Response of the Crappie Population to Regulatory Changes in Kentucky Lake, Kentucky: A Case History

Paul W. Rister, *Kentucky Department of Fish and Wildlife Resources, 30 Scenic Acres Drive, Murray, KY 42071*

Abstract: The objective of this case history was to document the response of the crappie (*Pomoxis* spp.) population at Kentucky Lake to restrictive harvest regulations. In the late 1980s and early 1990s, crappie abundance declined due to poor recruitment and high mortality during severe drought years. A tagging study estimated minimum exploitation at 45%. Following the drought, restrictive harvest regulations (30 fish creel and 254 mm minimum length limit) were implemented to reduce exploitation, and subsequently increase survival of crappie from age 1 to age 2. Annual survival of these smaller crappie, determined from cohort analysis, was increased from approximately 21% to 48% following implementation of restrictive regulations. Abundance of adult crappie increased following the restrictive regulations. Recruitment variability was not affected by the restrictive regulations, and probably was affected more by environmental changes. Mean lengths of age-2 crappie declined from 252 mm preregulation to 236 mm postregulation. Angler acceptance of the 254 mm minimum length limit has been good. However, if the growth rates continue to decline then a less restrictive minimum length limit might be appropriate.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 55:304–315

White crappie *(Pomoxis annularis)* and black crappie *(P. nigromaculatus)* are popular sportfish in most large reservoirs in the United States. In 1996, over 6.3 million anglers fished for crappie in the United States, ranking crappie as the fourth most popular freshwater game fish species (U.S. Dep. Int., 1997*a*). Miranda (1999) reported that crappie are some of the most heavily exploited freshwater fishes, and that annual recreational harvest averaged almost 5 kg/ha in a sample of 279 reservoirs where crappie occurred. McDonough and Buchanan (1991) suggested that crappie ranked either first or second in the Tennessee Valley region. In Kentucky, crappie were the third most sought after species by anglers, with black bass and catfish ranking first and second, respectively (U.S. Dep. Int., 1997*b*). On Kentucky Lake, an estimated 51% of anglers fished for crappie in the Kentucky portion (Rister and Garthaus 1998). Malvestuto (1998) indicated that over one-third of all angling effort was for crappie on the Tennessee portion of Kentucky Lake.

Beginning in 1985, the Tennessee Valley region suffered a severe drought that lasted for 3 years. Prior to 1985, average annual rainfall in the region was 1,298 mm as measured at the National Weather Service in Nashville. The average annual rainfall dropped to 788 mm during the 3-year drought period (1985–1988). The total annual rainfall in 1989 was 1,449 mm. From 1989 to 2000, total annual rainfall did not drop below 991 mm. The average annual rainfall for the period 1989 to 2000 was 1,236 mm.

Impacts of the drought on the hydrology of Kentucky Lake were evident. The average daily discharge through Kentucky Dam from 1983 to 2000, excluding the drought period, was 1,874 m^3/second. The average daily discharge from 1985 to 1988 was 1,080 m^3/second. The reduction in discharge increased the hydraulic retention time, thereby increasing water clarity. The clear, warmer water, associated with low flows, made conditions favorable for the expansion of aquatic macrophytes. In 1985, it was estimated that there were 128 ha of aquatic plant coverage in the entire reservoir. By 1987, aquatic vegetation coverage in Kentucky Lake had increased to 2,878 ha (Dr. David Webb, pers. commun). The expansion of aquatic macrophytes resulted in changes in the fish community. Buynak et al. (1991) reported that drought-induced changes at Kentucky Lake resulted in an increase in largemouth bass recruitment.

Many authors have investigated factors affecting crappie year-class strength, and suggested management solutions to offset the cyclic nature of crappie populations. Swingle and Swingle (1967) found that strong year classes of crappie were produced at intervals of every 3 to 5 years. The weaker year classes were the results of low reproductive and/or recruitment rates. However, as strong year classes passed onto age groups 3 and 4, a gradual reduction in numbers resulted from high exploitation and natural mortality. By controlling exploitation, the abundance of adult fish in these larger year classes could be spread out. Mitzner (1991) found that water turbidity negatively influenced age-0 year class strength. Martin (1981) and Mitzner (1981) found that low lake levels during the spawning season reduced the reproductive success of crappie, while above normal water levels could enhance recruitment success. Sammons and Bettoli (2000) suggest that crappie recruitment was positively correlated to mean daily discharge of Normandy Reservoir, Tennessee, during 1 January to 31 March. Miller et al. (1990) also found that year-class strength was positively related to spring water levels. Beam (1983) reported that water level management could be an effective management tool to increase crappie reproduction and recruitment success. In some cases where crappie become over populated, commercial harvest was the preferred management solution to boost the crappie fishery (Schramm et al. 1985, Miller et al. 1990). In other studies (Colvin 1991*a*,*b*, Webb and Ott 1991, Allen and Miranda 1995, Maceina et al. 1998, Hale et al. 1999, Miranda and Allen 2000) restrictive regulations have been the focus for crappie management.

The crappie population at Kentucky Lake is similar in many ways to those studied in other waters. Changes in the crappie population at Kentucky Lake have been attributed to variable recruitment, environmental conditions, and high mortality. Because water level manipulation is not normally an option on a flood control reservoir, restrictive regulations have been the focus of crappie management at Kentucky Lake.

Prior to 1988, the crappie fishery at Kentucky Lake was managed with very liberal harvest regulations. The daily creel limit for crappie was 60 with no size restriction. On 1 January 1988 the daily creel limit for crappie was reduce to 30 statewide. At Kentucky Lake, a 254-mm length limit was implemented on 1 January 1991. The objective of this case history was to document the response of the crappie population at Kentucky Lake to these restrictive harvest regulations.

I wish to thank the numerous biologists and fishery technicians with the Kentucky Department of Fish and Wildlife Resources that assisted in collecting data. Partial funding was provided by the Sport Fish Restoration Act (Dingell-Johnson, Wallop-Breaux), District Fisheries Management F-50 (8-23), Project 1: Lake and Tailwater Fishery Surveys.

Methods

Kentucky Lake is a Tennessee Valley Authority mainstem reservoir on the Tennessee River located in western Kentucky and Tennessee. The drainage area of Kentucky Lake is approximately 11,900 km^2. The majority of this area is in Tennessee. Kentucky Lake is the last mainstem reservoir on the Tennessee River system. Therefore, it is greatly influenced by the entire watershed of the Tennessee River, which also includes portions of Virginia, North Carolina, Georgia, Alabama, and Mississippi. Kentucky Lake was impounded by the completion of Kentucky Dam at Tennessee River mile 22.4 in 1944. The reservoir covers an area of 64,873 ha at summer pool, with approximately 19,824 ha in Kentucky. The lake is classified as eutrophic (Anon. 1996). The study area included only the Kentucky portion of Kentucky Lake.

The crappie population was sampled utilizing trap net, tagging, and creel surveys. Fall trap netting was conducted from 1985 to 2000. Trap net construction consisted of a frame that was approximately 1 x 2 m and 4 76-cm diameter hoops covered with 6-mm mesh. The leads on the trap nets were 21 x 1 m with 14-mm mesh. Trap nets were fished during October when water temperature normally ranges from 15 to 20 C. In most years, 20 trap nets were set at fixed locations and fished for 4 consecutive nights. Slightly less effort was exerted in a few years due to lost nets and weather. Fish were removed from the nets daily. Length (mm) and weight (g) were recorded for each crappie caught. Catch per unit effort (CPUE) was defined as the average of the catch/net. Otoliths were removed from 10 to 20 crappie per 2.5-cm length intervals for age and growth calculations. The age data obtained were expanded for the entire sample to determine CPUE per age class. Mortality calculations were made from catch curves analysis. Survival estimates were made from cohort analysis. Pre- and postsurvival calculations were tested for significant differences using a *t*-test at a 95% probability level. Age structure was determined by calculating the percentage of age-4 and older crappie from the number of age-1 and older crappie collected in trap nets. The length of crappie during their third growing season (age 2 at capture in fall trap netting) was used as a measure of growth rates. The age structure and growth rate parameters are similar to those described by Colvin and Vasey (1986).

In 1988 a tagging study was conducted on the Kentucky portion of Kentucky Lake to determine an exploitation rate for crappie. A total of 998 crappie were collected by electrofishing in late February and early March. Each crappie was measured to the nearest 3 mm, tagged with a sequential numbered Floy T-tag, and then released. The smallest crappie tagged was 241 mm. A reward of $5 was offered to anglers returning tags during 1988–1989. Calculations were not made to determine tag loss and non-reporting rates. Tag loss is usually not significant; however, the non-reporting rate of 25% estimated by Reed and Davies (1991) on Weiss Reservoir, Alabama, was used.

Daytime roving creel surveys were conducted on Kentucky Lake from 1 March to 31 October, in 1984–1987, 1991, and 1998. Creel clerks interviewed anglers to obtain information on species sought, number of fish caught, whether the fish were kept or released, length of fish kept, and duration of fishing trip. Estimates were made by species of total angler pressure, catch and harvest rates, average length and weight of harvested fish, and yield (kg).

Restrictive harvest regulations were necessary to manage the crappie fishery at Kentucky Lake. A minimum length of 254 mm was determined by the length of crappie at the end of their third growing season. The size was also assumed to be acceptable to anglers because the average size of crappie harvested in previous years was 269 mm.

Results

The CPUE for age-0 crappie collected in trap nets was 6.0 and for age-2, 3.6, during 1985 (Table 1). By 1988, CPUE had decreased to 1.1 and 1.8, respectively. CPUE of age-2 crappie was still low in 1989 and 1990. While the density of age-2 crappie was low, their average length was 257 mm for the period of 1985 through 1990. CPUE of crappie ≥254 mm peaked in 1987 trap netting data at 4.6, then dropped below 1.0 during 1988 to 1991 (Fig. 1). The age structure was low but stable from 1985 to 1988 (1.5%), then declined to less than 1.0% in 1989 through 1992 (Fig. 2). Personal communication with crappie anglers during this period indicated that fishing success was low in 1988, and worse in 1989 and 1990.

Trap netting in 1989 yielded an age-0 CPUE of 21.5 (Table 1) and a correspondingly high CPUE of age 1 in 1990, indicating a strong year class in 1989. Age and growth data indicated it would be 2 years (1991) before the 1989 year class would recruit to the fishery. Poor recruitment had been identified as the cause for the previous decline in the crappie fishery and not necessarily over harvest. However, knowing that fishing success had been low, it was anticipated that anglers would begin harvesting crappie from this strong year class before age 2. Therefore, a 254-mm minimum length limit was implemented on 1 January 1991. This date marks the change from pre- and post regulation for later discussion. It was hoped that the 254-mm minimum length limit would help improve survival of crappie past age 2 and older, and allow the crappie fishery to recover to harvest levels reported in 1984-1987.

During the mid 1990s the harvestable size crappie population recovered from the poor years observed during 1988 to 1990 (Fig. 1). The next high catch rate of age-0 crappie in trap nets was not observed again until 1996 (Table 1). However, catch

Table 1. CPUE by age, total mortality rates (A) estimated from catch curves, and survival (S) from age-1, –2, age-2, –3; and age-3, –4 of crappie collected from fall trap-net samples at Kentucky Lake, Kentucky, 1985–2000.

Year	Age 0	1	2	3	4	>4	A	S_{age1-2}	S_{age2-3}	S_{age3-4}
1985	6.0	17.7	3.6	0.8	0.8	0.4	54			
1986	3.6	2.6	1.9	0.4	0.1	0.1	48	11	11	8
1987	2.5	10.2	1.1	0.7	0.1	0.1	54	43	35	28
1988	1.1	3.0	1.9	0.3	0.1	0.1	52	18	22	9
1989	21.5	8.3	0.6	0.5	0.0	0.1	63	20	26	10
1990	4.2	14.7	1.1	0.1	0.0	0.1	44	13	22	8
MEAN	6.5	9.4	1.7	0.5	0.2	0.1	53	21	23	13
254-mm Length Limit										
1991	5.0	9.9	6.4	0.2	0.0	0.0	94	43	20	18
1992	3.3	11.3	5.8	2.0	0.1	0.1	61	58	31	28
1993	2.9	9.3	3.4	1.9	0.9	0.1	75	30	33	43
1994	3.1	6.9	3.8	1.3	0.8	0.3	57	41	38	40
1995	5.6	13.5	2.6	1.1	0.1	0.5	52	37	28	5
1996	30.2	14.0	6.9	0.5	0.2	0.1	63	51	20	20
1997	4.2	8.2	5.2	4.0	0.3	0.6	60	37	58	66
1998	18.1	20.7	11.0	5.6	3.3	0.2	45			83
1999	2.0	9.7	11.4	3.4	1.3	1.3	56	55	31	24
2000	1.8	8.6	7.8	3.4	0.8	0.9	62	80	30	24
MEAN	7.6	11.2	6.4	2.3	0.8	0.4	63	48	32	35

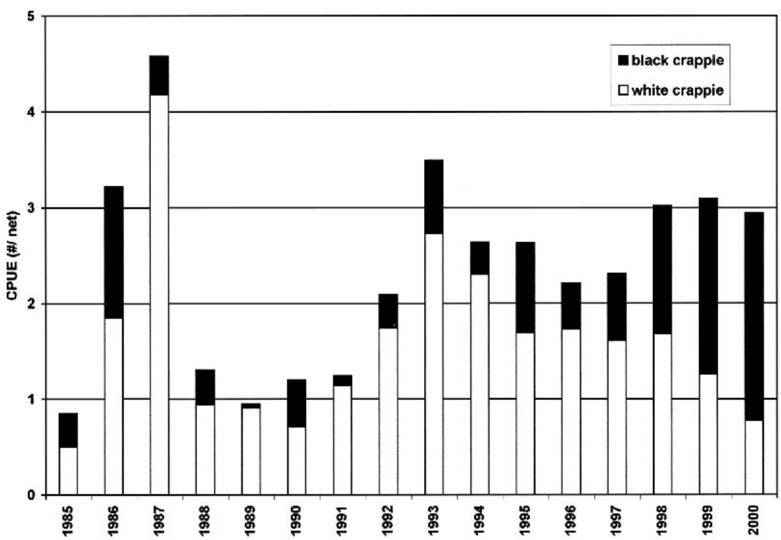

Figure 1. CPUE of crappie ≥254 mm collected in trap nets during 1985–2000 from Kentucky Lake, Kentucky.

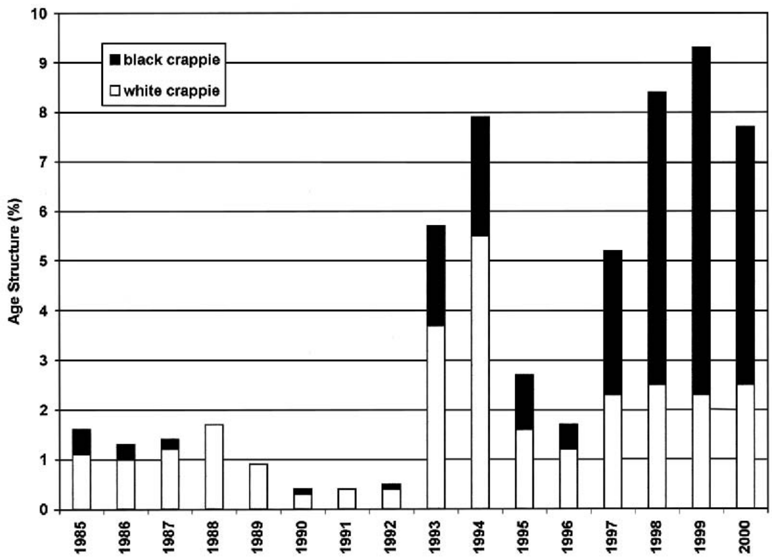

Figure 2. Age structure of the crappie population determined from trap netting data collected during 1985–2000 at Kentucky Lake, Kentucky.

rates of age-1 crappie the following year did not indicate that this was a strong year class. Above average catch rates for age-1 crappie were observed in 1995 and 1996. These high catch rates of age-1 crappie corresponded to above average catch rates of age-2 crappie in following years. In 1993 and 1994 the age structure remained skewed towards age-4 and older fish as a result of the 1989 spawn and subsequent weak year classes (Fig. 2). The age structure declined in 1995 and 1996, before increasing in following years. Though strong year classes cycled through the crappie population, CPUE of crappie ≥254 mm collected in trap nets stayed relatively high from 1993 through 2000, averaging 2.9, with a peak at 3.5 in 1993 (Fig. 1).

Throughout the mid 1990s the growth rate for crappie was stable in spite of the increased numbers of adult crappie in the population. Most age-2 crappie caught in fall trap netting ranged from 216 to 264 mm during the mid 1990s. The lower end of this range was more representative of data collected in the late 1990s. Prior to 1997, black crappie on the average made up less than 20% of the trap-netting sample. In 1997, black crappie comprised approximately 63% of the catch in trap nets. Black crappie continued to dominate the fall trap-netting catch in subsequent years. Age and growth data suggest the black crappie are slower growing than white crappie; therefore, the average length at age 2 for all crappie caught in trap netting has declined. The preregulation mean length at age 2 for white crappie was 253 mm and 249 mm for black crappie. The postregulation mean lengths were 245 mm and 226 mm, respectively.

During 1998–2000, trap-netting data indicated that the number of harvestable crappie remained stable with an average CPUE of 3.0 (Fig. 1). During this period CPUE of age-0 crappie was high only in 1998 (Table 1). The catch rate of age-2 crappie in 1998 was more than double the average from previous years, corresponding to the high catch of age 0 in 1996, though it declined slightly in 2000 (Table 1). The average CPUE of age-2 crappie was 10.1 during this period. The age structure was also high during 1998–2000, with an average of 8.5.

The mean annual mortality was 59±6% for all years (1985–2000) (Table 1). The mean annual mortality was 53%±5% prior to implementation of the minimum length limit. During postregulation years, mean annual mortality was calculated to be 63% ± 8%. The pre- and postregulation annual mortality was not significantly different ($P > 0.05$). Cohort survival was calculated between ages 1–2, 2–3 and 3–4 (Table 1). The average preregulation annual survival was 21% ± 11% from age 1 to 2 and 23% ± 8% from age 2 to 3. The average postregulation annual survival increased to 48% ± 10% and 32% ± 7%, respectively. Annual survival from age 1 to 2 calculated pre- and postregulation was significantly different ($P < 0.05$). However, the difference from age 2 to 3 was not significantly different ($P > 0.05$). The 1998 data were omitted for determining cohort survival because the CPUE of age 2 was higher than the CPUE of age 1 collected in 1997. Annual survival was calculated pre- and postregulation for age 3 to 4 at 13% ± 8% and 35% ± 15%, respectively. Annual survival between ages 3 and 4 calculated pre- and postregulation was significantly different ($P < 0.05$).

The exploitation rate was estimated from the 1988 tagging study at Kentucky Lake to be at least 45%. This estimate would be considered to be the minimum exploitation rate because no calculations were made to determine tag loss and non-reporting rates. It is possible that exploitation could have been as high as 70% based on a non-reporting rate estimated by Reed and Davies (1991). After the first 10 days of tagging fish, approximately 15% of the tagged fish had been caught. Within 30 days of tagging, the return rate was 36%. The last tag returned was recorded 762 days after the fish was tagged.

During a creel survey conducted in 1984, crappie accounted for almost 53% of all fish harvested from Kentucky Lake. Approximately 36% of the anglers creeled sought crappie. In 1985, crappie accounted for 55% of all fish harvested. The number of anglers fishing for crappie increased to 46%. A creel survey in 1986 indicated that crappie accounted for 69% of all fish harvested. Approximately 56% of the anglers creeled sought crappie. Over this 3-year period (1984–1986) the number of crappie harvested increased from 16.7 to 25.1/ha. The average number of crappie caught /ha was 26.9. The yield (kg) of crappie increased from 4.0/ha in 1984 to 6.2/ha in 1986. The mean length and weight of crappie harvested during the period was 262 mm and 0.23 kg, respectively. A slight decline was reported in the number of crappie harvested in the 1987 creel survey (23.9/ha). However, yield increased (7.3/ha) as did the average length harvested (287 mm). Crappie accounted for 59% of the fish harvested during this survey period, while the number of anglers seeking crappie dropped to 43%.

During the 1991 creel survey, crappie accounted for 26% of all fish harvested. Approximately 46% of the anglers surveyed sought crappie. The crappie harvested had an averaged length of 272 mm and weighed 0.28 kg. The number of crappie caught ha was 25.7, and the number harvested/ha was 14.1. The harvest of sublegal size (<254 mm) crappie was approximately 5%, which amounted to 0.3 fish/ha.

During the 1998 creel survey, crappie accounted for 55% of the fish harvested, which is slightly above the average from previous creel surveys. The number of anglers that sought crappie was 51%, which was only slightly higher than the average reported from previous creel surveys. The mean length (292 mm) and weight (0.36 kg) of crappie harvested was considerably higher in the 1998 creel survey. Although trap-netting data suggested a change in species dominance from white to black crappie, the harvest from this creel survey did not indicate this change. Black crappie made up 12% of the crappie caught and 17% of the harvest. During the 1991 creel survey, black crappie made up 13% of the crappie caught and 16% of the harvest.

Discussion

Restrictive creel regulations for crappie at Kentucky Lake were implemented at a time when the crappie population structure was declining. Anglers enjoyed good fishing success in 1986 and 1987, and fishing pressure subsequently increased. The high exploitation rate for crappie led to poor survival of age-2 and older crappie. The poor survival of adult crappie in conjunction with poor recruitment resulted in a declining population. By the time a statewide reduction in creel limit was implemented, the quality fishery was already devastated. The time period between the reduction in creel (1988) and the imposed minimum length limit (1991) was inadequate at making any inferences about changes in the crappie population structure. Wilde (1997) and Allen and Pine (2000) suggested that long evaluation periods are necessary to detect responses to restrictive creel regulations. The 254-mm minimum length limit was implemented following a year in which recruitment improved. Most anglers would have begun harvesting crappie readily when they reached a length of 203 mm, which is during the second growing season. Colvin (1991*a*) found that when a strong year class followed 2 or 3 weak ones, harvest of age-1 fish contributed substantially to the total harvest for the year. Therefore, at Kentucky Lake a minimum length limit was warranted.

The crappie population structure indicated that a 254-mm minimum length limit would be effective. The growth rate was considered good. Age-2 crappie collected in fall trap netting, prior to the implementation of a minimum length limit, averaged 252 ± 11 mm in length. Total annual mortality was moderate, averaging 52% in preregulation years. The estimated minimum annual exploitation rate was 45%. Reed and Davies (1991) recommended against length limits if natural mortality is too high, but given the estimates of annual mortality (59%) and exploitation (45%), natural mortality of the Kentucky Lake crappie population appeared to be low (14%). Angler satisfaction and compliance is also a factor. At Kentucky Lake, even before the implementation of a minimum length limit, crappie harvested averaged over 254 mm. Although, of the crappie less than 254 mm that were caught, 42% were harvested. The harvest of sublegal crappie during the 1991 creel survey was approximately 5%, so non-compliance did not seem to be a factor.

In spite of increased abundance of adult crappie in the population (1993–2000), growth rates declined only slightly. The average length of age-2 crappie caught in preregulation samples was 252 mm, which declined to 235 mm in postregulation years. As more black crappie were collected in trap nets, the average length for both species combined declined. Although the combined (white and black crappie) average length at age 2 declined slightly, the change by species was more obvious. The high catch rates of black crappie probably did not signify a change in species abundance within the crappie population. Creel data from the Kentucky portion of Kentucky Lake indicated white crappie made up 83% of the crappie harvest. Broadbent (1999) indicated similar trends in the Tennessee portion of Kentucky Lake. In the Tennessee portion, black crappie were collected at higher densities during fall trap netting; however, they had not contributed considerably to the anglers' creel.

The implementation of the 254-mm minimum length limit at Kentucky Lake reduced the variability of adult (age 2 and older) crappie population abundance. The crappie population now also contained a higher percentage of older fish. Webb and Ott (1991) and Colvin (1991*a*) indicated that minimum length limits would help to maintain a more stable supply of preferred-size crappie. Prior to the minimum length limit the age structure was poor (1%). During postregulation years the age structure averaged 5%. Excluding the data from the 2 years immediately following the implementation of the 254-mm minimum length limit, the age structure averaged 8%. Colvin and Vasey (1986) reported that in a good white crappie population, age-4 and older fish should make up 10% to 19% of the catch in fall trap nets.

At Kentucky Lake, in postregulation years the variability of recruitment was not reduced; however, recruitment did increase. Although the crappie were now protected past 1 spawning season, and the density of adult stock had increased, recruitment was still variable. Miranda and Allen (2000) also found that minimum length limits did not reduce variability in recruitment. This led to the conclusion that crappie recruitment at Kentucky Lake was affected more by environmental conditions. Many authors have also reported that recruitment is affected by environmental conditions (Ploskey 1986, Willis 1986, McDonough and Buchanan 1991, Miranda and Allen 2000, Sammons et al. 2000). However, on the average of all years sampled, the abundance of age-1 crappie was higher postregulation than preregulation. This might be suspected, as the abundance of the adult stock increased so does the reproductive potential of the crappie population.

Annual mortality of crappie in Kentucky Lake averaged 59 ± 6% over a 16-year period. This was lower than annual mortality rates reported for crappie at other lakes. Colvin (1991*a*) reported the average annual mortality on 3 lakes in Missouri to be 80%. Allen and Miranda (1995) estimated the average annual mortality at 75% from 17 different lakes. Reed and Davies (1991) reported total annual mortality of 69% for crappie ≥ 250 mm at Weiss Reservoir. Annual survival from age 1 to 2 was increased in years following the implementation of a minimum size limit from 21% to

48%. Annual survival from age 2 to 3 was not increased significantly from pre- to postregulation years, while from age 3 to 4 it increased from 13% to 35%, respectively. Hale et al. (1999) reported that annual mortality from age 2 to 3 black crappie decreased from 80% to 34% after a 254-mm length limit was imposed. At Kentucky Lake an increasing adult population influenced the increase in annual survival from age 3 to 4 for postregulation years. Prior to the 254-mm minimum length limit, angler harvest accounted for 45% of the annual crappie mortality at Kentucky Lake. Allen and Miranda (1995) reported that the average fishing mortality for 10 lakes considered in their study was 42%. Colvin (1991*a*) reported an average fishing mortality of 49% from 3 lakes in Missouri. Therefore, angler mortality was considered to be moderate at Kentucky Lake.

Management Implications

Crappie in most lakes and reservoirs are highly exploited, and recruitment is highly variable. There is probably no single factor that determines year-class strength of crappie from year to year. However, when high exploitation and good growth conditions are present, a minimum length limit is probably the regulatory solution to sustain the fishery from boom and bust scenarios. The minimum length limit will protect smaller fish, increasing their potential to being recruited into the population. As seen in this study and several others, the minimum length limit will also help to reduce the variability of adult population, which is normally caused by variable recruitment. The variable recruitment would not be controlled with a minimum length limit; however, with a restrictive minimum length limit the average size of crappie harvested will often increase. This has been observed in numerous studies, but is not always the case where growth rates are slow.

When considering a minimum length limit, often the average length of crappie during their third growing season is used. At Kentucky Lake the average length of age-2 crappie declined only slightly after the implementation of the minimum length limit. Colvin (1991*a*,*b*) and Webb and Ott (1991) found that the average size of white crappie harvested could be improved through minimum length limits. Although, Colvin (1991*a*) concluded that when crappie averaged 229 mm or less during the third growing season, then a 229-mm length limit should be imposed. Hale et al. (1999) also reported that after a 6-year trial period on Delaware Reservoir, Ohio, that the 254-mm minimum size limit was reduced to a 229-mm minimum length limit. In this case, slow growth was found to be influenced by the predominance of black crappie in the population.

In conclusion, it was determined that the 254-mm minimum length limit increased the adult population of crappie at Kentucky Lake. Schmidt (2001) listed Kentucky Lake as one of the top lakes to catch a trophy-size crappie in a recent *In-Fisherman* magazine article. The success of this restrictive regulation still depends on growth rates and annual mortality. If growth rates decline below a satisfactory level or annual mortality increases, then this minimum length limit could reduce the yield. A less restrictive minimum length limit may need to be considered under these conditions. Acceptance of the 254-mm minimum length limit at Kentucky Lake by anglers has been very good. However, personal communication with numerous anglers has indicated that very few would agree with a less restrictive length limit even if the data support such.

Literature Cited

Anonymous. 1996. Trophic state and restoration assessment of Kentucky's lakes. Ky. Nat. Resour. and Environ. Protection Cabinet, Dep. Environ. Protection, Div. Water, Frankfort.

Allen, M.S. and L.E. Miranda. 1995. An evaluation of the value of harvest restrictions in managing crappie fisheries. North Am. J. Fish. Manage. 15:766–772.

______ and W.E. Pine III. 2000. Detecting fish population responses to a minimum length limit effects of variable recruitment and duration of evaluation. North Am. J. Fish. Manage. 20:672–682.

Beam, J.H. 1983. The effects of annual water level management on population trends of white crappie in Elk City Reservoir, Kansas. North Am. J. Fish. Manage. 3:34–40.

Broadbent, T. 1999. Annual reservoir report—Kentucky Reservoir. Tenn. Wildl. Resour. Agency, Nashville. 6pp.

Buynak, G.L., W.N. McLemore, and B. Mitchell. 1991. Changes in largemouth bass populations at Kentucky and Barkley lakes: environmental or regulation responses? North Am. J. Fish. Manage. 11:285–292.

Colvin, M.A. and F.W. Vasey. 1986. A method of qualitatively assessing white crappie populations in Missouri reservoirs. Pages 79–85 *in* G.E. Hall and M.J. Van Den Avyle, eds. Reservoir fisheries management: strategies for the 1980s. Am. Fish. Soc., South. Div., Reservoir Comm., Bethesda, Md.

Colvin, M.A. 1991*a*. Population characteristics and anglers harvest of white crappie in four large Missouri reservoirs. North Am. J. Fish. Manage. 11:572–584.

______. 1991*b*. Evaluation of minimum-size limits and reduced daily limits on the crappie populations and fisheries in five large Missouri reservoirs. North Am. J. Fish. Manage. 11:585–597.

Hale, R.S., M.E. Lundquest, R.L. Miller, and R.W. Petering. 1999. Evaluation of a 254-mm minimum length limit on crappies in Delaware reservoir, Ohio. North Am. J. Fish. Manage. 19:804–814.

Maceina, M. J., O. Ozen, and M.S. Allen. 1998. Use of equilibrium yield models to evaluate length limits for crappie in Weiss Lake, Alabama. North Am. J. Fish. Manage. 18:854–863.

Malvestuto, S. 1998. Tennessee reservoir creel survey 1998. Tenn. Wildl. Resour. Agency, Fish. Rep. 99–39, Nashville. 8pp.

Martin, D.B. 1981. Spring and summer water levels in a Missouri River reservoir; effects on age 0 fish and zooplankton. Trans. Am. Fish. Soc. 110:370–381.

McDonough, T.A. and J.P. Buchanan. 1991. Factors affecting abundance of white crappie in Chickamauga Reservoir, Tennessee, 1970–1989. North Am. J. Fish. Manage. 11:513–524.

Miller, S.J., D.D. Fox, L.A. Bull, and T.D. McCall. 1990. Population dynamics of black crappie in Lake Okeechobee, Florida, following suspension of commercial harvest. North Am. J. Fish. Manage. 10:98–105.

Miranda, L.E. 1999. A typology of fisheries in large reservoirs of the United States. North Am. J. Fish. Manage. 19:536–550.

______ and A.S. Allen. 2000. Use of length limits to reduce variability in crappie fisheries. North Am. J. Fish. Manage. 20:752–758.

Mitzner, L. 1981. Influence of floodwater storage on abundance of juvenile crappie and subsequent harvest at Lake Rathbun, Iowa. North Am. J. Fish. Manage. 1:46–50.

______. 1991. Effects of environmental variables upon crappie young, year-class strength, and the sport fishery. North Am. J. Fish. Manage. 11:534–542.

Ploskey, G.R. 1986. Effects of water-level changes on reservoir ecosystem, with implications for fisheries management. Pages 86–97 *in* G.E. Hall and M.J. Van Den Avyle, eds. Reservoir fisheries management: strategies for the 1980s. Am. Fish. Soc., South. Div., Reservoir Comm., Bethesda, Md.

Reed, J.R. and W.D. Davies. 1991. Population dynamics of black crappies and white crappies in Weiss Reservoir, Alabama: Implications for the implementation of harvest restrictions. North Am. J. Fish. Manage. 11:598–603.

Rister, P.W. and M. Garthaus. 1998. District fisheries management pProject. Annual performance report for research and survey, lakes and tailwaters. Ky. Dep. Fish and Wildl. Resour. Proj. F-50-21. 24pp.

Sammons, S.M. and P.W. Bettoli. 2000. Population dynamics of a reservoir sport fish community in response to hydrology. North Am. J. Fish. Manage. 20:791–800.

Schmidt, C. 2001. All-time crappie greats. In-Fisherman 26(1): 57–59.

Schramm, H.L., J.V. Shireman, D.E. Hammond, and D.M. Powell. 1985. Effects of commercial harvest of sportfish on the black crappie population of Lake Okeechobee, Florida. North Am. J. Fish. Manage. 5:217–226.

Swingle, H.S. and W.E. Swingle. 1967. Problems in dynamics of fish populations in reservoirs. Pages 229–243 *in* Reservoir committee, eds. Reservoir fishery resources symposium. Am. Fish. Soc., South. Div., Reservoir Comm., Bethesda, Md.

U.S. Department of the Interior. 1997*a*. 1996 National survey of fishing, hunting, and wildlife associated recreation. U.S. Dep. Int. U.S. Fish and Wildl. Serv., Washington, D.C. 12pp.

U.S. Department of the Interior. 1997*b*. 1996 National survey of fishing, hunting, and wildlife associated recreation: Kentucky. U.S. Dep. Int. U.S. Fish and Wildl. Serv., Washington, D.C. 20pp.

Webb, M.A. and R.A. Ott Jr. 1991. Effects of length and bag limits on population structure and harvest of white crappies in three Texas reservoirs. North Am. J. Fish. Manage. 11:614–622.

Wilde, G.R. 1997. Largemouth bass fishery response to length limits. Fisheries 22(6):14–23.

Willis, D.W. 1986. Review of water level management on Kansas reservoirs. Pages 110–114 *in* G.E. Hall and M.J. Van Den Avyle, eds. Reservoir fisheries management: strategies for the 1980s. Am. Fish. Soc., South. Div., Reservoir Comm., Bethesda, Md.