The Characteristics of the White Crappie Population of Sooner Lake, Oklahoma

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From 1981 to 1983 white crappie (*Pomoxis annularis)* in Sooner Lake grew fast and were in excellent condition. However, each year class generally dominated the population for only one year and 3-year-old crappies quickly disappeared from the population. Angling pressure and harvest of white crappies increased from spring 1981 to spring 1982, but the population showed no signs of excessive harvest. Two separate estimates of annual fishing mortality gave values of 7%. The rapid disappearance of 3-year-olds from the population plus the low average fishing mortality for all age classes indicated very high natural mortality during the third and fourth years of life.

INTRODUCTION

The white crappie is important to Oklahoma anglers and constitutes the second most sought after species in the state (1). Maintenance of quality crappie fishing is difficult in Oklahoma because many populations become composed of a few large fish and many small ones. Several explanations have been proposed for the development of this population structure, the most common being stunting (decreased growth rates) caused by intraspecific or interspecific competition (2, 3) at one of three periods: at some specific stage of reservoir development (4 - 6); at some point in the development of the crappie population (7, 8); or at some point in the development of a specific year class (9,10). This hypothesis of a competition-induced population structure is not universally accepted because: (1) growth rates can vary greatly among fish of the same age, even in unstunted populations (2, 11); and (b) there is evidence of disproportionately high mortality among large crappies (12-16).

The study described here was undertaken to examine this possibility of high mortality of larger crappies by evaluating the structure of the unharvested and harvested crappie populations of a relatively new reservoir.

STUDY AREA

Sooner Lake was built in 1976 by the Oklahoma Gas and Electric Company (OG&E) as a power-plant cooling reservoir. The 2185-ha lake is on Greasy Creek, 35 km north of Stillwater, Oklahoma, in Pawnee and Noble counties (Fig. 1). Makeup water for cooling is pumped into Sooner Lake from the Arkansas River and excess water is released back into the river. At peak capacity, the heated effluent discharge (126,000 m^3/min) was 11 °C above ambient water temperature (17) but had returned to within 1 °C of ambient by the time the water reached the main reservoir.

The lake had an average depth of 8.5 m and a maximum depth of 27 m (18) and stratified at 16 - 18 m in summer (19). Secchi disk readings ranged from 0.7 m to over 2.5 m. Mean surface water temperatures ranged from 7.2 to 27.7 °C during 1981 and 1982. Other characteristics such as dissolved oxygen and pH were comparable to those of other lakes in the region. However, makeup water from the Arkansas River caused Sooner Lake to have somewhat higher conductivities (1,370 to 1,550 μmho/cm) than other such lakes (19,20). Cover was sparse throughout the lake.

DATA COLLECTION AND ANALYSIS

Creel Survey

A creel survey was begun in March 1981 and continued through February 1983. This survey was a modified version (all anglers were creeled from the bank) of the

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Standardized Creel Survey (anglers are creeled from a boat) developed by the Oklahoma Department of Wildlife Conservation (21). The standardized design calls for creel sampling during only three seasons (spring, summer, fall) but a fourth winter season (December, January, February) was included on the basis of our observation that there was a significant amount of winter fishing for crappie.

Population Study

The crappie population was sampled each month except December 1981 from February 1981 through December 1982. Fish were collected in barrel (hoop) nets (22), gill nets, frame nets, and by boat electroshocking, but barrel nets were used as the primary sampling gear during most of the study because they yielded the highest catch rates and caused the least mortality. Barrel nets were set overnight in areas with flooded trees and brush where crappies are known to congregate (23), in areas along rock riprap, and in areas where no cover was apparent. These areas represented the available habitats in Sooner Lake. Each fish was finclipped with a clip specific to each section of the lake prior to release. Recapture data were used to determine movement patterns and population numbers.

Total length (mm) and weight (g) were recorded for each white crappie captured, and a scale sample was removed for age and growth determination. The Proportional Stock Density (PSD) of Anderson (24) and Relative Weight (W_r) of Wege and Anderson (25), as well as catch per hour (c/h), were also determined.

Examination of mean length at age by month (Fig. 3) was used to assign angler-harvested fish to age groups and to allow individual year classes to be followed throughout the study. The midpoint between each pair of respective age-group mean-length values, as determined from barrel-net-captured fish that were aged, was chosen as the dividing point between those ages. This estimated age frequency distribution (presented by year class) for angler-harvested white crappie provided an estimate of the total harvest (numbers) of each year class for each season of the creel survey.

Determination of Mortality Components

Age frequencies were plotted as catch curves and were used to determine differences (chi-square test) in age structure between fish from different sections of the reservoir. Total mortality of net-captured white crappie was determined from the catch curve by the method of Jackson (26) where mortality (A) = 1 - survival *(S)*, and

$$S = (n_4 + n_5)/(n_3 + n_4)$$

where n_3, n_4, and n_5 represent consecutive ages, with n_3 representing the first fully recruited age in the sample, and n_5 representing the oldest age found in the sample.

A segment of the discharge canal that was closed to fishing from boats between 1978 and 1982 was used to measure mortality in an unexploited segment of the population (Fig. 1). We assumed that demographic parameters of the unexploited subpopulation would be representative of a population theoretically existing in Sooner Lake with no angling pressure. We also assumed that crappie captured in a heavily

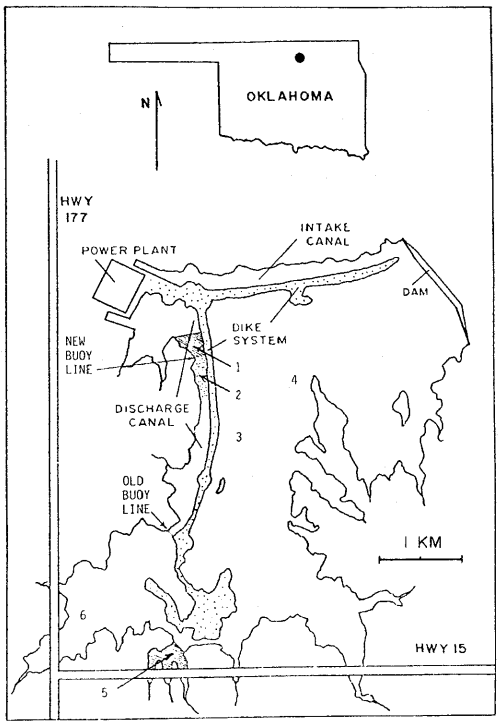

FIGURE 1. Map of Sooner Lake, Noble and Pawnee Counties, Oklahoma.

fished cove (27) adjacent to the west boat ramp (Fig. 1, Area 5) were representative of a heavily exploited subpopulation. Length and age distributions of white crappie collected by hoopnets from each area were compared using the chi-square test to determine if differences existed between the two subpopulations (28).

Population estimates were made in 1982 by using the Schnabel multiple-mark-and-recapture technique on net-captured white crappie (29) from the unexploited subpopulation in the closed area of the discharge canal (Fig. 1, Area 1) and the heavily exploited population in the cove adjacent to the west boat ramp (Area 5). In order to estimate population numbers, white crappie populations in the subsections were arbitrarily considered to be closed and standing crop estimates (number/ha and kg/ha) were calculated.

To test for movement between subpopulations, we sampled two subsections of the discharge canal adjacent to the closed area (Fig. 1, Areas 1 and 2). These two areas were of approximately equal size (10 ha), and subsequent analysis of movement data supported the assumption of limited emigration or immigration.

The relative effect of angling on the Sooner Lake white crappie population was determined by comparing length and age distributions of fished to unfished subpopulations and population estimates to angler harvest. These data reflected the effects of fishing plus natural mortality in the fished area but only natural mortality in the unfished area. Comparison of population estimates to the estimated angler harvest (from the creel survey) yielded direct numerical estimates of exploitation and natural mortality.

RESULTS

Creel Survey

Fishing pressure for crappie was highest in the spring and lowest in the fall and winter (Table 1). Crappie harvest was estimated to be 14×10^3 fish in spring 1981, and to exceed 38×10^3 in spring 1982, but was much lower during other seasons. Catch of crappies per hour was highest during spring 1982. Mean length of crappies harvested ranged from 230 mm in summer 1981 to 271 mm in winter 1982 (Table 1). No seasonal patterns in size of fish harvested were apparent, although mean length of harvested white crappie and total harvest continued to increase over previous seasons beginning with spring 1981.

Population Study

Catch per hour (c/h) was highest during the cooler months of the year, and during the spring (Table 2). Growth rates were well above the state average for the first two years of growth, but were near average by the fourth and fifth years of growth (Table 3).

Length frequency distributions of net-captured white crappie were unimodal for all seasons with Fig. 2 (spring 1982) illustrating the typical distribution. Length frequency thus could not be used to validate the annular determinations. The annular determinations did, however, appear to be valid on the basis of several other lines of reasoning: (a) back-calculation shows the largest growth increments during the early years of growth (Table 3), (b) the weighted mean lengths at annulus formation are generally very similar for the two separate years covered under this study, and (c) weighted mean lengths at annulus formation are very close to those values calculated for the same lake by previous researchers (19,20,31).

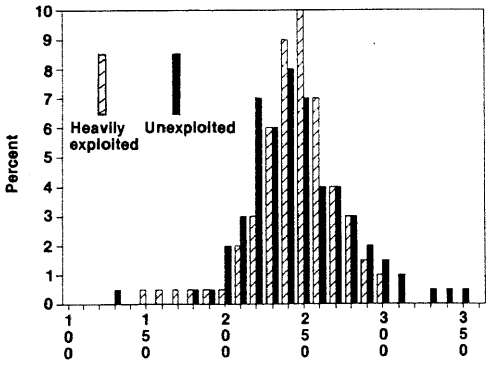

FIGURE 2. White crappie length frequency distributions for net–captured fish from unexploited sub- population (area 1) and heavily exploited subpopulation (area 5), spring 1982.

Proportional stock densities (*PSD*s) for net-caught white crappie showed little evidence of seasonal trends within years (Table 4). In addition, monthly PSD values were higher in 1982 than they were in 1981.

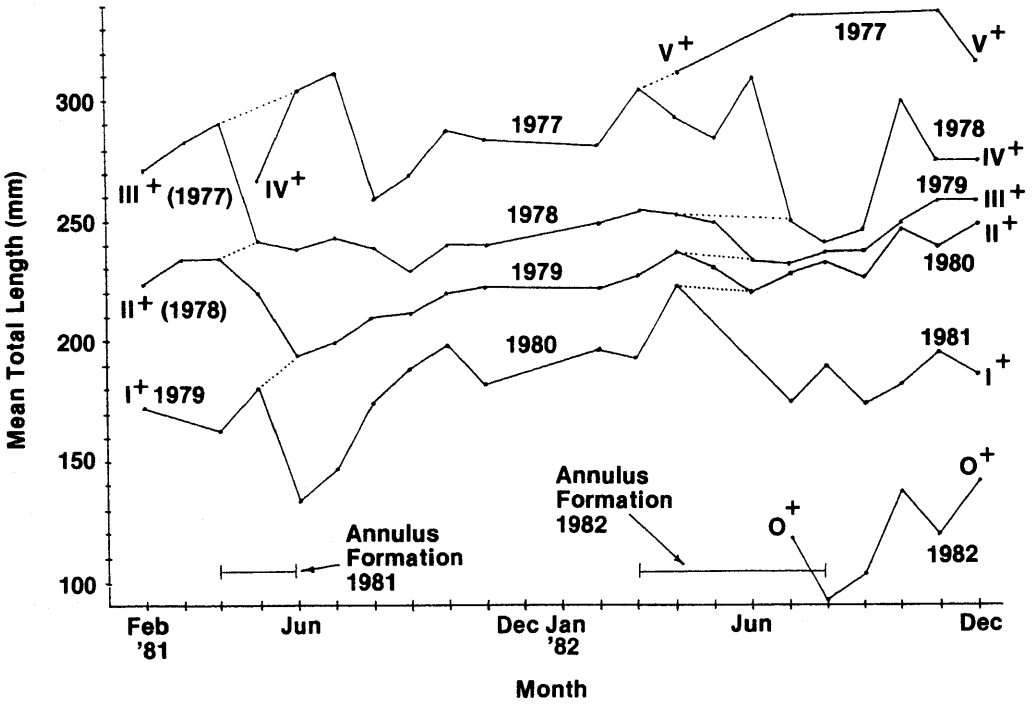

FIGURE 3. White crappie mean length at age by month, with dates referring to year classes.

Condition

Mean relative weight (W_r) by year was above 100% (state average) during the cooler months of each year, then decreased during the spring coincident with the spawning season (Fig. 4). Condition was always poorest during the summer months, although it did not drop as low in 1982 as it did in 1981. In both years, condition improved in the fall with the onset of cooler water temperatures.

Catch Curves

Catch curves for net-sampled Sooner Lake white crappie revealed considerable gear selectivity against yearling and young-of-the-year fish (Fig. 5). Young-of-the-year were taken in fairly large numbers in 1982, but none were caught in 1981. Large numbers of white crappie adults were captured in 3 m of water or less during March through May 1982 but similar concentrations of adult fish were not noted during the spring of 1981. This high catch ratio of adult fish in shallow water and high numbers of young-in-the-year in 1982 probably indicates very successful reproduction. There was very high total mortality of the older age classes (III-V) of crappie as evidenced by the steeply descending slope of the catch curves at these ages. If a steady-state age distribution were assumed, and age group 3+ was considered to be fully represented in the net samples, then the Jackson estimates of annual survival for 3-5-year-old fish would be 6.7% (calculated from the 1981 data) and 9% calculated from the 1982 data (29). Data from both years showed extremely poor survival between fourth (age 3+) and fifth (age 4+) years of life. Fish in their sixth year of life (age 5+) were essentially absent from the population. Similar population conditions were evidenced from fisherman harvest by age class (Table 5).

Movement

Of the 1446 white crappie finclipped in 1981, 26 were recaptured. All recaptures were easily recognizable up to a year after finclipping. All fish recaptured in 1981 had been originally marked in the area in which

TABLE 1. Seasonal harvest of Sooner Lake white crappie.

	Total estimated white crappie harvest	Total estimated pressure(hr)	Catch/ hour	Angler harvest[a]		Net samples[a]	
				TL	wt	TL	wt
1981							
Spring	13,895	63,989	0.217	242	182	224	136
Summer	407	29,384	0.014	240	176	197	98
Fall	436	11,593	0.038	262	229	222	146
Winter 81–82	3,420	9,508	0.360	253	190	237	–
1982							
Spring	38,439	64,766	0.594	246	208	247	214
Summer	7,142	28,263	0.253	246	177	230	150
Fall	4,501	10,284	0.438	253	190	242	194
Winter 82–83	2,565	11,257	0.223	271	231	252	249

[a]TL: Total length, mean (mm); wt: Weight, mean (g).

TABLE 2. Catch per hour of white crappie by gear type and month.

	Electro-shocker	Gill net	Hoop net	Frame net
April 1980	–	0.11	–	0.10
June	1.60	0.22	–	–
July	–	0	0.39	0.73
October	–	0.05	–	–
December	1.00	–	–	–
February 1981	8.00	0.18	0.46	0.50
March	–	0.06	0.19	–
April	–	0.16	0.13	0.34
May	67.00	0.57	0.48	0.39
June	–	0.26	0.15	2.89
July	–	–	0.17	–
August	–	0.42	0.19	–
September	–	1.68	0.18	–
October	0.66	0.10	0.14	–
November	–	–	0.01	–
February 1982	–	–	0.15	–
March	–	–	0.19	–
April	2.00	–	0.25	–
May	–	–	0.45	–
June	–	–	0.02	–
July	–	–	0.12	–
August	–	–	0.26	–
September	–	–	0.15	–
October	–	–	0.14	–
November	–	–	0.18	–
December	–	–	0.42	–

(–) denotes no effort with that particular gear type

they were recaptured.

In 1982 the lake was subdivided into smaller sections to ensure greater sensitivity in detection of movement. Of 2595 white crappie finclipped in 1982, 129 were recaptured. Of these recaptures, 20 (15.5%) were marked in different areas from where they were recaptured. One fish had moved approximately 6 km linear distance, another had moved approximately 5 km, and two

TABLE 3. Age and mean back-calculated length at each annulus for white crappie in Sooner Lake during October and November 1981.

Year-class	Age group	Mean calculated total length (mm)				
		N	1	2	3	4
1981	0	0				
1980	1	40	111			
1979	2	242	117	176		
1978	3	181	121	177	220	
1977	4	11	133	196	239	270
Weighted average			118	177	221	270
Growth increment			118	59	44	49
Regional averages[a]			79	145	185	

From Hicks and Russell (31).

[a]All fish were credited with an annulus at the outer margin of the scale.

TABLE 4. Monthly and yearly proportional stock density values for Sooner Lake white crappie.

Month	Number stock[a]		Number quality[b]		Proportional stock density (%)	
	1981	1982	1981	1982	1981	1982
January	–	–	–	–	–	–
February	71	63	48	59	68	94
March	23	291	16	255	70	88
April	65	721	45	700	69	97
May	229	266	207	253	90	95
June	295	140	139	120	47	86
July	62	200	34	194	55	97
August	94	353	60	329	64	93
September	215	189	153	175	71	93
October	186	135	156	117	84	87
November	113	241	104	228	92	95
December	–	236	–	224	–	95

[a]>130 mm

[b]>200 mm

had moved about 4.5 km. The other 16 white crappie had moved from the area in which they were marked to adjacent sections in the discharge canal (areas 1 and 2). The considerable majority (84.5%) of the fish recaptured had remained in the area in which they were marked, or within 1 km of that area, and there was no evidence of differential mobility based on size. These data appear to indicate that movement of white crappie was minimal and different areas of the lake can be considered to be inhabited by separate subpopulations.

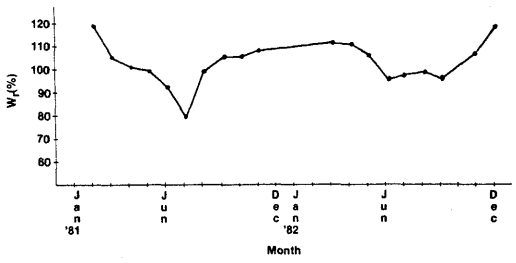

FIGURE 4. White crappie mean relative weight (W_r) by month.

Population Estimates and Calculation of Mortality Components

Using the results of the movement data, we treated two subsections of Sooner Lake (Fig. 1, areas 1 and 5) as closed sampling units. The Schnabel population estimate obtained in area 1 (the closed area of the

TABLE 5. Estimated seasonal harvest of white crappie, by year class, derived from the creel survey.

Season	1977	1978	1979	1980	1981	1982	Total
1981							
Spring	2,880	9,964	1,051	–	–	–	13,895
Summer	81	179	147	–	–	–	407
Fall	194	116	121	5	–	–	436
Winter ('81–'82)	992	1583	718	127	–	–	3,420
1982							
Spring	2,907	15,986	16,567	2,979	–	–	38,439
Summer	123	3,801	1,655	1,134	398	31	7,142
Fall	267	1,114	936	1,694	490	–	4,501
Winter ('82–'83)	410	1,026	342	684	103	–	2,565
	7,854	33,769	21,537	6,623	991	31	70,805
1981 Total[a]	3,486	10,787	1,558	47	–	–	15,878
1982 Total[a]	4,095	22,298	19,865	6,120	922	31	53,331

[a]Calendar year

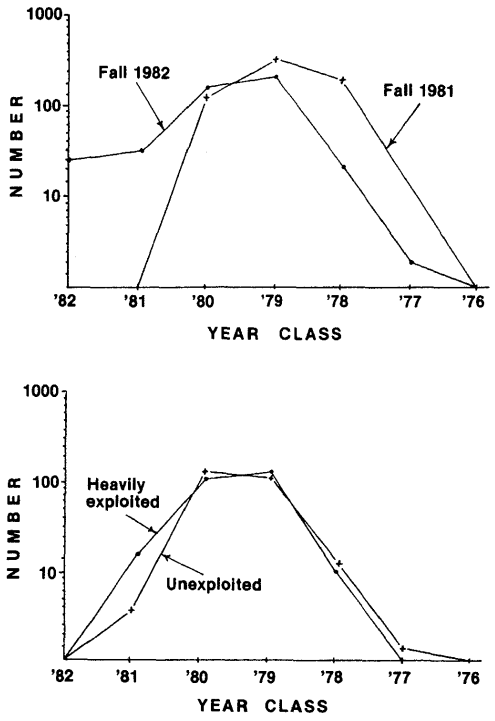

FIGURE 5. White crappie catch curves for fall 1981 and fall 1982 (upper), and for net-captured fish from unexploited subpopulation (area 1) and heavily exploited subpopulation (area 5), spring 1982 (lower).

discharge canal, area sampled 10.62 ha) was 4857 white crappie, or 457 fish/ha (98 kg/ha) with 95% confidence limits of 3527 – 7798. The estimate in area 5 was 14,334 white crappie with 95% confidence limits of 8467 - 46,512. We used the estimate in area 1 in all further calculations requiring population estimates because of the higher precision of this estimate.

The standing crop estimate for the closed area of the discharge canal, 457 fish/ha, may seem excessively high but generally adult white crappie are found in water less than 10.67 m deep during the spawning season (Table 6). The total surface water area of Sooner Lake less than 10.67 m deep was 1550 ha (30). The estimate based on the assumption of all fish in water less than 10.67 m deep, no movement between areas, and homogeneity of habitat with respect to crappie suitability yielded a lakewide population estimate of 708,217 white crappie. The age distribution of this theoretical population was assumed to be the same as that of our fall 1981 net samples (Fig. 5). These data gave a lakewide standing crop of 365 white crappie/ha (78 kg/ha), which was assumed to represent the population present at the beginning of the calendar year 1982. Exploitation rates were calculated by year class, based on the 1982 expanded creel results (Table 7). Annual exploitation during 1982 was lowest on the abundant 1979 year class (5.48%) and highest on the older 1977 year class (27.12%). The average of these values yields an annual fishing mortality estimate of 7.35%.

TABLE 6. Depth (m) and rate of capture (number/hr) in hoop nets of white crappie in Sooner Lake, spring 1982.

	Depth (m)								
Week	1.51	3	4.6	6.1	7.6	9.1	10.7	12.2	13.7
2/23–2/24	–	0.010	0.200	0.609	0.042	–	–	–	–
3/16–3/18	–	0.089	0.253	0.223	0.237	0.213	–	–	–
3/23–3/26	–	–	0.207	0.085	0.103	0.042	–	–	–
4/7–4/9	–	–	–	0.053	0.018	–	0	–	0
4/13–4/16	0.279	0.213	0.174	0.057	0	–	–	–	–
4/21–4/23	0.111	0.172	0.383	–	–	–	–	–	–
4/27–4/30	0.292	0.268	0.082	0.109	–	–	–	–	–
5/4–5/7	0.284	0.151	0.101	–	–	–	–	–	–

(–) denotes no effort

TABLE 7. Lakewide expanded population estimates, estimated angler harvest, and estimated angler exploitation of white crappie by year class.

Year class	Spring 1982 expanded population estimate	1982 estimated angler harvest	1982 estimated exploitation (%)
1982	–	31	–
1981	–	922	–
1980	106,370	6,120	5.75
1979	362,343	19,865	5.48
1978	224,406	22,298	9.94
1977	15,098	4,095	27.12
Total	708,217	53,331	Mean = 7.53

Catch curves and length frequency distributions (Figs. 2 and 5) differed ($P < 0.001$) in the closed section of the discharge canal and the heavily fished cove (Fig. 1, areas 1 and 5, respectively). The Jackson estimates of total mortality (29) for age groups III-V from both areas yielded an annual mortality estimate of 87% for the closed section of the discharge area (unexploited) and 94% for the heavily exploited area (Fig. 1). We assumed total mortality to be equal to natural mortality in the absence of fishing pressure; thus the total annual mortality of 87% in the closed area of the discharge canal is an estimate of natural mortality for the Sooner Lake population. The total annual mortality of 94% for the heavily fished area was assumed to be the sum of natural and fishing mortality. Subtraction yields a second annual fishing mortality estimate of 7%, which agrees quite closely with our previous 7.35% estimate of annual fish mortality.

Corresponding annual instantaneous forces of total mortality (Z), fishing mortality (F), and natural mortality (M) are as follows for Sooner Lake white crappie:

$Z = -\ln S = 0.90$ (ages 3+ to 5+, fall 1981 catch curve)

$F = EZ/1 - S = 0.105$ (based on 1982 creel results over all year classes, with E representing exploitation)

$M = Z - F = 0.795$ (based on 1982 creel results over all year classes)

DISCUSSION

In each year of the study except the last, a different age II year class appeared to dominate the population. This sequential dominance resulted from a rapid disappearance of fish of age classes III and IV. One possible explanation of the disappearance of crappies before age IV could be angler harvest. During the eight seasons of this study, crappies were the most sought after species in Sooner Lake. However, estimates of pressure and harvest, relative to that in

other lakes, appeared to be moderate. In addition, if overharvest was limiting the population, one would not expect a rapid and almost complete elimination of 3-year-old fish, but would expect a gradual decrease in numbers. Also in an overharvest situation, one would expect the average size of the harvested crappies to decline over time. To the contrary, average size, growth, and condition remained above the state average and did not change much in 1978-81. These findings, along with our estimate of approximatly 7% annual fishing mortality, lead us to conclude that natural factors led to elimination of 3- and 4-year-old crappies from the Sooner Lake population.

The natural mortality did not appear to result from poor physical condition. Growth of crappies in Sooner Lake was above regional averages and fish reached quality size early in the third growing season, rather than at the end of the growing season, as they did elsewhere in the region (21). In addition, the condition of crappies as evidenced by W_r values was generally higher than the state average except for brief periods during the spawning season and during periods of high water temperatures in summer.

Spring *PSD* values for all years were near 90% and indicated a sample dominated by large fish. Such values have been interpreted as reflecting a highly unbalanced fish population (R.O. Anderson, personal comunication) brought on by repeated year class failures. However, these data could also reflect biased sampling and selection against fish in the 130 to 200 mm length group. Such selectivity did appear to occur whether gill nets, seines, or electroshocking were used. Some spatial or behavioral factor or factors seemed to be involved in gear avoidance. In spite of these biases, the hypothesis of year-class failure could not be substantiated because fish 220 mm long continued to be recruited into the population in large numbers. It appears, therefore, that the Sooner Lake population did not conform to the picture of the classic stunted crappie population. In fact, most of the population appeared to be fast growing but short-lived.

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