Age, growth, home range, movement, and habitat selection of redeye bass (*Micropterus coosae*) from the middle Tallapoosa River tributaries (Alabama, USA).

by

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Abstract

Redeye bass *Micropterus coosae* is a common, but underutilized sport fish resource in Alabama. This species is the most attractive of all the black basses, and has a reputation as a formidable catch on light tackle. Redeye bass are typically abundant in rivers and streams only navigable by canoes or kayaks. The purpose of this study was to determine age and growth, movement, home range, and habitat selection of redeye bass from the middle Tallapoosa Watershed, in Alabama.

Age and growth was determined using validated hard structures (otoliths). Additionally, alternative non-lethal structures (spines) were also investigated. Results indicated there were minimal differences in age assignment between structures when data were combined; however variation was observed when individual age classes were examined. Spine aging tended to underestimate actual age, but this structure may be useful to gain a general understanding of age class structure if euthanasia is not desired. Differences in age and growth between tributary and mainstream resident redeye bass were not observed.

Movement, home range, and habitat selection were determined using radio telemetry methods. Proper tagging procedures were determined prior to initiation of this study. Redeye bass generally showed some evidence of site fidelity during hydrologically stable periods, but did not show fidelity during high flow periods. Movement rates were more variable for smaller redeye bass, while larger fish moved less. On average redeye bass moved 705 m during the ten weeks they were monitored.

Home range estimates were difficult to determine due to limited battery life of transmitters. Fifty percent (core) kernel density estimates were similar to what was reported for other black bass species. Ninety-five percent kernel density estimates were calculated, but this research lacked sufficient samples sizes to conclude any valid biological inferences. Future research should focus on tagging larger fish that can be tagged with larger transmitters to gain a better understanding of home range for the species.

Habitat research indicated that there appeared to be some intra-specific competition between redeye bass. Tagged fish were never associated with one another, and juvenile fish appear to occupy sub-optimal habitats. Results from habitat selection analysis indicated that the presence of canopy cover and interactions between specific variables were important predictor variables of redeye bass selection. Some differences were observed between adult and juvenile habitat selection. Adult fish selected locations with an interaction between interactions between relative depth and presence of instream features, interactions between boulders and canopy cover, and presence of instream features reduced distances to shore interactions. Juvenile fish also selected areas with increasing canopy cover, increasing relative depth, interactions between the presence of instream features and depth, and a complex interaction between boulder and sand substratum, that had increased depths. Results from this research will assist managers with gaining a greater understanding of life history requirements of redeye bass, and facilitate management of this potentially valuable fisheries resource.

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INTRODUCTION

Redeye bass *Micropterus coosae* (Hubbs and Bailey 1940 Teleostei, Centrarchidae) are the quintessential black bass species of piedmont streams in Alabama. An attractive fish in every respect, redeye bass are unique from all other black basses, having an olivaceous to bronze dorsal coloration, with rows of dark spots on sides, a pale abdomen, and typically three dark bars on the cheek, unique from all other black basses (Parsons 1954, Boschung and Mayden 2004). The eyes and fins are brick red, (occasionally orange) with dark vertical bars on the back and side, extending to the midline, and an iridescent white or frosted orange color pattern on the outer margins of the caudal fin lobe (Parsons 1954; Ramsey 1973; 1975**;** Page and Burr 1991; Boschung and Mayden 2004, Rohde et al. 2009). Redeye bass are most similar in appearance to the shoal bass, although the species is actually morphologically aligned with Alabama bass (Williams and Burgess 1999). Redeye bass are native to the Mobile basin (Coosa, Tallapoosa, Cahaba, and Black Warrior), above the Fall line (Boschung and Mayden 2004; Etnier and Starnes 1993). The species also occurs in the Chattahoochee and the Savannah River Drainages in Georgia, North, and South Carolina (Etnier and Starnes 1993; Boschung and Mayden 2004; Rohde et al. 2009).

A small fish, in comparison to other black basses, Parsons (1954) called the redeye bass the “brook trout” of the warmwater sport fish. The species has a reputation as a scrappy, hard fighting fish, resistant to capture (Hurst et al. 1975; Koppelman and Garrett 2002; Boschung and Mayden 2004). Historically, redeye bass were not heavily pursued as a sport fish (Hurst et al. 1975), although recreational angling has recently increased for redeye bass from streams

(Catchings 2000; http://www.outdooralabama.com/fishing/freshwater/fish/bassblack/redeye/fishing.cfm). Data are needed regarding population structure, and critical habitat needs to effectively manage this potentially valuable sportfish.

Age, growth, and sexual maturity of redeye bass are not well understood. Maximum age is assumed to be about 9-10 years, while sexual maturity was estimated at three or four years, based on three age and growth studies using scales (Parsons 1953; Tatum 1965; Hurst et. al 1975; Gwinner et al. 1975; Catchings 1978; Etnier et al. 1993). Such aging estimates lack precision, accuracy, and often underestimate the true age of older fish (Beamish and Harvey 1969; Sharp and Bernard 1988; Hammers and Miranda 1991; Soupir et al. 1997). Additional research on redeye bass age and growth were actually research conducted on shoal bass (Parsons and Crittenden 1959; Hurst 1969; Williams and Burgess 1999).

Therefore research is needed to accurately characterize age and growth of redeye bass based on validated aging procedures. Otoliths are now regarded as the superior aging structure for temperate fishes (Erickson 1983; Boxrucker 1986; Hammers and Miranda 1991; Welch et al. 1993; Lowerre-Barbieri et al. 1994; Kocovsky and Carline 2000; Ihde and Chittenden 2002). Given the lack of reliable information on age, growth, and sexual maturity of redeye bass, research is needed to facilitate proper management of the species based on validated aging procedures. Specifically, such information can be used to establish minimum length regulations, determine total mortality, and determine exploitation of redeye bass from Alabama streams.

Aging fish using otoliths is a lethal process, therefore a non-lethal technique for aging redeye bass could be an effective alternative for evaluating population structure, when euthanasia is not desired. Because redeye bass likely have a life span of 10 years or less, age estimates based on spines may be an alternative non-lethal aging method. Welch et al. (1993) demonstrated spine aging was relatively precise and accurate for striped bass (*Morone saxatilis*) age-10 and younger. Additionally, several studies indicated that age estimates based on spines were more reliable than scale aging, particularly in older fish (Beamish and Harvey 1969; Erickson 1983; Praghakaran 1989; Kocovsky and Carline 2000; Borkholder and Edwards 2001). A study of lingcod, *Ophiodon elongates* found spine aging was superior to all other methods (Cass and Beamish 1983).

Movement studies on redeye bass are limited to a single mark-recapture study (Catchings 1975-1977, unpublished data) and no data are available for home range analysis of redeye bass. Home range estimates conducted on aquatic organisms historically used either linear home range or minimum convex polygons (Woodward and Noble 1997; Hooge and Eichenlaub 1997), although research now indicates that kernel density estimates of home range provide more accurate estimations than minimum convex polygons, when sufficient sample sizes (e.g., ≥ 30) are available (Seaman and Powell 1996). Advances in radio telemetry technology facilitated a greater definition of habitat use, movement, and home ranges of other black basses (Winter 1977; Warden and Lorio 1975; Savitz et al. 1983; Kynard et al. 2000), and these data are also needed for redeye bass management in Alabama.

Other black bass species are well studied and population characteristics can be related to habitat quality on multiple scales. Redeye bass are limited to upland streams with canopy cover, cool water temperatures vegetative cover, undercut banks, and rock ledges or large boulders (Etnier and Starnes 1993; Boschung and Mayden 2004; Parsons1954). The species typically avoids impoundments and navigational pools, due to competition with the larger Alabama bass and largemouth bass (Parsons 1954; Barwick and Moore 1983; Koppelman and Garrett 2002; Boschung and Mayden 2004). Specific studies on redeye bass habitat use are limited to distribution/status and presence/absence surveys, and no research is currently available investigating habitat selection for the species. Current knowledge of redeye bass habitat use does not address whether habitat associations observed are actually critical to fitness of the species. No information is available evaluating differences in habitat use or selection between juvenile and adult redeye bass.

Johnson (1980) defined “usage” as the quantity of a component used by an organism in a fixed period of time, while selection is defined as a process, which an animal actually chooses a component. Furthermore, a ranking system is required to determine “preference” for an organism by measuring the difference between the rank of usage and the rank of availability to determine resource selection (Johnson 1980). While landscape level features have been identified for redeye bass (Irwin et al. 2005), it is currently unknown if redeye bass select habitats based on specific instream or general habitat features.

There are three study designs for evaluating selection of resources (Thomas and Taylor 1990). Design one measures used, unused, and/or available resources at the population level (i.e., individual animals are not identified) and resource units are sampled from the entire study area. This design is often less expensive because data collection is less intensive, and is basically a single stage process (Manley 2003). A disadvantage to this design is that selection can only determined at the population level, because individuals are not identified (Thomas and Tayler 1990).

Design two and three identify individual animals, while design two measures availability population level whereas design three measures individual habitat and at least two sets (used, unused, and available) for each animal. Both designs allow inferences on the population level, based on the assumption that all animals identified are a random sample of the population, but require a several stage process to evaluate selection, usage and availability, and often involve sub-sampling (Manley 2003). Advantages to these two designs are that they allow examination of variation in resource selection strategies (Thomas and Taylor 1990). Although, some studies cautioned against using the design three approach, because the study organism has already made a resource selection (Johnson 1980).

Recent studies used resource selection functions (RSF) to describe selection by animals (Boyce et al 2002; Manly et al. 2003; Osko et al. 2004; Zielinski et al. 2004). A resource selection function (RSF) is defined as any function that is proportional to the probability of use by an animal (Manly et al. 2003). Specifically the units selected by an animal are predictor variables or covariates of resources (Boyce at al. 2002). In order to evaluate resource selection for a particular organism, the proper scale of selection must first be determined (Manly et al. 2003). Advantages to using RSF models are that binomial generalized models, such as logistic regression, can be used as an estimating function (but not necessarily statistical inferences). In this case, logistic regression yields the probability of use of a resource unit (Boyce et al. 2002).

This probability can be incorporated into an information theoretic approach, such as Akaike’s Information Criterion (AIC), by calculating the maximized log-likelihood value and the Kullback-Leibler distance (Burnham and Anderson 1998). The relationship between these two values generates and estimate of the expected relative distance between a model and the unknown mechanism generated from empirical data (Burnham and Anderson 1998). This approach is recognized as the most appropriate model selection criteria for ecological studies (Burnham and Anderson 1998).

A major issue (or limitation) of using telemetry data to characterize resource selection of animals, specifically when data are pooled across individuals is autocorrelation (Gillies et al. 2006). Typically, a fixed-effect modeling procedure is used (e.g., logistic regression) to estimate coefficients from the RSF model (Boyce et al 2002; Manly et al. 2003; Osko et al. 2004; Zielinski et al. 2004). Specifically, such procedures result in incorrect variance estimates (Otis and White 1999) and an increase in Type I error rate (Leban et al. 2001). Recent advances in maximum likelihood theory (and resulting advances in statistical packages), have enabled implementation of a random-effects modeling procedure (Proc Glimmix; SAS Cary, NC) to minimize the effects of autocorrelation on RSF models (Gillies et al. 2006). This approach may facilitate more robust inferences of resource selection, based on telemetry data.

Specific habitat characteristics critical to quality redeye bass populations are needed on multiple scales (watershed to microhabitat). Data are currently available identifying landscape factors influencing redeye bass distribution (Irwin et al. 2005), although information is still needed to identify microhabitat use and selection of the species from Alabama streams. When specific microhabitat habitat data are coupled with fish movement data, critical habitats and/or management units can be identified to determine the proper scale (e.g., stream reach or watershed) needed to protect or enhance redeye bass populations. For example, if risks to critical habitats are identified (e.g., water withdrawals from gas-fired power plants or severe flow regulation), protection, mitigation or habitat enhancement may be possible (Irwin et al. 2005).

Objectives

The objective of this thesis was to determine age, growth, movement, home range, habitat use, and habitat selection of redeye bass from the middle Tallapoosa basin in Alabama.

Specifically, radio telemetry methods were used to determine movement, home range, and habitat use for redeye bass in Hillabee Creek, a tributary to the Tallapoosa River system to test the hypothesis that on a microhabitat scale, redeye bass distribution is positively influenced by the presence of specific instream and riparian features (e.g., large substratum, instream cover, and canopy cover). Differences in habitat use and selection were also evaluated between adult and juvenile redeye bass (based on age and growth). Habitat use, movement, and home range data can used to identify scale (e.g., stream reach or watershed) of which habitat protection and enhancement is needed to properly manage redeye bass from piedmont streams in Alabama. Possible differences in habitat associations between adult and juvenile redeye bass may provide additional insights in management units needed for protection and enhancement from piedmont streams in Alabama.

Age and growth was determined by using otolith aging techniques. Specifically age, growth, and sexual maturity of redeye bass was used to provide a technique needed for fisheries managers to characterize redeye bass populations from piedmont streams in Alabama. In addition, estimates of age and growth were evaluated using spines for aging redeye bass in order to provide a possible alternative to lethal aging techniques for fisheries managers

METHODS

Field Methods

Backpack electrofishing (BPEF; Smith Root® model POW 12B) techniques were used to collect redeye bass from wadeable areas of the middle Tallapoosa River and tributaries during base-flow periods. Fish collected for age and growth were euthanized in MS-222 (180 mg/l), placed on ice, and returned to the laboratory. Redeye bass collected to determine movement, home range, habitat use, and habitat selection were tagged from Hillabee Creek (Tallapoosa County, Alabama; Figure 1).

Surgical procedures- Validated surgical techniques were required in order to minimize mortality and ontogenetic changes that may result in reduced tag retention, which could bias the effectiveness of monitoring efforts (Taylor 2004). Surgical implantation of radio transmitters, for telemetry studies, into the body cavity of a fish is recognized as the best method for long-term attachment because this technique is less detrimental to growth and behavior of fish (Winter 1983; Adams et al. 1998).

Prior to surgeries, redeye bass were anesthetized with Tricaine methanesulfonate (MS-222) at 90mg/l, which was previously determined as the optimal dosage. This anesthetic is widely recognized as a suitable anesthetic for fish (Martinelli and Shively 1997; Bunnell et al. 1998; Burrell et al. 2000; Walsh et al. 2000; Baldwin et al. 2002; Isely et al. 2002). At this dosage fish began to lose consciousness and equilibrium, gill movements slowed but maintained a steady pace, were sedated for at least 3-4 minutes, and exhibited no apparent adverse effects observed once placed back into fresh water.

Anesthetized fish were placed in a v-shaped trough and wrapped with a wet cloth to limit movement. Transmitters were implanted following guidelines established by Winter (1983). Tags weights were either 1.7 or 2.1 g in air, therefore fish as small as 85 g could be tagged (tags < 2.0% fish body weight; Winter 1983). Approximately a 2 cm incision was created ventrally, between the anal papillae and the pelvic fins using a sterile scalpel. The transmitter was submerged in betadine and inserted into the peritoneal cavity. The incision was sutured with 3/0 non-absorbable nylon sutures (Vetus Animal Health Product # 271-0175). Two to three sutures were used to seal the incision, leaving the antennae trailing. After sealing the incision, the wound was coated with betadine and the fish was placed in fresh water until recovery was apparent.

Tag retention study- A tag retention study was conducted to determine the effects of surgical techniques and on redeye bass. Initially, pond raised largemouth bass were used as a surrogate species. Once surgical techniques were validated, wild caught redeye bass were implanted with constructed simulated (dummy) transmitters. All simulated transmitters were constructed to the specifications of Advanced Telemetry Systems (ATS) models F1430 and F1440. Transmitters were constructed with craft casting resin and coated with beeswax (J. Isely personal communication). Epindorf tubes (volume 2ml) were used as a cast and monofilament line was inserted into the transmitters mimicking the antennae (J. Isely personal communication). All fish were held for a period of 30 days prior to surgery to acclimate to the Alabama Cooperative Fish and Wildlife Research Unit aquaculture facilities, then wild fish were tagged and held for a period of 35 days to determine any potential adverse effects of surgical procedures. Fish were then euthanized and a necropsy was performed to determine any potential adverse effects of the surgical procedures.

Radio telemetry- Twelve redeye bass were tracked from Hillabee Creek (an unregulated stream). Fish were implanted with ATS tags (F1430 and F1440; frequency range 40.600 to 40.691 MHz) and tracked at least twice weekly (August - October 2003) for the life of the transmitters (53-80 days). All tracking was conducted during diurnal periods, and tracking times ranged from 0825 to 1755 hours.

An ATS Model R2000 receiver with a loop receiving antenna was used for locating tagged fish. Fish were initially located by triangulation, and specific locations were determined by using the null antennae method (Kynard et al. 2000). Because the antennae cable alone receives a dilute signal from the tagged fish, the cable was detached from the antennae and placed in the stream to increase locational accurately of tracked fish (Kynard et al. 2000), by placing transmitters in random locations and tracked, while recording distance from observed position verses true position. Differences between observed locations and actual transmitter locations were recorded and used to establish accuracy of tracking. Specifically this difference was used to determine the size of the area of probable occurrence (APO; Dare and Hubert 2000), An APO of one meter was established based on the preliminary accuracy assessment and each telemetry location was recorded four times (then averaged) within one meter in circumference of the observed location.

Habitat use- The following habitat measurements were recorded at each telemetry location to determine habitat use of redeye bass (Table 1); global position system (GPS) location (Wesche et al. 1987), co-dominant substratum size (modified Wentworth scale; Bovee 1982; Moyle and Baltz 1985; Sowa and Rabeni 1995), mean depth (cm), mean current velocity recorded at 0.6 depth when total depth was < 75cm deep and at 0.8 and 0.2 depth when depth was > 75cm (Moyle and Baltz 1985; Sowa and Rabeni 1995), presence of instream cover and type (e.g., bedrock, boulders, snags, and/or undercut banks; Simpkins et al. 2000; Walters and Wilson 1996; Bowen et al. 1998). For an instream cover to be considered biologically meaningful, water velocity must significantly decrease downstream from the structure and conceal at least half of the fish's body (Simpkins et al. 2000). Canopy cover was also measured using a spherical densitometer (Wesche et al. 1987; Sowa and Rabeni 1995). Distance to closest shoreline was recorded using a 50-meter measuring tape or an optic range finder (Martinelli and Shively 1997). Presence/absence of submerged and rooted aquatic plants (*Justicia spp*.) and mesohabitat type (riffle, run, or pool) were also recorded.

Habitat availability- Habitat availability data were collected *ad hoc*. All availability data were collected at similar conditions (in terms of mean discharge) to when telemetry data were collected (based on USGS gage 02415000, Hillabee Creek near Hackneyville Al.). Mean discharge during the telemetry study was 166 cubic feet per second (cfs) while mean discharge was 149 cfs (February 05, 2008), and 153 cfs (January 05, 2008) for availability data collection. All habitat measurements recorded for habitat use were also recorded to determine habitat availability.

Random habitat availability points were determined using ARCGIS software (ESRI Redlands, CA). The entire reach was mapped manually using a Garmin 76s handheld GPS. Data were plotted over the Digital Raster Graphics (DRG), to check for mapping accuracy. The reach was smoothed based on stream margins from the DRG. Additional polygons were created based on the presence of island margins, in order to exclude from habitat availability dataset. Next the entire reach was converted to a grid (one meter in size). Each grid cell was assigned a unique GPS coordinate (Universal Transverse Mercator), and availability points were randomly identified from this grid. Habitat availability points were stratified based on home range analysis from telemetry data, which two distinct patterns of home range behavior were observed. Specifically, availability points were stratified based on whether fish exhibited fidelity to the shoal where collected or movements were random (i.e. no site fidelity observed from the shoal). These points were then exported from ARCGIS and loaded into a Garmin 76CS, using Minnesota DNR Garmin software (http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html).

Laboratory Methods

Sagittal otoliths were extracted for age and growth research on redeye bass. Otoliths were mounted in crystal bond, sanded with 400-grit sandpaper, and polished with 600-grit sandpaper (Maceina 1988). Once polished, otoliths were read using a compound microscope at 64X magnification, using reflected light. Two independent readers assigned ages based on annuli (hereafter termed a concert read). Discrepancies between readers were resolved by mutual examination of the questionable structures. Sexual maturity of redeye bass was also determined at this time, by examining gonad development.

Fish euthanized for otolith extraction were also used to determine validity of age estimations based on dorsal spines. The second and third dorsal spines were removed, dried, stored in envelopes, and then boiled to remove any tissue from the spines. Spines were mounted in small cube trays using Castin'Craft clear casting resin, and allowing 24h before sectioning. Next, spines were sectioned using a jeweler's saw (blade size 1/0). At least three or four sections were cut to a width less than 1.5mm, beginning at the base of the spine. Sections were ground using 400-grit sandpaper, and then polished using 600-grit paper to increase clarity. If needed mineral oil was used to further increase clarity of the spine sections. All spine sections were interpreted using a compound microscope at 64X magnification, using transmitted light. When using transmitted light the annuli appear light, while the growth zone appears dark, a situation opposite to more commonly used reflected light (Chilton and Beamish 1982). Two independent readers interpreted spine sections. Discrepancies between readers were resolved by a concert read.

Statistical analysis- Ages assigned to otoliths and spines were analyzed to determine agreement between aging structures. Mean length at age estimates were calculated to determine differences between structures. Fisheries Analysis Simulation Tools (FAST) was used to calculate the von Bertalanffy growth equation, the weight-length relation, and catch curves (estimates of survival and theoretical maximum age) of redeye bass using data for both structures (Slipke and Maceina 2000). Analysis of co-variance (ANCOVA) was used to detect differences between aging structures within the Tallapoosa watershed (SAS Cary, NC).

All movement and home range analysis was conducted using the Animal Movement Extension (AMAE) in Arcview 3.2a (Hooge and Eichenlaub 1997). Telemetry data were imported into Arcview to determine total movement, mean successive movement, and mean daily movement. Total movement (m) was defined as the summed movement during entire radio telemetry period. Mean successive movement (m) was the total movement between each radio telemetry location. Mean daily movement (m) was movement between locations when radio telemetry points were collected within a 24-hour period. In two circumstances, fish movement calculated by the AMAE, fell out of bounds of the mapped stream segment (Fish 40.600 and 40.681). When this occurred, movements within terrestrial areas were clipped and distance moved was reanalyzed using the Arcview measuring tool. When this situation occurred manual calculations were conducted and incorporated into the data set. Additional analysis conducted included linear regression to determine if any correlation existed between redeye bass size and movement rates.

Prior to home range analysis telemetry data were subjected to a site fidelity test to determine if a home range existed (Hooge and Eichenlaub 1997; Spencer at al. 1990). This created random angles and used distances between sequential points to determine walk points, using Monte Carlo simulation techniques to determine whether observed movements had more site fidelity than should randomly occur (Hooge and Eichenlaub 1997; Spencer at al. 1990). The actual movement path values were compared to the ranked values derived from random walks in order to determine significance (Hooge et al 1997). Specifically, the recorded animal locations must show no considerable dispersion or linearity (Hooge et al 1997).

Home range analysis was conducted using fixed kernel density home range estimates (Seaman and Powell 1996; Seaman et al. 1999). Kernel estimates are recognized as one of the most robust technique for estimation of home range (Worton 1989). Fixed kernel density estimations were used with a smoothing factor calculated using a least-squares-cross-validation (LSCV), which is considered the most robust kernel technique (Hooge and Eichenlaub 1997; Seaman and Powell 1996). The two kernel contours were used, the 95% kernel which represents the area the animal uses and 50% that represents the core area of activity (Hooge et al. 1998). All home range estimations were clipped in Arcview by land features (streambank and island margins) to reduce overestimation of home ranges by eliminating terrestrial areas from the home range estimation.

Resource selection was determined for redeye bass using logistic regression (SAS 9.2; Cary, NC) to analyze the potential importance of habitat variables (Zielinski et al. 2004; Manly 2003). Specifically, the dependant variable was used to distinguish between habitats used (i.e., telemetry points), coded as “1” and habitats available (i.e., randomly selected) coded as “0” for the logistic regression model (Boyce et al. 2002). To minimize the effect of autocorrelation (i.e., non-independence) of telemetry data, a random effects modeling approach was used (Proc Glimmix; SAS 9.2 Cary, NC; Gillies et al. 2006).

Prior to analyses several tests were conducted to determine the importance of each habitat measurement. A Spearman rank test was used to determine whether multi-colinearity existed between habitat measurements. All co-linear measurements were either reduced to a single measurement or not analyzed together within a model. Next, univariate logistic regression was used to determine the potential importance of each individual variable, by determining whether data collected at used locations were different from random (available) locations (Zielinski et al. 2004; Manly 2003). Specifically, the significance of each measurement was determined by a type III test of fixed effects, to determine whether data recorded was significantly different than random. The relative importance of each variable was determined by examining the odds ratios and the least squared means (http://www2.sas.com/proceedings/sugi30/196-30.pdf).

Habitat measurements associated with each location that were different than random (available) locations were incorporated into the multivariate logistic model as independent variables. Because sample sizes were insufficient to determine individual home range estimates individual habitat selection (within each home range) could not be determined; therefore, habitat data were pooled across all individuals prior to RSF model fitting and habitat selection was determined at the population level (Thomas and Taylor 1990; Zielinski et al. 2004). Additional analysis was conducted to determine whether differences existed between tagged adult and juvenile fish. Specifically, fish were separated into two different groups based on age and growth analysis.

Habitat use verses random (availability) data within the study reach were initially analyzed using a resource selection function (RSF) to distinguish between selected and available habitats (Manly et al. 2003). The RSF equation takes the form:

$$W(\chi) = \exp(\beta_0+\beta_1\chi_1+\beta_2\chi_2+\ldots\beta_n\chi_n)$$

Where W (χ) was the relative probability of resource use for a given combination of covariates (χ_i), and slopes (β_i) derived from logistic regression. Typical methods used to evaluate prediction success for presence/absence data are not appropriate for presence/available data (Boyce et al. 2002). Therefore, data were analyzed by examining the distribution of relative probabilities of selected and random data, instead of presence/available (Zielinski et al. 2004).

Selection of the best fitting candidate model was determined using Akaike's Information Criterion (AIC), which is recognized as the most appropriate model selection criteria for ecological studies (Burnham and Anderson 1998). AIC model selection was used to rank the plausibility of competing models (Manly et al. 2003; Burnham and Anderson 1998). Within the AIC context, AIC_c was used as an adjustment for small sample sizes (Burnham and Anderson 1998). The best fitting models were identified based on the AIC_c weights (ω_i) and the ΔAIC_c values (Burnham and Anderson 1998; Triantis et al. 2003). Specifically, these models were identified when ΔAIC_c was less than 2, representing the best models from the set of models considered (Burnham and Anderson 1998). All models that exhibited a quasi-complete separation of points were eliminated from these analyses. In addition, all possible interactions between measurements that were expected to be correlated (such as distance to shore and canopy cover) were not investigated regardless of correlation tests.

Overdispersion and Goodness- of-Fit of data were evaluated for these data by calculating $\hat{c}$ from the global models, based on the Pearson χ^2statistic (Burnham and Anderson 1998).

Interpretation of fitness of the global models, were based on whether ĉ was greater than one, indicating overdispersion or inadequate model structure (Burnham and Anderson 1998). To further mitigate any potential autocorrelation a random effects modeling procedure (Proc Glimmix; SAS Cary, NC) was invoked to control for correlations among samples (Gillies et al. 2006)

RESULTS

Age and growth- Ninety-six redeye bass were collected from the Tallapoosa River and several tributaries for age and growth. The maximum observed age for all fish collected during this study was age seven. Growth of redeye bass was greatest from age-0 to age-1. After age-1, growth rates were similar up to age-4, then growth slowed considerably from ages-5 to age-7**.** The length-weight relationship equation for all redeye bass collected, based on otoliths, was linearized and took the form of $\log_{10}(W) = 1.634223 + .326119 * \log_{10}(L)$. Age structure was skewed toward young ages, with the highest percentage of fish collected representing age 2 and 3 (Table 2).

Sexual maturity of redeye bass was achieved usually by age-2 or 3. Several juvenile fish were yet to mature by age two and three fish (3.1%) had not matured by age three. The von Bertalanffy growth equation was constrained at 255 mm, based on the largest specimen collected during this study. Observed and predicted lengths were similar at ages-1, age-3, and age-5 (Figure 2). The predicted length at age-2 and age-7 exceeded the observed length, and the observed length was higher than the predicted length at age-4. The von Bertalanffy growth model predicted total lengths of 85 mm at age 1, 134 mm at age-2, 169 mm at age-3, 193 mm at age-4, and 211 mm at age-5 (Figure 2).

Comparisons of aging structures- Otolith age estimates ranged from age-0 to age-7, whereas spine ages ranged from age-0 to age-5 (Tables 2 and 3). Therefore, a direct comparison between structures could not be made for the age-7 class. Reader agreement between structures was low (66%), although reader agreement was greater between structures when the observed age deviated from the true age by only one year (95%). Age estimations based on spines tended to overestimate age for younger fish and underestimate ages for older fish (Figure 3).

Differences in growth between the two aging structures were examined (Table 4). Observed and predicted lengths for dorsal spines derived from the von Bertalanffy growth equation (constrained at 255mm), were similar for older fish (ages 3-5; Figure 4). Predicted length was underestimated, compared to observed lengths for age-1 fish and overestimated for age-2 fish. Predicted lengths between the two structures were also examined and were similar up to age-4 (Figure 5). At age-5, the predicted length for spines was higher than for otoliths. As mentioned previously, no age-7 fish were observed based on dorsal spines, therefore, no comparison were made for this age group between structures. Differences in growth were observed, based on the von Bertalanffy equation, with the growth coefficient (k) being greater for otoliths than spines (Table 3).

Results from the analysis of co-variance (ANCOVA) indicated that there was no difference in growth estimates between structures (df = 10, F = 56.67, $P < 0.01$). Survival estimates based on catch curve analysis for otoliths were 49% ($r^2 = 0.86$, $P < 0.01$) and 48% for spines ($r^2 = 0.87$, $P = 0.06$). The theoretical maximum age derived from catch curve analysis was 7.3 years for otoliths and spines.

Tag retention study - Simulated transmitters constructed for this study ranged from 1.6-2.1 g in air. Water temperature when this study was initiated was 22 °C. Ten captive redeye bass were tagged and they ranged in weight from 69.7 to 141.4g. Five fish were not tagged and kept in the re-circulating system as a control to monitor water quality effects on fish. The entire surgical procedure took less than two minutes before fish were placed back into fresh water for recovery. After 35 days, nine of the 10 fish tagged were completely healed from surgery. One fish showed signs of infection at the sutured area. Sutures were stretched and the surgical area was swollen. Ten radio tagged wild redeye bass were used for the field tag retention study. One fish was tagged but never re-located. Two fish expelled transmitters at days 41 and 44 (fish 40.651 and 40.631, respectively). One released tag was expelled due to an apparent predation event (40.620). The transmitter was recovered on the bank of the study area. Two tags were then re-implanted into two additional fish on October 1, 2003.

Movement- Ten fish were initially implanted with radio transmitters on 13, August 2003. Transmitter failure for all tags was observed between day 63 and day 69 of this study. All other fish (75%) retained transmitters for entire battery life (63-70 days). There was no relation observed between wild released fish size and tag retention (r^2 =0.07; $P = 0.52$).

Mean total movement for all fish observed was 705.6 m (SD = 1,180.7) and ranged from 31.1 to 4,018.0 m (Table 5). Mean total movement for redeye bass was 773.1 m (SD = 1,222.0) and ranged from 31.6 to 4,018.0 m. Mean successive movement for all fish was 59.4 m (SD = 106.8) and ranged from 3.9 to 365.3 m (Table 5). Mean successive movement for fish with greater than 11 or more locations was 78.9 m (SD = 121.3) and ranged from 8.5 to 365.3 m. Mean daily movement for all fish was 19.8 (SD = 31.0) and ranged from 0.5 to 110.0 m. Mean daily movement for fish with greater than 11 or more locations was 23.1 m (SD = 28.3) and ranged from 4.6 to 110.0 m (Table 4).

Two general trends of redeye bass movement were observed. Three fish exhibited highly variable movement patterns (both upstream and downstream). One fish (40.681) moved downstream (685.5 m), returned back upstream (636.2 m, 4 days later), then moved downstream again (2,524.9 m, relocated seven days later). After this large downstream migration, the fish never moved more than 97.1 m again, for the duration of the study. Fish 40.600 initially moved

886.3 m downstream, then never moved more than 14.1 m again. Fish 40.671 initially moved 225.3 m downstream and then did not move more than 45.1 m for 8 days. Next, this fish moved downstream 496.7 m, stayed at this location for six days then moved back upstream, within 12 m of the its previous location a month earlier. At this point fish 40.671 never moved more than 23.4 m during the rest of the study period.

All other fish observed (N = 8) showed a more sedentary behavior. Fish 40.611 moved 37.9 m post-tagging, and then never moved more than 29.2 m for the duration of the study. Fish 40.620 moved 66.0 m post-tagging, then an additional 143.2 m two days later. No other successive movement was greater than 36.9 m between relocations. Fish 40.631 never moved more than 13.0 m, between relocations, for the entire study. Fish 40.631.1 moved 16.3 m seven days post-tagging, then never moved 14.0 m for the duration of the study. Fish 40.641 also did not show any drastic movement post-tagging and never moved more than 40.9 m between relocations. Fish 40.651 initially moved downstream 86.6 m then never moved more than 55.9 m again between re-locations. Fish 40.661 did not move more than 19.7 m between relocations. Fish 40.621.1 movement rates never exceeded 18.0 m.

Home range- Only four of the 11 fish had at least 16 relocations. Results from the site fidelity tests indicated five of the 11 fish exhibited site fidelity. One fish did not show site fidelity, but was included in the home range analysis (40.671). This fish made two large-scale movements downstream then back upstream to nearly the same location. Movement was considered random based on site fidelity tests, but for the purposes of this analysis, it was assumed this behavior was an occasional “sally” (defined as occasional exploratory trips outside of the home range, which are not included in home range estimation; Burt 1943) from its natural home range (possibly due to the high discharge event or stress associated with tagging), since the fish returned to within 50 m of its original location. Therefore, six fish were used for home range analysis.

Home range sizes based 50% (core) kernel density estimations ranged from 29.7 - 5,826.8 m^2 (Table 6). A linear relationship was observed between the natural log of home range size and fish size (r^2= 0.87, $P < 0.01$). A negative relation was observed between the number of locations and 50% (core) kernel density size (r^2= 0.83, $P = 0.01$).

Home range sizes for 95% kernel density estimates ranged from 309.0-26,216.1 m^2. Again, a linear relation was observed for the natural log of home range size and fish size, (r^2= 0.86, $P < 0.01$). A negative relation was observed between the number of locations and the natural log of the 95% kernel density size, and was modestly significant (r^2= 0.64, $P = 0.06$). No relation was observed when 95% kernel density estimations were compared with the total days of the study.

Habitat use- Total mean habitat use (all telemetry data pooled) indicated that redeye bass were typically associated with boulder and sand substratum (77% of all relocations). Mean depth was 0.59 m (SD = 0.40) and mean current velocity was variable (0.13 m/sec, SD = 0.21). Redeye bass were relocated near instream cover 70.1% of the time, although no specific type of cover seem to be preferred (Table 7). Fish were generally associated with stream margins (mean distance to shore was 11.49 m, SD = 16.95) and canopy cover. Mean canopy cover at relocations was 54.96% (SD = 33.16). Redeye bass were most frequently relocated in run habitats (71.09%), and were not associated with aquatic vegetation (Table 7).

Adult redeye bass were associated with boulders, much more so than juveniles (51.76 and 17.07%, respectively). Adults and juveniles were associated with canopy cover (Table 7). Adult fish were relocated in runs with shallower depths with higher current velocities and a greater percentage of instream habitats (70.31%); whereas, juvenile fish were most frequently observed in pools habitats, with lower current velocities, and had a weaker association with instream cover (46.34%).

Habitat Selection- Based on telemetry data, 84% (109 locations) occurred within the "shoal" reach., while 16% (20 locations) did not occur within the shoal reach (defined as the wetted area within Hillabee Creek where all home range estimates lie within). Therefore, habitat availability was collected from 109 randomly selected points within the area defined as the shoal; the remaining 20 availability points were randomly selected points were collected from within the entire study reach.

Prior to RSF multivariate analysis, univariate procedures were conducted to reduce variables retained for modeling. Only variables that were significantly different from random (indicating a selection) were retained. These analyses indicated that presence of bedrock, boulders, and silt as substratum, were significantly different from random locations. Canopy cover, an increase in relative depth, decreased current velocities, decreased distance to shore, presence of instream features were also different from random locations. Boulders and undercut banks represented as instream habitats were also significantly different from random locations. Riffles, runs, and pools represented as mesohabitats were also different from random locations.

The global model was initially inspected to determine whether overdispersion existed. Results indicated that $\hat{c} = 0.80$; therefore, no additional overdispersion adjustment was needed. Based on RSF analysis (for all fish), two models were identified based on ΔAIC_c. The most parsimonious model, given the candidate model set, indicated that redeye bass selected locations with canopy cover, and depth*velocity, depth* presence of instream habitat, presence of boulder*canopy cover, and presence of instream habitat *distance to shore interactions (Table 8).

The second model yielded a ΔAIC_c of 1.85, also indicating support for this model based on empirical data. This second most parsimonious model, given the candidate model data set, indicated that redeye bass selected locations with boulder substratum, canopy cover and interactions between and depth*velocity, depth*instream habitat, and instream habitat*distance to shore (Table 8). Canopy cover was present in all candidate models, and appeared to be the most influential individual variable, based on data set. In both models (based on ΔAIC_c), the interaction term between depth and presence of instream features was the most influential affect on redeye bass locations, based on odds ratios (Table 11). In both models all variables were significant except the interaction between depth and velocity.

Age and growth analysis indicated sexual maturity analysis occurred at about 130 mm. Therefore data were analyzed to examine whether there were differences in habitat selection between adult and juvenile fish. Seven fish were considered adults for this analysis; whereas, four fish were considered juveniles. Based on univariate analysis boulders and sand (represented as substratum), canopy cover, current velocity, distance to shore, and presence of instream features were significantly different from random locations for adult redeye bass. Boulders, limbs (or large woody debris), and undercut banks as instream features were also different from random locations. Riffle and run mesohabitats were also different from random locations.

Inspection of the global model for adult redeye bass indicated no overdispersion existed ($\hat{c} = 0.57$), therefore no additional adjustment was needed to account for autocorrelation. RSF analysis identified two models based on ΔAIC_c given the dataset used. The most parsimonious model, given the candidate model set, indicated that adult redeye bass selected locations with canopy cover, decreasing current velocities, and interactions between depth and presence of instream features, boulder and canopy cover, and presence of instream features and decreasing distance to shore.

The second model yielded a ΔAIC_c of 1.12, also indicating substantial support based on data collected. This model, given the candidate model data set, indicated that redeye bass selected locations with canopy cover, presence of instream features, and interactions between and depth and instream features, presence of boulders and canopy cover interactions, and presence of instream habitats and decreasing distance to shore (Table 9). Again canopy cover was the only variable included in all competing models. Based on odds ratios, currently velocity was the most influential predictor of adult redeye bass. Top models (based on ΔAIC_c), given dataset used, indicated that the interactions between depth and presence of instream features were important predictors of redeye bass locations (Table 12).

Univariate analysis for juvenile redeye bass indicated that bedrock and sand (represented as substratum, canopy cover, depth, current velocity, distance to shore, and presence of instream features were different from random locations. Undercut banks, represented as instream habitats were different than random locations, as was riffles and pool mesohabitats. Multivariate analysis indicated that juvenile redeye bass habitat selection was best predicted based by the following model; canopy cover, depth, current velocity, interactions between presence of instream features and depth, and interactions between boulder, sand, and depth (Table 10). This was the only model, given the set of candidate models with any substantial support (i.e., $\Delta AIC_c < 2$). Again, analysis indicated that no additional adjustment was needed for overdispersion ($\hat{c} = 0.64$). Canopy cover was also included in all models evaluated for juvenile redeye bass. Odds ratios indicated that depth was the most important predictor of redeye bass locations (Table 13).

DISCUSSION

Age and growth- Observed growth of redeye bass was similar to predicted growth based on the von Bertalanffy growth models, based on ages derived from otoliths. Results indicated growth was greatest during the first year, then similar for each subsequent year up to age-4 and growth slowed dramatically at age-5 and beyond. These results were similar to growth rates for redeye bass presented by Parsons (1954) and Catchings (1978), but lower than growth rates of an introduced population of redeye bass (Tatum 1965). As expected, growth of redeye bass was much slower in comparison to other black basses (Parsons and Crittenden 1959**;** Hurst 1969; Webb and Reeves 1975). Gwinner (1973) reported that growth rates were similar for redeye bass and smallmouth bass *M. dolomieu* up to age-3, and then smallmouth bass growth was greater than redeye bass. Redeye bass growth may be a factor limiting distribution for the species. During collections from Hillabee Creek, a longitudinal distributional gradient was observed for *Micropterus* species. Largemouth bass were occasionally collected in shallow habitats higher in the watershed, but were primarily distributed lower in the watershed in lentic habitats. Alabama bass were often collected in proximity to largemouth bass. On occasion, redeye bass were collected lower in reaches of the Hillabee Creek watershed. As sampling was conducted higher (spatially) in the watershed, largemouth bass were rare, and Alabama bass collections increased (Knight and Irwin, unpublished data).

In Hillabee Creek Alabama bass and redeye bass were often collected associated with one another. Sampling from headwater streams yielded redeye bass almost exclusively. The two faster growing *Micropterus* species, may out compete redeye bass for both food and habitat preference, causing a behavioral adaptation by redeye bass to occupy sub-optimal habitats, higher in the watershed generally avoiding this inter-specific competition.

Catchings (1978) aged specimens from the Coosa River system that were nine years in age, compared to seven years for this study. Redeye bass may reach age nine in the Tallapoosa River system, but none were collected for this project and are likely rare. Although it should be noted that Catchings (1978) used scale aging to describe age and growth, compared to otoliths used for this project. Beamish and Harvey (1969) found scale ages were precise up to 5 years, but little agreement was evident after eight years. Hammers and Miranda (1991) found that otoliths were far more precise and accurate than scale aging for other Centrachid fishes such as white crappie *Pomoxis annularis*. Validated aging methods for redeye bass based on scales was not conducted during this study, but previous research on other species indicated it is likely this method is not reliable for redeye bass. Therefore, direct comparisons between structures for older fish should be made with caution.

Redeye bass reached sexual maturity earlier than previously reported. Sexual maturity was consistently observed at age-2, and in one circumstance age-1. Other research projects indicated that redeye bass reach sexual maturity at age-3 or age-4 (Hurst et al. 1975). Differences were likely due to inaccurate age estimates based on scales. It should be noted that although age-2 fish did exhibit maturity, the reproductive contribution of this age class is unknown. Older fish were far more gravid and probably represent a greater reproductive contribution to redeye bass populations in the Tallapoosa basin (Knight and Irwin, unpublished data).

Redeye bass, representing the age-2 and 3 were the most abundant age group collected, possibly representing a gear selection bias for larger fish (Reynolds 1983) or strong year classes when fish were collected. The most likely explanation is that these age classes represent the largest proportion of redeye bass from the Tallapoosa watershed or may simply represent strong year classes. Conservative estimates for survival and theoretical maximum age from catch curve analysis were observed, but still were significant for redeye bass. These values were likely lower than the true values for the species, due to lack older fish in the dataset used for this analysis. Results from an age and growth study conducted on an introduced population of redeye bass also reported a maximum age of seven years for redeye bass in the Tennessee system (Tatum 1965). Several other studies collected nine and 10-year-old fish, based on scales (Parsons 1954; Catchings 1978).

Comparisons of aging structures- Because otoliths are regarded as the superior aging structure for temperate fishes, this structure was chosen as the primary technique to evaluate the efficacy aging using alternative structures (Erickson 1983; Boxrucker 1986; Hammers and Miranda 1991; Welch et al. 1993; Lowerre-Barbieri et al. 1994; Kocovsky and Carline 2000; Ihde and Chittenden 2002). Annulus formation from sectioned otoliths was more clearly defined, and false annuli were less apparent in comparison to dorsal spines. A high number of false annuli were observed for dorsal fin spines which likely attributed to low absolute reader agreement, within structures as well as between structures.

Numerous studies evaluated age and growth of redeye bass, using scales (Parsons 1954; Gwinner 1973; Catchings 1978), but no literature is currently available evaluating age and growth using dorsal fin spines. Therefore age estimates based on dorsal spines for redeye bass was evaluated as possibly a more reliable non-lethal aging alternative to scale aging. Erickson (1983) reported that dorsal fin spine aging was more accurate than scale aging for walleye, *Sander vitreus*. Age discrepancies between structures did not consistently overestimate or underestimate true ages. A general trend was observed when comparing aging structures. Dorsal fin spine ages were overestimated at younger ages (up to age-3) and underestimated for older fish (ages-3 to 5). Differences were observed between aging methods, but these differences were not statistically different in reference to growth, indicating that dorsal fin spine aging may be used as a non-lethal alternative, if management objectives are to minimize mortality of redeye bass during sample collection.

Survival of redeye bass post-extraction of dorsal spines was not evaluated for this project. Therefore, additional research is needed to determine adverse effects of this procedure**.** Multiple sections of dorsal spines were evaluated to determine optimal sectioning placement on the dorsal fin spine. The second or third spines were optimal for aging, although spines were required to be removed as close to the body as possible to ensure inclusion of the basal recess (or groove) as possible, without incorporating the recess in the sectioned area. All fish were euthanized for this study for extraction of otoliths, therefore post-handling survival was not determined for redeye bass. Sterile techniques are likely required, as well as antiseptic treatment for the area where spines are removed.

Tag retention study- This study represented the first study of tag retention for redeye bass. Redeye bass did retain simulated (Dummy) tags in controlled environments. Infections and subsequent health problems were not apparent, except in one fish. This fish showed signs of infection, but was likely due to over-feeding that resulted in stretching of sutures. Sutures were heavily strained and infections appeared a result of this strain. Due to the short time frame of this study fish were not acclimated to artificial diets and live food (*Pimephales* spp.) was used and feeding regimes were not closely monitored.

Several studies investigated the effects of implantation methods on transmitter loss (Isely et al. 2002; Walsh et al. 2000; Bunnell and Isely 1999). Bunnell and Isely (1999) observed that, at higher temperatures, transmitter expulsion was significantly greater (10°C verses 20°C). The initial temperature for the laboratory was 22°C, but was not continuously monitored, although results of this study indicated that temperature did not affect tag retention. During the field study, temperatures ranged from 15°C to 22.5°C. Observed tag expulsion was observed when temperatures were greater than 18°C, a threshold recommended by Bunnell and Isely (1999). Future studies should conduct implantation in early spring or late fall in order to potentially alleviate this problem.

Walsh et al. (2000) investigated the effects of suture material and antennae placement on loss of simulated transmitters. The study found no differences in choice of suture material or antennae placement of tag retention. This project did not investigate these two variables, but was supported by Walsh et al. (2000). This study did observe some minor irritation when the antenna was left trailing, yet the wounds were sufficiently healed and irritation did not appear as a serious constraint for the subsequent telemetry study. Isely et al. (2002) also investigated the effects of antennae placement (trailing versus non-trailing) on hybrid striped bass (*Morone saxatilis* x *M. chrysops*), and indicated that tag retention was greater when antennas were not left trailing. Logistic issues, such as limited tag range, prevented this study from utilizing non-trailing antennas. In order to comply with guidelines established by Winter (1997), all transmitters must be less than 2% of a fish's body weight to not adversely affect growth and behavior of redeye bass, therefore transmitters with trailing antennas were used for this project were 1.7-2.1 g in air, due to the relatively small size of redeye bass, in comparison to other fish used in telemetry studies. Although, it should be noted that future telemetry studies might be able to use these non-trailing antennas as an alternative, since it appears redeye bass collected in the Tallapoosa River system can reach sizes large enough to implant larger transmitters (with greater ranges).

Movement- Total movement of redeye bass was highly variable during this study. Some redeye bass that did show large movement patterns did not appear to show any consistent pattern of movement. Initial movement was either the result of behavioral changes due to tagging or high discharge (943 cfs; USGS 02415000, Hillabee Creek near Hackneyville Al) shortly after tag implantation. Fish tagged were not monitored for a period of seven days to minimize any adverse affects on fish behavior associated with surgery (Martinelli and Shively 1997; Matheney and Rabeni 1995; Mesing and Wicker 1986; Warden and Lorio 1975; Winter 1977). Therefore, this initial high movement rate appears to be the result of unusually high discharge post-tagging. Hubert (1981) observed a similar behavior (movements of 400-1000 m downstream) for smallmouth bass following high discharge. Nine of the 11 redeye bass showed a larger initial movement and seven of these fish never moved more than this initial movement rate for the duration of the study.

Gatz and Adams (1994) reported similar successive movement rates for largemouth bass in two warmwater streams, indicating 2/3 of largemouth bass investigated yielded successive movement rates less than 100 m, and rarely observed successive movements greater than 1 km (Gatz and Adams 1994). Conversely, Winter (1977) determined largemouth bass daily movements were between 166 and 229 m in lentic habitats. This study indicated 91% of redeye bass had successive movement rates and daily movement rates did not exceed 100 m, therefore movement rates of redeye bass appear to be negatively correlated with body size (the exception was fish 40.671). Several other studies suggested that mobility was negatively related to fish size (Hasler and Wisby 1958; Moody 1960; Wanjala et al. 1986).

Redeye bass movement was primarily confined to a wadeable, shoal reach on Hillabee Creek (73%). One fish moved downstream to a habitat best characterized as a deep run habitat, but returned back to the shoal after flows subsided and remained for the duration of the study. Two additional fish did move downstream and remained in unique deep run habitats for the duration of the study. Inferences again are limited due to the small dataset recorded during this study.

Home range- Two home range estimates were used due to the limited dataset collected. The 95% kernel estimate should be interpreted cautiously. Given the lack of fidelity, this estimate should be considered the maximum home range estimate, and was only used to establish the study area for collection of habitat availability data. Although results from the site fidelity tests indicated some fish did show evidence for home ranges, results should be interpreted with caution. Seaman et al. (1999) determined that a sample size of 30 was required to accurately determine kernel density estimation of home range, although their research was conducted with simulated data potentially subject to autocorrelation and did not give precise predictions about the performance of empirical data. Dispersal of several fish from the original tagging location and the short battery life of the tags used for this project prevented collection of 30 data points for each individual.

Therefore 50% (core) estimations were used to determine the core area of activity for redeye bass, which were least affected by deviations from the assumptions of home range models (Hooge et al. 1998). These home range estimates likely represent the only biologically meaningful estimates of home range for redeye bass. Other techniques such as minimum convex polygons (MCP) estimations suffer from sample size effects, and likely contain areas never used by an organism (Hooge et al. 1998; Seaman et al. 1999). Therefore these estimates were not considered for this project.

The largest discrepancies between home range estimations were observed for fish with the fewest observed locations (40.600 and 40.620). Again, results from these analyses should be interpreted cautiously. In this circumstance, the approach used for this project (clipping terrestrial areas) caused this under estimation. Results from the 95% kernel estimation yielded two distinct home ranges, both of which were likely overestimated. When the 50% kernel estimation was used the home range was reduced to one kernel, but the procedure may have overestimated the actual home range. In this case, the 50% kernel removed that initial point and likely provided a more realistic approximation of home range.

An apparent high flow event caused a downstream movement, then when flows subsided the fish returned to its original home range and stayed for the duration of the study. Although no site fidelity could be determined based on this analysis, this downstream “sally” was likely the reason the fish did not show fidelity and given the high affinity for the original location it is assumed that this did indicate some biological fidelity for this location. The home range of this fish incorporated an area that it passed through but never occupied. This fish was observed within the upstream kernel once and never returned and twice in the downstream kernel and never returned. Again, in this circumstance the 50% kernel estimation represents the best estimation.

The three remaining fish (40.611, 40.641, and 40.661) represented fish with the most relocation points and represent the only home range estimates that warrant a biological inference. These fish had 19 location points, a sample size sufficient for home range estimations according to Silverman (1986). All locations for these fish were confined to a shoal habitat and were constricted in nature. The 50% kernel estimation reduced the number of kernels to three, two, and one, respectively. Again these fish did show some affinity for specific areas on this shoal, and if more relocations were available, it is assumed this fidelity could have been statistically validated.

No other research is currently available investigating redeye bass home range size. The majority of home range literature focused on black basses in lentic habitats. Gatz and Adams (1994) estimated a linear home range for riverine largemouth bass, but did not calculate area. In comparison to other research investigating black bass home ranges estimations values derived for this project were underestimated. This was likely the case because of the absence of open water habitats not available in lotic systems, particularly the size of Hillabee Creek. Winter (1977) used MCP estimations to determine largemouth bass maximum home ranges were 3,000-14,000 m^2 yet all home range estimates for redeye bass were smaller. Mesing and Wicker (1986) found maximum home range sizes for largemouth bass in Florida were from 100 to 5160 m^2, similar core kernel estimations were found in this study. Woodward and Noble (1997) estimated home ranges for largemouth bass were 260-7830 m^2, again similar to core estimations. Ridgway and Shuter (1996) reported home range estimations for non-displaced smallmouth bass were far greater (mean = 183,000 m^2) than redeye bass investigated in this study.

Core (50%) kernel estimations indicated a negative relation between numbers of days monitored and home range estimations. This was likely the case because of the increased resolution of home ranges with increased location points. These results differ from Winter (1977) and Hansteen et al. (1997) that concluded MCP home range size and kernel estimates respectively increased with number of locations. This study supports results presented by

Seaman et al. (1999) stating that small sample sizes provide are poor a representation in the tails of distribution and area estimations for kernel estimations.

Results from core kernel estimations indicated little overlap of home ranges. Redeye bass were not collected in locations associated with other fish. Subsequent telemetry monitoring also did not indicate any overlap. Fish were solitary in nature and never were observed spatially associated with one another.

Habitat selection- Johnson (1980) defined “usage” as the quantity of a component used by an organism in a fixed period of time; whereas, selection is defined as a process, which an animal actually chooses a component. Redeye bass were re-located frequently in areas that had a prevalence of boulder and sand habitats, although only juvenile redeye bass was associated with both these substrates. Adult fish selected areas with boulders, based on models, although it could not be established whether this was substratum selection or an interaction of this substrata with canopy cover. Irwin et al. (2005) also indicated redeye bass used boulder habitats most frequently on the mainstream Tallapoosa River. Redeye bass probably do not have an affinity to a substratum type except during spawning periods, when they spawn over gravel (Gwinner 1965). Only juvenile fish appeared to select either of these two substratum types, and in reality that selection was probably due to intra-specific competitive exclusion from optimal habitats with larger more territorial bass. So it is assumed that the choice of sand substrata was actually an intra-specific avoidance behavior.

Pooled data indicated redeye bass selected areas with increased relative depth, decreased velocities and interaction of increased depth and presence of instream features. No individual model could be identified for pooled data or adult fish based on these analyses; although given the similarities between the two competing models, a biological inference can be made. Adult fish selected areas with greater depth only when that location had an instream feature. Juvenile fish selected greater depths. Redeye bass selected locations that had canopy cover and the presence of instream habitats. Canopy cover appeared to be the single most influential factor for habitat selection of all sizes of redeye bass. This variable was retained in all models evaluated for this project. Irwin et al. (2005) reported similar results, indicating that on a landscape scale agricultural areas were negative predictors of redeye bass locations. Whereas specific mechanisms as to why redeye bass selected forested landscapes (i.e., areas with high percentages of canopy cover) are only hypothetical, it is assumed that forested watersheds provide is critical canopy cover and intream habitat features.

Manley et al. (2003) stated that in order to evaluate resource selection for a particular organism, a researcher must also determine what scale or scales of selection to focus on. Scale of instream habitat was evaluated by modeling whether there was a preference of redeye bass for a particular habitat feature. Redeye bass selected areas associated with instream habitat features, but were indiscriminant about the type of instream habitat (i.e., bedrock, boulders, presence large woody debris, or undercut banks). There was some evidence that areas that had undercut bank were avoided, based on individual RSF values (preliminary univariate analysis). Mesohabitat type was also initially analyzed but was removed from models because each microhabitat measurement recorded was a component which defined a mesohabitat (i.e., depth, velocity, and substratum type). Additionally it was assumed that a simple mesohabitat type was too coarse of a scale to effectively describe habitat selection for the species.

Redeye bass did not use or select areas associated with emergent vegetation (i.e., *Justicia* spp.) as suggested by others (Etnier and Starnes 1993; Boschung et al. 2004; Rhode et al. 2009). Although the species was associated with shoals that had large amounts emergent vegetation, the species was rarely observed directly associated with this instream feature. Redeye bass also avoided areas over silt substrata (and by inference), which are typical substrata types associated with *Justicia* spp. beds.

Differences in habitat selection between adult and juvenile fish were subtle. Both selected areas with specific interaction between microhabitat variables, such as the presence of instream features interacting with current velocities. Adult fish selected areas with slightly higher current velocities and juvenile fish selected areas with lower current velocities. Both selected areas relatively close to shore lines; adult fish were more positively associated with shore line areas than juvenile fish (based on parameter estimates generated from the RSF models). Differences in habitat selection between adult and juvenile redeye bass are likely best explained by intra-specific competition. Evidence of intra-specific competition was apparent when comparing use between adult and juvenile fish.

Due to limitations in battery life (approximately 70 days) and range of radio tags (~100 meters) used for this project Thomas and Taylor's (1990) design I was used to determine habitat selection of redeye bass, available resources were measured at the population level, and individuals were not identified. Results from home range analysis indicated the number of relocation points was not sufficient to determine 95% kernel home range estimates, therefore habitat availability for individual fish could not be determined. Additionally fish dispersed after tagging and daily tracking of each individual fish from Hillabee Creek was not feasible.

Landscape factors could affect distribution of redeye bass but these factors were not investigated for this project. Irwin et al. (2005) found that percent agriculture within a watershed negatively affected distribution; whereas, increased stream order, and adjacent spatial distribution above the fall line were predictors of redeye bass presence. Redeye bass tracked from the mainstem Tallapoosa River and a tributary to that system (Hillabee Creek) were observed in similar instream habitats (Irwin et al. 2005); it is unclear whether fish from mainstem Tallapoosa River utilize tributary habitats when conditions are unfavorable to the species (e.g. hydropeaking events). If these fish do use this resource, additional research questions could be asked to determine how often and how much does this use contribute positively to the life history of the species. Additional studies are also needed across an environmental gradient to determine whether these habitat features are critical to persistence of the species.

All movement, home range, and habitat selection of redeye bass was conducted during late summer and fall months from a large tributary to the Tallapoosa River, and inferences about winter and spring movement, home range, and habitat selection were not possible. Catchings (1977, *unpublished data*) reported that redeye bass moved to deeper habitats during the winter, and additional telemetry data are still needed to fill in the gaps of knowledge about redeye bass movement, home range and habitat selection to effectively manage the species in Alabama. Additionally habitat slection analysis is still needed from the mainstem Tallapoosa River population of redeye bass, to determine how hydropeaking activities affect movement, home range, and habitat selection.

MANAGEMENT IMPLICATIONS

Redeye bass are not a heavily exploited sport fish species in Alabama. If the management objective is promote a fishery for the species then effort should be directed toward creating access points in the higher reaches of the Tallapoosa watershed and major tributaries for non-motorized vessels such as canoes or kayaks. Given the species' affinity to canopy cover, efforts should be made to maintain riparian zones around redeye bass streams which should also minimize non-point source inputs of fine sediments into redeye bass habitats (a substrata the species avoided during this study). Additional research is needed to determine whether redeye bass populations are adversely effected by anthropogenic changes in the landscape. Construction of new impoundments within the Tallapoosa watershed should be avoided because the species does not seem to tolerate such habitats.

There was little evidence of inter-species competition between redeye bass and other black bass species. In fact, only Alabama bass were collected in similar habitats. Sampling for redeye bass from Hillabee Creek was initiated at the State Route 22 Bridge and few individuals were collected there. The dominant black bass at that location was Alabama bass. As sampling continued up the watershed there appeared to be an antidotal shift in abundance from Alabama bass to redeye bass. Fish monitored during this habitat study never migrated down to the SR 22 shoal, in fact most fish stayed in the vicinity of the Hillabee Creek water intake shoal for the duration of the study.

Results from this study indicated some evidence for intra-specific competition for between individual redeye bass. Each individual fish monitored appeared solitary in nature, and no two fish were ever relocated in the vicinity of one another. Therefore, the species may be susceptible to over exploitation if streams reaches received a large increase in fishing pressure. A catch-and-release fishery is recommended until research is conducted to ascertain the effects on harvest on redeye bass populations. Alternatively, a ten inch minimum size regulation would likely mitigate any potential effects of over exploitation of redeye bass populations from the Tallapoosa watershed. Additional data are still needed to ascertain whether the species is susceptible to over-exploitation. Redeye bass populations appear to be stable and there does not appear to be a need to supplement these populations via a stocking program.

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TABLES

Table 1. Summary of habitat variables measured, type of measurement, and definition of that measurement collected during the telemetry study.

Variable	Type	Definition and unit
Bedrock	Continuous	Bedrock (%) as a co-dominant substrate, within APO
Boulder	Continuous	Boulder (%) as a co-dominant substrate, within APO
Cobble	Continuous	Cobble (%) as a co-dominant substrate, within APO
Gravel	Continuous	Gravel (%) as a co-dominant substrate, within APO
Sand	Continuous	Sand (%) as a co-dominant substrate, within APO
Silt	Continuous	Silt (%) as a co-dominant substrate, within APO
Cover	Continuous	Canopy cover (%)
Depth	Continuous	Average depth (m) within APO
Velocity	Continuous	Average current velocity (m/sec) within APO
Distance	Continuous	Distance (m) from nearest shoreline
Instream	Categorical	Presence (+/-) of instream habitat within APO
Bed	Categorical	Presence (+/-) of instream habitat, as bedrock within APO
Bould	Categorical	Presence(+/-) of instream habitat, as boulder within APO
Limb	Categorical	Presence (+/-) of instream habitat, as limb within APO
Undercut	Categorical	Presence (+/-) of instream habitat, as undercut bank within APO
Pool	Categorical	Presence (+/-) of measohabitat type within APO
Riffle	Categorical	Presence (+/-) of measohabitat type within APO
Run	Categorical	Presence (+/-) of measohabitat type within APO
Veg	Categorical	Presence (+/-) of *Justicia spp*.

Table 2. Summary of ages, mean length, standard deviation, and number collected of all redeye bass based on otoliths.

Age Group	Mean Length (mm)	Number (N)	Standard Deviation
0	57.75	4	10.34
1	89.70	10	18.80
2	127.60	35	34.39
3	166.03	29	35.97
4	198.78	9	35.84
5	205.43	7	22.74
7	212.00	1	0.00

Table 3. Summary of ages, mean length, standard deviation, and number collected of all redeye bass based on dorsal spines.

Age Group	Mean Length (mm)	Number (N)	Standard Deviation
0	57.75	4	10.34
1	90.86	7	21.93
2	120.36	33	34.62
3	163.82	34	35.84
4	197.31	13	26.86
5	218.50	4	22.94

Table 4. Summary of derived values from the von Bertalanffy growth model for redeye bass, based on otoliths and dorsal spines.

Characteristic	Otoliths	Spines
Sample Size	96	96
Longevity (years)	7	5
Growth coef. (K)	0.338	0.284
L_{inf} (mm)	255	255
T_0	-0.196	-0.726

Table 5. Summary of number of locations, total movement, mean successive movements, and mean daily movements for redeye bass from Hillabee Creek.

Individual fish	Number of locations	Total movement (m)	Mean successive movement (m)	Mean daily movement (m)
40.620.1	5	31.6	7.9 (6.8)	5.0 (0.0)
40.631.1	6	52.5	10.5 (5.0)	8.2 (3.7)
40.631	9	31.1	3.9 (4.7)	0.5 (0.7)
40.600	11	950.1	95.0 (278.1)	7.1 (10.0)
40.620	11	337.8	17.8 (43.6)	19.2 (18.5)
40.651	12	224.7	20.4 (30.3)	4.6 (3.4)
40.681	12	4018.0	365.3 (761.2)	19.1 (27.0)
40.671	16	1425.1	95.0 (174.4)	110.0 (222.4)
40.611	19	298.7	15.7 (11.0)	21.4 (4.8)
40.641	19	239.6	13.3 (9.9)	13.1 (8.7)
40.661	19	152.9	8.5 (6.9)	8.2 (5.9)
Grand mean	139	705.6 (1180.7)	59.4 (106.8)	19.8 (31.0)

Table 6. Summary of redeye bass size and results from the home range estimations from Hillabee Creek.

Fish	Size (g)	50% Kernel (m^2)	95% Kernel (m^2)
40.600	81.3	5,826.8	20,126.9
40.671	103.6	1,334.5	26,216.1
40.620	112.1	2,950.4	13,258.3
40.611	129.6	307.4	1,536.8
40.641	187.1	188.6	918.2
40.661	200.0	29.7	309.0

Table 7. Summary of redeye bass total habitat use, adult habitat use, juvenile habitat use, and random (available) habitat measured during telemetry study.

	Total use			Adult use			Juvenile use			Random		
Variable	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Bedrock (%)	10.94	31.33	0-100	16.47	37.31	0-100	0	0	0-100	18.11	38.66	0-100
Boulder (%)	39.84	49.15	0-100	51.76	50.27	0-100	17.07	38.09	0-100	27.56	44.86	0-100
Cobble (%)	12.7	33.43	0-100	12.94	33.76	0-100	12.2	33.13	0-100	10.24	30.43	0-100
Gravel (%)	3.17	17.6	0-100	4.71	21.3	0-100	0	0	0-100	3.15	17.53	0-100
Sand (%)	37.3	48.55	0-100	25.88	44.06	0-100	60.98	49.39	0-100	38.58	48.87	0-100
Silt (%)	3.17	17.6	0-100	1.18	10.85	0-100	7.32	26.37	0-100	15.75	36.57	0-100
Cover (%)	54.96	33.16	0-100	57.98	32.94	0-100	50.64	33.17	0-100	17.28	22.75	0-100
Depth (m)	0.59	0.4	0.16-2.38	0.52	0.36	0.16-2.38	0.76	0.43	0.16-1.35	0.33	0.39	0.02-2.29
Velocity (m/sec)	0.13	0.21	-0.14-1.38	0.17	0.22	-0.24-1.38	0.06	0.18	0.14-0.97	0.26	0.26	0.03-1.21
Dist. to shore (m)	11.49	16.95	0-50.0	10.82	15.94	0-50.0	13.35	19.18	0-50.0	18.81	14.65	0-50.0
Instream cover (%)	70.31	45.87	0-100	81.18	39.32	0-100	46.34	50.49	0-100	29.92	45.97	0-100
Undercut bank (%)	14.06	34.9	0-100	7.06	25.77	0-100	26.83	44.86	0-100	0.79	8.87	0-100
Limb (%)	12.5	33.2	0-100	15.29	36.21	0-100	7.32	26.37	0-100	6.3	24.39	0-100
Riffle (%)	1.56	12.45	0-100	1.18	10.85	0-100	2.44	15.62	0-100	40.16	49.22	0-100
Run (%)	71.09	45.51	0-100	89.41	30.95	0-100	36.59	48.77	0-100	43.31	49.75	0-100
Pool (%)	27.34	44.75	0-100	9.41	29.37	0-100	60.98	49.39	0-100	14.96	35.81	0-100
Vegetation (%)	3.91	19.45	0-100	0	0	0-100	7.32	26.37	0-100	3.15	17.53	0-100

Table 8. Model selection results for resource selection analysis, containing habitat predictor variables for redeye bass.

Model	K	N	AIC	AICc	ΔAIC_c	ω_i
Cover, depth*velocity, depth*instream, boulder*cover, instream*distance	8	232	162.06	162.71	0.00	0.51
Boulder, cover, depth*velocity, depth*instream, instream*distance	8	232	163.91	164.56	1.85	0.20
Cover, depth*velocity, depth*instream, instream*distance	7	232	165.42	165.92	3.21	0.10
Cover, depth, velocity, depth*instream, instream*distance	7	232	165.86	166.36	3.65	0.08
Bedrock, cover, depth*velocity, depth*instream, instream*distance	8	231	166.17	166.81	4.10	0.07
Cover, boulder*cover, depth*instream, instream*distance	7	244	167.91	168.39	5.68	0.03
Boulder, cover, boulder*cover, depth*instream, instream*distance	8	244	169.90	170.51	7.80	0.01
Cover, depth*instream, velocity*instream*distance	6	232	172.89	173.26	10.55	0.00
Cover, depth, velocity, instream, boulder*cover, instream*distance	8	232	174.24	174.88	12.17	0.00
Cover, depth, velocity, instream, instream*distance	7	237	176.38	176.88	14.17	0.00

Table 9. Model selection results for resource selection analysis, containing habitat predictor variables models for adult redeye bass.

Model	K	N	AIC	AIC_c	ΔAIC_c	ω_i
Cover, velocity, depth*instream, boulder*cover, instream*distance	8	198	113.04	113.80	0.00	0.45
Cover, instream, depth*instream, boulder*cover, instream*distance	8	205	114.18	114.92	1.12	0.25
Cover, depth*instream, boulder*cover, instream*distance	7	205	115.47	116.04	2.24	0.15
Boulder, cover, depth*velocity, depth*instream, boulder*cover, instream*distance	9	198	117.07	118.02	4.22	0.05
Cover, depth, velocity, depth*instream, instream*distance	7	198	117.82	118.41	4.61	0.04
Boulder, cover, depth*velocity, depth*instream, instream*distance	8	198	118.58	119.34	5.54	0.03
Cover, depth*velocity, depth*instream, instream*distance	7	198	119.52	120.11	6.31	0.02
Cover, velocity, distance, boulder*sand, depth*instream	7	198	121.88	122.46	8.66	0.01
Boulder, cover, velocity, distance, depth*instream	7	198	123.96	124.55	10.75	0.00
Cover, velocity, distance, depth*instream	6	198	124.18	124.62	10.82	0.00

Table 10. Model selection results for resource selection analysis, containing habitat predictor variables models for juvenile redeye bass.

Model	K	N	AIC	AIC$_c$	ΔAIC$_c$	ω_i
Cover, depth, velocity, instream*depth, boulder*depth*sand	6	159	87.68	88.24	0.00	0.98
Cover, depth, velocity, instream*depth, boulder*sand	6	159	96.36	96.92	8.68	0.01
Sand, cover, velocity, instream*depth, boulder*depth	7	159	99.36	100.10	11.86	0.00
Cover, depth, instream, velocity*depth, boulder*depth*sand	6	159	100.89	101.44	13.20	0.00
Bedrock, cover, velocity, instream*depth, boulder*depth	7	159	102.79	103.53	15.29	0.00
Cover, velocity, instream*depth, boulder*depth	6	159	103.16	103.71	15.47	0.00
Bedrock, cover, velocity, instream*depth	6	159	104.13	104.68	16.44	0.00
Cover, velocity, instream*depth	5	159	107.28	107.67	19.43	0.00
Sand, cover, velocity, instream*depth	6	159	107.87	108.42	20.18	0.00
Cover, velocity, instream*depth, bedrock*depth	6	159	108.21	108.76	20.52	0.00

Table 11. Results of resource selection analysis, parameter estimates, standard error, odds ratio, and type III tests of significance effects for two most parsimonious models on all redeye bass.

Variable	Estimate	SE	Odds Ratio	*F*-stat	*P*-value
Intercept	-3.53	0.59			
Cover	0.03	0.01	1.04	14.52	0.0002
Depth*velocity	-2.28	2.88	0.10	0.03	0.8552
Depth*instream	1.47	0.56	4.34	15.21	<.0001
Boulder*cover	0.03	0.01	1.03	5.44	0.0207
Instream*distance	0.02	0.02	1.02	9.51	0.0001
Intercept	-3.82	0.63			
Boulder	1.11	0.59	3.04	3.5	0.0626
Cover	0.04	0.01	1.04	30.22	<.0001
Depth*velocity	-1.60	2.87	0.20	0.31	0.5786
Depth*instream	1.42	0.5653	4.14	19.26	<.0001
Instream*distance	0.02	0.02	1.02	11.27	<.0001

Table 12. Results of resource selection analysis, parameter estimates, standard error, odds ratio, and type III tests of significance effects for two most parsimonious models on adult redeye bass.

Variable	Estimate	SE	Odds Ratio	*F-stat*	*P*-value
Intercept	-5.42	1.06			
Cover	0.04	0.01	1.05	15.65	0.0001
Velocity	1.65	1.10	5.22	2.27	0.1332
Depth*instream	0.99	0.70	2.70	14.81	<.0001
Boulder*cover	0.04	0.02	1.04	5.71	0.0178
Instream*distance	0.02	0.04	1.03	9.43	0.0001
Intercept	-3.33	1.10			
Cover	0.05	0.01	1.05	19.64	<.0001
Instream	-2.34	1.29	0.10	3.28	0.0718
Depth*instream	0.95	0.68	2.57	6.27	0.0023
Boulder*cover	0.05	0.02	1.05	6.75	0.0101
Instream*distance	0.05	0.03	1.05	9.77	<.0001

Table 13. Results of resource selection analysis, parameter estimates, standard error, odds ratio, and type III tests of significance effects for the most parsimonious models on juvenile redeye bass.

Variable	Estimate	SE	Odds Ratio	*F-stat*	*P*-value
Intercept	-4.42	0.86			
Cover	0.05	0.01	1.05	18.83	<.0001
depth	6.18	1.53	481.45	15.02	0.0002
Velocity	-2.28	2.12	0.10	1.16	0.2829
Depth*instream	-5.09	1.39	0.01	13.44	0.0003
Depth*boulder*sand	36.94	13.63	1.101E+16	7.34	0.0075

FIGURES

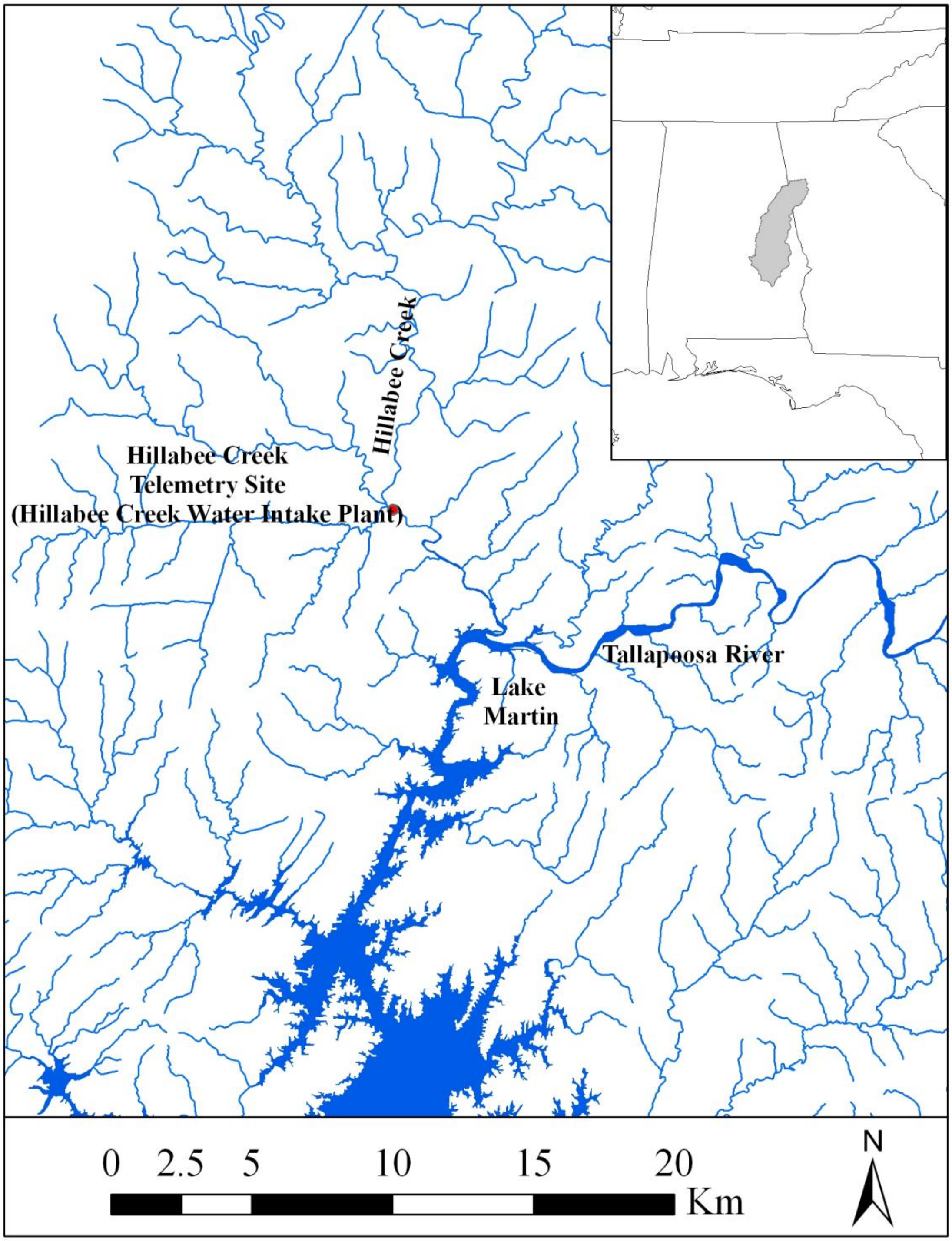

Figure 1. Location of habitat selection study on redeye bass, conducting using telemetry (August-October, 2003

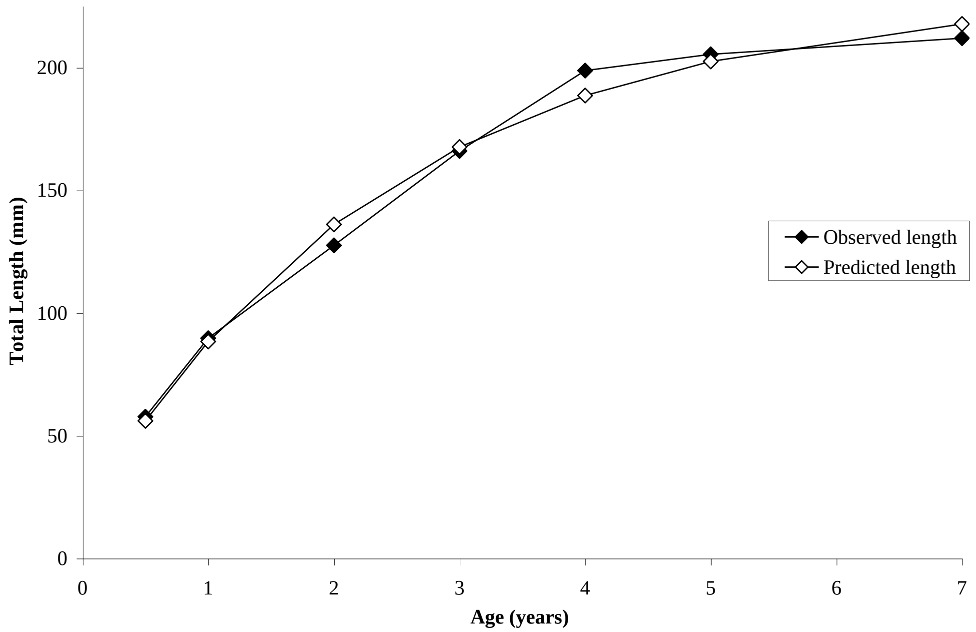

Figure 2. A comparison of observed and predicted lengths at age, derived from the von Bertalanffy growth equation for redeye bass, based on otoliths

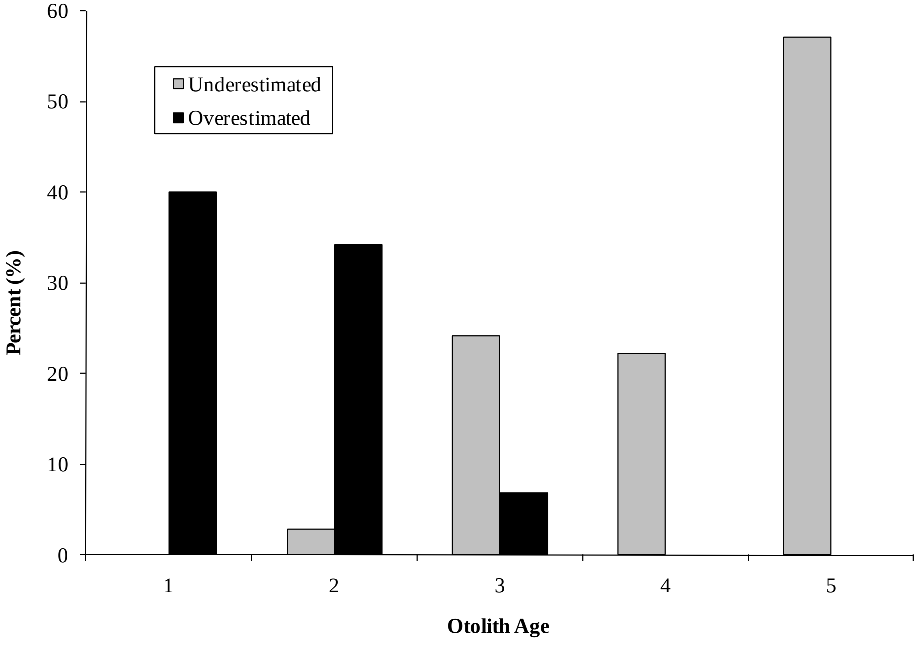

Figure 3. Percent disagreement between otolith and dorsal spine age estimates for redeye bass

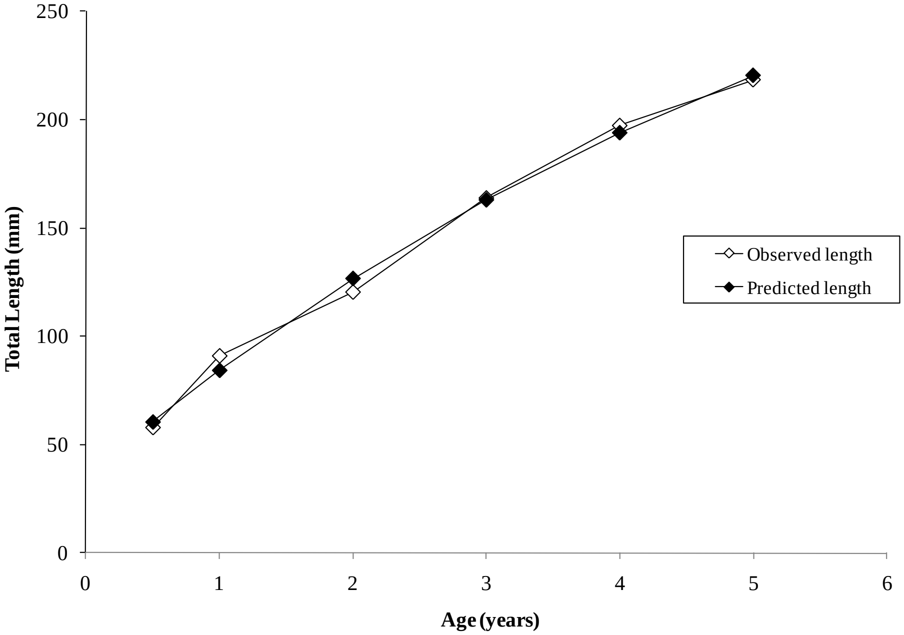

Figure 4. A comparison of observed and predicted lengths at age, derived from the von Bertalanffy growth equation for redeye bass, based on dorsal spines.

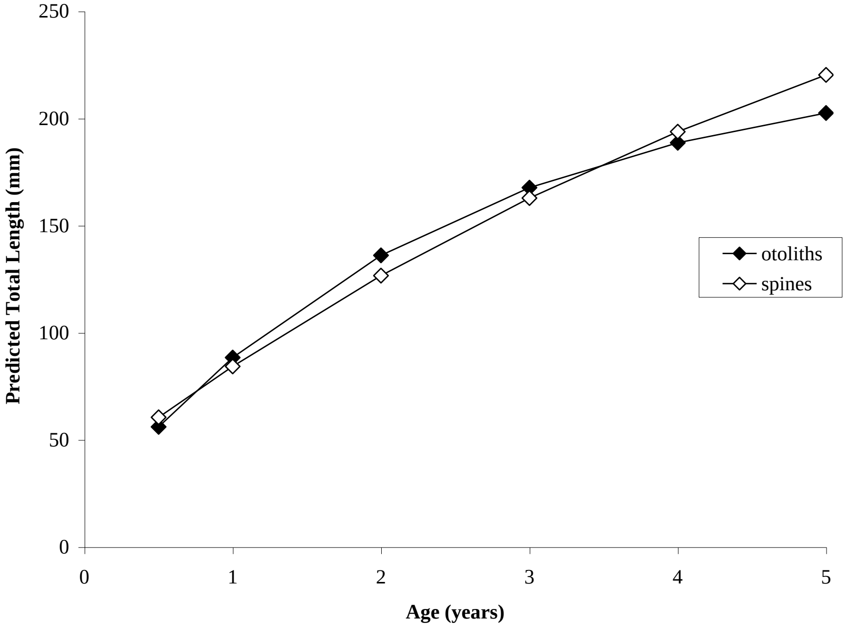

Figure 5. A comparison of predicted lengths at age, derived from the von Bertalanffy growth equation for redeye bass, based on otoliths and dorsal spines.