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Variation in Population Characteristics and Gear Selection between Black and White Crappies in Tennessee Reservoirs: Potential Effects on Management Decisions

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Abstract.—The population characteristics of crappies *Pomoxis* spp. were examined in three Tennessee reservoirs (Kentucky, Barkley, and Woods) sampled in fall with trap nets and electrofishing. Kentucky and Barkley reservoirs are large main-stem impoundments on the Tennessee and Cumberland rivers, respectively. Woods Reservoir is a small tributary storage impoundment on the Elk River in south-central Tennessee. Mean length at age was similar between white crappies *P. annularis* and black crappies *P. nigromaculatus* at ages 1 and 2 in Barkley Reservoir and at age 1 in Kentucky Reservoir. Thereafter, white crappies were consistently larger than black crappies at older ages, and the differences in mean length commonly exceeded 30 mm once the fish in both reservoirs were age 4. Crappie species compositions in concomitant electrofishing and trap-net samples were relatively similar in the two main-stem reservoirs. However, black crappies represented much higher proportions in the trap-net samples than they did in the electrofishing samples in Woods Reservoir. Electrofishing consistently collected larger fish than trap nets in all three reservoirs. Managers should be aware that variability in species composition and size structure due to sampling area and gear type can affect the estimates of crappie population characteristics, which can, in turn, affect modeling results and ultimately management decisions. We feel that the best sampling regime for collecting crappies in Tennessee reservoirs would be to use fall trap-net sampling to index year-class strength and concurrent electrofishing sampling to collect the larger individuals necessary for age and growth analysis.

Black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis* are important species in reservoir fisheries, often ranking first or second in angler preference (McDonough and Buchanan 1991; Mitzner 1991). However, sampling crappies to adequately depict rate functions, abundance, and species composition can be difficult to do in reservoirs. The primary tool used by fisheries managers to sample crappies has been the trap net (Gablehouse 1984; Colvin and Vasey 1986), which usually provides sufficient catches of age-0 or age-1 fish to estimate year-class strength (Boxrucker and Ploskey 1989; Maceina and Stimpert 1998). However, the use of trap nets has been ineffective in sampling crappies in many southeastern systems (Maceina et al. 1998; Sammons and Bettoli 1998a), and some biologists have attempted to modify traditional trap-net design to increase catch rates (Miranda et al. 1996).

Although black crappies and white crappies have different growth and food habits (Ellison 1984; Mosher 1984), these species are usually managed together because anglers rarely differentiate between them when fishing (Mitzner 1991; Maceina et al. 1998; Hale et al. 1999). In many systems, one species is more abundant than the other. Little is known of the differences in population characteristics between sympatric populations of black and white crappies, and no study has evaluated the differences in sampling biases between the two species. If population characteristics vary significantly between species, species-specific sampling bias may potentially affect management decisions when species are combined.

In Tennessee, trap nets are commonly used for sampling crappies, but low catch rates often limit the utility of the data. Because of the difficulties encountered in sampling crappies, crappie growth is undescribed for some Tennessee reservoirs and

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TABLE 1.—Reservoir type, area, mean depth (Z), mean annual hydraulic retention time (HRT), typical winter water level drawdown, and mean chlorophyll-*a* concentration (CHLA) for three Tennessee reservoirs sampled for black and white crappies during 1998–1999. Information for all reservoirs was obtained from various unpublished reports or calculated from data supplied by the Tennessee Valley Authority and the U.S. Army Corps of Engineers.

Reservoir	Type	Area (ha)	Z (m)	HRT (d)	Drawdown (m)	CHLA (μg/L)
Barkley	Main-stem	23,458	4.6	6	1.6	21.5
Kentucky	Main-stem	64,922	5.2	23	1.6	13.7
Woods	Tributary	1,612	5.7	85	1.0	8.0

poorly described in others. Although the differences in lengths and numbers of crappies collected by trap nets and electrofishing have been reported (Boxrucker and Ploskey 1989; McInerny 1989; Miranda et al. 1992), species selectivity has not been evaluated. Our purpose is to describe and compare the population characteristics of black and white crappies collected in three Tennessee reservoirs, and to evaluate the sampling biases associated with using trap nets and electrofishing gear to sample crappies.

Study Sites

Three reservoirs in Tennessee's Cumberland and Tennessee river drainages were sampled for crappies during the study (Table 1). The reservoirs exceeded 1,000 ha and were operated for water supply, flood control, and hydropower generation. Water level fluctuations followed a similar pattern in most study reservoirs. Water levels were drawn down in the fall to create storage space for winter floods, and reservoirs were allowed to fill during each spring. Retention times were generally lower for the main-stem reservoirs and higher for the tributary storage impoundment (Table 1).

Methods

Crappie Sampling

Crappies were collected in fall from 1998 to 1999 using electrofishing gear and trap nets (Table 2). Trap-net samples were obtained during the Tennessee Wildlife Resource Agency's (TWRA) annual fall sampling program. Trap nets were standard, Indiana style nets with 13-mm mesh (Colvin and Vasey 1986). Nets were set in fixed locations within each reservoir; fish were removed from the nets after 24 and 48 h. Total net nights ranged from 34 to 108 net nights per reservoir and followed TWRA reservoir sampling protocols (TWRA 1998). Electrofishing samples were collected during the day using a DC electrofishing boat equipped with boom-mounted electrodes (7 A current). Crappies were collected from a maximum of 10 sites allocated along the length of the reservoir. Since sampling was designed specifically to obtain large numbers of fish ($N > 100$), sample sites were not standardized by transect length or time. Only the Tennessee portions of Kentucky and Barkley reservoirs were sampled.

TABLE 2.—Sampling gear used (TN = trap net, EF = electrofishing) and total number of crappies sampled in three Tennessee reservoirs during 1998–1999.

Reservoir	Year	Gear	Black crappies	White crappies
Barkley	1998	EF	199	369
	1998	TN	268	1,192
Kentucky	1998	EF	302	539
	1998	TN	857	1,321
Woods	1999	EF	29	57
	1999	TN	40	15

The total length (TL; mm) and weight (g) were recorded for each crappie collected. Sagittal otoliths were removed from a maximum of 10 crappies of each species in each 25-mm size-group for age analysis. Aging procedures followed those in Heidinger and Clodfelter (1987). Ages were assigned to fish that were not aged using age-length keys (Ricker 1975). Black-nosed crappies, a morphological variant of the black crappie characterized by a black predorsal stripe (Buchanan and Bryant 1973), were stocked annually in Woods Reservoir throughout the duration of this study (Isermann et al., in press [a]). They were not included in the species composition analysis for this reservoir since we expected that stocking could artificially inflate the numbers of these fish found in our samples.

Data Analyses

Growth.—Growth was analyzed by calculating mean TL at age. Fish were assumed to have completed growth for that year, and age data were corrected by adding 1 to each age prior to analysis.

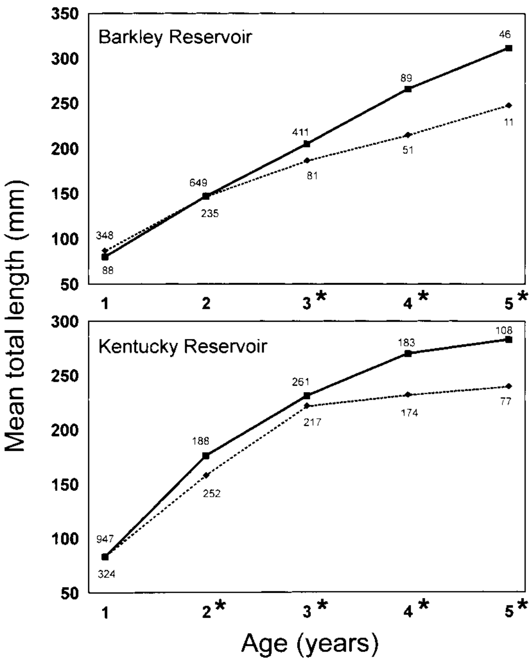

FIGURE 1.—Mean length at age of age-1 to age-5 black crappies (dotted lines) and white crappies (solid lines) collected from two Tennessee reservoirs in 1998. Numbers indicate the sample sizes for each age and species. Asterisks indicate that the mean length at age was different between species (t-test; $P < 0.02$).

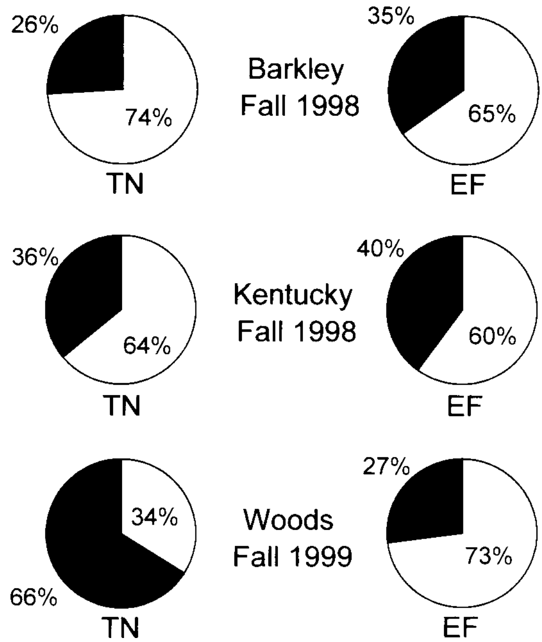

FIGURE 2.—Species composition (dark areas indicate black crappies, white areas white crappies) of samples taken from three Tennessee reservoirs from 1998 to 1999 using trap nets (TN) and electrofishing (EF).

The effect of gear type on mean TL at age was assumed to be negligible; therefore, electrofishing and trap-net data were combined to calculate mean TL at age. Mean TLs at age 1 to age 5 were compared in Kentucky and Barkley reservoirs to define age-related growth differences between the species; sample sizes were not adequate to allow this comparison in Woods Reservoir. Growth was compared only when n was 10 or larger for each species and age combination. Total lengths were $\log_{10}$ transformed to homogenize the variances, and the differences between species were assessed using t-tests (significance: $\alpha = 0.02$; Bonferroni adjustment, 0.1/5; SAS Institute 1996).

Gear selection.—Species composition was compared between sampling gears with Z-tests (Steel and Torrie 1980). The length frequencies in the trap-net and electrofishing samples from Barkley, Kentucky, and Woods reservoirs were compared using a Kolmogorov–Smirnov test; the mean lengths ($\log_{10}$ transformed) of fish collected in both gears were compared using a t-test (significance: $\alpha = 0.10$).

Results

A total of 5,218 crappies were collected during the course of this study, including 1,711 black crappies and 3,507 white crappies (Table 2). Approximately one-third of these fish were collected by electrofishing; the remainder were collected in trap nets. The mean TL of black crappies was smaller than that of white crappies at most ages in Kentucky and Barkley reservoirs; however, large differences in mean TL at age were not observed until crappies had reached age 4 (Figure 1).

White crappies represented a higher percentage of the trap-net catch than concomitant electrofishing catches in Kentucky ($Z = 2.02$; df = 3,017; $P < 0.05$; Figure 2) and Barkley reservoirs ($Z = 3.45$; df = 1,253; $P < 0.01$; Figure 2). In both cases, however, the differences in species compositions between the gears were relatively small (<10%) and may be an artifact of extremely large sample sizes. In contrast, white crappies represented 66% of the electrofishing sample but only 27% of the trap-net sample in Woods Reservoir ($Z = 3.01$; df = 139; $P < 0.01$; Figure 2).

The length frequencies of crappies collected in concomitant electrofishing and trap-net samples were different in Barkley (Kolmogorov–Smirnov

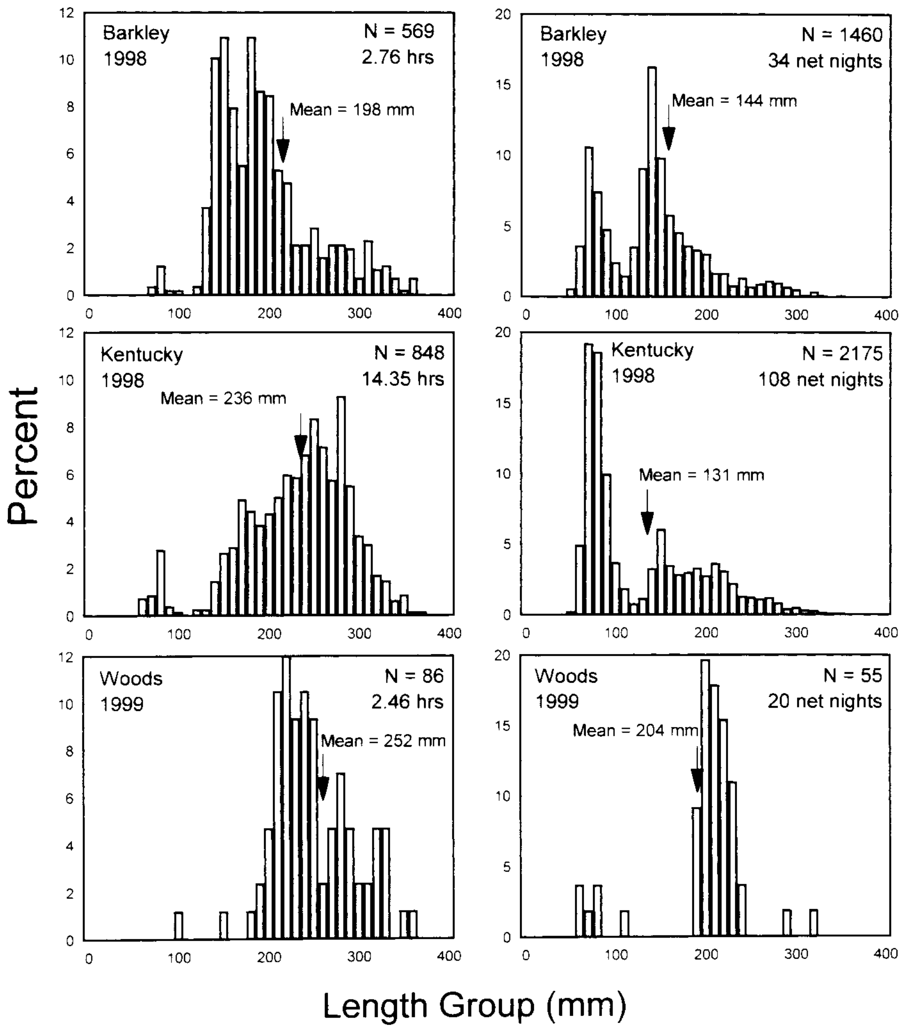

FIGURE 3.—Length frequencies (10-mm length groups) of black and white crappies collected in trap-net (TN) and electrofishing (EF) samples from three Tennessee reservoirs in 1998–1999.

test; KSa = 8.9; *P* = 0.0001), Kentucky (KSa = 15.0; *P* = 0.0001), and Woods (KSa = 3.0; *P* = 0.0001) reservoirs (Figure 3). Electrofishing consistently collected larger fish than did the use of trap nets in all three systems; the mean TL of crappies in trap nets was smaller than the mean TL of crappies in electrofishing in Barkley (*t* = 20.13; df = 1,035; *P* = 0.0001), Kentucky (*t* = 41.37; df = 3,014; *P* = 0.0001), and Woods reservoirs (*t* = 5.86; df = 108; *P* = 0.0001) (Figure 3).

Discussion

Black crappies grew more slowly than white crappies in most reservoirs. While white crappies are commonly thought to grow faster than black crappies due to their more piscivorous diet (Ellison 1984), this belief is not always supported by empirical data (Mosher 1984; Hale et al. 1999). The mean TL at age of black and white crappies were similar at ages 1 and 2 in Barkley Reservoir, and at ages 1–3 in Kentucky Reservoir; by age 4, the mean TL of black crappies was more than 30 mm smaller than that of white crappies in both systems. These divergences in growth rates were similar to those observed in a small Nebraska lake by Ellison (1984), where growth divergence between the species was attributed to diet differences; black crappies remained insectivores while white crappies switched to piscivory once they attained 200 mm.

The use of trap nets consistently resulted in the collection of smaller fish than did electrofishing in all three reservoirs. Trap nets have been used extensively in the Midwest to collect large samples of crappies of all sizes (Gablehouse 1984; Colvin and Vasey 1986; Boxrucker and Ploskey 1989; Guy et al. 1996). However, biologists in the southeastern United States often have less success using trap nets (Miranda et al. 1996; Maceina et al. 1998; Sammons and Bettoli 1998a; Allen et al. 1999); in some Tennessee reservoirs, trap net use does not yield larger fish at all, so the nets are used only in recruitment estimation (T. Churchill, TWRA, personal communication). Mesh size has often been considered a factor in determining the catch rates of trap nets, but Boxrucker and Ploskey (1989) and Miranda et al. (1992) both found that the use of trap nets with the same mesh as those used in our study sampled a wider range of sizes, and collected more fish, than did electrofishing. Besler et al. (2000) found that the catch rate of crappies approximately doubled with each increase in mesh size from 13 to 25 mm in North Carolina reservoirs, although little effect was seen on the size structure of samples collected from each mesh.

A greater percentage of black crappies were collected using trap nets than in electrofishing samples in Woods Reservoir, but species composition was more homogenous between sampling methods in Kentucky and Barkley reservoirs (possibly owing to the shallower basin morphology present in main-stem impoundments). Trap nets are passive-capture gears; therefore, successful sampling with trap nets requires that the target fish move and that the fish use the habitats where the nets are deployed. Crappies can be distributed offshore at certain times of the year where they may not be vulnerable to capture by trap nets (Gebhart and Summerfelt 1975). However, black crappies also dominated (>80%) the species composition of trap-net samples from Tennessee's Normandy Reservoir in the spring (when all fish should be shallow), while concomitant angling samples contained slightly more white crappies than black crappies (Sammons and Bettoli 1998a). Also, black crappies were often collected in offshore fall gill net samples (another passive gear) from Normandy Reservoir, whereas white crappies were rare in the same samples (Sammons and Bettoli 1998a). All of this implies that black crappies may simply exhibit greater movement rates than white crappies in tributary storage impoundments, making them more vulnerable to passive gears than white crappies. Conversely, electrofishing is an active-capture gear and capture rates may not be as affected by fish behavior.

Management Implications

Maximizing the predictability of models requires that the best possible data be used for the question at hand. If significant size or species bias exists in the sampling gear used to collect the data, then the result of the modeling effort may be incorrect. In Tennessee reservoirs, trap nets appeared to be biased toward small fish, which would overestimate mortality for older age-classes. Additionally, trap nets may select for black crappies in tributary storage impoundments. If both species are present, then sample bias towards black crappies could result in underestimated growth and survival rates of the crappie population. Since slower growth and higher mortality are two key factors that cause length limits to be ineffective (Allen and Miranda 1995; Isermann et al., in press [b]), biasing a sample of crappies toward black crappies could cause length limits to be dropped or not implemented when, in fact, they may allow benefits if faster-growing, longer-lived white crappies are more numerous than samples indicate. In contrast, electrofishing appeared to select for larger fish in the Tennessee reservoirs, and may have yielded a more representative species composition in tributary storage impoundments than trap nets. Electrofishing in the fall was particularly effective at describing growth, since sufficient numbers of all age-classes were collected.

Heterogeneity among reservoirs dictates that crappie sampling be tailored to individual systems to be most effective. In Tennessee main-stem reservoirs, trap nets allowed for the estimation of recruitment and survival of younger ages, whereas electrofishing was useful for estimating survival of older age-classes. Combining data from both gears resulted in a better and more complete estimate of growth than that obtained from either gear alone. By combining these gears, total effort should actually decrease; we rarely spent more than 3 d electrofishing each system to obtain the samples used in this study (mean effort = 5.13 h pedal time; range = 2.50–14.35 h).

In contrast, trap nets were not effective in collecting fish beyond age 1 in Woods Reservoir and may have been biased toward black crappies. In this system, electrofishing (particularly in the spring) was clearly superior in providing age and growth data (Isermann et al., in press [b]). In systems where fall sampling is ineffective, we suggest the implementation of a larval sampling program to index year-class strength (Sammons and Bettoli 1998b) and the use of spring electrofishing to obtain age and growth data. We suggest that other management agencies could also benefit from studies of this sort, and that the existing sampling programs for any species should be periodically scrutinized using multiple gears to ensure that the data obtained from such programs accurately reflect the population parameters of crappies in their systems.

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