RELATIVE POPULATION ABUNDANCE AND SIZE STRUCTURE DYNAMICS OF WHITE CRAPPIE IN SKIATOOK LAKE, OKLAHOMA, DURING A 5-YEAR STAGE-FILL

By

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CHAPTER I

INTRODUCTION

This thesis is comprised of one manuscript written for submission to the Transactions of the American Fisheries Society. Chapter I is an introduction to the rest of the thesis. The manuscript is complete as written and does not require additional support material. The manuscript is contained in Chapter II and is titled 'Relative population abundance and size structure dynamics of white crappie in Skiatook Lake, Oklahoma, during a 5-year stage-fill.'

CHAPTER II

RELATIVE POPULATION ABUNDANCE AND SIZE STRUCTURE DYNAMICS OF WHITE CRAPPIE IN SKIATOOK LAKE, OKLAHOMA, DURING A 5-YEAR STAGE-FILL

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Abstract.-Population dynamics of white crappie were monitored during the third, fourth, and fifth years of the 5-year stage-fill of a reservoir subjected to intense angling pressure. Anchor tags were used to estimate exploitation rates, and trap net catch rates were used to monitor relative abundances and size structures of the population. Whole otoliths were examined to ascertain ages and growth rates of white crappie collected in autumn quarters. Annual angler exploitation rates exceeded 40%, abundances progressively declined, and the fraction of the population consisting of large individuals (>250 mm TL) rapidly diminished. Growth rates declined despite the stage-fill. Poor survival past age 3 was attributed to high angler exploitation. New impoundments may require restrictive harvest regulations to maintain high quality crappie fisheries.

Crappie (Pomoxis spp.) angling is typically good in new reservoirs three or four years after impoundment (Thompson et al. 1951). However, average size of harvested crappie and their contribution to angler harvest decline in most of these lakes as they age (Thompson et al. 1951; Rutlege and Barron 1972). Conventional wisdom suggests that such populations are stunted because of reduced reservoir productivity and that enhanced exploitation would permit higher growth rates and greater yields (Ming 1971). However, excessive angler exploitation of quality-sized crappie (>200 mm total length) also could decrease average size (Colvin 1983) and result in apparently stunted populations. Populations consisting of mostly sub-harvestable-sized crappie in nearly all of the larger reservoirs in Missouri were attributed to high angler exploitation of larger crappie (Colvin 1982). Minimum length limits and reduced daily creel limits have been introduced in several states on some waters with high angling pressure to regulate harvest of crappie. Reports from Missouri and Texas indicate that length limits have improved the quality of crappie angling (Colvin 1983; Phil Durocher, Texas Parks and Wildlife Department, personal communication). Conversely, recent studies (Reed and Davies in press; Larson et al. in press) suggest natural mortality of crappie is high and reduced exploitation would have a negligible or deleterious effect on future yields.

I examined effects of intense angler exploitation on relative abundance and age/size structure of the developing white crappie (P. annularis) population in Skiatook Lake, Oklahoma. I sought to determine if restrictive harvest regulations were needed to maintain a high quality crappie fishery in this new reservoir.

Methods

Skiatook Lake is an impoundment of Hominy Creek located about 32 km northwest of Tulsa, Oklahoma, in Osage County. The reservoir is managed by the U.S. Army Corps of Engineers for flood control and recreation. Skiatook Lake was filled in stages from October 1984 to July 1989 in an attempt to extend the initial period of high productivity of the reservoir. At normal pool, the lake surface area is 4265 hectares with 257 km of shoreline. The maximum depth is 31 m and the mean depth is 10.4 m. The reservoir is relatively deep and clear by Oklahoma standards and much of the lake resembles other northeastern Oklahoma reservoirs with steep, wooded, and rocky shorelines.

Exploitation and mortality rates.-At least 1000 white crappie were tagged with anchor tags and released annually in 1987, 1988, and 1989 to estimate exploitation rates. Crappie were captured with trap and barrel nets during February and March when water temperatures were <15 C to permit handling of the fish without high mortality (Knapp 1985). Total length (TL) and weight of each tagged fish was measured. Only crappie ≥200 mm TL were tagged. A numbered anchor tag was attached to each fish prior to release.

Anglers returning tags were rewarded with a "Crappie Buster OSU" cap. Signs explaining the program and providing information on tag return procedures were posted at all boat ramps on the lake, other access areas, local bait shops, and convenience stores. Newspaper and television coverage also advertised the project.

Tag loss and tagging mortality rates were estimated in research ponds. White crappie were established in a pond with fish from nearby Lake Carl Blackwell in November 1989.

Fathead minnows were stocked to provide forage. In January 1990, 103 crappie $\geq$150 mm TL were captured with trap nets, tagged, fin-clipped and released back into the pond. The pond was drained one month later and the fish were collected to determine survival and tag-loss rates.

Two other ponds were used for longer term, tag-loss experiments. In March of 1989, 400 white crappie $\geq$150 mm TL were captured with trap and barrel nets in Lake Carl Blackwell, tagged, fin-clipped and released into two ponds (200 fish in each). Fathead minnows were stocked periodically to provide forage. One pond was drained after three months and the other after six months. The fish were collected and examined for tag loss.

Estimates of total annual mortality rates (A), annual survival rates (S), instantaneous annual mortality rates (Z), and annual angler exploitation rates (u), were calculated for white crappie tagged in Skiatook Lake using Ricker's (1975) method when marking is done at the start of fishing in two consecutive years. Adjustments for tag loss and tagging mortality were made using the results of the pond experiments. Tag returns were adjusted using the results of an experiment at Skiatook Lake that estimated the non-reporting rate to be 33% (A.V. Zale, Oklahoma Cooperative Fish and Wildlife Research Unit, personal communication).

Relative abundance and size structure.-Monthly samples of crappie were collected from September 1986 to November

1989 with trap nets set overnight throughout Skiatook Lake to monitor relative abundances and size structures of the population. Trap net sets were limited to gradually sloping areas with sparse bottom cover (as advised by Jeff Boxrucker, Oklahoma Department of Wildlife Conservation, personal communication). A Lowrance X-16 recording sonar unit was used to locate suitable sampling sites. Trap net sites could not be standardized due to rising water levels during the stage-filling of the lake. Netting was directed at maximizing white crappie catch rates, and unproductive sets were moved in an effort to find concentrations of white crappie.

Individuals collected in each net were counted, and total lengths of each were measured. Samples were pooled by quarter (e.g., March to May) to reduce variability that resulted from environmental fluctuations. Monthly effort varied in an attempt to collect at least 100 individuals per month and 600 individuals per quarter.

Relative abundances were expressed as catch-per-unit-effort (CPUE) rates (number per net-night) of all white crappie and white crappie $\geq$200 mm TL. Analysis of variance was used to determine if significant differences in mean catch-per-unit-effort rates existed among analogous quarters during the study period. Duncan's multiple range test was used to determine which quarters were significantly different from each other. Statistical significance was set at $P < 0.05$. Length-frequency distributions (expressed as length-interval specific catch-per-unit-effort rates) were constructed for each quarter to examine shifts in population size structures.

Age and growth.-Whole otoliths were examined to ascertain ages of crappie sampled during autumn quarters of 1986 through 1989. Otoliths are more reliable than scales for age and growth determination of crappie in Oklahoma and autumn samples best represent the actual age/size structure of the crappie population (Boxrucker 1986). Total length and weight of each fish were recorded in the laboratory. Scales and otoliths were removed and stored dry in coin envelopes. At least 350 sets of otoliths per autumn quarter were examined. Otoliths were placed in a black dish, immersed in water, and examined under a dissecting microscope using reflected light (Maceina and Betsill 1987). Otolith radius was measured from the kernel to the anterior tip with an ocular micrometer; distances to annuli were measured along the same axis (Schramm and Doerzbacher 1982). Total lengths at annuli were back-calculated using the Whitney and Carlander modification of the Lee method (Whitney and Carlander 1956; Carlander 1981; Carlander 1983).

The age/size structure of the crappie population was determined from length-at-age data obtained from otoliths. Both actual total lengths at capture and back-calculated total lengths at age of fish collected in autumn quarters of 1986 through 1989 were compared among years. Age-3 white crappie collected in 1986 and 1987 were not included in comparisons because of small sample sizes. Mean total lengths of age-3 white crappie in 1988 and 1989 were compared using a Student's t-test. Mean back-calculated total lengths-at-age of the 1985, 1986, and 1987 year classes were compared within year classes over time. Analysis of variance (ANOVA) was used to determine if significant differences in age/size structure and growth rates existed among autumn quarters during the study period. Duncan's multiple range test was used to determine which quarters were significantly different from each other.

Results

Exploitation and Mortality Rates

Tag loss in the pond experiments was 3.8% over three months and 6.6% over six months. In the tagging mortality study, no tag loss occurred in one month. Tagging mortality was 4.8%.

Total annual mortality rates were 87.7% in 1987, 80.0% in 1988, and 88.6% in 1989 (Table 1). Annual survival rates were 12.3% in 1987, 20.0 % in 1988, and 11.4% in 1989 (Table 1). Annual angler exploitation rates ranged from 41% to 53% (Table 1). The mean annual angler exploitation rate for the three years was 47.7%. Natural mortality rates were relatively constant, ranging from 36% to 39% (Table 1).

Relative Abundance and Size Structure

Catch-per-unit-effort rates of white crappie in trap nets varied seasonally within and among years (Figure 1). Significant differences in quarterly CPUE rates for all white crappie existed among years (autumn, P = 0.0001; winter, P = 0.0001; spring, P = 0.0001; summer, P = 0.0435). The overall trend suggested a progressive decline in CPUE rates among analogous quarters, except during spring (Figure 1). Autumn CPUE rates were significantly higher in 1986 and 1987 than in 1988 and 1989. Winter CPUE rates were significantly higher in 1986-1987 than in 1987-1988 and 1988-1989. Spring CPUE rates in 1989 significantly exceeded those in 1987 and 1988. No significant difference existed among progressively lower summer CPUE rates, probably because of small sample sizes (Figure 1). Significant differences in quarterly CPUE rates of harvestable-sized ($\geq$200 mm TL) white crappie also existed among years (autumn, P = 0.0001; winter, P = 0.0001; spring, P = 0.0001; summer, P = 0.0261). Quarterly trends in CPUE rates of harvestable-sized white crappie paralleled those of all sizes in aggregate (Figure 1).

Length-frequency distributions of white crappie collected in trap nets during autumn quarters shifted over the course of the study (Figure 2); large individuals progressively declined in relative abundance. Similar changes occurred in other seasons (Zale and Stubbs 1990).

White crappie $\geq$300 mm TL ("memorable" sized; Gabelhouse 1984) comprised 3.9%, 0.6%, 0.6%, and 0.5% of the white crappie collected during the autumn quarters in 1986, 1987, 1988, and 1989, respectively. White crappie $\geq$300 mm TL comprised 6.5% of the white crappie collected in trap nets during the first year of the study (autumn 1986 through summer 1987), 4.0% in the second year (autumn 1987 through summer 1988), and 3.4% in the third year (autumn 1988 through summer 1989). White crappie >250 mm TL averaged 9.3% of the combined 1986 and 1987 autumn trap net catches, but only 4.8% of the 1988 and 1989 combined catches.

Age and Growth

Growth rates of white crappie in Skiatook Lake declined during the study period (Figures 3 through 5). The largest declines in growth occurred during the first two years of the study. Significant differences in mean length-at-age existed among years for ages 1 through 3 ($P < 0.003$), but consecutive years were not always significantly different from each other (Table 2).

Mean total lengths of white crappie in the autumn of 1989 were 22.3%, 35.5%, and 27.2% less than in the autumn of 1986 for age 1, 2, and 3 fish, respectively. Angler-acceptable-size fish (>200 mm TL), comprised 39% of the age-1 white crappie collected in the autumn of 1986, but in the autumn of 1989, no age-1 white crappie had reached this size

(Figure 3). By 1989, white crappie did not reach 200 mm TL until age 2 or 3, and many two and three year-old fish were < 200 mm TL (Figures 4 and 5). Very few white crappie older than age 3 were collected during any of the four autumns.

Mean back-calculated total lengths-at-age of the 1985, 1986, and 1987 year classes declined over time (Tables 3 through 6). Mean back-calculated total lengths of age-1 white crappie in the 1985 year-class were 122.0 mm in 1986, 117.8 mm in 1987, and 116.3 mm in 1988 (Tables 4 through 6). Mean back-calculated total lengths of the 1985 year-class at age 2 were 192.7 mm in 1987, and 184.9 mm in 1988 (Tables 4 and 5). The declines in mean back-calculated total lengths of both age-1 and age-2 fish from the 1985 year-class were not significant (age 1, $P = 0.1779$; age 2, $P = 0.1758$). Estimated total lengths at age 1 of the 1986 year class sampled in 1987, 1988, and 1989 were 124.5 mm, 114.2 mm, and 97.0 mm, respectively (Tables 3 through 6). Each annual decline in mean back-calculated total lengths was significant ($P = 0.0001$). Estimated lengths of this cohort were 169.6 mm and 154.4 mm in 1988 and 1989 (Tables 2 and 3), and this difference was significant ($P = 0.0004$). Mean back-calculated total lengths of the 1987 year-class at age 1 were 100.1 mm in 1988 and 98.5 mm in 1989 (Tables 2 and 3). Mean back-calculated total lengths of this year-class declined slightly, but not significantly ($P = 0.4598$).

Discussion

Tagging mortality and tag loss rates can influence exploitation rates estimated from tag returns. My tagging mortality estimate of 4.8% from the pond study was nearly identical to a 5% estimate determined by Keefer (1982) in Georgia. Mortality of tagged and untagged white crappie in a Missouri pond study was 30% and 22%, respectively, during a 19-month period (Colvin 1983). A 4% tag loss rate was used to adjust the tag returns in my study, because most tags were returned within four months, and that rate was appropriate for that length of time. Tag loss rates of black crappie (P. nigromaculatus) in three Georgia reservoirs were 2-5% over two months; smaller fish lost tags at a slightly higher rate than larger fish (Larson et al. in press). Evidence suggests that tag loss, tagging mortality, and long-term, tag-induced mortality rates were relatively low.

Angler exploitation rate estimates at Skiatook Lake were similar to rates (40-60%) reported for white crappie fisheries in Missouri and Oklahoma that benefited from the implementation of minimum length limits and reduced creel limits (Colvin 1983; Jeff Boxrucker, personal communication). Actual tag return rates for Missouri lakes were generally higher than rates for Skiatook Lake, but Missouri offered $5.00 to $100.00 rewards for returned tags (Colvin 1983), whereas Skiatook Lake anglers received caps.

Missouri's reward system probably resulted in a higher percentage of anglers returning tags and possibly increased fishing pressure for crappie. Annual crappie angler effort increased 42% after rewards were offered at Jamesport Community Lake, Missouri (Stephen Eder, Missouri Department of Conservation, personal communication). I adjusted tag return rates from Skiatook Lake for a 33% non-return rate, but this was a conservative estimate and non-return rates may have been higher.

Total annual mortality rates (80-89%) for white crappie in Skiatook Lake were similar to those in Missouri's reservoirs (Michael Colvin, Missouri Department of Conservation, personal communication). Estimated total annual mortality was 90% in Lee County Lake, Alabama (Hornsby 1979). Black crappie in three reservoirs in Georgia suffered >80% total annual mortality, and total mortality was relatively constant despite major fluctuations in angler exploitation rates (Larson et al. in press).

Mosher (1985) surmised that survival was related to growth rates in Kansas crappie populations and hypothesized that fast growing crappies reached sexual maturity at a young age, encountered more physiological stress, and died at younger ages. Initially, Skiatook Lake white crappie fit this hypothesis; growth rates were good and few fish lived past three years of age (Zale and Stubbs 1989). However, many white crappie were harvested shortly after reaching 200 mm TL (Zale and Stubbs 1989), and never reached an age or size where natural mortality would be excessively high. The fact that total mortality rates varied as a function of exploitation rates and natural mortality rates were relatively constant is evidence that angler exploitation affected the white crappie population in Skiatook Lake.

Autumn trap net CPUE rates declined over the four years of the study, suggesting a reduction in the relative abundance of white crappie in Skiatook Lake. White crappie <175 mm TL, which are not usually harvested by anglers, declined in relative abundance, suggesting decreased recruitment. White crappie >250 mm TL probably declined in abundance because of high angler exploitation. The frequency of fish >300 mm TL also declined rapidly in angler catches (Zale and Stubbs 1988), suggesting selection by anglers for larger fish. A method of qualitatively assessing white crappie populations in Missouri reservoirs (Colvin and Vasey 1986) based on trap net catches, rated the white crappie population at Skiatook Lake as good in 1986 and 1987 but poor in 1988 and 1989.

At Skiatook Lake, white crappie older than age 2 persisted only after growth rates had slowed and most of the individuals comprising those year classes were <200 mm TL through the early summer period, and thereby avoided most of the angling pressure in that year. Size therefore appeared to mediate mortality more effectively than age. The age/size structures and growth rates of the white crappie population of Skiatook Lake in 1986 and 1987 were similar to those in Ft. Supply reservoir in Oklahoma, which was considered overharvested and had a 254-mm TL minimum length limit imposed in 1990 (Jeff Boxrucker, personal communication). The age/size structures and growth rates of the white crappie population in 1988 and 1989 in Skiatook Lake were similar to those reported in the overharvested Missouri lakes. Few age-3 white crappie survived and most fish were harvested at ages 2 or 3 (Zale and Stubbs 1989; Colvin 1983).

In 1985, 254-mm minimum length limits and 25-fish daily creel limits were applied to three Texas reservoirs. Angler pressure and yield decreased slightly immediately following implementation of the new regulations, but total yield increased at all three lakes after two years (Mark Webb, Texas Parks and Wildlife Department, personal communication). Most of the improvement was attributed to the minimum length limit. Few anglers harvested the 25-crappie daily limit before or after it was imposed. A statewide 254-mm minimum length limit for crappie has since been applied in Texas.

In Missouri, experimental 254-mm minimum length and 10-fish daily creel limits reduced mortality of age 1, 2, and 3 crappie and increased harvest of crappie $\geq$254 mm (Fred Vasey, Missouri Department of Conservation, personal communication). Restrictive harvest regulations such as length limits, may decrease the number of fish harvested but should increase the number of larger crappie and total weight harvested. A crappie that grows from 200 mm TL to 254 mm TL nearly doubles in weight and doubles again at 318 mm TL (Colvin 1982). Minimum length limits also may moderate cycles in crappie fisheries by assuring a broader age distribution. A fishery that is dependent on good recruitment of younger year classes, due to rapid removal of larger crappie by anglers (such as at Skiatook Lake), will have a poor harvest when few crappie remain to replace the fish removed.

The decline in growth rates of white crappie in Skiatook Lake is difficult to explain in consideration of the reservoir's youth, filling regime, and the high total mortality rate. Angler selection for larger fish was partially responsible for the apparent reduction in growth rates. However, age-1 white crappie were collected before they were recruited to the fishery and their declining growth rates could not be attributed to angler selection. Declining nutrient levels, inter- and intraspecific competition, and forage deficiencies may be possible explanations. By 1989, growth rates at Skiatook Lake had declined to levels precluding harvest of most white crappie younger than age 4 or 5 if a 254-mm TL minimum length limit were imposed. Natural mortality may reduce year-class strength at age 4 or 5 to a level that would make a 254-mm TL minimum length limit unproductive. A 228-mm TL minimum length limit would allow harvest of age-3 and older white crappie and increase the percentage of those year-classes available to anglers. Missouri has successfully used 228-mm TL minimum length limits to control harvest of crappie with slow growth rates (Michael Colvin, personal communication).

Angling pressure on Skiatook Lake has progressively increased (Zale and Stubbs 1989) and the close proximity of the reservoir to a major metropolitan area (Tulsa) makes it probable that angling pressure will continue to increase or remain high. Characteristics of the white crappie fishery at Skiatook Lake are similar to those in lakes where minimum length limits improved the quality of their crappie fisheries. I recommend a 228-mm TL minimum length limit be imposed to maintain and improve the quality of the crappie fishery at Skiatook Lake.

REFERENCES

Boxrucker, J. 1986. Evaluation of stocking inland silversides as supplemental forage for largemouth bass and white crappie. Pages 149-155 in G. E. Hall and M. J. Van Den Avyle, editors. Proceedings of the national symposium on managing reservoir fishery resources. Southern Division, American Fisheries Society, Bethesda, Maryland.

Carlander, K. D. 1981. Caution on the use of the regression method of back-calculating lengths from scale measurements. Fisheries (Bethesda) 6(1):2-4.

Carlander, K. D. 1983. Corrections to "caution on the use of the regression method of back-calculating lengths from scale measurements" with some additional comments. Fisheries (Bethesda) 8(5):25.

Colvin, M. A. 1982. In large reservoirs small crappies need a chance to grow bigger. Missouri Conservationist July:28-31.

Colvin, M. A. 1983. A study of the life history and management of the crappie. Missouri Department of Conservation. Dingell-Johnson Project F-1-R-32, Study I-7. Jefferson City, Missouri.

Colvin, M. A., and F. W. Vasey. 1986. Assessment of quality of white crappie populations in large reservoirs. Pages 79-85 in G. E. Hall, editor. Proceedings of the national symposium on managing reservoir fishery resources. Southern Division, American Fisheries Society, Bethesda, Maryland.

Gabelhouse, D. W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Hornsby, J. H. 1979. Population structure of a dominant black crappie (Pomoxis nigromaculatus) year class in Lee County Public Fishing Lake, Alabama. M. S. Thesis. Auburn University, Auburn, Alabama.

Keefer, L. C. 1982. Population dynamics of black crappie in Goat Rock Reservoir. Georgia Department of Natural Resources, Game and Fish Division, Final Report, Atlanta, Georgia.

Knapp, M. M. 1985. Effects of exploitation on crappie in a new reservoir. M.S. Thesis, Oklahoma State University, Stillwater, Oklahoma.

Larson, S., B. Saul, and S. Schleiger. In press. Exploitation and survival of black crappie in three Georgia reservoirs. North American Journal of Fisheries Management.

Maceina M. J., and R. K. Betsill. 1987. Verification and use of whole otolths to age white crappie. Pages 267-278 in R. C. Summerfelt and G. E. Hall, editors. The age and growth of fish. Iowa State University Press, Ames.

Ming, A. 1971. A review of the literature on crappies in small impoundments. Missouri Department of Conservation. Dingell-Johnson Project F-1-R-20, Study I-15. Jefferson City, Missouri.

Mosher, T. D. 1985. Assessment of white crappie growth and survival at two Kansas state fishing lakes. Kansas Fish and Game Commission, Final Report D-J/P-R Comprehensive Planning Option Project FW-9-p-(1-4), Pratt, Kansas.

Reed, J. R., and W. D. Davies. In press. Population dynamics of black and white crappie in Weiss Reservoir: implications for management. North American Journal of Fisheries Management.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, No. 191.

Rutlege, W. P., and J. C. Barron. 1972. The effects of the removal of stunted white crappie on the remaining crappie population of Meridian State Park, Lake Bosque, Texas. Texas Parks and Wildlife Department Technical Series No. 12.

Schramm, H. L., Jr., and J. F. Doerzbacher. 1982. Use of otoliths to age black crappie from Florida. Proceedings of the 36th Annual Conference Southeastern Association of Fish and Wildlife Agencies 36:95-105.

Thompson, W. H., H. C. Ward, and J. F. McArthur. 1951. The age and growth of white crappie, Pomoxis annularis (Rafinesque) from four small Oklahoma lakes. Proceedings of the Oklahoma Academy of Science 30:94-101.

Whitney, R. R., and K. D. Carlander. 1956. Interpretation of body-scale regression for computing body length of fish. Journal of Wildlife Management 20:21-27.

Zale, A. V. and K. C. Stubbs. 1988. Harvest and recruitment of white crappie in Skiatook Lake, Oklahoma, during the third and fourth years of a 5-year stage-fill plan. Oklahoma Department of Wildlife Conservation, Performance Report F-41-R-10, Job 13, Oklahoma City.

Zale, A. V. and K. C. Stubbs. 1989. Harvest and recruitment of white crappie in Skiatook Lake, Oklahoma, during the fourth and fifth years of a 5-year stage-fill plan. Oklahoma Department of Wildlife Conservation, Performance Report F-41-R-11, Job 13, Oklahoma City.

Zale, A. V. and K. C. Stubbs. 1990. Harvest and recruitment of white crappie in Skiatook Lake, Oklahoma, during the final year of a 5-year stage-fill plan. Oklahoma Department of Wildlife Conservation, Performance Report F-41-R-12, Job 13, Oklahoma City.

Table 1.- Instantaneous mortality (Z), annual mortality (A), annual survival (S), exploitation (u), and natural mortality (v) rates of white crappie >200 mm TL, Skiatook Lake, Oklahoma, 1987 to 1989, derived from tag return data.

Year Tagged	Z	A (%)	S (%)	u (%)	v (%)
1987	2.10	87.69	12.31	49.43	38.26
1988	1.61	80.05	19.95	40.97	39.08
1989	2.17	88.60	11.40	52.79	35.81

Table 2. Mean total lengths at capture (mm) and back-calculated total lengths at age (BC) of white crappie collected in the autumns of 1986-89. Within a column, lengths with a letter in common are not significantly different (P_{alpha}=0.05; Duncan's multiple range test).

Year	Age 1		Age 2		Age 3	
	Mean	BC	Mean	BC	Mean	BC
1986	a187.4 N=217	a121.1 N=119	a302.9 N=7	a233.1 N=7	a305.0 N=8	a245.4 N=4
1987	b163.8 N=519	a124.5 N=149	b237.2 N=267	b192.7 N=130	b218.0 N=1	a189.4 N=1
1988	c145.8 N=314	c100.1 N=62	c214.7 N=430	c169.6 N=111	a282.2 N=25	a245.7 N=25
1989	c145.6 N=183	b109.1 N=38	d195.3 N=386	c161.3 N=103	b224.0 N=64	a206.5 N=33

Table 3. Mean total lengths at capture and back-calculated total lengths at age (mm) of white crappie collected during the autumn of 1986 from Skiatook Lake, Oklahoma. Estimated ranges are presented below point estimates.

Year Class	N	TL at capture	Total length (mm) at annulus ± S			
			1	2	3	4
1985	119	187±35 129-271	122±22 74-186			
1984	7	303±32 254-339	147±50 79-214	234±54 152-302		
1983	5	305±17 281-327	87±05 79-90	177±30 138-206	245±33 198-273	
1982	1	331	75	142	243	297

Table 4. Mean total lengths at capture and back-calculated total lengths at age (mm) of white crappie collected during the autumn of 1987 from Skiatook Lake, Oklahoma. Estimated ranges are presented below point estimates.

Year Class	N	TL at capture	Total length (mm) at annulus ± S		
			1	2	3
1986	149	164±25 121-258	125±18 85-184		
1985	130	237±27 163-317	118±19 84-187	193±27 138-292	
1984	1	218	109	144	189

Table 5. Mean total lengths at capture and back-calculated total lengths at age (mm) of white crappie collected during the autumn of 1988 from Skiatook Lake, Oklahoma. Estimated ranges are presented below point estimates.

Year Class	N	TL at capture	Total length (mm) at annulus ± S: 1	2	3
1987	62	146±18 108-234	100±14 68-130		
1986	111	215±25 150-298	114±17 82-172	170±21 135-249	
1985	25	282±30 200-333	116±16 87-147	185±23 142-250	246±33 180-308

Table 6. Mean total lengths at capture and back-calculated total lengths at age (mm) of white crappie collected during the autumn of 1989 from Skiatook Lake, Oklahoma. Estimated ranges are presented below point estimates.

Year Class	N	TL at capture	Total length (mm) at annulus ± S: 1	2	3	4
1988	38	146±11 122-187	109±10 93-138			
1987	103	195±24 149-264	98±13 70-133	161±18 124-200		
1986	33	224±36 159-295	97±15 73-128	154±21 113-215	207±33 139-261	
1985	1	319	133	192	250	307

FIGURES CAPTIONS

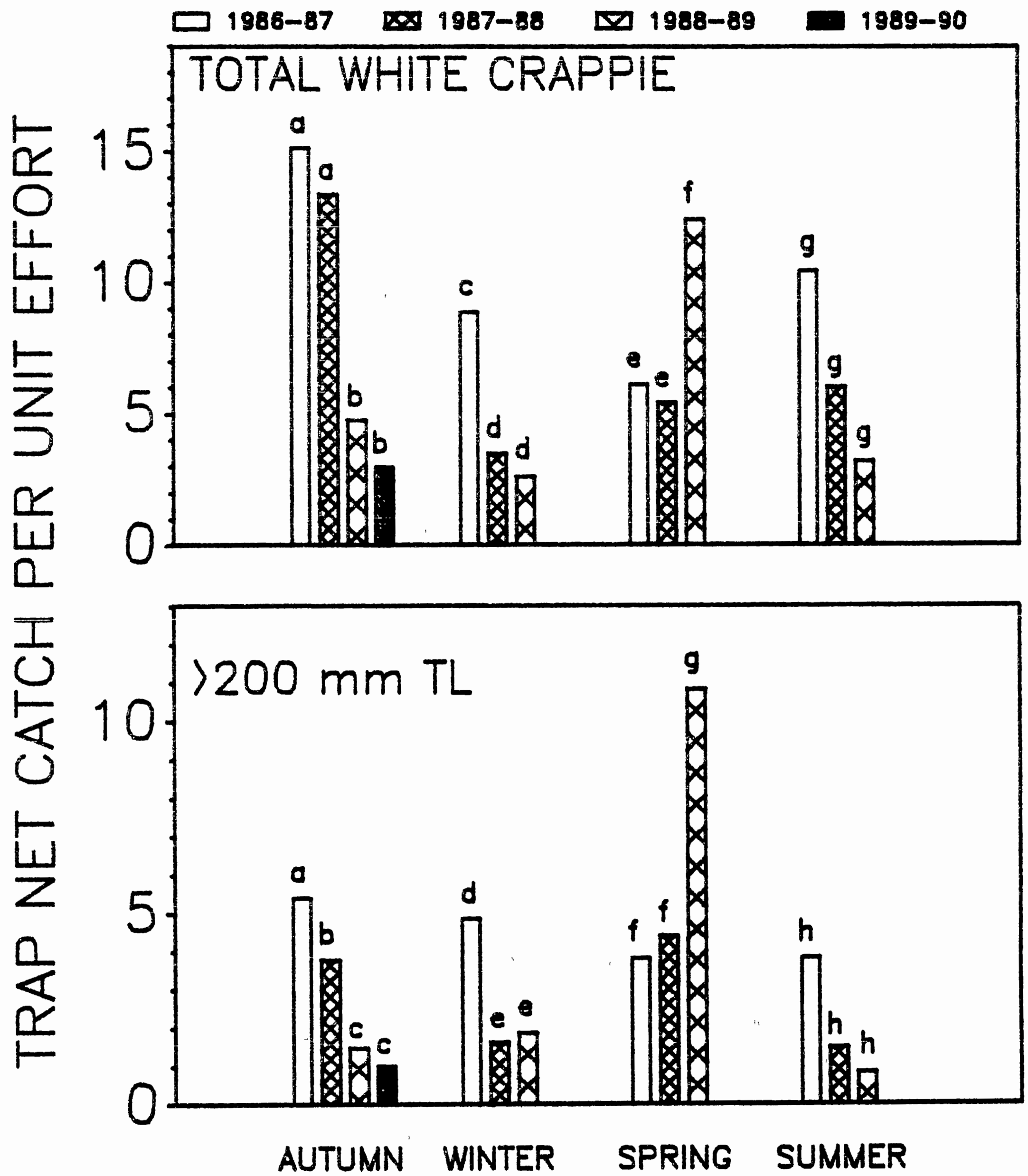
1. Quarterly trap net catch-per-unit-effort rates for white crappie, autumn 1986 through autumn 1989, Skiatook Lake, Oklahoma. Within a season, bars with a letter in common are not significantly different (Palpha=0.05; Duncan's multiple range test).

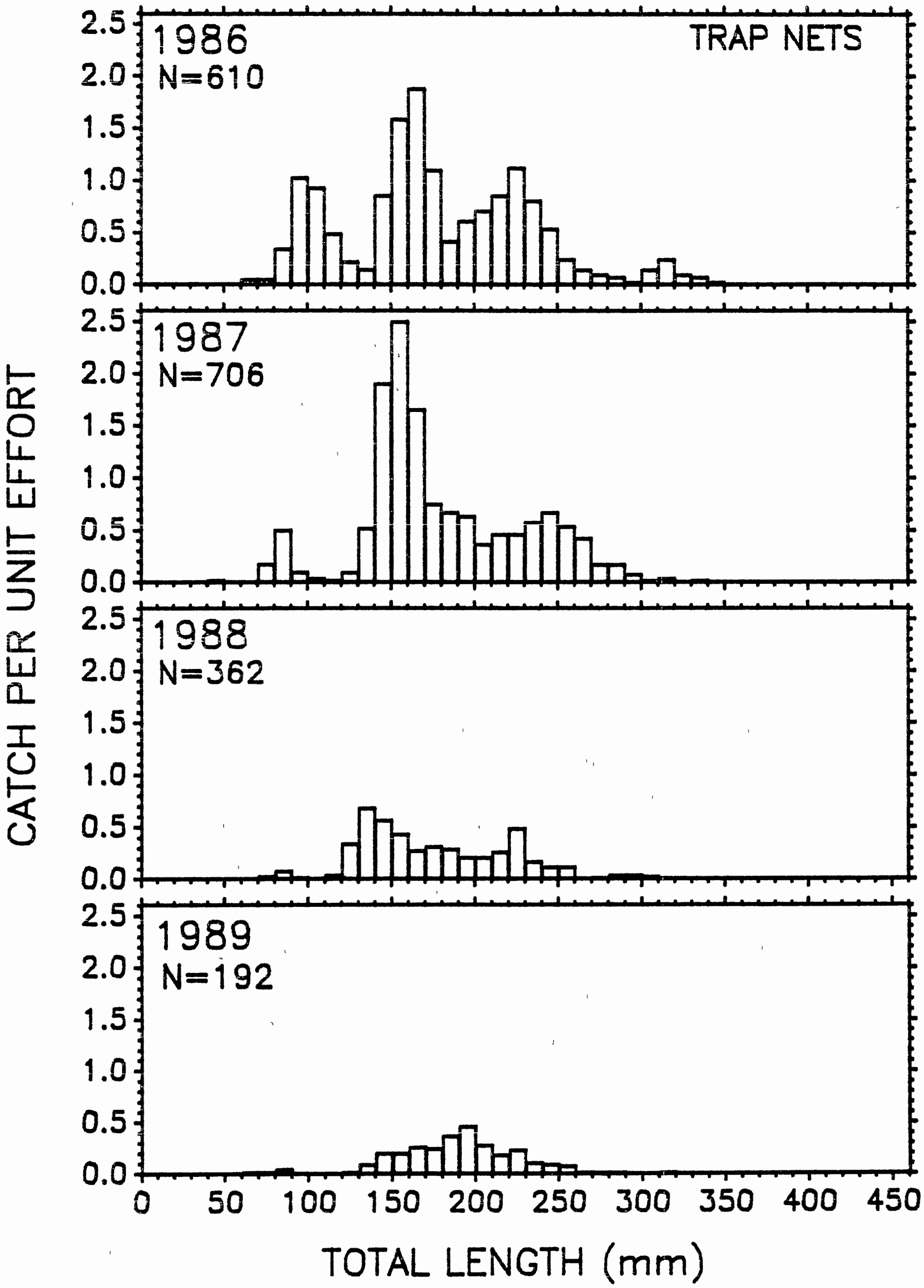
2. Length-frequency distributions of white crappie captured in trap nets expressed as length-interval specific catch-per-unit-effort rates, autumn 1986 to autumn 1989, Skiatook Lake, Oklahoma.

3. Length-frequency distributions of age-1 white crappie collected with trap and barrel nets, autumns of 1986 to 1989, Skiatook Lake, Oklahoma. Ages were determined from examinations of whole otoliths.

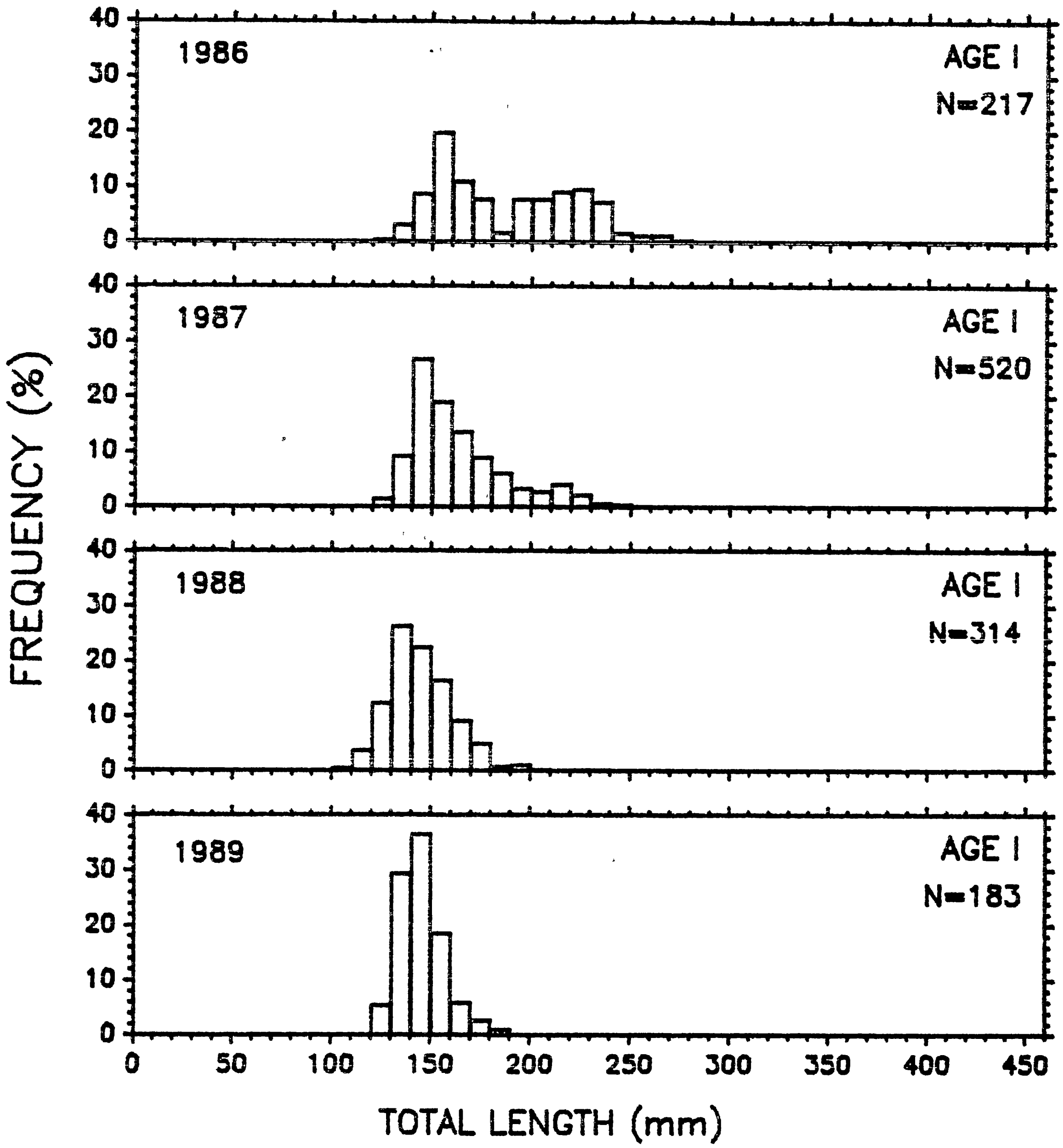
4. Length-frequency distributions of age-2 white crappie collected with trap and barrel nets, autumns of 1986 to 1989, Skiatook Lake, Oklahoma. Ages were determined from examinations of whole otoliths.

5. Length-frequency distributions of age-3 white crappie collected with trap and barrel nets, autumns of 1986 to 1989, Skiatook Lake, Oklahoma. Ages were determined from examinations of whole otoliths. Only one age-3 fish was collected in 1987.

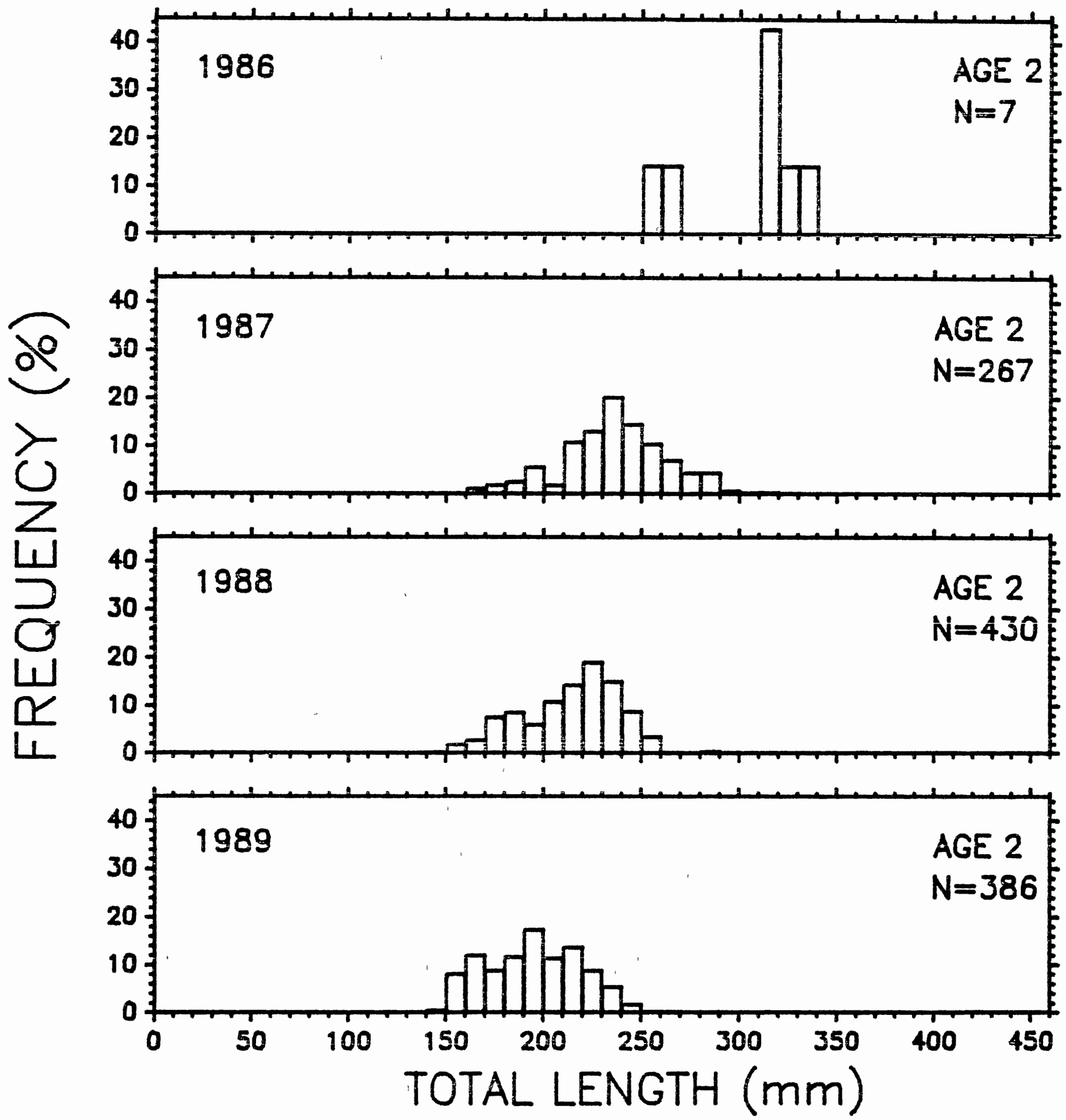

1986-87
1987-88
1988-89
1989-90
TOTAL WHITE CRAPPIE
>200 mm TL
TRAP NET CATCH PER UNIT EFFORT
0
5
10
15
AUTUMN
WINTER
SPRING
SUMMER

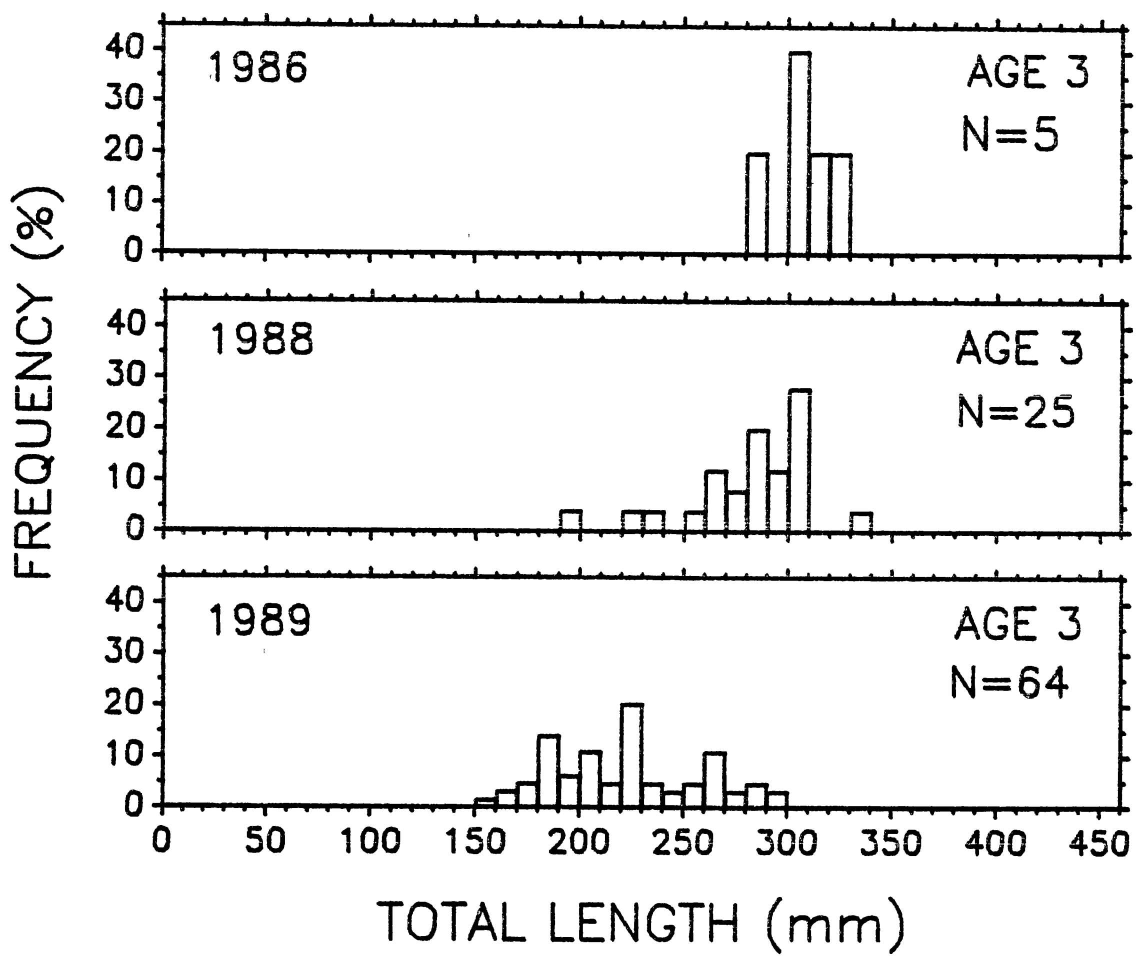


1986
N=610
TRAP NETS
1987
N=706
1988
N=362
1989
N=192
CATCH PER UNIT EFFORT
TOTAL LENGTH (mm)
0.0
0.5
1.0
1.5
2.0
2.5
0
50
100
150
200
250
300
350
400
450



FREQUENCY (%)
1986
AGE I
N=217
1987
AGE I
N=520
1988
AGE I
N=314
1989
AGE I
N=183
0
10
20
30
40
0
50
100
150
200
250
300
350
400
450
TOTAL LENGTH (mm)


1986
AGE 2
N=7
1987
AGE 2
N=267
1988
AGE 2
N=430
1989
AGE 2
N=386
FREQUENCY (%)
TOTAL LENGTH (mm)
0
10
20
30
40
0
50
100
150
200
250
300
350
400
450


FREQUENCY (%)
1986
AGE 3
N=5
1988
AGE 3
N=25
1989
AGE 3
N=64
0 10 20 30 40
0 50 100 150 200 250 300 350 400 450
TOTAL LENGTH (mm)

VITA

Kevin Charles Stubbs

Candidate for the Degree of

Master of Science

Thesis: RELATIVE POPULATION ABUNDANCE AND SIZE STRUCTURE DYNAMICS OF WHITE CRAPPIE IN SKIATOOK LAKE, OKLAHOMA, DURING A 5-YEAR STAGE-FILL

Major Field: Wildlife and Fisheries Ecology

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