Influence of Selected Physical Factors on the Catch Rate of White Crappie in Trap Nets

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Abstract: We investigated effects of selected physical factors on the catch rate of white crappie (*Pomoxis annularis*) in trap nets in Mississippi lakes. Population data were collected on 7,782 white crappie from 557 trap-net samples in the fall (*N* = 4,679 fish/243 nets) and spring (*N* = 3,103 fish/314 nets), 1987–1989. Generally, catch/day (*N* fish/24 hours) estimates were higher and less variable in trap nets set at water depths of 1.0–2.9 m and on bottom slopes of 0.0%–7.9%. Catch/day estimates were higher, but equally variable, in trap nets set perpendicular to the shoreline and at water temperatures of 16.0–19.9 C in the fall and 20.0–23.9 C in the spring. These findings indicate trap-netting efficacy could be augmented by sampling under the specified ranges of sampling conditions.

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White crappie and black crappie (*P. nigromaculatus*), abundant in many reservoirs and natural lakes in the southeastern United States, support economically important fisheries. Fishing pressure exerted on crappie populations continues to increase; however, there are several management problems that have not been resolved (Hooe 1991). Among the many challenges to managers of crappie fisheries (e.g., irruptive recruitment cycles, overcrowding, and stunting), sampling and assessment methodologies deserve immediate attention.

Trap nets are generally more cost effective than other gears (e.g., electrofishers, gill nets, and chemicals) for sampling crappie populations (Boxrucker and Ploskey 1988, McInerny 1988, Miranda et al. 1990). Trap-net catch rates, however, can be extremely variable (Miranda et al. 1990); hence, intensive sam-

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pling may be required to calculate abundance estimates with a reasonable level of precision. Because the trap net is a passive sampling gear, catch rates are largely dependent on crappie movements, which are influenced by both environmental and habitat conditions (Gebhart and Summerfelt 1975, Markham et al. 1991, Guy et al. 1992).

Presently, there is little published information on the effects of environmental and habitat variables on the catch rates of crappie in trap nets. The trap-net set interval (soak time) can have a significant effect on estimates of abundance and size structure (Schorr and Miranda 1989); however, effects of many other variables have not been examined. Ecological studies of crappie populations suggest water depth and bottom slope (O'Brien et al. 1984, Markham et al. 1991), water temperature (Kelley 1953, Mitzner 1991), and water clarity (Mitzner 1991) could be important factors affecting catch rates in trap nets. Findings from other investigations suggest net orientation relative to the bank (perpendicular vs. parallel) may have a substantial effect on trap-net catch rates (Craig and Fletcher 1982, Hubert 1983).

We investigated effects of 5 trap-net set variables on catch rate of white crappie in Mississippi lakes. Specific objectives were to quantify the effects of water depth, bottom slope, water temperature, water clarity, and net orientation on the mean catch rate and precision of the estimate.

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Methods

Fall (Oct–Dec) and spring (Mar–May) trap-netting was conducted in 3 reservoirs (Columbus, Grenada, and Ross Barnett) and 1 oxbow lake (Moon) in Mississippi, 1987–1989. These lakes, located in the northern half of the state, ranged from 894 to 25,640 ha and supported white crappie fisheries.

Trap-Net Description and Sampling

Trap nets (described from anterior to posterior) consisted of a single 0.9- × 20.0-m lead attached to the trap mouth (first frame); 2 0.9- × 1.8-m frames (spaced 0.76 m apart) with center braces; 4 0.76-m diameter hoops (second frame and first hoop spaced 0.81 m apart; hoops spaced 0.61 m apart); and a 0.61-m long cod end (extending from fourth hoop) with a purse string. Fish passageways consisted of a vertical slit entrance (5.1-cm wide slit on each side of center brace) in the second frame and a funnel-shaped throat (15.5-cm diameter hole) between the first and second hoops. The frames and hoops were constructed of 6.5 to 8.0-mm diameter steel and netting material of the trap (including throats) and lead consisted of 13-mm square nylon mesh.

Nets were set under a wide range of conditions in subjectively selected habitats and fished at 5- to 7-day intervals. Nets were anchored at the anterior part of the lead and posterior part of the trap (cod end). White crappie were measured (TL) to the nearest mm.

Trap-Net Catch/Day

An index of relative abundance (Schorr and Miranda 1989), the trap-net catch/day (*N* fish/24 hours) was estimated for small (<130 mm), medium (130–199 mm), and large (≥200 mm) white crappie. The coefficient of variation (CV) was used as an index of precision for the mean catch/day. Trap-netting methods that yield catch statistics with relatively low CV values would be desirable, because more precise estimates can be obtained with less sampling effort.

Identification of Set Variables

Four physical factors (water depth, bottom slope, surface water temperature, and water clarity) were measured at all of the trap-net sites during the 2-year study. Treatment levels were defined *a posteriori* to make valid statistical comparisons of data collected under various sampling conditions. Water depth (m) represented average depth of the trap-net set, calculated from measurements made at each end of the net; shallow- and deep-water treatments were 1.0–2.9 and 3.0–5.9 m, respectively. Bottom slope (expressed as a percent; 45 degrees = 100% slope) represented the local gradient (change in vertical distance) on which the net was set; moderate- and steep-slope treatments were 0.0%–7.9% and 8.0%–16.9%, respectively. Surface water temperature (C) was measured at each set; fall treatments were 12.0–15.9 and 16.0–19.9 C and spring treatments were 12.0–15.9, 16.0–19.9, 20.0–23.9, and 24.0–27.9 C. Water clarity was measured (cm) using a Secchi disk; low- and high-clarity treatments were 10–39 and 40–79 cm, respectively.

Net orientation relative to the shoreline was examined only in fall 1988. Eleven pairs of trap nets were fished perpendicular and parallel to the shoreline at selected sites in the 4 lakes. Paired sets were approximately 50 m apart (to reduce gear competition) and within 10 m of the shoreline. Perpendicular sets were made with the lead nearest the bank and the trap offshore.

Data Analysis

Statistical analyses were performed to test for effects of the selected physical factors (main effects) on catch rates of white crappie. Fall and spring data for each size group (small, medium, large) were analyzed separately. Catch/day from each combination of sampling date, lake site, water depth, bottom slope, water temperature, and water clarity was treated as an experimental unit. Catch data were log-transformed [$\log_e(x + 1)$] to satisfy assumptions of parametric statistical testing. Analysis of variance was used to test for the main effects on the mean catch/day. Duncan's multiple means comparison tests were performed when main effects were significant. Paired *t*-tests were used to make comparisons between CV values (8 lake-year pairs) associated with various treatment levels.

Effects of trap-net orientation on catch rates of white crappie were analyzed using paired *t*-tests. Comparisons were made between paired catch/day estimates (means and CV values) from perpendicular and parallel trap-net sets.

Analyses were performed using general linear models and means procedures of the Statistical Analysis System (SAS 1985). Significance was declared at the 0.10 α level.

Results and Discussion

General Effects of Set Variables

A total of 7,782 white crappie were collected from 557 trap-net samples in the fall (N = 4,679 fish/243 nets) and spring (N = 3,103 fish/314 nets). The mean catch/day varied significantly with water depth, bottom slope, and water temperature, depending on the season and size group, but not with water clarity. Also, there were significant differences in the CV values for depth and slope, but not for water temperature and clarity. There were significant differences in mean catch/day relative to net orientation, but not in CV values.

Effects of Water Depth

Fall catch/day of small and medium fish and spring catch/day of medium and large fish were higher in trap nets fished in shallow water than in deep water; fall CV values for small fish and spring CV values for large fish were lower in shallow water (Fig. 1). Total fall catch (all sizes) averaged 5.61 fish/day (CV = 86%) in shallow water and 2.94 fish/day (CV = 105%) in deep water; spring catch averaged 2.89 fish/day (CV = 89%) and 2.09 fish/day (CV = 117%), respectively.

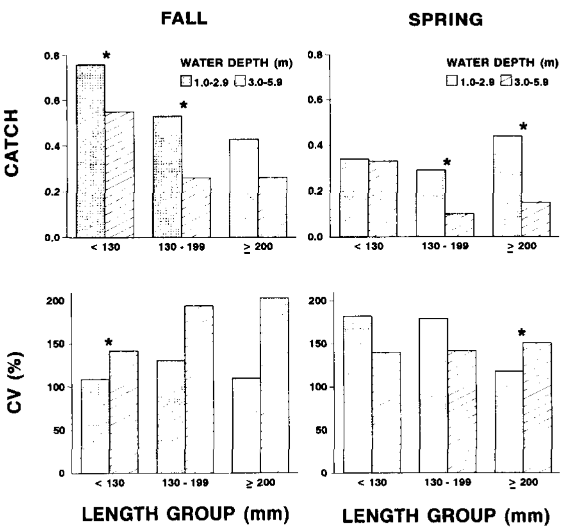

Figure 1. Mean $\log_e$-transformed catch/day (N/24 hours + 1) and coefficient of variation (CV) for 3 size groups of white crappie collected in trap nets at 2 depth ranges in 4 Mississippi lakes, fall 1987–spring 1989. Asterisks denote statistical significance at the 0.10 α level.

Angyal et al. (1987) also reported higher catch rates of white crappie in Sooner Lake, Oklahoma, from trap nets fished in water <3 m deep. Higher trap-net catch rates in shallow water probably reflect the littoral distribution of certain ages and sizes of white crappie (Gebhart and Summerfelt 1975, Markham et al. 1991), as well as gear performance. Shallow-water nets probably catch more fish because there is less open area above the lead, which increases the probability fish will encounter the gear and swim into the trap. Conversely, in deep-water sets, greater vertical distance between the gear and water surface provides a larger area for fish to swim over the net and avoid capture.

Seasonal and ontogenetic changes in the vertical and horizontal distribution of white crappie in lakes (Grinstead 1969, Gebhart and Summerfelt 1975, O'Brien et al. 1984) can make trap-net catches highly variable (Boxrucker 1984, Boxrucker and Ploskey 1988). Although trap-netting would not be an appropriate method for studying the vertical distribution of white crappie, our results imply it is an effective method for sampling in shallow waters of lakes. Trap-netting in shallow water, therefore, can be used to assess recruitment in the fall when crappie populations are more evenly distributed in the water column (Grinstead 1969, Gebhart and Summerfelt 1975); however, spring assessments could be biased toward adults as they move into littoral areas to spawn (Boxrucker 1984).

Effects of Bottom Slope

Fall catch/day of small and medium fish and spring catch/day of all size groups were higher in trap nets fished on moderate slopes than in nets fished on steep slopes; fall CV values for small fish were lower on moderate slopes (Fig. 2). Total fall catch averaged 5.60 fish/day (CV = 85%) on moderate slopes and

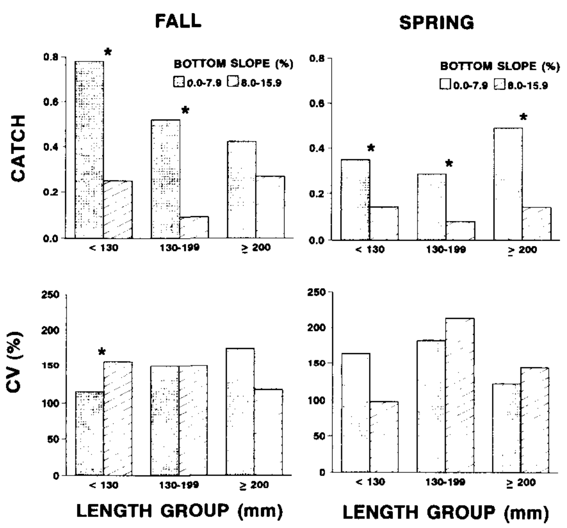

Figure 2. Mean $\log_e$-transformed catch/day (N/24 hours + 1) and coefficient of variation (CV) for 3 size groups of white crappie collected in trap nets on 2 bottom slope ranges in 4 Mississippi lakes, fall 1987–spring 1989. Asterisks denote statistical significance at the 0.10 α level.

1.85 fish/day (CV = 102%) on steep slopes; spring catch averaged 3.06 fish/day (CV = 93%) and 1.43 fish/day (CV = 124%), respectively.

Bottom gradients may affect trap-net catch rates of white crappie by influencing gear performance and fish behavior. Like most passive-sampling gears, trap nets function most effectively when taut, which can be accomplished by setting the net on firm, gently sloping bottoms (Crowe 1950). Conversely, nets set on steep slopes, if not tied to some structure, would be more likely to collapse. Different types of substrates (not investigated in this study), which can alter the security of the anchors and thus tautness in the net (Hubert 1983), also may have influenced variation in trap-net catch rates.

In addition to considering the effects of bottom gradients on trap-net efficacy, managers should consider the habitat preferences of white crappie. In Delaware Reservoir, Ohio, Markham et al. (1991) reported white crappie ≥271 mm TL consistently utilized areas with relatively steep bottom gradients of 6°–22° (roughly equivalent to 10%–40% slopes) in the summer. Results from this study, however, imply trap nets function more effectively on bottom slopes <8% than on slopes ≥8%. Therefore, the best approach may be to set trap nets on flat to gently sloping gradients within areas that offer abrupt bottom contours and other features where crappie may congregate.

Effects of Water Temperature

Fall catch/day of small and medium fish were higher in trap nets fished at 16.0–19.9 C than at 12.0–15.9 C; however, CV values were statistically similar (Fig. 3). Total catch averaged 3.86 fish/day (CV = 100%) at 16.0–19.9 C and 1.97 fish/day (CV = 128%) at 12.0–15.9 C.

In the upper Mississippi River, Kelley (1953) reported high trap-net catches

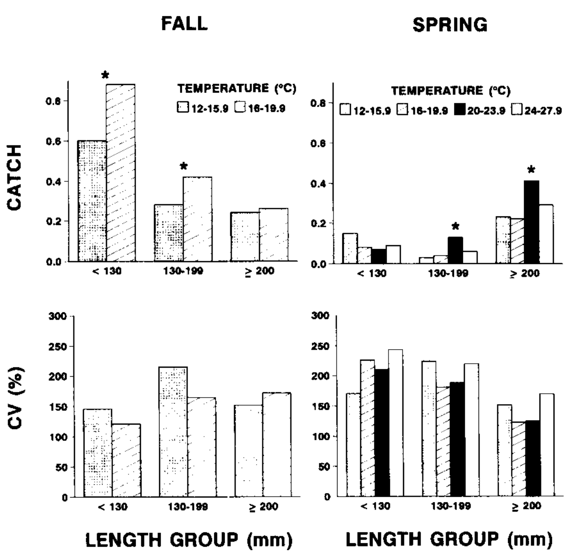

Figure 3. Mean $\log_e$-transformed catch/day (N/24 hours + 1) and coefficient of variation (CV) for 3 size groups of white crappie collected in trap nets at 4 water temperature ranges in 4 Mississippi lakes, fall 1987–spring 1989. Asterisks denote statistical significance at the 0.10 α level.

of crappie at all temperatures of 16.0–21.0 C; this was largely attributed to increased movements of fish at warmer temperatures. In addition to warmer temperatures in early fall (Oct–Nov), relatively stable weather patterns may also contribute to higher catch rates of crappie (Boxrucker and Ploskey 1988). Several state conservation agencies have implemented October–November trap-netting surveys to assess crappie populations in southeastern reservoirs (Colvin and Vasey 1986, Boxrucker and Ploskey 1988, McInerny and Degan 1991).

Spring catch/day of medium and large fish were higher in trap nets fished at 20.0–23.9 C than in nets fished at lower or higher temperatures; however, CV values were statistically similar (Fig. 3). Total catch averaged 2.92 fish/day (CV = 73%) at 20.0–23.9 C and 1.67 fish/day (CV = 121%) at other temperatures.

Relatively high spring catch rates of large white crappie at 20.0–23.9 C (late Apr–May) were probably related to spawning movements. In other southern impoundments, high spring catches of sexually mature white crappie in trap nets have been reported in late April–May at similar temperatures (Carter 1954, Boxrucker and Ploskey 1988). Mitzner (1991) concluded 16.0 C was the "threshold" spawning temperature for white crappie in Lake Rathbun, Iowa, and spawning activity peaked at about 21.0 C; this corroborates our findings. Decreased trap-net catch rates of large crappie at 24.0–27.9 C (observed in this study) probably reflect post-spawning movement of adults into cooler, deeper waters (Carter 1954).

Effects of Water Clarity

Water clarity did not have a significant effect on trap-net catch rates or CV values (Fig. 4). This lack of significance, however, should be interpreted cautiously. Possibly, the range of Secchi disk visibilities measured in this study

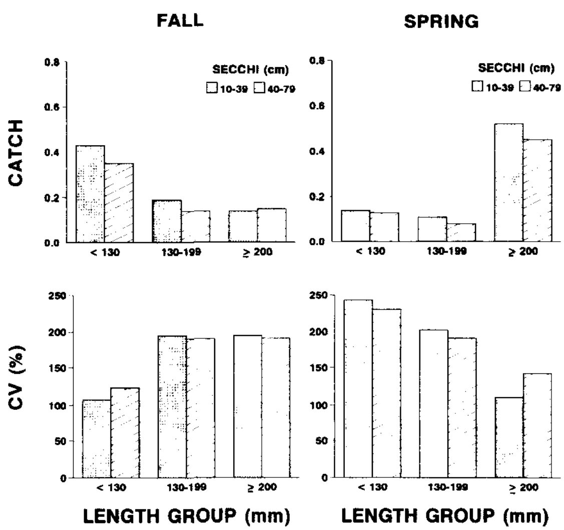

Figure 4. Mean $\log_e$-transformed catch/day (N/24 hours + 1) and coefficient of variation (CV) for 3 size groups of white crappie collected in trap nets at 2 water clarity (Secchi disk depth) ranges in 4 Mississippi lakes, fall 1987–spring 1989.

was too narrow to observe pronounced differences in catch rates. Moreover, white crappie responses may have been more sensitive to other factors contributing to variations in water clarity, such as clay turbidity and plankton densities, which were not determined in this study.

In spite of our findings, several investigators have concluded water clarity influences fish biology and gear performance. Mitzner (1991) reported turbidity had a negative impact on the reproductive behavior of white crappie in Lake Rathbun, Iowa, suggesting adults did not spawn and young did not survive at Secchi disk visibilities <5 cm. In Lake Texoma, Oklahoma-Texas, Grinstead (1969) reported white crappie were more concentrated near the surface during periods of increased turbidity. Hansen (1944, 1953), however, suggested a "turbidity threshold" may exist which reduces the frequency of escapement from hoop nets. Moreover, this could impair the fish's ability to see the net and avoid the gear, and thus increase catch rate. Many studies have concluded certain fishes are captured more effectively in gill nets composed of netting material that becomes transparent at low levels of light intensity (Brown 1937, Jester 1977, Cui et al. 1991).

Perhaps, under certain conditions, the effects of water clarity on fish biology and gear performance may be contradictory. White crappie are visual feeders and, thus, populations should respond positively (e.g., strong recruitment, fast growth rates, and increased abundance of large piscivores) with improved water clarity. However, because these fish probably avoid (and escape from) trap nets better in clear water, catch rates should be negatively related to water clarity providing other conditions remain constant. Consequently, the true relationship between water clarity and trap-net catch rate may be obscured by population changes. For this reason, water clarity alone may not be a useful indicator of trap-net catch. Furthermore, caution should be exercised when comparing catch rates between lakes which exhibit substantial differences in water clarity.

Effects of Net Orientation

Fall catch rates of small and medium fish were higher in trap nets set perpendicular rather than parallel to the shoreline; however, CV values were statistically similar (Fig. 5). Total catch averaged 3.46 fish/day (CV = 75.9%) in perpendicular-set nets and 1.34 fish/day (CV = 96.1%) in parallel-set nets.

Perpendicular bank orientations of passive net gears seem to be effective for capturing fish that inhabit shallow littoral areas. Craig and Fletcher (1982) reported significantly higher catches of fish in gill nets set perpendicular rather than parallel to the shore. Trap nets, selective for fish in littoral habitats of lakes (Hubert 1983), are usually positioned perpendicular to the shoreline with the free end of the lead secured at or near the bank (Boxrucker and Ploskey 1988, McInerny 1988). Ideally, this type of set would cause fish swimming along the shoreline to encounter the lead and follow it into the trap. Higher catch rates of small and medium fish in perpendicular-set trap nets (our study) suggest fall aggregations of white crappie apparently move along the shoreline contours of lakes.

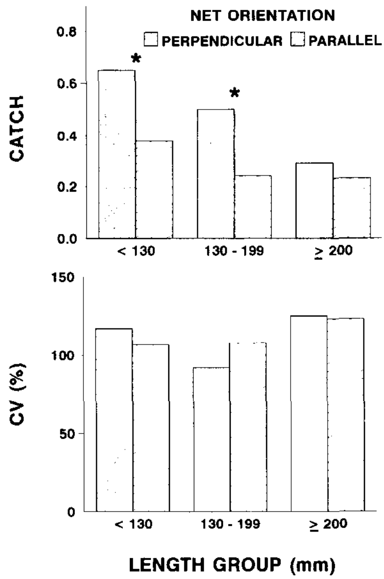

Figure 5. Mean $\log_e$-transformed catch/day (N/24 hours + 1) and coefficient of variation (CV) for 3 size groups of white crappie collected in trap nets fished parallel and perpendicular to the shoreline in 4 Mississippi lakes, fall 1988. Asterisks denote statistical significance at the 0.10 α level.

Sampling Implications

Water depth, bottom gradient, water temperature, and net orientation can influence the catch of white crappie in trap nets. Our findings indicate trap-netting within specified ranges of sampling conditions can increase catch rates and improve statistical precision. Larger catches could be collected with less effort by setting trap nets perpendicular to the shoreline (at least in the fall), in shallow water, on moderate bottom slopes, and at surface temperatures of 16.0–19.9 C in the fall and 20.0–23.9 C in the spring. Variability in catch rates may be reduced substantially by setting trap nets in shallow water and on moderate bottom slopes.

Habitat preferences of white crappie, though not addressed in this study, should be incorporated into sampling designs. However, certain habitats are difficult to sample with trap nets. Crappie habitat often includes steep bottom gradients, deep-water areas, and other features which reduce the effectiveness of trap-net sampling. Preliminary surveys should be conducted to establish trap-net sites within or adjacent to crappie habitat zones.

Development and implementation of standardized procedures for sampling crappie in southeastern lakes could provide managers with higher catch rates and more precise estimates of abundance. Failure to recognize the effects of certain variables on trap-net performance could result in unnecessary sampling and extremely variable catch rates. In situations where standardized sampling is not feasible, trap-net set variables should be documented so potential biases in the data can be recognized. This approach would reduce the risk of making erroneous statistical comparisons and unwise management decisions. Although catch statistics can be adjusted to reflect a standardized set of sampling conditions (Somerton and Merritt 1986, Pierce et al. 1990), such data manipulations should be viewed with caution. Additional research should focus on variables that influence the spatial and temporal movements of white crappie (e.g., dissolved oxygen, barometric pressure, wind velocity), and that possibly relate to trap-net performance (substrate firmness), in an effort to improve sampling programs and the management decisions they support.

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