An Evaluation of Crappie Supplemental Stocking in Arkansas Impoundments

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Abstract: Supplemental stocking of sport fish has been an important management tool used by fisheries management agencies, but published accounts of stocking success are infrequent. Both black crappie (*Pomoxis nigromaculatus*) and white crappie (*P. annularis*) have been stocked throughout the southeastern United States with over one million stocked annually in Arkansas alone. Stocking contribution was determined for six impoundments that ranged in size from 58 to 503 ha. In October 2010 and 2011, crappies were marked with oxytetracycline hydrochloride and stocked at rates that ranged from 53 to 246 fish ha^{-1}. Age-0 crappies were collected using trap nets each month for three months following the 2010 stocking but size selective gear bias precluded accurate short-term contribution estimates. Trap net collections in 2011 and 2012 produced no marked age-1 crappies in any impoundment. Low stocking contribution may be related to a combination of the presence of a strong natural year class, high mortality associated with the stocking process, naivety to predators, or a competitive disadvantage of stocked crappie due, in part, to relatively small size at stocking. Additional evaluation of crappie stocking techniques, fate of stocked crappies, and management strategies for improving crappie year-class strength are warranted.

Key words: oxytetracycline, stocking contribution, *Pomoxis*

Crappie (*Pomoxis spp.*) fishing is popular throughout the United States, especially in the southeast. In 2011, 46% of Arkansas anglers targeted crappies, making them the most sought after species in the state, just ahead of black bass (*Micropterus* spp.) (U.S. Fish and Wildlife Service and U.S. Census Bureau 2011). High variability in recruitment is typical of crappie populations (Allen and Miranda 1998, 2001) and can create difficulties for fisheries biologists to manage crappie populations effectively (Maceina and Stimpert 1998). Supplemental stocking of crappies has been utilized as a management tool by several state agencies (Myers et al. 2000, Isermann et al. 2002, Racey and Lochmann 2002). More than one million crappies are stocked annually through the Arkansas Game and Fish Commission's (AGFC) hatcheries and nursery ponds (J. Miller, AGFC, personal communication).

Although large numbers of crappies are stocked, most previous studies have reported low contribution to year-class strength. Myers et al. (2000) found that only 4.8% of black crappie (*P. nigromaculatus*) sampled 10 months after stocking were stocked fish in Lake Jeffords, Florida. Racey and Lochmann (2002) evaluated white crappie (*P. annularis*) stocked into Lake Chicot, Arkansas, and found contributions ranged from 0.0% to 3.1% over several years. Isermann et al. (2002) found that year-class contribution of black-nosed crappie, a morphological variant of the black crappie, in three Tennessee reservoirs varied from 0% to 93%. These studies suggested that variable stocking contribution can be related to

high mortality due to handling and hauling stress, mortality by predation from resident piscivores, or naturally strong year classes.

Managing a crappie fishery by stocking hatchery fish presumes that other management strategies would be less effective than stocking, that resources are best used by growing crappie for supplemental stocking, and that stocked crappie contribute to the fishery. Without an assessment of stocking success, these presumptions cannot be evaluated. Thus the objectives of our study were to estimate short-term (1 to 3 mo) and long-term (1 yr) contributions of stocked crappies to year classes in Arkansas impoundments and to compare the size structure of stocked and wild cohorts.

Methods
Study Area

Our study was conducted in six Arkansas impoundments ranging in size from 58 to 503 ha that were historically stocked with crappies by the AGFC (Table 1). Impoundments were selected among a candidate pool to ensure a broad range of historical natural recruitment. Rotenone data collected by the AGFC from 1986 to 2009 (S. Todd, AGFC, personal communication) were examined and mean densities of age-0 crappies (fish ha^{-1} ≤100 mm TL) were calculated to assess natural recruitment history. Recruitment ranged from 449 to 4189 fish ha^{-1} among impoundments (Table 1). In addition, annual recruitment variability was high as coefficient of variation ranged from 94% to 232% among impoundments.

Table 1. Impoundment surface area (ha), historical recruitment (fish ha-1 ± SD), and mean catch per unit effort (fish net-night-1; CPUE) of the crappie species stocked. Historical recruitment is the mean fish ha-1 of age-0 (≤100 mm) black crappie (BC) and white crappie (WC) collected in cove rotenone samples by the AGFC during the period 1986 to 2009.

Impoundment	Surface area	Historical recruitment	Species stocked	Age-1 CPUE	
				2010 year class	2011 year class
Barnett	100	449 ± 782 $n = 13$	BC	0.7	1.2
Cargile	58	726 ± 778 $n = 8$	WC	2.2	2.2
Cox Creek	103	661 ± 1531 $n = 10$	BC	<0.1	<0.1
Harris Brake	503	2971 ± 6648 $n = 18$	WC	<0.1	1.2
Overcup	345	3453 ± 3424 $n = 18$	WC	5.9	1.2
Upper White Oak	248	4189 ± 3922 $n = 23$	BC	4.9	0.1

Crappie Marking

Crappies were raised to fingerling size in ponds by AGFC biologists at three state hatcheries. Oxytetracyline hydrochloride (500 mg L^{-1} in 1000- to 2400-L holding vats) marking was conducted in October 2010 and 2011. Anhydrous sodium phosphate dibasic buffer was added to the oxytetracycline (OTC) solution to stabilize the pH of the marking solution before the solution was added to holding vats (Isermann et al. 1999). Water temperature, pH, and dissolved oxygen were monitored during the marking process (Parker 2002). Aeration was constant and additional buffer was added if pH fell more than 0.5 units during the marking process. Crappies remained immersed for 6 h and once marking was completed the OTC solution was flushed from the holding vats.

A sub-sample of at least 50 fish from each vat was measured for total length (TL, mm) to determine size of stocked fish in 2010. Estimating stocking contribution of age-0 crappie in 2010 was unsuccessful due to size selectivity of the trap nets, so total lengths of stocked fish were not measured in 2011. Numbers of fish stocked were estimated gravimetrically in both 2010 and 2011. Hauling densities never exceeded 0.12 kg L^{-1} and marked crappies were stocked at boat ramps at the respective impoundments. Prior to stocking, hauling truck water was tempered with lake water using standard AGFC protocols. Stocking rates were generally based on a combination of fish availability and the AGFC crappie management plan recommendation to stock fewer than 125 fish ha^{-1} for reservoirs smaller than 1215 ha (AGFC 2002).

In 2010, 30 to 40 crappies were collected from each vat immediately after completion of OTC marking to evaluate marking efficacy. Crappies were held in 100-L recirculating tanks at 20 C for one month. Water quality was maintained via particulate, chemical, biological, and ultraviolet treatments. Fish were fed brine shrimp (*Artemia* spp.) nauplii and instars daily, *ad libitum*. After one month, sagittal otoliths were removed from the crappies and examined by two readers for OTC marks. Sagittal otoliths were cleaned and mounted dorsal side down on a standard glass microscope slide in thermoplastic cement (Isermann et al. 1999, Racey and Lochmann 2002). Otoliths were viewed at 4 – 100 × magnification using an Olympus BX-50 compound microscope fitted with a 100-W, high-pressure mercury burner; and an Olympus filter cube (420- to 490-nm excitation filter, 505-nm dichroic mirror, and a 515-nm barrier filter). Otoliths were wet ground with 800-grit sand paper to make OTC marks more visible. Marking efficacy was calculated as the percentage of otoliths with an OTC mark.

Field Collection

Age-0 crappies from the six study impounds were collected in 2010, and age-1 fish from both stocking years were collected in 2011 and 2012. Due to suspected under sampling age-0 crappie due to gear bias in 2010, we did not attempt to evaluate stocking contribution of age-0 fish the following year. Impoundments were sampled using approximately 30 trap net-nights each month for three months beginning one month post-stocking, in November (AGFC 2002). Trap nets (1.3-cm square mesh) were constructed of two rectangular frames (0.9 m high × 1.8 m wide, spaced 76 cm apart) followed by four 0.8-m diameter hoops spaced 0.6 m apart. Leads were 15 m in length and 1 m deep and permanently attached to the second frame center brace. Nets were set perpendicular to the shoreline at the mouth of coves, off points, or areas near old river channels for 24 h. In 2011 and 2012, sampling specifically targeted age-1 crappies with a target goal of collecting 100 age-1 crappies of the species stocked in each impoundment the previous year. Fish ≤275 mm TL were identified as potential age-1 based on length-age analysis conducted for each impoundment (Wright 2012). All crappies were identified to species and measured for TL. Otoliths of age-0 (2010) and age-1 (2011 and 2012) crappies of the species stocked were examined for the presence of an OTC mark as previously described. Fish with OTC marks were considered to be stocked fish.

Data Analysis

Stocking contribution (%) of crappies in each impoundment was estimated as the percentage of OTC-marked crappies collected during trap net sampling. Catch-per-unit-effort (CPUE; fish net-night^{-1}) was calculated for age-1 crappies in 2011 (2010 year class) and 2012 (2011 year class) in each impoundment. We compared the size distribution of hatchery fish stocked in October 2010 to

the size distribution of wild fish collected from all impoundments in November 2010. Three hundred and fifty fish, representing all three hatcheries, were measured prior to stocking. A random subsample of 40 hatchery fish, weighted according to the respective contributions of each hatchery to the total number of stocked fish, was generated from the original 350-fish sample. We used a Kolmogorov-Smirnov two-sample test (Proc Univariate, SAS Institute 2008) to compare the two length distributions ($P = 0.05$).

Results

Approximately 128,000 and 136,000 crappies were marked with OTC at AGFC hatcheries in 2010 and 2011, respectively. Water temperature ranged from 15 to 19 C. Dissolved oxygen ranged from 5.5 to 8.4 mg L^{-1}. Initial water pH was near neutral, dropped no more than 0.65 units with the addition of the buffered OTC solution, and returned to original levels after the OTC solution was flushed from the vats. One-month marking efficacy was determined to be 100%.

During October 2010 and 2011, crappies were stocked at densities ranging from 53 to 246 fish ha^{-1} and 87 to 123 fish ha^{-1}, respectively. Biomass ranged from 54 to 200 g 100 fish^{-1} in 2010 and 96 to 322 g 100 fish^{-1} in 2011 (Table 2). Mean (SD) TL of hatchery fish stocked in October 2010 was 52 (14) mm, while the mean TL of wild age-0 fish sampled in November 2010 was 124 (24) mm. The two distributions were significantly different (D = 0.950, $P < 0.001$), with hatchery fish being generally smaller than wild fish.

Table 2. Stocking density (fish ha-1) and biomass (g 100 fish-1) of oxytetracycline hydrochloride marked black crappies (BC) and white crappies (WC) in Arkansas impoundments.

Impoundment	Species stocked	2010		2011	
		Stocking density	Biomass	Stocking density	Biomass
Barnett	BC	246	123	110	104
Cargile	WC	104	218	87	324
Cox Creek	BC	97	54	92	96
Harris Brake	WC	53	220	92	302
Overcup	WC	88	220	123	322
Upper White Oak	BC	121	54	90	98

Table 3. Age-1 stocking contributions of black crappies (BC) and white crappies (WC) in six Arkansas impoundments.

Impoundment	Species stocked	Number examined / contribution (%)	
		2010 year class	2011 year class
Barnett	BC	11 / 0	13 / 0
Cargile	WC	109 / 0	80 / 0
Cox Creek	BC	2 / 0	2 / 0
Harris Brake	WC	0 / -	100 / 0
Overcup	WC	114 / 0	90 / 0
Upper White Oak	BC	46 / 0	8 / 0

A total of 699 age-0 crappies were collected and examined for OTC marks between 1- and 3-mo post stocking in 2010. Only 13 fish were identified as hatchery fish with TL ranging from 70 to 134 mm. The 1.3-cm square mesh size of trap nets was likely too large to collect a representative sample of stocked crappie and therefore, stocking contribution of age-0 was not calculated.

Trap nets captured 282 and 293 age-1 crappies among all six impoundments in 2011 and 2012, respectively. Black crappie age-1 CPUE ranged from <0.1 to 4.9 fish net-night^{-1} (Table 1). White crappie age-1 CPUE ranged from <0.1 to 5.9 fish net-night^{-1}. No OTC-marked age-1 crappies were collected in any impoundment in either year (Table 3).

Discussion

Stocking hatchery fish remains an important tool in a fishery manager's repertoire. Conover and Sheehan (1996) noted that crappies, "… are stocked in several states, but stocking success is seldom evaluated." Studies published since 1996 (Isermann et al. 1999, Myers et al. 2000, Isermann et al. 2002, Racey and Lochmann 2002) illustrate that crappies continue to be stocked and that evaluations are still rare. Studies, such as the present one, are still necessary to determine the conditions under which hatchery crappies contribute to year classes and enhance crappie fisheries.

In this study, no age-1 stocked crappies were collected during fall trap netting. These results were consistent across all study impoundments during both years of the study. Results were the same for black crappie and white crappie originating from different hatcheries. We recovered no age-1 hatchery crappies despite using the same marking method as other studies (Conover and Sheehan 1996, Isermann et al. 1999) and despite using a sampling approach that consistently collects age-1 crappies (Miranda and Boxrucker 2009). Our observations are lower than results from Myers et al. (2000) who calculated stocking contributions of age-1 crappies at 4.8% in Lake Jeffords (65 ha), Florida. Racey and Lochmann (2002) reported stocking contributions as high as 3.1% for age-1 crappies and 0.2% for age-2 and age-3 crappies in Lake Chicot (2024 ha), Arkansas. Isermann et al. (2002) found contributions of black-nosed crappie stocked in Tennessee reservoirs varied from 0% in Graham Reservoir (200 ha, age-1), to 11% to 24% in Woods Reservoir (1,600 ha, age-1 and age-2), and 34% to 93% in Normandy Reservoir (1,300 ha, age-1 to age-3). We recognize the wide size range of stocked systems in these studies, and the general trend that larger systems appear to exhibit greater stocking contributions. The mechanism for such a trend is unclear, but warrants further examination.

The reasons for the absence of stocking contributions in this study are unclear. Observed OTC marking efficacy in this study

was high and similar to other studies (Conover and Sheehan 1996, Isermann et al. 1999, Racey and Lochmann 2002). Conover and Sheehan (1996) noted that observer experience did not affect the correct classification of OTC marks. Hence, low age-1 stocking contributions were not likely due to our inability to distinguish OTC marks on hatchery fish. Low stocking contributions could be due to stocking insufficient numbers of crappies to have a measureable influence on a year class. However, stocking densities in this study were similar to or higher than densities from other crappie stocking assessments (Isermann et al. 2002, Racey and Lochmann 2002). Poor stocking contributions observed in our study could also be related to small samples sizes. We unsuccessfully attempted to examine 100 otoliths from each impoundment. This goal was only met for Lake Cargile and Lake Overcup in 2011 and Harris Brake in 2012. The goal was nearly achieved in Lake Cargile ($n = 80$) and Lake Overcup ($n = 90$) in 2012.

Isermann et al. (2002) noted that stocking contributions vary with fluctuations in natural year-class strength. Myers et al. (2000) and Racey and Lochmann (2002) hypothesized that the natural strength of the year-class contributed to low stocking contribution. Additionally, Heidinger and Brooks (1998) reported that stocking contribution of saugers (*Sander canadensis*) in the Illinois River was negatively related to levels of natural recruitment. However, stocking contributions in our study were zero for all impoundments and no relationship was apparent between stocking contribution and CPUE values for age-1 crappies. Furthermore, the contributions of hatchery fish to year classes were null, regardless of whether the system was categorized as high or low recruitment based on historical AGFC rotenone data.

The poor survival of hatchery crappies may be related to factors associated with the hatchery rearing and stocking processes. Fish raised in hatchery settings may not be exposed to predators and may be particularly vulnerable to predation (Schlechte et al. 2005, Schlechte and Buckmeier 2006). Additionally, crappies in Arkansas are normally stocked at boat ramps, thus stocked fish are immediately vulnerable to littoral predators. Young crappies have a pelagic distribution in lakes and reservoirs (O'Brien et al. 1984) that limits their interactions with littoral predators. It has been speculated that differential survival of stocked crappies due to predation by largemouth bass (*Micropterus salmoides*) or other piscivores has reduced stocking success and hatchery contribution to year classes for crappies (Isermann et al. 2002, Racey and Lochmann 2002). Sammons et al. (2000) found that stocked black-nosed crappie fingerlings were present in 14% to 42% of predator stomachs containing food 1 to 6 h after stocking. Largemouth bass were present in all impoundments in our study and may have reduced survival for stocked crappies. Smaller systems, which have

a greater proportion of littoral to pelagic area, may have a greater problem with predation on stocked crappies. This could partially explain differences in stocking contributions among systems of different sizes noted above. Stocking crappies into the pelagic zone of lakes, rather than at boat ramps, would be advisable in lakes with high littoral predator abundances.

Stocking larger crappies might increase survival and stocking contribution. Isermann et al. (2002) reported mean total length of stocked age-0 black-nosed crappies was 57 mm. Crappies stocked into Arkansas impoundments in our study averaged just a few mm smaller than crappies from Iserman et al. (2002). However, hatchery crappies stocked into Arkansas impoundments were less than half the size of wild age-0 crappies. Stocking crappies smaller than their wild counterparts could affect survival on two levels. First, larger fish are less vulnerable to gape-limited predators. This has been demonstrated for walleye (*Sander vitreus*) (Brooks et al. 2002), sauger (Heidinger and Brooks 1998), and muskellunge (*Esox masquinongy*) (Szendrey and Wahl 1996). Wright (1970) examined preferred forage size and found forage size ranged from 37% to 59% of largemouth bass total length. Hence, the hatchery-raised crappies from our study were well within the preferred forage size range of largemouth bass. Second, smaller stocked crappies may be at a disadvantage at feeding and overwinter survival when compared to their larger wild counterparts. Stocking crappies that are similar in size to their wild counterparts would also remedy the sampling bias our study experienced, when standard trap nets under-sampled the smaller age-0 hatchery fish relative to wild fish. Studies that intend to monitor stocking contribution during the period immediately after stocking will need to identify sampling strategies that do not suffer from such size-selective weaknesses.

In summary, stocking crappies in these impoundments failed to improve the fishery in any meaningful way as we were unable to document a single stocked crappie surviving to age 1. The combination of poor survival of hatchery-reared crappies and the prolific nature of natural crappie recruitment likely lead to the low contribution estimates. Our results are consistent with several previous crappie stocking evaluations that have generally reported low contribution of stocked crappies to year-class strength.

Acknowledgments

Literature Cited

Allen, M. S. and L. E. Miranda. 1998. An age-structured model for erratic crappie fisheries. Ecological Modeling 107:289–303.

_____ and _____. 2001. Quasi-cycles in crappie populations are forced by interactions among population characteristics and environment. Canadian Journal of Fisheries and Aquatic Sciences 58:594–601.

Arkansas Game and Fish Commission (AGFC). 2002. Crappie management plan. AGFC. Little Rock, Arkansas.

Brooks, R. C., R. C. Heidinger, R. J. H. Hoxmeier, and D. H. Wahl. 2002. Relative survival of three sizes of walleye stocked into Illinois lakes. North American Journal of Fisheries Management 22:995–1006.

Conover, G. A. and R. J. Sheehan. 1996. Evaluation of oxytetracycline marks in sagittal otoliths of juvenile black crappies. North American Journal of Fisheries Management 16:686–688.

Heidinger, R. C. and R. C. Brooks. 1998. Relative survival and contribution of saugers stocked in the Peoria Pool of the Illinois River, 1990–1995. North American Journal of Fisheries Management 18:374–382.

Isermann, D. A., P. W. Bettoli, and S. M. Sammons. 1999. Efficacy of identifying stocked crappies in a Tennessee reservoir through oxytetracycline marking. North American Journal of Fisheries Management 19:1122–1123.

_____, _____, _____, and T. N. Churchill. 2002. Initial poststocking mortality, oxytetracycline marking, and year-class contribution of black-nosed crappies stocking into Tennessee reservoirs. North American Journal of Fisheries Management 22:1399–1408.

Maceina, M. J. and M. R. Stimpert. 1998. Relations between reservoir hydrology and crappie recruitment in Alabama. North American Journal of Fisheries Management 18:104–113.

Miranda, L. E. and J. Boxrucker. 2009. Warmwater fish in large standing waters. Pages 29–42 *in* S. A. Bonar, W. A. Hubert, and D. W. Willis, editors. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesday, Maryland.

Myers, R. A., M. S. Allen, and D. E. Colle. 2000. Survival of fingerling black crappie tagged with microwire tags stocked in a Florida lake. North American Journal of Fisheries Management 20:534–537.

O'Brien, W. J., B. Loveless, and D. Wright. 1984. Feeding ecology of young white crappie in a Kansas reservoir. North American Journal of Fisheries Management 4:341–349.

Parker, R. O. 2002. Water requirements for aquaculture. Pages 331–375 *in* R. Parker, editor. Aquaculture Science, second edition. Delmar, Thomson Learning, Albany, New York.

Racey, C. L. and S. E. Lochmann. 2002. Year-class contribution of white crappies stocked into Lake Chicot, Arkansas. North American Journal of Fisheries Management 22:1409–1415.

Sammons, S. M., P. W. Bettoli, and D. A. Isermann. 2000. Crappie population dynamics and stocking success in Tennessee reservoirs. Tennessee Technological University, Fisheries Report 00-13, Cookville.

SAS Institute. 2008. SAS/STAT 9.2 User's guide. Cary, North Carolina: SAS Institute, Inc.

Schlechte, J. W., R. K. Betsill, and D. L. Buckmeier. 2005. A laboratory evaluation of poststocking predatory losses for cultured largemouth bass. Transactions of the American Fisheries Society 134:141–148.

_____ and D. L. Buckmeier. 2006. A pond evaluation of habituation as a means to reduce initial mortality associated with poststocking predation of hatchery-reared largemouth bass. North American Journal of Fisheries Management 26:119–123.

Szendrey, T. A. and D. H. Wahl. 1996. Size-specific survival and growth of stocked muskellunge: effects of predation and prey availability. North American Journal of Fisheries Management 16:395–402.

U.S. Fish and Wildlife Service and U.S. Census Bureau. 2011. 2011 National survey of hunting, fishing, and wildlife-associated recreation. USFWS and U.S. Census Bureau, U.S. Government Printing Office, Washington, D.C.

Wright, L. D. 1970. Forage size preference of the largemouth bass. The Progressive Fish Culturist 32:39–42

_____. 2012. An evaluation of crappie recruitment and supplemental stocking in Arkansas reservoirs. MS Thesis, Arkansas Tech University.