Comparison of Growth, Condition and Population Structure of White Crappie in Lake Carl Blackwell, 1984-1985 to 1998

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White crappie, *Pomoxis annularis*, is an important sport fish in Oklahoma, but some populations grow slowly or have undesirable population structure. The management of the species is not a settled issue and requires data bases for temporal and/or lake to lake comparisons. This paper reports decadal changes in growth, condition and population structure for white crappie in Lake Carl Blackwell, Oklahoma, a turbid, wind-swept reservoir. We determined age and growth, condition and population size structure of white crappie in 1998 and compared our data to earlier data that were obtained in nearly the same manner (1984-1985). Growth of Age-1 and Age-2 fish increased significantly between decades. Size structure of white crappie changed modestly. Relative weight of quality fish was below 100 in both decades. However, gears used in 1984-85 and 1998 and seasonal sampling effort was different so any resulting gear selectivity may confound the W_r and population structure comparisons. Further research is needed to learn whether white crappie growth, condition, and population structure observed in 1998 continue to change. ***©2003 Oklahoma Academy of Science***

INTRODUCTION

White crappie (*Pomoxis annularis*) is an important sport fish in Oklahoma. Sometimes growth is poor, however, because of high interspecific competition for forage (Crawley 1954, Goodson 1966) or growth overharvest (Webb and Ott 1991). In the latter case high fishing mortality can remove larger white crappie selectively, leading to relatively large numbers of smaller fish (Colvin 1991). Assessment of crappie populations is accomplished by comparing growth in length and weight and size structure and from time to time or place to place. However, frequently such comparisons are short-term and often sampling is not standardized. The purpose of this research was to describe the long-term changes in white crappie growth, condition and population structure in Lake Carl Blackwell (LCB), Oklahoma, from 1984-1985 and 1998. A long-term study such as this is possible when some organization builds a data base over many years at the same site. Our study was possible because of the efforts of scientists at Oklahoma State University who studied nearby LCB almost from the year of its construction (1937) and produced numerous papers, theses and reports on all aspects of the lake (for example, Crawley 1954, Burris 1956, Schoch 1981, Howick 1983, Muoneke et al 1992, 1993 and Doyle 1999). The research reported here also contributes to this data base for white crappie.

To every extent possible, we followed sampling protocols used in the 1984-1985 by Muoneke et al (1992, 1993). The 1980s study was conducted to determine how to better manage the white crappie fishery in LCB because white crappie was considered

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undesirable by anglers because of their relatively small average size (Muoneke et al 1992). In a limited respect, this was also a goal of this research.

LCB is a shallow, turbid, windswept impoundment in north-central Oklahoma. At spillway elevation the reservoir has a surface area of 554 ha and mean and maximum depths of 4.9 and 15 m, respectively (Howick 1983). Surface turbidities range from 15-75 nephelometric turbidity units and are caused by suspended solids. Intermittent streams add water to the lake and water is lost over the spillway during wet seasons.

The fish community of LCB includes predators, such as hybrid striped bass (striped bass *Morone saxatilis* x white bass *M. chrysops*) and saugeye (walleye *Stizostedion vitreum* x sauger *S. canadense*), largemouth bass (*Micropterus salmoides)*, channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictus olivaris*), white bass (*Morone crysops*), occasionally black crappie (*P. nigromaculus*), and white crappie. Prey species are gizzard shad (*Dorosoma cepedianum*), inland silversides (*Menidia beryllina*), sunfish (*Lepomis* spp.), and small crappie (*Pomoxis* spp.).

With the two exceptions described below, all species mentioned above successfully reproduce in the lake. Hybrid striped bass were stocked during 1981-1984 at a rate of 2.7-3.8/ha. Additional stockings as fingerlings (32-51 mm Total Length, TL) were made during 1993-1998 at rates 2.6-8.1/ha. A single stocking of fingerlings (70 mm TL) occurred in 1991 at a 0.1/ha. Saugeye were stocked as fingerlings (31-44 mm TL) during 1993-1998 at a rate of 8.2/ha except for 1994 and 1995 when the respective stocking rate of fingerlings was 5.6 and 11.5/ha. (William Wentworth, personal communication, 2002).

METHODS

Six coves were selected for sampling, representing different habitat types based upon turbidity and underwater structure (presence or absence of tree stumps). In each cove two sites were selected as permanent sampling stations. One site was at the mouth of the cove, while the other was at the back of the cove. Locations of coves and sites can be found in Mouneke et al (1993) and Doyle (1999). Each site was sampled with one hoop net and one frame net at depths of 2-8 m within 15-20 m of another. Each month the coves to be sampled were randomly selected (a randomized block design). Soak time was overnight. Nets were then redeployed, without replacement, in another cove, soaked overnight and redeployed until all six coves had been sampled for the month. Twelve frame nets and 12 hoop nets, respectively, were fished per month from June to December 1998.

Hoop nets were made of 13 mm-bar-mesh multifilament with 12 cm funnels at both ends supported by five metal or composite hoops 0.9-m in diameter and held in place by two wooden supports (Houser 1960). Frame nets were made of 13 mm-bar-mesh and had three rectangular (1.3 X 0.9 m) frames, four 0.9-m diameter frames, and a 15-m center lead.

The authors of the 1984-1985 study used hoop and frame nets of the same construction, set them at the same depths and the same sites in the same coves and at the same frequency and duration as described above (Muoneke et al 1992, 1993). But, there were two differences between the studies. They also used one multifilament gillnet per site; we did not. Their gillnets were (11.4 x 2.0 m) with four equal panels of bar mesh sizes of 25, 51, 76 and 102 mm. Also, while we sampled 7 months, June-December 1998, Muoneke et al (1992) sampled 16 months, June 1984 to September 1985. They had a spring and winter sample and two summer samples. We did not.

White crappie were put on ice, taken to the laboratory, and processed within 3 h after sampling. Total length (mm) and weight (g) of each fish were obtained. Scales were taken from the area below the lateral line near the point of the pectoral fin when the fin is pressed to the body. Scales were pressed on acetate slides and read by using an Eberbach 32X microfiche projector. Back-calculated lengths were determined by using Lee's equation $L = a + CS$, where L = total length, S = length of scale radius, a = y – intercept, and C = slope. A least squares regression of the total length of each fish against the specimen's scale radius length had a slope of 237 and an intercept of 36 mm ($r^2 = 0.89$, $n = 768$, SE = 1.90). This was the procedure used for fish collected in 1984-1985 by Muoneke et al (1992).

Growth comparisons for white crappie Ages 1 and 2 in our samples were made from fish taken in September, October, and November, 1998. We assumed that Age 0 fish, collected in the fall of 1998, had attained a TL very close to that of the back-calculated length for this cohort at Age 1 (i.e., in 1999). We compared only ages 1-3 where scale readings are reasonably accurate. Because the 1980s growth data were reported without variances, we assumed the variances of the 1984-1985 data were the same as ours. Therefore, to compare incremental growth in 1984-1985 to incremental growth in 1996-98 we replaced the pooled standard deviation estimate in a two population t-test with the 1996-1998 estimate of standard deviation (S_1) to arrive at the t-test. Values of t were calculated as follows.

$$t = \frac{\bar{Y}_1 - \bar{Y}_2}{S_1 \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where is the mean incremental growth in 1996 - 1998, $\bar{Y}_2$ is the mean incremental growth in 1984-1985, n_1 is the number of observations in 1996-1998 and n_2 is the number of observations in 1984-1985. The degrees of freedom for this test statistic was assumed to be $n_1 + n_2 - 2$.

To compare the changes in size categories in 1996-1998 to the 1984-1985 study, a 5x2 (5 size categories by 2 studies) contingency table was created. A chi-square test was performed to assess whether the overall distribution of the two studies across size category differed. Also performed was a gamma statistic, which uses the ordinal nature of the size category. The gamma statistic measures the relationship of ordinal categorical variables and can be thought of as a correlation coefficient for a two-way contingency table.

Other fisheries statistics were calculated according to usual protocols as used also by Muoneke et al (1992) as adopted from Anderson (1980), Gablehouse (1984) or Anderson and Newman (1996). Relative condition, W_r, compares the weight-length relationship for the population with a standard for the population, i.e. the 95 percentile weight for a given length of all populations sampled. In both studies

$$\log_{10} W_r = -5.102 + 3.112 \log_{10} + L$$

W_r is a measure of plumpness or fitness. Values of W_r of ≥ 100 are regarded as excellent growth.

Population structure in both studies was assessed using indices of relative balance. Length categories are established based upon what is considered to be sustainable harvest of sizes acceptable to anglers. Stock size is the length of the fish upon recruitment, upon being vulnerable to fishing mortality. Other size categories denote an increasing degree of preference by anglers. In both studies stock-quality was 130 – 199 mm; quality-preferred was 200-249 mm, preferred- memorable 250-299 mm, memorable-trophy 300-379 mm and trophy ≥380 mm. Accordingly, relative stock density (RSD) for a size category is:

100 (number fish in a size category)
number in stock

Another widely used index, proportional stock density (PSD), is indicative of balance in populations that will support sustainable harvest by anglers. PSD is equivalent to RSD for quality-preferred fish category (Muoneke et al 1992).

PSD = 100 (number of quality fish)
number in stock

All statistical tests were performed by using either Microsoft Excel (Dodge et al 1995) or PC SAS (2000).

RESULTS and DISCUSSION

Back-calculated growth data indicate that 150 mm TL is attained by Age 2 fish (Table 1). For all but age 1 fish back-calculated growth decreased between ages 3-9. Nine age groups were represented. Fish attained >229 mm TL after 5 y, but after age 5 numbers of older fish in the catch declined markedly.

TABLE 1. Average back-calculated total lengths (mm) for each age class of white crappie collected in 1998 in Lake Carl Blackwell.

Age	Year	N	1	2	3	4	5	6	7	8	9
1	1998	39	102[1]								
2	1997	190	97	151							
3	1996	140	95	147	181						
4	1995	265	82	137	171	195					
5	1994	112	83	136	166	195	217				
6	1993	7	98	152	184	210	239	258			
7	1992	5	84	134	168	196	229	270	302		
8	1991	3	82	142	197	218	248	284	323	357	
9	1990	1	81	135	157	195	224	250	291	314	325

1 = total length Age 0 fish at capture.

TABLE 2. Mean incremental growth in mm of white crappie in Lake Carl Blackwell and values of t for comparison between decades.

	1984-1985		1998			
Growth during Age	Mean (SD)	N	Mean (SD)	N	t	*P*[1]
1	87 (ND)[2]	150	102 (10.716)	39	0.790	<0.001
2	42 (ND)	779	54 (12.163)	190	13.211	<0.001
3	33 (ND)	437	34 (15.037)	140	0.697	>0.400

[1] *P* = 0.05

[2] ND = no data

Mean incremental growth at Ages 1 and 2 increased significantly from 87 to 102 mm and from 42 to 54 mm between 1984-1985 and 1998, respectively (Table 2). Mean incremental growth during Age 3 was almost the same in both decades. Figure 1 shows a shift in the age frequency distribution of white crappie population at least to Age 5. Other indices of age structure reveal that these changes from 1984-1985 to 1998 were statistically significant.

PSD shifted from 2 in 1984-1985 to 18 in 1998. There was a change in RSD stock–quality and quality-preferred length groups, but numbers of white crappie above the preferred length (250 mm) were still low (Table 3). The chi-square statistic testing the overall relationship was highly significant ($\chi^2 = 781.17$, df = 4, $P = 0.0001$), indicating that the size distribution for the two studies is not equivalent. The gamma statistic was also highly significant ($\gamma = 0.7232$, $P <$

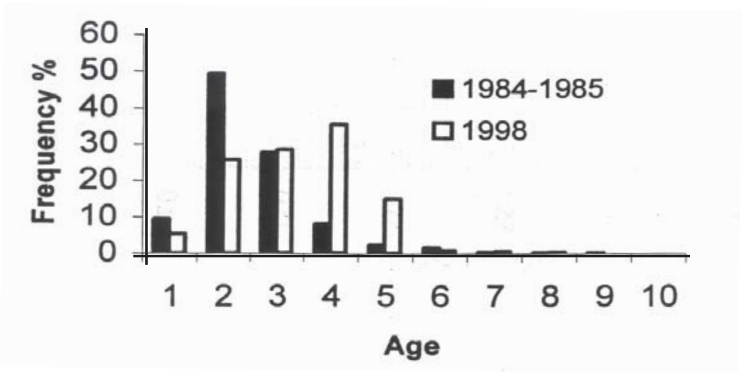

Figure 1. Comparison of age frequency distribution of white crappie from 1984-1985 and 1998, using data from both studies.

TABLE 3. RSD and W_r comparisons for crappie collected in 1998 to crappie collected in 1984-1985 (Muoneke et al 1992). PSD was 2 (1984-1985) and 18 (1998).

	1984-1985			1998		
Size Category[1]	No. fish	RSD[2]	W_r[3]	No. fish	RSD	W_r
Stock	6571	96	79	1597	78	81
Quality	161	2	86	387	18	78
Preferred	62	1	106	47	2	86
Memorable	42	1	109	14	1	105
Trophy	5	0	123	1	0	109

[1] See text for lengths
[2] RSD = relative stock density
[3] W_r = relative weight, see text for definitions

0.0001), indicating an increase in larger fish for the 1996-1998 study relative to the 1984-1985 study.

Relative weights of white crappie in stock-quality and quality-preferred classes were < 87. Few fish in either the 1984-1985 or 1998 had $W_r > 100$.

Gear selectivity ought to be absent for a direct comparison of white crappie between decades. One bias in these comparisons may result from the gillnet data from the 1980s that were used to determine PSD and RSD. We did not use gillnets in this study to avoid by-catch of wipers and especially saugeyes, the latter were not in the lake in 1984-1985. Muoneke et al (1992) reported that white crappie collected in the gear types they used had mean lengths of 139 mm TL, range 76-386 mm TL, SD= 20 mm, N= 4040 for hoop nets, mean 154 mm TL, range 73-392 for hoop nets, mean 154 mm TL, range 73-392 mm TL, SD= 34 mm, N = 3321 for frame nets, and mean 155 mm TL, range 97-445 mm TL, SD = 28 mm, N= 1188 for gillnets. Fish captured in gillnets and frame nets had almost the same mean length. In a statistical comparison of hoopnets and frame nets, Muoneke et al (1993) concluded that the sizes of white crappie captured were about the same, but the overall mean of the size of fish captured in frame nets tended to be larger. The CPUE of hoop nets and frame nets was similar, except in summer when hoop nets captured significantly more and smaller fish. Thus, because our data set did not include gillnet samples, our population size may be more weighed toward smaller fish than Muoneke et al (1992). But, had we used gillnets, more large fish would be in our samples with the net effect of increasing even more the PSD value we observed which was nine times that reported by Muoneke et al (1992.) Also, the 1984-85 study had twice the effort in summer when smaller fish were captured in hoop nets.

As a result, the 1980s data should be biased toward smaller fish and thus RSDs of Muoneke et al (1992) would be expected to be lower than ours. However, without a direct seasonal comparison of 1980s data and ours, there is no way to determine the exact effect of a difference in effort between decades.

Seasonal changes in W_r also complicate comparison between decades. Spring samples in 1984-1985 but not in 1998 could result in higher overall W_r values for the 1980s because fish in spawning condition should increase W_r. Thus, W_r values from the 1980s ought to be higher than those in the 1990s as was the case except for quality-preferred fish (Table 3).

The reason for an apparent increase in growth of ages 1 and 2 white crappie is not clear but introduction of a predator, saugeye, may be one reason. Saugeye prey on small white crappie in Thunderbird Reservoir, OK (Summers et al 1994, Boxrucker 1996). Leeds (1988) showed that in the same lake, about 30% of the food ingested by saugeye (>401 mm) was white crappie.

When this study was conducted (1998) there was a relatively large abundance of saugeye <300 mm (Doyle 1999). Most saugeye were only capable of consuming white crappie <25% of the saugeye's body length or <60 mm TL (Doyle 1999). In addition, maximum prey sizes consumed by other piscivorous fishes can be substantially smaller than predator gape size (Juanes et al 2002). Thus, it is likely that saugeye were eating only Age-0 white crappie, and as a result only growth of Age-1 and Age-2 white crappie might be expected to increase, as, in fact, we observed.

Population size structure and W_r comparisons between years were statistically different but owing to inherent tendency for these estimates to vary across the seasons and the real possibility of gear bias, any conclusions about 1980s-1990s change must be tempered. Variation in recruitment of white crappie and other forage fish (Mitzner 1984), changes in angling mortality (Webb and Ott 1991), environmental changes (Hill 1984), predation (Willis et al 1984) and competition could also produce a change in W_r and size structure that we observed. Nevertheless, our data represent a baseline against which future research may be compared. We speculate that if saugeye continue to be stocked in LCB as a management tool to improve growth of slow-growing white crappie (Summers et al 1994), then the apparent changes we observed should become fixed, at least for small sizes, and white crappie recruitment should decline as it has in Thunderbird Reservoir (Horton and Gilliland 1990).

White crappie feed upon zooplankton and aquatic insects until they reach 150 mm TL (Burris 1956), but beyond this size they are not efficient planktivores (Wright et al 1983). If fish forage is available, white crappie >150 mm can have good growth rates (O'Brien et al 1984). But, 150 mm is short of 200 mm, when anglers want to start harvesting white crappie. Thus, the real challenge for a good white crappie fishery in LCB might be the size of the available base of fish forage, which may be limited because of low ecosystem productivity in this turbid lake. More research is needed to determine the limits of top-down man-agement of panfish in turbid lakes. Hunter and Price (1992) discuss the general issue of resources versus predators in structuring aquatic food webs.

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