EXPLOITATION OF WHITE CRAPPIE AND ASSOCIATED SPECIES IN SOONER LAKE, OKLAHOMA

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1980

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1982

EXPLOITATION OF WHITE CRAPPIE AND ASSOCIATED

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PREFACE

The objective of this project was to investigate exploitation of white crappie in a cooling water reservoir. Activities included a literature review, crappie population study, and a creel survey. The 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.

Much of the credit for the successful completion of this project and my degree go to my wife, Linda Glass. My gratitude for her confidence and support cannot be adequately expressed. I would also like to thank my parents, Leo and Carol Glass, for the guidance and direction given me during my early years.

I thank Dr. O. Eugene Maughan for his confidence in my abilities and for his advice and review both during the project and during the preparation of this thesis. I also thank Dr. Larry Talent and Dr. Tony Echelle for their effort in reviewing this thesis and serving on my committee.

Also deserving thanks is Harold Namminga and the personnel of the Oklahoma Fisheries Research Lab. Thanks also go to many of the students and staff of the Oklahoma Cooperative Fisheries Research Unit, some of which include: Gene Gilliland, Bob Angyal, Jim and Nancy Layzer, Bill Layher, Vicky Gregory, Judy Gray, Charlotte

Krugler, David Latham, Zoe Ann Stinchcomb, Ruby Collins, Bonnie Bilodeau, Margaret Wagner and Francis Grant.

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INTRODUCTION

This thesis is submitted to the faculty of the Graduate College of Oklahoma State University in partial fulfillment of the requirements for the degree of Master of Science in Zoology. This research project was funded through the Oklahoma Cooperative Fishery Research Unit by the Oklahoma Department of Wildlife Conservation. Funds were made available as part of D-J Federal Aid to Fish Restoration Project F-41-R, Job 7. The thesis is written in the format required for the D-J Final Report.

FINAL REPORT

State: OKLAHOMA Project Number: F-41-R

Project Title: Factors influencing fish populations in Oklahoma lakes and ponds

Study Title: Exploitation of white crappie and associated species in Sooner Lake, Oklahoma

Period Covered: 1 October 1980 through 31 December 1982

Objective Number: VII

Job Number: 7

ABSTRACT

Crappie populations in Oklahoma are often characterized by few large fish and many small older fish. Explanations for these problems include interspecific and intraspecific competition, high natural mortality of larger crappie due to stress or disease, and overharvest by anglers. The objective of this project was to evaluate the effect of angler harvest on a new crappie population.

Compared to the state average, the crappie population of Sooner Lake had excellent growth and was in excellent condition. However, each year class dominated the population for only one year and three year old crappie quickly disappeared from the population. This yearly turnover of year-class dominance and the disappearance of three year old white crappie apparently had no adverse effects on the crappie population. Pressure, harvest and average total length increased for white crappie from Spring 1981 to Spring 1982, but pressure and harvest generally decreased for all other species of game fish. The Sooner Lake crappie population does not show the

classic symptoms of excessive angler harvest but high illegal harvest of sublegal largemouth bass (Micropterus salmoides) was seen. An extremely high harvest of striped bass x white bass hybrids (Morone saxitilis x Morone chrysops) was also seen in the area of the power plant's effluent discharge.

I. OBJECTIVE

To investigate the population exploitation of white crappie using fishing pressure and population parameters.

II. BACKGROUND

Oklahoma anglers rate white crappie (Pomoxis annularis) as the second most sought after fish species in Oklahoma (Mense, 1978). This popularity has generated considerable interest in maintaining and improving Oklahoma's crappie fishery. There are two related problems within this fishery: (1) few large fish and (2) many small older fish.

Stunting, or slow growth, has often been cited as being responsible for few large fish and many small fish. This stunting is often said to result from competition (intraspecific (Jenkins, 1954), interspecific (Jenkins, 1956) or a combination of both) for resources. A major concern in crappie management is the observation that growth rates normally are high in new impoundments but begin to decline after three to five years (Bennett, 1947; Crawley, 1954; Jenkins, 1954; and Thompson, et al., 1949). In general this decline has been attributed to competition and/or predation. Rutledge and Barron (1972) hypothesized that newly impounded waters have rapidly expanding fish populations and that competition begins when this expansion fills available habitat. Concomittant with competition, growth rates and fishing success decline. Nelson et al. (1967) suggested that an abundance of vulnerable forage occurs in the early history of a reservoir and is subsequently eliminated by predation. The resulting competition (intraspecific and interspecific) for forage would cause reduced growth. Several observations are in accordance with the competition hypothesis: (1) Sneed and Thompson (1950) found rapid fish growth in new waters to be correlated with low fish population densities; they believed that these low densities insured a minimum of resource competition; (2) Burris (1956) found that slow growth of crappie in older lakes was caused by a shortage of forage for those less than seven inches in length; and (3) growth increments of older fish are often larger than those of younger fish (Burris, 1956 and Jossell, 1969); this has been explained by the hypothesis that once fish grew to a size (>150 mm) where they could utilize larger forage they were able to overcome the stunting effect of the earlier lack of nourishment (Bailey and Lagler, 1938; Rutledge and Barron, 1972).

Much of the limited resources hypothesis has been based upon competition or predation by other species. For example, Swingle and Swingle (1967) indicated periodic overcrowding of crappie resulted from the fact that during some years crappie spawn earlier or at the same time as largemouth bass and then escape predation from young-of-year bass by moving into deep water. These conditions cause large age classes of crappie. Years when these conditions are not met result in small age classes. In support of this hypothesis the Swingles noted that in ponds with heavy crappie reproduction and a strong age I bass year class, crappie numbers were moderated and a cyclic pattern did not occur.

More recently, intraspecific competition has been implicated as a major cause of slow growth in crappie. This hypothesis is based on observations that some crappie populations are, in terms of year-class abundance, cyclic (Swingle and Swingle, 1967) at intervals of three to five years. In cyclic populations fish of age groups I and II of a large year-class are typically slow growing and begin to suffer heavy mortality. Predation by adult crappie appears to be the principal cause of this mortality. For example, Ball and Kilambi (1972) found that when many crappie were smaller than the gizzard shad, larger crappie consumed more young-of-year crappie than shad, whereas shad was usually the dominant food item. The cycle repeats itself when adult numbers are reduced by fishing and natural mortality which in turn reduces predation pressure and allows successful reproduction.

The limited resource hypothesis for stunting is not universally accepted. One reason for the difference in opinion is that even in unstunted populations growth rates can be highly variable. For example, Jenkins (1954) found that most white crappie reached six inches between two and three years. However, in the same population he also found a few fish that attained a much larger size before they were age I while others failed to reach six inches before age V. These data are similar to those obtained for crappie from Lake Carl Blackwell, Payne County, Oklahoma (Jenkins, 1954) and indicate that individuals may exhibit different growth rates even when subjected to similar resource availability. These different strategies have been attributed to environmental controls or to heredity (genetic control of growth). The heredity hypothesis does not seem tenable because stunted crappie placed in a new reservoir show dramatically increased growth rates. Thus, stunting seems primarily a function of the environment (Tennant, 1957; Rutledge and Barron, 1972).

Another explanation of the lack of large crappie is that high mortality may occur among the larger crappie. In many cases crappie will not reach a quality size (>200 mm) until their third year. However, Hanson (1951) found that relatively few crappie live longer than three or four years and concluded that short life span was characteristic of some populations. For example, Hanson (1951) found that in Lake Decatur, Illinois, the 1933, 1934, and 1935 year classes disappeared at ages of about four years and four months, four years, and three years, three months, respectively. Similarly, Jenkins (1954) found that of 10,560 white crappie collected from 130 bodies of water in Oklahoma 97% were less than five years old.

Several explanations have been proposed for high adult mortality in crappie. Some authors believe that mortality is due to stress, especially during the hot summer months, or to so-called physiological burnout. In accord with this hypothesis, Starrett and Fritz (1965) and Hanson (1951) observed high natural mortality of adult crappie at Lake Chautauqua, Illinois, and in Lake Decatur, respectively, during warm months of certain years.

The possibility that disease may account for the disappearance of adult crappie seems remote. There are no known die-offs due to disease organisms. However, crappie are commonly subjected to one disease, Lymphocystis. This disease appears in the form of white, granular, irregularly shaped lumps on fins and bodies and is not known to be fatal. However, the disease was found on 19.5% of the crappie in one area of Lake Decatur (Hanson, 1951).

Vasey (1979) hypothesized for crappie in Table Rock Reservoir, Missouri, that the small sized adult crappie may result from overharvest of larger individuals. However, most workers have concluded that this is not a major factor. Starrett and Fritz (1965) estimated that 95% of three year old crappie died from natural mortality and only 5% from fishing mortality (sport and commercial) and Erickson and Zarbock (1954) found similar results. As further evidence against the overfishing hypothesis, Schoffman (1964) reported that since the prohibition of commercial fishing in Reelfoot Lake, Tennessee, a decrease in growth has been seen and anglers were catching more crappies of smaller size.

The objective of my project was to evaluate the effect of angler harvest on a new crappie population. Sooner Lake, Noble and Pawnee counties, Oklahoma, was chosen for the study because it was a new reservoir which initially had exceptionally good crappie fishing and high fishing pressure (Oklahoma Department of Wildlife Conservation (ODWC) law enforcement personnel, pers. comm.), followed three to four years after impoundment by a decline in the quality and quantity of the crappie harvest. Anglers and others believed that overharvest of crappie may have been the cause of this decline. Therefore, a creel survey and a population study were initiated to determine if heavy crappie harvest was responsible for the reported decline in the size and numbers of crappie and to determine the extent of exploitation of other major game species.

III. PROCEDURES

Description of Study Area

Sooner Lake was built in 1976 by the Oklahoma Gas and Electric Company (OG&E) as a power-plant cooling reservoir. The lake is located on Greasy Creek 35 kilometers north of Stillwater, Oklahoma, in Pawnee and Noble counties. The area of the lake is approximately 2,185 hectares and at capacity it contains 149,000 acre feet of water. The small watershed necessitates that makeup water be pumped into Sooner Lake from the Arkansas River. This water is circulated around the lake by dikes, then released back into the river. At peak capacity, the heated effluent discharges 126,000 m^3/min with a maximum rise in water temperature of 11^o C from ambient (Gilliland, 1981).

The lake has an average depth of 8.5 meters with a maximum depth of 27 meters (OG&E, 1980). Secchi disk readings range from 0.70 meters to over 2.5 meters near the dam. Mean surface water temperatures ranged from 7.2^o C to 27.6^o C during 1981 and 1982 (Table 1). Sooner Lake stratifies during the summer with a thermocline at 16 to 18 meters (Hicks, 1979). The heated effluent is cooled to within 1^o C of ambient by the time it reaches the main body of the lake. Other factors, such as oxygen and pH levels are comparable to those of other lakes in the region. However, due to the use of the Arkansas River as a water source, Sooner Lake has somewhat higher conductivities than other lakes, ranging from 1,370 to 1,550 micromhos/cm (Hicks, 1978 and 1979). Cover is sparse throughout the lake.

The ODWC stocked Sooner Lake in 1977 with 300,000 native largemouth bass (Micropterus salmoides) fingerlings, 125,000 Florida largemouth bass (Micropterus salmoides floridanus) fingerlings, 110,000 channel catfish (Ictalurus punctatus) fingerlings and an unknown number of inland silversides (Menidia beryllina). In 1980 9,300 adult threadfin shad (Dorosoma petenense) were stocked. Between 1977 and 1982 over 831,000 striped bass x white bass hybrid (Morone saxatilis x Morone chrysops) fry were also stocked (Hicks and Russel, 1980). Crappie came from the native populations in the drainage.

Data Collection and Analysis

Population Study

Excepting December 1981 and January 1982, the crappie population was sampled each month from February 1981 through June 1982. Sampling in 1981 was lakewide but in 1982 effort was concentrated in the southwest corner of the lake and in the discharge channel. Fish were collected in barrel nets (Houser, 1960) and frame nets and by electroshocking (Novatny and Priegel, 1974). However, because of higher catch rates and survival of crappie in barrel nets compared with other gear, I used barrel nets as the primary sampling gear during most of the project. Frame nets and electroshocking were used to a limited extent during the spawning season. Barrel nets and frame nets were set overnight during 1981 and for periods of 24 hours during 1982. Nets were set in areas with flooded trees and brush where crappie tend to congregate (Miller and Robison, 1973), in areas along rock riprap, and in areas where no cover was apparent. These three categories represent most of Sooner Lake's available habitat. Shoreline electroshocking was done with a 3,750 W, boat-mounted pulsed DC unit in 30-minute units of effort during the night.

Total length (mm) and weight (g) were recorded for each specimen. Scales were removed from the left side of the fish near the tip of the pectoral fin. Ages were determined from scale impressions (Tesch, 1971) and growth rates back-calculated by computer. Proportional Stock Density (PSD) and Relative Weights (Wr) (Anderson, 1978 and Wege and Angerson, 1978, respectively) and catch/hour (c/hr) were also determined. PSD is a ratio of the number of quality size fish (>200 mm for crappie) divided by the total number of stock size fish (>130 mm for crappie) multiplied by 100. Wr is the percent of the state average crappie's weight at a particular length. Seasonal length-frequencies for fish from different sites were analyzed for differences using the Chi-square (X^2) test (Snedecor and Cochran, 1978).

Creel Survey

The creel survey began in March of 1981, continued through May 1982 and was based on the Standardized Creel Survey developed by the ODWC (Mense, 1978). This design was selected to allow comparison of my data to that from other lakes in Oklahoma. This design normally results in creel surveys being conducted during three seasons (spring, summer, fall) but I included a fourth season based on observations that there was a significant amount of winter fishing pressure on crappie. Seasonal data were for the following months: spring = March, April and May; summer = June, July and August; fall = September, October and November; and winter = December, January and February.

The creel survey was conducted for 20 days each season; each survey-day consisted of a 10-hour period between sunrise and sunset. Creel dates and starting times were randomly selected by computer. I also conducted 24-hour creel surveys for five days in April to determine how completely the 10-hour day reflected the temporal fishing patterns on Sooner Lake. Each standard creel survey consisted of four one-hour pressure counts during which all anglers were counted and three two-hour periods when angler interviews were conducted. All pressure counts and interviews were done from the shore. To facilitate analysis, Sooner Lake anglers were characterized as follows: (1) bank anglers in the discharge channel; (2) bank anglers along highways 177 and 15; (3) and (4) bank anglers and boat anglers fishing on or having launched from the west and east boat ramps, respectively. During Spring 1982 the lake was further divided into two more sections to look more closely at areas with different levels of fishing pressure. These sections were of similar size and habitat but section 63 was adjacent to a boat ramp and received considerably more pressure than section 52 which was a short distance away (Figure 1). Seasonal length-frequencies of crappie caught from these areas were analyzed for differences by means of the X^2 test.

For each pressure count on each section, the number of bank anglers, boats, boat anglers, and tube anglers were recorded. During each interview, information was recorded on the section fished, type of fishing, number in party, time fished and species sought. For each of the major game species seen in the creel, the species, number of individuals and total lengths (mm) were recorded. When anglers did not allow us to measure all individuals in a catch, a random sample of each species was measured, lengths taken, and the total number of each species recorded.

The major game species for which information was collected were the white crappie, largemouth bass, striped bass x white bass hybrid (hybrid), white bass (Morone chrysops) and channel catfish. The number of black crappie (Pomoxis nigromaculatus) was negligible so data on black and white crappie were combined.

At the end of each season all data from the creel survey were compiled by personnel at the Oklahoma Fisheries Research Laboratory (OFRL). Estimates of pressure and harvest were expanded by the number of daylight hours available in a particular season. Seasonal estimates of total pressure, pressure and harvest of each major game species, catch rates, angler preferences, mean lengths and weight of fish caught (based on length-weight regressions) and length-frequencies for each species were developed. The creel survey also provided seasonal estimates of the percentage of sublegal ($<$356 mm) largemouth bass harvested and an estimate of the effect of the heated water discharge on hybrid harvest.

Comparison with Data from Previous Work on Sooner

Some previous information had been gathered by ODWC on the crappie population in Sooner Lake. Comparisons were made between earlier years data and my data using length-distributions, age structure, growth, condition, and PSD (Hicks, 1978 and 1979 and Hicks and Russel, 1980).

Comparisons with Data from Other Lakes

Fishing pressure, harvest and other parameters on Sooner Lake and six other reservoirs were evaluated to determine if trends in these factors were present. These lakes include Draper, Eufaula, Hefner, and Overholser in Oklahoma and Melvern and Milford in Kansas. Data on Oklahoma lakes were provided by the OFRL and those on the two Kansas lakes by the Kansas Fish and Game Commission.

Population data was available for 1979 on lakes Hefner and Overholser and for 1980 on lakes Draper and Eufaula. Population data were available on lakes Milford and Melvern for 1981. Creel data were available on Draper, Hefner, Overholser and Eufaula during 1980 and during 1981 on Milford and Melvern. Crappie populations in the four Oklahoma lakes were sampled by experimental gill netting and electroshocking, and those in the two Kansas lakes by trap netting. Most comparisons were done on a per hectare basis to compensate for the large variations in surface area (680 to 41,480 hectares).

Comparisons were made by using regression analyses of three independent variables: total pressure, pressure on crappie, and crappie harvest, versus 10 dependent variables: total pressure, pressure on crappie, crappie harvest, crappie harvest by weight, c/hr, c/hr by weight, mean total length, mean weight, PSD and Wr.

IV. FINDINGS

Population Study

Data on age and growth were collected during each sampling season. However, only those data collected during October and November 1981 are discussed (see Table 14 for data from other seasons). Discussion was restricted to this portion of the data because of the large sample size during these months and because data collected at or near the end of the growing season most accurately reflected age groups.

Difficulties were encountered in aging scales. These included false annuli and checks, lack of annuli and erosion of scale edges. These conditions have been reported previously (Triplett, 1976) and do not seem due to the heated water discharge. The difficulty in reading scales was equal in all parts of the lake and crappie did not move extensively. If heated effluent was responsible for scale abnormalities one would expect greater numbers of aberrances near the effluent outfall.

Age and growth data show only four year-classes, 1977 through 1980 (Table 2). The 1981 year-class did not appear in the nets until Spring 1982 because young-of-year crappie were biased against by our gear. In 1981 the 1979 year-class was dominant but by June 1982 the 1980 year-class was becoming dominant. Growth rates were well above regional averages although they appeared to be declining. Monthly relative weights (Wr) ranged between 85 and 115 percent of the state average (Figure 2) with values below 100 percent during the spring of both years and Summer 1981.

Monthly barrel net c/hr were similar for each month with the exceptions of February 1981 and May of both years. During these periods c/hr was higher than usual (Figure 3).

Seasonal length-frequencies of crappie caught in my nets (Figures 4 through 8) were unimodal for all five seasons sampled

(Spring 1981 through Spring 1982). The mode remained relatively constant throughout the study but X^2 tests did show significant differences ($P \leqq 0.0001$). Data from Winter 1981 were not included in these tests because of the small sample size. Seasonal PSD values ranged from 55% in Summer 1981 to 94% in Winter 1981-82 (Table 3).

Creel Survey

Total fishing pressure was highest during the spring with Spring 1981 pressure being within 2% of the Spring 1982 level (Table 4). Lowest levels were in the winter. Fishing pressure for crappie was highest in the spring and lowest in fall with the Spring 1982 level being 47 percent greater than the Spring 1981 level. Pressure for largemouth bass was highest in the summer and lowest in winter. Pressure for hybrids was highest in Spring 1981 and lowest in winter but also remained low during Spring 1982. Pressure for white bass and channel catfish was very low during all seasons.

Crappie harvest was estimated at 14,000 fish in Spring 1981, over 40,000 in Spring 1982, but was much lower during other seasons (Tables 5 and 6). Seasonal largemouth bass harvest varied from 265 to 1,540 with the peak in Spring 1981. Estimated Spring 1981 hybrid and white bass harvest was over 4,700 and 7,700, respectively, but were at very low levels during the rest of the study. Seasonal channel catfish harvest was neglible during all seasons and never exceeded 1,000 fish.

Catch of crappie per hour for bank and boat anglers combined was highest during Spring 1982 (Tables 7 and 8). Seventy-five percent of the anglers fished from boats.

To measure species popularity, the percentage of total hours fished for each species was calculated (Table 9). For three out of five seasons, anglers fished for crappie more than for any other species and in fall the hours fished for largemouth bass and crappie were very similar. Only in Summer 1981 was the largemouth bass sought for more hours than were crappie.

Average length of crappie harvested varied from 230 mm in Summer 1981 to 253 mm in Winter 1981 (Table 10). No seasonal patterns were apparent for any species, although the average length of the hybrid harvested declined considerably between Spring 1981 and Spring 1982.

The seasonal length-distributions of crappie seen in the creel were unimodal and showed little variation (Figures 4 through 8). However, significant seasonal differences occurred among the length-frequencies of crappie harvested ($P = 0.001$) and among seasonal length-frequencies of crappie captured with our sampling gear versus those harvested ($P = 0.001$).

24-Hour Creel Survey

The five 24-hour creel surveys conducted in April showed that total pressure at night was 12% of the total (Figure 10). However, for crappie, 17% of the pressure and 30% of the harvest was at night. Fifty-three percent of the white bass harvest was at night but nighttime harvest values for all other species were below 10%. Eighty-eight percent of the night hours fished were spent fishing for crappie as opposed to 59% of the daytime hours. Only 5% of the night hours were spent fishing for largemouth bass.

Subsection Comparison

Eleven thousand five hundred hours of fishing pressure were projected for subsections 52 and 63 during Spring 1982. Pressure in section 52 (4,915 hours) was 75% of that for section 63 (6,585 hours). The pressure for crappie alone was 39% higher in section 63 (6,659 hours) than in section 52 (4,036 hours) and harvest of crappie was more than twice as high in section 63 (8,012) as in section 52 (3,656). Values of c/hr were similar between sites and X^2 comparisons of the length-frequencies of the crappie harvested showed no significant differences ($P = 0.4028$).

Striped Bass x White Bass Hybrid Harvest

The harvest and c/hr of hybrids declined dramatically from Spring 1981 to Spring 1982 as did the average length of fish caught (Table 10). In Spring 1981, an estimated 10,809 hybrids were caught. Almost 95% of the pressure resulted from bank anglers along the discharge channel (Figure 1). Of the anglers fishing at the discharge channel, 50% were fishing for hybrids as compared to 19% on the rest of the lake. Few hybrids were seen in the creel at any location other than the discharge channel.

Sublegal Largemouth Bass Harvest

The unexpanded sublegal bass harvest (combined boat and bank anglers) varied seasonally from 8 to 67% of all bass taken and averaged 41% (Table 11). Compliance rates were greater for bass anglers than for non-bass anglers (Table 15).

Earlier Years' Data on Sooner Lake

ODWC personnel sampled Sooner Lake in 1978, 1979 and 1980. The 1978 survey revealed a crappie population dominated by the 1976 year-class. The mean length and weight was 227 mm and 179 g, respectively. The mode of the length-frequency distribution was about 220 mm and c/hr was 0.46. Growth rates were slightly above the statewide average. The mean coefficient of condition was 1.4. Over 91% of the white crappie were of harvestable size (>203 mm) (Hicks, 1978).

In 1979 the 1977 year-class was dominant. Growth rates were at or above state average at age I and were more than double the statewide average at age II. Crappie were still in good condition; mean relative weights for all length groups ranged from 94 to 117 percent of the state average. Eighty-eight percent of all crappie collected were of harvestable size and the PSD was 87%. Mean length and weight of crappie were 230 mm and 181 g, respectively. The mode of the length-frequency distribution was 220 mm and c/hr was 0.26 (Hicks, 1979).

In 1980 the 1978 year-class now appeared to be dominant and the length-frequency showed two modes, one at 160 mm and one at 240 mm. Growth for all year classes when they were at age I was above regional averages and at age II was double the regional average. Mean relative weights for all length groups ranged from 99% to 110% of the state average. Crappie had an average length of 222 mm, an average weight of 149 g, and c/hr was 0.13. Eighty-three percent of all crappie collected were of harvestable size. A PSD of 99% was calculated (Hicks and Russel, 1980).

V. ANALYSIS

Crappie Population in 1981-1982

Growth of crappie in Sooner Lake is above regional averages, although growth rates are declining slightly (Table 1). Crappie are reaching quality size early in the third growing season opposed to the regional average where they reached quality size at the end of their third growing season (Hicks and Russel, 1980). Some seasonal variation was seen in the mean size of fish (Table 3) but in general the changes appear to be the result of natural variation and sampling bias. For example, more large crappie were caught during the spring spawning season. There does, however, seem to be some actual changes in the population over time. For example, the mean total length of crappie caught in barrel nets increased 20 mm from Spring 1981 to Spring 1982.

Each year of the study a different year-class appeared to become dominant. This sequential dominance indicates a turnover caused by rapid decline in the numbers of age III fish. Currently we have no concrete explanation for this loss of age III fish.

The condition of crappie was generally higher than the state average. Lower condition than the state average in late spring corresponded with the spawning season and that in July corresponded with the high summer water temperatures. Wr values quickly rebounded to above state average as water temperatures cooled.

Seasonally variable PSD values (Table 3) are believed to be related to the seasonal variation in the size specific vulnerability of crappie to the sampling gear. The high average PSD seen in 1981

(71%) may be inflated because of the sampling gears bias against fish in the 130 to 200 mm size group. This selectivity is not due to mesh size and is probably due to some spatial or behavioral factor. Absence of small fish in the sample occurred regardless of whether gill nets, seines, or electroshocking were used. However, PSD values are comparable over the study since the bias is constant. The PSD for the first half of 1981 (PSD of 69%) is appreciably different from that for the first half of 1982 (PSD of 92%). This same trend was seen when the length-frequencies from Spring 1981 and Spring 1982 were compared. The two frequencies were significantly different ($P = 0.0001$) with most of the difference arising from the increase in the number of fish from 241 to 280 mm. These data apparently reflect an actual change in the population structure towards a larger percentage of quality sized crappie. One explanation of these data is a decline in harvest of large crappie. However, such a decline was not reflected in the creel. It seems more reasonable to hypothesize lower recruitment to smaller size classes as an explanation of these data.

Because seasonal length-frequencies of crappie were consistently unimodal, it is not possible to determine age groups by the use of length-frequencies. Variable growth rates of fish of the same age in the same area has been previously reported (Jenkins, 1954) and probably represents different developmental strategies within the cohort. These seasonal differences in length-frequencies result from growth through the year. For example, the greatest difference between the length-frequencies of fish in Summer 1981 and Fall 1981 resulted from the decline in the number of crappie in the 141 mm to 180 mm size class in Fall 1981.

Annulus formation of crappie in Sooner Lake appears to occur between April and June with larger fish laying down the annulus earlier than the smaller fish (Figure 9). Size specific differences in annulus formation may be due to dietary differences between size classes and the possibility that larger fish begin growth earlier in the year. At the beginning of the growing season the larger fish have forage available that was spawned the previous year while the smaller fish will not have fish available until later.

One year old fish seldom appeared in the barrel nets but did appear in the creel. The decline in percent harvest of one year old fish from Spring 1981 (22%) to Spring 1982 (3%) may indicate a weak 1981 year-class (Figure 12). This apparently weak year-class may cause a decline in the number of crappie available to anglers in later years. This same trend is also seen when looking at PSD classes of stock (130 mm to 200 mm) and quality (>200 mm) (Figure 13).

Creel Survey - Crappie

During the five seasons of this study, crappie was the most sought after species in Sooner Lake. Harvested crappie averaged 230 to 253 mm.

Estimates of pressure and harvest, relative to that in other lakes, appear to be moderate and probably under estimate actual values due to the number of anglers missed during the evening and night time hours.

Although pressure on the crappie population increased by only

47% from Spring 1981 to Spring 1982, the harvest of crappie increased by 65%. Simultaneously, catch rates increased from 0.22/hr for boat and bank anglers to 0.348/hr for boat anglers and 0.894/hr for bank anglers. Increase in quantity was not accompanied by a decline in the average size of crappie caught. Since total fishing pressure remained the same from Spring 1981 to Spring 1982, this increase in pressure on crappie during Spring 1982 was a result of the decrease in angler catch rates for all other species.

Seasonal length-frequencies of crappie revealed that anglers caught more large crappie during the cool months (spring and fall). However, comparison of the seasonal length-frequencies of crappie in the creel to those caught in the barrel nets revealed that anglers were more selective for larger crappie than were the barrel nets. Chi-square length-frequency comparisions verified this observation. This selection for larger crappie, and, for the most part, correspondingly older crappie is also seen in seasonal percent harvest (Figures 4 through 8).

Length-frequencies of the crappie were statistically different in the two subsections studied (52 and 63) (OSL = 0.0233). The difference came from a greater number of crappie of 201 to 220 mm in the less fished area. This difference in the numbers of this size class may not be biologically significant since this difference was not seen in comparing harvest between the two areas.

Colvin (Mike Colvin, pers. comm.) reported that on a yearly average in Missouri reservoirs, about 17% of the crappie harvested were 1 year olds, 42% are 2 year olds, and 33% are 3 year olds.

More specifically, in the James River Arm of Table Rock Lake, Missouri, most of the crappie were removed as 1 and 2 year olds and few large crappie were caught. Implementation of a creel limit (10 crappie daily) and a minimum length limit (254 mm) did not decrease harvest but resulted in an increased average length of crappie caught (from 191 mm to 280 mm). Although growth rates were similar, harvest patterns in Sooner Lake were not as concentrated on the young fish as those of Table Rock. This difference in harvest pattern indicates that overharvest is not a significant problem in Sooner Lake.

Creel Survey - Other Species

Generally most fishermen fished for crappie in Sooner Lake. However, angling for largemouth bass and hybrids was about the same as that for crappie in Summer and Fall 1981 and Summer 1981, respectively (Table 9). Little effort was expended for white bass and channel catfish, possibly because of the low catch per unit effort (Table 8). However, fishing pressure on channel catfish is underestimated because this species is often sought after dark, and most creel surveys were conducted during the day. Both white bass and channel catfish appear underutilized relative to their population density (Hicks and Russel, 1981).

Most of the hybrid harvest in Spring 1981 occurred in a small area adjacent to the effluent discharge. This concentration of harvest was probably due to an attraction of hybrids to the current or to areas of abundant forage. In Spring 1982 this pattern was not seen, probably because a generating unit was shut down causing lower water temperatures in the discharge channel. These lower water temperatures may have caused the Spring 1981 decrease in forage abundance, particularly threadfin shad (Gilliland, 1981).

The ODWC imposed a 356 mm (14-inch) minimum length limit on all black bass in Sooner Lake January 1, 1979 to minimize the "boom and bust" cycle (Hicks, 1978). However, many anglers failed to comply with this regulation. Kansas lakes also have high illegal bass harvest (Table 13). Low visibility of the regulation on a particular lake, lack of understanding about the purpose of the regulation, and low levels of enforcement may all contribute to high illegal harvest. Lack of interest in the largemouth bass as a resource may also be important as evidenced by a breakdown of data on the 1981 bass harvest in Melvern Reservoir in Kansas into bass harvested by bass anglers and non-bass anglers. Only 1.6 percent of the bass harvested by bass anglers were of illegal size whereas 26.3 percent of the bass harvested by non-bass anglers were of illegal size (Table 15). This trend was also seen in Sooner Lake, where sublegal bass ($<$356 mm) harvest by bass anglers was 28% while that of non-bass anglers was 47%.

Comparisons of Sooner Crappie Population Over Time

Crappie populations in Sooner Lake have not changed much (condition and mean length) since 1978. Growth and condition of the crappie has remained above the state average and the mean fish length has remained relatively constant. Rapid growth, high condition and a population made up of a large percentage of harvestable size crappie would appear to support the conclusion of Hicks and Russel (1980) that stockpiling and competition for food are not currently serious problems.

During the last five years a different year-class has been dominant each year. In most cases two-year-old crappie dominate the harvest and the strength of the crappie fishery appears to be set by the survival of this age-class. It appears that three year old fish generally disappear from the population before reaching their fourth year of life.

Comparison with Data from Other Lakes

Of the 27 regressions calculated to look at relationships in population parameters between lakes, only three showed significant correlations. The amount of fishing pressure for crappie was positively correlated with crappie harvest (OSL = 0.0271, $r^2 = 0.8452$) and crappie harvest was positively correlated with crappie c/hr (OSL = 0.0003, $r^2 = 0.9390$). These correlations make sense intuitively; however, the absence of some correlations were unexpected. One might expect that fishing pressure for crappie would be positively correlated with total pressure. However, this correlation did not occur (OSL = 0.9729, $r^2 = 0.004$). One possible explanation of this lack of correlation was the creel design. When anglers were asked what species they were fishing for, many would state no preference (Table 9). However, many of these same fishermen were fishing in a manner and a location indicative of crappie fishing. Therefore, I believe that a large percentage of the hours fished for "nothing in particular" were hours actually fished for crappie. If this hypothesis is true, total pressure and crappie pressure should be strongly correlated.

A high correlation occurred between total fishing pressure and PSD (OSL = 0.0464, r^2 = 0.6698). As total pressure increased, PSD decreased (Figure 11). Because PSD decreases as the number of large fish decreases, relative to the number of small fish, this correlation could be interpreted to support the hypothesis of overfishing. However, the age structure of the harvest and increased lengths from Spring 1981 to Spring 1982 do not appear to support this hypothesis.

VI. CONCLUSIONS

Compared to the state average, the crappie in Sooner Lake has excellent growth and condition. During the study, crappie harvest showed some seasonal variability but in general the mean size of crappie harvested was constant and recruitment appeared adequate for maintaining the current level of harvest. The reported decline in size of the crappie during late 1979 and early 1980 could not be documented. It is possible that a decline in numbers made crappie fishing appear unsatisfactory but there is no evidence of a drastic decline in growth rates or in condition factors. In fact, crappie harvested from Sooner Lake are generally larger than crappie from the other lakes evaluated (Table 12). I believe that angler harvest may sometimes adversely affect crappie populations but based on the evidence from this project, see no evidence that harvest on Sooner Lake has caused such an effect.

It could be of concern that three-year-old fish rapidly disappear from the population. This high mortality rate probably results from both natural and fishing mortality but the relative proportion of each type of mortality is not known. However, in Sooner Lake, high mortality of three-year-old crappie does not appear detrimental to the fishery.

Many management recommendations for crappie in Oklahoma are based on information obtained by the standard creel survey. However, the 24-hour creel surveys during April 1982 indicated that crappie pressure and harvest were underestimated with this approach. Extending the census until one hour after dark would ensure that most of the harvest was measured.

One of the bonuses of this project was the opportunity to collect information on sublegal largemouth bass harvest and pressure and harvest on largemouth bass in general. Pressure and harvest of largemouth bass declined between Spring 1981 and Spring 1982. This decline may have resulted from the previous large harvest of sublegal bass. However, the decline may also reflect a phsychological preconception among anglers that as Sooner Lake ages quality of fishing declines. The high sublegal bass harvest in Sooner Lake and other lakes indicates that anglers are not completely educated to the presence and purpose of length limits and that enforcement levels and penalties are not high enough to act as a deterrant.

A second bonus of the project was the opportunity to monitor harvest of hybrids. The information that almost the entire 1981 hybrid harvest was obtained from a small portion of the discharge channel emphasized the need for specific regulations for this area of the lake. The current regulations on hybrid harvest in the discharge channel will probably forestall harvest as large as that observed in 1981.

VII. RECOMMENDATIONS

There is no evidence that changes in crappie fishing regulations are needed for Sooner Lake crappie. However, the compliance rate for the length limit regulation on largemouth bass must be improved if positive results are to be expected. This problem might be approached with an informational brochure distributed as part of the fishing license. Also, high enforcement visibility needs to be maintained. Low hybrid harvest and fishing pressure necessitate periodic monitoring to see if returns justify expenditures.

Future research on crappie populations should be modified as follows: (1) The creel census should be extended through the evening hours, at least until just after full dark; (2) a tagging program should be implemented to determine angler exploitation rates of crappie (especially by age) and to estimate population size; (3) research should be begun immediately following impoundment; and (4) the relationship between age and size of crappie should be carefully studied.

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Table 1. Average monthly water surface temperatures in Sooner Lake from February 1981 to June 1982.

Months	Degrees (^oC) 1981	1982
January	-	-
February	8.5	7.2
March	14.1	13.2
April	15.4	15.7
May	17.1	18.0
June	22.2	24.8
July	27.6	-
August	26.2	-
September	23.3	-
October	18.1	-
November	15.8	-
December	-	-

Table 2. Age and mean back calculated length at each annulus for white crappie in Sooner Lake during October and November 1981.

Year-Class	Age Group	N	Mean calculated total length in mm 1	2	3	4
1981	0	0				
1980	1	40	111			
1979	2	242	117	176		
1978	3	181	121	177	220	
1977	4	11	133	196	239	270
Weighted Average			118	177	221	270
Growth Increment			118	59	44	49
Regional Averages[a]			79	145	185	

[a]Taken from Hicks and Russel (1980).

Table 3. Monthly number of stock and quality size crappie and PSD values for Sooner Lake from February 1981 to June 1982.

	Stock (>130 mm)		Quality (>200 mm)		PSD	
Month	1981	1982	1981	1982	1982	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	-	34	-	55	-
August	94	-	60	-	64	-
September	215	-	153	-	71	-
October	186	-	156	-	84	-
November	113	-	104	-	92	-
Total	1,353	1,481	962	1,387	-	-

Table 4. Seasonal estimates[a] of fishing pressure (hours) on the major game species of Sooner Lake from Spring 1981 through Spring 1982.

Species	1981				1982
	Spring	Summer	Fall	Winter	Spring
Crappie	25,377	3,962	3,619	5,107	37,280
Largemouth bass	6,986	7,374	3,904	233	4,655
Striped bass x white bass hybrid	10,809	4,759	1,240	1,218	2,096
White bass	1,455	264	117	39	1,101
Channel catfish	326	1,779	228	103	-
Other[b]	19,036	11,133	2,155	2,731	17,820
Total	63,989	29,385	11,593	9,508	62,952

[a]Seasonal estimates of pressure are expanded by total hours of available daylight.

[b]Includes hours fished for any other species or no species in particular.

Table 5. Seasonal estimates[a] of the number of fish harvested from Sooner Lake from Spring 1981 through Spring 1982.

	1981				1982
Species	Spring	Summer	Fall	Winter	Spring
Crappie	14,015	1,039	965	4,141	40,561
Largemouth bass	1,540	877	400	265	660
Striped bass x white bass hybrid	4,783	870	282	536	689
White bass	7,745	240	64	268	2,569
Channel catfish	738	994	118	0	900

[a]Seasonal estimates expanded by number of available daylight hours.

Table 6. Seasonal estimates[ab] of the weight (kg) of fish harvested from Sooner Lake from Spring 1981 through Spring 1982.

	1981				1982
Species	Spring	Summer	Fall	Winter	Spring
Crappie	3,828	407	446	810	5,351
Largemouth bass	1,750	2,349	817	170	373
Striped bass x white bass hybrid	14,251	1,906	1,412	533	181
White bass	1,398	109	26	124	427
Channel catfish	608	2,177	291	0	678

[a]Seasonal estimates expanded by number of available daylight hours.

[b]Weights determined from length-weight regression values from population sampling.

Table 7. Seasonal angler catch per hour from boat and bank in Sooner Lake from Spring 1981 through Spring 1982.

	1981								1982	
	Spring		Summer		Fall		Winter		Spring	
Species	Boat	Bank	Boat	Bank	Boat	Bank	Boat	Bank	Boat	Bank
Crappie	0.220	0.220	0.020	0.069	0.104	0.034	0.570	0.103	0.348	0.894
Largemouth bass	0.015	0.029	0.039	0.006	0.036	0.032	0.000	0.061	0.005	0.016
Striped bass x white bass hybrid	0.014	0.120	0.032	0.028	0.018	0.037	0.020	0.099	0.000	0.021
White bass	0.008	0.206	0.007	0.012	0.001	0.014	0.034	0.021	0.003	0.077
Channel catfish	0.005	0.017	0.007	0.090	0.010	0.010	0.000	0.000	0.021	0.008

Table 8. Seasonal angler catch per hour (kg)[a] from boat and bank in Sooner Lake from Spring 1981 through Spring 1982.

	1981								1982	
	Spring		Summer		Fall		Winter		Spring	
Species	Boat	Bank	Boat	Bank	Boat	Bank	Boat	Bank	Boat	Bank
Crappie	0.06	0.06	0.01	0.02	0.05	0.02	0.11	0.02	0.03	0.13
Largemouth bass	0.01	0.06	0.10	0.01	0.07	0.07	0.00	0.04	0.00	0.01
Striped bass x white bass hybrid	0.05	0.35	0.09	0.02	0.14	0.08	0.05	0.06	0.00	0.01
White bass	0.00	0.04	0.00	0.01	0.00	0.01	0.02	0.01	0.00	0.01
Channel catfish	0.00	0.02	0.05	0.14	0.03	0.01	0.00	0.00	0.00	0.02

[a]Weights determined from length-weight regression values collected from population sampling.

Table 9. Percent total hours fished for a particular species by anglers.

	1981				1982
Species	Spring	Summer	Fall	Winter	Spring
Crappie	40.0	13.0	31.0	53.7	59.0
Largemouth bass	11.0	25.0	34.0	2.5	7.4
Striped bass x white bass hybrid	17.0	16.0	11.0	12.8	3.3
White bass	2.0	0.9	1.0	0.4	1.7
Channel catfish	0.5	6.0	2.0	1.1	0.0
No preference	30.0	38.0	19.0	29.0	28.3

Table 10. Seasonal mean fish lengths (and weights) of fish harvested from Sooner Lake from Spring 1981 through Spring 1982.

Species	1981				1982
	Spring	Summer	Fall	Winter	Spring
Crappie	242[a] (182[b])	230 (167)	245 (173)	253 (189)	248 (212)
Largemouth bass	356 (826)	426 (1,271)	396 (971)	294 (348)	333 (545)
Striped bass x white bass hybrid	400 (1,485)	336 (633)	393 (1,245)	346 (755)	208 (124)
White bass	250 (117)	276 (150)	190 (55)	410 (421)	288 (169)
Channel catfish	367 (543)	359 (508)	432 (404)	- -	- -

[a]Lengths (mm) taken directly from interviews.

[b]Weight (g) taken from length-weight regression values collected from population sampling.

Table 11. Numbers and percentages of sublegal bass (<356 mm) seen in the angler's creel in Sooner Lake from Spring 1981 through Spring 1982[a].

Season	N	Sublegal Bass	Legal Bass
Spring 1981	58	36 (62%)	22 (38%)
Summer 1981	38	6 (8%)	32 (92%)
Fall 1981	41	10 (24%)	31 (76%)
Winter 1981	18	12 (67%)	6 (33%)
Spring 1982	26	11 (42%)	15 (58%)
Total	181	75 (41%)	106 (59%)

[a]Data gathered from interviews conducted on the bank and from boat ramps.

Table 12. Values used in regression analysis of interlake comparisons.

Variable	Lake						
	Sooner	Draper	Hefner	Overholser	Eufaula	Melvern	Milford
Total Pressure Per Hectare	52.39	197.63	128.87	309.26	22.30	74.77	36.56
Crappie Pressure Per Hectare	17.42	30.02	6.67	6.81	10.45	-	-
Crappie Harvest Per Hectare (N)	9.23	22.56	1.06	7.07	10.35	100.00	11.80
Crappie Harvest Per Hectare (kg)	2.51	3.55	0.17	40.30	2.20	43.96	5.00
Catch Per Hour (N)	0.17	0.11	0.01	0.05	0.23	1.34	0.33
Catch Per Hour (kg)	0.04	0.02	0.00	0.31	0.05	-	-
PSD (%)	71.00	56.00	-	8.00	61.00	71.00	51.00
Mean Length (mm)	220.00	218.00	155.00	175.00	212.00	224.00	210.00
Mean Weight (s)	-	157.00	45.00	73.00	178.00	183.00	130.00
Wr	100.00	-	-	-	-	88.00	83.00

Table 13. Illegal largemouth bass harvest on some lakes and reservoirs in Kansas[a].

Impoundment	Year	% Legal	% Illegal	Illegal Size
Brown SFL[b]	1974	73	27	12 - 15"
	1976	82	18	
	1977	100	0	
	1979	92	8	
Cowley SFL[b]	1973	52	48	12 - 15"
	1975	60	40	
	1976	50	50	
	1977	100	0	
	1979	100	0	
Jewell SFL[b]	1975	60	40	12 - 15"
	1976	37	63	
McPherson SFL[b]	1974	79	21	12 - 15"
	1975	86	14	
	1976	80	20	
	1977	100	0	
	1979	100	0	
Montgomery SFL[b]	1974	75	24	12 - 15"
	1976	60	40	
	1977	100	0	
	1979	99	1	

Table 13. Continued.

Impoundment	Year	% Legal	% Illegal	Illegal Size
Nemaha SFL[b]	1974	54	46	12 - 15"
	1975	71	29	
	1976	69	21	
	1977	100	0	
	1979	100	0	
Melvern RES[c]	1974	5	95	<15"
	1975	17	83	
	1976	26	74	
	1977	37	63	
	1979	93	7	
	1981	88	12	
Milford RES[c]	1974	40	60	<15"
	1975	38	62	
	1976	49	51	
	1977	100	0	
	1979	75	25	

[a]Data courtesy of Kansas Fish and Game.

[b]State fishing lake.

[c]Reservoir.

Table 14. Seasonal age and growth data for white crappie collected from barrel nets on Sooner Lake*.

Time Period	Year-Class	Age Group	N	Mean calculated total length in mm 1	2	3	4
Spring 1981	1981	0	0				
	1980	1	42	99			
	1979	2	300	122	199		
	1978	3	79	124	201	244	
	1977	4	3	136	176	214	246
Summer 1981	1981	0	0				
	1980	1	104	92			
	1979	2	371	105	170		
	1978	3	108	110	184	224	
	1977	4	4	113	199	239	277
Spring 1982	1982	0	0				
	1981	1	44	124			
	1980	2	499	129	183		
	1979	3	605	137	196	232	
	1978	4	58	144	213	252	274

*Some problem was encountered in determining year-class due to nearness of annulus formation.

Table 15. Illegal harvest of largemouth bass by bass anglers and non-bass anglers on Sooner Lake (<356 mm) and Melvern Reservoir (<381 mm).

	Sooner		Melvern	
	Bass Anglers	Non-Bass Anglers	Bass Anglers	Non-Bass Anglers
Legal	72%	47%	98%	74%
Illegal	28%	53%	2%	26%

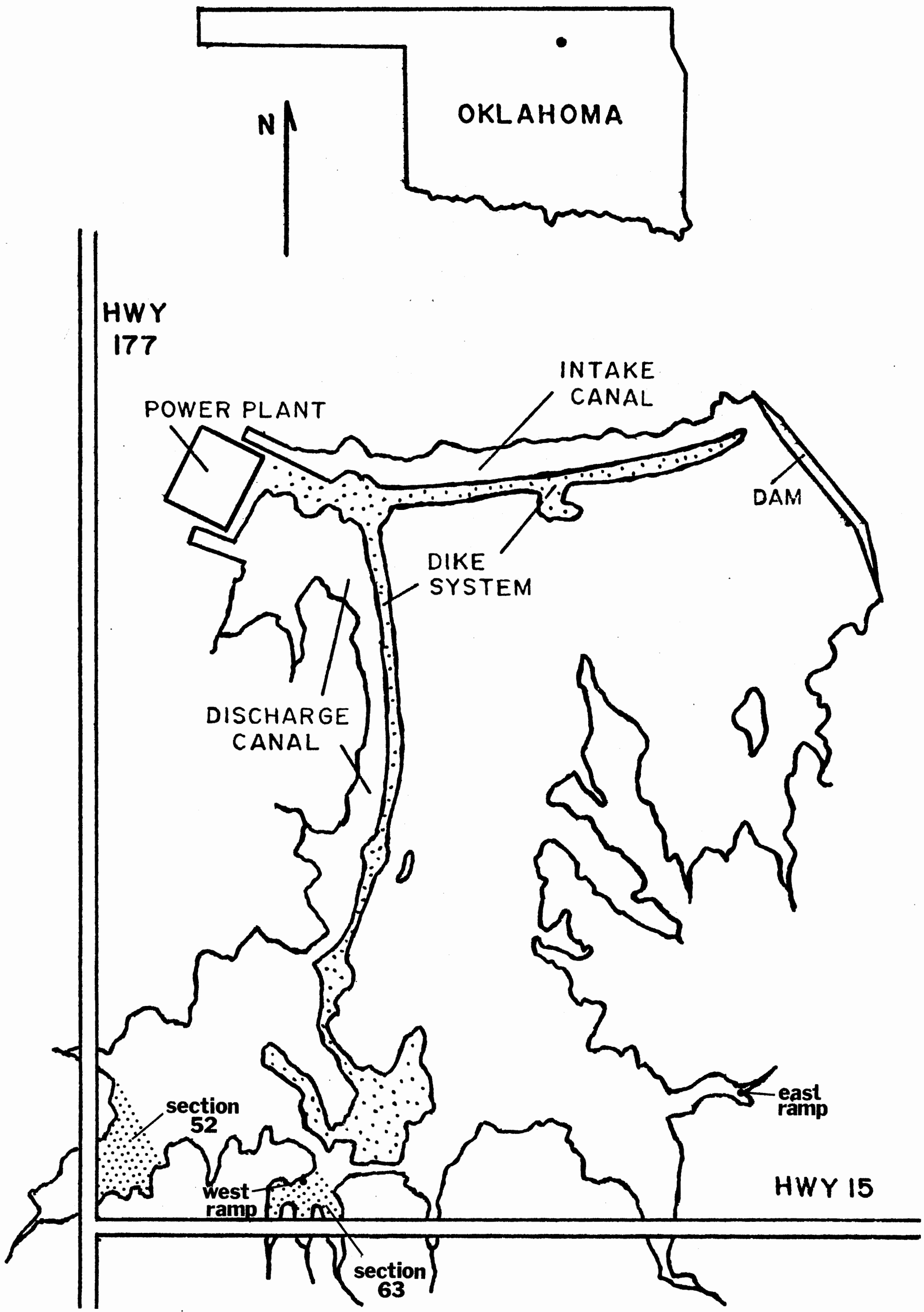

Figure 1. Sooner Lake, Pawnee and Noble counties, Oklahoma.

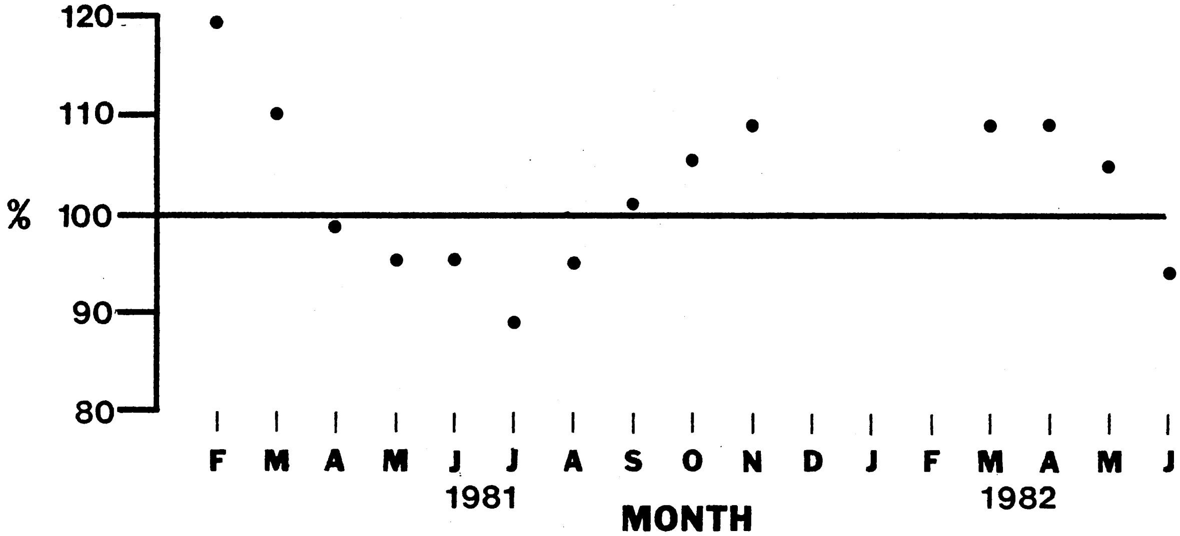

Figure 2. Monthly mean relative weights for white crappie caught during population study of Sooner Lake from February 1981 through June 1982.

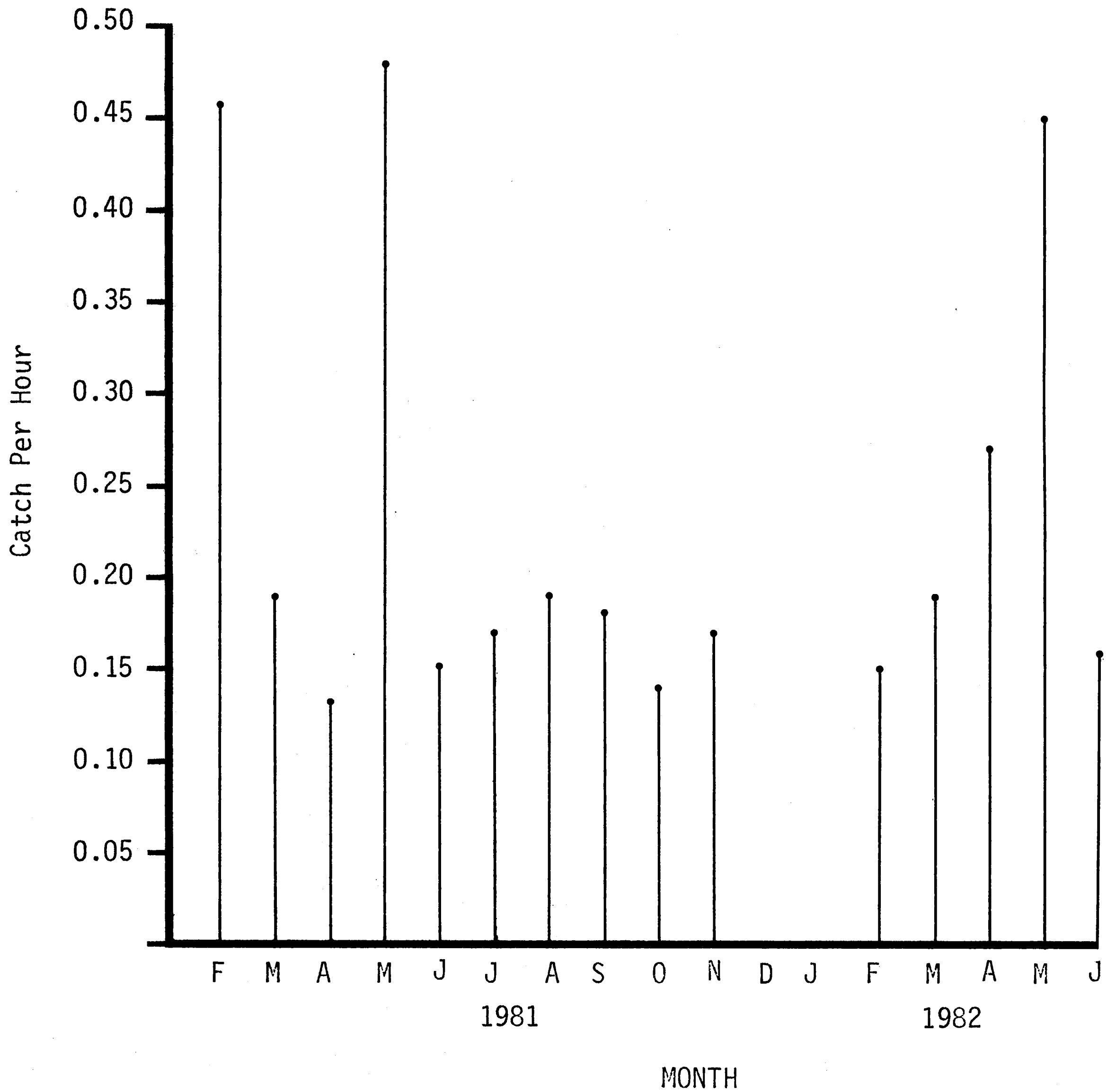

Figure 3. Monthly catch per hour values for white crappie caught in barrel nets in Sooner Lake from February 1981 through June 1982.

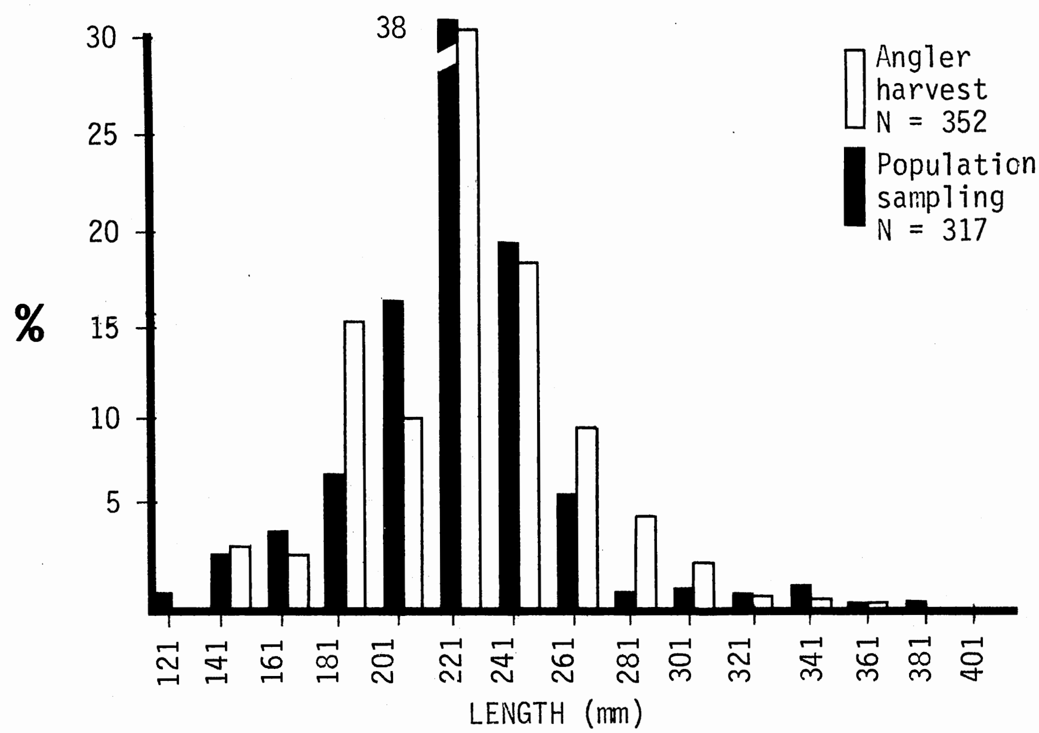

Figure 4. Spring 1981 length-frequencies of crappie collected by anglers and by sampling gear.

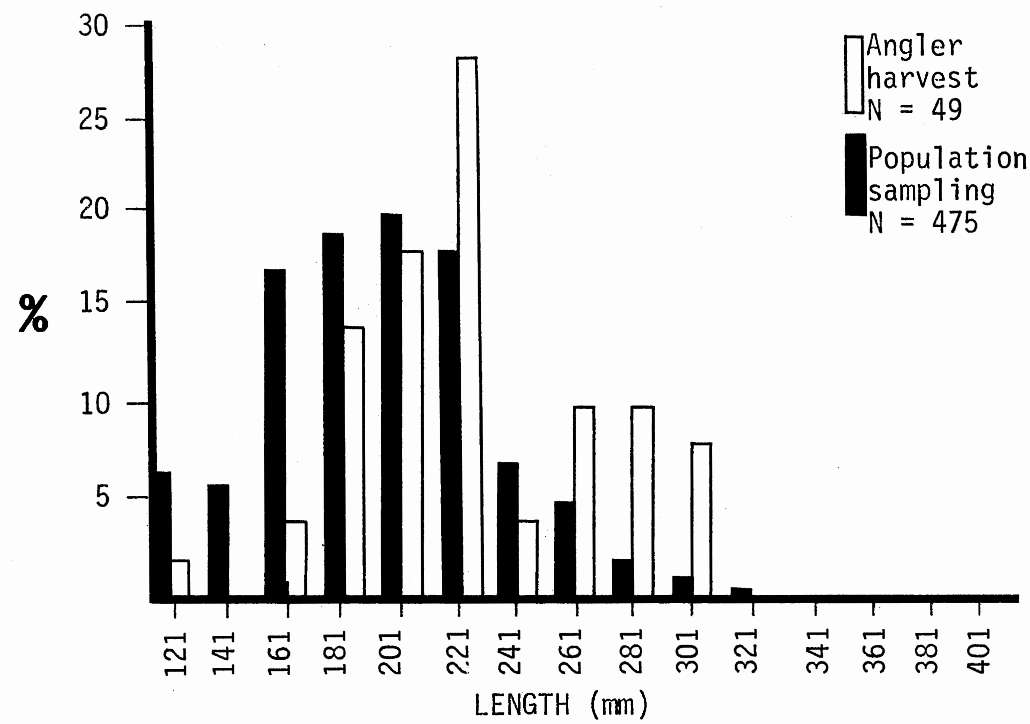

Figure 5. Summer 1981 length-frequencies of crappie collected by anglers and by sampling gear.

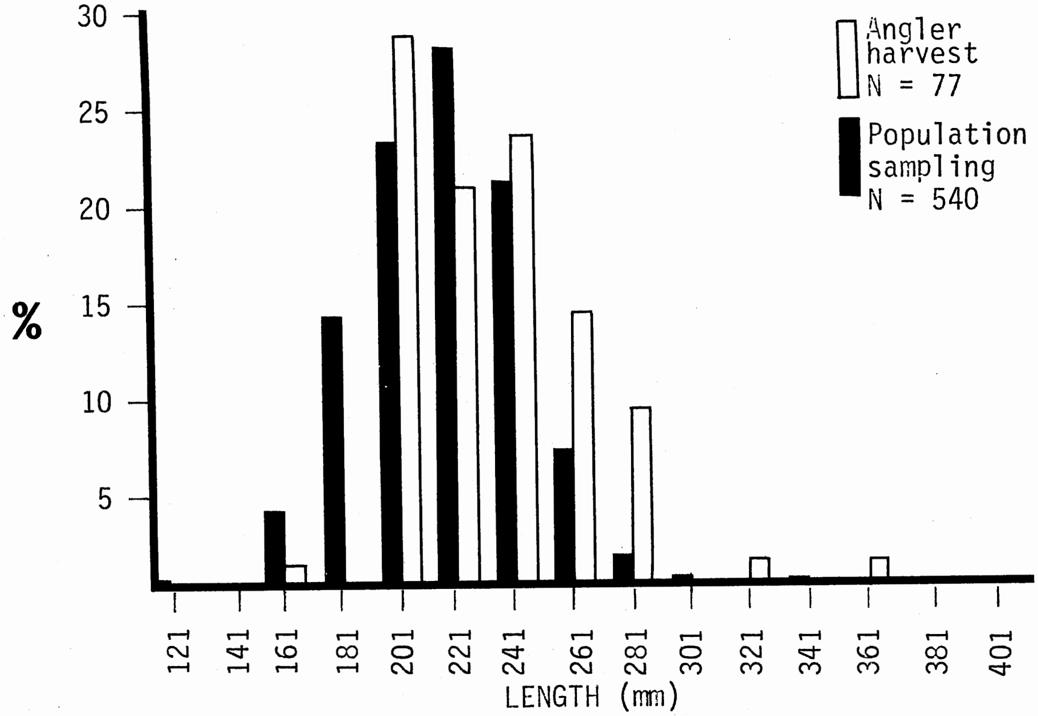

Figure 6. Fall 1981 length-frequencies of crappie collected by anglers and by sampling gear.

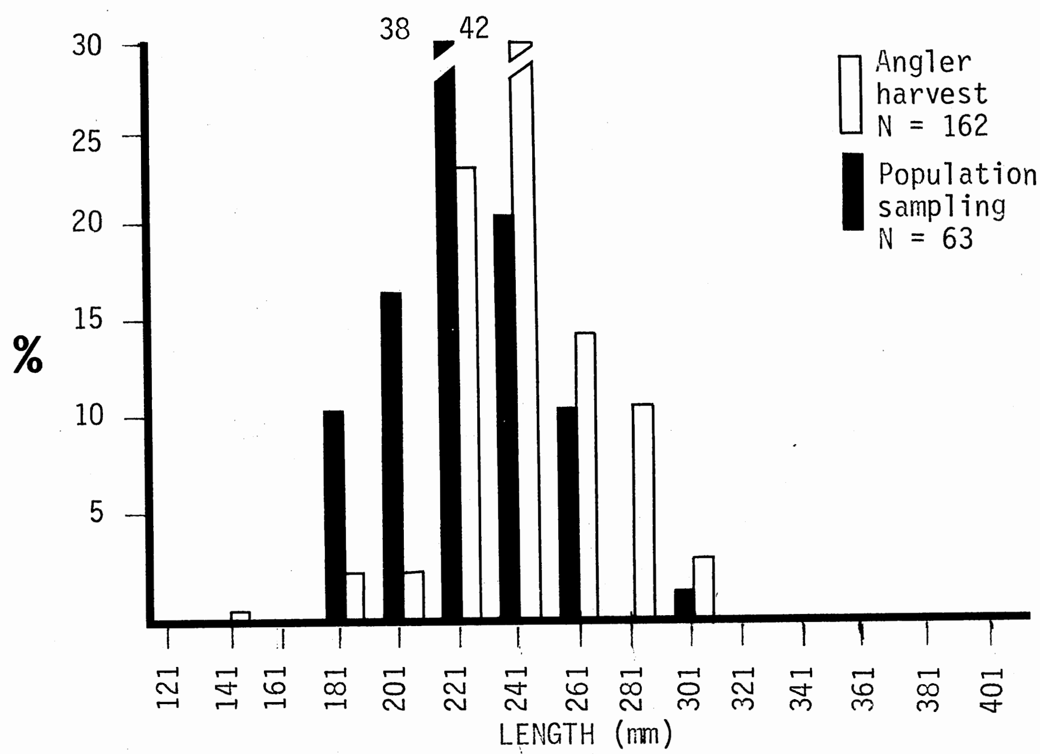

Figure 7. Winter 1981 length-frequencies of crappie collected by anglers and by sampling gear.

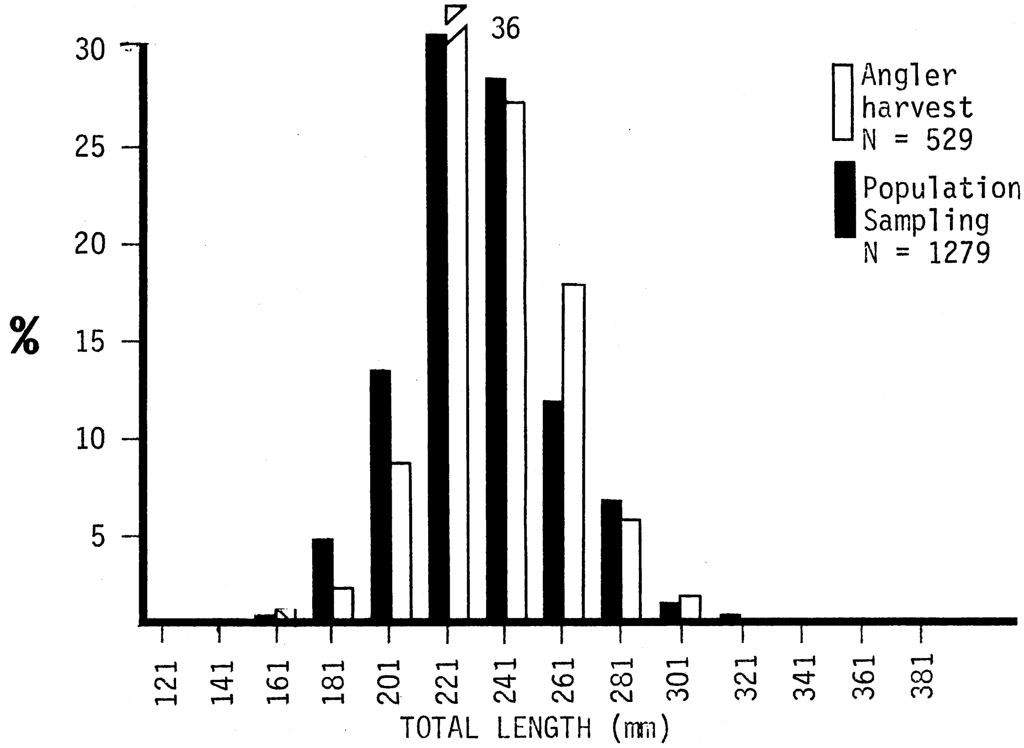

Figure 8. Spring 1982 length-frequencies of crappie collected by anglers and by sampling gear.

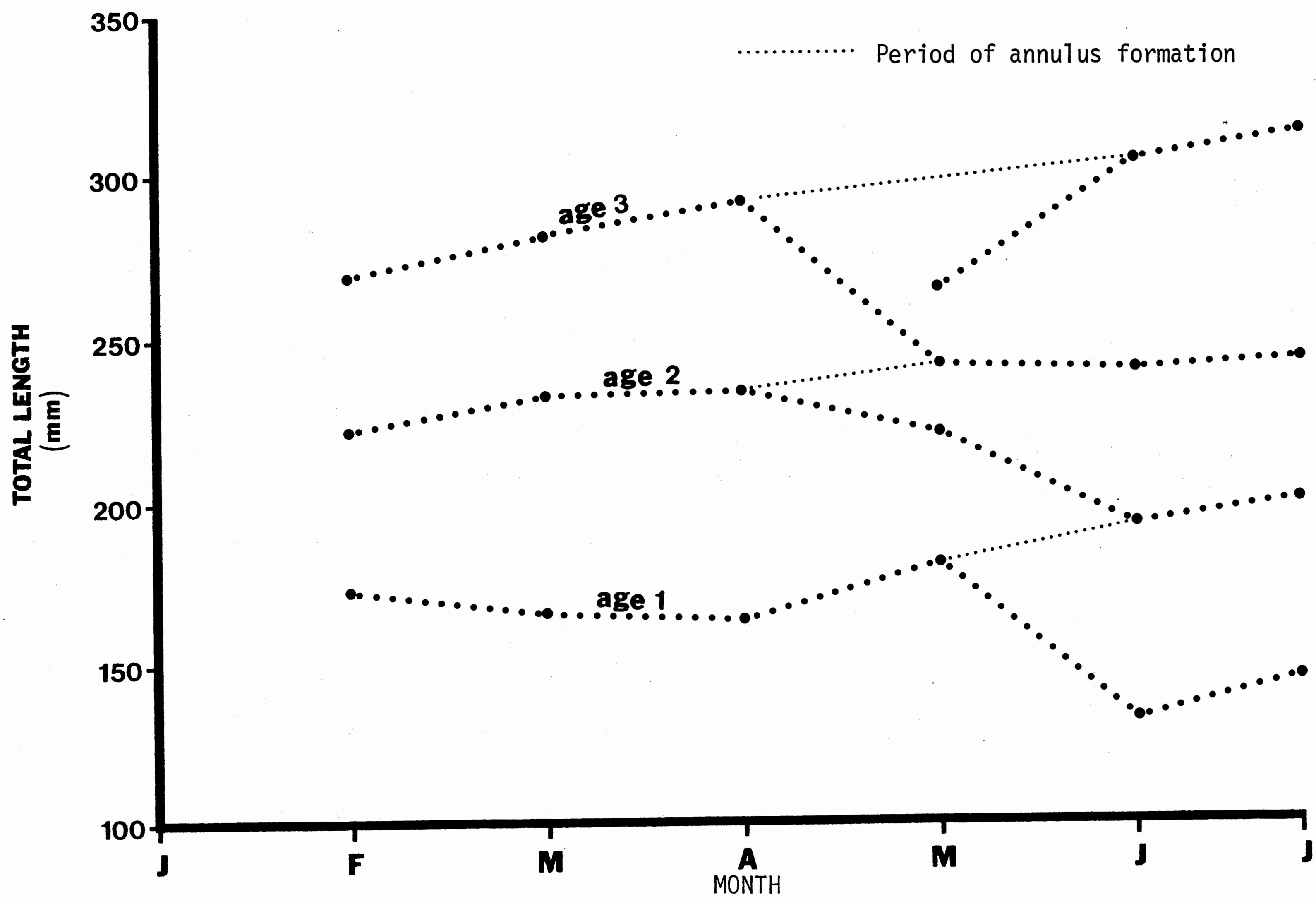

Figure 9. Monthly mean total lengths of white crappie in Sooner Lake during 1981.

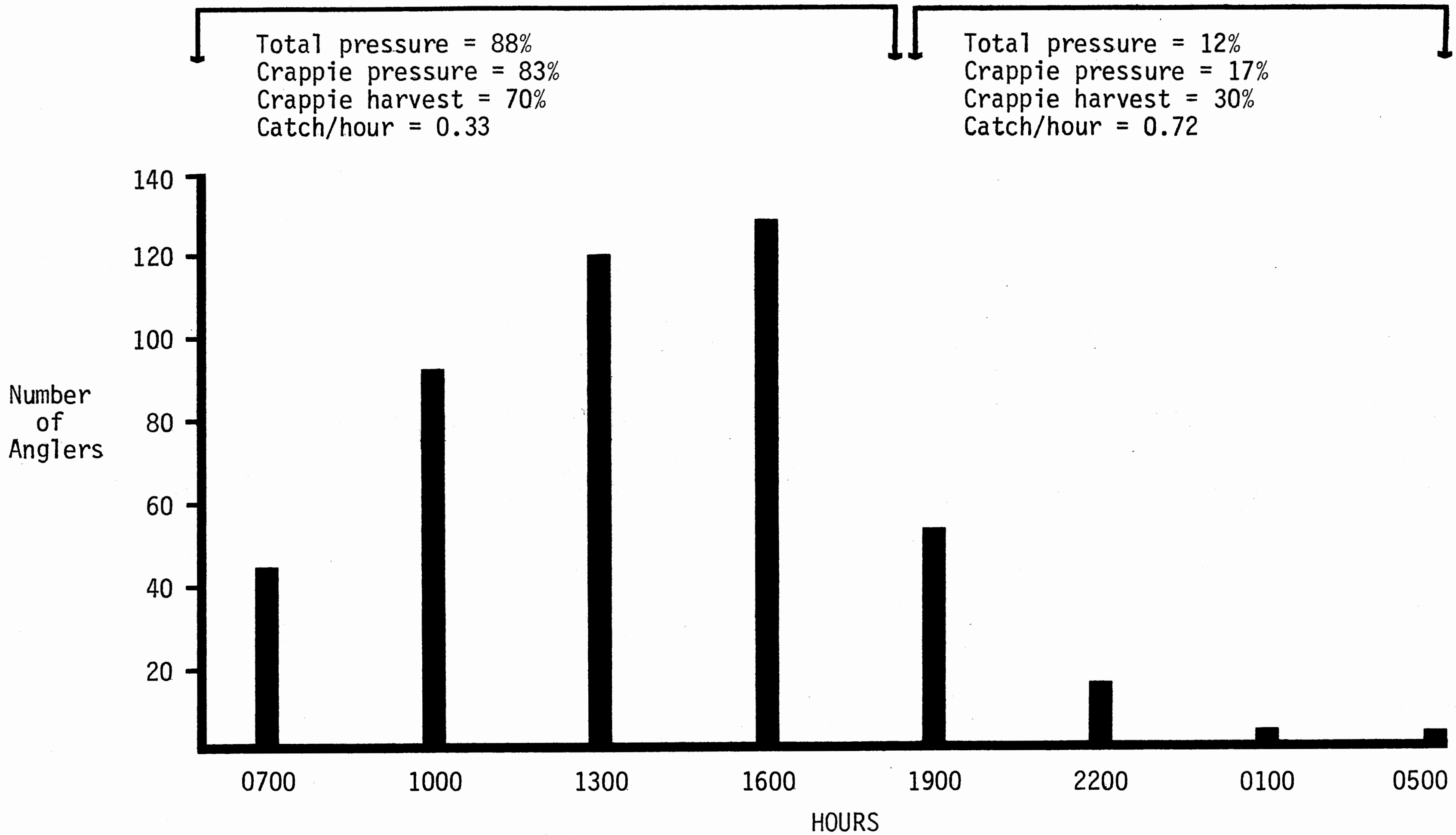

Figure 10. Total pressure, crappie pressure, harvest, and catch per hour and hourly distributions of anglers during the 24-hour creel surveys on Sooner Lake during 1982.

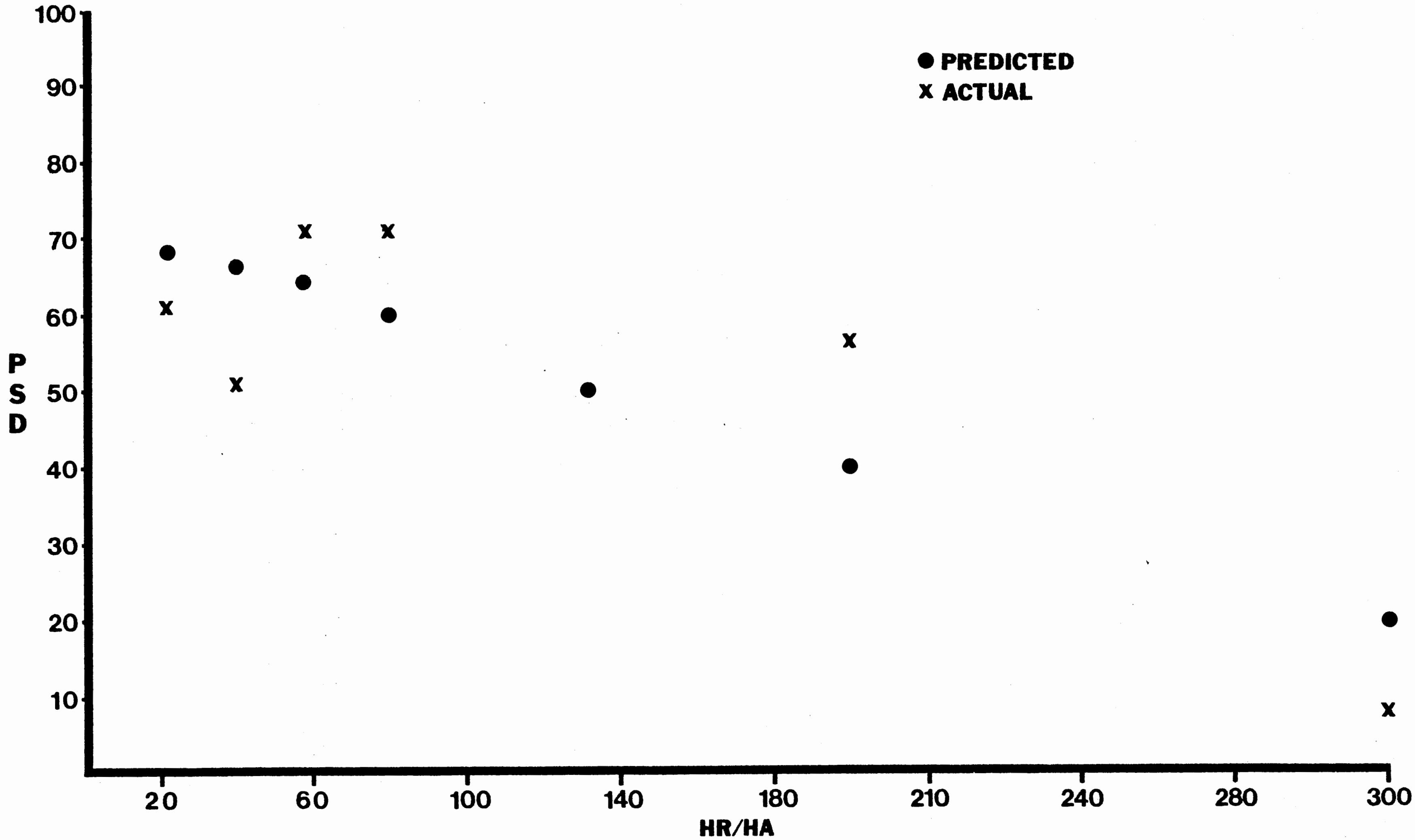

Figure 11. Plot of PSD versus total pressure (hours/ha) for fish populations in six reservoirs.

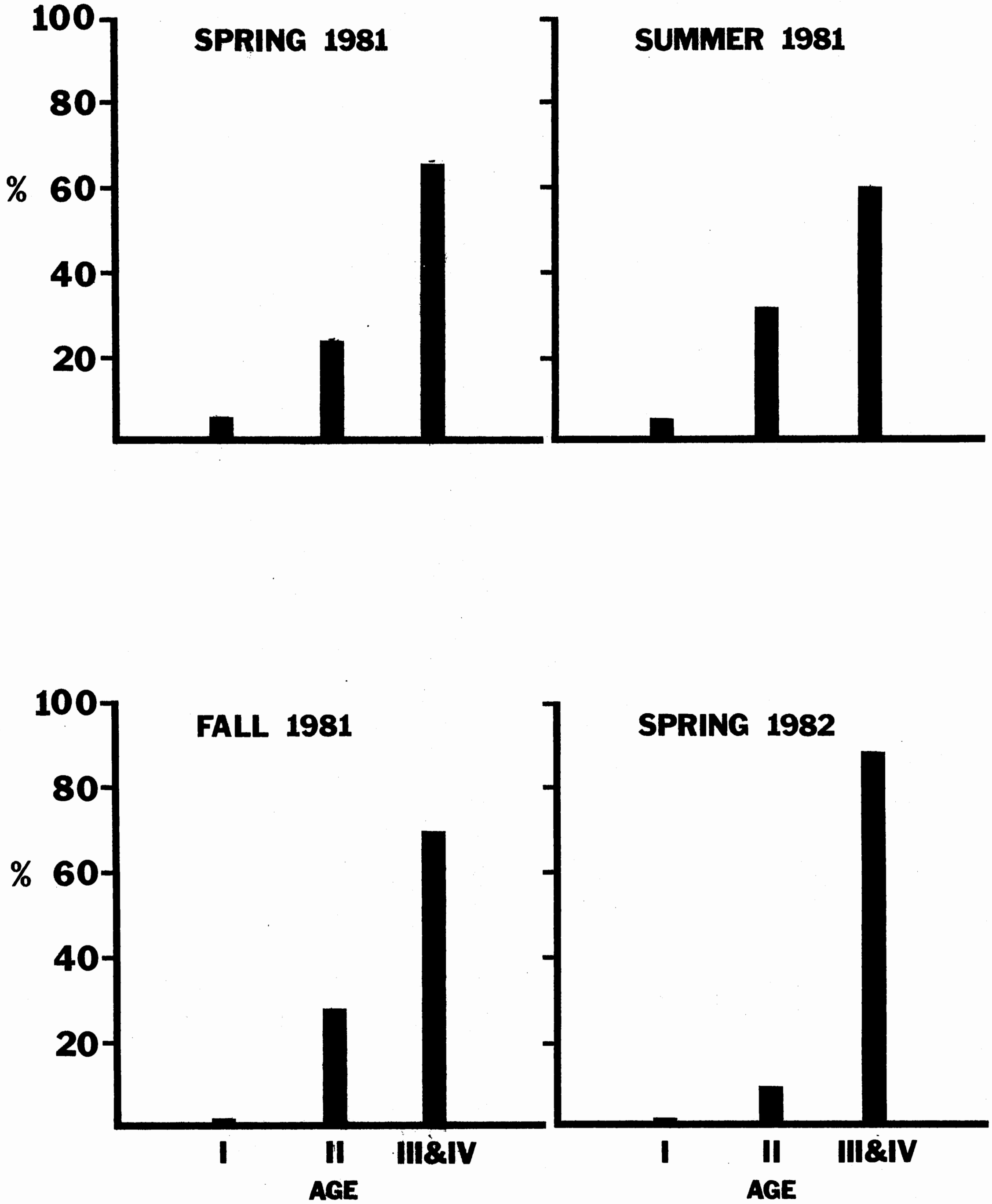

Figure 12. Seasonal harvest of Sooner Lake crappie based on age groups.

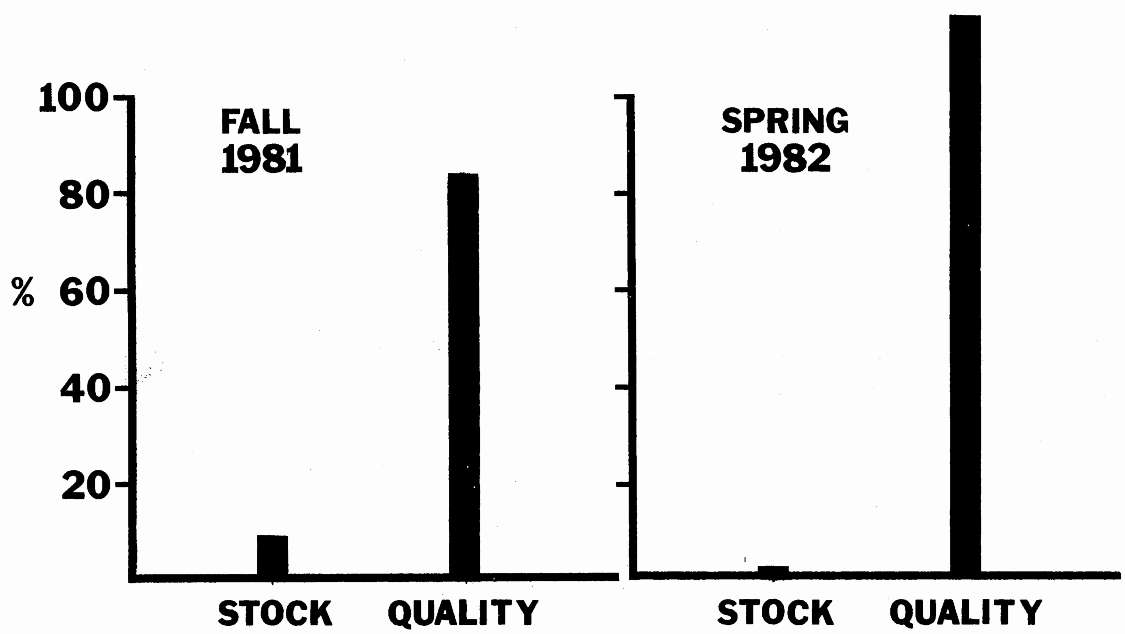

Figure 13. Seasonal harvest of Sooner Lake crappie based on PSD length classifications.

VITA[2]

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Master of Science

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