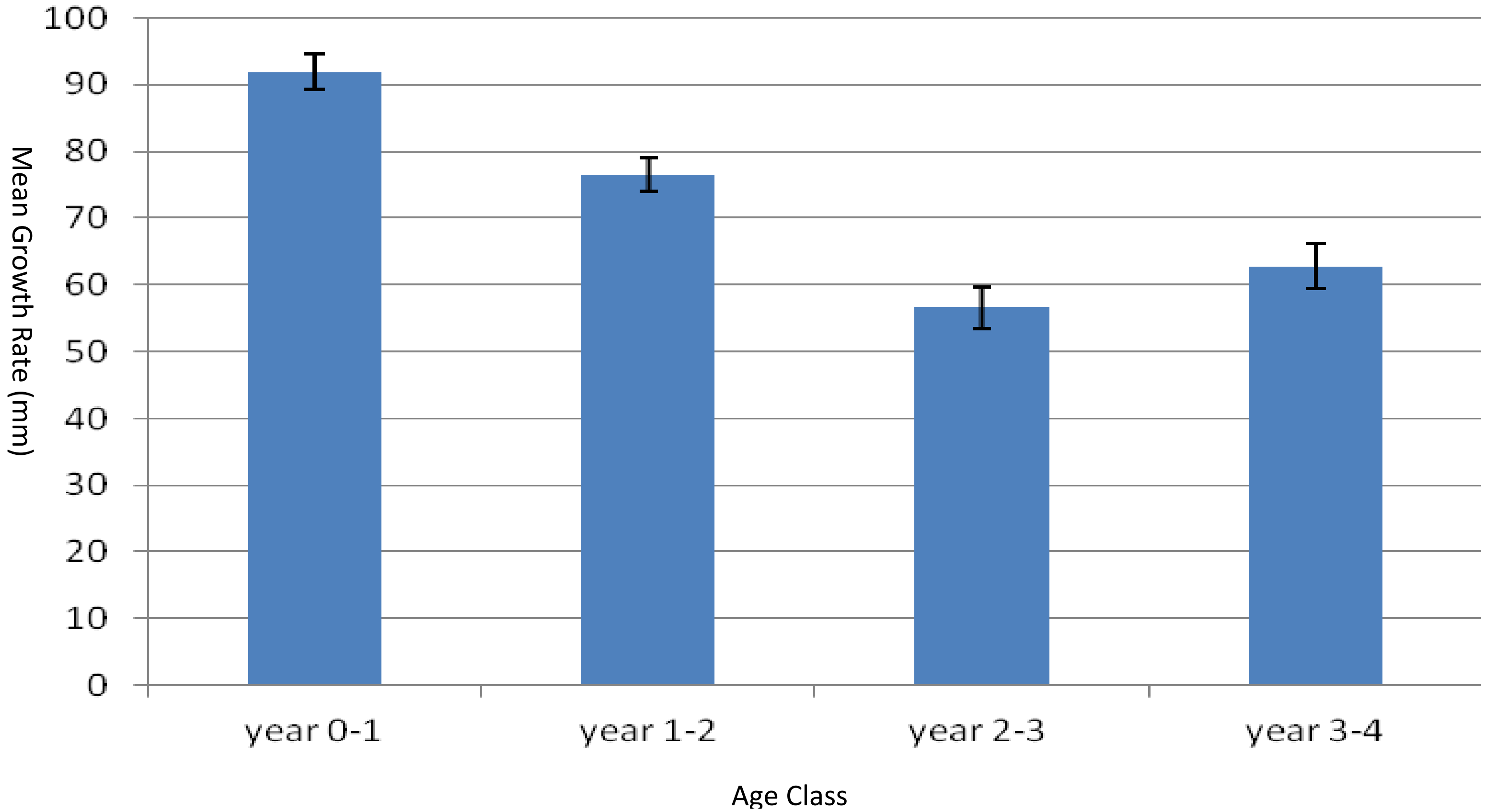


Figure 6. Mean growth rates for age classes of smallmouth bass sampled from Silver Creek, Madison Co., KY, 2011-2012.

Vita

Justin Basham graduated from Centre College in May 2010 with a Bachelor degree in Biology. Upon graduation he volunteered at the district fisheries office for the Kentucky Fish and Wildlife Resources in Bowling Green, KY. and has worked at the Big South Fork National River and Recreation Area for the past two years as the Biological Sciences Wildlife Technician.