QUANTIFYING PATTERNS AND SELECT CORRELATES OF THE SPATIALLY AND TEMPORALLY EXPLICIT DISTRIBUTION OF A FISH PREDATOR (BLUE CATFISH, *ICTALURUS FURCATUS*) THROUGHOUT A LARGE RESERVOIR ECOSYSTEM

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Abstract

Understanding how and why fish distribution is related to specific habitat characteristics underlies many ecological patterns and is crucial for effective research and management. Blue Catfish, *Ictalurus furcatus*, are an important concern for many fisheries agencies; however, lack of information about their distribution and habitat use remains a hindrance to proper management. Here, over all time periods and across months, I quantified Blue Catfish distribution and environmental correlates of distribution in Milford Reservoir, the largest reservoir in Kansas. I tested relationships among acoustically tagged Blue Catfish and three groups of variables postulated to influence Blue Catfish distribution in the literature (i. localized microhabitat variables, ii. larger-scale mesohabitat variables, iii. biotic variables). Blue Catfish were consistently aggregated in two locations of the reservoir across five months during summer and fall, 2013. Using multiple linear regression and an information theoretic model selection approach, consistent correlates of distribution included localized, microhabitat variables (i.e., dissolved oxygen, slope) larger-scale, mesohabitat variables (i.e., distance to channel, river kilometer from the dam) and a biotic variable (i.e., Secchi depth). This research identified which 5 of the 12 variables identified in the literature were most influential in determining Blue Catfish distribution. As a guide for future hypothesis generation and research, I propose that Blue Catfish distribution was driven by three ecologically-relevant tiers of influence. First, Blue Catfish avoided extremely low dissolved oxygen concentrations that cause physiological stress. Second, Blue Catfish aggregated near the channel, an area of bathymetric heterogeneity that may offer a foraging advantage. Third, Blue Catfish aggregated near low Secchi depths, shown here to be associated with increased productivity and prey abundance. Building on my results, future research into the distribution and habitat use of Blue Catfish should incorporate aggregated

distributions of fish into research designs, focus on how both small and large scale relationships interact to produce patterns of distribution, and explore further the mechanisms, consequences, and interactions among the three tiers of influence identified here.

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Introduction

Understanding where fish are located and why is central to fish ecology, fisheries biology, and effective fisheries management (Hartig and Kelso 1999, Scheiner and Willig 2011). Knowledge of fish distribution is critical for researchers to design meaningful studies, determine the spatial resolution of studies, and identify study sites (Garton et al. 2001, Manly 2002). Managers need to know fish distribution to collect stock assessment, age, growth, diet, and other data needed to build and maintain productive sport fisheries (Van Den Avyle and Hayward 1999, Zale et al. 2012). In addition, determining spatial patterns of organisms can provide insights about the abiotic and biotic factors that drive distribution and aid our understanding of habitats that are crucial to maintaining healthy populations of fish (Benaka 1999, Manly 2002).

Because fish react to habitat conditions (e.g., water quality, physical structure, prey availability) to conserve and increase energy intake (Mittlebach 1981, Lorna et al. 2012), understanding how and why fish use specific characteristics of habitats underlies many ecological patterns and is crucial for effective research and management of fish populations (Benaka 1999, Pörtner and Peck 2010). Fish habitat includes all physical, chemical, and biological features needed to maintain life (McMahon et al. 1996). Variables commonly found to be important to fish include water quality variables related to physiology (e.g., temperature, dissolved oxygen), physical variables (e.g., shorelines, depth, current velocity), and biotic variables (e.g., productivity, prey abundance) (McMahon et al. 1996, Edds et al. 2002). Habitat variables can work interactively to determine fish distribution and, accordingly, fish distribution can be related to variables across multiple spatial scales (e.g., small scale microhabitat relationships with bathymetric slope, larger scale mesohabitat relationships with proximity to shorelines; McMahon et al. 1996, Fisher et al. 2012). While many studies only focus on a single scale of habitat use (Fausch et al. 2002), quantifying relationships across multiple scales is essential to fully understanding important fish-habitat relationships (McMahon et al. 1996, Fausch et al. 2002, Johnson and Host 2010).

Although Blue Catfish (*Ictalurus furcatus*) are widespread and a popular sport fish, relatively little peer reviewed literature exists on their distribution, habitat use, and foraging habits (Graham 1999). Blue Catfish are native to large rivers throughout the United States (Cross 1967). As a popular sport and food fish, Blue Catfish have been successfully introduced to reservoir systems and are an important management concern for natural resource agencies attempting to maintain healthy populations of large Blue Catfish (Arterburn et al. 2002). However, Blue Catfish remain the least studied of the ictalurid catfishes (Boxrucker 2007) and lack of information about their biology, general life history, and habitat requirements is a hindrance to research and management (Graham 1999, Garrett 2010, Schmitt and Shoup 2013). A review of three environmental science literature data bases (Web of Science, Wildlife and Ecology Studies Worldwide, Environmental Sciences and Pollution Management), two technical committee websites for the Ictalurid Technical Committees (North Central Division - American Fisheries Society, Southern Division - American Fisheries Society), and two published specialty symposia on catfish (Catfish 2000; Conservation, Biology, and Management of Catfish) revealed only 13 publications that provide original data on abiotic and biotic habitat characteristics related to Blue Catfish distribution (Table 1). These publications focus on a range of environmental variables and provide little consensus about the variables most important for determining Blue Catfish distribution.

Below, I briefly review this literature to justify my choice of abiotic and biotic variables for this study. I also include informative and relevant non peer-reviewed studies such as theses (e.g., Grist 2002, Garrett 2010) and aquaculture guidelines (e.g., Wyatt et al. 2006, Torrans et al. 2012). In general, fish will not consume food or grow well at extremely high or low temperatures, but will have optimal growth at intermediate temperatures (Wyatt et al. 2006). Blue Catfish distribution has been related to temperature (Fischer et al. 1999, Grist 2002, Garrett and Rabeni 2011, Tripp et al. 2011) and Blue Catfish were found to use intermediate values of available temperatures (Fischer et al. 1999, Grist 2002). Physiological relationships with dissolved oxygen can be important as dissolved oxygen concentrations below 4 mg/L can severely stress Blue Catfish and lead to reduced growth rates (Wyatt et al. 2006, Torrans et al. 2012). Accordingly, Blue Catfish were found to avoid concentrations of dissolved oxygen below 5 mg/L when they occurred in a reservoir (Grist 2002).

In addition to temperature and dissolved oxygen, relationships with other localized, microhabitat variables have been suggested. Blue Catfish have been associated with increased depths in both rivers and reservoirs (e.g., Fischer et al. 1999, Edds et al. 2002, Grist 2002, Miranda and Killgore 2011). In rivers, higher numbers of Blue Catfish have been associated with increased current velocities (e.g., Driscoll et al. 1999, Graham and DeiSanti 1999, Garrett and Rabeni 2011, Miranda and Killgore 2011, Tripp et al 2011) and areas with moderate bathymetric slope (e.g., Driscoll et al. 1999, Miranda and Killgore 2011).

Research on Blue Catfish has also examined mesohabitat features that affect fish distribution across larger spatial scales. Greater numbers of Blue Catfish were found near shoreline structures (e.g., wing dikes) and steep drop-offs in the Mississippi River (Driscoll et al. 1999, Garrett 2010, Garrett and Rabeni 2011). River kilometer, a measure of upriver and downriver distance, has been related to Blue Catfish distribution in both rivers and reservoirs as Blue Catfish often make seasonal movements upriver in spring and downriver in fall (e.g., Fischer et al. 1999, Bartram et al. 2011, Garrett and Rabeni 2011, Rypel 2011). Numbers of Blue Catfish are often greatest near main channels in rivers (e.g., Jackson 1995, Driscoll et al. 1999, Garrett and Rabeni 2011, Miranda and Killgore 2011) and were found to be greatest near the river channel in a reservoir (Edds. et al. 2002). Relationships with shorelines were also documented in a reservoir setting as Blue Catfish used areas close to shorelines in spring and summer and moved to areas further from shorelines in fall and winter (Grist 2002).

Lastly, the distribution of biotic variables such as prey and primary productivity is hypothesized to affect Blue Catfish distribution (e.g., Herod et al. 1997, Edds et al. 2002, Bartram et al. 2011, Bonvechio et al. 2011) as fish seek to meet energetic needs (Eggleton and Schramm 2004). Blue Catfish feed on a wide range of prey items (e.g., Minckley 1962, Herod et al. 1997, Edds et al. 2002, Eggleton and Schramm 2004, Bonvechio et al. 2011) with Gizzard Shad and chironomid larvae being especially common prey items in reservoirs (Edds et al. 2002). Relationships with productivity may also be important as greater numbers of Blue Catfish were found in reservoirs with low Secchi depths and increased primary productivity (Bartram et al. 2011). High primary productivity is associated with increased Gizzard Shad abundance in reservoirs (Michaletz 1998) and may offer a direct or indirect foraging advantage to Blue Catfish.

Here I used acoustic tags and a 57 site, system-wide tracking survey to test statistical hypotheses about Blue Catfish distribution and select environmental variables responsible for that distribution. To relate Blue Catfish distribution to important variables across multiple spatial scales, I quantified patterns and correlates of Blue Catfish distribution across Milford Reservoir, a large Kansas reservoir that offers a variety of environmental characteristics and contains a naturally reproducing population of Blue Catfish. I tested four statistical hypotheses about correlates of Blue Catfish distribution based on the groups of variables reviewed above. The first statistical hypothesis tested the importance of variables related to physicochemical conditions that occur at specific point locations, and are referred to as microhabitat variables (e.g., temperature, dissolved oxygen, depth, current velocity, slope). My second statistical hypothesis examined the impact of mesohabitat variables that characterize physical conditions at larger spatial scales (e.g., number of drop-offs, distance to channel, distance to shoreline, regional associations quantified with river kilometer). A third statistical hypothesis evaluated variables related to prey and productivity (e.g., number of Gizzard Shad, number of chironomid larvae, Secchi depth as a proxy for productivity). My fourth, ad hoc hypothesis, tested combinations of the strongest variables from the first three hypotheses. I used these hypotheses to ask the following research questions: 1) How are Blue Catfish distributed in Milford Reservoir across all time periods of the field season and what are the environmental correlates of Blue Catfish distribution over all time periods combined? 2) Do patterns and environmental correlates of Blue Catfish distribution change when individual months of summer and fall are examined?

Methods

Study System

Milford Reservoir, a large heterogeneous ecosystem, is an impoundment of the Republican River (39°08'42"N, 96°56'54"W; Dickinson, Clay, and Geary counties, KS) within the Lower Republican watershed, KS (Figure 1). Milford Reservoir was built for flood control in 1962 (WRAPS 2011) and is the largest reservoir in Kansas, with a surface area of 6,555 ha and 262 km of shoreline dominated by limestone, cobble and boulders (Reinke 2001). Characterized as a eutrophic to hypereutrophic reservoir (EPA Region 7), Milford Reservoir receives water from a watershed with ~ 50% cropland (WRAPS 2011). Common sport fish within the reservoir include White Bass (*Morone chrysops*), hybrid striped bass (*Morone saxatillis* x *Morone chrysops*), Walleye (*Stizostedion vitreum*), Channel Catfish (*Ictalurus punctatus*), Flathead Catfish (*Pylodictus ovlivarus*), and Blue Catfish. Gizzard Shad (*Dorosoma cepedianum*) is a common forage fish.

Milford Reservoir can be divided into three geographic regions [upper (U), middle (M), and lower (L)] that represent regions characteristic of many reservoirs (Wetzel 2001; Figure 1). The upper, middle, and lower regions are 6.7, 8.9, and 6.4 km long (longitudinal length along centerline) with surface areas of ~17, 13, and 15 km^2, respectively (Figure 1). The upper (mean width = 2.5 km) and lower regions (mean width = 2.5 km) are wider than the middle region (mean width = 1.7 km), with the upper region funneling into a constriction near the Madison Creek confluence (Figure 1). As with most reservoirs, a longitudinal gradient exists from the inflow of the river to the dam, with shallowest depths (3 - 6 m) in the upper reservoir, moderate depths (6 - 13 m) throughout the middle reservoir, and greatest depths (13 - 18 m) in the lower reservoir (Figure 2A). The upper region of the reservoir is relatively uniform and is characterized by low bathymetric slope (i.e., change in depth). The middle reservoir has a mix of both low and intermediate slopes, and the largest slopes are found in the lower reservoir near the dam (Figure 2B). Because they are flooded rivers, a sinuous channel of variable depth follows the longitudinal gradient along the historic river channel (Figure 2C). River kilometer, a measure of distance from the dam, is highest near the inflow of the reservoir and lowest near the dam (Figure 2D).

Research Design

For my research, which quantified system-wide spatial heterogeneity, I collected data on acoustically tagged Blue Catfish and select abiotic and biotic variables at 57 tracking sites (Figure 1). The 57 spatially explicit sampling locations provided good resolution for quantifying system-wide Blue Catfish distribution, provided substantial statistical power for model selection using multiple regression, and allowed the production of detailed spatial maps of Blue Catfish distribution and environmental correlates.

Fish Tagging

In June 2013, I tagged 75 Blue Catfish [mean = 517 mm total length, SE = 17.8 mm, range = 300 - 1000 mm] with VEMCO V9 and V13 acoustic transmitters. The sizes of tagged fish reflected size distribution obtained from a management survey in Milford Reservoir (John Reinke, personal communication). I implanted tags into the coelomic cavity of the fish by inserting the tag into an incision behind the pectoral fin. Fish were anesthetized with Aqui-S (30 mg/L) before tagging and given an intramuscular injection of antibiotic (Liquamycin - 0.1mg/kg fish mass) after tagging in order to reduce the stress of the tagging process, ensure quick healing, and increase tag retention. This methodology was previously tested and is applicable to a variety of fish species (Kennedy 2013). Tagged fish were released at three locations distributed across the reservoir (Figure 1). I presumed fish that were repeatedly detected at different locations survived the tagging process and retained their tags.

Tracking Survey of Tagged Blue Catfish

During June through November 2013, I conducted monthly tracking surveys to quantify the distribution of tagged Blue Catfish throughout the reservoir. Fish were tracked with a VEMCO VR-100 receiver fitted with a VH-165 omni-directional hydrophone deployed from the side of a boat approximately 0.33 m below the bottom of the boat. The range of the tracking receiver in Milford Reservoir was 500 m. At each of the 57 pre-determined tracking sites (0.8 km^2, Figure 1), I anchored the boat at the centroid of the tracking site and deployed the hydrophone for 15 minutes to detect the number of individually tagged fish across all depths within the detection radius, a methodology tested and successfully used previously (Kennedy 2013). This process was repeated each month and all tracking sites were visited within nine days during each month of tracking. Tracking in October was split between the last few days of October and first two days of November; for clarity, this time period is referred to as October. Because I used a standard method to survey an identical area across all locations, the number of unique individuals detected at each of the 57 survey sites was used as the response variable in all analyses (Table 2).

Environmental Correlate Data Collection

Data on microhabitat, mesohabitat, and biotic variables were collected across all 57 tracking sites in Milford Reservoir. Some variables were measured on a monthly basis (i.e., temperature, dissolved oxygen, Secchi depth, number of Gizzard Shad, number of chironomid larvae) while other variables were measured once during the field season (i.e., depth, slope, number of drop-offs, current velocity, distance to shoreline, distance to channel, river kilometer). Due to the system-wide approach used in this research, detailed spatial resolution was of primary interest in data collection. In some cases, temporal resolution of data was sacrificed in order to collect data with a fine spatial resolution.

Temperature and Dissolved Oxygen

Temperature (°C) and dissolved oxygen (mg/L) were measured at each tracking site at the same time as tagged fish were detected during tracking. For these environmental variables, data were collected at the centroid of each tracking site. Temperature and dissolved oxygen were measured with a YSI Pro2030 water quality meter, 2 m from the bottom of the water column because Blue Catfish often use benthic habitats (Fischer et al. 1999).

Depth and Slope

At each tracking site, depth (m) was quantified by taking a total of 200 depth measurements across two perpendicular transects, one transect oriented north-south and the other oriented east-west. Along these transects, depth measurements were taken every 10 m with a Hummingbird 1198c SI Combo side scan sonar unit. Slope (cm/m), a measure of bottom gradient, was quantified by calculating the change in depth across each 10 m section of both transects. For all analyses, depth and slope were summarized as the average of all measurements at a site (Table 2).

Current Velocity

Current velocity (m/s) was measured using an acoustic doppler current profiler system (SonTek RiverSurveyor M9 system). A custom transect line was determined for each site to ensure transects would best capture longitudinal flow in the reservoir (i.e., aligned perpendicular to the direction of latitudinal flow). For each tracking site, ArcMap 10.2.2 was used to draw a line that intersected the centroid of the tracking site, extended to both longitudinal banks of the reservoir, and intersected both banks closest to perpendicular. The line passing through each tracking site was 1 km in length and was used as the transect line for the acoustic doppler current profiler. I measured current velocity twice along each transect to ensure accurate measurements. Velocity data were recorded at one second intervals. Because a tradeoff exists between the resolution of a single data collection event and number of sampling events, velocity data, which requires a large amount of time to accurately measure, was measured in detail one time during the field season. Velocity data were collected at each tracking site one time from August to October, 2013. For all analyses, current velocity was summarized as the average of all measurements at a site (Table 2).

Drop-Offs

I quantified the number of drop-offs at each site by calculating the number of slope values greater than 10 cm/m, a relatively large value of slope for Milford Reservoir (but relatively small for slopes in other rivers and reservoirs). For all analyses, numbers of drop-offs at a site were summed (Table 2).

Distance to Channel, Distance to Shoreline, River Kilometer

Spatial variables such as distance to channel (km), distance to shoreline (km), and river kilometer (km) were calculated using ArcMap 10.2.2. To calculate distance from the channel, a channel line was drawn to represent the best known location of the river channel from a Navionics bathymetric map. The distance of each site from the channel was calculated by measuring the shortest distance, by water, from the centroid of each tracking site to the channel line. The distance of each site from the shoreline was calculated by measuring the shortest distance, by water, from the centroid of each tracking site to the shoreline, including the dam. The river kilometer distance associated with each tracking site represents the distance of the site from the dam (dam = river kilometer 0). To measure river kilometer, 30 points were positioned along a line extending longitudinally through the center of Milford Reservoir. The distance of each point from the dam was measured along the center line and each tracking site was assigned the river kilometer distance of the closest point along the line by water, measured from the centroid of each tracking site. A single value was calculated for each of the three distance metrics at each site (Table 2).

Number of Gizzard Shad

I collected Gizzard Shad using pulsed DC boat electrofishing (Miranda 2009) during a three day period each month from July to October, 2013. The order in which sites were sampled was changed between months to prevent temporal bias in the sampling design. Electrofishing was started at the centroid of the tracking site and the boat was driven in a continuously expanding spiraling pattern for 10 minutes to capture fish in the most efficient way possible while covering the largest amount of area. Two netters collected and counted the number of Gizzard Shad.

I estimated the number of Gizzard Shad at each tracking site by subsampling locations from each reservoir region (upper, middle, lower) and habitat type (within tributary, close to channel and far from shoreline, close to channel and shoreline, close to shoreline and far from channel, midway between channel and shore) (n = 1-3 per region-habitat group). A subsample was used because all sites could not have been sampled in a reasonable amount of time each month. The number of Gizzard Shad was estimated for each tracking site as follows. The average number of fish from sampled sites within each region and habitat group was used to generate a Poisson distribution, a distribution that is defined by a single parameter in which the variance equals the mean. For each site in a region-habitat group, 10 samples were drawn from the Poisson distribution. The average of the 10 estimates was used to calculate a single Gizzard Shad estimate for a single site in the group. This was repeated for each region-habitat group and time period to provide values for all 57 tracking sites during each month. The average number of Gizzard Shad at each site was used for the analysis of all time periods combined (Table 2).

Number of Chironomid Larvae

The number of chironomid larvae at each site was quantified by filtering a sediment grab (7 kg Ponar grab), collected at the center of each sampling site, through a sediment sieve (Field Master 500 micron). Samples were collected monthly in July through October, 2013, at the same time as tracking. The average number of chironomid larvae was used for the analysis of all time periods combined (Table 2).

Secchi Depth

Secchi depth (m), a measure of water turbidity, was measured using a 20-cm Secchi disk at the center of each tracking site at the same time as tracking each month. To identify how trends in Secchi depth were related to productivity, in August, 2014, I measured Secchi depth and simultaneously collected water samples at 20 locations positioned along a longitudinal gradient in Milford Reservoir, from the inflow to the dam. Samples, collected in dark bottles, were immediately packed on ice in the field and kept in a refrigerator until samples were processed (< 3 days). In the lab, concentrations of inorganic matter and dissolved organic matter were quantified by heating filtered samples using Method 1684 of the U. S. Environmental Protection Agency (2001). Spectrophotometric analysis was used to quantify corrected chlorophyll *a* concentration in water samples following methods outlined in Environmental Sciences Section Method 150.1 (USEPA 1991). Relationships between Secchi depth and productivity were calculated by regressing Secchi depth against water quality parameters. A negative relationship was found between Secchi depth and inorganic matter (mg/L) [r^2 = 0.48, β = -25.49, 95% CI = (-0.39 , -0.12), P = 6.99E-4], dissolved organic matter (mg/L) [r^2 = 0.64, β = -10.96, 95% CI = (-0.15 , -0.07) P = 2.37E-5], and corrected chlorophyll *a* concentration (µg/L) [r^2 = 0.32, β = -0.04, 95% CI = (-7.39E-4, -0.12E-4), P = 8.85E-3]. These data suggested low Secchi depths were related to both increased inorganic and dissolved organic matter, including elevated primary productivity. Because Gizzard Shad abundance is highly variable and notoriously difficult to quantify in a spatially and temporally explicit manner (Michaletz 1996), I also related Secchi depth to Gizzard Shad abundance. When average Secchi depth was regressed against the average number of Gizzard Shad at each site across all months (June - October), a significant relationship was found [r^2 = 0.27, β = -32.49, 95% CI = (-46.92, -18.06), P = 3.42E-5], suggesting low Secchi depth was also related to increased secondary productivity. Scatterplots of Secchi depth relationships are shown in Appendix A. Because Secchi depth was related to both primary and secondary productivity, and Blue Catfish relationships with Secchi depth have been related to productivity in previous research (Bartram 2011), I use Secchi depth as a proxy for productivity in this research. It should be noted, however, that Secchi depth was related to both inorganic matter (e.g., suspended sediment) *and* productivity. For all time periods combined, Secchi depth represents the average Secchi depth recorded at a site across all months (Table 2).

Statistical Analyses

Multiple linear regression and an information theoretic approach (i.e., AIC_c) were used to test which microhabitat, mesohabitat, and biotic variables were related to the distribution of Blue Catfish for all time periods combined and for each month of the field season (June - October). For an information theoretic approach, a thoughtful *a priori* selection of potential variables is critical. Specifically, the number of models tested should be limited to maintain parsimony and variables should be chosen to test meaningful ecological concepts (Burnham and Anderson 2002). After thoughtful exploratory data analysis of all variables, I combined less than five variables in select models that sequentially tested three statistical hypotheses about how microhabitat (statistical hypothesis 1), mesohabitat (statistical hypothesis 2), and biotic (statistical hypothesis 3) variables impacted Blue Catfish distribution during each time period. In addition, in order to guide future research, I tested an ad hoc hypothesis that grouped combinations of the strongest variables from each of the three *a priori* hypotheses for each time period (statistical hypothesis 4; Anderson et al. 2001).

In some cases, variables were transformed to meet the assumptions of regression analysis and allow the use of explanatory variables that otherwise would have been problematic for linear regression. For all analyses, the number of Blue Catfish was $\log_{10}$ transformed to satisfy the assumptions of normality and homogeneity of variance (Mendenhall and Sincich 2011). Slope and number of drop-offs were $\log_{10}$ transformed for all analyses to remove high leverage associated with a few relatively large samples (Mendenhall and Sincich 2011). Log_{10}

transformation were also applied to the number of Gizzard Shad in August, September, and October, and the number of chironomid larvae in July to remove high leverage associated with a small number of high-abundance samples. To identify if higher numbers of Blue Catfish were found near intermediate values of available temperatures and dissolved oxygen concentrations, a relationship reported in the literature (e.g., Grist 2002), absolute deviation from median values were calculated for temperature and dissolved oxygen for all analyses (Table 2). Small values of absolute deviation represented intermediate temperatures or dissolved oxygen concentrations and high values of absolute deviation represented very high or low temperatures or dissolved oxygen concentrations.

Prior to model selection, variance inflation factors (VIF) were calculated for each variable in the global model to detect problems of multicollineairty. Function *vif* in *R* was used to calculate VIF (R Core Team 2014). A VIF > 3 was considered a problematic level of multicollinearity (Zuur et al. 2010). When multicollineariy occurred, I conducted a principle component analysis between the two regressors with the highest VIF values before recalculating VIF values for the new global model that excluded the collinear variables and included scores from the principle component analysis (Graham 2003). Principle components analysis was conducted using function *princomp* in the *stats* package in *R* (R Core Team 2014). Scores of the first component were used to replace collinear variables in the model selection process since the first component explained more than 80% of the total variation in all cases (Zuur et al. 2007). In hypothesis 1 for June, a principle components analysis was conducted between absolute deviation from median temperature (VIF = 3.96) and absolute deviation from median dissolved oxygen concentration (VIF = 2.80). The first principle component, referred to as PC_TD, accounted for 90% of the variability among the variables, with both variables loading negatively on the PC (loading = -0.71). PC_TD represented low deviation from median temperature and dissolved oxygen. The second principle component accounted for 10% of the variabilty among the variables and was not considered further. For hypothesis 4 of all time periods combined, June, July, and August analyses, a principle components analysis was conducted between river kilometer (VIF = 3.94 - 14.26) and Secchi depth (VIF = 3.53 - 12.20). The first principle component, referred to as PC_RS, accounted for 91 to 97% of the variability among the predictors in each time period. In all cases, river kilometer loaded positively on the PC (loading = 0.71) and Secchi depth loaded negatively on the PC (loading = -0.71). PC_RS represented increased river kilometer distance and decreased Secchi depth. The second principle component accounted for 3 - 9% of the variability among the variables in each time period and was not included in further analyses. For hypothesis 4 in the October analyses, a principle components analysis was performed on depth (VIF = 2.62) and secchi depth (VIF = 3.85). The first principle component, referred to as PC_DS, accounted for 81% of the variability among the variables. Both depth and Secchi depth loaded positively on the PC (loading = 0.71), with PC_DS representing increased depth and Secchi depth. The second principle component accounted for 19% of the variability among the predictors and was not included in further analyses. Pearson's correlation coefficients among all regressors are included in Appendix B.

For each group of variables and time period, multiple regression models were compared using AIC_c, a model selection tool for small sample sizes (Burnham and Anderson 2002). Values of AIC_c were calculated using package *MuMIn* in *R* (Barton 2015). Models within 2 ΔAIC_c units were retained to ensure only models with substantial support as being the Kullback-Leibler best model were considered (Burham and Anderson 2011). Model weights (ω_i) and adjusted R^2 (Model Adj R^2) were calculated to measure the importance and explanatory power of each model (Burnham and Anderson 2002). Homogeneity of variance and independence met MLR assumptions. Cook's D (< 1) and variance inflation factor (VIF) (< 3) did not identify influential observations or multicollinearity (Quinn and Keough 2002, Graham 2003).

To compare the influence of individual variables, I calculated model averaged regression coefficients (β_j), unconditional standard errors (SE), and 95% confidence intervals (95% CI) using a "natural average" method that averages over the models where regressor j occurs (Burnham and Anderson 2002). I also calculated variable importance ($w+j$) to estimate the relative importance of each variable. Variable importance is the sum of model weights (ω_i) for all top models ($\Delta AIC_c < 2$) where regressor j occurs (Burnham and Anderson 2002). Importance values are scaled relative to the variable with the highest summed importance value so that a variable included in all top models $\Delta AIC_c < 2$ will have an importance value of 1.00. Thus, a high importance value represents higher relative importance of the specific variable in the model selection process and a higher probability that the variable is in the best model (Burnham and Anderson 2002). I calculated β_j and SE using function *model.avg* in package *MuMIn* in *R* (Barton 2015). Function *confit* in *stats* package in *R* was used to calculate 95% CI (R Core Team 2015). Variable importance was calculated using function *model.avg* in package *MuMIn* in *R* (Barton 2015).

I also used hierarchical partitioning to confirm the importance of variables identified from the model selection process. Hierarchical partitioning uses an all-subsets multiple regression approach to identify variables whose independent correlation with a response variable is important as opposed to variables whose correlation with the response variable results from joint correlation with other variables, a potential point of confusion in the interpretation of multi-model selection results (Mac Nally 2002). Following a multi-model approach, the incremental improvement in model R^2 by the addition of each variable is averaged over all combinations of the global model to determine the percent of total independent explained variance (I%) attributed to each variable. I calculated I% for each variable in the global model for each hypothesis using function *hier.part* in package *hier.part* in *R* (Walsh and Mac Nally 2013).

A goal of my research was to identify consistently influential correlates of Blue Catfish distribution from the list of possible variables identified in the literature. I identified influential correlates using four criteria: 95% CI, *w+j*, I%, and Model Adj R^2. I considered variables influential in determining Blue Catfish distribution when the 95% CI did not overlap zero, *w+j* and I% were high relative to other variables in the set of models, and Model Adj R^2 was > 0.20 to avoid focusing on very weak relationships. To allow all potentially important variables to be tested in hypothesis 4, I included all variables from hypothesis 1 through 3 that were in top models ($\Delta AIC_c < 2$) and contained 95% CI that did not overlap zero, regardless of *w+j*, I%, and Model Adj R^2. I then evaluated variables in hypothesis 4 using the same four criteria described above. To interpret influential variables identified in each hypothesis, I examined the consistency in β_j across time periods and considered the ecological meaning of all regressor-catfish relationships. For all time periods, all models are shown. For months, only the averaged model is interpreted, although all regression models are shown in Appendix C. In order to summarize all results, I created a table that compared influential variables across all time periods combined and in individual months. The influential variables were then mapped and compared to Blue Catfish distribution.

Results

Overview

For all time periods combined, then again for summer and fall months, I sequentially reviewed three types of results. First, I summarized the spatial distribution of Blue Catfish throughout Milford Reservoir. Then, I identified influential regressors for all four statistical hypotheses using the AIC_c model selection process and results of hierarchical partitioning. Lastly, to summarize general patterns (all time periods combined and monthly), I reviewed spatially explicit maps of statistically influential and ecologically meaningful environmental correlates of Blue Catfish distribution.

Detections

Across all months of the field season, an average of 48 individuals (64% of tagged fish) was detected during tracking surveys. Fish were detected at 51 of 75 sites throughout the reservoir across the entire field season. More than 50% and up to 73% of tagged fish were detected in each monthly tracking survey (46, 55, 46, 42, and 51 individuals detected in June, July, August, September, and October, respectively). Fish were detected at an average of 33 sites each month (21, 27, 32, 40, and 43 sites in June, July, August, September, and October, respectively).

All Time Periods

Averaged across all time periods, numbers of Blue Catfish were not evenly distributed throughout the reservoir. Blue Catfish were not common in the northernmost sites in the upper reservoir, the lower reservoir sites (especially near the dam), and many sites within the middle region (Figure 3, blue sites). Two zones of higher numbers of fish were seen. One aggregation occurred in the upper region where the reservoir width started to narrow (hereafter referred to as the funnel) and extended to just below the Madison Creek confluence (hereafter referred to as the upper constriction) (Figure 1; Figure 3, green and red sites). The other smaller aggregation occurred in a constricted western edge of the middle reservoir (hereafter referred to as the middle constriction) (Figure 3, green and red sites). Within both aggregations, select sites had especially high numbers of tagged Blue Catfish (average of 5.0 - 8.8 individuals; Figure 3, red sites).

Select microhabitat, mesohabitat, and biotic variables were influential correlates of Blue Catfish distribution for all time periods combined. Hypothesis 1 contained six models $\Delta AIC_c < 2$ with a Model Adj R^2 of 0.22 - 0.25 (Table 3A). Influential microhabitat variables included absolute deviation from median dissolved oxygen [β_j = -0.10, SE = 0.05, 95% CI = (-0.20, -0.01), $w{+}j$ = 0.88, I% = 31.92] and slope [β_j = -0.60, SE = 0.21, 95% CI = (-1.03, -0.17), $w{+}j$ = 1.00, I% = 40.56] (Table 3A). More fish were detected at intermediate dissolved oxygen concentrations (i.e., low deviation from median dissolved oxygen) and low slopes. Hypothesis 2 contained three models $\Delta AIC_c < 2$ with a Model Adj R^2 of 0.39 - 0.40 (Table 3B). Influential mesohabitat variables included distance to channel and river kilometer. More fish were detected close to the channel and at increased river kilometer distance, away from the dam. Hypothesis 3 contained two models $\Delta AIC_c < 2$ with a Model Adj R^2 of 0.32 and the only influential variable was Secchi depth [β_j = -0.41, SE = 0.08, 95% CI = (-0.57, -0.24), $w{+}j$ = 1.00, I% = 85.60] (Table 3C). More fish were detected at low Secchi depths. Hypothesis 4 contained two models $\Delta AIC_c <$ 2 with a Model Adj R^2 of 0.42 - 0.44 (Table 3D). Influential variables included distance to channel [β_j = -0.14, SE = 0.04, 95% CI = (-0.23, -0.05), $w{+}j$ = 1.00, I% = 27.93] and PC_RS [β_j = 0.09, SE = 0.02, 95% CI = (0.05, 0.13), $w{+}j$ = 1.00, I% = 52.80], confirming distance to channel, river mile, and Secchi depth as the most influential correlates of distribution across all time periods combined (Table 3D).

Summer Months

In June, July, and August, no Blue Catfish were detected in sites of the lower reservoir (Figure 4A-C, blue sites). Similar to the distribution of fish found across all time periods combined, Blue Catfish were aggregated in two zones of the reservoir described above, the funnel to the upper constriction and in the middle constriction (Figure 4A-C, green and red sites).

Variables found to be influential in summer months were generally the same as those identified for all time periods combined. In July, PC_TD [β_j = 0.10, SE = 0.03, 95% CI = (0.04, 0.15), $w+j$ = 1.00, I% = 51.52] was an influential microhabitat variable (Table 4B) as higher numbers of fish were detected near intermediate temperatures and, similar to all time periods combined, near intermediate dissolved oxygen concentrations. In August, consistent with trends across all time periods combined, absolute deviation from median dissolved oxygen concentration [β_j = -0.13, SE = 0.05, 95% CI = (-0.23, -0.03), $w+j$ = 1.00, I% = 41.75] and slope [β_j = -0.65, SE = 0.32, 95% CI = (-1.30, -0.01), $w+j$ = 0.84, I% = 27.74] were the most influential microhabitat variables (Table 4C) as more fish were detected near intermediate dissolved oxygen concentrations and at low slopes.

Relationships with mesohabitat variables found in summer months were also consistent with trends found across all time periods combined as distance to channel and river kilometer were identified as influential correlates in select summer months. More fish were detected at increased river kilometer distance in June [β_j = 0.02, SE = 0.01, 95% CI = (0.01, 0.04), $w+j$ = 1.00, I% = 77.31] (Table 4A), July [β_j = 0.03, SE = 0.01, 95% CI = (0.02, 0.04), $w+j$ = 1.00, I%

= 88.63] (Table 4B), and August [β_j = 0.03, SE = 0.01, 95% CI = (0.02 , 0.04), *w+j* = 1.00, I% = 72.16] (Table 4C) and close to the channel in August [β_j = -0.17, SE = 0.06, 95% CI = (-0.30 , -0.04), *w+j* = 1.00, I% = 22.13] (Table 4C).

As with all time periods combined, Secchi depth was the most influential biotic variable in hypothesis 3 during select summer months. Secchi depth was an influential correlate in both July [β_j = -0.36, SE = 0.08, 95% CI = (-0.53 , -0.19), *w+j* = 1.00, I% = 71.33] (Table 4B) and August [β_j = -0.50, SE = 0.07, 95% CI = (-0.65,-0.36), *w+j* = 1.00, I% = 95.13] (Table 4C) as more fish were detected in low Secchi depths. When variables were combined in hypothesis 4, PC_RS was the only influential variable in June [β_j = 0.09, SE = 0.03, 95% CI = (0.03, 0.15), *w+j* = 1.00, I% = 59.57] July [β_j = -0.11, SE = 0.03, 95% CI = (-0.17 , -0.04), *w+j* = 1.00, I% = 63.85] and August [β_j = 0.16, SE = 0.03, 95% CI = (0.11, 0.21), *w+j* = 1.00, I% = 56.08], confirming river kilometer and Secchi depth as the most influential correlates of distribution in summer months (Table 4A-C).

Fall Months

In September and October, numbers of Blue Catfish remained highest in the two zones of aggregation described above (funnel to upper constriction and in the middle constriction; Figure 4D, E; green and red sites). Numbers of Blue Catfish increased in the lower reservoir during fall (Figure 4D, E; green sites), but numbers remained low relative to the two areas of aggregation found in previous months.

Relationships with microhabitat and biotic variables were weak in fall months when fish dispersed; however, influential mesohabitat relationships with distance to channel mirrored those found across all time periods combined. In October, distance to channel [β_j = -0.23, SE = 0.06, 95% CI = (-0.34, -0.11), $w+j$ = 1.00, I% = 79.50] was an influential variable as more fish were detected close to the channel (Table 4E). When variables were combined in hypothesis 4, distance to channel [β_j = -0.23, SE = 0.06, 95% CI = (-0.34, -0.11), $w+j$ = 1.00, I% = 83.35] was the only influential variable in October (Table 4E), confirming the importance of channel relationships during this time period.

Spatiall Explicit Maps of Environmental Correlates

Below, I summarize consistently influential correlates of Blue Catfish distribution by describing spatial maps of the variables. Of the 12 variables indentified in the literature, 5 variables were consistently related to Blue Catfish distribution across all time periods combined and in monthly analyses (Table 5). These variables included absolute deviation from median dissolved oxygen, slope, distance to channel, river kilometer, and Secchi depth (Table 5).

Dissolved oxygen was an influential correlate across all time periods combined and in select summer months (Table 5A) when numbers of Blue Catfish were greatest near median dissolved oxygen concentrations (all time periods combined median = 6.62 mg/L, July median = 4.78 mg/L, August median = 5.35 mg/L). When influential relationships with dissolved oxygen were found (i.e., all time periods combined, July, August), intermediate dissolved oxygen concentrations (4 - 7 mg/L) most often occurred from the funnel to the upper constriction and in select sites of the middle reservoir (Figure 5A, C, D; green sites). Sites in the upper region often had the highest concentrations (> 7 mg/L; Figure 5, C, D; red sites) while sites in the lower region had very low concentrations of dissolved oxygen (< 4 mg/L; Figure 5A, C, D; blue sites).

Slope was an influential correlate of Blue Catfish distribution across all time periods combined and in August, when higher numbers of Blue Catfish were detected near low to intermediate slopes (0 - 2 cm/m) (Table 5A). In general, sites in the upper reservoir contained very low slopes (< 1 cm/m; Figure 2B, blue sites), low and intermediate slopes (0 - 2 cm/m) were found throughout the middle reservoir (Figure 2B, blue and green sites), and intermediate and large slopes (1 - 5 cm/m) were found in the lower reservoir near the dam (Figure 2B, green and red sites).

Consistent relationships with the channel were found as distance to channel was an influential correlate of distribution across all time periods combined and in select summer and fall months (Table 5B). During these time periods, Blue Catfish were found in greater numbers near the channel (< 0.5 km). Many of the sites around the funnel, upper constriction, and middle constriction of the reservoir were close to the channel (< 0.5 km; Figure 2C, blue sites) while tributaries and the wider upper and lower regions of the reservoir contained sites far from the channel (> 1km; Figure 2C, red sites).

River kilometer was an influential correlate of Blue Catfish distribution across all time periods combined and in summer months, when fish were found in greater numbers at increased river kilometer distance, away from the dam (Table 5B). As expected, river kilometer was lowest (< 6 km) in the lower region near the dam, moderate (6 - 15 km) in the middle region and highest (> 15km) in the upper region of the reservoir (Figure 2D).

Lastly, a consistent trend was found with Secchi depth across all time periods combined and in summer months (Table 5C) when higher numbers of Blue Catfish were found in low Secchi depths. Averaged across all months and in each individual month, Secchi depth was lowest (< 0.5 m) in the upper reservoir, intermediate (0.5 - 1.0 m) in the middle reservoir, and highest (> 1.0 m) in the lower reservoir (Figure 6).

Discussion

Averaged across all time periods, two areas of Blue Catfish aggregation were identified in Milford Reservoir. The primary aggregation extended from the funnel, where the width of the reservoir started to narrow, to the upper constriction, near the Madison Creek confluence. A second, smaller aggregation was found on the west side of the middle constricted area of the reservoir. Fish were rarely detected in the lower reservoir throughout the field season. Aggregations of Blue Catfish have been documented in other studies (Grist 2002, Garrett and Rabeni 2011), but aggregations across an entire reservoir ecosystem that persists across summer and fall months has not.

Seasonally, numbers of Blue Catfish were highest in the two areas of aggregation identified across all time periods combined, although slight seasonal variation occurred. In summer months, aggregations of fish were detected in the two areas of aggregation found across all time periods combined (the funnel to the upper constriction and in the middle constriction). No Blue Catfish were detected in the lower reservoir during summer months. In fall, numbers of Blue Catfish remained highest in the two areas of aggregation described above, but numbers of fish began to increase in the lower reservoir. This relationship is consistent with a previous reservoir study that found Blue Catfish use the middle of the reservoir during summer months and move to the lower reservoir, near the dam, in fall (Fischer et al. 1999). This pattern suggests some Blue Catfish fish make seasonal movements to lower regions of reservoirs in fall, a pattern previously documented in rivers (Garrett and Rabeni 2011).

Microhabitat variables were influential correlates of distribution across all time periods combined and in summer months (Table 5A). Blue Catfish were found in higher numbers near intermediate dissolved oxygen concentrations and avoided concentration below 4 mg/L when they occurred, a relationship found elsewhere (Grist 2002). Higher numbers of fish also occurred near low to intermediate slopes, a relationship found in rivers (Miranda and Killgore 2011) but not previously quantified in a reservoir setting. In July, PC_TD was an influential correlate of distribution as higher numbers of fish were found near intermediate temperatures and dissolved oxygen concentrations. Blue Catfish physiological requirements are considered similar to those of channel catfish, which can tolerate temperatures ranging from 0 - 40°C (Tucker and Robinson 1999, Wyatt et al. 2006). Because temperatures ranged from 23.4 - 29.3°C in July, well within the thermal tolerance of Blue Catfish, temperature was likely not a limiting factor driving distribution during this time period. Very low levels of dissolved oxygen (0.04 mg/L) occurred in the reservoir during July and more likely resulted in the influential relationship found with PC_TD. However, interactions between temperature and dissolved oxygen can determine fish distribution in complex ways (Coutant 1985) and exploring relationships between Blue Catfish distribution and temperature may be of interest in future research efforts. More details of temperature relationships found in this research are described in Appendix D.

Mesohabitat relationships with distance to channel and river kilometer were consistently influential correlates of Blue Catfish distribution (Table 5B). Distance to channel was an influential correlate across all time period combined, and in summer and fall, when higher numbers of fish were detected near the channel. Hypothesis 4 confirmed the strong influence of distance to channel and river kilometer in determining distribution (Table 5D). This is the first study to quantify the proximity of Blue Catfish to the channel across a continuous gradient in a reservoir. Consistent with the limited literature on channel relationships in reservoirs, Blue Catfish were often found in greater numbers near the river channel. River kilometer was influential across all time periods combined and in summer, when higher numbers of fish were detected away from the dam. Similarly, Blue Catfish were most often located near the middle reservoir (away from the dam) in a Missouri impoundment (Fischer et al. 1999).

Lastly, biotic relationships with Secchi depth were influential across all time periods combined and in summer months when higher numbers of Blue Catfish were located in areas with low Secchi depth. Hypothesis 4 confirmed the strong influence of Secchi depth in determining distribution (Table 5D). Although not previously quantified in a spatially explicit manner, others have suggested Blue Catfish seek areas of high productivity with increased foraging opportunities (Grist 2002, Eggleton and Schramm 2004, Garrett 2010) and have found greater numbers of Blue Catfish in reservoirs with low Secchi depths (Bartram et al. 2011). Here, consistent with the literature, I quantified Secchi depth in a spatially and temporally explicit manner and found higher numbers of Blue Catfish near decreased Secchi depths, associated with increased primary and secondary productivity.

Trends of the most influential variables suggest Blue Catfish distribution was driven by three tiers of influence (i.e., groups of variables that drive distribution and occur on multiple spatial and temporal scales) that can be used to guide future research efforts. As a primary tier, tagged Blue Catfish avoided very low dissolved oxygen concentrations (< 4 mg/L) when they occurred. As a second tier of influence, Blue Catfish aggregated near the channel, an area that may offer bathymetric heterogeneity that enhances foraging opportunities (McClain and Barry 2010). As a third tier, Blue Catfish aggregated near low Secchi depths, associated with increased productivity. In Milford Reservoir, characteristics of all three tiers of influence (i.e., suitable dissolved oxygen concentration, close to channel, low Secchi depth) most often co-occurred in the upper and middle reservoir and may have led to influential relationships with low slopes and increased river kilometer distances, both found in the upper and middle reservoir.

The three tiers of influence may act to drive distribution on multiple spatial and temporal scales and vary in importance throughout the year. For example, avoidance of low dissolved oxygen concentrations is a microhabitat scale relationship that may be most important in summer months when low dissolved oxygen concentrations occur. Relationships with proximity to the channel that occur over larger spatial scales may be important throughout the year and act as a staging ground for Blue Catfish foraging, offering areas for Blue Catfish to find and capture prey (McClain and Barry 2010). Lastly, Blue Catfish may aggregate in areas of low Secchi depth and increased productivity in summer months, when productivity is highest (Matthews 1998, Wetzel 2001).

This study quantified relationships between Blue Catfish distribution and three groups of environmental variables using multiple linear regression in an information theoretic framework, an approach with advantages and disadvantages. By focusing on three separate groups of explanatory variables, I was able to evaluate the importance of a range of variables postulated to affect Blue Catfish distribution in the literature but previously untested in the same system. However, detailed relationships among the influential correlates couldn't be determined and experimental approaches and other statistical analyses (e.g., path analyses) are needed to better understand relationships among the variables. Here, I identified which variables would be useful to test further and proposed an explanation for the way the variables may act to drive Blue Catfish distribution (i.e., three tiers of influence). These insights should be used to develop and test future hypotheses regarding habitat use of Blue Catfish.

Research and Management Implications

Below, I provide several research and management implications to assist future work on the habitat use of Blue Catfish.

First, knowing how fish are distributed is a critical information need that underlies the effectiveness of all research and management activities. Without knowing fish distribution, many research and management activities are compromised, including collection of data for the efficient management of populations (e.g., size, growth, survival, recruitment) and biological data collection (Van Den Avyle and Hayward 1999, Garton et al. 2001, Zale et al. 2012). Future research efforts can benefit from identifying areas of Blue Catfish aggregation in order to study fine scale habitat use of Blue Catfish. In addition, managers should account for aggregated distributions of Blue Catfish in population estimates and data collection.

Second, the entire study system needs to be considered as an integrated, multi-scale unit. Effective research and management efforts require knowledge of habitat use across a range of spatial scales; however, most research and management efforts only focus on microhabitat *or* mesohabitat scales (Fausch et al. 2002). Focusing on microhabitat scales can provide insights about important habitat requirements that promote feeding and growth (e.g., Vokoun and Rabeni 2005) but can limit the applicability of research to management efforts (Fausch et al. 2002). Observing relationship across mesohabitat scales can be used to understand the full extent of resource exploitation and identify limiting resources (e.g. Garrett and Bennett 1995) but can mask important relationships occurring at finer scales (Roni et al. 1999). The results of this study show that relationships across both microhabitat and mesohabitat scales are important and interact to create patterns of distribution; integrating these scales is essential.

Lastly, if generalizing the results of this research to other reservoirs, interactions among all three tiers of influence should be considered. Trends in Blue Catfish distribution were explained by a combination of variables rather than any single variable alone. Reservoirs often share physical, chemical, and biotic properties and can be divided into three general regions that apply to the three tiers proposed above. Three general regions of reservoirs include a riverine region near the river inflow, a transition region in the middle of the reservoir, and a lacustrine region near the dam (Wetzel 2001). Riverine regions tend to have shallow depths, high dissolved oxygen concentrations, and high organic and inorganic matter input (Wetzel 2001). Transition regions are characterized by increased depths, intermediate dissolved oxygen concentrations, and high primary productivity (Wetzel 2001). Lacustrine zones are characterized by deep depths, variable dissolved oxygen concentrations that can be very low when stratification occurs, and low nutrient concentrations that result in low productivity (Wetzel 2001). Because reservoirs are almost always formed in river valleys, reservoirs may contain one or more river channels that extend throughout the reservoir. Taking the three tiers of influence proposed above into account, higher numbers of Blue Catfish should be found in transition zones of reservoirs, characterized by suitable dissolved oxygen concentrations and increased primary productivity. Within transition zones, fish should be located near the river channel(s), if present.

Supplemental maps and plots are provided in Appendices E and F, respectively.

Figures and Tables

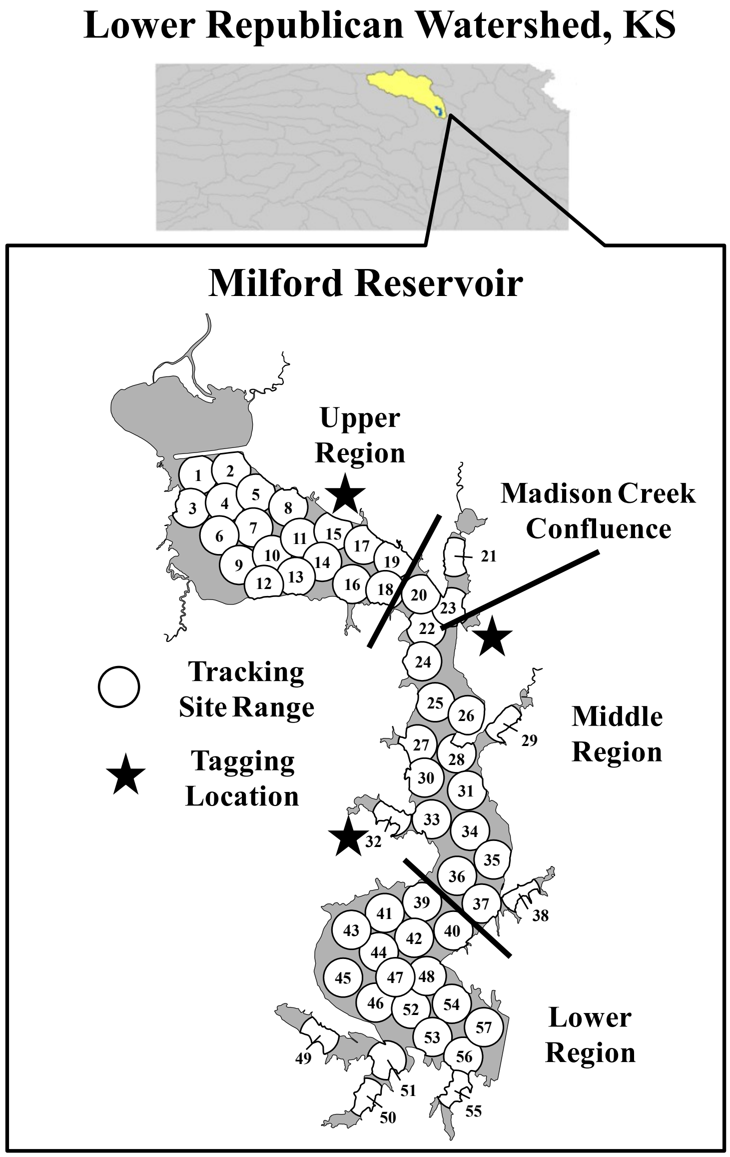

Figure 1. Map of Milford Reservoir, located in the Lower Republican watershed, KS. Included in the map of Milford Reservoir are divisions of three distinct regions of the reservoir (upper region, middle region, lower region), tagging locations of Blue Catfish (star), and tracking ranges for the 57 site tracking survey (circles and numbers) used to quantify the distribution of acoustically tagged Blue Catfish. Regions are used to describe trends and are not used as a quantitative test of geographic position. The dam is in the lower region of the reservoir.

Milford Reservoir Physical Variables

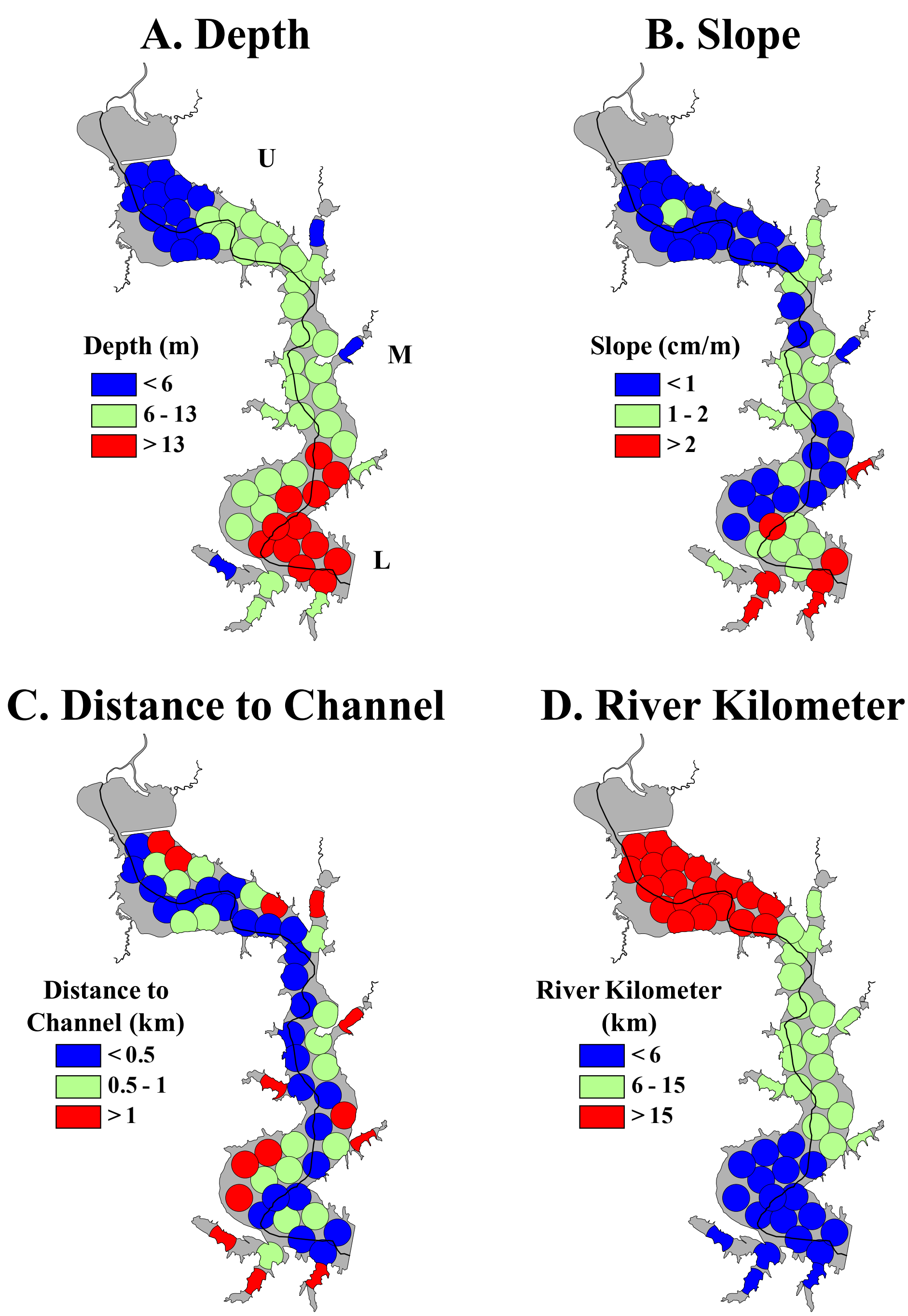

Figure 2. Maps showing the spatial distribution of (A) depth (m), (B) slope (cm/m), (C) distance to channel (km), and (D) river kilometer (km) in Milford Reservoir, KS.

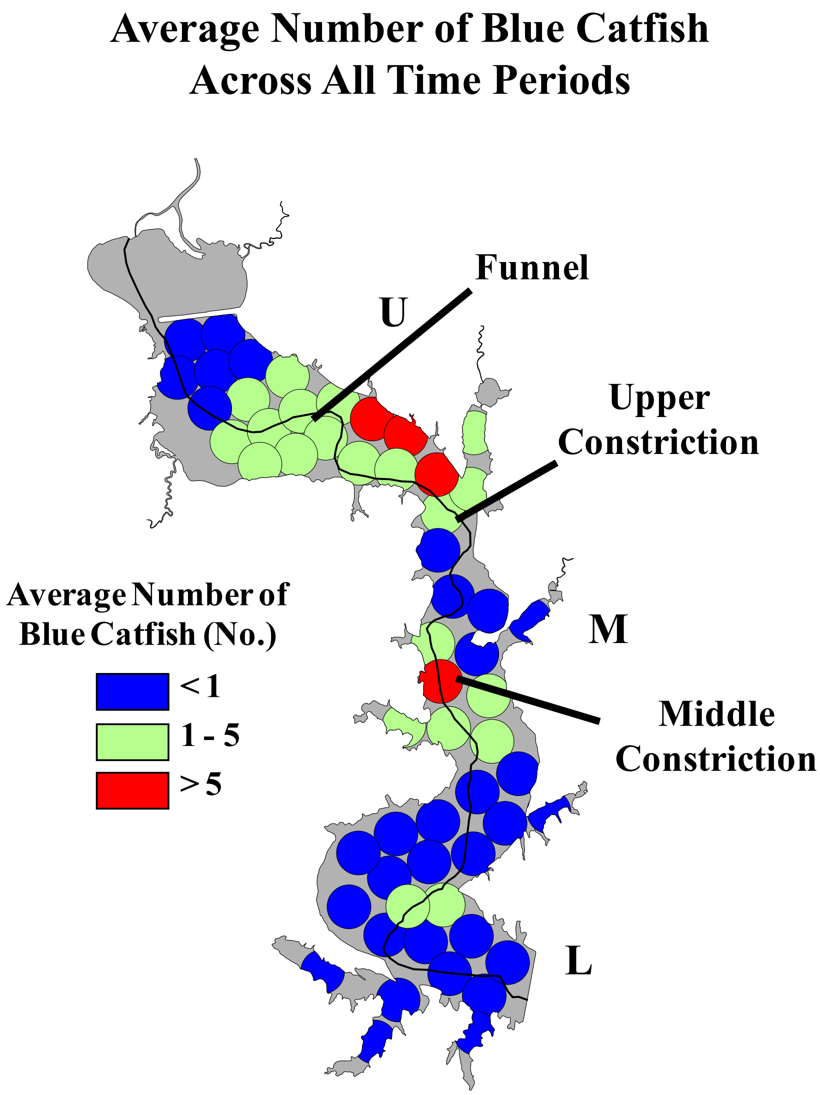

Figure 3. Map of the average number of individually tagged Blue Catfish (No.) detected at each tracking site across all time periods of the field season (June - October, 2013) in Milford Reservoir, KS. U, M, L indicate the upper, middle, and lower regions of the reservoir. Also shown are the funnel, upper constriction, and middle constriction, areas where Blue Catfish tended to aggregate throughout the field season.

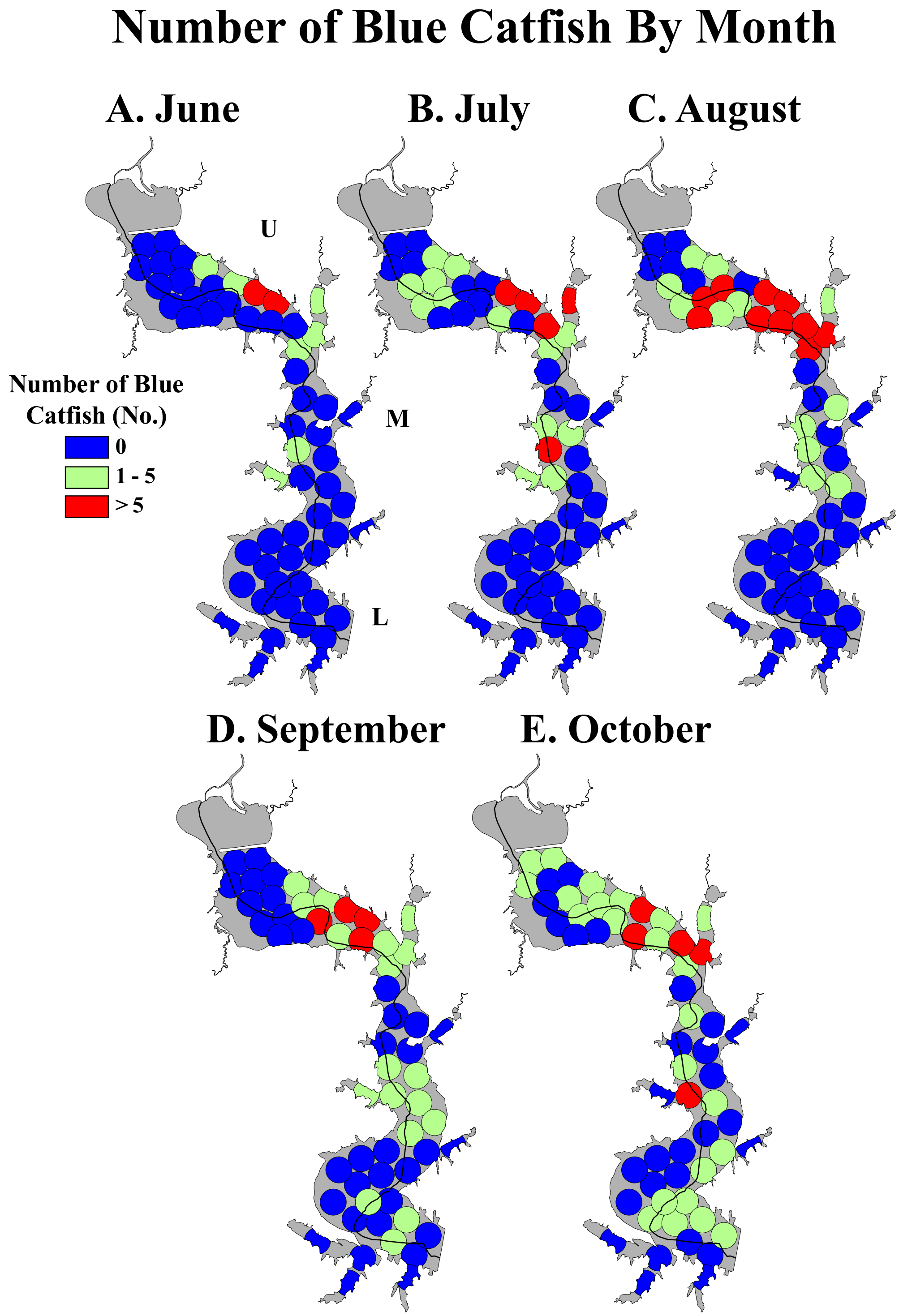

Figure 4. Maps showing the spatial distribution of tagged Blue Catfish in (A) June, (B) July, (C) August, (D) September, and (E) October, 2013, in Milford Reservoir, KS. U, M, L indicate the upper, middle, and lower regions of the reservoir.

Dissolved Oxygen

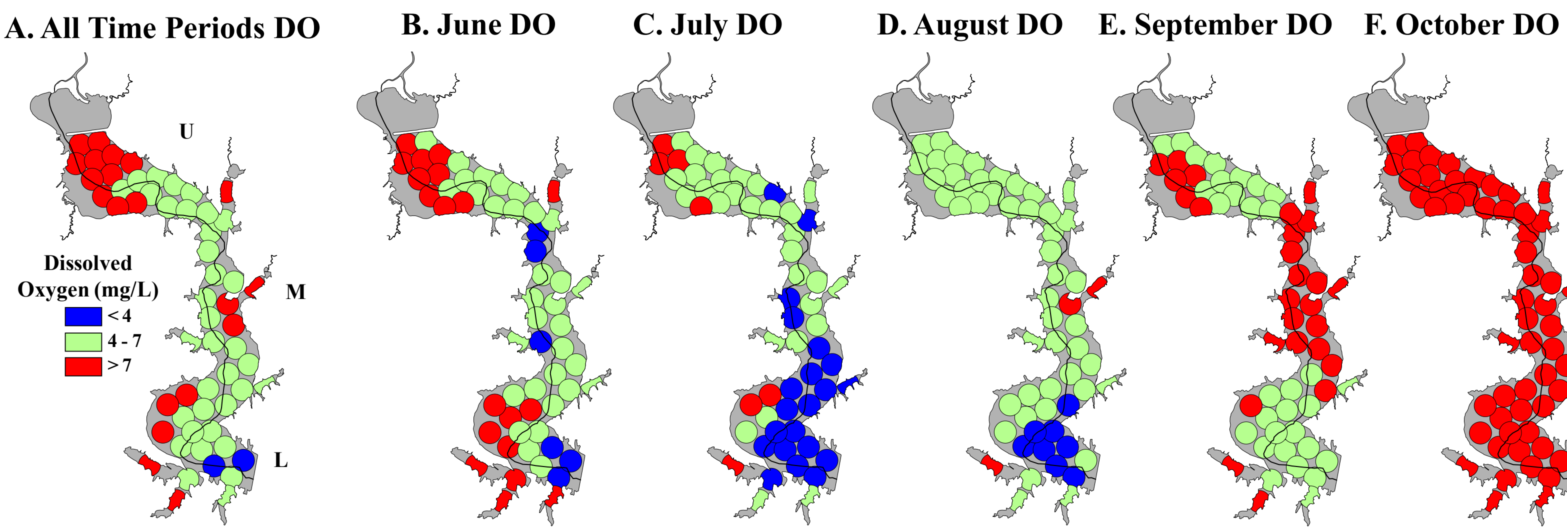

Figure 5. Maps showing the spatial distribution of dissolved oxygen concentration (mg/L) for (A) all time periods combined, (B) June, (C) July, (D) August, (E) September, and (F) October, 2013, in Milford Reservoir, KS. U, M, L indicate the upper, middle, and lower regions of the reservoir.

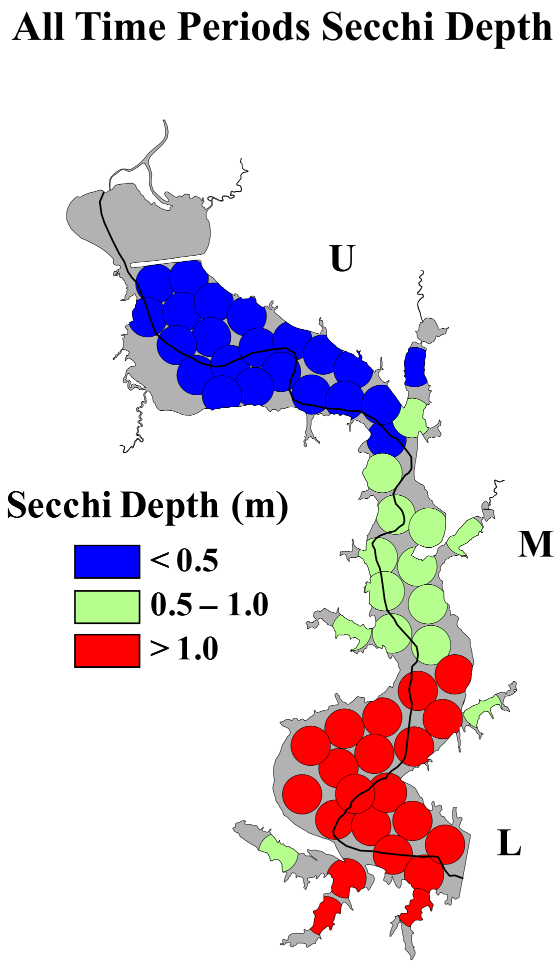

Figure 6. Map of the average Secchi depth (m) across all time periods (June - October, 2013) in Milford Reservoir, KS. U, M, L indicate the upper, middle, and lower regions of the reservoir.

Table 1. Peer-reviewed publications that provide original, quantitative data about specific variables related to abiotic and biotic factors that affect Blue Catfish distribution. Theses and other non-peer reviewed literature are not included here but are discussed in the text. Current peer reviewed publications provide original, quantitative data on relationships between Blue Catfish distribution and physiological variables (e.g., temperature, dissolved oxygen), physical bathymetry and structural variables (e.g., depth, slope, drop-offs), current velocity, regional and spatial variables (e.g., distance to channels, distance to shorelines, river kilometer), prey abundance, and Secchi depth, as a proxy for productivity. The publications focus on a range of variables and provide little consensus about the variables most important for determining Blue Catfish distribution.

	Variables Quantified					
Publication	**Physiological**	**Physical Bathymetry/Structure**	**Current Velocity**	**Regional/ Spatial**	**Prey**	**Productivity**
Minckley (1962)					x	
Jackson (1995)				x		
Driscoll et al. (1999)		x	x	x		
Fischer et al. (1999)	x	x		x		
Graham and DeiSanti (1999)			x			
Edds et al. (2002)		x		x	x	
Eggleton and Schramm (2004)					x	
Bartram et al. (2011)	x	x		x	x	x
Bonvechio et al. (2011)					x	
Garrett and Rabeni (2011)	x	x	x	x		
Miranda and Killgore (2011)		x	x	x		
Rypel (2011)	x			x		
Tripp et al. (2011)	x		x			

Table 2. Descriptions of response and explanatory variables used in all analyses, including transformations where relevant.

Variable	Calculation	Units
Response		
Number of Blue Catfish	Number of individual tagged Blue Catfish detected at each site. For all time periods combined, number of Blue Catfish represents the average number of individuals detected at each site across all months. A $\log_{10}$ transformation was applied to the raw number of individuals detected for all analyses.	($\log_{10}$ No.)
Explanatory		
Absolute deviation from median temperature	Absolute deviation from the median temperature recorded at all sites. For all time periods combined, temperature represented the average temperature recorded across all time periods (June - October).	(°C)
Absolute deviation from median dissolved oxygen	Absolute deviation from the median dissolved oxygen concentration recorded at all sites. For all time periods combined, dissolved oxygen concentration represented the average dissolved oxygen concentration recorded across all time periods (June - October).	(mg/L)
Depth	Average depth.	(m)
Current velocity	Average velocity across the entire water column.	(m/s)
Slope	Average change in depth. The average change in depth was $\log_{10}$ transformed for all analyses.	($\log_{10}$ cm/m)
Drop-offs	Number of locations where depth changes more than 10 cm/m, measured at 10 meter increments along two perpendicular transects (1 km each) in each site. The raw number of drop-offs was $\log_{10}$ transformed for all analyses.	($\log_{10}$ No.)
Distance to channel	Distance from the centroid of the tracking site to the historic channel line.	(km)
Distance to shoreline	Distance from the centroid of the tracking site to the shoreline, including the dam.	(km)
River kilometer	Distance from the dam.	(km)
Number of gizzard shad	Number of gizzard shad collected. For all time periods combined, number of gizzard shad represent the average number of gizzard shad detected at each site across all months. Raw numbers of gizzard shad were $\log_{10}$ transformed in August, September, and October analyses.	(No.) or ($\log_{10}$ No.)
Number of chironomids	Number of chironomid larvae collected. For all time periods combined, the number of chironomid larvae represents the average number of chironomid larve collected at each site across all months. The raw number of chironomid larvae was $\log_{10}$ transformed in July analyses.	(No.) or ($\log_{10}$ No.)
Secchi depth	Secchi depth recorded at the centroid of each tracking site. For all time periods combined, Secchi depth represents the average Secchi depth recorded across all time periods (June - October).	(m)

Table 3. Results of multiple regression and AIC_c model selection for (A) microhabitat, (B) mesohabitat, (C) biotic, and (D) combinations of variables across all time periods combined. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_RS represents scores of the first principle component in a principle component analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71). Coefficients (β) and standard errors (SE) are shown for all explanatory variables in each model. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2 (Model Adj R^2), and variance inflation factors (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables					Evaluation Criteria				

A. Microhabitat

Model No.	Absolute deviation from median temperature β SE	Absolute deviation from median dissolved oxygen β SE	Depth β SE	Current velocity β SE	Slope β SE	K	ΔAICc	ωi	Model Adj R^2	VIF
1		-0.11 (0.04)		2.60 (1.66)	-0.58 (0.21)	5	0.00	0.16	0.25	1.06
2	-0.17 (0.11)	-0.08 (0.05)			-0.58 (0.21)	5	0.15	0.15	0.25	1.28
3		-0.11 (0.04)			-0.56 (0.21)	4	0.18	0.14	0.23	1.06
4	-0.13 (0.12)	-0.09 (0.05)		2.03 (1.73)	-0.59 (0.21)	6	1.16	0.09	0.25	1.33
5		-0.12 (0.04)	0.01 (0.01)	3.45 (1.83)	-0.68 (0.23)	6	1.22	0.09	0.25	1.54
6	-0.26 (0.11)				-0.67 (0.21)	4	1.33	0.08	0.22	1.00
βj (SE)	-0.19 (0.12)	**-0.10 (0.05)**	0.01 (0.01)	2.67 (1.80)	**-0.60 (0.21)**					
95% CI	-0.43 , 0.06	**-0.20 , -0.01**	-0.01 , 0.03	-0.93 , 6.27	**-1.03 , -0.17**					
ω + (j)	0.45	**0.88**	0.12	0.47	**1.00**					
I%	15.83	**31.92**	4.59	7.11	**40.56**					

B. Mesohabitat

Model No.	Drop-offs β SE	Distance to channel β SE	Distance to shoreline β SE	River kilometer β SE	K	ΔAICc	ωi	Model Adj R^2	VIF
1		-0.16 (0.05)	-0.14 (0.09)	0.02 (3.98E-3)	5	0.00	0.33	0.40	1.16
2		-0.13 (0.05)		0.02 (4.03E-3)	4	0.18	0.30	0.39	1.03
3	0.10 (0.08)	-0.12 (0.05)		0.02 (4.60E-3)	5	0.97	0.20	0.39	1.36
βj (SE)	0.10 (0.08)	**-0.14 (0.05)**	-0.14 (0.09)	**0.02 (4.30E-3)**					
95% CI	-0.06 , 0.27	**-0.24 , -0.04**	-0.32 , 0.04	**0.01 , 0.03**					
ω + (j)	0.24	**1.00**	0.40	**1.00**					
I%	3.60	**30.67**	2.46	**63.26**					

C. Biotic

Model No.	Gizzard shad β SE	Chironomids β SE	Secchi depth β SE	K	ΔAICc	ωi	Model Adj R^2	VIF
1			-0.39 (0.08)	3	0.00	0.48	0.32	1.00
2	0.00 (1.40E-3)		-0.44 (0.09)	4	1.18	0.27	0.32	1.37
βj (SE)	-1.47E-3 (1.40E-3)		**-0.41 (0.08)**					
95% CI	-2.69E-3, 1.65E-3		**-0.57 , -0.24**					
ω + (j)	0.36		**1.00**					
I%	6.60	7.80	**85.60**					

D. Combination

Model No.	Absolute deviation from median dissolved oxygen β SE	Distance to channel β SE	PC_RS β SE	K	ΔAICc	ωi	Model Adj R^2	VIF
1	-0.06 (0.04)	-0.14 (0.04)	0.08 (0.02)	5	0.00	0.42	0.44	1.22
2		-0.14 (0.04)	0.09 (0.02)	4	0.43	0.34	0.42	1.02
βj (SE)	-0.06 (0.04)	**-0.14 (0.04)**	**0.09 (0.02)**					
95% CI	-0.13 , 0.02	**-0.23 , -0.05**	**0.05 , 0.13**					
ω + (j)	0.51	**1.00**	**1.00**					
I%	19.27	**27.93**	**52.80**					

Table 4. Results of multiple regression and AIC_c model selection conducted with microhabitat, mesohabitat, biotic, and combinations of variables for (A) June, (B), July, (C) August, (D) September, and (E) October. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_TD represents scores of the first principle component in a principle components analysis between absolute deviation from median temperature (loading = -0.71) and absolute deviation from median dissolved oxygen (loading = -0.71). PC_DS represents scores of the first principle component in a principle components analysis between depth (loading = 0.71) and Secchi depth (loading 0.71). PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71). Diagnostics for explanatory variables include model averaged coefficients (βj), standard errors in parentheses (SE), variable importance (*w+j*), and percent total independent explained variance (I%). Ranges of model adjusted R^2 (Model Adj R^2) are also shown. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables. Drop-offs was excluded as an influential variable in June due to its low I% (9.42%) relative to other variables in the model.

	Variable	A. June βj (SE)	ω + (j)	I%	Model Adj R^2	B. July βj (SE)	ω + (j)	I%	Model Adj R^2	C. August βj (SE)	ω + (j)	I%	Model Adj R^2	D. September βj (SE)	ω + (j)	I%	Model Adj R^2	E. October βj (SE)	ω + (j)	I%	Model Adj R^2
Microhabitat	Absolute deviation from median temperature	-0.09 (0.03)	1.00	43.14						0.22 -0.15	0.46	5.83		0.07 (0.08)	0.14	3.06		0.10 (0.06)	0.63	25.18	
	Absolute deviation from median dissolved oxygen			13.17	0.14				0.19	**-0.13 (0.05)**	**1.00**	**41.75**	0.24	0.14 (0.10)	0.25	9.04	0.08	-0.09 (0.07)	0.14	5.06	0.09
	Depth	-0.01 (0.01)	0.11	13.12	-			16.03	-	-0.02 (0.01)	0.43	17.69	-	0.02 (0.01)	0.86	12.40	-	0.02 (0.01)	1.00	33.93	-
	Current velocity	2.41 (1.89)	0.37	12.99	0.18	3.05 (2.17)	0.47	15.48	0.21	3.87 (2.38)	0.41	7.00	0.30	5.06 (2.41)	0.73	20.46	0.14			7.30	0.11
	Slope	-0.35 (0.23)	0.46	17.58		-0.33 (0.28)	0.39	16.97		**-0.65 (0.32)**	**0.84**	**27.74**		-0.86 (0.32)	1.00	55.02		-0.62 (0.30)	0.67	28.52	
	PC_TD					**0.10 (0.03)**	**1.00**	**51.52**													
Mesohabitat	Drop-offs	0.23 (0.10)	0.86	9.42		0.22 (0.11)	0.71	6.38		0.12 (0.11)	0.25	4.44		0.14 (0.12)	0.21	8.12		-0.10 (0.09)	0.25	3.25	
	Distance to channel	0.04 (0.05)	0.15	1.80	0.26			2.71	0.28	**-0.17 (0.06)**	**1.00**	**22.13**		-0.15 (0.07)	1.00	49.31	0.08	**-0.23 (0.06)**	**1.00**	**79.50**	0.22
	Distance to shoreline	-0.17 (0.11)	0.46	11.47	-			2.28	-	-0.13 (0.12)	0.27	1.23	0.45	-0.09 (0.13)	0.14	1.85	-			3.77	-
	River kilometer	**0.02 (0.01)**	**1.00**	**77.31**	0.29	**0.03 (0.01)**	**1.00**	**88.63**	0.32	**0.03 (0.01)**	**1.00**	**72.16**		0.01 (0.01)	0.70	40.72	0.11	0.01 (0.01)	0.35	13.48	0.23
Biotic	Gizzard Shad							26.13		-0.06 (0.09)	0.19	0.39	0.46	0.05 (0.08)	0.52	46.05	0.03	-0.07 (0.06)	0.42	7.60	0.09
	Chironomids				0.17			2.54	0.24	0.02 (0.02)	0.31	4.48	-	-2.46E-3 (0.01)	0.13	2.89	-	-0.03 (0.02)	0.52	11.93	-
	Secchi depth	-0.53 (0.15)	1.00	100.00		**-0.36 (0.08)**	**1.00**	**71.33**		**-0.50 (0.07)**	**1.00**	**95.13**	0.47	-0.09 (0.10)	0.66	51.06	0.04	-0.34 (0.13)	1.00	80.47	0.12
Combination	Absolute deviation from median temperature	-0.06 (0.03)	0.77	33.06																	
	Absolute deviation from median dissolved oxygen									-0.03 (0.03)	0.29	14.89									
	Current velocity				0.25								0.51	3.19 (2.20)	0.48	14.75	0.08				0.22
	Slope				-				0.28			12.50	-	-0.50 (0.27)	0.65	35.77	-	-0.33 (0.23)	0.37	14.02	-
	Drop-offs	0.17 (0.09)	0.70	7.37	0.28								0.52				0.14				0.24
	Distance to channel									**-0.17 (0.06)**	**1.00**	**16.52**		-0.16 (0.07)	1.00	49.49		**-0.23 (0.06)**	**1.00**	**83.35**	
	River kilometer																				
	PC_TD					0.04 (0.03)	0.39	36.15													
	PC_DS																	-0.03 (0.03)	0.23	2.63	
	PC_RS	**0.09 (0.03)**	**1.00**	**59.57**		**-0.11 (0.03)**	**1.00**	**63.85**		**0.16 (0.03)**	**1.00**	**56.08**									

Table 5. Summary table showing variable importance values (*w+j*) for influential (A) microhabitat variables, (B) mesohabitat variables, (C) biotic variables, and (D) combinations of variables found across all time periods combined and in individual months. PC_TD represents scores of the first principle component in a principle components analysis between absolute deviation from median temperature (loading = -0.71) and absolute deviation from median dissolved oxygen (loading = -0.71). PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71). Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$.

Time Period	**A. Microhabitat Variables**						**B. Mesohabitat Variables**				**C. Biotic Variables**			**D. Combination**	
	Absolute deviation from median temperature	**Absolute deviation from median dissolved oxygen**	**Depth**	**Current velocity**	**Slope**	**PC_TD**	**Drop-offs**	**Distance to channel**	**Distance to shoreline**	**River kilometer**	**Gizzard shad**	**Chironomids**	**Secchi depth**	**Distance to channel**	**PC_RS**
All Time Periods		0.88			1.00			1.00		1.00			1.00	1.00	1.00
Summer															
June										1.00					1.00
July						1.00				1.00			1.00		1.00
August		1.00			0.84			1.00		1.00			1.00	1.00	1.00
Fall															
September															
October								1.00						1.00	

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Appendix A - Secchi Depth Relationships

I related Secchi depth to water quality parameters and productivity by regressing Secchi depth against parameters collected at 20 locations throughout Milford Reservoir, KS. I also related Secchi depth to Gizzard Shad abundance by regressing the average Secchi depth at each tracking site against the average number of Gizzard Shad at each tracking site. The data suggested low Secchi depths were related to increased inorganic matter, dissolved organic matter, primary productivity, and secondary productivity (measured through prey abundance).

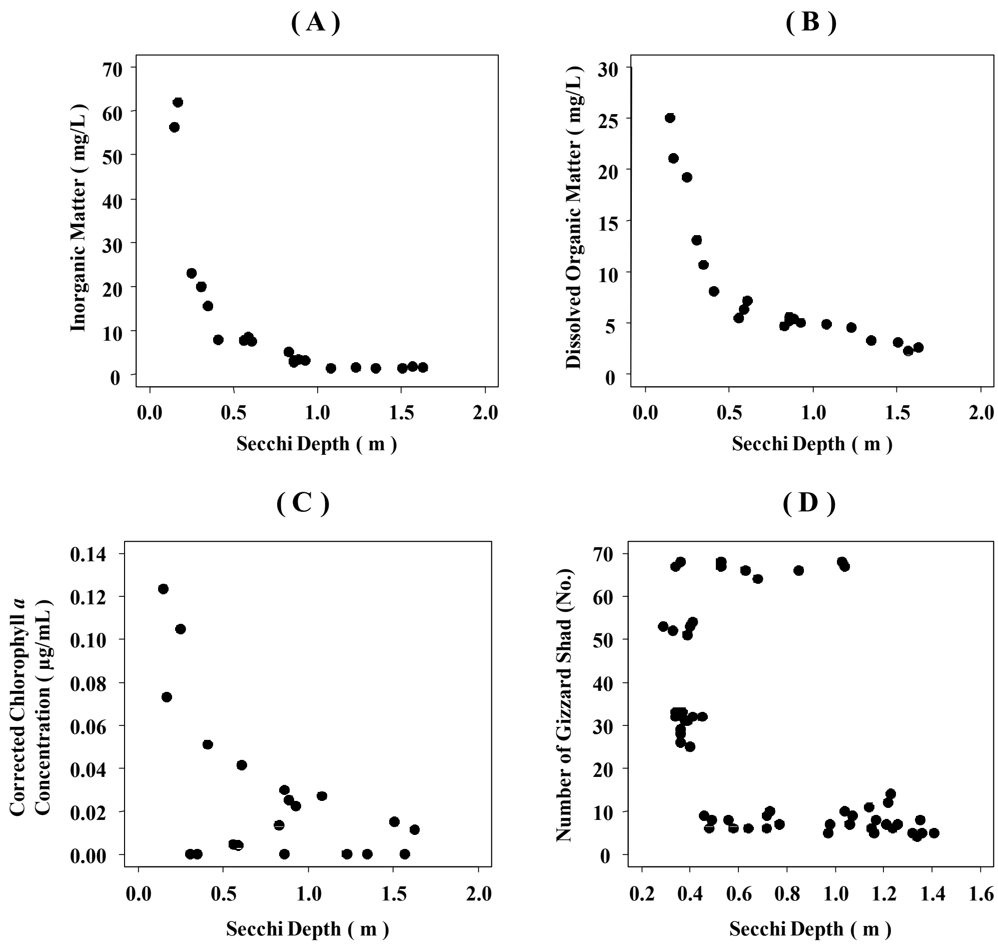


Figure 7. Scatterplots of relationships between Secchi depth and (A) inorganic matter (mg/L), (B) dissolved organic matter (mg/L), (C) corrected chlorophyll *a* concentration (µg/L), and (D) number of Gizzard Shad (No.). For inorganic matter, dissolved organic matter, and corrected cholorphyll *a* concentration, I measured Secchi depth and simultaneously collected water samples at 20 locations spaced across a latitudinal gradient in Milford Reservoir. For numbers of

Gizzard Shad, I regressed the average Secchi depth against the average number of Gizzard Shad recorded at each tracking site across all time periods combined (June - October). A negative relationship was found between Secchi depth and inorganic matter [r^2 = 0.48, β = -25.49, 95% CI = (-0.39 , -0.12), P = 6.99E-4], dissolved organic matter [r^2 = 0.64, β = -10.96, 95% CI = (-0.15 , -0.07) P = 2.37E-5], and corrected chlorophyll *a* concentration [r^2 = 0.32, β = -0.04, 95% CI = (-7.39E-4, -0.12E-4), P = 8.85E-3]. These data suggest low Secchi depths were related to both increased inorganic and dissolved organic matter, including elevated primary productivity. When average Secchi depth was regressed against the average number of Gizzard Shad, a negative relationship was found [r^2 = 0.27, β = -32.49, 95% CI = -46.92 , -18.06), P = 3.42E-5], suggesting low Secchi depth was also related to increased secondary productivity. Secchi depth was used as a proxy for productivity in this research.

Appendix B - Correlations Among All Regressors

This appendix includes tables of Pearson's correlation coefficients among all variables used in all analyses. To ensure no problematic multicollinearity occurred between variables in the same model, a violation of the assumptions of multiple regression, variance inflations factors (VIF) were calculated between all variables in each global model. In cases where problematic multiocollinearity occurred (i.e., VIF > 3), scores from a principle components analysis between the collinear variables were used in the regression process.

Table 6. Pearson's correlation coefficients among all variables used in the analysis of all time periods combined. Descriptions of explanatory variables are shown in Table 2. PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71).

	Absolute deviation from median temperature	Absolute deviation from median dissolved oxygen	Depth	Current Velocity	Slope	Drop-offs	Distance to channel	Distance to shoreline	River kilometer	Number of Gizzard Shad	Number of Chironomids	Secchi depth	PC_RS
Absolute deviation from median temperature	1.00	0.41	0.19	-0.26	0.04	0.05	0.26	-0.14	-0.41	-0.32	-0.15	0.35	-0.38
Absolute deviation from median dissolved oxygen	0.41	1.00	0.29	0.02	0.23	0.02	0.09	-0.01	-0.38	-0.30	-0.27	0.44	-0.41
Depth	0.19	0.29	1.00	-0.35	0.41	0.35	-0.33	0.10	-0.75	-0.40	-0.31	0.82	-0.79
Current Velocity	-0.26	0.02	-0.35	1.00	0.06	0.00	0.10	0.03	0.31	0.11	0.02	-0.29	0.30
Slope	0.04	0.23	0.41	0.06	1.00	0.74	0.15	-0.27	-0.70	-0.35	-0.28	0.61	-0.66
Drop-offs	0.05	0.02	0.35	0.00	0.74	1.00	-0.11	-0.36	-0.46	-0.13	-0.08	0.37	-0.42
Distance to channel	0.26	0.09	-0.33	0.10	0.15	-0.11	1.00	-0.35	-0.18	-0.09	-0.24	0.08	-0.13
Distance to shoreline	-0.14	-0.01	0.10	0.03	-0.27	-0.36	-0.35	1.00	0.12	0.04	-0.09	0.02	0.05
River kilometer	-0.41	-0.38	-0.75	0.31	-0.70	-0.46	-0.18	0.12	1.00	0.55	0.51	-0.95	0.99
Number of Gizzard Shad	-0.32	-0.30	-0.40	0.11	-0.35	-0.13	-0.09	0.04	0.55	1.00	0.31	-0.52	0.54
Number of Chironomids	-0.15	-0.27	-0.31	0.02	-0.28	-0.08	-0.24	-0.09	0.51	0.31	1.00	-0.49	0.50
Secchi depth	0.35	0.44	0.82	-0.29	0.61	0.37	0.08	0.02	-0.95	-0.52	-0.49	1.00	-0.99
PC_RS	-0.38	-0.41	-0.79	0.30	-0.66	-0.42	-0.13	0.05	0.99	0.54	0.50	-0.99	1.00

Table 7. Pearson's correlation coefficients among all variables used in June analyses. Descriptions of explanatory variables are shown in Table 2. PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71).

	Absolute deviation from median temperature	Absolute deviation from median dissolved oxygen	Depth	Current Velocity	Slope	Drop-offs	Distance to channel	Distance to shoreline	River kilometer	Secchi depth	PC_RS
Absolute deviation from median temperature	1.00	0.65	0.46	-0.13	0.12	0.03	-0.13	0.03	-0.37	0.34	-0.37
Absolute deviation from median dissolved oxygen	0.65	1.00	-0.01	0.02	-0.03	-0.07	-0.02	0.05	-0.04	0.00	-0.02
Depth	0.46	-0.01	1.00	-0.35	0.41	0.35	-0.33	0.10	-0.75	0.77	-0.80
Current Velocity	-0.13	0.02	-0.35	1.00	0.06	0.00	0.10	0.03	0.31	-0.43	0.38
Slope	0.12	-0.03	0.41	0.06	1.00	0.74	0.15	-0.27	-0.70	0.44	-0.60
Drop-offs	0.03	-0.07	0.35	0.00	0.74	1.00	-0.11	-0.36	-0.46	0.23	-0.36
Distance to channel	-0.13	-0.02	-0.33	0.10	0.15	-0.11	1.00	-0.35	-0.18	0.08	-0.13
Distance to shoreline	0.03	0.05	0.10	0.03	-0.27	-0.36	-0.35	1.00	0.12	0.07	0.03
River kilometer	-0.37	-0.04	-0.75	0.31	-0.70	-0.46	-0.18	0.12	1.00	-0.83	0.96
Secchi depth	0.34	0.00	0.77	-0.43	0.44	0.23	0.08	0.07	-0.83	1.00	-0.96
PC_RS	-0.37	-0.02	-0.80	0.38	-0.60	-0.36	-0.13	0.03	0.96	-0.96	1.00

Table 8. Pearson's correlation coefficients among all variables used in July analyses. Descriptions of explanatory variables are shown in Table 2. PC_TD represents scores of the first principle component in a principle components analysis between absolute deviation from median temperature (loading = -0.71) and absolute deviation from median dissolved oxygen (loading = -0.71). PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71).

	Absolute deviation from median temperature	Absolute deviation from median dissolved oxygen	Depth	Current Velocity	Slope	Drop-offs	Distance to channel	Distance to shoreline	River kilometer	Number of Gizzard Shad	Number of Chironomids	Secchi depth	PC_TD	PC_RS
Absolute deviation from median temperature	1.00	0.80	0.68	-0.17	0.41	0.33	-0.20	-0.01	-0.58	-0.45	-0.09	0.64	-0.95	0.64
Absolute deviation from median dissolved oxygen	0.80	1.00	0.52	-0.19	0.26	0.17	-0.03	0.08	-0.53	-0.40	-0.20	0.65	-0.95	0.61
Depth	0.68	0.52	1.00	-0.35	0.41	0.35	-0.33	0.10	-0.75	-0.62	-0.21	0.85	-0.63	0.83
Current Velocity	-0.17	-0.19	-0.35	1.00	0.06	0.00	0.10	0.03	0.31	0.29	0.12	-0.28	0.19	-0.30
Slope	0.41	0.26	0.41	0.06	1.00	0.74	0.15	-0.27	-0.70	-0.61	-0.21	0.47	-0.35	0.61
Drop-offs	0.33	0.17	0.35	0.00	0.74	1.00	-0.11	-0.36	-0.46	-0.35	-0.12	0.28	-0.27	0.38
Distance to channel	-0.20	-0.03	-0.33	0.10	0.15	-0.11	1.00	-0.35	-0.18	-0.23	-0.25	-0.04	0.12	0.07
Distance to shoreline	-0.01	0.08	0.10	0.03	-0.27	-0.36	-0.35	1.00	0.12	0.20	0.08	0.12	-0.04	0.00
River kilometer	-0.58	-0.53	-0.75	0.31	-0.70	-0.46	-0.18	0.12	1.00	0.87	0.41	-0.86	0.59	-0.97
Number of Gizzard Shad	-0.45	-0.40	-0.62	0.29	-0.61	-0.35	-0.23	0.20	0.87	1.00	0.42	-0.73	0.45	-0.82
Number of Chironomids	-0.09	-0.20	-0.21	0.12	-0.21	-0.12	-0.25	0.08	0.41	0.42	1.00	-0.31	0.15	-0.37
Secchi depth	0.64	0.65	0.85	-0.28	0.47	0.28	-0.04	0.12	-0.86	-0.73	-0.31	1.00	-0.68	0.97
PC_TD	-0.95	-0.95	-0.63	0.19	-0.35	-0.27	0.12	-0.04	0.59	0.45	0.15	-0.68	1.00	-0.66
PC_RS	0.64	0.61	0.83	-0.30	0.61	0.38	0.07	0.00	-0.97	-0.82	-0.37	0.97	-0.66	1.00

Table 9. Pearson's correlation coefficients among all variables used in August analyses. Descriptions of explanatory variables are shown in Table 2. PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71).

	Absolute deviation from median temperature	Absolute deviation from median dissolved oxygen	Depth	Current Velocity	Slope	Drop-offs	Distance to channel	Distance to shoreline	River kilometer	Number of Gizzard Shad	Number of Chironomids	Secchi depth	PC_RS
Absolute deviation from median temperature	1.00	0.62	0.07	-0.06	0.09	0.07	0.21	-0.20	-0.29	-0.18	-0.11	0.10	-0.20
Absolute deviation from median dissolved oxygen	0.62	1.00	0.31	0.00	0.36	0.20	0.27	-0.23	-0.51	-0.11	-0.13	0.45	-0.49
Depth	0.07	0.31	1.00	-0.35	0.41	0.35	-0.33	0.10	-0.75	-0.16	0.04	0.81	-0.79
Current Velocity	-0.06	0.00	-0.35	1.00	0.06	0.00	0.10	0.03	0.31	0.04	0.07	-0.30	0.31
Slope	0.09	0.36	0.41	0.06	1.00	0.74	0.15	-0.27	-0.70	-0.13	-0.11	0.59	-0.66
Drop-offs	0.07	0.20	0.35	0.00	0.74	1.00	-0.11	-0.36	-0.46	0.02	0.05	0.35	-0.41
Distance to channel	0.21	0.27	-0.33	0.10	0.15	-0.11	1.00	-0.35	-0.18	-0.03	-0.12	0.09	-0.13
Distance to shoreline	-0.20	-0.23	0.10	0.03	-0.27	-0.36	-0.35	1.00	0.12	-0.05	-0.09	0.00	0.06
River kilometer	-0.29	-0.51	-0.75	0.31	-0.70	-0.46	-0.18	0.12	1.00	0.19	0.16	-0.92	0.98
Number of Gizzard Shad	-0.18	-0.11	-0.16	0.04	-0.13	0.02	-0.03	-0.05	0.19	1.00	-0.12	-0.13	0.16
Number of Chironomids	-0.11	-0.13	0.04	0.07	-0.11	0.05	-0.12	-0.09	0.16	-0.12	1.00	-0.10	0.13
Secchi depth	0.10	0.45	0.81	-0.30	0.59	0.35	0.09	0.00	-0.92	-0.13	-0.10	1.00	-0.98
PC_RS	-0.20	-0.49	-0.79	0.31	-0.66	-0.41	-0.13	0.06	0.98	0.16	0.13	-0.98	1.00

Table 10. Pearson's correlation coefficients among all variables used in September analyses. Descriptions of explanatory variables are shown in Table 2.

	Absolute deviation from median temperature	Absolute deviation from median dissolved oxygen	Depth	Current Velocity	Slope	Drop-offs	Distance to channel	Distance to shoreline	River kilometer	Number of Gizzard Shad	Number of Chironomids	Secchi depth
Absolute deviation from median temperature	1.00	0.14	0.30	-0.21	0.22	0.23	-0.06	-0.29	-0.23	-0.38	-0.09	0.08
Absolute deviation from median dissolved oxygen	0.14	1.00	0.23	-0.12	0.23	0.13	0.18	-0.22	-0.29	-0.38	-0.16	0.23
Depth	0.30	0.23	1.00	-0.35	0.41	0.35	-0.33	0.10	-0.75	-0.45	-0.16	0.78
Current Velocity	-0.21	-0.12	-0.35	1.00	0.06	0.00	0.10	0.03	0.31	0.24	-0.23	-0.24
Slope	0.22	0.23	0.41	0.06	1.00	0.74	0.15	-0.27	-0.70	-0.47	0.01	0.62
Drop-offs	0.23	0.13	0.35	0.00	0.74	1.00	-0.11	-0.36	-0.46	-0.20	0.05	0.40
Distance to channel	-0.06	0.18	-0.33	0.10	0.15	-0.11	1.00	-0.35	-0.18	-0.29	-0.12	0.06
Distance to shoreline	-0.29	-0.22	0.10	0.03	-0.27	-0.36	-0.35	1.00	0.12	0.27	-0.13	0.03
River kilometer	-0.23	-0.29	-0.75	0.31	-0.70	-0.46	-0.18	0.12	1.00	0.66	0.15	-0.92
Number of Gizzard Shad	-0.38	-0.38	-0.45	0.24	-0.47	-0.20	-0.29	0.27	0.66	1.00	-0.05	-0.57
Number of Chironomids	-0.09	-0.16	-0.16	-0.23	0.01	0.05	-0.12	-0.13	0.15	-0.05	1.00	-0.20
Secchi depth	0.08	0.23	0.78	-0.24	0.62	0.40	0.06	0.03	-0.92	-0.57	-0.20	1.00

Table 11. Pearson's correlation coefficients among all variables used in October analyses. Descriptions of explanatory variables are shown in Table 2. PC_DS represents scores of the first principle component in a principle components analysis between depth (loading = 0.71) and Secchi depth (loading = 0.71).

	Absolute deviation from median temperature	Absolute deviation from median dissolved oxygen	Depth	Current Velocity	Slope	Drop-offs	Distance to channel	Distance to shoreline	River kilometer	Number of Gizzard Shad	Number of Chironomids	Secchi depth	PC_DS
Absolute deviation from median temperature	1.00	-0.29	-0.44	0.23	-0.53	-0.43	-0.21	0.31	0.64	0.62	0.05	-0.53	-0.54
Absolute deviation from median dissolved oxygen	-0.29	1.00	0.59	-0.13	0.55	0.31	0.05	-0.03	-0.74	-0.26	-0.33	0.69	0.71
Depth	-0.44	0.59	1.00	-0.35	0.41	0.35	-0.33	0.10	-0.75	-0.61	-0.31	0.62	0.90
Current Velocity	0.23	-0.13	-0.35	1.00	0.06	0.00	0.10	0.03	0.31	0.30	-0.02	-0.18	-0.30
Slope	-0.53	0.55	0.41	0.06	1.00	0.74	0.15	-0.27	-0.70	-0.29	-0.26	0.72	0.63
Drop-offs	-0.43	0.31	0.35	0.00	0.74	1.00	-0.11	-0.36	-0.46	-0.26	-0.05	0.45	0.44
Distance to channel	-0.21	0.05	-0.33	0.10	0.15	-0.11	1.00	-0.35	-0.18	0.20	-0.17	0.23	-0.05
Distance to shoreline	0.31	-0.03	0.10	0.03	-0.27	-0.36	-0.35	1.00	0.12	0.10	-0.11	-0.16	-0.03
River kilometer	0.64	-0.74	-0.75	0.31	-0.70	-0.46	-0.18	0.12	1.00	0.53	0.39	-0.91	-0.92
Number of Gizzard Shad	0.62	-0.26	-0.61	0.30	-0.29	-0.26	0.20	0.10	0.53	1.00	0.21	-0.45	-0.59
Number of Chironomids	0.05	-0.33	-0.31	-0.02	-0.26	-0.05	-0.17	-0.11	0.39	0.21	1.00	-0.40	-0.40
Secchi depth	-0.53	0.69	0.62	-0.18	0.72	0.45	0.23	-0.16	-0.91	-0.45	-0.40	1.00	0.90
PC_DS	-0.54	0.71	0.90	-0.30	0.63	0.44	-0.05	-0.03	-0.92	-0.59	-0.40	0.90	1.00

Appendix C - Monthly Model Selection Tables

This appendix includes all monthly model selection tables to show specific results of the AIC_c model selection process. Original model selection tables for all time periods combined are included in Table 3. Monthly model selection results are summarized in Table 4. A cutoff of ΔAIC_c of 2 was used for all analyses.

Table 12. Results of multiple regression and AIC_c selection for microhabitat variables in June. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2 (Model Adj R^2), and variance inflation factors (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No microhabitat variables were considered influential correlates of Blue Catfish distribution in June as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables					**Evaluation Criteria**				
Model No.	**Absolute deviation from median temperature** β SE	**Absolute deviation from median dissolved oxygen** β SE	**Depth** β SE	**Current Velocity** β SE	**Slope** β SE	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1	-0.09 (0.03)				-0.34 (0.23)	4	0.00	0.15	0.16	1.01
2	-0.10 (0.03)					3	0.01	0.15	0.15	NA
3	-0.09 (0.03)			2.51 (1.88)	-0.37 (0.23)	5	0.51	0.11	0.18	1.03
4	-0.09 (0.03)			2.29 (1.90)		4	0.81	0.10	0.15	1.02
5	-0.08 (0.03)		-0.01 (0.01)			4	1.62	0.06	0.14	1.28
βj (SE)	-0.09 (0.03)		-0.01 (0.01)	2.41 (1.89)	-0.35 (0.23)					
95% CI	-0.15 , -0.03		-0.03 , 0.01	-1.38 , 6.20	-0.81 , 0.11					
ω + (j)	1.00		0.11	0.37	0.46					
I%	43.14	13.17	13.12	12.99	17.58					

Table 13. Results of multiple regression and AIC_c selection for mesohabitat variables in June. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2 (Model Adj R^2), and variance inflation factors (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables								**Evaluation Criteria**				
Model No.	**Drop-offs**		**Distance to Channel**		**Distance to Shoreline**		**River Kilometer**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**					
1	0.25	(0.10)					0.03	(0.01)	4	0.00	0.32	0.28	1.27
2	0.20	(0.10)			-0.14	(0.10)	0.02	(0.01)	5	0.37	0.27	0.29	1.45
3	0.26	(0.10)	0.04	(0.05)			0.03	(0.01)	5	1.85	0.13	0.27	1.36
4					-0.22	(0.10)	0.02	(4.70E-3)	4	1.98	0.12	0.26	1.02
βj (SE)	0.23	(0.10)	0.04	(0.05)	-0.17	(0.11)	**0.02**	**(0.01)**					
95% CI	0.03 , 0.43		-0.07 , 0.15		-0.38 , 0.05		**0.01 , 0.04**						
ω + (j)	0.86		0.15		0.46		**1.00**						
I%	9.42		1.80		11.47		**77.31**						

Table 14. Results of multiple regression and AIC_c selection for biotic variables in June. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2 (Model Adj R^2), and variance inflation factors (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No biotic variables were considered influential correlates of Blue Catfish distribution in June as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables						**Evaluation Criteria**				
Model No.	**Gizzard shad**		**Chironomids**		**Secchi depth**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**					
1					-0.53	(0.15)	3	0.00	0.99	0.17	NA
βj (SE)					-0.53	(0.15)					
95% CI					-0.83 , -0.23						
ω + (j)					1.00						
I%					100.00						

Table 15. Results of multiple regression and AIC_c selection for a combination of variables in June. All microhabitat, mesohabitat, and biotic variables with 95% confidence intervals that did not overlap zero were included in this hypothesis. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_RS represents scores of the first principle component of a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71). Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance ($w+j$), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, $w+j$ and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, $w+j$, and I% are bolded for influential variables.

	Explanatory Variables						Evaluation Criteria				
Model No.	**Absolute deviation from median temperature β**	**SE**	**Drop-offs β**	**SE**	**PC_RS β**	**SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1	-0.06	(0.03)	0.16	(0.09)	0.09	(0.03)	5	0.00	0.42	0.28	1.35
2	-0.06	(0.03)			0.07	(0.02)	4	0.92	0.27	0.25	1.16
3			0.18	(0.09)	0.11	(0.02)	4	1.42	0.21	0.25	1.15
βj (SE)	-0.06	(0.03)	0.17	(0.09)	**0.09**	**(0.03)**					
95% CI	-0.12 , 6.79E-4		-0.01 , 0.35		**0.03 , 0.15**						
ω + (j)	0.77		0.70		**1.00**						
I%	33.06		7.37		**59.57**						

Table 16. Results of multiple regression and AIC_c selection for microhabitat variables in July. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_TD represents scores of the first principle component in a principle components analysis between absolute deviation from median temperature (loading = -0.71) and absolute deviation from median dissolved oxygen (loading = -0.71). Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables				Evaluation Criteria				
Model No.	**Depth**	**Current Velocity**	**Slope**	**PC_TD**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β SE	**β SE**	**β SE**	**β SE**					
1				0.10 (0.03)	3	0.00	0.24	0.19	NA
2		2.89 (2.16)		0.10 (0.03)	4	0.46	0.19	0.20	1.04
3			-0.30 (0.28)	0.09 (0.03)	4	1.09	0.14	0.19	1.14
4		3.27 (2.17)	-0.36 (0.28)	0.08 (0.03)	5	1.10	0.14	0.21	1.21
βj (SE)		3.05 (2.17)	-0.33 (0.28)	**0.10 (0.03)**					
95% CI		-1.30 , 7.41	-0.89 , 0.23	**0.04 , 0.15**					
ω + (j)		0.47	0.39	**1.00**					
I%	16.03	15.48	16.97	**51.52**					

Table 17. Results of multiple regression and AIC_c selection for mesohabitat variables in July. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables								Evaluation Criteria				
Model No.	**Drop-offs**		**Distance to Channel**		**Distance to Shoreline**		**River Kilometer**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**					
1	0.22	(0.11)					0.03	(0.01)	4	0.00	0.38	0.32	1.27
2							0.03	(0.01)	3	1.77	0.16	0.28	1.00
βj (SE)	0.22	(0.11)					**0.03**	**(0.01)**					
95% CI	-1.49E-4 , 0.43						**0.02 , 0.04**						
ω + (j)	0.71						**1.00**						
I%	6.38		2.71		2.28		**88.63**						

Table 18. Results of multiple regression and AIC_c selection for biotic variables in July. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables			Evaluation Criteria				
Model No.	**Gizzard shad β SE**	**Chironomids β SE**	**Secchi depth β SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1			-0.36 (0.08)	3	0.00	0.57	0.24	NA
βj (SE)			**-0.36 (0.08)**					
95% CI			**-0.53 , -0.19**					
ω + (j)			**1.00**					
I%	26.13	2.54	**71.33**					

Table 19. Results of multiple regression and AIC_c selection for a combination of variables in July. All microhabitat, mesohabitat, and biotic variables with 95% confidence intervals that did not overlap zero were included in this hypothesis. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_TD represents scores of the first principle component in a principle components analysis between absolute deviation from median temperature (loading = -0.71) and absolute deviation from median dissolved oxygen (loading = -0.71). PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71). Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance ($w+j$), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, $w+j$ and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, $w+j$, and I% are bolded for influential variables.

	Explanatory Variables		**Evaluation Criteria**				
Model No.	**PC_TD** β SE	**PC_RS** β SE	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1	0.04 (0.03)	-0.10 (0.03)	3	0.00	0.60	0.28	NA
2		-0.12 (0.03)	4	0.92	0.38	0.28	1.76
βj (SE)	0.04 (0.03)	**-0.11 (0.03)**					
95% CI	-0.03 , 0.11	**-0.17 , -0.04**					
ω + (j)	0.39	**1.00**					
I%	36.15	**63.85**					

Table 20. Results of multiple regression and AIC_c selection for microhabitats variables in August. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj R^2 > 0.20. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables										**Evaluation Criteria**				
Model No.	**Absolute deviation from median temperature**		**Absolute deviation from median dissolved oxygen**		**Depth**		**Current Velocity**		**Slope**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**					
1	0.23	(0.15)	-0.15	(0.05)			4.16	(2.29)	-0.66	(0.30)	6	0.00	0.13	0.30	1.93
2			-0.11	(0.04)			3.93	(2.32)	-0.75	(0.30)	5	0.22	0.12	0.28	1.16
3			-0.11	(0.04)					-0.72	(0.31)	4	0.83	0.09	0.25	1.15
4			-0.10	(0.04)	-0.02	(0.01)			-0.56	(0.32)	5	0.89	0.09	0.27	1.30
5	0.22	(0.15)	-0.15	(0.05)					-0.64	(0.31)	5	1.01	0.08	0.27	1.93
6	0.20	(0.15)	-0.14	(0.05)	-0.02	(0.01)			-0.50	(0.32)	6	1.50	0.06	0.28	2.02
7	0.23	(0.15)	-0.16	(0.05)	-0.02	(0.01)					5	1.56	0.06	0.26	1.83
8			-0.11	(0.04)	-0.02	(0.01)					4	1.68	0.06	0.24	1.10
9			-0.10	(0.04)	-0.01	(0.01)	3.00	(2.56)	-0.64	(0.33)	6	1.90	0.05	0.27	1.50
βj (SE)	0.22	(0.15)	**-0.13**	**(0.05)**	-0.02	(0.01)	3.87	(2.38)	**-0.65**	**(0.32)**					
95% CI	-0.08 , 0.52		**-0.23 , -0.03**		-0.04 , 0.01		-0.90 , 8.65		**-1.30 , -0.01**						
ω + (j)	0.46		**1.00**		0.43		0.41		**0.84**						
I%	5.83		**41.75**		17.69		7.00		**27.74**						

Table 21. Results of multiple regression and AIC_c selection for mesohabitat variables in August. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables								**Evaluation Criteria**				
Model No.	**Drop-offs**		**Distance to Channel**		**Distance to Shoreline**		**River Kilometer**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**					
1			-0.16	(0.06)			0.03	(0.01)	4	0.00	0.40	0.45	1.03
2			-0.19	(0.07)	-0.13	(0.12)	0.03	(0.01)	5	1.16	0.22	0.45	1.16
3	0.12	(0.11)	-0.15	(0.06)			0.03	(0.01)	5	1.30	0.21	0.45	1.36
βj (SE)	0.12	(0.11)	**-0.17**	**(0.06)**	-0.13	(0.12)	**0.03**	**(0.01)**					
95% CI	-0.11 , 0.34		**-0.30 , -0.04**		-0.38 , 0.11		**0.02 , 0.04**						
ω + (j)	0.25		**1.00**		0.27		**1.00**						
I%	4.44		**22.13**		1.23		**72.16**						

Table 22. Results of multiple regression and AIC_c selection for biotic variables in August. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables						**Evaluation Criteria**				
Model No.	**Gizzard shad β**	**SE**	**Chironomids β**	**SE**	**Secchi depth β**	**SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1					-0.50	(0.07)	3	0.00	0.45	0.47	NA
2			0.02	(0.02)	-0.50	(0.07)	4	0.91	0.28	0.47	1.01
3	-0.06	(0.09)			-0.51	(0.07)	4	1.94	0.17	0.46	1.02
βj (SE)	-0.06	(0.09)	0.02	(0.02)	**-0.50**	**(0.07)**					
95% CI	-0.24 , 0.13		-0.02 , 0.06		**-0.65 , -0.36**						
ω + (j)	0.19		0.31		**1.00**						
I%	0.39		4.48		**95.13**						

Table 23. Results of multiple regression and AIC_c selection for a combination of variables in August. All microhabitat, mesohabitat, and biotic variables with 95% confidence intervals that did not overlap zero were included in this hypothesis. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_RS represents scores of the first principle component in a principle components analysis between river kilometer (loading = 0.71) and Secchi depth (loading = -0.71). Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables								Evaluation Criteria				
Model No.	**Absolute deviation from median dissolved oxygen β**	**SE**	**Slope β**	**SE**	**Distance to Channel β**	**SE**	**PC_RS β**	**SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1					-0.17	(0.06)	0.16	(0.02)	4	0.00	0.50	0.52	1.02
2	-0.03	(0.03)			-0.16	(0.06)	0.15	(0.03)	5	1.75	0.21	0.51	1.39
βj (SE)	-0.03	(0.03)			**-0.17**	**(0.06)**	**0.16**	**(0.03)**					
95% CI	-0.10 , 0.04				**-0.29 , -0.06**		**0.11 , 0.21**						
ω + (j)	0.29				**1.00**		**1.00**						
I%	14.89		12.50		**16.52**		**56.08**						

Table 24. Results of multiple regression and AIC_c selection for microhabitat variables in September. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was log_{10} transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No microhabitat variables were considered influential correlates of Blue Catfish distribution in September as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables										**Evaluation Criteria**				
Model No.	**Absolute deviation from median temperature**		**Absolute deviation from median dissolved oxygen**		**Depth**		**Current Velocity**		**Slope**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**					
1					0.02	(0.01)	4.91	(2.40)	-0.90	(0.30)	5	0.00	0.17	0.13	1.45
2			0.14	(0.10)	0.02	(0.01)	5.18	(2.39)	-0.97	(0.30)	6	0.54	0.13	0.14	1.46
3									-0.58	(0.28)	3	1.68	0.07	0.06	NA
4	0.07	(0.08)			0.02	(0.01)	5.21	(2.43)	-0.94	(0.30)	6	1.72	0.07	0.12	1.48
5					0.02	(0.01)			-0.76	(0.30)	4	1.92	0.06	0.08	1.20
βj (SE)	0.07	(0.08)	0.14	(0.10)	0.02	(0.01)	5.06	(2.41)	-0.86	(0.32)					
95% CI	-0.09 , 0.22		-0.07 , 0.33		-1.01E-3 , 0.05		0.23 , 9.90		-1.50 , -0.21						
ω + (j)	0.14		0.25		0.86		0.73		1.00						
I%	3.06		9.04		12.40		20.46		55.02						

Table 25. Results of multiple regression and AIC_c selection for mesohabitat variables in September. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was log_{10} transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No mesohabitat variables were considered influential correlates of Blue Catfish distribution in September as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables								Evaluation Criteria				
Model No.	**Drop-offs β**	**SE**	**Distance to Channel β**	**SE**	**Distance to Shoreline β**	**SE**	**River Kilometer β**	**SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R²**	**VIF**
1			-0.14	(0.07)			0.01	(0.01)	4	0.00	0.21	0.11	1.03
2			-0.16	(0.07)					3	0.38	0.18	0.08	NA
3	0.14	(0.12)	-0.13	(0.07)			0.01	(0.01)	5	1.11	0.12	0.11	1.36
4			-0.16	(0.07)	-0.09	(0.13)	0.01	(0.01)	5	1.93	0.08	0.10	1.16
βj (SE)	0.14	(0.12)	-0.15	(0.07)	-0.09	(0.13)	0.01	(0.01)					
95% CI	-0.11 , 0.38		-0.29 , -0.01		-0.36 , 0.17		-2.11E-3 , 0.02						
ω + (j)	0.21		1.00		0.14		0.70						
I%	8.12		49.31		1.85		40.72						

Table 26. Results of multiple regression and AIC_c selection for biotic variables in September. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No biotic variables were considered influential correlates of Blue Catfish distribution in September as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables						**Evaluation Criteria**				
Model No.	**Gizzard shad**		**Chironomids**		**Secchi depth**		**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β	**SE**	**β**	**SE**	**β**	**SE**					
1					-0.16	(0.08)	3	0.00	0.25	0.04	NA
2	0.12	(0.07)					3	0.06	0.24	0.04	NA
3	0.08	(0.08)			-0.10	(0.10)	4	1.38	0.12	0.04	1.48
4			-0.02	(0.03)	-0.17	(0.09)	4	1.96	0.09	0.03	1.04
βj (SE)	0.11	(0.07)	-0.02	(0.03)	-0.14	(0.09)					
95% CI	-0.04 , 0.25		-0.08 , 0.05		-0.33 , 0.04						
ω + (j)	0.52		0.13		0.66						
I%	46.05		2.89		51.06						

Table 27. Results of multiple regression and AIC_c selection for a combination of variables in September. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was log_{10} transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No variables in the combination were considered influential correlates of Blue Catfish distribution in September as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables			**Evaluation Criteria**				
Model No.	**Current Velocity β SE**	**Slope β SE**	**Distance to Channel β SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1		-0.50 (0.27)	-0.15 (0.07)	4	0.00	0.28	0.12	1.02
2	3.25 (2.18)	-0.51 (0.27)	-0.15 (0.07)	5	0.06	0.27	0.14	1.03
3			-0.16 (0.07)	3	1.15	0.16	0.08	NA
4	3.08 (2.23)		-0.17 (0.07)	4	1.49	0.13	0.10	1.02
βj (SE)	3.19 (2.20)	-0.50 (0.27)	-0.16 (0.07)					
95% CI	-1.22 , 7.60	-1.04 , 0.03	-0.29 , -0.02					
ω + (j)	0.48	0.65	1.00					
I%	14.75	35.77	49.49					

Table 28. Results of multiple regression and AIC_c selection for microhabitat variables in October. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No microhabitat variables were considered influential correlates of Blue Catfish distribution in October as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables					**Evaluation Criteria**				
Model No.	**Absolute deviation from median temperature**	**Absolute deviation from median dissolved oxygen**	**Depth**	**Current Velocity**	**Slope**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
	β SE	**β SE**	**β SE**	**β SE**	**β SE**					
1			0.02 (0.01)		-0.70 (0.27)	4	0.00	0.15	0.10	1.20
2	0.08 (0.06)		0.02 (0.01)		-0.53 (0.30)	5	0.47	0.12	0.11	1.51
3	0.12 (0.05)		0.02 (0.01)			4	1.37	0.08	0.07	1.24
4	0.12 (0.05)	-0.09 (0.07)	0.03 (0.01)			5	1.95	0.06	0.09	1.75
βj (SE)	0.10 (0.06)	-0.09 (0.07)	0.02 (0.01)		-0.62 (0.30)					
95% CI	-0.02 , 0.22	-0.24 , 0.05	1.32E-3 , 0.04		-1.21 , -0.03					
ω + (j)	0.63	0.14	1.00		0.67					
I%	25.18	5.06	33.93	7.30	28.52					

Table 29. Results of multiple regression and AIC_c selection for mesohabitat variables in October. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables				Evaluation Criteria				
Model No.	**Drop-offs β SE**	**Distance to Channel β SE**	**Distance to Shoreline β SE**	**River Kilometer β SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1		-0.23 (0.06)			3	0.00	0.26	0.22	NA
2		-0.22 (0.06)		0.01 (0.01)	4	0.27	0.22	0.23	1.03
3	-0.10 (0.09)	-0.24 (0.06)			4	1.00	0.16	0.22	1.01
βj (SE)	-0.10 (0.09)	**-0.23 (0.06)**		0.01 (0.01)					
95% CI	-0.29 , 0.08	**-0.34 , -0.11**		-3.02E-3 , 0.02					
ω + (j)	0.25	**1.00**		0.35					
I%	3.25	**79.50**	3.77	13.48					

Table 30. Results of multiple regression and AIC_c selection for biotic variables in October. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (w+j), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, w+j and I% were large relative to other variables in the set of models, and Model Adj $R^2 > 0.20$. No biotic variables were considered influential correlates of Blue Catfish distribution in October as all models were weak (Model Adj $R^2 < 0.20$).

	Explanatory Variables						Evaluation Criteria				
Model No.	Gizzard shad		Chironomids		Secchi depth		K	ΔAICc	ωi	Model Adj R^2	VIF
	β	SE	β	SE	β	SE					
1			-0.03	(0.02)	-0.35	(0.12)	4	0.00	0.29	0.11	1.19
2					-0.27	(0.11)	3	0.28	0.25	0.09	NA
3	-0.07	(0.06)	-0.03	(0.02)	-0.41	(0.13)	5	0.70	0.20	0.12	1.43
4	-0.07	(0.06)			-0.35	(0.12)	4	0.80	0.19	0.10	1.26
βj (SE)	-0.07	(0.06)	-0.03	(0.02)	-0.34	(0.13)					
95% CI	-0.18 , 0.04		-0.07 , 0.01		-0.59 , -0.09						
ω + (j)	0.42		0.52		1.00						
I%	7.60		11.93		80.47						

Table 31. Results of multiple regression and AIC_c selection for a combination of variables in October. All microhabitat, mesohabitat, and biotic variables with 95% confidence intervals that did not overlap zero were included in this hypothesis. The response variable was the average number of Blue Catfish (No.). The number of Blue Catfish was $\log_{10}$ transformed. Detailed explanations of explanatory variables are provided in Table 2. PC_TD represents scores of the first principle component in a principle components analysis between depth (loading = 0.71) and Secchi depth (loading = 0.71). Coefficients (β) and standard errors (SE) are shown for each explanatory variable. Model evaluation criteria include number of parameters (K), ΔAIC_c, Akaike weights (ω_i), model adjusted R^2, and variance inflation factor (VIF). Also shown are the model averaged coefficients (βj), standard errors in parentheses (SE), 95% confidence intervals (95% CI), variable importance (*w+j*), and percent total independent explained variance (I%) for each variable. Variables were considered influential correlates of Blue Catfish distribution when 95% CI did not overlap zero, *w+j* and I% were large relative to other variables in the set of models, and Model Adj R^2 > 0.20. βj, SE, *w+j*, and I% are bolded for influential variables.

	Explanatory Variables			Evaluation Criteria				
Model No.	**Slope β SE**	**Distance to Channel β SE**	**PC_DS β SE**	**K**	**ΔAICc**	**ωi**	**Model Adj R^2**	**VIF**
1		-0.23 (0.06)		3	0.00	0.36	0.22	NA
2	-0.33 (0.23)	-0.22 (0.06)		4	0.13	0.33	0.24	1.02
3		-0.24 (0.06)	-0.03 (0.03)	4	1.10	0.21	0.22	1.00
βj (SE)	-0.33 (0.23)	**-0.23 (0.06)**	-0.03 (0.03)					
95% CI	-0.80 , 0.13	**-0.34 , -0.11**	-0.08 , 0.02					
ω + (j)	0.37	**1.00**	0.23					
I%	14.02	**83.35**	2.63					

Appendix D - Temperature Relationships

This appendix includes information about relationships between Blue Catfish distribution and temperature. Although relationships with temperature were not influential in most time periods, Blue Catfish were often detected near intermediate values of available temperatures across all time periods combined and in summer months, when longitudinal gradients of temperature occurred throughout the reservoir. Blue Catfish have been found in greater numbers near intermediate temperatures in previous research (Fischer et al. 1999, Grist 2002) and may be of potential interest for future research efforts.

Across all time periods combined, tagged Blue Catfish were often found in higher numbers near intermediate temperatures (22.5 - 23.0 °C) while fewer fish were found in low temperatures (< 22.5 °C) and almost no fish were detected in the highest temperatures (> 23.0 °C). Across all time periods combined, intermediate temperatures (22.5 - 23.0 °C) were largely found in the upper reservoir (Figure 8A, green sites). The lowest temperatures (< 22.5 °C) were found in discrete locations of the middle and lower reservoir, while the highest temperatures (> 23.0 °C) were found along shorelines of the upper and lower reservoir, and in tributaries (Figure 8A).

In June and July, when longitudinal gradients of temperature occurred, fish were most often found in intermediate temperatures of 25 - 28 °C and largely avoided temperatures below 25 °C or above 28 °C. During these months, intermediate temperatures (25 - 28 °C) were largely found in the upper reservoir, the lowest temperatures (< 25 °C) were found throughout the middle and lower reservoir, and the highest temperatures (> 28 °C) were found along an upper shoreline and middle tributary (Figure 8B,C).

Literature Cited

Fischer, S. A., S. Eder, and E. D. Aragon. 1999. Movements and habitat use of channel catfish and Blue Catfish in a small impoundment in Missouri. Pages 239-255 *in* Irwin, E. R., W. A. Hubert, C. F. Rabeni, H. L. Schramm, and T. Coon, editors. Catfish 2000: proceedings of the international ictalurid symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Grist, J. D. 2002. Analysis of a Blue Catfish population in a southeastern reservoir: Lake Norman, North Carolina. Master's thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Temperature

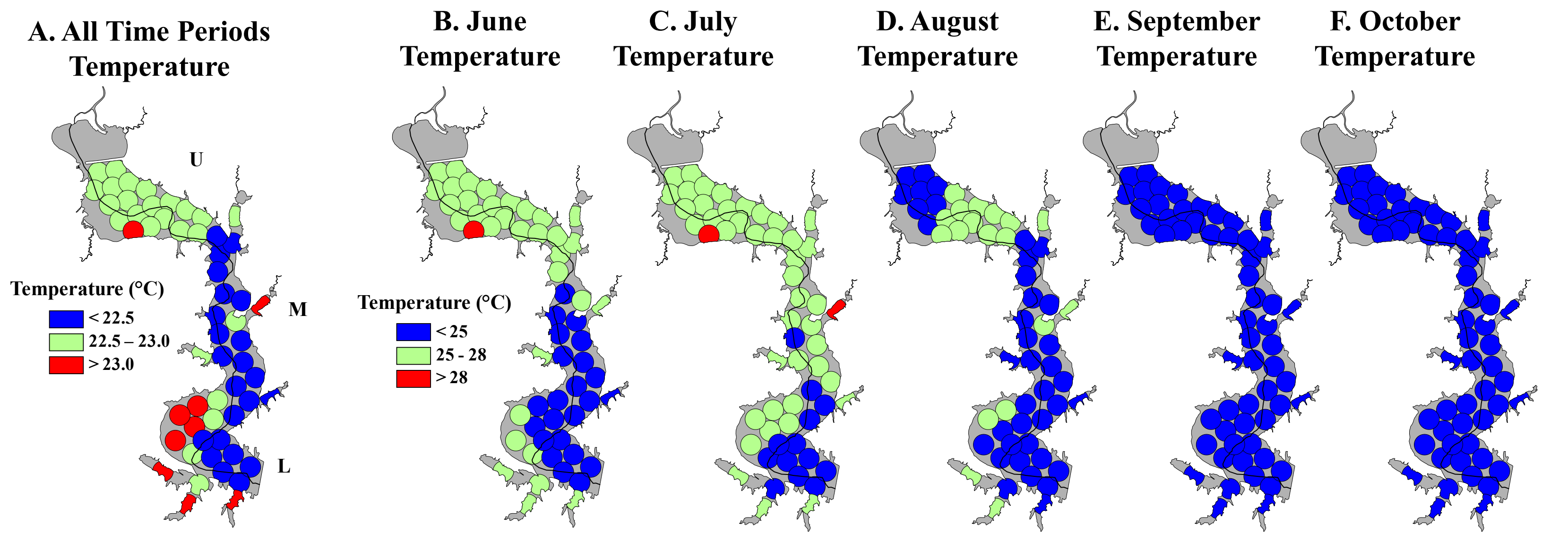


Figure 8. Maps showing the spatial distribution of temperature (°C) in (A) all time periods combined, (B) June, (C) July, (D) August, (E) September, and (F) October, 2013 in Milford Reservoir, KS. Different legends are shown for all time periods combined and monthly maps. Greater numbers of fish were detected in intermediate temperature across all time periods combined and in June and July, when longitudinal gradients of temperature occurred across Milford Reservoir.

Appendix E - Supplementary Maps

This appendix includes supplementary maps not included in the main figures or previous appendices. Maps are included to show the spatial distribution of absolute deviation from median temperature, absolute deviation from median dissolved oxygen, number of Gizzard Shad, number of chironomid larvae, and Secchi depth.

Absolute Deviation from Median Temperature

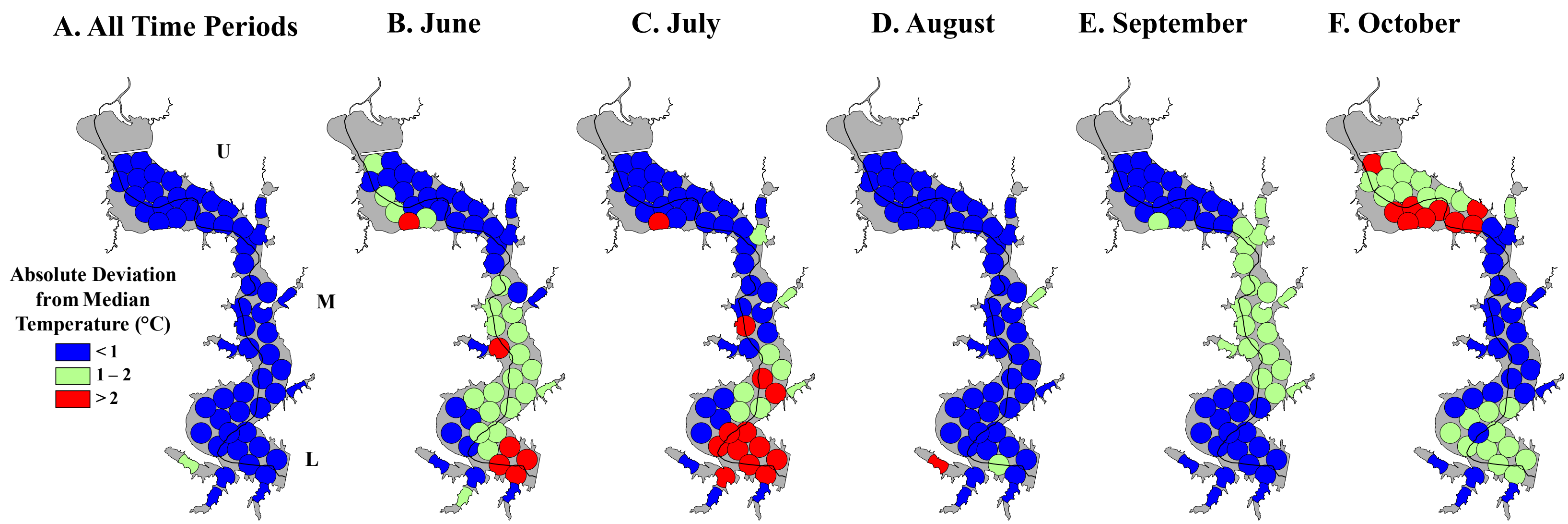


Figure 9. Maps showing the spatial distribution of absolute deviation from median temperature (°C) in (A) all time periods combined (median = 22.6 °C), (B) June (median = 25.7 °C), (C) July (median = 26.8 °C), (C) August (median = 24.9 °C), (D) September (median = 23.2 °C), and (E) October (median = 14.1 °C), 2013 in Milford Reservoir, KS.

Absolute Deviation from Median Dissolved Oxygen

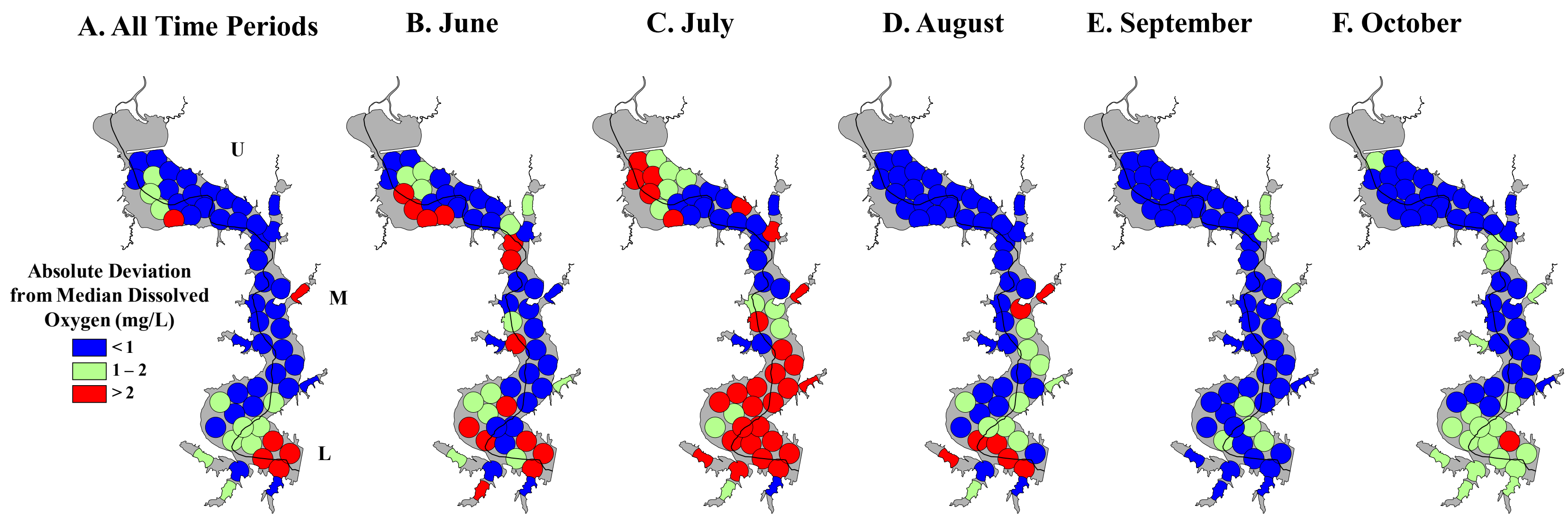


Figure 10. Maps showing the spatial distribution of absolute deviation from median dissolved oxygen concentration (mg/L) in (A) all time periods combined (median = 6.6 mg/L), (B) June (median = 6.5 mg/L), (C) July (median = 4.8 mg/L), (C) August (median = 5.4 mg/L), (D) September (median = 7.0 mg/L), and (E) October (median = 9.8 mg/L), 2013 in Milford Reservoir, KS.

Number of Gizzard Shad

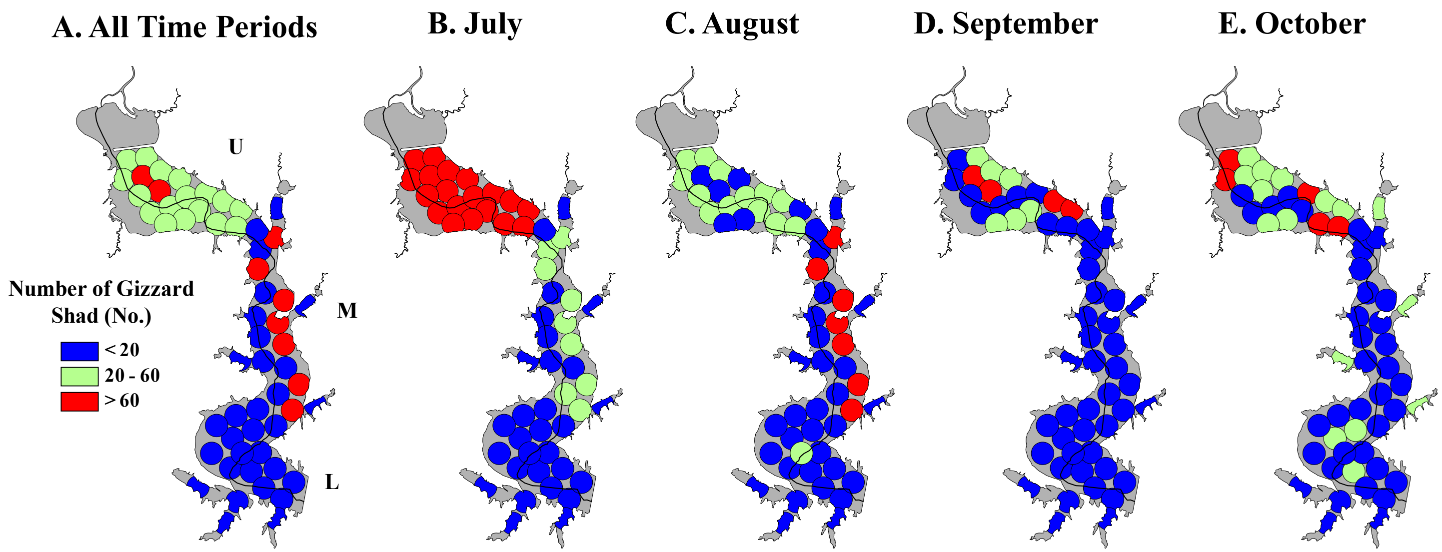


Figure 11. Maps showing the spatial distribution of numbers of Gizzard Shad (No.) in (A) all time periods combined, (B) July, (C) August, (D) September, and (E) October, 2013 in Milford Reservoir, KS. Data on Gizzard Shad were not collected in June.

Number of Chironomid Larvae

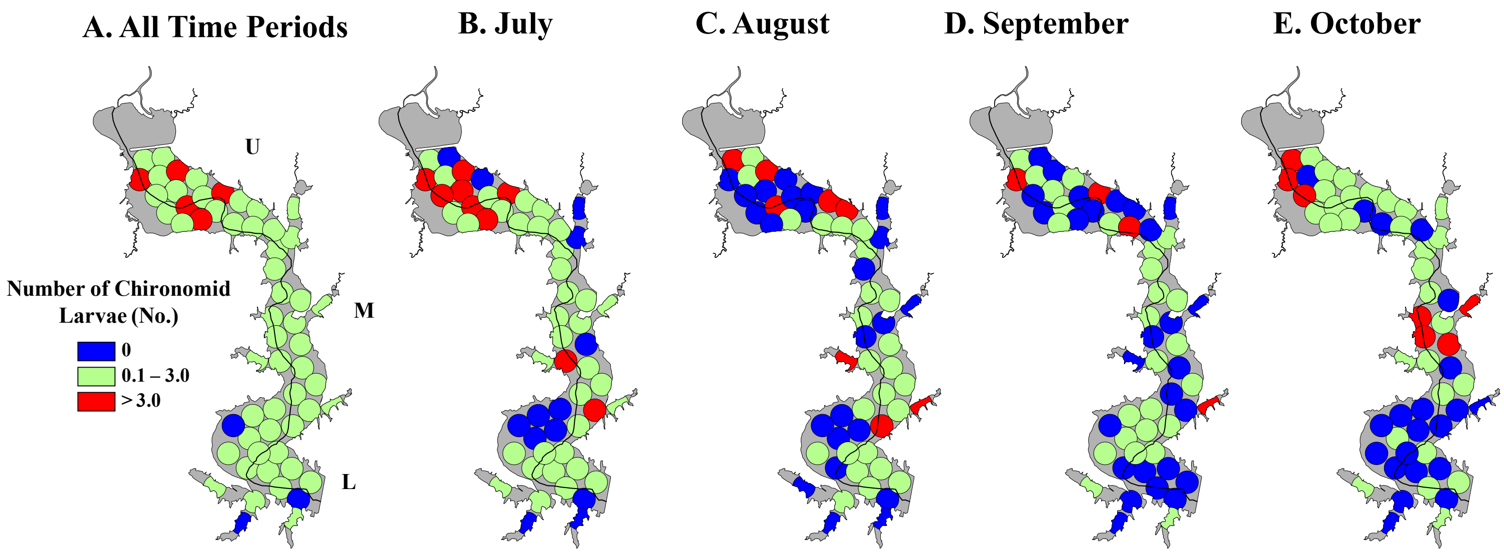


Figure 12. Maps showing the spatial distribution of numbers of chironomid larvae (No.) in (A) all time periods combined, (B) July, (C) August, (D) September, and (E) October, 2013 in Milford Reservoir, KS. Data on chironomid larvae were not collected in June.

Secchi Depth

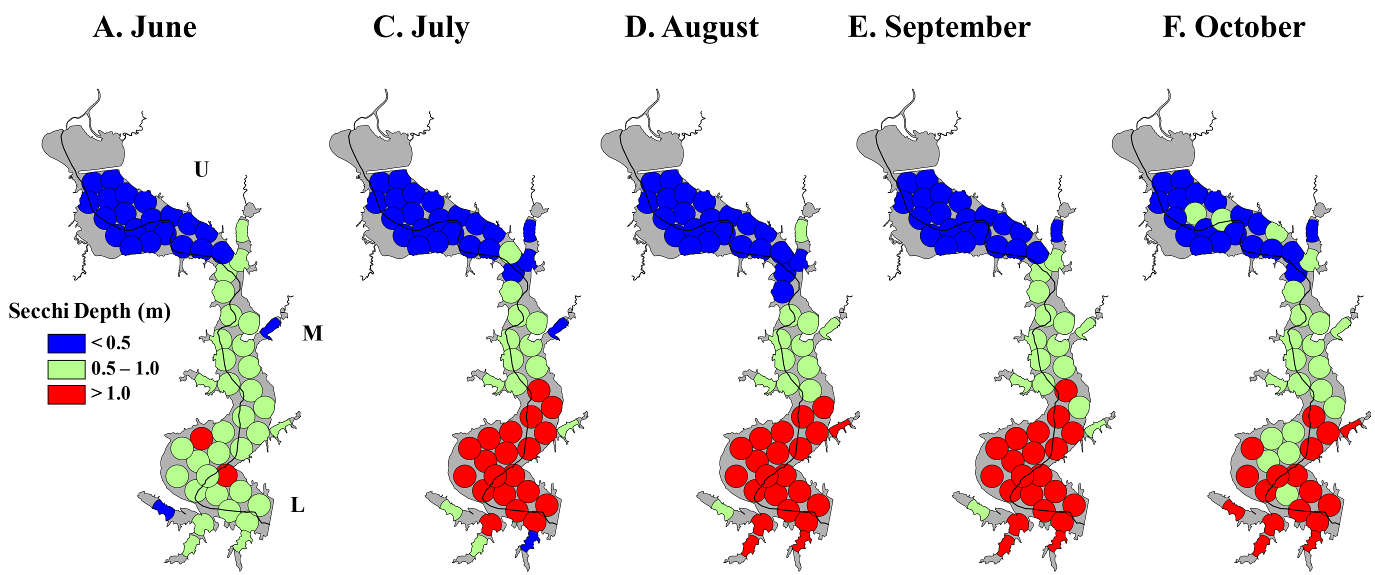


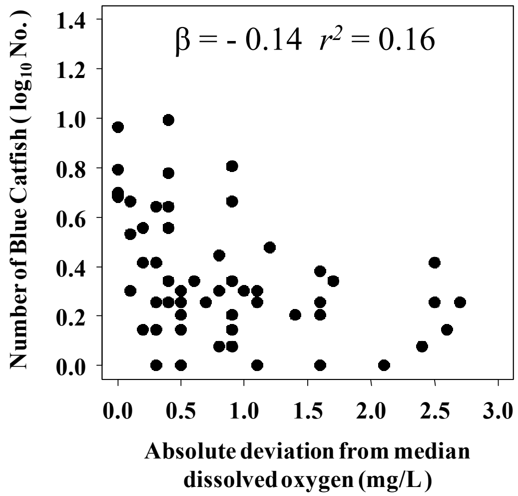
Figure 13. Maps showing the spatial distribution of Secchi depth (m) in (A) June, (B) July, (C) August, (D) September, and (E) October, 2013 in Milford Reservoir, KS.

Appendix F - Supplementary Plots

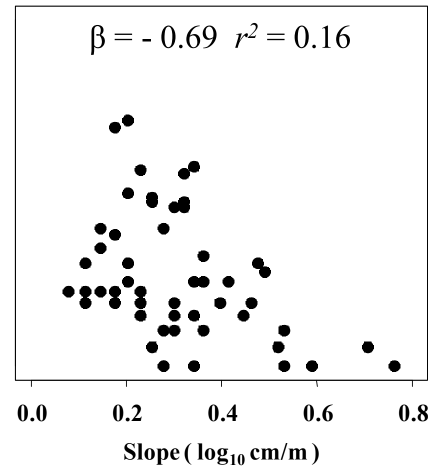
This appendix includes univariate scatterplots of influential variables found in all time periods combined and monthly analyses. Univariate plots are only shown to provide visual displays of relationships between numbers of Blue Catfish and influential variables and were not included in analyses or interpretations of the main thesis. For all time periods combined, plots are shown for all variables determined to be influential in at least one of the four hypotheses. For summer months, plots are shown for variables determined to be influential in at least one summer month (June - August). For fall, plots are shown for variables determined to be influential in at least one fall month (September - October). All influential variables are summarized in Table 5.

All Time Periods Combined Scatterplots

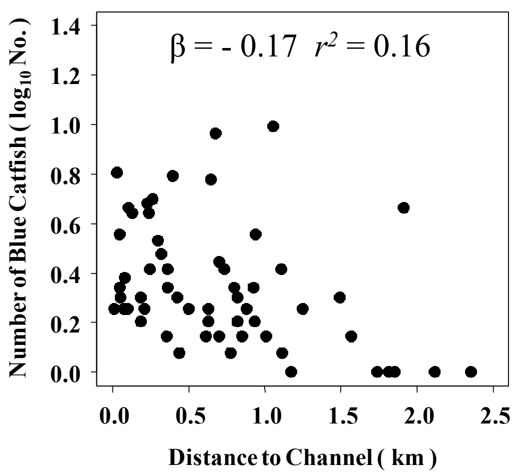
Dissolved Oxygen



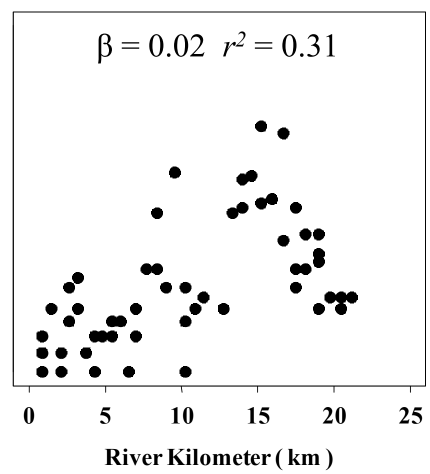
Slope



Distance to Channel



River Kilometer



Secchi Depth

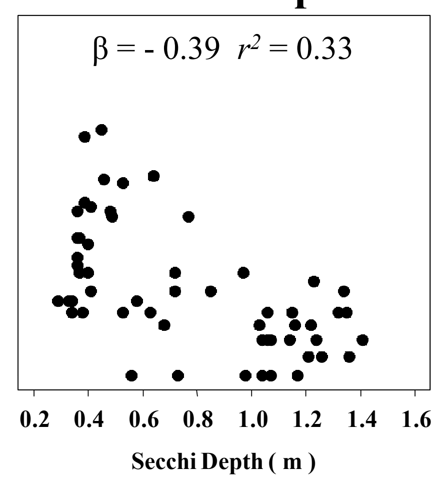


Figure 14. Scatterplots of influential variables for all time periods combined. Influential variables are summarized in Table 5. Scatterplots show relationships between numbers of Blue Catfish and absolute deviation from median dissolved oxygen (mg/L), slope (cm/m), distance to channel (km), river kilometer (km), and Secchi depth (m). Scatterplot diagnostics include slopes (β) and coefficients of determination (r^2).

Summer Microhabitat Scatterplots

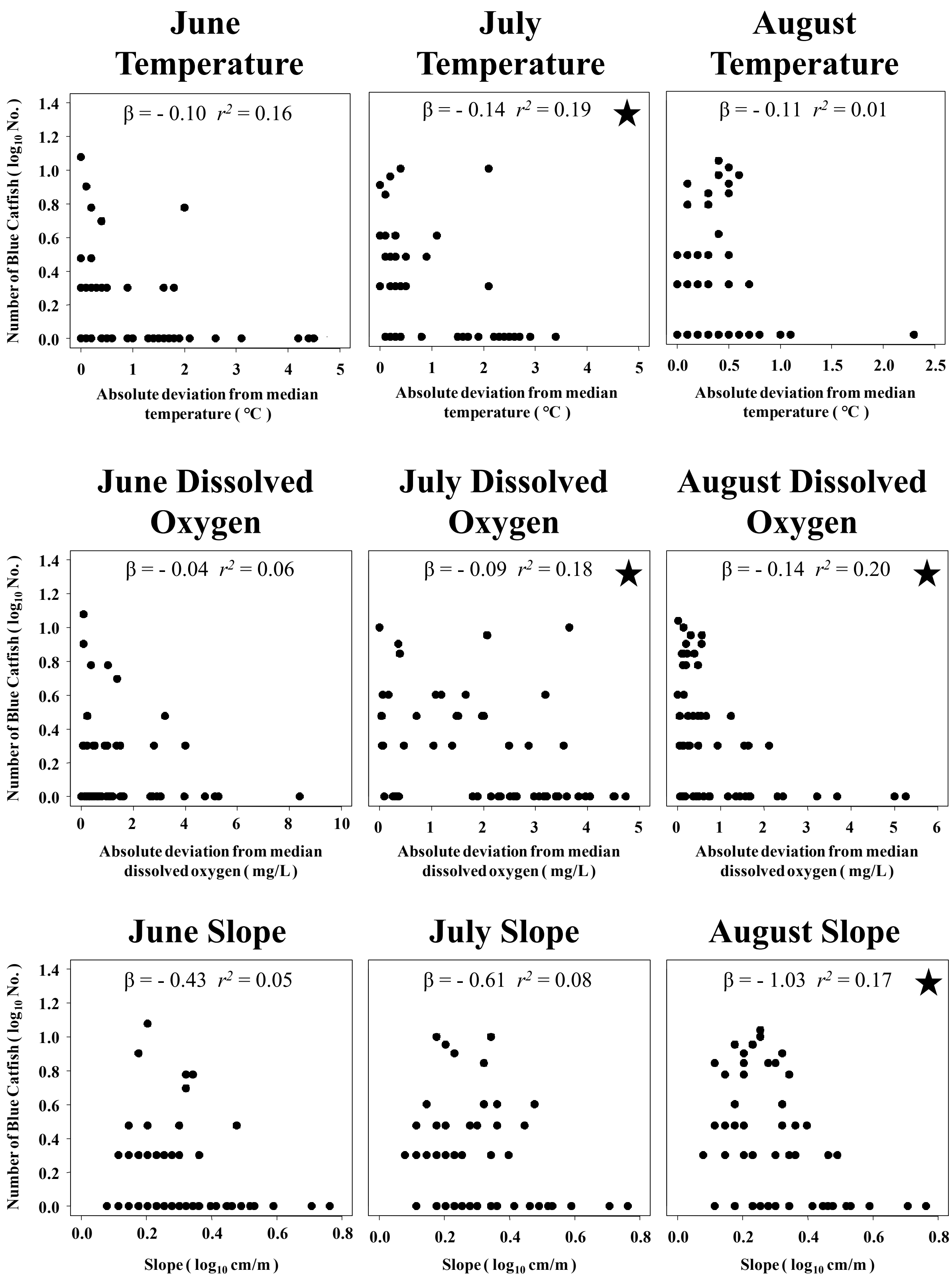


Figure 15. Scatterplots of influential microhabitat variables in select summer months. Influential variables are summarized in Table 5. Plots are shown for variables determined to be influential, or included in a principle component that was determined to be influential, in at least one summer month (June - August). Stars are shown on scatterplots where influential relationships were determined in the model selection process. Scatterplots show relationships between numbers of Blue Catfish and absolute deviation from median temperature (°C), absolute deviation from median dissolved oxygen (mg/L), and slope (cm/m). Scatterplot diagnostics include slopes (β) and coefficients of determination (r^2).

Summer Mesohabitat and Biotic Scatterplots

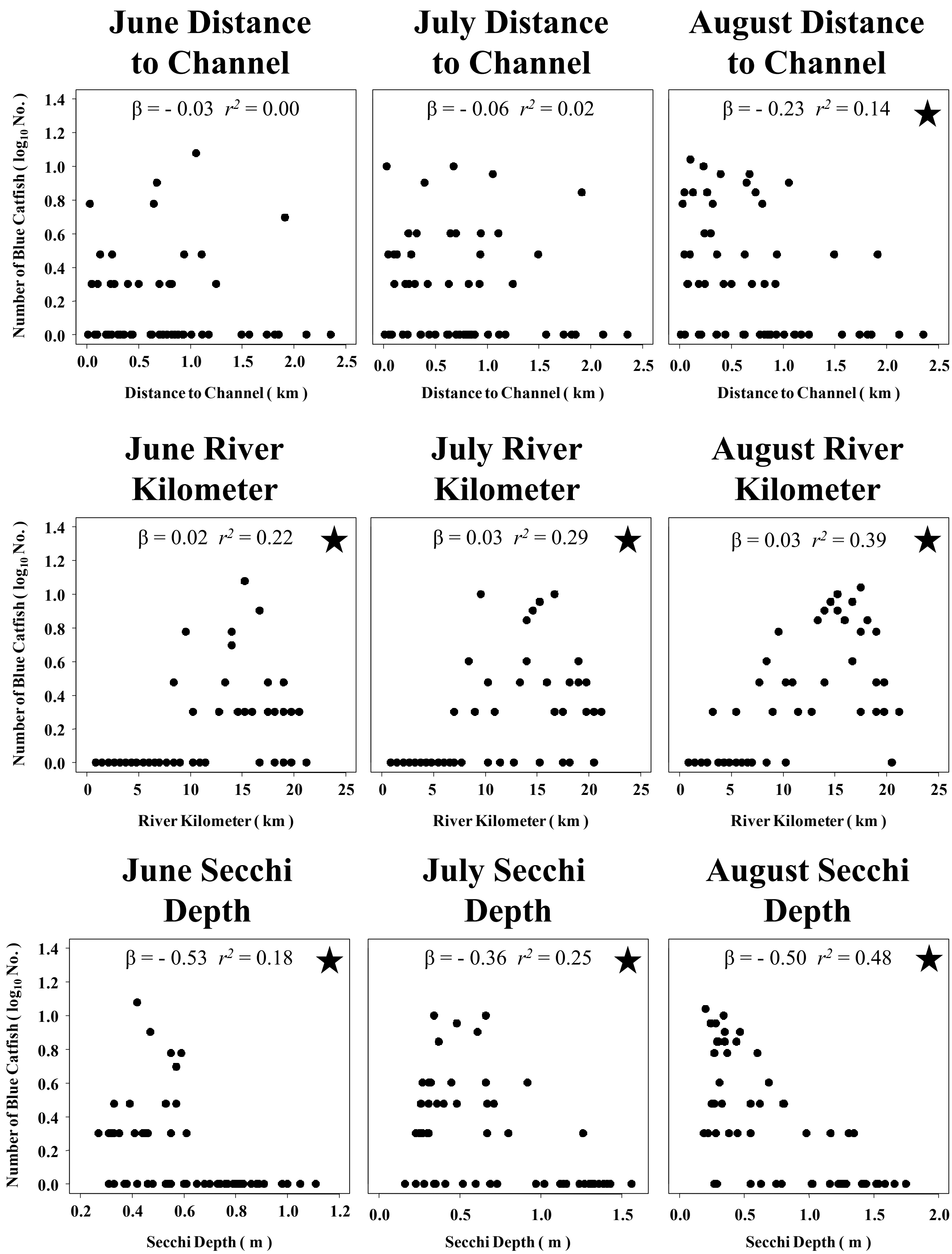


Figure 16. Scatterplots of influential mesohabitat and biotic variables in select summer months. Influential variables are summarized in Table 5. Plots are shown for variables determined to be influential, or included in a principle component that was determined to be influential, in at least one summer month (June - August). Stars are shown on scatterplots where influential relationships were determined in the model selection process. Scatterplots show relationships between numbers of Blue Catfish and distance to channel (km), river kilometer (km), and Secchi depth (m). Scatterplot diagnostics include slopes (β) and coefficients of determination (r^2).

Fall Scatterplots

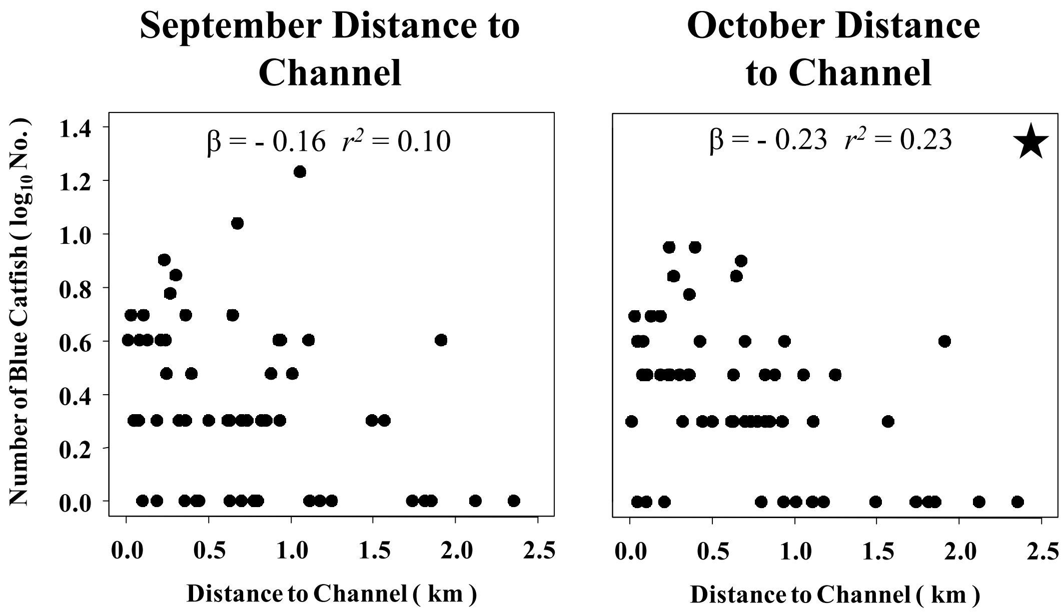


Figure 17. Scatterplots of distance to channel in fall, the only variable determined to be influential in the model selection process for fall months (September and October). Influential variables are summarized in Table 5. A star is shown in the scatterplot for October to represent the influential relationship between numbers of Blue Catfish and distance to channel during the time period. Scatterplot diagnostics include slopes (β) and coefficients of determination (r^2).