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Population Demographics Of White Crappie In Three Illinois Reservoirs

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Population Demographics of White Crappie

in Three Illinois Reservoirs

(TITLE)

BY

Candice Marie Miller

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ABSTRACT

Crappie provide important sport-fisheries throughout the United States. Because of the propensity of this species to display growth stunting, an assessment of crappie population demographics is needed in Midwestern reservoirs. I assessed the population demographics of white crappie, *Pomoxis annularis*, in three Illinois reservoirs. Samples were collected by three-phase AC boat electrofishing. All crappie were weighed, measured, and the otolith and scale samples were removed for age estimation. Relative density, as measured by catch per unit of effort (CPUE; fish/hour), was different at Lake Mattoon (0.53±0.15), Lake Charleston Side Channel Reservoir (1.17±0.15), and Paradise Lake (1.04±0.18). Size structure of white crappie differed among reservoirs (KS=0.199, $p<0.001$) with Lake Mattoon having the largest mean length and Lake Paradise having the smallest mean length. Additionally, I found that crappie condition differed among reservoirs ($F=33.54$; $p<0.001$) with Lake Mattoon having the greatest mean relative weight. When modeling growth using von Bertalanffy models, Lake Charleston Side Channel Reservoir exhibits the lowest theoretical maximum length (L_∞) when aged with both otoliths (241.2 mm) and scales (239.7 mm) while Lake Paradise exhibited the highest L_∞ when aged with both otoliths (431.5 mm) and scales (413.1 mm). Lake Charleston Side Channel Reservoir also exhibits the lowest annualized mortality rate at 13%. Because Lake Charleston Side Channel Reservoir exhibits the lowest growth rate, lowest mortality rate, and highest CPUE, it can be concluded that Lake Charleston Side Channel Reservoir is displaying growth stunting.

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This study would not have been completed without the help of my fellow students, especially Ethan Stephenson, Sarah Thompson, Gregory King, TJ Evans, John West and Daniel Hiatt. Additionally, I would like to thank Mike Mounce of the Illinois Department of Natural Resources for aiding in the collection of specimens. I would also like to thank my family: Colleen and Rick Krapp, Carol Wiest and Ashley Miller for all of their support.

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INTRODUCTION

Sport fishing has long been a popular form of recreation in the United States. According to the U.S. Fish and Wildlife Service (2006), 30 million United States residents over the age of 16 participated in fishing, spending $42 billion on travel and lodging expenses, license fees, and boating and fishing equipment. Among these anglers, 25.4 million fished in freshwater with expenditures of $26.3 billion, making it the more popular type of fishing.

Because sport fishing is popular in the United States, management of these fisheries is necessary. Bennett (1970) defines fisheries management as the art and science of producing sustained annual crops of wild fish for recreational and commercial uses. This definition recognizes the importance of a balance between recreational and commercial fisheries as well as pointing out that not only is fisheries management a science, it is also an art.

Fisheries managers use tools such as age, growth, and condition variables to characterize and evaluate fish populations. One of the simplest and first-used tools in fisheries management, however, is evaluation of the population's size structure. Length-frequency histograms are the most frequently used method of examining size structure. These histograms reflect recruitment, growth, and mortality within a population (Anderson and Neumann 1996, Vokoun et al. 2001). Another method of evaluating size structure is with the use of proportional size distribution (PSD) values (Anderson 1976, Guy et al. 2007). PSD values are a standard numerical representative of length-frequency within a population (Anderson and Neumann 1996). The ability to evaluate these characteristics is important for fisheries managers to understand such that populations can be managed effectively and efficiently.

Most fish, including crappie, experience indeterminate growth and thus, growth is often measured as a function of age. Growth, however, is plastic with influence from environmental factors such as water quality (Hall et al. 1954), habitat suitability (Maceina and Shireman 1982), food availability (Muoneke et al. 1992, Schramm et al. 1999) and also such things as angling pressure and harvest rates (Webb and Ott 1991). Growth can be reported many different ways but a common method is using mean length at age of capture. To model growth, the von Bertalanffy (1938) equation is used most often, as it frequently fits fish length data well.

The von Bertalanffy growth model is ideal for modeling fish growth because of its flexibility, simplicity and similarity to the actual growth trajectory of fish (Haddon 2001). It is also ideal because of its ability to be applied to a single sample integrated across year-classes (Isely and Grabowski 2007). This growth model estimates several parameters that can be compared among populations including the Brody growth coefficient (K) and theoretical maximum length (L_∞) (Haddon 2001, Van Den Avyle and Hayward 1999). The ability to compare growth among populations can provide insight into the efficacy of management tools (Isely and Grabowski 2007).

An effective qualitative method to evaluate a fishery is examining body condition of the fish. One method of examining condition is the weight-length relationship (Anderson and Neumann 1996, Cone 1989). This relationship has been recognized as an essential element in fisheries management because results can potentially reflect environmental conditions affecting condition. The Fulton condition factor, relative condition factor, and relative weight are all variations of condition indices which are easily interpreted alternatives to weight-length relationships because of the numerical nature of these indices. Relative weight (W_r) is the most widely used of these indices because of its practical application and wide use by fisheries managers and researchers (Wege and Anderson 1978).

Yet another tool used by fisheries managers is mortality. Mortality is an important aspect to the population ecology of any species, especially the population dynamics throughout the life history of a species. In the early life stages of fish, the egg and larval stages often experience the highest rates of mortality (Almany and Webster 2006,Houde 1994). As a fish reaches juvenile and adult stages, mortality often comes from two sources, natural and fishing (Ricker 1975). Mortality is most often modeled using catch curves that are based on three assumptions: 1) uniform survival rate, 2) random sampling, and 3) constant recruitment (Allen 1997). Catch curves are a regression of the logarithmic frequency of fish at age with the resulting slope (Z) indicating instantaneous total mortality which can be used to calculate total annual mortality ($A = 1 - e^{-Z}$).

Using all of these tools, fisheries managers can manage difficult species that experience growth stunting such as crappie. Growth stunting is the result of no or slow growth that is below the potential of the species. Stunting has several causes including reduced food supply, inadequate or lack of habitat, and oligotrophic conditions (Spier 2002). Growth stunting in fish is often managed with length regulation and predator pressure (Boxrucker 1987, Webb and Ott 1991).

Because of the possibility of growth stunting, evaluations of population dynamics and management of crappie are important across their range. Therefore, the primary objective of this study is to evaluate and compare the populations of white crappie in three reservoirs by: 1) determining size structure, 2) condition, and 3) calculating growth and mortality. Comparing three populations will allow for the evaluation of possible growth stunting and determination of these factors will allow for proper management of white crappie.

CHAPTER TWO

COMPARISON OF AGING STRUCTURES

INTRODUCTION

Many population metrics including mortality and growth require the estimated age of individuals and thus accurate aging is necessary for gaining accurate population demographics. Age structure of a population can reflect year-class variability and potentially aide in the assessment of environmental factors that potentially affect year-class variability (Boxrucker 2002). Most fish, including crappie, experience indeterminate growth and thus, growth is often measured as a function of age. Growth, however, is plastic with influences from environmental factors such as water quality, habitat suitability, and food availability (Spier 2002). Plasticity in growth can potentially bias a structure used to age fish.

Aging analysis uses hard structures that develop growth rings similar to that of a tree, the most common of these structures is the sagittal otolith (Devries and Frie 1996). Another structure commonly used in aging centrarchids is the scale. Many studies have used scales as a primary method of aging crappies (Ellison 1984, Gabelhouse 1984, Colvin 1991, Larson et al. 1991) even though researchers have encountered problems with aging scales such as inaccuracy in older ages, difficulty determining annuli, and possible regeneration of scales (Boxrucker 1986, Hammers and Miranda 1991, Ross et al. 2005). Despite this discrepancy, both aging structures have been used to calculate population metrics used to assess a fishery.

Age, growth, and mortality information are critical when assessing a fishery.

Because of the potential difference in estimated age from using different aging structures and the potential impact on calculated population metrics, the objective of my study was to compare the precision of age estimates obtained using otoliths to age estimates obtained from scale tissue. I also compared the population metrics reliant on age estimation, growth and mortality, using both aging structures.

METHODS

During Fall 2009 and Spring 2010, crappie were collected from three reservoirs in east-central Illinois, Lake Mattoon, Lake Charleston Side Channel Reservoir and Lake Paradise. I collected fish using three-phase AC boat electrofishing and returned them to the Eastern Illinois University fisheries laboratory for age analysis. A three-person crew was used to sample with one boat driver and two individuals with dip nets. Samples were taken from haphazardly-chosen littoral habitats.

Total length (± 1 mm) and a mass (± 1 g) were recorded for each individual. Both sagittal otoliths and scales were extracted from each individual for aging analysis. Whole sagittal otoliths were placed in a dark brown dish, covered in mineral oil to define the opaque band, and examined under a dissecting microscope at 40x magnification (Maceina and Betsill1987). Scale samples were taken behind the pectoral fin by scraping with the blade of a scalpel. Scales were then placed in a coin envelope and allowed to dry. After drying, scales were mounted between two glass microscope slides and aged using a dissecting microscope (Hammers and Miranda 1991). For all otolith and scale aging, two independent readers, with one constant between all reservoirs, estimated ages and disagreements were resolved by both readers coming to a consensus. If a consensus could not be reached, the specimen was removed from any further analyses. Age estimates for the two structures was compared using their average percent error (APE) and coefficient of variation (CV=100 × SD/Mean) (Beamish and Fournier 1981, Chang 1982). Differences in ages were then analyzed by comparing the slope of an age bias plot with 1, the slope indicating equality (Campana et al. 1995).

Age structure was evaluated using age frequency histograms generated for each reservoir. Histograms were created for both aging structures, otoliths and scales. I compared age frequency distributions using a Kolmogorov-Smirnoff test.

Growth was estimated using von Bertalanffy growth models which are non-linear regressions. The model uses the equation

$$l_t = L_\infty[1 - e^{-K(t-t_0)}]$$

where l_t is length at time t, L_∞ is the theoretical maximum length, K is the Brody growth coefficient, and t_0 is the theoretical length at time zero (von Bertalanffy 1938). Von Bertalanffy growth models were constructed for sampled fish based on both otoliths and scales.

Mortality was estimated using catch curves (Ricker 1975). Catch curve analysis was performed to estimate instantaneous mortality by using slopes of the regression lines, and was calculated for both otoliths and scales. Annual mortality was calculated using the instantaneous mortality value from the catch curve analysis.

$$A = 1 - e^{-Z}$$

Catch curves of white crappie from all reservoirs were compared using homogeneity of slopes test which is analogous a test of interaction using ANCOVA (Sokal and Rohlf 1995).

RESULTS

A consensus of white crappie age was reached on all individuals; therefore all were used in analysis. Age was estimated with two structures and precision between the structures appeared high for Lake Mattoon (APE=5.3, CV=9.6) and Lake Charleston Side Channel Reservoir (APE=5.0, CV=9.8), but lower for Lake Paradise (APE=10.8, CV=24.9). An age bias plot showed different age estimation between structures (Figure 1).

In Lake Charleston Side Channel Reservoir and Lake Mattoon, age frequency histograms using otoliths and scales did not differ (Figure 2). However, in Lake Paradise there was a difference in age frequency histograms using otoliths and scales (KS=0.13, $p<0.001$, Figure 2).

Growth was modeled with von Bertalanffy growth models using both otoliths and scale ages. Results for theoretical maximum length (L_∞) and Brody's growth coefficient (k) were similar between otoliths and scale ages in Lake Charleston Side Channel Reservoir and Lake Mattoon (Table 1, Figure 3). Lake Paradise has the largest difference between $L\infty$ and k (Table 1, Figure 3).

Mortality was estimated using catch curves. Mortality did not differ between otoliths and scales in Lake Charleston Side Channel Reservoir, Lake Mattoon or Lake Paradise (Figure 4).

DISCUSSION

Results of the age bias plot indicate that otoliths are a more precise aging structure than scales. Analysis of age frequency histograms showed similar results, with a difference between aging structures in Lake Paradise. These results are similar to those in previous aging studies (Boxrucker 1986, Hammers and Miranda 1991, Ross et al. 2005), allowing me to conclude that otoliths are a more reliable aging structure. Lake Mattoon and Lake Charleston Side Channel Reservoir showed similar aging structures, however, suggesting scales could be an acceptable aging structure. This is similar to a previous study of black crappie in South Dakota (Kruse et al. 1993).

When calculating growth, only Lake Paradise had a difference between aging structures, which is similar to the results in Hammers and Miranda (1991). When calculating mortality, there was no difference between aging structures in any of the three sampled lakes. These results suggest that both otoliths and scales provide a precise age which can be used to calculate population metrics such as growth and mortality.

The discrepancy in my results could be due to geographical location of our sample lakes. It has been suggested that at higher latitudes, scales are as precise as otoliths when aging fish (Kruse et al. 1993) because of the slow rate of growth in winter allows a distinguishable annuli to form on the scales. While at lower latitudes, the lack of a distinct slow growth season does not allow for a distinguishable annuli to form on the scales (Boxrucker 1986, Hammers and Miranda 1991). Centrally-located Illinois could potentially have lakes where scales are similarly precise as otoliths while others differ in precision. Therefore, I recommend that otoliths be used for aging to avoid the potential inaccuracies that might result from aging fish using scales.

Table 1. von Bertalanffy parameters for white crappie at Lake Charleston Side Channel Reservoir, Lake Mattoon, and Lake Paradise using both otolith and scale ages. L_∞ is theoretical maximum length, k is Brody's growth coefficient, and t_0 is initial size.

	Otolith			Scale		
Reservoir	L_∞	k	t_0	L_∞	k	t_0
Lake Charleston Side Channel Reservoir	241.2	1.897	0.175	241.5	1.224	-0.471
Lake Mattoon	275.8	0.444	-1.471	285.5	0.346	-2.122
Lake Paradise	400.2	0.097	-3.473	426.6	0.141	-1.515

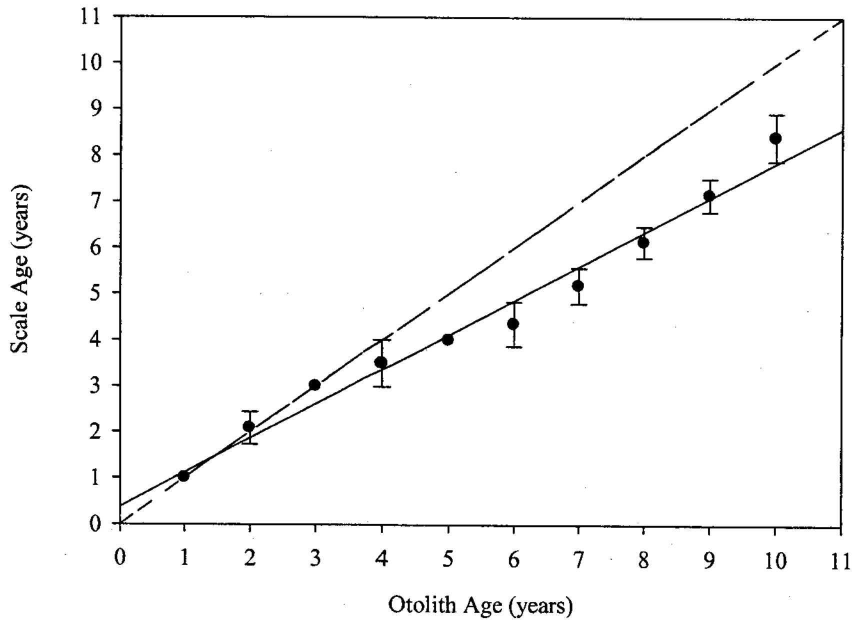

Figure 1. Age bias plot for otoliths compared to scales in white crappie. Solid line represents regression between otolith age and scale age, dashed line represents a slope of one, and error bars represent ± 1 S.E

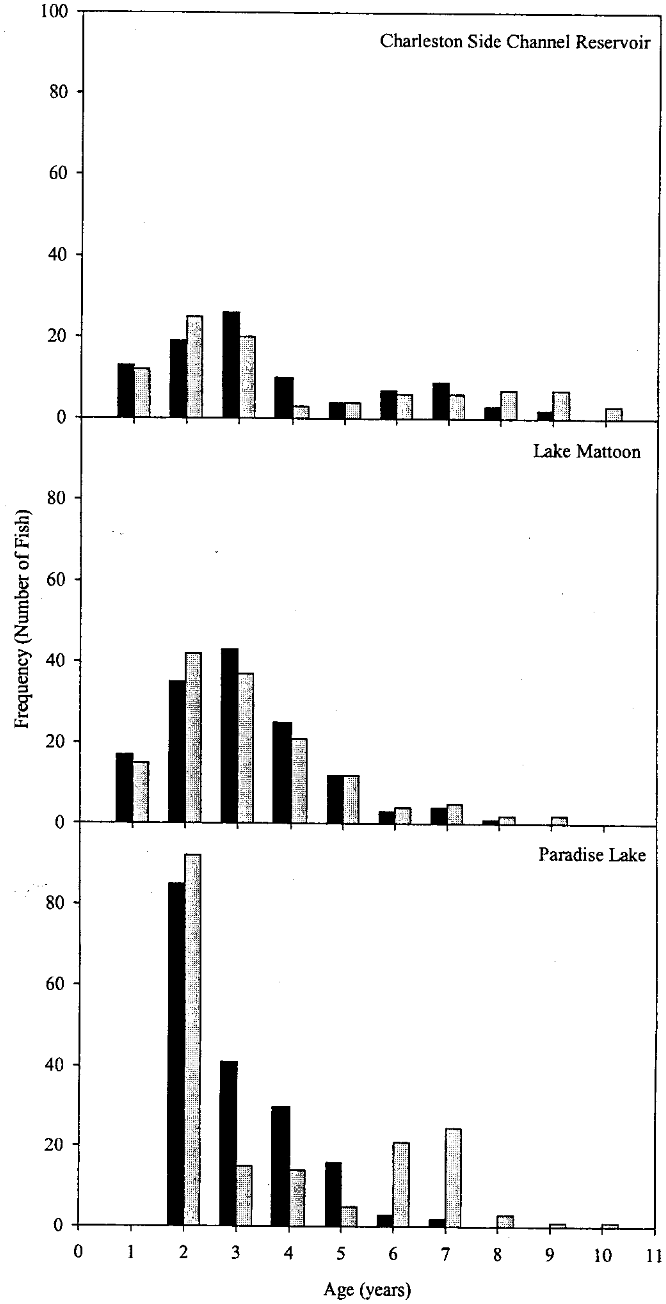

Figure 2. Age frequency histograms for white crappie in Lake Charleston Side Channel Reservoir, Lake Mattoon, and Lake Paradise using both aging structures. Black bars represent scale ages and gray bars represent otolith ages.

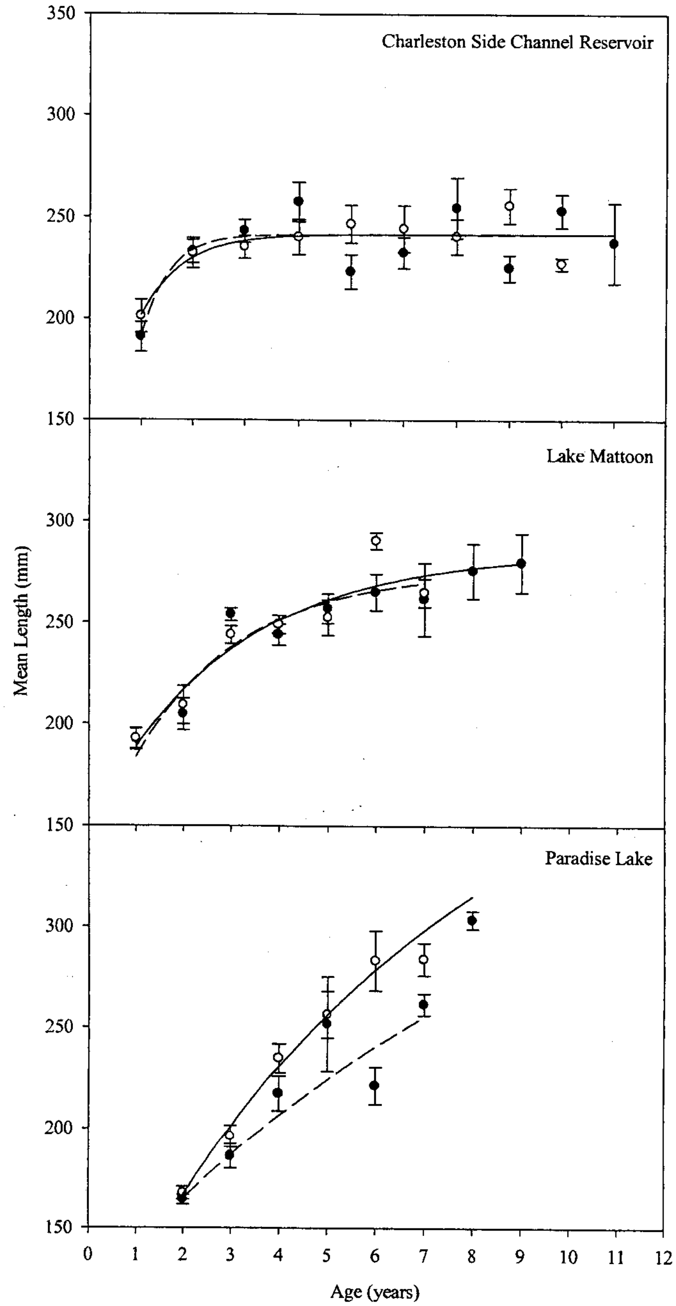

Figure 3. White crappie mean length at age ± 1 S.E. and von Bertalanffy models for Lake Charleston Side Channel Reservoir, Lake Mattoon, and Lake Paradise. Filled circles and solid line represent scales and open circles and dashed line represent otoliths.

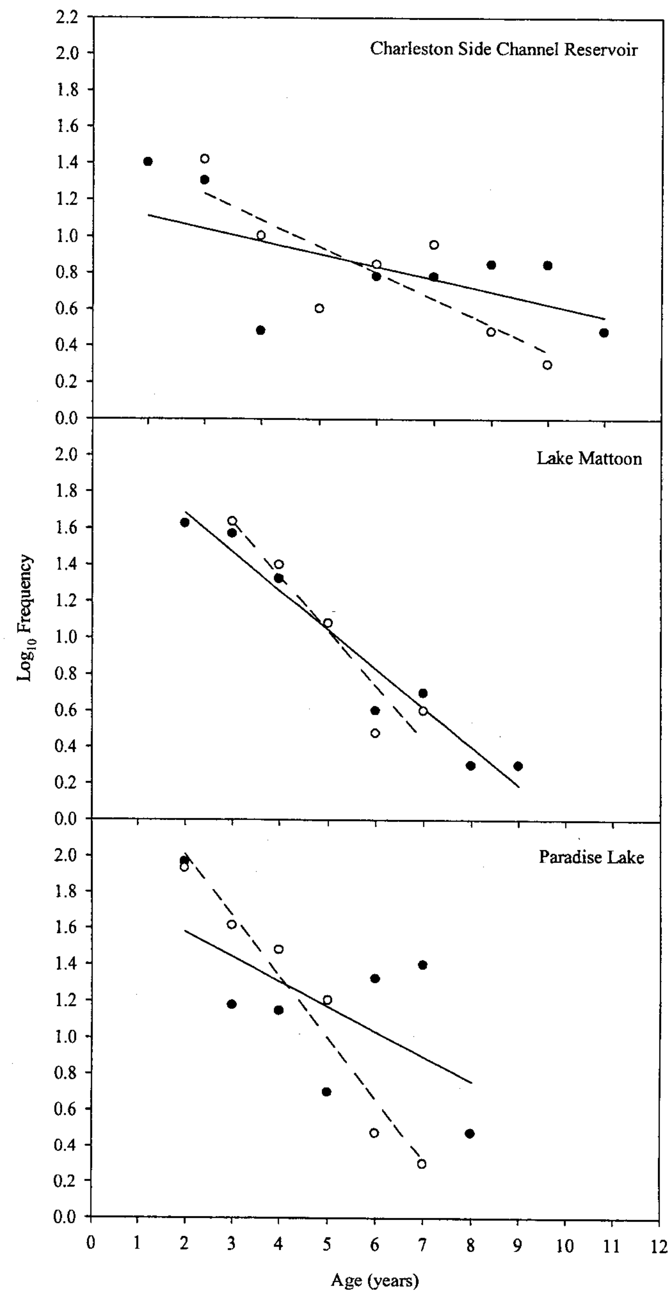

Figure 4. Mortality catch curves for white crappie in Lake Charleston Side Channel Reservoir, Lake Mattoon, and Lake Paradise. Filled circles and solid line represent otoliths and open circles and dashed line represent scales.

CHAPTER THREE

CRAPPIE MANAGEMENT

INTRODUCTION

White crappie (*Pomoxis annularis*) is a common game fish in many lakes and reservoirs in Illinois, with 36% of anglers targeting the species (U.S. Fish and Wildlife Service 2006). Because of the possibility of growth stunting, overpopulation is of concern in several Illinois reservoirs as the size of fish that need to be removed are often smaller than desirable, most of which anglers are not willing to harvest (Hale et al. 1999). Growth stunting is the result of no or slow growth that is below the potential of the species. Stunting can be caused by a myriad of reasons including a reduced food supply, inadequate or lack of habitat, and oligotrophic conditions (Spier 2002). White crappie are exclusively planktivorous until they are approximately 150 mm; then they switch to piscivory (O'Brien et al. 1984). If food resources are limited, the switch to piscivory may not take place, thereby limiting growth of the fish. Habitat could also be a limiting factor for white crappie populations. Similar to other centrarchids, white crappie use cover which is often limited in aquatic systems. Regardless of the cause, growth stunting in fish is often managed with length regulation and predator pressure (Boxrucker 1987, Webb and Ott 1991).

Growth stunting is common in white crappie populations; therefore, the objectives of this study are to evaluate and compare the populations of white crappie in three reservoirs by: 1) determining size structure, 2) condition, and 3) calculating growth and mortality. Comparing three populations will allow for the evaluation of possible growth stunting and determination of these factors will allow for proper management of white crappie.

METHODS

Study Site

During Fall 2009 and Spring 2010, crappie were collected from three reservoirs in east-central Illinois: Lake Mattoon, Lake Charleston Side Channel Reservoir and Lake Paradise. Lake Mattoon is a 425 ha impoundment on the Little Wabash River with a maximum depth of 9.4 m and an average depth of 3.5 m, Lake Charleston Side Channel Reservoir is a 133 ha impoundment on the Embarrass River with a maximum depth of 4.8 m and an average depth of 2.3 m and Lake Paradise is a 71 ha impoundment on the Little Wabash River with a maximum depth of 4.9 m and an average depth of 2.6 m (IL DNR 2007).

Collection Techniques

I collected fish using three-phase AC boat electrofishing and returned them to the Eastern Illinois University fisheries laboratory for aging analysis and sex determination. Electrofishing samples were taken with a boat-mounted, three-electrode AC power generated unit. A three-person crew was used to sample with one boat driver and two individuals with dip nets. Samples were obtained from haphazardly-chosen littoral habitats.

Total length (± 1 mm), mass (± 1 g) and sex were determined for each individual. Otoliths were extracted from each individual for aging analysis. A total of 140 white crappie was sampled from Lake Mattoon, 93 white crappie from Lake Charleston Side Channel Reservoir and 179 white crappie was sampled from Lake Paradise.

Relative Density

To quantify relative abundance of crappie in each reservoir, catch per unit effort (CPUE; fish/hour) was calculated for each reservoir using additional sampling. Four, 15-minute electrofishing transects were completed at randomly chosen sites in each reservoir. The CPUE data was $\log_{10}(X+1)$-transformed and tested using an analysis of variance (ANOVA).

Size Structure

Size structure was evaluated using length frequency histograms generated for each reservoir. Length frequency histograms were constructed using absolute length frequency and 10-mm interval widths. I compared length frequency distributions using a Kruskal-Wallis test. Size structure was also evaluated using Proportional Size Distribution (PSD), a ratio of minimum total fish lengths:

$$\text{PSD} = \frac{\textbf{number of fish} \geq \textbf{minimum quality length}}{\textbf{number of fish} \geq \textbf{minimum stock length}} \times 100$$

(Gabelhouse 1984). Comparisons of PSD values between lakes were calculated using a chi-square test (Neumann and Allen 2007). PSD-Preferred (PSD-P) was also calculated for each lake using the equation:

$$\text{PSD-P} = \frac{\textbf{number of fish} \geq \textbf{minimum preferred length}}{\textbf{number of fish} \geq \textbf{minimum stock length}} \times 100$$

and statistical significance was determined using a chi-square test.

Weight-length relationships were calculated with linear regression using logarithmically transformed data to assess the condition of the fish. An analysis of covariance (ANCOVA) was used to determine significance among regression lines with length as the covariate. As an assessment of condition, relative weight (W_r) was calculated for each fish using the standard weight equation (Neumann and Murphy 1991):

$$\log_{10} W_s(\text{g}) = -5.642 + 3.332 \log_{10}\text{TL(mm)}$$

and significance of relative weight among reservoirs was tested using ANOVA.

Age Structure

Age structure was evaluated by age frequency histograms generated for each reservoir. Age frequency histograms were constructed using absolute age frequency. I compared age frequency distributions using a Kruskal-Wallis test.

Mortality

Mortality was estimated using catch curves (Ricker 1975). Catch curve analysis was performed to estimate instantaneous mortality by using slopes of the regression lines. Annual mortality was calculated using the instantaneous mortality value from the catch curve analysis using the following formula:

$$A = 1 - e^{-Z}$$

in which –Z is instantaneous mortality rate. Catch curves of white crappie from all reservoirs were compared using homogeneity of slopes test which is analogous a test of interaction using ANCOVA (Sokal and Rohlf 1995). Additionally, mortality was estimated using Heincke's method to validate the results of the catch curve analysis (Miranda and Bettoli 2007). Annual mortality was calculated using the following formula:

$$A = n_0/N$$

in which n_0 is the number of fish in the youngest age considered, and N is the sum of all fish considered.

Growth

Growth was estimated using von Bertalanffy growth models which are non-linear regressions. The model uses the equation:

$$l_t = L_\infty[1 - e^{-K(t-t_0)}]$$

where l_t is length at time t, L_∞ is the theoretical maximum length, K is the Brody growth coefficient, and t_0 is the theoretical length at time zero (von Bertalanffy 1938). Von Bertalanffy growth models were constructed for each reservoir.

Sexual Demographics

Age structure was evaluated by age frequency histograms generated for both sexes in each reservoir. Age frequency histograms were constructed using absolute age frequency. I compared age frequency distributions using a Kolmogorov-Smirnoff test. Additionally, von Bertalanffy growth models were constructed for both sexes in each reservoir.

RESULTS

Relative Density

Density of crappie in each lake was estimated using CPUE. Mean CPUE (fish/hour) was highest at Lake Charleston Side Channel Reservoir (67±43.50) then Lake Paradise (52±43.20) and Lake Mattoon (13±13.21; Figure 5). Catch rates differed among reservoirs ($F_{2,9}$=4.26, p=0.05).

Size Structure

Length frequency histograms show a difference of white crappie among all lakes (p<0.001; Figure 6). In size structure analyses, Lake Mattoon had the highest mean length (233±42 mm) followed by Lake Charleston Side Channel Reservoir (232±31 mm) and Lake Paradise (196±49 mm). Similar to length frequency distributions, PSD values calculated for white crappie also show a difference in size structure between all lakes (X^2 = 21.21, p < 0.0001; Table 2), with Lake Mattoon having the highest PSD followed by Lake Charleston Side Channel Reservoir and Lake Paradise. The PSD-P values calculated for white crappie show a difference in size structure among all lakes (X^2=21.21 , p<0.0001), with Lake Mattoon having the highest PSD-P followed by Lake Charleston Side Channel Reservoir and Lake Paradise.

Weight-length regressions were different among all lakes ($F_{3,406}$=3017.18, p<0.0001; Figure 7). Relative weight also differed between all lakes ($F_{2,407}$=49.61, p<0.0001). Mean relative weight was highest at Lake Mattoon followed by Lake Charleston Side Channel Reservoirand Lake Paradise(Table 3).

Age Structure

Age frequency histograms do not show a difference of white crappie among all lakes (Figure 8). In age structure analyses, Lake Charleston Side Channel Reservoir had the highest mean age (5±3 years) followed by Lake Paradise (4±2 years) and Lake Mattoon (3±2 years).

Mortality

Mortality did not differ among reservoirs (Figure 9). Annual mortality is highest at Lake Paradise followed by Lake Mattoon and Lake Charleston Side Channel Reservoir. Mortality estimates calculated using Heincke's method were not similar to those calculated using catch curves because the assumption of constant recruitment was violated for both models (Table 4). Therefore, neither estimate of mortality is accurate.

Growth

Lake Charleston Side Channel Reservoir exhibits the largest growth coefficient (k) and the smallest theoretical maximum length (L_{∞}) and Lake Paradise exhibits the smallest growth coefficient and the largest theoretical maximum length (Table 5; Figure 10).

Sexual Demographics

Age frequency histograms between sexes differed in all reservoirs, Lake Charleston Side Channel Reservoir (KS=0.20, p=0.001), Lake Mattoon (KS= 0.12, p=0.05), Lake Paradise (KS=0.12, p=0.04; Figure 11). Results for theoretical maximum length (L_∞) and Brody's growth coefficient (k) differed between sexes in Lake Charleston Side Channel Reservoir and Lake Paradise (Table 6, Figure 12). Lake Mattoon had similar results for L_∞ and k for both sexes.

DISCUSSION

Relative density estimates indicate that the density of crappie in Lake Mattoon is a fraction of that in Lake Charleston Side Channel Reservoir and Lake Paradise. This suggests overpopulated populations of crappie in both Lake Charleston Side Channel Reservoir and Lake Paradise. Overpopulation is often cause for stunting in crappie populations, therefore stunting is possible in both Lake Charleston Side Channel Reservoir and Lake Paradise (Clark 1952, Hall et al. 1954, Bennett 1970).

Size structure analyses (length frequency, PSD, weight-length, and relative weight) indicate a difference between all reservoirs. This difference could be attributed to the season in which the reservoirs were sampled. Lake Paradise was the only reservoir sampled during spring when age-1 fish have just become recruited to the gear (Miranda et al. 1990). Calculations of PSD revealed similar results with Lake Paradise having lower PSD and PSD-P values than both Lake Mattoon and Lake Charleston Side Channel Reservoir. Although these differences might indicate a stunted population in Lake Paradise, that assessment cannot be verified based on length frequency or PSD analyses because of the sample bias and seasonal component to sampling effort (Boxrucker and Ploskey 1988, Pope and Willis 1996). Analyses of relative weight indicate that Lake Mattoon white crappie are at an optimal relative weight, while white crappie in Lake Paradise have the lowest mean relative weight. This could indicate possible stunting in Lake Paradise. Lake Paradise was sampled in Spring, however, when individual fish mass is at its lowest because of fat reserve loss during Winter. Therefore, an assessment of stunting is not appropriate (Gabelhouse 1991, Neumann and Murphy 1991, 1992, Pope and Willis 1996).

Methods of estimating mortality assume constant rates of recruitment and mortality, and equal catchability (Chapman and Robson 1960, Robson and Chapman 1961). Although equal catchability is not of concern when using electrofishing for collecting white crappie, the assumption of constant recruitment can pose a concern (Allen 1997). Crappie are known to exhibit sporadic recruitment which is often a cause for stunting. This sporadic recruitment violates one of the assumptions of the catch-curve analysis. Violating this assumption does not, however, nullify the results of a catch-curve analysis. The catch-curve analysis can actually show sporadic recruitment, providing evidence for possible stunting in crappie populations. Allen (1997) suggests catch curve estimates of annual mortality can be used to make management decision only if consideration is given to annual mortality estimates ± 10% of the calculated value. Sporadic recruitment is evident in both Lake Charleston Side Channel Side Reservoir and Lake Paradise, which is evidence for stunting in both populations.

When growth was modeled using von Bertalanffy growth curves, Lake Charleston Side Channel Side Channel Reservoir exhibited the lowest theoretical maximum growth but also the highest growth coefficient. These results indicate that while white crappie in Lake Charleston Side Channel Reservoir grow rather quickly, they do not grow very large. This could indicate white crappie are not switching to piscivory, a diet which leads to higher growth rates (Ellison 1984).

When age structure was separated by sex in Lake Charleston Side Channel Reservoir, the von Bertalanffy growth model showed a higher L_∞ for males, indicating that males grow larger than females. This is an indication males in the Lake Charleston

Side Channel Reservoir population grow to a harvestable size and are harvested at a higher rate than their female counterparts which have a slower growth rate.

The results indicate that white crappie in Lake Charleston Side Channel Reservoir are experiencing growth stunting. White crappie in Lake Charleston Side Channel Reservoir are long-lived reaching around 10 years of age while only approaching lengths of 240 mm. There is a distinct difference in ages and growth between males and females which could indicate that because males grow larger they are being harvested from the population leaving only the small, female fish to occupy the population. While Lake Paradise appears to have some evidence to suggest growth stunting, further sampling would be needed to verify that assessment. The data indicating growth stunting at this site were influenced by season. Therefore, samples collected in fall could provide better estimates with which to base any growth stunting assessments (Pope and Willis 1996).

Management Implications

Of the three reservoirs that were sampled, Lake Charleston Side Channel Reservoir is the only reservoir with a current regulation on crappie of a creel limit of ten fish under ten inches (254 mm) and ten fish over ten inches (254 mm; IL DNR 2011). The L_∞ for Lake Charleston Side Channel Reservoir is only 241 mm, meaning the current regulation only applies as a maximum length regulation. By allowing a limited amount of harvest below 254 mm, the population has become over populated (Willis et al. 1994). I would recommend a regulation change in order to properly manage this population, and I would recommend removing all regulations on crappie in Lake Charleston Side Channel Reservoir until the smaller individuals have been removed from the population. Once sampling shows high growth rates in individuals, I recommend placing a regulation similar to the previous regulation but only after completing creel surveys to determine harvest pressure on crappie in Lake Charleston Side Channel Reservoir.

Table 2. Proportional size distribution values for white crappie in three Illinois reservoirs sampled during fall 2009 and spring 2010 using three phase electrofishing (Stock = 130mm; Quality = 200mm; Preferred = 250mm).

Reservoir	PSD	PSD-P
Lake Mattoon	86	44
Lake Charleston Side Channel Reservoir	85	34
Lake Paradise	36	20

Table 3. Mean relative weight (W_r) of white crappie in three Illinois reservoirs sampled using three phase electrofishing. SE= Standard Error of the Mean.

Reservoir	Mean	SE
Lake Mattoon	100.800	10.355
Lake Charleston Side Channel Reservoir	93.459	9.882
Lake Paradise	89.084	23.214

Table 4. Annual mortality estimates using Heincke's method for white crappie in three Illinois reservoirs sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

Reservoir	A	SE
Lake Mattoon	50.60%	4.47%
Lake Charleston Side Channel Reservoir	44.64%	5.52%
Lake Paradise	50.27%	3.70%

Table 5. von Bertalanffy parameters for white crappie in Lake Charleston Side Channel Reservoir, Lake Mattoon, and Lake Paradise sampled using three phase electrofishing.

Reservoir	$L\infty$	k	t_0
Lake Mattoon	275.8	0.4443	-1.4711
Lake Charleston Side Channel Reservoir	241.2	1.8966	0.1754
Lake Paradise	400.2	0.0968	-3.4731

Table 6. von Bertalanffy parameters for white crappie by sex in Lake Charleston Side Channel Reservoir, Lake Mattoon, and Lake Paradise sampled using three phase electrofishing

	Male			Female		
Reservoir	$L\infty$	k	t_0	$L\infty$	k	t_0
Lake Mattoon	260.1	0.6147	-1.1399	268.5	0.6350	-0.8762
Lake Charleston Side Channel Reservoir	306.3	0.3298	-1.8969	240.7	5.0527	0.6831
Lake Paradise	238.6	0.3422	-1.3568	331.3	0.1918	-1.5892

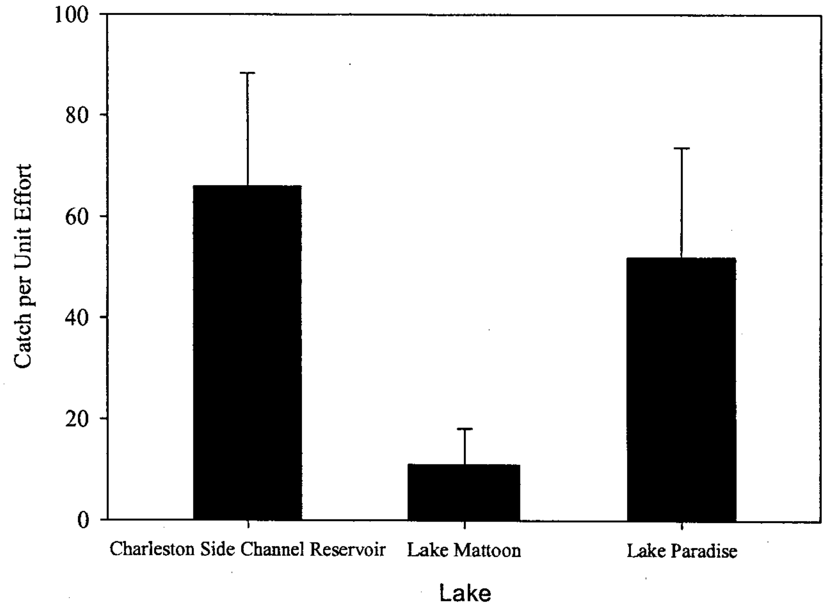

Figure 5. Mean CPUE (Catch Per Unit Effort) ± SE for crappie in Lake Mattoon, Lake Charleston Side Channel Reservoir, and Lake Paradise sampled during Spring 2010 using three phase electrofishing.

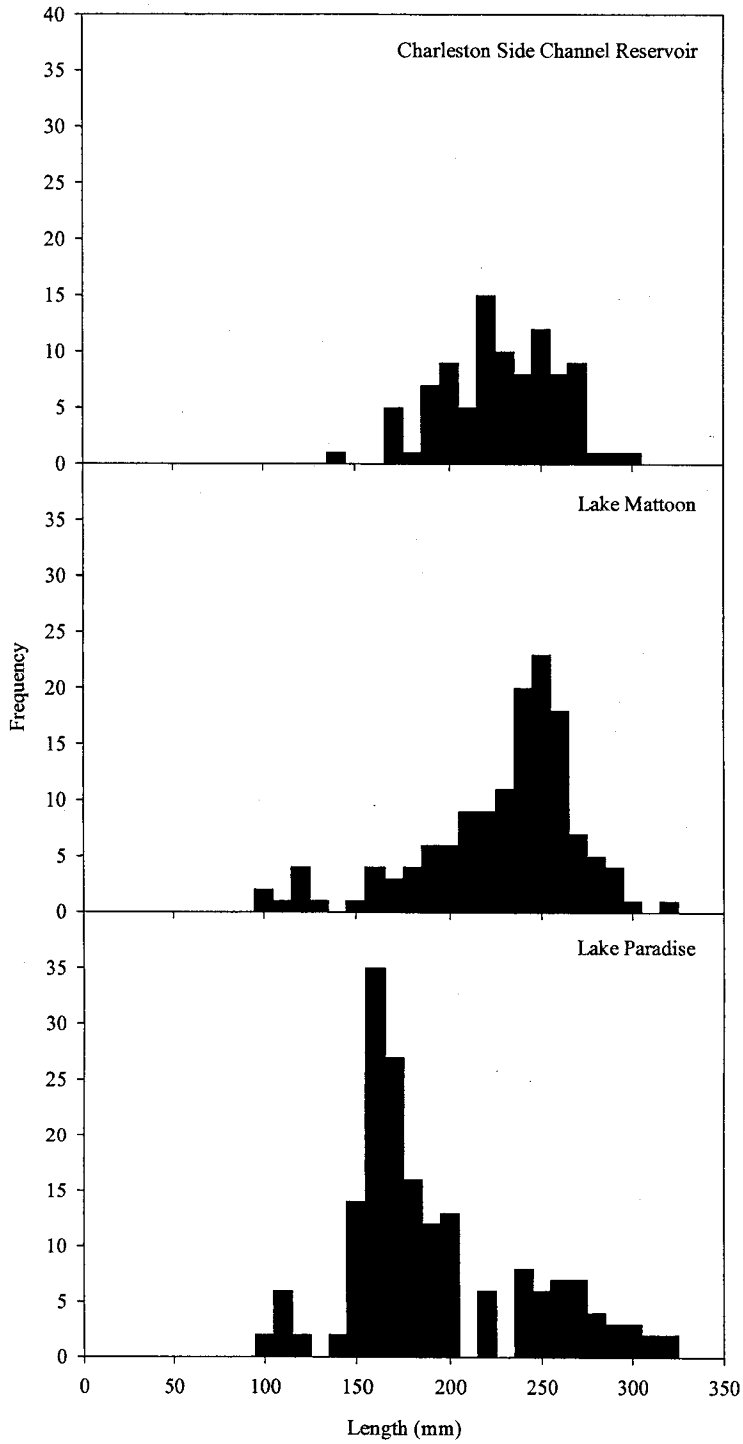

Figure 6. Length frequency histograms for white crappie in Lake Mattoon, Lake Charleston Side Channel Reservoir and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

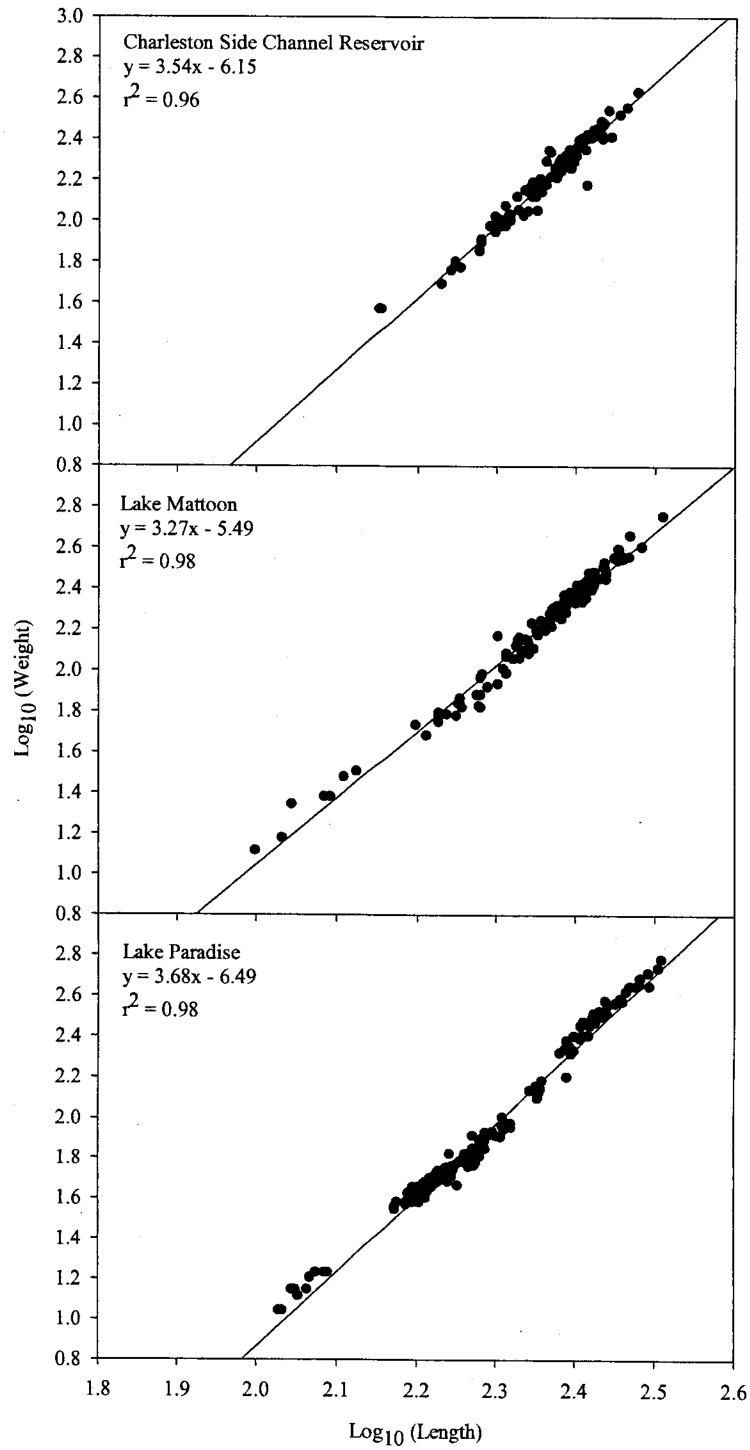

Figure 7. Weight-length regressions for white crappie in Lake Mattoon, Lake Charleston Side Channel Reservoir, and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

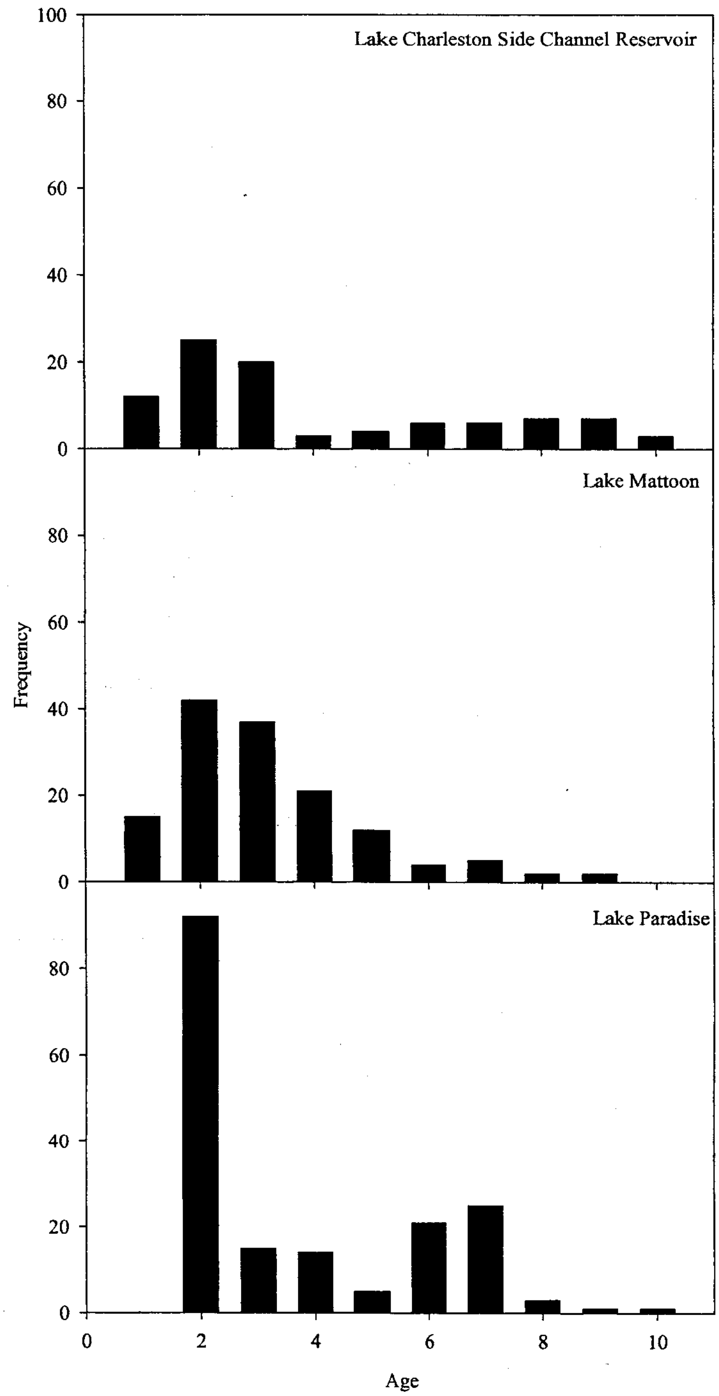

Figure 8. Age frequency histograms for white crappie in Lake Mattoon, Lake Charleston Side Channel Reservoir and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

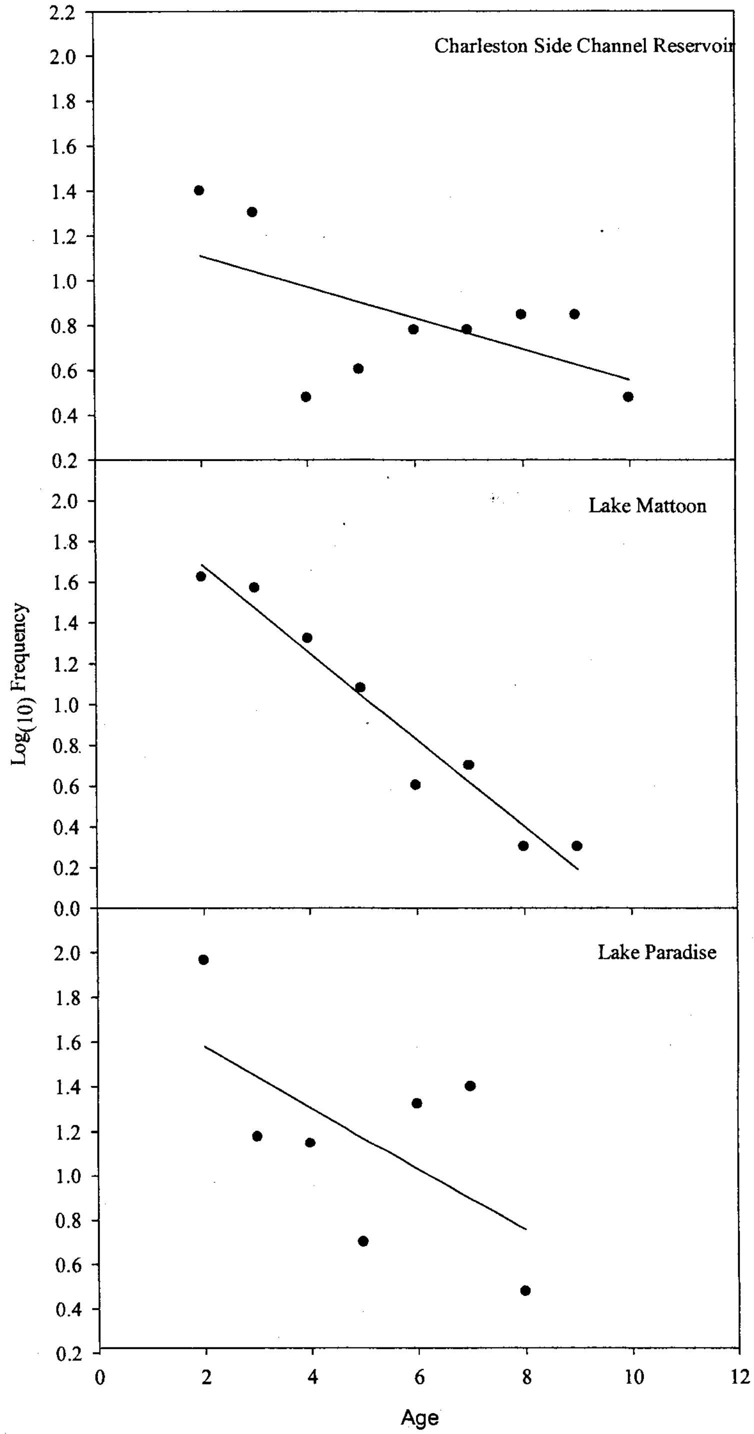

Figure 9. Mortality catch curves for white crappie in Lake Mattoon, Lake Charleston Side Channel Reservoir, and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

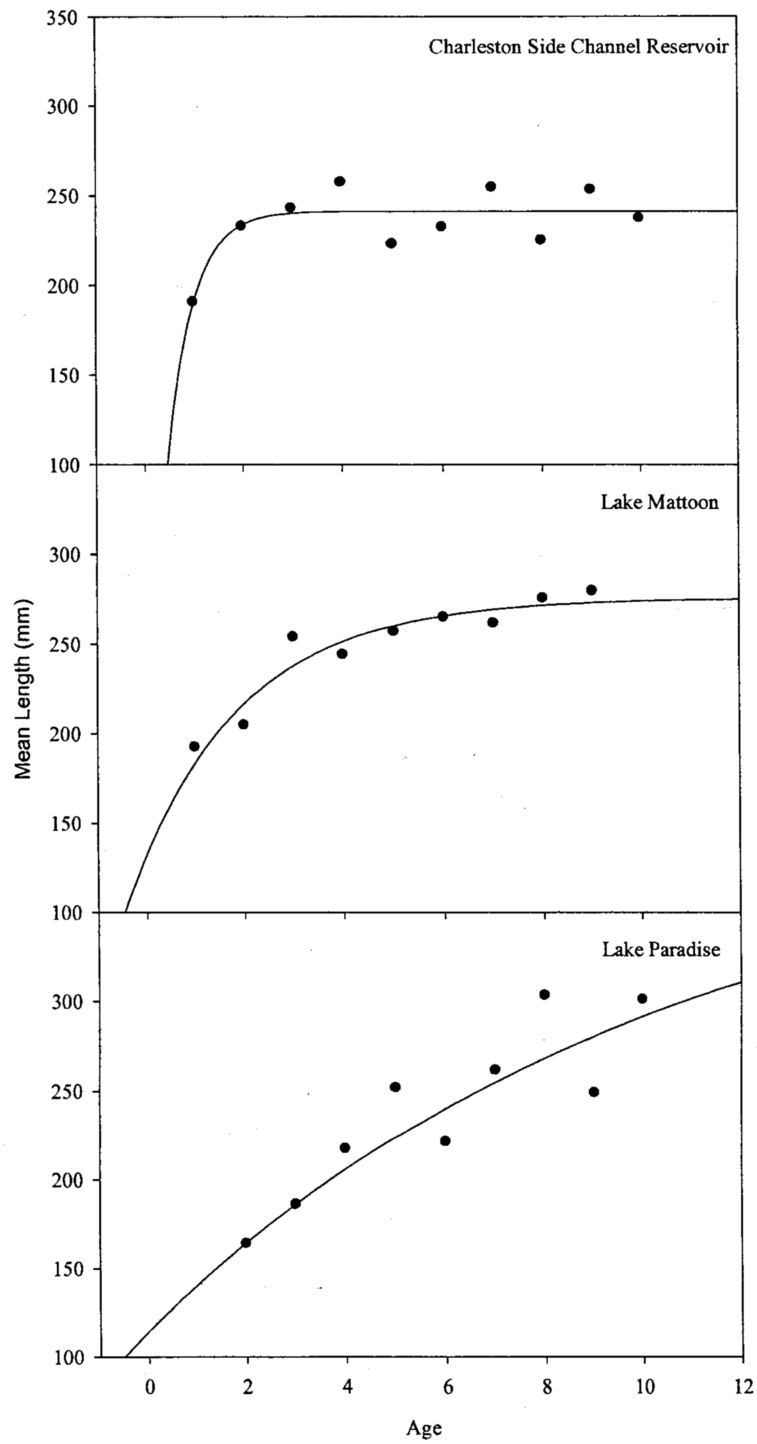

Figure 10. Mean length at age and von Bertalanffy growth model for white crappie Lake Mattoon, Lake Charleston Side Channel Reservoir, and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

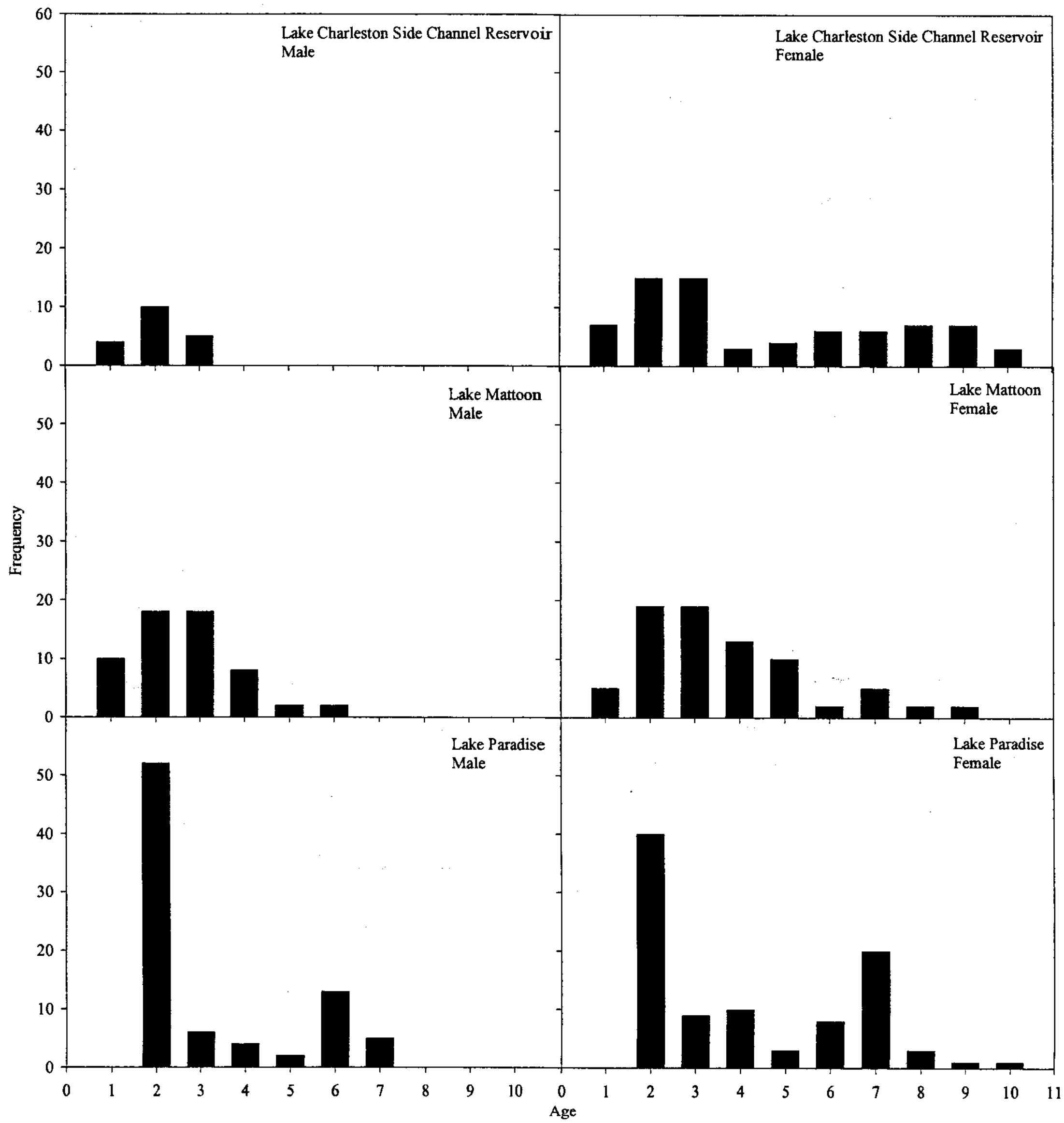

Figure 11. Age frequency histograms for white crappie in Lake Mattoon, Lake Charleston Side Channel Reservoir and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing.

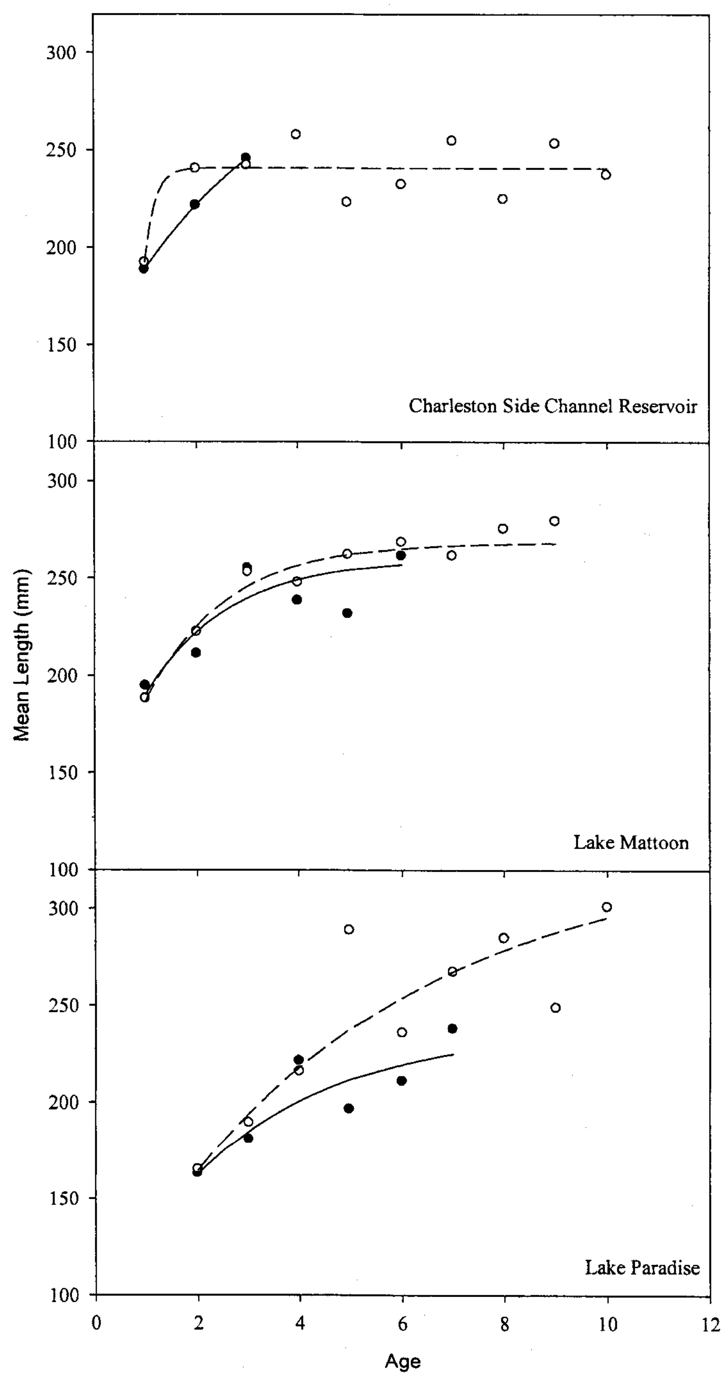

Figure 12. Mean length at age and von Bertalanffy growth model for white crappie by Lake Mattoon, Lake Charleston Side Channel Reservoir, and Lake Paradise sampled during Fall 2009 and Spring 2010 using three phase electrofishing. Filled circles and solid lines represent males while empty circles and dotted lines represent females.

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APPENDIX

Species	ID	Length	Weight	Sex	Lake	Age-Otolith	Age-Scale
WHC	2	257	226	F	Mattoon	4	3
WHC	3	219	141	M	Mattoon	2	3
WHC	4	282	355	F	Mattoon	5	6
WHC	5	229	165	M	Mattoon	3	2
WHC	6	242	179	F	Mattoon	3	3
WHC	7	265	280	M	Mattoon	3	3
WHC	8	237	195	F	Mattoon	2	2
WHC	9	252	239	M	Mattoon	3	3
WHC	10	305	402	F	Mattoon	5	4
WHC	11	253	232	F	Mattoon	2	3
WHC	12	239	207	M	Mattoon	3	4
WHC	13	262	285	F	Mattoon	5	5
WHC	14	234	177	M	Mattoon	1	1
WHC	15	254	249	F	Mattoon	2	2
WHC	16	201	147	M	Mattoon	5	5
WHC	17	231	157	M	Mattoon	2	3
WHC	18	239	184	F	Mattoon	4	4
WHC	19	191	76	M	Mattoon	2	3
WHC	20	245	232	M	Mattoon	3	4
WHC	21	242	201	F	Mattoon	3	3
WHC	22	228	175	M	Mattoon	3	3
WHC	23	245	192	F	Mattoon	5	5
WHC	24	243	210	F	Mattoon	4	3
WHC	25	285	344	M	Mattoon	3	3
WHC	26	223	128	M	Mattoon	4	4
WHC	27	240	194	F	Mattoon	5	4
WHC	28	214	115	F	Mattoon	1	1
WHC	29	190	67	M	Mattoon	1	1
WHC	30	245	204	F	Mattoon	3	3
WHC	31	179	69	F	Mattoon	2	1
WHC	32	290	358	F	Mattoon	3	3
WHC	33	210	114	M	Mattoon	2	1
WHC	34	220	121	M	Mattoon	4	4
WHC	35	235	164	M	Mattoon	3	3
WHC	36	258	245	F	Mattoon	7	7
WHC	37	257	242	M	Mattoon	3	3
WHC	38	180	69	M	Mattoon	2	2
WHC	39	260	236	F	Mattoon	2	2
WHC	40	260	273	F	Mattoon	7	5
WHC	41	163	48	M	Mattoon	1	1
WHC	42	249	222	F	Mattoon	4	5
WHC	43	225	156	F	Mattoon	2	2
WHC	44	189	76	M	Mattoon	2	2
WHC	45	218	142	M	Mattoon	1	1

WHC	46	252	214	F	Mattoon	6	5
WHC	47	251	239	F	Mattoon	4	4
WHC	48	266	265	M	Mattoon	3	3
WHC	49	259	224	F	Mattoon	3	3
WHC	50	255	246	M	Mattoon	2	2
WHC	54	269	279	F	Mattoon	2	2
WHC	55	248	240	M	Mattoon	6	4
WHC	56	253	261	F	Mattoon	3	3
WHC	57	255	243	F	Mattoon	3	3
WHC	58	263	278	M	Mattoon	3	3
WHC	59	290	352	F	Mattoon	4	4
WHC	60	264	248	F	Mattoon	5	4
WHC	61	275	279	M	Mattoon	4	3
WHC	62	256	256	F	Mattoon	5	4
WHC	63	250	228	F	Mattoon	2	3
WHC	64	289	350	F	Mattoon	8	8
WHC	65	246	232	F	Mattoon	3	2
WHC	66	238	189	M	Mattoon	2	2
WHC	67	260	260	F	Mattoon	5	4
WHC	68	274	287	F	Mattoon	3	3
WHC	69	241	195	F	Mattoon	3	2
WHC	70	265	265	F	Mattoon	3	3
WHC	71	230	164	M	Mattoon	2	2
WHC	72	206	117	M	Mattoon	1	1
WHC	73	258	260	M	Mattoon	3	3
WHC	74	260	226	F	Mattoon	3	2
WHC	75	201	86	M	Mattoon	1	1
WHC	76	254	236	F	Mattoon	7	7
WHC	77	195	83	F	Mattoon	1	1
WHC	78	229	170	F	Mattoon	3	3
WHC	79	244	197	F	Mattoon	2	2
WHC	80	191	66	M	Mattoon	1	1
WHC	81	252	233	M	Mattoon	3	3
WHC	82	173	61	F	Mattoon	1	1
WHC	83	257	216	F	Mattoon	2	2
WHC	84	245	232	F	Mattoon	3	2
WHC	85	169	59	M	Mattoon	1	1
WHC	86	169	56	M	Mattoon	1	1
WHC	87	262	299	F	Mattoon	8	7
WHC	88	213	141	F	Mattoon	3	3
WHC	89	214	145	M	Mattoon	2	2
WHC	90	240	192	F	Mattoon	4	4
WHC	91	256	241	F	Mattoon	2	2
WHC	92	206	97	M	Mattoon	1	1
WHC	93	178	60	F	Mattoon	1	1
WHC	94	181	66	F	Mattoon	1	1
WHC	95	264	260	F	Mattoon	2	2
WHC	96	241	200	F	Mattoon	2	2

WHC	97	244	217	F	Mattoon	5	5
WHC	98	275	300	F	Mattoon	2	2
WHC	99	264	251	F	Mattoon	4	5
WHC	101	274	317	M	Mattoon	3	4
WHC	102	273	319	M	Mattoon	4	4
WHC	103	266	302	F	Mattoon	4	3
WHC	104	245	204	M	Mattoon	3	4
WHC	105	244	233	M	Mattoon	2	3
WHC	106	253	239	M	Mattoon	3	2
WHC	107	275	293	M	Mattoon	6	5
WHC	108	263	298	F	Mattoon	5	3
WHC	109	222	170	M	Mattoon	2	5
WHC	110	122	24	UNK	Mattoon	2	2
WHC	111	294	359	F	Mattoon	9	6
WHC	112	324	568	F	Mattoon	7	5
WHC	113	124	24	F	Mattoon	2	2
WHC	114	129	30	F	Mattoon	2	2
WHC	115	206	121	M	Mattoon	4	4
WHC	116	243	195	F	Mattoon	4	4
WHC	117	285	392	F	Mattoon	6	7
WHC	118	238	190	M	Mattoon	4	3
WHC	119	259	261	M	Mattoon	3	3
WHC	120	262	275	M	Mattoon	5	4
WHC	121	295	456	F	Mattoon	3	6
WHC	122	226	149	F	Mattoon	2	4
WHC	123	265	256	F	Mattoon	9	4
WHC	124	111	22	UNK	Mattoon	2	2
WHC	125	124	24	F	Mattoon	2	2
WHC	126	244	219	F	Mattoon	3	4
WHC	127	250	232	F	Mattoon	4	4
WHC	128	108	15	UNK	Mattoon	2	2
WHC	129	100	13	UNK	Mattoon	2	2
WHC	130	274	336	F	Mattoon	3	3
WHC	131	286	390	M	Mattoon	3	3
WHC	132	236	201	F	Mattoon	4	3
WHC	133	257	263	M	Mattoon	4	2
WHC	134	234	189	F	Mattoon	3	5
WHC	135	212	132	F	Mattoon	7	3
WHC	136	220	135	M	Mattoon	2	4
WHC	137	215	125	M	Mattoon	4	3
WHC	138	214	141	M	Mattoon	2	3
WHC	139	204	102	M	Mattoon	2	2
WHC	140	192	96	F	Mattoon	4	3
WHC	141	191	92	M	Mattoon	2	3
WHC	142	180	73	M	Mattoon	2	2
WHC	143	158	54	F	Mattoon	2	3
WHC	144	169	62	M	Mattoon	2	2
WHC	145	134	32	UNK	Mattoon	2	2

WHC	1	231	155	F	Charleston	2	3
WHC	2	143	37	F	Charleston	1	2
WHC	3	202	101	M	Charleston	3	3
WHC	4	252	226	M	Charleston	3	3
WHC	5	208	107	M	Charleston	2	3
WHC	6	228	147	F	Charleston	5	7
WHC	7	225	112	F	Charleston	6	4
WHC	8	199	88	F	Charleston	2	3
WHC	9	222	131	F	Charleston	5	4
WHC	10	196	94	M	Charleston	2	3
WHC	11	191	78	UNK	Charleston	1	1
WHC	12	286	329	F	Charleston	2	2
WHC	131	207	106	F	Charleston	6	4
WHC	132	217	141	M	Charleston	2	2
WHC	133	272	251	F	Charleston	7	4
WHC	134	216	106	F	Charleston	8	6
WHC	135	269	270	F	Charleston	2	3
WHC	136	191	81	M	Charleston	2	2
WHC	137	260	149	F	Charleston	7	7
WHC	138	259	222	F	Charleston	10	7
WHC	139	228	138	F	Charleston	6	5
WHC	140	272	292	F	Charleston	7	7
WHC	141	240	176	F	Charleston	3	2
WHC	142	268	282	F	Charleston	9	6
WHC	149	230	155	F	Charleston	9	9
WHC	150	271	289	F	Charleston	9	5
WHC	151	244	207	M	Charleston	2	3
WHC	152	265	277	F	Charleston	3	3
WHC	153	292	356	F	Charleston	3	3
WHC	154	231	195	F	Charleston	2	1
WHC	155	190	71	F	Charleston	2	1
WHC	156	225	141	M	Charleston	2	2
WHC	157	255	235	F	Charleston	10	8
WHC	158	255	233	F	Charleston	2	2
WHC	159	180	59	F	Charleston	3	3
WHC	160	253	227	F	Charleston	2	3
WHC	161	208	100	F	Charleston	1	1
WHC	162	250	194	F	Charleston	8	5
WHC	163	201	97	F	Charleston	5	3
WHC	164	240	195	M	Charleston	3	3
WHC	165	205	94	F	Charleston	2	2
WHC	166	213	113	F	Charleston	8	7
WHC	167	301	424	F	Charleston	7	6
WHC	186	220	144	F	Charleston	1	2
WHC	187	260	250	F	Charleston	3	4
WHC	188	177	61	F	Charleston	1	1
WHC	189	256	252	F	Charleston	2	3
WHC	190	271	263	F	Charleston	9	8

WHC	191	247	221	F	Charleston	4	3
WHC	192	273	298	M	Charleston	3	2
WHC	193	260	252	M	Charleston	2	2
WHC	194	231	150	F	Charleston	2	2
WHC	195	175	57	M	Charleston	1	1
WHC	196	222	146	F	Charleston	1	1
WHC	197	279	256	F	Charleston	2	2
WHC	198	222	154	F	Charleston	3	4
WHC	199	255	246	F	Charleston	3	3
WHC	200	229	148	M	Charleston	2	2
WHC	201	277	345	F	Charleston	4	4
WHC	202	237	181	F	Charleston	6	6
WHC	203	203	94	F	Charleston	7	4
WHC	204	241	200	F	Charleston	5	6
WHC	205	254	238	F	Charleston	3	3
WHC	206	200	97	F	Charleston	8	7
WHC	207	220	137	F	Charleston	3	3
WHC	208	248	180	F	Charleston	4	4
WHC	209	177	61	M	Charleston	1	1
WHC	210	234	164	M	Charleston	2	2
WHC	211	271	291	F	Charleston	9	7
WHC	212	224	131	F	Charleston	9	9
WHC	213	264	254	F	Charleston	6	4
WHC	214	260	262	M	Charleston	3	3
WHC	215	205	118	F	Charleston	1	1
WHC	216	254	247	F	Charleston	3	3
WHC	217	227	160	F	Charleston	8	7
WHC	218	177	63	M	Charleston	1	1
WHC	219	237	167	F	Charleston	9	5
WHC	220	212	131	M	Charleston	2	2
WHC	221	245	186	F	Charleston	3	3
WHC	222	220	144	F	Charleston	3	1
WHC	223	234	216	F	Charleston	3	2
WHC	224	227	152	F	Charleston	8	6
WHC	225	238	162	F	Charleston	3	3
WHC	226	271	305	F	Charleston	2	1
WHC	227	219	111	F	Charleston	7	6
WHC	228	225	144	M	Charleston	1	2
WHC	229	250	213	F	Charleston	2	2
WHC	230	252	207	F	Charleston	3	3
WHC	231	241	174	F	Charleston	8	8
WHC	232	170	49	F	Charleston	1	1
WHC	233	199	105	F	Charleston	2	3
WHC	234	198	95	F	Charleston	10	3
WHC	235	233	220	F	Charleston	6	7
WHC	1	312	443	F	Paradise	7	6
WHC	2	275	375	F	Paradise	7	6
WHC	3	256	283	M	Paradise	4	5

WHC	4	262	254	F	Paradise	6	5
WHC	5	155	42	M	Paradise	2	2
WHC	6	149	36	F	Paradise	2	2
WHC	7	159	45	F	Paradise	2	2
WHC	8	176	51	M	Paradise	2	2
WHC	9	160	38	F	Paradise	2	3
WHC	10	174	56	F	Paradise	2	3
WHC	11	188	68	M	Paradise	6	4
WHC	12	225	143	M	Paradise	4	4
WHC	13	150	38	F	Paradise	2	2
WHC	14	168	47	M	Paradise	2	2
WHC	15	189	60	M	Paradise	2	2
WHC	16	257	254	M	Paradise	7	4
WHC	17	149	35	F	Paradise	2	2
WHC	18	292	416	F	Paradise	7	7
WHC	19	248	224	F	Paradise	7	4
WHC	20	175	66	M	Paradise	2	2
WHC	21	266	324	F	Paradise	7	4
WHC	22	258	296	F	Paradise	7	3
WHC	23	189	70	M	Paradise	2	4
WHC	24	207	90	F	Paradise	4	3
WHC	25	162	40	F	Paradise	2	2
WHC	26	158	41	F	Paradise	2	2
WHC	27	166	46	M	Paradise	2	2
WHC	28	320	543	F	Paradise	7	5
WHC	29	229	564	F	Paradise	8	4
WHC	30	263	283	F	Paradise	7	6
WHC	31	154	37	F	Paradise	2	2
WHC	32	188	58	M	Paradise	2	3
WHC	33	184	59	M	Paradise	2	3
WHC	34	277	356	F	Paradise	4	2
WHC	35	296	441	F	Paradise	8	4
WHC	36	255	246	M	Paradise	7	4
WHC	37	267	294	F	Paradise	5	4
WHC	38	246	239	M	Paradise	6	5
WHC	39	160	42	F	Paradise	2	2
WHC	40	287	383	M	Paradise	6	4
WHC	41	122	17	M	Paradise	2	2
WHC	42	112	14	M	Paradise	2	2
WHC	43	270	329	F	Paradise	7	5
WHC	44	311	514	F	Paradise	8	5
WHC	45	108	11	M	Paradise	2	2
WHC	46	245	217	F	Paradise	7	5
WHC	47	303	452	F	Paradise	8	4
WHC	48	160	45	M	Paradise	2	3
WHC	49	163	40	M	Paradise	2	2
WHC	50	172	54	M	Paradise	2	2
WHC	51	192	78	F	Paradise	4	5

WHC	52	188	65	M	Paradise	2	3
WHC	53	163	45	F	Paradise	2	2
WHC	54	181	61	F	Paradise	2	3
WHC	55	301	440	F	Paradise	10	5
WHC	56	288	381	F	Paradise	7	5
WHC	57	175	53	F	Paradise	2	2
WHC	58	181	61	M	Paradise	2	2
WHC	59	175	55	F	Paradise	2	2
WHC	60	157	44	F	Paradise	2	2
WHC	61	295	440	F	Paradise	5	3
WHC	62	265	309	F	Paradise	7	4
WHC	63	283	364	M	Paradise	6	4
WHC	64	265	299	F	Paradise	7	3
WHC	65	228	139	M	Paradise	7	3
WHC	66	276	323	F	Paradise	4	4
WHC	67	249	206	F	Paradise	9	3
WHC	68	245	217	M	Paradise	2	2
WHC	69	183	66	F	Paradise	2	2
WHC	70	169	48	M	Paradise	2	2
WHC	71	160	43	M	Paradise	2	3
WHC	72	204	101	M	Paradise	6	5
WHC	73	180	60	M	Paradise	6	4
WHC	74	206	92	F	Paradise	3	3
WHC	75	164	47	M	Paradise	2	2
WHC	76	190	70	M	Paradise	5	2
WHC	77	170	50	F	Paradise	2	2
WHC	78	174	55	M	Paradise	2	2
WHC	79	170	53	F	Paradise	2	2
WHC	80	170	49	M	Paradise	2	2
WHC	81	162	47	F	Paradise	2	2
WHC	82	117	16	M	Paradise	2	2
WHC	83	176	54	M	Paradise	2	2
WHC	84	178	58	F	Paradise	2	2
WHC	85	176	57	F	Paradise	2	2
WHC	86	167	48	F	Paradise	2	3
WHC	87	155	39	F	Paradise	2	3
WHC	88	323	601	F	Paradise	6	5
WHC	89	163	46	M	Paradise	2	3
WHC	90	245	219	M	Paradise	7	4
WHC	91	192	74	M	Paradise	6	
WHC	92	171	50	F	Paradise	2	2
WHC	93	169	51	M	Paradise	2	3
WHC	94	161	42	M	Paradise	2	3
WHC	95	162	46	M	Paradise	2	2
WHC	96	183	62	M	Paradise	4	3
WHC	97	173	56	M	Paradise	2	2
WHC	98	167	50	M	Paradise	2	2
WHC	99	203	80	M	Paradise	5	5

WHC	100	172	51	M	Paradise	2	2
WHC	101	160	42	M	Paradise	2	2
WHC	102	171	52	M	Paradise	2	2
WHC	103	167	49	F	Paradise	2	2
WHC	104	156	43	M	Paradise	2	2
WHC	105	177	55	M	Paradise	3	2
WHC	106	111	14	M	Paradise	2	2
WHC	107	157	45	F	Paradise	2	2
WHC	108	205	87	M	Paradise	7	4
WHC	109	174	48	F	Paradise	2	2
WHC	110	168	50	F	Paradise	2	2
WHC	111	168	52	M	Paradise	2	2
WHC	112	191	64	M	Paradise	3	2
WHC	113	154	38	M	Paradise	2	2
WHC	114	187	70	F	Paradise	4	3
WHC	115	195	80	M	Paradise	6	4
WHC	116	196	82	M	Paradise	6	5
WHC	117	289	372	F	Paradise	7	5
WHC	118	171	50	F	Paradise	2	2
WHC	119	107	11	M	Paradise	2	2
WHC	120	157	39	F	Paradise	2	2
WHC	121	194	70	M	Paradise	6	2
WHC	122	165	46	F	Paradise	2	3
WHC	123	221	136	M	Paradise	4	4
WHC	124	251	252	F	Paradise	6	3
WHC	125	200	81	F	Paradise	6	3
WHC	126	191	64	M	Paradise	2	3
WHC	127	157	38	F	Paradise	2	2
WHC	128	176	54	F	Paradise	2	3
WHC	129	209	94	M	Paradise	6	4
WHC	130	204	91	F	Paradise	3	2
WHC	131	206	91	F	Paradise	3	3
WHC	132	241	208	F	Paradise	7	4
WHC	133	165	47	M	Paradise	2	2
WHC	134	123	17	M	Paradise	2	2
WHC	135	169	49	F	Paradise	2	2
WHC	136	261	43	M	Paradise	2	2
WHC	137	246	159	F	Paradise	7	4
WHC	138	160	43	F	Paradise	2	2
WHC	139	163	48	F	Paradise	2	2
WHC	140	163	43	F	Paradise	2	2
WHC	141	164	46	M	Paradise	3	2
WHC	142	304	484	F	Paradise	5	4
WHC	143	187	81	F	Paradise	6	2
WHC	144	158	43	M	Paradise	2	2
WHC	145	226	125	F	Paradise	4	3
WHC	146	276	327	F	Paradise	7	7
WHC	147	119	17	M	Paradise	2	2

WHC	148	174	52	F	Paradise	3	3
WHC	149	155	38	M	Paradise	3	2
WHC	150	164	43	M	Paradise	2	2
WHC	151	194	77	M	Paradise	6	4
WHC	152	166	45	F	Paradise	3	3
WHC	153	191	76	M	Paradise	6	4
WHC	154	209	89	F	Paradise	7	4
WHC	155	205	96	F	Paradise	4	4
WHC	156	204	91	F	Paradise	4	3
WHC	157	166	46	F	Paradise	2	2
WHC	158	198	85	F	Paradise	6	5
WHC	159	186	63	F	Paradise	3	3
WHC	160	205	94	F	Paradise	4	4
WHC	161	165	50	F	Paradise	3	2
WHC	162	173	53	M	Paradise	2	3
WHC	163	170	51	F	Paradise	3	2
WHC	164	270	333	F	Paradise	7	2
WHC	165	251	214	F	Paradise	7	2
WHC	166	193	75	M	Paradise	6	4
WHC	167	113	13	M	Paradise	2	2
WHC	168	169	54	F	Paradise	2	2
WHC	169	163	43	M	Paradise	2	3
WHC	170	170	49	M	Paradise	3	3
WHC	171	179	46	F	Paradise	4	2
WHC	172	194	84	F	Paradise	6	4
WHC	173	227	133	F	Paradise	3	3
WHC	174	273	314	F	Paradise	6	3
WHC	175	173	56	F	Paradise	2	2
WHC	176	229	152	M	Paradise	3	3
WHC	177	185	57	M	Paradise	2	3
WHC	178	185	59	M	Paradise	2	3
WHC	179	116	14	M	Paradise	2	2