EFFECTS OF EXPLOITATION ON CRAPPIE
IN A NEW RESERVOIR

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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, 1985

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NEW RESERVOIR

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ACKNOWLEDGEMENTS

The objective of this project was to determine the effects of exploitation on crappie in a newly impounded Oklahoma reservoir. The project was funded through the Oklahoma Cooperative Fish and Wildlife Research Unit with support from the Oklahoma Department of Wildlife Conservation, Oklahoma State University, and the U.S. Fish and Wildlife Service.

I am grateful for the confidence and support given to me by Harold Namminga, Kim Erickson, Dale Toetz, and Gene Maughan during completion of this project. Special thanks are due Larry Talent for his tireless efforts on behalf of this project and as my major advisor.

Thanks also go to the many students and staff of the Oklahoma Cooperative Fish and Wildlife Research Unit, some of whom are: Ruby Collins, Mike England, Judy Gray, Vicki Gregory, Ray Jones, Mike Kemmerer, Stuart Leon, Julie Matlock, Susan Mearns, Maurice Muoneke, David Oakey, Krista Peters and especially Lori Gatzy Rochelle, Jim Carlton Wahnee.

Above all I am grateful to my daughter, Terra Knapp, whose patience and inspiration were major factors in the completion of this project.

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CHAPTER I

INTRODUCTION

Crappie are one of the most popular game fish in Oklahoma reservoirs (Mense, 1978a) and are especially important in the fishery of new reservoirs. As a reservoir ages, however, black crappie (*Pomoxis nigromaculatus*) tend to decrease in abundance and white crappie (*P. annularis*) tend to become abundant but small in size (stunted).

Cyclic reproductive success (having an extremely abundant year class every three to five years) has been suggested as one explain-ation for stunting (Rutledge and Barron, 1972; Glass, 1982). In this explanation the abundant year class dominates the crappie population and causes intraspecific competition for food resources (Buck and Cross, 1951; Hall et al., 1954) which in turn results in poor growth and reproduction.

A common management strategy to deal with an overabundance of slow growing crappie is to remove a portion of the year class by drawdown, rotenone or other means (Jenkins, 1957; Rutledge and Barron, 1972). These procedures, however, do not provide a long-term solution to overcrowding and stunting because they must be repeated. Another method to decrease overcrowding is to concentrate fish around submerged habitat structures to increase angler harvest (Hall et al., 1954). However, high fecundity has prohibited removal methods from being totally effective in controlling overcrowding in crappie. For example, Jenkins (1957) reported that after removal of all crappies from Ardmore City Lake, Ardmore, Oklahoma, 50 adult crappies produced over 200,000 crappie by the following year.

Stunting may also be related to the availability of "buffer" food supply during the planktivorous to piscivorous transition (usually at about 100 mm TL) in crappie. Triplett (1976) hypothesized that if such a buffer food supply (benthic fauna, aquatic insects, and in particular *Hexagenia*) were absent, crappie less than 100 mm TL may remain as slower growing planktivores. Where adequate buffer food supply existed (especially *Hexagenia*), this trophic barrier was often bridged and the crappie grew to the size necessary for efficient piscivory and, upon transition, established a pattern of rapid growth (Siefert, 1969; Triplett, 1976). The length of the transition period from planktivory to piscivory varies and is probably related to food quantity and quality. Keast (1968) found that the transition period was also related to physical factors such as temperature.

Once crappie reach a size large enough for piscivory, gizzard shad (*Dorosoma cepedianum*) are important forage. Where shad are absent or scarce, growth rates of crappie may be slow (Buck and Cross, 1951; Mosher, 1982). Even where forage fish are abundant, they may not be readily available in tubid waters because both black and white crappie are sight feeders (Keast, 1968; Schoch, 1981). Therefore, in turbid water, such as those often found in Oklahoma, growth rates may be slow, at least in part, due to poor foraging conditions.

If stunting is due primarily to competition for critical food resources, it seems possible that increased harvest could reduce competition among crappie and high growth rates would result. However, predominantly older, presumably piscivorous, individuals are harvested by anglers. Decreasing the density of large adults may in turn reduce predation on the younger age classes by larger crappie and increase competition for food among younger age classes. Under these circumstances, crappie population may appear stunted even under optimal forage conditions due to overfishing of large adults. In Missouri, intense harvest of older age classes of crappie produced a population of small subharvestable individuals. In that situation, an increase in the length limit resulted in an increase in the number of individuals in the Age IV+ and older age groups (Colvin, 1982).

Heavy exploitation of fast growing individuals by anglers has also been suggested to directly select for slow growth. Although Miller (1957) felt that great caution should be used in assuming that exploitation could cause selective genetic effects, studies conducted primarily on salmonids (Donaldson and Menasveta, 1961; Kincaid et al., 1977) and cichlids (Silliman, 1975), have demonstrated that growth rate is heritable and have lent some credibility to this hypothesis.

Spangler et al., (1977) in studies conducted on percids, noted that there are five general responses by a fish community to exploitation pressure -changes in variability of recruitment; changes in growth rate; changes in age of maturity; biological interactions among species within the community; and changes in genetic composition of wild stocks. Stocks predisposed to rapid growth such as percids, might be endangered by a strongly size-selective fishery which would remove those individuals exhibiting rapid growth, and a selective advantage would fall to the slower growing individuals. Over time

(Silliman [1975] indicated at least three generations are necessary) the fish populations would consist of a number of slow growing fish, few of which reach the size valuable in angling. Moav et al., (1978) supported the idea that exploitation could act as an important selective force and felt that exploitation had created such severe genetic depletion in commercial stocks of salmonids that new strains were needed as additions to the stock for genetic revitalization.

A definitive study by Favro et al., (1979) on brown trout (Salmo trutta) in Michigan used a simulation model to examine the effects of exploitation on growth rates of trout. Exploitation rates were set at 10, 20, 30, and 40% and the model was developed for a time range of up to 30 years. The model showed that the numbers of large brown trout decreased as the fishing pressure increased. The decrease in the abundance of large fish was inversely related to size limit in the fishery. In other words, as the size limit decreased, the rate at which the large fish disappeared increased. In the model, these effects were demonstrated only five years after exploitation had begun. Field data from brown trout in Michigan streams supported the hypotheses generated by the model (Favro et al., 1979).

This study was initiated to investigate the specific effect of angler harvest on the population structure and growth characteristics of crappie in Copan Reservoir. These factors should be easier to measure in a new reservoir where food and space are probably not limiting factors (Eschmeyer and Jones, 1941; Buck and Cross, 1951) and characterizing angler exploitation on crappie in a new impoundment will help clarify the processes that occur as a reservoir is impounded and begins to age. The specific objective of the study was to determine the effects of angler exploitation on crappie in a new reservoir by evaluating age structure, growth, condition, and angler harvest of Copan Reservoir crappie.

CHAPTER II

MATERIALS AND METHODS

Study Site

Copan Reservoir is located in Washington County in northeastern Oklahoma (Figure 1). The reservoir (impounded 1 April 1983) was designed by the U.S. Army Corps of Engineers to provide flood control, in tandem with Hulah Reservoir, for the communities of Dewey and Bartlesville, Oklahoma.

The watershed of Copan Reservoir consists of approximately 510 square miles of rolling sandstone hills partially forested with blackjack oak (Quercus marilandica), chinquapin oak (Q. prinoides), hickory (Carya cordiformis) and native grasses (Andropogon spp., etc.). At conservation pool (710 feet msl), the reservoir provides 31 miles of shoreline and 33,600 acre feet of conservation storage. In addition to flood control, the reservoir was designed for municipal water supply, low flow augmentation, recreation, and fish and wildlife. The reservoir was filled in stages. Initially the reservoir was filled from 687.0 feet msl to 709 feet msl and nominally maintained at that level from 1 April 1983 until 1 October 1983. In October the reservoir was raised to 710 feel msl and has subsequently been maintained at that level.

Water depth at conservation pool at Copan Reservoir varies from a maximum of 13 meters near the dam to an average of three meters in the basin. One third of the proposed basin was cleared of timber and

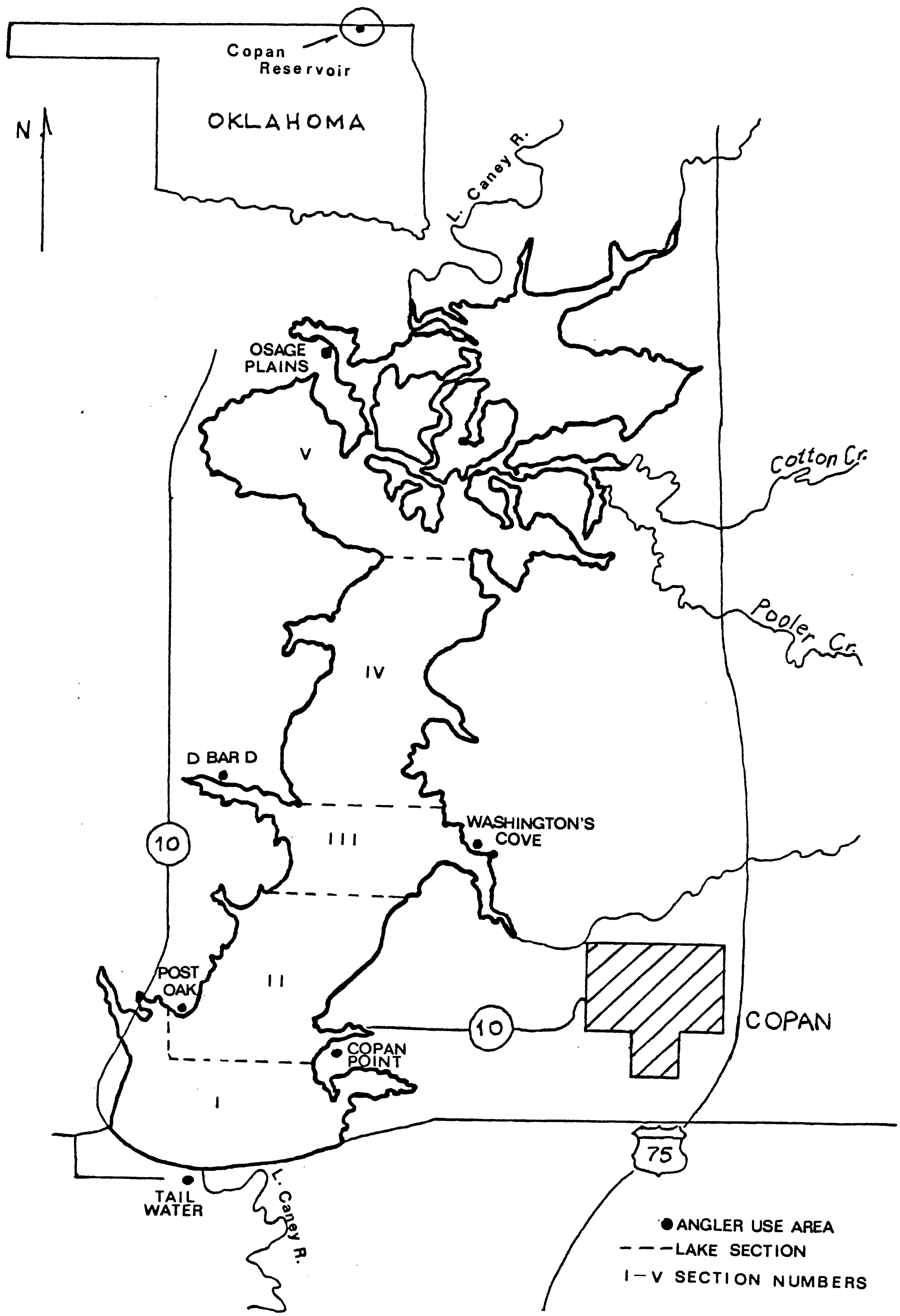


Figure 1. Map of Copan Reservoir, Washington County, Oklahoma

vegetation before impoundment. Vegetation and timber in the remaining area was left standing.

Fish species present in the lake include white crappie, Pomoxis annularis, black crappie, P. nigromaculatus, largemouth bass, Micropterus salmoides, (native and stocked), bluegill, Lepomis macrochirus, (native and stocked), gar, Lepisosteus spp., gizzard shad, Dorosoma cepedianum, threadfin shad, D. Petenense, (stocked), common carp, Cyprinus carpio, warmouth sunfish, Lepomis gulosus, longear sunfish, L. megalotis, redear sunfish, L. microlophus, green sunfish, L. cyanellus, spotted bass, M. punctulatus, freshwater drum, Aplodinotus grunniens, smallmouth buffalo, Ictiobus bubalus, River carpsucker, Carpiodes carpio, black bullhead, Ictalurus melas, yellow bullhead, I. natalis, channel catfish, I. punctatus, (native and stocked), white bass, Morone chrysops, white bass x striped bass hybrid, M. chrysops x M. saxatilis, (stocked), golden shiner, Notemigonus crysoleucas, and creek chub, Semotilus atromaculatus.

Problems with field identification, led me to combine white bass and striped bass x white bass hybrids as "Morone sp." in this paper.

Sampling - 1983

A standard sampling site was selected in each of five major habitat types in Copan Reservoir (Figure 1). These five standard sites were sampled with barrel nets and rectangular fyke nets with 20 meter leads. Barrel nets were used in 96.9% of the sampling effort during the first year and the remaining 3.10% of effort was with fyke nets. Samples were taken on a bimonthly basis.

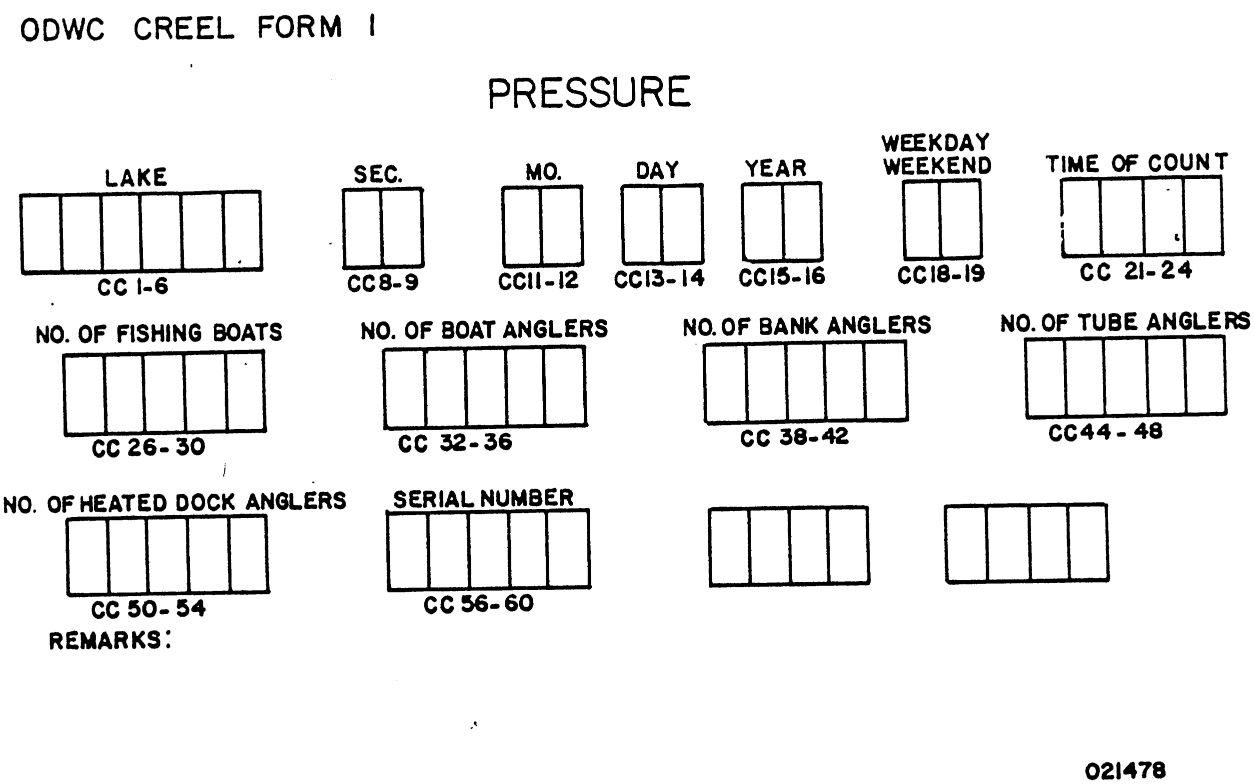
Sampling - 1984

In 1984 the five original standard sampling sites were retained but, in addition, a random site was also sampled within each major habitat area. Standard sites and random sites were sampled alternately with sampling occurring twice monthly. Barrel nets and fyke nets were again employed but, in addition, gill nets and electrofishing were used. Gill nets were 67 meters in length with four panels having mesh of 2.5 cm, 5 cm, 7.5 cm, and 10 cm, respectively. Electrofishing was conducted during the night using a boat mounted, 3750 W DC generator.

Creel Survey

A twenty-four month creel survey using a standardized creel survey format established by the Oklahoma Department of Wildlife Conservation (Mense, 1978b) was employed for this study. The creel survey began on 2 December 1982 and ended 28 November 1984. Creel days were selected at random and each creel day consisted of 10 hours between sunrise and sunset. Six pressure counts were conducted each creel day and consisted of visual sightings of angler use in each section of the lake. The number of boats, boat anglers, and bank anglers were recorded on standardized forms (Figures 2 and 3). Interviews were conducted with bank anglers while they were fishing and with boat anglers as they returned to the dock.

During an interview, the angler (or angling party) was asked for information about species sought, length of trip, number in party, species and number returned to the water, and species, number and size



ODWC CREEL FORM I

PRESSURE

LAKE CC 1-6

SEC. CC8-9

MO. CC11-12

DAY CC13-14

YEAR CC15-16

WEEKDAY WEEKEND CC18-19

TIME OF COUNT CC 21-24

NO. OF FISHING BOATS CC 26-30

NO. OF BOAT ANGLERS CC 32-36

NO. OF BANK ANGLERS CC 38-42

NO. OF TUBE ANGLERS CC44-48

NO. OF HEATED DOCK ANGLERS CC 50-54

SERIAL NUMBER CC 56-60

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Figure 2. Pressure Card Used for Creel Survey, Copan Reservoir Washington County, Oklahoma

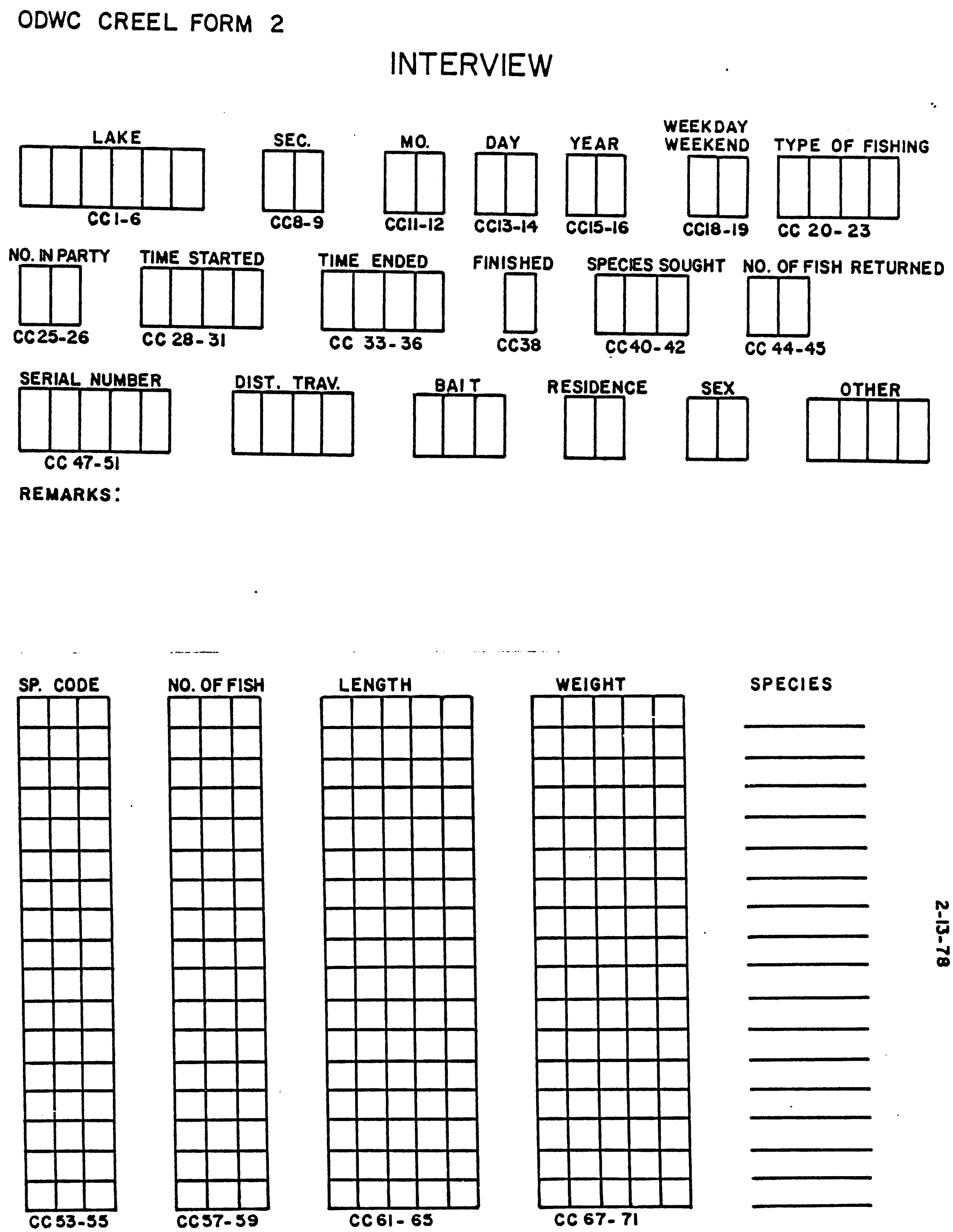


Figure 3. Interview Card Used for Creel Survey at Copan Reservoir, Washington County, Oklahoma

in creel basket. Generally, all species in the creel basket were weighed to the nearest gram, measured to the nearest mm TL and scale or spine samples were taken. However, if the angler was in a hurry to leave, only crappie measurements and scale samples were taken to expedite the interview.

Twenty creel days were conducted in each season. The seasons were Winter - December, January, and February; Spring - March, April, and May; Summer - June, July, and August; Autumn - September, October, and November. The twenty creel days per season consisted of 12 weekend days and 8 weekdays. The staff of the Fisheries Research Laboratory tabulated all creel results and also expanded all creel day estimates to cover all daylight hours.

Age and Growth

Crappie captured during sampling and those examined in the creel were measured in the field for total length (TL) to the nearest mm, weighed to the nearest gram, and scales were taken from above the lateral line at the tip of the left pectoral fin. Length frequency distributions of the sampled fish were compared to the length frequency distribution of fish from creel samples. In addition, comparisons of length frequency distributions by year were made.

Length and weight measurements were also used to calculate Proportional Stock Density (PSD) for the population (Anderson, 1980). PSD has been defined as the ratio of "quality" sized crappie (greater than 200 mm TL) to "stock" sized crappie (greater than 130 mm TL) multiplied by 100 and was used to characterize the relative size distribution of the population.

Condition of crappie at Copan was determined by calculating relative weight (Wege and Anderson, 1978) and comparing the length-weight relationship of the population to the statewide average (Mense, 1976; for Oklahoma).

The age distribution of crappie in Copan Reservoir was estimated by counting scale annuli. Scales were pressed on acetate slides and the impressions were read using an Eberbach scale projector. Age was estimated using the method described by Tesch (1971). The scales of crappie taken in sampling during March, April, and May of both 1983 and 1984 and all crappie scales from the creel were aged and total scale radius as well as increments between annuli were recorded. A linear scale-length to body-length relationship was assumed and the measurements were used to calculate body length of the fish at each annulus formation using the formula (from Angyal, 1983);

$$L' = C + S'/S\ (L-C) \tag{1}$$

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 y intercept in the scale-length to body-length relationship and is used to correct for length of fish at first scale formation (Table I). Back calculated growth rates were used to estimate growth between age classes. In addition, catch curves were graphed in which the natural log of the frequency of occurrence of ages were plotted against age.

Tagging Study

During March, April, and May of both 1983 and 1984, crappie greater than 200 mm TL captured during sampling were tagged with FLoy FD68B

TABLE I

LINEAR REGRESSION PARAMETERS FOR TOTAL LENGTH VERSUS TOTAL SCALE RADIUS FOR WHITE CRAPPIE AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA BY YEAR

Year	Slope	Intercept	N (Number)	R-Square
1983	1.288	47.2	898	0.92
1984	1.321	50.8	307	0.91

anchor tags near the posterior end of the dorsal fin on the left side. Fish were not anesthetized and were tagged only when water temperature did not exceed 18 degrees C. All tagged fish were measured, weighed, scales taken, and released as quickly as possible at the same site where they were captured. All subsequent recaptures of tagged crappie during sampling were recorded and all anglers were asked to return any tags on crappie they caught.

During 1983, anglers were asked to voluntarily return tags. During 1984, a reward system was initiated whereby each angler returning a tag received a reward of from $1.00 to $100.00 depending on a random assignment of values for each tag.

Many forms of the media were used to help familiarize anglers with the tag effort and to stimulate return compliance. Advertisements were placed in three local newspapers, on two local cable channels, and in "fishing reports" on local radio programs. Handbills were printed and placed in local convenience stores, restaurants, and bait shops. Five large signs were painted with details about the program and posted in public use areas above the dam and in the tailwater area. Presentations were made to community groups and local sport clubs detailing the tagging program and fisheries research on the lake.

Survival and Mortality

Three survival rate estimates were used. The first method was Bailey's deterministic model:

$$S12 = M2 \times R13 \; / \; M1 \; (R23 + 1) \qquad (2)$$

where S12 = survival rate from time one to time two, M1 = number of individuals marked during time one, M2 = number of individuals marked during time two, R13 = number of time one tags recaptured in time three, R23 = number of time two tags recaptured in time three (Ricker, 1975).

Survivorship and mortality for each age class were calculated from Ricker (1975) using the formula:

$$Z = -(\log e\ Nt+1 - \log e\ Nt)$$

where Z is instantaneous mortality; log e is natural logarithm; and, Nt and Nt+1 are the numbers of individuals at time t and t+1 respectively. Instantaneous mortality was used as input for Ricker's (1975) tables and from them survivorship (S) and mortality (A) data were figured.

The second equation was a modified Seber-Jolly equation:

$$Si = Bi + 1 / Bi - mi + Mi \qquad (3)$$

where Bi = number of marked fish in the population just prior to capturing the ith sample; Bi-mi = old marks that were not recaptured at time i; and Mi = new marks that were just released (Ricker, 1975).

The third method used was the catch curve method from Jackson (1939) where mortality is estimated by the formula:

$$A = 1 - \text{Survival (S)} \qquad (4)$$

where:

$$S=Nt+1+Nt+2+Nt+3.../Nt+Nt+1+Nt+2+Nt+3... \qquad (5)$$

and Nt, Nt+1, etc. represent consecutive ages with Nt being the first fully recruited age in the sample, and Nt+3 representing the oldest age in the sample.

Population Estimates

Calculations from the Bailey deterministic model were used to estimate population size by the formula:

$$N2 = M2(C2+1)(R13) / (R12+1)(R23+1) \tag{6}$$

(Ricker, 1975). Another population estimate was calculated from the Seber-Jolly method by the formula:

$$Ni = Bi (Ci + 1) / Mi + 1 \tag{7}$$

(Ricker, 1975). A third population estimate was calculated from creel survey results. If the respective estimates for survival and for population agreed closely, a mean for each was used as a single population estimate.

Exploitation Rate Estimates

Exploitation rates, u, were also estimated three ways. The first estimate was simply the ratio of estimated catch (from the creel survey) to the estimated population size; the second was the estimated catch (from tag returns) to the population size. The third was the Robson-Seber formula:

$$ui = miRi / TiMi \tag{8}$$

where Ri = tag returns during or after year i; Mi = number marked in year i; Ti = total cumulative recaptures; and mi = sum of all tags returned in year i regardless of origin (Ricker, 1975).

CHAPTER III

RESULTS AND DISCUSSION

Population Sampling

Catch Data

Catch per unit effort (c/f - measured in fish per hour and reported here as a dimensionless number) ranged from a high of 1.133 to a low of 0.000 (Table II). This variation may have resulted because each gear type was not used for a consistent proportion of the sampling effort during the sampling period. Most of the data was obtained from barrel nets but even these data show no real pattern in c/f. Data from all gear types were pooled for age and growth calculations, the assumption being that cumulative gear selectivity was equal across all ages and sizes of crappie.

Catch per unit effort by month at Copan Reservoir was generally lower than data previously reported at Sooner Reservoir (Glass, 1982; Angyal, 1983). This low c/f could be explained by the fact that Copan is a new reservoir and sampling occurred before, during and after the filling process. Crappie were originally restricted to the river and small adjacent farm ponds. But as the lake was impounded, water flooded into the basin and created large new areas of habitat for the crappie. Densities of the crappie may have been lower immediately following impoundment and higher after the crappie population had filled available habitat. Variability in c/f could be expected under

TABLE II

CATCH PER HOUR OF WHITE CRAPPIE BY GEAR TYPE AND MONTH NUMBER OF HOURS EFFORT (IN PARENTHESES) * = MINUTES FOR COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA

	GEAR TYPE			
MONTH-YEAR	ELECTRO-SHOCKER	BARREL NET	FYKE NET	GILL NET
March-1983	-	0.110 (556)	-	-
April	-	0.062 (5232)	-	-
May	-	0.130 (3294)	-	-
June	-	0.272 (1096)	-	-
July	-	0.141 (396)	-	-
August	-	0.129 (576)	-	-
September	-	0.049 (184)	-	0.050 (20)
October	-	0.071 (240)	0.000 (48)	-
November	-	0.188 (48)	0.249 (177)	0.167 (6)
December	-	0.333 (6)	-	-
January-1984	-	0.000 (136)	-	-
February	-	-	-	0.046 (108)
March	2.0 (200)*	0.006 (324)	0.524 (103)	0.000 (18)
April	-	-	0.700 (20)	0.091 (66)
May	-	0.077 (239)	0.284 (88)	-
June	-	-	1.031 (510)	-
July	-	-	-	-
August	-	0.051 (216)	1.133 (150)	0.148 (176)
September	-	-	-	0.248 (210)
October	-	-	0.304 (125)	0.147 (102)
November	-	-	0.111 (144)	0.042 (120)

expected under these conditions because crappie had not established fixed patterns of predictable inshore-offshore movements in the newly created lake.

All population sampling during 1983 and 95% during 1984 was conducted using barrel nets and fyke nets (Table III). Barrel nets selected for crappie greater than 200 mm TL since about 60% of the crappie catch during both 1983 and 1984 were in this size range (Figures 4 and 5). On the other hand, eighty percent of 1983 and 65% of 1984 fyke net samples were less than 200 mm TL (Figures 6 and 7). Electroshocking sample sizes were low and no pattern was apparent (Figure 8). Gill nets seemed to select for crappie less than 200 mm TL (Figure 9) and 75% of the crappie collected with gill nets in 1984 were less than 200 mm TL.

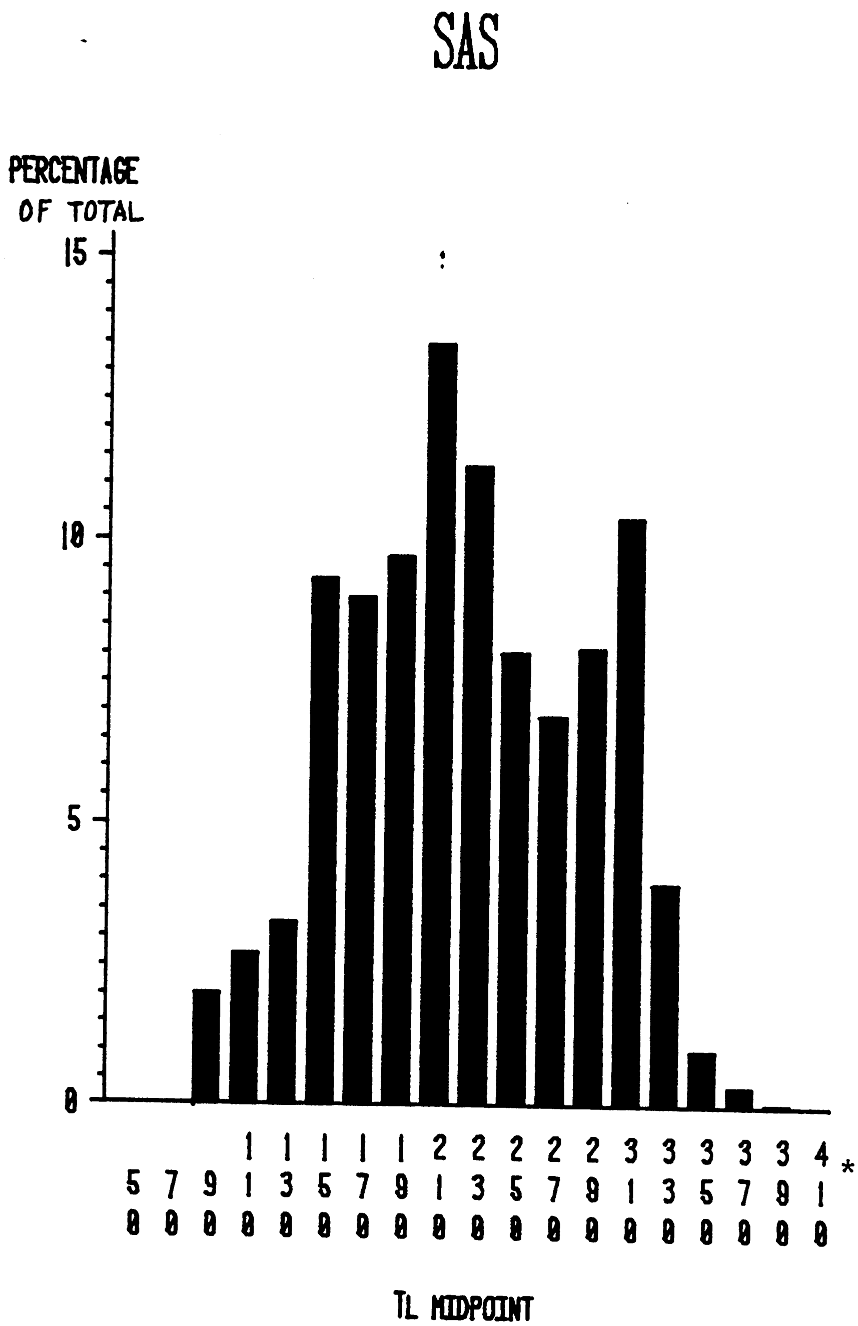
Creel Survey

Angling pressure, harvest, and c/f for crappie are typically high in late winter and early spring on most Oklahoma lakes. At Copan, however, both winters of the creel survey (1982 - 1983 and 1983 - 1984; Table IV) had low pressure (188 and 791 hours, respectively), low harvest (24 and 73 crappie, respectively), and low c/f of crappie (0.129 and 0.092 c/f). Spring 1983 had the least amount of pressure, harvest and c/f for the entire creel year (144 hours, 0 crappie, and 0.000 c/f). In spring 1984 both harvest (5440 crappie) and pressure (13,235 hours) increased. These 1984 spring values are more typical of Oklahoma angler patterns and with the exception of the winter season, 1984 was similar to Oklahoma angling patterns on other reservoirs (Angyal, 1983).

TABLE III

PERCENTAGE OF USE BY GEAR TYPE FOR COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

	Gear Types			
Year	Electro-Shocker	Fyke Net	Barrel Net	Gill Net
1983	-	3.10%	96.90%	-
1984	0.36%	85.95%	9.01%	4.68%



*Scale is read vertically and measured in mm.

Figure 4. Total Length Distribution for Barrel Net Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma for 1983

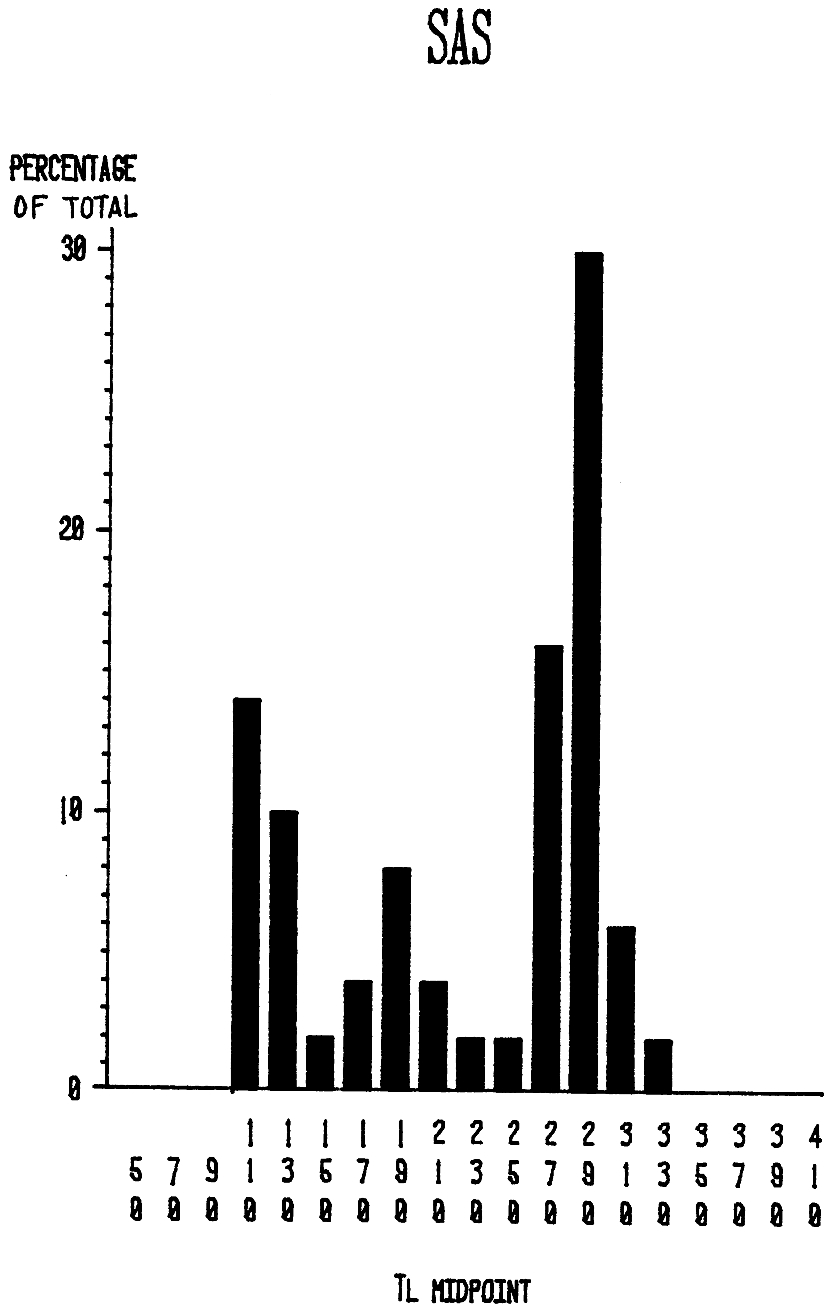


Figure 5. Total Length Distribution for Barrel Net Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1984.

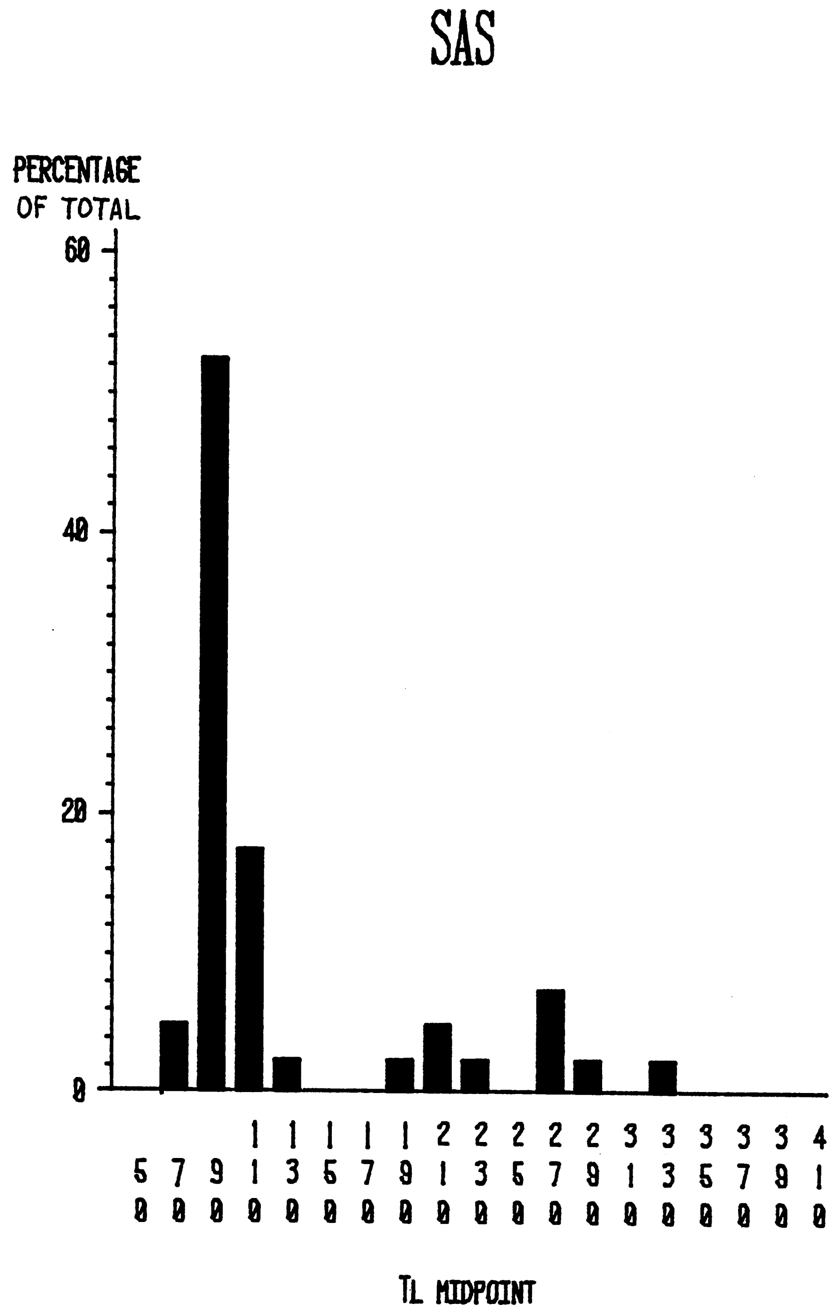


Figure 6. Total Length Distribution for Fyke Net Samples of White Crappie Collected at Copan Reservoir , Washington County, Oklahoma, for 1983.

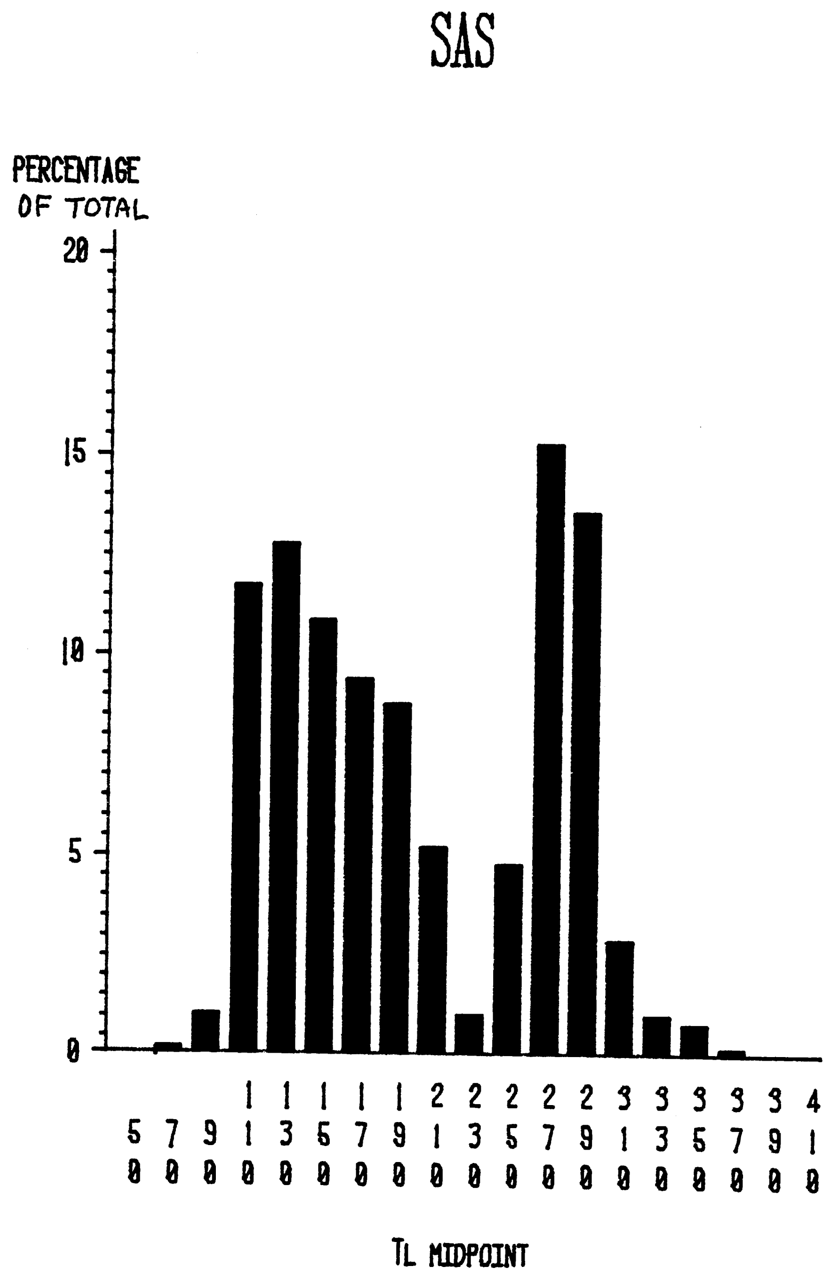


Figure 7. Total Length Distribution for Fyke Net Samples of White Crappie Collected at Copan Reservoir ,Washington County , Oklahoma, for 1984.

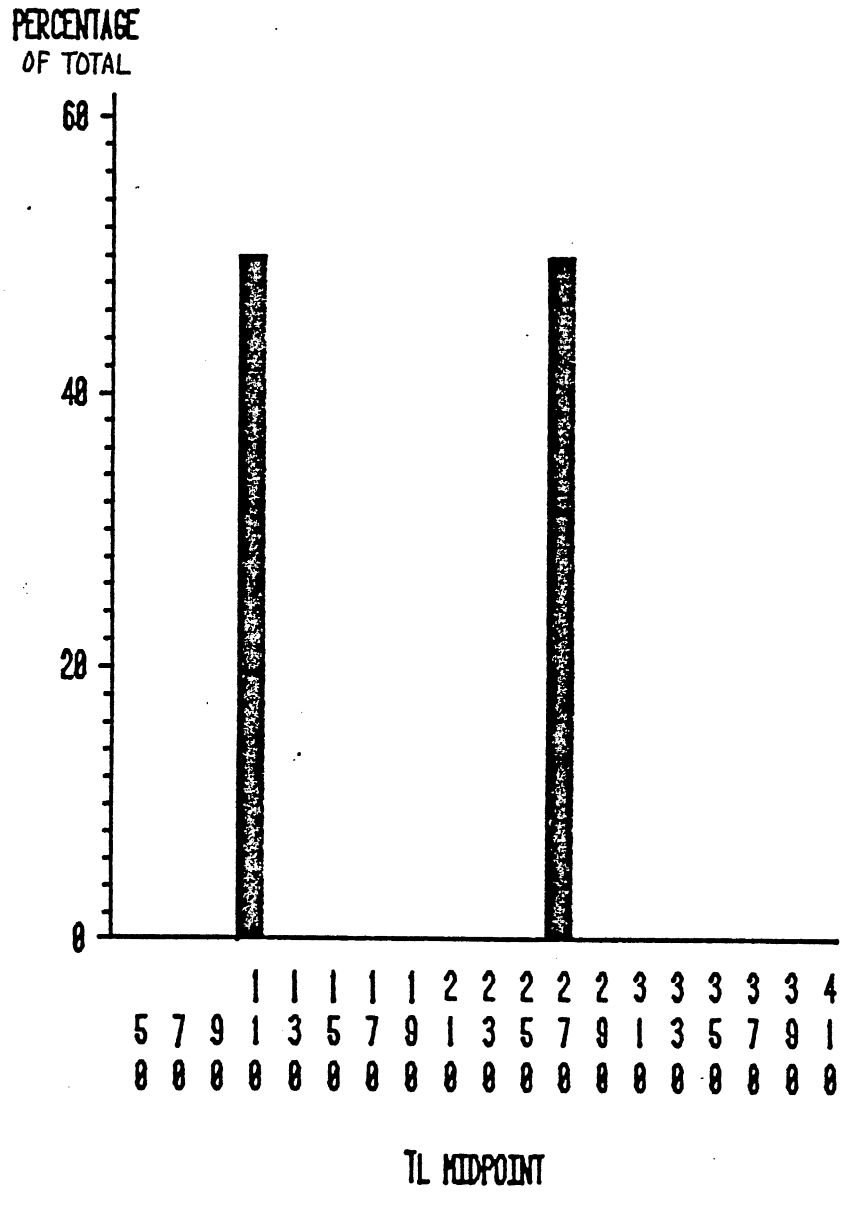


Figure 8. Total Length Distribution of Electroshocking Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma for 1984.

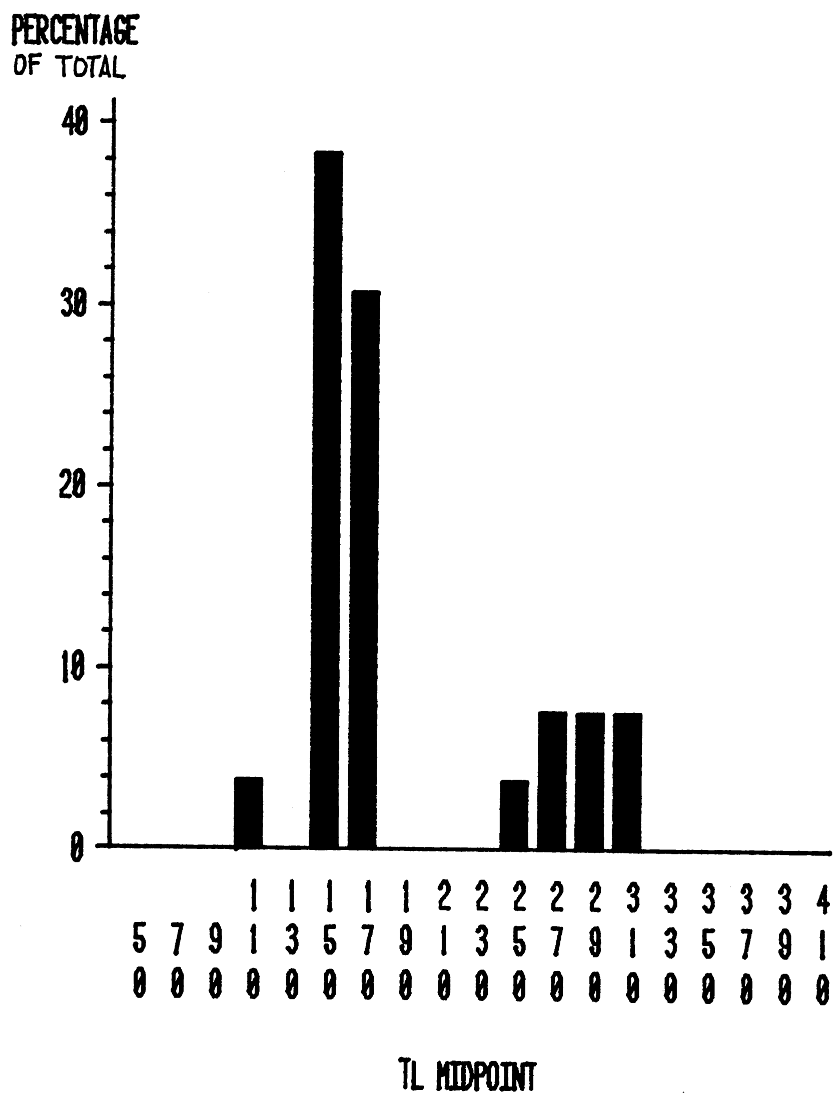


Figure 9. Total Length Distribution for Gill Net Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1984.

TABLE IV

SEASONAL HARVEST OF WHITE CRAPPIE CAUGHT AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA

Season	Total Est.[a] Harvest (Numbers)	Total Est. Pressure (Hrs)[b] Total/Crappie	c/f (Hours)	Mean TL/Wt (mm/grams) Creel	Mean TL/Wt (mm/grams)[c] Sampling
Winter 1982-1983	24	579/188	0.129	178/-	-
Spring 1983	0	181/144	0.000	-	216/194
Summer 1983	3874	13284/8785	0.441	261/272	204/141
Autumn 1983	305	8882/1686	0.181	278/350	176/111
Winter 1983-1984	73	1192/791	0.092	345/675	247/297
Spring 1984	5440	23720/13235	0.411	287/421	228/263
Summer 1984	519	28681/2835	0.183	250/215	175/175
Autumn 1984	0	7238/242	0.000	-	176/88

a - Est. = Estimated
b - Total/Crappie = Total pressure (hrs)/Crappie pressure (hrs)
c - Sampling = Data from sampling gear

The 1983 creel year was an atypical creel year, probably because the lake was new and anglers were not fully aware of its angling opportunity. In addition, the creel figures for winter 1982-1983 represent angling on the river only, since the lake had not been impounded. The river had fewer surface acres of water and fewer miles of shoreline than the reservoir and lower pressure might be expected. In addition, many anglers believed that the lake was closed to fishing, even after impoundment in April of 1983. This mistaken belief, along with the fact that boat ramps were not finished until October of 1983, probably explains the low values during the spring months of 1983.

The summer of 1983, however, was a season of high crappie angler use (8785 hours) and the highest c/f (0.441 for crappie) of any season of the creel. High crappie angling success in the summer, particularly in August of 1983, as was the case for this study, is very unusual for Oklahoma waters (Angyal, 1983).

Crappie was the most sought after species by anglers in comparison with other species at Copan Reservoir in 1983. In 1984, 25% of the effort was expended to catch both crappie and black bass (Micropterus punctulatus and M. salmoides) (Table V). Angling effort for crappie was 47% of the total in 1983 and 25% of the total effort in 1984. Anglers sought bass 5% and 25% of the time in 1983 and 1984, respectively. Channel catfish angling comprised 11% and less than 1% of the effort in 1983 and 1984, respectively, and anglers seeking "nothing in particular" comprised 35% and 46% of the total fishing effort in 1983 and 1984, respectively.

TABLE V

MEAN LENGTH AND WEIGHT OF SPECIES SOUGHT AND NUMBERS AS PERCENTAGE OF TOTAL ESTIMATED FROM CREEL SURVEY RESULTS AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA

Species Sought	% of Total Pressure 1983	% of Total Pressure 1984	$\overline{X}$ TL/Wt 1983	$\overline{X}$ TL/Wt 1984	c/f (Fish/hour) 1983	c/f (Fish/hour) 1984
"Nothing in Particular"	35%	46%	-	-	-	-
Crappie	47%	25%	239/311	261/437	0.188	0.172
Black Bass	5%	25%	279/384	251/193	1.235	0.380
Channel Catfish	11%	< 1%	296/414	282/158	0.241	0.099
Morone sp.	1%	< 1%	210/77	242/150	0.124	4.586
Black Bullhead	< 1%	< 1%	247/269	250/274	0.554	1.247

Bass fishing increased on Copan Reservoir from 1983 to 1984 (5% to 25% of total effort; Table V). This increase probably resulted because the largemouth bass that were stocked in the reservoir began to reach legal length (greater than 356 mm TL) during this period. During the spring, summer, and autumn seasons of 1984, bass just under the limit were readily caught on artificial or live bait. However they were returned to the water by the anglers, and data on their estimated length and weight were not available in the creel. High catchability (c/f greater than 1.0 in 1983; greater then 0.30 in 1984) was probably a stimulus for bass anglers to use Copan Reservoir, although few bass greater than 356 mm TL were observed in the creel in 1983 or 1984. Few illegal bass (less than 356 mm TL) were observed by the creel clerk but low sample size, and a few illegal fish resulted in the overall mean length for 1983 to be below the legal limit.

Catch for summer of 1983 was 893 black bass, both creeled and released, and a catch per unit of effort of 2.40 c/f (Table VI). Catch for summer of 1984 was 9674 black bass and catch per unit of effort of 1.112 c/f.

Channel catfish harvest remained low but relatively constant throughout 1983 and 1984 (Table VII). Channel catfish that had been stocked in the lake were observed in the creel and probably represented most of the catch. Average length and weight in 1983 was 296 mm TL and 414 g and for 1984 was 282 mm TL and 158 g (from Table V).

Morone sp. were not highly sought after in 1983 or 1984 (1% and less than 1%, respectively, of total pressure from Table V) but their harvest was 11789 for the spring of 1984 (Table VIII) and catch per

TABLE VI

SEASONAL CATCH AND HARVEST OF BLACK BASS CAUGHT AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA

Season	Total Est.[a] Catch/Harvest (Numbers)	Total Est. Pressure (Hrs Total/Bass	c/f Catch/Harvest (Fish/hour)
Winter 1982-1983	-	579/-	-
Spring 1983	-	181/-	-
Summer 1983	893/0	13284/372	2.400/0
Autumn 1983	61/0	8882/793	0.077/0
Winter 1983-1984	0/0	1192/13	0/0
Spring 1984	358/274	23720/2560	0.140/0.081
Summer 1984	9674/300	28681/8696	1.112/0.041
Autumn 1984	1465/871	17238/5503	0.266/0.158

a - Est. = Estimated

TABLE VII

SEASONAL HARVEST OF CHANNEL CATFISH AT COPAN RESERVOIR
WASHINGTON COUNTY, OKLAHOMA

Season	Total Est.[a] Harvest (Numbers)	Total Est. Pressure (Hrs) Total/C. Catfish	c/f (Fish/hour)
Winter 1982-1983	0	579/6	0
Spring 1983	-	181/-	-
Summer 1983	172	13284/359	0.480
Autumn 1983	505	8882/2084	0.242
Winter 1983-1984	4	1192/134	0.029
Spring 1984	131	23720/1058	0.123
Summer 1984	473	28681/1932	0.245
Autumn 1984	-	17238/97	0

a - Est. = Estimated

high (11789 for the spring of 1984; Table VIII) and catch per unit of effort was highest of any species during the spring of 1984 (8.530; Table VIII).

Black bullheads were not highly sought after (less than 1% of total pressure in both 1983 and 1984; Table V) but catch per unit of effort was relatively high for this species (0.900 in summer of 1983; 2.213 in Autumn 1984; Table IX). Black bullheads were used as a food fish and as bait for trot lines and raccoon traps.

Most anglers (66%) used the lake on weekends in 1983, but use in 1984 was divided almost equally between weekend and weekdays (Table X). Bank angling comprised 15% of the pressure in 1983 and 29% in 1984. Boat anglers comprised 84% of all anglers in 1983 and 70% in 1984. Tube anglers were observed on only two occassions.

The increase of bank anglers from 1983 to 1984 (15% - 29%) as well as the increase of anglers fishing for "nothing in particular" from 1983 to 1984 (35% - 46%) probably indicates a general increase in knowledge about Copan Reservoir and its angling opportunities.

The total length distribution of crappie showed approximately a unimodal distribution (Figure 10) in 1983 but a bimodal distribution in 1984 (Figure 11). Out of 555 crappie captured during 1984, only 6 were in the length interval 220-240 mm. The relatively infrequent capture of fish in this length range might be explained by gear selectivity. Barrel nets which select for crappie greater than 200 mm TL were used for only 10% of the population sampling effort in 1984.

Another explanation for the bimodal length frequency distribution in 1984 might be related to variation in growth rates of crappie. Crappie tend to switch from insectivory to piscivory in the length

TABLE VIII

SEASONAL HARVEST OF *MORONE* SP. CAUGHT AT COPAN RESERVOIR
WASHINGTON COUNTY, OKLAHOMA

Season	Harvest (Numbers)	Total Est.[a] Pressure (Hrs) Total/*Morone*	c/f (Fish/hour)
Winter 1982-1983	-	579/-	-
Spring 1983	-	181/-	-
Summer 1983	60	13284/298	0.18
Autumn 1983	142	8882/2084	0.068
Winter 1983-1984	-	1192/-	-
Spring 1984	11789	23720/1382	8.530
Summer 1984	389	28681/604	0.642
Autumn 1984	-	17238/-	-

a - Est. = Estimated

TABLE IX

SEASONAL HARVEST OF BLACK BULLHEAD CAUGHT AT COPAN RESERVOIR WASHINGTON COUNTY, OKLAHOMA

Season	Total Est.[a] Harvest (Numbers)	Total Est. Pressure (Hrs) Total/B. Bullhead	c/f (Fish/hour)
Winter 1982-1983	-	579/-	-
Spring 1983	-	181/-	-
Summer 1983	338	13284/376	0.900
Autumn 1983	436	8882/2102	0.207
Winter 1983-1984	-	1192/-	-
Spring 1984	672	23720/-	0.028
Summer 1984	-	28681/-	-
Autumn 1984	270	17238/122	2.213

a - Est. = Estimated

TABLE X

ESTIMATED WEEKEND VS WEEKDAY USE AND BANK VS BOAT USE AS PRESSURE IN HOURS AND AS A PERCENTAGE OF TOTAL FOR COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

	Pressure (hrs)		Percentage of Total	
	1983	1984	1983	1984
Weekend	15732	34460	66%	49%
Weekday	7878	36437	33%	51%
Bank	3461	20887	15%	29%
Boat	19464	49910	84%	70%

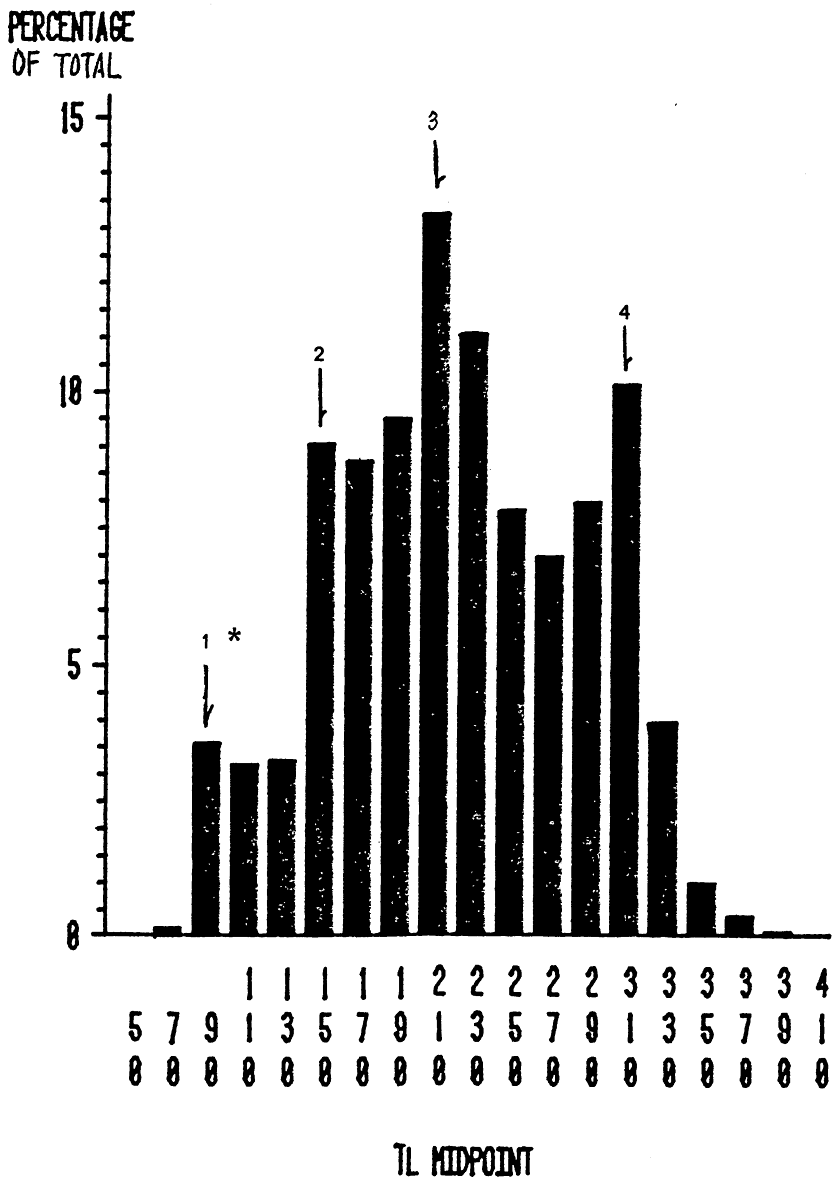


Figure 10. Total Length Distribution for All Gear Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma for 1983.

*Numbers indicate possible positions of age class

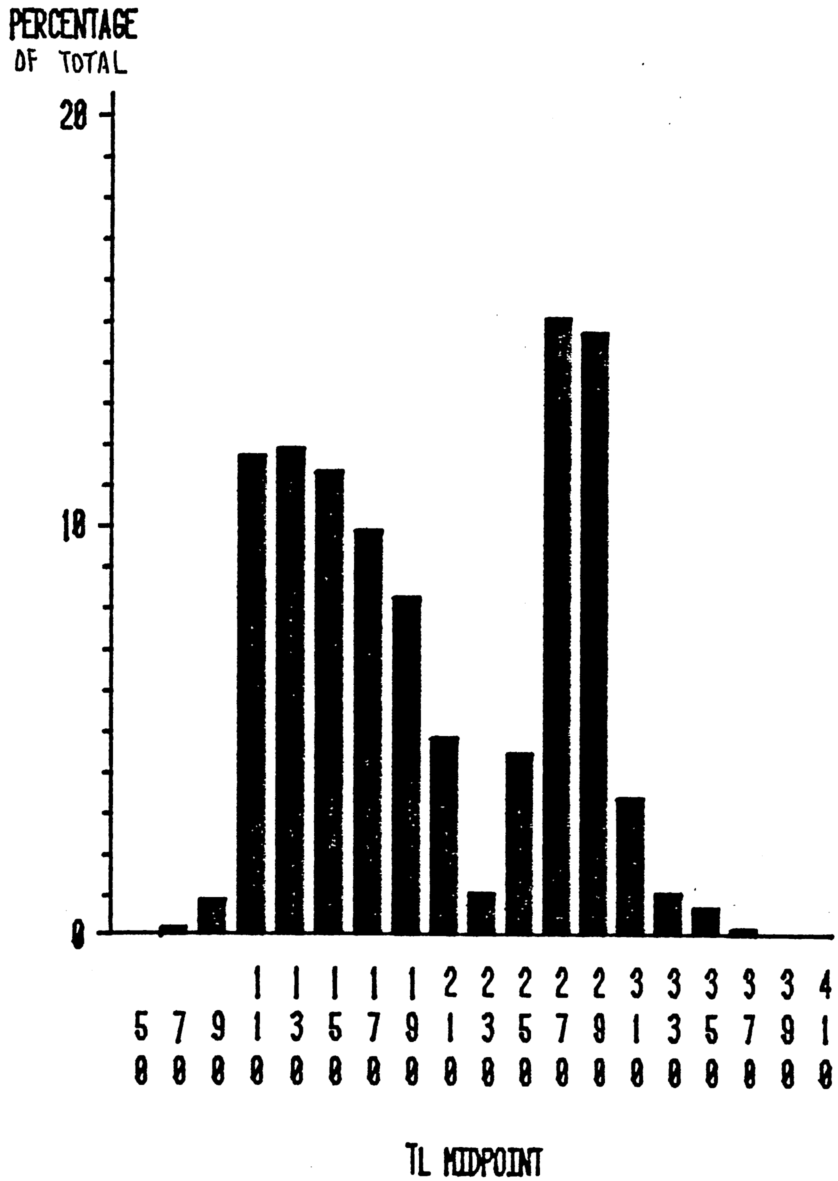


Figure 11. Total Length Distribution for All Gear Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma for 1984.

range of 160-200 mm TL (Keast, 1968; Siefert, 1969; Triplett, 1976) and begin to grow rapidly thereafter. They sometimes tend to remain smaller than this transition length if a buffer food is in low abundance. The age of 200 mm TL crappie is approximately 2+ for Copan Reservoir (Table XI) and the growth increments for age 2 to age 3 crappie (Table XII) are greater than the growth increments for age 1 to age 2 crappie for both 1983 and 1984 and for all ages of fish except for age 6 crappie in 1984. The data may indicate that growth rates increase after this transition period. However, the population needs further study before the factors regulating growth rates in Copan Reservoir can be determined.

Total length distribution of crappie in the sampling data is compared with total length distribution in creel data in Figures 10 and 12 for 1983 and in Figures 11 and 13 for 1984 and also in Table XIII).

Anglers selected for significantly larger crappie (student t-test $p<0.001$; Table XIV) than the mean of the population in both 1983 and 1984 (Figure 10-13, Table XIII). Anglers typically captured crappie that ranged in size from 160 to 200 mm TL. This same trend was also demonstrated in Sooner Lake in 1981 and 1982 (Glass, 1982).

In 1983 two major length groups were represented in the samples (Figure 10). These length groups were 200-220 mm TL and 300-320 mm TL and they comprised 13.5% and 10%, respectively, of the samples in 1983. In contrast, anglers in 1983 (Figure 12) selected crappie from the two major length groups of 220-240 mm TL and 300-320 mm TL which comprised 23.0% and 23.5%, respectively, of the anglers' total 1983 catch.

TABLE XI

MEAN TOTAL LENGTH (IN MM) BY AGE FOR WHITE CRAPPIE AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR OF STUDY

	Year					
	1983			1984		
Age	N	Mean TL	Std. Dev.	N	Mean TL	Std. Dev.
0	1	108.0	-	4	98.8	15.108
1	162	151.9	33.408	57	138.7	32.923
2	340	218.1	38.915	149	244.2	45.943
3	330	282.6	36.205	107	288.9	27.257
4	113	308.1	26.040	22	304.8	26.027
5	12	330.3	28.439	3	302.3	45.786
6	1	301.0	-	1	388.0	-
7	2	374.0	8.485	0	-	-

TABLE XII

WHITE CRAPPIE BACK CALCULATED GROWTH RATES FROM SCALES FOR COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

1983

Year Class	Age Group	N	Mean Calculated Total Length in mm at End of Year 1	2	3	4	5	6	7
1983	0	2							
1982	1	162	86						
1981	2	340	80	166					
1980	3	328	78	146	250				
1979	4	113	70	111	183	286			
1978	5	12	79	121	182	248	316		
1977	6	1	61	96	166	217	247	275	
1976	7	2	68	108	184	234	299	338	359
Number of fish		960	958	796	456	128	15	3	2
Weighted Average			79	151	231	281	309	317	359
Growth Increment			79	72	80	50	28	8	42
State Average (Jenkins, 1953)			74	150	199	249	298	330	358

1984

Year Class	Age Group	N	Mean Calculated Total Length in mm at End of Year 1	2	3	4	5	6	7
1984	0	0							
1983	1	57	98						
1982	2	149	83	164					
1981	3	107	77	142	232				
1980	4	22	72	116	201	262			
1979	5	3	70	98	142	215	271		
1978	6	1	103	162	204	240	306	362	
Number of fish		339	339	282	133	26	4	1	
Weighted Average			83	151	225	256	280	362	
Growth Increment			83	68	74	31	24	82	
State Average (Jenkins, 1953)			74	150	199	249	298	330	

TABLE XII

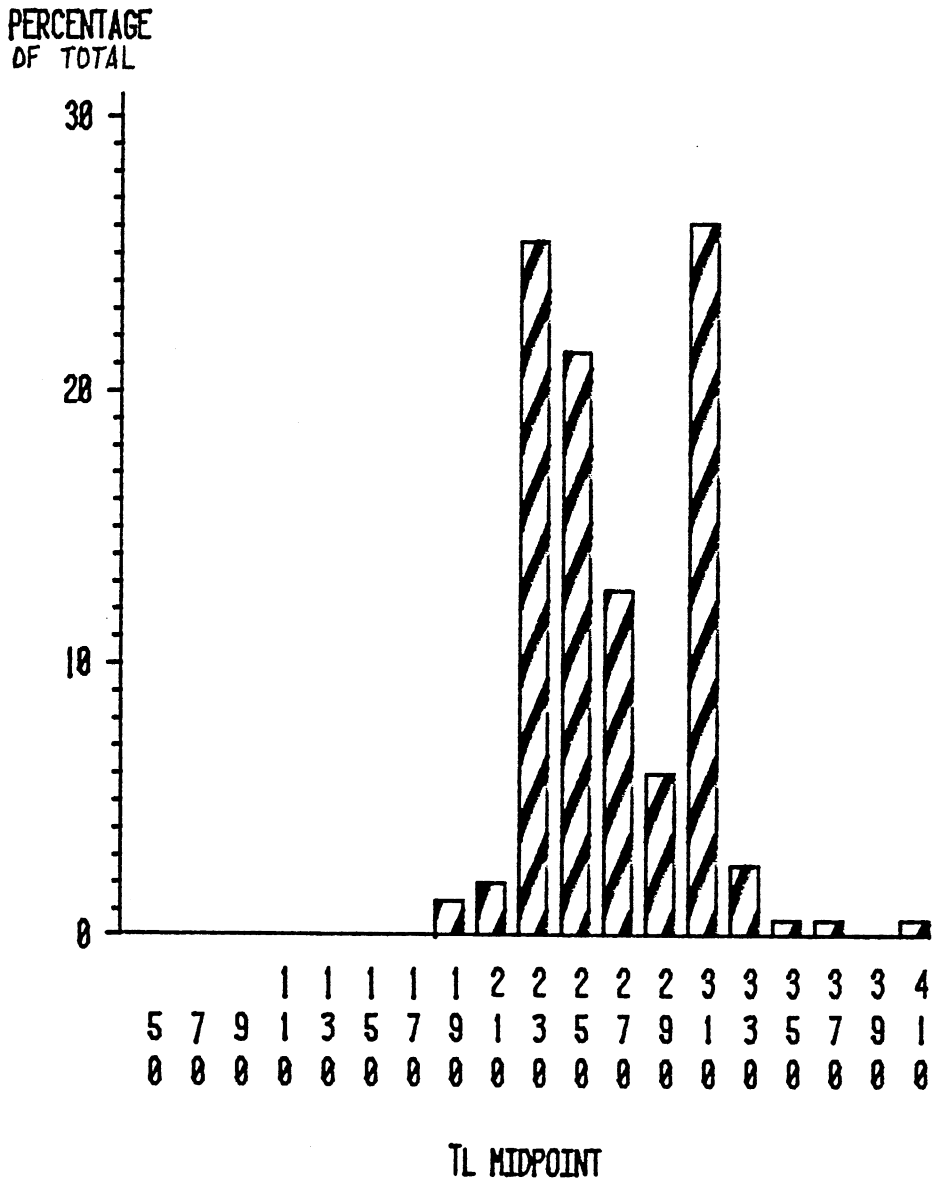


Figure 12. Total Length Distribution for Creel Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma for 1983.

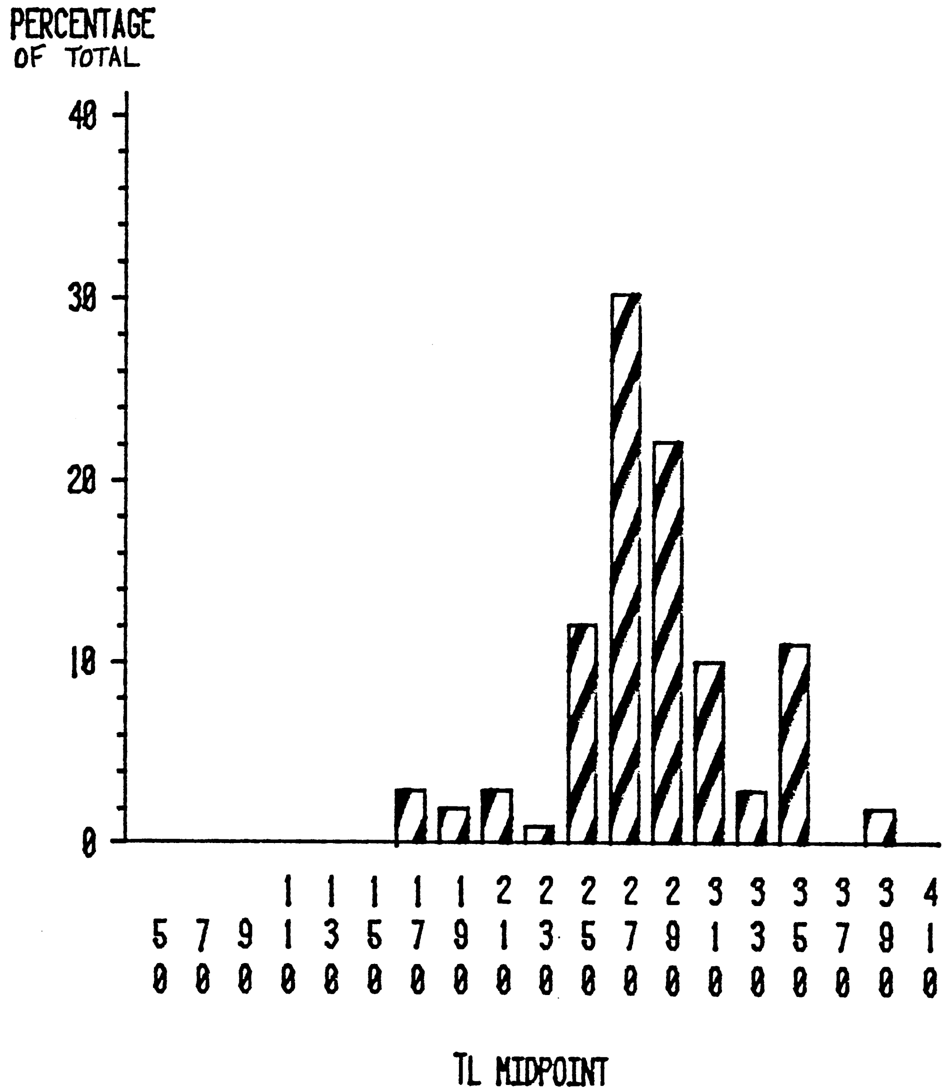


Figure 13 . Total Length Distribution for Creel Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1984.

TABLE XIII

WHITE CRAPPIE MEAN LENGTH AND WEIGHT BY MONTH FOR EACH METHOD OF CAPTURE AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

Gear	Year	Month	Mean TL (mm)	Mean wt (grams)
Creel	1983	July	253.2	239.6
		August	268.3	305.9
		September	259.7	279.7
		October	297.2	420.0
	1984	February	345.0	675.0
		April	296.1	480.7
		May	278.2	361.7
		June	250.0	215.0
Population Sampling	1983	March	166.4	67.2
		April	232.3	244.3
		May	247.7	271.0
		June	213.2	160.3
		July	182.8	97.6
		August	216.9	165.5
		September	201.4	159.0
		October	207.3	141.5
		November	112.5	33.0
		December	212.5	112.5
	1984	January	283.0	435.0
		February	245.3	344.3
		March	228.9	248.5
		April	239.3	316.7
		May	216.4	222.5
		June	191.5	155.5
		October	175.1	76.2
		November	177.2	99.4

TABLE XIV

STUDENT T-TEST ON DIFFERENCES IN TOTAL LENGTH FOR WHITE CRAPPIE FROM SAMPLING POPULATION VERSUS CREEL POPULATION AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

Year	Gear	N	Mean	Std. Dev.	T
1983	Sample	1293	222.7	65.029	
	Creel	149	268.6	35.513	8.465
1984	Sample	555	204.9	69.866	
	Creel	99	284.2	40.072	10.971

In 1984, anglers took crappie that were 260-280 mm in length. Crappie in this size range comprised 30% of the crappie creeled (Figure 13). Population samples, however, revealed two major length groups; one at 120-140 mm TL (12%) and another at 260-280 mm TL (16%; Figure 11).

Age and Growth

Most crappie were captured during the months of March, April, and May of 1983 and 1984. Since there was a large number of scales available from these months, they were used in age determination. Most scales did not show evidence of new annulus formation, but those scales that did have a new annulus were not used in age determination. Scales of Copan crappie were relatively easy to read because there was no erosion or evidence of false annuli formation as noted by other authors (Glass, 1982, and Angyal, 1983; for Sooner Reservoir crappie).

The age distribution found in population samples in 1983 was 0 to 7 whereas age classes ranged from 0 to 6 in 1984 (Figure 14 - 1983; Figure 15 - 1984). A recent study at Sooner Lake found no crappie older than 5+ (Angyal, 1983).

There was a large amount of overlap in the lengths of crappie in each age group (Figure 16 - 1983; Figure 17 - 1984) and the ages of crappie in each size class (Figure 18 - 1983; Figure 19 - 1984; Table XI). For example, the mean length for age 6 (301.0 mm) was less than that for age 5 (330.3 mm) in 1983 and the mean length for age 5 (302.3 mm) was less than that for age 4 (304.8 mm) in 1984. In both cases, this variability was probably a result of small sample sizes in the older age groups as well as the generally high degree of variability

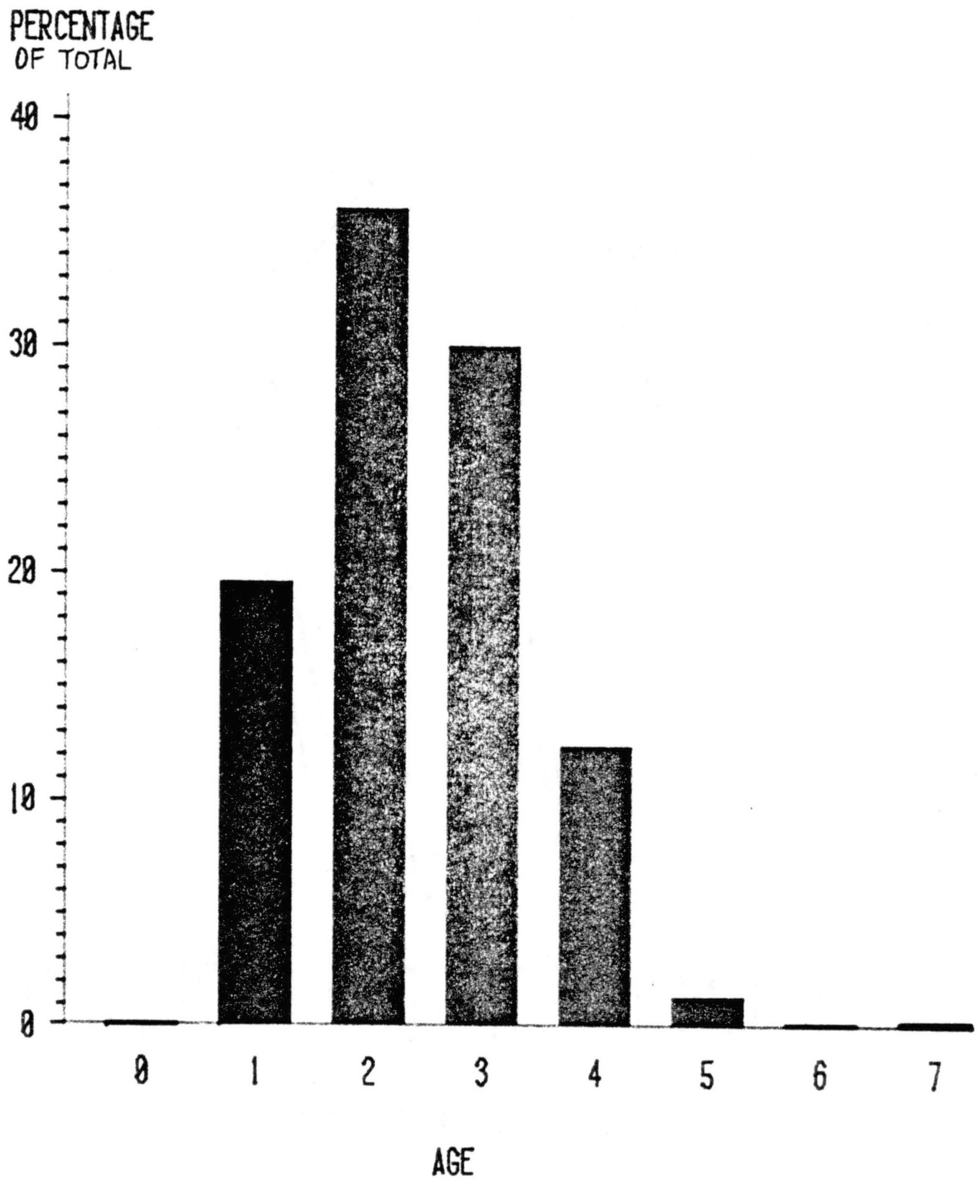


Figure 14. Age Distribution for All Gear Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1983.

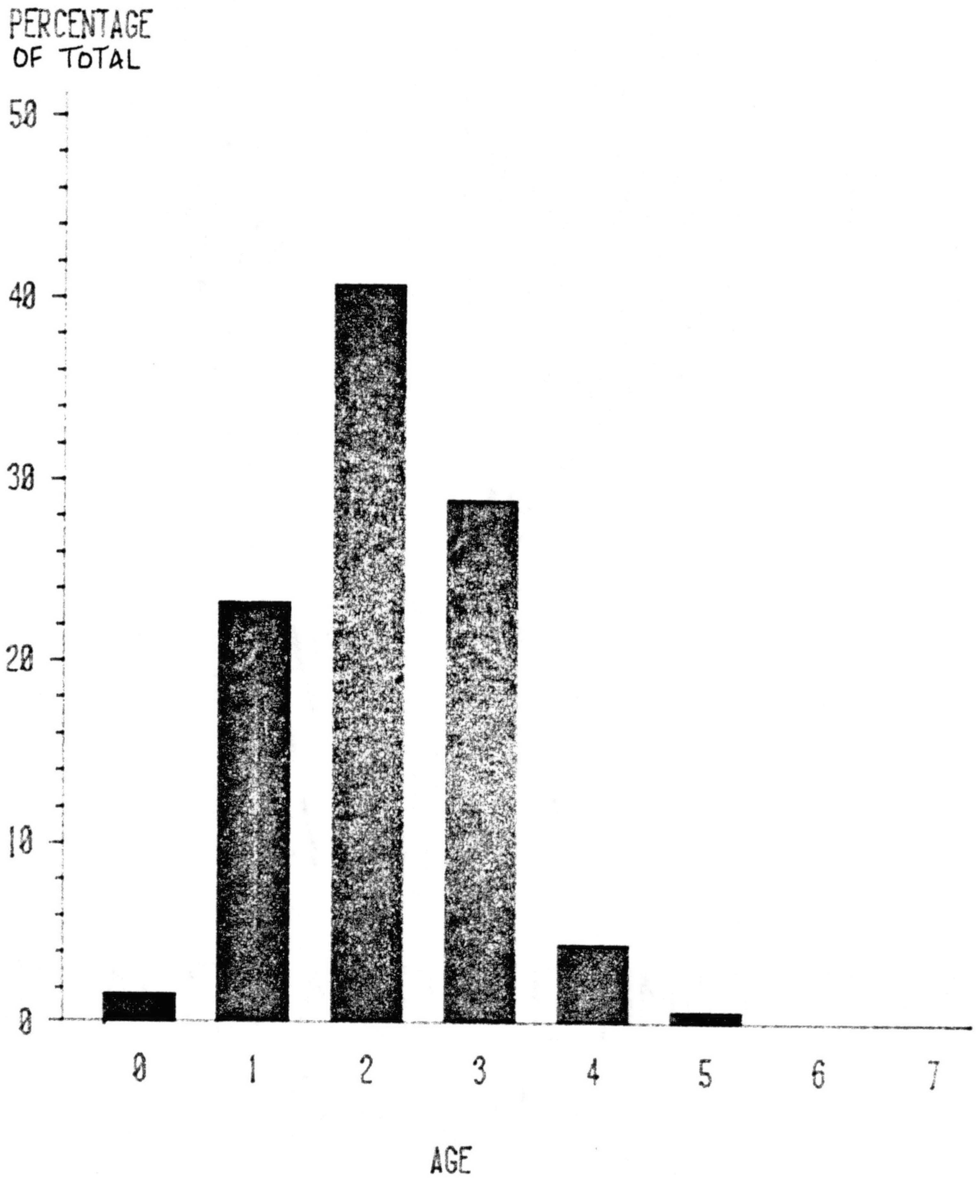


Figure 15. Age Distribution for All Gear Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1984.

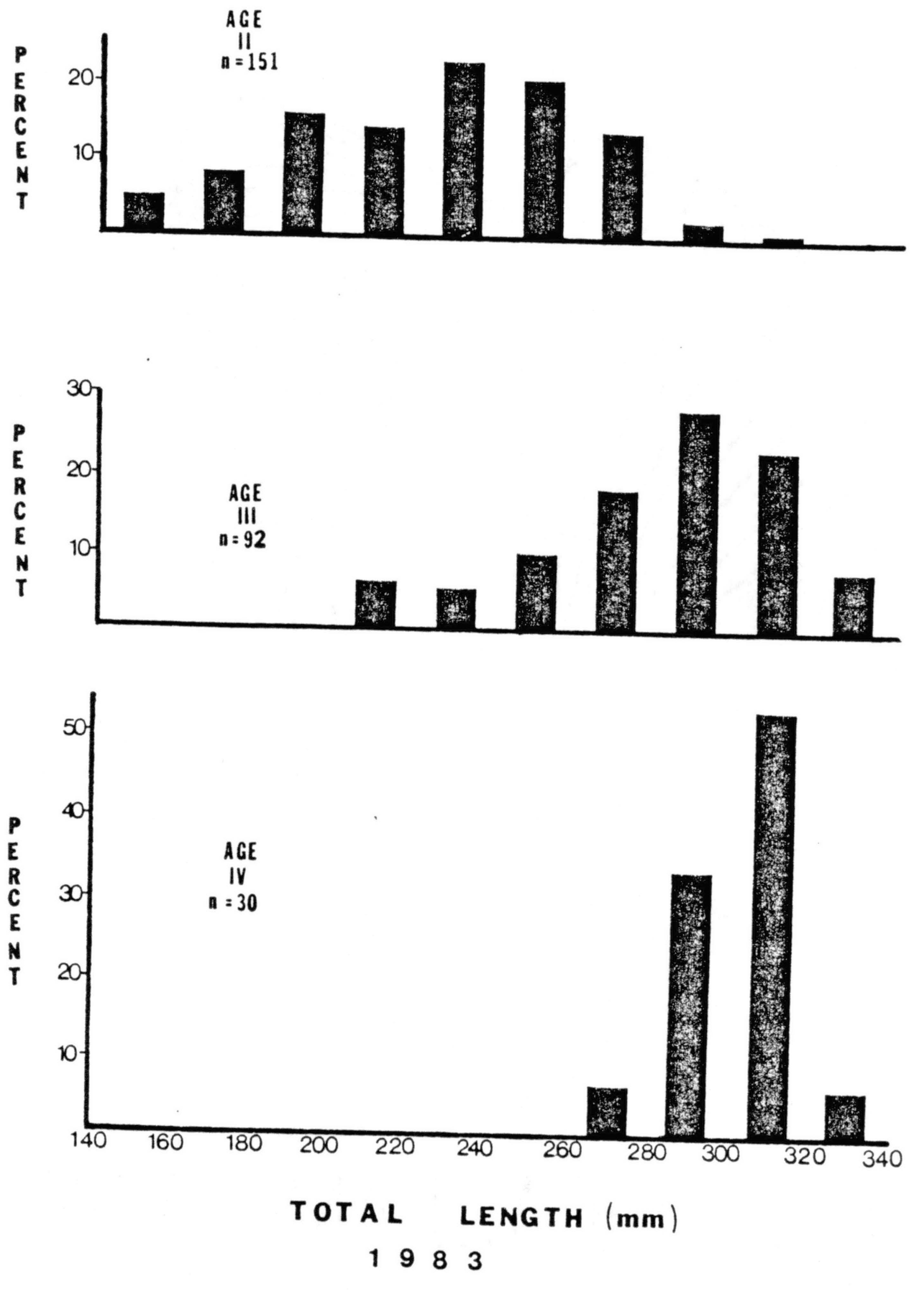


Figure 16. Length Distribution by Age for Ages II, III, and IV, White Crappie Collected by All Gear Types at Copan Reservoir, Washington County, Oklahoma, for 1983.

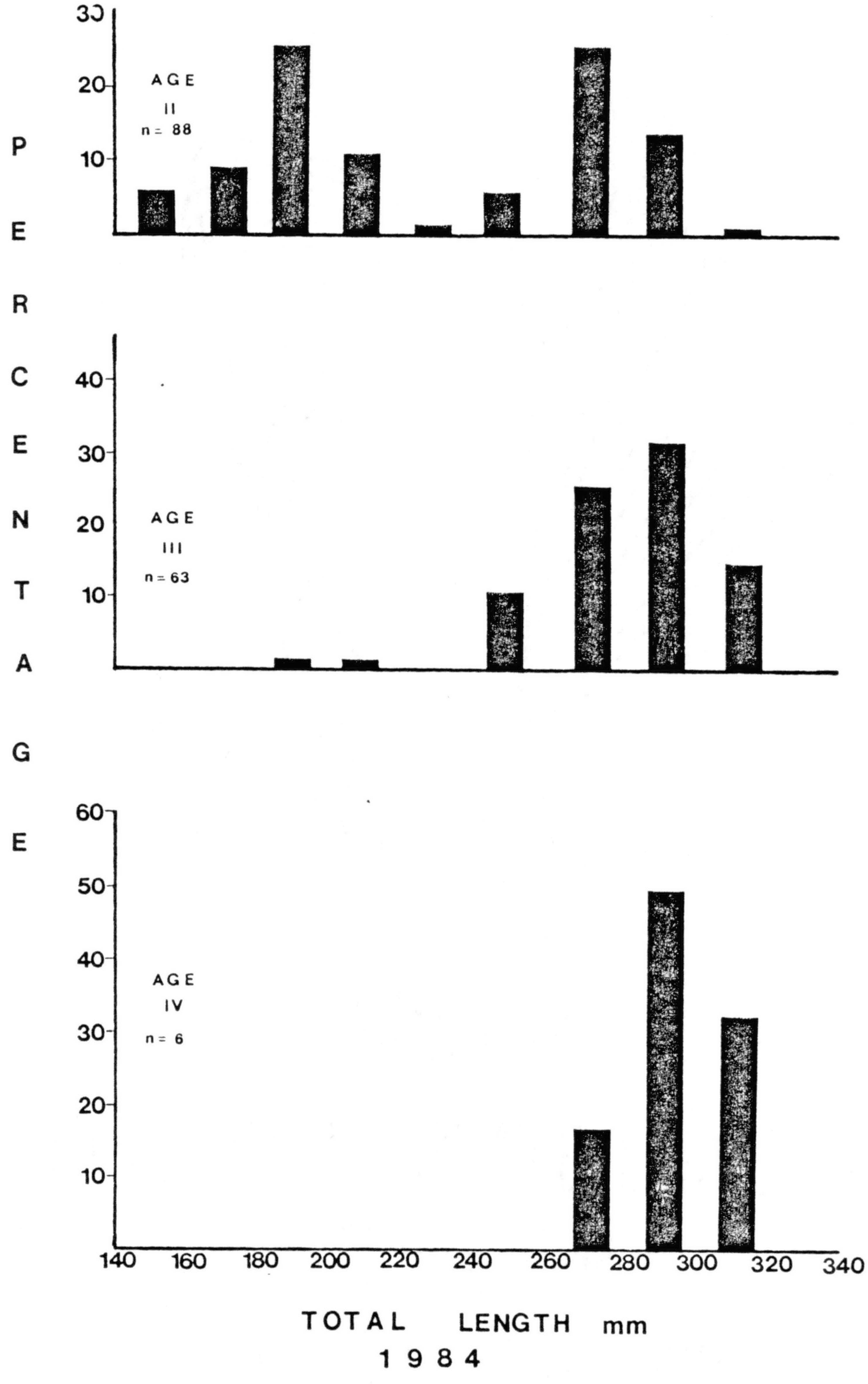


Figure 17. Length Distribution by Age for Ages II, III, and IV, White Crappie Collected by All Gear Types at Copan Reservoir, Washington County, Oklahoma, for 1984.

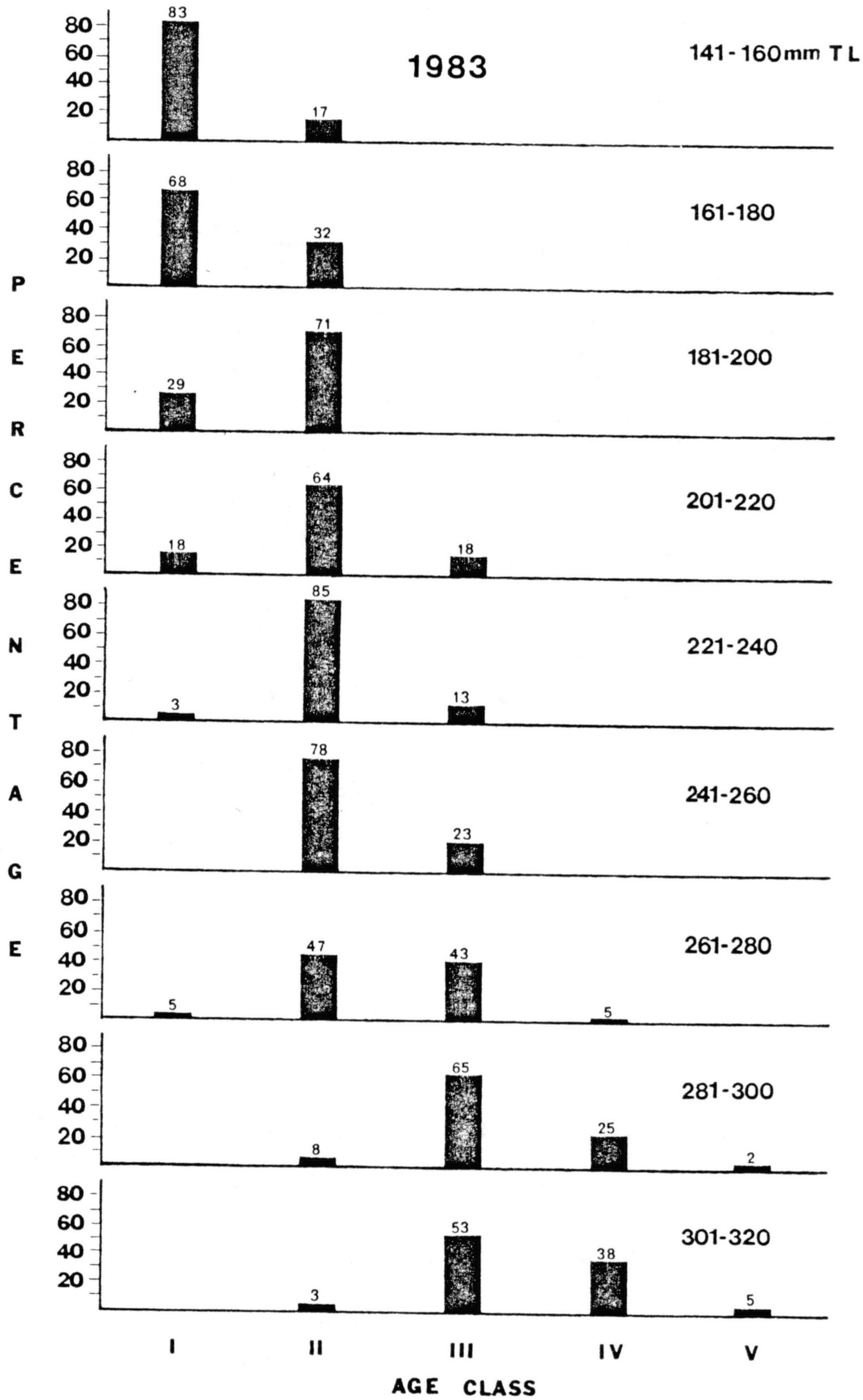


Figure 18. Age Distribution by Length Group for White Crappie Collected by All Gear Types at Copan Reservoir, Washington County, Oklahoma, for 1983.

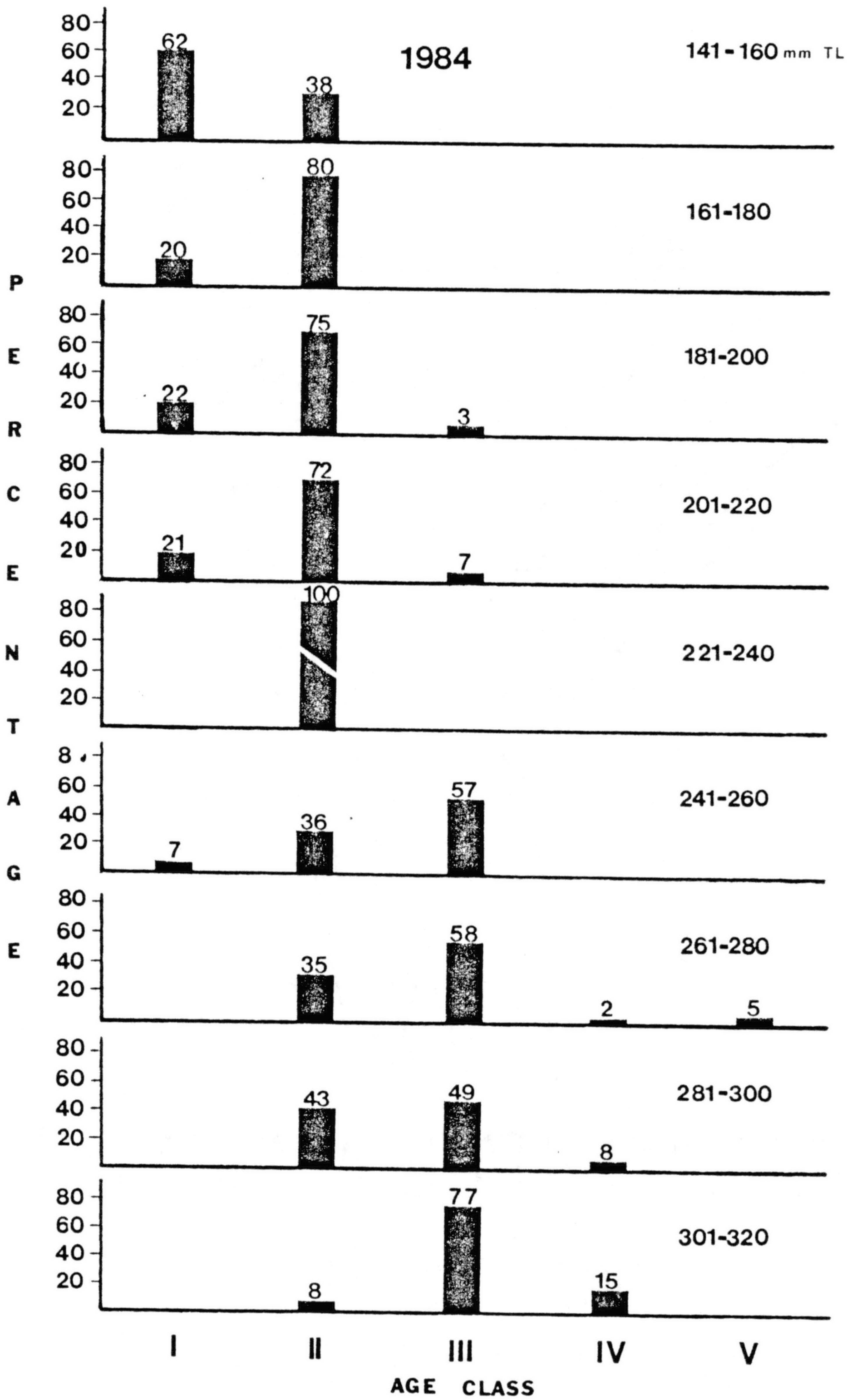


Figure 19. Age Distribution by Length Groups for White Crappie Collected by All Gear Types at Copan Reservoir, Washington County, Oklahoma, For 1984.

among age groups. The standard deviation of age 1 back calculated lengths was 45.943 mm for age 2 crappie collected in the spring of 1984 (Table XII).

Nevertheless, age groups can be roughly assigned based on the length distributions of the population samples in 1983 and 1984. For example, in 1983 peaks indicating age classes or cohorts, can be seen at 90 mm, 150 mm, 210 mm, and 310 mm (Figure 10). This distribution confirms the rough approximations of age by total length in Table XI for 1983. However, the standard deviation for the back calculated mean lengths at each age class had too much overlap to allow me to accurately assign a mean length for age.

The differences in age distribution were also significant; (student t-test; $p<0.001$) for both 1983 and 1984 between creeled fish and population samples (Table XV). Although anglers selected two disparate groups in 1983 (220-240 mm and 300-320 mm TL) by length, only age 3 was dominant (57.05%; Figure 20). Age 2 fish were dominant in the creel (50%-Figure 21) and also in the sample population (40.8%) (Figure 19) in 1984. Age 3 fish also represented a large proportion of both creel (38%) and sample population (29%) in 1984. Age 2 fish represent the 1982 cohort and Age 3 the 1981 cohort. Although anglers selected crappie in the 1980 cohort in 1983 the 1980 cohort represented only 10% of the 1984 catch.

Average growth rates for Copan crappie were above state average all years of growth. Lee's phenomenon, which typically shows slower growth for older age fish in back calculation data, was observed for both 1983 and 1984. Data from both years agreed closely on weighted average length at annulus and on growth increments (Table XII).

TABLE XV

STUDENT T-TEST ON DIFFERENCES IN AGE FOR WHITE CRAPPIE FROM SAMPLED POPULATION VERSUS CREEL POPULATION AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

Year	Gear	N	Mean Age	T
1983	Sample	812	2.411	
	Creel	149	2.731	3.7114
1984	Sample	245	2.143	
	Creel	98	2.653	4.8495

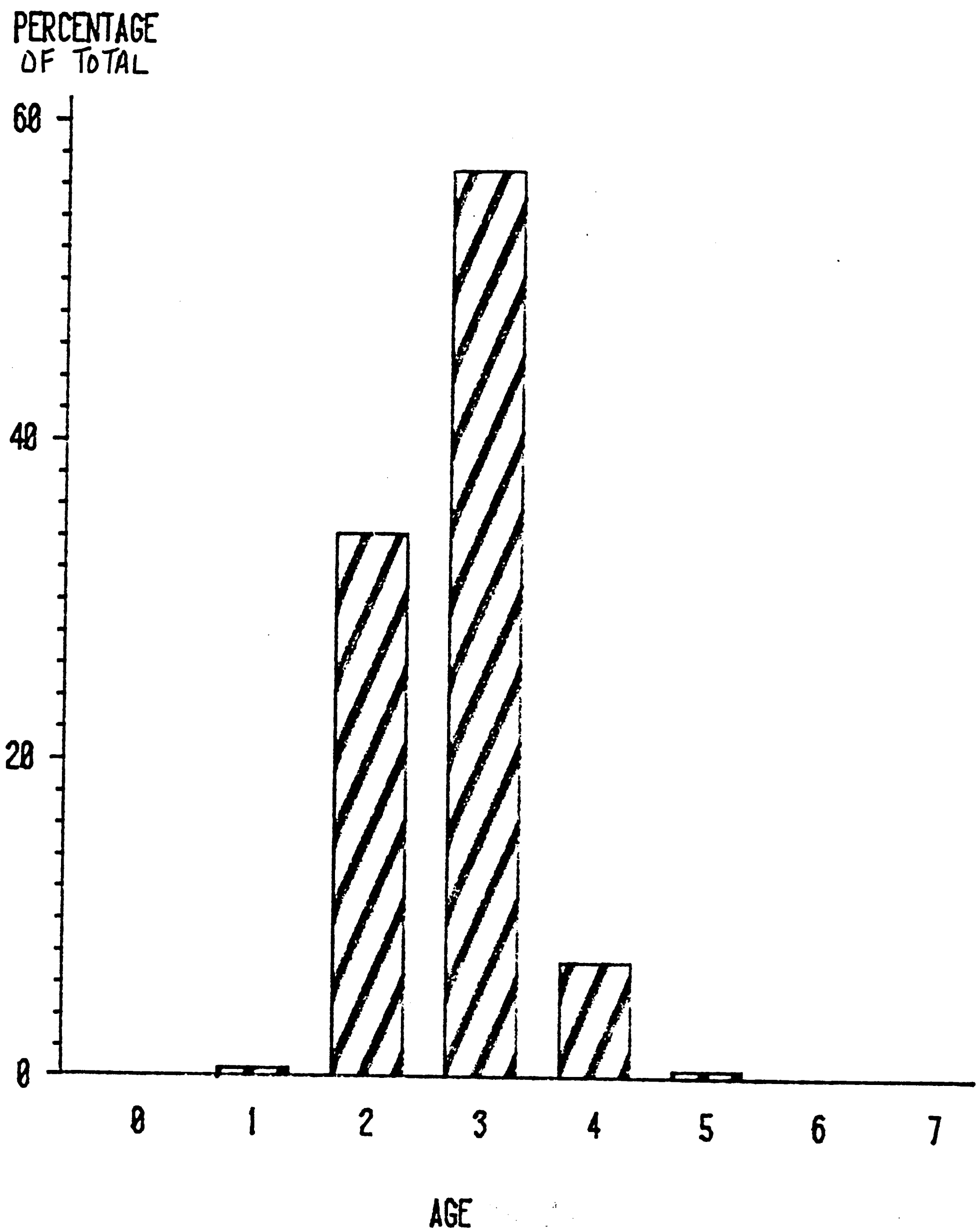


Figure 20. Age Distribution for Creel Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1983.

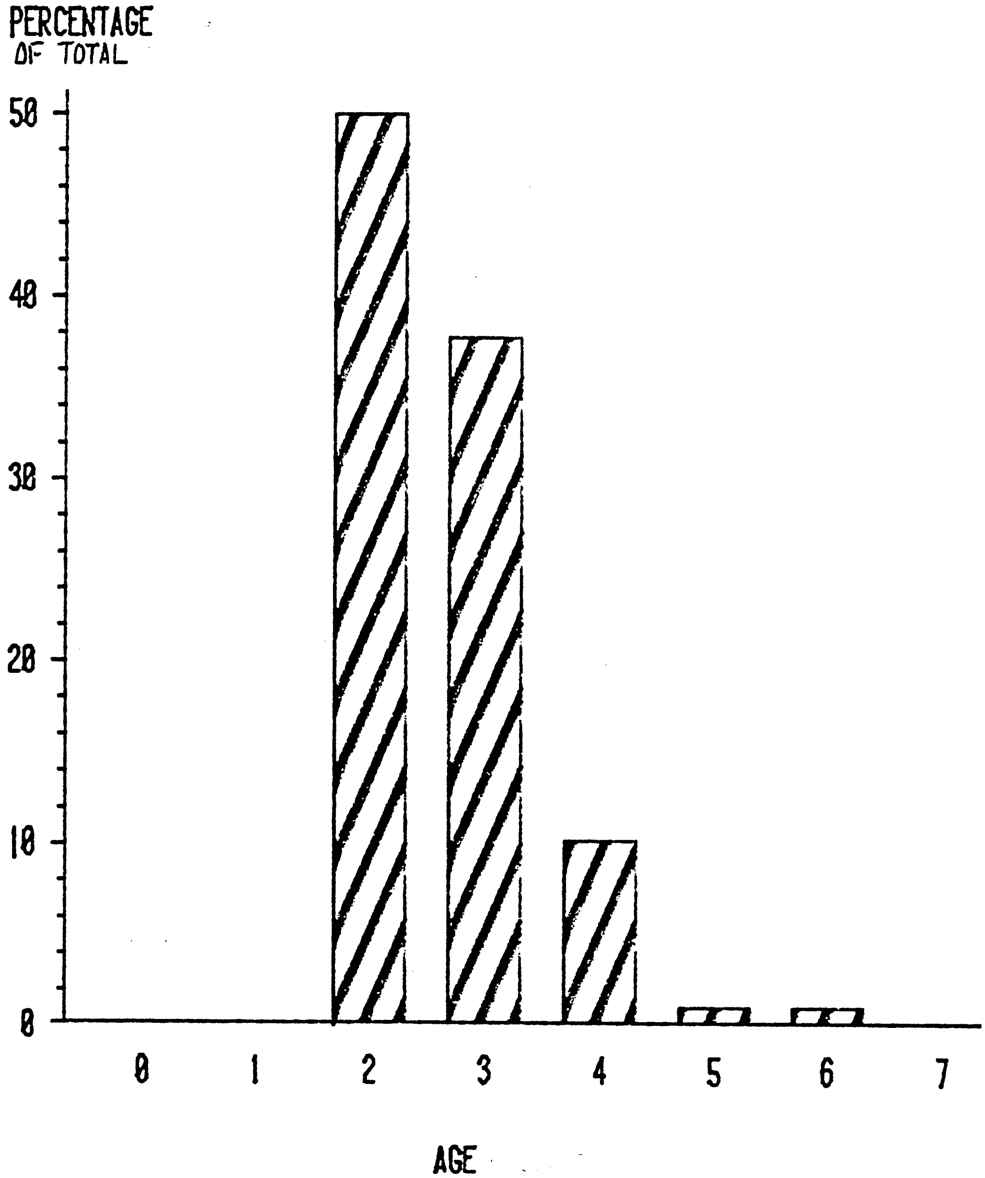


Figure 21 . Age Distribution for Creel Samples of White Crappie Collected at Copan Reservoir, Washington County, Oklahoma, for 1984.

Growth increments of crappie were greater on average in Copan Reservoir than those reported by Glass (1982) and Angyal (1983) for Sooner, and Jenkins (1953) for the state averages. Expanded habitat and allochthonous food and nutrient supply encountered during the early years following impoundment may serve to enhance this already rapid rate of growth.

PSD

Seasonal trends were not apparent in the proportional stock density (PSD) (Table XVI-including crappie from population samples). However, there were relatively low readings in the months of March 1983 (14%) , October 1984 (13%) and November 1984 (10%). Low sample size was probably also responsible for the 100% readings in December 1983 and January and February of 1984. Yearly totals were 72% for 1983 and 65% for 1984. Gablehouse (1984) has noted that PSD for crappie should be in the range of 40-70% for a "balanced" crappie population.

RSD-P [Preferred size (greater than 250 mm TL) to stock size ratio] and RSD-M [Memorable size (greater than 305 mm TL) to stock size ratio] was also calculated for both years for the crappie population and reported in Table XVI. Copan RSD-P values for 1983 and 1984 were 40% and 57% and RSD-M value for 1983 and 1984 were 15% and 9%. Gablehouse (1984) noted that a balanced crappie population should have RSD-P values in the range of 10-40% and RSD-M values in the range of 0-10%. These data seem to indicate that Copan has a relatively balanced crappie population.

TABLE XVI

PROPORTIONAL STOCK DENSITY (PSD) AND RELATIVE STOCK DENSITY (PREFERRED (RSD-P) AND MEMORABLE (RSD-M)) FOR WHITE CRAPPIE AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

	Proportional Stock Density (PSD) a N>200mm/N>130mm		Relative Stock Density (RSD-P Preferred) N>250mm/N>130mm		Relative Stock Density (RSD-M Memorable) N>305mm/N>130mm	
Month	1983	1984	1983	1984	1983	1984
January	-	100%	-	100%	-	0%
February	-	100%	-	100%	-	17%
March	14%	70%	10%	59%	0%	3%
April	62%	93%	49%	83%	26%	12%
May	80%	78%	54%	72%	23%	15%
June	72%	70%	14%	58%	1%	7%
July	38%	-	14%	-	2%	-
August	87%	-	48%	-	9%	-
September	73%	-	60%	-	0%	-
October	89%	13%	72%	9%	22%	2%
November	71%	10%	29%	5%	14%	5%
December	100%	-	0%	-	0%	-
Total	72%	65%	40%	57%	15%	9%

a - N = Number

Wr

Relative weight (Wr) was over 1.00 (state average) for half of the months during 1983 and for most of the months during 1984 (Table XVII). Yearly averages were over 1.00 for both years of the study for both creel and population samples. There was a significant difference ($p<0.1$) between relative weights of creeled fish versus fish from population samples for 1984 but not for 1983 (Table XVIII).

Catch Curves

The catch curves (Figures 22, 23, 24, and 25) for 1983 and 1984 had 1) ascending legs which indicated possible gear selectivity against young of the year fish, and 2) moderate descending legs from age 3 to age 6 which indicated moderate mortality for fish in those age groups.

Tagging Study

Movement

Eight hundred and fifty-four and one hundred and fifty-seven crappie were tagged in 1983 and 1984, respectively, in Copan Reservoir (Table XIX). Ninety percent of the angler tag returns for 1984 and 40% of 1983 angler tag returns were captured below the dam gates in the tailwater (Table XX). These tailwater returns were more frequent during the early months of the year when discharge through the dam gates was high due to seasonal rains. Tagged crappie were captured by anglers on average 4 months after first capture and release by the tagging crew during 1983. Ten crappie tagged during 1983 were recaptured in 1984, one as much as 14 months after tagging and

TABLE XVII

RELATIVE WEIGHT (Wr) FOR WHITE CRAPPIE CAUGHT IN POPULATION SAMPLING AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

	Year			
	1983		1984	
Month	N	Mean Wr	N	Mean Wr
January	0	-	2	1.4934
February	0	-	6	1.4888
March	24	0.9820	68	1.3201
April	303	1.1123	61	1.4370
May	429	1.1774	130	1.2158
June	321	1.2652	175	1.1478
July	50	1.0404	0	-
August	74	1.1373	0	-
September	9	0.9733	0	-
October	18	0.9450	91	0.9692
November	57	0.7439	21	1.0944
December	2	0.9610	0	-

TABLE XVIII

STUDENT T-TEST ON DIFFERENCES IN RELATIVE WEIGHT (Wr) FOR WHITE CRAPPIE POPULATION SAMPLES VERSUS CREEL SAMPLES AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, BY YEAR

Year	Gear	N	Mean Wr	Std. Dev.	T
1983	Creel	149	1.1711	0.1185	0.9205
	Sample	1287	1.1485	0.2970	
1984	Creel	99	1.2627	0.2222	1.3467
	Sample	554	1.1903	0.5265	

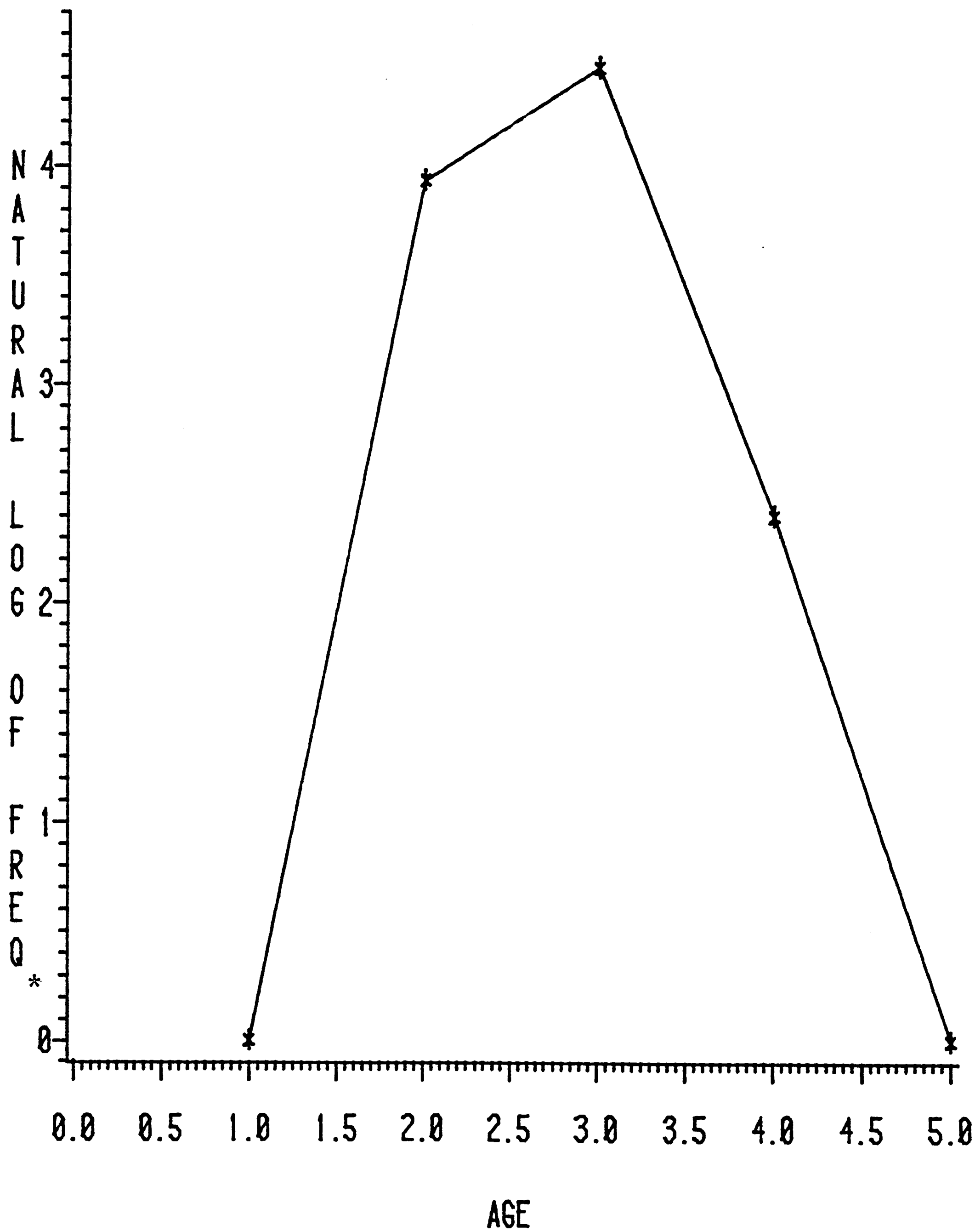


Figure 22. Catch Curve for White Crappie from 1983 Creel Samples at Copan Reservoir, Washington County, Oklahoma.

* FREQ = Frequency of Occurrence of Age Class

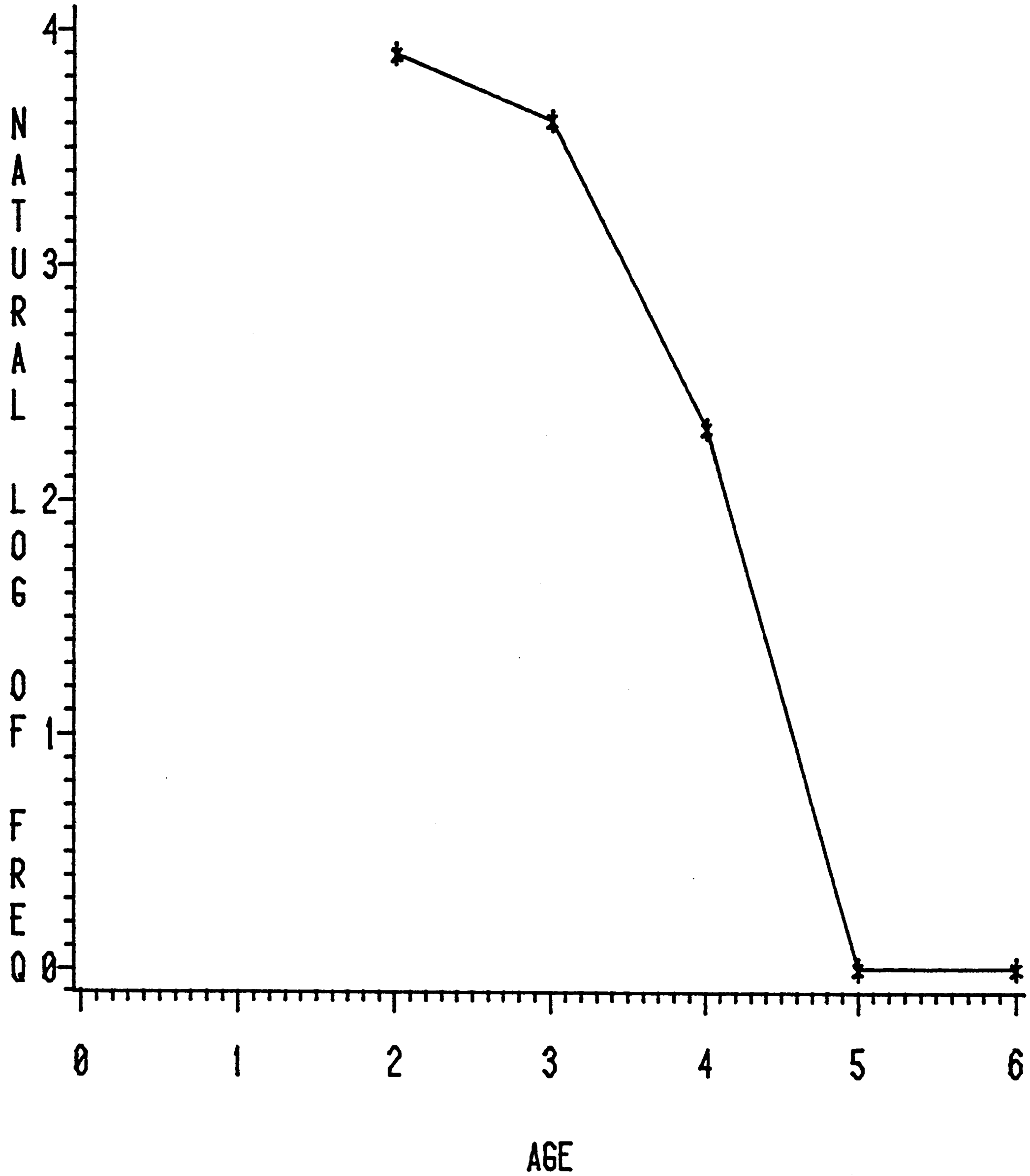


Figure 23 . Catch Curve for White Crappie from 1984 Creel Samples at Copan Reservoir, Washington County, Oklahoma.

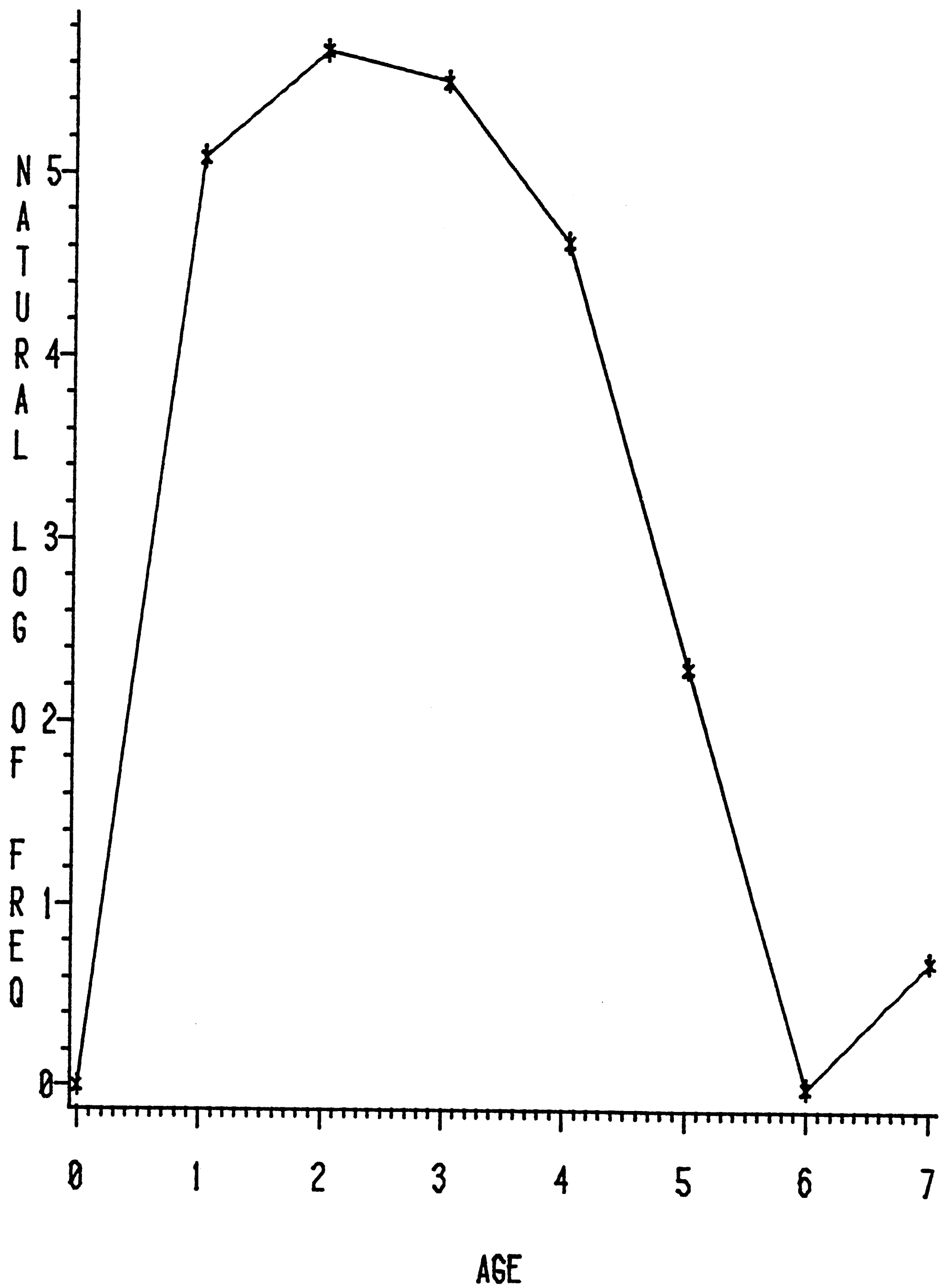


Figure 24. Catch Curve for White Crappie from 1983 Population Samples at Copan Reservoir, Washington County, Oklahoma for 1983.

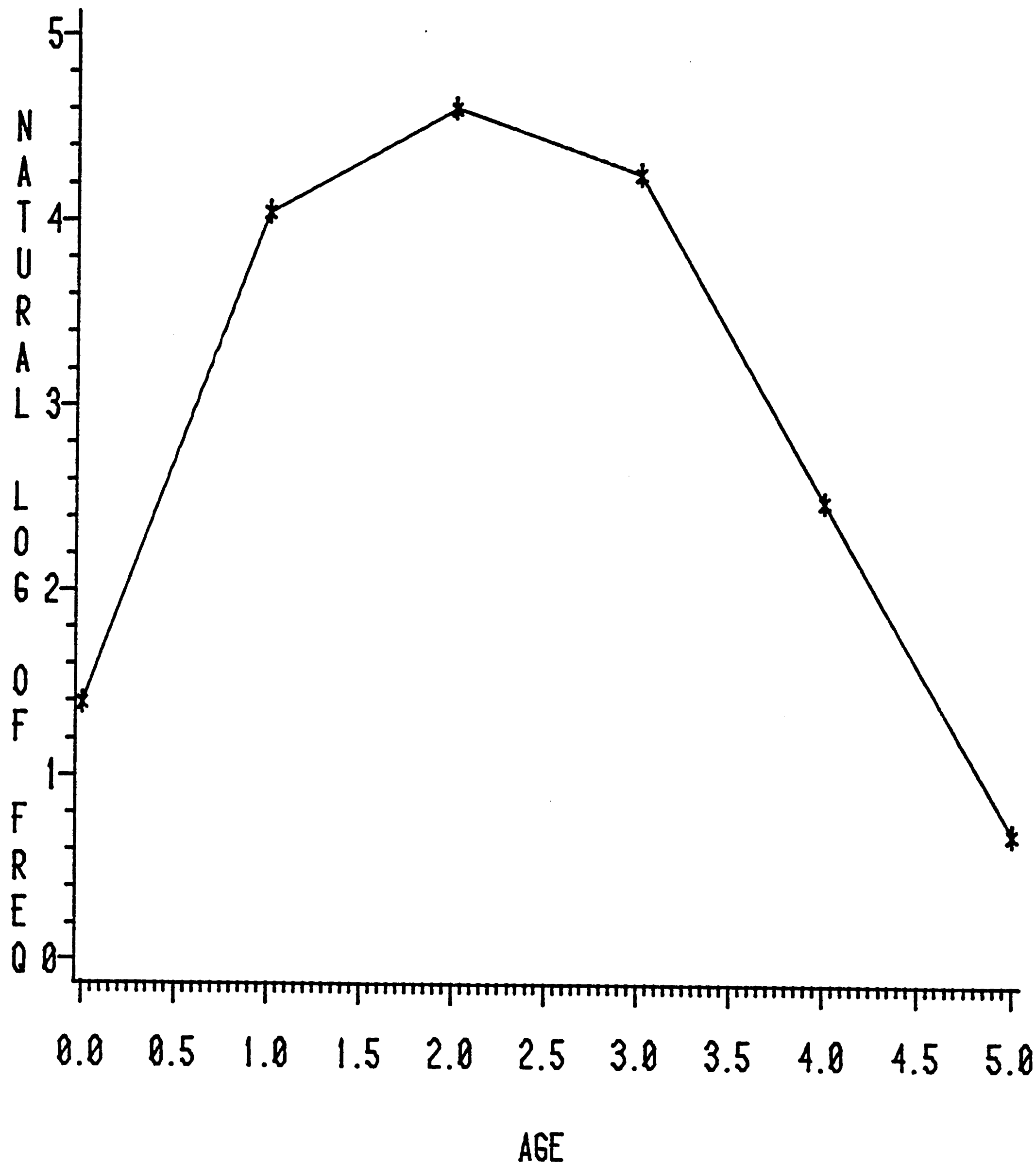


Figure 25 . Catch Curve for White Crappie from 1984 Population Samples at Copan Reservoir, Washington County, Oklahoma for 1984.

TABLE XIX

NUMBER OF WHITE CRAPPIE TAGGED WITH FLOY FD68B ANCHOR TAGS AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA FOR 1983 AND 1984 BY MONTH

	Year	
Month	1983	1984
March	17	-
April	242	10
May	266	23
June	245	124
July	21	-
August	49	-
September	5	-
October	9	-

release.

Distance between tagging and recapture sites averaged 2 km. Angyal (1983) reported that distances traveled by crappie after tagging averaged between 1 and 2 km in Sooner Reservoir.

Assumptions

For a tagging study to be valid, some of the critical assumptions to be met are 1) that the population is "closed" and that 2) marked individuals experience the same mortality as the unmarked population.

Most studies involving tagging, operate on the untested hypothesis that the reservoir population is a "closed" one. In this project, however, numbers of crappie have been documented below the dam gates during periods of high runoff. This fact by itself could invalidate the assumption of closure, were it not for the fact that there is sufficient inflow from the Little Caney river, Cotton Creek and other advective streams during periods of high runoff to bring in new immigrants to the population. Since no system is ever truly "closed", the assumption that immigration equals and balances emigration was made for this project. Further research is needed to test this hypothesis.

In addition to the previous assumption, I also assumed that marked and unmarked individuals experienced the same mortality. Recent studies in Missouri (Colvin, 1982), Illinois (Huffstodt, 1984), Indiana (Shipman, 1980 -bluegill), Kansas (Vasey, 1979), Georgia (Keefer, 1982), and Washington State (Gonyea, 1979; Gross, 1983) all on centrarchids tagged with Floy FD68B tags, report no significant tag loss or tagging mortality. Since most of the individuals in this

TABLE XX

DISTANCE AND DIRECTION TRAVELED, AND DURATION BETWEEN CAPTURE AND RECAPTURE FOR WHITE CRAPPIE TAGGED AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA, DURING 1983

N	Distance Traveled (Km)	Direction	Duration Between Capture and Recapture (months)
2	2 (Tailwater)	South	0.5
3	1 (Tailwater)	South	0.5
2	1	North,East	1.0
8	2 (Tailwater)	South	1.0
1	1 (Tailwater)	South	1.0
1	0	-	1.0
1	2 (Tailwater)	South	1.5
1	1 (Tailwater)	South	2.0
3	2 (Tailwater)	South	2.0
1	2 (Tailwater)	North,East	2.0
1	2	North,East	2.0
5	1	East	3.0
4	0	-	3.0
1	1	North	3.0
1	2	North	3.0
1	2	West	3.0
7	0	-	4.0
1	1	West	4.0
4	2	West	4.0
2	4	North	4.0
2	1	East	4.0
2	2 (Tailwater)	South	4.0
1	1 (Tailwater)	South	11.0
2	1 (Tailwater)	South	12.0
2	2 (Tailwater)	South	12.0
1	3 (Tailwater)	South	12.0
3	3 (Tailwater)	South	13.0
1	2	South	14.0

project were tagged when water temperatures were below 18 degrees C and further since almost 20% of the recaptures were from fish tagged over a year earlier, the assumption of no differential mortality for tagged individuals may be valid but needs further study.

Survival and Mortality

Survival, from 1983 to 1984 for all age groups using the Bailey's deterministic model, was estimated to be 0.613 $\pm$ 0.063 (Table XXI). Survivorship of different age classes, using the Ricker (1975) method of calculation, was variable (Table XXII) but averaged 0.37 and 0.35 for 1983 and 1984, respectively. These estimates seems to be reasonable in view of the relatively short life span of crappie in this study.

Estimated survival from the Seber-Jolly method (Table XXI) was 0.669 $\pm$ 0.034, which is in rather close agreement with estimates from Bailey's deterministic model.

Survival estimates using the catch curve method of Jackson (1939) gave an estimate of 0.547 for 1984 survival and 0.706 for 1983.

Population Size

Using Bailey's deterministic model we estimated the total crappie population size at 22,419 $\pm$ 8,407 crappie (Table XXI, 1984). The Seber-Jolly equations gave a population estimate of 42,805 $\pm$ 263 crappie greater than 200 mm TL (Table XXI). Both of these figures appear to be low compared to those reported for other Oklahoma Reservoirs (Angyal 1983). However, Copan Reservoir has almost half of the surface area of the lake composed of flooded timber which is thereby inaccessible to angling or population sampling. If we make

TABLE XXI

TABLES USED TO CALCULATE SURVIVAL, MORTALITY, POPULATION SIZE, AND EXPLOITATION RATE OF WHITE CRAPPIE AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA

Bailey's Deterministic Method

Time	Crappie Newly Marked	Crappie Examined For Marks	Recaptures From First Tagging	Recaptures From Second Tagging
1	M1 = 854			
2	M2 = 157	C2 = 1327	R12 = 86	
3		C3 = 958	R13 = 10	R23 = 2

Seber-Jolly Method

Time	Crappie Newly Marked	Crappie Examined For Marks	Recaptures of Crappie Marked At Time 1	2	3	4	Total	Ki (Zi)
1	M1=525							
2	M2=329	C2=816	R12=26				m2=26	4
3	M3=127	C3=511	R13= 4	R23=0			m3= 4	10
4	M4=0	C4=163	R14=10	R24=0	R34=0		m4=10	2
5		C5=795	R15= 0	R25=0	R35=2	R45=0	m5= 2	

Robson-Seber Method

Year	Number of Crappie Marked	Recaptures Made And Reported During Year 1	2	Totals
1	M1=854	R11=55	R12=10	R1=65
2	M2=157		R22= 0	R2= 0
Totals		m1 =55	m2= 10	

Year of Mark	Cumulative Recaptures Made During Year 1	2
1	b11 = 65	b12 = 10
2		b22 = 0
Totals	T1 = 65	T2 = 10

TABLE XXII

ESTIMATED INSTANTANEOUS MORTALITY (Z), SURVIVAL (S) AND MORTALITY (A) FOR WHITE CRAPPIE AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA; BY YEAR (FROM TABLES IN RICKER (1975))

	1983		
Ages	Z	S	A
7-6	-0.69	-	-
6-5	2.48	0.084	0.916
5-4	2.24	0.106	0.894
4-3	1.07	0.343	0.657
3-2	0.03	0.97	0.03
2-1	-0.71	-	-

	1984		
Ages	Z	S	A
6-5	1.10	0.330	0.667
5-4	1.99	0.137	0.863
4-3	1.58	0.206	0.794
3-2	0.33	0.719	0.281
2-1	-0.09	-	-

the assumption that the population is of equal density and is randomly distributed over all possible habitat types, the population estimate could be as much as 50% greater than the one calculated.

The population estimate of 42,804 $\pm$ 263 crappie greater than 200 mm TL translates to approximately 4 crappie greater than 200 mm TL per hectare. Angyal (1983) reported 70 crappie greater than 200 mm TL per hectare at a similar sized lake in Oklahoma and Gross (1983) recently reported a range of 20-141 crappie per hectare at a small lake in Washington State (Table XXIII) . Copan Resrvoir is a newly impounded reservoir and it would be unreasonable to expect the population to be at carrying capacity. Therefore, population numbers for the first years of impoundment would necessarily be lower than in older reservoirs of similar size. Further evidence of low populations is seen in the low average c/f values during 1983 and 1984 (Table II).

Crappie in Copan Reservoir did not move great distances and only 50% of the lake is accessible to anglers and sampling. Therefore, it seems reasonable to expand our estimate of crappie greater than 200 mm TL at Copan in spring of 1984 to 84,000 or 8 per hectare and 17 per acre (Table XXIII).

Exploitation Rate Estimates

The exploitation estimate using the Robson-Seber method was 1.27% for 1984 (Table XXIV) but there was a very low tagging effort and very low tag return rate for 1984. Ricker's models (1975) estimated exploitation rates for 1983 and 1984 of 6.44% and 1.60%, respectively, which are in close agreement with the Robson-Seber estimate (Table XXIV).

The estimated angler harvest for spring of 1984 was divided into age groups according to their relative abundance in the creel. The same was done for the population estimate using those ages found in net sampling. Exploitation rates ranged from 7.78% to 13.22% with a mean of 9.38% (Table XXV).

The means for estimated exploitation rates varied between a low of 1.27% and a high of 9.38%. The low values resulted from calculations performed on recapture data. Only 157 crappie were tagged in 1984 and of these only 2 were recaptured. Fifty-six tags were returned during 1983 when 854 fish were marked. Therefore, data from 1983 plus estimates from creeled fish are probably realistic exploitation rate estimates. Exploitation rates of 6.44% and 9.38% are quite low when compared to values reported for Missouri (55% - Colvin, 1982) and Illinois (greater than 50% - Huffstodt, 1984) for crappie in large impoundments. They agree rather closely, however, with values reported by Angyal (1983) at Sooner Reservoir in Oklahoma (7% for crappie; surface hectares=2300).

If the higher creel exploitation estimate (9.38%) is used for age specific mortality, it can be observed that 50% of the angler effort was concentrated on Age 2 crappie during 1984. If half of the exploitation was directed at age two fish, survival should theoretically be reduced from only 0.450 to 0.400. This reduction does not appear to be significant. It does illustrate, however, that angler exploitation is not always directed at the older age classes.

There were no significant differences in growth rate between

TABLE XXIII

ESTIMATED NUMBERS OF WHITE CRAPPIE PER HECTARE FOR COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA COMPARED WITH OTHER WATERS

Copan (1984)	Sooner (Oklahoma, 1982)	Long (Washington, 1983)
8 per hectare 17 per acre	70 per hectare 141 per acre	19-141 per hectare

TABLE XXIV

ESTIMATES OF ANNUAL SURVIVAL AND MORTALITY RATES FOR WHITE CRAPPIE IN 1983 AND 1984 AT COPAN RESERVOIR, WASHINGTON COUNTY, OKLAHOMA

Year	Survival Rate,S Method Bailey	Seber-Jolly	Jackson	$\overline{X}$	Mortality Rate,A	Exploitation Rate,u Method Robson-Seber	Tags	Creel
1983			.547	.547	.453		6.44	
1984	.613	.669	.706	.663	.337	1.27	1.60	9.38

TABLE XXV

EXPANDED POPULATION ESTIMATES, ESTIMATED ANGLER HARVEST, AND ESTIMATED ANGLER EXPLOITATION BY YEAR CLASS (FROM CREEL DATA AND TAG RETURNS) FOR WHITE CRAPPIE AT COPAN RESERVOIR WASHINGTON COUNTY, OKLAHOMA

Year Class	Expanded Population Estimate	Estimated Angler Harvest	Estimated Exploitation
1984	1369	-	-
1983	19547	-	-
1982	34288	2666	7.78%
1981	24024	2012	8.38%
1980	4116	544	13.22%
1979	689	56	8.13%
1978	-	-	-
Totals	84000	5440	$\overline{X}$ = 9.38%

crappie from creel samples and crappie from population samples. However, over time, if anglers continue to select crappie which are larger, older, and more robust than what is present in the crappie population, then changes might occur. These changes could take the form of a decreased growth rate of all crappie as the reservoir ages and/or decreased condition. These changes would necessarily occur in conjunction with exploitation at a sustained rate and directed at crappie with specific characterisitics. Given the model that Favro et al., (1979) have developed, these changes could begin to occur at Copan reservoir within a period of five years and would result in smaller/less robust crappie than those caught during the first few years of impoundment.

CHAPTER IV

CONCLUSIONS

1. Copan Reservoir in the first two years following impoundment (1983 and 1984) had a relatively low density white crappie population (about 8 crappie greater than 200 mm TL per hectare).

2. The crappie population was characterized by many large, fast growing (growth rates above state average) individuals (50% and 60% greater than 200 mm TL in 1983 and 1984, respectively).

3. The crappie population was further characterized by a number of older individuals (maximum age 1983 - 7+; maximum age 1984 - 6+). Recent studies in Oklahoma did not report crappie greater than age 5+.

4. Relative number of crappie greater than 200 mm TL compared to all those greater than 130 mm TL (PSD) was high for 1983 (72%) and 1984 (65%). This range has been cited in the literature (Gablehouse, 1984) as being characteristic of a "balanced" crappie population.

5. Copan crappie relative robustness (Wr) was also high, averaging 17% above state average for the two years of the study.

6. Anglers at Copan selected crappie that were significantly larger (1983 and 1984), had significantly different age distributions

(1983 and 1984), and had significantly higher Wr (1984) than the population as a whole.

7. Exploitation rate was relatively low over the first two initial years of impoundment due to high variability in angler usage and probably also due to low crappie density.

CHAPTER V

RECOMMENDATIONS

Further studies on this crappie population approximately five and ten years after impoundment would be recommended to check for changes in length and age distribution and relative stock density and condition factor.

Comparison between the data collected in this project and that in subsequent studies might help to elucidate effects higher angler pressure would have on the Copan Reservoir crappie population.

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