2-2009

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Management Brief.

Published in *North American Journal of Fisheries Management*, Vol. 29, Issue 1 (February 2009) at doi: 10.1577/M07-110

North American Journal of Fisheries Management 29:189–195, 2009

DOI: 10.1577/M07-110

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Habitat Characteristics of Black Crappie Nest Sites in an Illinois Impoundment

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Abstract.—Ten nest colonies of black crappie *Pomoxis nigromaculatus* were visually located and verified by angling in Campus Lake, a small urban impoundment in southern Illinois. Habitat characteristics were measured at these nest sites and compared to habitat measurements obtained from 45 unused sites. Seven habitat characteristics (substrate firmness, temperature, dissolved oxygen, distance to deep water [3.8-m depth contour], substrate type, vegetation height, and vegetation density) were significantly different between nest sites and unused sites. Although temperature and dissolved oxygen were significantly different between nest sites and unused sites, all values were within the suitable range for black crappie spawning to occur. Black crappies selected nest sites close to deep water with firm substrates and low vegetation height and density. Our results present insight on habitat characteristics of black crappie spawning locations in a small urban impoundment. Interestingly, we located several black crappie nesting colonies with more than 10 individual nests in close proximity to one another; colonial nesting by black crappies has not previously been reported in the literature. Furthermore, we suggest that degree of shoreline modification and other anthropogenic influences in and adjacent to Campus Lake did not affect black crappie nest site selection. Black crappie nest sites in Campus Lake were always located near deep water (3.8 m), in low-density, short vegetation, and on firm clay or sand substrate; because nest site selection can influence earlylife survival and recruitment of black crappie, the availability of these habitat characteristics may regulate black crappie population demographics in Campus Lake. Efforts to limit sediment inputs will be important for maintaining suitable black crappie spawning habitat in Campus Lake and other small impoundments.

Survival of early life stages has been shown to be elemental in regulating adult fish population demographics (Ricker 1975; Gulland 1982). Spawning habitat characteristics can strongly influence earlylife survival of fishes. Thus, a thorough investigation of spawning habitat characteristics is a necessary component for understanding the complex mechanisms that structure adult population dynamics. Knowledge of these mechanisms can aid in the restoration, maintenance, and enhancement of spawning habitat.

Limited information exists on crappie *Pomoxis nigromaculatus* spawning habitat characteristics (see Pope and Willis 1997). Due to high turbidity, Pope and Willis (1997) used ultrasonic telemetry to locate black crappie nests (all nests were located in less than 2-m water) in large, rural waterbodies in the northern United States. However, the distribution of black crappie extends far south of this latitude (Page and Burr 1991) and includes many small, urban impoundments across the midwestern United States. The objectives of this study were to determine habitat characteristics of black crappie nest sites in a small, urban impoundment in the southern Midwest and to compare these characteristics with nest sites chosen by black crappies in two South Dakota waters (Pope and Willis 1997). Results of this study will contribute to improved understanding of black crappie nest site selection across a broad range of latitudes and lake characteristics and will further understanding of spawning habitat characteristics of black crappie.

Study Site

Campus Lake is a small impoundment located on the campus of Southern Illinois University—Carbondale in Jackson County, Illinois, within the Big Muddy River watershed. The reservoir has a surface area of 16.2 ha, a maximum depth of 5.2 m, and a mean depth of 2.43 m (Muchmore et al. 2004). The Campus Lake watershed, which covers 94 ha, is primarily urban to the north (one-half of the catchment), heavily wooded to the south, and a mix of woods and grasses to the west. No permanent tributaries feed the lake, and water inputs result from either direct rainfall or from urban stormwater runoff. Mean water retention time is 1.73 years (Muchmore et al. 2004).

Campus Lake is eutrophic and has frequent summer blooms of green algae *Spirogyra* spp. Submergent macrophytes consist mainly of coontail *Ceratophyllum demersum* and curlyleaf pondweed *Potamogeton crispus*. Emergent vegetation includes common cattail *Typha latifolia* and nearshore reeds.

Campus Lake was last drained and dredged in 1957,

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Received June 26, 2007; accepted June 10, 2008
Published online February 23, 2009

and the majority of the fish community was stocked shortly thereafter; no major stockings have taken place in recent years (Muchmore et al. 2004). The fish community consists of black crappie, bluegill *Lepomis macrochirus*, bowfin *Amia calva*, channel catfish *Ictalurus punctatus*, common carp *Cyprinus carpio*, grass carp *Ctenopharyngodon idella*, green sunfish *L. cyanellus*, largemouth bass *Micropterus salmoides*, longear sunfish *L. megalotis*, redear sunfish *L. microlophus*, and warmouth *L. gulosus*.

Methods

The entire littoral zone was visually inspected for black crappie nest locations on March 31, 2007, (via canoe to ensure that fish would not be displaced) from 0800 to 1300 h. Black crappies were collected off nests by angling in order to identify species and sex. Nest locations were defined as a nesting site when at least five black crappies were collected from the visually located site and when males or females were milting or running ripe. Nest sites were further defined by males exhibiting territorial, sweeping, or guarding behavior. We investigated the entire shoreline, visually locating spawning colonies (Gosch et al. 2006) and using angling for confirmation, so that black crappie nest sites could be verified. All sites were marked with a GPS unit. We were unable to locate nests in water deeper than 2 m because of turbidity. However, a previous study reported that all black crappie nest sites were located in water less than 2 m deep (Pope and Willis 1997).

Habitat characteristics were measured once at each of the nesting sites in the early afternoon of April 2, 2007, following the methods described in Pope and Willis (1997). Depth (m), surface water temperature (YSI 85; Yellow Springs Instruments, Yellow Springs, Ohio), and surface dissolved oxygen (mg/L; YSI 85; Yellow Springs Instruments) were measured at the middle of each spawning location. Secchi depth (m) was measured directly out from the nest site where the water was deep enough so the bottom was not visible. Substrate firmness (cm) was measured as the distance a 32-mm-diameter pole with a 9.3-kg weight attached to the top penetrated into the substrate when dropped (Mitzner 1987). Substrate type was visually classified as gravel, sand, clay, or muck (silt and decaying vegetation). Vegetation classification included height (none, short, medium, and tall), density (none, low, moderate, and high), and type. Short vegetation height was subjectively defined as vegetation extending to the bottom third of the water column (at the depth of the nest), medium height as vegetation extending to the middle third, and tall height as vegetation extending to the top third. Low vegetation density was subjectively defined as the ability to see the substrate through interstitial spaces in the vegetation, moderate density as more limited ability to see the substrate, and high density as inability to see the substrate (Gosch et al. 2006). Distance from the site to submerged woody debris (m) was measured. Littoral gradient was measured as the descent in elevation from shore (i.e., shoreline–water interface) to a depth of 0.85 m. Maximum fetch (measure of maximum wind and wave disturbance), distance from the spawning colony to the south shore (measure of north wind and wave disturbance), and distance to deep water (defined as the distance from the spawning colony to the 3.8-m contour, which is the depth at which vegetation does not persist) were measured in ArcView GIS 9 (Environmental Systems Research Institute, Redlands, California). We also categorized the shoreline nearest to the nest or random site as modified (manicured grass or rip-rap), partially modified (grassy with a few remaining trees), and unmodified (natural woods).

Forty-five unused sites were selected by placing 200 evenly-spaced sites around the perimeter of the lake with ArcView GIS 9, then using Random Number Generator for Microsoft Excel to make 45 site selections. The unused sites were located along a contour representing the mean depth of the nest sites, and the same habitat characteristics (with the exception of depth) were measured at each of the unused sites around midday on April 3, 2007. Differences between nesting sites and unused sites were analyzed with a chi-square test of homogeneity for categorical data (i.e., substrate type and vegetation height, type, and density) of habitat characteristics, and a Kolmogorov–Smirnov goodness-of-fit test for continuous data (i.e., distance to deep water, south fetch, maximum fetch, substrate firmness, shoreline gradient, secchi depth, temperature, dissolved oxygen, and distance to woody debris).

Results

Ten black crappie nesting sites were located on the southern and eastern perimeter of Campus Lake (Figure 1) with a mean depth of 0.85 m (range = 0.5–1.0 m, SE = 0.05). In several instances, black crappies appeared to be nesting in colonies, which we defined as 10 or more nests within close proximity (<60 cm) to one another.

Temperature (nest sites: mean = 21.31°C, SE = 0.27; unused sites: mean = 20.46°C, SE = 0.09) and dissolved oxygen concentration (mean = 9.12 mg/L, SE = 0.22; mean = 8.33 mg/L, SE = 0.10) were both significantly higher at nest sites than at unused sites (temperature: KSa [Kolmogorov–Smirnov asymptotic test statistic] = 1.59, $P = 0.01$; dissolved oxygen: KSa = 1.84, $P = 0.002$). Secchi depth was not significantly

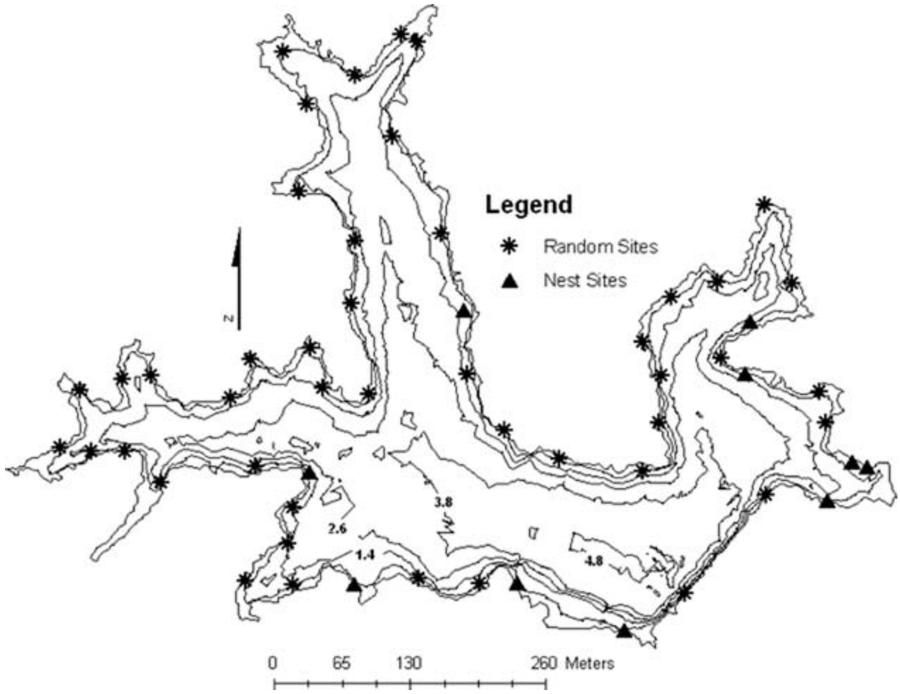

FIGURE 1.—Locations of the 10 black crappie nest sites and 45 unused sites in Campus Lake, Carbondale, Illinois. Contour lines are in meters.

different between nest sites (mean = 117.7 cm, SE = 3.42) and unused sites (mean = 111.38 cm, SE = 1.51).

Substrate firmness at nest sites (mean = 10.4 cm, SE = 1.86) was significantly different compared with that at unused sites (mean = 23.2 cm, SE = 3.48; KSa = 1.33, P = 0.05) with firmer substrates occurring at nesting colonies (Figure 2). Substrate type (gravel, sand, clay, or muck) at nest sites was also significantly different than at unused sites ($\chi^2 = 27.40$, df = 3, $P < 0.0001$). All nesting sites occurred on either sand or clay, while substrate type at unused sites consisted of muck 60% of the time (Figure 2). Vegetation height (none, short, moderate, or tall) and vegetation density (none, low, moderate, or high) at nest sites were significantly different than at unused sites (height: $\chi^2 = 9.46$, df = 3, $P = 0.02$; density: $\chi^2 = 10.19$, df = 3, $P = 0.02$). All nests occurred in areas with short vegetation height and low vegetation density (Figure 3). Vegetation type (coontail, curleyleaf pondweed, reeds, or cattail) and shoreline development (developed, partially developed, and undeveloped) were not significantly different at black crappie nesting sites compared with unused sites (type: $\chi^2 = 4.52$, df = 3, $P = 0.34$; development: $\chi^2 = 1.56$, df = 2, $P = 0.46$).

Nest sites (mean = 86.55 m, SE = 12.47) were closer to deep water than unused sites (mean = 167.95, SE = 16.49; KSa = 1.59, $P = 0.01$; Figures 1 and 4). Littoral gradient (mean = 0.16 m, SE = 0.02; mean = 0.17 m, SE = 0.009), maximum fetch (mean = 398.75 m, SE = 48.94; mean = 337.09 m, SE = 23.88), and the distances to the south shore (mean = 25.7 m, SE = 12.77; mean = 80.26 m, SE = 15.34) and to woody debris (mean = 7.6 m, SE = 1.65; mean = 5.62 m, SE = 0.81) were not significantly different between nest sites and unused sites.

Discussion

Mean black crappie spawning depth in Campus Lake was 0.85 m, which is similar to the 0.4–0.8 m range of spawning depths described by Pope and Willis (1997). The observation of black crappies nesting in colonies with individual nests less than 60 cm apart (termed "surrounded" in Avila 1976) was unexpected, and we are unaware of any other studies that have documented this behavior by black crappies. Furthermore, we did not locate any solitary nesting black crappies in Campus Lake.

Differences in temperature and dissolved oxygen occurred between nest sites and unused sites; however, these water quality measurements were within the temperature and dissolved oxygen tolerance limits for black crappie (Siefert and Herman 1977; Pine and

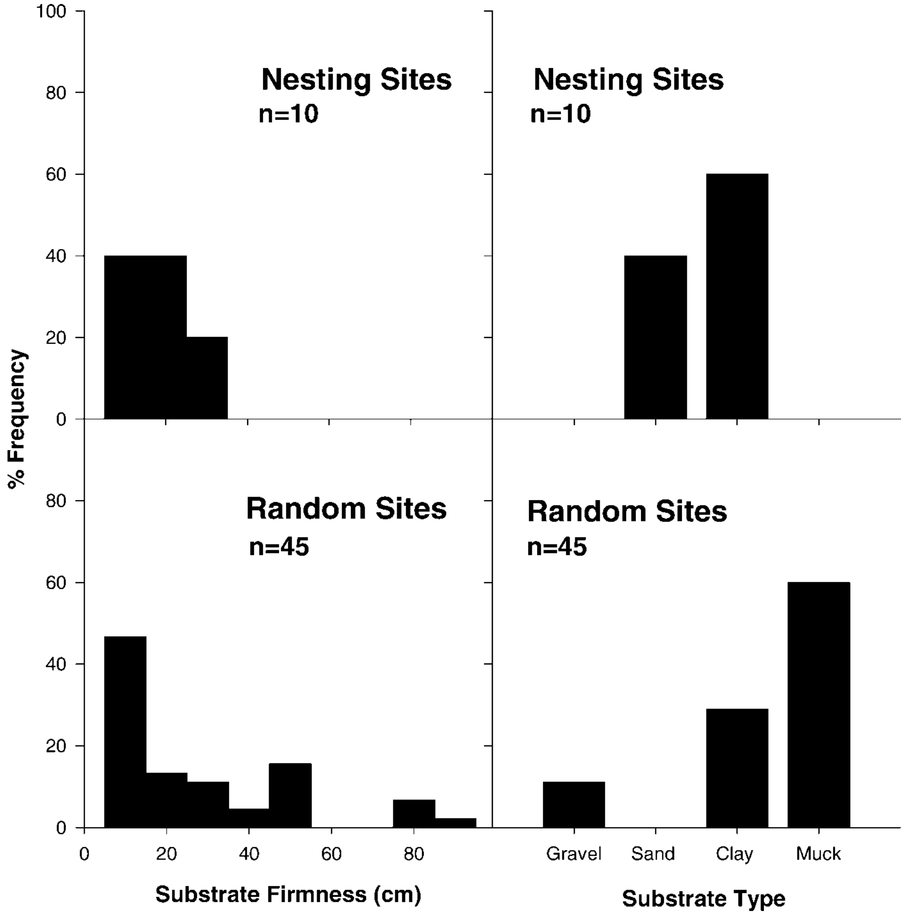

FIGURE 2.—Substrate firmness (distance [cm] that a 32-mm diameter pole with a 9.3 kg-weight attached penetrated the substrate) and substrate types (gravel, sand, clay, or muck) at black crappie nest sites and unused sites in Campus Lake, Carbondale, Illinois.

Allen 2001). However, Gosch et al. (2006) did find that nest sites of bluegills, another centrarchid, were located in areas of higher dissolved oxygen.

Nests in Campus Lake occurred on significantly firmer substrates than those of the unused sites; similarly, Mitzner (1991) determined through regression analysis that optimum nesting substrate firmness for crappies *Pomoxis* spp. in Rathbun Lake, Iowa, was approximately 10 cm penetration. Black crappies in Campus Lake used sand and clay substrate for nest sites in higher proportion than availability. We suspect that sand and clay substrates were used because eggs would be less likely to be covered by silt, which would lead to eggs being exposed to anoxic conditions and subject to increased mortality. Other research has reported similar results. For example, Mitzner (1991) found that potential crappie nest sites were located on hard clay substrate but were less common in sand, gravel, and rock.

Nesting black crappies did not appear to show preference for any particular vegetation species. While Pope and Willis (1997) reported that crappie nest sites were located in areas with cattails and woody debris, black crappie nest sites in Campus Lake occurred near all classified vegetation types. Furthermore, Pope and Willis (1997) reported that black crappies used dense cover for spawning, whereas nest sites on Campus Lake were located in areas with low vegetation density and short vegetation height. While areas with high vegetation cover may provide refuge, areas with low density and short vegetation may ease construction of nests. Low vegetation density may also allow easier protection of nests as both redear sunfish and bluegills in Campus

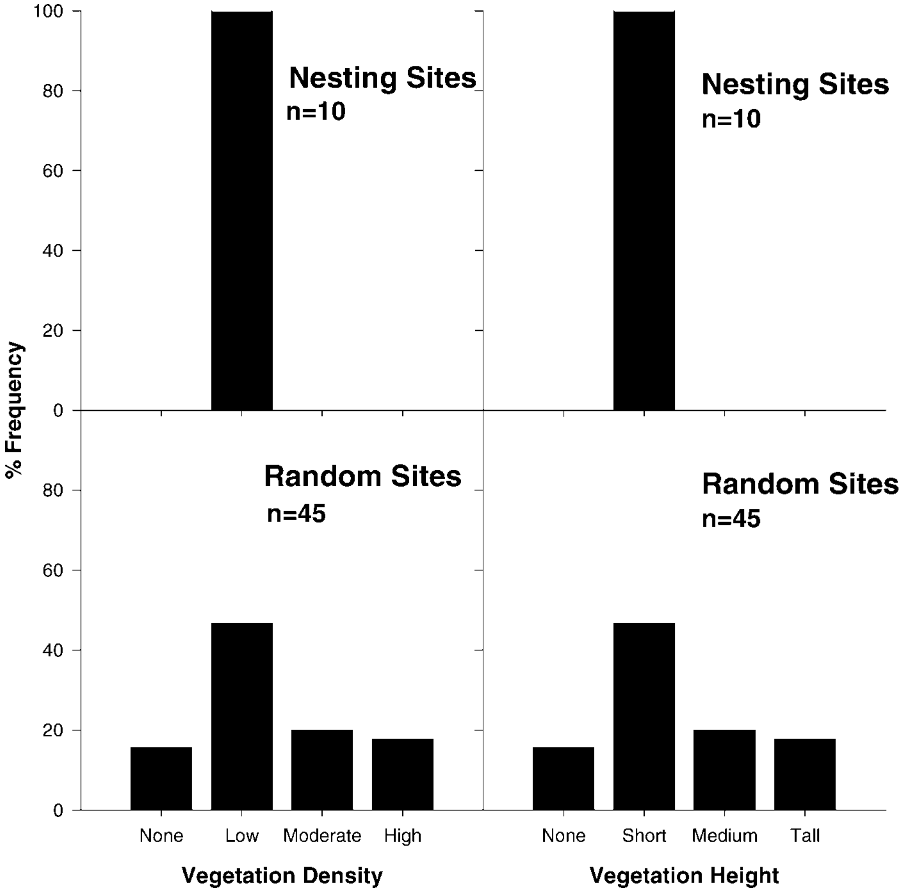

FIGURE 3.—Vegetation height (none, short, medium, and tall) and vegetation density (none, low, moderate, and high) at black crappie nest sites and unused sites in Campus Lake, Carbondale, Illinois.

Lake have been found to prey upon fish eggs during the spring (N. Wahl, unpublished data).

The small size of Campus Lake may not allow for wind generated wave action and displacement or desiccation of eggs, which is likely the reason that maximum fetch and south fetch were not significantly different between nest sites and unused sites. However, Pope and Willis (1997) determined that black crappie nest site locations in 335- and 405- ha lakes were located in areas that were protected from wind and wave action. Additionally, Mitzner (1991) found that larval crappies in a 4,450-ha lake were in lower abundance in conditions of sustained high winds over a great fetch.

Distance to deepwater was significantly different between nest sites and unused sites, which is most likely used by larvae for refugia from predators or for open-water foraging (Faber 1967; Post et al. 1995; Pope and Willis 1998). We believe that distance to deep water may have been related to sediment accumulation (which alters multiple habitat characteristics) in coves in the upper end of the lake.

We found no significant difference in distance to structure or degree of shoreline modification between unused sites and nest sites. However, this does not indicate that black crappies did not spawn in areas with modified shorelines or other anthropogenic influences. In fact, the two largest spawning colonies were located at the Campus Lake marina, which is the largest man-made structure on the lake. Unlike other studies where anthropogenic influences have been shown to be detrimental to fish spawning habitat (Rust et al. 2002), our results suggest that man-made structures and shoreline modification apparently had little or no influence on black crappie nest site selection.

Black crappie nest sites in Campus Lake were always located near deep water, in low-density, short vegetation, and on firm clay or sand substrate. (Based

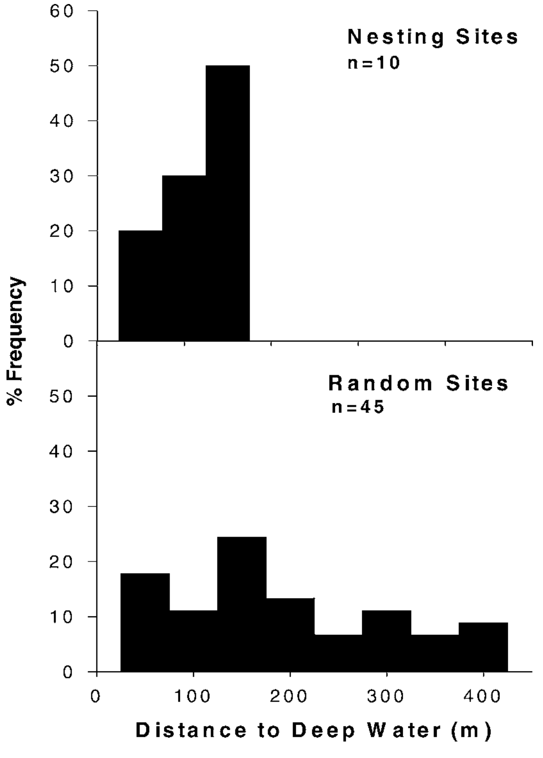

FIGURE 4.—Distance to deep water (m) from black crappie nest sites and unused sites in Campus Lake, Carbondale, Illinois. Deep water was defined as the 3.8-m contour line.

on an informal observation during 2008, black crappies used the same nest site locations as were found during the 2007 study.) Further research should be conducted to develop our knowledge of black crappie spawning habitat characteristics on a latitudinal gradient, including multiple lake or reservoir types (oligotrophic, mesotrophic, and eutrophic). We also suggest future research to elucidate relationships between habitat characteristics at black crappie nesting sites and early life stage survival.

Knowledge of habitat characteristics of black crappie nest sites is of value for habitat management. Specifically, black crappies used hard clay or sand substrates; areas with these substrates should be protected or enhanced to promote black crappie recruitment. However, in water bodies with an overabundance of black crappies, these areas could be reduced, which may reduce black crappie population size. We found no black crappie nests in the backs of coves that had muck substrates and received sediments from stormwater runoff. The installation of sediment retention basins or vegetated buffer strips in channels that feed these coves would reduce sediment inputs to the lake, thus, reducing the rate at which locations with suitable spawning substrates and vegetation for black crappie nesting are lost due to sedimentation. Similar efforts to limit sediment inputs will probably be important for maintaining suitable black crappie spawning habitat in other small impoundments.

Acknowledgments

We would like to thank the Southern Illinois University Fisheries and Illinois Aquaculture Center for equipment use and support. Furthermore, our manuscript was improved markedly by comments from three anonymous reviewers and the associate editor.

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