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Assessment of Smallmouth Bass Populations in Iowa Interior Rivers

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Smallmouth bass *Micropterus dolomieu* are a popular sport fish throughout North America and occupy an important ecological role as top predators in aquatic systems. Despite the importance of smallmouth bass, knowledge of their population structure and dynamics in Iowa interior rivers is limited. The objective of this study was to describe population dynamics (e.g., relative abundance, size and age structure, growth, mortality) of smallmouth bass in six Iowa rivers. Smallmouth bass were sampled from the Upper Iowa, Maquoketa, and Wapsipinicon rivers in northeast Iowa and the Des Moines, Iowa, and South Skunk rivers in central Iowa using electrofishing during the fall of 2005. Scales were removed for age and growth estimation. Dorsal spines were removed from fish greater than 350 mm for comparison with scales. Relative abundance, size structure, condition, age structure, growth, and mortality varied among populations. For instance, proportional size distribution varied from 26 to 73, relative weight (*Wr*) varied from 83 to 102, and total annual mortality of age-2 and older fish varied from 23 to 62% among populations. Smallmouth bass in the Maquoketa and South Skunk rivers generally had the fastest growth rates, while smallmouth bass in the Iowa and Wapsipinicon rivers exhibited the slowest growth. This study provides information that contributes to our knowledge of smallmouth bass ecology, and will be useful for guiding management decisions and making regional and national comparisons.

INDEX DESCRIPTORS: smallmouth bass, population characteristics, Iowa rivers.

Smallmouth bass *Micropterus dolomieu* are a popular sport fish in North America (Buynak and Mitchell 2002), particularly in Iowa. For instance, Paragamian (1984) found that smallmouth bass were abundant in all major streams in northeast Iowa and comprised 3–15% of the total angler catch in the 1970s and 1980s. Smallmouth bass remain one of the most important sport fish in Iowa. Smallmouth bass generally inhabit areas of small rivers with swift flowing water and gravel substrates where they are important consumers of fishes, crustaceans, and aquatic invertebrates (IDNR 1987; Pflieger 1997). In Iowa rivers, smallmouth bass begin feeding on fishes at a length of about 38 mm (1.5 inches) and are generally the most abundant piscivore in these systems (IDNR 1987; Paragamian 1980a, 1980b). Consequently, smallmouth bass not only provide important recreational opportunities, but they are an important component in aquatic food webs due to their role as a top predator.

Despite their recreational and ecological importance, information on smallmouth bass populations in Iowa is limited. Descriptive population parameters were investigated on smallmouth bass in Iowa waters in the late 1970s and early 1980s (e.g., Paragamian 1980a, 1980b). Additionally, a few studies have collected basic population parameters information when evaluating catch-and-release smallmouth bass regulations (IDNR 1992, 1999, 2002), but a more recent description of smallmouth bass population parameters is needed for management. The objectives of this study were to provide a general description of the population characteristics (i.e., relative abundance, size structure, age structure, mortality) of smallmouth bass populations and estimate growth of smallmouth bass in six interior river systems of Iowa.

STUDY AREA

Populations sampled as part of this study included those from the Des Moines, Iowa, Maquoketa, South Skunk, Upper Iowa, and Wapsipinicon rivers. The Des Moines, Iowa, and South Skunk rivers are located in central Iowa and the Maquoketa, Upper Iowa, and Wapsipinicon rivers are located in northeast Iowa. The Des Moines, Iowa, and South Skunk rivers are located within the Des Moines Lobe ecological region (Prior 1991). Stream networks within this landform are generally poorly-developed and widely-spaced, while major rivers often have deep, steep-sided valleys. The Maquoketa and Wapsipinicon rivers are within the Iowan Surface ecological region (Prior 1991). Some large rivers in this area have back-water ponds that contribute to a high diversity of aquatic habitat and a diverse fish assemblage. The Upper Iowa River lies within the Paleozoic Plateau ecological region of Iowa (Prior 1991). Rivers and streams in this ecological region are deeply embedded in valleys, and are dominated by cool-water fish assemblages.

MATERIALS AND METHODS

Smallmouth bass were sampled by Iowa Department of Natural Resources (IDNR) fisheries management biologists and Iowa State University (ISU) personnel during the fall of 2005. One location on each study river was sampled (Table 1). Sampling locations on the Upper Iowa and Maquoketa rivers

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Table 1. Sampling information for selected Iowa rivers sampled for smallmouth bass during 2005.

River	Sample dates	Hours of electrofishing
Upper Iowa	August 15–19	5.8
Maquoketa	October 17–26	11.8
Wapsipinicon	September 3	3.0
Iowa	October 18	2.1
South Skunk	October 6	2.0
Des Moines	September 23	1.1

were within special angling regulation areas. All other locations sampled in the study rivers were not managed with special angling regulations, other than a statewide minimum length limit of 305 mm (12 inches). The Upper Iowa and Maquoketa rivers were also the only study rivers to be sampled on multiple dates (Table 1). All sampling was completed using boat-mounted, pulsed-DC electrofishing, except for the South Skunk River which was sampled using a tow-barge electrofishing unit due to water depth and access issues that prevented the use of a boat. Each sampling site was subdivided into 3–10 small, contiguous segments. Fish were sampled and processed separately for each segment. All smallmouth bass were measured to the nearest millimeter (total length) and weighed to the nearest gram. Scales were collected from each fish below the lateral line, beneath the tip of the pectoral fin when extended posterior along the fish's body (Austen and Orth 1988). Scale samples were transferred to coin envelopes and allowed to air dry. Five to ten scale samples per centimeter length group were collected. In addition, the second dorsal spine was collected from fish greater than 350 mm to corroborate scale ages. Spines were removed by cutting the spine at its junction with the body wall. All fish were returned to the river immediately after processing.

Scales were pressed onto acetate slides using a roller-scale press and aged at 30× magnification using a microfiche reader. Dorsal spines were mounted in epoxy and cross-sectioned using an Isomet low-speed saw (Buehler LTD., Lake Bluff, IL). Spines were aged using a stereoscope for comparison with scale ages. All growth measurements (e.g. location of focus, distance to each annulus, distance to scale edge) were digitized using the WinFin program (Nebraska Game and Parks Commission).

Catch-per-unit-effort (CPUE) was estimated as the number of fish captured per hour of electrofishing for each segment within a site. Mean CPUE was estimated for each site by taking the average of all segments. Size structure was analyzed using length structure indices (Willis et al. 1993; Anderson and Neumann 1996). Proportional size distribution (PSD) was estimated as the number of fish greater than or equal to quality length (280 mm) divided by the number of fish greater than or equal to stock length (180 mm), multiplied by 100 (Gabelhouse 1984; Anderson and Neumann 1996; Guy et al. 2007). We also calculated PSDs using the proportion of fish of a specified length group divided by the number of fish greater than or equal to stock length, multiplied by 100 (Anderson and Neumann 1996). We estimated PSDs for preferred- (PSD-P, preferred length = 350 mm), memorable- (PSD-M; memorable length = 430 mm), and trophy-length smallmouth bass (PSD-T; trophy length = 510 mm). Condition of smallmouth bass was evaluated using relative weight (*Wr*; Anderson and Neumann 1996; Blackwell et al. 2000; Kolander et al. 1993).

An age-length key was used to evaluate age structure of each population (DeVries and Frie 1996). Age-structure data were then used to estimate total annual mortality using a catch curve (Ricker 1975). Total annual mortality was estimated for age-2 and older smallmouth bass because age-1 fish were not fully recruited to the sampling gear. Back-calculated lengths at age were estimated using the Fraser-Lee method with a standard *a*-value of 35 millimeters (Carlander 1982; DeVries and Frie 1996).

Differences in mean CPUE and *Wr* among smallmouth bass populations were examined using analysis of variance (ANOVA; Hubert and Fabrizio 2007; Pope and Kruse 2007). When results of the ANOVA indicated differences among populations, least-square means were used to examine pairwise differences in catch rates and condition. Differences in size structure indices (i.e. PSD, PSD-P) were evaluated using a Chi-square analysis (Neumann and Allen 2007).

RESULTS AND DISCUSSION

Catch-per-unit-effort was highly variable among the study populations (Fig. 1). Catch rates of all smallmouth bass were highest in the Maquoketa and South Skunk rivers with mean CPUEs above 100 fish/hr. The lowest catch rates were observed in the Upper Iowa, Wapsipinicon, and Iowa rivers where CPUE generally averaged less than 50 fish/hr (Fig. 1). Similarly, CPUE of substock- and stock-length smallmouth bass were highest in the South Skunk, Maquoketa, and Des Moines rivers and lowest in the Upper Iowa, Wapsipinicon, and Iowa rivers (Fig. 1). Catch rates of quality- and preferred-length smallmouth bass were highest in the Des Moines, South Skunk, Maquoketa, and Iowa rivers. Previous studies on the Upper Iowa River found higher catch rates (i.e., 73 fish/hour in 1977; Paragamian 1980b) than those observed in our study. Conversely, mean CPUE of smallmouth bass in the Maquoketa River was much higher in our study than the previous estimate of 5 fish/hour in 1978 (Paragamian 1989), and more recently 0–15 fish/hour in 2002 (IDNR 2002). Smallmouth bass catch rate varied from 5–71 fish/hour for the Red Cedar River in Wisconsin (Paragamian and Coble 1975), which is similar to catch rates observed in this study. Catch rates for the populations used in the current study were generally higher than those reported for smallmouth bass sampled from the Tennessee River in northern Alabama (Weathers and Bain 1992).

Size structure also varied among populations, PSD varied from 26 to 73 among populations (Fig. 2). The highest PSD values were generally observed for those populations located in central Iowa (i.e. Des Moines lobe), while the Maquoketa, Upper Iowa, and Wapsipinicon rivers (i.e., northeastern portion of Iowa, Iowan Surface and Paleozoic Plateau) had the lowest PSD values. The Des Moines and Iowa rivers had the highest PSD-P and PSD-M values and the Upper Iowa, Maquoketa, and Wapsipinicon rivers had the lowest values (Fig. 2). Although previous data are not available for all populations used in this study, size structure estimates from the Maquoketa River were much higher in our study than those reported from the same system during 1977–1979 (Paragamian 1980a). Proportional size distribution values (i.e., PSD) for the Maquoketa River varied from 11–76 from 1987 to 2002 (IDNR 2002). The Upper Iowa had a similar PSD value in 1977 (i.e., PSD = 19) as compared to our estimate for the same system (Paragamian 1980b). In general, PSD values were much lower for Iowa rivers used in this study compared to smallmouth bass sampled from the Tennessee River in Alabama (Weathers and Bain 1992). However, PSD for the Iowa rivers were much higher than smallmouth bass sampled from Glover

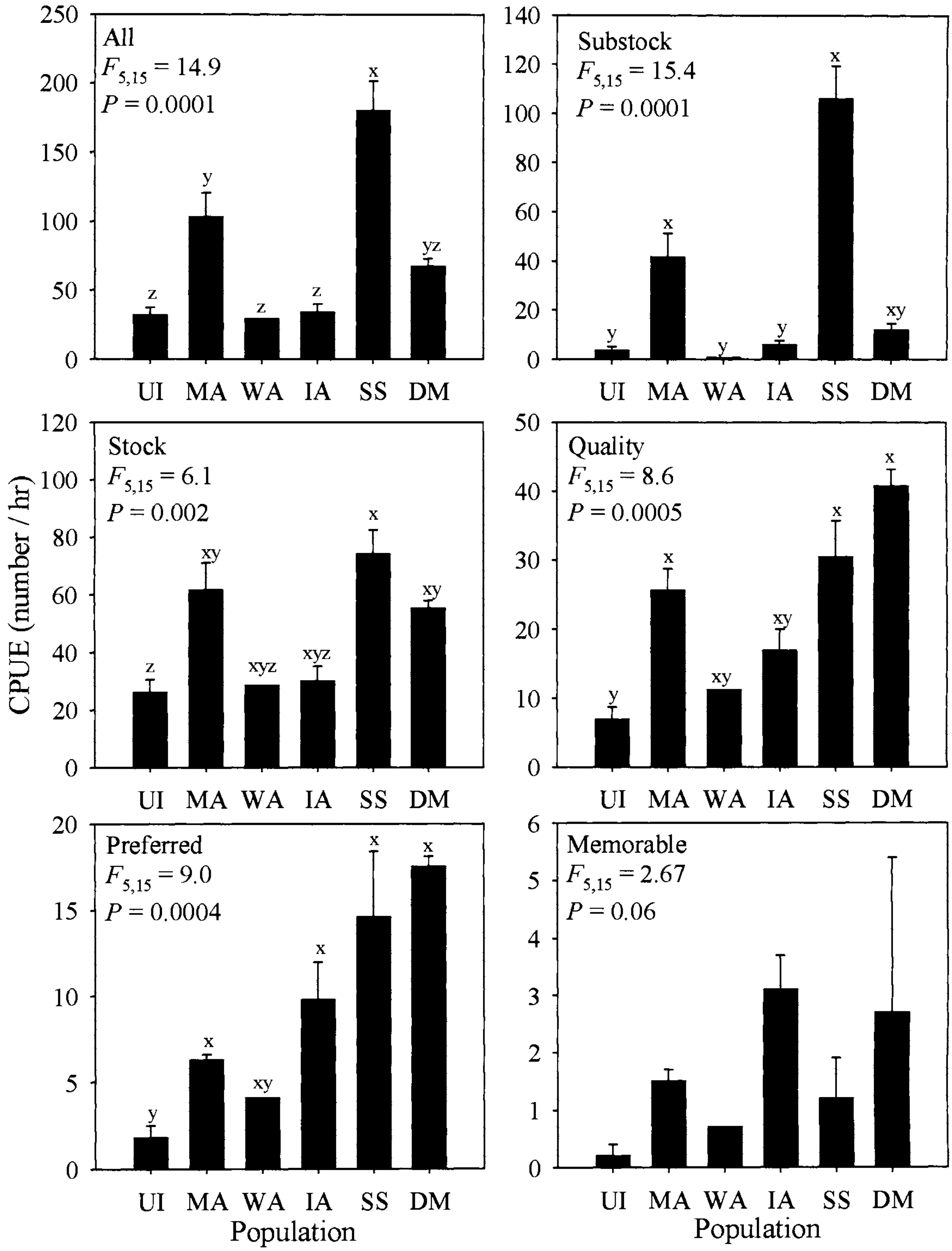

Fig. 1. Catch-per-unit-effort (CPUE = number /hr) of smallmouth bass sampled from six Iowa rivers, 2005. Catch rates are provided for substock- (< 180 mm), stock- (≥ 180 mm), quality- (≥ 280 mm), preferred- (≥ 350 mm), and memorable-length (≥ 430 mm) smallmouth bass. Smallmouth bass populations include the Upper Iowa (UI), Maquoketa (MA), Wapsipinicon (WA), Iowa (IA), South Skunk (SS), and Des Moines (DM) rivers and are sequenced based on latitude (UI is furthest north and DM is the furthest south). Test statistics represent the results from an analysis of variance and populations with the same letter indicate that mean CPUE was not significantly different (i.e., $P > 0.05$) between populations.

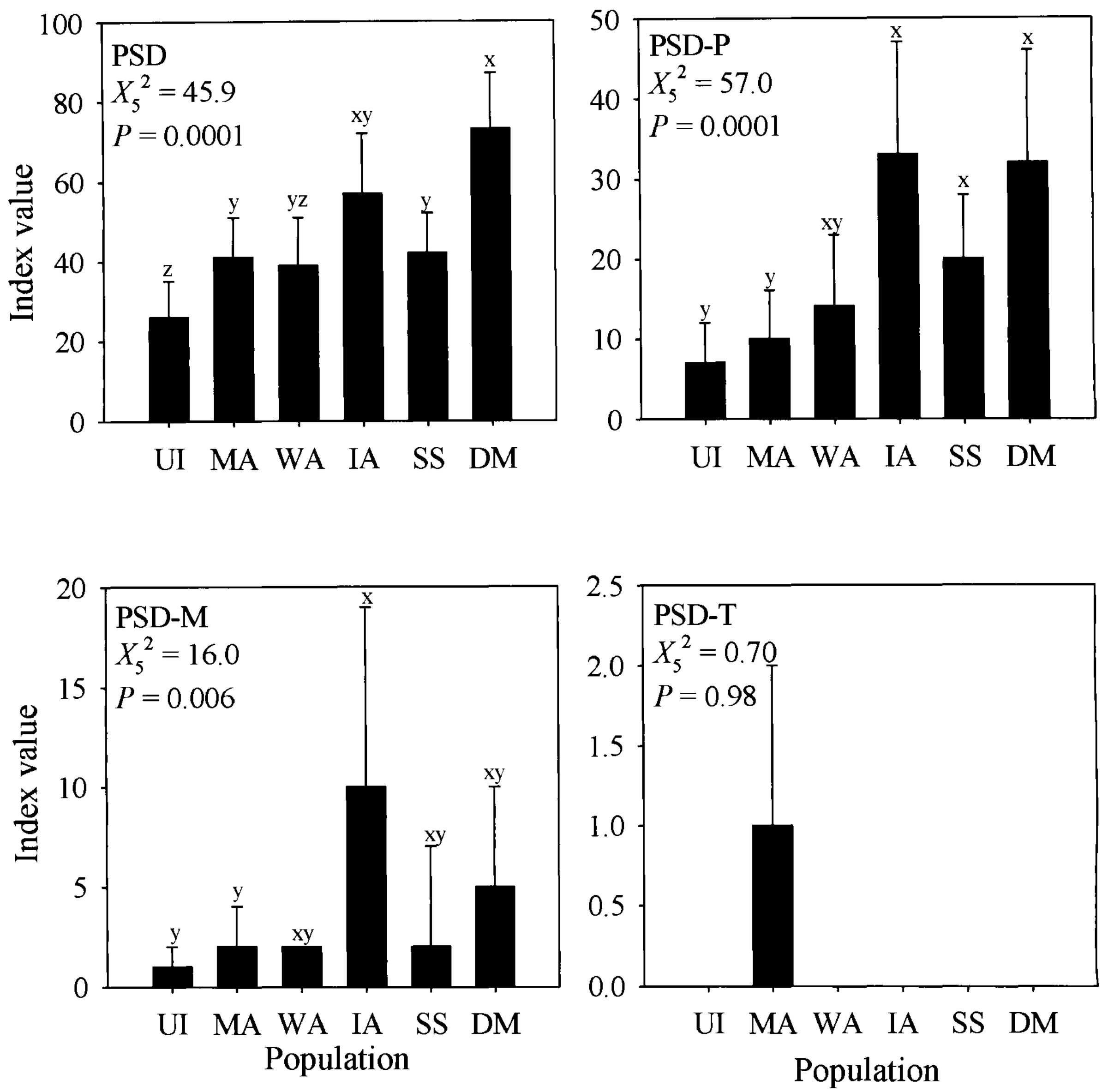

Fig. 2. Proportional size distribution (PSD) values for smallmouth bass sampled from six Iowa rivers, 2005. Proportional size distributions are presented for preferred- (PSD-P, ≥ 350 mm), memorable- (PSD-M, ≥ 430 mm), and trophy-length (PSD-T, ≥ 510 mm) smallmouth bass. Smallmouth bass populations include the Upper Iowa (UI), Maquoketa (MA), Wapsipinicon (WA), Iowa (IA), South Skunk (SS), and Des Moines (DM) rivers and are sequenced based on latitude (UI is furthest north and DM is the furthest south). Test statistics represent the results from a chi-square analysis and populations with the same letter indicate that size structure values were not significantly different (i.e., $P > 0.05$) between populations. No relationships between populations are presented for the PSD-T category because trophy-length (≥ 510 mm) smallmouth bass were only captured from one population.

Creek, Oklahoma (Orth et al. 1983), and the Laramie River, Wyoming (Patton and Hubert 1996).

Mean *Wr* of smallmouth bass was less than 100 for all populations except the Upper Iowa River (Fig. 3). Smallmouth bass from the Maquoketa and Des Moines Rivers were generally in poor condition relative to the other populations. However, smallmouth bass mean *Wr* for the Maquoketa River was similar to mean *Wr* estimates from 1987–2001 (IDNR 2002) Although mean *Wr* varied among populations for each length category, mean *Wr* generally decreased with increasing length. This observation differs from smallmouth bass collected from the Tennessee River in Alabama, where mean *Wr* averaged over 100 for smallmouth bass greater than 300 mm (Weathers and Bain 1992). Additionally, considerably lower *Wr*s were found for smallmouth bass in the New River in Virginia where mean *Wr* varied from 73 to 83 in 1982 (Austen and Orth 1988). The range of mean relative weight of these streams is comparable to an unexploited Missouri Ozark stream (Reed and Rabeni 1989). Water temperature has been shown to affect variability in relative weight and therefore may need to be considered in future investigations (McClendon and Rabeni 1987).

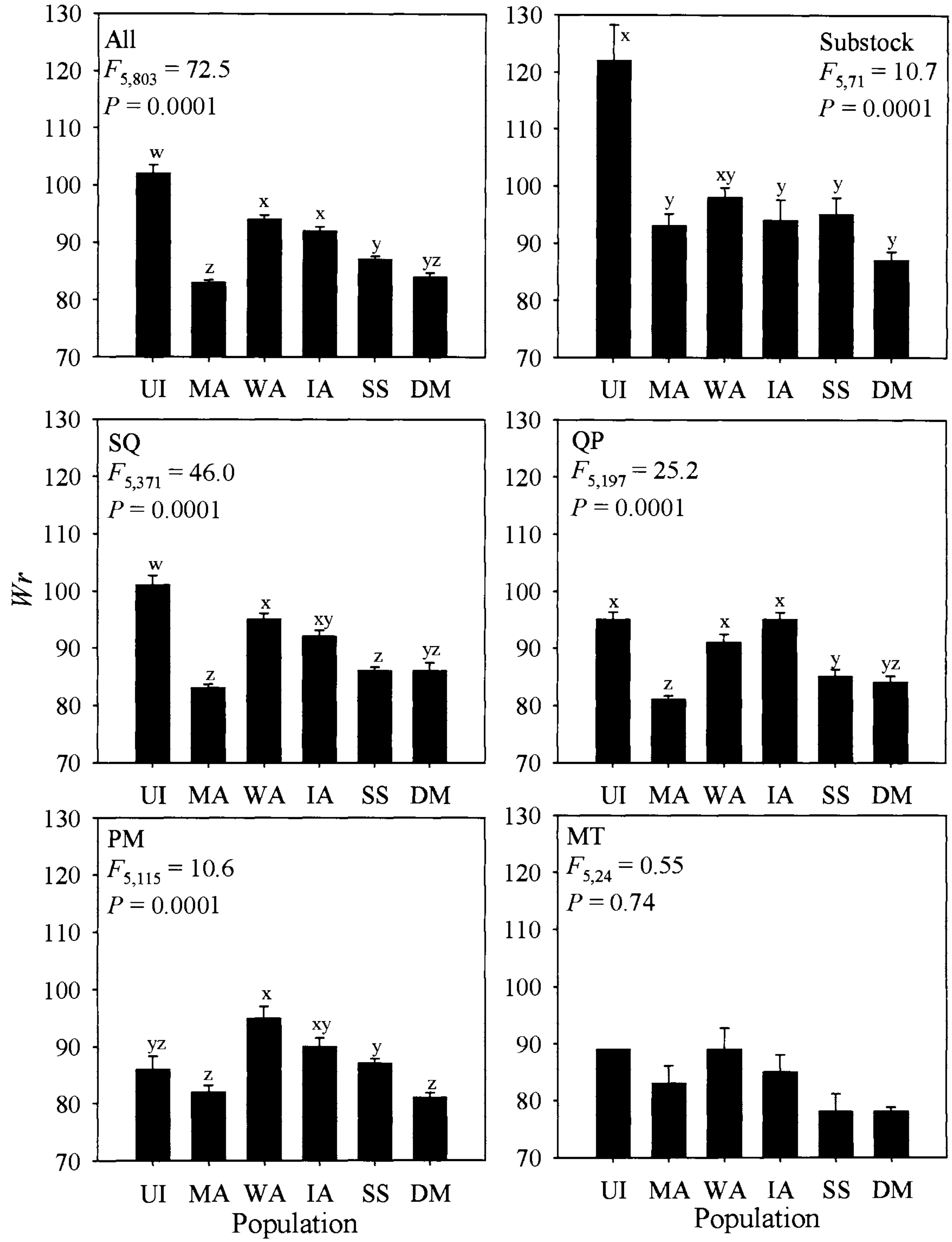

Fig. 3. Relative weight (*Wr*) values for smallmouth bass sampled from six Iowa rivers, 2005. Relative weight is presented by incremental size categories including substock- (< 180 mm), stock- to quality- (180–279 millimeters), quality- to preferred- (280–349 mm), preferred- to memorable- (350–429 mm), and memorable- to trophy-length (430–509 mm) smallmouth bass. Smallmouth bass populations include the Upper Iowa (UI), Maquoketa (MA), Wapsipinicon (WA), Iowa (IA), South Skunk (SS), and Des Moines (DM) rivers and are sequenced based on latitude (UI is furthest north and DM is the furthest south). Test statistics represent the results from an analysis of variance and populations with the same letter indicate that relative weight values were not significantly different (i.e., $P > 0.05$) between populations.

Table 2. Mean back-calculated lengths at age (mm) and total annual mortality estimates (*A*; %) of smallmouth bass sampled in selected Iowa rivers during 2005. Numbers in parentheses represent one standard error.

		Mean back-calculated length at age (mm)								
River	N	1	2	3	4	5	6	7	8	A
Upper Iowa	86	93 (3)	173 (4)	246 (4)	322 (11)	379 (9)	415 (14)	449 (0)		61.9
Maquoketa	168	95 (3)	179 (9)	259 (8)	332 (7)	389 (5)	430 (6)	466 (12)	500 (0)	43.5
Wapsipinicon	73	90 (5)	162 (7)	219 (9)	279 (12)	323 (21)	415 (0)			43.4
Iowa	60	93 (4)	157 (6)	214 (11)	263 (14)	319 (13)	371 (12)	412 (3)	435 (0)	22.9
South Skunk	174	86 (3)	157 (9)	241 (12)	323 (11)	387 (19)	461 (0)			59.2
Des Moines	63	90 (3)	173 (8)	250 (7)	314 (5)	356 (0)				35.9

The Iowa River had the lowest total annual mortality estimate (23%), while the Upper Iowa River (62%) had the highest mortality estimate (Table 2). The Des Moines and Iowa rivers had relatively low mortality estimates compared to the South Skunk River which had a relatively high mortality estimate. Previous research in Iowa found that total annual mortality was between 62 and 89% from 1977 to 1979 in the Maquoketa River (Paragamian 1980a). In 1977, total annual mortality for the Upper Iowa River was only 42% (Paragamian 1984). In Wisconsin, high estimates of total annual mortality between 52–65% were found for the Galena River and are most comparable to estimates obtained for the Upper Iowa and South Skunk rivers (Forbes 1989). Similarly, total annual mortality estimates were also found to exceed 50% in the Red Cedar and Plover rivers of Wisconsin (Paragamian and Coble 1975).

Age of smallmouth bass varied from age 0 to age 8 among populations in Iowa rivers (Table 2), but most fish were less than age 4. Smallmouth bass sampled from the Maquoketa and South Skunk rivers exhibited the fastest growth, while smallmouth bass from the Iowa and Wapsipinicon rivers had the slowest growth rates (Table 2). Growth of smallmouth bass in the Des Moines River was similar to that of smallmouth bass in the South Skunk River until age 4, but then decreased thereafter. A similar pattern was observed for smallmouth bass in the Maquoketa and Upper Iowa rivers in northeastern Iowa. Growth of smallmouth bass in the Maquoketa River (i.e., current study) was similar to growth of smallmouth bass observed in 1977 (Paragamian 1984). In contrast, growth estimates for the Upper Iowa River were higher than those observed in 1977 (Paragamian 1984). Results from our study are comparable to those found for growth of smallmouth bass in Wisconsin (Paragamian and Coble 1975; Forbes 1989) and Missouri (Reed and Rabeni 1989).

Numerous abiotic and biotic factors have been shown to influence growth of smallmouth bass. For instance, Putnam et al. (1995) found that the percent substrate as large cobble had a negative influence on growth of large smallmouth bass (i.e., greater than 200 mm). The authors speculated that the result was likely due to large smallmouth bass selecting large cobble substrate and the concentrations of large smallmouth bass influenced their growth rates through density-dependent inter-acations. Similarly, Paragamian (1991) found that population densities of smallmouth bass were low in Iowa stream reaches with silt-dominated substrates. Stream discharge can also affect smallmouth bass growth. Paragamian (1987) found that growth of age-1 smallmouth bass was highest in streams with stream discharge at 10 m^3/s. However, large (i.e. age 2–4) smallmouth bass were not affected by stream discharge to the same extent at age-1 fish (Paragamian 1987). Beamesderfer and North (1995) showed that growth of smallmouth bass decreased as the number of days with temperatures greater than 10°C increased. Although the purpose of this study was not to determine specific factors associated with growth, these factors (e.g., density-dependence, instream habitat) should be further evaluated to better understand the influence of abiotic and biotic conditions on smallmouth bass growth rates.

Population characteristics of smallmouth bass in Iowa rivers were highly variable and few consistent patterns were observed among populations. Habitat quality, environmental conditions, and management regulations likely influence smallmouth bass populations in Iowa (e.g., Paragamian 1991; Beamesderfer and North 1995; Orth and Newcomb 2002). For example, the Maquoketa and South Skunk rivers exhibited the fastest growth rates, despite differences in ecological regions, instream habitat, flow dynamics, and fish assemblage structure. As such, unmeasured abiotic and biotic factors are likely having a substantial influence on the population dynamics of smallmouth bass in Iowa rivers. Unquestionably, further research on small-mouth bass populations in Iowa rivers is needed to help elucidate factors influencing their population dynamics. However, this study provides a foundation for future research on these populations. Investigations on the influence of environmental variables and population modeling with regards to management regulations are avenues that should be explored. Although the results of this study are largely descriptive, these data contribute to our knowledge of smallmouth bass population dynamics in Midwestern river systems and provide information that can be used to make regional comparisons.

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