DETERMINATION OF FISHING AND NATURAL MORTALITY OF WHITE CRAPPIE IN SOONER LAKE, OKLAHOMA

By

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PREFACE

The objective of this project was to determine the fishing and natural mortalities of the white crappie population in a cooling water reservoir. Activities included a literature review, crappie population sampling, and a creel survey. This project was funded by the Oklahoma Department of Wildlife Conservation, and permission to conduct the research on Sooner Lake was granted by the Oklahoma Gas and Electric Company.

I thank Dr. O. Eugene Maughan for the opportunity to do this research, his guidance during the project, and for his review of the drafts. I also thank Dr. Anthony Echelle and Dr. Dale Toetz for their effort in reviewing this thesis and serving on my committee.

Also deserving thanks is Dr. Harold Namminga and the personnel of the Oklahoma Fisheries Research Laboratory. Thanks also go to many of the staff and students of the Oklahoma Cooperative Fisheries Research Unit for their input and assistance with the field and lab work, some of who include: Randy Glass, Gene Gilliland, Vicky Gregory, Judy Gray, David Latham, Charlotte Krugler, Francis Grant, Zoe Ann Stinchcombe, Bonnie Bilodeau, Margarat Wagoner, Ruby Collins, Lori Rochelle, Derek Smithee, and Lloyd Landreth.

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CHAPTER I

INTRODUCTION

A recent survey of Oklahoma anglers showed the white and black crappie (Pomoxis annularis Rafinesque and P. nigromaculatus LeSeur, respectively) to be the second most fished for gamefish and the third most desirable catch (Mense 1978). This popular gamefish attracts great numbers of anglers to Sooner Lake, especially in the spring of the year. According to fishermen reports, angling for crappie in Sooner Lake was excellent during the first two to three years following impoundment. Following this period of reported excellent fishing the crappie fishery began a decline, and fewer catches of large crappie were taken.

Either slow growth (stunting) or high mortality of the larger size classes may explain a reduction in apparent crappie size such as that reported in Sooner Lake. There is no universal definition of stunting but Hall et. al. (1954) report that unstunted crappie reach a length of 203 mm in three years and 254 mm in four years in Oklahoma. These size criteria along with examination of crappie size distributions from various Oklahoma lakes would lead to the conclusion that there are large numbers of stunted crappie populations in Oklahoma (Burris 1956, Crawley 1954, Jossell 1969).

The dynamics of crappie stunting have been studied but these studies result in several different explanations of the phenomenon.

A decrease in growth rate has been linked to reservoir aging. For example, Vasey (1972) found a decline in white crappie growth rate correlated with increasing reservoir age in Pomme de Terre Reservoir, Missouri as that impoundment aged. In Oklahoma, Thompson et. al. (1949) found good initial crappie growth rate but poor subsequent growth rate in four small impoundments. Sneed and Thompson (1950) found the same phenomenon for white crappie and largemouth bass (Micropterus salmoides) in Lake Texoma, Oklahoma. Jenkins (1954) found that white crappie growth in Oklahoma was best during the first three years following impoundment. This high growth rate in new impoundments has generally been attributed to abundant nutrients, an abundance of flooded terrestrial invertebrates, and a lack of severe competition (Eschemeyer and Jones 1941). Growth rate of crappie have also been related to physical factors. Hall et. al. (1954) and Jenkins (1954) found that white crappie generally grow faster in smaller lakes and ponds than in larger lakes and reservoirs and in clear rather than turbid waters. The length of the growing season was implicated by Goodson (1966) who found that growth rate was negatively correlated with the shorter growing season at higher altitudes.

Heredity has generally been discounted as an explanation for fish stunting. The reason for this refusal to accept a hereditary basis for stunting is that when bluegills (Lepomis macrochirus) from a stunted population are transferred to a less crowded habitat, the transplanted fish initially exhibit good growth (Bennett et. al. 1940). Failure to switch from one food source to another has also been hypothesized to result in stunting (Triplett 1982).

Crappie less than 150 mm have generally been observed to be exclusively zooplankton feeders (Nelson et. al. 1967, Siefert 1969). Some authors report this food supply is never limiting and stunting begins sometime after the first year of life (Crawley 1954, Hansen 1951). The onset of recognizable stunting seems in some cases to begin at approximately 150 mm when white crappie generally shift from invertebrates to fish. However, this relationship between crappie size and diet shift is not universal since Maret and Peters (1979) found the larvae of the mayfly Hexagenia to be the most important food item of 194-300 mm white crappie in Nebraska. Undoubtedly, white crappie are opportunistic feeders such as many other fish species.

The quality of diet of larger size groups of crappie has also been implicated in stunting. Jossell (1969) and Crawley (1954) attributed poor condition in a stunted white crappie population in Boomer Lake, Oklahoma to low availability and low nutritive value of useable food. Burris (1956) found low condition factors in 127 to 178 mm fish. However, the 254 to 356 mm fish were in unusually good condition, although they were not abundant. Burris hypothesized that 254 to 356 mm fish were exploiting a different food source than smaller individuals. Bimodality of white crappie length frequency distributions (one mode <150 mm and one mode >150 mm) has been found within fish of the same age groups (Triplett 1982). Triplett hypothesized that the smaller subpopulation retained food dependence on zooplankton but the larger subpopulation shifted to fish. In contrast to these data, Schoch (1981) examined food habits from crappie from four small Oklahoma lakes and concluded that growth rates were not determined by the quantity or types of forage present or consumed, but may be related to some unidentified physiological factors. The controversy involving diet is far from resolved.

Crappie are known to be extremely prolific, and have the capacity for rapid population expansion (Hall et. al. 1954, Jenkins 1954). These authors hypothesize that interspecific and intraspecific competition may limit crappie growth. Based on this hypothesis, several attempts have been made to alleviate stunting by density reduction or by the increase in available forage. Some data indicates that reduction in numbers is the key to increasing growth rates. For example, Schoffman (1964) found a steady decrease in the average size of white crappie since commercial fishing was prohibited on Reelfoot Lake, Tennessee. Jenkins (1955) found improved crappie growth rate and condition immediately following density reduction of the entire fish population by treatment with rotenone. Rutledge and Barron (1972) found some increased growth rate of white crappie following mechanical removal of part of the population. These studies tend to validate some relationship between stunting and density.

The introduction of supplemental forage had also been successful in increasing crappie growth rate and alleviating stunting in some locations. Range (1972) and Heidinger (1977) found the growth rate of crappie age 2 and older increased after the introduction of threadfin shad (Dorosoma petenense). Kimsey et. al. (1957) reported similar increases in crappie growth after threadfin shad introduction in California. These results strongly suggest that the paucity of suitable forage may be at least partially responsible for stunting.

An alternative to slow growth as a reason for small average size is high mortality of the larger size classes. Such a hypothesis would explain the observation of small average size whether mortality resulted from natural causes or from fishing. Crappie are not generally considered a long lived species, although Schoffman (1964) found white crappie up to 8 years of age in Reelfoot Lake, Tennessee and Carlander (1953) noted crappie up to age 8 in Minnesota. Jenkins (1954) found 97% of the crappie from Oklahoma lakes to be less than five years old, indicating very high annual mortality for the species. Similar findings have been reported by Vasey (1972) in Missouri, Keefer (1982) in Georgia, and Starrett and Fritz (1965) in Illinois. Some evidence thus points to some sort of "physiological burnout" affecting matural mortality, whereby very fast growth shortens the longevity of the individual. This is supported by Carlander's observation of age 8 crappie in Minnesota where the short growing season might cause a relatively slow growth rate.

If larger white crappie were dying from some sort of physiological limit to longevity, one would expect to see evidence of dead fish in nature. There is some evidence of such die offs. Erickson and Zarbock (1954) observed a large die off in the spring of 1954 in Lake St. Mary's, Ohio and Goodson (1966) noted that several large spring die offs of adult crappie (203-279 mm) occurred in California. Goodson (1966) attributed the die off to natural mortality of old fish during and following spawning. These die offs did not appear to be related to disease. The only pathogenic condition which has been regularly reported from crappie populations is lymphocystis. However, lymphocystis generally affects only a small portion of the population and is not thought to be fatal (Hansen 1951, Whiteside 1964).

Crappie have been known to undergo population cycles (Swingle and Swingle 1967), but cyclicity does not appear to be universal (Jenkins 1953, Oklahoma; Neal 1963, Iowa; and Keefer 1982, Georgia). When cycles occur, they affect the relative abundance of year classes and the apparent average size of fish.

Swingle and Swingle (1967) believe cycles occur because a dominant year class holds down the numbers of subsequent year classes through cannibalism and intraspecific competition. The abundance of this dominant year class is gradually reduced (through natural attrition) until survival of a younger year class occurs due to the reduction of cannibalism and competition. The younger year class then becomes dominant, starting the cycle over. The periodicity of the cycle is approximately five years. Cycling may explain the changing relative abundance of crappie year (size) classes which has been observed in some lakes. For example, Starrett and Fritz (1965) and Starrett and McNeil (1952) found dominant year classes in Illinois, along with apparent disappearance of year classes in the summer. Cannibalism on young-of-the-year white crappie, as hypothesized by Swingle and Swingle (1967) has been noted in Beaver Reservoir, Arkansas by Ball and Kilambi (1972).

Overharvest by fishermen has also been postulated as a cause of high mortality of crappie. Vasey (1972) compared harvest in two arms of Table Rock Lake, Missouri, and found that the arm with light fishing pressure has a higher proportion of older, larger white crappie than did the arm with heavy fishing pressure. In a later study, Colvin (1982) showed high exploitation (43-52%) of white crappie in Table Rock Lake. Some researchers have argued that high mortality occurs in the absence of high fishing pressure. Starrett and Fritz (1965) estimated that the 1948 year class of white crappie lost 65-70% of their numbers during the third year of life, and that 5% of the mortality resulted from fishing and 95% from natural causes. Keefer (1982) also observed a high annual mortality of 70% of black crappie in Goat Rock Reservoir in Georgia, but he was not able to partition this mortality between natural causes or fishing.

This study was initiated to investigate the apparent decline in the quality of crappie fishing in Sooner Lake. The objective of my study was to quantify natural mortality rates of white crappie, and to determine the effect of angler exploitation on the older, larger crappie by the evaluation of age structure, growth rates, condition, and angler harvest. Quantification of natural and fishing mortality will clarify whether the Sooner Lake white crappie are dying from predominantly natural causes or whether angling is removing the majority of the fish before they reach a large size.

CHAPTER II

METHODS AND MATERIALS

Description of Study Site

Sooner Lake, a 2150 ha impoundment located on Greasy Creek in Pawnee and Noble Counties, Oklahoma, lies approximately 24 km south of Ponca City (Figure 1). The lake was constructed by Oklahoma Gas and Electric Company as a source of cooling water for two coal fired generators, and it was first filled in 1976. The very small watershed necessitated that makeup water be continuously added from the nearby Arkansas River. Water is circulated through a closed cooling system to and from the power plant by a series of riprap dikes. At peak capacity 126,000 m^3/min of heated effluent is discharged with a maximum rise in water temperature of 11° C (Gilliland 1981). The heated effluent comes within 1° C of ambient lake temperature by the time it reaches the main lake.

Sooner Lake is always characterized by high dissolved oxygen concentration in the epilimnion and throughout the water column during turnover. Stratification usually occurs during the summer with a thermocline near 15 m (Hicks and Russell 1980). Sooner Lake has a maximum depth of 27 m, and an average depth of 8.5 m (OG&E 1980). Conductivities are high (1630-1750 micromhos/cm) due to the filling of the lake with highly saline Arkansas River water (Hicks and Russell

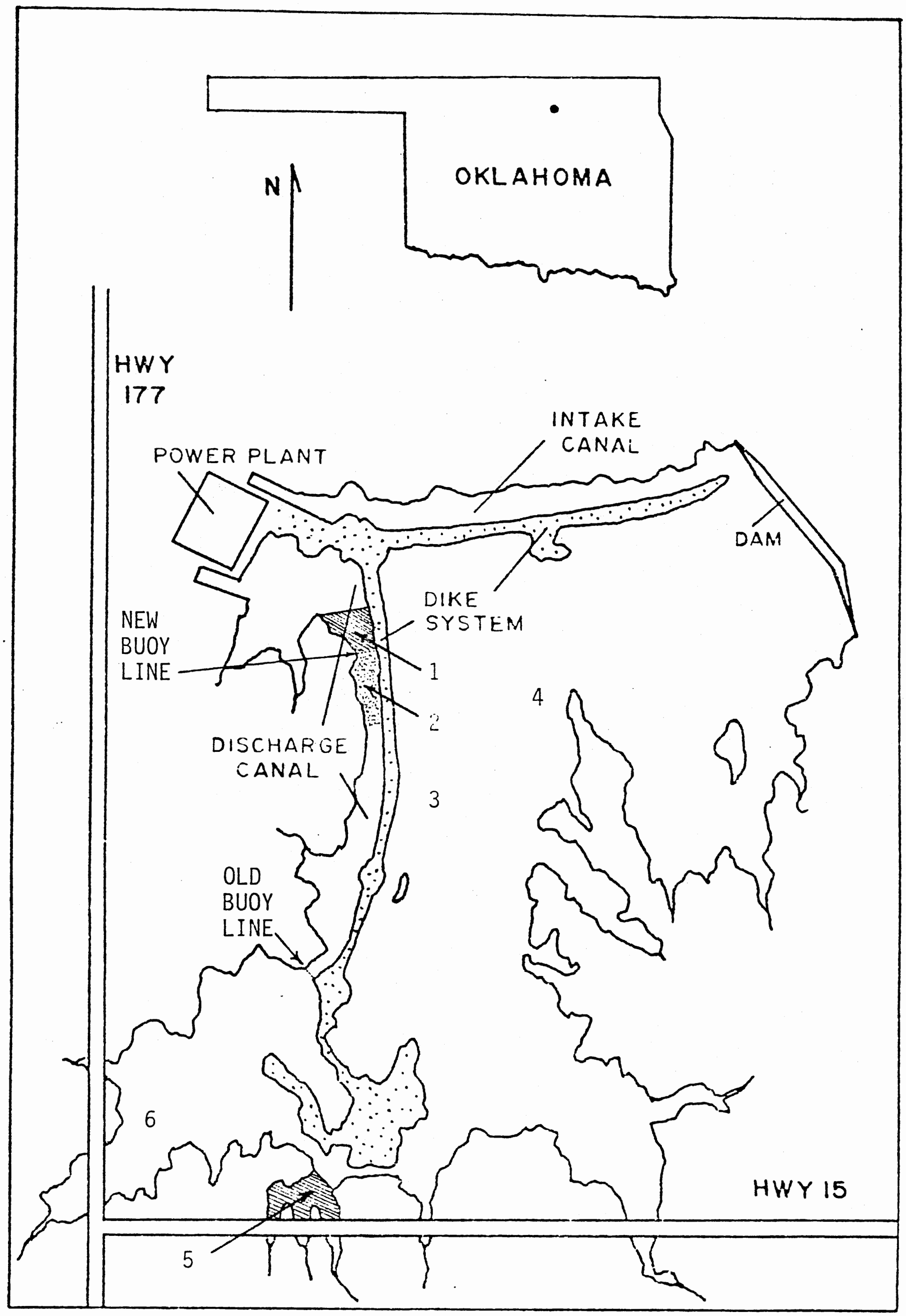

Figure 1. Map of Sooner Lake, Noble and Pawnee Counties, Oklahoma

1980). Values of pH are typically between 8.0-8.4. Secchi disk values are typically 1 m, with a maximum of 2 m observed near the dam (Hicks and Russell 1980). Brush piles and littoral vegetation are sparse throughout the lake, although brush piles were placed by the Oklahoma Department of Wildlife Conservation (ODWC) before impoundment and their location marked on the fishing map provided by the owners.

Makeup water for Sooner Lake is pumped from the Arkansas River, and the water level of the lake is held relatively constant. However, the lake was drawn down over 1 m during July, 1980, to repair the riprap dike system. The lake was returned to normal level about six months later. A storm during March, 1982, did further damage to the riprap on the dikes and dam, and another drawdown (approximately 2 m) was implemented to allow repair. The lake was raised to normal level in February, 1983.

The lake was stocked by the ODWC. Fish stocked in 1977 included 110,000 channel catfish (Ictalurus punctatus), 300,000 native largemouth bass fingerlings, 125,000 Florida largemouth bass fingerlings (Mictopterus salmoides Floridensis), 300,000 hybrid striped bass x white bass fry (Morone saxatilis x M. chrysops), and an unknown number of adult inland silversides (Menidia beryllina). Hybrid striped bass x white bass fry (280,000) were again stocked in 1978. In 1980 stockings included 280,000 hybrid striped bass x white bass fry and 9,300 adult threadfin shad (Hicks and Russell 1980). Hybrid striped bass x white bass fry were again stocked in 1982. The black crappie and white crappie plus other species present in Sooner Lake came from preimpoundment populations in Greasy Creek, inundated farm ponds, or from the Arkansas River.

Creel Survey

The Sooner Lake creel survey begun in March 1981 was completed in May 1982 as part of another project but was continued from June 1982 through February 1983. This survey, as described by Glass (1982), is a modification of the ODWC Standardized Creel Survey whereby all pressure counts were done from the shore. A fourth season (Winter) was added because of the observation that considerable fishing pressure occurs at that time on Sooner Lake. The creel survey was conducted on 12 randomly selected weekdays and 8 randomly selected weekend days each three month season. Each survey day consisted of a randomly selected 10 hour block between sunrise and sunset during which 4 pressure counts were taken and as many anglers interviewed as possible. Lengths were recorded for all angler harvested fish inspected. Counts of anglers were then expanded to all available daylight hours during each season to yield a total pressure estimate for the season. Interview data yielded catch/effort (c/f) for white crappie, which was then expanded to the total estimated number of hours of pressure during the season to yield a total estimated harvest of white crappie during that season, along with a length frequency distribution of the harvested fish. Pressure and harvest data for white crappie obtained for the first five seasons (Glass 1982) are compared with those for the three seasons completed on this project. These data are also used in the estimates of angler exploitation of white crappie.

Population Survey

White crappie were collected during April, June, July, October, and December of 1980, February through November, 1981 and February through December, 1982. Gillnets (not used after October 1981), frame nets, hoop nets (Houser 1960), and a boat mounted, 3750 W DC electroshocker were used to collect crappie. Most sampling was accomplished with hoop nets to minimize trauma and maximize efficiency of capture. Hoop nets were set overnight during the early part of 1981 but left in place for 24 hour sets thereafter. Gear types in 1982 were limited to hoop nets plus several hours of electroshocking during spawning. Data from all gear types is pooled in the data analysis, the assumption being made that all gear types select equally by size and age group. Henceforth, any reference to "net sampled fish" refers to fish sampled by all gear types (excluding angling).

Sampling in 1981 was lakewide but a concentrated sampling effort was also directed at an area of flooded trees in the southwest corner of the lake where crappie tended to congregate (Figure 1, area 6). Sampling in 1982 was again lakewide but effort was also concentrated in the discharge canal (areas 1 and 2), the southwest corner of the lake (area 6), and a heavily fished area next to the west boat ramp (area 5). Catch/hour (c/hr) was determined for each gear type for each month of sampling.

Total length (mm) and weight (g) were recorded for each white crappie captured, and a scale sample of 5-10 scales was removed just posterior to the left pectoral fin tip beneath the lateral line for age and growth determination. A finclip (one pelvic and/or partial caudal), specific to each section of the lake, was made prior to release (Table I). Recapture data were used to determine movement patterns and population numbers.

TABLE I

WHITE CRAPPIE FINCLIP COMBINATIONS IN SOONER LAKE DURING 1981 AND 1982

Sampling area of lake (Figure 1)	1981 Combination	1982 Combination
1	no sampling	left pelvic + upper caudal
2	left pelvic	right pelvic + upper caudal
3	upper caudal	upper caudal
4	upper caudal	upper caudal
5	left pelvic	right pelvic + upper caudal
6	left pelvic	right pelvic + lower caudal

Food Analysis

Stomach samples were taken with glass tubes (Gilliland et. al 1982) during 1980. These data are used to characterize food habits for crappie in Sooner Lake. Stomach samples were preserved in 70% ethanol in the field, and the contents were later dried under vacuum in the laboratory. Items were separated and assigned to the lowest identifiable taxon. Number of individuals in each taxon were counted or estimated (when there were large numbers of disarticulated parts), weighed to the nearest 0.1 g, and the volume determined to the nearest 0.1 ml. Percent frequency of occurrence, percent total volume, and percent total number of each food item were calculated.

Length, Weight, Age, and Growth

Length frequencies were compared between white crappie captured by anglers and white crappie caught in our sampling gear, and between net sampled white crappie captured in different sections of the lake. Differences between these distributions were analyzed by the use of the chi-square test (Snedecor and Cochran 1978).

Proportional stock density (PSD) was calculated for the population (Anderson 1978). Proportional stock density is the ratio of the number of "stock" sized fish (defined by the ODWC for crappie as >130 mm) divided by the number of "quality" sized fish (defined by the ODWC for crappie as >200 mm) multiplied by 100. This value was then used to characterize the relative size distribution of the population.

Condition of white crappie in Sooner Lake was determined by the calculation of Rw (mean relative weight) (Wege and Anderson 1978).

This index shows the length-weight relationship of the population compared to the statewide length-weight relationship (ODWC, personal communication). Thus, it is a percent of the statewide average.

Ages were determined by the use of scale impressions made on acetate plastic and read on an Eberbach scale projector. Four to six scales (removed from a standardized area just off the tip of the left pectoral fin below the lateral line) were randomly selected from each fish. A computer was used to perform the back calculation computations, utilizing the equation:

$$L' = C + \frac{S'}{S}(L - C)$$

where L represents length at capture, L' represents length at annulus formation, S represents total length of scale radius, S' represents length of scale radius to annulus, and C represents the correction factor to correct for length of fish at first scale formation. A linear body length-scale length relationship is assumed, and the correction factor C was empirically determined from my samples by extrapolating backwards to determine the Y-intercept of the body length-scale length relationship.

Age frequencies were plotted as catch curves and were used to determine differences (chi-square test) in age structure between fish from different sections. Total mortality of net captured white crappie was determined from the catch curve by the method of Jackson (1939) 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.

Comparison to Previous Work

Fish populations in Sooner Lake were sampled by the ODWC in 1978, 1979, and 1980 (Hicks 1978, Hicks 1979, Hicks and Russell 1980) and by Glass in 1981-82 (Glass 1982). The ODWC sampled as outlined in "Standardized Sampling Procedures for Lake Management Recommendations" and Glass (1982) used methods similar to those used in this study. Harvest and length data from the creel survey conducted by Glass (1982) were compared to the results of the creel survey conducted by me.

Comparison of Closed Vs. Open Sections

A segment of the discharge canal was used to measure mortality in an unexploited segment of the population (unexploited subpopulation). The entire discharge canal was closed to all boat traffic and fishing pressure from boats from 1978 to 1982. In 1982 the closed area was reduced and fishing allowed in an additional 2.5 km of the canal (Figure 1). In 1982 I obtained permission to sample within the restricted area behind the new location of the buoy line (area 1), and extensive samples were taken from this area. It is my assumption that the demographic parameters of the unexploited subpopulation are representative of a population theoretically existing in Sooner Lake with no angling pressure. I also assume that crappie captured in a heavily fished cove (Glass 1982) adjacent to the west boat ramp (Figure 1, area 5) were representative of a heavily exploited population.

Length and age distributions of white crappie collected by hoop nets from each area were compared using the chi-square test to determine if differences existed between the two subpopulations (Snedecor and Cochran 1978).

Population Estimates

Population estimates were made using the Schnabel multiple mark and recapture technique on net captured white crappie (Schnabel 1938) on two subsections of the lake during 1982: the closed area of the discharge canal (Figure 1, area 1) (unexploited subpopulation) and the heavily fished cove adjacent to the west boat ramp (area 5) (exploited subpopulation). Since the period of population estimation was only six weeks (23 March 1982 - 7 May 1982), I concluded that no assumptions of the Schnabel method (no mortality, random distribution of marked fish within area of population estimate) were seriously violated. The lack of distinct coves and the need to minimize interference with anglers precluded rotenone census with block netting. In order to estimate population numbers, white crappie populations in the subsections were arbitrarily considered to be closed in these two areas and standing crop estimates (number/ha and kg/ha) were calculated on the basis of these assumptions.

In order to test for closure of these subpopulations, I decided to sample in a section (Figure 1, area 2) immediately adjacent to the closed section of the discharge canal (area 1) in order to test for movement between these two sections. These two areas were of approximately equal size (10 ha), and marked fish were always released in the centers of the two respective areas (sites of release were at least 0.5 km apart) to facilitate random mixing within each section. Subsequent analysis of movement data supported the assumption of no emigration or immigration.

Calculation of Natural Mortality

The relative effect of angling on the Sooner Lake white crappie population was determined by comparison of fished vs. unfished subpopulations and comparison of population estimates to angler harvest. The first method used comparative length and age distributions for fish from the fished and unfished areas. These data can be expected to reflect the effects of fishing plus natural mortality on the fished area but only natural mortality on the unfished area. Comparison of population estimates to the estimated angler harvest (from the creel survey) yields direct numerical estimates of exploitation, and natural mortality.

CHAPTER III

RESULTS

Creel Survey

Creel survey results from Summer and Fall 1982 and Winter 1982-83 creel show similar seasonal trends in total pressure (hr), harvest (number), and catch/unit effort (c/f) for white crappie as those presented by Glass (1982) for the previous five seasons (Table II). Hours of pressure and number of white crappie harvested in both studies were consistently highest during the spring and the highest c/f of the eight seasons occurred during the spring of 1982. Mean length of harvested white crappie and total harvest continued to increase over previous seasons beginning with Spring 1981.

Population Study

Food Analysis

Thirty one percent of the white crappie sampled during 1980 contained food (Table III). Zooplankton, insect, and fish remins were the principal food items (Table IV). *Daphnia* made up the greatest percentage of items by number, with *Hexagenia* larvae making up the greatest number by volume. *Chaoborus* larvae and unidentified fish remains occurred most frequently.

TABLE II

SEASONAL HARVEST OF SOONER LAKE WHITE CRAPPIE

Season	Total estimated white crappie harvest	Total estimated pressure (hr)	Catch /hour	Angler harvest TL(mm)	Angler harvest wt(g)	Net samples TL(mm)	Net samples wt(g)
Spring 1981	13895	63989	0.217	242	182	224	136
Summer 1981	407	29384	0.014	240	176	197	98
Fall 1981	436	11593	0.038	262	229	222	146
Winter 1981-82	3420	9508	0.360	253	190	237	-
Spring 1982	38439	64766	0.594	246	208	247	214
Summer 1982	7142	28263	0.253	246	177	230	150
Fall 1982	4501	10284	0.438	253	190	242	194
Winter 1982-83	2565	11257	0.223	271	231	252	249

TL: Total length
wt: Weight

TABLE III

FREQUENCY OF FULL STOMACHS OF SOONER LAKE WHITE CRAPPIE DURING 1980

	April	June	July	Aug	Oct	Dec	Total
Number of white crappie	19	38	68	3	9	1	138
Mean weight (g)	185	174	107	36	135	50	136
% of total number with food	32	26	40	0	0	0	31

TABLE IV

THE NUMBER AND VOLUME OF ORGANISMS IN STOMACHS OF ALL WHITE CRAPPIE FROM SOONER LAKE IN 1980 PRESENTED BY MONTH

Organism	April No.	April Vol(ml)	June No.	June Vol(ml)	July No.	July Vol(ml)	Total No.	Total % of Tot No.	Total Vol(ml)	Total % of Tot Vol	% Occurrence (numbers) Of All Fish	% Occurrence (numbers) Of Those w/ Food
Copepoda	-	-	-	-	1	T	1	0.07	T	T	0.7	2.3
Daphnia	518	T	617	T	62	T	1257	87.78	T	T	4.3	13.9
Amphipoda	-	-	-	-	2	T	2	0.14	T	T	1.5	4.6
Odonata	-	-	-	-	1	T	1	0.07	T	T	0.7	2.3
Ephemeroptera	2	T	-	-	-	-	2	0.14	T	T	0.7	2.3
Hexagenia	-	-	20	1.43	14	0.21	34	2.37	1.64	74.89	10.1	32.6
Caenis	-	-	5	0.01	-	-	5	0.35	0.01	0.46	2.2	7.0
Trichoptera	-	-	-	-	2	T	2	0.14	T	T	1.5	4.6
Diptera												
Chironomidae	6	0.01	48	0.11	6	T	60	4.19	0.12	5.48	8.7	27.9
Chaoborus	-	-	36	0.01	23	0.01	59	4.12	0.02	0.91	12.5	39.5
Pupae	-	-	4	0.12	-	-	4	0.23	0.12	5.48	2.2	7.0
Unidentified Insecta	-	T	-	T	-	T	-	-	T	T	5.1	16.3
Pisces												
D. cepedianum	1	T	-	-	-	-	1	0.07	T	T	0.7	2.3
M. beryllina	-	-	-	-	1	0.04	1	0.07	0.04	1.83	0.7	2.3
Larvae	-	-	-	-	3	0.01	3	0.21	0.01	0.46	0.7	2.3
Unidentified Fish Remains	-	-	-	T	-	0.23	-	-	0.23	10.50	12.3	39.5

(T < 0.01) (Tot: Total)

Catch Data

Catch per hour (c/f) was highest during the cooler months of the year, and during the spring (Table V). Gill nets had a higher c/f than other sampling gear during certain months but crappie thus captured were generally moribund. Electroshocking success was also very high during certain spring months, but this method was generally found to be unreliable for the capture of Sooner Lake white crappie. Data from all gear types was pooled for age and growth calculations, the assumption being made of equal gear selectivity with respect to age and size of white crappie.

Age and Growth

Age and growth data on white crappie were collected for every month in which sampling occurred but only those data collected during the months of September, October, November, and December are presented. Data from these months are represented by large sample sizes. Scales taken from the spring period of annulus formation and the early summer were often difficult to interpret. For example, a short period of growth on a scale collected in May may represent a very recent annulus formation and subsequent growth, or it may represent a very poor previous year of growth and a delayed annulus formation. As noted by Glass (1982), scales from all areas of the lake were often difficult to read because of severe scale erosion and false annuli. There was little difficulty in recognizing growth interruptions on the scales.

Average growth of white crappie was much better than the state

TABLE V

CATCH PER HOUR OF WHITE CRAPPIE BY GEAR TYPE AND MONTH

	Electro-shocker	Gill net	Hoop net	Frame net
April 1980	-	0.109	-	0.095
June	1.601	0.223	-	-
July	-	0	0.393	0.730
October	-	0.052	-	-
December	1.000	-	-	-
February 1981	8.000	0.182	0.458	0.500
March	-	0.065	0.189	-
April	-	0.157	0.133	0.344
May	67.000	0.566	0.476	0.386
June	-	0.256	0.153	2.889
July	-	-	0.166	-
August	-	0.416	0.189	-
September	-	1.683	0.182	-
October	0.660	0.099	0.143	-
November	-	-	0.006	-
February 1982	-	-	0.151	-
March	-	-	0.189	-
April	2.000	-	0.249	-
May	-	-	0.452	-
June	-	-	0.016	-
July	-	-	0.122	-
August	-	-	0.259	-
September	-	-	0.150	-
October	-	-	0.142	-
November	-	-	0.179	-
December	-	-	0.416	-

(-) denotes no effort by that particular gear type average for the first two years of growth, but it was near average by the fourth and fifth years of growth (Table VI). Lee's phenomenon was not noted, but back calculated growth was greater the further back one examines the mean back calculated length for fish of the same age. For example, back calculated growth at first annulus formation, based on 1981 samples, is greatest for the 1977 year class and least for the 1980 year class. Also, back calculated first year growth was consistently greater for white crappie of the same year class calculated from 1981 samples than first year growth of the same year class back calculated from the 1982 samples.

There was some overlap of sizes by different age groups, indicating variability in white crappie growth within Sooner Lake. For example, the standard deviation of the age 1 mean back calculated lengths was 12.3%, based on analysis of age 3^+ white crappie collected in October 1982. The standard deviation for the mean back calculated length at age 2^+ was 16.7%. This would give 95% confidence limits of 75-124 mm for length at first annulus and 159-272 mm for length at second annulus. While only applicable to one age group for one month, these standard deviations are representative of the entire study and point to the difficulty of basing conclusions about growth on results from scale reading and of back calculation.

Length frequency distributions of net captured white crappie were unimodal in all seasons, or the modes were too indistinct to allow separation of year classes by visual examination (Figures 2, 3, and 4). Thus, length frequency analysis has no value here as a means of validating the annuli determinations. But, the annular determinations of Sooner Lake white crappie appear to be valid based on several other

TABLE VI

WHITE CRAPPIE BACK CALCULATED GROWTH RATES FROM SEPTEMBER - DECEMBER SAMPLES, PRESENTED BY YEAR OF COLLECTION

1981

Year class	Age group	No.	Mean calculated total length in mm at end of year				
			1	2	3	4	5
1981	0	0					
1980	1	155	110				
1979	2	528	116	173			
1978	3	327	120	175	215		
1977	4	22	128	185	230	260	
Number of fish		1032	1032	877	349	22	
Weighted average			117	174	216	260	
Growth increment			117	57	42	44	
State average (Jenkins 1954)			74	150	199	249	

1982

Year class	Age group	No.	Mean calculated total length in mm at end of year				
			1	2	3	4	5
1982	0	40					
1981	1	51	91				
1980	2	271	100	207			
1979	3	357	108	155	229		
1978	4	33	111	180	218	252	
1977	5	2	128	234	282	305	320
Number of fish		754	714	663	392	35	2
Weighted average			104	178	228	255	320
Growth increment			104	74	50	27	65
State average (Jenkins 1954)			74	150	199	249	

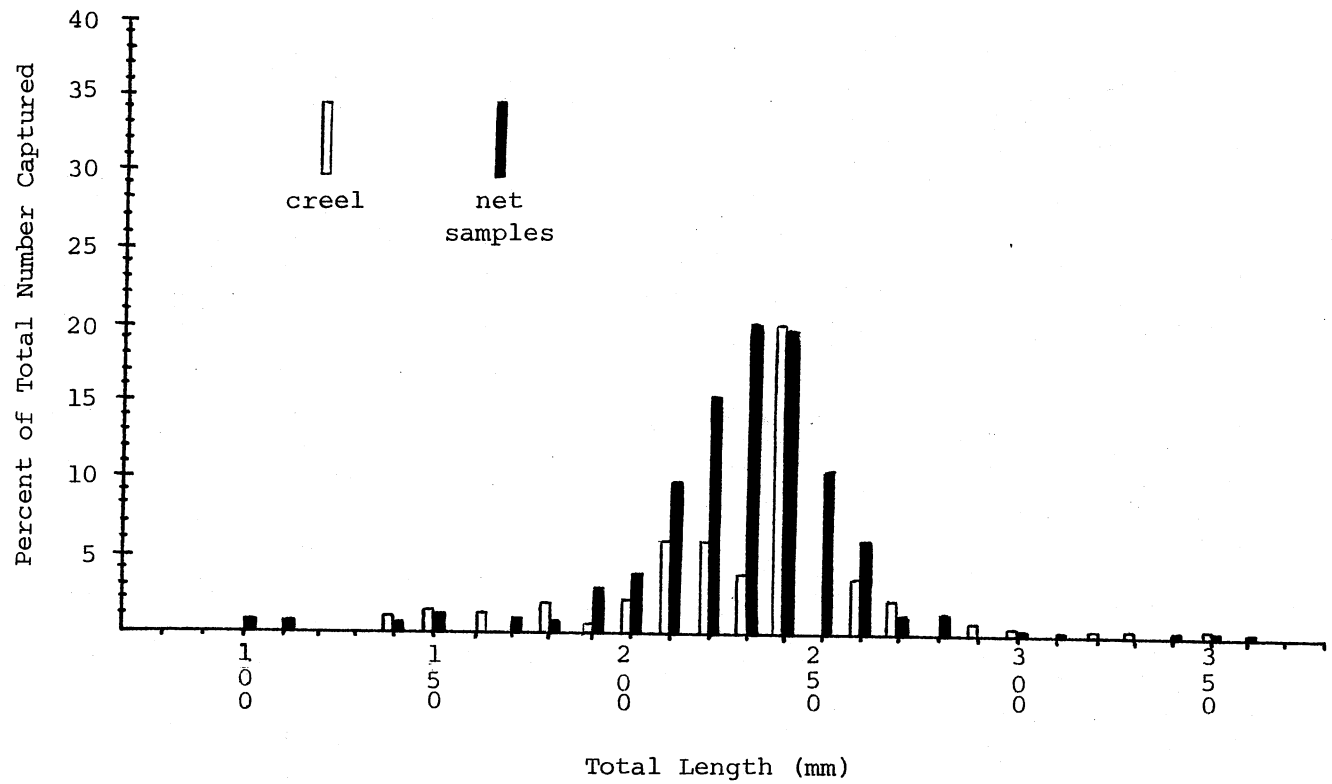

Figure 2. White crappie length frequency distributions for Summer 1982 season

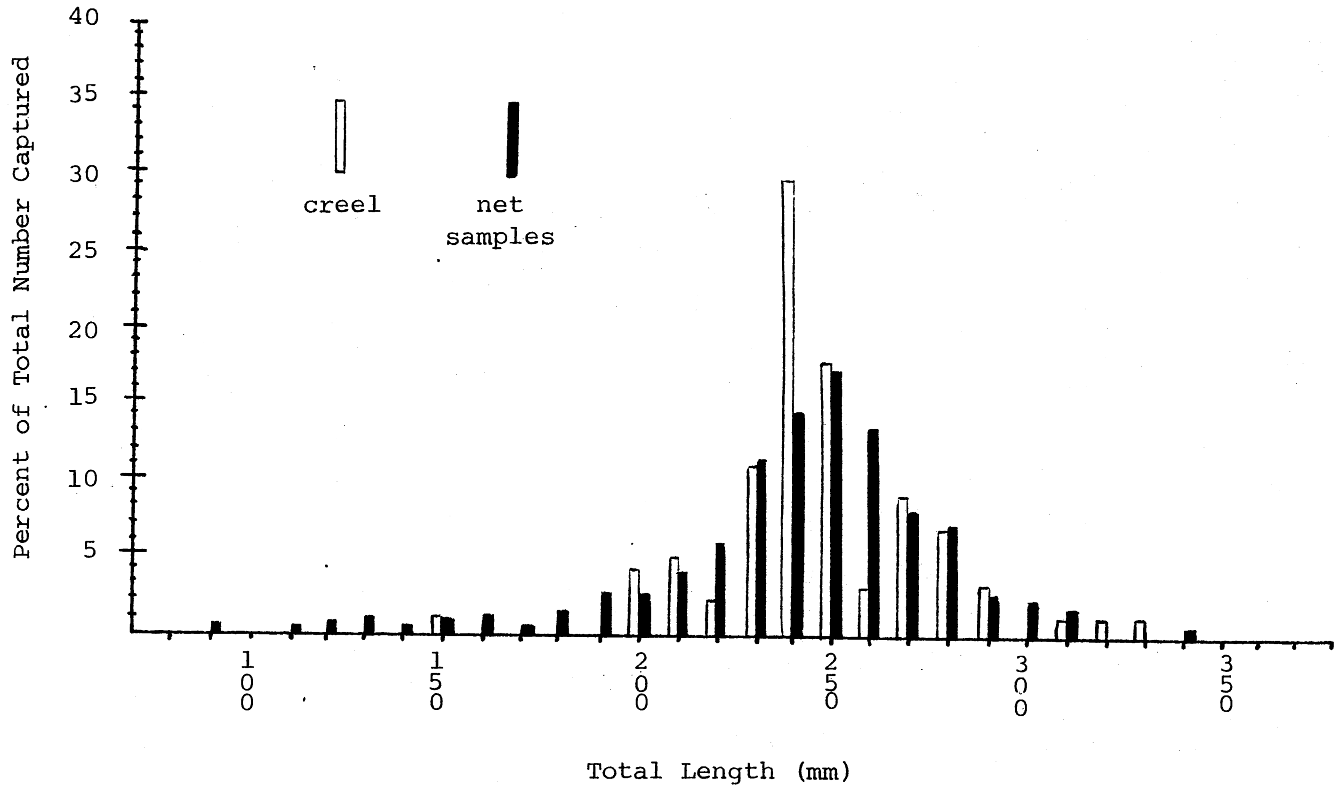

Figure 3. White crappie length frequency distributions for Fall 1982 season

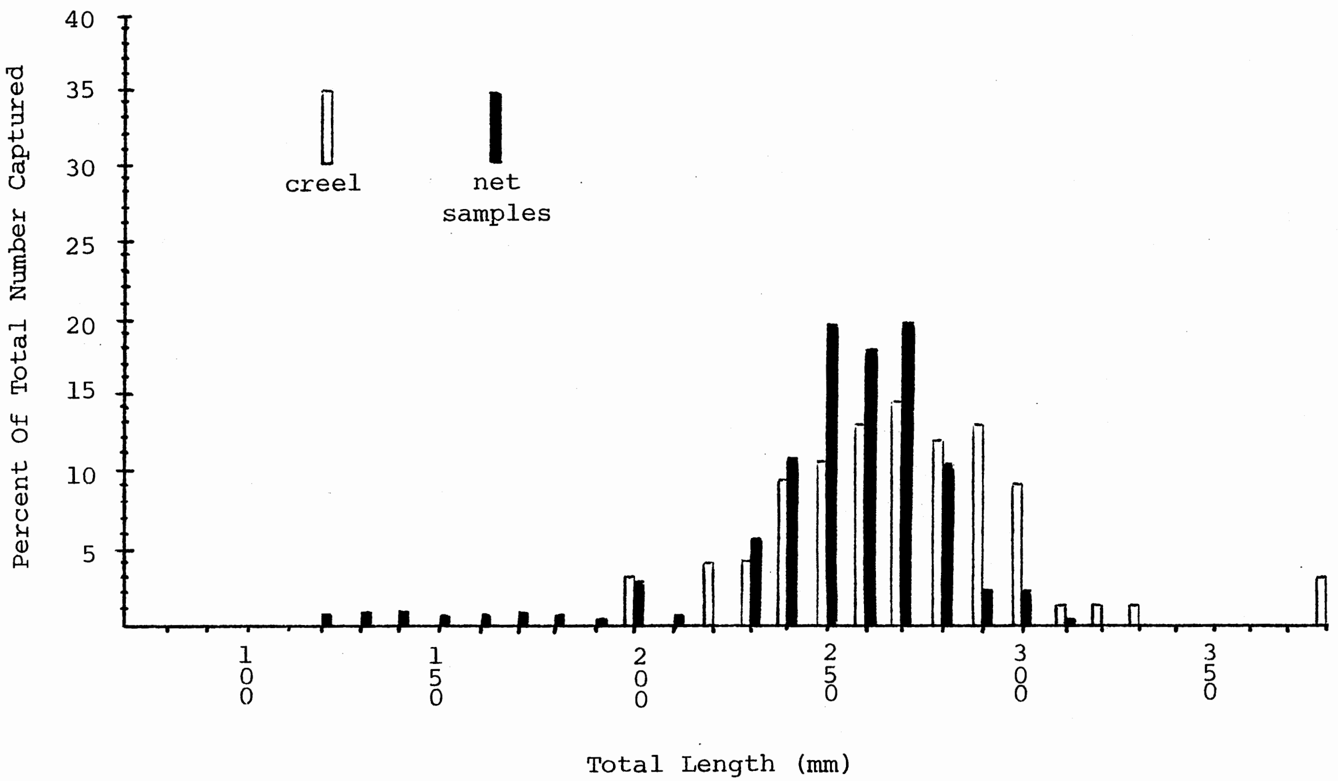

Figure 4. White crappie length frequency distributions for Winter 1982 season

lines of evidence: 1) mean back calculated growth increments appear reasonable, with the largest increments occurring during the early years of growth, 2) with the exception of the oldest age classes (due to the very small sample sizes) the weighted mean lengths at annulus formation are very close for the two separate years covered under this study, and 3) weighted mean lengths at annulus formation calculated for this study are very close to those values calculated by the previous researchers working on Sooner Lake white crappie (Hicks 1978, Hicks 1979, Hicks and Russell 1980).

Glass (1982) has previously reported that the Spring 1981 to Spring 1982 length frequency distributions of angler harvested fish were significantly different from the length frequency distributions of net captured fish from the same season for all seasons ($p=0.001$), and the seasonal length frequency distributions of creeled fish were significantly different from one another ($p=0.001$). Analysis of Summer, Fall, and Winter 1982 data again indicated that these comparisons were significantly different ($p<0.005$ for all comparisons). Mean lengths of white crappie from the creel survey were larger than the mean lengths from the net caught fish in all seasons except Spring 1982, when the fish caught in the nets were 1 mm larger than those from the creel survey (Table II).

Separation of year classes by visual examination of the length frequency distributions from either the creeled or net caught fish is virtually impossible because of the indistinct, generally unimodal nature of the distributions. However, examination of mean length at age by month (Figure 5) provides a method of assigning age groups to fish in the creel survey, and it allows individual year class

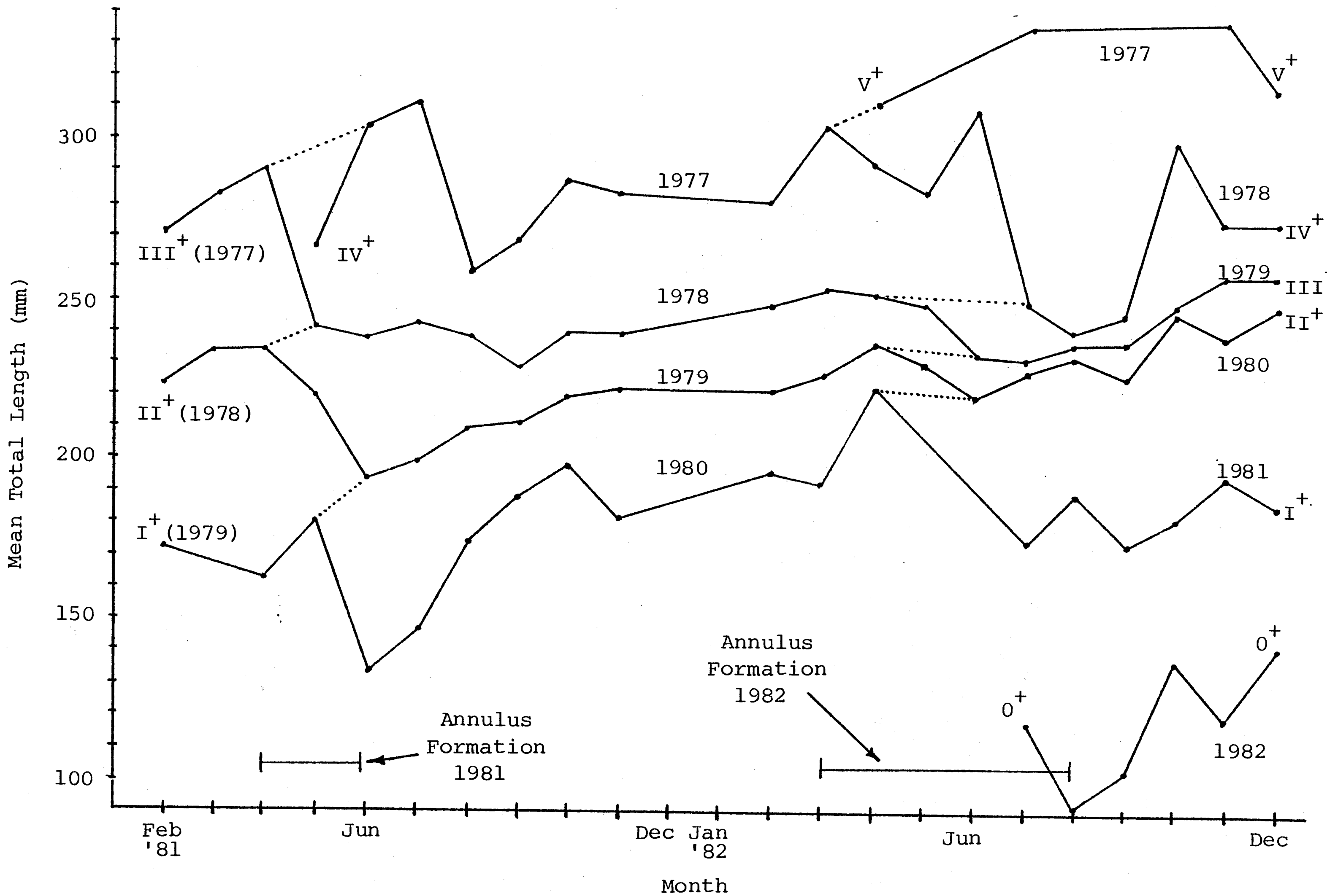

Figure 5. White crappie mean length at age by month, with dates referring to year classes

growth to be followed throughout the study. This figure was constructed from lengths at capture of known age fish taken in the monthly net samples. I made the assumption that the mean length of known age fish taken in the net samples was the same as mean length of fish seen in the creel survey for the same age at the same time. The individual monthly values for a given age class in Figure 4 were then averaged by three month seasons to coincide with the three month creel seasons. The dashed lines on Figure 5 represent likely periods of annulus formation for each year class, and each year class may thus be followed throughout the duration of the study as successive annuli are formed and the age of the fish increases.

The midpoint between each pair of age group values was chosen as the dividing point between those ages. For example, if the Fall (September, October, November) averaged mean length for age group 1^+ were 160 mm and the averaged mean length for age group 2^+ were 210 mm then the midpoint between these values would be 185 mm. If the midpoint between age 2^+ and 3^+ were calculated to be 230 mm, then any fish seen in the creel survey during that fall falling between 185 mm and 230 mm would be assigned to age group 2^+. Thus, the length frequency distributions of the creeled white crappie (Figures 2, 3, and 4) are used to generate an estimated age frequency distribution (presented by year class) for angler harvested white crappie to be used in the calculation of exploitation estimates. This is presented in Table VII, which provides estimated total harvest (numbers) of each year class for each season of the creel survey.

Proportional stock densities (PSD's) for net caught white crappie showed little evidence of seasonal trends within years (Table VIII).

TABLE VII

ESTIMATED SEASONAL HARVEST OF WHITE CRAPPIE, BY YEAR CLASS, DERIVED FROM THE CREEL SURVEY

Season	1977	1978	1979	1980	1981	1982	Total
Spring 81	2880	9964	1051	-	-	-	13895
Summer 81	81	179	147	-	-	-	407
Fall 81	194	116	121	5	-	-	436
Winter 81	992	1583	718	127	-	-	3420
Spring 82	2907	15986	16567	2979	-	-	38439
Summer 82	123	3801	1655	1134	398	31	7142
Fall 82	267	1114	936	1694	490	-	4501
Winter 82	410	1026	342	684	103	-	2565
	7854	33769	21537	6623	991	31	70805
1981 Total[1]	3486	10787	1558	47	-	-	15878
1982 Total[1]	4095	22298	19865	6120	922	31	53331

1. Calendar year.

TABLE VIII

MONTHLY AND YEARLY PROPORTIONAL STOCK DENSITY VALUES FOR SOONER LAKE WHITE CRAPPIE

	Number Stock (130mm)		Number Quality (200mm)		Proportional Stock Density	
Month	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%

In addition, monthly PSD values were higher for each month in 1982 than they were in 1981.

Condition

Mean relative weight (Rw) by year was above 100% (state average) during the cooler months of each year, then decreased during the spring coincident with the spawning season (Figure 6). 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

Examination of the catch curves for net sampled Sooner Lake white crappie revealed considerable gear selectivity against yearling and young-of-the-year (Figure 7). This is shown by the ascending leg of the catch curve as discussed by Ricker (1975). However, young-of-the-year were taken in fairly large numbers in 1982, while none were caught in 1981. This high catch probably indicates a very successful 1982 year class. Young-of-the-year white crappie were not captured in the hoop nets as were the larger crappie, but rather they became gilled in the 16 mm bar mesh of the hoop nets during Fall 1982. The capture of large numbers of white crappie adults in 3 m of water or less occurred during March through May 1982 (Table IX). Similar concentrations of adult fish were not noted during the spring of 1981, and no young-of-the-year were captured that fall. These data would seem to indicate a much higher relative abundance of young-of-the-year during the fall of 1982 than in the fall of 1981.

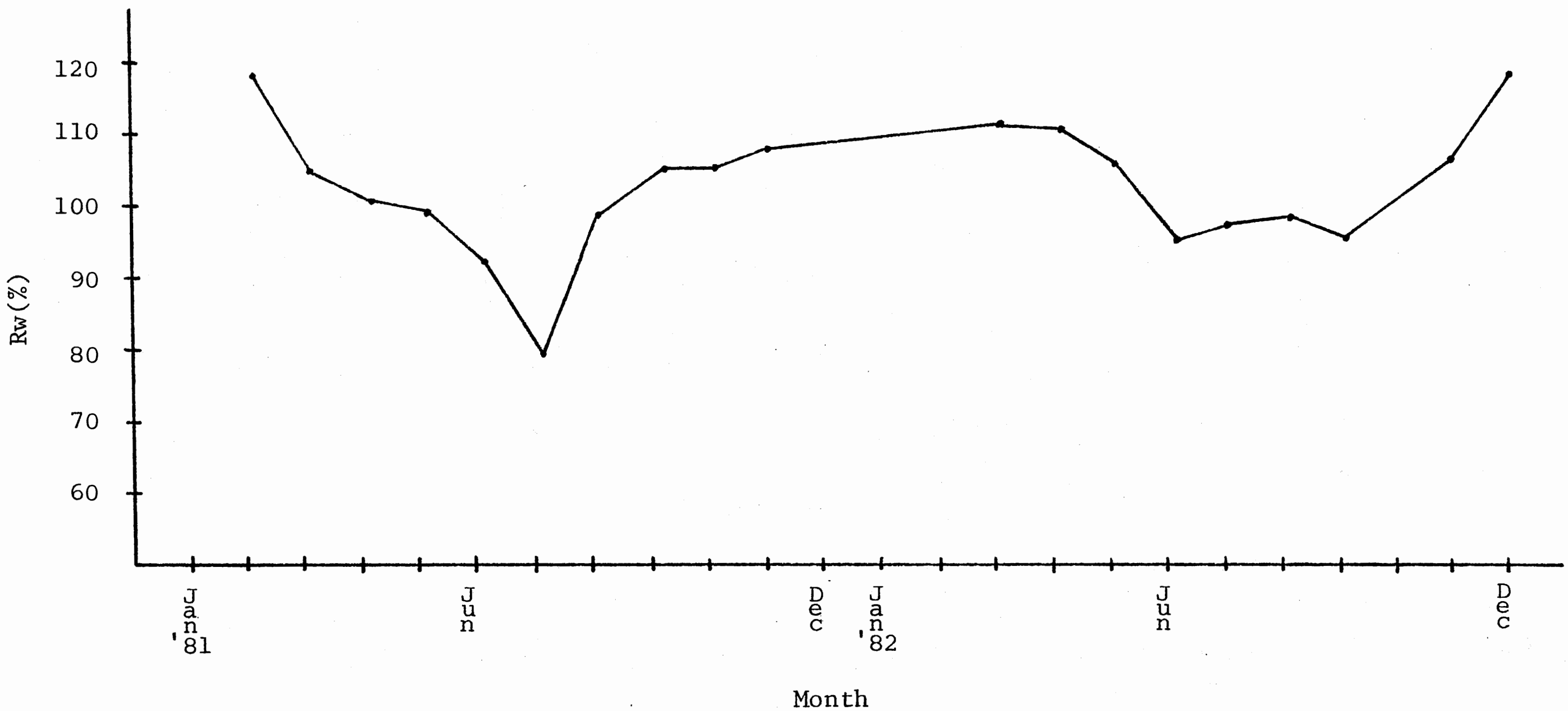

Figure 6. White crappie mean relative weight (Rw) by month

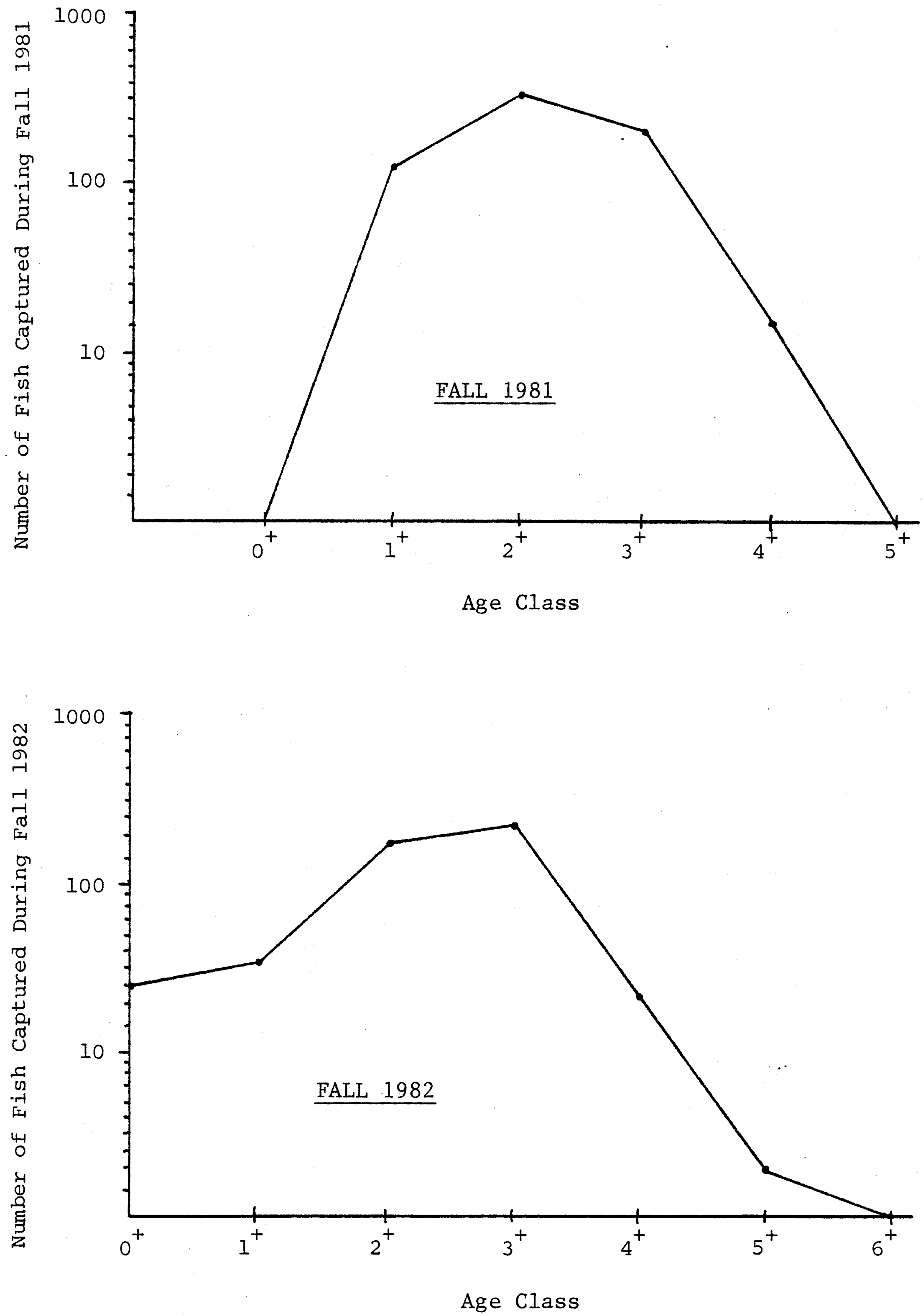

Figure 7. White crappie catch curves for Fall 1981 and Fall 1982

TABLE IX

DEPTH AND RATE OF CAPTURE IN HOOP NETS OF WHITE CRAPPIE IN SOONER LAKE, SPRING 1982

Week	1.5	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	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

There was very high total mortality of the older age classes (3-5) 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 was 6.7% (calculated from the 1981 data) and 9% calculated from the 1982 data (Jackson 1939). Data from both years showed extremely poor survival between the 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.

The decrease of the 1977 year class in 1981 exemplifies this high mortality. The 1977 year class suffered a drastic reduction in numbers during the summer of 1981, declining from a relative abundance in the net catches of 19% during the spring of 1981 to only 6% during the spring of 1982. The 1978 year class had a relative abundance of only 4% in the Fall 1982 samples but a relative abundance of 33% during the fall of 1981.

Movement

Of the 1446 white crappie finclipped in 1981, 26 were recaptured in that year. All recaptures were easy to recognize, as even partially regenerated caudal fin marks were recognizable due to distorted fin rays and a scar representing the original cut. All fish recaptured in 1981 had been originally marked in the respective areas in which they were recaptured.

In 1982 the lake was subdivided into smaller sections to ensure greater sensitivity in detection of movement with respect to the assignment of finclips (Table I). Of 2595 white crappie finclipped in 1982, 129 were recaptured. Of these recaptures, 29 (15.5%) were marked in different areas from where they were recaptured. One fish had moved approximately 6 km linear distance (from the southwest corner of the reservoir (Figure 1, area 6)), through the channels to the main portion of the reservoir (area 4). Another had moved approximately 5 km linear distance (from the west boat ramp (area 5) to the main portion of the reservoir (area 4)). Two had moved from the southwest corner of the reservoir (area 6) to the discharge canal (areas 1 and 2) (about 4.56 km).

Of the other 16 white crappie recaptured outside of their areas of origin, all came from adjacent sections in the discharge canal (areas 1 and 2). Thus, 83% of the fish recaptured in the discharge canal had remained in the area in which they were marked, or within an area of the discharge canal approximately 1 km long. Of the fish which had moved in the discharge canal, 7 moved away from the generating station while 9 moved towards it. These data appear to indicate that at least over an 11 month sampling period movement of white crappie is minimal and different areas of the lake can be considered to be inhabited by separate subpopulations.

Population Estimates

Based on the results of the movement data, I treated two subsections of Sooner Lake (Figure 1, areas 1 and 5) as closed sampling units. The Schnabel population estimate obtained in area 1 (the closed area of the 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. I used the estimate in area 1 in all further calculations requiring population estimates because of the higher precision of this estimate.

Calculation of Natural Mortality by Comparison of Closed Vs. Open Sections of the Discharge Canal

Catch curves and length frequency distributions (Figures 8 and 9) from the closed section of the discharge canal and the heavily fished cove adjacent to the west boat ramp (Figure 1, areas 1 and 5 respectively) were significantly different from one another ($p<0.001$) for both comparisons. These results indicate that the areas contained different populations.

If angler harvest were having an effect on the mortality of the older age classes (whose larger size is assumed to be more desirable to anglers), then one would expect this difference to be evident in the age distribution of the heavily fished population. It would manifest itself as a relative decrease in the number of older fish. If the assumption of equal growth rates between the two sections is made, then one would also expect to see a difference in the size distribution between the two sections.

The Jackson estimates of total mortality (Jackson 1939) for age groups 3-5 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. I assumed total mortality to be equal to natural mortality in the absence of fishing pressure, thus the total

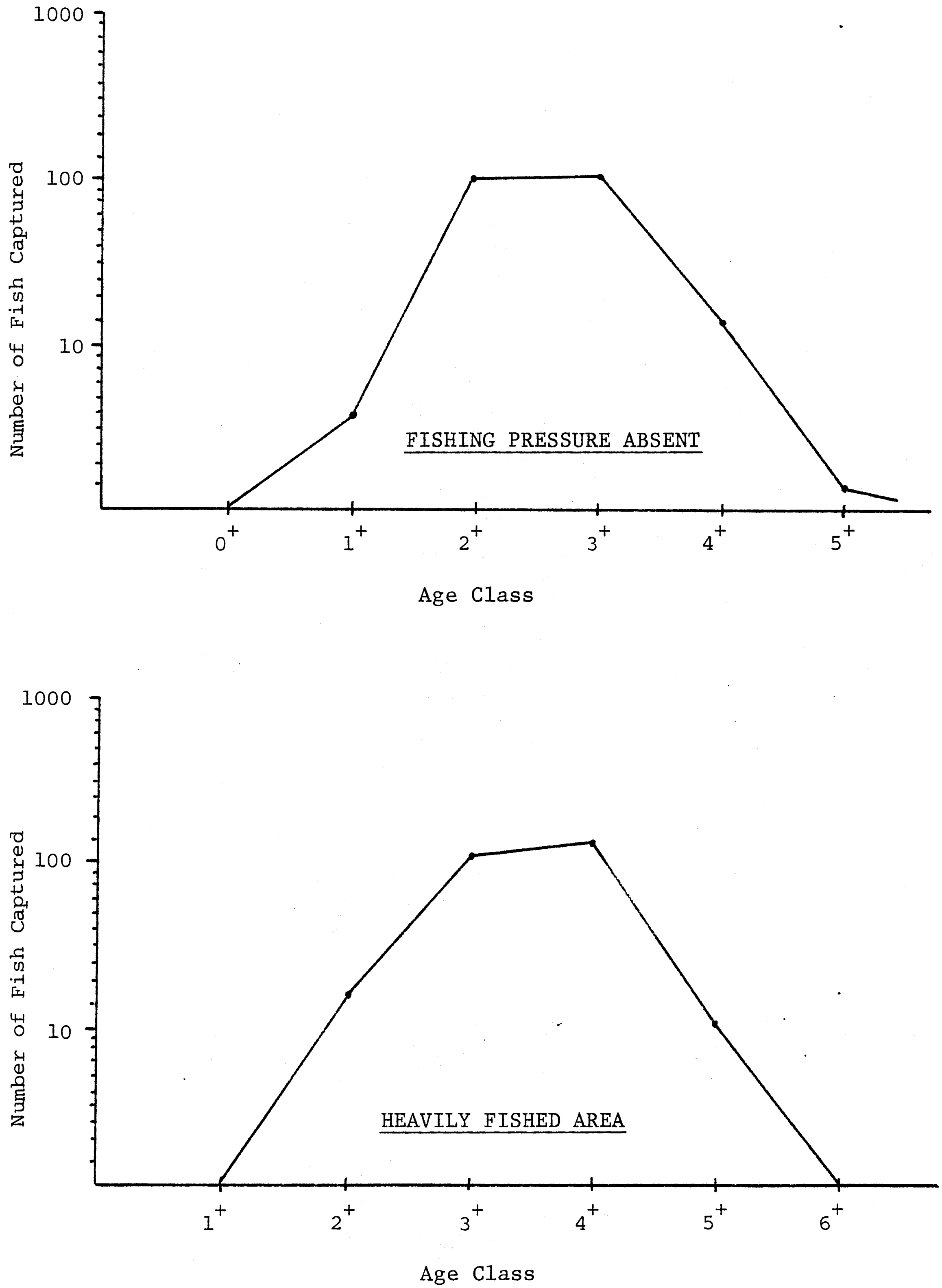

Figure 8. White crappie catch curves for net captured fish from unexploited subpopulation (area 1) and heavily exploited subpopulation (area 5), Spring 1982

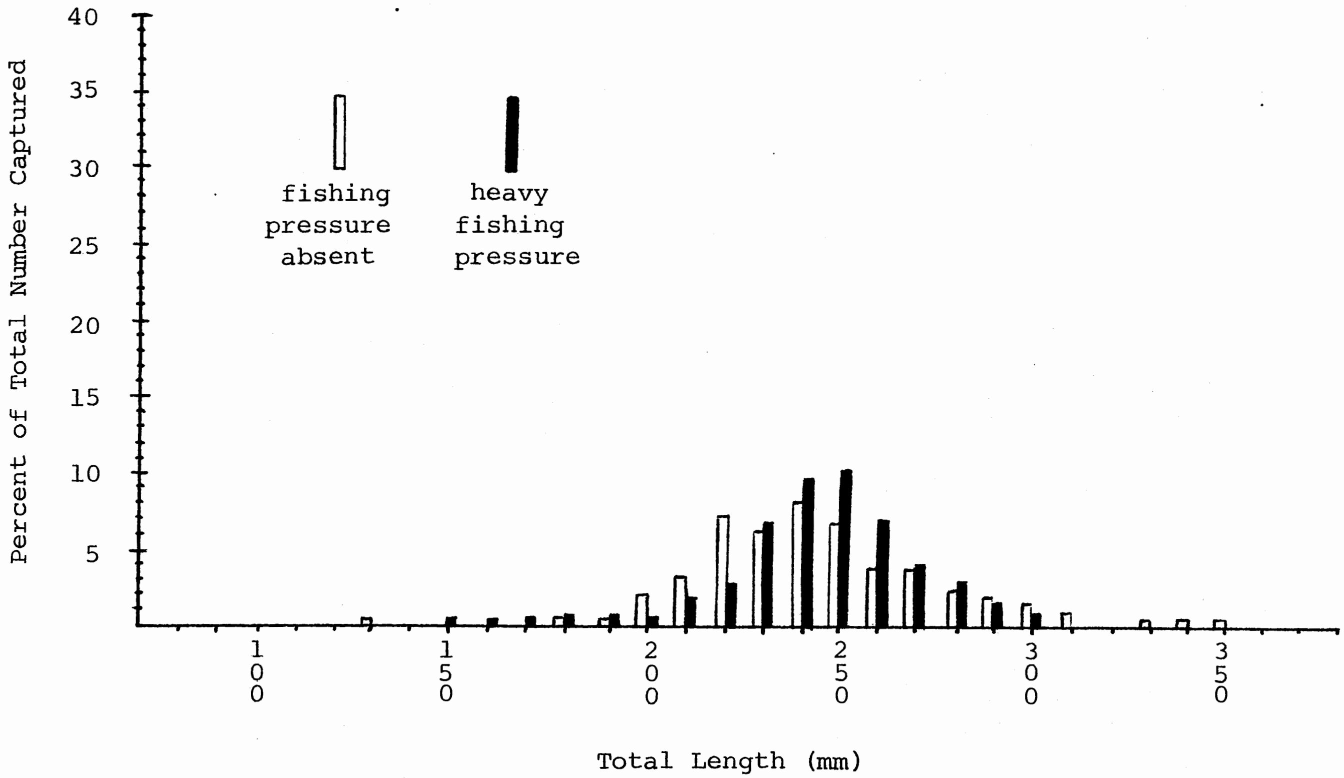

Figure 9. White crappie length frequency distributions for net captured fish from unexploited subpopulation (area 1) and heavily exploited subpopulation (area 5), Spring 1982

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. Examination of Figure 9 reveals a greater proportion of fish from the unexploited population in the 300-350 mm size range, but visual interpretation of the length frequency distributions is more difficult than the calculation of total mortality from the catch curves by the method of Jackson (1939).

Calculation of Natural Mortality by Comparison of Population Estimate With Creel Results

The lakewide population estimate of white crappie, made by expanding the data obtained from the 10.57 ha subsection of the discharge canal to the entire area of the lake, was compared by year class to the estimated harvest from the expanded creel survey. At first glance the standing crop estimate of 457 fish/ha in the 10.57 ha subsection may seem excessively high. However, if the assumption is made that all adult white crappie (fully recruited into the size range of the sampling gear) are found in less than 10.67 m during the spawning season (the time of the subsection population estimate), then this estimate becomes more reasonable. C/f by depth of capture (Table IX) helps to demonstrate this onshore movement during the spring of 1982. The total surface water area of Sooner Lake was 1940 ha (exclusive of islands) (OG&E 1976), with a water area 10.67 m deep of 1550 ha. The subsection population estimate expanded to the entire area of the lake (based on the assumption that all fish were in water less than 10.67 m deep and did not move between areas) yielded a lakewide population estimate of 708,217 white crappie. The age distribution of this estimated population was assumed to be the same as that of our Fall 1981 net samples (Figure 7). These values gave a lakewide standing crop of 365 white crappie/ha (78 kg/ha), and this 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 X). 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, 7.53%, agrees quite closely with our 7% annual fishing mortality estimate from the previous section.

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^{+}-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)

TABLE X

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	106370	6120	5.75%
1979	362343	19865	5.48%
1978	224406	22298	9.94%
1977	15098	4095	27.12%
Total	708217	53331	Mean = 7.53%

CHAPTER IV

DISCUSSION

Food Habits

The 1980 food analysis revealed an approximately equal utilization of invertebrates and fish (Table IV). This result was unexpected since the sampling gear selects against white crappie <150 mm long. Crappie greater than 150 mm are generally reported to be predominantly piscivorous. The high percentage of food volume composed of *Daphnia* may indicate that *Daphnia* is an unusually abundant food resource. Threadfin shad were introduced into Sooner Lake in 1980 but were never conclusively identified in white crappie stomachs. However, the possibility that threadfin shad were utilized by crappie cannot be entirely discounted since they may have been present in unidentified fish remains.

Age and Growth

Growth rates for white crappie in Sooner Lake were above average for the region (Table VI). However, the first year growth increment of crappie has been decreasing slowly since the reservoir was impounded. This decrease has been noted in other reservoirs and may result from decreasing productivity.

The observation that the reverse of Lee's phenomenon occurred most likely indicates that some sort of sampling bias occurred or that there was some sort of differential mortality (either fishing or natural) associated with the rate of growth of individual white crappie. For example, if slower growing individuals suffered from a higher mortality as time passed, then back calculations based on fish collected one year after an initial sample should result in larger growth increments, since the later sample is biased in the direction of the faster growth rates.

Visual examination of the length frequency distributions makes it very difficult to determine if the two methods of capture (angling vs. netting) select for different sizes of white crappie (Figures 2, 3, and 4). However, white crappie harvested by anglers were consistently larger in mean total length than net sampled white crappie, and a slow increase in mean total length of both angler harvested and net sampled white crappie was also evident when one examines the white crappie mean total length by season (Table II). This increase most likely resulted from the progressive growth of the very strong 1979 year class.

Examination of mean monthly length at age showed high variability in the mean length of the 4^{+}-5^{+} age groups (year classes 1977 and 1978), which is most likely caused by the small sample sizes. The similar mean lengths of year classes 1978 through 1980 during the summer of 1982 illustrates the difficulty in trying to distinguish age classes by lengths. The longer period of annulus formation in 1982 (4 months) as opposed to that in 1981 (3 months) is most likely a result of differing environmental conditions in the lake during the two spring seasons.

Examination of Proportional Stock Density (PSD) by month revealed that monthly 1982 values were consistently higher than those for 1981 (Table VIII). These differences resulted from the slowly increasing mean length of white crappie. If one examines Table VIII and Figure 5 simultaneously it becomes evident that one reason for the lowering of the 1981 value is the large number of the strong 1979 year class (size range 130-200 mm). In 1982 these fish exceeded 200 mm, and the large numbers of this year class raised the 1982 PSD values. Thus, as an indicator, PSD indicates direction of changes taking place in the population, but absolute values are meaningless to use as long as there is size selectivity by gear in the size range <200 mm.

The spring decrease in mean Rw that occurred in both years (Figure 6) indicated something acting to affect the condition of the population during the warmer months of the year. Most likely this results from stress due to spawning, high summer water temperatures, or possibly forage unavailability. Changes in forage availability could result from behavior of either the white crappie or the forage in response to the rising water temperatures. Scale erosion and false annuli are common on Sooner Lake white crappie scales, and they may also be caused by the same phenomenon affecting condition.

Examination of the catch curves for fish from the fall seasons of 1981 and 1982 (based on all gear) revealed a shifting of the dominant age groups from 2^+ in 1981 (1979 year class) to 3^+ in 1982 (1979 year class) (Figure 7), indicating that the 1980 year class is not as strong as the 1979 year class. This complicates the estimates of survival since the method of catch curve analysis depends on the assumption of constant year class strength. The size of two year old fish (>200 mm) in Sooner Lake can be considered fully recruited in our sampling gear, but the observation of unequal year class strength has forced me to only use ages 3^+-5^+ in the estimates, and in 1982 this selection of ages is less than ideal because of the aforementioned lack of constant year class strength. However, even with the bias incurred by including the unusually strong 1979 year class (which would tend to decrease the estimate) the 1982 annual estimate of survival (9%) is greater than the 1981 estimate (6.7%), indicating an actual increase in survival.

The finding that 83% of recaptured fish in the discharge area remained in the area of initial marking supports the assumption that the Sooner Lake white crappie exhibit relatively minimal mobility between different areas of the lake (although they will range between shallow and deeper depths depending on season). These results are supported by Grinstead (1969) who found 75% of tagged white crappie in Lake Texoma, Oklahoma remained within 2 miles of their release point.

Comparison to Previous Year's Data

Hicks (1978) characterized the 1978 Sooner Lake white crappie population as being dominated by the 1976 year class (age 2^+) and having above average growth rates. The mean length of the fish sample was 227 mm and the mean weight was 179 g. An average condition factor of 1.4 was described as indicating a population in good condition. Hicks employed a number of gear types including experimental gill nets and shoreline seining, but gear selectivity against yearlings and young-of-the-year was suspected.

The 1979 white crappie population was found to be dominated by the 1977 year class (age 2^+) (Hicks 1979). Mean length was found to be 230 mm and mean weight was 181 g. Relative weight ranged between 97% and 114% and again indicated the population was in good condition. Growth rates were again characterized as excellent with growth equal to the state average during the first year of life and with double the state average growth increment during the second year. A PSD of 87% was calculated for white crappie captured in gill nets.

During 1980 growth was again found to be above state average, with increments similar to those in 1979 (Hicks and Russell 1980). The 1978 year class (age 2^+) was found to be dominant. Relative weight varied between 99% and 110%, indicating good condition. The greatest number of fish were captured by electrofishing, and these fish had a mean length of 232 mm and a mean weight of 171 g. A PSD of 99% was calculated for these fish.

Our data indicated that the Sooner Lake white crappie population had changed little over the years. Hicks (1978, 1979) and Hicks and Russell (1980) found the 2^+ age class dominated catches, and that the population had very good growth rates and condition. With the exception of the 1982 dominance by the 3^+ age class, our results from 1981 and 1982 were similar to those from other years. It remains to be seen whether this switch in dominance is temporary or is the start of a cycling trend. A cycle would be produced if a strong year class somehow held down the abundance of subsequent year classes.

Natural Mortality

Both methods used in estimating angler exploitation produced annual estimates of 7%. However, an age specific analysis indicated an annual exploitation rate of 27% during 1982 on the 1977 year class (age 5^+) (Table X). This would indicate an annual natural mortality rate of 73% on this year class if one assumes all age 5^+ fish die. This is reasonable as no age 6^+ white crappie have ever been found. Even at this high exploitation rate on older fish, angler harvest would seem to be of minimal consequence compared to natural mortality up to age 5^+. For example, if the 1978 year class declined as quickly in 1982 as the 1977 year class did in 1981 (that is, assuming steady state, a drop in relative abundance of approximately 93%), 1982 fishing mortality on this year class would account for only 10.7% of the decline with the remainder (89.3%) due to natural mortality. If natural mortality did not increase with age, but remained at the value of 38% (the total mortality observed during the third year of life during 1981) then the oldest fish in the population would be 8^+. If the 6% 1982 exploitation value for the third year of life were subtracted from this total mortality rate, fish would live even longer.

CHAPTER V

CONCLUSIONS

The Sooner Lake white crappie population is characterized by above average growth rates, but the long term trend indicates a slight decrease in rate of growth. Condition was generally above state average, and went below that average only during the warmer months. Spawning stress and high summer water temperatures may explain these data. *Daphnia*, dipteran and ephemeropteran larvae, and unidentified fish remains were the dominant foods taken by Sooner Lake white crappie. PSD values were very high in 1981 and consistently near 100% in 1982. These data may result from a strong 3^+ age class adding growth (and being recruited into the >200 mm size range) and high gear selectivity against white crappie <200 mm TL.

The Sooner Lake creel survey indicated highly seasonal pressure which peaked in the spring and reached a low in the fall and winter. Seasonal pressure varied little between 1981 and 1982 but harvest was over three times higher in 1982. Mean total length of angler harvested white crappie has been steadily increasing throughout the 8 continuous seasons of this creel survey.

In general my data supports conclusions regarding age, growth, and condition made by previous authors. However, in 1982 age 3^+ white crappie (1979 year class) were dominant in the samples. Previously this same year class had been dominant as age 2^+ white crappie and in fact age 2^+ fish had always dominated the fishery. This departure from age 2^+ dominance is unique for Sooner Lake as is the same year class being dominant in two consecutive years. My data indicates that the 1982 year class is also a very strong year class. If patterns seen in the 1981-82 data continue, we predict an excellent fishery starting in 1984, and continuing through 1985.

With the exception of inshore-offshore seasonal movement, recapture data indicated that the Sooner Lake white crappie population is largely immobile.

Population estimates indicated a white crappie standing crop of 78 kg/ha (95% confidence limits 71-157). Fishing mortality rates derived by comparison of the expanded population estimates with creel survey results and estimated fishing mortality obtained by analysis of data from unexploited vs. heavily exploited sections both showed fishing mortality of about 7%/year.

Analysis of catch curves indicated a very high mortality of the older age classes (3^+-5^+) of fish. Annual survival from ages 3^+-5^+ was only 6%-8%. These data would seem to indicate minimal angler impact on the population.

CHAPTER VI

RECOMMENDATIONS

These data do not indicate any need to change fishing regulations for white crappie in Sooner Lake. In fact, the high rate of natural mortality would suggest that the resource may be under-utilized. One approach to increasing harvest is to increase the daily limit. However, few crappie anglers actually catch the daily limit (37 fish), and therefore lifting of this regulation might have the psychological effect of advertising the fishery and stimulating additional pressure. Additional pressure might result in an increase white crappie harvest and fewer white crappie dying of natural causes. Present ramp and parking facilities, however, are often at capacity and additional pressure may not be desirable to the property owners.

In order to further investigate the population dynamics of white crappie in aging reservoirs, several new studies should be initiated:

1) Mark a portion of the population each year in order to better follow angler exploitation and natural mortality through tag returns by anglers and recaptures noted in the standard surveys.

2) Initiate an intensive study on the ecological requirements of age 3^{+} and older white crappie to attempt to document reasons for the rapid natural decline of these age groups with respect to habitat, forage abundance, and physiochemical parameters.

3) Mark known-age fish and determine the patterns of scale check

marks to allow better age determination of white crappie, especially with respect to scale erosion and false annuli.

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VITA 2

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